2. Natural Conditions

2.1 Physiography

In conducting the water resources review of Jakarta Metropolis, it was necessary to consider areas beyond the city boundary, because Jakarta urban water sources are mainly coming from Jatiluhur reservoirs on the Citarum River, about 65 km southeast of the Metropolis in distrance, together with other local rivers. Therefore, the study area for the water resources evaluation was extended beyond the city boundary, including the whole of the Jabotabek and the Citarum River Basin as shown in Fig. 2.1.

The Jabotabek region occupies an area of some 5,500 km2. According to the estimates by JMDP (1980) the area of agricultural land and the undeveloped area in the region are 3,950 km2 and 1,000 km2, respectively, and urban, suburban and villages cover 550 km2 in expanse.

The urban and suburban area will be expanded acquiring at least additional 500 km2 from agricultural land by the end of this century. The catchment area of the Citarum River at Jatiluhur damsite occupies 4,450 km2 including Bandung area.

In topographic features the whole region is divided into the three regions as shown in Fig. 2.1.

(1) Jakarta coastal flat plain area
(2) Bogor hilly slope area
(3) Southern mountains area

Jakarta is located on the coastal deltaic plain of 0 m to 50 m above sea level. The coastal lowlands stretching along the coast are 5 to 10 km in width and no more than 10 m in elevation. This area is practically flat and often swampy. Topographic gradients rarely exceeds 1.0 m/km. This plain slopes up from the sea of Java towards the southern inland mountains.

The transitional hilly area of piedmont zone lies between the southern mountains and coastal plain, in a narrow belt ranging from 100 m to 400 m in elevation. Volcanic materials are making up he slopes of Bogor.

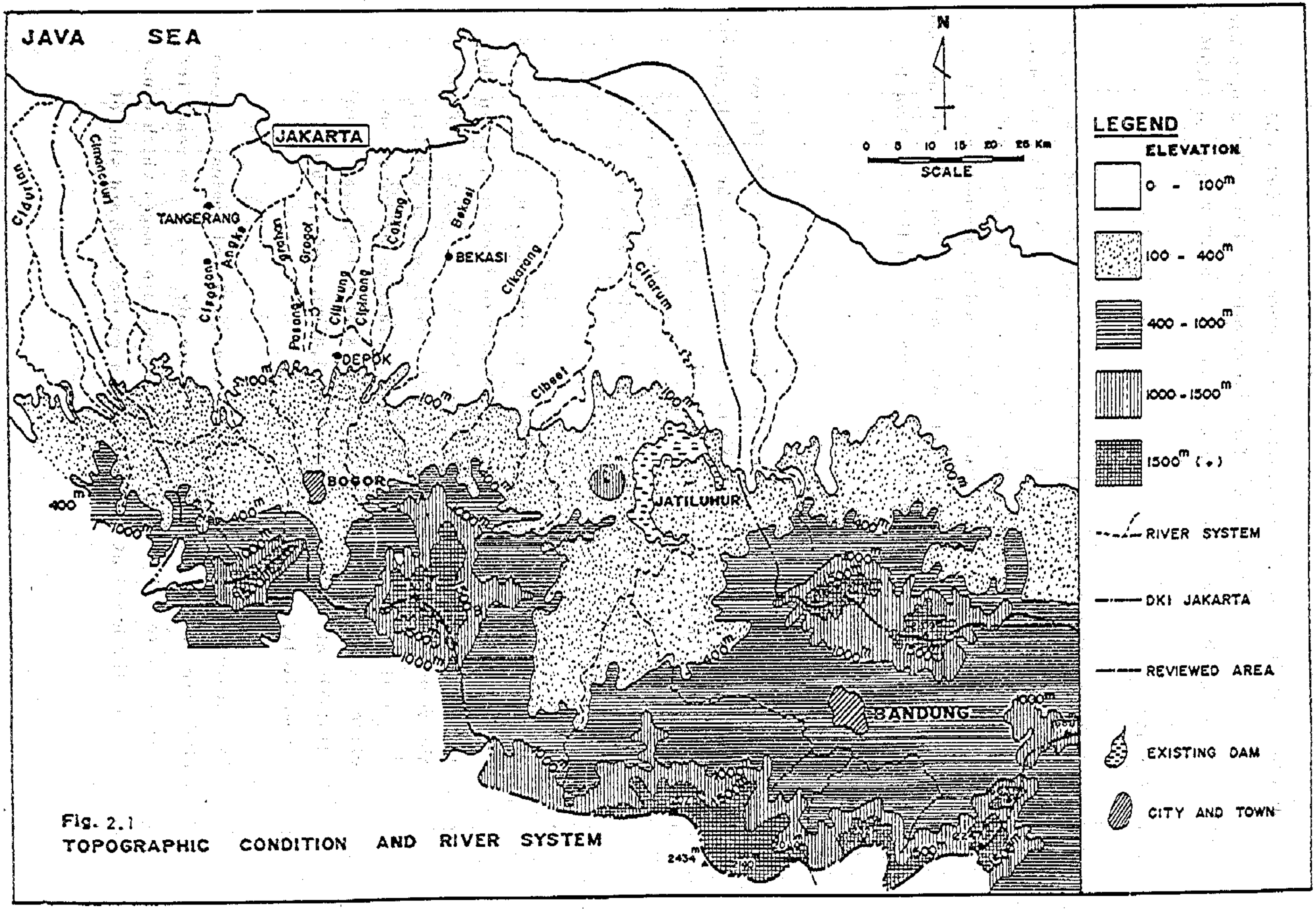


Fig. 2.1
TOPOGRAPHIC CONDITION AND RIVER SYSTEM

Southern mountains are make up of volcanoes, more than 1,000 m high above sea level, extending inland for approximately 50 km. The slopes are steep including the particularly precipitous zone of Mt.Pangrango (3,019 m).

2.2 Climate

Jakarta and surrounding areas belong to the tropical climate zone, typical in West Java. However, precipitation and temperature in this area varies considerably in the North-South direction due to topographic conditions, which varies from the coastal plain to the rugged mountainous zone in the south. Meteorological observations are available for Jakarta and Bogor as shown in Table 2.1 and general rainfall pattern in the West Java is illustrated in Fig. 2.2.

(1) Precipitation

Precipitation of the area can be characterized by significant seasonal variation in each year. Two seasons can be distinguished, the rainy season, which runs from November through May and coincides with the north-west monsoon, and dry season, which runs from June through October and coincides with the south-east monsoon.

The region receives a considerable rainfall varying from 5,500 mm/year in the southern mountains to 1,500 mm/year in the coastal plain. The wet months are November to May when 70% of the yearly rainfall can be expected. From June to October, precipitation is low with monthly rainfall below 100 mm and often almost zero. According to the statistics, mean annual rainfalls at Jakarta and Bogor are 1,868 mm and 3,816 mm, respectively.

The Citarum catchment is more or less sheltered against monsoon winds from the east. Before the humid air messes can reach the catchment, the air has to pass high mountain ranges which cause most of the humid air to precipitate on the windward side of

Table 2.1. Meteorogical Data of Jakarta and Bogor

Meteorogical Data	Area	J	F	M	A	M	J	J	A	S	O	N	D	Total/ average
Rainafall (mm)	Jakarta	390	322	242	126	117	87	56	53	68	92	135	130	1868
	Bogor	460	447	381	403	117	198	224	224	317	370	328	347	3816
Mean Temperature (°C)	Jakarta	26.3	26.3	26.9	27.5	27.7	27.2	27.0	27.1	27.6	27.8	27.3	26.7	27.1
	Bogor	25.0	25.1	25.4	25.8	25.9	25.8	25.5	25.4	25.8	26.2	25.7	25.6	25.6
Mean Relative humidity (%)	Jakarta	85	85	83	82	80	78	76	74	73	75	79	82	
	Bogor	91	90	88	89	86	82	91	78	90	81	83	86	
Sunshine (%)	Jakarta	39	47	57	68	70	71	78	83	82	71	56	48	
	Bogor	27	32	51	55	56	51	49	60	63	59	48	41	
Wind direction	Jakarta	NW	NW	NW	E	E	E	E	E	N	N	N	NW	
	Bogor	NW	NW	W	NE	NE	NE	NE	NE	NE	N	N	W	
Wind velocity (m/s)	Jakarta	1.6	1.7	1.5	1.5	1.6	1.6	1.8	1.7	1.8	1.8	1.9	1.5	
	Bogor	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.6	
Potential evaporation (mm/day) (Penmman)	Jakarta	4.1	4.4	4.8	4.9	4.6	4.3	4.6	5.2	5.7	5.6	5.0	4.5	
	Bogor	3.3	3.6	4.2	4.0	3.7	3.3	3.3	3.9	4.4	4.2	4.6	3.9	

Source : C-J-C Water Resources Development Plan, Annex D, Sogreah-Ooyne & Bellier, 1979, NEDECO, 1983..

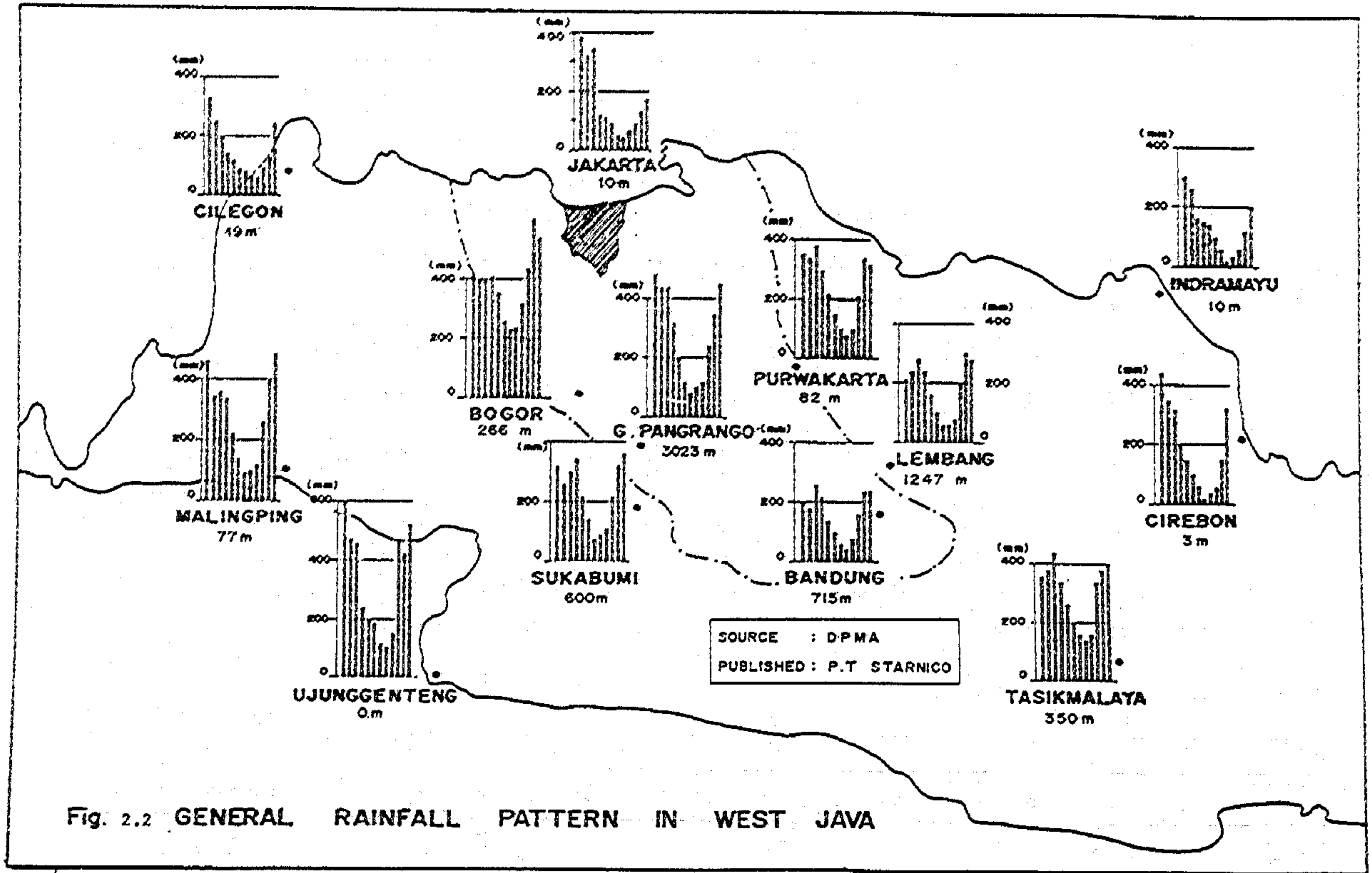


Fig. 2.2 GENERAL RAINFALL PATTERN IN WEST JAVA

these ranges. Therefore, mean annual rainfalls at Saguling, Jatiluhur and Curug stations record 2,262 mm, 2,406 mm and 2,432 mm, respectively.

(2) Temperature

The mean monthly temperatures as measured at two stations, are also shown in Table 2.1. The temperature varies slightly throughout the year with an average annual temperature of 27.1°C at Jakarta and 25.6°C at Bogor.

(3) Evaporation

The monthly mean potential evaporation and precipitation of Jakarta and Bogor are as follows :

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
Jakarta	390	322	242	126	177	87	56	53	68	92	135	180	1,868	
Bogor	460	447	381	403	117	198	224	224	317	370	328	347	3,816	
				Potential Evaporation (mm) (Penman)										
Jakarta	127	123	149	147	143	129	143	161	171	174	150	140	1,757	94.0%
Bogor	96	101	130	120	115	99	102	121	132	130	138	121	1,405	36.8%

The average annual potential evaporation and precipitation are nearly equal in Jakarta, but the potential evaporation exceeds the precipitation during low rainfall months through April to November except the rainy season. Comparing with Jakarta, the pattern of Bogor is different with the annual potential evaporation accounting for only 36.8% of annual precipitation.

Meteorological conditions widely varies between Jakarta and Bogor, according to the existing data such as temperature, relative humidity, sunshine, wind direction and velocity, as shown in Table 2.1. The mean temperature of Jakarta is higher than Bogor, ranging from 26.3°C to 27.8°C instead of that of Bogor which is 25.0°C to 26.2°C. Sunshine and Wind Velocity of Jakarta is also higher than Bogor. Otherwise, mean relative humidity of Bogor is higher than Jakarta. A large difference is in total rainfalls. Bogor has heavy rainfalls in a year, reaching more than twice of those in Jakarta.

The area experiences mean wind velocities of 1.6 m/s in north-west direction from December through March, 1.65 m/s in the easterly direction from April through August and also, 1.65 m/s in the northerly direction from September through November.

2.3 Hydrology

Hydrologic features related to the study of surface water sources for Jakarta city are treated on the main factors, precipitation and river system.

1) Precipitation

The general characteristics of precipitation in the region are described in the previous section of Climate (2.2). Yearly and monthly average precipitation over the study area has been analysed, based upon the observation records covering the period of more than 100 years from 1880 to 1981, kept by over 50 precipitation stations, and the results are presented in Fig. 2.3 (NEDECO, 1983).

The average annual precipitation of the Jabotabek and the Citarum catchment areas is considerably different from area to area. It is less than 2,000 mm/year along the northern coastal plain where Jakarta lies, while the southern mountain area receives to one over 4,000 mm/year. A specially heavy rainfall over 5,000 mm/year has been encountered near Bogor.

Table 2.2 summarizes mean annual rainfalls in the catchment area evaluated by Thiessen averages. The mean annual rainfalls in the Citarum river basin at Saguling, Palumbon, Jatiluhur and Curug range from 2,315 mm to 4,833. On the other hand, those of the local river basins of Cibeet, Cikarang, Bekasi at each weir ranges from 3,283 mm/year to 3,660 mm/year. In the Cisadane river basin at Masing and Serpong, the mean annual rainfalls are 4,100 mm and 2,450 mm, respectively, as evaluated by Isohyetal estimations.

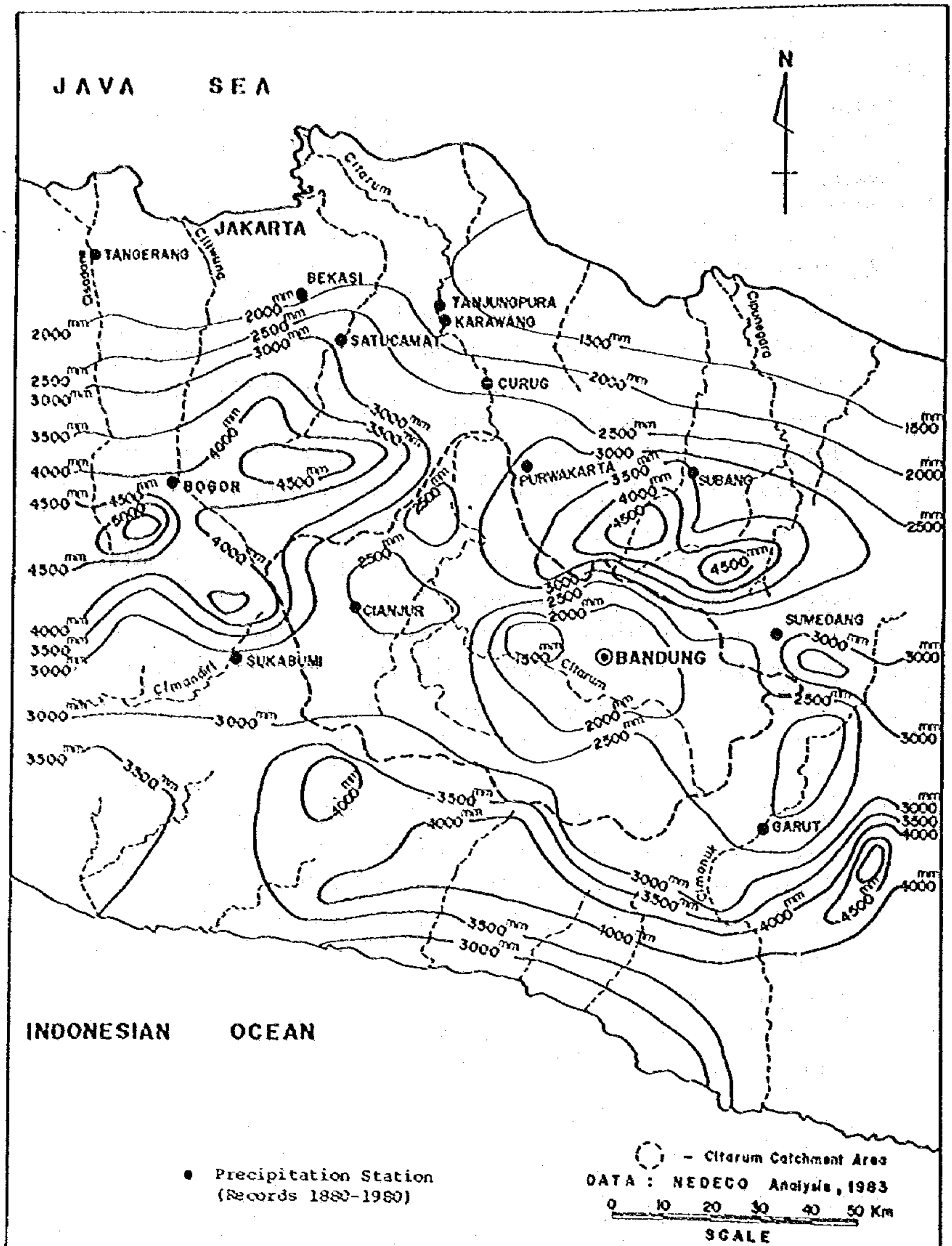


Fig. 2.3 AVERAGE ANNUAL PRECIPITATION OF JAKARTA AND CITARUM CATCHMENT AREA

Table 2.2 Hydrologic Conditions of River System Surrounding Jabotabek Area

No.	River	Station or Location	Catchment Area (Km2)	Mean Annual Rainfall (mm)	Mean Annual Discharge (m3/s)	Monthly Minimum Discharge (m3/s)	Records of Discharge
1.	Citarum R.	Saguling St.	2,315	2,262 *	99.0	26.0	Yearbooks NEDECO, 1983
2.	Citarum R.	Palumbon St.	4,059	2,391 *	160.0	54.0	POJ, 1963-1980
3.	Citarum R.	Jatiluhur Dam	4,550	2,406 *	181.0	64.0	POJ, 1963-1980
4.	Citarum R.	Curug Weir	4,833	2,432 *	185.0	147.0	POJ, 1969-1980
5.	Cibeet R.	Cibeet Weir	507	3,283 **	37.4	11.0	POJ, 1970-1980
6.	Cikarang R.	Cikarang Weir	226	3,467 **	15.9	7.0	POJ, 1970-1980
7.	Bekasi R.	Bekasi Weir	412	3,660 **	32.7	15.0	POJ, 1970-1980
8.	Ciliwung R.	Rawajati St	318	1,950 ***	17.0	9.3	Sogreah, 1979
9.	Cisadane R.	Masing St.	129	4,100 ***	10.7	7.1	Sogreah, 1979
10.	Cisadane R.	Serpong St.	1,074	2,450 ***	97.9	62.2	Sogreah, 1979
11.	Cidurian R.	Kapomaja St.	304	2,550 ***	22.8	15.3	Sogreah, 1979

Note : * Thiessen averages by NEDECO, 1983

** Thiessen average by Sogreah/ Coyne & Bellier, 1979

*** Isohyetal average estimation.

2) River System

Fig.2.4 illustrates the river system serving for the water supply to Jakarta Metropolis, and the hydrologic data of those surrounding Jabotabek area are presented in Table 2.2.

The Citarum river is the biggest river in the West Java with a catchment area of 4,550 km^2 at Jatiluhur damsite and the average annual flow of about 517 billion m^3 or 181 m^3/sec of average discharge. The Cisadane river is another big river within the region. The mean annual discharge of the Cisddane river is 97.9 m^3/sec and its monthly minimum discharge is 62.2 m^3/sec at Serpong gauging station with 1,074 km^2 catchment, based on the data of Sogreah, 1979. Most of other local rivers contributing to the water supply, such as the Cibeet, the Cikarang, the Bekasi, the Ciliwung and the Cidurian rivers, occur between these two big rivers, flowing northward to the Java Sea.

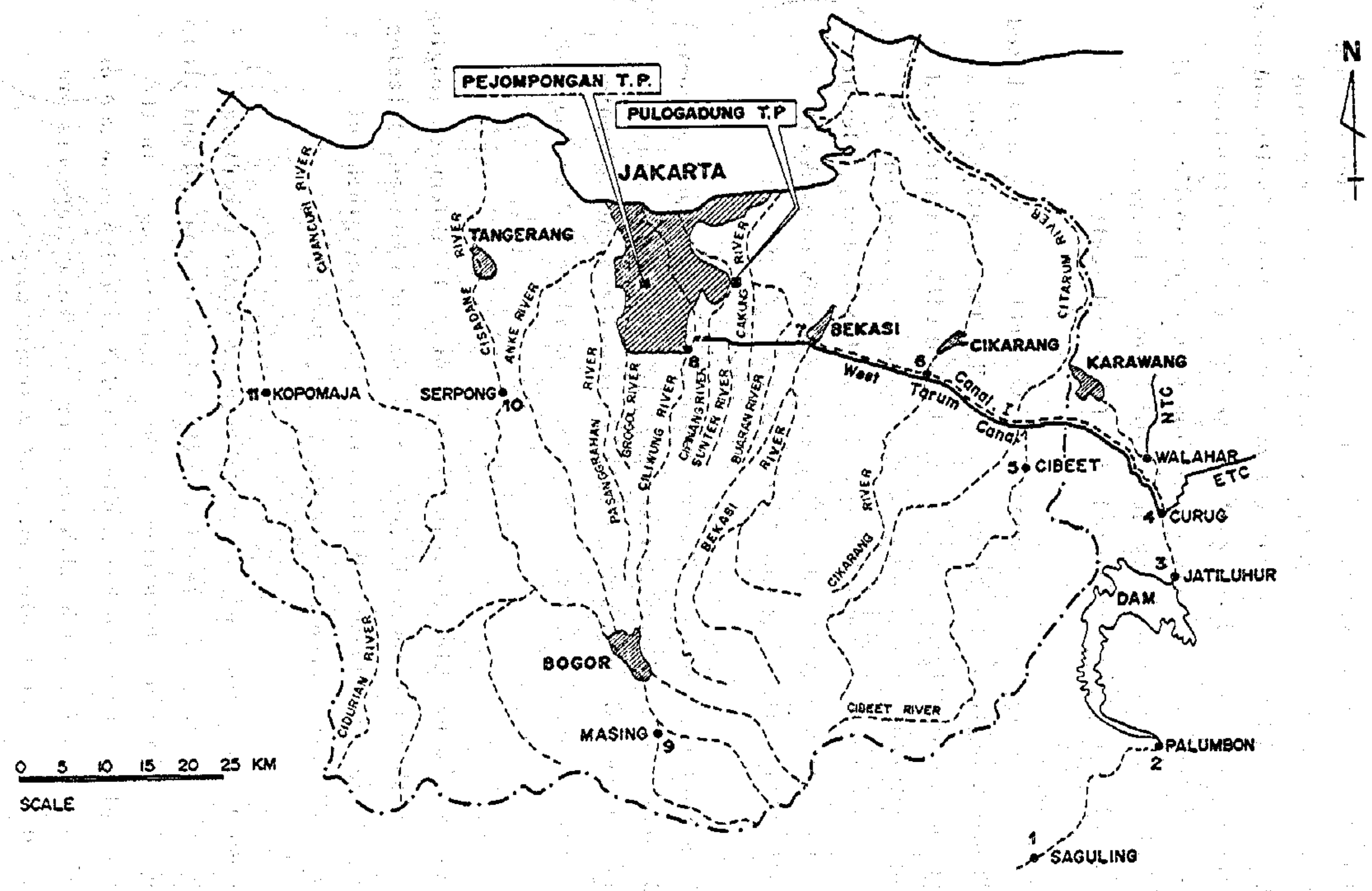


Fig. 2.4 RIVER SYSTEM AND RIVER FLOW GAGING STATION IN JABOTABEK AND SURROUNDING AREA

2.4 Geology

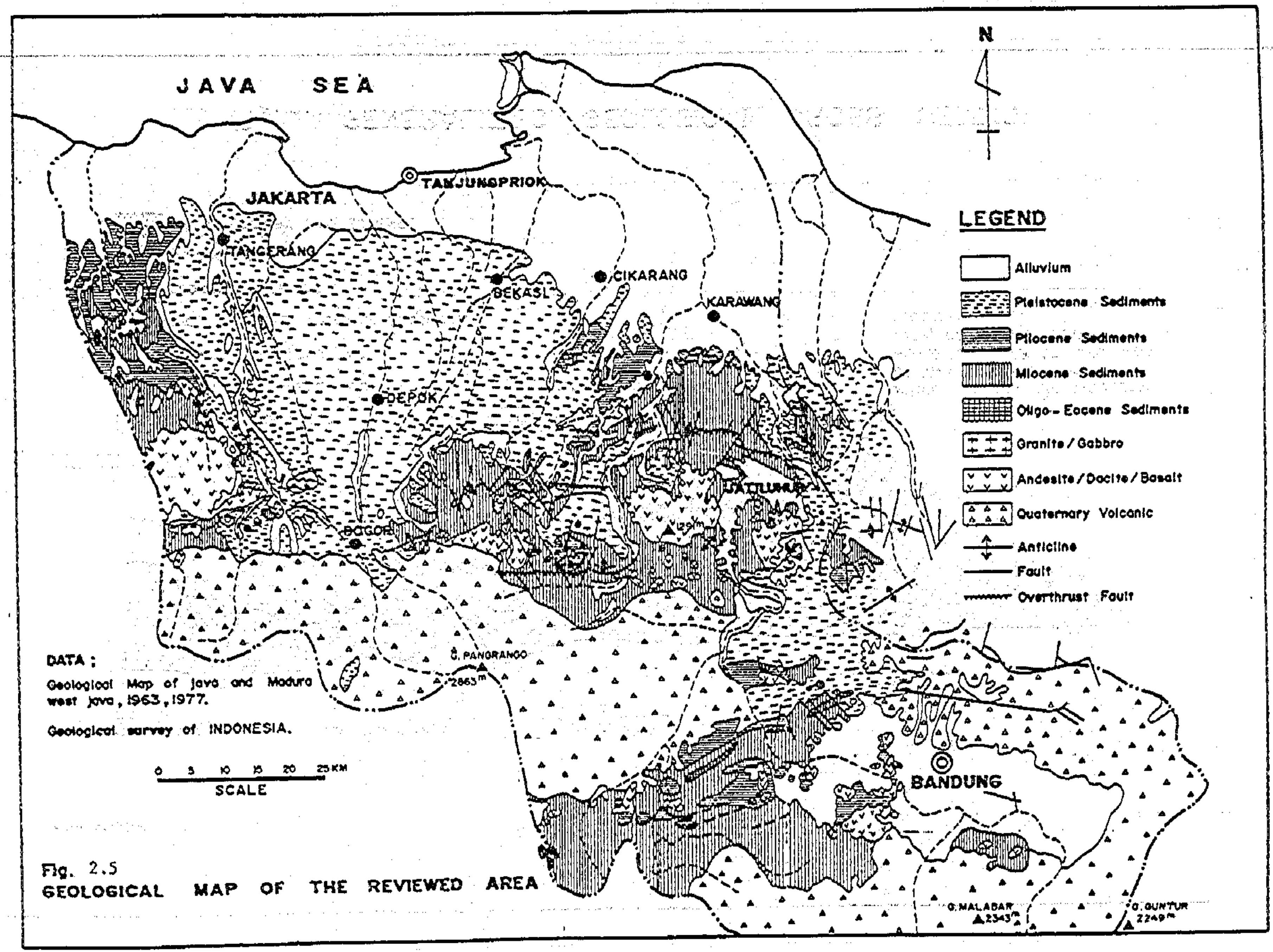
The geological conditions of the reviewed area of Jabotabek and the Citarum river basins are illustrated in Fig. 2.5. The ancient rocks of Oligo-Eocene sediments slightly crop out in the west of Bandung associating with Miocene and Pliocene sediments. Alsi, faults and over-thrust faults are observed generally in NE-SW and NW-SE directions. Tertiary sediments deposited in the marine conditions in the end of Miocene, Pliocene and Quaternary are affected by an intrusive and extrusive volcanic rocks associated with folds and faults.

