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FINAL REPORT

VOLUME III

SUPPORTING REPORT II

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JAPAN INTERNATIONAL COOPERATION AGENCY

DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
MINISTRY OF PUBLIC WORKS
THE REPUBLIC OF INDONESIA

THE STUDY
ON
COMPREHENSIVE MANAGEMENT PLAN
FOR
THE WATER RESOURCES OF THE BRANTAS RIVER BASIN
IN
THE REPUBLIC OF INDONESIA

FINAL REPORT

VOLUME III

SUPPORTING REPORT I

OCTOBER 1998

NIPPON KOEI CO., LTD.
NIKKEN CONSULTANTS, INC.

THE STUDY
ON
COMPREHENSIVE MANAGEMENT PLAN
FOR
THE WATER RESOURCES OF THE BRANTAS RIVER BASIN
IN
THE REPUBLIC OF INDONESIA

COMPOSITION OF REPORTS

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Volume II : ***Main Report***

Volume III : ***Supporting Report I***

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1. Meteorology and Hydrology
2. Watershed Conservation, Sabo, and Flood Control
3 Water Quality.
4. Water Demand Forecast
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6. Water Resources Development
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11. Institutional Study
12. Organization and Management
13. Human Resources Development
14. Financial Plan and Budget Resources
15. Water Charge Mechanism
16. Economic Evaluation
17. Socio-economic Framework

Volume V : ***Data Book***

MH Meteorology and Hydrology
WQ Water Quality
IR Irrigation Water Demand
RS River Survey
CB Community and Beneficiaries' Participation Survey
BI Biodiversity Inventory Survey
AR PJT's Annual Report

EXCHANGE RATE

The exchange rates used in this Study are:
US Dollar(US$) 1.00 = Indonesia Rupiah(Rp.) 2,446.6
Japanese Yen(¥) = Indonesia Rp.21.4
as of June, 1997

N

LOCATION MAP

KALIMANTAN
SUMATRA
JAWA SEA
Jakarta
Surabaya
PROJECT AREA
INDONESIAN OCEAN

SURABAYA URBAN DEVELOPMENT PROJECT
SURABAYA
GUNUNGSARI DAM
KALI SURABAYA RIVER IMPROVEMENT
KASANGPILANG TREATMENT WORKS
BRANTAS DELTA IRRIGATION AREA
MENTURUS RUBBER DAM
BENG IRRIGATION AREA 3200 HA
GOTTAN LOSARI IRRIGATION AREA 4200 HA
NEW LENGKONG DAM
KEDUNGWARAK DAM
JATIN LEBEK RUBBER DAM
BENG DAM
MOJOKERTO
SEMANTOK DAM
WIDAS EXTENSION AREA 2250 HA
BENING DAM
TURI TUNGGORONO IRRIGATION AREA
SIDOARJO
MADURA STRAIT
KALI PORONG RIVER IMPROVEMENT
GLATIK DAM
WIDAS FLOOD CONTROL
NGANJUK
KERTOSONO
PASURUAN
UMBULAN SPRING
KUNCIR DAM
WIDAS SOUTH IRRIGATION AREA 5500 HA
MIDDLE REACH RIVER IMPROVEMENT
MT. ARJUNO
BABADAN DAM
MT. WILIS
KEDIRI
BELORENJO MULTIPURPOSE DAM
K.KONTO II DAM
MT. KELUD
MT. KAWI
MALANG
UPPER BRANTAS WATERSHED MANAGEMENT
TUGU DAM
TULUNGAGUNG
BLITAR
WONOREJO IRRIGATION AREA
TRENGGALEK IRRIGATION AREA
LUMBANGSARI DAM
KEPANJEN DAM
MT. SEMERU
UPPER LESTI WATERSHED MANAGEMENT
KESAMBEN DAM
FLOOD DIVERSION
LESTI LEFT IRRIGATION AREA 2300 HA
LESTI III DAM
GENTENG I DAM
INDONESIAN OCEAN

LEGEND :

- Boundary of Catchment area for Brantas River Basin
- Dam Site
- Completed Project
- Under-Construction Project
- Proposed Project

SCALE
0 5 10 15 20 km

STUDY AREA

N

LOCATION MAP

KALIMANTAN
SUMATRA
JAVA SEA
Jakarta
Surabaya
INDONESIAN OCEAN
PROJECT AREA

SURABAYA URBAN DEVELOPMENT PROJECT
SURABAYA
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JATIM LEREK RUBBER DAM
BENG DAM
MOJOKERTO
SEMANTOK DAM
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TURI TUNGGORONO IRRIGATION AREA
BENING DAM
WIDAS IRRIGATION AREA
WIDAS FLOOD CONTROL
GLATIK DAM
NGANJUK
KERTOSONO
WARUJAYENG IRRIGATION AREA
WIDAS SOUTH IRRIGATION AREA 5500 HA
MIDDLE REACH RIVER IMPROVEMENT
KUNCIR DAM
BABADAN DAM
MRICAN BARRAGE
KEDIRI
MT. WILIS
MT. ARJUNO
SELOREJO MULTIPURPOSE DAM
K KONTO II DAM
MT. KELUD
MT. KAWI
SEGAWE WEIR
WONOREJO DAM
(MT. KELUD DEBRIS CONTROL)
MALANG
TULUNGAGUNG GATE
TULUNGAGUNG
BLITAR
TUGU DAM
WONOREJO IRRIGATION AREA
TRENGGALEK IRRIGATION AREA
LODOYO TULUNGAGUNG IRRIGATION AREA
WLINGI MULTIPURPOSE DAM
LAHOR DAM
LUMBANGSARI DAM
KEPANJEN DAM
UPPER BRANTAS WATERSHED MANAGEMENT
UPPER LESTI WATERSHED MANAGEMENT
MT. SEMERU
LODOYO AFTERBAY
PARIT AGUNG CANAL
SOUTH TULUNGAGUNG TUNNEL
KESAMBEN DAM
SUTAMI MULTIPURPOSE DAM
SENGGURUH DAM
GENTENG I DAM
LESTI III DAM
LESTI LEFT IRRIGATION AREA 2300 HA
FLOOD DIVERSION
TULUNGAGUNG HEPP
INDONESIAN OCEAN

LEGEND :

- Boundary of Catchment area for Brantas River Basin
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SCALE

STUDY AREA

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ABBREVIATIONS

1 UNIT

Length		Weight	
mm	millimeter	gr	gram
cm	centimeter	kg	kilogram
m	meter	t, ton	metric ton
km	kilometer		
Area		**Time**	
mm^2	square millimeter	sec	second
cm^2	square centimeter	min	minute
m^2	square meter	hr	hour
km^2	square kilometer	yr	year
ha	hectare		
Volume		**Others**	
cm^3	cubic centimeter	%	percent
m^3	cubic meter	℃	degree centigrade
Ltr	liter	10^3	thousand
		10^6	million
		10^9	billion

2 PLAN

ADIPURA	Kota Bersih *(Clean City)*
PROKASIH	Program Kali Bersih *(Clean River Program)*
REPELITA VI	Rencana Pembangunan Lima Tahun Tahap VI *(Sixth Five Year Development Plan)*

3 ORGANIZATION

BAPEDAL	Badan Pengendalian Dampak Lingkungan *(Environmental Impact Management Agency)*
BAPEDALDA	Badan Pengendalian Dampak Lingkungan Daerah *(Provincial Office of Environmental Impact Management Agency)*
BAPPEDA	Badan Perencanaan Pembangunan Daerah *(Regional Development Planning Agency)*
BAPPENAS	Badan Perencanaan Pembangunan Nasional *(National Development Planning Agency)*
BBLH	Biro Bina Lingkungan Hidup *(Bureau of Environmental Guidance, East Java)*
BKPMD	Badan Koordinasi Penanaman Modal Daerah *(East Java Regional Investment Coordinating Board)*
BMG	Badan Meteorologi dan Geofisika *(Meteorological and Geophysical Agency)*
BPPI	Balai Penelitian dan Pengembangan Industri, Surabaya *(Agency of Industrial Research and Development, Surabaya)*

BPPT	Badan Pengkajian dan Penerapan Teknologi *(Agency for the Assessment and Application of Technology)*
BPS	Biro Pusat Statistik *(Central Bureau of Statistic)*
BRLKT	Balai Rehabilitasi Lahan dan Konservasi Tanah *(Land Rehabilitation and Soil Consevation Agency, Ministry of Forestry)*
BTKL	Balai Teknik Kesehatan Lingkungan *(Agency of Environment Health Techniques, Ministry of Health)*
DBPP	Direktorat Bina Program Pengairan *(Directorate of Planning and Programming, DGWRD)*
Dep.HUT	Departmen Kehutanan *(Ministry of Forestry)*
Dep.KES/MOH	Departemen Kesehatan *(Ministry of Health)*
Dep.KEU	Departemen Keuangan *(Ministry of Finance)*
Dep.PE/MME	Departemen Pertambangan dan Energi *(Ministry of Mining and Energy)*
Dep.PRINDAG/MIT	Departemen Perindustrian dan Perdagangan *(Ministry of Industry and Trade)*
Dep.PU	Departemen Pekerjaan Umum *(Ministry of Public Works)*
Dep.TAN	Departmen Pertanian *(Ministry of Agruculture)*
DGWRD	Direktorat Jenderal Pengairan *(Directorate General of Water Resources Development, Ministry of Public Works)*
DIPENDA	Dinas Pendapatan Daerah Propinsi Daerah Tingkat I *(Provincial Revenue Service)*
DIPERTA	Dinas Pertanian Daerah Propinsi Daerah Tingkat I *(Provincial Agricultural Service)*
DJBM	Direktorat Jenderal Bina Marga *(Directorate General of Highways, Ministry of Public Works)*
DJCK	Direktorat Jenderal Cipta Karya *(Directorate General of Human Settlements,Ministry of Publiuc Works)*
DPERIKAN	Dinas Perikanan Daerah Propinsi Daerah Tingkat I *(Provincial Fishery Service)*
DPRIND	Dinas Perindustrian Daerah Propinsi Daerah Tingkat I *(Provincial Industry Service)*
DPU	Dinas Pekerjaan Umum *(Public Works Service)*
DPUK	Dinas Pekerjaan Umum Kabupaten *(Municipal Public Works Service)*
DPU Pengairan	Dinas Pekerjaan Umum Pengairan Daerah Propinsi Daerah Tingkat I *(Provincial Water Resources Service)*
GOI	*(Government of Indonesia)* Pemerintah Indonesia
GOJ	*(Government of Japan)* Pemerintah Jepang

HIPPA	Himpunan Petani Pemakai Air *(Water Users Association)*
IBRD	*(International Bank for Reconstruction and Development)*
IPAIR	Iuran Pelayanan Irigasi *(Irrigation Service Fee)*
JICA	*(Japan International Cooperation Agency)*
Kem. Neg. LH	Kementrian Negara Lingkungan Hidup *(State Ministry of Environment)*
KPH	Kesatuan Pemangku Hutan *(Unit of Forestry Management)*
KPPPLH	Komisi Pengendalian dan Penanggulangan Pencemaran Lingkungan Hidup *(Commision for Environmental Pollution Control and Abatement)*
LIPI	Lembaga Ilmu Pengetahuan Indonesia *(Indonesian Institute of Science)*
MIT/Dep.PRIND	*(Ministry of Industry and Trade)* Departemen Perindustrian dan Perdagangan
MME/Dep.PE	*(Ministry of Mining and Energy)* Departemen Pertambangan dan Perdagangan
MOC	*(Ministry of Construction, Japan)*
MOF	(Ministry of Finance)
MOH/Dep.KES	*(Ministry of Health)* Departemen Kesehatan
OECF	*(Overseas Economics Cooperation Fund, Japan)*
PBS	Proyek Induk Pengembangan Wilayah Sungai Bengawan Solo *(Bengawan Solo River Basin Project)*
PDAB	Perusahaan Daerah Air Bersih *(Regional Clean Water Supply Company)*
PDAM	Perusahaan Daerah Air Minum *(Regional Drinking Water Supply Company)*
PGK	Proyek Gunung Kelud *(Volcanic Disaster Prevention Project of Mt. Kelud, DOI)*
PGKS	Proyek Pengendalian Banjir Lahar G. Kelud Semeru *(Volcanic Disaster Prevention Project of Mt. Kelud Semeru)*
PJT	Perum Jasa Tirta *(Jasa Tirta Public Corporation)*
PKB	Proyek Pengembangan Wilayah Sungai Kali Brantas *(Brantas River Basin Development Project)*
PLN	Perusahaan Umum Listrik Negara *(State Electric Power Company)*
PLN PJB II	P.T. PLN Pembangkitan Tenaga Listrik Jawa - Bali II *(PLN Electric Power Generator Corporation Java Bali II)*
POJ	Perum Otoritas Jatiluhur *(Jatiluhur Authority Public Corporation)*
PPPLD	Pengendalian dan Penanggulangan, Pencemaran Limbah Domestik *(Work Team for Controlling and Overcoming Domistic Waste Pollution)*

PPPLI	Pengendalian dan Penanggulangan, Pencemaran Limbah Industri *(Work Team for Controlling and Overcoming Industrial Waste Pollution)*
UNDP	*(United Nations Development Program)*
USAID	*(United States of Agency for International Development)*
WARDEC	*(Water Resources Development Corporation)*

4 OTHERS

APBD	Anggaran Pendapatan dan Belanja Daerah *(Provincial Government Resources and Expenditure Budget)*
APBN	Anggaran Pendapatan dan Belanja Negara *(Central Government Resources and Expenditure Budget)*
BOD	*(Biochemical Oxygen Demand)*
Bupati	*(Head of Regency)*
Camat	*(Head of sub District)*
COD	*(Chemical Oxygen Demand)*
CPI	*(Costumer Price Index)*
DIP	Daftar Isian Proyek *(Development Budget Allocation)*
DO	*(Dissolved Oxygen)*
EOM	*(Effective Operation & Maintenance (ISSD under IBRD)*
FFWS	*Flood Forecasting and Warning System*
GDP	*(Gross Domestic Product)*
GERBANG KERTOSUSILA	Gresik, Bangkalan, Mojokerto, Surabaya, Sidoarjo,Lamongan
GRDP	*(Gross Regional Domestic Product)*
HWL	*(High Water Level)*
IPEDA	Iuran Pendapatan Daerah *(Village Land Tax)*
ISF	*(Irrigation Service Fee)*
ISSP	*(Irrigation Subsector Project) (IBRD Project)*
Kabupaten	*(Regency)*
Kanwil	Kantor Wilayah *(Provincial Office of a Ministry)*
Kecamatan	*(District)*
Kotamadya	*(Municipality)*
LWL	*(Low Water Level)*
O&M	*(Operation & Maintenance)*
Polowijo	*(Second crop or collective term for all annual crops other than paddy and sugarcane)*
SS	(Suspended Solid)

ANNEX - 1

METEOROLOGY AND HYDROLOGY

ANNEX - 1 METEOROLOGY AND HYDROLOGY

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1. Meteorological and Hydrological Observatories

1.1 Meteorological and Hydrological Observatories in the Brantas River Basin

The meteorological and hydrological observations are conducted in the Brantas river basin by various agencies including PJT (Jasa Tirta Public Corporation), Dinas PU Pengairan (Provincial Water Resources Service) and BRLKT (Land Rehabilitation and Soil Conservation Bureau, Ministry of Forestry) as shown in Table A1-1. Some of the meteorological equipment used in those observatories is provided by BMG (Meteorological and Geophysical Center) in Malang. Observed meteorological data must be furnished to BMG by those agencies however this has not sufficiently been achieved yet.

1.2 Meteorological and Hydrological Observation by PJT

(1) Observation Organization in PJT

The Planning and Controlling Unit is responsible for the meteorological and hydrological observation in PJT. The site observation is carried out by ASA I (Division of upstream water service) located close to the Lahor dam and ASA II (Division of downstream water service) located in Kediri. Figure A1-1 shows the organization chart of meteo-hydrological observation in PJT. The data sent from these observatories are compiled at the processing center in Malang. ASA I and ASA II consist of three(3) sub divisions each of which operate all the observatories located in the catchment area of the Brantas river. The historical data of operation and maintenance costs of the observation is as shown in Table A1-2. There is no particular mentioned problem within observation organization in PJT.

(2) Meteorological Observation

The PJT operates 109 meteorological stations as shown in Figure A1-2. ASA I manages 68 stations including 18 telemetering stations of the FFWS (Flood Forecasting and Warning System) stations while ASA II manages 41 stations including eight(8) telemetering stations. Table A1-3 shows the meteorological stations operated by PJT. The rainfall data of 26 telemetering stations are sent to PJT, Malang by the telecommunication system after the installation of FFWS in 1991.

(3) Hydrological Observations

The PJT operates 52 hydrological stations of which 28 stations are operated by ASA I and 24 by ASA II (ref. Figure A1-3 and Table A1-4). The hydrological stations including 21 telemetering stations are conducting water level and outflow observations.

(4) Meteo-hydrological Data Management and Analysis

The Planning and Controlling Bureau is responsible for meteorological and hydrological data management and analysis as well as their observations. Figure A1-4 shows the organization chart of the Planning and Controlling Bureau. In the Planning and Controlling Bureau, "Technical Planning and Controlling Department" and "Computer and FFWS Unit" concern

the meteo-hydrological data collection and its analysis. Table A1-5 shows the job descriptions and problems of sections concerned with meteo-hydrological service in the Technical Planning and Controlling Department.

In the present condition of the Computer and FFWS Unit, even with the roles of each post are well defined, some of the roles are overlapped each other or the tasks have not been decided in detail. Therefore, it is unclear where the responsibility lies for data management and analysis in some cases. Moreover, lack of technical knowledge and unsuitable staffing of several posts apt to deteriorate job quality and to provoke indigestion of their tasks.

The problems of meteo-hydrological data management and analysis within the Planning and Controlling Bureau are caused mainly by the following reasons:

- Lack of basic technical knowledge regarding meteo-hydrological observation, data management and its analysis especially among actual acting staff.
- Communication problem between "Technical Planning and Controlling Department" and "Computer and FFWS Unit". Data and information exchange is not carried out frequently.
- Hydrological analysis has been carried out by both "Technical Planning and Controlling Department" and "Computer and FFWS Unit". The boundary of each task is unclear.

Conceivable measures against such problems are concluded as follows:

(a) Personnel training

On the job training by a long-term meteo-hydrological specialist for the actual acting staff. Both "Technical Planning and Controlling Department" and "Computer and FFWS Unit" staff should be technically trained meteo-hydrological technical matters by the specialist.

(b) Establishment of meteo-hydrological databases and computer network

To create meteo-hydrological databases and sharing meteo-hydrological information between "Technical Planning and Controlling Department" and "Computer and FFWS Unit" utilizing a computer network. This plan includes 1 staff increase (computer specialist) for "Data Processing Center" in Computer and FFWS Unit. As this plan will utilize existing computers, the additional cost will be only for hardware to establish the computer network.

(c) Improvement of organization

To shift "Hydrologica Application" under "Technical Planning and Controlling Department" and staff increase (2 hydrologists) for Hydrological Application. This plan unifies the dispersed information of hydrological analysis between both departments. Simultaneously, the coordinator of "Technical Planning and Controlling Department" will become a full-time position, who holds the position of

"Licensing Water Allocation and Flood Control" also in the present condition, to improve the check function of technical matters.

The improvement plans introduced above are summarized as shown in Table A1-6.

