No. 33

MALAYSIA

FEASIBILITY STUDY ON SMALL SCALE HYDROELECTRIC POWER DEVELOPMENT PROJECT AT UPPER LIWAGU RIVER BASIN IN SABAH

FINAL REPORT

APPENDIX VOL. II

OCTOBER, 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

MALAYSIA

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List of Appendixes

Appendix 12 TECHNICAL TRANSFER

Appendix 12

TECHNICAL TRANSFER

CONTENTS

1. Outline of Technical Transfer on Small Scale Hydroelectric Power Development Project at upper Liwagu River Basin

Economic Planning Unit (EPU) on behalf of Government of Malaysia requested to Japan International Cooperation Agency (JICA) on behalf of Government of Japan to make much of technical transfer concerning the small scale hydroelectric power development during the study.

Based on the request, JICA Study Team carried out the technical transfer including technical seminar to the counterparts in SEB at the SEB office and the sites.

The technical transfer by JICA Study Team was carried out by the following procedures.

(1) Technical Transfer during Field Survey

During visit to Sabah State, JICA Team carried out technical transfer to the counterparts in SEB on the methodology, analysis, design criteria and so on, for the related subjects: site reconnaissance, power survey, field investigations, development plan, preliminary design, economic and financial analysis. Project Memorandum for these subjects were prepared. Based on the Memorandum, the Team explained, discussed and advised to the counterparts in SEB.

Project Memorandums prepared by JICA Study Team are listed in **2.**

(2) Technical Seminar

JICA Team held technical seminar for SEB's engineers on June 24 and 25, 1992 at Kota Kinabalu. The subjects of the seminar were based on the study result of Small Scale Hydroelectric Power Development Project at Upper Liwagu River Basin.

Programme, text and related data of the technical seminar are shown in **3.**

(3) Seminar on Small Scale Hydroelectric Power Development

In addition to the technical transfer mentioned above, JICA planned a seminar regarding new technology and management for the small scale hydro-electric power development. The seminar intended for engineers in electric power sector and energy sector including not only SEB but also TNB and SESCO.

The seminar was held on March 11 and 12, 1992 at Kota Kinabalu.

The programme, text and related data of the seminar are shown in **4.**

Minutes of Meeting Regarding Technical Transfer on Small Scale Hydroelectric Power Development Project at Upper Liwagu River Basin

Date : July 29, 1991

Time : 3:00 p.m.--4:00 p.m.

Venue : SEB, 5th Floor, Hydro/Civil Dept. Meeting Room

Present:

SEB

Mr.Nicholas Santani, Senior Engineer
Mr.Baharuddin, Civil Engineer
Mr.Siva, Electrical Engineer
Mrs.Norlian, Electrical Engineer
Mr.Che Nan, Mechanical Engineer

JICA Study Team

Mr.T.Tezuka, Team Leader
Mr.K.Yoshioka, Civil Engineer
Mr.H.Kagami, Electrical Enginner
Mr.T.Hatano, Geologist

SEB and JICA Study Team were discussed and agreed with the Programme of Technical Transfer proposed by the Team as attached.

Mr.Nicholas Santani
Senior Engineer
Hydro/Civil Dept.
SEB

Mr.T.Tezuka
Team Leader
JICA Study Team

1. Programme of Technical Transfer

Based on the Scope of Work for Feasibility Study on Small Scale Hydroelectric Power Development Project at Upper Liwagu River Basin concluded on March 13, 1991 between EPU and JICA, and the Inception Report, the JICA Study Team will carry out Technical Transfer to the Malaysian counterparts (SEB's Engineers) through the implementation of the Study as mentioned below.

SEB will provide the following Engineers as SEB's counterparts.

Civil Engineer	1 person
Electrical Engineer	1 person
Mechanical Engineer	1 person
Transmission Line Engineer	1 person
Power Planning Engineer	1 person

1.1 Identification Stage

1.1.1 Site Reconnaissance

The Team will carry out site reconnaissance together with SEB's counterparts. The following items will be transferred to the counterparts through the reconnaissance.

- Procedure of site survey about the diversion weir site, waterway, and powerhouse site for the planned projects

- Procedure of power survey (present situation on the existing power grids, power demand and extension program of 11 kV HV lines)

- Procedure of site selection of gauging station

1.1.2 Site Selection Study

The following items will be practically transferred to the counterparts thought co-study in SEB's office.

What does the future demand require to this project?

- Characteristics of future demand
- Supply capabilities of existing power plants
- Installed capacity, firm power, effective annual energy, pond capacity of this project

How to make plans for hydropower project sites

- Layout of headrace, head pond, penstock, powerhouse, construction roads and transmission lines
- Intake level, tailrace level, gross head, net head and head loss calculation
- Catchment area, flow duration, firm discharge, maximum discharge, firm power, maximum power and annual energy
- Construction cost estimation

How to evaluate the sites

- Economical condition; construction cost/effective annual energy
- Future expansion and others

Appropriate power system configuration for the project will be transferred to the counterparts after the Team studied 11 kV HV line route and power flow study including possibility of the interconnection with Bundu Tuhan.

1.2 Field Investigation Stage

1.2.1 Topographic Survey

- Planning of the survey area and mapping procedure
- Planning of aero-photograph mapping procedure

1.2.2 Geological Investigation

During the field investigation stage, the Team will transfer technology of the geological investigation as follows.

- Geological information around the project area
- Evaluation procedure of drilling cores
- Evaluation procedure of seismic prospecting

1.2.3 Hydrological Study

The Team will transfer technology to the counterparts the following items.

- Low flow analysis
- Flood flow analysis
- Sedimentation

1.2.4 Power Demand Forecast Study

- Correlation of Westgrid o Sabah and projected area
- Economic activities and power demand in Kundassang and Ranau town

1.2.5 Environmental Impact Study

- Field survey items and methodology regarding the environmental impact around the project area

1.3 Preliminary Design Stage

1.3.1 Design Procedure of Civil Structures

- Diversion weir and desanding basin
- Headrace, head pond, penstock
- Powerhouse
- Hydraulic Design

1.3.2 Design Procedure of Electro-mechanical Equipment

- Turbine, Generator and Transformer including Control System
- Lifting crane
- Transmission line

1.3.3 Construction Plan

- Plan of construction procedure
- Plan of implementation schedule
- Contract administration and cost control

1.3.4 Economic Analysis

- Methodology of economic and financial analysis

1.4 Technical Seminar

On the time of the draft final report is prepared, the Team will be held a technical seminar at the SEB. The following items are tentatively planned.

- Small Scale Hydro Power Development
- Design of Intake dam and Waterway Facilities

- Design of Electro-mechanical Equipment
- Operation and Maintenance of Hydropower Facilities

2. List of Project Memorandum

List of Project Memorandum

No.	Subject	Date
Identification Stage		
ID-001/91	Site Selection Study	Jul. 19, 1991
ID-002/91	Site Reconnaissance Procedure	Jul. 30, 1991
ID-003/91	Survey at Naradau Site	Aug. 8, 1991
ID-004/91	Geology in the Project Area	Aug. 6, 1991
ID-005/91	Power Survey	Aug. 7, 1991
ID-006/91	Site Selection Study (2)	Aug. 8, 1991
ID-007/91	Site Selection of Gauging Station	Aug. 7, 1991
ID-008/91	Design of Civil Structures	Aug. 8, 1991
ID-009/91	Result of Reconnaissance on Environment	Aug. 8, 1991
ID-010/91	Result of Reconnaissance on Environment (2)	Aug. 8, 1991
ID-011/91	Submittal of Documents	
Field Investigation Stage		
FI-001/91	Survey Work Schedule	Dec. 10, 1991
FI-002/91	Geological Investigation	Dec. 10, 1991
FI-003/92	Topographic Survey	
FI-004/92	Environmental Impact Assessment	Feb. 18, 1992
FI-005/92	Hydrological Analysis	Feb. 18, 1992
FI-006/92	Geological Investigation	
FI-007/92	Topographic Survey	Mar. 2, 1992
FI-008/92	Environmental Impact Assessment	Jun. 20, 1992
Preliminary Design Stage		
PD-001/92	Operation of Carabau Mini Hydro	Feb. 12, 1992
PD-002/92	Turbine Generator Cost of Mini Hydro	Feb. 14, 1992
PD-003/92	Preliminary Design	Mar. 17, 1992
PD-004/92	Selection of Optimum Plan	Mar. 7, 1992
PD-005/92	Technical Seminar	Jun. 18, 1992
PD-006/92	Economic and Financial Analysis	Jun. 21, 1992

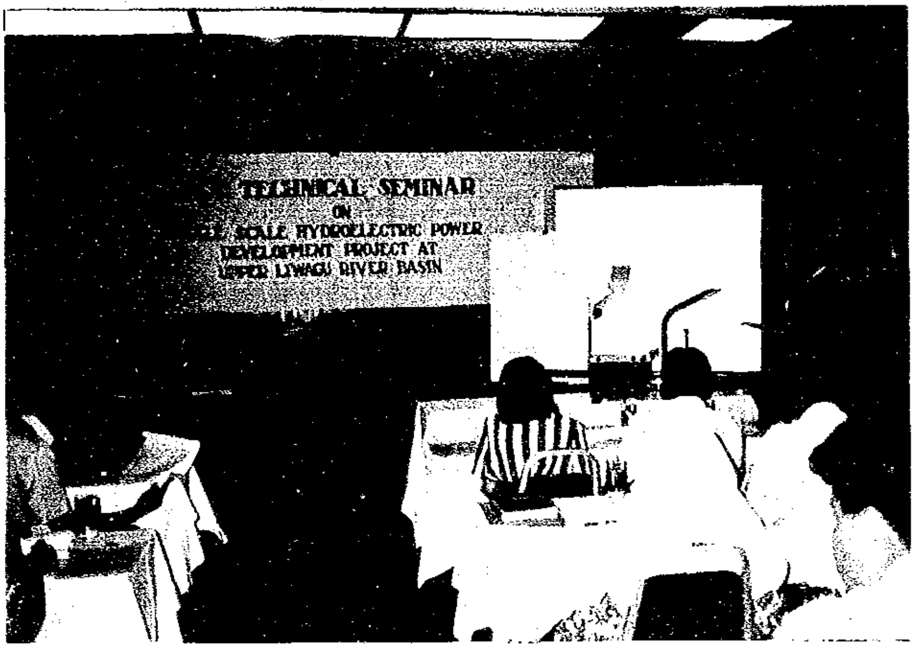
3. Technical Seminar on Small Scale Hydroelectric Power Development Project at Upper Liwagu River Basin

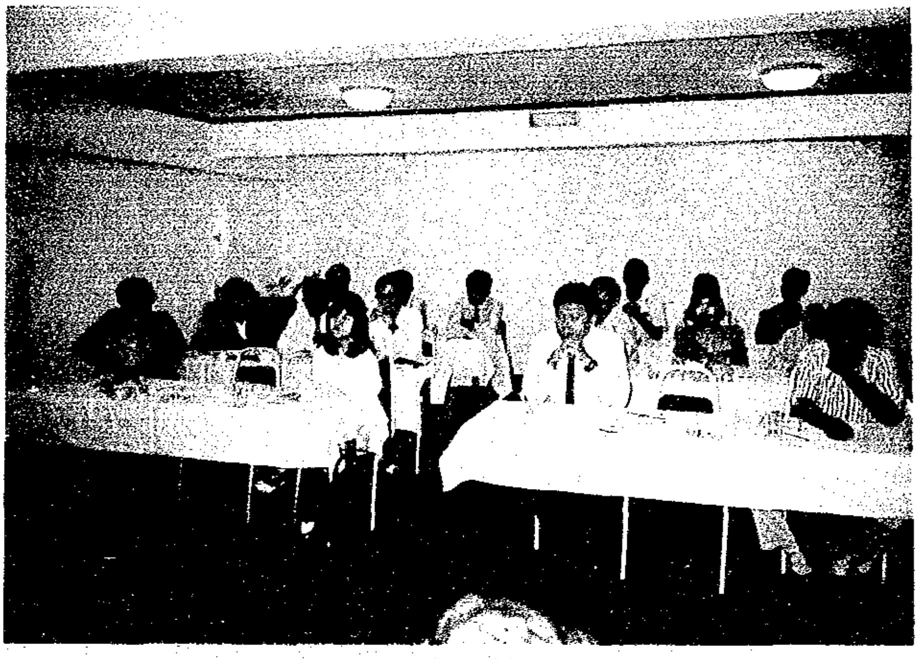
The technical seminar was held by JICA Study Team as follows.

Date : July 24 and 25, 1992

Venue: Palace Hotel, Kota Kinabalu


SMA


TECHNICAL SEMINAR
ON
SCALE HYDROELECTRIC POWER
DEVELOPMENT PROJECT AT
RIVER BASIN



TECHNICAL SEMINOR ON SMALL SCALE HYDROPOWER DEVELOPMENT PROJECT AT UPPER LIWAGU RIVER BASIN

JUNE 1992

JICA STUDY TEAM

PROGRAMME OF TECHNICAL SEMINAR BY JICA STUDY TEAM

June 24 (Wed)

9:00 - 9:15	Welcome Speech by JICA Study Team
9:15 - 9:45	Site Selection of Small Scale Hydropower Development Project in Upper Liwagu River Basin By Mr.Tezuka, Team Leader
9:45 - 10:45	Power Demand Forecast in Project Area By Mr.Kagami, Electrical Engineer
10:45 - 11:00	Tea Break
11:00 - 12:00	Hydrological Analysis Design Discharge and Flood Discharge By Mr.Washizawa, Hydrologist
12:00 - 13:30	Lunch Time
13:30 - 15:00	Open Discussion

June 25 (Thu)

9:00 - 9:30	Outline of Naradaw Project By Mr.Tezuka, Team Leader
9:30 - 10:30	Preliminary Design of Civil Structures and Hydraulic Design By Mr.Takeoka, Civil Engineer By Mr.Tomita, Civil Engineer
10:30 - 11:00	Preliminary Design of Ele-Mecha. Equipment By Mr.Kagami, Electrical Engineer
11:00 - 11:15	Tea Break
11:15 - 11:45	Economic and Financial Analysis By Mr.Fukuda, Project Economist
11:45 - 12:15	Construction Management of Hydropower Project By Mr.Tezuka, Team Leader
12:15 - 14:00	Lunch Time
14:00 - 15:00	Open Discussion
19:00 - 21:00	Cocktail Party (Palace Hotel)

Tokuji TEZUKA, Team Leader
Electric Power Development Co.,Ltd.(EPDC)
Japan

Mr.TEZUKA graduated in Civil Engineering Course of Chuo University in 1959. He entered EPDC after the graduation and was engaged in the field of design, hydraulic model test, construction supervision on hydropower development projects in Japan.

Since 1976, he has been actively involved in feasibility study, detail design and construction supervision of hydropower projects in foreign countries such as Thailand, Korea, Turkey, Malaysia and Nepal. Particularly in Malaysia, he was involved in feasibility study of Pahan State Small Scale Hydropower Development Project.

Hiroshi Kagami, Power Survey & Electrical Planning
Electric Power Development Co., Ltd.(EPDC)
Japan

Mr.KAGAMI graduated in Electrical Engineering Course of Hiroshima Technical Institute in 1953. After that he entered EPDC and was engaged design, construction supervivion and maintenance of electro-mechanical facilities of hydropower projects in Japan.

Since 1964, he has been involved in feasibility study and construction supervision as electrical engineer in foreign countries such as Philipine, Peru, Colombia, Paraguay, Lao P.D.R. and so on.

Takeshi WASHIZAWA, Hydrological Analysis
Electric Power Development Co., Ltd.(EPDC)
Japan

Mr.WASHIZAWA graduated in Civil Engineering Course of Hokkaido University in 1977. After that he entered EPDC and was engaged hydraulic model test, detail design, hydrological analysis of hydropower projects in Japan.

In the mean time, he has been involveed in feasibility study as hydrologist in foreign countries such as Turkey, China and so on.

Minaichi TAKEOKA, Civil Design
Electric Power Development Co., Ltd.(EPDC)
Japan

Mr.TAKEOKA graduated in Civil Engineering Course of Tokushima Technical Insutitute in 1956. He entered EPDC after the graduation and was engaged planning, detail design, construction supervision of hydropower development projects in Japan.

Since 1977, he has been involved in feasibility study, detail design and construction supervision in foreign countries such as Taiwan, Bhutan, India, USA and so on.

Simpei TOMITA, Civil Design
Electric Power Development Co., Ltd.(EPDC)
Japan

Mr.TOMITA graduated in Civil Engineering Course of Waseda University in 1976. After that he entered EPDC and was engaged in planning, detail design and construction supervision of hydropoer development projects in Japan.