Fig. 2.6 is the generalized geological cross section of the area based on the "Geology of Indonesia by Van Bemmelen". The heavily folded marine sediments of Oligocene shale interbedded with sandstone and limestone. The overall thickness is assumed to be around or over 1,000 m. Since volcanic phenomena started during Miocene, volcanics consist mainly of breccia and basaltic lava. Intrusive rocks of gabgro and diorite also crop out in the area.

The Genteng formation of lower Pliocene are composed largely of pumice tuff and tuffaceous sandstone interbedded with tuffaceous clay of about 700 m in thickness (Van Bemmelen). Plio-Plistocene volcanic sediments consist of conglomerate, breccia, mud flows and volcanic debris.

Jakarta is covered by thick Quaternary sediments, the thickness ranging from 100 m to 300 m and the sediments of marine and continental facies have been alternated. Table 2.3 illustrates the stratigraphy of Quaternary sediments around Jakarta (Soekardi, 1975).

In the southern mountains and piedimont area, volcanic materials consisting of breccia, tuff, lapilli tuff, volcanic lava and mud flows are prevalent, making up the slopes of the volcanic cones. In the coastal flat plain, on the other hand, Alluvial deposits composed of clay, sandy clay, silt, sands with coral or limestone fragments are dominant. These materials are mostly of volcanic origin.



DATA :

Geological Map of Java and Madura west Java, 1963, 1977.

Geological survey of INDONESIA.

Fig. 2.5
GEOLOGICAL MAP OF THE REVIEWED AREA

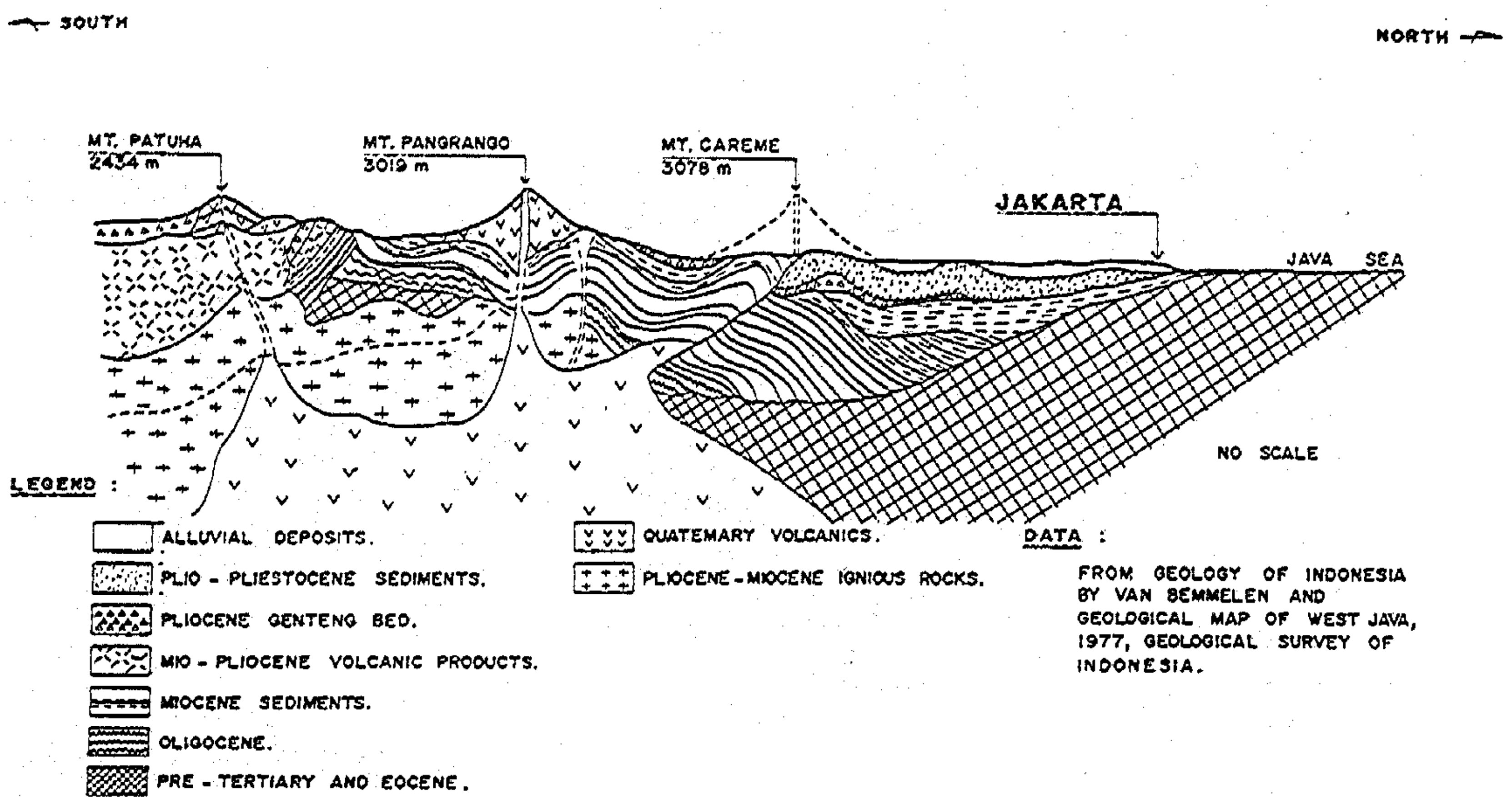


Fig. 2.6 GENERALIZED GEOLOGICAL CROSS SECTION

TABLE 2.3 STRATIGRAPHY OF JAKARTA AND ADJACENT AREAS

GEOLOGIC AGE		THICKNESS (M)	FACIES	DISCRIPTION
QUARTERNARY	Holocene	20 - 50	Marine	Grey clay, blue, clay-sand or sands. Sometime Coral Splinter are found or floral fossils remainder in it.
			Continental	Sandy clay, sand, gravel and sandstone. Yellow tuff clay or reddish brown.
	Upper Plistocene	4 - 12	Marine	Solid clay, green; yellow to brownish. Contain foraminifera fossils and coral remainders
		30 - 65	Continental	Yellow clay to brown, claysands, sand, tuff sandstone, conglomerate, gravel. Floral remainder are found downside. At Kebayoran Baru deep well, Mammalia fossil are found.
	Middle Plistocene	35 - 60	Marine	Clay, green claysand, grey to yellow. Sometime contains coral remainder.
			Continental	Claysand with sand insertion contain floral remainder elements downside.
		4 - 18	Marine	Green solid clay, yellow, grey to blue, contain coral splinter or coral. Sometime marl or limestone insertion are found.
	Lower Plistocene	25 - 100	Continental	Claysand or tuffaceous clay, grey sandy clay contain quartz or Kril. Black clay, grey, blue, green, yellow to brown. Contain foraminifera fossils, coral splinter and floral remainder especially at downside layers.
		40 - 60	Marine	Thin sand layer, especially quartzsand, soft element to rough. Solid clay, blue to green, or clay sand contain gravel fragment or limestone. Contain foraminifera fossil and coral remainder.
		30 - 50	Continental	Sandy sediment, as a thin insertion in limestone, or clay sand. Sometime contain floral remainder.
TERTIARY	Pliocene	?	Marine	Marl, hard clay, solid green colour to blue, contain coral fossil or limestone fragment and gravel with thin insertion of sand elements contain coral fossil especially downside.

DATA : MENURUT SOEKANRDI, 1975

The general direction of sedimentation is south-north due to the transgression and regression of the ocean and several marine clay layers about 5 m to 10 m thick are also found in Plistocene sections.

The low lands and swampy area of the coastal plain are mantled with Holocene (Recent) sediments consisting of clay, silt, sand, gravel and pebbles which are mostly of volcanic origin. The thickness is less than 30 m around Jakarta.

2.5 Hydrogeology

In the coastal plain, a north-south Tertiary anticline ridge is found around Tangerang. Hydrogeologically this ridge separates two Quaternary basins, namely Jakarta artesian basin to the east and Serang artesian basin to the west (Coyne et Bellier, 1979).

The base of Jakarta artesian basin is underlain by Miocene to Pliocene sedimentary rocks, consisting of green to grey shell remains and coral containing clay, with intercalations of andesitic sandstone layers. These Tertiary sedimentary rocks are encountered at about 300 m in depth overlain by 200 - 300 m thick Quaternary sediments.

The Quaternary sediments consist of alternating layers of clay, sand and gravel deposited under continental and marine environments. These Quaternary sediments were presumably derived from two sources such as from the south and from the north, as indicated by the presence of andesitic fragments and quartz grains, respectively. (Soekardi, 1975 - 1982).

The Quaternary aquifer is considerably important in the Jakarta area, since it has been one of the main sources of domestic and industrial water. The sediments contain relatively freshwater, occasionally in salty water near the coast. Dr. S. Yamamoto, 1972 and recently, Ir. Soekardi and his staff, Environmental Geology Bandung, 1975 - 1982, studied the hydrogeological conditions of Jakarta area. According to these studies, the study area of Jakarta is hydrogeologically classified into the four main aquifers :

2.5.1 Unconfined and Semi-confined Aquifers

The shallow aquifer is an unconfined one which is located at a shallower depth and tapped by shallow wells used for domestic in densely populated area. However, basic data of such as the number of wells and their capacities are lacking and unreliable. Shallow groundwater can be found almost everywhere under the coastal plain. The thickness of this aquifer rarely exceeds 60 m. The water levels range from 2 m to 10 m below ground surface. Annual water level fluctuations in the wet and the dry seasons are negligible in some areas, while in others the levels may vary from 3 m to 5 m. The specific capacity is 1.0 to 1.5 l/sec/m or 86 to 130 m^3/day/m.

2.5.2 Confined Aquifers

Groundwater in the deeper aquifers is found in three principal zones ranging from 60 m to the maximum depth of 394 m. These zones are formed by a series of the discontinuous, interfingering permeable strata separated by layers of low permeable materials.

The aquifers do not continue for long distances and the various zones of permeability layers are regularly found throughout the deposits underlying Jakarta city. Water bearing formations are also present at greater depths than 225 m in Jakarta, but these deeper zones produce highly mineralized water and therefore, are not considered as suitable water sources for private use.

The three water bearing zones range from 60 m to 150 m, 150 m to 225 m and 225 m below ground surface, respectively. The hydrogeological cross sections shown in Fig. 2.7 were prepared by Soekardi, 1975 to show the subsurface conditions in Jakarta area.

1) Aquifer from 60 m to 150 m in depth

   Better quality of water has been tapped from this aquifer. The specific capacity is 0.5 to 1.0 l/sec/m or 43 to 86 m^3/day/m.

2) Aquifer from 150 m to 225 m in dep h

   Good quality of water, extensively exploited for domestic and industrial use. The specific capacity is 1.0 to 1.5 l/sec/m or 86 to 130 m^3/day/m.

3) Aquifer below 225 m in depth

   This aquifer is not currently exploited due to mineralized water.

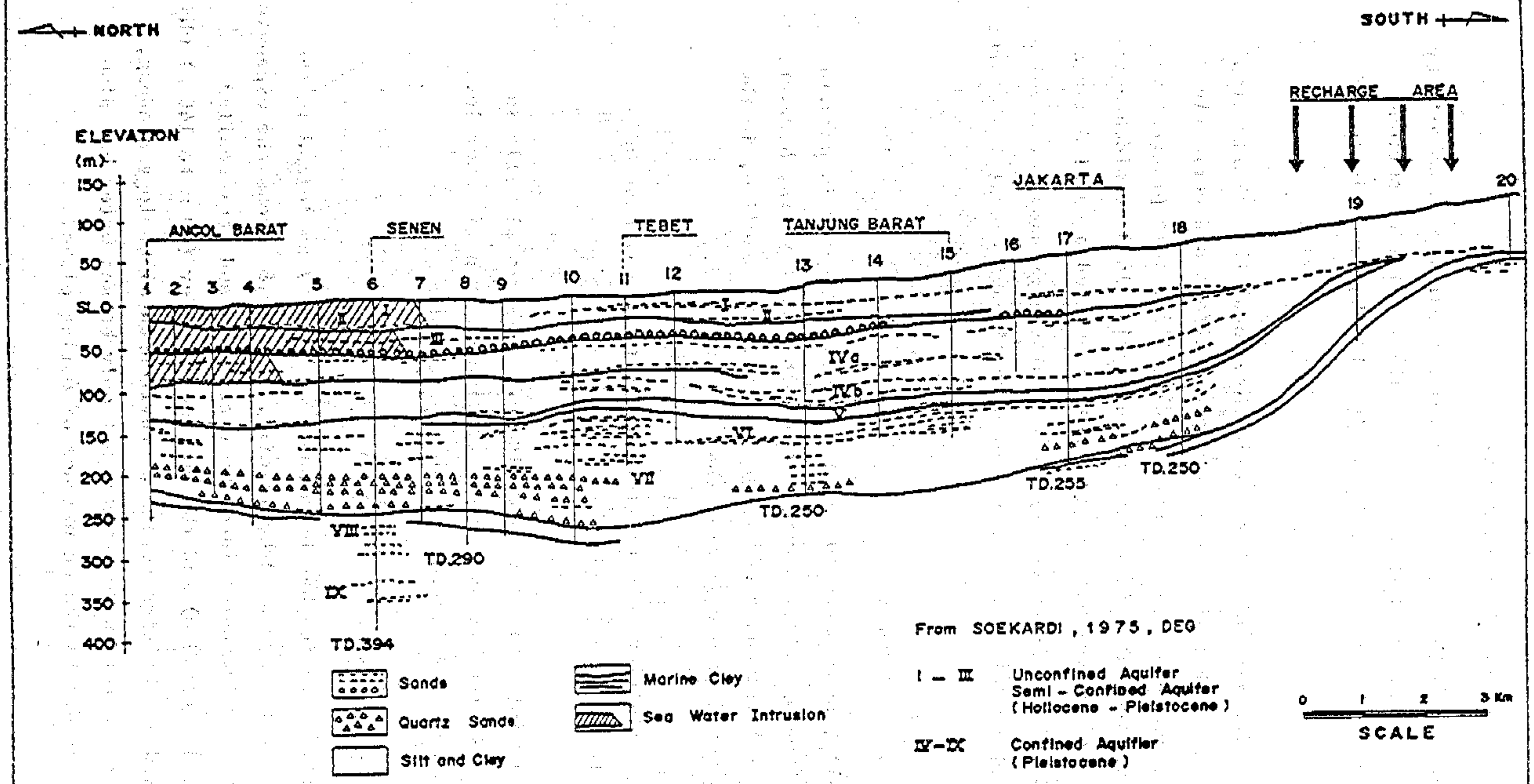


Fig. 2.7 HYDROGEOLOGICAL CROSS SECTION IN JAKARTA CITY

2.5.3. Groundwater Problems in Jakarta

Fig. 2.6 illustrates the groundwater level contour map in Jakarta by Djaeni, 1982. It is noted that there are three parts of serious groundwater depletion zones, namely Tanjung Priok, Penjaringan and Cengkareng.

The continuous lowering of water levels throughout the Jakarta area strongly indicates that the regional deep aquifers are currently being over-exploited and piezometric levels will become progressively deeper. Actual sea water intrusion and potential land subsidence has been occurred in the northern high densely populated area of Jakarta. Accordingly it is highly necessary to control the groundwater development and to plan appropriate conservation of natural environment in Jakarta city.

1) Groundwater Level Decline

Historically, some 30 to 40 years ago, wells located in Jakarta produced flowing artesian conditions. In recent years, however, groundwater levels have undergone a significant decline, in the serious cases declined greater than 20 m to 30 m.

The average lowering rate of groundwater table may have been 5 m to 10 m in the last years.

According to the newspaper in September, 1983, local wells in Setiabudi area ran dry due to the continuous drop of water level as well as seasonal fluctuation in dry period.

2) Sea Water Intrusion

Saline water intrusion has been observed up to 7 km inland in the nothern coastal zones of Jakarta city. Fig. 2.8 shows the expansion of saline water intrusion into the unconfined and semi-confied aquifer (20 m to 60 m) and the confined aquifer (60 m to 140 m) which was prepared by the Directorate of Environmental Geology Bandung, 1982. Saline water intrusion may not only be sea water but also connate water due to the occurrence of marine clays.

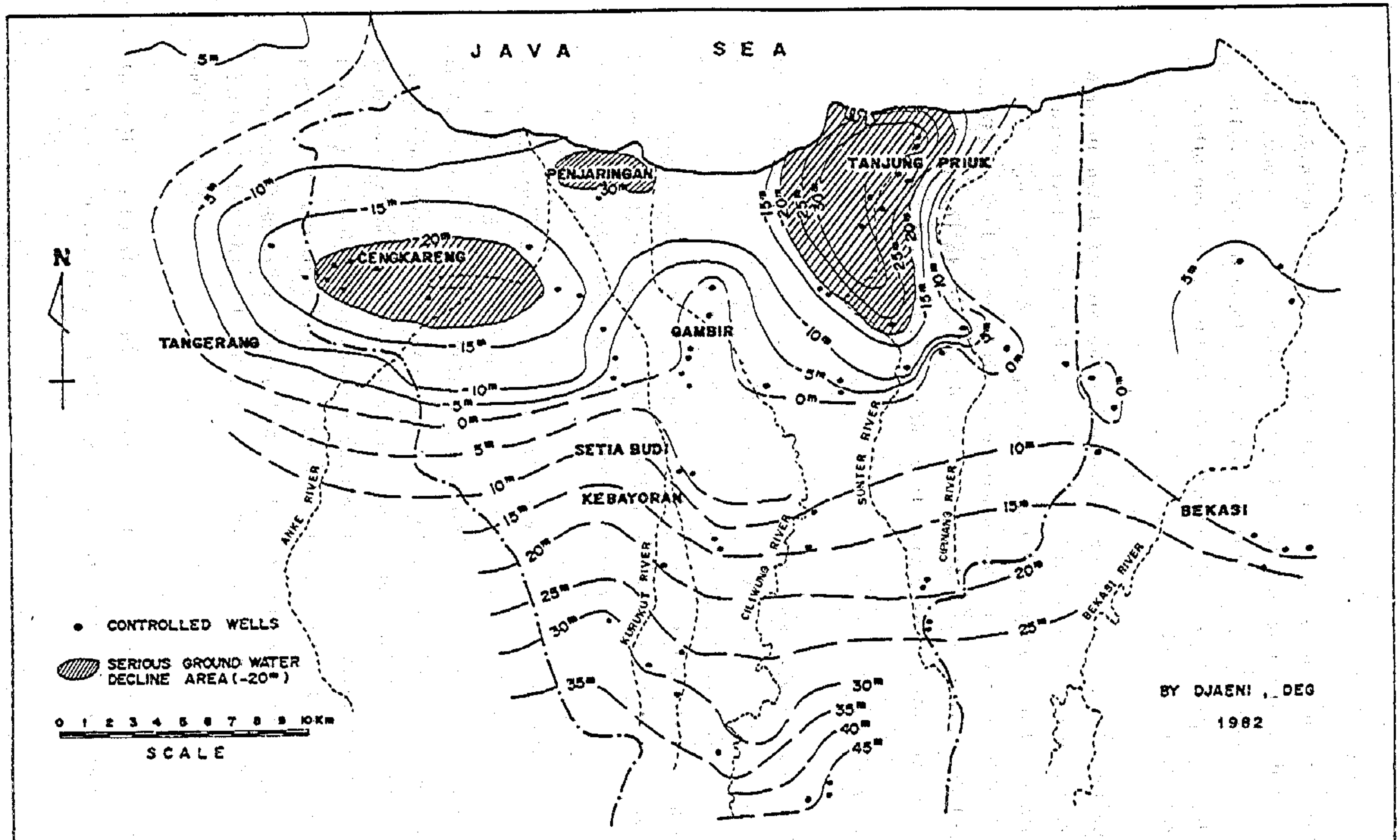


Fig. 2.8 GROUNDWATER LEVEL CONTOURS IN JAKARTA CITY

3) Land Subsidence

There are no reports on significant evidence of land subsidence related to groundwater extraction in Jakarta area. However, the potentiality of land subsidence in Jakarta is hydrogeologically large compared with that evidences of Bangkok, Tokyo and other areas in the world.

The leveling survey has been planned in the area of Jalan Thamrin where signs of land subsidence, a rise of buildings, have been rather slight. Tanjung P iok, Penjaringan and Cengkareng should be observed so that significant evidence of land subsidence including extrusion of deep wells could be found in the areas due to the large piezometric level declines.

3. SURFACE WATER RESOURCES FOR JAKARTA WATER SUPPLY

3.1 Present Water Sources for Jakarta Water Supply System

The main water sources for Jakarta water supply system consist of water of the rivers, most of them flowing through the City. The major rivers contributing to the system are listed as follows:

Name of River	Yearly Average Flow (m^3/sec)
1. Ciliwung	17.0
2. Sunter	1.4
3. Cipinang	0.9
4. Cakung	0.6
5. Buaran	0.5

(For the details of the discharges of each river, refer to Table 3.1)

In the dry season from June to October, the total river flow in the region reduces to merely 10.6 m^3/sec to 14.7 m^3/sec. The Ciliwung, the largest river in the area, supplies approximately 5.7 m^3/sec to Pejompongan water treatment plant and the two mini-plants of Muara Karang and Pejarten. The Sunter river provides about 1.1 m^3/sec to Pulogadung plant and one mini-plant of Sunter.

The extension program of these existing plants is now under way, and on completion, is expected to enhance the intake from these rivers, namely to 6.6 m^3/sec from the Ciliwung, 4.4 m^3/sec from the Sunter and 0.6 m^3/sec from other rivers. (In case of the Sunter, the flow is expected to increase by contribution from the West Tarum Canal intercepting this stream.) In addition, minor rivers such as the Grogol and the Angke are expected to supply 0.5 m^3/sec to other mini-plants, Cilandak, Cakung, Tarogong, Cengkareng and Pesing. The existing water treatment plants, together with the related river systems, are indicated in Fig. 3.1 and Table 3.2

In addition to these natural streams, the City has several canals to receive supplies of raw water from the rivers outside DKI Jakarta. The

Table 3.1 Monthly River Discharge in Jakarta City

Unit : m3/s

No:	River	Wet Season							Dry Season					Year	Note
		N	D	J	F	M	A	M	J	J	A	S	O		
1	Buaran	0.4	0.4	0.9	0.9	0.9	0.6	0.4	0.3	0.3	0.3	0.3	0.3	0.5	*B
2	C a k u n g	0.5	0.5	1.0	1.0	1.0	0.7	0.5	0.4	0.4	0.4	0.4	0.4	0.6	*B
3	Sunter	1.3	1.3	2.5	2.5	2.5	1.6	1.3	0.8	0.8	0.8	0.8	0.8	1.4	*B
4	Cipinang	0.8	0.8	1.6	1.6	1.6	1.1	0.8	0.5	0.5	0.5	0.5	0.5	0.9	*B
5	Ciliwung (Rawajati 318 km2)	15.6	18.1	24.6	25.4	23.3	23.2	19.0	13.4	10.6	9.3	9.5	12.2	17.0	*A

Note :* A- Monthly Mean Discharges, coyne Et Bellier, 1979
* B- Estimated Reliable Flows, NEDECO, 1983

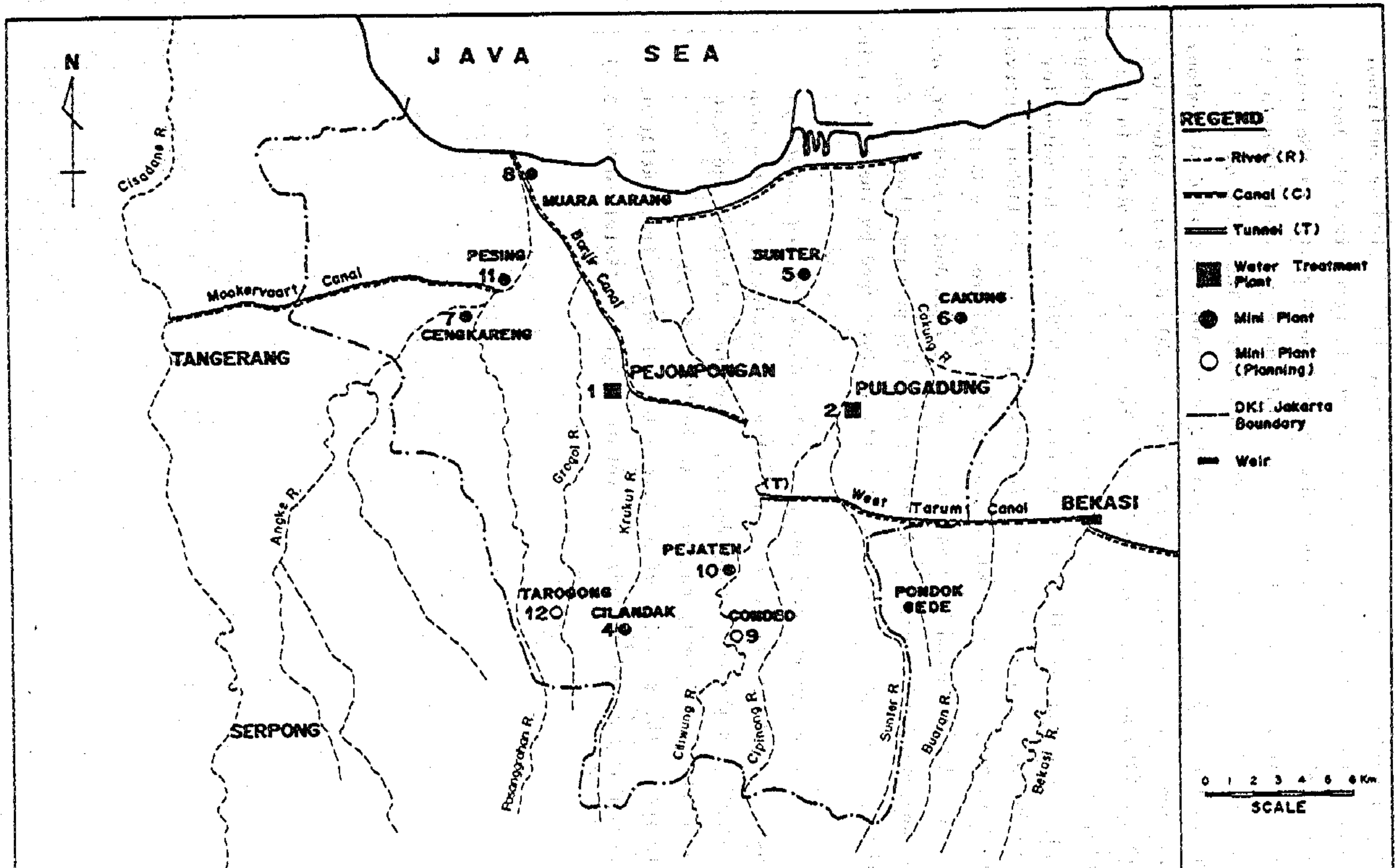


Fig. 3.1 RIVER SYSTEM AND WATER TREATMENT PLANTS IN JAKARTA

most important one is the West Tarum Canal, which is fed by Jatiluhur reservoir and on its way to Jakarta intercepts water from the local rivers such as the Cibeet, the Cikarang and the Bekasi. As the result, the water in the last section of the canal, namely Bekasi - Jakarta, is comprised of the contributions from these four. The ratio of the contributions can be known from discharge readings recorded at various diversion weirs. For reference, average monthly discharge values for 1979 and 1980 are presented in Tables 3.3 & 3.4. As shown in the table, in the Bekasi - Jakarta section of the canal, the main contribution at present comes from the Bekasi river. In 1979/80, it accounted for 62 to 95% of the total flow in this section, whereas Jatiluhur reservoir, only 1 to 25%. The available discharge in 1978 from the West Tarum Canal was varied between 4 and 6 m^3/sec from June to October, and from November to May between 0 and 4 m^3/sec because the flows of the Ciliwung, the Cipinan and the Sunter rivers increased by the heavy rain.