2. Flood Analysis

In order to review the design flood discharge distribution recommended in the previous master plan study (Widas flood control and drainage project), rainfall data for the recent 13 years; 1984 through 1996 are additionally included in the present study while the previous study used the rainfall data for a period of 1960 through 1983. Daily rainfall data of the 23 stations, which are available presently in PJT have rather continuous observation period. Out of above daily rainfall data collected in the Study, annually three-day rainfall, which is an amount of rainfall in a sequence of three-days data, were selected every year. It is considered that three-day rainfall could cover one flood period in the catchment of the Brantas river and the duration.

The 23 rainfall stations are shown in Figure A1-5. Based on the selected three day rainfall amount and the Thiesen polygon shown in Figure A1-5, annual maximum three day basin mean rainfall at the New Lengkong Dam for 13 years are computed as shown in Table A1-7.

The following table shows the probable three day rainfall by Gumbel method of the New Lengkong Dam catchment for the previous master plan study and the present study. The present study have incorporated 37 years of annual maximum three day rainfall including those computed in the previous study and presently computed in the Study.

Return Period (Year)	Previous Study (1960~1983) (mm)	Present Study (1960~1996) (mm)
2	76	73
5	88	86
10	96	94
25	106	105
50	114	113
100	121	121

Estimated probable rainfall in the table show that the present value is almost the same as the previous study.

A recent big flood were observed in March 1984 and March 1992. The maximum discharge at Ploso station were 1,228 m^3/s and 1,078 m^3/s respectively. The discharge of 1228 m^3/s at Ploso station is less than 1,500 m^3/s of the present design flood discharge. The present design flood distribution is not changed and utilized in this study by the reasons mentioned above.

3. Sediment Analysis of the Existing Reservoirs

3.1 General

To formulate a comprehensive water resources management plan, it is necessary to accurately grasp current storage volume and sediment volume as well as to forecast the future sediment intrusion into the reservoirs. The sediment analysis has been carried out including confirmation of the past survey results and re-computation of the reservoir storage.

3.2 Previous Survey

The survey of reservoirs has not been carried out periodically but it was carried out several times in the past, which are compiled in Table A1-8. The PJT has determined in January 1997 to survey all the reservoirs every 2 years.

3.3 Change of the Storage

The following table shows the gross and effective storage of each reservoir:

Name of Reservoir	H.W.L. (El.m)	L.W.L. (El.m)	Original			Latest Survey			(Latest) / (Original)	
			Gross Storage (Mil.m3)	Effective Storage (Mil.m3)	Completion Year	Gross Storage (Mil.m3)	Effective Storage (Mil.m3)	Survey Date	Gross Storage (%)	Effective Storage (%)
Senggruh	292.5	291.4	21.50	2.50	1988	3.37	1.17	Jul.1996	15.7%	46.8%
Sutami	272.5	246.0	343.00	253.00	1972	*183.42*	*146.63*	Aug.1997	53.5%	58.0%
Lahor	272.7	253.0	36.10	29.40	1977	32.88	26.54	Jul.1995	91.1%	90.3%
Wlingi	163.5	162.0	24.00	5.20	1977	4.97	1.41	Nov.1996	20.7%	27.1%
Lodoyo	136.0	125.5	5.80	4.20	1980	2.35	2.35	Nov.1996	40.5%	56.0%
Serolejo	622.0	598.0	62.30	50.10	1970	48.76	44.51	Nov.1993	78.3%	88.8%
Bening	108.6	96.4	32.90	28.40	1981	31.70	28.05	Nov.1993	96.4%	98.8%

Source : PJT, *Italic* is estimated by the Study Team

The above table shows a large reduction in the effective storage of the Sengguruh, Sutami, Wlingi and Lodoyo reservoirs with a range from 27% of the original in Wlingi reservoir to 58% in the Sutami reservoir.

3.4 Evaluation of Sedimentation in Sengguruh and Sutami-Lahor Reservoirs

In August 1997, a new survey in Sutami reservoir has been conducted by PJT. The change of riverbed level of the four cross sections is depicted in Figure A1-6. No big contradictions are observed in the figure as long as a result of four sections is concerned. Figure A1-7 through Figure A1-10 show the change of longitudinal sections of the Sengguruh reservoir along the Brantas and the Lesti rivers as well as that of the Sutami and Lahor reservoirs.

Based on the cross sections and longitudinal sections stated above, it is concluded that the past survey data can be utilized for the volume calculation. Then, the evaluation of past

surveys in the Sengguruh, the Sutami and Lahor reservoirs has been carried out simultaneously.

The reservoir storage capacity in the Sutami reservoir is recomputed by the Study Team as shown in the following table:

Survey Year	Gross Storage		Effective Storage		Storage between El.260m and H.W.L		Remarks
	(Mil.m^3)	(1977) = 100	(Mil.m^3)	(1977) = 100	(Mil.m^3)	(1977) = 100	
1977	261.68	100.0	194.48	100.0	108.19	100.0	Surveyed by HRS
1982	221.29	84.6	167.20	86.0	97.88	90.5	Surveyed by PKB
1987	192.41	73.5	152.87	78.6	95.34	88.1	Surveyed by PKB
1988	193.82	74.1	151.35	77.8	92.77	85.7	Surveyed by PKB
1989	192.39	73.5	152.63	78.5	94.37	87.2	Surveyed by PKB
1992	194.65	74.4	154.81	79.6	96.86	89.5	Surveyed by PJT
1994	185.27	70.8	148.41	76.3	96.31	89.0	Surveyed by PJT
1995	184.59	70.5	148.62	76.4	95.38	88.2	Surveyed by PJT
1997	183.42	70.1	146.63	75.4	94.45	87.3	Surveyed by PJT

Source : Computed by the Study Team.

The change of accumulated sediment volume calculated from the storage shown above is illustrated in Figure A1-11. The figure shows clearly that the completion of the Sengguruh dam in 1988 has contributed to reduce the additional sedimentation in the Sutami reservoir though the possible effect of compaction of the sediment should be taken into consideration. Even though after the Sengguruh reservoir is almost full by accumulated sediment after 1993, the increase of sediment in the Sutami reservoir has been insignificant. The ascent of the riverbed level is possible to be seen at upstream of the Senggruh reservoir after completion of the Senggruh dam. There is a possibility that this "back sand" is the cause of the low level sediment increase in the Sutami reservoir. However, since there is no observation in the riverbed upstream of the Senggruh reservoir, the detailed of regular survey is recommended to confirm the effect of back sand.

3.5 Estimation of the Sedimentation in the Future

The estimation of the effective storage capacity of the Sutami and Lahor reservoir towards year 2020 is required to analyze low flow balance and water availability during drought season against future water demand. The storage in the future is estimated based on the change of sediment volume as follows:

Sutami reservoir

Year	Gross Storage (Mil.m^3)	Effective Storage (Mil.m^3)	Storage between El.260m and H.W.L (Mil.m^3)
2000	180.72	144.76	94.18
2005	176.23	141.64	93.74
2010	171.73	138.52	93.29
2015	167.24	135.40	92.85
2020	162.74	132.28	92.40

Source : Estimated by the Study Team based on the change of the sediment volume from 1987 to 1997.

Lahor reservoir

Year	Gross Storage (Mil.m^3)	Effective Storage (Mil.m^3)	Storage between El.260m and H.W.L (Mil.m^3)
2000	31.99	25.75	20.33
2005	31.09	24.95	19.62
2010	30.20	24.16	18.92
2015	29.30	23.36	18.21
2020	28.41	22.57	17.51

Source: Estimated by the Study Team based on the change of the sediment volume from the original to 1995.

H-V curve of the Sutami and Lahor reservoirs of the latest survey and in 2020 are shown in Figure A1-12.

4. Lowflow Analysis

4.1 General

The observed discharges are subject to various river structures such as dam and barrages, intakes, sluices and so forth. In order to examine low flow balance under various conditions of demand, reservoir capacity etc., a simulated runoff (hereinafter called as "natural flow") is computed assuming no intakes or supply from storage. The method is mentioned below.

The New Lengkong dam site located immediately downstream of the fork of the Surabaya river and the Porong river is selected as the checkpoint of the natural flow in the Brantas river basin based on the following reasons:

- The largest water consumption area within the Brantas river basin extends from the middle and the lower reaches to the delta area which includes Surabaya city, its satellite towns, irrigation fields and fishponds.
- Long-term observed discharge records at the New Lengkong dam are available.
- The outflow from the New Lenkong dam is almost zero during the drought season, and the negligible water is taken from the Porong river downstream of the New Lengkong dam.

Since almost all the tributary flow is consumed by irrigation fields in the drought season, the inflow from the tributaries where irrigation field exists to the Brantas river is very small. Since the inflow from the tributaries will not be expected for the time being, the calculation of the natural flow is limited to the main stream of the Brantas river.

4.2 Natural Flow at the New Lengkong Dam

The 10-day base natural flow at the New Lengkong dam from 1977 to 1996 is calculated based on the observed discharges at the New Lengkong dam by adding the following :

(1) Irrigation intake

- Brantas Atas irrigation (Kekep, Sarem, Prambatan, Gedanklutuk, Ngukir intakes)
- Brantas Bawah irrigation (Sengkaling, Kadalpang intakes)
- Molek irrigation
- Lodagung irrigation
- Warujayeng-Kertosono irrigation (Mrican Kiri irrigation)
- Turi-Tunggorono irrigation (Mrican Kanan irrigation)
- Brantas Kiri Kediri irrigation
- Jatimlerek irrigation
- Menturus irrigation
- Jatikulon irrigation
- Brantas Delta irrigation (Voor canal I, Voor canal II)

Return flow from irrigation area is assumed to 30 % of water taken from each intake.

(2) Industry intake

- PG.Ngadirejo (sugar factory)
- PG.Mrican (sugar factory)
- PG.Lestari (sugar factory)
- PG.Gempol Kerep (sugar factory)
- Ajinomoto

(3) Storage capacity of the Sutami and Lahor reservoirs

(4) Discharge to the Surabaya river (at the Mrilip gate)

The schematic diagram of the methodology of natural flow calculation is illustrated in Figure A1-13. Return flow from the irrigation area is considered as Figure A1-13. The observed discharge at the New Lengkong dam is shown in Table A1-9, the outflow from the Sutami reservoir is shown in Table A1-10, and the total irrigation intake discharges along the Brantas river for 20 years from 1977 to 1996 is shown in Table A1-11 respectively. Figure A1-14 shows the calculated natural flow at the New Lengkong dam for the period 1977 to 1996.

4.3 Drought Year

To work out available discharge during a drought season in the Brantas river basin, total discharge in drought season is analyzed. The drought season is defined as the six months from June to November in the present Study. The total natural flow at the New Lengkong dam during the drought season is compared for the late 20 years. The table shown below includes total natural flow in the drought season, the rank of the runoff in the late 20 years and the water level in the Sutami reservoir.

Year	Potential Flow in drought season (Million m^3)	Rank in 20 years	Water level in Sutami reservoir		
			1 June (Daily average)	30 November (Daily average)	Minimum water level in the drought season
1977	818.90	2	269.61	248.90	247.81
1978	3,927.99	20	273.05	261.21	260.84
1979	1,736.72	12	272.82	261.25	260.59
1980	992.21	4	271.92	N.A.	(257.54)
1981	2,316.85	19	271.13	262.96	257.87
1982	741.05	1	272.34	250.01	249.89
1983	1,846.52	13	272.21	258.82	256.66
1984	1,891.80	14	272.41	261.10	260.00
1985	1,656.38	11	272.44	260.90	260.62
1986	2,063.86	16	272.44	261.56	261.81
1987	891.25	3	270.84	264.03	259.29
1988	1,382.38	8	272.34	261.78	257.86
1989	2,254.38	18	272.80	N.A	(262.81)
1990	1,211.62	7	272.23	259.91	259.83
1991	1,053.75	6	272.36	261.58	261.03
1992	2,135.94	17	272.34	262.74	260.73
1993	1,492.73	9	272.43	260.51	256.60
1994	1,033.85	5	272.50	259.18	257.86
1995	2,008.16	15	272.40	266.12	263.23
1996	1,597.57	10	272.42	259.64	259.42

Source : Potential flow is calculated by the Study Team. Water level is from PJT.

Remarks : Minimum water level in 1980 and 1989 are the lowest water level within the available data.

Based on the above table, the year 1977 that is the second serious drought year in the late 20 years is adopted as a 10-year drought year. Figure A1-15. illustrates the observed discharge and the natural flow at the New Lengkong dam in three years of 1982, 1977 and 1987 which respectively correspond to the first, second and third doughtiest year in the late 20 years.

4.4 Miscellaneous Flow

The miscellaneous inflow and outflow between the Sutami dam and New Lengkong dam that is not included in the potential flow simulation is estimated for 1996 case as presented in Table A1-12. The table shows that the discharge of 9.89 m^3/s at a minimum in 10-day average flows into the Brantas river at the river range from the Sutami dam to the New Lengkong dam.

Table A1-1 Meteorological and Hydrological Observation in the Brantas River Basin

・Meteorological Observation

Observation Agency		Number of Observatories	Remarks
PJT	ASA I (Division of upstream water service)	68	63 stations observe only rainfall.
	ASA II (Division of downstream water)	41	38 stations observe only rainfall.
	Total	109	
DPU Pengairan	Coordination office of region I, Malang	59	Rainfall only.
	Coordination office of region II, Kediri	112	Rainfall only.
	Coordination office of region III, Jombang	98	Rainfall only.
	Coordination office of region IV, Mojokerto	59	Rainfall only.
	Total	328	
BRLKT		6	Rainfall only.
DIPERTA		3	Rainfall only.

・Hydrological Observation

Observation Agency		Number of Observatories	Remarks
PJT	ASA I	28	
	ASA II	24	
	Total	52	
BRLKT		6	
PGK		5	Bed load only.

Source : Surveyed by the Study Team

Remarks : Within the Brantas river basin, several agency such as BMG, the sugar factories, the universities observe rainfall in addition to the above table.

Table A1-2 Operation and Maintenance Budget of the Observation in 1997

No.	Area	Unit	Nos.	Cost (Rp.)
	Central Office (Malang)			
1	Periodical O & M for FFWS	Unit	1	100,000,000.00
2	Occasional Maintenance for FFWS	Unit	1	200,000,000.00
	Sub Total			300,000,000.00
	Division of Upstream Water Service (ASA - I)			
1	Sumber Brantas	Unit	1	351,000.00
	- Meteorological Station			
2	Sengguruh Dam			
	- Meteorological Station	Unit	1	351,000.00
	- Rainfall Station	Unit	22	10,450,000.00
	- FFWS Station	Unit	6	1,080,000.00
3	Sutami Dam/Lahor Dam			
	- Meteorological Station	Unit	1	351,000.00
	- Rainfall Station	Unit	9	4,275,000.00
	- FFWS Station	Unit	4	720,000.00
4	Wlingi Dam/Lodoyo Dam			
	- Meteorological Station	Unit	1	351,000.00
	- Rainfall Station	Unit	7	3,325,000.00
	- FFWS Station	Unit	3	540,000.00
5	Selorejo Dam			
	- Meteorological Station	Unit	1	351,000.00
	- Rainfall Station	Unit	9	4,275,000.00
	- FFWS Station	Unit	3	540,000.00
6	Parit Raya/Parit Agung			
	- Meteorological Station	Unit	1	351,000.00
	- Rainfall Station	Unit	26	12,350,000.00
	- FFWS Station	Unit	5	900,000.00
	Sub Total			40,561,000.00
	Division of Upstream Water Service (ASA - II)			
1	Bening Dam			
	- Meteorological Station	Station	2	1,400,000.00
	- Rainfall Station	Station	16	3,000,000.00
	- Salary of worker	Month	12	8,406,000.00
2	Kediri			
	- Meteorological Station	Unit	1	504,000.00
	- Rainfall Station	Unit	11	1,496,000.00
	- Salary of worker	Month	12	4,800,000.00
3	Porong			
	- Salary of worker	Month	12	960,000.00
4	Brantas Downstream			
	- Meteorological Station	Station	10	1,000,000.00
	- Salary of worker	Month	12	1,300,000.00
	Sub Total			22,866,000.00
	T o t a l			**363,427,000.00**

Source : PJT

Table A1-3 Meteorological Station by PJT (1/2)

No.	Name of Station	Observation Items	Established Year	Managed by
	BRANTAS UPSTREAM AREA			
1	Senggurah	a,b,c,d,e,f	1982	ASA I (FFWS)
2	Pagak	a	1984	ASA I
3	Gondanglegi	a	1979	ASA I
4	Turen	a	1982	ASA I
5	Tawangrejeni	a	1985	ASA I
6	Srimulyo	a	1983	ASA I
7	Ampel Gading/Tirtoyudo	a	1980	ASA I
8	Patok Picis	a	1983	ASA I
9	Gubuk Klakah	a	1980	ASA I
10	Jabung	a	1979	ASA I
11	Singosari	a	1979	ASA I
12	Wagir	a	1979	ASA I (FFWS)
13	Dau	a	1985	ASA I
14	Sumber Brantas	a	1980	ASA I
15	Malang			
	a. Perum Jasa Tirta	a	1982	ASA I
	b. Brawijaya University	a,b,c,d,e,f,g,h,i	1972	ASA I
16	Poncokusumo	a	1979	ASA I (FFWS)
17	Tangkil	a	1979	ASA I (FFWS)
18	Dampit	a	1979	ASA I (FFWS)
	HYDROELECTRIC AREA			
19	Sutami Dam (Joint Control with BMG)	a,b,c,d,e,f,h	1964	ASA I (FFWS)
20	Selorejo Dam	a,b,c,d,e,f	1967	ASA I (FFWS)
21	Wlingi Dam	a,b,c,d,e,f,i	1972	ASA I (FFWS)
22	Jajagan	a	1978	ASA I
23	Talangagung	a	1980	ASA I
24	Babadan	a	1978	ASA I
25	Pujon	a	1978	ASA I (FFWS)
26	Kedungrejo	a	1977	ASA I
27	Batu	a	1979	ASA I
28	Blitar	a	1980	ASA I
29	Garum	a	1980	ASA I
30	Semen	a	1980	ASA I (FFWS)
31	Badak	a	1980	ASA I
32	Birowo	a	1980	ASA I (FFWS)
33	Sutojayan	a	1980	ASA I
34	Bendosari	a	1981	ASA I
35	Doko	a	1991	ASA I (FFWS)
36	Tunggorono	a	1991	ASA I (FFWS)
37	Nyunyur	a	1980	ASA I
38	Pagersari	a	1979	ASA I
39	Jomblok	a	1979	ASA I
40	Bangelan	a	1977	ASA I
41	Sumber Agung	a	1978	ASA I (FFWS)
42	Wates Wlingi	a	1991	ASA I (FFWS)
	TULUNGAGUNG AREA			
43	Bendo Dam	a	1977	ASA I
44	Tumpakmargo	a	1981	ASA I
45	Sendang	a	1977	ASA I
46	Jimbe Kademangan	a	1980	ASA I
47	Keboireng Besuki	a	1980	ASA I
48	Karangtuwo	a	1980	ASA I
49	Jati Karangan	a	1980	ASA I
50	Gandekan	a	1980	ASA I
51	Jaeyan	a	1980	ASA I
52	Pule	a	1981	ASA I
53	Paingan Dam	a	1981	ASA I
54	Bagong Dam	a	1981	ASA I

Source : PJT

Remarks : a; Precipitation, b; Temperature, d; Evaporation, e; Sunshine duration, f; Humidity, g; Solar radiation, h; Wind velocity, i; Soil temperature
ASA I; Division of upstream water service, ASA II; Division of downstream water service