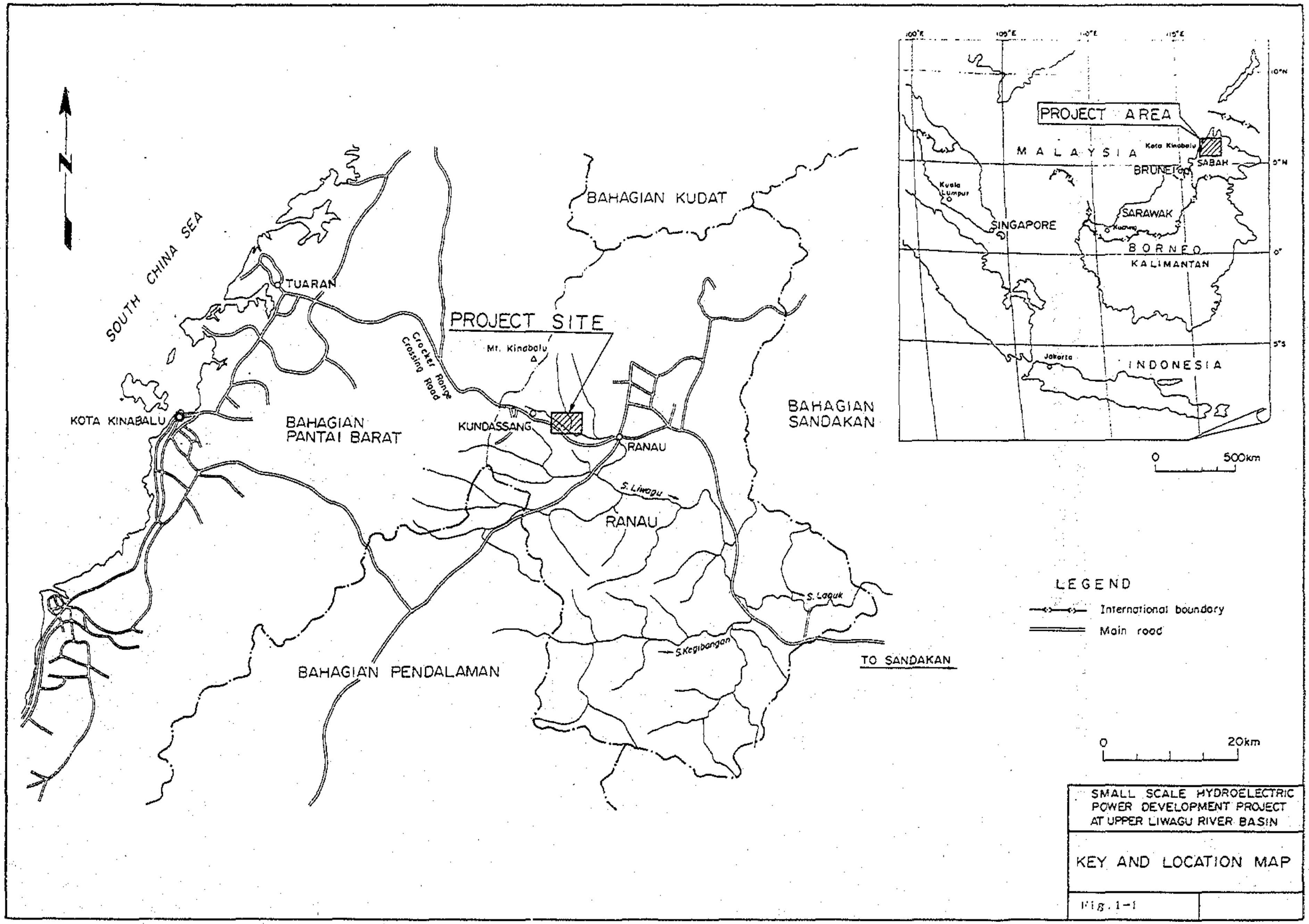
In the mean time, he has been involved in detail design and supervision of hydropower projects in foreign countries such as Turkey, Thailand, Peru and so on.

Tetsuya FUKUDA, Economic Analysis
EPDC International Co., Ltd.(EPDCI)
Japan

Mr.FUKUDA garaduated in Low Department of Hokkaido University in 1954. He entered EPDC and was engaged in survey of electric power development and economic analysis in foreign country's projects.

Since 1976, he transfered to EPDCI and he has been involved in master plan, feasibility study as project economist in foreign countries such as Indonesia, Philipine, India, Bhutan, Tanzania and so on.

1. SITE SELECTION OF SMALL SCALE HYDROPOWER DEVELOPMENT PROJECT AT UPPER LIWAGU RIVER BASIN



SMALL SCALE HYDROELECTRIC POWER DEVELOPMENT PROJECT AT UPPER LIWAGU RIVER BASIN

KEY AND LOCATION MAP

Fig. 1-1

Table 8-3 Summary of 20 Sites at Upper Liwagu River Basin

No.	River Name	Site Name	Type of P/S		Catchment Area	Design Flows	Water Levels		Gross Head	Installed Capacity	Screening			
											Net Head	95% Flows	Firm Power	
			Storage	Run off River			Head	Tail						
					km²	m³/s	ft	ft	m	MW	m	m³/s	kW	
1	Bambangan	Tembaga		O	15	1.0	4,000	3,300	213	1.7	181	0.20	290	X
2	Kegibangan	Walau	O		510	40.4	800	650	46	16				
3	Kegibangan	Barambang	O		33	2.4	1,200	920	85	2				
4	Kegibangan	Lamas 2		O	68	3.7	4,000	1,750	686	22	583	0.88	4,100	O
5	Kegibangan	Lamas 1	O		68	4.4	4,250	1,750	762	29				
6	Kegibangan	Pudau	O		303	21.7	1,085	990	29	5				
7	Kegibangan	Tinonun	O		391	28.6	990	880	34	8				
8	Liwagu	Lobok		O	14	0.8	4,000	3,500	152	1.0	129	0.18	190	X
9	Liwagu	Gantong A		O	67	3.9	2,800	2,200	183	6.2	156	0.87	1,090	O
10	Liwagu	Gantong B		O	67	3.9	2,800	2,000	244	8.2	207	0.87	1,440	O
11	Liwagu	Pakai		O	97	5.6	2,050	1,360	210	10.2	179	1.26	1,800	O
12	Liwagu	Kigiok B	O		200	11.4	1,480	1,200	85	8.4				
13	Liwagu	Kigiok A	O		200	11.4	1,500	1,410	27	2.6				
14	Liwagu	Nampasan	O		390	23.3	1,260	1,140	37	7.3				
15	Mesilau	Kauluan		O	23	1.6	4,650	3,200	442	5.9	376	0.30	900	X→O
16	Mesilau	Naradaw		O	29	1.8	3,400	2,800	183	2.8	156	0.38	470	O
17	Mindahuan	Solong	O		54	4.1	2,948	750	670	23.8				
18	Samalang	Peropot		O	145	9.2	1,610	1,510	30	2.3	25	1.89	390	X
19	Tabasan	Serpong B	O		161	8.8	1,750	1,350	122	9.2				
20	Tami Tamis	Nimbalai	O		25	1.4	2,300	1,300	305	3.5				

Source: Hydropower Options Study - Inventory of Identified Site, Liwagu River Basin. Tonkin & Taylor 1990

Estimated by JICA Team o 700 kW or more
X less than 700 kW

Fig. 8.5 Hydro-power Planning Procedure

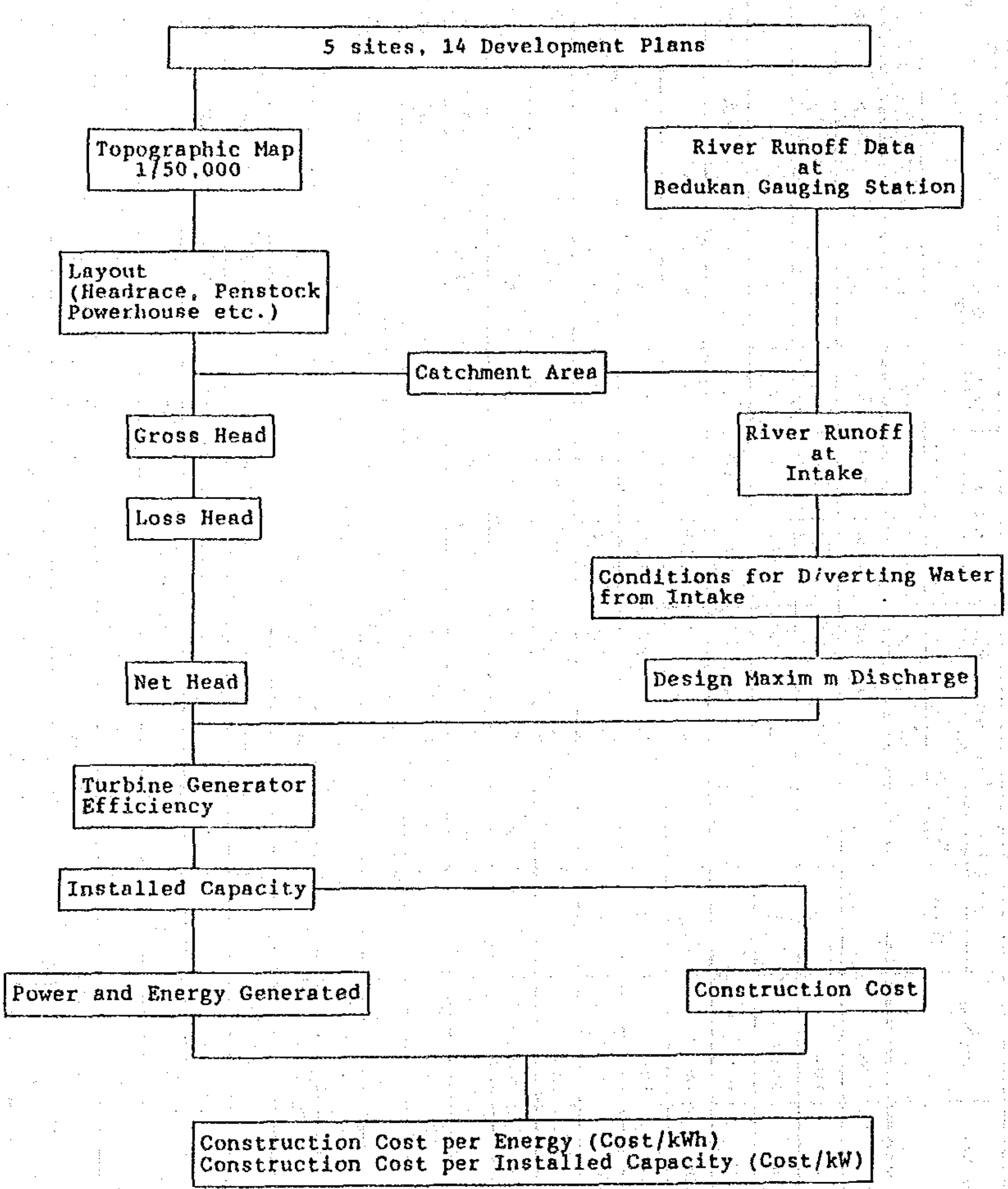


Table 8-4 Data Summary Sheet (1), Small Hydro Power Project at Upper Liwagu River

No.	Site Name	River	Installed Capacity kW	Annual Energy GWh	Const. Cost 1/ 1000 M$	Cost/kW M$	Cost/kWh M$	Rank	Note
1	Naradaw A	Liwa/Mesi	1,340	10.3	11,410	8,515	1.11		1/
2	Naradaw B	Liwagu	850	6.6	8,656	10,184	1.31	1	Carabau based unit prices are adopted for the cost of civil works tentatively.
3	Naradaw C	Mesilau	490	3.7	6,090	12,429	1.65		
4	Naradaw D	Liwa/Mesi	1,540	11.9	11,410	7,409	0.96		
5	Naradaw E	Liwa/Mesi	1,070	8.3	10,620	9,925	1.28		
6	Gantong A	Liwagu	1,600	12.3	16,580	10,363	1.35		
7	Gantong B	Liwagu	2,140	16.5	21,290	9,949	1.29	2	
8	Gantong C	Liwa/Mon	2,340	18.1	25,300	10,812	1.40		
9	Gantong D	Liwagu	1,610	12.4	13,510	8,391	1.09		
10	Gantong E	Liwa/Kihop	1,700	11.2	14,340	8,435	1.28		
11	Pakai	Liwagu	2,700	17.7	22,270	8,248	1.26	3	
12	Kauluan	Mesilau	1,150	8.8	10,980	9,548	1.25	3	
13	Lamas 2	Kegibangan	8,400	65.0	37,790	4,500	0.58		
14	Lamas 3	Kegibangan	3,180	27.7	29,080	9,145	1.05	-	

2 POWER DEMAND FORECAST IN PROJECT AREA

Fig. 4-1 11 kV HV EXISTING DISTRIBUTION LINE

(RANAU - KUNDASSANG GRID)

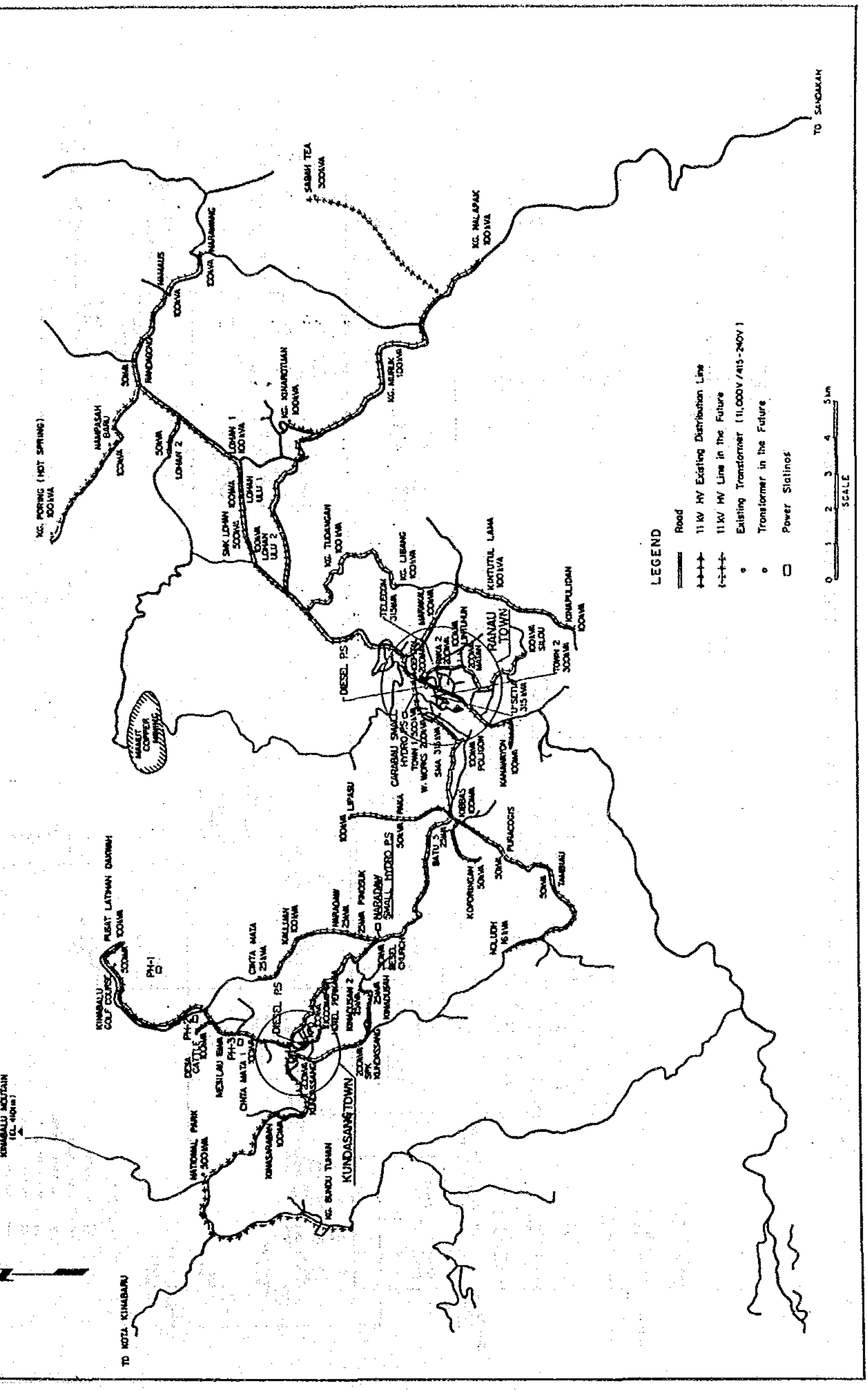


Fig. 3-1 11kV INTERCONNECTION OF RANAU AND KUNDASSANG GRIDS (As of July 1991)