The streams in Jakarta city have been fully developed for not only drinking but other uses such as flushing and irrigation. To enhance the supply for the increasing demand, a program enlarging the West Tarum Canal is currently ongoing. (Refer to Sec 3.3)
Furthermore, the transfer of a large volume of water from Jatiluhur reservoir is now under study as a future program. (Refer to Sec 3.3)

TABLE - 3.2 WATER SOURCE AND WATER TREATMENT

PLANTS IN JAKARTA, 1983 - 1985

Plant	No.	Name	Water Source	Water* Quality	Production Capacity (L/S)	
					1983	1985
Treatment Plant	1.	Pejompongan	(Ciliwung River) Banjir Canal	B	5.000	5.600
	2.	Pulogadung	Sunter River	B	1.000	4.000
	3	Ciburial	Springs, Bogor	A	300	300
Mini - Plant	4.	Cilandak	Krukut River	A	200	450
	5.	Sunter	Sunter River	B	50	50
	6.	Cakung	Irrigation Canal	A	25	25
	7.	Cengkareng	Angke River	A	50	50
	8.	Muara Karang	Banjir Canal	B	100	200
	9.	Condet	Ciliwung River	A	*	100
	10.	Pejaten	Ciliwung River	A	5	5
	11.	Pesing	Angke River	B	5	5
	12.	Tarogong	Grogol River	A	*	100
TOTAL CAPACITY (L/S)					6.735	10.885

Data from PDAM, July, 1983

* Water Quality, JICA, 1983

A ; Good

B ; Contaminated

Table 3.3 Mixing ratios at weirs on the West Tarum Canal, 1980.

Year	Section Cibeet - Cikarang			Section Cikarang - Bekasi			Section Bekasi - Jakarta		
	Flows (m^3/s)		Mixing Ratio	Flows (m^3/s)		Mixing Ratio	Flows (m^3/s)		Mixing Ratio
1980	Inflow in Canal at Curug	Inflow in Canal at K.Cibeet	Jatiluhur / Cibeet	Outflow of canal sec. Cibeet-Cik.	Inflow of Cikarang	Canal / Cikarang	Outflow of canal sec. Cik. - Bek.	Flow of K.Bekasi	Canal / K. Bekasi
January	15.4	13.6	1.13	8.2	29.8	0.28	2.1	38.5	0.06
February	12.6	11.1	1.14	5.4	20.7	0.26	3.2	39.6	0.08
March	14.2	8.5	1.67	4.5	20.1	0.22	3.2	40.4	0.08
April	19.6	11.2	1.75	9.3	5.0	0.62	3.5	34.7	0.10
May	21.0	9.6	2.19	5.4	9.8	0.55	2.0	31.3	0.06
June	29.6	6.9	4.29	9.8	4.0	2.47	2.4	9.7	0.25
July	41.3	6.9	5.99	17.2	5.9	2.93	7.4	12.0	0.62
August	33.2	5.7	5.77	15.4	7.7	2.01	6.7	22.7	0.30
September	30.8	7.6	4.06	10.7	2.6	4.10	2.4	28.7	0.08
October	28.1	10.0	2.81	12.6	5.3	2.41	1.8	29.6	0.06
November	29.5	14.0	2.21	11.6	15.5	0.75	2.2	27.7	0.09
December	23.6	13.0	1.82	11.8	10.3	1.15	1.6	33.0	0.05
Average	24.9	9.8	2.9	10.2	12.2	1.48	3.2	29.0	0.15
Annual Flow(10^6 m3)	785.2	309.1	-	321.7	384.7	-	100.9	914.5	-

Table 3.4 Monthly percentage distribution of origin of water in the West Tarum Canal, 1980.

Years	Origin of Water in various sections of the West Tarum Canal (%)								
	Section Cibeet - Cikarang		Section Cikarang - Bekasi			Section Bekasi - Jakarta			
1980	Jatiluhur	Cibeet	Jatiluhur	Cibeet	Cikarang	Jatiluhur	Cibeet	Cikarang	K. Bekasi
January	53.1	46.9	11.5	10.1	78.4	0.6	0.5	4.1	94.8
February	53.2	46.8	11.0	9.7	79.3	0.8	0.7	6.0	92.5
March	62.6	37.4	11.5	6.8	81.7	0.9	0.5	6.1	92.5
April	63.6	36.4	24.4	13.9	61.7	2.2	1.3	5.6	90.9
May	68.6	31.4	24.4	11.2	64.4	1.5	0.7	3.8	94.0
June	81.1	18.9	57.7	13.5	28.8	11.4	2.7	5.7	80.2
July	85.7	14.3	63.9	10.7	25.4	24.4	4.1	9.7	61.8
August	85.2	14.8	56.9	9.9	33.2	13.0	2.3	7.6	77.1
September	80.2	19.8	64.5	15.9	19.6	5.0	1.2	1.5	92.3
October	73.8	26.2	52.1	18.5	29.4	3.0	1.1	1.7	94.2
November	67.8	32.2	29.1	13.8	57.1	2.2	1.0	4.4	92.5
December	64.5	35.5	34.5	19.0	46.5	1.6	0.9	2.2	95.3
Average	70.0	30.0	36.9	12.8	50.3	5.6	1.4	4.9	88.1

3.2 Future Water Sources for Jakarta Water Supply System

As referred to in the foregoing section, the future water supply for Jakarta must depend upon the water resources outside the City. For the urgent and mid-term planning, the development of the eastern basin, particularly the Citarum river basin, has been the predominant requirement, and for the long-term one, that of the Cisadane river in the western area has been the object of the essential study. In this section, therefore, the available water in these two basins are discussed.

1) Water Resources in the Eastern Basin

Table 3.4 summarizes the hydrologic data of the river systems in the eastern area of Jakarta Metropolis. The Citarum river basin with Jatiluhur reservoir along its upperstream is the main river basin in the region and other local river basins consist of the Cibeet, the Cikarang and the Bekasi.

The available Citarum water resources at Jatiluhur and Curug are annually 5,708 x 10^6 m^3 and 5,834 x 10^6 m^3, respectively, based on the data of Jatiluhur Authority (POJ), 1963 - 1980. The average runoff coefficient is around 50% to 52% of the catchment rainfalls. On the other hand, the available runoff of the Citarum river was analyzed to be 6,100 x 10^6 m^3/year by NEWJEC, 1981 in the report of feasibility analysis, although it was later revised to be 5,400 x 10^6 m^3/year by NEDECO.

The average meteorological factors measured at Jatiluhur reservoir are shown in Table 3.5 . The estimated evapotranspiration indicates 41.4% against the Thiessen average annual rainfalls of 2,406 mm. Therefore, the above figures of available Citarum water resources at Jatiluhur and Curug could be reliable ones.

The available water resources of the other rivers, the Cibeet, the Cikarang and the Bekasi at each weir are 1,179 x 10^6 m^3/year, 501 x 10^6 m^3/year and 1,031 x 10^6 m^3/year, respectively, according to the POJ

Table 3.4 Hydrologic Evaluation of River System

No.	River	Location	Catchment Area (Km2) (A)	Mean Annual Rainfall (mm) (B)	Total Rainfall (C)*** (10^6 m3)	Annual Average Discharge (10^6 m3) (D)	Runoff Coefficent (D/C)
1.	Citarum	Saguling St.	2,315	2,262 *	5,236	3,122	0,596
2.	Citarum	Jatiluhur Dam	4,550	2,406 *	10,947	5,708	0.521
3.	Citarum	Curug St.	4,833	2,432 *	11,754	5,834	0.496
4.	Cibeet	Cibeet Weir	507	3,283 *	1,664	1,179	0,709
5.	Cikarang	Cikarang Weir	226	3,467 **	784	501	0.639
6.	Bekasi	Bekasi Weir	412	3,660 **	1,508	1,031	0,684

Note : * Thiessen average by NEDECO, 1983

** Thiessen average by Sogreah/Coyne & Billier, 1979.

*** C = A x B

Table 3.5 Average Meteological factors measured at Jatiluhur reservoir

Month	Ranfall * (mm)	Temperature (°C)	Windspeed (Km/day)	Humidity (%)	Pan evaporation (mm/month)	Estimated evapotranspiration (mm/month)
Jan	278	26.5	25	86	70	60
Feb	243	27.0	23	85	72	61
Mar	296	28.0	18	85	90	77
Apr	268	27.1	14	83	94	80
May	192	28.0	14	82	99	84
Jun	103	27.8	14	83	89	76
Jul	83	27.8	16	80	103	87
Aug	78	27.8	22	78	113	96
Sep	102	28.3	24	77	112	95
Oct	201	28.5	20	79	128	101
Nov	278	28.3	15	81	123	105
Dec	284	27.8	17	83	88	75
Average total	2,406	27.7	18	82	1,171	997 (41.4 %)

Note : * Thissen Average Monthly Catchment area Rainfall at Jatiluhur

Catchment Area of 4,550 Km2

POJ / NEDECO, 1983

operational records, 1970 - 1980.

Water in the Citarum basin is in full use for various purposes. Particularly irrigation requirement accounts for nearly 75% of all the usage of the river water. In the year of drought, therefore, water shortage is likely to affect the supply program. In fact there is obviously a 5-year cycle of drought, as indicated by the past record of 1967, 1972, 1977 and recently 1982 when the reservoir water level dropped to the order of 80 m from the average 100 m. (Refer to Fig. 3.2 for water level fluctuation in Jatiluhur reservoir.) In this case the first priority must be given to drinking water requirement.

2) Water Resources in the Western Basin

The Cisadane river runs across the western basin outside DKI Jakarta, and has been considered to be one of future water sources for Jakarta supply system. Table 3.6 and Fig. 3.3 show the mean monthly discharge of the stream. Discharge records collected at the Tangerang Cisadane River Observation Station from 1960 through 1971 indicate the mean annual discharge to be 42.4 m^3/sec. During this same period, maximum and minimum point discharge were recorded at 560 and 4 m^3/sec, respectively. On the other hand, according to the data of Sogreah, 1979, the mean annual discharge of the Cisadane is 97.9 m^3/sec and monthly minimum discharge is 62.2 m^3/sec at Serpong gauging station with a 1,074 km^2 catchment area. However, there are no detailed data and the Sogreah figures seem to be overestimated.

To obtain a stable supply of raw water in an appreciable quantity from this uncontrolled river, there is a necessity of constructing the dam/s at suitable location/s. This reason has left the development of the river basin for the long-term planning. The survey in detail is expected to start in the near future, but the prospect for the possible allocation for water supply is in the order of 10 m^3 to 20 m^3/sec.

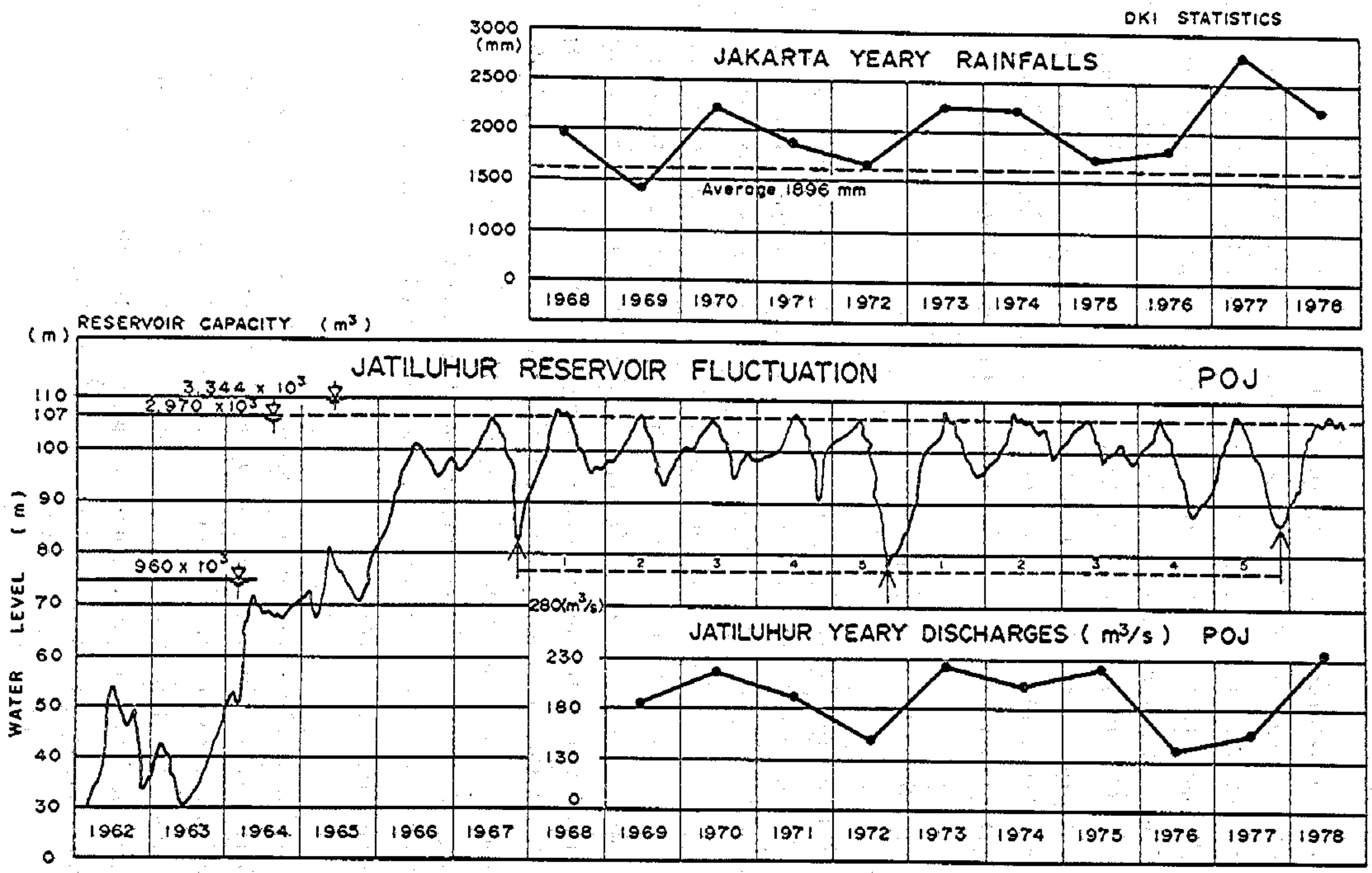


Fig. 3.2 JATILUHUR RESERVOIR CAPACITY AND FLUCTUATION 1962-1978

Table 3.6 Mean River Discharge - Cisadane River, Cidurian River

Tangerang Observation, Catchment Area 1349 km (m3/sec)

Year / Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean Annual Flow
1960	54.8	77.8	40.1	83.9	34.6	35.3	106.7	51.5	77.3	86.6	88.1	59.1	66.2
1961	50.7	68.8	78.0	20.9	23.9	33.2	21.8	14.8	12.2	15.0	20.0	55.5	34.5
1962	9.5	20.6	9.9	25.8	40.2	25.3	35.5	25.3	15.6	20.1	15.1	20.2	22.0
1963	15.0	29.3	29.5	42.9	40.0	36.2	50.0	22.3	23.7	10.3	43.5	47.4	32.5
1964	50.1	40.3	25.3	155.8	44.9	44.8	30.0	44.9	14.8	34.5	45.0	40.0	47.4
1965	80.0	42.0	33.0	50.7	47.9	35.2	40.0	29.2	30.2	61.1	51.3	50.7	48.1
1966	78.3	37.7	35.3	41.4	45.0	25.1	29.7	44.8	24.8	41.2	31.2	55.1	41.4
1967	87.3	29.7	25.2	86.7	45.4	30.3	33.2	16.1	17.5	36.5	38.9	48.9	41.4
1968	129.2	57.1	66.7	78.1	40.6	54.4	45.9	48.4	46.0	43.0	31.3	38.9	56.8
1969	38.9	35.2	37.6	61.6	40.2	27.8	27.0	25.0	20.1	27.9	26.8	20.7	33.0
1970	30.7	30.3	34.3	51.3	44.3	30.7	29.0	32.1	43.7	52.4	61.2	86.5	44.5
1971	130.5	236.2	205.0	63.3	117.4	58.6	57.4	69.1	58.2				
Mean Monthly Flow	61.8	58.8	52.1	64.3	47.0	37.0	42.2	35.2	32.7	38.9	41.1	47.5	42.5
	(Study on a Potential Water Source Cisadane River, JM Montyomery, 1977)										Cisadane River		
	(Serpong Observation station. 1074 km, Sogreah/Coyne & Billier, 1979)												
Mean Monthly Discharge	120	120	120	124	116	80.6	67.1	62.2	68.3	90.3	115	73.7	97.9
											(Cisadane River)		
	(Cidurian River, Kopomaja 304 km3)												
Mean Monthly Discharge	20.0	20.6	31.4	31.9	27.5	32.7	26.0	18.6	15.3	16.0	15.5	18.0	22.8
	(Coyne Et Bellier, 1979)												

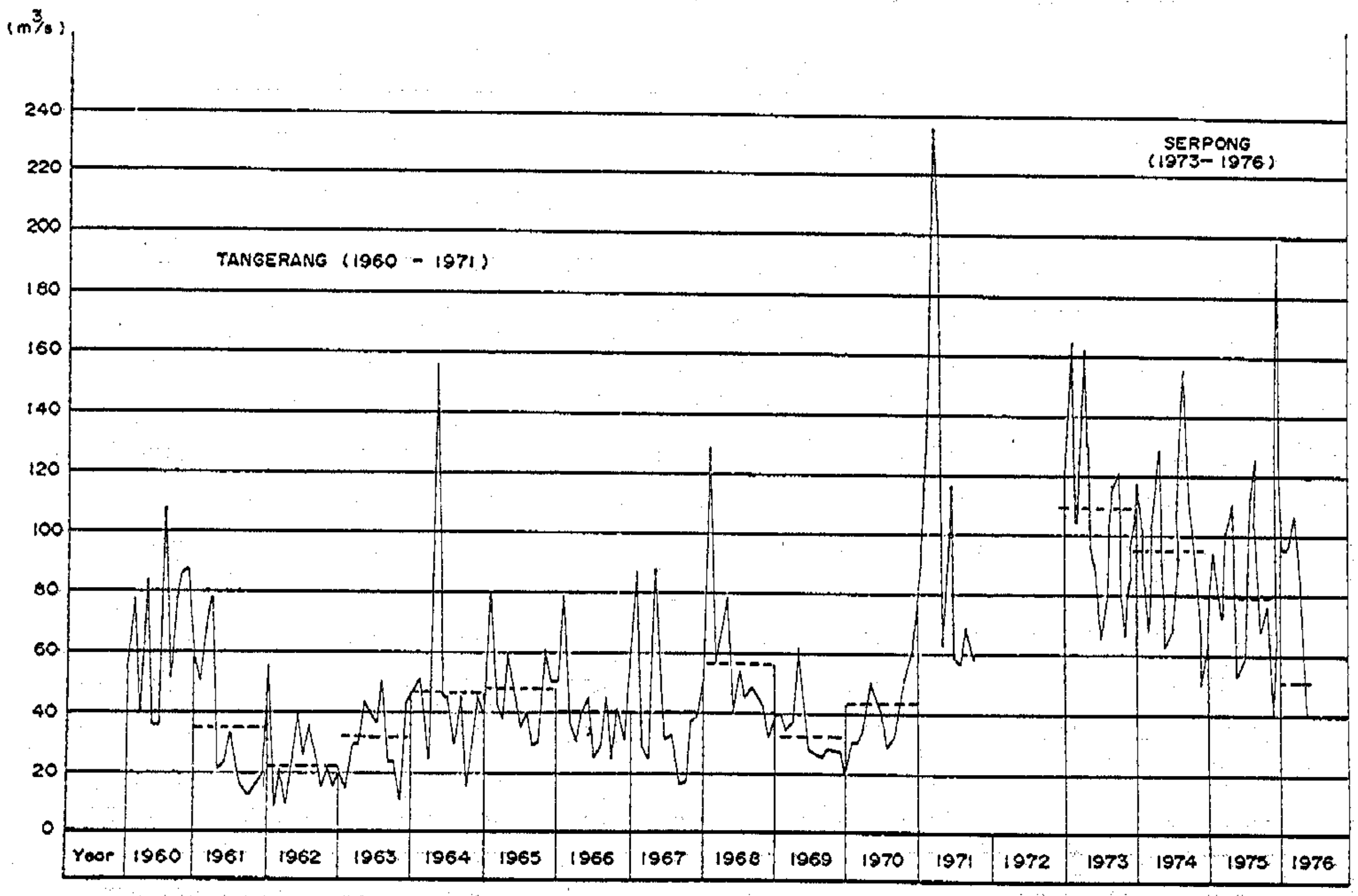


FIG. 3.3 DISCHARGE HYDROGRAPH OF CISADANE RIVER AT TANGERANG (1960–1971) AND SERPONG (1973 – 1976)

(DATA, DPMA BANDUNG)

3.3 Water Resources Development Planning

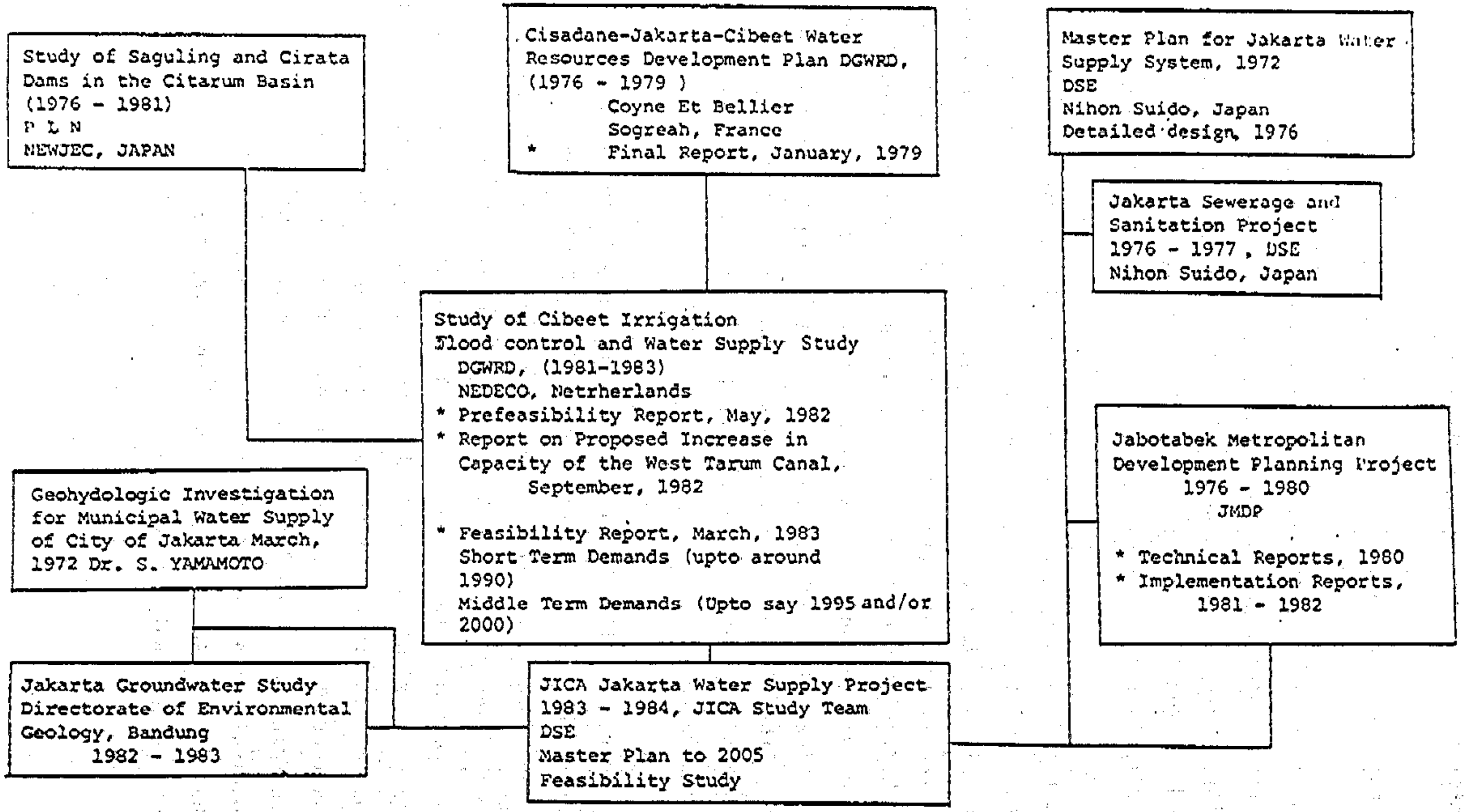
1) Situation of Water Resources Development Studies

In an effort to seek available water resources for Jakarta Metropolis, various water resources development studies for urban water supply and city development planning have been carried out by the Government Agencies and International Consultants. The relation between the preceding major studies and the present JICA study is schematically shown in Fig. 3.4 .

At the first stage, a broad outline of the future water resources development in this region between the Cisadane and the Cibeet rivers was proposed in the CJC Master Plan, 1976 - 1979 by Coyne & Bellier and Sogreah. This plan put a particularly strong emphasis on the development of half of the eastern region involving the construction of Pangkalan reservoir on the Cibeet river as the first priority due to possible advantages from both economic and social points of view. On the other hand, the Citarum river was considered merely as a supplementary source in this comprehensive plan. For reference, this development plan is illustrated in Fig. 3.5.