Table A1-3 Meteorological Station by PJT (2/2)

No.	Name of Station	Observation Items	Established Year	Managed by
55	Sumber Pandan	a	1981	ASA I
56	Widoro Dam	a	1982	ASA I
57	Boyolangu	a	1982	ASA I
58	Prambon Dam	a	1982	ASA I
59	Dongko	a	1984	ASA I
60	Salam	a	1984	ASA I
61	Watulimo	a	1984	ASA I
62	Campurdarat	a	1981	ASA I
63	Pangkal	a	1984	ASA I
64	Tangkilan (Besuki - Neyama)	a	1980	ASA I
65	Tapan	a	1980	ASA I
66	Pagerwojo	a	1974	ASA I (FFWS)
67	Kampak	a	1974	ASA I (FFWS)
68	Tugu	a	1974	ASA I (FFWS)
	BRANTAS MIDDLE REACH AREA			
69	Mrican Barrage	a,b,c,d,e,f,h	1977	ASA II
70	Mojoagung	a,c,d,e,f,h	1977	ASA II
71	Ploso	a	1978	ASA II
72	Siman	a	1980	ASA II
73	Wates	a	1980	ASA II (FFWS)
74	Kandangan	a	1980	ASA II
75	Pagu Menang	a	1980	ASA II
76	Mojo Besuki/Wilis	a	1980	ASA II (FFWS)
77	Blimbing	a	1980	ASA II
78	Jombang	a	1980	ASA II (Out of order)
79	Prambon	a	1981	ASA II
80	Lengkong	a	1981	ASA II
81	Pare	a	1982	ASA II
82	Begendeng	a	1986	ASA II
83	Jeli	a	1991	ASA II (FFWS)
84	Kediri	a	1991	ASA II (FFWS)
85	Kertosono	a	1977	ASA II (FFWS)
	WIDAS AREA			
86	Ngudikan	a	1974	ASA II
87	Gemarang	a	1975	ASA II
88	Widas/Bening Dam	a,b,c,d,e,f,h	1975	ASA II
89	Ngliman	a	1978	ASA II
90	Sawahan	a	1979	ASA II
91	Loceret	a	1981	ASA II
92	Kalimati	a	1981	ASA II
93	Ngrambek	a	1981	ASA II
94	Semantok	a	1981	ASA II
95	Ngluyu	a	1981	ASA II
96	G. Lengko	a	1981	ASA II
97	Pace	a	1981	ASA II
98	Tunglur	a	1981	ASA II
99	Berbek	a	1991	ASA II (FFWS)
100	Wates Sawahan	a	1991	ASA II (FFWS)
	BRANTAS DOWNSTREAM AREA			
101	Semimi	a	1970	ASA II (Out of order)
102	Gubeng Dam	a	1972	ASA II
103	Memung	a	1975	ASA II
104	Porong	a	1978	ASA II
105	Kabuh	a	1978	ASA II
106	Sumberaji	a	1978	ASA II
107	Sukodadi	a	1978	ASA II
108	Mojokerto	a	-	ASA II
109	Tampung	a	1980	ASA II (FFWS)

Source : PJT

Remarks : a; Precipitation, b; Temperature, d; Evaporation, e; Sunshine duration, f; Humidity, g; Solar radiation, h; Wind velocity, i; Soil temperature

ASA I; Division of upstream water service, ASA II; Division of downstream water service

Table A1-4 Hydrological Stations by PJT

No.	Name of Station	Name of River	Established Year	Discharge Data	Managed by
	BRANTAS UPSTREAM AREA				
1	Sengguruh Dam	Brantas	1988	O	ASA I (FFWS)
2	Pandanpuro	Lanang	1986	-	ASA I
3	Madyopuro	Amprong	1986	-	ASA I (No operation from 1996)
4	Wandanpro	Manten	1986	-	ASA I
5	Kedung Pendaringan	Brantas	1986	-	ASA I
6	Gadang	Brantas	1978	O	ASA I (FFWS)
7	Sumber Kembar	Genteng	1986	-	ASA I
8	Clumprit	Lesti	1989	O	ASA I
9	Tawangrejeni	Lesti	1986	O	ASA I (FFWS)
10	Blobo	Brantas	1986	O	ASA I
	HYDROELECTRIC POWER AREA				
11	Sutami Dam	Brantas	1974	O	ASA I (FFWS)
12	Selorejo Dam	Brantas	1972	O	ASA I (FFWS)
13	Wlingi Dam	Brantas	1979	O	ASA I (FFWS)
14	Lahor Dam	Lahor	1976	O	ASA I
15	Lodoyo Barrage	Brantas	1983	O	ASA I (FFWS)
16	Kali Bambang	Bambang	1980	-	ASA I
17	Kali Legi	Legi	1989	-	ASA I
18	Kali Biru	Biru	1989	-	ASA I
19	Kali Metro	Metro	1989	-	ASA I
20	Jugo	Brantas	1989	-	ASA I
21	Kedungrejo	Konto	1989	-	ASA I
22	Tangkil	Lekso	1989	-	ASA I
	TULUNGAGUNG AREA				
23	Bendungan	Bendungan	1982	-	ASA I
24	Paingan Dam	Bodeng	1991	-	ASA I
25	Kali Song	Song	1982	-	ASA I
26	Ngujang	Brantas	1972	-	ASA I (Replaced from Pakel)
27	Bendo	Parit Raya	-	O	ASA I (FFWS)
28	Inlet Gate	South T.Agung	-	O	ASA I (FFWS)
	BRANTAS MIDDLE REACH AREA				
29	Mrican Barrage	Brantas	1973	O	ASA II (FFWS)
30	Kertosono	Brantas	1984	O	ASA II (FFWS)
31	Keras	Keras	-	-	ASA II
32	Jongbiru	Brantas	1977	O	ASA II
33	Ploso	Brantas	1989	O	ASA II (FFWS)
34	Jeli	Brantas	-	O	ASA II (FFWS)
35	Kediri	Brantas	1989	O	ASA II (FFWS)
36	Menturus	Brantas	1993	O	ASA II
	WIDAS AREA				
37	Sawahan	Kuncir	1979	-	ASA II
38	Keringan	Kuncir	1979	-	ASA II
39	Ketandan	Ketangan	1988	-	ASA II
40	Petung	Petung	-	-	ASA II
41	Semantok	Semantok	1993	-	ASA II
42	Kedung Suko	Kedung Soko	-	-	ASA II
43	Lengkong	Widas	-	O	ASA II (FFWS)
44	Bening Dam/Widas	Bening	-	O	ASA II (FFWS)
	BRANTAS DOWNSTREAM AREA				
45	Memung Upstream	Marmoyo	1975	-	ASA II
46	Porong	Porong	-	O	ASA II (FFWS)
47	Perning	Surabaya	-	O	ASA II (FFWS)
48	Sepanjang	Surabaya	1977	-	ASA II
49	Gunungsari	Surabaya	-	O	ASA II (FFWS)
50	Jagir Upstream	Surabaya	1978	O	ASA II
51	Mojokerto	Brantas	-	O	ASA II
52	New Lengkong	Brantas	-	O	ASA II (FFWS)

Source : PJT

Remark : O ; Data available , - ; Data not available

ASA I ; Division of upstream water service , ASA II ; Division of downstream water service

Table A1-5 Job Description and Problems of Sections Concerned Meteo-hydrological Services in Technical Planning and Controlling Department

Name of Position		Number of Staff	Job Description in the Present Condition	Problems
Technical planning and controlling department	Chief of technical planning and controlling department	1	Controlling survey, investigation, evaluation on meteo-hydrology and research for the sake of company operation.	As it is impossible to control in detail, the checking function of technical output is not enough.
			Management of reservoir operation pattern and flood warning manual.	- do -
			Controlling technical recommendation of licensing on water usage, sand mining, land , water, waste disposal and environmental protection, both in operational or conceptual manners.	- do -
	Coordinator	1	Coordinating survey and investigation and technical controlling for the sake of planning operation.	As coordinator holds the position of licensing water allocation and flood control in the present consition, verification of the technical matter is not enough.
			Preparing reservoir operation pattern and flood warning manual.	- do -
			Evaluating technical recommendation.	- do -
			Coordinating technical planning control.	- do -
	Licensing water allocation and flood control	1	Responsible for technical recommendation as the requirement of licensing water usage.	As PJT does not manage all Brantas river basin, it is impossible to license in total balance in the basin.
			Responsible for water allocation pattern, reservoir operation in dry and rainy seasons.	Lowflow management is not based on actual rainfall, but based on only the forcast.
			Responsible for making flood warning manual.	Flood warning manual is not revised every year properly. Basical hydrological analysis such as creating H-Q curve is very poor.
	Survey and investigation	3	Responsible for both the subcontracted or self management surveys as well as the technical requirement.	No understanding to the purpose of each survey. Delay of result of each survey. Lack of initiative to subcontractors. Lack of verification ability for the survey result from subcontractors.
			Responsible for maintenance of survey and investigation instrument at head	Maintenance for imported instrument in Indonesia.

Sourse : The Study Team

Table A1-6 Countermeasures to Improve Meteo-hydrological Data Management and Analysis

Problems to be Improved	Effect	Procedure
• Personnel training		
•Lack of technical knowledge regarding to meteo-hydrological observation, data management and its analysis especially among actual acting staff. It has a bad influence on the quality of technical output from PJT.	•Improvement of technical output by understanding of the purpose and method of tasks. •To know the data management and analysis procedure.	•To dispatch a long-term meteo-hydrological technical specialist by foreign aid. •The specialist trains both 'Technical Planning and Controlling Department' and 'Computer and FFWS Unit'. •The specialist educates both purpose and method of meteo-hydrological observation in the site observatories.
• Establishment meteo-hydrological database and computer network		
•Data and information exchange between 'Technical Planning and Controlling Department' and 'Computer and FFWS Unit' is not frequently. It result in lack of utilization of useful information and meteo-hydrological contradiction or difference of technical output.	•Easy to share data and information between 'Technical Planning and Controlling Department' and 'Computer and FFWS Unit' •Possible to keep the latest data or information in the server machine. •Easy to manage meteo-hydrological data.	•Establishing meteo-hydrological database and sharing data and information between 'Technical Planning and Controlling Department' and 'Computer and FFWS Unit'. •Utilizing existing computers. •Creating unified data and analysis format. •Data input by site staff with existing computers and compiled by Data Processing Center. -1 staff increase (computer specialist) of 'Data Processing Center' to manage computer network and database system. Rp.1,500,000/month is estimated as salary. •Rp.3,200,000 is estimated to establish network system for 10 machines. •To create database, existing application will be utilized for easy use.
• Improvement of organization		
•Hydrological analysis has been carried out by both 'Technical Planning and Controlling Department' and 'Computer and FFWS Unit'. The boundary of each task is unclear. •Lack of staff for meteo-hydrological analysis has a bad influence of the quality of technical output.	•To avoid task overlap. •To share tasks properly. •Strengthen of checking function for technical output.	•To shift 'Hydrological Application' under 'Technical Planning and Controlling Department' from 'Computer and FFWS Unit' to unify hydrological analysis section. •2 staff increase (hydrologist) of 'Hydrological Application' to digest tasks with satisfied quality. The coordinator of 'Technical Planning and Controlling Department', who holds the position of 'Licensing Water Allocation and Flood Control' in the present condition, will be concentrated on coordination task instead to improve the check function of technical matters. Rp.3,000,000/month is estimated as salary for 2 staff.

Table A1-7 Annual Maximum 3-day Basin Mean Rainfall at the New Lengkong Dam

Year	Period	3-day rainfall (mm)	Remarks
1960	1-3 March	81	
1961	17-19 February	92	
1962	21-23 January	88	
1963	1-3 February	68	
1964	2-4 March	109	
1965	2-4 February	72	Period Covered
1966	14-16 March	83	by the
1967	2-4 January	77	Previous Study
1968	5-7 February	72	
1969	22-24 January	76	
1970	20-22 January	68	
1971	18-20 November	86	
1972	6-9 March	73	
1973	1-3 March	64	
1974	26-28 February	62	
1975	23-25 December	73	
1976	1-3 March	104	
1977	18-20 January	87	
1978	1-3 January	80	
1979	5-7 March	71	
1980	20-22 February	68	
1981	6-8 January	80	
1982	24-26 December	67	
1983	28-30 December	71	
1984	3-5 February	90	
1985	6-8 March	80	
1986	7-9 Jaunty	53	
1987	2-4 January	75	Period Added
1988	23-25 January	69	in the
1989	31-2 December	54	Present Study
1990	1-3 January	63	
1991	5-7 January	60	
1992	8-10 January	92	
1993	7-9 April	48	
1994	24-26 March	73	
1995	20-22 January	79	
1996	21-23 March	70	

Source : Data from PJT.

Table A1-8 Surveys in Reservoirs

Name of Reservoirs	No.	Survey Date	Survey Data	Surveyed by	Report	Published by	Remarks
Senggruh	1	1987	O	PKB	-	-	Before impounding.
	2	June 1989	O	PKB	-	-	
	3	January 1992	O	PKB	-	-	
	4	October 1993	O	PJT	O	PJT	
	5	July 1996	O	PJT	O	PJT	
Sutami	1	1973	-	PKB	-	-	Survey result is poor.
	2	June 1977	O	HRS	O	HRS	
	3	July 1980	O	NK	O	NK	
	4	1981	-	PKB	O	PKB	Survey data not found.
	5	June 1982	O	PKB	O	PKB	
	6	1983	-	PKB	O	PKB	Survey data not found.
	7	March 1984	-	PKB	O	PKB	Survey data not found.
	8	1985	-	PKB	O	PKB	Survey data not found.
	9	1986	O	PKB	O	PKB	
	10	1987	O	PKB	O	PKB	
	11	June 1988	O	PKB	-	-	
	12	August 1989	O	PKB	-	-	
	13	April 1992	O	PJT	O	PJT	
	14	1994	O	PJT	O	PJT	
	15	June 1995	O	PJT	O	PJT	
	16	August 1997	O	PJT	-	-	
Lahor	1	July 1987	O	PKB	-	-	
	2	September 1988	O	PKB	-	-	
	3	September 1989	O	PKB	-	-	
	4	1994	O	PJT	O	PJT	
	5	1995	-	PJT	O	PJT	Survey data not found.
Wlingi	1	July 1982	O	HRS	O	HRS	
	2	1985	-	PKB	O	PKB	
	3	April 1986	O	PKB	O	PKB	
	4	1987	O	PKB	O	PKB	
	5	July 1996	O	PKB	O	PKB	Different beacons with the previous.
	6	August 1996	O	PKB	-	-	Different beacons with the previous.
Lodoyo	1	October 1993	O	PJT	O	PJT	
	2	August 1996	O	PKB	-	-	Different beacons with 1996's.
Serolejo	1	June 1977	O	HRS	O	HRS	
	2	June 1982	O	HRS	O	HRS	
	3	1983	-	PKB	O	PKB	Survey data not found.
	4	1986	O	PKB	-	-	
	5	1988	O	PKB	-	-	
	6	1993	-	PJT	O	PJT	
Bening	1	November 1993	-	PJT	O	PJT	Survey data not found.

Source : The Study Team

Remarks : O ; Available
- ; Not Available
HRS ; Hydraulics Research Station
NK ; Nippon Koei Co.,LTD

Table A1-9 10-day Discharges at the New Lengkong Dam

Unit : m^3/s

Month	10-day	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
January	1st	136.57	304.98	594.58	199.62	317.54	395.29	309.64	218.22	225.29	377.97	463.20	56.30	320.80	247.50	194.70	194.70	312.75	60.58	69.98	214.92
	2nd	133.56	263.14	560.58	316.86	329.50	480.08	265.70	334.36	337.82	222.71	227.90	178.70	266.20	151.90	362.80	352.80	352.10	293.42	184.62	207.51
	3rd	308.09	302.10	645.92	392.81	373.80	431.08	137.94	447.71	355.18	271.49	362.90	518.90	199.40	262.40	387.00	425.60	423.67	267.26	302.16	284.15
February	1st	265.20	326.16	549.60	252.91	348.49	495.84	327.81	602.71	379.14	304.84	385.10	408.00	122.70	244.60	331.20	447.20	442.02	371.60	459.70	255.77
	2nd	234.58	381.14	535.00	349.76	256.90	421.72	296.68	568.78	341.59	474.45	650.90	237.20	323.50	172.90	325.90	436.30	182.99	380.00	417.11	314.89
	3rd	238.88	428.47	579.75	456.93	421.51	358.34	314.91	354.07	344.66	254.55	549.90	109.80	367.70	372.90	240.00	282.50	154.04	288.09	362.62	346.25
March	1st	257.89	258.31	425.80	274.68	375.95	455.44	299.65	570.08	549.90	317.33	437.80	142.20	255.30	393.20	270.10	224.00	93.51	500.14	325.09	188.15
	2nd	356.20	412.36	293.65	209.60	266.44	495.22	329.39	404.30	347.70	338.49	229.60	301.20	144.50	249.20	160.40	613.20	205.17	448.03	476.78	289.98
	3rd	383.09	427.74	318.91	144.82	218.16	237.10	352.52	330.95	349.30	522.09	209.70	253.80	140.00	138.80	98.00	308.40	279.56	582.51	444.30	241.72
April	1st	321.20	212.99	293.35	129.54	215.50	244.32	244.65	365.17	283.02	575.88	91.00	161.30	333.40	77.20	250.20	430.50	446.18	260.37	442.72	26.97
	2nd	212.37	261.78	426.00	291.98	92.87	229.64	207.71	574.42	256.68	448.62	30.50	51.40	157.90	75.30	304.90	416.70	400.29	252.17	247.18	326.59
	3rd	152.60	88.34	386.40	269.80	166.55	210.86	276.11	231.06	304.89	262.66	39.50	39.40	119.90	86.00	364.50	227.10	216.28	205.88	69.19	177.35
May	1st	40.32	202.94	542.40	165.48	299.00	77.08	457.24	196.51	121.76	70.47	47.00	132.40	196.90	8.10	165.30	70.70	114.99	80.44	109.58	4.87
	2nd	12.12	368.08	384.60	17.61	293.18	7.91	358.33	163.10	51.86	37.22	22.80	153.10	98.30	65.40	36.20	33.00	14.12	43.43	36.15	0.00
	3rd	9.04	314.07	413.18	1.26	69.09	0.27	354.68	90.30	49.04	16.02	4.20	67.10	162.20	191.30	1.30	94.40	9.03	0.00	1.35	0.10
June	1st	37.23	477.55	373.60	0.00	27.16	0.00	159.08	27.89	275.99	71.77	23.20	31.40	312.50	49.60	0.00	111.20	10.32	0.00	8.65	0.00
	2nd	31.83	440.28	257.00	0.00	17.26	0.00	103.57	54.78	160.45	160.44	2.80	15.40	297.90	0.00	0.00	7.90	131.48	0.00	48.55	0.00
	3rd	37.59	299.02	31.06	0.00	174.54	0.00	29.70	11.33	65.16	89.64	1.30	0.00	144.80	38.20	1.60	0.00	42.30	0.00	110.19	0.00
July	1st	0.00	540.91	12.98	0.00	83.06	0.00	36.35	40.13	11.37	118.27	0.00	0.00	75.20	30.20	0.00	5.90	0.00	0.00	1.54	0.00
	2nd	0.00	251.14	21.95	0.00	193.68	0.00	31.97	1.26	27.55	29.93	0.00	0.00	66.00	0.00	0.00	0.00	0.00	0.00	0.68	0.00
	3rd	0.00	163.07	1.88	1.23	56.91	5.26	0.00	0.00	11.39	15.15	0.00	0.00	135.80	0.00	0.00	0.00	0.00	0.00	0.94	0.27
August	1st	0.00	106.97	21.70	2.72	7.38	0.00	0.55	0.00	9.76	13.29	0.00	0.00	64.40	0.00	0.00	0.00	0.00	0.00	0.00	1.05
	2nd	0.00	80.35	4.48	0.00	1.37	0.00	0.00	0.00	5.65	1.15	0.00	0.00	19.00	0.00	0.00	0.00	0.00	0.00	0.00	35.36
	3rd	0.00	37.06	0.00	0.00	20.38	0.00	0.00	11.13	2.57	10.30	0.00	0.00	0.00	11.50	0.00	0.00	0.00	0.00	0.00	0.62
September	1st	0.00	91.19	0.00	0.00	6.99	0.00	0.00	48.92	1.22	20.40	0.00	0.00	0.00	19.00	0.00	55.80	0.00	0.00	0.00	0.00
	2nd	0.00	55.79	0.00	0.00	2.71	0.00	0.00	167.04	0.00	5.36	0.00	0.00	0.00	18.60	0.00	0.00	0.00	0.00	0.00	0.00
	3rd	0.00	72.62	0.00	0.00	50.04	0.00	0.00	63.42	0.00	14.12	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00
October	1st	0.00	61.07	0.00	0.00	97.88	0.00	0.00	129.10	0.00	8.13	0.00	0.00	0.00	5.20	0.00	64.80	0.00	1.10	0.00	5.27
	2nd	0.00	34.31	0.00	0.00	32.27	0.00	11.90	73.77	0.00	76.82	0.00	0.00	0.00	2.20	0.00	34.90	0.00	4.15	0.00	0.50
	3rd	0.00	75.64	0.00	0.18	27.50	0.00	66.91	15.28	40.37	23.21	0.00	0.00	12.30	2.50	0.00	53.40	0.00	0.00	0.00	38.99
November	1st	0.00	73.17	0.76	1.49	11.66	0.00	105.40	0.00	16.03	107.73	0.00	0.00	131.30	5.90	0.00	57.70	0.00	0.00	0.00	66.07
	2nd	0.00	172.91	1.53	23.37	111.44	0.00	174.48	4.16	0.39	109.73	0.00	174.68	32.80	0.00	1.40	53.60	5.14	0.00	106.53	121.22
	3rd	0.00	115.18	2.69	168.64	228.62	0.00	237.49	85.94	61.77	171.96	19.60	58.20	0.00	8.80	9.50	150.10	27.85	0.61	330.70	104.89
December	1st	5.10	141.41	58.67	380.55	274.73	0.00	85.12	*301.70*	203.33	48.63	192.20	62.88	2.10	20.60	112.60	257.70	180.52	15.77	325.91	128.17
	2nd	34.36	302.38	72.64	142.21	374.54	47.90	64.08	187.11	38.18	120.07	333.00	30.00	15.40	107.60	48.10	296.50	104.09	42.33	257.08	330.56
	3rd	151.15	414.97	231.19	245.55	253.35	123.78	229.96	279.93	129.09	133.55	222.00	135.53	20.30	308.60	122.20	125.20	66.78	0.00	79.85	18.79
Total Dis. (Mil.m^3)		2934.39	7471.33	6987.16	3824.76	5283.85	4082.58	5115.51	6,049.16	4,650.79	5,091.27	3,901.82	2,932.82	3,915.61	2,922.85	3,283.85	5,076.86	3,682.60	3,564.21	4,518.26	3,214.24

