CHAPTER 4

HYDROLOGY

CHAPTER 4 HYDROLOGY

4.1 General

The location of the Garang river basin and hydrological observatories are shown in Fig. 2.1.1 and the conditions of data recording are tabulated in Table 4.1.1. These observatories are being operated by Provincial Public Works Services (DPUP), Center of Meteorology and Geophysics (BMG), or Institute of Hydraulic Engineering (IHE).

Hourly rainfall data are available at two (2) automatic rainfall stations, namely BMG-Semarang station in lowland and Kaligading station in highland. Manual rainfall stations have only daily rainfall data. The stations shown in the table and figure were selected in the Feasibility Study in 1993.

There are three (3) automatic water level stations in the Garang river system. One is Panjangan station which is located at immediately downstream of the confluence of Garang River and Kreo River. It was set up in 1983, but the data before 1986 are not available. The others are Patemon station in Garang River upstream and Kalipancur station in Kreo River. Those were both set up in 1992.

Besides, intermittent water level data at Simongan Weir recorded manually at flood time are available.

In this study stage, the kinds and periods of the hydrological data are added to the data used in the Feasibility Study. The "Additional Data" ranging from 1991 to 1996 are shown in the right part of Table 4.1.2. The hydrological analyses, which are necessary for the flood control plan and water use plan, are supposed to be updated using the additional data.

4.2 Flood Control Analysis

4.2.1 Probable Rainfall

(1) Annual Maximum Rainfall

Hourly rainfall data are available at BMG-Semarang station and Kaligading station. Of the two, the latter has a shorter record period of 17 years and contains many missing data. And it was found in the Feasibility Study that probable rainfall by the latter is smaller than that by the former. Therefore, the former, which has longer record period and contains less missing data, is adequate to be adopted.

Annual maximum rainfall for each duration (5, 10, 15, 30, 45, 60, 120 minutes, 3, 6, 12 hours and 1 day) at BMG-Semarang station in 28 years until 1996 are extracted and tabulated in Table 4.1.2.

(2) Probable Rainfall

Gumbel Method was employed to calculate probable rainfalls. The results are shown in Table 4.2.1 and Figs. 4.2.1 and 4.2.2. One (1) hour probable rainfall of 100-year return period was calculated at 144.6 mm, and one (1) day rainfall of 100-year at 319.4 mm.

(3) Rainfall Intensity Formula

As to Rainfall Intensity Formula, the Horner Type equation is used as well as the Feasibility Study. The results of calculation are shown in Tables 4.2.2 and 4.2.3 and Fig. 4.2.3. Two types of rainfall intensity curves are presented in Fig. 4.2.3 for short duration less than two (2) hours which is used for planning urban drainage and long duration more than one (1) hour which is used for planning flood control.

(4) Design Storm

The length of one (1) day is appropriate to the duration of design storm to be used in the flood control plan, considering actual rainfall patterns, the size of river basin and the kind of flood control facilities.

Hourly distribution pattern of the design storm should be made from hourly rainfall data of actual storms. Hourly rainfall data of annual maximum rainfalls in the past 10 years at BMG-Semarang station are tabulated in Table 4.2.4. The ratios of each hourly rainfall to total are calculated, and shifted so that the peak ratio can locate in center time. Shown in Table 4.2.5 are the results. The average ratio of 10 storms are adopted to express the hourly distribution ratio of the design storm.

The design storm of each return period is calculated from probable one (1) day rainfall multiplied by the hourly distribution ratio (refer to the lower part of Table 4.2.5). One (1) hour rainfall at peak time accounts for 39 percent of one (1) day rainfall. Illustrated in Fig. 4.2.4 is the design storm of 100-year return period.

4.2.2 Probable Peak Discharge

(1) Annual Maximum Flood Discharge

In the case which has less flood discharge data, probable flood discharge is calculated by a flood run-off model with input design storm. However, in the case of Garang River, probable flood discharge can be calculated directly from the peak discharge data at flood time.

Annual maximum water levels at Simongan Weir have been recorded manually from 1961 to 1996 at present. Annual maximum discharges are able to be converted from these water level data with the discharge formula for overflow as a rating curve.

Simongan Weir consists of flood discharge section at center portion with fixed weir and with flushing gates on both sides. The gates are closed even at flood time, and the river water overflows above the gates with the same overflow depth as that of the center portion.

Different discharge coefficients were applied to the center portion and the side portions of the weir. Shown in Table 4.2.6 are annual maximum discharges at Simongan Weir in the past 36 years calculated by the overflow discharge formula.

(2) Probable Peak Discharge

Gumbel Method was employed to calculate probable flood discharges, with annual maximum discharges shown in Table 4.2.6. The results of calculation are shown in Table 4.2.7 and Fig. 4.2.5

According to this, 100-year probable discharge is 1,010 m^3/s, and 25-year probable discharge is 790 m^3/s (rounded up from raw value of 785 m^3/s).

4.2.3 Flood Run-off Model

(1) Outline of Storage Function Method

Probable peak discharges have been estimated as described in Section 4.2.2. In addition to the peak discharge, probable discharge hydrograph is necessary to establish a flood control plan with dams. Accordingly, a flood run-off model, which can converts input hyetograph into discharge hydrograph, is needed.

The Storage Function Method is recommended to be employed as a flood run-off model. This method receives wide recognition as the de-facto standard method in planning flood control with dams.

The Storage Function Method has been developed to express non-linear characteristics of run-off phenomena. This method can give the process of transformation from rainfall to run-off on the assumption that there is a one-to-one functional relation between the volume of storage and run-off. Calculations of the run-off from rainfall are made through the use of the volume of storage as medium function. The relationship between the volume of storage of a basin and the discharge is expressed as follows:

$$S = K * qP$$

where,

S : depth of storage (mm)
q : depth of run-off (mm/hr)
K, P : constants

This formula is used as a substitution for the solution of equation of motion. That is, this formula establishes that the run-off is proportional to the exponent of the volume of storage. This is equivalent to the thinking in which the phenomena of rainfall and run-off are considered to be similar to the run-off from a notch in a container filled up with water.

Run-off calculations are performed by the combination of this equation of motion with the following equation of continuity.

$$dS/dt = F * Ra(t) - q(t+TL)$$

where,

F : inflow coefficient
Ra(t) : average rainfall in a watershed (mm/hr)
q(t+TL) : depth of run-off with lag time (mm/hr)
TL : lag time (hr)
t: : time

When making the run-off calculations for a basin, it is necessary to make calculations of effective rainfall. With the Storage Function Method, it is thought that coefficient (F) is not related to rainfall (Ra) but to the catchment area (A). Namely, it is thought that F=F1 in the early stages of rainfall (termed the primary run-off rate) and that only the area F1*A (called the run-off zone) causes the run-off. When cumulative rainfall exceeds Rsa (saturated rainfall), then F=1 (this is termed the saturated run-off rate), and the run-off may occur even from the remaining part (1-F1)*A (infiltration zone) due to the rainfall exceeding Rsa.

However, both the run-off zone and infiltration zone should be calculated separately for the run-off until the end of the flood. The volume of run-off from the basin should be the sum of run-off from both zones plus base run-off. Run-off (m^3/s) from the basin (including the base run-off) is given by the following formula:

$$Q(t) = F1*A*qt(t)/3.6 + (1-F1)*A*qs(t)/3.6 + Qb$$

where,

Q(t)	:	run-off (m^3/s)
F1	:	primary run-off rate
A	:	catchment area (km^2)
qt(t)	:	run-off by total rainfall (mm/hr)
qs(t)	:	run-off by rainfall after saturation (mm/hr)
Qb	:	base flow (m^3/s)

(2) Hourly Data of Rainfall and Discharge at Flood Time

Hourly discharges are able to be calculated from the water level data recorded manually at Simongan Weir at flood time intermittently, with the same rating curve as the calculation of annual maximum discharge mentioned before. Discharge hydrograph of major floods are available to be used as check data for the calibration of flood run-off model.

Five (5) annual maximum floods since 1987 were selected as the calibration data of flood run-off model considering the response between rainfall and discharge. The basin average daily rainfalls during those floods are calculated with Thiessen Polygon (refer to Fig. 4.2.6) and shown in Table 4.2.7.

It is appropriate that hourly rainfall data of Kaligading station in highland are used after its total daily rainfalls have being adjusted to the basin average daily rainfalls shown in Table 4.2.8.

The following data in five (5) floods are contained in Table 4.2.9.

(a) hourly water levels

(b) hourly discharges by (a)

(c) hourly rainfalls at Kaligading station

(d) basin average hourly rainfalls proportional to (c)

(3) Calibration of Flood Run-off Model

If the whole Garang river basin is expressed by sole basin model of Storage Function Method, the parameters in the model (namely K, P, TL, F) can be counted backward analytically using the data mentioned above. The results of backward analysis are shown in Table 4.2.10 and Fig. 4.2.7.

(4) Flood Run-off Model for Garang River Basin

The flood run-off model should be divided by smaller basins so that it can express the effects of flood control by dams and the confluence of tributaries. Sub-basin division for the Garang river basin is shown in Fig. 4.2.8. Shown in Fig. 4.2.9 is the model diagram for flood run-off calculation which consists of basin units and channel units

The parameters in the flood run-off model by Storage Function Method are tabulated in Table 4.2.11. Here, the main parameters for basin units are determined by the average values from backward analysis shown in Table 4.2.10. For channel units, only the time lag of flow down is taken into account, because the storage effect in the river channel seems little, considering from the size of the river channels.

(5) Area Reduction Factor

The hydrograph of probable flood are obtained from the flood run-off model with design storm as input. However, the peak discharge in hydrograph becomes bigger than the probable discharge estimated directly from annual maximum discharges in Section 3.3.3.

The difference between the peak discharge in hydrograph and the probable discharge is adjusted by the area reduction factor which means the ratio of basin average rainfall to point rainfall. The area reduction factors, which depend on the catchment area and the magnitude of storm, were estimated at Simongan Weir site as shown in the table below. And the distribution curves of the area reduction factor for catchment area are shown in Fig. 4.2.10. Here, the area reduction factor is 1.0 at catchment area of zero, and 0.75 at catchment area of 204 km^2 in the case of 100-year return period.

Return Period	5-year	10-year	25-year	50-year	100-year
Area Reduction Factor	0.667	0.697	0.723	0.738	0.750

(at Simongan Weir, A=204 km^2)

4.2.4 Flood Control Plan

(1) Design Flood Discharge for River Improvement

The design storm multiplied by area reduction factor was inputted into the flood run-off model by Storage Function Method and then the flood routing calculation by Jatibarang Multipurpose Dam was carried out. The results are shown in Tables 4.2.12 to 4.2.14 and Fig. 4.2.11, and the summary is shown in the table below

Return Period (year)	Peak Discharge at Dam			Peak discharge at Simongan	
	Inflow (m^3/s)	Outflow (m^3/s)	Out-max. (m^3/s)	without Dam (m^3/s)	with Dam (m^3/s)
5	150	20	60	520	400
10	180	30	70	640	500
25	220	30	90	790	620
50	260	40	100	900	700
100	290	40	120	1,010	790

Note : Discharge figures were rounded up to the nearest 10 m3/s

The design scale of Garang River/West Floodway is 100-year return period and the 100-year probable discharge is 1,010 m^3/s. The design discharge of river channel at the downstream of confluence was calculated at 790 m^3/s with the flood control by Jatibarang Multipurpose Dam. This design discharge is equivalent to 25-year probable discharge without the dam.

The distribution diagram of the design flood discharges in the Garang river system is shown in Fig. 4.2.12.

(2) Flood Control Capacity of Jatibarang Multipurpose Dam

Since the catchment area of Jatibarang Multipurpose Dam is as small as 53.0 km^2, it is difficult to operate flood gates properly because of fast flood run-off from basin. Therefore, the no-gate-discharging system is employed as the flood control system of Jatibarang Multipurpose Dam.

The flood control outlet of the dam shapes open spillway whose crest elevation equals the normal water level of the reservoir. The width of over flow section is determined at 15 m so that the peak discharge of 100-year return period at Simongan Weir site should be 790 m^3/s with the flood control by the dam. The outflow and storage conditions used in the flood routing calculation are shown in Table 4.2.13.

The net value for the flood control capacity required of Jatibarang Multipurpose Dam is estimated at 2,505,000 m^3 as shown in Table 4.2.12. Therefore, the flood control capacity of Jatibarang Multipurpose Dam is determined at 3,100,000 m^3 including 20 percent allowance in accordance with "Manual for River Works in Japan".

4.2.5 Probable Discharge at Damsite

(1) Area Reduction Factor

The area reduction factor for the whole catchment area of 204 km^2 was used in the flood control plan of the Garang river system. On the other hand, the area reduction factor for the dam catchment area of 53 km^2 should be used in calculating the flood discharge at the dam site as a design control point. The flood discharge at the dam site is useful for the design of related facilities such as diversion tunnel, stilling basin, or emergency spillway.

The area reduction factors of design storms for the dam site are shown in Fig. 4.2.10. The value is approximately C = 0.90 not depending on design scale.

(2) Design Discharge of Diversion Tunnel

The design discharge of diversion tunnel, which is necessary for dam construction work, differs with dam type. In general, once a year frequent flood discharge is used for concrete type dam, and 25-year probable flood for fill type dam.

Daily rainfall of once a year frequency cannot be calculated by Gumbel Method. It can be estimated by frequency analysis. The frequency distribution of daily rainfall in the past 10 years is tabulated in Table 4.2.15. According to this data, daily rainfall of once a year frequency becomes 128 mm by proportion.

The 25-year probable one (1) day rainfall is 256.7 mm as shown in Table 4.2.1.

The hourly rainfall pattern same as the design storm used already in flood control plan is adopted (refer to Table 4.2.5). The flood run-off calculations for once a year frequent rainfall and 25-year probable rainfall at the dam site are carried out considering the area reduction factor. The results are shown in Table 4.2.16. The once a year frequent flood discharge is calculated at 140 m^3/s, and the 25-year probable discharge at 280 m^3/s.

That is to say, the diversion discharge becomes 140 m^3/s for concrete dam, and 280 m^3/s for fill type dam.

(3) Design Discharge for Stilling Basin

For the decision of design discharge of stilling basin, the 100-year probable discharge at dam site as a design control point is necessary. The design storm of 100-year probability was already described in flood control plan. What should be changed is only the area reduction factor. The results of flood run-off calculation are also shown in Table 4.2.16. The 100-year probable discharge at dam site as a design control point is 340 m^3/s.

4.2.6 Probable Maximum Flood

(1) Probable Maximum Precipitation

The Probable Maximum Flood (PMF), which is the subject flood for the design of emergency spillway of dams, is calculated by the same flood run-off model as flood control plan with the Probable Maximum Precipitation (PMP) as the input storm.

There are two (2) kinds of methods for estimating PMP, namely meteorological method and statistical method.

Statistical procedures for estimating PMP are used wherever sufficient precipitation data are available, and are particularly useful for making quick estimates or where other meteorological data such as dew point and wind records are lacking. Our study area quite corresponds to the above conditions.

The Hershfield Method in statistical methods is employed to estimate PMP for Jatibarang Multipurpose Dam because it is the most commonly used and recommended by the World Meteorological Organization (WMO).

The following equation has been developed as the principal approach of the Hershfield Method:

$$Xp = Xn' + Km * Sn'$$

where,

Xp : point PMP

Xn' : adjusted average of a series of the annual maximum precipitation

Sn' : adjusted standard deviation of a series of the annual maximum precipitation

Km : statistical coefficient

The adjusted average and standard deviation values (Xn' and Sn') in the above equation are estimated from the unadjusted values (Xn and Sn) calculated by the observed annual maximum precipitation (data at BMG Semarang), multiplied by the adjustment factors developed by Hershfield (refer to Table 4.2.17 and Fig. 4.2.13).

The statistical coefficient (Km) in the above equation is also estimated from the relationship of the Km and Xn values developed by Hershfield (refer to Fig. 4.2.14).

The point PMP can be estimated through the above procedures and converted into the areal average PMP using the area reduction factor curves. The area reduction curves were developed by WMO based on average values obtained from the depth-area-duration (DAD) analysis of major general-type storms in the world (refer to Fig. 4.2.14).

The finally estimated areal average PMP with time durations of one (1), six (6) and 24 hours are respectively 220 mm, 478 mm and 963 mm as shown in Table 4.2.17.

(2) Probable Maximum Flood

The model hyetograph of a center-concentrated pattern can be made from the PMP values mentioned above. This storm pattern should be used as input of the flood run-off model. It is inappropriate to use the design storm pattern by only one (1) day rainfall which was used in the flood control plan, because one-hour and 6-hour rainfalls in the design storm pattern exceed that of PMP.

The model hyetograph as input data into the flood run-off model, and the discharge hydrograph as the result of calculation, are shown in Table 4.2.18 and Fig. 4.2.15. The peak inflow discharge of PMF is calculated at approximately 1,600 m^3/s, which could be within the proper limits of the PMF enveloped curve for all dams in Indonesia (refer to Fig. 4.2.16).

4.3 Water Utilization

4.3.1 Low Flow Analysis

(1) Daily Rainfall

Low flow analysis aims to convert a series of daily rainfalls into a series of daily discharges. The daily rainfall data at Sumurjurang station (No.65c), which is located in the middle reaches of the Garang river basin, are used as a representative daily rainfall pattern. The rainfall data at Sumurjurang station in the past 30 years (from 1967 to 1996) are tabulated monthly in Table 4.3.1 (after supplementation of missing data).