However, attention has recently been drawn to the priority of the Citarum by the Citarum River Basin Study, 1976 - 1981 (NEWJEC) which stressed the necessity of the Citarum water resources and hydro-electric power development including the construction of Suguling and Citra dams as a more advantageous plan than the one in the CJC Master Plan. In response to this proposal, decision was made by the Government to postpone the further study of the foregoing plan, and the investigation was conducted to assess how and until when the resources of Citrum could further be exploited. This assessment by NEDECO has brought a conclusion that the resources in this basin would be enough to sustain the required supply to Jakarta Metropolis at least until the end of 1955 and probably up to 2000.

Fig. 3.4 THE REVIEW OF WATER RESOURCES STUDY CONCERNING JAKARTA WATER SUPPLY



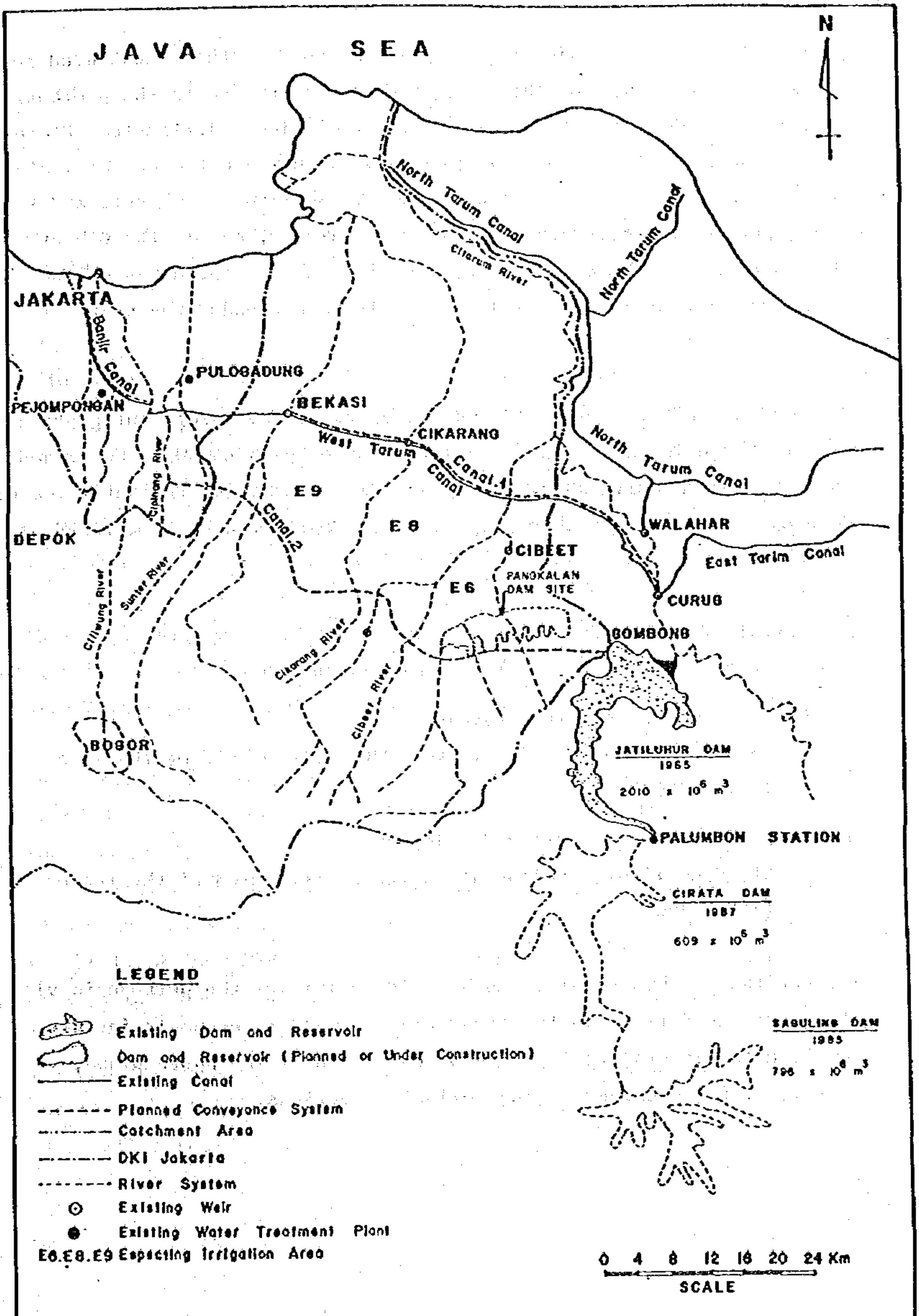


Fig. 3.5 GENERAL PROJECT LOCATION MAP OF THE CJC EASTERN HALF AREA

Besides these large-scale programs, a plan to meet the urgent need for the increasing demand of the Metropolis was discussed in the prefeasibility report, 1981 by NEDECO for the Study of Cibeet Irrigation, Flood Control Supply, 1981 - 1983. It proposed to increase the capacity of the existing West Tarum Canal being fed by Jatiluhur reservoir and three local rivers it intercepts on its way to Jakarta, namely the Cibeet, the Cikarang and the Bekasi. The adoption of this plan was decided by the Government in June of 1982, and it is now under the stage of the detailed design.

Meanwhile, the present JICA study is aimed at reviewing, integrating all these studies and constructing the master plan to suit the present conditions of Jakarta water supply system. Concerning the water resources development related to this purpose, the program can be summarized as follows:

1. Urgent water resources development
   - Enlargement of the West Tarum Canal (1987 - 1990)

2. Mid-term water resources development
   - Construction of Canal 1 in the CJC eastern half of the area (1991 - 2000)

3. Long-term water resources development
   - Cisadane river development in the western area of the region (after 2001)

The outline of this program can be said to fit for the purpose in view of natural conditions in the study area as well as economic factors involved in the project implementation. Each of the above plans, therefore, is described in the following sections.

2) Urgent Water Resources Development
   - Enlargement of West Tarum Canal

The West Tarum Canal flows westward from Curug on the Citarum river to the Ciliwung river in Jakarta with a total channel length of 68 km. It intercepts the rivers of Cibeet, Cikarung and Bekasi on its way to Jakarta.

The Canal commenced service in 1968. It is the only existing system with the possibility of feeding additional raw water to the Metropolis from the remote area, and NEDECO proposed in 1981 to enlarge the existing canal for the purpose of meeting the short term needs of the city, since all other alternative programs took time for the acquisition of land and the construction of a new conveyance system. Although Jatiluhur Authority, which is one of the main contributors to this Canal, had commited to providing Jakarta with water in a volume of 10 m^3/sec through this Canal, the survey by NEDECO in 1982 has proved that the Canal cannot convey more than 6 m^3/sec of water due to the size of one of its final section between the Bekasi and the Cipinang.

Under such circumstances, the enlargement of the West Tarum Canal was decided by the Government in June of 1982. According to this program, the Canal will feed both the Ciliwung and the Sunter rivers eventually to contribute to the operation of existing Pejompogan, Pulogadung plants and a new treatment plant to be completed in 1987 as well as to the flushing requirements of central Jakarta up to 5 m^3/sec at the exit of Ciliwung tunnel.

The enhance capacity of the canal is determined to be 19 m^3/sec at the intake point of a proposed new treatment plant, and is planned to be allocated for the following uses:

(1)	Pejompongan Plant	:	5.6 x 1.1* = 6.2 m^3/sec
(2)	Pulogadung Plant	:	4.0 x 1.1* = 4.4 m^3/sec
(3)	Immediate Program	:	2.0 x 1.1* = 2.2 m^3/sec
(4)	Flushing Use	:	5.0 m^3/sec
(5)	Loss in the Canal	:	1.2 m^3/sec
	T O T A L	:	19.0 m^3/sec

(*10% to allow for conveyance losses)

The detailed design is now under progress, and the target of the project completion is determined at the end of 1968. Upon completion, the enlarged canal is expected to provide additional raw water to not only the existing water treatment plants with their capacities enhanced but the immediate program to meet the demand up to the year of 1990 as well.

For reference, the present conditions and the enlargement plan of the Canal are shown in Table 3.7 . The flow pattern for the enlarged canal is planned, as shown in Table 3.8 .

TABLE 3.7 ENLARGEMENT OF WEST TARUM CANAL CAPACITIES

No.	Design Section		Length (Km)	Design Capacity (M3/s)	Existing* Capacity 1982 (M3/s)	Enlargement Target Capacity (M3/s)	Note
1	Curug To Cibeet	Ia	7.2	85	56	81	
		Ib	10.5	84	55	79	
		IIa	3.9	81	40	73	
		IIb	2.3	77	44	72	
2	Cibeet To Cikarang	III	2.5	80	48	80	
		IVa	4.2	66	41	56	
		IVb	2.4	57	41	54	
		IVc	6.2	49	33	49	
3	Cikarang To Bekasi	V	2.1	45	24	39	
		VIa	6.8	32	18	35	
		VIb	3.9	29	25	32	
		VIc	2.1	21	19	31	
4	Bekasi to Buaran	VIIa	8.5	14	5.8	19	
	Sunter	VIIb	1.6	14	5.8	19	
			1.9	14	5.8	12	
	Cipinang	VIIc	1.6	14	5.1	12	
	Ciliwung	Tunnel	1.2	10.8	7.2	11.7	

* Existing Capacity of WTC at full supply water level NEDECO, 1982 - 1983.

Table 3.8 Flow Pattern in the enlarged West Tarum Canal (m3/s)

N O D E	JANUARY I	JANUARY II	FEBRUARY I	FEBRUARY II	MARCH I	MARCH II	APRIL I	APRIL II	M A Y I	M A Y II	JUNE I	JUNE II	JULY I	JULY II	AUGUST I	AUGUST II	SEPTEMBER I	SEPTEMBER II	OCTOBER I	OCTOBER II	NOVEMBER I	NOVEMBER II	DECEMBER I	DECEMBER II	CRTC
TUNNEL	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	8.7	8.7	10.7	10.7	11.7	11.7	9.7	9.7	6.7	6.7	6.7	6.7	11.7
PINANG	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	8.7	8.7	10.7	10.7	11.7	11.7	9.7	9.7	6.7	6.7	6.7	6.7	11.7
SUNTER	6.8	6.8	6.8	6.8	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	8.7	8.7	10.7	10.7	11.7	11.7	9.7	9.7	6.7	6.7	6.7	6.7	11.7
BUARAN	14.4	14.5	14.4	14.5	14.2	14.2	14.1	14.1	14.1	14.1	14.1	14.1	16.1	16.1	18.1	18.2	19.1	19.1	17.1	17.1	14.1	14.1	14.1	14.1	19.1
CAKUNG	14.7	15.0	14.8	15.0	14.4	14.3	14.3	14.2	14.1	14.1	14.1	14.1	16.1	16.2	18.2	18.3	19.3	19.2	17.2	17.2	14.1	14.1	14.1	14.2	19.3
IRIG45	15.2	15.6	15.4	15.6	14.6	14.5	14.4	14.3	14.2	14.2	14.2	14.2	16.2	16.3	18.4	18.5	19.4	19.3	17.3	17.3	14.2	14.2	14.2	14.3	19.4
Bekasi	19.2	18.9	23.2	22.3	22.5	18.6	21.0	27.5	32.4	30.3	27.3	29.6	29.8	23.4	28.3	18.5	19.4	19.3	17.3	22.2	24.7	29.8	23.6	22.5	32.4
BEKASI	19.7	19.4	23.7	22.8	23.8	19.1	21.5	28.8	32.9	30.8	29.8	32.1	31.5	25.9	22.8	21.8	21.9	21.8	19.8	24.7	25.2	29.5	26.4	23.8	32.9
IRIG44	0.0	0.8	1.3	.4	2.9	0.0	0.0	3.6	14.7	12.6	28.7	23.8	26.8	26.4	17.8	13.2	18.1	18.0	12.8	17.7	11.6	13.9	12.9	9.7	26.8
IRIG43	.1	.1	1.4	.5	2.9	-.4	.4	5.8	13.8	12.9	28.9	23.1	26.8	28.4	17.8	13.2	18.2	18.1	13.2	18.1	11.9	16.1	13.1	10.8	26.8
IRIG40	1.4	.9	2.5	.9	3.3	2.9	4.7	9.3	18.2	16.3	23.9	25.3	26.6	28.3	17.1	13.3	18.3	18.1	15.9	22.3	15.6	18.9	15.5	12.2	26.6
IRIG35	2.2	1.4	3.6	2.1	4.4	3.5	4.8	12.8	21.8	18.3	25.9	27.6	28.9	21.5	17.3	15.5	18.5	18.3	16.8	22.5	17.8	21.1	17.4	12.9	28.9
IRIG34	5.3	2.5	6.6	4.1	10.1	8.8	18.3	21.3	29.9	26.2	31.4	32.9	32.6	22.6	17.4	13.6	18.6	22.3	19.9	29.2	25.3	29.3	23.7	17.3	32.9
Karang	8.6	4.8	18.8	7.8	23.3	19.3	17.5	29.7	45.3	40.8	39.2	48.8	39.9	28.5	19.4	15.6	18.6	38.6	28.1	37.3	32.4	42.1	35.8	26.3	45.3
KARANG	9.1	4.5	11.3	8.3	23.8	19.8	18.8	30.2	45.8	41.3	41.7	42.3	42.4	31.8	21.9	18.1	21.1	33.1	30.6	40.8	32.9	42.6	35.5	26.8	45.8
IRIG33	0.0	0.0	0.0	0.0	11.3	7.4	6.7	19.8	37.6	33.1	39.2	40.0	41.2	29.8	21.3	17.4	28.1	32.2	28.3	37.7	29.3	38.9	30.7	22.8	41.2
IRIG29	.7	.4	.4	.2	11.7	9.8	9.3	28.9	39.9	33.3	41.2	41.1	41.7	30.2	21.6	17.7	28.3	32.6	31.8	40.5	31.7	40.4	32.6	23.6	41.7
IRIG26	2.5	1.5	2.1	1.6	13.8	13.6	12.3	26.8	43.3	40.8	43.4	44.3	44.1	31.2	21.8	17.9	28.6	32.8	34.3	43.7	36.8	44.6	36.7	26.8	45.4
IRIG23	3.2	1.6	2.3	1.7	15.1	15.7	14.8	27.7	47.2	41.8	46.3	44.9	44.5	31.6	22.0	18.1	28.9	33.1	36.3	46.8	38.4	46.3	38.4	27.3	47.2
CIBEET	9.4	6.3	11.8	7.1	21.4	27.7	34.4	44.8	68.8	63.3	63.7	68.8	53.2	37.1	24.3	18.3	21.8	33.3	45.3	64.1	54.4	64.3	52.2	41.8	68.8
IRIG21	0.0	0.0	0.0	0.0	.7	6.6	12.0	21.3	49.3	44.8	58.6	53.8	58.7	34.6	22.6	16.6	19.5	33.8	43.4	62.3	43.8	53.7	40.4	29.3	62.3
IRIG19	.8	0.8	.2	0.8	3.2	9.1	13.8	23.3	51.3	46.9	59.3	56.8	51.8	34.8	22.7	16.7	19.7	36.6	46.2	65.1	45.6	55.9	42.3	38.7	65.1
IRIG16	1.7	.5	.7	.2	3.3	12.1	16.9	25.8	54.1	49.6	61.9	57.3	51.4	35.1	23.8	16.9	19.9	36.9	49.5	68.3	48.5	57.8	44.5	32.5	68.3
IRIG03	2.5	.6	.9	.2	5.4	14.5	18.9	27.9	56.7	52.1	63.7	58.3	52.4	36.8	23.6	17.4	20.4	39.8	52.6	71.9	50.9	68.6	46.8	34.4	71.9
CURUG	2.9	.7	1.8	.3	6.4	13.7	28.8	29.8	58.1	53.5	64.8	59.4	53.2	36.6	24.1	17.8	28.8	41.2	54.2	73.7	52.2	62.1	48.1	35.4	73.7

Notes : - CRTC : largest value (critical capacity) for the particular reach of the Canal occurring in a particular period

- total irrigated area 67,400 ha. NEDECO, 1983

3) Mid-Term Water Resources Development
- Construction of Canal 1B

After 1990 following the urgent development plan, an additional supply of water is required to meet the demand for drinking and flushing in Jakarta Metropolis. To cope with the situation, a program for the mid-term water resources development has been under way. Among various plans, the most acceptable one is the development of the Citarum river in the CJC eastern half of the region involving the construction of new damsites at Saguling and Cirata. The major source for this development depends upon the capacity of Jatiluhur reservoir located upstream to the south.

According to the feasibility report by NEWJEC, this program includes the construction of Saguling dam in 1985 and Cirata in 1987 along the Citarum and a new conveyance system of a canal to transport raw water of this river. Concerning the construction of the canal, alternatives were closely studied by NEDECO, and eventually Canal 1B/North Bank Route, which closely runs in parallel with the existing West Tarum Canal, was recommended. This proposal, was reportedly accepted during the interdepartment meeting in January, 1983 for the construction by the end of 1990 with an expected capacity of 30 m^3/sec to satisfy the demand for 1991 to 2000. However, the capacity of Canal 1B will be subject to the results of the study by the present JICA team.

As previously reported in Sec. 3-2-1, the Citarum river is in full use for various uses (for the details, refer to Attachment 4), and the relation between available flow and the multi-purpose usage including the supply to Jakarta water system is roughly outlined as follows.

Time Horizon	Total Demand	Average Flow (million m^3/year)		
	(million m^3/year)	NEWJEC (1981)	NEDECO (1982)	POJ (1983)
1990	4,000	6,100	5,400	5,708
1995	5,200	6,100	5,400	5,708
2000	5,500	6,100	5,400	5,708

The balance of water between supply and demand shows the sensitivity of selection of a time horizon. The Citraum river can supply the demand of year 2000. However, in the case of the year 2000 demand (5,500 million m^3/year), it is already very close to the estimated river discharge at present (5,708 million m^3/year), which will probably cause some water shortage during the drought period. For the control of supply, therefore, it will be necessary to establish a supply priority rule, based on the storage volume of the reservoir. (Refer to Attachment).

The construction of a new canal involves an important aspect in connection with the water distribution in Jakarta city. Since water pollution of the local rivers in and around Jakarta is in progress, Jatiluhur water through Canal 1B with a good quality should be allocated chiefly for drinking use through the analysis of the existing facilities and the network of conveyance systems. After Canal 1B becomes operational, the following arrangement is recommendable:

Canal 1B	———	Pulogadung plant and proposed new plants
Enlarged West Tarum Canal	———	Pejompongan plant

By this arrangement, a part of the supply from the West Tarum Canal can be allocated to flushing use. (Refer to Attachment .) This change of function of the canals necessitates the alteration of the flow pattern of the West Tarum Canal, as shown in Table 3.9. (Refer to the initial flow pattern in Table 3.8.)

Table 3.9 Flow Pattern the enlarged West Tarum Canal after change of function with the Canal 1,

N O D E	JANUARY		FEBRUARY		MARCH		APRIL		M A Y		JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		CRTC
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	
TUNNEL	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	8.7	8.7	10.7	10.7	11.7	11.7	9.7	9.7	6.7	6.7	6.7	6.7	11.7
PIHANG	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	8.7	8.7	10.7	10.7	11.7	11.7	9.7	9.7	6.7	6.7	6.7	6.7	11.7
SUNTER	6.8	6.8	6.8	6.8	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	8.7	8.7	10.7	10.7	11.7	11.7	9.7	9.7	6.7	6.7	6.7	6.7	11.7
DUARAN	11.0	11.2	11.1	11.2	10.9	10.8	12.8	12.8	13.8	13.8	14.0	14.0	16.0	16.0	18.8	18.9	19.8	19.8	17.8	17.8	13.8	13.8	13.8	13.8	19.8
CAKUNG	11.3	11.6	11.5	11.6	11.1	10.9	12.9	12.9	13.8	13.8	14.0	14.0	16.9	16.9	19.0	19.0	20.0	19.9	17.9	17.9	13.8	13.6	13.8	13.9	20.0
IRIG45	11.7	12.2	11.9	12.2	11.3	11.1	13.1	13.0	13.9	13.9	14.9	14.9	17.0	17.0	19.1	19.4	20.1	20.1	18.0	[illegible]	13.9	13.5	13.9	[illegible]	[illegible]
Bekasi	13.7	13.4	19.8	18.9	19.2	13.2	19.7	26.7	32.1	30.0	28.0	30.3	29.7	24.1	21.0	19.2	20.1	20.1	18.0	22.9	24.4	28.7	25.3	22.2	32.1
BEKASI	16.2	15.9	20.3	19.4	19.7	15.7	20.2	26.7	32.6	30.5	30.5	32.8	32.2	26.6	23.5	21.7	22.6	22.6	20.5	25.4	24.9	29.2	25.8	22.7	32.8
IRIG44	8.8	8.8	8.8	8.8	8.8	8.0	0.0	4.2	14.4	12.3	21.4	23.7	26.7	21.1	17.7	15.9	18.8	18.7	13.3	18.4	11.3	13.6	12.6	9.4	26.7
IRIG43	.1	.1	.1	.8	0.0	.4	.4	4.3	14.7	12.6	21.7	23.8	26.7	21.1	17.7	15.9	18.9	18.0	13.9	18.0	11.6	15.8	12.8	9.7	26.7
IRIG40	1.4	.9	1.2	.5	.3	2.9	4.7	8.0	17.9	16.0	24.7	26.0	27.3	21.2	17.9	16.1	19.8	18.9	16.6	23.8	15.3	18.6	15.2	11.9	27.3
IRIG35	2.2	1.4	2.4	1.7	1.3	3.5	4.8	10.7	20.7	18.0	26.6	28.3	29.6	22.2	18.0	16.2	19.2	19.8	16.7	23.2	17.5	20.8	17.1	12.6	29.6
IRIG34	5.3	2.6	3.4	3.7	7.1	8.8	10.5	20.2	29.6	25.9	32.2	33.6	33.4	23.3	18.1	16.3	19.3	23.0	20.6	30.0	25.2	29.0	23.4	16.9	33.6
Karang	8.6	4.8	9.5	7.4	20.3	19.3	17.5	20.4	45.6	40.5	39.9	40.7	40.6	29.3	20.2	16.3	19.3	31.3	20.9	38.2	32.1	41.8	34.7	26.0	45.0
KARANG	9.1	4.5	10.0	7.9	20.0	19.0	18.0	20.9	45.5	41.0	42.4	43.2	43.1	31.6	22.7	18.8	21.8	33.8	31.4	40.7	32.6	42.3	35.2	26.5	45.5
IRIG33	8.8	8.8	8.8	8.8	8.3	7.4	6.7	17.6	37.3	32.0	39.9	40.7	41.9	30.3	22.8	18.1	20.0	32.9	29.1	38.4	29.0	38.6	30.4	21.7	41.9
IRIG29	.8	.5	.4	.2	8.7	9.9	9.3	19.3	39.6	35.8	41.9	41.9	42.4	31.0	22.3	18.5	21.2	33.4	31.8	41.2	31.4	40.3	32.3	23.3	42.4
IRIG26	2.5	1.5	2.1	1.6	9.9	13.6	12.5	24.7	45.8	39.7	46.2	45.3	44.8	32.0	22.5	18.6	21.3	33.6	35.8	44.5	36.5	44.3	36.4	25.7	46.2
IRIG23	3.3	1.6	2.4	1.7	12.1	15.7	14.8	26.4	46.9	41.5	47.8	45.7	45.2	32.3	22.8	18.8	21.6	35.8	37.3	46.8	38.1	46.2	38.1	27.0	47.8
CIBEET	9.4	6.4	11.1	7.2	18.4	27.3	34.3	42.7	67.7	63.2	64.4	61.6	53.9	37.8	25.8	19.8	21.7	36.9	46.8	64.9	54.1	64.8	51.9	48.7	67.7
IRIG21	8.8	8.8	8.8	8.8	8.8	6.6	12.8	28.2	49.8	44.3	59.4	56.5	51.5	35.3	23.3	17.3	20.3	34.6	44.2	63.8	43.5	53.4	40.1	28.9	63.8
IRIG19	.8	8.8	.2	8.8	2.5	9.2	13.8	22.2	51.2	46.6	60.2	56.8	51.7	35.5	23.5	17.4	20.4	37.4	47.8	65.9	45.3	55.6	42.8	30.4	65.9
IRIG16	1.7	.5	.7	.2	2.6	12.1	17.8	24.4	53.8	49.3	62.6	58.1	52.1	35.9	23.7	17.6	20.6	37.7	50.2	69.2	48.2	57.5	44.2	32.2	69.2
IRIG05	2.6	.6	.9	.3	4.8	14.6	19.8	26.6	56.4	51.8	64.4	59.3	53.2	36.7	24.4	18.2	21.2	40.5	53.3	72.7	50.6	60.3	46.6	34.1	72.7
CURUG	3.8	.7	1.1	.3	5.8	15.8	20.1	27.7	57.7	53.2	65.3	60.1	54.0	37.3	24.9	18.6	21.6	42.8	55.8	74.5	51.9	61.8	47.0	35.1	74.5

4) Long-Term Water Resources Development
-Cisadane River Development

The development of the new conveyance system, namely the enlargement of the West Tarum Canal and Canal 1 as decided in the water resources development plan, would satisfy urban water requirements up to the year of 2000. After this, another water source together with a new conveyance system is necessary for ever-increasing requirement.

During the years from 1963 to 1977, the hydrogeologic study was carried out in the Cisadane river basin to determine the feasibility of diverting supplies to Jakarta city. This study found the demands from the irrigation projects of Prosida and Empang were quite large and that during the dry season the discharge of the Cisadane was not enough to satisfy even these irrigation requirements (Refer to Sec 3.3 for the river discharge.) It recommended, therefore, to construct a new impoundment dam to enable additional water to be diverted to Jakarta.

A much more accurate picture of the future balance of water availability against water demands was completed by the Cisadane-Jakarta-Cibeet Water Resources Development Study in 1979 (Coyne & Bellier and Sogreah).
In this study, the possibility of constructing dams at Parungbadak and Sodong on the upper reaches of the Cisadane river was investigated for the Jakarta urban water supply. The expected maximum capacities of Parungbadak and Sodong dams are 950 million m^3 and 600 million m^3, respectively. (Refer to Fig. 3.6 for the layout of the development plan.)

These basic storage capacities were aimed at supplying urban water to Jakarta through a new conveyance system of Canal 3 in an amount of 10 m^3/sec to 20 m^3/sec as well as serving the other requirements for irrigation and flushing which are expected to reach 54 m^3/sec in the year of 2000, based on the survey of J.M. Montgomery in 1977 as follows.