Source : PJT, *Italic* is estimated bu the Study Team

Table A1-10 10-day Outflow Records in the Sutami Reservoir

Unit : m^3/s

Month	10-day	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
January	1st	58.67	41.31	136.45	**58.51**	**51.41**	**119.79**	55.98	88.88	*68.18*	100.60	120.71	99.09	89.33	95.31	**111.20**	60.90	136.21	38.81	49.93	108.77
	2nd	64.07	70.98	126.87	**55.71**	**52.07**	**102.74**	60.99	108.00	88.87	119.37	131.90	122.06	76.86	105.73	**104.06**	63.71	132.23	81.40	56.22	123.37
	3rd	61.39	58.14	149.37	**52.91**	**52.74**	**85.69**	57.76	94.78	112.11	116.92	119.04	133.77	53.08	91.33	**96.92**	89.30	147.93	138.93	54.37	110.81
February	1st	65.10	60.61	**143.01**	**50.11**	**53.40**	68.63	62.05	99.35	79.47	88.26	124.14	160.20	49.97	96.79	89.79	113.05	136.39	152.90	88.71	88.91
	2nd	57.20	46.33	136.66	**47.30**	**54.06**	70.54	95.48	134.51	120.26	110.32	124.06	143.83	67.45	67.53	84.67	142.64	106.47	151.48	135.73	135.71
	3rd	45.29	45.00	120.65	**44.50**	**54.72**	81.92	102.35	134.97	96.73	74.64	115.69	121.13	115.39	59.25	90.37	83.61	98.87	117.85	151.07	110.38
March	1st	46.78	48.52	96.54	41.70	**55.38**	105.75	84.82	177.62	*147.16*	94.12	100.16	103.48	130.31	93.31	105.30	98.61	92.58	158.62	138.46	70.40
	2nd	55.18	67.84	78.19	42.89	**56.05**	129.25	68.84	155.43	133.55	108.08	84.10	123.87	107.27	128.26	71.08	174.47	100.30	145.31	102.27	109.61
	3rd	52.19	83.92	67.30	42.10	**56.71**	66.57	74.35	140.76	132.74	130.06	**75.09**	135.19	75.62	75.69	55.50	116.47	110.75	173.69	136.84	106.82
April	1st	77.72	79.72	58.84	41.31	57.37	80.89	79.21	156.92	103.24	137.78	66.09	96.03	115.91	73.89	95.60	129.35	110.11	121.86	107.55	73.33
	2nd	79.70	70.73	67.02	64.38	50.80	93.84	89.53	187.52	67.73	137.53	57.48	81.05	80.96	74.60	91.54	136.92	134.20	127.93	104.47	138.52
	3rd	59.16	63.16	84.73	91.75	49.36	84.88	103.99	137.95	94.88	113.33	57.55	64.60	72.41	68.34	95.14	96.90	91.31	121.57	87.52	97.93
May	1st	60.00	42.32	**95.74**	**67.43**	62.54	53.32	132.80	104.18	59.76	63.95	71.33	84.23	90.98	56.75	39.87	75.67	85.27	86.24	85.20	64.29
	2nd	53.78	104.79	**106.74**	43.11	89.25	45.37	98.38	106.66	50.38	60.95	53.54	88.48	58.00	54.76	49.18	71.02	63.03	77.32	69.39	54.43
	3rd	54.95	93.38	117.75	39.03	70.30	46.58	110.24	76.57	71.98	65.31	63.55	64.08	76.77	98.66	65.87	80.33	62.11	58.34	50.95	56.19
June	1st	53.04	134.35	129.13	36.23	67.12	43.95	73.64	68.20	94.12	101.38	94.17	82.12	105.63	54.85	38.30	69.93	63.17	56.87	60.35	54.42
	2nd	49.36	95.23	89.43	37.47	54.15	41.80	72.36	72.36	111.21	101.92	69.73	68.35	118.31	45.63	38.17	53.71	80.64	49.44	80.99	48.57
	3rd	40.62	94.97	60.74	37.44	61.69	45.80	80.19	55.43	53.25	101.57	59.74	41.12	69.90	54.83	34.81	45.29	57.95	44.99	64.37	47.40
July	1st	39.33	133.71	62.43	**44.31**	52.05	**45.64**	94.45	61.41	46.84	95.80	60.42	48.27	65.08	58.36	32.55	63.12	46.40	43.22	54.86	48.95
	2nd	47.51	72.06	61.15	**51.18**	94.51	45.49	73.76	55.05	56.95	71.41	53.49	42.13	75.03	47.78	31.60	49.90	55.80	52.77	61.52	59.92
	3rd	44.03	93.01	64.80	58.05	74.35	74.97	44.43	53.34	54.02	59.31	48.43	41.22	94.13	45.78	30.61	50.77	60.41	58.60	91.15	68.84
August	1st	44.88	50.46	60.40	51.69	64.19	49.87	50.45	53.36	54.35	68.91	29.49	47.07	90.38	41.44	28.79	47.42	53.93	51.43	58.09	52.73
	2nd	39.56	69.18	56.87	**53.90**	57.17	51.38	49.55	51.37	52.65	59.14	31.83	51.47	62.07	42.10	28.23	53.11	50.75	48.00	51.61	86.65
	3rd	40.37	71.38	44.63	56.11	73.73	51.95	50.04	62.68	60.35	76.62	33.43	56.82	55.53	60.41	28.05	57.10	53.18	46.31	41.17	51.36
September	1st	43.69	56.21	51.40	46.37	61.97	44.90	44.31	68.38	54.59	71.50	31.27	47.16	62.02	54.66	27.63	68.19	57.32	51.22	36.76	43.76
	2nd	39.43	73.54	57.07	48.09	67.68	44.52	40.85	93.73	56.01	52.15	29.78	47.90	55.70	59.81	23.73	61.94	55.77	52.41	40.32	46.67
	3rd	44.14	74.82	61.14	50.68	56.06	42.26	44.01	88.20	52.93	64.69	29.14	42.96	51.27	43.04	26.40	61.57	55.71	50.75	35.66	48.32
October	1st	40.97	71.30	52.94	41.97	62.51	38.28	44.33	91.76	45.24	58.95	36.33	39.65	44.45	41.57	49.80	89.12	54.75	58.63	35.53	57.27
	2nd	39.47	69.60	37.73	39.55	**59.41**	38.24	42.10	91.22	41.20	73.37	29.76	56.15	43.99	40.09	22.81	90.75	41.20	43.34	37.27	60.46
	3rd	33.70	73.10	33.39	39.60	**56.30**	35.00	53.43	54.49	60.96	60.94	29.75	67.54	53.61	43.65	21.97	121.76	41.81	35.70	36.12	75.83
November	1st	30.71	78.86	48.01	37.61	53.20	37.57	64.29	41.80	71.83	85.03	35.83	47.07	*127.08*	55.32	22.93	132.79	41.52	34.83	48.34	75.65
	2nd	32.36	77.10	48.96	58.66	54.18	37.76	78.33	38.43	50.73	94.56	36.80	56.71	*69.34*	45.36	39.56	96.90	43.13	34.96	85.89	75.68
	3rd	33.74	118.87	55.50	48.77	73.34	35.49	103.32	57.05	74.63	108.14	47.48	49.72	*47.06*	44.04	51.64	114.41	42.86	34.88	141.31	70.78
December	1st	32.44	69.89	59.90	**49.43**	75.64	33.69	56.00	113.35	97.18	71.37	*86.94*	86.94	52.61	47.49	104.37	135.94	47.48	40.71	205.76	58.17
	2nd	45.35	76.69	65.73	**50.09**	118.39	38.17	52.53	97.67	70.14	71.88	*145.03*	145.03	52.24	51.00	44.95	135.89	51.26	46.06	147.30	103.20
	3rd	29.71	74.02	61.31	**50.75**	136.84	43.46	75.65	61.33	85.45	72.85	*141.95*	141.95	55.86	118.33	64.21	122.01	40.10	44.11	103.04	47.07
Total Dis. ($Mil.m^3$)		1519.07	2376.65	2486.82	1551.41	2057.87	1883.49	2238.53	2,904.83	2,427.91	2,752.68	2,205.95	2,564.58	2,363.03	2,053.95	1,775.88	2,852.58	2,362.81	2,387.63	2,555.06	2,385.29

Source : Calculated from daily records by PKB and PJT. *Italic* is from Monthly report by PKB and PJT. **Bold** is estimated by the Study Team.

Table A1-11 10-day Total Irrigation Intake Discharges along the Brantas River

Unit : m^3/s

Month	10-day	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
January	1st	91.44	88.11	93.37	107.78	101.04	98.29	97.13	95.15	88.02	90.57	83.02	75.77	95.02	89.03	91.33	108.32	119.98	90.80	93.32	93.26
	2nd	93.28	90.33	94.05	104.32	96.93	100.57	97.38	95.32	87.39	101.61	81.97	87.69	103.47	89.58	117.44	89.30	119.99	83.30	95.00	87.75
	3rd	95.58	95.56	96.98	106.04	98.99	104.43	92.32	96.66	80.87	104.95	97.41	104.66	112.40	86.29	101.02	82.86	119.27	84.43	84.84	83.37
February	1st	89.55	89.02	92.04	103.00	103.33	111.35	96.30	92.51	78.55	86.87	85.31	92.97	101.72	85.88	105.50	70.28	113.32	74.29	82.49	85.88
	2nd	88.91	85.94	93.79	101.89	99.30	105.72	91.01	92.21	87.06	72.13	80.53	113.08	110.29	113.87	132.13	94.78	121.10	85.92	89.03	87.98
	3rd	94.13	88.49	96.14	107.01	103.01	94.81	99.33	93.59	61.66	78.44	81.66	126.77	110.82	103.85	99.31	99.55	106.62	101.95	103.69	90.97
March	1st	94.38	89.71	123.13	96.80	95.25	93.01	99.64	89.53	72.22	126.84	82.32	92.24	104.14	87.68	88.79	109.04	116.66	110.94	106.45	89.91
	2nd	91.11	106.44	98.95	93.72	97.24	85.10	102.33	73.93	62.93	92.91	90.94	94.45	117.28	110.30	121.76	83.18	117.82	85.10	110.06	89.88
	3rd	88.63	99.60	100.05	97.84	86.23	83.17	97.23	94.62	72.00	75.33	90.52	88.17	104.21	70.77	90.99	77.69	86.76	93.60	99.57	85.55
April	1st	83.39	91.45	95.58	113.06	92.55	88.26	87.63	132.37	83.14	68.08	77.71	86.59	112.20	100.91	80.92	75.31	92.30	91.27	78.99	83.26
	2nd	81.09	91.88	96.82	120.38	88.81	68.82	123.96	86.94	92.65	89.41	91.11	85.10	102.56	114.11	75.43	71.07	88.70	82.52	65.61	75.53
	3rd	80.13	85.50	88.67	108.20	91.91	88.68	79.78	124.70	94.19	78.24	89.79	86.91	82.13	85.84	74.66	77.38	94.46	80.37	76.77	76.41
May	1st	79.14	91.24	111.26	96.91	98.19	81.78	80.96	78.84	75.63	72.12	77.88	85.03	91.45	90.73	80.56	83.74	98.02	84.73	71.83	83.77
	2nd	78.96	91.75	94.85	92.40	98.78	87.49	78.03	75.59	77.95	74.45	75.94	74.95	78.56	90.36	83.55	90.43	100.80	79.74	77.30	75.36
	3rd	75.12	96.17	96.25	86.33	95.99	82.10	76.41	74.57	79.58	74.33	72.75	72.25	75.75	83.94	81.56	88.32	95.65	90.85	77.70	75.00
June	1st	78.60	93.16	95.11	81.82	93.57	82.17	79.65	78.91	82.44	74.65	75.61	76.42	72.28	91.28	73.50	95.03	81.55	89.47	79.78	70.03
	2nd	79.16	92.09	92.80	64.26	84.46	73.90	84.26	79.48	81.89	75.97	75.76	83.89	72.77	72.53	71.46	89.08	82.19	79.83	85.40	70.89
	3rd	74.85	89.85	91.58	62.95	98.18	68.86	85.15	76.75	79.90	74.90	73.08	64.24	100.15	81.94	66.14	81.79	79.74	71.88	76.97	62.59
July	1st	61.95	93.37	90.68	60.07	88.99	62.56	85.63	79.78	76.33	75.57	70.47	61.71	79.16	74.56	62.50	70.21	72.11	57.48	75.09	60.32
	2nd	60.77	81.89	90.47	61.94	83.99	58.77	78.43	75.52	72.15	73.36	68.68	59.08	79.97	69.60	59.42	67.20	64.48	55.35	66.87	58.78
	3rd	55.95	87.64	88.51	61.64	86.51	75.67	63.59	70.23	74.75	72.76	56.55	55.16	74.57	58.68	56.78	64.58	66.62	58.04	67.62	57.67
August	1st	49.94	84.91	87.50	77.85	75.77	56.45	56.71	62.70	75.51	70.35	42.69	77.12	66.58	57.38	54.60	61.28	57.03	54.64	57.32	55.29
	2nd	47.98	87.98	89.14	63.02	69.87	55.19	57.04	66.01	69.46	61.35	37.87	55.01	60.80	50.78	49.90	59.94	58.49	50.19	51.50	68.27
	3rd	45.39	80.20	68.57	53.92	80.10	53.97	52.25	74.58	70.48	68.11	34.68	50.00	56.93	52.04	46.64	60.59	59.16	46.79	49.54	55.39
September	1st	48.02	77.21	59.65	53.53	63.16	45.78	49.50	74.04	66.02	65.15	31.33	47.71	55.67	51.86	44.22	50.31	49.45	45.92	44.85	50.97
	2nd	44.33	77.90	67.41	50.54	62.05	45.87	44.60	66.60	59.60	58.13	30.76	45.37	50.02	57.11	53.66	48.56	49.91	45.99	37.27	47.26
	3rd	42.52	76.41	68.46	50.06	65.95	45.05	44.97	73.91	55.08	56.82	30.56	39.97	43.51	48.99	45.86	53.06	50.84	46.09	38.82	47.14
October	1st	37.19	73.95	64.55	47.34	56.99	43.77	47.59	70.26	48.84	56.54	31.63	40.59	38.96	42.31	54.60	57.28	52.39	43.94	34.43	51.83
	2nd	35.36	72.03	49.92	46.15	54.98	43.98	51.91	75.85	41.96	55.54	30.01	46.64	31.91	39.52	47.84	59.61	48.48	44.77	40.61	52.13
	3rd	35.33	71.89	53.90	42.76	61.34	42.43	58.64	76.72	66.00	49.91	30.96	51.61	41.11	47.92	41.89	69.76	44.32	39.10	43.76	59.92
November	1st	28.90	82.39	72.34	43.28	67.73	41.89	68.00	64.41	70.50	57.66	28.85	48.72	39.41	59.28	47.95	77.24	36.59	38.58	47.63	68.68
	2nd	38.86	79.46	76.43	62.66	79.45	43.24	75.85	62.49	64.48	64.24	27.52	63.00	59.19	54.95	73.42	80.55	56.70	41.52	56.56	71.26
	3rd	50.07	82.29	83.85	79.02	83.21	35.02	78.77	76.54	64.90	66.75	43.90	75.60	63.01	57.07	83.00	90.34	71.87	47.68	61.12	78.59
December	1st	58.15	81.38	93.16	82.19	88.85	38.01	94.07	82.40	62.29	71.33	55.63	85.95	72.50	79.05	88.27	97.98	82.87	69.83	87.02	90.66
	2nd	64.39	86.05	102.26	86.11	91.99	75.64	102.02	84.22	91.62	71.14	59.23	80.35	66.01	80.44	92.62	106.04	86.33	83.45	86.35	77.14
	3rd	80.67	94.21	102.61	94.63	96.28	91.05	106.85	88.52	111.78	72.06	59.32	95.99	75.31	91.29	100.03	118.68	89.67	68.47	86.21	88.21
Total Dis. ($Mil.m^3$)		2,118.59	2,740.85	2,766.77	2,500.68	2,696.46	2,235.32	2,505.41	2,587.95	2,352.71	2,345.43	1,971.53	2,330.36	2,448.30	2,376.02	2,394.41	2,502.73	2,563.56	2,182.93	2,261.59	2,280.27

Remarks : (1) This table includes the Brantas Atas, Brantas Bawah, Molek, Lodagung, Warujayeng-Kertosono, Turi-Tunggorono, Brantas Kiri Kediri, Jatimlerek, Menturus, Jatikulon, Voor Canal I, and Voor Canal II.