The basin average daily rainfalls are calculated by multiplying daily rainfalls at Sumurjurang and the modification coefficient together (refer to Table 4.3.4) based on the Thiessen polygon shown in Fig. 4.3.1.

(2) Water Balance and Annual Loss

The data at three (3) automatic water level stations (namely, Panjangan, Patemon and Kalipancur stations) in the Garang river basin are available as daily average discharge. Those discharge data are compiled monthly in Table 4.3.2. Fig. 4.3.2 shows daily discharge fluctuation at Panjangan station in the past 10 years (from 1987 to 1996).

Flow regime and water balance by observed discharge are tabulated in Table 4.3.3. According to this, Annual loss (= annual rainfall - annual runoff depth) at Panjangan station amounts 1,181 mm in average. This amount of loss corresponds to 73 % of pan evaporation, and it seems pertinent amount from a hydrological view. Compared with this, annual loss at Kalipancur station makes extremely small amount at 408 mm. It seems to be caused by the rating curve being used.

(3) Selection of Calibration Data

The daily discharge data at Jatibarang Multipurpose Dam and Simongan Weir sites are necessary in water use simulation mentioned later. Simongan Weir site is located very near from Panjangan station. Therefore, the discharges at Simongan Weir should be calculated from the discharges at Panjangan multiplying by the catchment area ratio (=204.0/192.6km^2).

On the other hand, although Kalipancur station is located near Jatibarang Multipurpose Dam in Kreo River, the data at Kalipancur has a problem about accuracy as mentioned above. Therefore, it is appropriate that the discharges at Jatibarang Multipurpose Dam also should be calculated from the discharges at Panjangan multiplying by the catchment area ratio (=53.0/192.6km^2).

Accordingly, the available daily discharge data observed at Panjangan station in the past 10 years are used in low flow analysis as calibration data for a run-off model.

(4) Outline of Tank Model Method

The Tank Model Method is applied to low water run-off analysis. This method incorporates calculations of direct run-off during rainfall as well as other elements such as the separation of infiltrated rainwater, evapotranspiration, and oozing-out of groundwater.

Serial storage type model, which is called the Tank Model, is used for run-off calculations in which the catchment is replaced with containers having several run-off holes on their sides and bottoms (refer to Fig. 4.3.3). Rainwater is placed in the top container of the model. Containers below the top one receive water from the hole in the bottom of a higher container. Part of water in each container runs off to the outside through the holes on the side, while the remaining water moves to a lower container. The sum of run-off from the holes on the sides of containers of all stages becomes the discharge of a river.

(5) Tank Model Simulation

Daily rainfalls at Sumurjurang multiplied by modification coefficient 0.99 are inputted into Tank Model. Evaporation amount, which is subtracted daily from Tanks, is 1,181 mm by annual total, and monthly pattern of evaporation is assumed to be proportioned to pan evaporation pattern (refer to Table 4.3.5).

The parameters of Tank Model, which include run-off holes, seepage holes and initial storage depths, were determined by trial simulation so that the calculation discharges can simulate the observed ones well. The parameters are finally determined as shown in Fig. 4.3.3.

The flow regime of calculated discharges and observed discharges in the past 10 years are compared in Table 4.3.6, and the simulation plottings of discharges in the past 30 years are shown in Fig. 4.3.4, where the calculated discharges and observed discharges in the latest 10 years are plotted by comparison. It is obvious that the Tank Model simulation resulted in success.

As to the discharge data which should be used in water use simulation described later, the observed discharges in the latest 10 years, and the calculated discharges by Tank Model in the previous 20 years, are adopted. The flow regime and water balance at Simongan Weir site in the past 30 years are shown in Table 4.3.7. The average annual loss in 30 years became exactly 1,200 mm finally.

(6) 5-days Discharge for 30 years

The water use simulation described later are carried out with 5-days intervals. The data of 5-days discharges in the past 30 years are contained in Table 4.3.8.

4.3.2 Water Use Simulation

(1) Required Water Quantity

Water requirement in the downstream of Jatibarang Multipurpose Dam consists of two (2) kinds of discharges, namely, river maintenance discharge, and water use discharge which is taken into PDAM facilities at one (1) kilometer upstream from Simongan Weir.

Jatibarang damsite and Simongan Weir site are necessary and sufficient as control points in water use plan. As to Simongan Weir site, the maintenance flow for Semarang River which diverts to the right bank, and another maintenance flow for existing channel in the left bank side, are required. No maintenance flow is required for West Floodway, because the downstream stretch from Simongan Weir lies in a tidal compartment.

The intake records of maintenance flow in the past 10 years are arranged annually in Table 4.3.10, and monthly details are contained in Table 4.3.11. As to minimum discharge to be secured, 0.50 m^3/s for Semarang River and 0.15 m^3/s for the Left Channel is determined to be adopted, aiming at average quantity of annual minimum intake rate in the past 10 years. It was recommended in the Master Plan in 1992 that the discharge of 1.0 m^3/s should be secured for the future maintenance flow of Semarang River after the completion of Mundingan Dam.

Regarding Jatibarang damsite, water use discharge is unnecessary. As to maintenance flow, the discharge of 0.26 m^3/s (= 1.0 m^3/s x 53/204 km^2), which is estimated from maintenance discharge of Semarang River desirable in the future (1.0 m^3/s), multiplied by the catchment ratio, is adopted. This maintenance discharge means the minimum outflow from the dam. The necessary quantity of outflow from the dam is almost determined by the deficit discharge at Simongan Weir. Therefore, the storage capacity of the dam necessary for water use does not so much depend on the maintenance discharge at dam site.

The water use discharge at Simongan Weir site means the intake rate by PDAM for water supply including existing intake rate and newly developed water volume. The existing intake rate is evaluated as 0.58 m^3/s which is the design capacity of intake facilities from Garang River as of the Feasibility Study in 1993.

Possible water quantity to be taken from river depends on the water use capacity of dam, and is determined by water use simulation.

(2) Calculation Procedure

Schematic diagram for water use simulation is shown in Fig. 4.3.5, and the calculation procedure is described in Table 4.3.9. The balance of discharges required at two (2) control points (dam site and Simongan Weir) must be calculated. If the balance makes deficit, the amount must be released from the dam. On the contrary, if the balance makes surplus, it can be stored in the dam reservoir.

The water use simulation consisting of such calculation procedures was carried out for the past 30 years in five-day intervals, and the necessary storage volume of dam for each year was estimated as accumulation of deficit discharge. The actual calculation example is shown in Table 4.3.12.

(3) Storage Capacity for Water Use

Dam storage volumes required for water use with variously assumed intake rates added to newly developed water quantity were obtained, as shown in Table 4.3.13. The water use capacity of the dam is determined by No. 3 low flow for the past 30 years (corresponding to No. 1 low flow for 10 years). Shown in Fig. 4.3.6 is the relation between newly developed water quantity and water use capacity of dam.

Even in the case without new intake rate, the water use capacity of $1.0*10^6$ m^3 is needed to ensure existing water rate and maintenance flow. It means that the present condition of water use is unstable.

In the case of new intake rate of 1.46 m^3/s, which is the same condition as the Feasibility Study and confirmed as the maximum amount to be developed anew by Jatibarang Multipurpose Dam, water use capacity (Vn) required is approximately $10.4*10^6$ m^3 (in 1991: design drought of 3rd / 30 years).

The discharge data by observation were used for recent 10 years, and the discharge data calculated by Tank Model whose precision was enhanced by calibration data for 10 years were used for the previous 20 years.

Illustrated in Fig. 4.3.7 is dam reservoir use conditions such as dam vacant volume, inflow and outflow at dam site, and discharges at Simongan Weir site. The secured discharge at Simongan Weir site is 2.69 m^3/s which includes 0.65 m^3/s for river maintenance, 0.58 m^3/s for existing intake, and 1.46 m^3/s for new intake.

(4) Evaporation from Reservoir

Although evaporation phenomenon occurs from ground surface everywhere, the evaporation amount from reservoir water surface is bigger. For that reason, the volume of evaporation increase due to the change from ordinary ground to reservoir were estimated, as shown in Table 4.3.14.

Evaporation from reservoir can be regarded as equal to pan evaporation. Accordingly, the difference between pan evaporation and basin evaporation becomes the amount of evaporation increase in depth (1,610 - 1,200 = 410 mm/year ≈ 1.12 mm/day). With this increase in depth being multiplied by average pounding area (819,000 m^3) and number of supplying days from dam in the design drought (108 days in 1991), the total volume of evaporation increase in drought time is estimated at approximately Ve = 0.1×10^6 m^3.

Therefore, with net capacity (Vn) being added to evaporation increase volume (Ve), the water use capacity of dam (Vw) comes to 10.5×10^6 m^3 (Vw=Vn+Ve).

TABLES

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Table 4.1.1 HYDROLOGICAL STATIONS AND DATA COLLECTION

No.	Station	Organi-zation	Start Year	Year of Record																													
				67	*	*	70	*	*	*	*	75	*	*	*	*	80	*	*	*	*	85	*	*	*	*	90	91	*	*	*	*	96
				by Feasibility Study in1993																								Additional Data					
(1) Daily Rainfall Data																																	
25	Kebonadem	PU,BMG	1951	A	A	A	A	A	A	A	A	B	B	A	A	A	A	A	A	A	A	A	A	A	B	A	A						
33	Karangtengah	PU,BMG	1948	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A						
34	Ngareanak	PU,BMG	1951	A	A	A	A	A	A	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	B	B						
37	Boja	PU,BMG	1969			B	A	A	A	A	A	B	B	A	B	A	A	B	B	A	A	B	A	A	B	B	B						
39	Limbangan	PU,BMG	1951	A	A	A	A	B	A	B	B	A	A	B	B	B	A	A	A	A	A	A	A	A	B	A	A						
41d	Bringinmangkang	BMG	1958	B	A	A	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	B	A	A						
41e	BMG Semarang	BMG	1968		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
44	Mijen	PU,BMG	1958	A	A	A	A	A	A	B	A	A	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
59	Candi	BMG	1958	A	A	A	A	A	A	A	A	B	B	A	A	A	A	A	B	A	B	B	A	A	A	A	B						
65c	Sumurjurang	PU,BMG	1952	B	B	A	A	B	A	B	A	B	A	A	A	A	A	B	A	A	A	B	B	A	A	A	A	B	A	A	A	B	A
68b	Klepu	BMG	1951	B	A	B	B	B	B	B	B	B	B	A	A	A	A	B	A	B	B	B	B	B									
97	Plamongan	PU,BMG	1958	B	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A						
99	Banyumeneng	PU,BMG	1956	B	A	B	A	A	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A						
(2) Hourly Rainfall Data																																	
41e	BMG Semarang	BMG	1959	(1959-1966=A)									A	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
5	Kaligading	IHE	1980														B	A	A	A	A	B	A	A	B	B	A	B	B	A	B	A	A
(3) Daily Discharge Data																																	
	Panjangan	IHE	1983	(Garang River A=192.6km2)																				A	A	A	A	A	A	A	A	A	A
	Patemon	IHE	1992	(Garang River A= 75.0km2)																									B	A	A	A	A
	Kalipancur	IHE	1992	(Kreo River A= 66.1km2)																									B	A	A	A	A
(4) Hourly Water Level Data																																	
	Simongan Weir	PU	1987	(Garang River A=204.0km2)																				B	B	B	B	B	B	B	B	B	B
			1961	(Annual Maximum Water Level =1961-1996)																				C	C	C	C	C	C	C	C	C	C

Note : Symbol=A means complete data, Symbol=B means incomplete data, Symbol=C means intermittent data

Table 4.1.2 ANNUAL MAXIMUM RAINFALL FOR EACH DURATION AT BMG-SEMARANG STATION

Unit : mm

No.	year	5-min.	10-min.	15-min.	30-min.	45-min.	60-min.	120-min.	3-hours	6-hours	12-hours	1-day
1	1959	20	25	30	50	53	53	55	55	55	55	75
2	1960	18	22	32	46	46	47	51	57	67	71	87
3	1961	21	26	28	40	43	44	50	66	87	116	124
4	1962	11	20	25	30	35	38	45	52	73	76	100
5	1963	22	24	25	38	40	40	44	62	70	118	120
6	1964	21	31	42	62	78	80	89	91	98	100	100
7	1965	11	15	18	28	38	40	41	44	91	125	166
8	1966	27	30	34	43	50	54	72	80	90	91	91
9	1976	17	20	32	43	59	75	107	107	135	183	206
10	1978	17	25	36	60	72	85	98	102	115	115	115
11	1979	15	24	29	37	50	56	99	114	126	126	126
12	1980	14	28	62	82	82	91	175	185	192	192	192
13	1981	20	40	50	65	70	80	113	120	204	228	253
14	1982	10	10	16	47	58	69	80	103	131	131	157
15	1983	18	36	54	73	83	93	93	96	96	96	96
16	1984	16	27	35	47	61	67	79	83	85	81	91
17	1985	15	25	35	55	71	96	149	149	149	247	253
18	1986	31	46	62	72	86	100	105	123	129	130	130
19	1987	27	32	37	60	85	88	93	93	96	138	138
20	1988	15	26	36	51	71	81	102	102	117	174	174
21	1989	16	26	30	44	55	80	100	100	108	142	142
22	1990	10	20	30	50	57	58	66	70	82	100	115
23	1991	10	20	30	40	48	49	70	71	125	132	132
24	1992	16	21	30	55	75	80	88	94	98	99	99
25	1993	22	30	40	75	84	92	108	110	130	182	238
26	1994	20	30	36	55	56	68	79	79	86	90	90
27	1995	15	22	35	60	67	79	100	100	100	100	124
28	1996	25	37	41	66	85	110	114	116	117	117	117

Table 4.2.1 **PROBABLE RAINFALL FOR EACH DURATION AT BMG-SEMARANG STATION**

Data N=28 (1959-1966, 1976-1996)

Return Period T (year)	Gumbel ariable Y	5-min. (mm)	10-min. (mm)	15-min. (mm)	30-min. (mm)	45-min. (mm)	60-min. (mm)	120-min. (mm)	3-hours (mm)	6-hours (mm)	12-hours (mm)	1-day (mm)
2	0.36651	17.1	25.2	33.7	50.6	60.4	68.2	83.4	89.2	103.9	120.1	130.0
3	0.90273	19.6	28.8	38.9	57.1	68.0	77.8	98.1	103.7	120.2	142.1	154.0
5	1.49994	22.5	32.8	44.8	64.4	76.4	88.6	114.5	119.9	138.3	166.6	180.7
8	2.01342	25.0	36.2	49.8	70.6	83.7	97.9	128.5	133.8	153.8	187.7	203.7
10	2.25037	26.2	37.8	52.1	73.5	87.0	102.2	135.0	140.2	161.0	197.5	214.3
20	2.97020	29.6	42.6	59.1	82.2	97.2	115.2	154.7	159.7	182.8	227.0	246.5
25	3.19853	30.7	44.1	61.3	85.0	100.4	119.3	160.9	165.8	189.8	236.4	256.7
30	3.38429	31.6	45.3	63.1	87.2	103.1	122.6	166.0	170.9	195.4	244.1	265.0
40	3.67625	33.0	47.3	65.9	90.8	107.2	127.9	174.0	178.8	204.2	256.1	278.1
50	3.90194	34.1	48.8	68.1	93.5	110.4	132.0	180.2	184.9	211.1	265.3	288.2
60	4.08596	35.0	50.0	69.9	95.7	113.0	135.3	185.2	189.9	216.6	272.9	296.4
80	4.37574	36.4	52.0	72.7	99.3	117.1	140.5	193.2	197.7	225.4	284.8	309.4
100	4.60015	37.5	53.4	74.9	102.0	120.3	144.6	199.3	203.8	232.2	294.0	319.4
150	5.00730	39.5	56.2	78.9	106.9	126.0	151.9	210.4	214.8	244.6	310.7	337.6
200	5.29581	40.9	58.1	81.7	110.4	130.1	157.1	218.3	222.6	253.3	322.6	350.5
1000	6.90723	48.6	68.8	97.4	130.0	152.9	186.2	262.4	266.2	302.2	388.8	422.6
	Xo	15.28	22.80	30.16	46.16	55.23	61.53	73.42	79.25	92.81	105.01	113.64
	1/a	4.83	6.66	9.73	12.14	14.13	18.05	27.36	27.07	30.31	41.08	44.73

Note : X = Xo + Y*(1/a)

Table 4.2.2 RAINFALL INTENSITY FOR SHORT DURATION

(T < 2 hours)