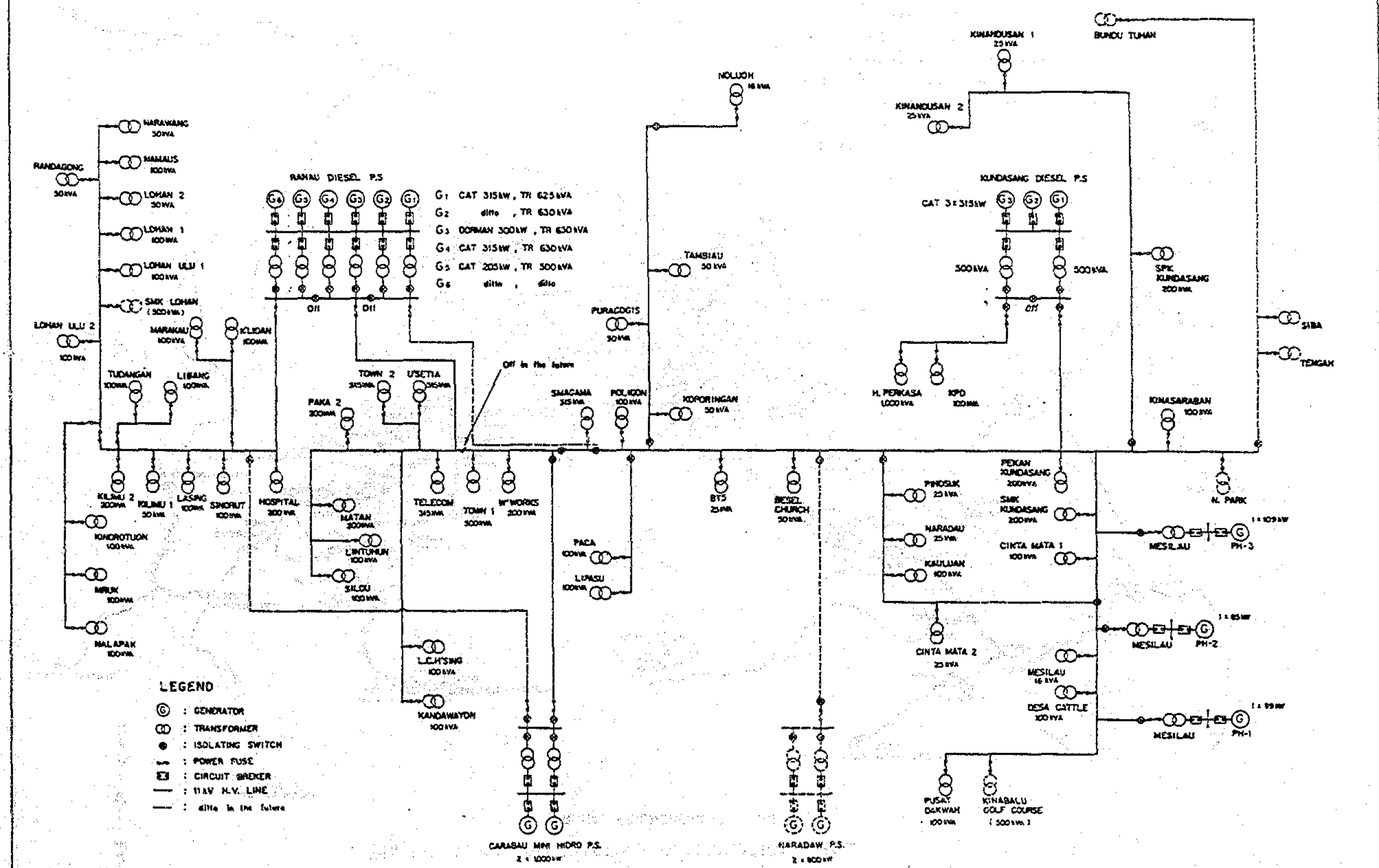


Table 3-7 Actual Power Demand at the End of Customers

Number of Customers

Year	Ranau District					Kundassang District					Bundu Tuhan			Total
	Light Industry ID_1	Houses Dm	Shops Cm_1	Public Lighting PL	Sub-Total	Light Industry ID_1	Houses Dm	Shops Cm_1	Public Lighting PL	Sub-Total	Houses Dm	Shops Cm_1	Sub-Total	
1985	7	1,410	224	7	1,648	7	232	19	–	258	119	13	132	2,038
1986	8	1,617	228	8	1,861	7	247	34	–	288	127	12	139	2,288
1987	8	1,797	258	8	2,071	7	248	39	–	294	129	13	142	2,507
1988	10	1,893	267	7	2,177	7	263	41	1	312	138	13	151	2,640
1989	11	1,934	281	7	2,233	8	280	42	1	331	144	14	158	2,722
1990	16	1,936	332	12	2,296	9	426	46	1	482	166	16	182	2,960

Energy Sold to Customers (MWh)

Year	Ranau District					Kundassang District					Bundu Tuhan			Total
	Light Industry ID_1	Houses Dm	Shops Cm_1	Public Lighting PL	Sub-Total	Light Industry ID_1	Houses Dm	Shops Cm_1	Public Lighting PL	Sub-Total	Houses Dm	Shops Cm_1	Sub-Total	
1985	363	1,056	671	60	2,150	392	170	60	–	622	60	4	64	2,836
1986	379	1,127	778	64	2,348	429	186	62	–	677	74	4	78	3,103
1987	457	1,440	924	93	2,914	568	201	109	–	878	61	10	71	3,863
1988	493	1,963	1,243	78	3,777	580	240	198	7	1,025	62	11	73	4,875
1989	506	1,981	1,267	67	3,821	621	275	171	9	1,076	63	11	74	4,971
1990	583	2,234	1,324	131	4,272	629	300	174	7	1,110	89	13	102	5,484

Unit Energy Consumption per Customers (Average kWh per Month)

Year	Ranau District					Kundassang District					Bundu Tuhan			Total (Average)
	Light Industry ID_1	Houses Dm	Shops Cm_1	Public Lighting PL	Sub-Total (Average)	Light Industry ID_1	Houses Dm	Shops Cm_1	Public Lighting PL	Sub-Total (Average)	Houses Dm	Shops Cm_1	Sub-Total (Average)	
1985	4,321	62	250	714	109	4,667	61	263	–	201	42	27	40	116
1986	3,948	58	264	667	105	5,107	62	152	–	196	49	28	47	113
1987	4,760	67	298	969	117	6,762	68	233	–	249	39	64	42	128
1988	4,108	86	388	929	145	6,905	76	402	7	273	37	71	40	154
1989	3,833	85	376	798	143	6,469	82	339	9	271	36	65	39	152
1990	3,036	96	332	909	155	5,824	59	315	7	192	45	68	79	154

Table 4-1 Actual Power Demand at Ranau-Kundassang Grid

year	Number of Consumers	Generated Energy (MWh)	Engergy Sold of Consumers (MWh)	Energy Loss (%)	Monthly Unit Sold per Consumer (KWh)
1985	2038	3,210	2,836	11.7	116
1986	2288	3,530	3,103	12.1	113
1987	2507	4,150	3,836	6.9	128
1988	2640	5,303	4,875	8.1	154
1989	2722	5,532	4,971	10.1	152
1990	2960	6,025	5,484	9.0	154
Annual Growth Rate	7.8	13.4%	14.1%	–	5.8%

Table 4-2 Power Demand Forecast for Ranau-Kundassang Grid from 1991 to 2015

No.	Year	Estimated Population in Kundassang -Ranau Grid	Potential Number of Consumers	Electrification Ratio (%)	Number of Consumers Electritied	*1 Monthly Average Conslmption Per Customers (kWh)	Annual Energy Requirement at Consumers End (MWh)	Energy Loss Factor (%)	at Generating End: Annual Load Factor (%)	at Generating End: Annual Energy Requirement (MWh)	at Generating End: Annual Maximum Demand (kW)	Remarks
Historical Data	1985	26,900	5,270	38.7	2,038	116	2,836	11.7	50.1	3,210	730	
	1986	28,000	5,490	41.7	2,288	113	3,103	12.1	51.0	3,530	790	Note *1
	1987	29,100	5,700	44.0	2,507	128	3,863	6.9	50.9	4,150	930	Growth Rate :
	1988	30,200	5,920	44.6	2,640	154	4,875	8.1	49.2	5,303	1,230	1990~1995 : 6 %
	1989	31,400	6,160	44.1	2,722	152	4,971	10.1	50.1	5,532	1,260	1995~2000 : 4 %
	1990	32,600	6,390	46.3	2,960	154	5,484	9.0	51.7	6,025	1,330	2000~2005 : 3 %
1	1991	33,900	6,650	47.0	3,130	163	6,122	10.0	52.0	6,734	1,480	2005~2010 : 2 %
2	1992	35,200	6,900	49.0	3,380	173	7,017	10.0	52.0	7,719	1,690	2010~2015 : 1 %
3	1993	36,600	7,180	51.0	3,660	183	8,037	11.0	53.0	8,921	1,920	
4	1994	38,000	7,450	53.0	3,950	194	9,196	11.0	53.0	10,208	2,200	Power demand in National Park
5	1995	39,500	7,750	55.0	4,260	206	10,530	11.0	53.0	11,583	2,520	is included from 1992.
6	1996	41,000	8,040	56.0	4,500	214	11,556	12.0	54.0	12,943	2,740	
7	1997	42,600	8,350	57.0	4,760	223	12,738	12.0	54.0	14,267	3,020	
8	1998	44,300	8,690	58.0	5,040	232	14,031	12.0	54.0	15,715	3,320	
9	1999	46,000	9,020	59.0	5,320	241	15,385	12.0	54.0	17,201	3,640	
10	2000	47,800	9,370	60.0	5,620	251	16,927	12.0	55.0	18,958	3,930	
11	2001	49,000	9,610	61.0	5,860	258	18,143	12.0	55.0	20,320	4,220	
12	2002	50,300	9,860	62.0	6,110	266	19,503	12.0	55.0	21,843	4,530	
13	2003	51,600	10,120	63.0	6,380	274	20,977	12.0	55.0	23,494	4,880	
14	2004	53,000	10,390	64.0	6,650	282	22,504	12.0	55.0	25,204	5,230	
15	2005	54,300	10,650	65.0	6,920	291	24,164	12.0	55.0	27,064	5,620	
16	2006	55,800		66.0		296		12.0	55.0			
17	2007	57,200		67.0		302		12.0	55.0			
18	2008	58,700		68.0		308		12.0	55.0			
19	2009	60,200		69.0		315		12.0	55.0			
20	2010	61,800	12,120	70.0	8,480	321	32,665	12.0	55.0	36,585	7,590	
21	2011	63,400		70.0		324		12.0	55.0			
22	2012	65,000		70.0		327		12.0	55.0			
23	2013	66,700		70.0		331		12.0	55.0			
24	2014	68,500		70.0		334		12.0	55.0			
25	2015	70,200	13,760	70.0	9,630	337	38,944	12.0	55.0	43,617	9,050	
Annual Growth Rate (%)		3.1	3.1	–	4.8	3.1	8.2	–	–	8.2	8.0	

Table 4-5 Correlation of Ranau-Kundassang Grid with West Coast Grid

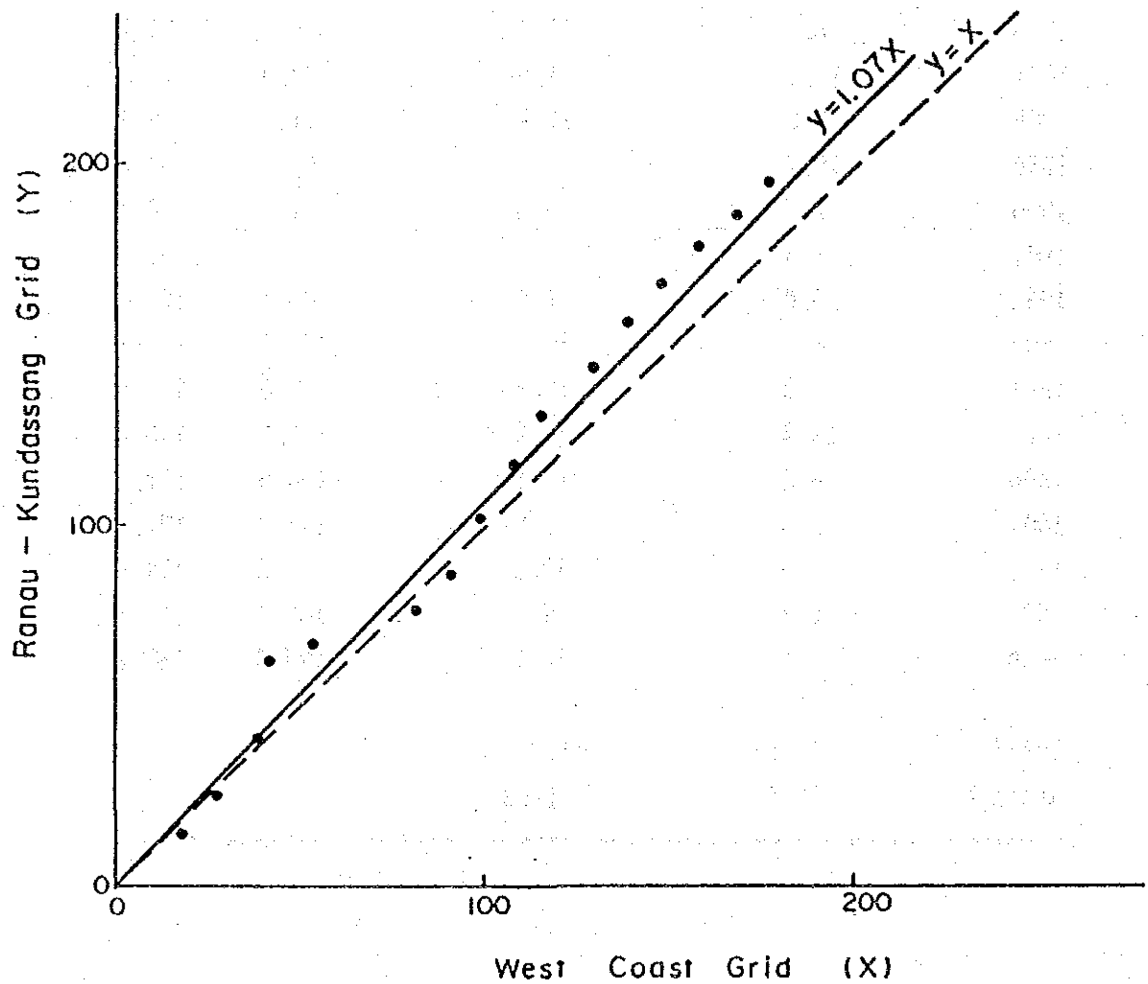
No.	Year	West Coast Grid						Ranau-Kundassang Grid				Remarks
		Peak (MW)	Generated (GWh)	Load Factor (%)	Generated Growth (%)	Energy Sold (GWh)	Loss (%)	Peak (kW)	Generated (MWh)	Load Factor (%)	Generated Growth (%)	
Historical Data	1980	35.3	187.1	60.5	–	153.1	18.2	370	1,460	45.0	–	
	1981	42.0	212.7	57.8	13.7	170.5	19.8	430	1,780	47.3	21.9	1984 : Tenom Pangi Hydro Power
	1982	46.3	240.7	59.3	13.2	193.2	19.7	490	1,970	45.9	10.7	Plant + Kota Kinabalu +
	1983	51.8	272.7	60.0	13.3	201.8	26.0	600	2,420	46.0	22.8	Beanfor
	1984	57.3	311.2	62.0	14.1	211.4	32.1	640	2,810	50.1	16.1	1989 : Plas Keningau + Tenom
	1985	69.3	367.1	60.5	17.9	289.2	21.2	730	3,210	50.1	14.2	1990 : Plus Labuan
	1986	76.2	399.7	59.8	8.9	296.4	25.8	790	3,530	51.0	10.0	
	1987	82.0	447.7	62.3	12.0	337.6	24.6	930	4,150	50.9	17.6	
	1988	84.5	460.1	62.2	2.8	351.5	23.6	1,230	5,303	49.2	21.7	
	1980	89.3	509.2	65.1	10.7	411.1	19.3	1,260	5,532	50.1	4.3	(1) Annual Generated Energy
	1990	115.5	655.2	64.7	28.7	534.2	18.5	1,330	6,025	51.7	8.9	Growith Rate from 1985 to 1990
1	1991	129.7	738.2	65.0	8.5	568.4	27.1	1,480	6,734	52.0	10.8	West Coast Grid : 12.3%
2	1992	140.8	801.9	65.0	8.6	625.5	22.0	1,690	7,719	52.0	14.6	Ranau-Kundassang : 13.4%
3	1993	153.1	871.6	65.0	8.7	686.7	21.2	1,920	8,921	53.0	15.6	
4	1994	166.6	948.6	65.0	8.8	756.6	20.2	2,200	10,208	53.0	14.4	(2) Annual Generated Energy
5	1995	188.6	1,073.6	65.0	13.2	880.0	18.0	2,520	11,583	53.0	13.5	Growth Rate from 1990 to 2000
6	1996	205.9	1,172.7	65.0	9.2	973.3	17.0	2,740	12,943	54.0	11.7	West Coast Grid : 10.0%
7	1997	225.2	1,282.4	65.0	9.3	1,077.2	16.0	3,020	14,267	54.0	10.2	Ranau-Kundassang : 12.1%
8	1998	246.7	1,404.7	65.0	9.5	1,193.9	15.0	3,320	15,715	54.0	10.1	
9	1999	270.6	1,541.0	65.0	9.7	1,325.3	14.0	3,640	17,201	54.0	9.5	(3) Power demand in National Park
10	2000	297.4	1,693.5	65.0	.8	1,473.3	13.0	3,930	18,958	55.0	10.2	is included from 1992
11	2001	331.1	1,885.7	65.0	11.3	1,640.5	13.0	4,220	20,320	55.0	7.2	
12	2002	369.3	2,103.2	65.0	11.5	1,829.8	13.0	4,530	21,843	55.0	7.5	
13	2003	412.7	2,349.9	65.0	11.7	2,044.4	13.0	4,880	23,494	55.0	7.6	
14	2004	461.6	2,630.0	65.0	11.9	2,288.1	13.0	5,230	25,204	55.0	7.3	
15	2005	517.6	2,948.6	65.0	12.1	2,585.3	13.0	5,620	27,064	55.0	7.3	
16	2006				12.0							
17	2007				12.0							
18	2008				12.0							
19	2009				12.0							
20	2010	912.6	5,196.5	65.0	12.0	4,521.0	13.0	7,590	36,585	55.0	–	
21	2011				10.0							
22	2012				10.0							
23	2013				10.0							
24	2014				10.0							
25	2015	1,469.2	8,366.3	65.0	10.0	7,278.8	13.0	9,050	43,617	55.0	–	
Annual Growth Rate (%)		10.7	10.7	–	–	11.0	–	8.0	8.2	–	–	