(2) Original data is from PJT and DPU Pengairan. The missing data is complemented by the Study Team.

Table A1-12 Calculation of Miscellaneous Flow between the Sutami Dam and the New Lengkong Dam

YEAR : 1996

Unit : m^3/s

Month		Outflow			Total Irrigation Intake Discharge from Sutami to N.L	Total Industrial Intake Discharge from Sutami to N.L.	Mrilip Gate	Total Utilizable Return Flow from Sutami to N.L.	New Lengkong Dam Observed Discharge	Calculated Outflow from Sutami and Lahor	Miscellaneous Inflow from Sutami to N.L.
		Sutami	Lahor (*1)	Total							
		a	b	c = a+b	d	e	f	g	h	i=d+e+f+h-g	j = i-c
January	1st	108.77	0.00	108.77	84.97	2.35	55.69	10.11	214.92	347.82	239.05
	2nd	123.37	0.00	123.37	79.52	2.35	69.94	8.38	207.51	350.93	227.56
	3rd	110.81	0.00	110.81	74.38	2.35	69.95	8.16	284.15	422.66	311.85
February	1st	88.91	0.00	88.91	77.30	2.35	62.33	7.88	255.77	389.87	300.96
	2nd	135.71	0.00	135.71	78.87	2.35	43.93	8.10	314.89	431.95	296.23
	3rd	110.38	0.00	110.38	82.60	2.35	46.44	8.03	346.25	469.61	359.24
March	1st	70.40	0.00	70.40	80.86	2.35	45.98	7.71	188.15	309.63	239.23
	2nd	109.61	0.00	109.61	80.69	2.35	50.73	8.05	289.98	415.70	306.10
	3rd	118.54	0.00	118.54	76.36	2.35	61.70	8.06	241.72	374.06	255.52
April	1st	73.33	0.00	73.33	75.08	2.35	68.54	7.66	26.97	165.28	91.94
	2nd	138.52	10.68	149.20	67.06	2.35	62.53	7.79	326.59	450.74	301.55
	3rd	97.93	3.26	101.19	67.58	2.35	61.57	7.66	177.35	301.19	200.00
May	1st	64.29	0.00	64.29	75.69	2.35	61.62	7.16	4.87	137.37	73.07
	2nd	54.43	0.00	54.43	66.82	2.35	32.86	7.11	0.00	94.92	40.50
	3rd	56.19	0.00	56.19	66.41	2.35	33.44	6.91	0.10	95.39	39.20
June	1st	54.42	0.00	54.42	62.20	2.35	33.46	6.36	0.00	91.65	37.23
	2nd	48.57	0.00	48.57	62.62	2.35	34.51	6.05	0.00	93.43	44.87
	3rd	47.40	0.00	47.40	54.35	2.35	32.36	5.88	0.00	83.18	35.78
July	1st	48.95	0.00	48.95	52.72	2.35	33.38	5.74	0.00	82.71	33.76
	2nd	59.92	0.00	59.92	50.44	2.35	31.42	5.12	0.00	79.09	19.17
	3rd	68.84	0.00	68.84	49.50	2.35	31.22	4.60	0.27	78.74	9.90
August	1st	52.73	0.00	52.73	47.58	2.35	31.86	4.50	1.05	78.34	25.61
	2nd	86.65	0.00	86.65	60.80	2.35	32.85	4.17	35.36	127.19	40.55
	3rd	51.36	0.00	51.36	48.48	2.35	23.80	4.00	0.62	71.25	19.89
September	1st	43.76	0.00	43.76	43.30	2.35	24.67	3.74	0.00	66.58	22.82
	2nd	46.67	0.00	46.67	39.65	2.35	23.34	3.81	0.00	61.53	14.86
	3rd	48.32	0.00	48.32	39.73	2.35	27.35	3.80	0.00	65.64	17.32
October	1st	57.27	0.00	57.27	44.93	2.35	30.70	3.82	5.27	79.43	22.16
	2nd	60.46	0.00	60.46	46.04	2.35	31.60	3.82	0.50	76.67	16.21
	3rd	75.83	0.00	75.83	52.61	2.35	36.80	3.73	38.99	127.02	51.20
November	1st	75.65	0.00	75.65	60.66	2.35	37.50	3.84	66.07	162.74	87.10
	2nd	75.68	0.00	75.68	62.69	2.35	36.90	3.85	121.22	219.31	143.63
	3rd	70.78	0.00	70.78	70.14	2.35	37.20	3.81	104.89	210.77	140.00
December	1st	58.17	0.00	58.17	82.26	2.35	37.24	5.36	128.17	244.66	186.49
	2nd	103.20	0.00	103.20	69.16	2.35	39.20	8.05	330.56	433.21	330.02
	3rd	47.07	0.00	47.07	79.50	2.35	35.75	7.70	18.79	128.69	81.61
Total Dis.(Million m^3)		2,405.98	12.04	2,418.02	2,030.41	74.31	1,326.21	193.54	3,244.15	6,481.55	4,063.53

Source : Inflow and outflow discharges, Irrigation and industry intake discharges, Mrilip gate discharge and observed discharge at New Lengkong dam are from PJT and DPU Pengairan. Missing data is supplemented by the Study Team.

Remarks : (*1) Exclude tunnel discharge to Sutami reservoir.

( ) :Number of Staff

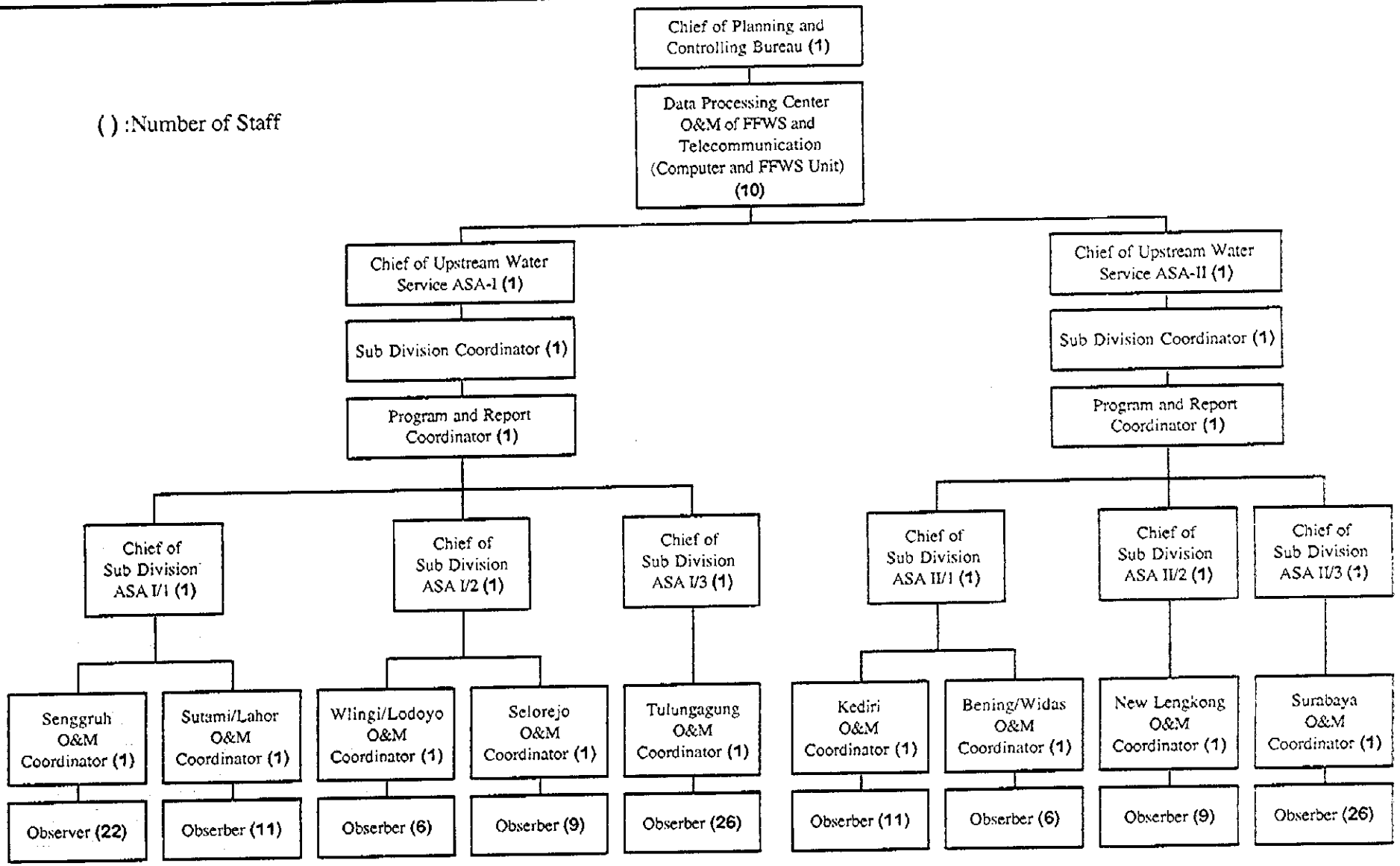
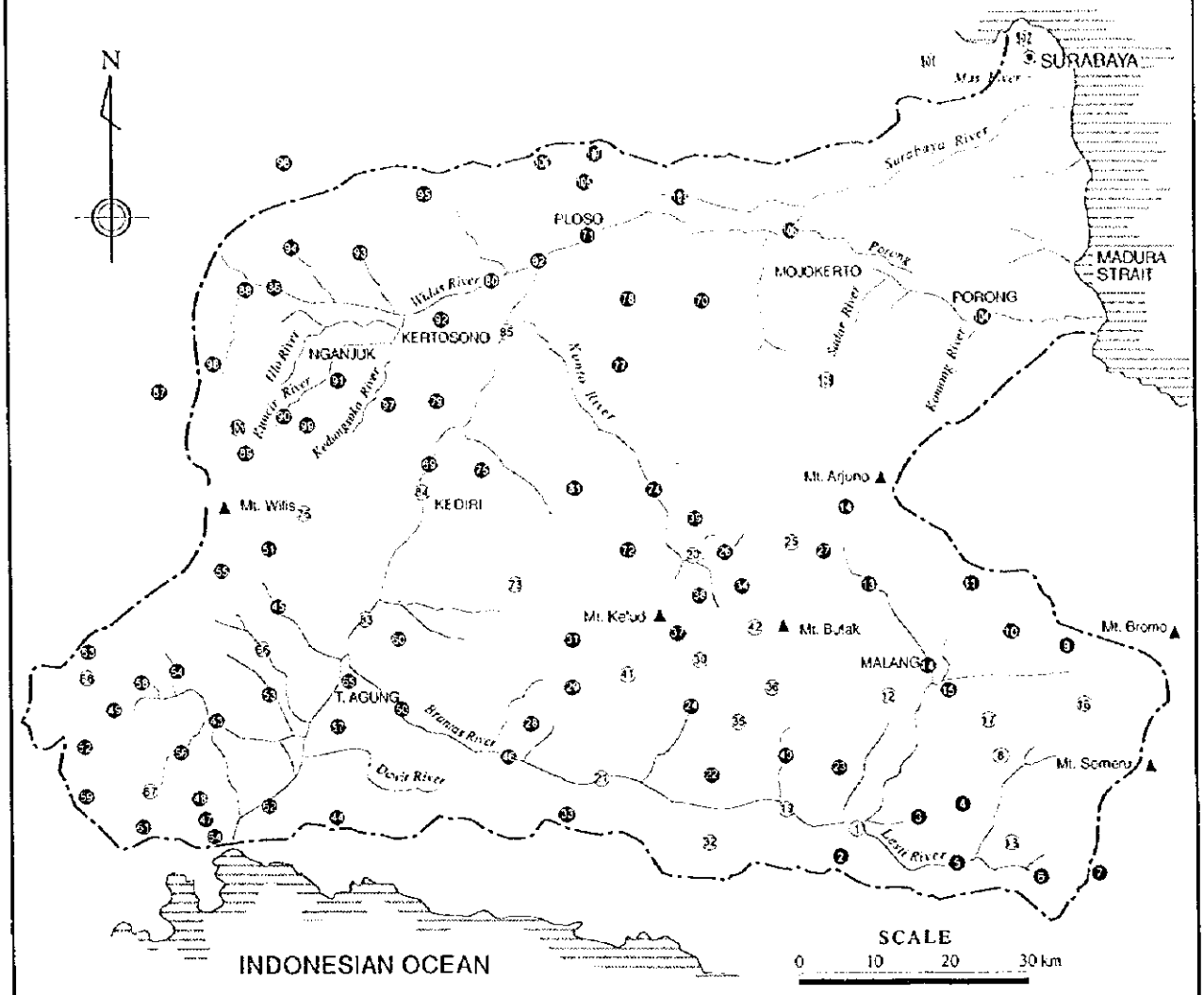


Figure A1-1 Organization Chart of Meteo-hydrological Observation in PJT



BRANTAS UPSTREAM AREA

① Sengguruh
② Pagak
③ Gondanglegi
④ Turen
⑤ Tawangrejeni
⑥ Srimulyo
⑦ Ampel Gading/Tirtoyudo
⑧ Patok Picis
⑨ Gubug klakah
⑩ Jabung
⑪ Singosari
⑫ Wagir
⑬ Dau
⑭ Sumber Brantas
⑮ Malang
a. Perum Jasa Tirta
b. Agriculture Brawijaya
⑯ Poncokusumo
⑰ Tangkil
⑱ Dampit

HYDROELECTRIC AREA

⑲ Sutami Dam
⑳ Selorejo Dam
㉑ Wlingi Dam
㉒ Jajagan
㉓ Talangagung
㉔ Babadan
㉕ Pujon

㉖ Kedungrejo
㉗ Batu
㉘ Blitar
㉙ Garum
㉚ Semen
㉛ Badak
㉜ Birowo
㉝ Sutojayan
㉞ Bendosari
㉟ Doko
㊱ Tunggorono
㊲ Nyunyur
㊳ Pagersari
㊴ Jomblok
㊵ Bangelan
㊶ Sumber Agung
㊷ Wates Wlingi

TULUNGAGUNG AREA

㊸ Bendo Dam
㊹ TumpakMargo
㊺ Sendang
㊻ Jimbe Kademangan
㊼ Keboireng Besuki
㊽ Karangtuwo
㊾ Jati Karangan
㊿ Gandekan
(51) Jaeyan
(52) Pule
(53) Paingan Dam
(54) Bagong Dam
(55) Sumber Pandan

(56) Widoro Dam
(57) Boyolangu
(58) Prambon Dam
(59) Dongko
(60) Salam
(61) Watulimo
(62) Campurdarat
(63) Pangkal
(64) Tangkilan (Besuki-Neyama)
(65) Tapan
(66) Pagerwojo
(67) Kampak
(68) Tugu

BRANTAS MIDDLE REACH AREA

(69) Mrican Barrage
(70) Mojoagung
(71) Ploso
(72) Siman
(73) Wates
(74) Kandangan
(75) Pagu Menang
(76) Mojo Besuki/Wilis
(77) Blimbing
(78) Jombang
(79) Prambon
(80) Lengkong
(81) Pare
(82) Begendeng
(83) Jeli
(84) Kediri
(85) Kertosono

WIDAS AREA

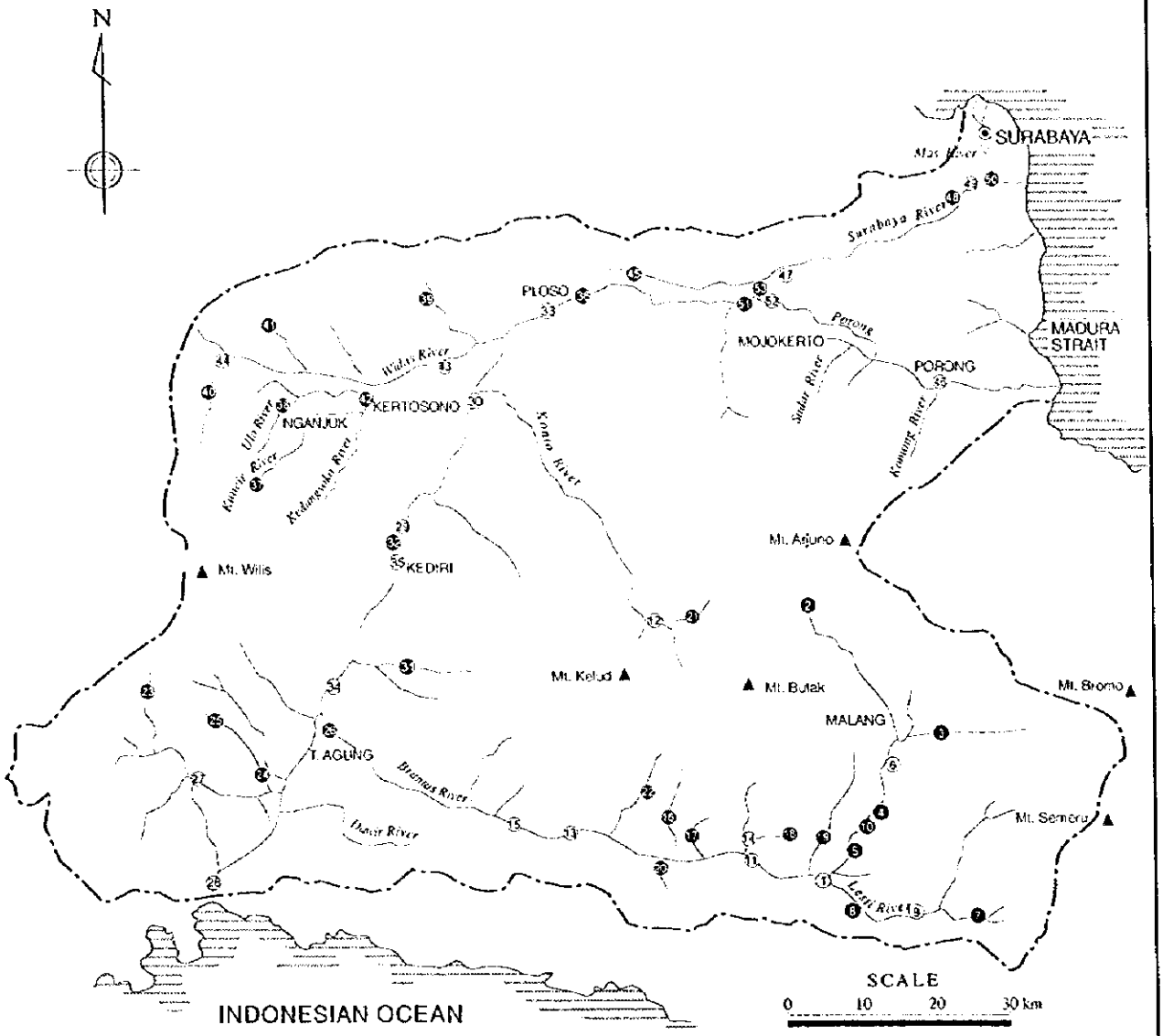
(86) Ngudikan
(87) Gemarang
(88) Widas/Bening Dam
(89) Ngliman
(90) Sawahan
(91) Loceret
(92) Kalimati
(93) Ngrambek
(94) Semantok
(95) Ngluyu
(96) G.Lengko
(97) Pace
(98) Tunglur
(99) Berbek
(100) Wates Sawahan