Return Period T (year)	Time (min.)	Probable Dat (mm/hr)	by Formula (mm/hr)	Difference (%)	Rainfall Intensity Formula (R=mm/hr, T=min.)
	5	204.6	195.0	-4.7	
	10	151.4	160.9	6.3	
	15	134.9	138.1	2.4	
2	30	101.2	99.4	-1.8	R = 1567.1/(T+11.79)^0.739
	45	80.5	79.3	-1.5	
	60	68.2	66.7	-2.2	
	120	41.7	42.6	2.2	
	5	270.2	261.2	-3.3	
	10	196.7	209.0	6.3	
	15	179.0	177.2	-1.0	
5	30	128.7	127.1	-1.2	R = 1271.9/(T+ 6.95)^0.638
	45	101.9	102.3	0.4	
	60	88.6	87.0	-1.8	
	120	57.2	57.8	1.0	
	5	313.8	305.6	-2.6	
	10	226.7	240.6	6.1	
	15	208.2	202.9	-2.5	
10	30	146.9	145.4	-1.0	R = 1230.2/(T+ 5.20)^0.600
	45	116.1	117.6	1.3	
	60	102.2	100.5	-1.7	
	120	67.5	68.0	0.7	
	5	355.4	348.2	-2.0	
	10	255.5	270.8	6.0	
	15	236.2	227.5	-3.7	
20	30	164.4	163.0	-0.9	R = 1241.4/(T+ 4.12)^0.575
	45	129.6	132.2	2.0	
	60	115.2	113.4	-1.6	
	120	77.3	77.6	0.4	
	5	368.8	361.9	-1.9	
	10	264.7	280.4	5.9	
	15	245.2	235.3	-4.0	
25	30	170.0	168.7	-0.8	R = 1245.5/(T+ 3.81)^0.568
	45	133.9	136.9	2.2	
	60	119.3	117.6	-1.4	
	120	80.5	80.7	0.2	
	5	409.6	403.9	-1.4	
	10	292.7	309.7	5.8	
	15	272.5	259.1	-4.9	
50	30	187.0	185.8	-0.6	R = 1273.4/(T+ 3.06)^0.550
	45	147.2	151.2	2.7	
	60	132.0	130.2	-1.4	
	120	90.1	90.2	0.1	
	5	450.0	445.5	-1.0	
	10	320.6	338.8	5.7	
	15	299.7	282.9	-5.6	
100	30	204.0	202.9	-0.5	R = 1318.3/(T+ 2.53)^0.537
	45	160.3	165.5	3.2	
	60	144.6	142.8	-1.2	
	120	99.6	99.5	-0.1	

Table 4.2.3 RAINFALL INTENSITY FOR LONG DURATION

(T > 1 hour)

Return Period T (year)	Time (min.)	Probable Dat (mm/hr)	by Formula (mm/hr)	Difference (%)	Rainfall Intensity Formula (R=mm/hr, T=min.)
	60	68.2	68.8	0.9	
	120	41.7	41.2	-1.2	
2	180	29.7	30.0	1.0	R = 2417.0/(T+10.80)^0.836
	360	17.3	17.2	-0.6	
	720	10.0	9.8	-2.0	
	1440	5.4	5.5	1.9	
	60	88.6	90.0	1.6	
	120	57.2	55.1	-3.7	
5	180	40.0	40.6	1.5	R = 3245.6/(T+14.75)^0.831
	360	23.0	23.6	2.6	
	720	13.9	13.5	-2.9	
	1440	7.5	7.6	1.3	
	60	102.2	104.2	2.0	
	120	67.5	64.3	-4.7	
10	180	46.7	47.5	1.7	R = 3721.3/(T+15.67)^0.826
	360	26.8	27.7	3.4	
	720	16.5	15.9	-3.6	
	1440	8.9	9.1	2.2	
	60	115.2	117.8	2.3	
	120	77.3	73.1	-5.4	
20	180	53.2	54.2	1.9	R = 4202.2/(T+16.63)^0.824
	360	30.5	31.7	3.9	
	720	18.9	18.3	-3.2	
	1440	10.3	10.4	1.0	
	60	119.3	122.0	2.3	
	120	80.5	76.0	-5.6	
25	180	55.3	56.3	1.8	R = 4430.3/(T+17.47)^0.826
	360	31.6	33.0	4.4	
	720	19.7	19.0	-3.6	
	1440	10.7	10.8	0.9	
	60	132.0	135.3	2.5	
	120	90.1	84.6	-6.1	
50	180	61.6	62.8	1.9	R = 4923.2/(T+18.23)^0.824
	360	35.2	36.9	4.8	
	720	22.1	21.3	-3.6	
	1440	12.0	12.1	0.8	
	60	144.6	148.3	2.6	
	120	99.6	93.1	-6.5	
100	180	67.9	69.3	2.1	R = 5426.1/(T+19.02)^0.824
	360	38.7	40.8	5.4	
	720	24.5	23.5	-4.1	
	1440	13.3	13.4	0.8	
	60	186.2	191.6	2.9	
	120	131.2	121.4	-7.5	
1000	180	88.7	90.7	2.3	R = 7100.8/(T+20.89)^0.822
	360	50.4	53.6	6.3	
	720	32.4	31.0	-4.3	
	1440	17.6	17.7	0.6	

Table 4.2.4 HOURLY RAINFALL DATA IN ANNUAL MAXIMUM DAILY RAINFALL AT BMG-SEMARANG STATION

Unit : mm

Year	Date	Total	8:00	9:00	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	1:00	2:00	3:00	4:00	5:00	6:00	7:00
1987	Jan.27	138.0	0	0	0	0	0	4.2	45.8	29	9	7.4	2.2	3.3	2	8	9.5	4.5	9.5	3	0.6	0	0	0	0	0
1988	Dec.17	174.6	0	0	0	0	0	0	0	0	0	0	0	0	0	2.6	44.2	10.4	4.2	2.3	4.2	44	13.7	17	29.9	2.1
1989	Feb. 6	141.5	6.5	0	3	5.5	0.3	0.7	0	0.3	0.7	0	4.9	1.6	6.5	8	41	5	2.5	9.7	4	1	28	9	1.5	1.8
1990	Jan.22	115.0	0	0	0	0	0	0	0	0	0.2	4.2	9.6	4	17	14	3.5	15.5	10.5	8.5	8.5	4	0.5	10	3	2
1991	Dec.26	132.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	3.9	0.1	35.5	23	27	16.5	11.5	12	1.3	0.7
1992	Mar.11	98.8	0	0	0	0	0	0	0	0	0	0	0	40	47	7.3	3.2	0.3	1	0	0	0	0	0	0	0
1993	Jan.28	237.5	1.5	11	4	10.5	33	15	0.2	0	0.3	0	0	24.5	22	16	18	34	10	16	10.5	1	0.5	8	1.5	0
1994	Mar. 8	90.0	0	0	0	0	0	0	6	0	56	7	10.5	6	4.5	0	0	0	0	0	0	0	0	0	0	0
1995	Dec.12	124.0	1.2	1.3	7.5	1.5	0	4	0	0	0	0	0	2	12.5	51	10	2.5	0.5	0	0	0.5	5	3.5	4	17
1996	Apr. 23	116.9	0	0	0	0	0	0	0	0	0	0.6	0	0	0.1	114	1.8	0	0	0	0	0	0	0	0	0

Table 4.2.5 HOURLY RAINFALL RATIO IN ANNUAL MAXIMUM DAILY RAINFALL AND DESIGN STORM

Year	Date	Total	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	Peak	1	2	3	4	5	6	7	8	9	10	11	12
1987	Dec. 4	1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.33	0.21	0.07	0.05	0.02	0.02	0.01	0.06	0.07	0.03	0.07	0.02	0.00
1988	Jan. 7	1.0	0.00	0.00	0.00	0.00	0.00	0.01	0.25	0.06	0.02	0.01	0.02	0.25	0.08	0.10	0.17	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1989	Oct.15	1.0	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.05	0.06	0.29	0.04	0.02	0.07	0.03	0.01	0.20	0.06	0.01	0.01	0.05	0.00	0.02
1990	Jan.25	1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.08	0.03	0.15	0.12	0.03	0.13	0.09	0.07	0.07	0.03	0.00	0.09	0.03	0.02	0.00
1991	Feb. 7	1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.27	0.17	0.20	0.13	0.09	0.09	0.01	0.01	0.00	0.00	0.00	0.00	0.00
1992	Nov.22	1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.48	0.07	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	Jan.29	1.0	0.14	0.06	0.00	0.00	0.00	0.00	0.00	0.10	0.09	0.07	0.08	0.14	0.04	0.07	0.04	0.00	0.00	0.03	0.01	0.00	0.01	0.05	0.02	0.04
1994	Mar. 5	1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.62	0.08	0.12	0.07	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	May.10	1.0	0.06	0.01	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.02	0.10	0.41	0.08	0.02	0.00	0.00	0.00	0.00	0.04	0.03	0.03	0.14	0.01	0.01
1996	Apr. 2	1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.98	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
*Average(*Ai)		*1.0	0.02	0.01	0.00	0.00	0.00	0.00	0.03	0.02	0.02	0.03	0.07	0.39	0.09	0.07	0.07	0.03	0.02	0.03	0.02	0.01	0.02	0.03	0.01	0.01
Return Period		Rd(mm)	Design Storm Rs (mm)																							
5-year		180.7	3.6	1.8	0.0	0.0	0.0	0.0	5.4	3.6	3.6	5.4	12.6	70.5	16.3	12.6	12.6	5.4	3.6	5.4	3.6	1.8	3.6	5.4	1.8	1.8
10-year		214.3	4.3	2.1	0.0	0.0	0.0	0.0	6.4	4.3	4.3	6.4	15.0	83.6	19.3	15.0	15.0	6.4	4.3	6.4	4.3	2.1	4.3	6.4	2.1	2.1
25-year		256.7	5.1	2.6	0.0	0.0	0.0	0.0	7.7	5.1	5.1	7.7	18.0	100.1	23.1	18.0	18.0	7.7	5.1	7.7	5.1	2.6	5.1	7.7	2.6	2.6
50-year		288.2	5.8	2.9	0.0	0.0	0.0	0.0	8.6	5.8	5.8	8.6	20.2	112.4	25.9	20.2	20.2	8.6	5.8	8.6	5.8	2.9	5.8	8.6	2.9	2.9
100-year		*319.4	6.4	3.2	0.0	0.0	0.0	0.0	9.6	6.4	6.4	9.6	22.4	124.6	28.7	22.4	22.4	9.6	6.4	9.6	6.4	3.2	6.4	9.6	3.2	3.2

Note : (Hourly Rainfall in Design Storm)Rs = (Average Ratio)Ai * (Probable Rainfall in a day)Rd

Table 4.2.4 HOURLY RAINFALL DATA IN ANNUAL MAXIMUM DAILY RAINFALL AT BMG-SEMARANG STATION

Unit : mm

Year	Date	Total	8:00	9:00	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	1:00	2:00	3:00	4:00	5:00	6:00	7:00
1987	Jan.27	138.0	0	0	0	0	0	4.2	45.8	29	9	7.4	2.2	3.3	2	8	9.5	4.5	9.5	3	0.6	0	0	0	0	0
1988	Dec.17	174.6	0	0	0	0	0	0	0	0	0	0	0	0	0	2.6	44.2	10.4	4.2	2.3	4.2	44	13.7	17	29.9	2.1
1989	Feb. 6	141.5	6.5	0	3	5.5	0.3	0.7	0	0.3	0.7	0	4.9	1.6	6.5	8	41	5	2.5	9.7	4	1	28	9	1.5	1.8
1990	Jan.22	115.0	0	0	0	0	0	0	0	0	0.2	4.2	9.6	4	17	14	3.5	15.5	10.5	8.5	8.5	4	0.5	10	3	2
1991	Dec.26	132.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	3.9	0.1	35.5	23	27	16.5	11.5	12	1.3	0.7
1992	Mar.11	98.8	0	0	0	0	0	0	0	0	0	0	0	40	47	7.3	3.2	0.3	1	0	0	0	0	0	0	0
1993	Jan.28	237.5	1.5	11	4	10.5	33	15	0.2	0	0.3	0	0	24.5	22	16	18	34	10	16	10.5	1	0.5	8	1.5	0
1994	Mar. 8	90.0	0	0	0	0	0	0	6	0	56	7	10.5	6	4.5	0	0	0	0	0	0	0	0	0	0	0
1995	Dec.12	124.0	1.2	1.3	7.5	1.5	0	4	0	0	0	0	0	2	12.5	51	10	2.5	0.5	0	0	0.5	5	3.5	4	17
1996	Apr. 23	116.9	0	0	0	0	0	0	0	0	0	0.6	0	0	0.1	114	1.8	0	0	0	0	0	0	0	0	0

Table 4.2.5 HOURLY RAINFALL RATIO IN ANNUAL MAXIMUM DAILY RAINFALL AND DESIGN STORM

Year	Date	Total	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	Peak	1	2	3	4	5	6	7	8	9	10	11	12
1987	Dec. 4	1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.33	0.21	0.07	0.05	0.02	0.02	0.01	0.06	0.07	0.03	0.07	0.02	0.00
1988	Jan. 7	1.0	0.00	0.00	0.00	0.00	0.00	0.01	0.25	0.06	0.02	0.01	0.02	0.25	0.08	0.10	0.17	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1989	Oct.15	1.0	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.05	0.06	0.29	0.04	0.02	0.07	0.03	0.01	0.20	0.06	0.01	0.01	0.05	0.00	0.02
1990	Jan.25	1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.08	0.03	0.15	0.12	0.03	0.13	0.09	0.07	0.07	0.03	0.00	0.09	0.03	0.02	0.00
1991	Feb. 7	1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.27	0.17	0.20	0.13	0.09	0.09	0.01	0.01	0.00	0.00	0.00	0.00	0.00
1992	Nov.22	1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.48	0.07	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	Jan.29	1.0	0.14	0.06	0.00	0.00	0.00	0.00	0.00	0.10	0.09	0.07	0.08	0.14	0.04	0.07	0.04	0.00	0.00	0.03	0.01	0.00	0.01	0.05	0.02	0.04
1994	Mar. 5	1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.62	0.08	0.12	0.07	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	May.10	1.0	0.06	0.01	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.02	0.10	0.41	0.08	0.02	0.00	0.00	0.00	0.00	0.04	0.03	0.03	0.14	0.01	0.01
1996	Apr. 2	1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.98	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Average(=Ai)		1.0	0.02	0.01	0.00	0.00	0.00	0.00	0.03	0.02	0.02	0.03	0.07	0.39	0.09	0.07	0.07	0.03	0.02	0.03	0.02	0.01	0.02	0.03	0.01	0.01
Return Period		Rd(mm)	Design Storm Rs (mm)																							
5-year		180.7	3.6	1.8	0.0	0.0	0.0	0.0	5.4	3.6	3.6	5.4	12.6	70.5	16.3	12.6	12.6	5.4	3.6	5.4	3.6	1.8	3.6	5.4	1.8	1.8
10-year		214.3	4.3	2.1	0.0	0.0	0.0	0.0	6.4	4.3	4.3	6.4	15.0	83.6	19.3	15.0	15.0	6.4	4.3	6.4	4.3	2.1	4.3	6.4	2.1	2.1
25-year		256.7	5.1	2.6	0.0	0.0	0.0	0.0	7.7	5.1	5.1	7.7	18.0	100.1	23.1	18.0	18.0	7.7	5.1	7.7	5.1	2.6	5.1	7.7	2.6	2.6
50-year		288.2	5.8	2.9	0.0	0.0	0.0	0.0	8.6	5.8	5.8	8.6	20.2	112.4	25.9	20.2	20.2	8.6	5.8	8.6	5.8	2.9	5.8	8.6	2.9	2.9
100-year		319.4	6.4	3.2	0.0	0.0	0.0	0.0	9.6	6.4	6.4	9.6	22.4	124.6	28.7	22.4	22.4	9.6	6.4	9.6	6.4	3.2	6.4	9.6	3.2	3.2

Note : (Hourly Rainfall in Design Storm)Rs = (Average Ratio)Ai * (Probable Rainfall in a day)Rd

Table 4.2.6 ANNUAL MAXIMUM DISCHARGE AT SIMONGAN WEIR

Year	Date	Data max. H (E.L. m)	Head h=H-5.6 (m)	Center Portion Q1 (m3/s) =1.57*64.6m*h^1.5	Side Portion Q2 (m3/s) =1.8*10.4m*h^1.5	Discharge Q=Q1+Q2 (m3/s)
1961		7.9	2.3	353.8	65.3	419
1962		7.3	1.7	224.8	41.5	266
1963		9.4	3.8	751.3	138.7	890
1964		6.9	1.3	150.3	27.7	178
1965		7.4	1.8	244.9	45.2	290
1966		x	x	x	x	x
1967		x	x	x	x	x
1968		6.6	1.0	101.4	18.7	120
1969		7.1	1.5	186.3	34.4	221
1970		7.0	1.4	168.0	31.0	199
1971		7.0	1.4	168.0	31.0	199
1972		6.9	1.3	150.3	27.7	178
1973		6.9	1.3	150.3	27.7	178
1974		7.8	2.2	331.0	61.1	392
1975		6.9	1.3	150.3	27.7	178
1976		7.9	2.3	353.8	65.3	419
1977		7.5	1.9	265.6	49.0	315
1978		7.5	1.9	265.6	49.0	315
1979		7.2	1.6	205.3	37.9	243
1980		6.7	1.1	117.0	21.6	139
1981		8.1	2.5	400.9	74.0	475
1982		7.7	2.1	308.6	57.0	366
1983		7.4	1.8	244.9	45.2	290
1984		7.3	1.7	224.8	41.5	266
1985		8.2	2.6	425.2	78.5	504
1986		7.4	1.8	244.9	45.2	290
1987	Dec.21	7.70	2.1	308.6	57.0	366
1988	Mar.25	7.80	2.2	331.0	61.1	392
1989	Feb.05	7.60	2.0	286.9	52.9	340
1990	Jan.26	9.40	3.8	751.3	138.7	890
1991	Jan.09	8.25	2.7	437.5	80.8	518
1992	Jan.09	8.05	2.5	388.9	71.8	461
1993	Jan.30	9.10	3.5	664.1	122.6	787
1994	Mar.11	7.50	1.9	265.6	49.0	315
1995	Nov.29	7.65	2.1	297.7	54.9	353
1996	Dec.02	7.90	2.3	353.8	65.3	419

Note : Max. H means annual maximum water level by watching at site.
Water level data were given by RANTING DINAS (DOLOG PENGGARON)
Gates at side portions are closed even at flood time.