Table 4-4 Annual Growth Rate of Generating Energy at West Coast Grid and Ranau-Kundassang Grid

Unit:%

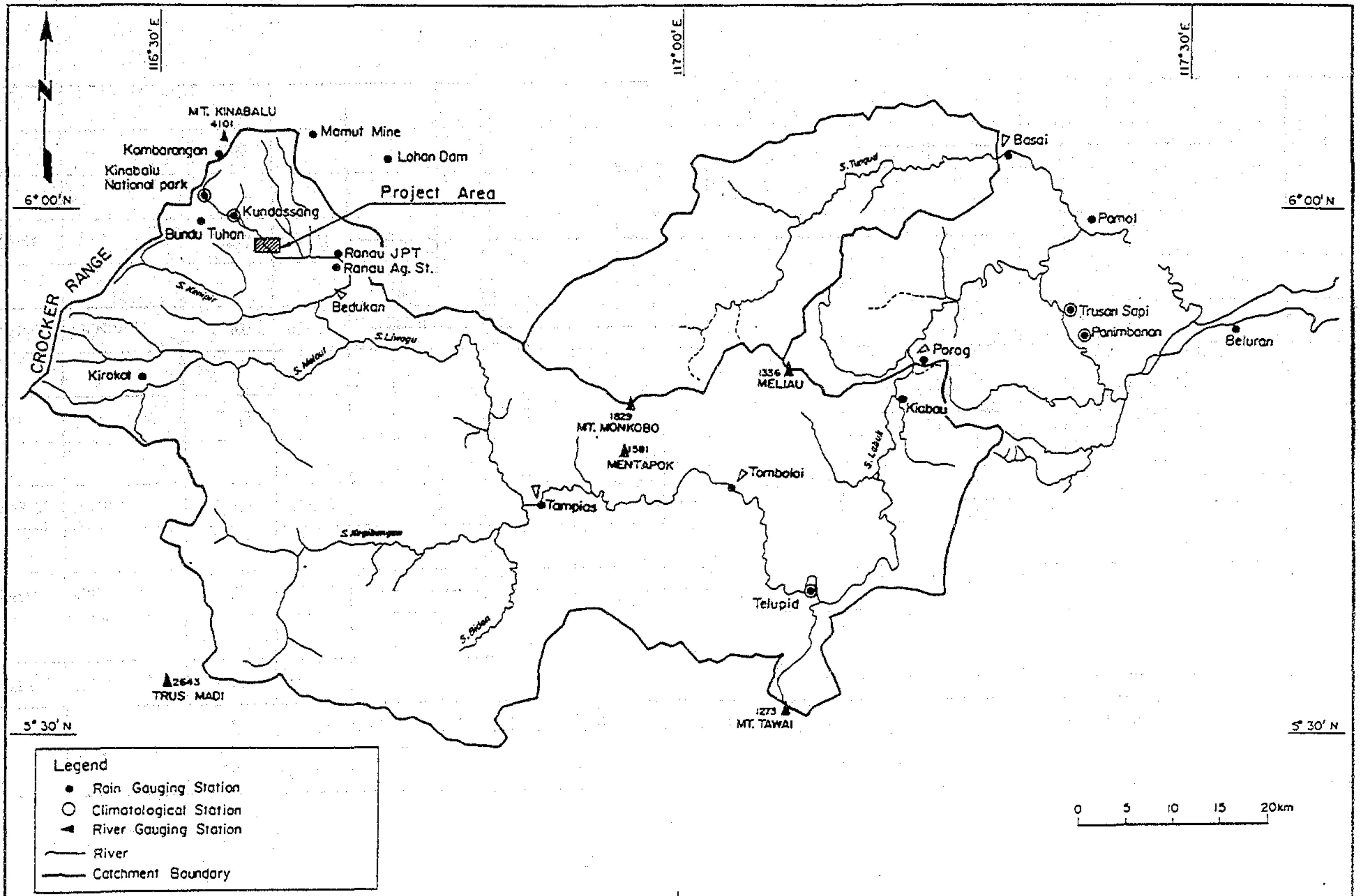
Year	(A) West Coast	(B) Ranau-Kundassang	Σ(A)	Σ(B)
1985	17.9	14.2	17.9	14.2
1986	8.9	10.0	26.8	24.2
1987	12.0	17.6	38.8	41.8
1988	2.8	21.7	41.6	63.5
1989	10.7	4.3	52.3	67.8
1990	28.7	8.9	81.0	76.7
1991	8.5	10.8	89.5	87.5
1992	8.6	14.6	98.1	102.1
1993	8.7	15.6	106.8	117.7
1994	8.8	14.4	115.6	132.1
1995	13.2	13.5	128.8	145.6
1996	9.2	11.7	138.0	157.3
1997	9.3	10.2	147.3	167.5
1998	9.5	10.1	156.8	177.6
1999	9.7	9.5	166.5	187.1
2000	9.8	10.2	176.3	197.3
Total	176.3	197.3		
Average	11.0	12.3		

Fig. 4-2 Correlation of Ranau-Kundassang Grid with West Coast Grid



3 HYDROLOGICAL ANALYSIS

95 % flow (Firm discharge)	Liwagu intake Mesilau intake Total	0.24 m^3/s 0.21 m^3/s 0.45 m^3/s
70% flow (Design maximum discharge)	Liwagu intake Mesilau intake	0.70 m^3/s o.47 m^3/s
Return period 50 years (Design flood discharge)	Liwagu intake Mesilau intake powerhouse	200 m^3/s 180 m^3/s 220 m^3/s



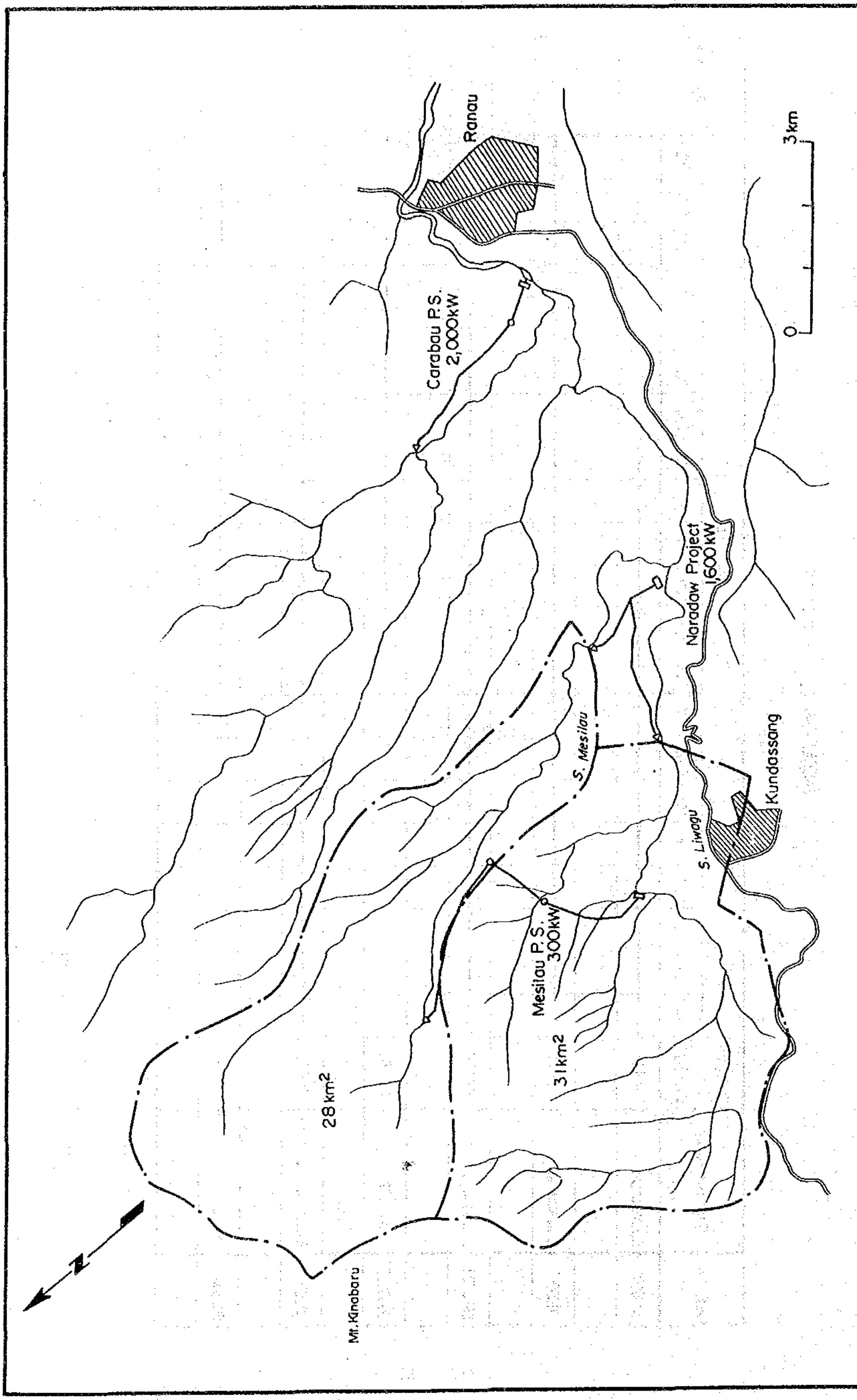
Location of Observatory Station

Gauging Station

Ref. No.	Station Name	Catchment Area km²	Gauged Period	'70	'71	'72	'73	'74	'75	'76	'77	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	Remarks
6065401	Kinabalu N.P.	11										—	—	—	—	—	—	—	—	—	—	—			Water Level
5966401	Bedukan	200	'70-'80	—	—	—	—	—	—	—	—	—	—	—											
5768401	Tampias	2,010	'77-'87								—	—	—	—	—	—	—	—	—						
〃	〃	2,010													—	—	—	—	—	—	—	—	—		Water Level
5770401	Tomboloi	2,460	'64-'77	—	—	—	—	—	—	—	—														
5872401	Porog	3,240	'63-'89	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—							
〃	〃	3,240													—	—	—	—	—	—	—	—	—		Water Level

RAINFALL Station

Ref. No.	Station Name	Gauged Period	Year																					Remarks
			'70	'71	'72	'73	'74	'75	'76	'77	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	
6065001	Kambarangan	'57-'83																						
6065002	Kinabalu N.P.	'71-'90																						
5966002	Kundassang	'61-'86																						
5966001	Ranau JPT	'80-'90																						
5966001	Ranau Agricaluture	'54-'90																						
5968001	Tampias	'78-'87																						



Naradaw Catchment Area

	Bedukan G/S - Tampias G/S	Bedukan G/S - Tomboloi G/S
Period of Data	1977 - 1980	1970 - 1977
R	0.689	0.776
A	0.06	0.05
B	2.53	0.70

Y = AX + b

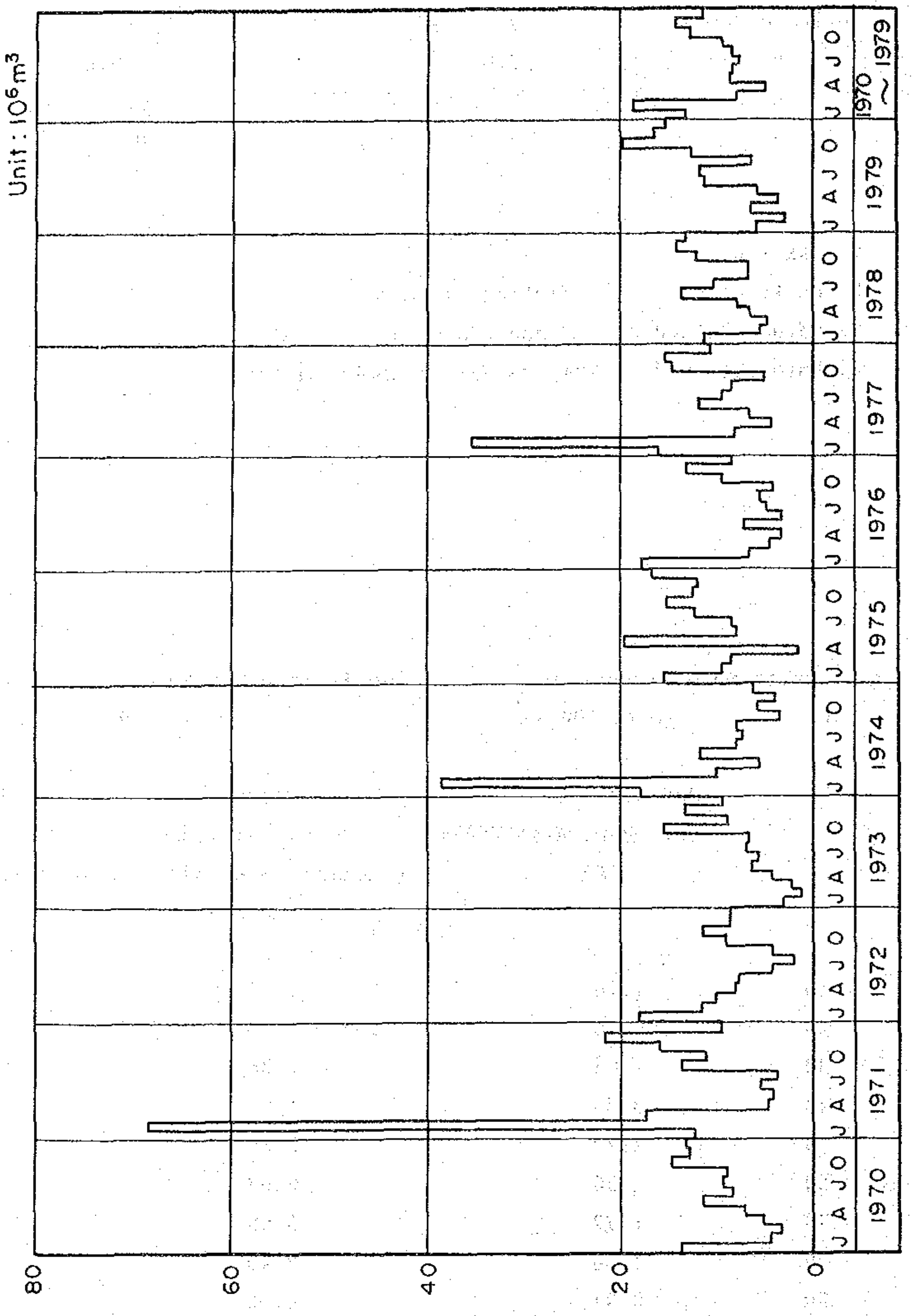
R: Coefficient of Correlation

Y: Data obtained at Bedukan G/S

X: Data obtained at Tampias G/S or Tomboloi G/S

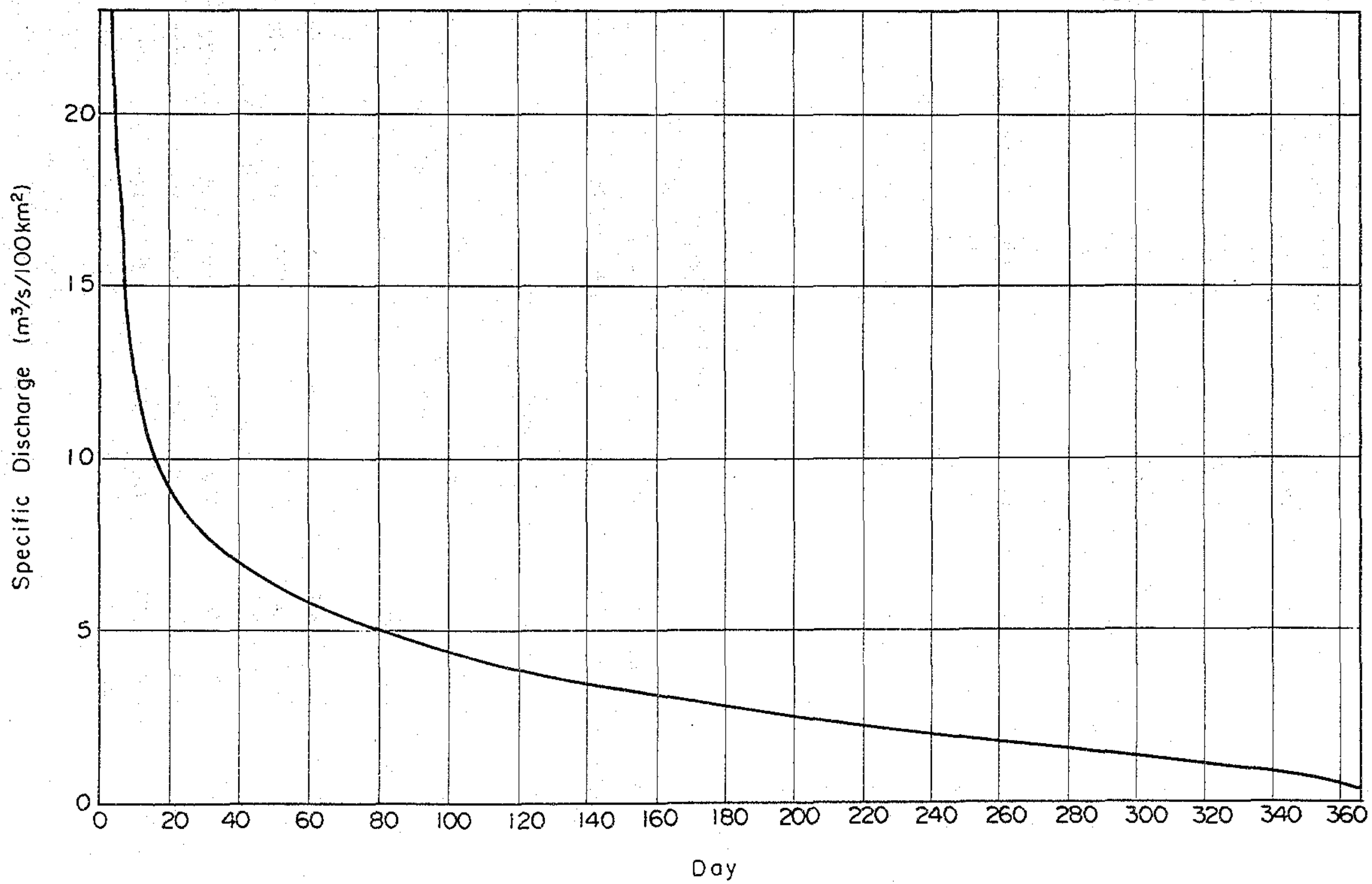
Duration (%)	Daily Mean Discharge ($m^3/s/100\ km^2$)	Daily Mean Discharge (m^3/s)	
	Bedukan G/S Catchment Area $200km^2$ (A)	Liwagu Intake Dam Site Catchment Area $31km^2$ (A) x 0.31	Mesilau Intake Dam Site Catchment Area $28km^2$ (A) x 0.28
10	7.16	2.22	2.00
20	5.25	1.63	1.47 0:69
30	4.06	1.26	1.14
40	3.33	1.03	0.93
50	2.72	0.84	0.76
60	2.20	0.68	0.62
70	1.77	0.55	0.50
80	1.38	0.43	0.39
90	0.97	0.30	0.27
95	0.76	0.24	0.21