BRANTAS DOWNSTREAM AREA

(101) Semini
(102) Gubeng Dam
(103) Mernung
(104) Porong
(105) Kabuh
(106) Sumberaji
(107) Sukodadi
(108) Mojokerto
(109) Tampung

LEGEND :
① Telemeter Station
❶ Others

Figure A1-2 Location Map of Meteorological Stations Observed by PJT



BRANTAS UPSTREAM AREA

1. Sengguruh Dam
2. Kali Lanang (Pandanpuro)
3. Kali Amprong (Madyopuro)
4. Kali Manten (Wandanrejo)
5. Kedung Pedaringan
6. Gadang
7. Genteng
8. Clumprit
9. Tawangrejeni
10. Blobo

HYDRO ELECTRIC AREA

11. Sutami Dam
12. Selorejo Dam
13. Wlingi Dam
14. Lahor Dam
15. Lodoyo Barrage
16. Kali Bambang
17. Kali Legi
18. Kali Biru
19. Kali Metro
20. Kali Jugo
21. Kedungrejo (Kali Konto)
22. Tangkil (Kali Lekso)

TULUNGAGUNG AREA

23. Bendungan
24. Paingan Dam
25. Kali Song
26. Ngujang
27. Bendo
28. Inlet Gate

BRANTAS MIDDLE REACH AREA

29. Mrican Barrage
30. Kertosono
31. Keras
32. Jongbiru
33. Ploso
34. Jeli
35. Kediri
36. Menturus

WIDAS AREA

37. Sawahan
38. Keringan
39. Ketandan
40. Petung
41. Semantok
42. Kedung Suko
43. Lengkong
44. Bening Dam/Widas

BRANTAS DOWNSTREAM AREA

45. Mernung Upstream
46. Porong
47. Perning
48. Sepanjang
49. Gunungsari
50. Jagir Upstream
51. Mojokerto
52. New Lengkong
53. Mrilip Gate

LEGEND :

① Telemeter Station

● Others

Figure A1-3 Location Map of Hydrological Stations Observed by PJT

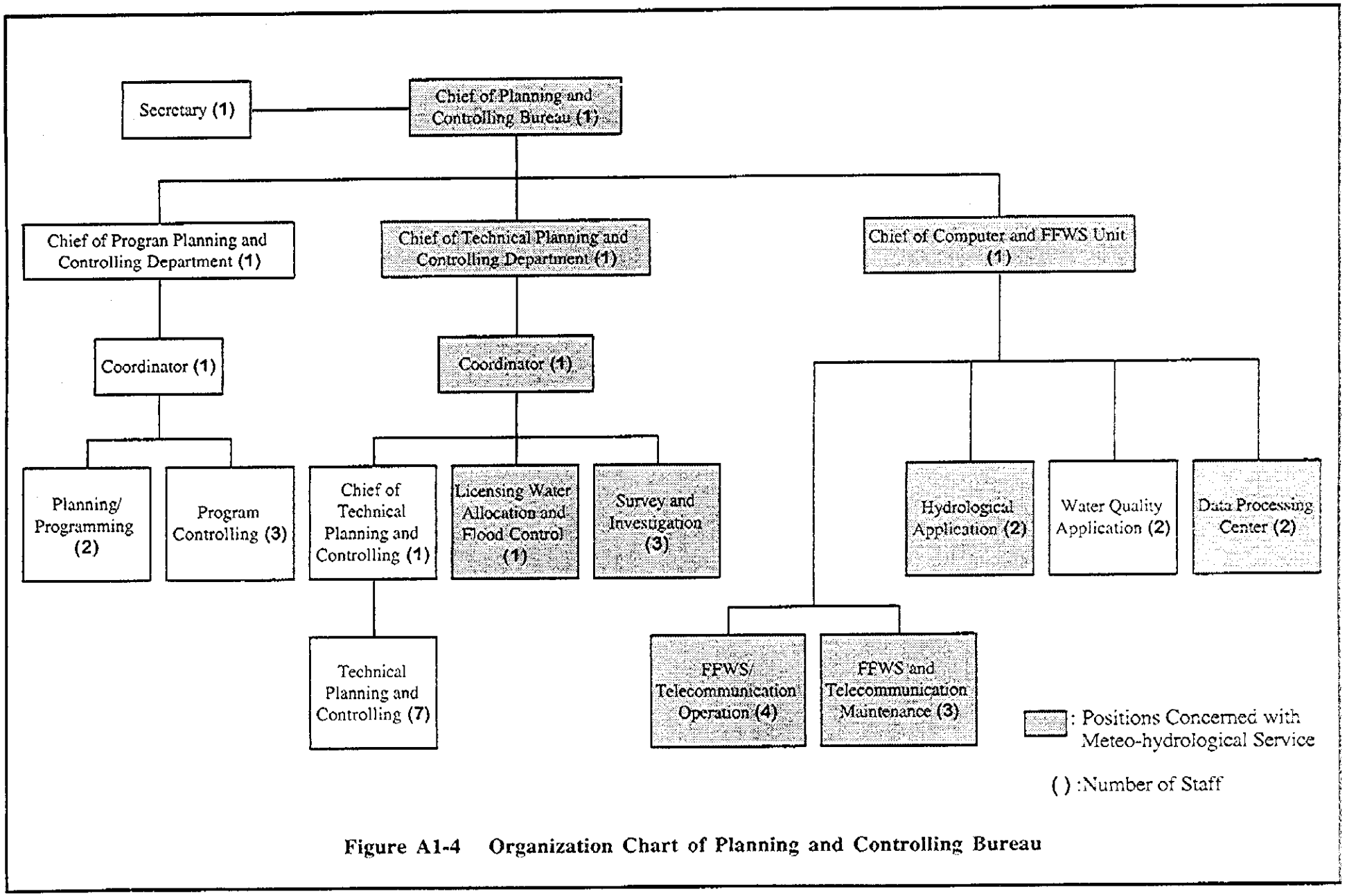


Figure A1-4 Organization Chart of Planning and Controlling Bureau

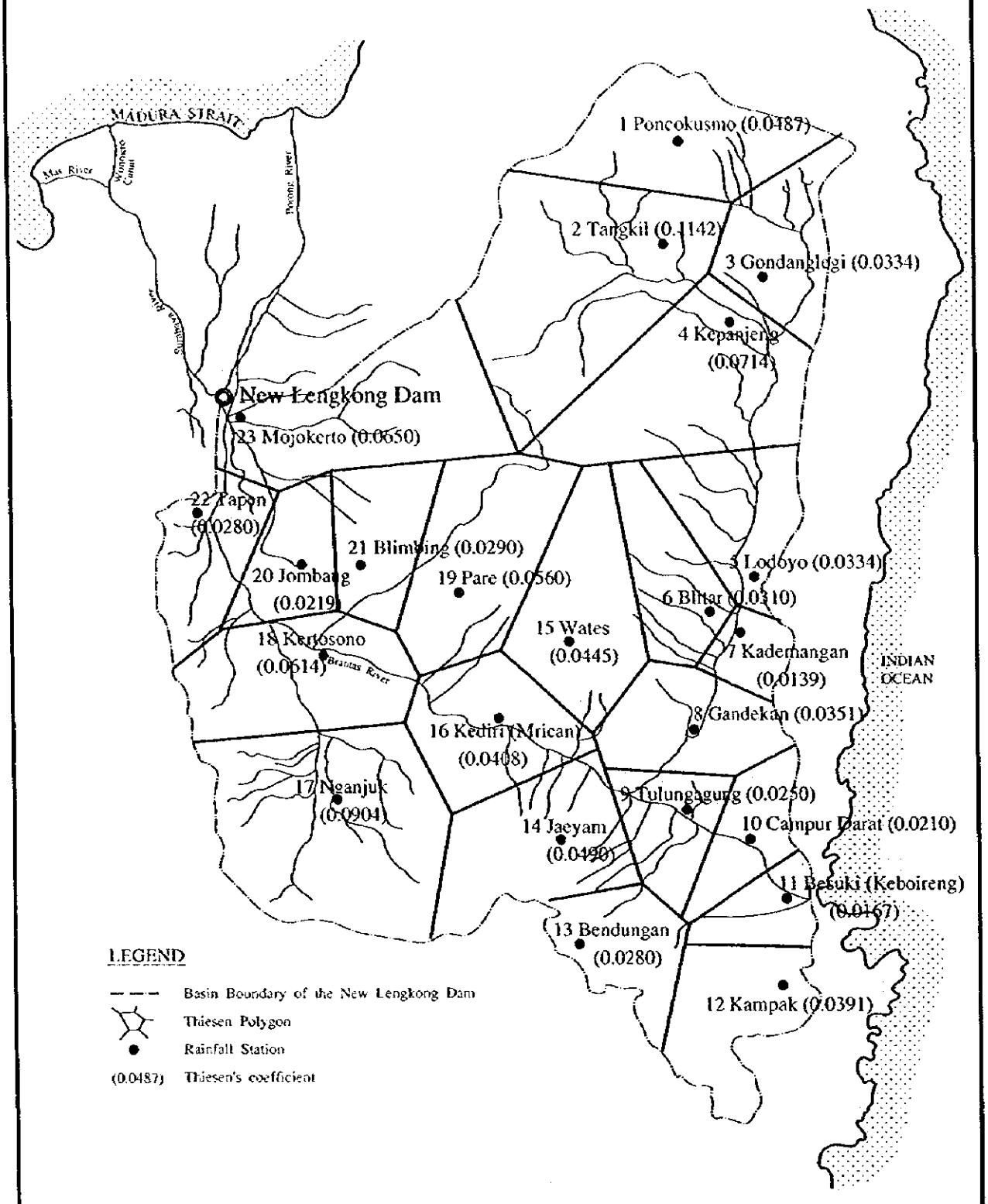
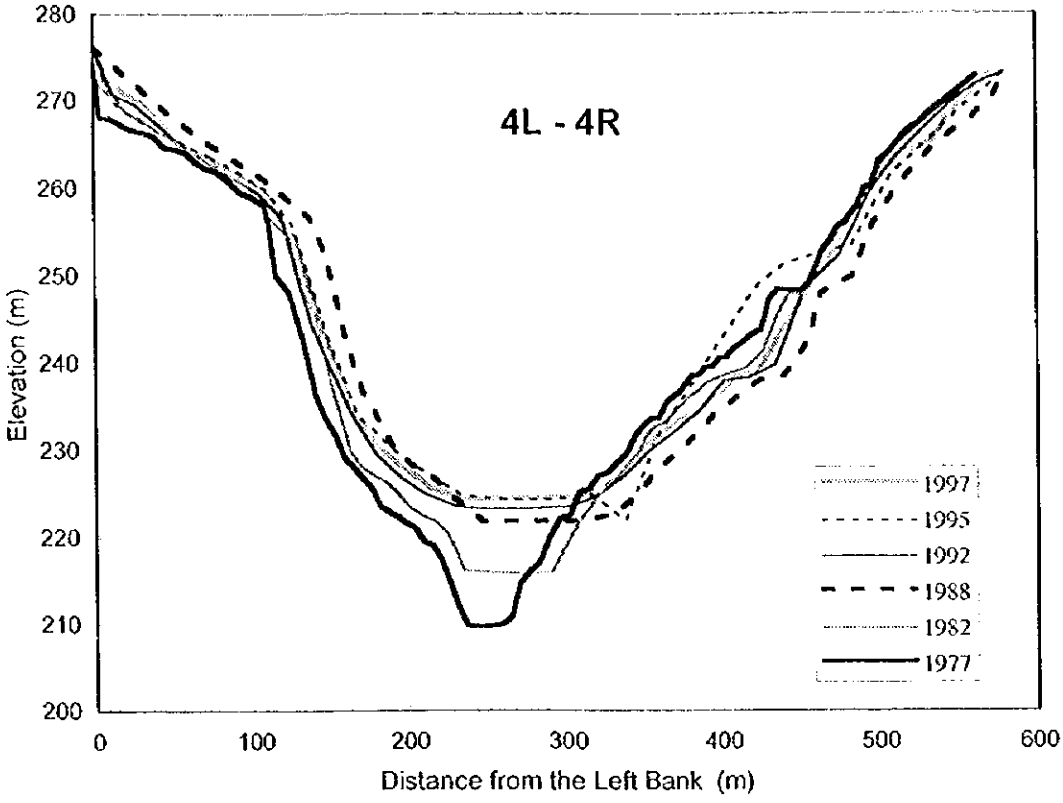


Figure A1-5 Thiesen Polygon in the Catchment Area of the New Lengkong Dam



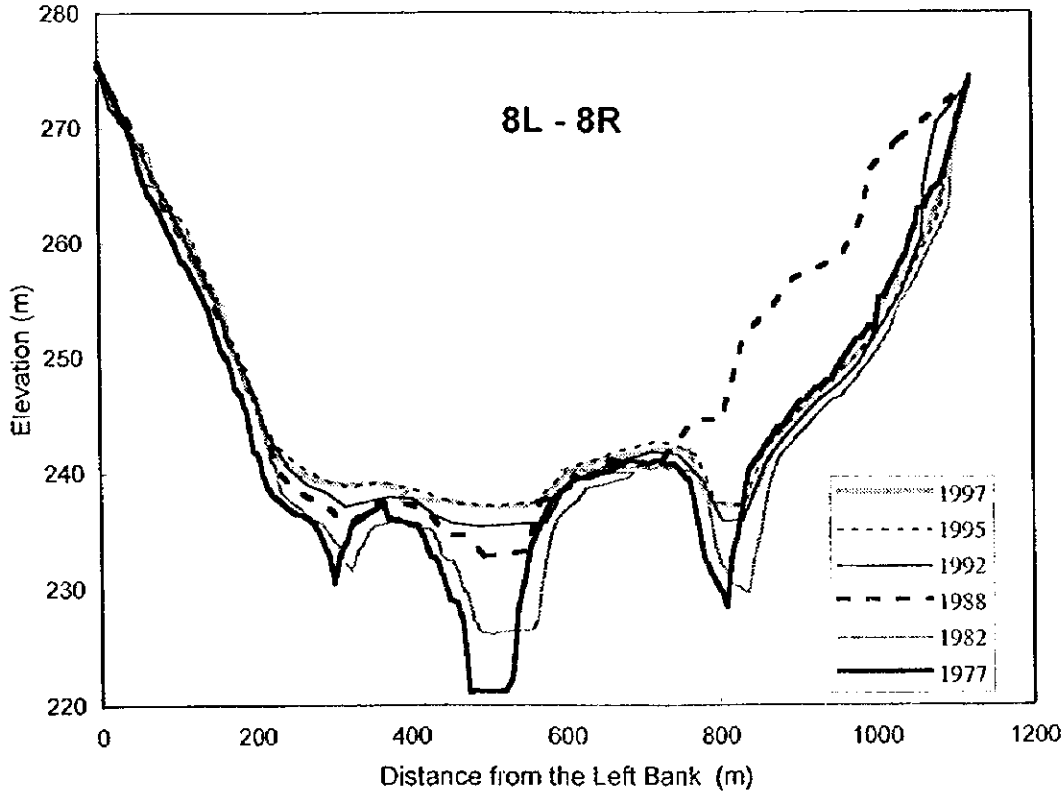
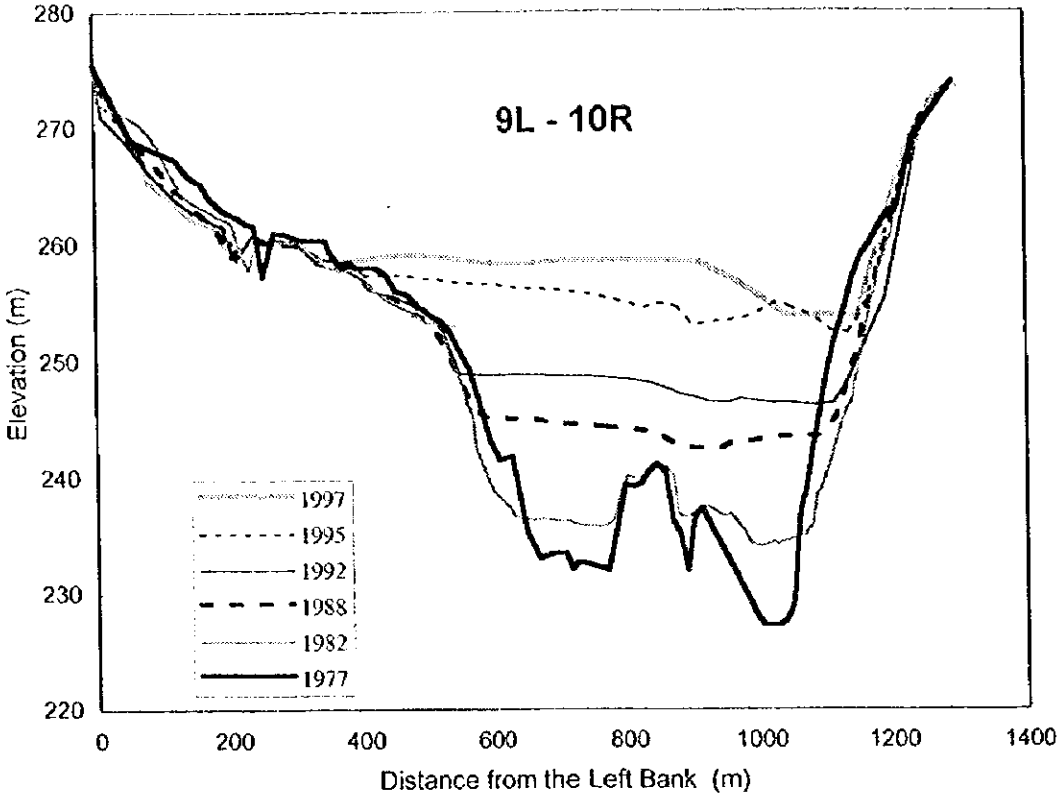


Figure A1-6 Cross Section of Sutami Reservoir (1/2)



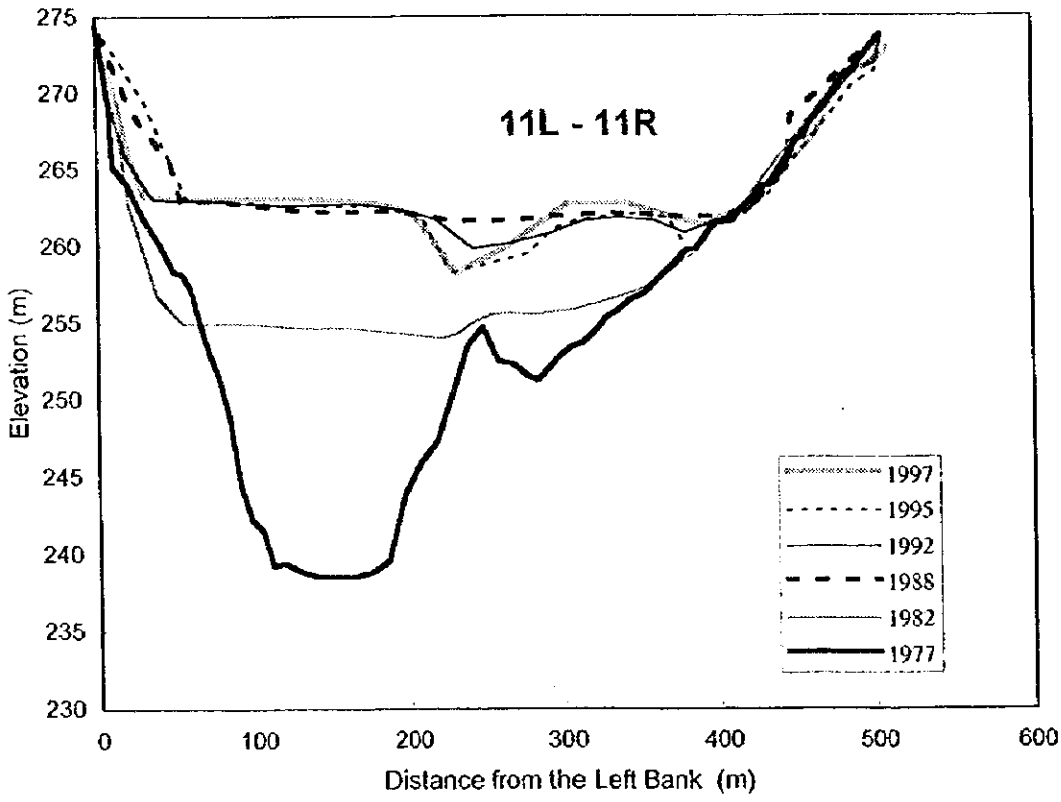


Figure A1-6 Cross Section of Sutami Reservoir (2/2)