Table 4.2.6 ANNUAL MAXIMUM DISCHARGE AT SIMONGAN WEIR

Year	Date	Data max. H (E.L. m)	Head h=H-5.6 (m)	Center Portion Q1 (m3/s) =1.57*64.6m*h^1.5	Side Portion Q2 (m3/s) =1.8*10.4m*h^1.5	Discharge Q=Q1+Q2 (m3/s)
1961		7.9	2.3	353.8	65.3	419
1962		7.3	1.7	224.8	41.5	266
1963		9.4	3.8	751.3	138.7	890
1964		6.9	1.3	150.3	27.7	178
1965		7.4	1.8	244.9	45.2	290
1966		x	x	x	x	x
1967		x	x	x	x	x
1968		6.6	1.0	101.4	18.7	120
1969		7.1	1.5	186.3	34.4	221
1970		7.0	1.4	168.0	31.0	199
1971		7.0	1.4	168.0	31.0	199
1972		6.9	1.3	150.3	27.7	178
1973		6.9	1.3	150.3	27.7	178
1974		7.8	2.2	331.0	61.1	392
1975		6.9	1.3	150.3	27.7	178
1976		7.9	2.3	353.8	65.3	419
1977		7.5	1.9	265.6	49.0	315
1978		7.5	1.9	265.6	49.0	315
1979		7.2	1.6	205.3	37.9	243
1980		6.7	1.1	117.0	21.6	139
1981		8.1	2.5	400.9	74.0	475
1982		7.7	2.1	308.6	57.0	366
1983		7.4	1.8	244.9	45.2	290
1984		7.3	1.7	224.8	41.5	266
1985		8.2	2.6	425.2	78.5	504
1986		7.4	1.8	244.9	45.2	290
1987	Dec.21	7.70	2.1	308.6	57.0	366
1988	Mar.25	7.80	2.2	331.0	61.1	392
1989	Feb.05	7.60	2.0	286.9	52.9	340
1990	Jan.26	9.40	3.8	751.3	138.7	890
1991	Jan.09	8.25	2.7	437.5	80.8	518
1992	Jan.09	8.05	2.5	388.9	71.8	461
1993	Jan.30	9.10	3.5	664.1	122.6	787
1994	Mar.11	7.50	1.9	265.6	49.0	315
1995	Nov.29	7.65	2.1	297.7	54.9	353
1996	Dec.02	7.90	2.3	353.8	65.3	419

Note : Max. H means annual maximum water level by watching at site.
Water level data were given by RANTING DINAS (DOLOG PENGGARON)
Gates at side portions are closed even at flood time.

Table 4.2.7 PROBABLE PEAK DISCHARGE AT SIMONGAN WEIR

Return Period T (year)	Gumbel Variable Y	Probable Discharge (m3/s) N=36 (1961-1996) Up-dated
2	0.36651	330
3	0.90273	416
5	1.49994	512
8	2.01342	595
10	2.25037	633
20	2.97020	748
25	3.19853	785
30	3.38429	815
40	3.67625	862
50	3.90194	898
60	4.08596	927
80	4.37574	974
100	4.60015	1010
150	5.00730	1075
200	5.29581	1122

Note : X = Xo + Y*(1/a)
Xo = 271.20   1/a = 160.60

Table 4.2.8 DAILY RAINFALL AT FLOOD TIME

Unit : mm

	BMG	Kaligading	Sumurjurang	Mijen	Thiessen
Ci=	0.13	0.12	0.58	0.17	Rt=Sum(Ri*Ci)
1987 Dec. 21	0.0	77.6	142.0	143.0	116.0
1990 Jan. 25	0.7	149.7	185.0	218.0	162.4
1993 Jan. 29	136.0	232.0	172.0	144.0	169.8
1994 Mar. 11	5.5	64.6	81.0	108.0	73.8
1995 Nov. 29	34.9	61.8	49.0	101.0	57.5

Table 4.2.9 (1/2) HOURLY DATA OBSERVED AT FLOOD TIME

Unit : mm

Date	Time	at Simongan Weir		Rainfall (mm)	
		Water Level H(m)	Discharge Q(m3/s)	Kaligading R(mm)	Basin Rainfall Rt(mm)
1987 Dec. 21	15:00			0.0	0.0
	16:00			0.4	0.6
	17:00			6.8	10.2
	18:00			45.3	67.7
	19:00	6.20	55.8	17.8	26.6
	20:00	7.55	327.1	6.6	9.9
	21:00	7.70	365.6	0.7	1.0
	22:00	7.40	290.1	0.0	0.0
	23:00	7.20	243.2	0.0	0.0
Dec. 22	0:00	7.00	199.0	0.0	0.0
	1:00	7.00	199.0	0.0	0.0
	2:00	6.40	86.0	0.0	0.0
	3:00			0.0	0.0
	Total			77.6	116.0
1990 Jan. 25	17:00			0.0	0.0
	18:00			2.8	3.0
	19:00			8.3	9.0
	20:00			11.2	12.2
	21:00	7.50	314.6	21.0	22.8
	22:00	8.54	605.6	57.0	61.8
	23:00	8.83	697.2	15.0	16.3
Jan. 26	0:00	8.87	710.0	26.0	28.2
	1:00	8.95	737.0	7.3	7.9
	2:00	9.40	890.0	0.2	0.2
	3:00	9.05	769.9	0.5	0.5
	4:00	8.55	609.9	0.4	0.4
	5:00	7.77	383.8	0.0	0.0
	6:00	6.98	195.7	0.0	0.0
	7:00	6.20	55.8	0.0	0.0
	8:00			0.0	0.0
	Total			149.7	162.4

Note : Q = (1.57*64.6m + 1.8*10.4m) * (H-5.6)^1.5

Table 4.2.9 (2/2) HOURLY DATA OBSERVED AT FLOOD TIME

Unit : mm

Date	Time	at Simongan Weir		Rainfall (mm)	
		Water Level H(m)	Discharge Q(m3/s)	Kaligading R(mm)	Basin Rainfall Rt(mm)
1993 Jan. 29	10:00			0.0	0.0
	11:00			1.4	1.0
	12:00			0.4	0.3
	13:00			0.0	0.0
	14:00			0.7	0.5
	15:00			1.2	0.9
	16:00			1.2	0.9
	17:00			15.2	11.1
	18:00	6.60	120.1	9.0	6.6
	19:00	7.50	314.6	20.0	14.6
	20:00	7.20	243.2	41.0	30.0
	21:00	7.80	392.0	10.0	7.3
	22:00	7.70	365.6	20.0	14.6
	23:00	8.50	593.3	40.5	29.6
Jan. 26	0:00	8.50	593.3	15.5	11.3
	1:00	9.00	753.2	30.5	22.3
	2:00	9.10	786.7	4.7	3.4
	3:00	8.70	655.7	4.8	3.5
	4:00	8.20	503.7	7.5	5.5
	5:00	7.60	339.8	7.2	5.3
	6:00	6.80	157.9	1.2	0.9
	7:00			0.0	0.0
	Total			232.0	169.8
1994 Mar. 11	11:00			0.0	0.0
	12:00			29.8	34.0
	13:00			6.2	7.1
	14:00	6.70	138.6	23.5	26.8
	15:00	7.45	302.3	3.3	3.8
	16:00	7.50	314.6	0.0	0.0
	17:00	7.20	243.2	0.4	0.5
	18:00	6.90	178.1	1.4	1.6
	19:00			0.0	0.0
	Total			64.6	73.8
1995 Nov. 29	11:00			0.0	0.0
	12:00			0.8	0.7
	13:00	6.20	55.8	30.0	27.9
	14:00	6.60	120.1	31.0	28.8
	15:00	7.65	352.6	0.0	0.0
	16:00	7.40	290.1	0.0	0.0
	17:00	7.10	220.7	0.0	0.0
	18:00	6.70	138.6	0.0	0.0
	19:00	6.60	120.1	0.0	0.0
	20:00	6.40	86.0	0.0	0.0
	21:00	6.40	86.0	0.0	0.0
	22:00	6.30	70.4	0.0	0.0
	23:00	6.30	70.4	0.0	0.0
Nov. 30	0:00	6.20	55.8	0.0	0.0
	1:00			0.0	0.0
	Total			61.8	57.5

Note : Q = (1.57*64.6m + 1.8*10.4m) * (H-5.6)^1.5

Table 4.2.10 PARAMETERS ESTIMATED BY FLOOD ANALYSIS

Flood	by Storage Function Method			
	K	P	TL(hr)	F
1987 Dec. 21	2.33	1.0	2	0.241
1990 Jan. 25	1.78	1.0	2	0.630
1993 Jan. 29	1.03	1.0	2	0.583
1994 Mar. 11	1.52	1.0	2	0.283
1995 Nov. 29	2.64	1.0	1	0.408
Average	1.9	1.0	2	0.43

Note : Constant P should be equal or less than 1.0

Table 4.2.11 PARAMETERS IN STORAGE FUNCTION METHOD

(for Basin Unit)

Sub Basin	A (km2)	K	P	TL (hr)	F1	Qb (m3/s)	Rsa (mm)
B - 1	73.5	1.9	1.0	2.0	0.43	3.7	300
B - 2	15.1	1.9	1.0	2.0	0.43	0.8	300
B - 3	36.6	1.9	1.0	2.0	0.43	1.8	300
B - 4	45.7	1.9	1.0	2.0	0.43	2.3	300
B - 5	7.3	1.9	1.0	2.0	0.43	0.4	300
B - 6	14.4	1.9	1.0	2.0	0.43	0.7	300
B - 7	11.4	1.9	1.0	2.0	0.43	0.6	300
Total	204.0						

Note : Qb = 0.05m3/s/km2

(for Channel Unit)

River Channel	K	P	TL (hr)	Length L(km)	Bed Slope I
C - 1	-	-	0.055	9.0	0.01429
C - 2	-	-	0.019	4.0	0.02500
C - 3	-	-	0.036	5.5	0.01250
C - 4	-	-	0.078	4.0	0.00143

Note: TL = 0.000736*L*I^-0.5

Table 4.2.12 100-YEAR PROBABLE FLOOD AND FLOOD CONTROL BY JATIBARANG DAM

Time (hour)	Design Storm 100-year (mm)	Dam Site Inflow (m3/s)	Dam Site Outflow (m3/s)	Simongan Weir Probable Flood (m3/s)	Simongan Weir Design Flood (m3/s)
1	6.4	3	0	10	8
2	3.2	3	0	10	8
3	0.0	15	1	54	41
4	0.0	16	2	62	48
5	0.0	11	3	44	35
6	0.0	7	3	30	25
7	9.6	5	3	22	19
8	6.4	4	4	17	16
9	6.4	22	4	79	63
10	9.6	27	6	102	81
11	22.4	29	7	112	90
12	124.6	37	11	140	114
13	28.7	67	17	246	198
14	22.4	283	40	1,010	788
15	22.4	226	76	890	730
16	9.6	178	99	702	615
17	6.4	149	110	585	541
18	9.6	108	114	429	430
19	6.4	77	110	306	336
20	3.2	65	103	254	291
21	6.4	52	95	204	246
22	9.6	38	86	150	198
23	3.2	36	77	138	180
24	2.9	41	70	155	186
1	0.0	32	64	124	157
2	0.0	25	57	99	132
Total	319.4				
Peak	124.6	283	114	1,010	788
Flood Control Volume (Vnet)			2,505,000	m3	
Flood Control Capacity (V=Vnet*1.2)			3,006,000	m3 (Jatibarang Dam)	

Note : Area Reduction Factor(0.75) is multiplied by Design Storm
Storage Function Method was used for Flood Run-off Calculation

Table 4.2.13 OUTLET CONDITION OF DAM FOR FLOOD CONTROL

Water Level H (EL.m)	Water Depth h=H-148.6 (m)	Outflow Q=C*B*h^1.5 (m3/s)	Storage Volum V (m3)	Volume > NWL dV=V-1730000 (m3)	Remarks
148.6	0.0	0.0	17,300,000	0	Normal W.L.
149.0	0.4	7.6			
150.0	1.4	49.7	18,641,000	1,341,000	
151.0	2.4	111.5			
152.0	3.4	188.1			
153.0	4.4	276.9			
154.0	5.4	376.5			
155.0	6.4	485.7	24,270,000	6,970,000	

Note : Overflow Width B=15m, Discharge Coefficient C=2.0

Table 4.2.14 PROBABLE PEAK DISCHARGE AND DESIGN DISCHARGE

(by Storage Function Method)

Return Period	Design Storm		Area	Peak Discharge at Simongan	
	Peak	Total	Reductio	Probable Discharge	After Dam Control
year	mm/hr	mm/day	Factor	m3/s	m3/s
5	70.5	180.7	0.667	512	399
10	83.6	214.3	0.697	633	493
25	100.1	256.7	0.723	785	612
50	112.4	288.2	0.738	898	700
100	124.6	319.4	0.750	1,010	788

Table 4.2.15 FREQUENCY OF DAILY RAINFALL

Unit : days

Daily Rainfall		> 190mm	> 170mm	> 150mm	> 130mm	> 110mm	> 90mm	> 70mm
Frequency	1987	1	1	1	3	4	5	13
	1988	0	0	0	0	0	4	13
	1989	0	0	0	0	0	1	9
	1990	0	1	1	1	1	3	7
	1991	0	0	0	0	0	6	8
	1992	0	0	0	0	3	4	9
	1993	0	1	3	3	3	3	5
	1994	0	0	0	0	0	0	3
	1995	0	0	0	0	0	0	0
	1996	0	0	0	0	1	1	1
Average(days/year)		0.1	0.3	0.5	0.7	1.2	2.7	6.8
Design Storm for Diversion					Rd =128mm/day (once/year)			

Note : Rainfall Data at Sumurjurang(No.65c) were used

Table 4.2.16 PROBABLE PEAK DISCHARGE AT JATIBARANG DAM SITE

(by Storage Function Method)

Return Period	Design Storm		Area	Peak Discharge	Remarks
	Peak	Total	Reductio	at Dam Site	
	mm/hr	mm/day	Factor	m3/s	
once / year	49.9	128.0	0.90	140	Diversion(Concrete)
25 year	100.1	256.7	0.90	280	Diversion(Fill Dam)
100 year	124.6	319.4	0.90	340	for Stilling Basin

Table 4.2.17 PROBABLE MAXIMUM PRECIPITATION (PMP) FOR JATIBARANG DAM

(1) Annual Maximum Rainfall at BMG Semarang Station Unit : mm

No.	Year	60 min.	6 hours	1 day
1	1959	53	55	75
2	1960	47	67	87
3	1961	44	87	124
4	1962	38	73	100
5	1963	40	70	120
6	1964	80	98	100
7	1965	40	91	166
8	1966	54	90	91
9	1976	75	135	206
10	1978	85	115	115
11	1979	56	126	126
12	1980	91	192	192
13	1981	80	204	253
14	1982	69	131	157
15	1983	93	96	96
16	1984	67	85	91
17	1985	96	149	253
18	1986	100	129	130
19	1987	88	96	138
20	1988	81	117	174
21	1989	80	108	142
22	1990	58	82	115
23	1991	49	125	132
24	1992	80	98	99
25	1993	92	130	238
26	1994	68	86	90
27	1995	79	100	124
28	1996	110	117	117

(2) Mean Value

Xn	(N=28, including all items)		71.2	109.0	137.5
Xm	(N=27, after excluding maximum items)		69.7	105.5	133.3
Xm / Xn			0.98	0.97	0.97
Adjustment for maximum data		C1=	1.02	1.01	1.01
Adjustment for record length		C2=	1.01	1.01	1.01
Adjusted Xn' = Xn * C1 * C2			73.4	111.2	140.3

(3) Standard Deviation Sn=((sum(x-xn)^2)/n)^0.5

Sn	(N=28, including all items)		19.9	33.5	49.4
Sm	(N=27, after excluding maximum items)		18.9	28.8	45.1
Sm / Sn			0.95	0.86	0.91
Adjustment for maximum data		C3=	1.07	0.97	1.03
Adjustment for record length		C4=	1.04	1.04	1.04
Adjusted Sn' = Sn * C3 * C4			22.1	33.8	52.9

(4) Point Value of PMP

Statistical Coefficient Km=			7.7	11.0	13.8
PMP from equation	PMP = Xn' + Km * Sn'		244	483	870
Adjustment for fixed interval observation		C5=	1.00	1.02	1.13
Adjusted PMP	PMP' = PMP * C5		244	493	983

(5) Areal Average PMP

Area Reduction Factor		C6=	0.90	0.97	0.98
PMP for 53km2	PMP" = PMP' * C6		220	478	963