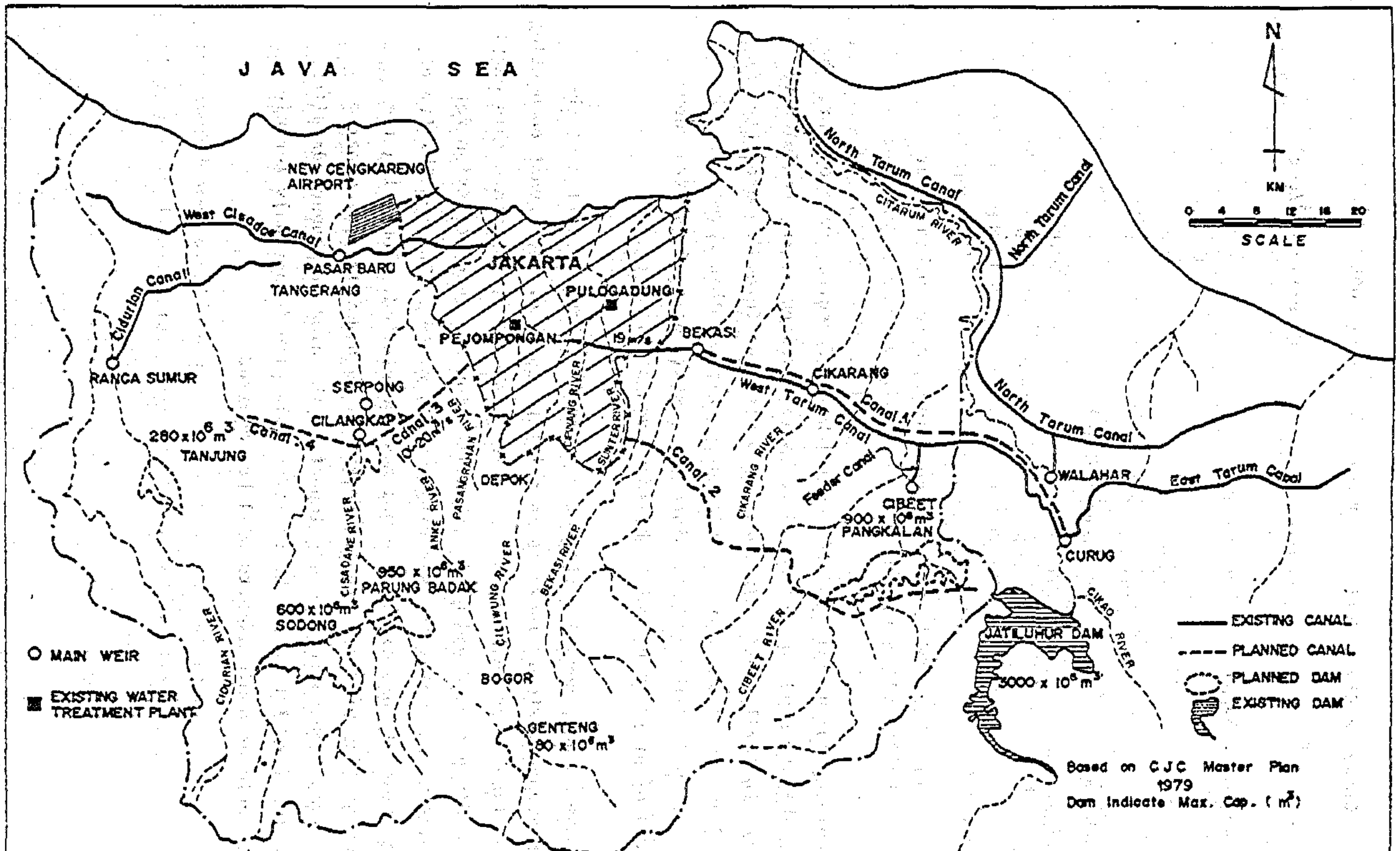


Fig. 3.6 WATER RESOURCES DEVELOPMENT PLAN

Cisadane River Estimated Demands for Year 2000

Purpose	Location	Quantity (m^3/sec)
Urban Water Supply	Tangerang	3.7
	Serpong	0.3
	Bogor	0.6
	Others	0.6
Flushing	Mookervaat Canal	1.8
Irrigation	Prosida	40.0
	Empang	7.0
T O T A L		54.0

Note: The above Table includes no allowance for urban water supply to Jakarta.

According to the Directorate General Water Resources Development, the feasibility study of the Cisadane basin development is scheduled to start in April, 1984. In connection with the foregoing projects, it is deemed necessary to complete the program of this development by the end of 2000 at the latest, since the western part of Jakarta shows signs of progressing water shortage even at present.

In this study, consideration must be given to the selection of the conveyance system. There is an existing canal of Mookervaat connecting the Cisadane at Pusar Baru weir with northwest of Jakarta. This canal is badly polluted and needs rehabilitation and reconstruction for conveying raw water for the urban supply system. The feasibility of the reuse of this existing canal must be studied, along with the construction of a new canal. Moreover, this development program involves much socio-economic impact on the area of planned damsites, and the formulation of the most feasible plan in not only technical but socio-economic aspects will be required.

4. GROUNDWATER CONDITION IN JAKARTA CITY

4.1 Groundwater Development in Jakarta

Groundwater is still an important source for domestic and industrial uses in Jakarta. However, groundwater resources problems such as declining of groundwater level, sea water intrusion and potential land subsidence have been raised mainly in the northern coastal area of densely populated area. These problems have been suggested by many hydrogeologists who studied groundwater conditions in Jakarta from 1972 till today. In response to these warnings, the control of groundwater development in the city was enacted in 1975.

In addition, the municipality enforced the installation of water meters at 2,208 production wells in March, 1983. The groundwater consumers are charged on the basis of the quantity they extract. Water meter readings are carried out by PDAM once a month. For a new groundwater development at present, the owner needs a permission from PDAM before drilling of the well. The Directorate of Environmental Geology, Bandung, assists the hydrogeological evaluation of the well, and then a water meter will be installed by PDAM.

Fig. 4.1 illustrates registered groundwater production in five districts of Jakarta city based on the PDAM data in August, 1983. The total groundwater production in 1982 was 26.2 million m^3/year from 2,171 registered wells as shown in Fig. 4.2 . The average production rate of the well ranges from 22 to 53 m^3/day/well, and average production rate of the area, from 46 to 266 m^3/day/ km^2. These figures suggest hydrogeologically low potential aquifer conditions in Jakarta city together with low transmissibility ranging from 18.7 m^2/day to 250 m^2/day. (Refer to Table 4.1 .)

The groundwater problem districts located in the northern part of the City, namely Jakarta Utara, Jakarta Barat and Jakarta Pusat, generally

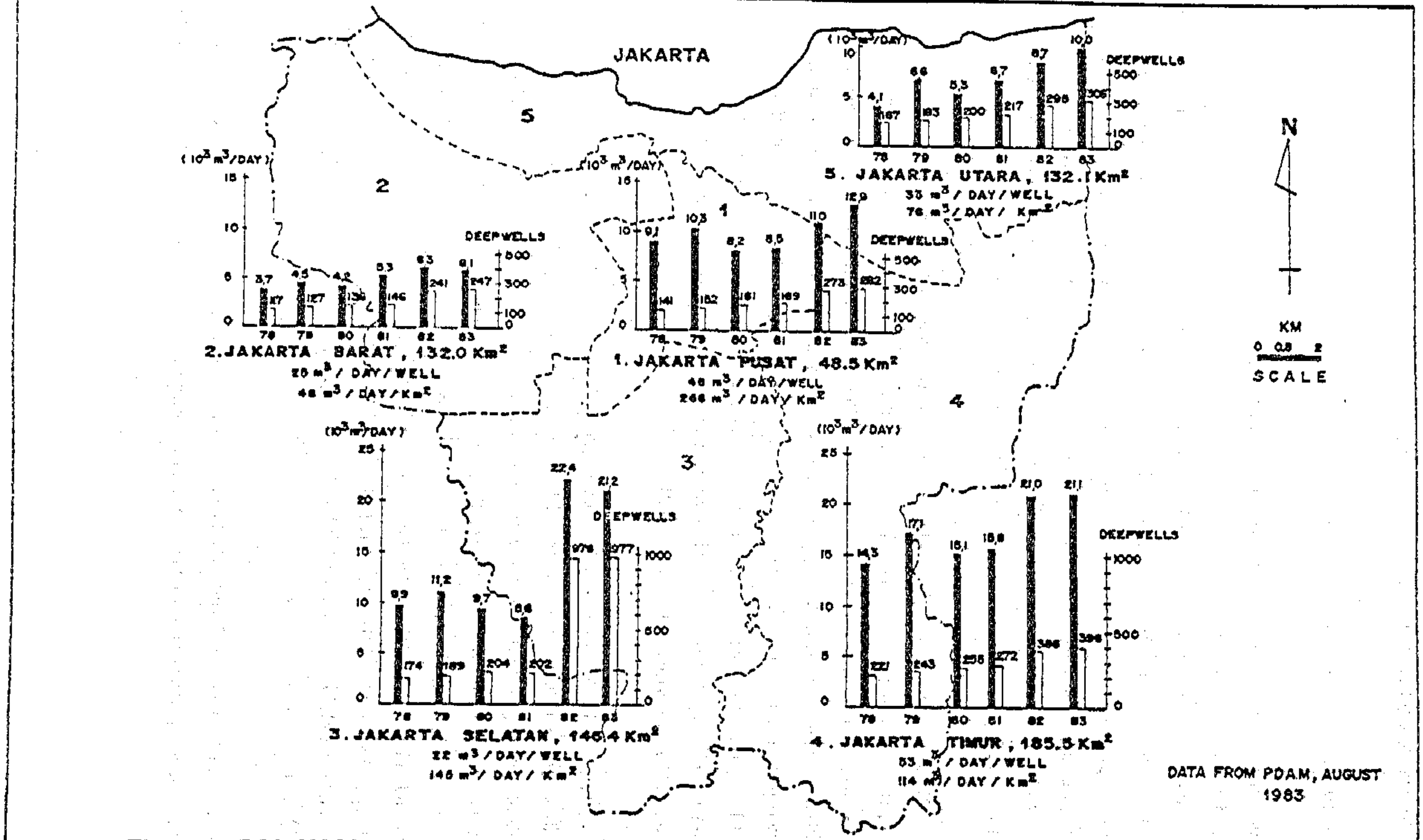


Fig. 4.1 REGISTERED GROUNDWATER PRODUCTION IN JAKARTA CITY, 1978 - 1983

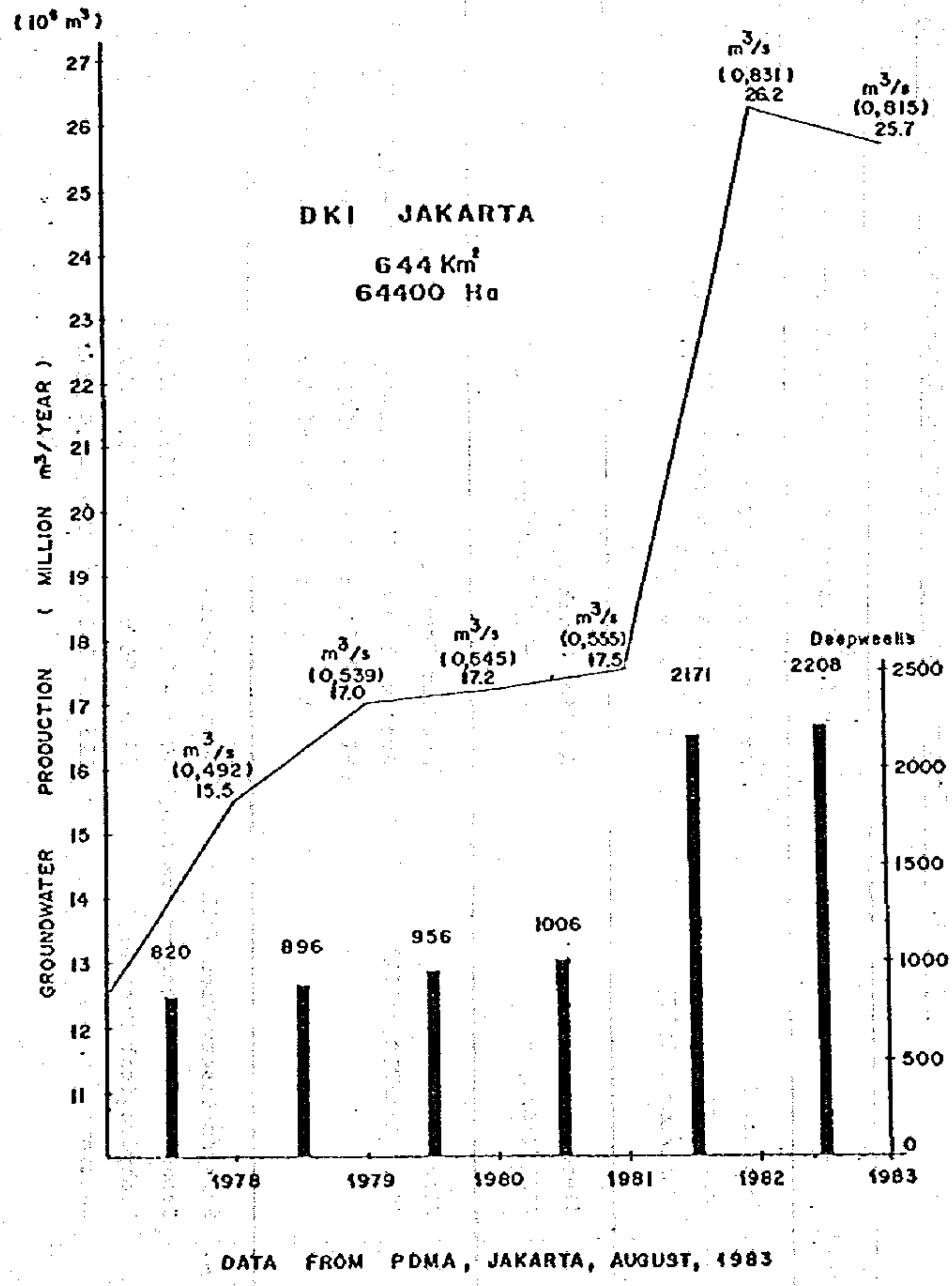


Fig. 4.2 REGISTERED GROUNDWATER PRODUCTION IN JAKARTA CITY

1978 - 1983

Table 4.1 Transmissibility and Storage Coefficient in Jakarta City

No.	Area and Data Source	Aquifer / Transmissibility / Storage Coefficient
1.	Well No. 1 Tangerang (Montgomer, 1977)	Aquifer Depth ; 150 m T : 2.3×10^{-3} m2/sec = 200 m2/day S : 4×10^{-3}
2.	Klender, Jakarta (SGI/IKSAN)	Aquifer Depth ; ? T : 3×10^{-3} m2/sec = 250 m2/day
3.	Ciracas Well (Dr. YAMAMOTO, 1972)	Aquifer Depth ; Approx. 30 m ; T = 170 m2/day S = 0.1 - 0.2 80 m - 120 m ; T = 130 m2/day S = 2×10^{-4} 150 m ; T = 150 m2.day S = 2×10^{-4}
4.	Semayan Observation Well Groundwater monitoring station, Geohydrogical Section Section	Aquifer Depth ; 18 m - 36 m ; T = 103.5 m2/day 84 m - 96 m ; T = 18.7 m2/day 126 m - 150 m ; T = 141.9 m2/day

suffer low production rate, compared with the southern districts of Jakarta Timur and Jakarta Selatan. The average production rate of unit area in the latter districts ranges from 114 to 145 m^3/day/km^2. Among the northern districts, Jakarta Pusat tends to keep high groundwater table ranging from 0 to -5 m in elevation, and although the front line of sea water intrusion is approaching there, it still can yield a higher production rate of 266 m^3/day/km^2 and 46 m^3/day/well. On the other hand, groundwater potentiality of the eastern parts of Jakarta, divided by the Ciliwung river, is higher than that of the western parts. The former ranges from 33 to 53 m^3/day/well against 22 to 25 m^3/day/well of the latter.

4.2 Future Groundwater Conditions in Jakarta

The unserved piped water population must depend on groundwater. Its demand was analyzed by the present JICA Study Team in 1983, as shown in Table 4.2 .

Its demand projection is categorized into two cases, Case 1 and Case 2. The former is based on the same unit consumption rate of piped-water population for various income groups.

Group I & II	20 lpcd
Group III & IV	150 lpcd
Group V	250 lpcd

However, in view of various factors such as the living conditions of unpiped-popualtion areas and the actual situation of groundwater development, the unit rates could be reduced as listed below, and these figures are adopted for Case 2 projection.

Group I & II	20 lpcd
Group III & IV	60 lpcd
Group V	150 lpcd

The division of three physical zones in the table is based on the JMDP Master Plan as shown in Fig. 4.3 . The groundwater requirement of each zone for Case 2 can be calculated as follows.

a. Physical Zone I

$$\frac{\text{Groundwater Demand } (m^3/sec)}{\text{Area of Zone I } (ha)} = \frac{1.4}{12,889} = 0.11\ \ell/sec/ha$$

$$= 950\ m^3/day/km^2$$

Table 4.2 Jakarta Groundwater Demand, 1980-2005

(in units of m^3/sec)

	1980	1985	1990	1995	2000	2005
A. Case 1						
a. Zone I	1.6	1.7	1.6	1.3	0.9	0.5
b. Zone II	1.7	2.2	2.4	2.6	2.6	2.5
c. Zone III	2.1	3.1	3.9	3.9	4.3	4.0
Total	5.4	7.0	7.9	7.8	7.8	7.0
B. Case 2						
a. Zone I	1.3	1.4	1.4	1.0	0.7	0.3
b. Zone II	1.4	1.7	1.8	2.0	2.0	1.9
c. Zone III	1.4	2.1	2.5	2.5	2.7	2.4
Total	4.1	5.2	5.7	5.5	5.4	4.6

*JICA Study, 1983

Zone I = 12,889 ha
Zone II = 19,334 ha
Zone III = 32,223 ha

b. Physical Zone II

$$\frac{\text{Groundwater Demand } (m^3/sec)}{\text{Area of Zone II (ha)}} = \frac{2.0}{19,334} = 0.10 \text{ l/sec/ha}$$

$$= 864 \ m^3/day/km^2$$

c. Physical Zone III

$$\frac{\text{Groundwater Demand } (m^3/sec)}{\text{Area of Zone III}} = \frac{2.7}{32,223} = 0.08 \text{ l/sec/ha}$$

$$= 691 \ m^3/day/km^2$$

Note: The demand in each Zone is the maximum one in the projection for Case 2 up to 2005 (Refer to Table 4.2).

The groundwater development to meet the above requirements can be estimated by the existing data of production wells as listed in Table 4.3 where the cumulative mean specific capacity ranges from 466 m^3/day/m to 675 m^3/day/m. Accordingly, a well in 1 km^2 penetrating five aquifers can satisfy the requirement in each zone at a drawdown of 2 to 3 m, although the actual drawdown of the existing wells tends to be around 5 m with production capacity of 200 m^3/day to 300 m^3/day probably due to the distribution density and/or penetration ratio of aquifers.

Meanwhile, Fug-4.3 illustrates the groundwater conservation map prepared by the Directorate of Environmental Geology in 1983. Zones I and II are designated to the groundwater conservation area since these zones have been greatly affected by the groundwater problems previously mentioned. In Zone III, the extraction of groundwater as calculated in the above paragraph can be allowed, but in the groundwater conservation areas, further development is not encouraged. It is recommended, therefore, that comprehensive systematic groundwater studies in Jakarta city including the analysis of the above groundwater problems, mechanism of groundwater recharge, sustainable yield and conservation of groundwater be made as early as possible.

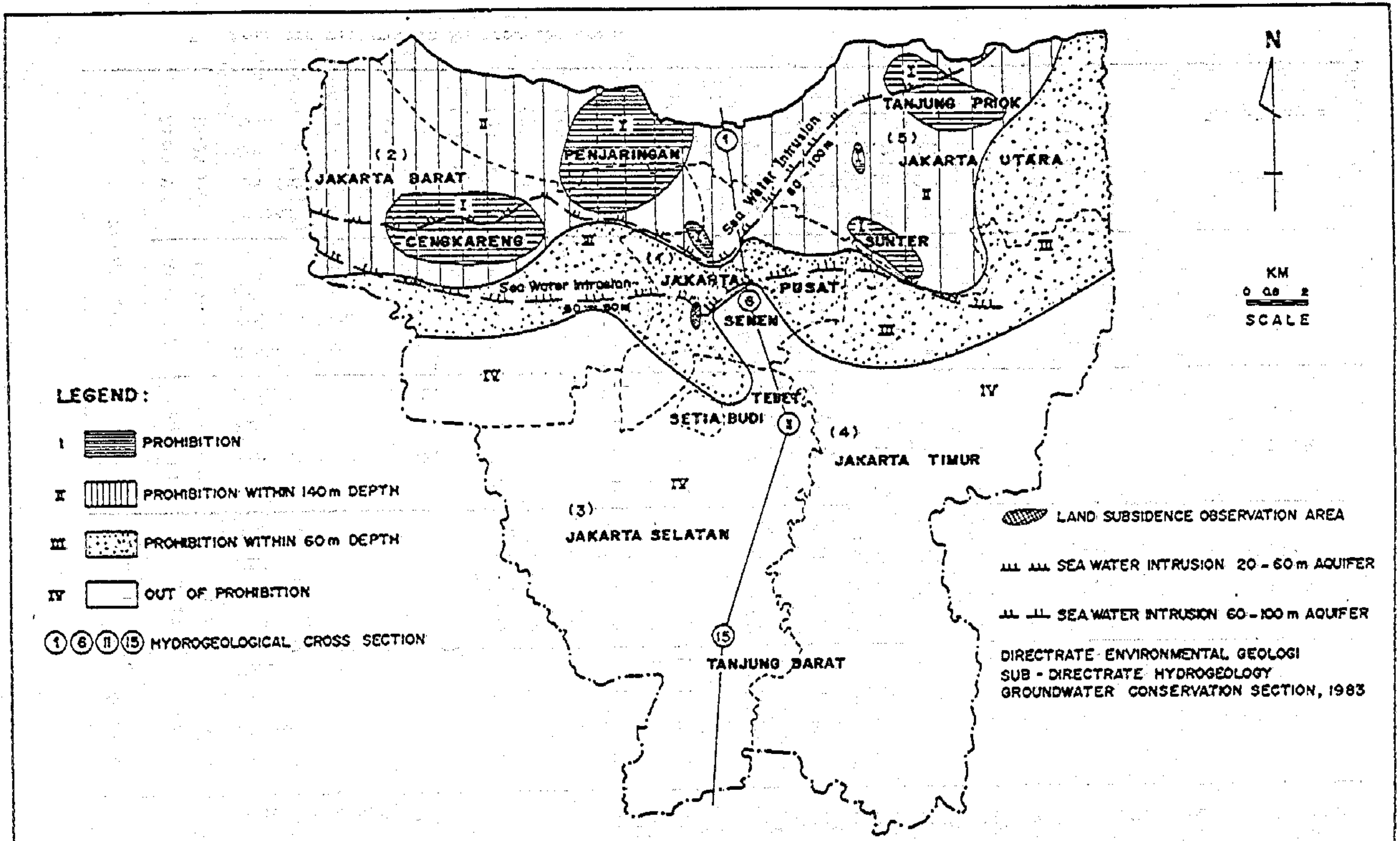


Fig. 4.3 PERMISSION OF GROUNDWATER DEVELOPMENT IN JAKARTA CITY

Table 4.3 Statistic Specifiec Capacity (m3/hour/m) in Jakarta City

Zone	Area	Aquifer (Depth in Meter)	I 20-40m	I 60m	II 80m	II 100m	120m	III 140m	160m	180m	IV 200m	220m	V 240m+	Cumulative Mean Specific Capacity
Zone I	Area I 0 - 5 Km	Number	0	0	2	4	7	1	2	4	7	2	4	
		Max (m3/h/m)			5.1	8.0	2.7	2.6	0.9	2.4	1.1	5.2	5.0	21.4 m3/h/m
		Min			2.7	0.1	0.8	-	0.5	1.0	0.7	1.1	1.9	513 m3/day/m
		Mean			3.9	2.4	1.7	2.6	0.7	1.7	2.0	3.2	3.2	
Zone II	Area II 5 - 10 Km	Number	0	2	6	4	1	1	5	3	1	0	3	
		Max (m3/h/m)		2.3	4.8	3.2	2.0	4.3	4.8	1.4	2.2		2.7	19.4 m3/h/m
		Min		0.7	0.4	0.8	-	-	0.7	0.8	-		0.8	466 m3/day/m
		Mean		1.5	1.9	2.3	2.0	4.3	2.3	1.1	2.2		1.8	
Zone III	Area III 10-15 Km	Number	1	0	1	3	3	1	3	0	1	0	0	
		Max (m3/h/m)	2.3		7.5	6.7	7.5	2.9	3.6		2.2			28.0 m3/h/m
		Min	-	-	-	4.5	1.2	-	0.7		-			675 m3/day/m
		Mean	2.3		7.5	5.5	5.3	2.9	2.3		2.2			
	Area IV 15-20 Km	Number	0	1	1	0	2	1	0	0	0	0	0	Few Data
		Max (m3/h/m)		1.3	4.4		0.5	2.5						
		Min		-	-		0.3	-						
		Mean		1.3	4.4		0.4	2.5						
	Area V 20-25 Km	Number	0	0	1	0	2	1	4	2	0	0	0	
		Max (m3/h/m)			2.0		5.9	16.5	1.8	0.6				23.5 m3/h/m
		Min			-		1.1	-	0.2	0.2				
		Mean			2.0		3.5	16.5	1.1	0.4				564 m3/day/m

* Area are measured in Km from the coast
An Advisary Report, 1982, DEG

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 General

The water sources for Jakarta Water Supply System must satisfy the requirements of the treatment plants in the aspects of both quantity and quality. Considering their economical and physiographic balance for Jakarta Metropolis, the water sources for a mid- and long-term planning should be sought in the Citarum-Cibeet river to the east and in the Cisadane river to the west.

5.2 Short Term Demand for Jakarta, 1987 - 1990

The enlargement of the West Tarum Canal was decided by the Government in June, 1982 in order to provide urgently needed drinking water for Jakarta. The enlargement of the canal between Bekasi and Cipinang is planned to have a capacity of 19 m^3/sec up to the intake point of an immediate program (2.2 m^3/sec) and will be completed by the end of 1986. The urban water requirements of Jakarta will be considered as follows:

(1)	Pejonpongan Plant	= 5.6 x 1.1	= 6.2 m^3/sec
(2)	Flushing, Central Jakarta		= 5.0 m^3/sec
(3)	Pulogadung Plant	= 4.0 x 1.1	= 4.4 m^3/sec
(4)	Immediate Program	= 2.0 x 1.1	= 2.2 m^3/sec
(5)	Canal Losses		= 1.2 m^3/sec
		T O T A L	19.0 m^3/sec

Detailed design of the enlargement of the West Tarum Canal now is in progress and should be finished at the end of 1984. The executing body of the enlargement of the West Tarum Canal is Jatiluhur Authority (POJ).

5.3 Mid-Term Demand for Jakarta, 1991 - 2000

According to the Cibeet Study (NEDECO, 1983), the alternative 1B is the most suitable to supply water for Jakarta up to the year 2000. Canal 1B, north bank route, from Curug to Bekasi was decided in the interdepartmental meeting on January, 1983 for construction by the end of 1990 and its capacity is expected to be 30 m^3/sec. However, the target capacity will be reviewed, considering the demand projection in JICA's present study.

5.4 Long Term Demand for Jakarta, after 2000

According to the Directorate General Water Resources Development, the schedule of the Feasibility Study of the Cisadane River Basin Development will launch in April, 1984, with the duration of 24 months. Possible water resources from the west of Jakarta must be developed before the year 2000 and be available to meet urban water supply demand in West Jakarta. The possible damsites of Sodong (600 million m^3), Cilangkap (85 million m^3), and Genteng (80 million m^3) on the Cisadane river, Tanjung (280 million m^3) on the Cidurian river will be studied, together with a conveyance system of Canal 3 from Cilangkap to West Jakarta as well as the use of the existing canal of Mookervaat connecting the Cisadane with Northwest Jakarta. This project involves many difficult problems, particularly socio-economic influence on the proposed damsite areas.

5.5 Scheduling of Development Program

The scheduling of the above development program is summarized in Fig. 5.1 . The feasibility of the water resources for urgent and mid-term plans has been already confirmed, but that of the Cisadane river is unknown yet. Since the western part of Jakarta is likely to suffer from water shortage in the near future, it seems quite important to expedite the study and the implementation of the development of the western water resources.