Monthly Discharge at Bedukan G/S



Duration Curve of Calculated Discharge at Mesilau and Liwagu Intake Dam Site

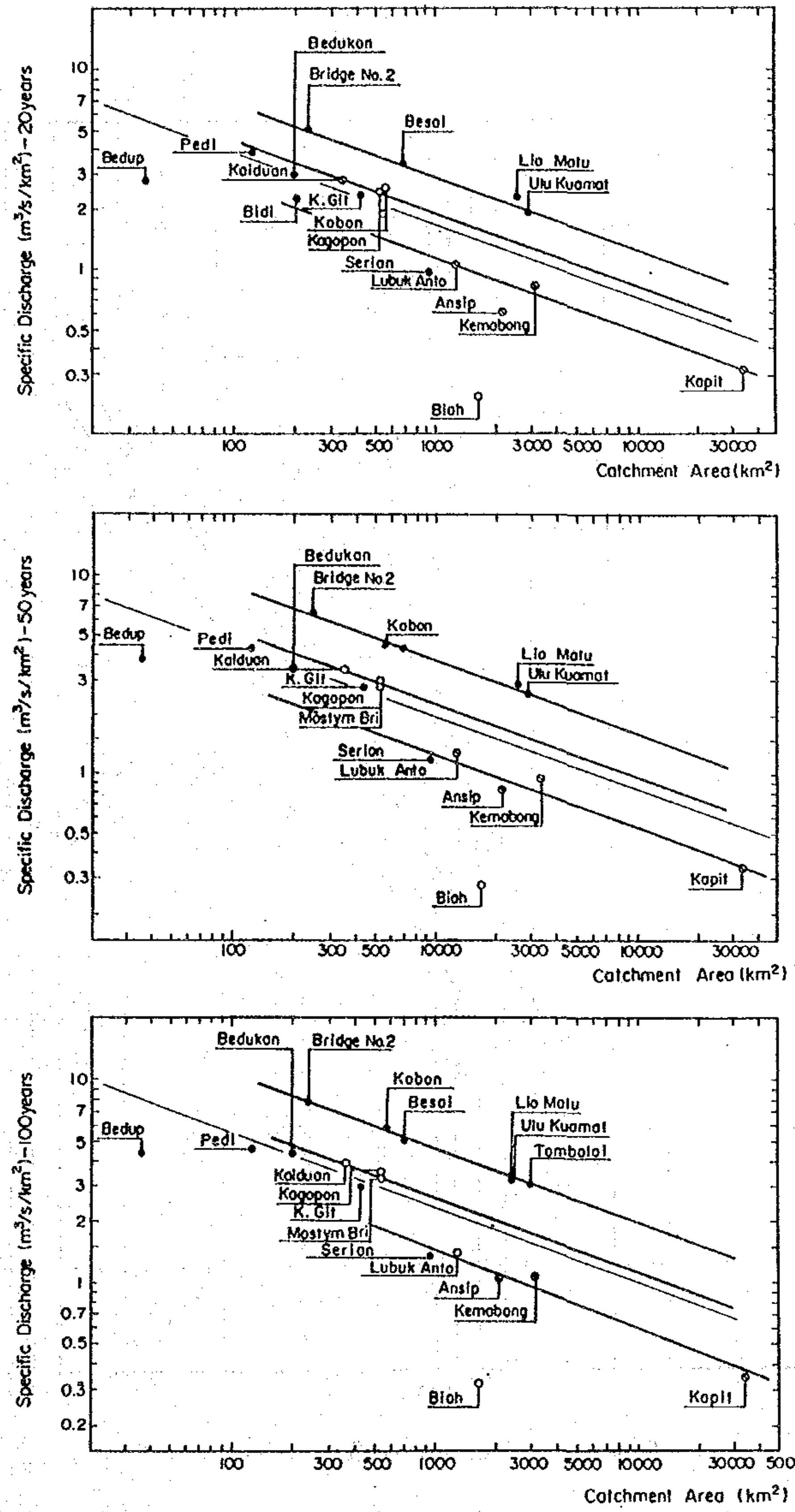
1970 – 1979 (Mean)



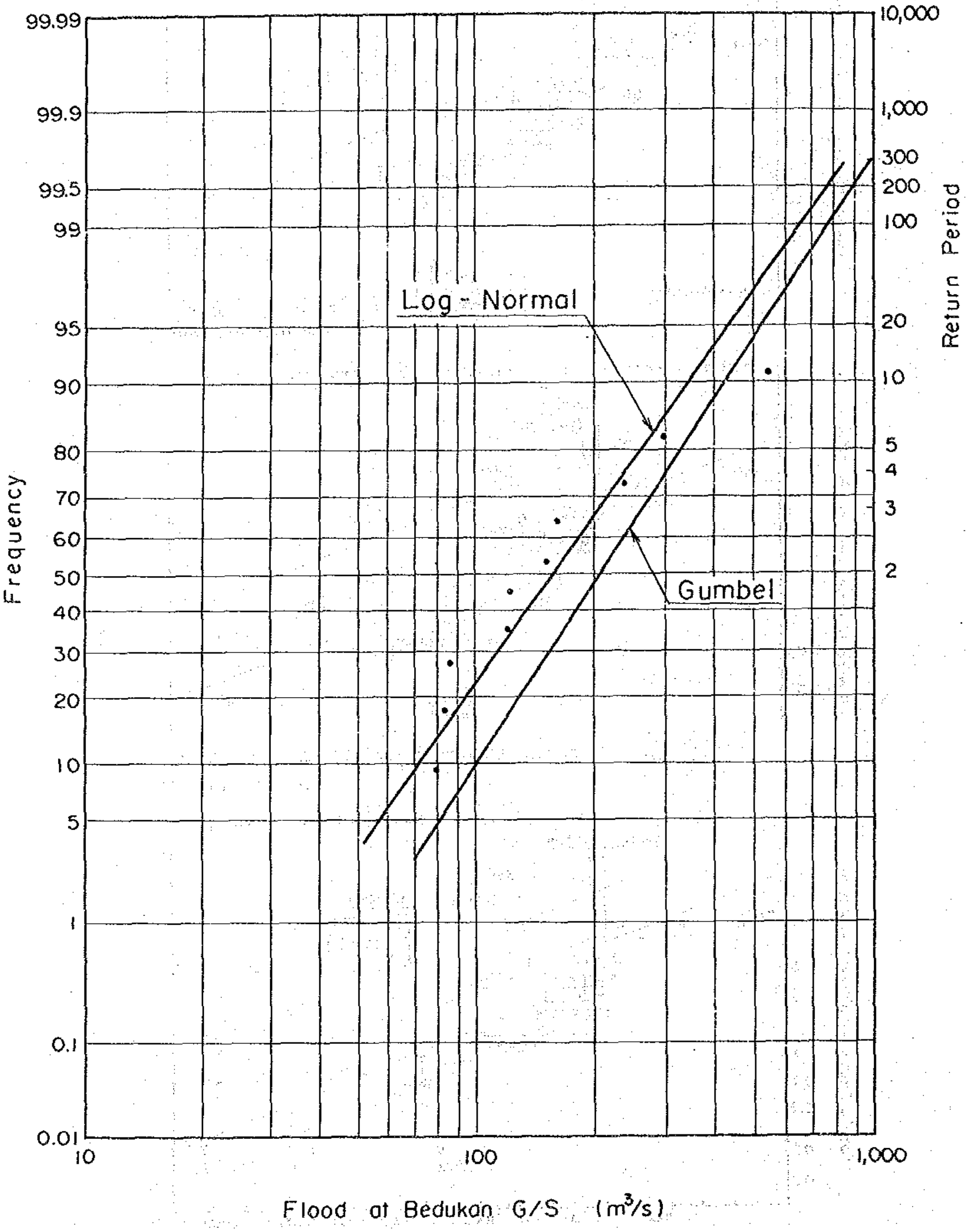
Date of Occurrence	Maximum Discharge (m^3/s)
December 3, 1970	83
November 18, 1971	235
January 18, 1972	123
September 15, 1973	153
February 13, 1974	543
February 24, 1975	85
May 23, 1976	159
February 21, 1977	299
January 13, 1978	120
October 18, 1979	79

Flood Discharge (m^3/s)

Return Period	Bedukan G/S (C.A.200km²)		Mesilau Intake Dam Site (C.A.28km²)		Liwagu Intake Dam Site (C.A.31km²)		Naradaw Intake Dam Site (C.A.34km²)	
	Gumbel	Log-Normal	Gumbel	Log-Normal	Gumbel	Log-Normal	Gumbel	Log-Normal
5	340	260	90	70	100	80	110	90
10	440	340	120	90	130	100	140	110
20	540	430	150	120	160	130	180	140
50	670	560	180	150	200	160	220	180
100	770	660	210	180	230	190	250	210



Relation between Specific Discharge and Catchment Area



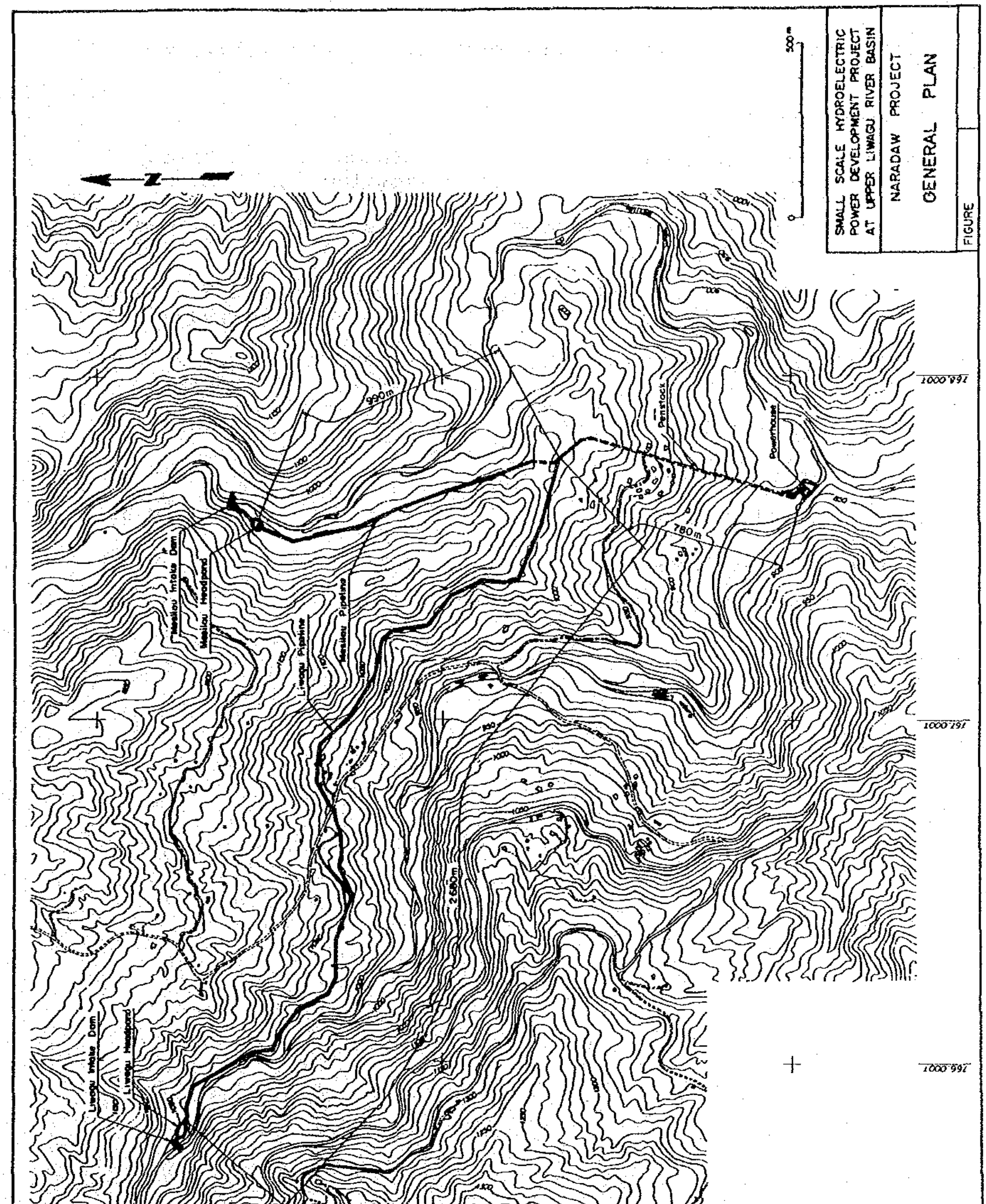
99.99
99.9
99.5
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
0.01
Frequency
10,000
1,000
300
200
100
20
10
5
4
3
2
Return Period
Log - Normal
Gumbel
10
100
1,000
Flood at Bedukan G/S (m³/s)

Annual Suspended Sediment

Name of River	Name of G/S	Catchment Area km^2	Suspended Sediment thousand ton/year	Suspended Sediment ton/year/km^2
Labuk	Porog	3,240	374	115

The Source: National Water Resources Study, Malaysia
(Sectoral Report Vol. 2 Meteorology and Hydrology 1982) JICA

4. OUTLINE OF NARADAW PROJECT


SMALL SCALE HYDROELECTRIC
POWER DEVELOPMENT PROJECT
AT UPPER LIWAGU RIVER BASIN
NARADAW PROJECT
GENERAL PLAN
FIGURE
0
500m
N
Liwagu Intake Dam
Liwagu Headpond
Liwagu Pipeline
Masilou Intake Dam
Masilou Headpond
Masilou Pipeline
Penstock
Powerhouse
990m
780m
2680m

Salient futures of the Naradaw projct are shown belows.