Table 4.2.18 PROBABLE MAXIMUM FLOOD (PMF) FOR JATIBARANG DAM BY STORAGE FUNCTION METHOD

Time (hour)	Model Hyetograph by PMP (mm)	Probable Maximum Flood (m3/s)
1	21.2	3
2	22.2	3
3	23.3	58
4	24.6	93
5	26.1	117
6	28.0	134
7	30.4	148
8	33.5	161
9	37.9	175
10	44.7	192
11	56.9	213
12	220.0	243
13	65.7	460
14	49.8	1,599
15	40.9	1,355
16	35.5	1,099
17	31.8	894
18	29.1	741
19	27.0	629
20	25.3	547
21	23.9	486
22	22.7	440
23	21.7	405
24	20.8	377
1	0.0	354
2	0.0	335
Total	963.0	
Peak	220.0	1,599

Table 4.3.1 MONTHLY RAINFALL FOR 30 YEARS AT SUMURJURANG STATION (No.65c)

Unit : mm

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1967	394.0	566.4	383.0	487.0	91.0	0.0	0.0	0.0	0.0	17.0	116.0	450.0	2,504.4
1968	664.0	369.7	369.0	404.0	262.0	297.0	211.0	144.0	99.0	52.0	259.0	361.4	3,492.1
1969	456.0	719.0	754.0	766.0	28.0	90.0	57.0	0.0	16.0	172.0	224.0	443.0	3,725.0
1970	454.0	308.0	444.0	367.0	248.0	186.0	160.0	0.0	124.0	119.0	379.0	778.0	3,567.0
1971	786.0	518.0	462.0	439.0	226.0	309.0	28.0	0.0	56.0	272.0	326.0	300.3	3,722.3
1972	668.0	336.0	545.0	74.0	154.0	18.0	0.0	0.0	0.0	0.0	180.0	242.0	2,217.0
1973	524.0	222.0	326.5	226.0	204.0	108.7	144.0	22.0	144.0	319.8	387.2	323.0	2,951.2
1974	549.0	259.0	671.0	318.0	154.0	16.0	44.0	72.0	96.0	373.0	214.0	439.0	3,205.0
1975	373.0	259.0	569.0	362.0	223.0	51.3	0.0	25.0	270.0	255.0	439.0	278.7	3,105.0
1976	952.0	442.0	668.0	67.0	18.0	33.0	3.0	16.0	0.0	57.0	269.0	228.0	2,753.0
1977	433.0	323.0	633.0	210.0	161.0	117.0	0.0	0.0	0.0	0.0	150.0	470.0	2,497.0
1978	764.0	462.0	443.0	88.0	102.0	129.0	83.0	37.0	212.0	139.0	143.0	254.0	2,856.0
1979	608.0	633.0	440.0	477.0	266.0	131.0	41.0	20.0	105.0	110.0	216.0	159.0	3,206.0
1980	734.0	315.0	331.0	399.0	254.0	0.0	71.0	126.0	36.0	176.0	379.0	566.0	3,387.0
1981	402.0	378.0	98.0	0.0	201.5	112.4	203.4	0.0	0.0	0.0	64.0	412.0	1,871.3
1982	364.0	263.0	626.0	525.0	0.0	0.0	0.0	0.0	0.0	0.0	124.0	250.0	2,152.0
1983	436.0	217.0	191.0	301.0	355.0	19.0	0.0	0.0	0.0	363.0	296.0	87.0	2,265.0
1984	228.0	516.0	243.0	111.0	56.0	70.0	87.0	51.0	426.0	84.0	232.0	391.0	2,495.0
1985	63.0	245.0	152.0	218.0	35.0	0.0	94.8	79.0	114.6	215.2	260.8	306.4	1,783.8
1986	592.6	245.0	568.0	209.0	72.0	223.0	44.0	101.0	119.0	94.0	147.0	199.0	2,613.6
1987	765.0	660.0	291.0	55.0	116.0	45.0	73.0	0.0	0.0	6.0	301.0	745.0	3,057.0
1988	566.0	589.0	442.0	345.0	190.0	31.0	33.0	20.0	26.0	220.0	192.0	884.0	3,538.0
1989	374.0	730.0	513.0	347.0	244.0	218.0	118.0	12.0	48.0	150.0	329.0	358.0	3,441.0
1990	760.0	237.0	287.0	157.0	93.0	168.0	56.0	74.0	46.0	49.0	182.0	604.0	2,713.0
1991	840.0	415.0	176.0	353.0	150.3	5.0	13.1	0.0	0.0	12.1	273.9	335.9	2,574.3
1992	382.0	281.0	405.0	367.0	250.0	141.0	7.0	253.0	180.0	254.0	120.0	410.0	3,050.0
1993	755.0	384.0	252.0	307.0	61.0	165.0	52.0	32.0	64.0	23.0	145.0	228.0	2,468.0
1994	640.0	300.0	575.0	211.0	53.0	3.0	2.0	14.0	0.0	103.0	306.0	435.0	2,642.0
1995	397.0	356.0	457.0	75.0	171.0	215.0	0.0	0.0	65.4	76.0	380.0	531.0	2,723.4
1996	319.0	726.0	350.0	72.0	95.0	28.0	30.0	87.0	83.0	213.0	259.0	527.0	2,789.0
Average	541.4	409.1	422.2	277.9	151.1	97.6	55.2	39.5	77.7	130.8	243.1	399.9	2,845.5

Note : After supplementation of missing data

Table 4.3.2 MONTHLY DISCHARGE OBSERVED IN GARANG RIVER SYSTEM

Panjangan Station in Garang River (A=192.6km2) Unit : m3/s

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1987	23.11	29.72	24.66	12.05	6.38	5.05	3.49	2.46	1.88	2.08	3.82	8.91	10.19
1988	16.21	20.73	22.69	10.68	6.66	2.95	2.53	1.70	1.75	3.51	4.17	11.42	8.73
1989	9.86	49.14	16.50	10.65	9.44	10.19	3.92	3.03	1.88	4.06	7.39	15.20	11.51
1990	40.18	14.76	12.71	7.77	7.07	5.22	3.55	3.05	2.15	1.67	2.63	13.52	9.54
1991	18.50	22.22	17.18	18.73	6.32	3.30	2.73	1.44	1.36	1.29	5.75	9.57	8.94
1992	9.97	11.79	12.07	14.13	9.62	7.18	5.34	6.27	6.50	6.65	5.11	14.77	9.11
1993	27.47	38.99	22.74	21.12	5.26	6.07	2.76	3.29	3.07	2.71	2.27	4.17	11.47
1994	15.14	12.38	27.17	16.31	7.23	3.88	2.98	2.26	1.64	3.03	3.51	4.49	8.32
1995	13.68	13.69	15.68	8.30	8.04	6.92	2.91	2.89	1.33	1.66	12.62	15.11	8.54
1996	14.95	28.09	21.55	10.93	7.18	5.22	2.79	3.07	3.01	5.58	10.67	16.37	10.73
Average	18.91	24.15	19.30	13.07	7.32	5.60	3.30	2.95	2.46	3.22	5.79	11.35	9.71

Patemon Station in Garang River Upstream (A=75.0km2) Unit : m3/s

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1992	X	X	2.60	4.13	2.83	1.87	1.11	1.87	1.70	1.64	2.18	3.19	2.30
1993	11.00	8.28	5.70	5.18	2.04	2.53	1.18	0.94	0.91	0.88	1.31	2.11	3.48
1994	9.51	4.54	10.10	7.03	2.05	1.04	0.81	0.60	0.34	0.25	0.39	1.62	3.19
1995	4.40	7.19	8.28	8.97	6.03	8.39	3.43	0.82	0.79	1.09	3.92	4.79	4.81
1996	4.09	8.06	12.30	6.20	3.53	2.24	1.59	1.64	1.28	1.66	3.36	8.74	4.55
Average	7.25	7.02	7.80	6.30	3.30	3.21	1.62	1.17	1.00	1.10	2.23	4.09	3.67

Kalipancur Station in Kreo River (A=66.1km2) Unit : m3/s

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1992	X	X	6.74	6.79	4.40	2.71	1.14	2.13	1.91	1.88	2.09	7.65	3.66
1993	16.71	13.74	9.19	10.54	5.38	8.26	7.17	7.59	6.79	5.97	4.91	4.50	8.36
1994	14.25	8.39	15.50	9.63	3.03	0.81	0.74	0.56	0.55	0.60	0.98	2.20	4.76
1995	2.75	2.94	4.92	3.38	2.88	4.27	2.60	2.04	0.97	0.92	2.92	9.41	3.34
1996	6.59	10.51	10.52	6.37	4.83	3.16	0.71	0.92	0.79	1.33	2.25	3.22	4.24
Average	10.08	8.90	9.37	7.34	4.10	3.84	2.47	2.65	2.20	2.14	2.63	5.40	4.87

Table 4.3.3 FLOW REGIME AND BALANCE IN OBSERVED DAILY DISCHARGE RECORDS

Panjangan Station in Garang River (A=192.6km2)

Year	Days	Flow Regime Max (m3/s)	25% (m3/s)	50% (m3/s)	75% (m3/s)	95% (m3/s)	99% (m3/s)	Min (m3/s)	Mean (m3/s)	Annual Run-off (1) mm	No.65c Rainfall (2) mm	Annual ainfall(mm) 3)=(2)*0.99	Annual Loss (3)-(1) mm	Run-off Ratio (%)
1987	365	99.20	11.10	5.35	2.62	1.77	1.64	1.50	10.19	1,668	3,057	3,026	1,358	55
1988	366	123.00	11.00	4.80	2.11	1.48	1.36	0.64	8.73	1,433	2,538	2,513	1,080	57
1989	365	187.00	12.50	8.31	3.41	1.82	1.57	1.28	11.51	1,885	3,441	3,407	1,522	55
1990	365	201.00	9.72	6.02	2.50	1.40	1.30	1.30	9.54	1,562	2,713	2,686	1,124	58
1991	365	63.60	14.00	4.62	1.80	1.14	1.02	1.02	8.94	1,464	2,574	2,548	1,084	57
1992	366	32.50	11.20	7.40	5.30	4.00	3.50	3.50	9.11	1,496	3,050	3,020	1,524	50
1993	365	309.00	12.30	3.72	2.77	2.13	1.45	1.45	11.47	1,878	2,468	2,443	565	77
1994	365	115.00	10.80	4.25	2.75	1.62	1.40	1.18	8.32	1,362	2,642	2,616	1,254	52
1995	365	45.40	10.80	6.80	2.75	1.18	0.52	0.52	8.54	1,398	2,723	2,696	1,298	52
1996	366	53.80	15.00	7.40	3.25	2.50	2.28	2.06	10.73	1,762	2,789	2,761	999	64
Average		122.95	11.84	5.87	2.93	1.90	1.60	1.45	9.71	1,591	2,800	2,772	1,181	58
Q/100km2		63.84	6.15	3.05	1.52	0.99	0.83	0.75	5.04					

(1)=Mean*Days*86.4/A

Patemon Station in Garang River Upstream (A=75.0km2) (2)*1.03

1992	366	22.50	2.37	1.50	1.22	1.10	0.95	0.74	2.30	970	3,050	3,142	2,172	31
1993	365	106.00	4.27	1.44	0.98	0.75	0.71	0.63	3.48	1,463	2,468	2,542	1,079	58
1994	365	50.50	4.40	1.01	0.53	0.23	0.21	0.21	3.19	1,341	2,642	2,721	1,380	49
1995	365	21.50	7.12	4.62	1.07	0.74	0.71	0.65	4.81	2,023	2,723	2,805	782	72
1996	366	28.80	6.30	3.10	1.46	1.22	1.14	1.10	4.55	1,918	2,789	2,873	955	67
Average		45.86	4.89	2.33	1.05	0.81	0.74	0.67	3.67	1,543	2,734	2,816	1,273	55
Q/100km2		61.15	6.52	3.11	1.40	1.08	0.99	0.89	4.89					

Kalipancur Station in Kreo River (A=66.1km2) (2)*1.00

1992	366	16.70	5.00	2.82	1.17	0.95	0.95	0.87	3.66	1,751	3,050	3,050	1,299	57
1993	365	134.00	8.40	6.80	5.00	3.82	3.40	3.00	8.36	3,989	2,468	2,468	-1,521	162
1994	365	40.00	8.00	1.25	0.65	0.50	0.42	0.30	4.76	2,271	2,642	2,642	371	86
1995	365	21.90	4.20	2.30	1.17	0.87	0.72	0.40	3.34	1,593	2,723	2,723	1,130	59
1996	366	17.30	6.50	3.20	0.95	0.65	0.50	0.47	4.24	2,028	2,789	2,789	761	73
Average		45.98	6.42	3.27	1.79	1.36	1.20	1.01	4.87	2,326	2,734	2,734	408	87
Q/100km2		69.56	9.71	4.95	2.70	2.05	1.81	1.52	7.37					

Table 4.3.4 THIESSEN COEFFICIENT AND BASIN RAINFALL

Station	Average Rainfall in 1971 - 1990 (mm/year)	Thiessen Coefficient		
		Catchment Area		
		Panjangan	Patemon	Kalipancur
No.59	2,365	0.16	0.12	0.00
No.44	2,563	0.16	0.45	0.00
No.39	3,380	0.14	0.26	0.12
No.65c	2,791	0.54	0.17	0.88
Total		1.00	1.00	1.00
Basin Rainfall		2,769	2,790	2,862
Basin Rainfall / No.65c		0.99	1.00	1.03

Table 4.3.5 MONTHLY EVAPORATION IN TANK MODEL

Month	Pan Evaporation (1) mm/day	Annual Loss mm/year	Evaporation in Tank Model (1)*0.734 mm/day
Jan.	3.3		2.42
Feb.	3.7		2.72
Mar.	3.8		2.79
Apr.	4.0		2.94
May	4.3		3.16
Jun.	4.5		3.30
Jul.	4.8		3.52
Aug.	5.1		3.74
Sep.	5.7		4.18
Oct.	5.5		4.04
Nov.	4.4		3.23
Dec.	3.8		2.79
Total(mm/yr)	1,610	1,181	1,181

Note : (Annual Loss) / (Annual Pan Evaporation) = 0.734

Table 4.3.6 COMPARISON OF FLOW REGIME BETWEEN TANK-MODEL AND OBSERVATION

Panjangan Station (A=192.6km2)

Kind of Data	Year	Flow Regime								Annual
		Max (m3/s)	25% (m3/s)	50% (m3/s)	75% (m3/s)	95% (m3/s)	99% (m3/s)	Min (m3/s)	Mean (m3/s)	Loss (mm)
by Tank Model	1987	115.41	11.68	4.41	2.02	0.61	0.56	0.54	10.82	1,254
	1988	100.65	14.64	6.69	3.44	1.81	1.51	1.39	12.54	1,444
	1989	86.57	15.10	9.11	5.11	3.19	3.00	2.83	12.56	1,350
	1990	126.40	10.58	5.97	3.43	1.73	1.42	1.33	9.62	1,111
	1991	81.09	11.61	5.37	2.98	1.02	0.95	0.93	9.54	986
	1992	72.02	10.93	6.33	4.19	2.97	2.80	2.68	9.75	1,419
	1993	178.31	8.85	5.15	3.05	1.63	1.42	1.35	8.98	973
	1994	68.13	11.07	4.72	2.38	0.96	0.89	0.88	8.85	1,167
	1995	51.15	10.99	5.47	2.99	1.34	1.10	1.03	8.53	1,299
	1996	67.42	10.93	5.23	3.30	1.95	1.68	1.64	9.05	1,275
	Average	94.72	11.64	5.85	3.29	1.72	1.53	1.46	10.02	1,228
by Observation	1987	99.20	11.10	5.35	2.62	1.77	1.64	1.50	10.19	1,358
	1988	123.00	11.00	4.80	2.11	1.48	1.36	0.64	8.73	1,080
	1989	187.00	12.50	8.31	3.41	1.82	1.57	1.28	11.51	1,522
	1990	201.00	9.72	6.02	2.50	1.40	1.30	1.30	9.54	1,124
	1991	63.60	14.00	4.62	1.80	1.14	1.02	1.02	8.94	1,084
	1992	32.50	11.20	7.40	5.30	4.00	3.50	3.50	9.11	1,524
	1993	309.00	12.30	3.72	2.77	2.13	1.45	1.45	11.47	565
	1994	115.00	10.80	4.25	2.75	1.62	1.40	1.18	8.32	1,254
	1995	45.40	10.80	6.80	2.75	1.18	0.52	0.52	8.54	1,298
	1996	53.80	15.00	7.40	3.25	2.50	2.28	2.06	10.73	999
	Average	122.95	11.84	5.87	2.93	1.90	1.60	1.45	9.71	1,181

Table 4.3.7 FLOW REGIME FOR 30 YEARS AT SIMONGAN WEIR

(Catchment Area at Simongan Weir A=204.0km2)