Fig. 5.1 WATER RESOURCES DEVELOPMENT SCHEDULE CONCERNING JAKARTA WATER SUPPLY

	DESCRIPTION	81	82	83	84	85	86	87	88	89	90	NOTE
Enlargement of West Tarum Canal	1. Definite Plan 2. Detailed design and documentation 3. Tender for section Jakarta-Bekasi 4. Construction of section Jakarta - Bekasi 5. Tender for Section Bekasi-Curug 6. Construction for Section Bekasi - Curug											NEDECO started Detailed Design, 1983
Canal 1	1. Feasibility Study 2. Select consultants for next stage 3. Detailed design and documentation 4. Tender and Contracts 5. Construction of Canal 1							?				Expecting Alternative 1B
Canal 3	1. Feasibility Study 2. Select Consultants for next stage 3. Detailed design and documentation 4. Tender and contracts 5. Construction of Canal 3											Cisadane River Development

Information from NEDECO, Feasibility Report, March 1983.

5.6 Function of Conveyance System

Functioning of the canals, namely the West Tarum Canal and Canal 1B, is summarized as follows:

1) Enlarged West Tarum Canal

This canal is planned chiefly to transport drinking water of the demand level of 1990 to Pejompongan, Pulogadung and additional new treatment plants and flushing water for Central Jakarta in the dry season.

2) Canal 1B

Canal 1B delivers only drinking water to Jakarta. No other offtakes on the way are considered to protect water quality against pollution by local rivers. Required capacity including 5% reserve is as follows:

Year	Capacity (m^3/sec)
1991	11.7
1995	19.3
2000	30.1

3) Change of Functions between the Two Canals

After Canal 1B becomes operational, supplies to Pulogadung plant and the new plant are provided by Canal 1B while Pelompongan plant continues to be supplied from the enlarged West Tarum Canal. The previous share of the West Tarum Canal in the drinking water supply shall be switched to flushing use. At this stage, flushing demand in all Jakarta is 4 to 8 m^3/sec, which roughly coincides with the previous share of the West Tarum Canal.

5.7 Water Resources Control Organization

At present there are no overall control of water resources, water rights, systematic measurements of flows, etc. Therefore, a water resources coordinating organization should be established to ensure equitable allocation of water resources, control of pollution, monitor rivers, promote multi-purpose capital works, and perform scientific water management and control in Jakarta and/or Jabotabek area.

5.8 Groundwater Development in Jakarta City

Groundwater is a supplementary water source in Jakarta, where hydrogeological conditions of aquifers are not favorable for development, due to low transmissibility ranging from 20 to 250 m^3/day. In fact, the production capacity of a well ranges from 200 to 300 m^3/day at a drawdown of about 5 m. Such a low production rate of the wells cannot be recommended for public use. Further development should be confined to the domestic use and the supply for areas which are not served by the piped water system.

5.9 Groundwater Resources Problems

Groundwater resources problems such as declining of groundwater level, sea water intrusion and potential land subsidence have been frequently encountered in the norther coastal Jakarta of densely populated area, but groundwater is still an important source for domestic and industrial uses. It is recommended, therefore, that comprehensive systematic groundwater studies in Jakarta city including the analysis of groundwater problems, mechanism of groundwater recharge, sustainable yield and conservation of groundwater be made as early as possible.

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1). Study of Cibeet Irrigation, Flood Control and Weter Supply.
NEDECO, Sir Alexander Gibb & Partners and Virma Karya Consultants.
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**	Excutive Summary	
Volume 1	Main Report	
Volume 2	Annex A :	Hydrology
	Annex B :	Water Demands
Volume 3	Annex C :	Water Management
Volume 4	Annex D :	West Tarum Canal
	Annex E :	Canal 1
Volume 5	Annex F :	Canal 2
	Annex G :	Land Acquisition and Resettlement
Volume 6	Annex H :	Pasir Combong Outlet Works
	Annex I :	Minor River Diversions
	Annex J :	Urban Water Supply
Volume 7	Annex K :	Soil Conservation
	Annex L :	Unit Rates
	Annex M :	Irrigation and Drainage
	Annex N :	Roads
	Annex O :	Land Suitability
	Annex P :	Agronomy
Volume 8	Annex Q :	Agro-economy
	Annex R :	Economic and Financial Evaluation
Volume 9	Annex S :	Topographic Surveys & Mapping
	Annex T :	Geotechnical and Soil Mechanics Investigations
Voulume 10	Supporting Data	

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Vol. 1 Main Report
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* Executive Summary
* Main Report
Annex A Urban Water Requirement
Annex B Agricultural Development & Crop Water Requirement
Annex C Environment
Annex D Water Resources
Annex E Water Works
Annex F Water Resources Development Programme

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* Vol. 1 Report
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Implementation Reports

* I/1 Excutive Summary
* I/5 The Development and Management of Water Resources in Jabotabek. May, 1981
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ATTACHMENTS

Attachment 1.

Hydrologic Data

Monthly discharges at Cibeet weir in m^3/s (POJ operational records)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1970	56	65	90	51	79	21	9	2	7	8	63	32	40.3
1971	46	82	49	66	34	27	10	5	4	33	40	35	36.0
1972	83	52	101	55	38	4	3	6	1	0	6	26	31.2
1973	71	107	50	53	80	20	19	12	24	40	18	26	43.4
1974	51	66	43	70	68	14	21	51	29	54	41	45	46.3
1975	60	64	54	81	54	22	7	10	22	39	64	21	41.5
1976	116	30	45	41	28	8	3	3	3	9	33	22	28.6
1977	73	82	72	58	40	40	3	2	6	1	12	27	34.8
1978	42	43	67	40	28	36	30	32	44	20	37	68	40.7
1979	71	57	35	67	55	17	5	11	17	27	50	57	39.8
1980	47	49	41	39	23	10	13	15	10	24	32	56	29.8
Aver	65	63	59	56	48	20	11	14	15	23	36	38	37.4
Stdv	21	21	21	14	20	11	9	15	13	17	19	16	5.8

Table A.17. Monthly discharges at Cikarang weir in m^3/s (POJ operational records)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1970	21	28	32	19	24	10	14	7	5	9	23	16	17.3
1971	35	52	29	28	21	17	12	9	8	17	10	16	21.1
1972	32	22	43	22	26	3	1	1	1	7	1	11	14.3
1973	16	44	27	17	35	11	14	10	19	23	11	16	20.2
1974	34	23	20	27	15	6	5	11	13	16	11	11	16.2
1975	17	22	21	23	20	8	5	8	19	22	12	7	15.4
1976	55	18	23	26	18	5	1	1	6	6	6	6	14.1
1977	29	30	30	17	11	12	1	1	3	1	5	7	12.3
1978	17	13	21	23	8	5	5	7	10	13	18	17	13.1
1979	37	21	19	31	18	10	10	10	8	16	27	21	19.0
1980	29	21	20	15	10	4	6	8	2	5	16	10	12.1
Aver.	29	27	26	23	19	8	7	7	9	12	13	13	15.9
Stdv.	12	12	7	5	8	4	5	4	6	7	8	5	3.1

Table A.18 Monthly discharges at Bekasi weir in m^3/s (POJ operational records)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1970	52	61	74	40	34	29	17	12	20	18	39	22	34.9
1971	49	66	28	40	25	28	17	10	8	26	34	27	30.3
1972	58	34	58	55	42	13	6	12	4	2	19	33	28.0
1973	46	73	44	59	62	34	23	25	34	40	18	26	40.4
1974	45	42	32	49	55	22	21	36	33	38	22	18	34.4
1975	35	66	55	79	37	16	14	23	31	22	28	17	35.4
1976	89	37	43	32	29	8	9	6	5	17	27	23	27.1
1977	60	49	56	53	45	35	8	5	20	7	28	35	33.4
1978	39	32	38	35	35	26	23	26	36	31	33	45	33.4
1979	49	34	32	45	34	28	21	17	23	31	47	31	32.5
1980	38	40	39	37	38	9	12	23	28	29	28	34	29.5
Aver.	51	48	45	48	40	22	15	18	22	24	29	28	32.7
Stdv.	15	15	14	14	11	10	6	9	12	12	8	8	3.8

NEDECO, 1983

Mean monthly discharges (m^3/s) of Citarum NEDECO, 1983

Name gauging station	Catchment (km^2)	No. of years with records	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Pagokan	65	5	3	4	6	5	4	3	2	1	1	1	1	3	3
Wangsisagara	154	11	7	7	8	9	6	5	4	2	2	3	4	7	5
Dayeuhkolot	1,367	6	66	81	75	95	61	36	23	13	10	20	35	55	48
Nanjung	1,761	25	97	103	114	128	87	44	22	17	19	38	68	101	70
Saguling	2,315	8	127	135	157	172	130	59	30	26	29	61	127	132	99
Cacaban	2,315	3	180	258	192	152	149	136	33	59	44	85	74	113	123
Rajamandala	2,431	9	109	125	142	139	100	44	31	16	12	37	84	127	80
Palumbon, YRB	4,059	38	239	241	281	280	214	114	69	51	50	98	172	236	170
" POJ	"	18	245	221	235	256	187	100	60	54	63	98	176	224	160
Jatiluhur	4,550	18	281	267	273	278	203	107	69	64	71	112	199	253	181
Cikao Bandung	4,555	9	273	304	293	320	224	139	130	89	68	93	196	242	201
Munjul	4,833	7	330	436	406	390	275	153	161	121	65	104	238	327	250
Tanjungpura	5,630	8	325	354	342	351	271	72	51	24	42	93	167	177	192

Note:
- Periods of records not the same; before comparison of data adjustments for wet and dry periods should be made.
- Tanjungpura affected by irrigation diversions, in particular in the dry season.
- Except for Palumbon-POJ and Jatiluhur, all data are extracted from the yearbooks.

Subject : MEAN MONTHLY DISCHARGE (m3/s) NEDECO, 1983
Station : PALUMBON (Cipetir)
File name : CIPAPO POJ

year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1960	*	*	*	*	*	*	*	*	*	*	*	*	*
1961	*	*	*	*	*	*	*	*	*	*	*	*	*
1962	*	*	*	*	*	*	*	*	*	*	*	*	*
1963	214	229	170	177	111	27	13	8	7	18	64	89	93.8
1964	117	100	164	252	165	61	28	47	60	141	179	190	125.1
1965	371	390	151	141	102	43	27	10	7	9	55	250	129.7
1966	234	205	286	142	109	57	15	9	22	155	197	272	141.9
1967	203	197	192	332	131	25	21	9	13	20	82	215	120.0
1968	240	127	290	250	258	237	207	240	120	79	156	223	202.3
1969	415	322	220	285	104	91	28	14	77	57	140	106	154.9
1970	226	177	500	285	306	159	70	31	49	79	273	223	198.2
1971	271	239	161	268	161	98	56	38	29	159	297	347	177.0
1972	296	271	294	225	165	25	15	18	6	7	66	139	127.3
1973	231	253	270	337	350	123	85	48	124	116	120	188	187.1
1974	113	152	95	331	250	50	78	156	130	263	209	230	171.4
1975	282	268	292	252	214	93	55	47	107	214	283	142	187.4
1976	253	176	176	244	118	40	18	28	20	70	184	206	127.8
1977	261	349	341	281	215	226	40	21	42	12	107	148	170.3
1978	245	118	269	176	200	243	233	130	154	149	243	399	213.9
1979	212	301	184	380	269	144	51	45	88	108	253	332	197.3
1980	226	110	170	253	140	59	44	60	81	106	257	332	153.2
Aver.	245	221	235	256	187	100	60	54	63	98	176	224	159.9
Stdv.	72	85	94	67	75	74	62	62	49	74	81	66	34.5

Subject : MEAN MONTHLY DISCHARGE (m3/s)
Station : JATILUHUR POJ
File name : MCIJAP

year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1960	*	*	*	*	*	*	*	*	*	*	*	*	*
1961	*	*	*	*	*	*	*	*	*	*	*	*	*
1962	*	*	*	*	*	*	*	*	*	*	*	*	*
1963	306	281	228	215	119	40	16	12	10	19	68	118	119.3
1964	165	122	201	323	218	65	38	58	78	174	213	218	156.1
1965	457	466	166	171	121	55	38	15	9	15	75	298	158.8
1966	261	235	346	178	152	96	33	22	27	167	202	315	169.5
1967	234	281	217	347	134	35	15	9	13	19	90	247	136.8
1968	238	167	302	257	270	238	236	244	125	82	161	255	214.6
1969	382	361	265	334	138	128	50	32	101	83	176	147	183.1
1970	252	214	516	299	324	170	93	36	56	83	301	227	214.3
1971	292	297	178	299	196	110	57	38	12	170	309	355	192.9
1972	322	282	351	254	165	35	24	18	6	12	94	162	147.1
1973	296	357	339	358	371	136	96	84	151	165	162	231	228.8
1974	161	191	127	375	299	59	104	177	151	292	274	256	205.5
1975	348	337	317	287	205	93	57	52	128	258	334	173	215.8
1976	326	194	198	246	122	35	17	25	16	78	209	203	139.1
1977	283	399	370	269	215	209	30	16	38	6	108	161	175.3
1978	253	140	343	178	206	230	220	171	182	170	265	440	233.2
1979	247	351	228	345	257	134	47	56	98	116	268	361	209.0
1980	229	137	197	267	127	65	66	88	68	112	266	366	165.7
Aver.	281	267	273	278	203	107	69	64	71	112	199	253	191.4
Stdv.	72	99	95	64	76	68	64	67	58	85	67	87	34.4

Monthly discharges at Jatiluhur in m^3/s as revised by NEDECO, 1983

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1920	328	328	346	307	121	80	80	41	114	173	196	119	186.3
1921	235	209	286	356	95	59	54	44	28	46	93	219	143.7
1922	232	227	302	379	372	93	62	60	43	144	209	150	189.4
1923	120	278	139	114	196	185	225	39	25	29	138	255	145.3
1924	249	228	314	427	235	114	74	30	30	193	248	296	203.2
1925	222	227	185	254	112	32	31	17	17	29	46	172	112.0
1926	165	342	413	159	248	69	34	17	22	103	101	144	151.4
1927	203	161	260	311	269	120	67	53	39	77	263	408	187.6
1928	407	292	325	405	153	120	55	77	46	94	329	440	228.6
1929	206	298	296	261	122	71	32	25	18	65	121	213	144.0
1930	152	246	384	405	458	100	69	37	30	140	218	204	203.6
1931	188	279	556	306	255	172	56	54	30	147	128	302	206.1
1932	263	222	372	455	387	196	69	31	72	62	124	150	200.3
1933	347	286	246	214	158	176	87	83	188	171	214	323	207.8
1934	346	196	123	308	172	57	39	28	77	82	250	338	166.0
1935	228	345	308	365	167	102	27	16	18	52	177	218	166.6
1936	172	289	427	309	205	90	49	44	28	84	281	227	183.8
1937	196	329	385	358	326	242	57	28	45	128	103	339	211.3
1938	319	196	432	264	280	215	179	110	40	41	283	283	220.2
1939	159	217	184	197	122	176	203	124	57	106	177	302	168.7
1940	207	199	610	409	399	206	129	72	27	34	111	296	224.9
1941	202	346	327	420	333	167	72	31	31	88	106	353	206.3
1942	374	208	233	206	261	169	77	100	84	185	262	174	194.4
1943	316	282	370	360	218	171	92	99	39	195	269	120	210.9
1944	406	213	309	307	156	67	57	56	107	81	239	206	183.7
1945	166	344	257	237	111	66	56	56	138	167	202	195	166.3
1946	191	233	389	152	82	65	65	63	102	56	145	333	156.3
1947	404	428	242	223	98	56	158	58	161	202	233	360	218.6
1948	324	241	366	189	96	66	103	56	65	69	237	348	180.0
1949	291	142	261	266	248	143	63	56	56	140	250	163	173.3
1950	225	226	274	273	234	130	136	56	60	137	301	161	185.1
1951	390	320	160	156	141	79	68	95	69	110	65	224	156.4
1952	319	294	386	252	106	93	37	52	75	169	205	234	185.2
1953	213	245	332	309	280	90	43	28	15	14	108	140	151.4
1954	288	252	242	148	202	153	64	95	107	123	381	399	204.5
1955	201	359	308	456	267	166	235	197	74	222	288	315	257.3
1956	310	165	238	308	185	262	102	87	185	178	219	184	201.9
1957	225	171	312	370	168	104	220	81	30	50	119	257	178.9
1958	245	430	352	360	293	105	204	179	95	118	207	329	243.1
1959	176	395	283	188	209	113	83	38	28	27	60	79	139.9
1960	203	199	271	416	153	45	45	32	21	32	235	207	155.0
1961	386	287	176	138	190	89	15	12	13	13	25	76	118.3
1962	171	253	352	313	175	90	138	60	35	155	195	358	191.3
1963	214	229	170	177	111	27	13	8	7	18	64	89	93.9
1964	165	122	201	323	218	65	30	50	78	174	213	218	156.1
1965	457	466	186	171	121	55	38	15	9	15	75	298	158.6
1966	261	235	346	178	152	96	33	22	27	167	202	315	169.5
1967	234	281	217	347	134	35	15	9	13	19	90	247	136.8
1968	238	167	302	257	270	238	236	244	125	82	161	255	214.6
1969	382	361	265	334	138	128	50	32	101	83	176	147	183.1
1970	252	214	516	299	324	170	93	36	56	83	301	227	214.3
1971	292	297	178	299	196	110	57	38	12	170	309	355	192.8
1972	322	282	351	254	185	35	24	18	6	12	94	182	147.1
1973	296	357	339	358	371	136	96	84	151	165	162	231	228.6
1974	161	191	127	375	299	59	104	177	151	292	274	256	205.5
1975	340	337	317	287	205	93	57	52	128	258	334	173	215.8
1976	326	194	198	246	122	35	17	25	16	78	209	203	139.1
1977	283	399	370	269	215	209	30	16	38	6	108	161	175.3
1978	253	140	343	178	206	230	220	171	182	170	265	440	233.2
1979	247	351	226	345	257	134	47	56	90	116	268	361	209.8
1980	229	137	197	267	127	65	66	88	60	112	266	366	165.7
Aver.	261	265	299	268	208	116	83	62	63	107	192	249	182.8
Stdv.	78	79	99	87	87	60	60	49	49	67	83	91	33.2

Subject : MEAN MONTHLY DISCHARGE (m3/s)
Station : CURUG
File name : MCURUG

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Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1969	216	323	174	265	140	103	119	106	104	103	94	103	154.2
1970	202	207	244	281	260	178	137	121	115	122	112	233	184.1
1971	292	201	148	128	127	133	139	125	126	143	132	230	160.4
1972	297	305	187	183	159	168	165	161	109	49	55	112	162.4
1973	135	170	160	319	390	166	148	158	178	221	174	195	201.3
1974	148	134	86	199	300	132	139	153	210	322	244	227	191.3
1975	232	238	239	229	226	153	146	148	308	182	319	232	220.5
1976	203	143	142	222	184	129	117	118	126	128	159	177	153.6
1977	186	204	305	300	241	248	153	145	122	117	158	172	195.9
1978	156	130	124	129	140	234	235	224	259	197	259	310	199.7
1979	256	266	193	335	303	190	157	148	180	157	220	251	221.2
1980	205	160	170	170	198	159	174	161	162	152	223	207	176.4
Aver	211	207	181	230	222	166	152	147	166	158	179	204	185.3
Stdv	52	65	59	71	80	42	31	30	65	69	76	58	24.0

MEAN AND STANDARD DEVIATION OF MONTHLY DISCHARGES
(m3/sec)

Sites		WET SEASON							DRY SEASON					Wet Seas	Dry seas	Year
		N	D	J	F	M	A	M	J	J	A	S	O			
Cibeet (Weir) (507 km2)	M*	32.1	37.8	61.8	63.5	58.0	51.9	38.1	19.5	13.6	9.1	9.6	17.8	49.0	13.9	34.4
	S*	19.6	19.5	31.8	29.3	24.1	19.2	21.1	14.3	12.3	10.5	14.4	18.5	11.4	9.7	7.5
Cikarang (Weir) (238 km2)	M	15.4	17.7	24.5	25.0	23.8	21.7	18.3	12.3	10.3	7.7	8.4	11.0	20.9	9.9	16.3
	S	6.3	5.5	7.2	7.6	6.1	4.3	5.6	4.3	4.4	4.2	5.8	6.2	3.3	3.5	2.4
Bekasi (Weir) (412 km2)	M	26.0	26.7	36.0	37.8	34.9	37.0	30.1	20.9	15.9	14.2	14.9	21.3	32.6	17.4	26.3
	S	9.2	8.1	10.9	10.4	9.3	13.7	9.6	6.4	6.9	8.6	9.6	10.1	6.1	6.4	4.8
Ciliwung (Rawajati) (318 km2)	M	15.6	18.1	24.6	25.4	23.3	23.2	19.0	13.4	10.6	9.3	9.5	12.2	21.3	11.0	17.0
	S	5.6	5.7	7.3	5.7	3.9	5.0	4.8	3.6	4.1	4.6	6.1	5.8	3.1	3.9	2.8
Cisadane (Masing) (129 km2)	M	11.2	12.4	13.4	14.0	13.4	13.0	13.0	8.9	7.6	7.1	7.1	9.2	12.7	8.0	10.7
	S	2.4	2.0	2.4	3.3	2.5	2.3	2.1	1.8	1.9	2.4	2.8	2.7	1.6	1.6	1.2
Cisadane (Serpong) * (1074 km2)	M	102	104	120	120	120	124	116	80.6	67.1	62.2	68.3	90.3	115	73.7	97.9
	S	28.9	23.0	26.4	24.7	26.3	25.6	27.5	20.6	28.3	32.4	39.4	37.6	15.8	24.7	14.7
Cidurian (Kopomaja) (304 km2)	M	20.0	20.6	31.4	31.9	27.5	32.7	26.0	18.6	15.3	16.0	15.5	18.0	27.2	16.4	22.8
	S	7.0	10.4	12.5	7.8	11.6	11.4	10.7	6.8	8.0	11.1	10.4	11.1	4.5	6.5	3.5

* M : Mean value – S : Standard deviation , Coyne at Bellier, 1979

* Serpong 6 | Cisadane | 1074 | WLR | – | PROSIDA | Data processed by DPMA

Estimated reliable flows (in m3/s) in Jakarta, NEDECO 1983

	Cipinang	Sunter	Buaran	Cakung	Total	Ciliwung
Jan	1.6	2.5	0.9	1.0	6	18
Feb	1.6	2.5	0.9	1.0	6	20
Mar	1.6	2.5	0.9	1.0	6	20
Apr	1.1	1.6	0.6	0.7	4	18
May	0.8	1.3	0.4	0.5	3	14
Jun	0.5	0.8	0.3	0.4	2	10
Jul	0.5	0.8	0.3	0.4	2	7
Aug	0.5	0.8	0.3	0.4	2	5
Sep	0.5	0.8	0.3	0.4	2	4
Oct	0.5	0.8	0.3	0.4	2	6
Nov	0.8	1.3	0.4	0.5	3	10
Dec	0.8	1.3	0.4	0.5	3	13

* NEDECO, 1983

(DPMA)

STATION. 201012. CISADANE - SERPONG   C.AREA. 1024 KM2   YEAR 1973

DISCHARGE IN CUBIC METER PER SECOND

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	185.0	53.0	87.5	178.0	210.0	161.0	76.1	24.4	108.0	105.0	129.0	47.6
2	156.0	56.5	84.6	107.0	144.0	94.8	56.3	54.8	84.2	160.0	87.8	41.2
3	136.0	49.1	117.0	76.2	115.0	70.0	48.7	56.5	126.0	191.0	73.9	55.9
4	172.0	73.9	203.0	195.0	105.0	93.8	44.3	39.2	109.0	91.7	91.5	74.3
5	298.0	299.0	202.0	133.0	160.0	83.7	48.5	66.0	77.3	121.0	104.0	101.0
6	197.0	317.0	127.0	98.0	125.0	95.4	123.0	88.4	65.0	142.0	115.0	232.0
7	118.0	325.0	89.7	129.0	127.0	214.0	123.0	54.3	106.0	212.0	135.0	135.0
8	129.0	342.0	191.0	114.0	137.0	123.0	99.7	155.0	120.0	89.2	104.0	98.5
9	101.0	238.0	144.0	89.6	153.0	72.5	86.4	205.0	103.0	65.4	66.0	91.1
10	100.0	126.0	112.0	86.5	143.0	73.6	52.7	129.0	86.0	55.3	66.1	77.7
11	102.0	109.0	94.2	145.0	131.0	58.7	41.4	99.9	104.0	60.2	59.4	56.9
12	105.0	234.0	101.0	120.0	106.0	47.1	43.5	66.3	136.0	64.4	64.0	50.8
13	92.4	251.0	103.0	309.0	169.0	39.9	74.3	55.9	77.5	72.0	55.7	53.2
14	172.0	172.0	88.5	245.0	146.0	35.0	150.0	43.8	103.0	69.2	53.8	46.7
15	133.0	108.0	69.1	190.0	139.0	42.8	71.7	43.3	94.9	74.9	50.1	44.6
16	220.0	114.0	57.7	202.0	170.0	44.1	135.0	65.5	62.5	58.2	45.7	65.4
17	130.0	114.0	68.1	198.0	164.0	34.7	86.3	123.0	72.4	45.1	40.8	71.5
18	120.0	163.0	94.4	266.0	150.0	33.3	60.7	126.0	98.0	69.4	37.5	135.0
19	88.2	183.0	94.4	174.0	137.0	114.0	58.6	74.1	73.0	68.1	37.3	202.0
20	77.2	145.0	84.7	155.0	123.0	68.8	106.0	46.5	243.0	61.9	33.8	102.0
21	89.3	144.0	84.1	167.0	130.0	56.2	68.1	103.0	274.0	113.0	33.4	61.2
22	123.0	137.0	74.5	221.0	93.6	41.0	60.0	68.8	161.0	111.0	53.7	69.5
23	144.0	151.0	91.0	209.0	84.3	36.1	54.1	60.0	137.0	110.0	72.9	98.4
24	81.0	180.0	95.1	250.0	86.4	31.9	40.0	62.6	166.0	180.0	74.6	117.0
25	66.1	210.0	101.0	215.0	55.2	31.1	34.6	69.1	125.0	129.0	51.9	76.1
26	56.4	144.0	70.7	142.0	95.0	72.6	30.8	73.4	99.4	247.0	44.4	58.1
27	128.0	98.2	55.9	102.0	90.5	207.0	28.7	41.1	136.0	370.0	48.5	106.0
28	109.0	85.6	54.0	159.0	108.0	262.0	29.9	76.7	149.0	185.0	55.0	75.2
29	71.0		66.5	141.0	157.0	201.0	25.0	64.1	103.0	157.0	60.7	76.6
30	57.7		200.0	96.7	104.0	132.0	26.3	56.9	101.0	106.0	57.7	73.8
31	53.9		164.0		136.0		30.5	120.0		237.0		87.2
TOTAL	3751.2	4608.2	3271.5	4917.0	4027.9	2691.0	2014.6	2412.5	3496.5	3759.9	2001.1	2679.7
MEAN	121.0	164.5	105.5	163.7	129.9	89.7	64.9	77.8	116.5	121.2	66.7	86.3
MAXI	298.0	342.0	206.0	309.0	210.0	267.0	150.0	205.0	274.0	379.0	135.0	232.0
MINI	53.9	49.1	54.0	76.2	84.3	31.1	25.0	24.4	62.5	45.1	33.6	41.2
LDEKM2=	112.6	0.0	98.2	152.4	120.9	85.5	60.5	72.4	108.5	112.9	62.1	80.2
TO ALF=	301.7	370.7	262.1	395.1	324.0	216.4	162.0	194.0	281.7	302.4	160.4	215.2
V(JUTA)=	324.1	398.1	282.6	424.3	348.0	232.5	174.0	208.4	302.1	324.8	172.4	231.1

(DPMA)