Development Plan

(1) Catchment Area	Liwagu Mesilau	31 km^2 28 km^2
(2) Design maximum discharge	Liwagu Mesilau	0.70 m^3/s 0.47 m^3/s
(3) Elevation of Intake crest	Liwagu Mesilau	EL.1,049.50 m EL.1,038.00 m
(4) Headpond waterlevel	Liwagu Mesilau	EL.1,048.30 m EL.1,036.50 m
(5) Tailrace Water Level		EL. 852.00 m
(6) Effective head		170 m
(7) Installed Capacity		1,600 kW
(8) Firm Peak Power		460 kW
(9) Supply Capable Energy		9.5 GWh

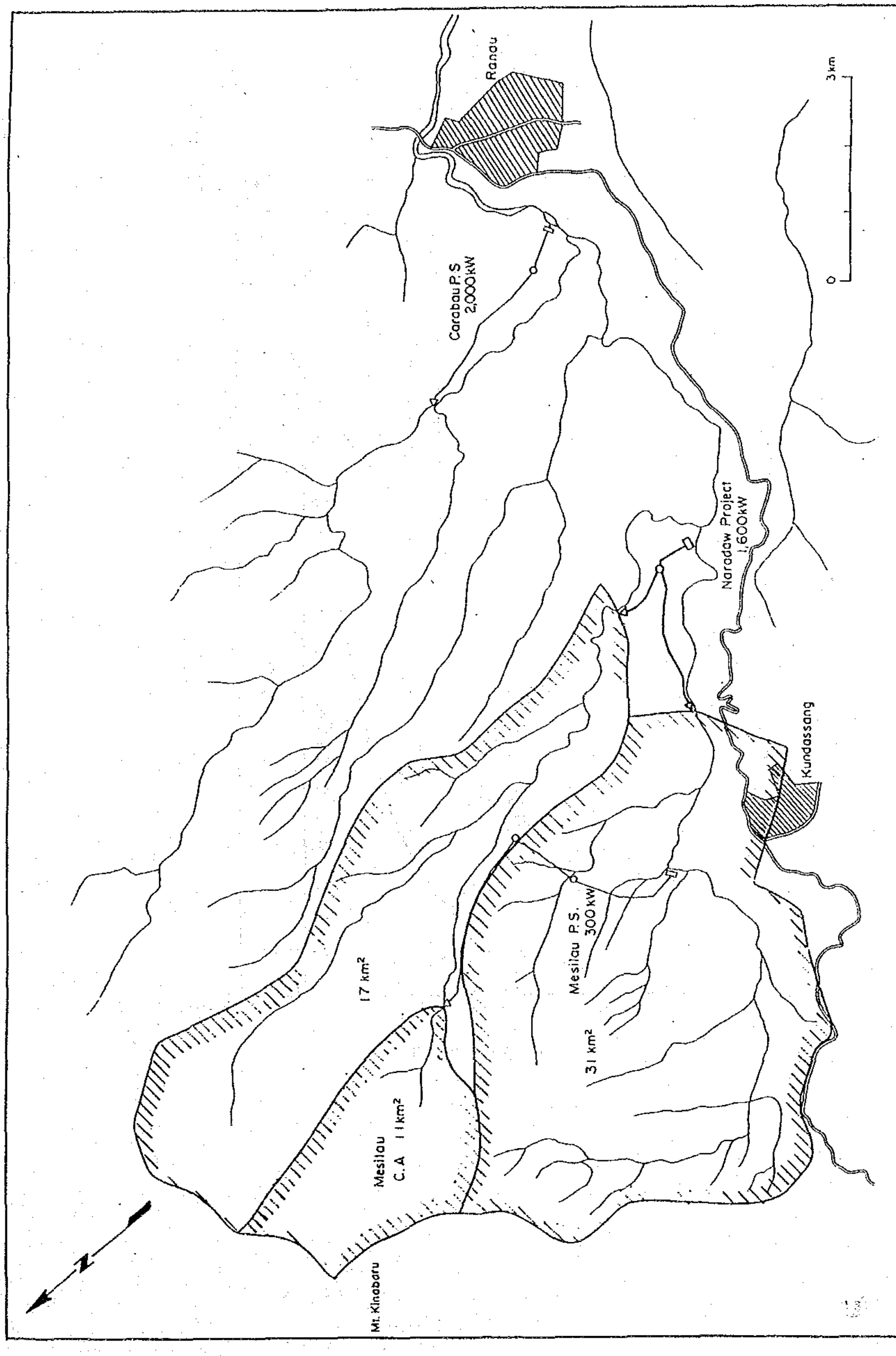
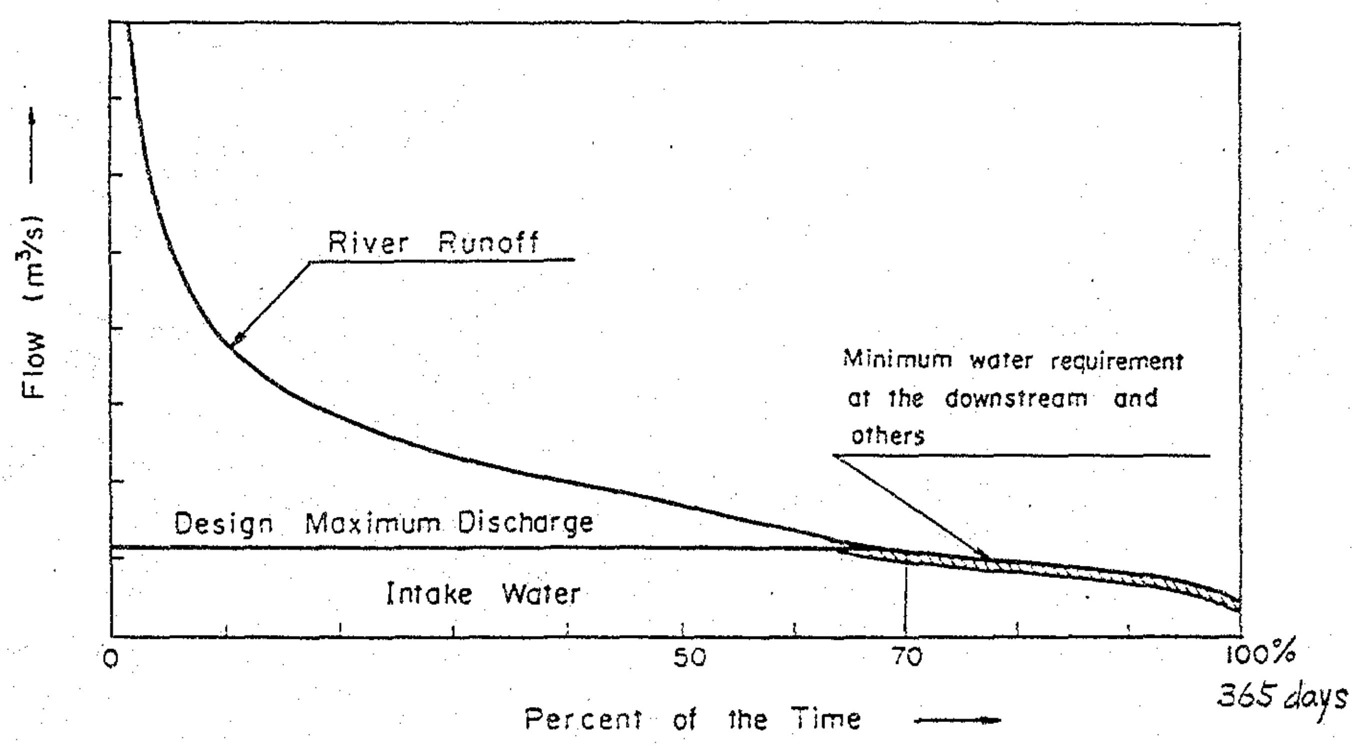
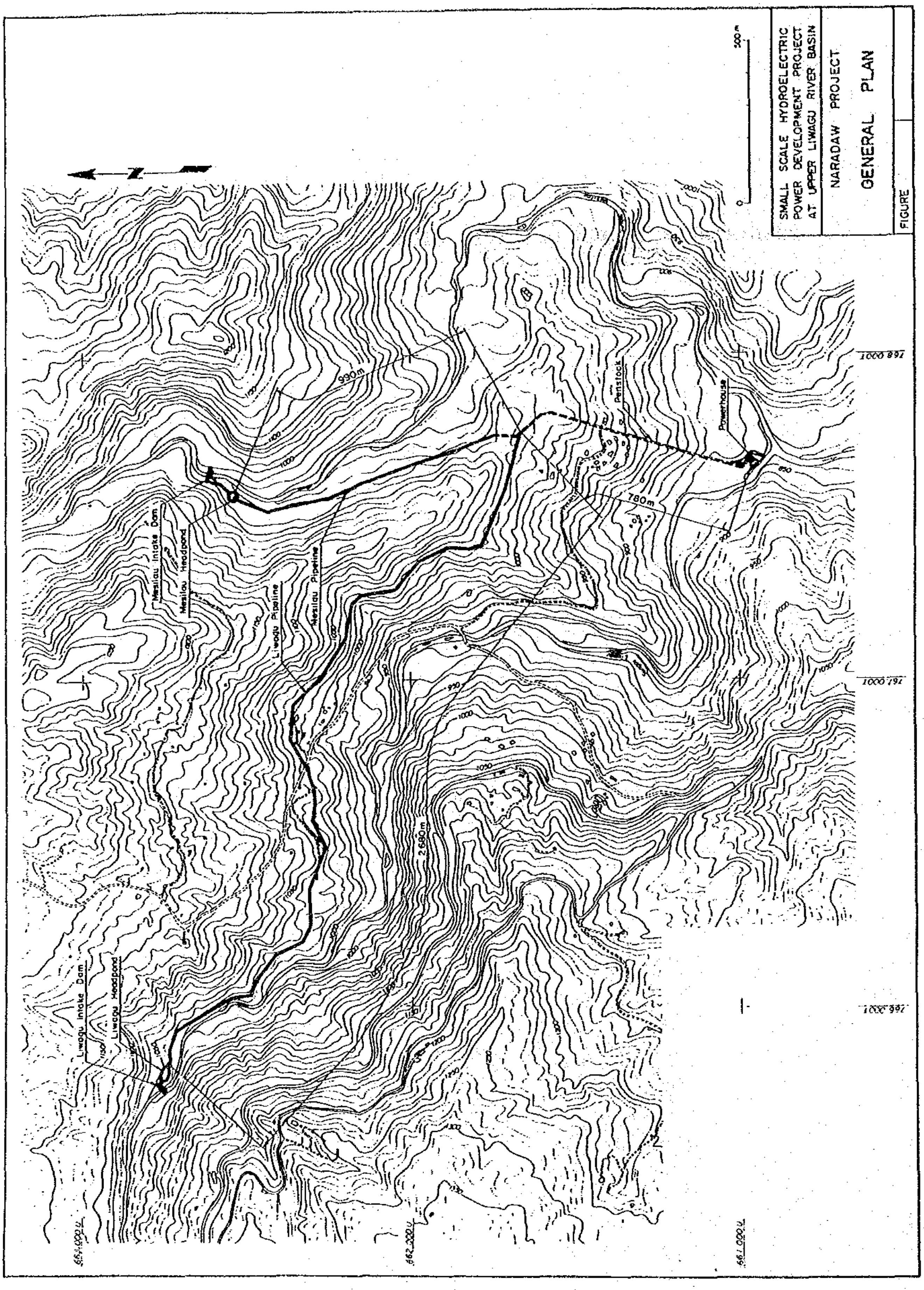


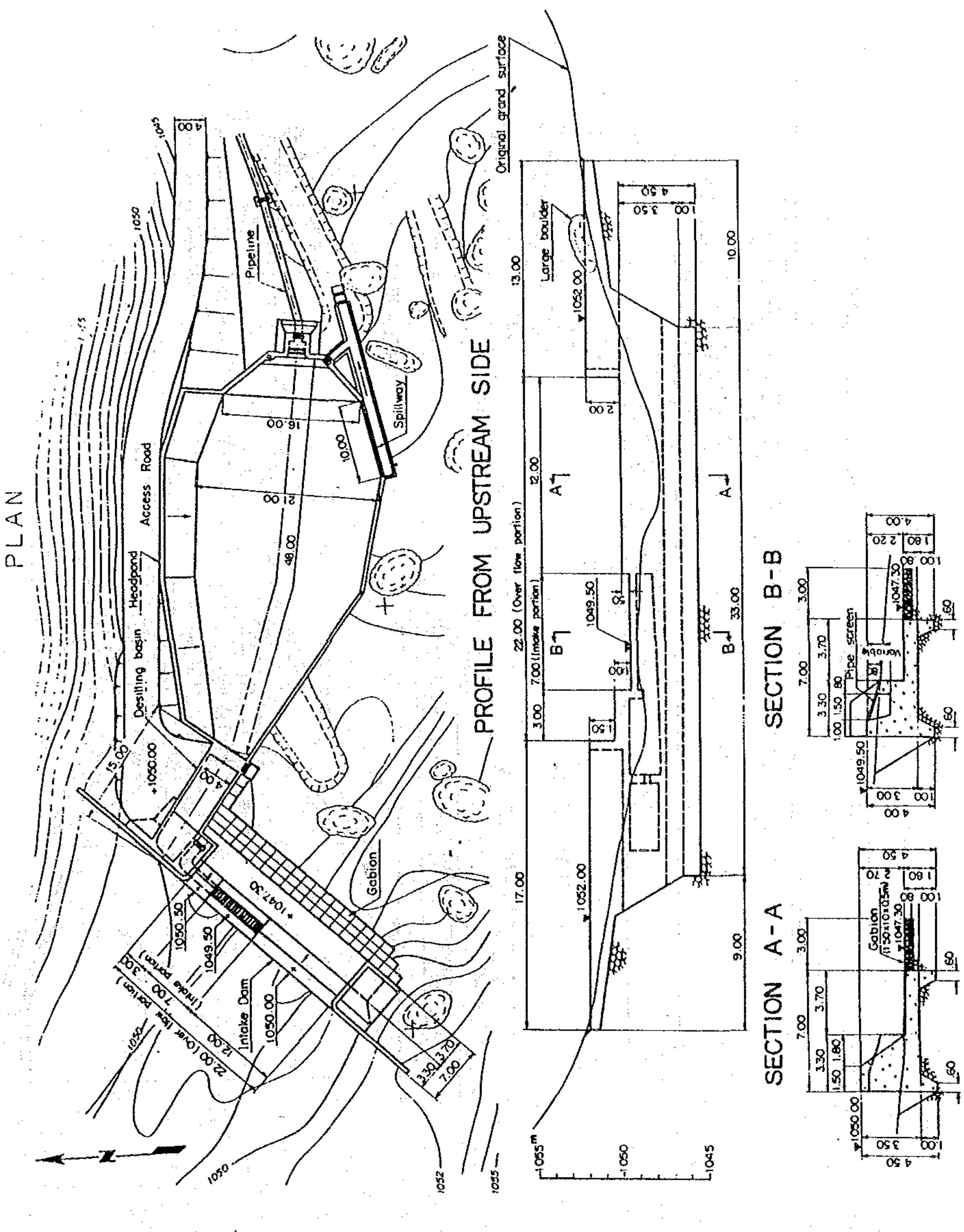
Fig. 8-7 Naradaw Catchment Area

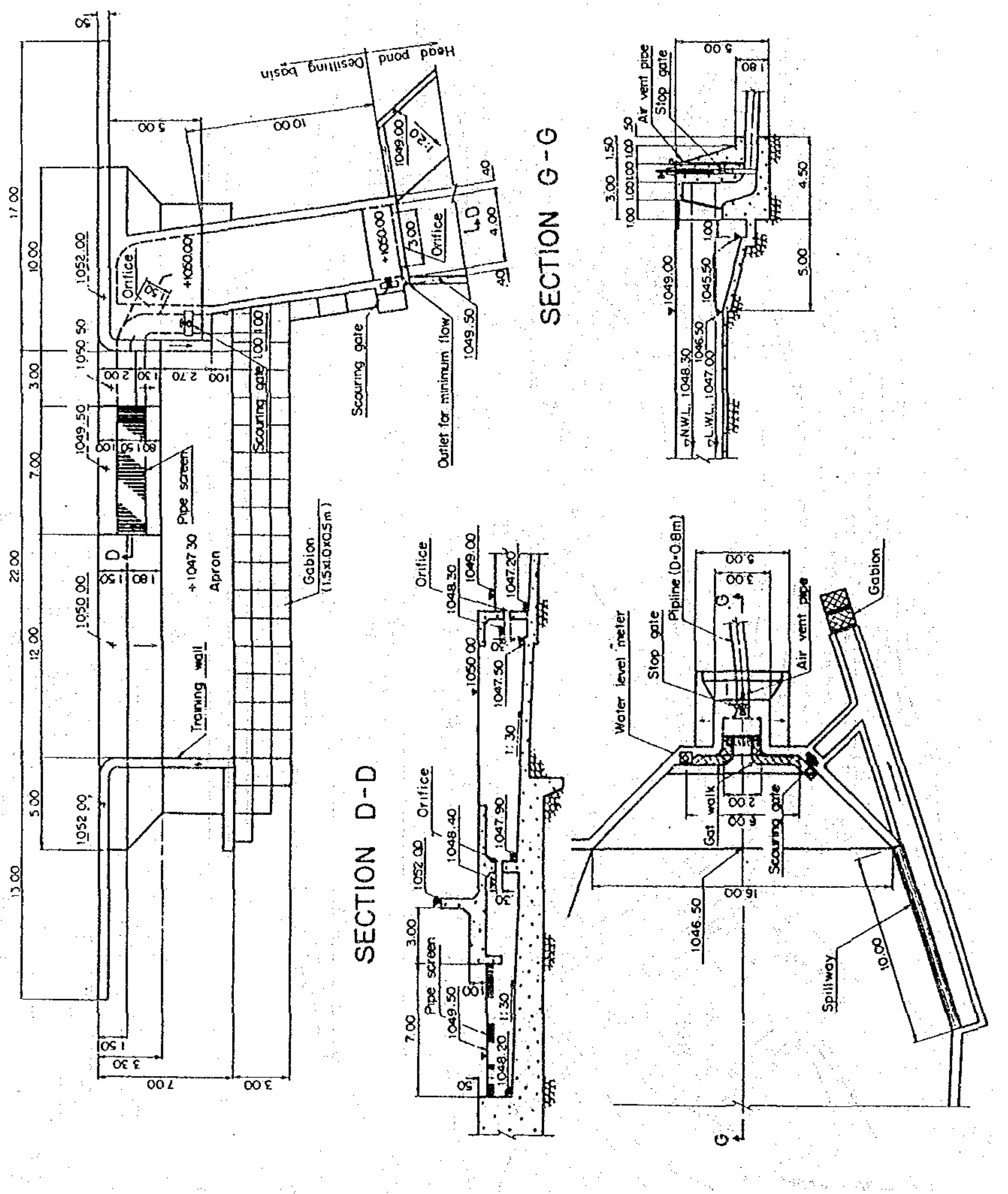
Fig. 8.6 Discharge Duration and Intake Water at a Site