Year	Days	Flow Regime Max (m3/s)	25% (m3/s)	50% (m3/s)	75% (m3/s)	95% (m3/s)	99% (m3/s)	Min (m3/s)	Mean (m3/s)	Annual Run-off (1) mm	No.65c Rainfall (2) mm	Annual Rainfall(mm) (3) =(2)*0.99	Annual Loss (3)-(1) mm
by Tank Model (= Discharge at Panjangan * 204.0km2/192.6km2)										(1)=Mean*Days*86.4/A			
1967	365	198.71	11.81	5.87	2.60	1.03	0.96	0.95	10.04	1,552	2,504	2,479	927
1968	366	115.98	12.94	7.82	5.38	3.89	3.37	3.21	12.43	1,928	3,492	3,457	1,529
1969	365	131.38	17.43	8.06	5.02	3.20	2.88	2.78	15.58	2,409	3,725	3,688	1,279
1970	365	128.67	15.20	9.76	5.75	3.59	3.08	3.00	13.18	2,037	3,567	3,531	1,494
1971	365	83.45	18.58	11.10	6.97	4.80	4.24	4.11	15.98	2,471	3,722	3,685	1,214
1972	366	144.85	10.21	5.75	3.07	1.44	1.37	1.35	9.95	1,542	2,217	2,195	653
1973	365	110.44	10.97	6.41	4.16	2.71	2.43	2.37	9.63	1,488	2,951	2,921	1,433
1974	365	89.68	14.35	7.49	4.89	3.33	2.90	2.80	12.33	1,906	3,205	3,173	1,267
1975	365	82.36	14.45	8.24	5.72	3.80	3.51	3.37	11.49	1,777	3,105	3,074	1,297
1976	366	148.87	12.78	6.21	3.36	1.65	1.45	1.44	12.21	1,893	2,753	2,725	832
1977	365	83.46	10.23	5.07	2.75	1.31	1.23	1.21	9.11	1,408	2,497	2,472	1,064
1978	365	81.98	10.81	5.57	4.12	2.96	2.65	2.60	10.33	1,596	2,856	2,827	1,231
1979	365	99.12	14.98	8.26	4.59	3.06	2.85	2.78	12.48	1,929	3,206	3,174	1,245
1980	366	262.16	14.14	8.04	4.62	2.46	2.01	1.92	12.70	1,969	3,387	3,353	1,384
1981	365	55.94	9.35	4.79	2.76	1.15	1.10	1.08	7.30	1,128	1,871	1,852	724
1982	365	112.35	8.81	3.97	1.60	0.89	0.83	0.80	8.13	1,258	2,152	2,130	872
1983	365	72.34	9.14	4.14	2.11	0.78	0.72	0.70	7.27	1,123	2,265	2,242	1,119
1984	366	53.07	8.57	3.58	2.29	1.45	1.09	0.97	7.03	1,090	2,495	2,470	1,380
1985	365	72.24	5.17	2.86	1.73	0.70	0.61	0.59	4.83	747	1,784	1,766	1,019
1986	365	107.93	10.15	4.83	3.18	1.94	1.72	1.61	8.75	1,352	2,614	2,588	1,236
by Observation (= Discharge at Panjangan * 204.0km2/192.6km2)													
1987	365	105.07	11.76	5.67	2.78	1.87	1.74	1.59	10.79	1,668	3,057	3,026	1,358
1988	366	130.28	11.65	5.08	2.23	1.57	1.44	0.68	9.25	1,433	3,538	3,503	2,070
1989	365	198.07	13.24	8.80	3.61	1.93	1.66	1.36	12.19	1,885	3,441	3,407	1,522
1990	365	212.90	10.30	6.38	2.65	1.48	1.38	1.38	10.10	1,562	2,713	2,686	1,124
1991	365	67.36	14.83	4.89	1.91	1.21	1.08	1.08	9.47	1,464	2,574	2,548	1,084
1992	366	34.42	11.86	7.84	5.61	4.24	3.71	3.71	9.65	1,496	3,050	3,020	1,524
1993	365	327.29	13.03	3.94	2.93	2.26	1.54	1.54	12.15	1,878	2,468	2,443	565
1994	365	121.81	11.44	4.50	2.91	1.72	1.48	1.25	8.81	1,362	2,642	2,616	1,254
1995	365	48.09	11.44	7.20	2.91	1.25	0.55	0.55	9.05	1,398	2,723	2,696	1,298
1996	366	56.98	15.89	7.84	3.44	2.65	2.41	2.18	11.37	1,762	2,789	2,761	999
Average (30 years)		117.91	12.18	6.33	3.59	2.21	1.93	1.83	10.45	1,617	2,845	2,817	1,200

Table 4.3.8 (1/3) 5-DAYS DISCHARGE AT PANJANGAN IN GARANG RIVER

by Tank Model (A=192.6 km2) Unit : m3/s

Year		1-5	5-10	10-15	15-20	20-25	25-31
1967	Jan	30.217	20.746	8.392	12.758	9.472	9.883
	Feb	30.350	84.102	19.676	9.312	6.770	9.807
	Mar	6.745	14.682	17.950	11.106	14.289	18.566
	Apr	37.578	14.250	16.112	12.420	15.906	26.187
	May	9.969	7.144	15.138	6.989	6.313	5.682
	Jun	5.454	5.248	5.047	4.850	4.658	4.469
	Jul	4.281	4.093	3.909	3.729	3.553	3.364
	Aug	3.174	3.003	2.835	2.670	2.509	2.336
	Sep	2.158	1.993	1.832	1.673	1.519	1.367
	Oct	1.222	1.081	1.005	1.241	0.973	0.946
	Nov	0.940	0.933	5.733	1.720	0.988	4.192
	Dec	4.033	9.637	25.054	11.790	7.462	17.417
1968	Jan	13.014	28.203	27.247	21.047	43.111	16.958
	Feb	7.852	12.068	6.758	18.061	26.394	14.315
	Mar	8.218	5.406	5.587	8.289	17.273	40.455
	Apr	49.662	50.193	12.233	7.807	5.701	5.181
	May	7.337	5.359	16.473	10.146	6.918	9.626
	Jun	9.024	6.173	13.542	9.860	16.667	12.693
	Jul	7.222	5.912	11.040	8.724	9.399	8.932
	Aug	6.009	7.638	5.311	7.881	6.866	6.529
	Sep	4.535	4.293	4.414	5.802	6.159	4.275
	Oct	3.905	3.779	3.642	3.439	3.251	3.627
	Nov	5.915	13.037	6.813	4.446	7.127	7.503
	Dec	8.735	5.148	6.174	9.226	38.200	12.466
1969	Jan	6.445	11.996	10.636	25.478	32.387	17.748
	Feb	27.542	15.574	13.276	54.026	51.037	24.727
	Mar	33.866	15.371	13.134	33.854	37.036	50.550
	Apr	80.459	21.614	42.584	20.174	53.628	20.367
	May	11.654	9.056	9.483	7.847	7.534	7.267
	Jun	7.003	18.622	7.956	6.734	6.470	6.245
	Jul	6.020	6.722	5.955	6.321	6.111	5.257
	Aug	5.026	4.817	4.613	4.413	4.217	4.007
	Sep	3.793	3.596	3.403	3.214	3.243	2.950
	Oct	5.196	7.143	3.291	2.722	6.772	5.291
	Nov	8.009	12.246	10.825	5.086	4.025	3.628
	Dec	2.971	15.984	6.072	24.911	21.053	14.484
1970	Jan	7.722	8.775	21.757	15.698	37.799	14.152
	Feb	16.910	11.902	10.937	22.832	9.903	9.413
	Mar	8.222	16.741	21.480	20.802	24.527	14.985
	Apr	19.788	15.642	11.334	9.421	23.614	11.621
	May	7.868	13.365	8.143	12.252	13.907	9.230
	Jun	17.735	7.876	6.240	9.712	8.662	6.853
	Jul	5.648	5.393	5.185	10.907	12.567	10.077
	Aug	5.945	4.879	4.675	4.475	4.280	4.070
	Sep	3.855	6.771	9.300	5.432	4.200	3.537
	Oct	3.701	3.428	3.118	2.941	14.139	4.032
	Nov	9.003	10.039	7.285	11.327	16.707	14.332
	Dec	19.982	65.348	17.448	10.345	18.770	41.304
1971	Jan	19.791	20.875	26.203	48.728	21.626	62.317
	Feb	18.267	26.393	37.750	17.895	27.865	32.505
	Mar	22.004	25.461	37.930	14.267	12.949	18.543
	Apr	24.181	21.450	31.522	26.411	20.009	10.711
	May	10.913	30.705	16.234	9.914	8.122	7.857
	Jun	10.809	28.052	13.164	8.737	15.680	12.464
	Jul	8.324	7.430	7.197	6.817	6.583	6.330
	Aug	6.079	5.853	5.632	5.415	5.203	4.976
	Sep	4.744	4.643	4.439	6.491	4.557	4.041
	Oct	8.146	5.203	8.580	8.443	10.237	8.387
	Nov	4.591	6.926	10.858	21.747	19.294	8.602
	Dec	15.054	11.578	14.420	9.405	9.548	7.364

Year		1-5	5-10	10-15	15-20	20-25	25-31
1972	Jan	21.397	23.726	65.685	46.327	13.007	10.310
	Feb	7.569	6.013	7.138	8.358	26.087	32.360
	Mar	19.012	29.806	17.643	23.143	27.982	28.253
	Apr	12.136	8.570	7.576	6.981	7.045	6.857
	May	6.516	15.654	11.131	7.753	6.618	6.014
	Jun	5.667	5.465	5.268	5.075	4.886	4.946
	Jul	4.742	4.442	4.259	4.080	3.904	3.716
	Aug	3.527	3.356	3.189	3.025	2.864	2.692
	Sep	2.514	2.350	2.189	2.031	1.877	1.725
	Oct	1.580	1.453	1.414	1.388	1.362	1.334
	Nov	1.308	1.287	4.988	11.525	5.059	3.613
	Dec	6.942	2.945	4.826	3.481	11.871	10.380
1973	Jan	6.710	49.657	35.171	29.428	8.645	4.998
	Feb	9.962	15.916	10.591	5.761	4.467	3.973
	Mar	6.379	10.960	9.805	8.981	11.778	9.618
	Apr	6.731	6.205	4.979	15.312	6.332	12.222
	May	5.683	4.579	5.882	10.438	9.520	7.519
	Jun	5.837	6.114	7.123	4.645	4.651	4.063
	Jul	3.721	3.549	24.349	7.157	4.274	3.431
	Aug	3.244	3.075	2.909	2.746	2.587	2.826
	Sep	3.736	2.868	2.820	2.581	5.453	3.756
	Oct	2.427	16.235	4.370	3.347	3.047	13.512
	Nov	17.673	16.731	27.189	10.407	5.602	8.826
	Dec	9.285	15.931	10.964	16.231	7.164	10.125
1974	Jan	9.631	6.288	42.923	42.462	15.573	11.128
	Feb	15.871	9.654	8.633	11.706	18.262	10.824
	Mar	15.458	26.761	21.155	40.081	43.457	16.588
	Apr	13.483	31.876	20.748	9.421	7.224	10.493
	May	10.774	24.309	10.370	7.659	6.332	6.054
	Jun	5.822	5.613	5.410	5.239	5.074	4.903
	Jul	4.733	4.541	5.411	4.364	4.138	4.037
	Aug	3.858	3.677	4.588	3.479	3.437	4.231
	Sep	4.430	7.949	5.113	3.263	2.991	2.813
	Oct	4.191	11.946	23.456	9.644	17.621	6.028
	Nov	5.820	4.149	3.860	3.108	14.790	10.845
	Dec	4.941	9.223	12.710	28.855	20.569	15.039
1975	Jan	13.338	7.380	5.741	11.922	31.755	15.800
	Feb	11.632	15.074	11.635	14.843	10.901	7.867
	Mar	9.610	32.423	15.858	17.491	16.086	34.963
	Apr	17.954	12.525	8.287	18.173	16.469	22.374
	May	10.423	18.647	9.008	8.589	8.512	12.048
	Jun	7.102	6.171	5.865	5.682	5.447	5.764
	Jul	5.495	5.016	4.818	4.624	4.435	4.231
	Aug	4.028	3.844	3.663	3.508	3.347	3.549
	Sep	5.345	5.647	16.171	5.818	4.961	5.645
	Oct	5.338	8.164	9.652	4.601	4.548	10.506
	Nov	11.075	7.481	10.943	20.063	16.700	22.252
	Dec	21.029	8.797	6.373	7.426	14.468	9.770
1976	Jan	40.029	30.030	23.932	16.529	96.741	33.956
	Feb	15.048	15.604	13.591	18.595	38.903	27.148
	Mar	38.088	23.533	55.371	44.809	20.458	11.777
	Apr	9.690	8.433	7.620	7.892	7.711	7.918
	May	7.021	6.860	6.687	6.450	6.236	6.005
	Jun	5.777	5.817	6.735	5.391	5.171	4.979
	Jul	4.787	4.596	4.409	4.226	4.047	3.861
	Aug	3.680	3.505	3.334	3.166	3.002	2.901
	Sep	2.747	2.577	2.410	2.247	2.087	1.931
	Oct	1.780	1.733	1.594	2.175	1.627	1.406
	Nov	1.566	1.526	1.846	14.166	11.475	8.986
	Dec	3.966	7.685	13.560	6.660	4.870	4.173

Table 4.3.8 (2/3) 5-DAYS DISCHARGE AT PANJANGAN IN GARANG RIVER

by Tank Model (A=192.6 km2) Unit : m3/s

Year	1-5	5-10	10-15	15-20	20-25	25-31	Year	1-5	5-10	10-15	15-20	20-25	25-31
1977							1982						
Jan	9.586	7.942	7.306	29.846	15.707	19.312	Jan	4.068	8.194	6.012	27.796	8.646	13.677
Feb	12.146	13.239	6.414	5.496	6.565	40.436	Feb	14.241	9.736	14.563	10.275	9.144	5.535
Mar	29.005	47.121	15.455	26.245	23.196	16.121	Mar	22.604	37.975	26.588	24.961	15.142	20.317
Apr	7.829	6.670	10.454	8.086	17.461	8.323	Apr	44.064	29.939	21.869	8.638	8.363	18.988
May	5.810	4.884	4.701	4.522	8.834	15.372	May	8.888	6.040	5.023	4.830	4.643	4.441
Jun	13.023	12.316	8.561	5.520	4.490	4.311	Jun	4.242	4.062	3.886	3.714	3.546	3.381
Jul	4.131	3.952	3.777	3.605	3.437	3.257	Jul	3.215	3.050	2.889	2.730	2.575	2.409
Aug	3.076	2.912	2.751	2.594	2.440	2.274	Aug	2.241	2.090	1.941	1.795	1.652	1.499
Sep	2.103	1.945	1.789	1.638	1.489	1.346	Sep	1.340	1.192	1.053	1.001	0.975	0.949
Oct	1.286	1.260	1.235	1.209	1.183	1.156	Oct	0.924	0.899	0.875	0.850	0.825	0.799
Nov	5.645	5.451	2.219	3.156	1.609	1.328	Nov	10.506	2.354	1.174	1.239	0.869	0.823
Dec	13.924	8.459	4.243	4.606	8.579	29.116	Dec	1.075	5.598	7.451	4.805	1.930	7.285
1978							1983						
Jan	47.722	14.487	19.136	25.221	35.694	33.829	Jan	20.303	17.622	20.027	22.114	8.553	5.334
Feb	22.264	30.208	33.380	13.618	19.541	11.589	Feb	9.514	7.317	4.669	9.216	4.035	8.279
Mar	10.075	7.130	11.837	18.959	38.403	23.474	Mar	8.812	6.458	18.834	5.546	3.888	3.132
Apr	8.767	7.076	8.880	6.412	5.725	5.204	Apr	5.459	5.582	14.018	16.583	12.491	5.318
May	5.084	4.880	6.372	7.308	7.091	4.969	May	12.331	14.735	18.662	9.943	7.198	7.017
Jun	4.569	5.180	4.464	6.134	4.564	4.948	Jun	4.792	3.742	3.539	3.353	3.187	3.024
Jul	4.778	4.461	7.637	4.530	3.867	3.688	Jul	2.861	2.699	2.540	2.383	2.231	2.067
Aug	4.078	3.646	3.334	3.203	3.030	2.848	Aug	1.902	1.752	1.606	1.462	1.322	1.171
Sep	9.279	7.370	6.574	4.658	4.469	2.996	Sep	1.014	0.868	0.759	0.731	0.706	0.681
Oct	5.219	6.698	3.470	3.761	3.587	2.616	Oct	7.310	2.890	0.896	7.252	15.301	14.880
Nov	3.922	3.736	2.921	4.800	3.944	3.165	Nov	4.484	2.092	1.298	1.104	5.727	36.950
Dec	3.873	11.862	9.222	5.768	7.692	6.249	Dec	16.337	4.698	4.795	2.409	1.602	3.480
1979							1984						
Jan	23.404	47.044	33.077	18.147	9.394	13.393	Jan	5.887	8.378	3.630	2.831	8.845	5.662
Feb	31.522	43.138	17.150	21.880	32.775	14.208	Feb	22.870	20.025	28.346	24.439	11.082	6.397
Mar	9.501	17.370	23.338	33.669	15.225	11.723	Mar	18.045	24.483	7.305	5.647	4.399	3.474
Apr	10.589	27.756	44.436	18.063	18.855	11.263	Apr	3.238	3.438	5.905	4.490	3.683	3.404
May	9.243	15.693	12.163	9.530	14.462	8.750	May	3.045	2.874	2.760	2.647	3.372	2.635
Jun	12.924	15.676	8.750	6.770	6.184	5.967	Jun	2.380	2.853	7.442	3.007	2.162	2.020
Jul	5.750	5.535	6.276	5.391	5.068	4.969	Jul	3.618	1.960	1.804	3.028	1.928	1.685
Aug	4.757	5.072	4.449	4.254	4.063	3.859	Aug	1.514	1.502	1.402	1.192	1.056	1.568
Sep	3.649	3.457	4.355	3.474	3.098	6.899	Sep	5.640	20.467	11.767	21.448	12.871	4.219
Oct	10.009	5.410	3.392	2.950	2.853	3.141	Oct	2.858	2.336	1.770	1.616	1.909	1.686
Nov	5.566	6.144	5.302	3.018	3.008	15.938	Nov	2.101	1.911	4.747	3.638	4.191	10.383
Dec	6.530	7.210	4.007	3.168	3.480	6.803	Dec	17.618	10.438	11.748	8.118	8.595	13.752
1980							1985						
Jan	8.791	7.234	19.980	14.141	105.25	23.267	Jan	6.500	4.693	3.737	2.899	2.800	2.516
Feb	9.430	17.905	15.130	14.249	13.978	9.079	Feb	2.356	2.244	6.594	5.115	25.695	9.594
Mar	6.732	8.800	7.773	24.110	15.723	15.202	Mar	7.991	8.062	4.518	4.301	4.998	3.706
Apr	9.479	10.304	10.217	29.126	18.018	16.135	Apr	3.230	3.087	3.558	9.831	14.482	6.712
May	18.699	10.897	7.120	5.653	5.363	22.773	May	3.684	2.885	2.698	2.828	2.446	2.288
Jun	9.046	6.147	5.201	5.005	4.814	4.626	Jun	2.131	1.989	1.850	1.714	1.581	1.451
Jul	4.438	4.251	4.068	3.890	3.714	6.518	Jul	1.608	1.365	1.567	1.149	5.027	1.683
Aug	6.803	7.567	14.109	5.237	3.699	3.390	Aug	2.207	1.379	0.998	0.865	0.784	1.972
Sep	3.192	3.009	4.718	2.974	2.686	2.514	Sep	6.607	5.338	1.661	0.829	0.686	0.640
Oct	2.349	2.188	2.053	1.904	3.290	16.340	Oct	0.613	0.589	1.013	0.822	9.693	9.260
Nov	17.408	6.234	14.110	5.288	8.208	22.050	Nov	8.246	3.954	4.292	4.424	2.359	9.971
Dec	22.048	23.960	11.479	7.462	52.725	17.407	Dec	28.093	8.130	3.786	2.131	4.805	14.546
1981							1986						
Jan	9.558	13.085	23.766	12.916	10.973	16.597	Jan	8.083	10.428	19.642	38.780	20.007	25.456
Feb	27.463	8.907	15.392	15.071	13.861	22.614	Feb	15.278	6.604	4.929	14.522	12.160	9.508
Mar	9.426	8.350	11.222	6.954	5.470	5.021	Mar	14.620	70.306	13.999	19.466	13.280	12.373
Apr	4.825	4.649	4.477	4.308	4.143	3.982	Apr	14.144	11.831	11.961	9.924	6.137	4.805
May	6.859	13.889	6.700	8.002	5.954	4.171	May	4.533	4.345	7.107	4.816	4.198	4.076
Jun	3.792	3.625	3.642	3.391	6.121	9.434	Jun	4.548	3.991	6.735	11.691	10.924	6.245
Jul	4.723	7.059	4.382	19.889	5.046	3.998	Jul	4.778	3.708	3.530	3.422	3.233	3.721
Aug	3.427	3.197	3.029	2.864	2.703	2.530	Aug	3.150	5.362	3.104	2.796	4.645	4.856
Sep	2.351	2.186	2.024	1.866	1.711	1.559	Sep	2.583	2.618	3.846	2.979	3.907	2.580
Oct	1.413	1.273	1.206	1.181	1.155	1.128	Oct	2.201	2.038	3.611	1.958	1.761	4.888
Nov	1.102	1.081	1.061	1.040	1.059	4.039	Nov	5.060	7.249	3.787	2.783	1.839	2.977
Dec	9.031	11.583	8.071	19.455	11.823	13.038	Dec	1.846	1.615	5.770	3.505	3.719	10.964