DISCHARGE IN CUBIC METER PER SECOND

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DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	94.3	71.2	82.9	111.0	116.0	43.7	195.0	75.8	42.2	161.0	77.9	77.7
2	137.0	90.9	87.5	84.6	94.8	41.0	94.5	89.3	36.7	136.0	79.4	67.4
3	163.0	71.7	135.0	75.3	82.5	59.6	61.3	66.6	86.9	150.0	69.8	44.6
4	265.0	83.7	94.3	114.0	120.0	96.2	47.8	38.9	150.0	127.0	62.6	43.4
5	157.0	80.8	60.8	107.0	246.0	70.0	41.3	35.8	204.0	122.0	59.2	46.3
6	138.0	73.8	46.1	147.0	96.2	41.0	36.2	66.8	158.0	123.0	64.2	77.5
7	101.0	65.1	69.1	127.0	66.5	34.5	67.7	94.6	177.0	116.0	56.4	90.6
8	89.5	96.0	72.1	124.0	82.7	30.6	75.0	108.0	117.0	94.6	48.9	79.2
9	88.7	118.0	57.2	133.0	103.0	28.9	46.6	147.0	255.0	94.6	68.8	51.3
10	312.0	131.0	55.2	119.0	77.6	25.5	67.6	99.8	115.0	104.0	104.0	45.7
11	179.0	121.0	43.7	122.0	95.9	24.3	110.0	158.0	428.0	54.7	75.1	40.3
12	127.0	102.0	38.6	140.0	278.0	32.2	76.4	242.0	190.0	56.3	79.0	41.6
13	171.0	153.0	35.3	319.0	234.0	41.1	96.4	183.0	257.0	54.0	160.0	41.8
14	112.0	103.0	33.7	191.0	195.0	37.5	78.1	120.0	257.0	179.0	163.0	37.1
15	143.0	181.0	33.6	146.0	186.0	25.9	75.3	97.5	293.0	151.0	131.0	39.7
16	139.0	195.0	30.9	107.0	324.0	43.5	56.4	69.4	172.0	142.0	86.0	42.0
17	126.0	86.7	33.3	244.0	310.0	93.4	74.2	53.1	230.0	87.2	87.4	37.7
18	98.1	75.1	24.6	165.0	236.0	67.2	75.3	83.5	121.0	83.4	65.0	37.[illegible]
19	117.0	76.8	27.7	117.0	130.0	51.1	52.1	82.1	100.0	63.7	67.1	34.2
20	87.0	67.1	39.[illegible]	104.[illegible]	112.[illegible]	73.3	38.1	79.1	165.[illegible]	61.[illegible]	65.[illegible]	36.5
21	67.2	63.5	73.5	77.8	87.9	65.4	31.7	75.7	138.[illegible]	65.4	63.2	44.6
22	46.5	54.4	80.3	61.9	94.1	62.7	26.3	98.2	109.0	79.3	64.7	73.[illegible]
23	51.2	56.7	40.1	59.1	76.7	66.5	26.2	79.1	95.0	76.7	94.5	46.7
24	88.4	67.4	50.2	45.4	84.6	56.1	55.4	84.4	104.0	93.0	140.0	65.[illegible]
25	46.2	48.4	89.2	43.5	90.1	72.7	81.4	59.3	78.2	262.[illegible]	81.7	81.1
26	52.0	46.5	60.3	40.5	80.9	94.4	68.1	87.9	67.0	130.0	57.6	72.3
27	165.0	48.4	65.1	35.4	83.5	66.6	91.0	76.0	153.0	88.6	50.6	53.7
28	92.1	90.4	99.6	37.5	67.2	49.3	77.8	66.3	188.0	91.2	49.9	44.4
29	68.9		114.0	102.0	58.2	78.4	54.1	90.6	129.0	71.7	49.6	31.8
30	96.3		217.0	191.0	55.7	292.0	44.9	86.5	116.0	81.6	81.5	26.2
31	86.8		129.0		47.7		52.4	61.1		79.0		74.3
TOTAL	3657.8	2525.7	2108.5	3494.1	4010.4	1864.5	2076.6	2857.9	4682.5	3353.4	2443.7	1570.1
MEAN	117.9	90.2	68.0	116.4	129.3	62.1	66.9	92.1	156.0	108.1	81.6	50.6
MAXI	312.0	195.0	217.0	319.0	324.0	292.0	195.0	242.0	428.0	262.0	188.0	90.0
MINI	51.2	46.5	27.7	35.6	47.7	24.3	26.1	35.0	36.7	61.9	48.9	24.3
LOFCN2=	109.0	0.0	63.3	108.4	120.4	57.8	62.5	85.8	145.3	100.7	75.8	47.1
TO ALR=	294.2	203.1	169.6	281.0	322.6	150.0	167.0	229.9	376.7	269.7	196.5	126.3
V(JUTE)=	316.0	218.7	182.1	301.8	346.5	161.1	179.4	246.9	404.5	289.7	211.1	135.6

MEAN 94.9 MAXIMUM 428.0 MINIMUM 24.3 VOLUME 2983.4MILLION M3 ANNUAL RUNOFF 2787.1MM

STAT.NO. 201012.   CISADANE - SERPONG   C.AREA. 1074 KM2   YEAR 197[illegible]

(DPMA)

DISCHARGE IN CUBIC METER PER SECOND

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DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	24.8	95.3	59.7	39.4	85.7	51.6	46.6	112.0	72.9	90.9	49.9	63.2
2	32.7	83.6	107.0	44.1	69.2	41.6	51.1	288.0	128.0	96.7	38.2	55.1
3	35.0	69.7	93.5	63.1	64.3	35.6	53.4	210.0	167.0	70.8	51.4	59.6
4	31.3	97.8	144.0	58.8	83.2	41.8	30.3	166.0	97.2	83.6	64.4	36.4
5	35.3	104.0	129.0	45.7	62.0	166.0	45.6	123.0	157.0	69.7	53.4	46.3
6	54.8	93.1	134.0	182.0	185.0	277.0	67.6	103.0	98.9	102.0	71.6	43.5
7	82.7	79.2	98.3	221.0	92.5	123.0	46.1	80.2	110.0	75.5	68.1	35.0
8	94.9	66.7	107.0	109.0	233.0	59.7	36.1	165.0	110.0	92.2	63.4	29.5
9	61.3	59.3	179.0	95.0	215.0	44.9	35.7	101.0	130.0	80.2	67.4	27.8
10	43.8	140.0	82.1	102.0	182.0	38.9	45.9	59.9	89.2	69.6	97.0	47.9
11	35.8	85.1	93.5	88.4	115.0	36.7	40.0	52.7	55.1	65.7	110.0	63.4
12	47.8	67.7	93.7	121.0	165.0	44.5	27.4	44.1	80.1	72.1	89.8	54.3
13	39.6	97.6	76.2	225.0	139.0	52.3	23.7	58.5	193.0	61.1	80.2	47.3
14	29.7	99.1	54.7	102.0	167.0	37.8	37.7	53.1	84.8	68.1	85.0	53.7
15	27.7	95.2	59.5	96.5	103.0	39.5	66.7	56.2	122.0	71.4	160.0	67.1
16	32.8	79.4	55.3	137.0	131.0	36.2	55.8	49.1	76.8	79.1	103.0	43.4
17	59.7	83.4	43.3	121.0	87.2	44.9	31.6	130.0	76.7	76.9	93.4	29.9
18	92.0	72.3	40.2	83.6	64.7	47.2	43.1	85.8	139.0	61.2	91.1	25.7
19	86.0	65.9	37.5	69.9	52.1	34.5	76.2	92.9	209.0	59.0	84.5	22.8
20	66.2	97.7	35.9	51.3	46.1	37.1	67.6	96.6	137.0	63.6	71.7	20.9
21	53.0	188.0	[illegible]	115.0	63.6	29.3	109.0	70.2	72.7	57.5	87.6	[illegible]
22	47.1	162.0	67.4	105.0	150.0	26.3	103.0	48.7	102.0	55.6	77.0	33.2
23	64.9	145.0	42.9	70.1	130.0	23.7	119.0	40.7	116.0	44.6	78.9	27.7
24	111.0	104.0	59.7	54.4	99.7	23.1	92.5	36.7	126.0	39.7	85.7	24.0
25	103.0	85.6	[illegible]	50.4	125.0	23.7	83.3	46.3	105.0	38.6	108.0	[illegible]
26	100.0	61.7	51.6	60.2	97.0	21.7	74.8	79.3	157.0	37.5	82.9	15.2
27	104.0	71.2	52.6	75.3	45.5	18.7	67.1	66.8	300.0	20.8	56.0	26.1
28	81.4	83.7	42.7	206.0	67.5	22.7	44.6	59.2	262.0	49.9	40.6	47.3
29	79.3		41.4	125.0	95.2	48.3	59.6	49.6	112.0	72.3	34.8	49.9
30	87.5		53.1	124.0	113.0	55.3	49.7	47.2	96.7	84.8	38.8	59.6
31	89.8		49.5		78.5		112.0	77.3		70.7		76.1
TOTAL	1994.6	2636.0	2283.2	3041.1	3446.0	1583.1	1837.9	2751.0	3793.0	2082.1	2283.7	1250.8
MEAN	64.0	94.1	73.6	101.3	111.1	52.7	59.2	88.7	126.4	67.1	76.1	40.3
MAXI	111.0	188.0	144.0	225.0	233.0	277.0	119.0	288.0	300.0	102.0	160.0	76.1
MINI	24.8	59.3	35.9	39.4	46.1	18.7	23.7	36.7	60.1	20.8	34.8	19.2
LDFKM2=	59.6	0.0	68.5	94.3	103.5	49.1	55.2	82.6	117.7	62.5	70.8	37.5
TC ALR=	159.6	212.0	183.6	244.6	277.2	127.3	147.8	221.3	305.1	167.5	183.7	100.6
V(JUTA)=	171.4	227.7	197.2	262.7	297.7	136.7	158.8	237.6	327.7	179.9	197.3	108.0

MEAN 79.3   MAXIMUM 300.0   MINIMUM 15.2   VOLUME 2503.3MILLION M3   ANNUAL RUNOFF 2330.8MM

(DPMA)

DISCHARGE IN CUBIC METER PER SECOND

C

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	71.0	307.6	59.7	73.0	190.2	68.3	19.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	114.0	247.2	73.2	65.3	131.4	68.3	20.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	97.4	154.5	76.1	61.9	123.7	72.2	16.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	83.8	105.4	344.5	55.3	87.7	61.0	22.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	114.0	94.0	207.6	56.5	90.7	90.7	35.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	115.0	81.2	211.1	123.0	140.7	68.3	51.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	117.0	73.2	116.7	75.2	167.4	40.5	46.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	117.0	76.1	123.7	63.9	130.1	34.0	29.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	79.7	110.1	107.6	69.1	104.2	65.6	52.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	83.9	98.5	89.5	77.9	103.1	52.4	21.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	73.1	61.9	77.1	42.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	94.6	75.2	77.3	62.6	76.1	32.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	85.7	67.8	64.3	103.1	61.9	41.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	111.0	55.1	65.0	89.6	[illegible]	42.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	390.0	52.7	61.2	97.4	[illegible]	46.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	169.0	47.5	58.1	219.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	177.0	46.4	[illegible]	164.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	144.7	[illegible]	[illegible]	[illegible]	47.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	69.6	[illegible]	[illegible]	[illegible]	27.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	113.3	66.2	[illegible]	141.4	[illegible]	21.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	399.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	521.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	279.7	[illegible]	[illegible]	[illegible]	[illegible]	22.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	210.4	157.1	[illegible]	[illegible]	[illegible]	23.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	234.4	103.1	[illegible]	[illegible]	35.8	19.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28	210.3	105.9	77.4	109.7	25.4	21.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	197.6	86.4	[illegible]	105.4	23.7	32.7	0.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	734.9		[illegible]	241.8	23.3	20.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
31	230.2		[illegible]		54.4		0.0	[illegible]		[illegible]		[illegible]
TOTAL	6153.2	2753.4	2955.7	3222.7	2185.6	1233.0	396.5	0.0	0.0	0.0	0.0	[illegible]
MEAN	198.4	94.9	95.3	107.4	70.5	41.1	12.7	0.0	0.0	0.0	0.0	[illegible]
MAXI	734.9	307.6	344.5	241.8	190.7	90.7	51.7	0.0	0.0	0.0	0.0	[illegible]
MINI	71.0	47.5	44.1	56.0	23.0	19.4	0.0	0.0	0.0	0.0	0.0	[illegible]
LOFKM2=	184.8	0.0	88.7	100.0	65.6	38.7	11.9	0.0	0.0	0.0	0.0	[illegible]
TG ALR=	495.0	221.5	237.7	259.2	175.6	99.1	31.9	0.0	0.0	0.0	0.0	[illegible]
VIJUTA)=	531.6	237.9	255.3	276.4	168.[illegible]	106.5	34.2	0.0	0.0	0.0	0.0	0.0

MEAN 51.6 MAXIMUM 734.9 MINIMUM 0.0 VOLUME 1633.0MILLION M3 ANNUAL RUNOFF [illegible]

[illegible] DISCHARGE AT [illegible] UNIT NO. [illegible] [illegible] YEAR 19[illegible] , DPMA, 1983

DISCHARGE IN CUBIC METER PER SECOND

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.0	0.0	51.3	24.4	47.3	22.2	22.2	24.0	20.1	23.0	35.9	0.0
2	0.0	0.0	52.4	25.0	55.7	21.2	19.5	25.2	20.1	23.0	39.4	0.0
3	0.0	0.0	45.0	24.0	65.5	24.0	20.1	23.3	21.2	20.1	34.0	0.0
4	0.0	0.0	40.5	25.3	53.1	23.0	19.8	27.5	23.7	19.2	27.1	0.0
5	0.0	0.0	31.3	22.2	45.0	24.0	19.8	25.3	21.9	19.9	27.1	0.0
6	0.0	0.0	32.7	[illegible]	[illegible]	21.9	[illegible]	35.9	21.9	19.8	24.4	0.0
7	[illegible]	0.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	30.5	21.5	20.1	21.5	0.0
8	[illegible]	0.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24.9	20.5	23.3	25.7	0.0
9	[illegible]	21.7	42.5	[illegible]	[illegible]	[illegible]	[illegible]	26.2	27.6	20.1	24.8	0.0
10	[illegible]	22.3	39.4	21.5	34.5	[illegible]	[illegible]	31.3	23.7	23.3	24.4	0.0
11	0.0	34.5	31.7	32.2	32.7	26.7	[illegible]	28.7	29.2	21.9	26.4	0.0
12	0.0	31.7	24.5	27.2	32.6	22.1	17.9	26.7	24.7	23.7	24.8	0.0
13	0.0	31.7	22.5	33.4	20.1	20.9	26.0	21.5	23.5	24.4	28.7	0.0
14	0.0	49.5	20.9	33.4	22.7	22.7	[illegible]	19.5	29.2	23.0	27.3	0.0
15	0.0	57.5	27.5	22.5	25.6	18.5	[illegible]	24.4	23.3	26.7	29.6	0.0
16	0.0	10.2	22.2	17.5	23.0	19.7	[illegible]	25.0	22.7	25.7	27.5	27.5
17	0.0	95.0	25.7	25.0	24.0	27.9	22.1	27.5	23.7	33.5	25.7	28.2
18	0.0	49.3	32.9	25.8	23.3	29.5	[illegible]	25.7	22.7	30.5	32.1	27.7
19	0.0	35.9	31.7	17.8	24.4	20.9	25.3	25.0	23.0	29.7	36.4	27.9
20	0.0	33.5	21.3	15.9	26.4	22.8	17.5	27.1	23.3	23.0	35.4	27.5
21	0.0	30.9	23.3	15.9	27.5	24.4	19.5	24.4	24.5	23.0	31.7	25.5
22	0.0	25.2	19.1	15.9	26.0	25.7	[illegible]	17.5	23.7	27.6	37.2	30.7
23	0.0	26.6	25.1	27.1	24.4	22.2	22.2	17.5	21.5	26.7	33.5	28.7
24	0.0	24.0	16.0	27.1	23.3	27.2	[illegible]	17.7	25.7	22.0	31.5	37.3
25	0.0	25.7	15.7	[illegible]	27.5	21.5	[illegible]	17.2	12.2	26.7	27.9	33.2
26	0.0	26.2	13.2	21.9	22.2	21.7	[illegible]	17.2	13.2	25.7	25.7	34.0
27	0.0	34.4	13.0	21.5	22.2	21.9	21.7	16.4	21.5	23.7	27.1	37.2
28	0.0	58.5	16.3	25.0	24.0	22.5	21.2	15.1	19.2	25.4	25.0	47.5
29	0.0	51.8	15.4	25.2	22.7	20.5	20.8	17.2	20.8	27.1	0.0	36.4
30	0.0		21.5	32.5	20.1	[illegible]	23.5	19.2	23.0	37.8	0.0	39.4
31	0.0		24.0		20.9		21.5	17.2		37.3		30.5
[illegible]	41.[illegible]	[illegible]5.2	843.5	72[illegible].5	759.6	555.4	552.1	732.5	691.5	790.2	719.7	515.3
[illegible]	1.3	27.2	27.2	24.2	30.9	21.2	[illegible]	23.5	22.7	25.1	27.7	15.5
[illegible]	[illegible]	95.2	52.4	33.4	65.8	25.0	[illegible]	39.9	29.7	37.8	39.4	47.6
[illegible]	0.0	0.0	0.0	15.5	20.1	18.8	[illegible]	15.1	13.2	19.2	0.0	0.0
[illegible]	[illegible]	0.0	59.9	13.5	69.1	49.1	[illegible]	52.1	50.2	55.4	53.1	36.6
[illegible]	[illegible]	150.2	160.5	133.6	182.6	124.7	[illegible]	139.5	127.6	165.4	155.8	93.2
[illegible]	[illegible]	59.1	72.[illegible]	52.9	[illegible]	55.6	[illegible]	53.3	56.[illegible]	67.4	79.7	44.6

[illegible] MAXIMUM 95.2 MINIMUM 0.0 VOLUME 725.4 [illegible] M3 ANNUAL [illegible] 1561.7[illegible]

STAT.NO. 30??3. DISCHARGE AT JEPEATAN GENIT NO. 30?00? C.AREA. 454 KM2 YEAR 1?81 ,DPMA, 1983

DISCHARGE IN CUBIC METER PER SECOND (m3/s)

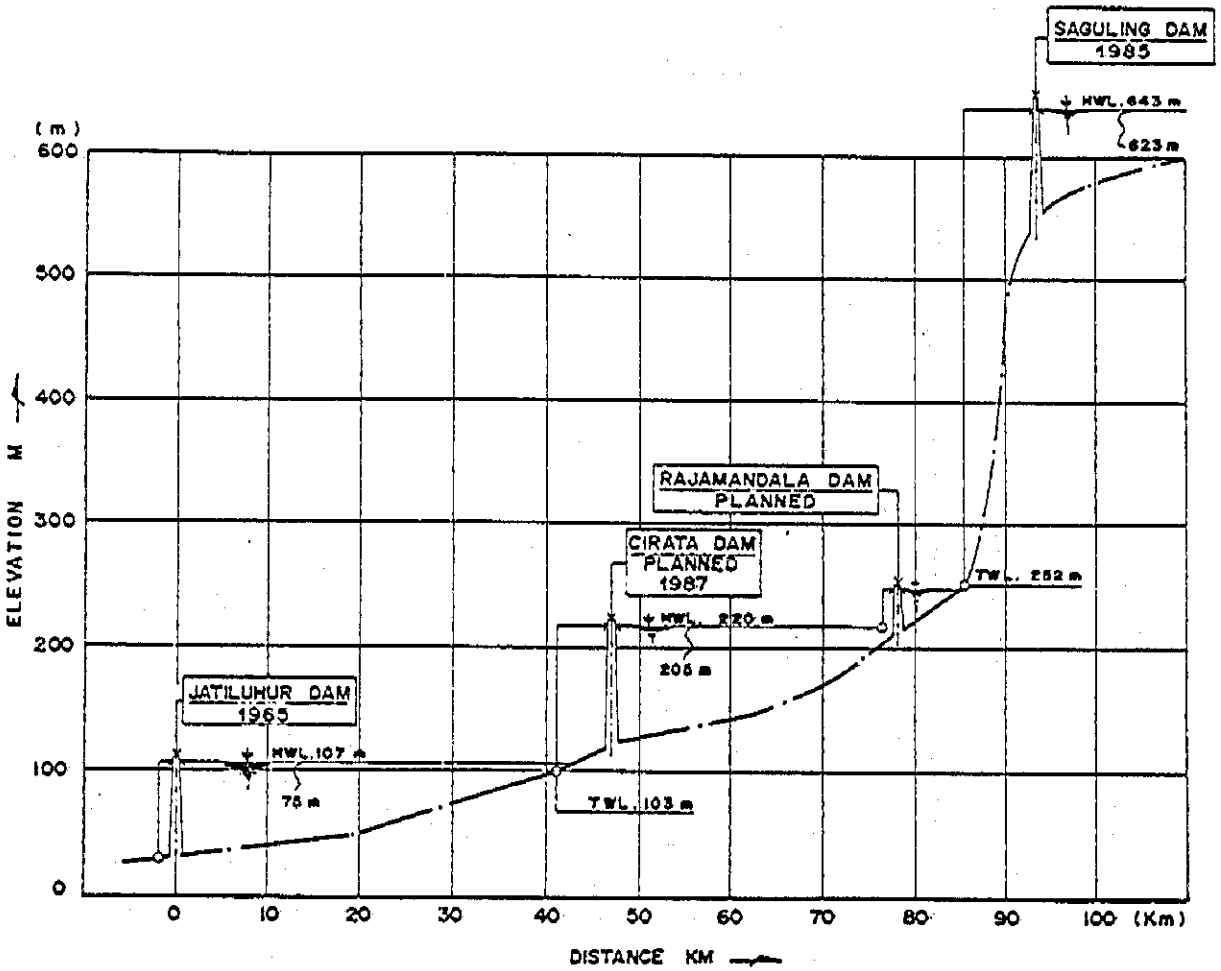
DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	19.0	41.5	22.0	27.7	0.0	17.9	22.5	22.7	18.8	19.3	20.0	15.9
2	17.3	32.5	17.9	26.2	0.0	17.6	23.9	25.5	18.2	20.5	21.9	19.6
3	16.7	29.8	30.0	25.4	0.0	18.8	27.1	24.2	20.5	20.5	19.9	17.6
4	15.9	27.4	44.3	20.5	0.0	17.5	24.5	21.1	14.2	23.4	22.?	17.5
5	26.0	24.5	45.6	21.6	0.0	17.2	23.9	22.7	15.5	??.8	[illegible]	19.7
6	0.0	22.7	35.5	22.3	28.3	17.5	20.2	20.8	15.9	?4.5	16.5	[illegible]
7	0.0	22.5	33.3	20.2	33.7	17.2	19.2	22.2	15.7	[illegible]	[illegible]	[illegible]
8	0.0	20.3	29.?	19.2	[illegible]	20.5	17.6	22.5	16.7	[illegible]	[illegible]	17.6
9	0.0	21.1	34.2	19.3	35.2	20.2	[illegible]	21.4	14.3	19.2	15.2	17.9
10	0.0	13.9	34.2	17.6	30.5	21.1	21.1	19.6	17.3	18.3	19.3	14.7
11	0.0	19.2	25.5	17.2	20.3	21.5	21.4	22.5	17.0	17.9	19.9	17.6
12	0.0	15.7	19.3	22.5	26.2	23.9	21.1	15.4	18.5	19.2	18.9	15.5
13	0.0	13.7	26.2	23.1	23.7	25.2	22.2	19.9	12.2	13.5	17.9	[illegible]
14	0.0	14.2	25.3	23.7	24.7	35.2	21.4	19.9	15.7	12.6	15.3	[illegible]
15	0.0	13.7	25.1	21.1	21.9	33.4	20.2	17.2	18.5	19.2	22.3	14.9
16	35.6	[illegible]	20.2	17.9	22.5	34.1	27.4	17.9	14.5	19.1	21.6	15.9
17	43.9	15.2	18.5	17.3	24.9	29.0	21.4	17.2	19.2	19.3	19.3	13.2
18	44.3	22.5	21.4	23.1	25.0	22.5	21.4	16.7	16.5	17.5	18.3	13.0
19	32.7	23.7	27.1	23.4	0.0	17.0	23.3	17.9	13.3	15.9	19.6	13.4
20	34.7	24.4	23.7	23.2	21.9	17.3	24.3	24.5	12.7	17.3	20.5	15.5
21	40.0	23.7	24.6	23.2	20.5	19.2	22.?	17.0	19.7	17.6	17.9	24.6
22	38.8	21.1	20.8	24.5	17.3	21.7	22.?	13.7	21.6	15.5	14.5	32.7
23	66.6	19.3	23.4	22.?	18.5	21.5	22.?	18.7	[illegible]	16.5	24.8	[illegible]
24	68.2	19.0	25.7	21.9	19.5	20.7	22.?	17.5	21.4	15.5	15.5	[illegible]
25	60.4	19.0	21.6	21.9	23.7	19.0	22.1	17.5	22.2	[illegible]	17.3	[illegible]
26	41.9	16.7	21.1	21.6	21.9	19.3	[illegible]	16.2	19.9	17.2	19.2	[illegible]
27	48.2	13.6	26.2	21.6	0.0	19.3	[illegible]	15.5	19.6	[illegible]	15.5	[illegible]
28	53.7	15.9	23.2	21.7	0.0	20.8	21.5	15.5	17.3	[illegible]	19.3	[illegible]
29	55.3		26.9	0.0	19.0	22.2	23.1	19.?	25.9	[illegible]	19.?	[illegible]
30	63.7		24.8	0.0	13.?	23.6	24.9	[illegible]	13.9	[illegible]	[illegible]	[illegible]
31	62.6		25.8		19.3		24.2	[illegible]		[illegible]		[illegible]
TOTAL	930.0	5?5.8	541.?	512.5	549.7	556.0	555.6	605.4	591.7	[illegible]	[illegible]	[illegible]
MEAN	30.0	20.9	27.1	20.4	17.7	21.4	22.1	19.5	19.3	[illegible]	[illegible]	[illegible]
MAXI.	68.7	41.5	46.5	27.7	35.2	35.4	27.2	25.6	23.?	34.5	[illegible]	[illegible]
MINI.	0.0	13.4	17.9	0.0	0.0	17.0	17.6	15.2	13.9	[illegible]	[illegible]	[illegible]
L/S/KM2.	66.0	0.0	59.9	44.9	39.0	48.1	48.7	43.0	40.5	39.6	40.?	[illegible]
MM.	[illegible]	111.6	160.2	116.5	104.5	124.2	130.4	115.2	105.0	103.4	106.?	[illegible]
MCM.	[illegible]	5?.7	72.7	52.0	47.5	55.6	59.2	52.3	47.6	46.9	48.2	[illegible]

MEAN [illegible] MAXIMUM [illegible] MINIMUM 0.0 VOLUME [illegible] MILLION M3 ANNUAL RUNOFF [illegible]

STAT.NO. [illegible]

Attachment 2.

Water Resources Development in Citarum River Basin



FROM
NEDECO, 1983

Fig. WATER RESOURCES DEVELOPMENT IN CITARUM RIVER BASIN, JATILUHUR, SAGULING AND CIRATA DAMS

Table Existing Dam and Dams Under Construction in Citarum River Basin

No.	DAM	Construction Year	High Water Level (m)	Reservoir Capacity (10^6m3)	Drainage Area (Km2)	Mean Annual Rainfall* (mm)	Mean Annual Discharge (m3/s)	Specific Discharge (m3/s/Km2)	Runoff Coefficient
1.	Jatiluhur	1965	107	3,000	4,550	2,406	181	0.0398	0.521
2.	Saguling	1985 Under Construction	643	796	2,315	2,262	99	0.0428	0.596
3.	Cirata	1989 Under Planning	220	609	4,074	2,392	170 - 160	0.0405	0.534

Note : * Mean Annual Rainfall, Data Period 1920-1945 and 1950-1978

Thiessen Average by NEDECO, 1983

(i) Period September to February

At the beginning of September a cut-back in irrigated area is made based on the storage available. The following rule is adopted :

water level (m)	reduction in area in %
>95	0
95 - 90	5
90 - 85	10
85 - 80	15
<80	20

If a cut-back in area is made then at the same time a 5% reduction in supply for the remaining area is applied.