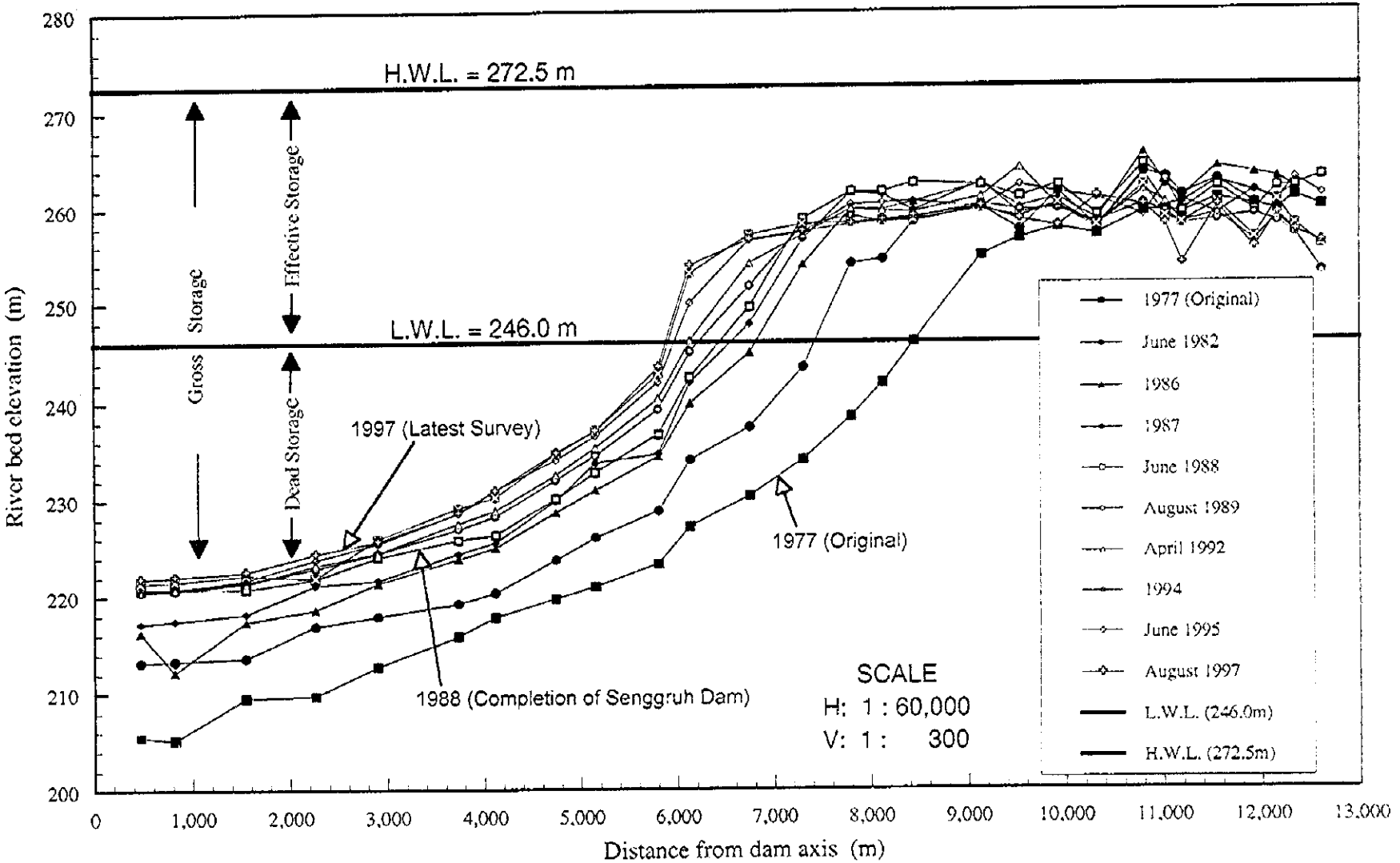


Figure A1-7 Longitudinal Sections in Sutami Reservoir (Brantas River)

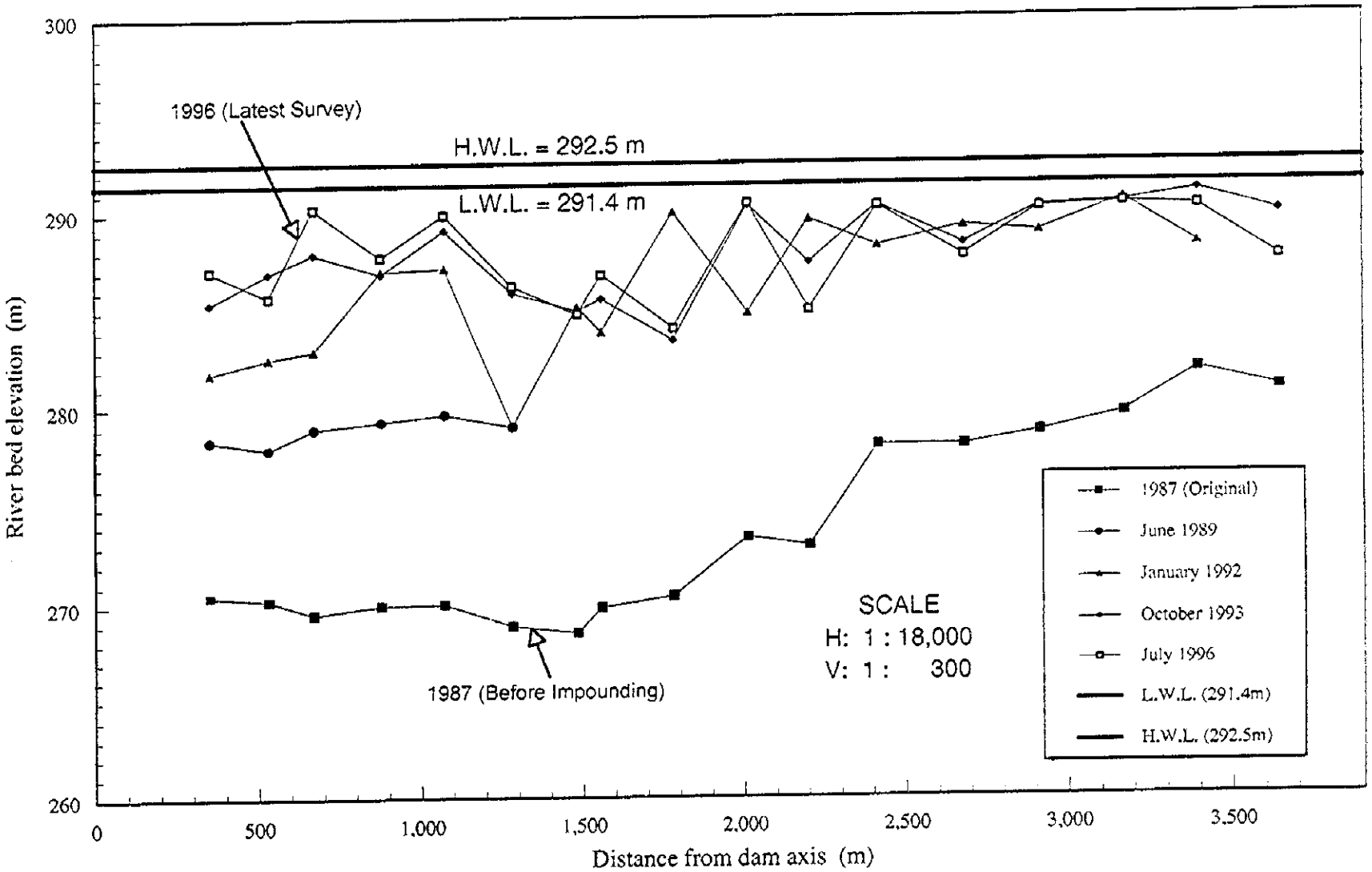


Figure A1-8 Longitudinal Sections in Senggruh Reservoir (Brantas River)

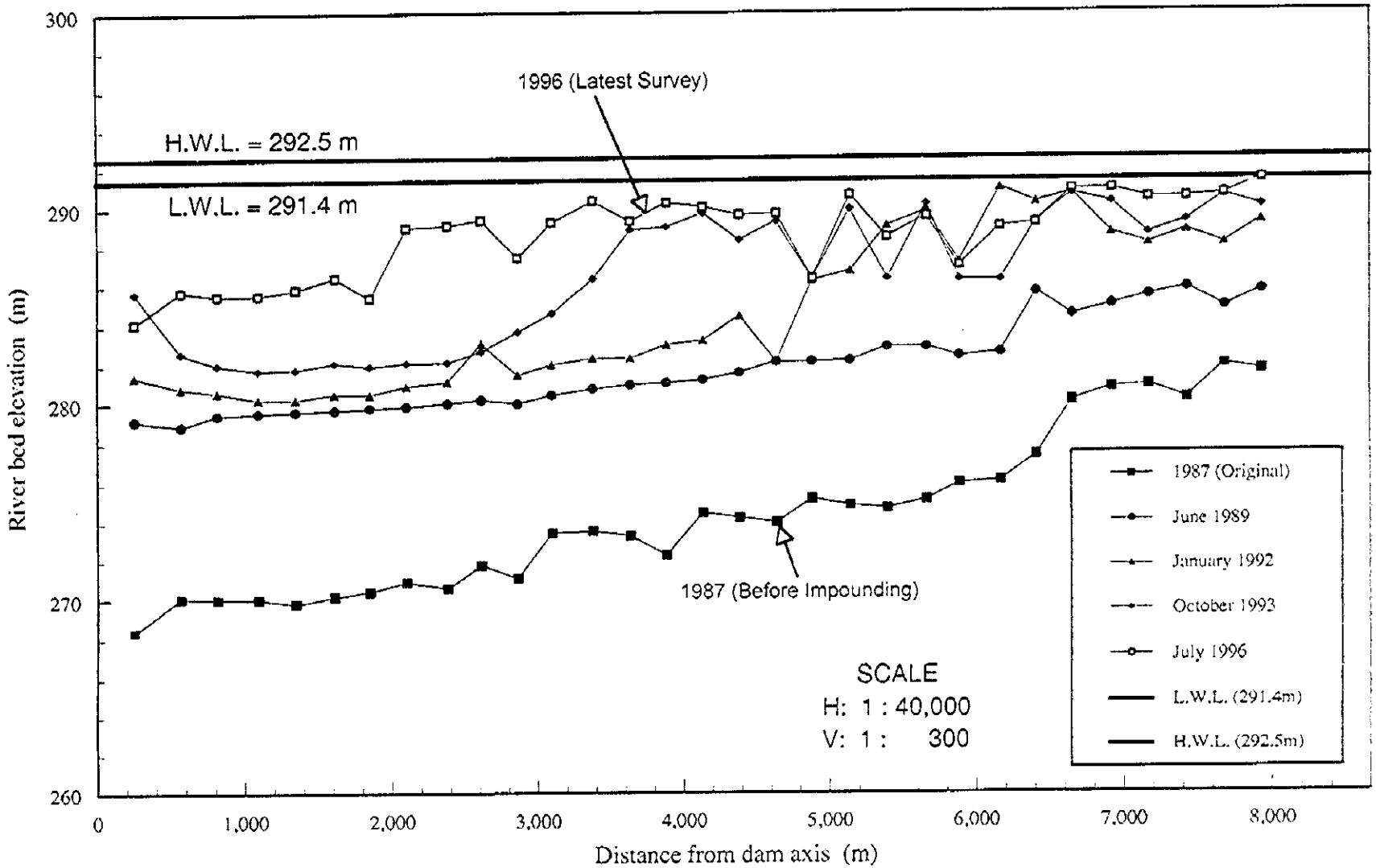


Figure A1-9 Longitudinal Sections in Senggruh Reservoir (Lesti River)

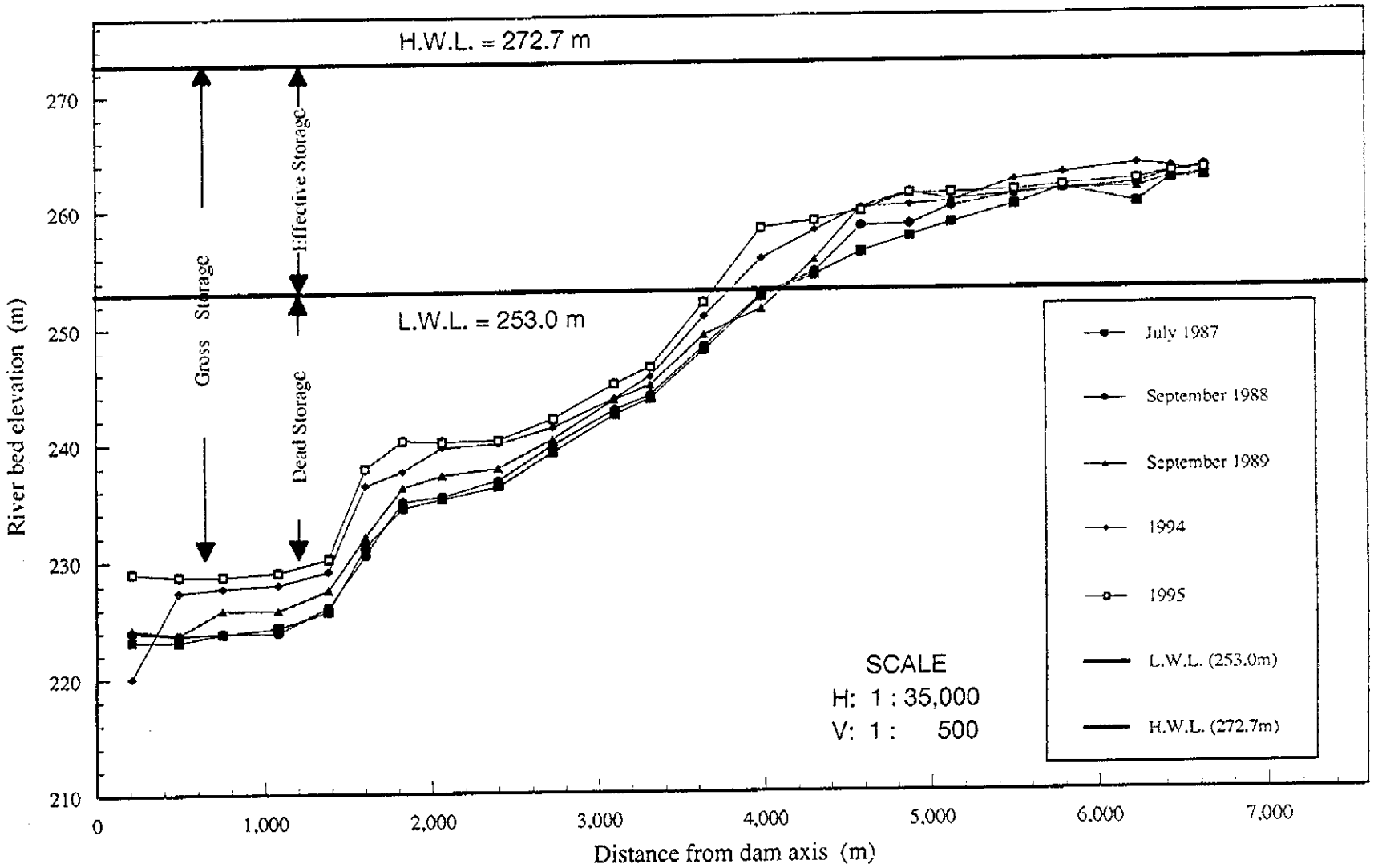
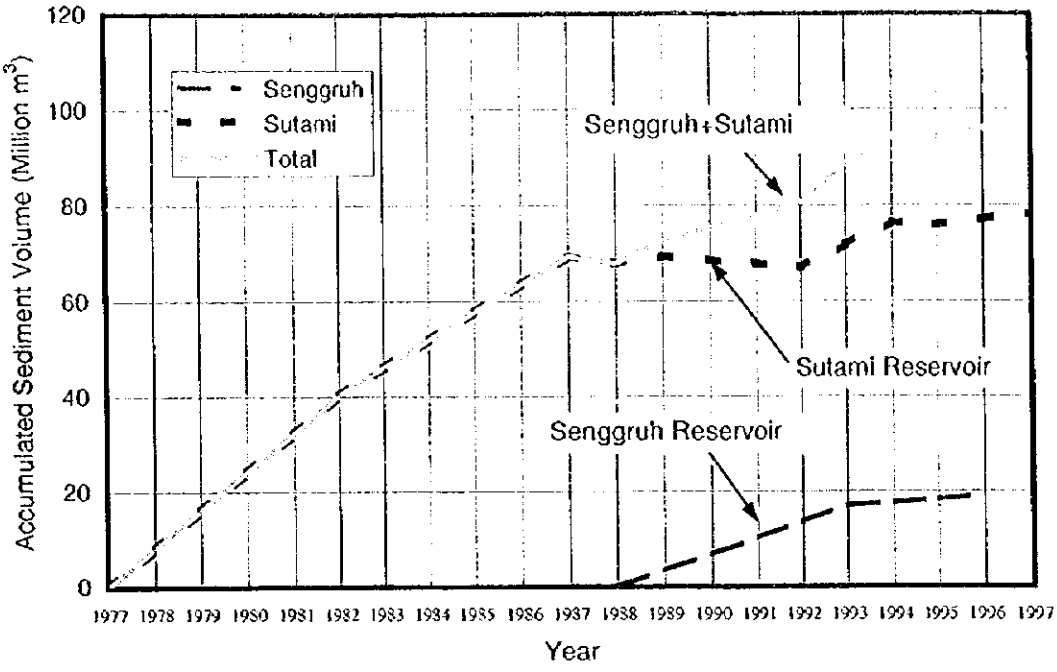


Figure A1-10 Longitudinal Sections in Lahor Reservoir (Lahor River)