Table 4.3.8 (3/3) 5-DAYS DISCHARGE AT PANJANGAN IN GARANG RIVER

by Observation (A=192.6 km2) Unit : m3/s

Year	1-5	5-10	10-15	15-20	20-25	25-31	Year	1-5	5-10	10-15	15-20	20-25	25-31
1987							1992						
Jan	7.528	7.856	23.920	45.620	24.620	28.133	Jan	6.440	12.980	12.720	7.360	10.380	9.967
Feb	10.902	29.680	40.820	31.640	37.860	25.867	Feb	13.840	10.820	9.400	14.480	12.420	9.250
Mar	34.160	21.680	11.480	16.340	29.020	33.533	Mar	9.780	13.580	14.560	17.440	9.440	8.367
Apr	9.954	17.996	19.200	8.650	9.514	6.992	Apr	16.160	12.800	21.240	10.720	12.400	11.440
May	7.300	7.842	6.436	6.458	4.752	5.665	May	7.340	8.440	10.960	7.520	7.380	15.000
Jun	6.578	6.854	4.430	4.020	3.814	4.596	Jun	11.220	10.480	6.500	5.180	5.060	4.620
Jul	4.206	3.356	3.150	3.672	3.218	3.342	Jul	5.420	5.480	6.440	5.310	4.750	4.750
Aug	2.762	2.700	2.490	2.310	2.284	2.245	Aug	5.260	4.450	5.300	3.700	9.680	8.750
Sep	1.798	1.962	1.988	1.798	1.718	2.018	Sep	7.240	9.100	8.240	5.600	4.420	4.400
Oct	2.212	1.910	1.826	2.898	1.962	1.728	Oct	7.900	10.160	5.080	5.910	5.840	5.300
Nov	1.772	3.078	2.230	3.276	5.120	7.436	Nov	4.990	6.620	3.550	3.900	5.910	5.690
Dec	6.550	7.198	7.714	10.756	14.828	6.822	Dec	21.680	17.500	24.820	12.800	8.000	5.658
1988							1993						
Jan	9.120	11.512	11.380	16.000	34.304	15.135	Jan	4.326	5.758	5.366	4.800	25.700	103.64
Feb	21.760	30.200	22.580	20.880	17.616	9.030	Feb	49.780	44.780	39.600	32.580	35.820	26.300
Mar	11.788	13.668	11.702	18.408	25.300	49.833	Mar	24.100	29.260	19.980	17.320	19.220	25.933
Apr	13.030	16.718	12.468	8.858	6.862	6.122	Apr	16.164	32.700	35.060	17.720	17.522	7.556
May	7.968	10.902	5.518	5.866	5.480	4.643	May	9.184	6.068	5.852	3.812	3.434	3.548
Jun	2.376	2.378	3.502	4.362	2.484	2.606	Jun	3.436	9.538	8.486	7.864	3.858	3.250
Jul	3.440	3.142	2.304	2.460	2.066	1.917	Jul	3.672	2.834	2.834	2.418	2.496	2.370
Aug	1.816	1.984	1.872	1.496	1.526	1.530	Aug	3.500	3.350	3.300	3.500	3.400	2.792
Sep	1.408	1.994	2.294	1.880	1.490	1.452	Sep	2.750	3.940	2.600	2.750	3.350	3.050
Oct	1.732	1.564	4.340	3.328	2.184	7.198	Oct	3.250	2.900	3.050	2.368	2.456	2.317
Nov	3.256	2.380	4.316	4.286	3.920	6.856	Nov	1.602	1.450	1.730	3.688	2.880	2.258
Dec	8.876	15.086	16.840	11.482	12.968	4.605	Dec	4.566	4.378	2.802	3.982	5.238	4.057
1989							1994						
Jan	10.336	12.436	7.122	8.154	10.516	10.460	Jan	7.680	12.800	21.680	22.020	13.120	13.800
Feb	52.940	54.660	25.900	38.480	86.740	27.400	Feb	12.000	14.160	14.480	9.320	12.800	10.933
Mar	29.880	17.060	11.084	9.994	17.280	14.183	Mar	11.120	27.560	24.840	11.160	55.840	31.617
Apr	9.076	11.500	6.380	9.904	13.588	13.480	Apr	16.240	14.280	20.500	18.800	17.300	10.720
May	8.822	9.504	8.816	16.320	4.412	8.903	May	10.400	8.800	8.580	5.900	5.600	4.600
Jun	13.420	8.782	9.518	12.160	10.902	6.354	Jun	4.450	4.350	3.650	3.650	3.700	3.500
Jul	3.852	7.534	4.792	2.334	2.744	2.552	Jul	3.450	3.250	3.050	2.900	2.750	2.583
Aug	4.242	3.894	2.976	2.726	2.290	2.195	Aug	2.600	2.650	2.456	2.236	1.972	1.730
Sep	2.134	1.834	1.706	1.484	1.864	2.232	Sep	1.664	1.796	1.620	1.620	1.620	1.512
Oct	4.192	2.816	2.080	4.760	4.098	6.032	Oct	1.356	2.192	2.500	3.650	4.150	4.133
Nov	3.014	2.898	8.076	11.480	6.984	11.906	Nov	5.050	3.350	3.050	2.550	2.750	4.340
Dec	17.420	11.648	13.060	22.718	8.316	17.555	Dec	3.072	8.290	4.452	2.706	5.560	3.150
1990							1995						
Jan	12.966	22.360	13.520	41.320	53.160	88.150	Jan	4.900	8.080	15.440	7.400	17.440	26.317
Feb	34.980	14.080	10.736	9.370	6.816	11.103	Feb	12.820	11.680	21.480	12.600	12.160	9.867
Mar	13.870	11.290	9.344	24.228	8.560	9.613	Mar	13.520	16.720	10.800	20.880	19.040	13.533
Apr	7.056	8.520	7.522	6.734	8.000	8.792	Apr	10.160	9.600	8.960	7.980	6.800	6.320
May	7.426	5.394	6.112	8.486	7.148	7.705	May	6.140	6.920	15.840	7.440	6.040	6.225
Jun	6.340	4.044	3.846	4.648	6.754	5.692	Jun	5.530	6.140	9.900	7.800	6.700	5.420
Jul	5.774	3.998	3.220	2.780	3.214	2.500	Jul	4.700	4.250	3.300	2.154	1.136	2.105
Aug	3.224	2.668	4.956	2.584	2.474	2.500	Aug	3.250	3.500	3.150	2.850	2.550	2.170
Sep	1.836	2.446	2.136	1.720	2.500	2.276	Sep	1.796	1.620	0.916	0.520	0.872	2.280
Oct	1.804	1.560	1.460	1.508	1.320	2.250	Oct	2.456	1.928	1.400	1.356	1.400	1.473
Nov	2.566	1.300	1.708	2.538	3.264	4.404	Nov	1.846	7.080	10.290	11.040	18.240	27.240
Dec	14.268	10.530	13.440	10.712	19.020	13.197	Dec	11.180	10.400	18.140	15.200	21.120	14.700
1991							1996						
Jan	22.860	27.820	8.092	13.590	15.700	22.183	Jan	13.680	16.800	10.080	14.320	17.640	16.817
Feb	18.600	18.740	28.760	21.800	27.920	14.367	Feb	20.800	27.260	32.820	31.040	20.720	37.850
Mar	15.600	19.140	20.500	19.720	13.580	15.000	Mar	29.980	32.700	27.160	14.480	16.720	10.467
Apr	26.260	14.910	14.320	14.440	27.420	15.040	Apr	8.980	9.260	10.800	16.920	11.920	7.680
May	12.350	6.964	6.442	5.530	3.712	3.483	May	8.360	7.220	6.740	7.360	6.710	6.750
Jun	3.128	3.098	3.386	3.648	3.516	3.034	Jun	5.250	6.090	5.400	4.870	4.754	4.970
Jul	3.192	3.004	2.990	2.790	2.370	2.175	Jul	3.100	3.100	2.706	2.476	2.650	2.708
Aug	1.800	1.542	1.356	1.380	1.308	1.260	Aug	2.750	3.562	2.956	3.000	3.056	3.083
Sep	1.806	1.332	1.500	1.212	1.236	1.092	Sep	2.650	3.860	3.050	2.950	3.000	2.568
Oct	1.068	1.236	1.236	1.380	1.434	1.345	Oct	2.236	4.238	3.450	3.750	3.350	14.667
Nov	2.226	3.084	7.598	5.538	8.818	7.244	Nov	9.170	13.480	7.280	7.180	20.800	6.130
Dec	12.144	9.184	9.622	5.534	7.518	12.760	Dec	16.480	21.460	22.660	11.920	11.200	14.833

Table 4.3.9 CALCULATION PROCEDURE FOR WATER USE SIMULATION

Symbol	Unit	Meaning	Equation to Calculate
Qpa	m3/s	Natural Discharge at Panjangan	20 years by Tank-Model, 10 years by Observation
Q1	m3/s	Inflow at Dam Site	Q1= Qpa * (53.0km2/192.6km2)
C1	m3/s	Maintenance Flow at Dam Site	C1= 1.0m3/s * (53.0km2/204.0km2) = 0.26 m3/s
B1	m3/s	Flow Required at Dam Site	B1= C1
E1	m3/s	Balance at Dam Site	E1= Q1 - B1
Y1	m3/s	Surplus at Dam Site	if E1>=0 then Y1=E1 : H1=0
H1	m3/s	Deficit at Dam Site	if E1<0 then Y1=0 : H1=E1
Q2	m3/s	Natural Discharge at Simongan	Q2= Y1+C1+Qpa * (151.0km2/192.6)
C2	m3/s	Maintenance Flow at Simongan	C2= 0.50m3/s + 0.15m3/s = 0.65 m3/s
L2	m3/s	Existing Intake Flow	L2= 0.58 m3/s
SS	m3/s	New Intake Flow	
B2	m3/s	Flow Required at Simongan	B2= C2 + L2 + SS
E2	m3/s	Balance at Simongan	E2= Q2 - B2
Y2	m3/s	Surplus at Simongan	if E2>=0 then Y2=E2 : H2=0
H2	m3/s	Deficit at Simongan	if E2<0 then Y2=0 : H2=E2
Yt	m3/s	Surplus Flow for Both Site	Smaller of Y1 and Y2
Ht	m3/s	Total Deficit Flow	Ht= H1 + H2
V	m3	Dam Vacant Volume	V = V' + (Ht-Yt)*86,400*Days
	m3		if V<0 then V=0
	m3		V' means V at Former Step
Dq	m3/s	Dam Operational Flow	Dq = (V-V')/86,400/Days
D1	m3/s	Outflow at Dam	D1 = Q1 + Dq
D2	m3/s	Dicharge at Simongan after Dam Operation	D2 = D1 + Qpa*(151.0km2/192.6km2)

Note : basically Days = 5 except end of month where Days = 3 to 6

Table 4.3.10 SUMMARY RECORD OF INTAKE DISCHARGE FOR MAINTENANCE

Unit : m3/s

Year	to Semarang River		to Left Channel		(Overflow to Floodway)	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
1987	0.306	0.306	0.102	0.102	58.6	0.0
1988	0.306	0.306	0.102	0.102	35.4	0.0
1990	0.412	0.306	0.200	0.102	3.2	0.0
1991	0.948	0.204	0.204	0.102	5.8	0.0
1992	0.640	0.153	0.209	0.054	35.3	0.0
1993	0.640	0.209	0.209	0.102	165.6	0.0
1994	0.880	0.107	0.209	0.054	10.5	0.0
1995	0.760	0.320	0.209	0.051	10.5	0.0
1996	0.760	0.410	0.209	0.153	8.9	0.0
1997	0.640	0.410	0.209	0.102	10.5	0.0
Average	0.629	0.273	0.186	0.092	34.4	0.0
Maximum	0.948	0.410	0.209	0.153	165.6	0.0