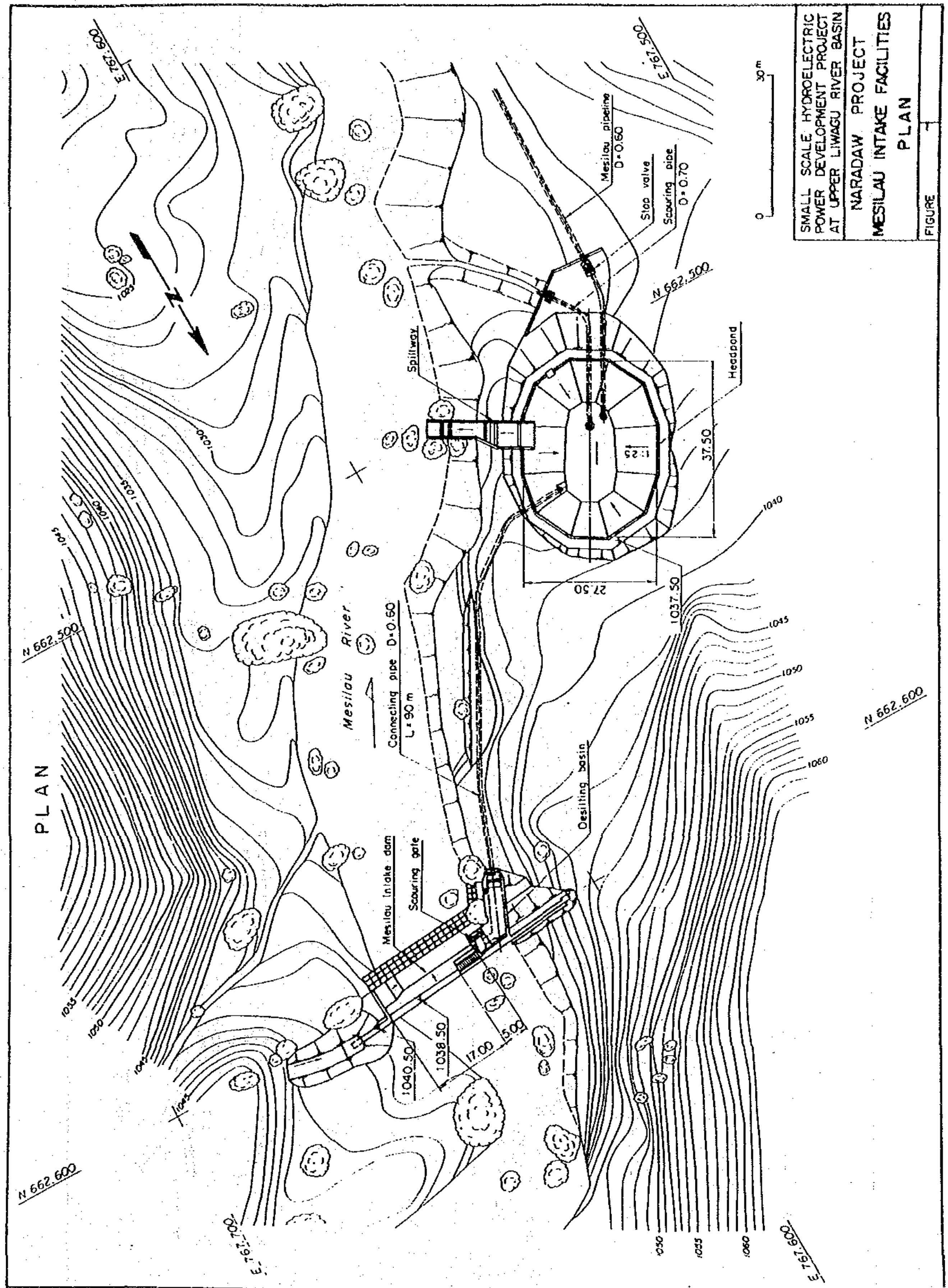


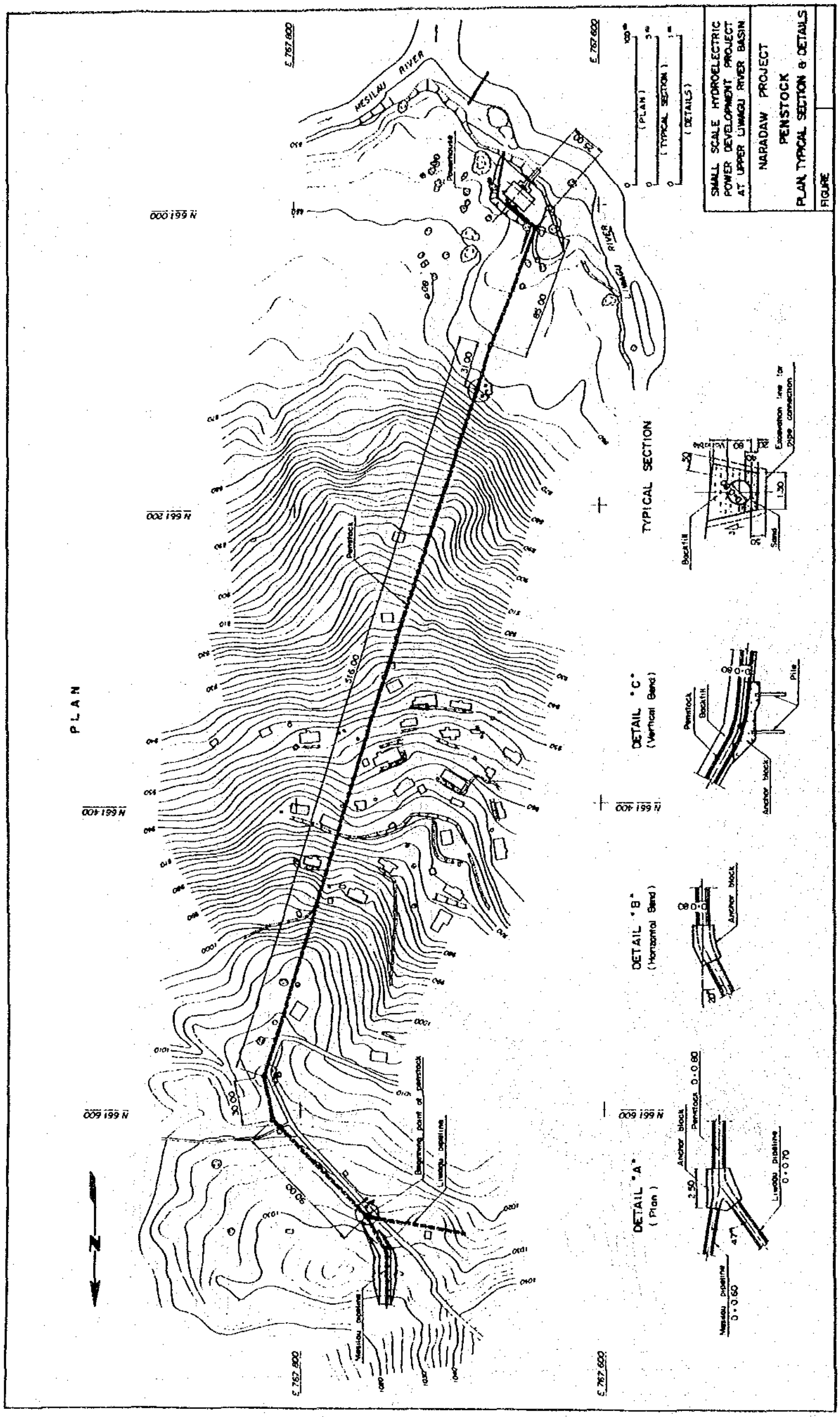
5. PRELIMINARY DESIGN OF CIVIL STRUCTURES AND HYDRAULIC DESIGN

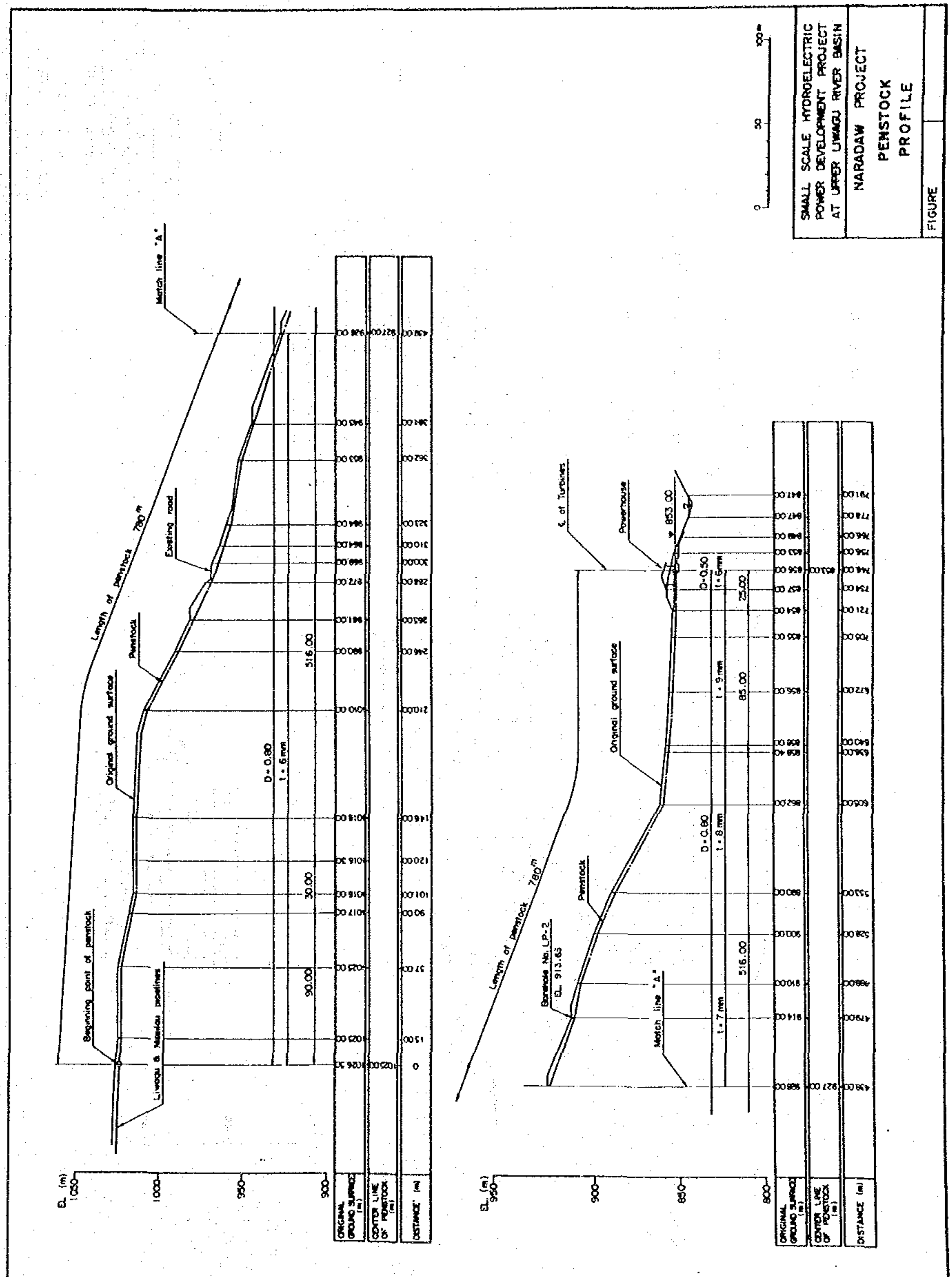

SMALL SCALE HYDROELECTRIC
POWER DEVELOPMENT PROJECT
AT UPPER LIWAGU RIVER BASIN
NARADAW PROJECT
GENERAL PLAN
FIGURE
500m
Mesilau Intake Dam
Mesilau Headpond
Liwagu Pipeline
Mesilau Pipeline
Penstock
Powerhouse
Liwagu Intake Dam
Liwagu Headpond
990m
780m
2,680m

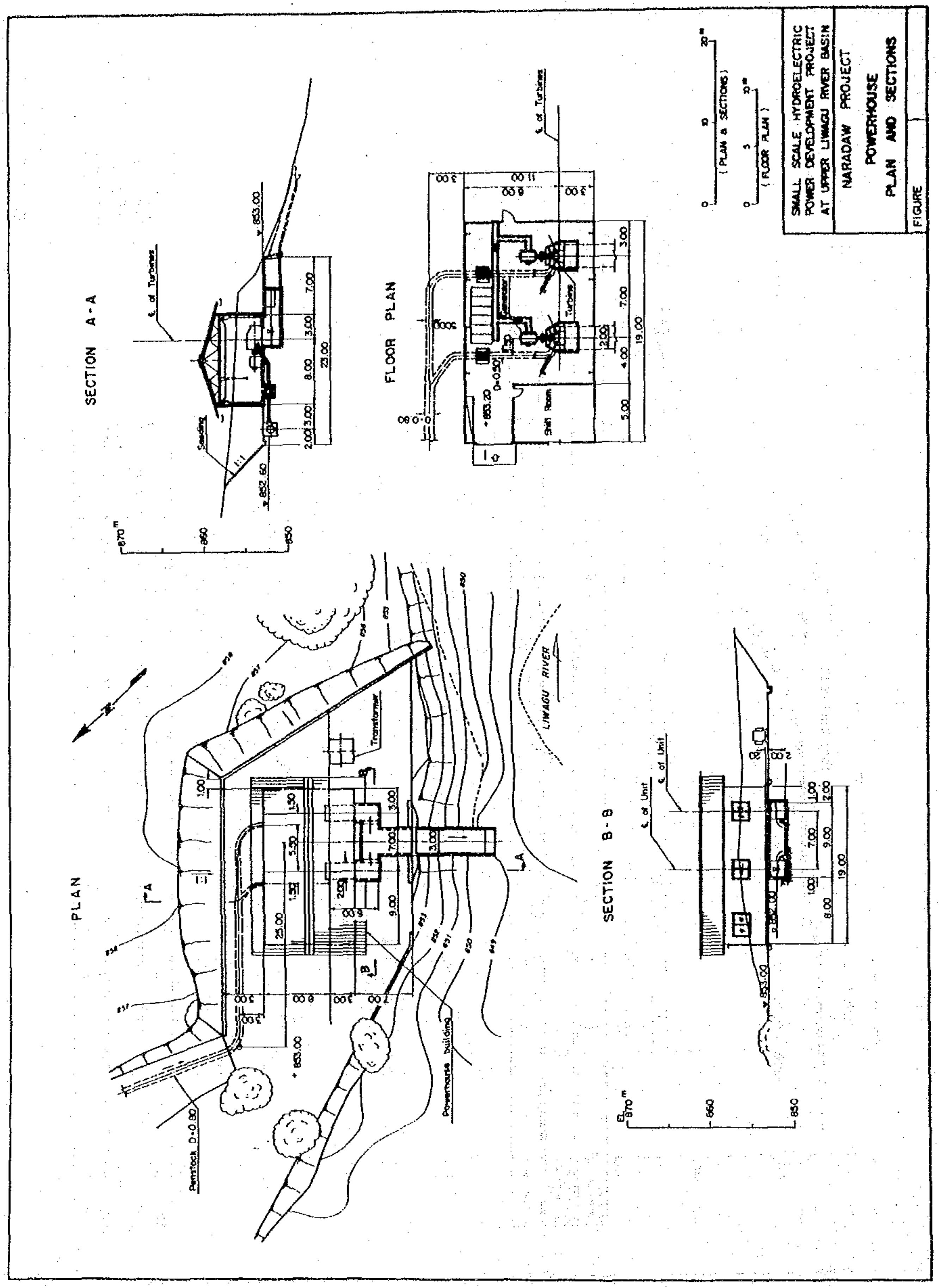

PLAN
Access Road
Headpond
Desilting basin
Pipeline
Spillway
Intake Dam
Gabion
PROFILE FROM UPSTREAM SIDE
22.00 (Over flow portion)
7.00 (Intake portion)
Large boulder
Original grand surface
SECTION A-A
SECTION B-B
Pipe screen