During the period September - February a further reduction is applied according to the following rules :

water level (m)	reduction for drinking water (%)	reduction for flushing (%)
>90	0	0
90 - 85	10	50
85 - 80	20	75
<80	20	75

(ii) Period March to August

A similar operation as for the period September to February is performed. A decision to cut back on irrigated area is made based on :

water level (m)	reduction in area in (%)
>90	0
90 - 85	5
85 - 80	10
80 - 75	15
<75	20

And a reduction in urban water supply is applied according to the following rules :

water level (m)	reduction drinking water (%)	reduction flushing (%)
>85	0	0
85 - 80	10	50
80 - 75	20	75
<75	20	75

Table A.[illegible] Estimated minimum reliable flows from intercepted rivers (m^3/s) NEDECO,1983

Month	Estimated from flow records			Derived, based on comparison of catchment rainfall with Cibeet			
	Cibeet	Cikarang	Bekasi	Cipamingkis weir	Cihoe diversion	Diversion to Cibeet weir	Cikao *)
Jan	23.3	10.1	24.5	6.8	3.2	14.5	7.7
Feb	24.8	12.2	22.4	7.2	3.5	15.5	8.4
Mar	20.7	12.5	20.1	6.0	2.9	12.9	6.5
Apr	22.5	11.3	22.5	6.5	3.1	14.0	7.4
May	18.8	8.3	18.3	5.5	2.6	11.7	5.4
Jun	5.1	2.6	9.2	1.5	0.7	3.2	0
Jul	2.5	1.3	5.6	0.7	0.3	1.5	0
Aug	1.7	0.7	5.8	0.5	0.2	1.1	0
Sep	1.5	1.0	3.9	0.4	0.2	0.9	0
Oct	1.9	2.3	7.0	0.6	0.3	1.2	0
Nov	10.7	3.7	13.6	3.1	1.5	6.7	1.9
Dec	11.9	4.9	13.3	3.5	1.7	7.4	2.5

*) allowing for increased abstraction upstream.

Table J. 14. Mixing ratios at weirs on the West Tarum Canal, 1979 NEDECO,1983

Year	Section Cibeet - Cikarang			Section Cikarang - Bekasi			Section Bekasi - Jakarta		
	Flows (m^3/s)		Mixing Ratio	Flows (m^3/s)		Mixing Ratio	Flows (m^3/s)		Mixing Ratio
1979	Inflow in Canal at Curug	Inflow in Canal at K.Cibeet	Jatiluhur / Cibeet	Outflow of canal sec. Cibeet-Cik.	flow of Cikarang	Canal/ Cikarang	Outflow of canal sec. Cik. - Bek.	Flow of K.Bekasi	Canal/ K. Bekasi
January	18.7	10.4	1.79	6.5	32.8	0.20	3.2	48.7	0.07
February	16.1	11.8	1.36	7.9	20.8	0.38	3.0	33.7	0.09
March	15.6	12.5	1.25	6.3	18.9	0.33	2.5	30.2	0.08
April	17.9	12.3	1.46	5.2	30.6	0.17	3.0	45.6	0.07
May	16.1	16.2	0.99	6.5	16.8	0.39	3.0	33.8	0.09
June	24.2	10.7	2.27	9.3	10.4	0.89	2.7	27.7	0.10
July	32.9	5.3	6.21	12.0	9.6	1.26	3.0	17.2	0.17
August	37.5	4.7	7.93	13.3	10.4	1.27	3.0	17.1	0.18
September	9.8	6.5	1.51	7.5	9.9	0.75	1.9	22.9	0.08
October	23.1	8.0	2.88	10.8	16.3	0.66	3.1	31.4	0.10
November	27.9	12.5	2.22	13.8	20.0	0.69	5.5	45.8	0.12
December	18.6	13.5	1.38	10.6	17.6	0.60	2.9	30.7	0.09
Average	21.6	10.4	2.62	9.1	17.8	0.64	3.1	32.0	0.1

Table J. 16. Monthly percentage distribution of origin of water in the West Tarum Canal, 1979. NEDECO,1983

Years 1979	Origin of Water in various sections of the West Tarum Canal (%)								
	Section Cibeet - Cikarang		Section Cikarang - Bekasi			Section Bekasi - Jakarta			
	Jatiluhur	Cibeet	Jatiluhur	Cibeet	Cikarang	Jatiluhur	Cibeet	Cikarang	K. Bekasi
January	64.2	35.8	10.6	5.9	83.5	0.7	0.4	5.2	93.7
February	57.7	42.3	15.8	11.6	72.6	1.3	1.0	6.0	91.7
March	55.5	44.5	13.9	11.1	75.0	1.1	0.9	5.7	92.3
April	59.4	40.6	8.6	5.8	85.6	0.5	0.4	5.2	93.9
May	49.8	50.2	13.9	14.0	72.1	1.1	1.1	5.8	92.0
June	69.4	30.6	32.8	14.4	52.8	2.9	1.3	4.7	91.1
July	86.1	13.9	48.0	7.7	44.3	7.1	1.2	6.6	85.1
August	88.8	11.2	49.7	6.3	44.0	7.5	0.9	6.6	85.0
September	60.1	39.9	25.8	17.2	57.0	2.0	1.3	4.3	92.4
October	74.2	25.8	29.5	10.3	60.2	2.7	0.9	5.4	91.0
November	69.0	31.0	28.2	12.6	59.2	3.0	1.4	6.4	89.2
December	58.0	42.0	21.7	15.7	62.6	1.8	1.3	5.3	91.6
Average	66.1	33.9	25.0	11.0	64.0	2.7	1.0	5.6	90.7

Table J. 18. Monthly percentage distribution of origin of water in the West Tarum Canal, 1990. NEDECO,1983

Month		Origin of Water in various sections of the West Tarum Canal (%)								
		Section Cibeet - Cikarang		Section Cikarang - Bekasi			Section Bekasi - Jakarta			
		Jatiluhur	Cibeet	Jatiluhur	Cibeet	Cikarang	Jatiluhur	Cibeet	Cikarang	K. Bekasi
January	I	0	100	0	0	100	0	0	0	100
	II	0	100	0	0	100	0	0	0	100
February	I	0	100	0	11.6	88.4	0	1.7	13.1	85.2
	II	0	100	0	0	100	0	0	10.8	89.2
March	I	32.5	67.5	18.0	37.2	44.8	4.4	9.2	11.1	75.3
	II	41.8	58.2	18.3	25.4	56.3	1.7	2.3	5.1	90.9
April	I	55.6	44.4	27.2	21.7	51.1	3.9	3.1	7.4	58.6
	II	66.7	33.3	46.3	23.2	30.5	15.7	7.9	10.4	66.0
May	I	78.4	21.6	67.0	18.4	14.6	38.0	10.4	8.3	43.3
	II	76.9	23.1	64.5	19.4	16.1	34.7	10.4	8.7	46.2
Juny	I	93.1	6.9	88.5	6.6	4.9	67.7	5.0	3.7	23.6
	II	93.0	7.0	88.6	6.7	4.7	69.1	5.2	3.7	22.0
July	I	96.2	3.8	94.0	3.7	2.3	81.3	3.2	2.0	13.3
	II	94.8	5.2	91.9	5.1	3.0	77.1	4.3	2.5	16.1
August	I	94.6	5.4	92.3	5.3	2.4	74.5	4.3	2.0	19.3
	II	93.4	6.6	90.7	6.4	2.9	71.6	5.0	2.3	21.1
September	I	94.9	5.1	91.7	5.0	3.3	79.3	4.3	2.9	13.5
	II	96.5	3.5	94.1	3.4	2.5	81.3	3.0	2.2	13.5
October	I	96.6	3.4	90.6	3.2	6.2	66.6	2.4	4.5	26.5
	II	97.5	2.5	93.0	2.4	4.6	72.5	1.9	3.6	22.0
November	I	82.9	17.1	75.5	15.6	8.9	43.4	9.0	6.1	42.5
	II	85.6	14.4	79.6	13.4	7.0	51.0	8.5	4.5	36.0
December	I	80.6	19.4	71.8	17.3	10.9	43.5	10.5	6.6	30.4
	II	75.7	24.3	65.1	20.9	14.0	36.3	11.7	7.8	44.2

Table J. 19. Summary of origin of water in West Tarum Canal NEDECO,1983

Canal section	Year	Origin of water in West Tarum Canal (%)							
		Jatiluhur		Cibeet		Cikarang		Kali Bekasi	
		Min	Max	Min	Max	Min	Max	Min	Max
Bekasi - Jakarta	1979	1	7	0	1	4	6	85	94
	1980	1	24	0	4	1	10	62	93
	1990	2	79	0	12	0	13	14	100
Cikarang - Bekasi	1979	11	50	6	17	44	84		
	1980	11	64	10	19	20	79		
	1990	0	93	0	37	2	100		
Cibeet - Cikarang	1979	50	89	11	50				
	1980	53	86	14	47				
	1990	0	98	2	100				
Curug - Cibeet	1979	100	100						
	1980	100	100						
	1990	100	100						

Attachment 3.

Alternative Scheme of Canal 1, Canal 2 and Pipeline System

Fig. Alternative Scheme of Canai 1 and Canal 2 Concerning Jakarta Water Supply (1987-2000)

2. The sufficient Capacity of 1995 Water Demands	3. The Sufficient Capacity of 2000 Water Demands
1A Canal 1, capacity 19.3 m3/s from Curug to Bekasi commissioning date, end of 1990	1B Canal 1, Capacity 30.1 m3/s from Curug to Bekasi commissionign date, end of 1990
2A Canal 2, Capacity 40.8 m3/s Jatiluhur reservoir-Gombong outlet to Cipinang River (DKI-boundary) Irrigation E6,E8 & E9. Commissioning date, end'90	2B Canal 2, Capacity 51.2 m3/s Jatiluhur reservoir - Gombong outlet to Cipinang River(DKI-boundary) Irrigation E6, E8, E9 Commissioning date, end of 1990
3 Canal 1, Capacity 19.0 m3/s (the Urban demands up to 1995) Canal 2, Capacity 31.3 m3/s (the 1995 - 2000 incremental urban demands and irrigation, E 6, E8 and E9) commissioning date, Mid 1995	

* Information from NEDECO, Feasibility Report, March, 1983

Comments for Pipeline system for Water Supply from Jatiluhur Tailrace to Jakarta

In response to the request of DSE on the pipeline system for raw water conveyance from Jatiluhur tailrace to Jakarta as an alternative to the Canal I, NEDECO Study Team estimated the construction/ operation costs as follows :

	Pipeline	Canal
- Construction costs including pipeline, pumping station and land aquisition	Rp. 378.5 billion	Rp.33 billion
- annual operation co.	Rp. 29.9 billion	Rp.4.14 billion
(Present worth-12 % discount rate)	Rp. 244 billion	Rp33.9 billion
- Total present worth	Rp. 622.5 "	Rp66.9 billion

Compared with the both costs of pipeline and Canal systems, it is clear that this plan is not feasible for the raw water conveyance system for water supply, because the pipeline system is costly as almost ten times high as Canal I. It is not only costly, but also will be presented the following difficulties at a technical aspect for the execution of the system.

1. The diameter of this conduit will be 3.6 m for single-line, As it is impossible to manufacture such big diameter pipe as 3.6 m, it must be constructed by shield tunnel method and be more costly. (unit cost will be approximately US$ 12,500 per meter)

2. For double-line conduit, the diameter will be 2.8 m. In this case, welded steel pipe or prestressed concrete pipe be used. In pipelaying works shall be performed by experienced foreign contractors. Width of the land to be acquired will be 12 m, which is almost same width for the Canal.

3. Total power of raw water transmission pumps with a capacity of 30 m3/sec and total head 81 m will be 32,000 KW, of which power will not be admitted to be supplied.

4. Unit cost of Raw water from Jatiluhur to Jakarta will roughly be estimated as follows :

- interest for total investment (12% per year) :	
Rp. 380 billion X 0.12	Rp. 45.6 billion
- Annual operation costs :	Rp. 30.0 billion
Total Annual Expenditure :	Rp. 75.6 billion
- Annual raw water conveyance :	
30 m3/s X 86,400 X 365 days	0.942 billion m3
- Raw water cost :	
Rp. 75.6 billion/0.942 billion m3 =	Rp. 80

Then, present water tariff shall be increased more than double by adding the raw water cost.

Attachment 4.

Water Requirement of Jatiluhur Area

WATER REQUIREMENTS OF JATILUHUR AREA

Of the total water requirements of Jatiluhur area, irrigation demand occupies over 75%. Irrigation water requirements are considered based upon the amount of irrigable land in the river basin, the water demand per hectare, and an assumed rate of land development. The total cultivated area is 214,100 ha at present (1981 - 1982) in the Tarum irrigation area and the total future area is estimated at 236,500 ha.

According to information of Jatiluhur Authority, the Tarum irrigation area consists of the North Tarum area (78,850 ha), the East Tarum area (90,250 ha) and the West Tarum area (45,000 ha). The irrigation areas of the North Tarum and the East Tarum are considered fully developed while the West Tarum area is expected to expand from 45,000 ha to 68,000 ha and then to decrease to 67,400 ha due to urbanization of Jakarta city.

The Tarum irrigation area is supplied by three primary canals, namely the North Tarum, the East Tarum and the West Tarum Canals with water from Jatiluhur reservoir on the Citarum river. Irrigation water is pumped into the West Tarum and the East Tarum Canals at Curug weir and the North Tarum Canal at Walahar weir.

1) West Tarum Area (1990)

The water requirements of the West Tarum area consist of those for irrigation (67,400 ha), Jakarta drinking water, flushing of central Jakarta and flushing downstream of Bekasi and Cikarang weirs. The West Tarum Canal is expected to deliver 14 m^3/sec of drinking water to Jakarta by 1990, and flushing water for central Jakarta which vary from 0 m^3/sec in the wet periods to 5 m^3/sec in the dry periods. A minimum flow of 2 m^3/sec downstream of the Bekasi and Cikarang weirs during the dry period from May to October has been allowed for flushing requirements. The total water requirements of the West Tarum Canal are

1,831 million m^3/year in 1990.

On the other hand, available water from the local rivers of the Bekasi, the Cikarang and the Cibeet is totally 892 million m^3/year. Therefore, annual requirements from Curug weir are 1,092 million m^3/year, including 153 million m^3/year of canal losses.

2) East Tarum Area

The water requirements of the East Tarum area include only irrigation demands for 90,250 ha including canal losses at about 1,921 million m^3/year. The available local inflow is estimated at 893 million m^3/year. Therefore, annual requirements from Curug weir are 1,028 million m^3/year.

3) North Tarum Area

The North Tarum Canal provides irrigation water for an area of 78,850 ha. Local sources for this canal are not available and the total water supply for irrigation is 1,836 million m^3/year diverted from the Citarum river at Walahar weir. Table presents the water requirements consisting of irrigation, flushing and canal losses which total 1,902 million m^3/year at Walahar weir.

4) Total Requirements from Jatiluhur

Water from Jatiluhur reservoir is expected to serve the above three areas at a total of about 4,022 million m^3/year in 1990. Additional flow between Jatiluhur reservoir and Curug weir is contributed to the Citarum river from the Cikao river. Reliable flow of the Cikao river can be used for diversion at Curug or Walahar weirs at about 105 million m^3/year excluding an allowance of 3 m^3/sec for increased future uses in the Cikao river basin itself for domestic and irrigation purposes. Therefore, water resources required from Jatiluhur in 1990 totals 3,917 million m^3/year as shown in Table

The future requirements for 1995 and 2000 from Jatiluhur are estimated as follows:

	Annual Demand ($x\ 10^6\ m^3$) 1995	2000
1. Tarum irrigation	5,500	5,500
2. Supply from local rivers	1,800	1,800
3. From Jatiluhur storage (1. - 2.)	3,700	3,700
4. Additional demand		
Jakarta water supply	1,300	1,600
Irrigation E6, E8 & E9	200	200
5. Total demand on Jatiluhur storage (3. + 4.)	5,200	5,500

(NEDECO,1983)

Table Use of Jatiluhur storage water by 1990

			DEMAND (10^6 m^3)
A.	WTC (enlarged by 1987)		
	Irrigation (67,400 ha)		1,300
	Jakarta drinking water (14 m^3/s)		+ 441
	Flushing Central Jakarta		+ 37
	Flushing downstream of Bekasi and Cikarang weirs *)		+ 53
			1,831
Use of water from local sources			
	Bekasi	421 (10^6 m^3)	
	Cikarang	171	
	Cibeet	300	
	Total	892	
			- 892
			939
	Canal losses		+ 153
	Annual requirement from Curug weir		1,092
B.	ETC		
	Irrigation (90,250 ha)		1,921
	Local inflow		- 893
	Annual requirement from Curug weir		1,028
C.	NTC		
	Irrigation (78,850 ha)		1,611
	Canal losses		+ 225
	Flushing downstream of Walahar		66
	Annual requirement from Walahar weir		1,902
	Total annual requirement at Curug and Walahar weirs		4,022
	Contribution by Cikao river		- 105
	Total annual requirement on Jatiluhur storage*		3,917

NEDECO, 1983

*) Excluding coastal strip requirements and unforeseen developments

Table Water requirements from Jatiluhur (1990) (in m^3/s)

		NTC	ETC	WTC*)	Total at Curug	Monthly average	Contrib. Cikao	Total from Jatiluhur
Jan	I	42.4	0	2.9	45.3	37.2	7.7	29.5
	II	28.3	0	0.7	29.0			
Feb	I	46.3	0	1.0	47.3	41.8	8.4	33.4
	II	34.2	1.8	0.3	36.3			
Mar	I	56.8	21.9	6.4	85.1	102.8	6.5	96.3
	II	68.5	36.1	15.7	120.3			
Apr	I	80.4	53.7	20.0	154.1	174.3	7.4	166.9
	II	93.6	71.7	29.0	194.3			
May	I	110.3	63.4	58.1	231.8	218.6	5.4	212.9
	II	104.6	47.3	53.5	205.4			
Jun	I	78.1	44.6	64.8	187.5	171.9	0	171.9
	II	68.2	28.6	59.4	156.2			
Jul	I	49.4	10.4	53.2	113.0	89.1	0	89.1
	II	28.6	0	36.6	65.2			
Aug	I	11.4	0	24.1	35.5	26.7	0	26.7
	II	0	0	17.8	17.8			
Sep	I	0	13.5	20.8	34.3	73.0	0	73.0
	II	29.8	40.7	14.2	111.7			
Oct	I	54.7	63.7	54.2	172.6	204.0	0	204.0
	II	78.8	82.8	73.7	235.3			
Nov	I	86.1	73.1	52.2	211.4	214.0	1.9	212.1
	II	92.4	62.1	62.1	216.6			
Dec	I	84.9	44.9	48.1	177.9	152.4	2.5	149.9
	II	69.3	22.2	35.4	126.9			
Total**) Volume		1,836	1,028	1,092	3,956	3,956	105	3,851

*) including 1990 drinking water for Jakarta and flushing Central Jakarta.

**) in million m^3

NEDECO, 1983

Table Water requirements from Jatiluhur (1990) at Curug

Unit; m3/sec

		NTC	ETC	WTC*)	Total at Curug	Monthly average
Jan	I	42.4	0	2.9	45.3	37.2
	II	28.3	0	0.7	29.0	
Feb	I	46.3	0	1.0	47.3	41.8
	II	34.2	1.8	0.3	36.3	
Mar	I	56.8	21.9	5.4	85.1	102.8
	II	68.5	36.1	15.7	120.3	
Apr	I	80.4	53.7	20.0	154.1	174.3
	II	93.6	71.7	29.0	194.3	
May	I	110.3	63.4	58.1	231.8	218.6
	II	104.6	47.3	53.5	205.4	
Jun	I	78.1	44.6	64.8	187.5	171.9
	II	68.2	28.6	59.4	156.2	
Jul	I	49.4	10.4	53.2	113.0	89.1
	II	28.6	0	36.6	65.2	
Aug	I	11.4	0	24.1	35.5	26.7
	II	0	0	17.8	17.8	
Sep	I	0	13.5	20.8	34.3	73.0
	II	29.8	40.7	14.2	111.7	
Oct	I	54.7	63.7	54.2	172.6	204.0
	II	78.8	82.8	73.7	235.3	
Nov	I	86.1	73.1	52.2	211.4	214.0
	II	92.4	62.1	62.1	216.6	
Dec	I	84.9	44.9	48.1	177.9	152.4
	II	69.3	22.2	35.4	126.9	
Total (x 10^6m3)		1,836	1,028	1,092	3,956	3,956
Annual Average		58.2	32.6	34.6	125.4	125.4

NEDECO,1983

*) including 1990 drinking water for Jakarta and flushing water for Central Jakarta

Table Water balance for the East Tarum Canal (in m^3/s)

		Requirement at secondary intakes	Available local flows *	Net requirement from Curug	Used locally
Jan	I	42.3	42.0	0	42.0
	II	24.0	42.0	0	24.0
Feb	I	37.0	39.9	0	37.0
	II	41.7	39.9	1.8	38.9
Mar	I	63.1	41.2	21.9	41.2
	II	77.3	41.2	36.1	41.2
Apr	I	95.0	41.3	53.7	41.3
	II	113.0	41.3	71.7	41.3
May	I	107.0	43.6	63.4	43.6
	II	90.9	43.6	47.3	43.6
Jun	I	64.3	19.7	44.6	19.7
	II	48.3	19.7	28.6	19.7
Jul	I	28.6	18.2	10.4	18.2
	II	7.7	18.2	0	7.7
Aug	I	0	15.5	0	0
	II	0	15.5	0	0
Sep	I	24.5	11.0	13.5	11.0
	II	51.7	11.0	40.7	11.0
Oct	I	79.5	15.8	63.7	15.8
	II	98.6	15.8	82.8	15.8
Nov	I	108.4	35.3	73.1	35.3
	II	97.4	35.3	62.1	35.3
Dec	I	92.3	47.4	44.9	47.4
	II	69.6	47.4	22.2	47.4
Total Volume (in 10^6 m3)		1,921	975	1,028	893

* Reliably available flows based on diverted flows during 1976 - 1981

** No further losses have been assumed in the primary canal. Losses from the primary canal are assumed to be re-used at the various downstream weirs.

NEDECO, 1983

Table Water Demand and Available Water from Jatiluhur

Year	Annual Water Demand (x 10^6 m^3) 1990	1995	2000
1) Tarum irrigation	5,756	5,500	5,500
2) Supply from local rivers	1,800	1,800	1,800
3) From Jatiluhur Storage	3,956	3,700	3,700
4) Additional Demand			
A. Jakarta Water Supply	441	1,300	1,600
B. Irrigation (E6,E8,E9)		200	200
5) Total Demand on Jatiluhur Storage		5,200	5,500
6) Available runoff Citarum River (Prefeasibility analysis,1981)		6,100	
7) Reliable supply from Jatiluhur		5,708	
8) Reliable supply, NEDECO,1983		5,400	

Based on
NEDECO,1983

Attachment 5.

Water Demand in Jakarta City

WATER DEMANDS IN JAKARATA CITY

1. Domestic Requirement

Domestic water for Jakarta is obtained from public distribution networks controlled by the public water supply corporation, PDAM, and also from private shallow and deep wells. Water consumption is considered based on population, unit water consumption of various income groups, distribution of the population over these income groups and unit water consumption for industrial, commercial, governmental and other uses.

Domestic water consumption was categorized depending on the income group as follows:

Group I & II	20 lpcd
Group III & IV	150 lpcd
Group V	250 lpcd

On the other hand, groundwater is the supplementary water source for Jakarta city. Groundwater demand has been analyzed for two cases. Cases 1 is for the same water consumption as that of the above figures for piped water consumption. The other, Case 2, is intended for water consumption lower than piped water and these figures are as follows:

Group I & II	20 lpcd
Group III & IV	60 lpcd
Group V	150 lpcd

Table A summarizes the water demand of Jakarta city from 1980 to 2005 as studied by the present JICA Study Team in 1983.

Table A Jakarta Water Demand, 1980-2005

(in units of m^3/sec)

	1980	1985	1990	1995	2000	2005
A. Piped Water						
a. Net Demand	4.7	6.7	9.8	13.7	19.4	21.8
b. Average Demand	10.0	13.1	17.2	22.0	25.7	29.1
c. Maximum Demand	12.0	15.7	20.6	26.4	30.8	34.9
B. Groundwater						
d. Case 1	5.4	7.0	7.9	7.8	7.8	7.0
e. Case 2	4.1	5.2	5.7	5.5	5.4	4.6
C. Total Demand						
f. (c)+(d)	17.4	22.7	28.5	34.2	38.6	41.9
g. (c)+(e)	16.1	20.9	26.3	31.9	36.2	39.5

* JICA Study, 1983

2. Flushing Requirement

Water for flushing means the minimum river maintenance flow required for preventing river pollution and saline water intrusion at the estuaries. For flushing water requirement during the dry season, May to October, a minimum downstream release is considered to improve downstream environmental conditions.

Jakarta flushing requirements were studied in the Jakarta flood control study (NEDECO, 1972). Due to the lack of a separate system in Jakarta city, the open drainage at present acts as a combined flood drainage and open sewer system. The flushing requirements were estimated on the basis of replacing the water contained in a open channel every 24 hours which amounts approximately to a requirement of 1 ℓ/sec/ha. The aspects of spatial and temporal distribution of flushing water should be considered together with the seasonal variations in the river flow.

Assuming a future urban area in Jakarta of 24,000 ha, the overall future flushing water requirement is estimated at 24 m^3/sec. In the Feasibility Study by NEDECO in 1983, the flushing water requirement in Jakarta of 22 m^3/sec was considered, based on the above study. Of the total requirements, the minimum requirement of 6 m^3/sec in September is assumed to be available from flow in the local rivers crossing the city, and the maximum one of 16 m^3/sec in September has to be supplied by Jatiluhur water sources.

Table B summarizes the flushing requirements in Jakarta and gross flushing requirements consist of Central Jakarta (9 m^3/sec), East Jakarta (10 m^3/sec), and South-East Jakarta (3 m^3/sec). The enlarged West Tarum Canal supplies 5 m^3/sec of flushing water to Central Jakarta and after completion of Canal 1B, about 8 m^3/sec of flushing water will be supplied to East Jakarta. Other flushing water is supplied from the local rivers crossing the city. However, there is not source of flushing water in South-East Jakarta for about 3 m^3/sec.

Table B <u>Estimation of flushing requirements : Summary of results (m3/s), NEDECO, 1983</u>

Central Jakarta *	January	February	March	April	May	June	July	August	September	October	November	December
Minimum monthly flow Ciliwung	18	20	20	18	14	10	7	5	4	6	10	13
Drinking water at Pejompongan treatment intake	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
Drinking water supply through tunnel	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
Gross flushing requirements	9	9	9	9	9	9	9	9	9	9	9	9
Flushing requirements through tunnel	0	0	0	0	0	0	2	4	5	3	0	0
Total supply through tunnel	6.7	6.7	6.7	6.7	6.7	6.7	8.7	10.7	11.7	9.7	6.7	6.7
East Jakarta **												
Minimum monthly flow local rivers (see Table 3.6)	6	6	6	4	3	2	2	2	2	2	2	2
Gross flushing requirements	10	10	10	10	10	10	10	10	10	10	10	10
Flushing requirement (from Canal 1 ~~or Canal 2~~)	4	4	4	6	7	8	8	8	8	8	7	7
South-East Jakarta **												
Flushing requirement (from Canal 2)	3	3	3	3	3	3	3	3	3	3	3	3
Total flushing requirement												
Central + East Jakarta	4	4	4	6	7	8	10	12	13	11	7	7
South-East Jakarta	3	3	3	3	3	3	3	3	3	3	3	3
Total requirement	7	7	7	9	10	11	13	15	16	14	10	10

* Supplied by enlarged West Tarum Canal

** to be supplied by Canal 1 and/or Canal 2