Note : Data by RANTING DINAS (Dolog Penggaron)   Missing Totally in 1989

Table 4.3.11 MONTHLY RECORDS OF INTAKE DISCHARGE FOR MAINTENANCE

Unit : m3/s

Year	Semarang Rive		Left Channel		(Overflow)		Year	Semarang Rive		Left Channel		(Overflow)	
Month	Max.	Min.	Max.	Min.	Max.	Min.	Month	Max.	Min.	Max.	Min.	Max.	Min.
1987							1993						
Jan	0.306	0.306	0.102	0.102	58.6	8.9	Jan	0.640	(0.000)	0.209	(0.000)	165.6	0.0
Feb	0.306	0.306	0.102	0.102	35.4	8.9	Feb	0.640	0.209			35.4	1.1
Mar	0.306	0.306	0.102	0.102	12.5	3.2	Mar	0.640	0.425	0.209	0.209	8.9	0.0
Apr			0.102	0.102	8.9	1.2	Apr	0.640	0.425	0.209	0.209	8.9	1.2
May	0.306	0.306	0.102	0.102	12.5	3.2	May	0.640	0.425	0.209	0.209	5.8	0.0
Jun	0.306	0.306	0.102	0.102	8.9	3.2	Jun	0.640	0.425	0.209	0.209	8.9	0.0
Jul	0.306	0.306	0.102	0.102	8.9	1.2	Jul	0.530	0.316	0.209	0.102	3.2	0.0
Aug	0.306	0.306	0.102	0.102	1.2	1.2	Aug	0.530	0.316	0.209	0.102	1.4	0.0
Sep	0.306	0.306	0.102	0.102	1.2	0.0	Sep	0.640	0.425	0.209	0.153	1.4	0.0
Oct	0.306	0.306	0.102	0.102	3.2	0.0	Oct	0.640	0.425	0.209	0.153	0.0	0.0
Nov	0.306	0.306	0.102	0.102	12.5	1.2	Nov	0.640	0.530	0.209	0.209	3.7	0.0
Dec	0.306	0.306	0.102	0.102	5.8	3.2	Dec	0.640	0.530	0.209	0.209	1.4	0.0
1988							1994						
Jan	0.306	0.306	0.102	0.102	35.4	3.2	Jan	0.640	0.530	0.209	0.209	10.5	0.0
Feb	0.306	0.306	0.102	0.102	35.4	3.2	Feb	0.640	0.530	0.209	0.153	6.7	1.4
Mar	0.306	0.306	0.102	0.102	12.5	3.2	Mar	0.760	0.640	0.209	0.209	10.5	0.0
Apr	0.306	0.306	0.102	0.102	8.9	1.2	Apr	0.880	0.640	0.209	0.209	10.5	0.0
May	0.306	0.306	0.102	0.102	8.9	3.2	May	0.880	0.640	0.209	0.209	3.7	0.0
Jun	0.306	0.306	0.102	0.102	3.2	0.0	Jun	0.760	0.640	0.209	0.209	1.4	0.0
Jul	0.306	0.306	0.102	0.102	3.2	1.2	Jul	0.760	0.425	0.209	0.209	0.0	0.0
Aug	0.306	0.306	0.102	0.102	0.0	0.0	Aug	0.425	0.209	0.209	0.102	0.0	0.0
Sep			0.102	0.102	0.0	0.0	Sep	0.209	0.107	0.102	0.054	0.0	0.0
Oct			0.102	0.102	3.2	1.2	Oct	0.425	0.153	0.102	0.054	1.4	0.0
Nov			0.102	0.102	3.2	1.2	Nov	0.530	0.425	0.153	0.102	1.4	0.0
Dec			0.102	0.102	5.8	1.2	Dec	0.760	0.425	0.209	0.153	3.7	0.0
1990							1995						
Jan							Jan	0.640	0.530	0.209	0.209	3.7	1.4
Feb							Feb	0.640	0.530	0.209	0.209	6.7	1.4
Mar							Mar	0.760	0.640	0.209	0.209	3.7	1.4
Apr							Apr	0.760	0.640	0.209	0.209	6.7	1.4
May	0.306	0.306	0.102	0.102	3.2	1.2	May	0.760	0.640	0.209	0.209	10.5	0.0
Jun			0.200	0.102	3.2	1.2	Jun	0.760	0.640	0.209	0.209	6.7	1.4
Jul			0.153	0.102	1.2	0.0	Jul	0.640	0.410	0.209	0.102	1.4	0.0
Aug							Aug	0.410	0.320	0.102	0.051	0.0	0.0
Sep	0.412	0.306	0.153	0.102	3.2	1.2	Sep	0.410	0.320	0.102	0.102	0.0	0.0
Oct							Oct	0.640	0.320	0.102	0.102	0.0	0.0
Nov							Nov	0.760	0.640	0.153	0.102	8.9	0.0
Dec							Dec	0.760	0.640	0.209	0.153	8.9	3.2
1991							1996						
Jan	0.412	0.306	0.153	0.102	5.8	3.2	Jan	0.760	0.640	0.209	0.153	8.9	3.2
Feb	0.412	0.306	0.204	0.153	5.8	3.2	Feb	0.760	0.410	0.209	(0.000)	8.9	0.0
Mar	0.412	0.306	0.153	0.102	5.8	0.0	Mar	0.760	0.640	0.209	0.209	5.8	1.2
Apr	0.412	0.306	0.153	0.102	3.2	1.2	Apr	0.760	0.640	0.209	0.209	3.2	0.0
May	0.412	0.306	0.153	0.102	3.2	1.2	May	0.760	0.530	0.209	0.209	1.2	0.0
Jun	0.948	0.306			3.2	1.2	Jun	0.760	0.640	0.209	0.209	1.2	0.0
Jul	0.412	0.306	0.153	0.102	5.8	0.0	Jul						
Aug	0.412	0.306	0.153	0.102	3.2	1.2	Aug						
Sep	0.412	0.306	0.153	0.102	0.0	0.0	Sep						
Oct	0.412	0.204	0.153	0.102	1.2	0.0	Oct						
Nov	0.412	0.306	0.153	0.102	3.2	1.2	Nov						
Dec	0.412	0.306	0.153	0.102	3.2	1.2	Dec						
1992							1997						
Jan	0.412	0.306	0.204	0.102	5.8	1.2	Jan	0.640	(0.000)	0.209	0.102	10.5	3.7
Feb	0.412	0.306	0.153	0.102	3.2	1.2	Feb						
Mar	0.412	0.306	0.153	0.102	3.2	1.2	Mar						
Apr	0.412	0.306	0.153	0.102	3.2	1.2	Apr	0.640	0.640	0.209	0.209	3.2	0.0
May	0.412	0.306	0.153	0.102	3.2	1.2	May	0.640	(0.000)	0.209	0.102	5.8	1.2
Jun	0.412	0.204	0.153	0.102	3.2	1.1	Jun	0.640	0.460	0.209	0.209	3.7	1.2
Jul	0.209	0.153	0.153	0.054	1.2	0.0	Jul	0.640	0.410	0.209	0.209	3.7	0.0
Aug	0.316	0.153	0.153	0.054	35.3	0.0	Aug	0.640	0.410	0.209	0.102	1.2	0.0
Sep	0.425	0.209	0.153	0.153	1.1	0.0	Sep	0.640	0.410	0.209	0.153	0.0	0.0
Oct	(3.660)	0.316	0.153	0.153	3.2	0.0	Oct						
Nov	0.640	0.425	0.153	0.153	3.2	0.0	Nov						
Dec	0.640	0.306	0.209	0.102	3.2	0.0	Dec						

Note : Data by RANTING DINAS (Dolog Penggaron), ( ) means Unusual Operation

Table 4.3.12 WATER USE SIMULATION OF JATIBARANG DAM WITH NEW DEVELOPED WATER

Year = 1991 (3rd / 30years)			Dam Site			Simongan Weir			Jatibarang Dam Operation				
Mont	Day	Q.data Qd 192.6km2 m3/s	Dam-in Q1 53km2 m3/s	Required B1 m3/s	Balance E1 Q1-B1 m3/s	Qi.weir Q2 204km2 m3/s	Required B2 m3/s	Balance E2 Q2-B2 m3/s	Surplus YT (E1,E2) m3/s	Shortage HT -E1-E2 m3/s	Volume V V'+HT-YT m3	Dam-out D1 Q1+V-V' m3/s	Qo.weir D2 Q2+V-V' m3/s
Jul.	11 - 15	2.990	0.823	0.260	0.563	3.167	2.690	0.477	0.477	0.000	0	0.823	3.167
	16 - 20	2.790	0.768	0.260	0.508	2.955	2.690	0.265	0.265	0.000	0	0.768	2.955
	21 - 25	2.370	0.652	0.260	0.392	2.510	2.690	-0.180	0.000	0.180	77,760	0.832	2.690
	26 - 31	2.175	0.599	0.260	0.339	2.304	2.690	-0.386	0.000	0.386	277,862	0.985	2.690
Aug.	01 - 05	1.800	0.495	0.260	0.235	1.906	2.690	-0.784	0.000	0.784	616,551	1.279	2.690
	06 - 10	1.542	0.424	0.260	0.164	1.633	2.690	-1.057	0.000	1.057	1,073,175	1.481	2.690
	11 - 15	1.356	0.373	0.260	0.113	1.436	2.690	-1.254	0.000	1.254	1,614,903	1.627	2.690
	16 - 20	1.380	0.380	0.260	0.120	1.462	2.690	-1.228	0.000	1.228	2,145,398	1.608	2.690
	21 - 25	1.308	0.360	0.260	0.100	1.385	2.690	-1.305	0.000	1.305	2,709,159	1.665	2.690
	26 - 31	1.260	0.347	0.260	0.087	1.335	2.690	-1.355	0.000	1.355	3,411,590	1.702	2.690
Sep.	01 - 05	1.806	0.497	0.260	0.237	1.913	2.690	-0.777	0.000	0.777	3,747,255	1.274	2.690
	06 - 10	1.332	0.367	0.260	0.107	1.411	2.690	-1.279	0.000	1.279	4,299,782	1.646	2.690
	11 - 15	1.500	0.413	0.260	0.153	1.589	2.690	-1.101	0.000	1.101	4,775,415	1.514	2.690
	16 - 20	1.212	0.334	0.260	0.074	1.284	2.690	-1.406	0.000	1.406	5,382,807	1.740	2.690
	21 - 25	1.236	0.340	0.260	0.080	1.309	2.690	-1.381	0.000	1.381	5,979,398	1.721	2.690
	26 - 30	1.092	0.300	0.260	0.040	1.156	2.690	-1.534	0.000	1.534	6,642,087	1.834	2.690
Oct.	01 - 05	1.068	0.294	0.260	0.034	1.131	2.690	-1.559	0.000	1.559	7,315,574	1.853	2.690
	06 - 10	1.236	0.340	0.260	0.080	1.309	2.690	-1.381	0.000	1.381	7,912,166	1.721	2.690
	11 - 15	1.236	0.340	0.260	0.080	1.309	2.690	-1.381	0.000	1.381	8,508,759	1.721	2.690
	16 - 20	1.380	0.380	0.260	0.120	1.462	2.690	-1.228	0.000	1.228	9,039,255	1.608	2.690
	21 - 25	1.434	0.395	0.260	0.135	1.519	2.690	-1.171	0.000	1.171	9,545,127	1.566	2.690
	26 - 31	1.345	0.370	0.260	0.110	1.424	2.690	-1.266	0.000	1.266	10,201,421	1.636	2.690
Nov.	01 - 05	2.226	0.613	0.260	0.353	2.358	2.690	-0.332	0.000	0.332	10,344,845	0.945	2.690
	06 - 10	3.084	0.849	0.260	0.589	3.267	2.690	0.577	0.577	0.000	10,095,581	0.272	2.690
	11 - 15	7.598	2.091	0.260	1.831	8.048	2.690	5.358	1.831	0.000	9,304,589	0.260	6.217
	16 - 20	5.538	1.524	0.260	1.264	5.866	2.690	3.176	1.264	0.000	8,758,541	0.260	4.602
	21 - 25	8.818	2.427	0.260	2.167	9.340	2.690	6.650	2.167	0.000	7,822,397	0.260	7.173
	26 - 30	7.244	1.993	0.260	1.733	7.672	2.690	4.982	1.733	0.000	7,073,741	0.260	5.939
Dec.	01 - 05	12.144	3.342	0.260	3.082	12.863	2.690	10.173	3.082	0.000	5,742,317	0.260	9.781
	06 - 10	9.184	2.527	0.260	2.267	9.727	2.690	7.037	2.267	0.000	4,762,973	0.260	7.460
	11 - 15	9.622	2.648	0.260	2.388	10.192	2.690	7.502	2.388	0.000	3,731,357	0.260	7.804
	16 - 20	5.534	1.523	0.260	1.263	5.862	2.690	3.172	1.263	0.000	3,185,741	0.260	4.599
	21 - 25	7.518	2.069	0.260	1.809	7.963	2.690	5.273	1.809	0.000	2,404,253	0.260	6.154
	26 - 31	12.760	3.511	0.260	3.251	13.515	2.690	10.825	3.251	0.000	718,935	0.260	10.264
Jan.	01 - 05	6.440	1.772	0.260	1.512	6.821	2.690	4.131	1.512	0.000	65,751	0.260	5.309
	06 - 10	12.980	3.572	0.260	3.312	13.748	2.690	11.058	3.312	0.000	0	3.420	13.596
	11 - 15	12.720	3.500	0.260	3.240	13.473	2.690	10.783	3.240	0.000	0	3.500	13.473
Maximum											10,344,845		

Note : Water quantity required at Simongan Weir B2 = 0.65(maintenance) + 0.58(existing) + 1.46(new) = 2.69 m3/s

Table 4.3.13

DAM STORAGE CAPACITY REQUIRED FOR WATER USE

Unit : m3

Year	Secured (m3/s) Q=0.65+0.58+0.0	Re-covery	Secured (m3/s) Q=0.65+0.58+1.0	Re-covery	Secured (m3/s) Q=0.65+0.58+1.4	Re-covery	Secured (m3/s) Q=0.65+0.58+2.1	Re-covery	Secured (m3/s) Q=0.65+0.58+3.1	Re-covery
1967	482,000	O.K.	5,095,000	O.K.	8,416,000	O.K.	13,926,000	O.K.	24,478,000	O.K.
1968	0	O.K.	0	O.K.	0	O.K.	0	O.K.	1,362,000	O.K.
1969	0	O.K.	0	O.K.	0	O.K.	193,000	O.K.	2,025,000	O.K.
1970	0	O.K.	0	O.K.	0	O.K.	105,000	O.K.	1,700,000	O.K.
1971	0	O.K.	0	O.K.	0	O.K.	0	O.K.	22,000	O.K.
1972	0	O.K.	2,999,000	O.K.	5,484,000	O.K.	9,840,000	O.K.	18,652,000	O.K.
1973	0	O.K.	0	O.K.	51,000	O.K.	1,011,000	O.K.	6,107,000	O.K.
1974	0	O.K.	0	O.K.	0	O.K.	222,000	O.K.	1,463,000	O.K.
1975	0	O.K.	0	O.K.	0	O.K.	0	O.K.	1,234,000	O.K.
1976	0	O.K.	1,843,000	O.K.	4,262,000	O.K.	8,551,000	O.K.	17,432,000	O.K.
1977	3,000	O.K.	3,576,000	O.K.	6,192,000	O.K.	11,599,000	O.K.	22,456,000	O.K.
1978	0	O.K.	0	O.K.	0	O.K.	290,000	O.K.	2,502,000	O.K.
1979	0	O.K.	0	O.K.	0	O.K.	223,000	O.K.	1,924,000	O.K.
1980	0	O.K.	116,000	O.K.	773,000	O.K.	2,443,000	O.K.	7,009,000	O.K.
1981	234,000	O.K.	5,454,000	O.K.	8,727,000	O.K.	14,197,000	O.K.	24,224,000	O.K.
1982	1,161,000	O.K.	8,296,000	O.K.	13,154,000	O.K.	20,842,000	O.K.	34,875,000	O.K.
1983	1,010,000	O.K.	5,273,000	O.K.	8,149,000	O.K.	13,459,000	O.K.	24,900,000	no
1984	48,000	O.K.	2,373,000	O.K.	4,514,000	O.K.	8,839,000	O.K.	19,782,000	O.K.
1985	1,344,000	O.K.	7,300,000	O.K.	12,516,000	O.K.	20,615,000	O.K.	38,018,000	no
1986	0	O.K.	343,000	O.K.	861,000	O.K.	2,193,000	O.K.	11,203,000	O.K.
1987	0	O.K.	979,000	O.K.	3,878,000	O.K.	9,515,000	O.K.	20,893,000	O.K.
1988	0	O.K.	2,661,000	O.K.	6,065,000	O.K.	11,697,000	O.K.	24,324,000	O.K.
1989	0	O.K.	702,000	O.K.	2,127,000	O.K.	5,057,000	O.K.	12,801,000	O.K.
1990	0	O.K.	1,594,000	O.K.	4,521,000	O.K.	10,056,000	O.K.	21,578,000	O.K.
1991	75,000	O.K.	6,267,000	O.K.	10,345,000	O.K.	16,668,000	O.K.	30,772,000	O.K.
1992	0	O.K.	0	O.K.	0	O.K.	0	O.K.	332,000	O.K.
1993	0	O.K.	702,000	O.K.	1,536,000	O.K.	4,758,000	O.K.	18,502,000	O.K.
1994	0	O.K.	1,892,000	O.K.	4,074,000	O.K.	8,841,000	O.K.	20,932,000	O.K.
1995	538,000	O.K.	3,492,000	O.K.	6,390,000	O.K.	12,434,000	O.K.	22,558,000	O.K.
1996	0	O.K.	0	O.K.	139,000	O.K.	2,001,000	O.K.	11,098,000	O.K.
1st /30years	1,344,000		8,296,000		13,154,000		20,842,000		38,018,000	
2nd /30years	1,161,000		7,300,000		12,516,000		20,615,000		34,875,000	
3rd/30years	1,010,000		6,267,000		10,345,000		16,668,000		30,772,000	

Note : Water Use Capacity is determined by the drought of 3rd/30years(1st/10years)

Table 4.3.14 EVAPORATION VOLUME TO INCREASE FROM RESERVOIR IN DROUGHT TIME

No.	Item	Value	Unit	Remarks
(1)	Pan Evaporation (= Reservoir Evaporation)	1,610	mm/yr	by BMG-Semarang
(2)	Evaporation from Basin	1,200	mm/yr	Average in 30 years
(3)	Evaporation to increase from Reservoir	410	mm/yr	(3)=(1)-(2)
(4)		1.12	mm/day	(4)=(3)/365
(5)	Storage Area at Normal Water Level	1,006	1000m2	N.W.L.= EL.148.6 m
(6)	Storage Area at Low Water Level	631	1000m2	L.W.L.= EL.135.7 m
(7)	Average Storage Area	819	1000m2	(7)=((5)+(6))/2
(8)	Reservoir Supply Days in Drought Year	108	days	in 1991, 3rd / 30years
(9)	Evaporation Volume to increase from Reservoir in Drought Time	99,000	m3	(9)=(4)*(7)*(8)