Year	Accumulated Sediment Volume (m^3)			Sediment Volume per Year (m^3)			Remarks
	Senggruh	Sutami	(Total)	Senggruh	Sutami	Total	
1977	-	0	0	-	-	-	
1978	-	-	8,076,501	-	8,076,501	8,076,501	
1979	-	-	16,153,002	-	8,076,501	8,076,501	
1980	-	-	24,229,503	-	8,076,501	8,076,501	
1981	-	-	32,306,004	-	8,076,501	8,076,501	
1982	-	40,382,505	40,382,505	-	8,076,501	8,076,501	
1983	-	-	46,159,430	-	5,776,925	5,776,925	
1984	-	-	51,936,355	-	5,776,925	5,776,925	
1985	-	-	57,713,279	-	5,776,925	5,776,925	
1986	-	-	63,490,204	-	5,776,925	5,776,925	
1987	-	69,267,129	69,267,129	-	5,776,925	5,776,925	
1988	0	67,857,166	67,857,166	-	-1,409,963	-1,409,963	Completion of Senggruh Dam.
1989	-	69,282,230	72,686,297	3,404,067	1,425,064	4,829,131	
1990	-	-	75,337,320	3,404,067	-753,044	2,651,023	
1991	-	-	77,988,342	3,404,067	-753,044	2,651,023	
1992	-	67,023,097	80,639,365	3,404,067	-753,044	2,651,023	
1993	17,020,335	-	88,735,542	3,404,067	4,692,110	8,096,177	
1994	-	76,407,316	94,096,326	668,675	4,692,110	5,360,785	
1995	-	75,898,161	94,255,847	668,675	-509,155	159,520	
1996	19,026,361	-	96,102,373	668,675	1,177,851	1,846,526	
1997	-	78,253,862	-	-	1,177,851	-	

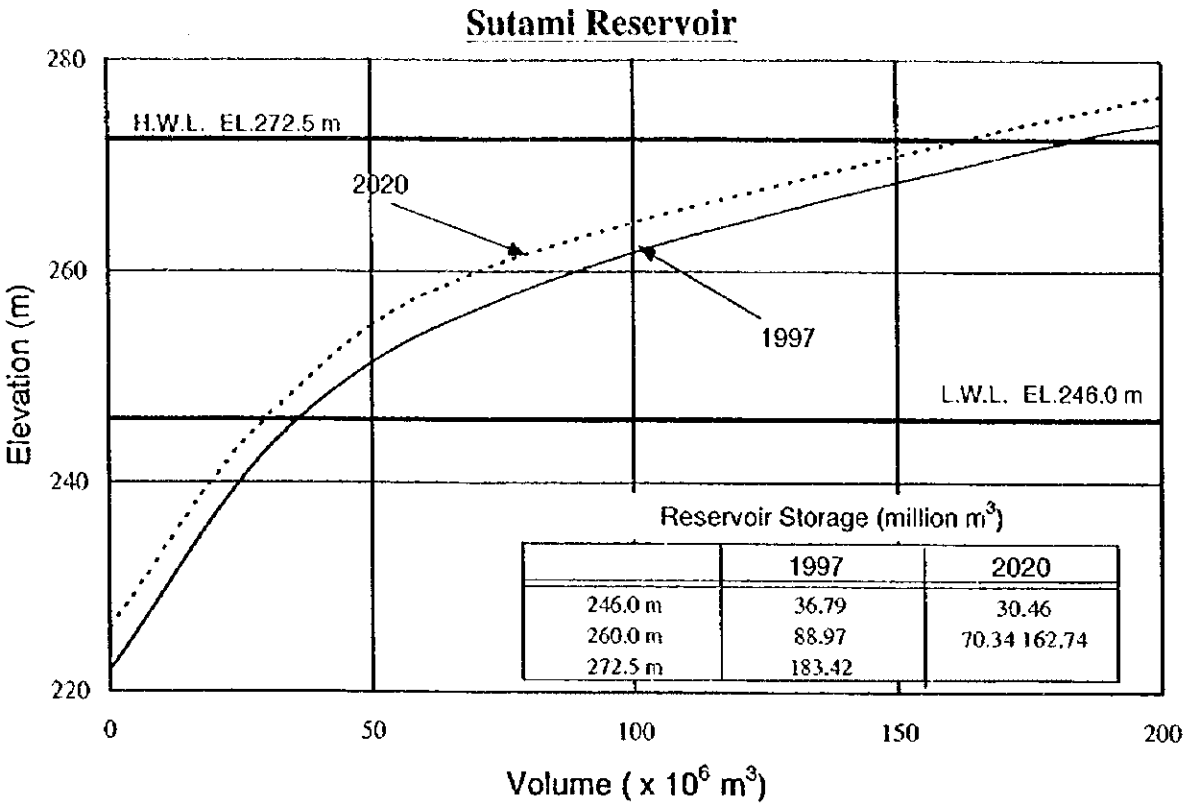
Remarks :

(1) Sediment volume of Senggruh reservoir is calculated by the Study Team in accordance with the survey report by PJT.

(2) Sediment volume of Sutami reservoir is calculated by the Study Team in accordance with the original survey data.

(3) The sediment volume in 1977 is set at 0 m^3 due to the lack of applicable survey result before 1977.

Figure A1-11 Transition of Sediment Volume in Senggruh and Sutami Reservoir



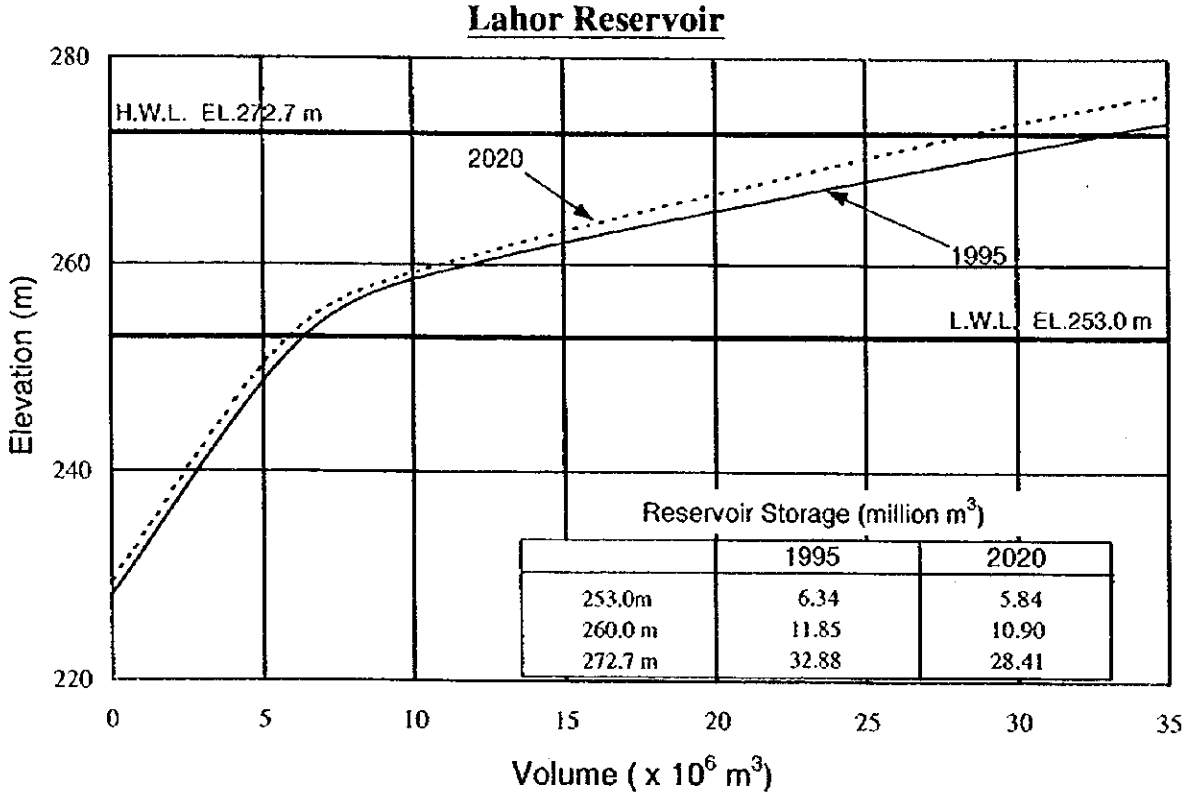


Figure A1-12 H-V Curve of the Sutami and Lahor Reservoirs

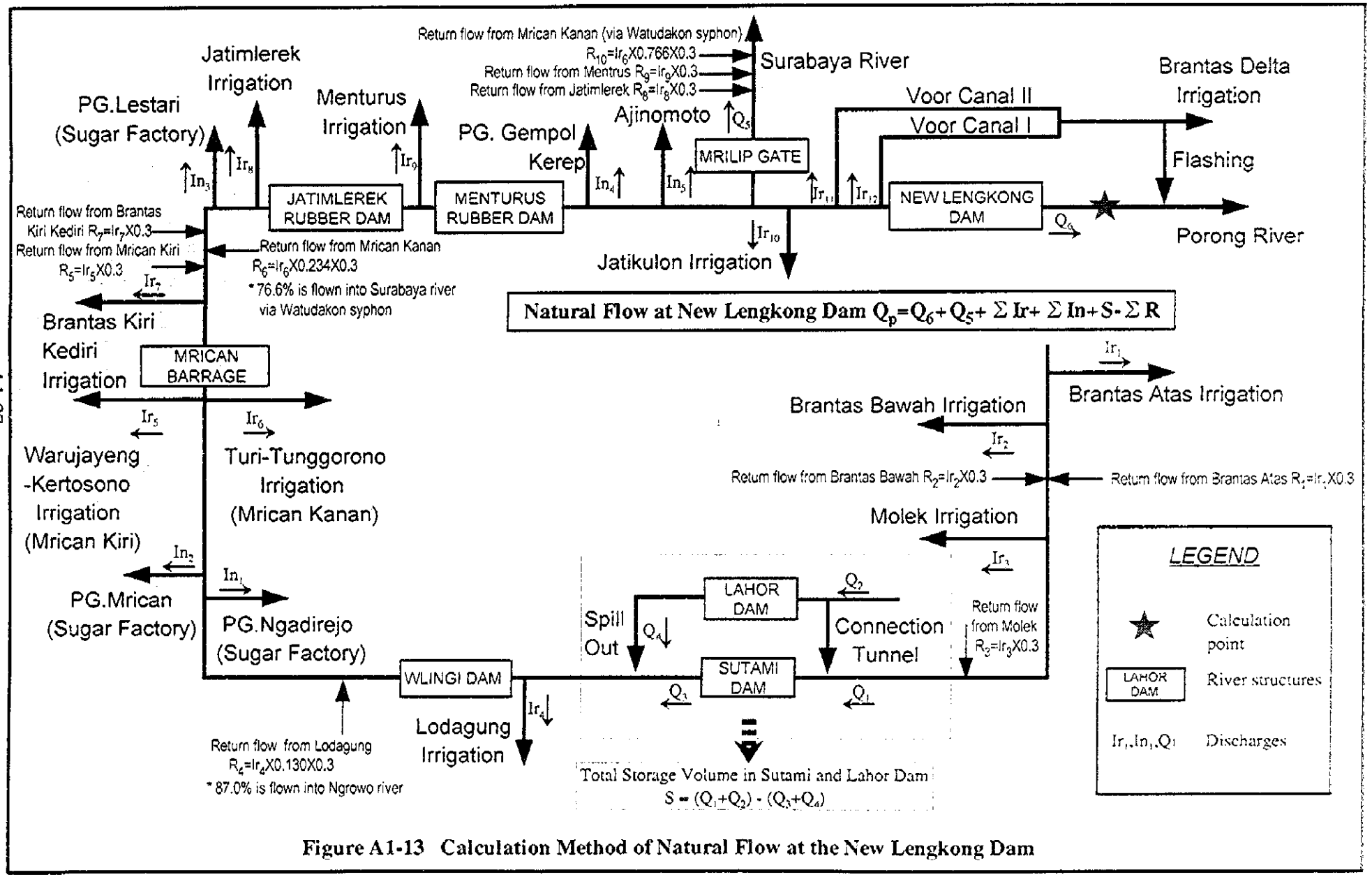


Figure A1-13 Calculation Method of Natural Flow at the New Lengkong Dam

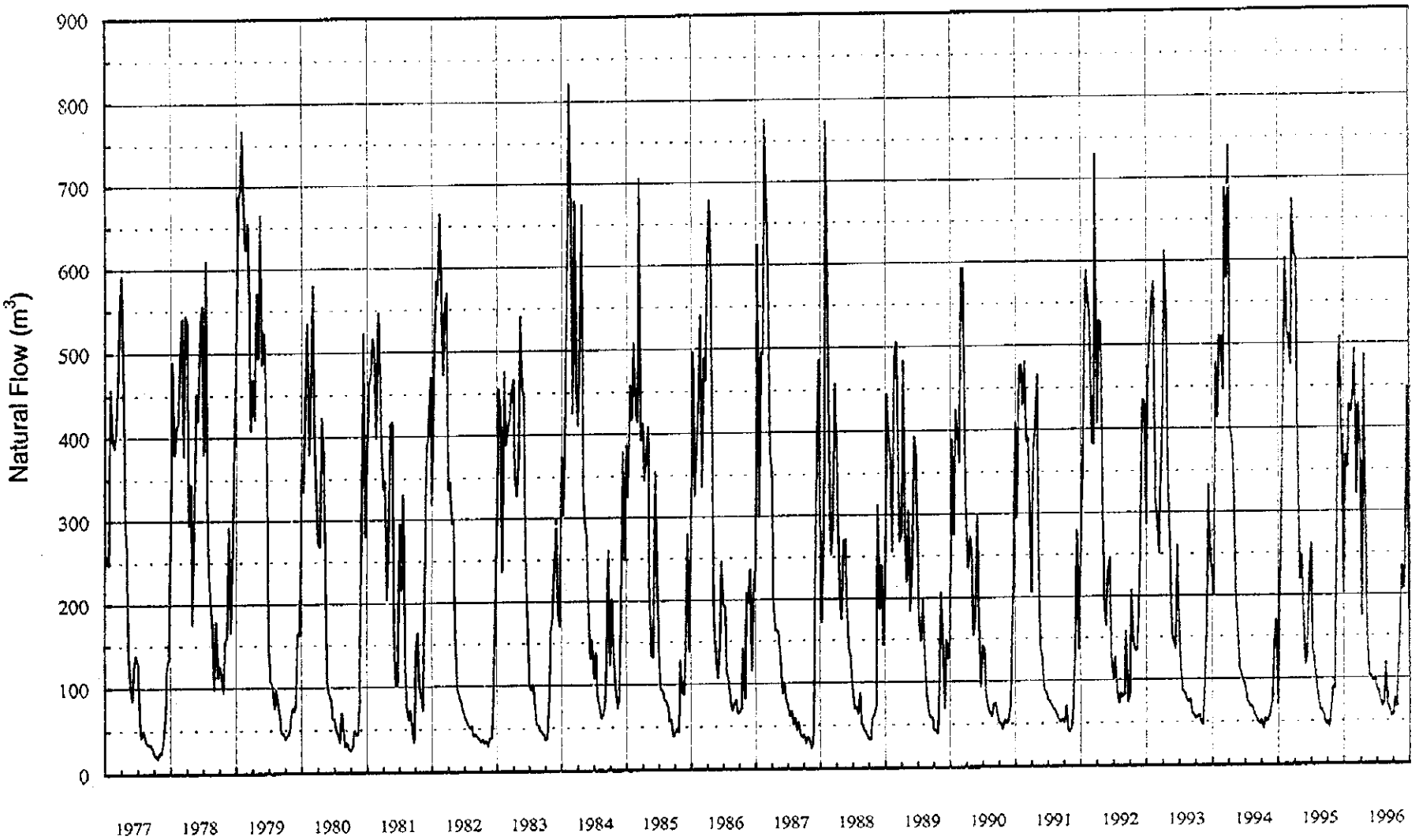


Figure A1-14 Natural Flow at the New Lengkong Dam (1977 - 1996)

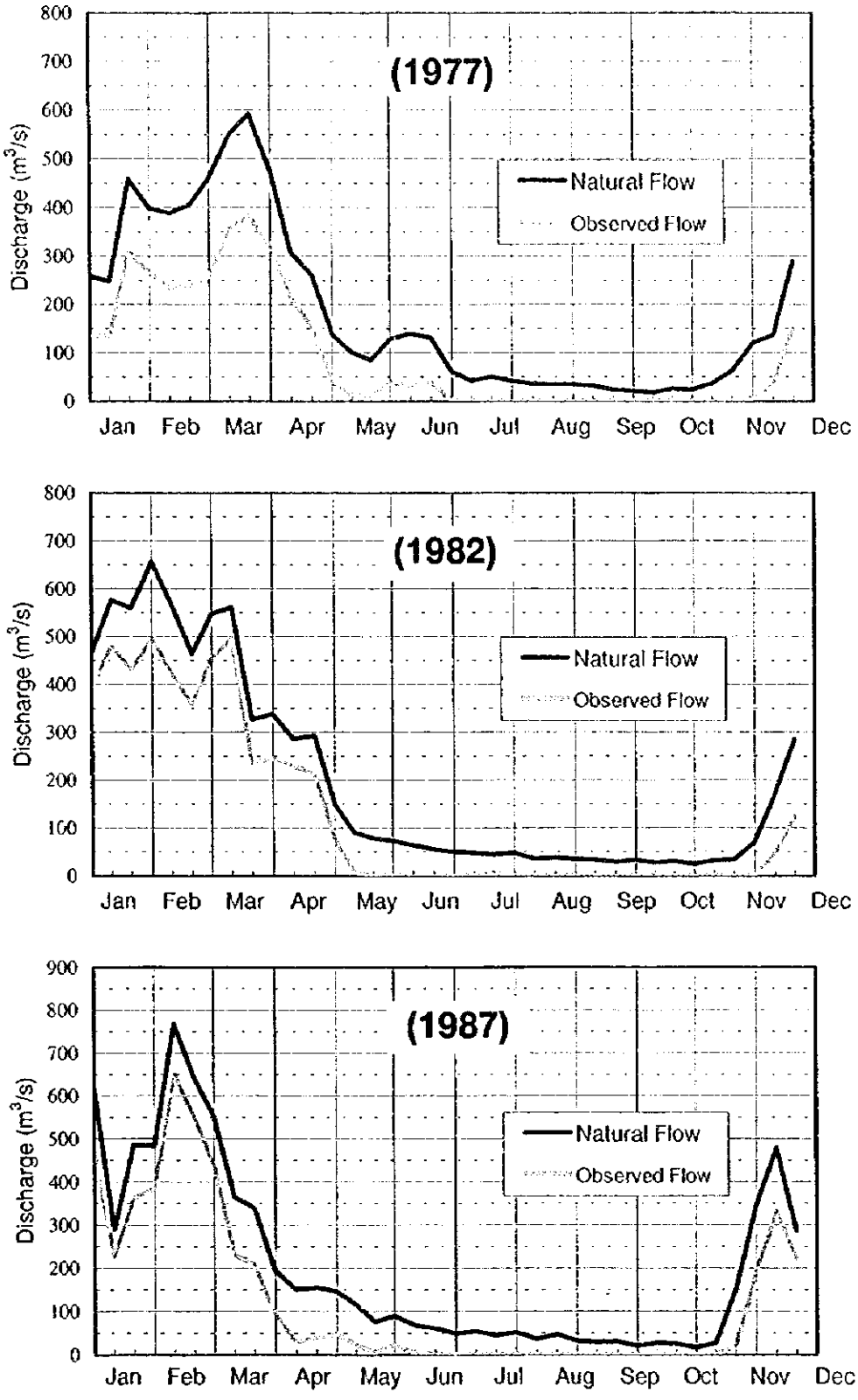


Figure A1-15 Natural Flow and Observed Flow at the New Lengkong Dam