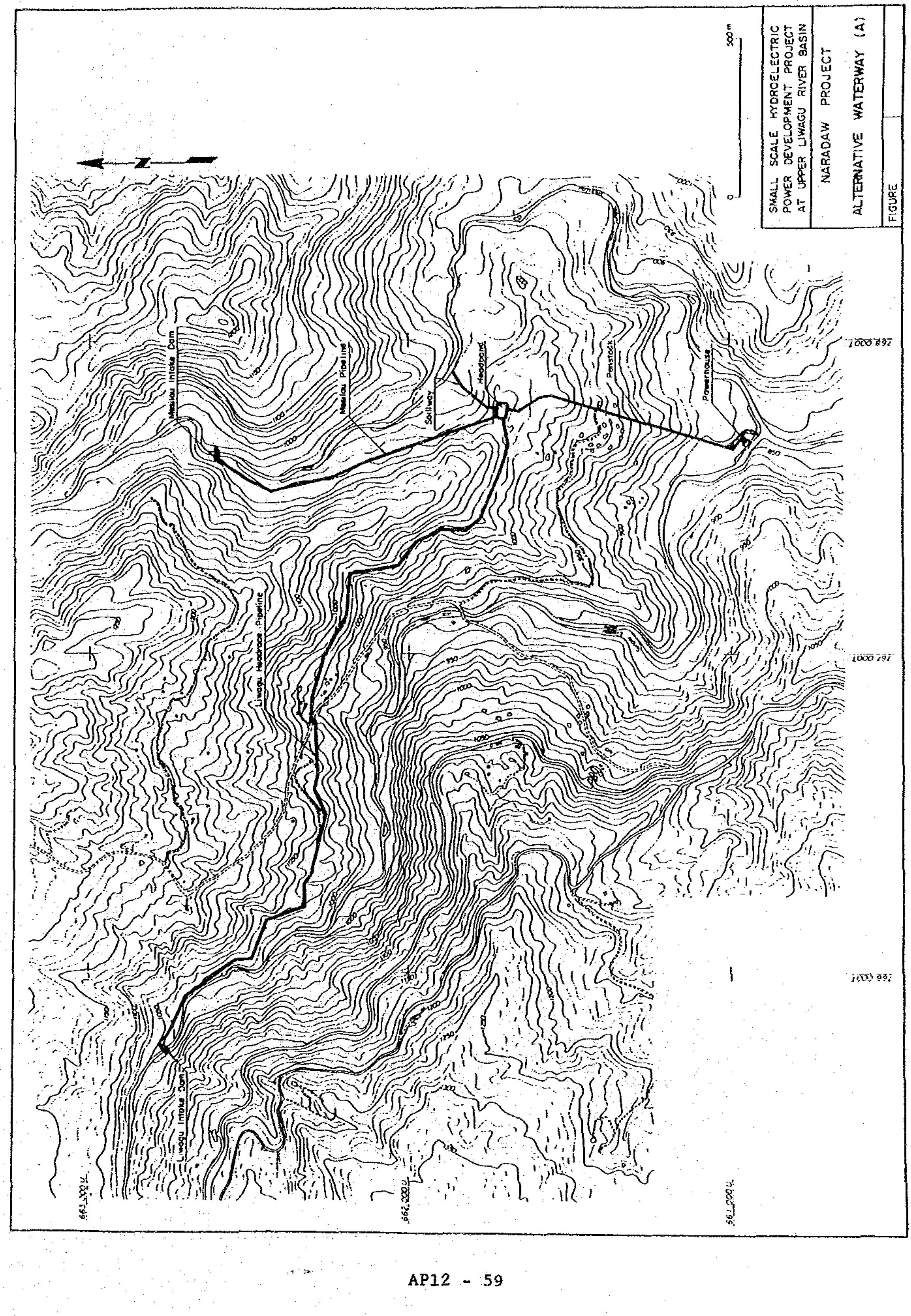

PLAN
SECTION D-D
SECTION G-G
Head pond
Desilting basin
Orifice
Scouring gate
Outlet for minimum flow
Pipe screen
Apron
Training wall
Gabion (1.5x1.0x0.5m)
Water level meter
Stop gate
Pipline (D=0.8m)
Air vent pipe
Gat walk
Spillway
Gabion
N.W.L. 1048.30
L.W.L. 1047.00
1052.00
1050.50
1050.00
1049.50
1049.00
1048.40
1048.30
1048.20
1047.90
1047.50
1047.30
1047.20
1046.50
1045.50
1:30
1:2.0

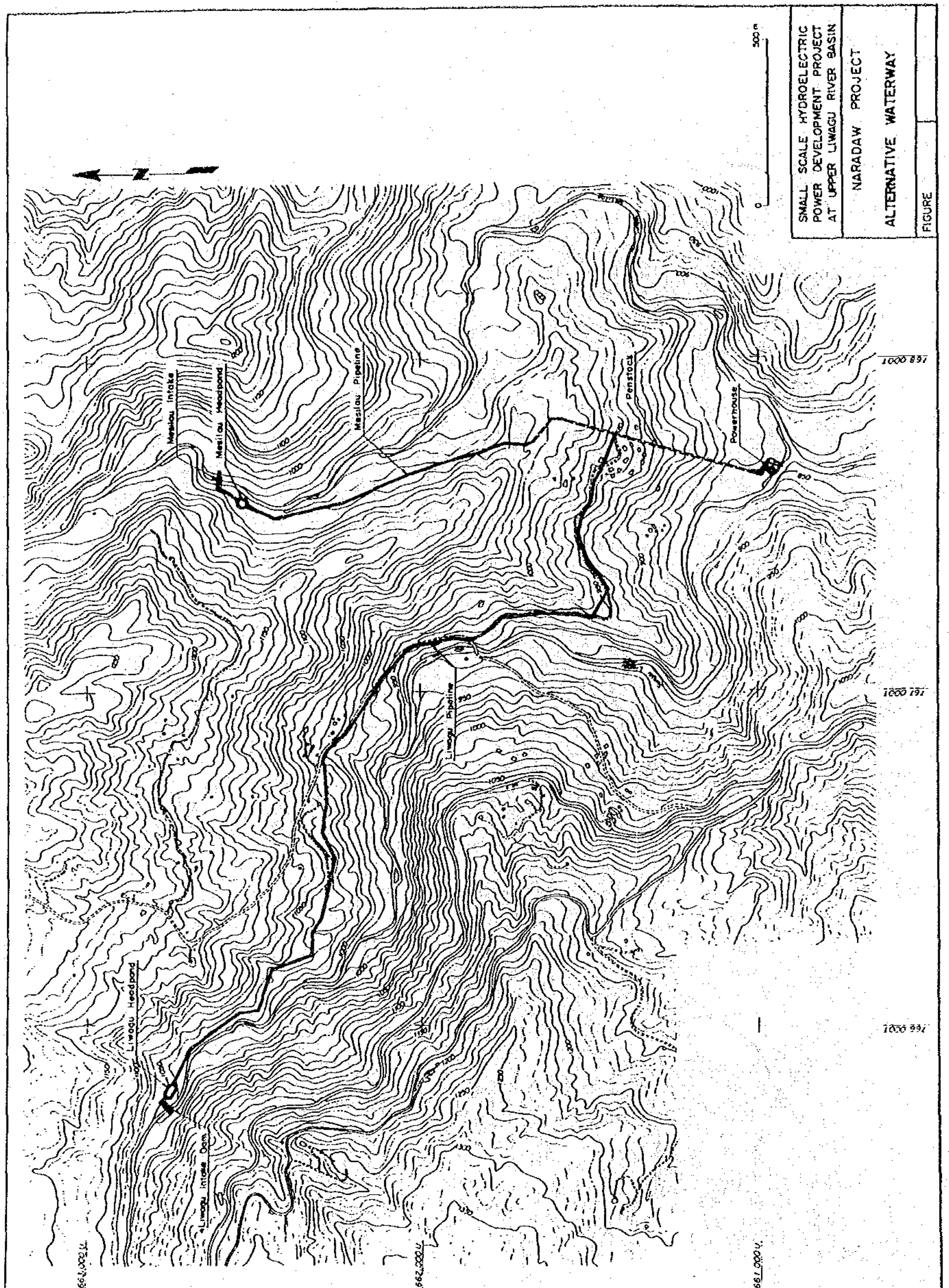

SMALL SCALE HYDROELECTRIC POWER DEVELOPMENT PROJECT AT UPPER LIWAGU RIVER BASIN
NARADAW PROJECT
MESILAU INTAKE FACILITIES
PLAN
FIGURE
PLAN
Mesilau pipeline D=0.60
Stop valve
Scouring pipe D=0.70
Headpond
Spillway
Mesilau River
Connecting pipe D=0.60 L=90 m
Desilting basin
Mesilau Intake dam
Scouring gate
37.50
27.50
1037.50
1040.50
1038.50
17.00
5.00
1:2.5
E 767.600
E 767.500
E 767.700
N 662.500
N 662.600
0
30m

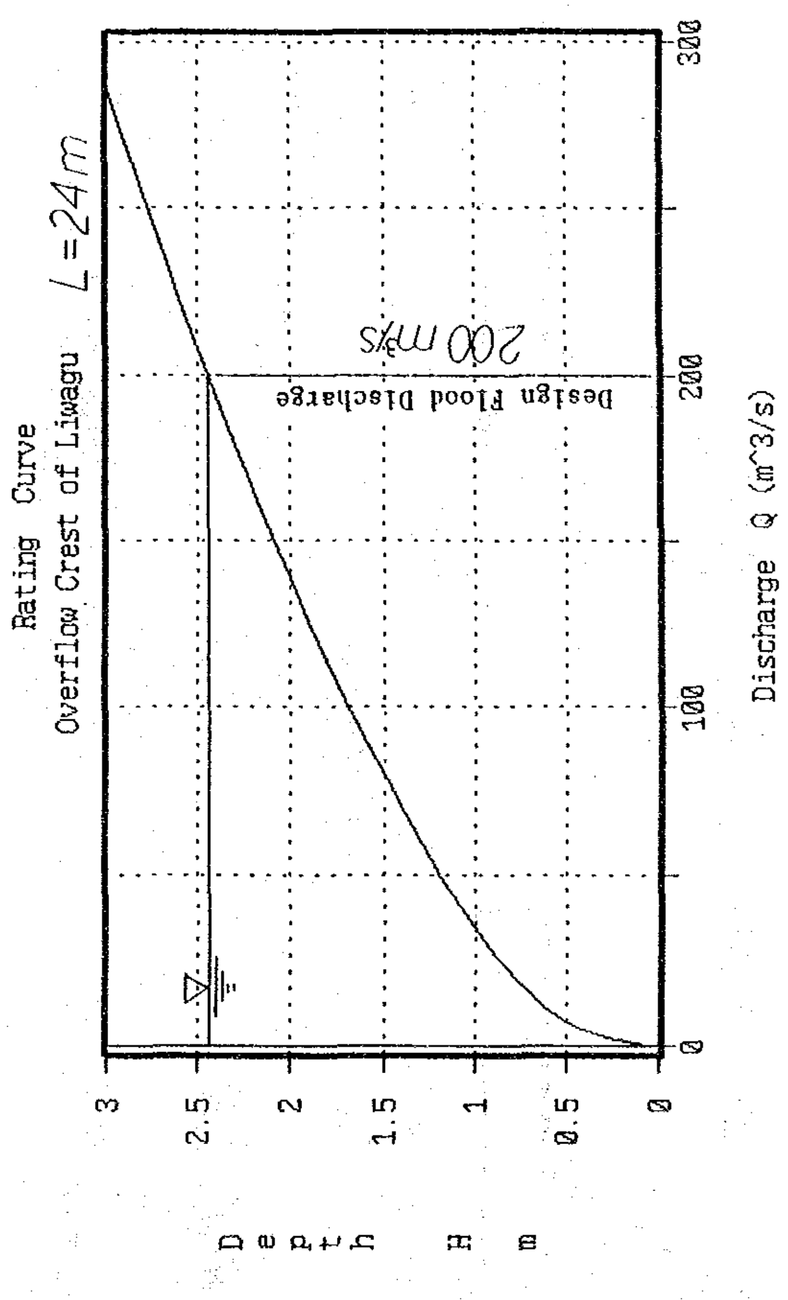

SMALL SCALE HYDROELECTRIC
POWER DEVELOPMENT PROJECT
AT UPPER LIWAGU RIVER BASIN
NARADAW PROJECT
PENSTOCK
PLAN, TYPICAL SECTION & DETAILS
FIGURE
PLAN
TYPICAL SECTION
DETAIL "A"
(Plan)
DETAIL "B"
(Horizontal Bend)
DETAIL "C"
(Vertical Bend)
MESILAU RIVER
LIWAGU RIVER
Powerhouse
Penstock
Beginning point of penstock
Liwagu pipeline
Mesilau pipeline
Anchor block
Backfill
Sand
Pile
(PLAN)
(TYPICAL SECTION)
(DETAILS)
N 661 000
N 661 200
N 661 400
N 661 600
E 767 800
E 767 600
516.00
85.00
31.00
30.00


SMALL SCALE HYDROELECTRIC
POWER DEVELOPMENT PROJECT
AT UPPER LIWAGU RIVER BASIN
NARADAW PROJECT
PENSTOCK
PROFILE
FIGURE
Length of penstock 780m
Match line "A"
Existing road
Penstock
Original ground surface
Beginning point of penstock
Liwagu & Mesilau pipelines
D=0.80
t=6mm
516.00
30.00
90.00
ORIGINAL GROUND SURFACE (m)
CENTER LINE OF PENSTOCK (m)
DISTANCE (m)
EL (m)
℄ of Turbines
Powerhouse
853.00
D=0.50
t=6mm
25.00
t=9mm
85.00
D=0.80
t=8mm
516.00
t=7mm
Borehole No. LP-2
EL 913.63

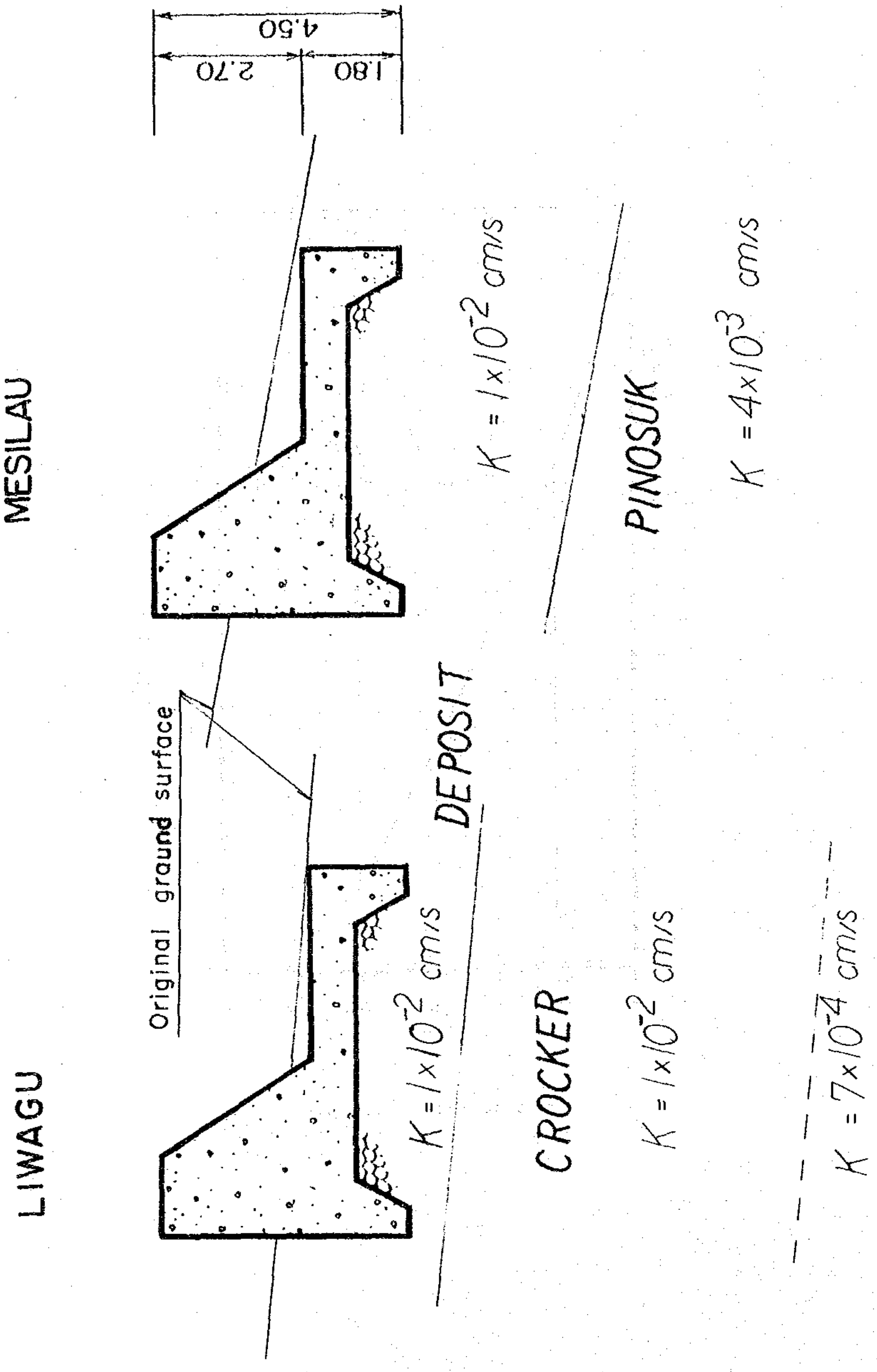

SECTION A - A
FLOOR PLAN
PLAN
SECTION B - B
Transformer
Powerhouse building
Penstock D=0.80
LIWAGU RIVER
Shift Room
Turbine
℄ of Turbines
℄ of Unit
(PLAN & SECTIONS)
(FLOOR PLAN)
SMALL SCALE HYDROELECTRIC POWER DEVELOPMENT PROJECT AT UPPER LIWAGU RIVER BASIN
NARADAW PROJECT
POWERHOUSE
PLAN AND SECTIONS
FIGURE

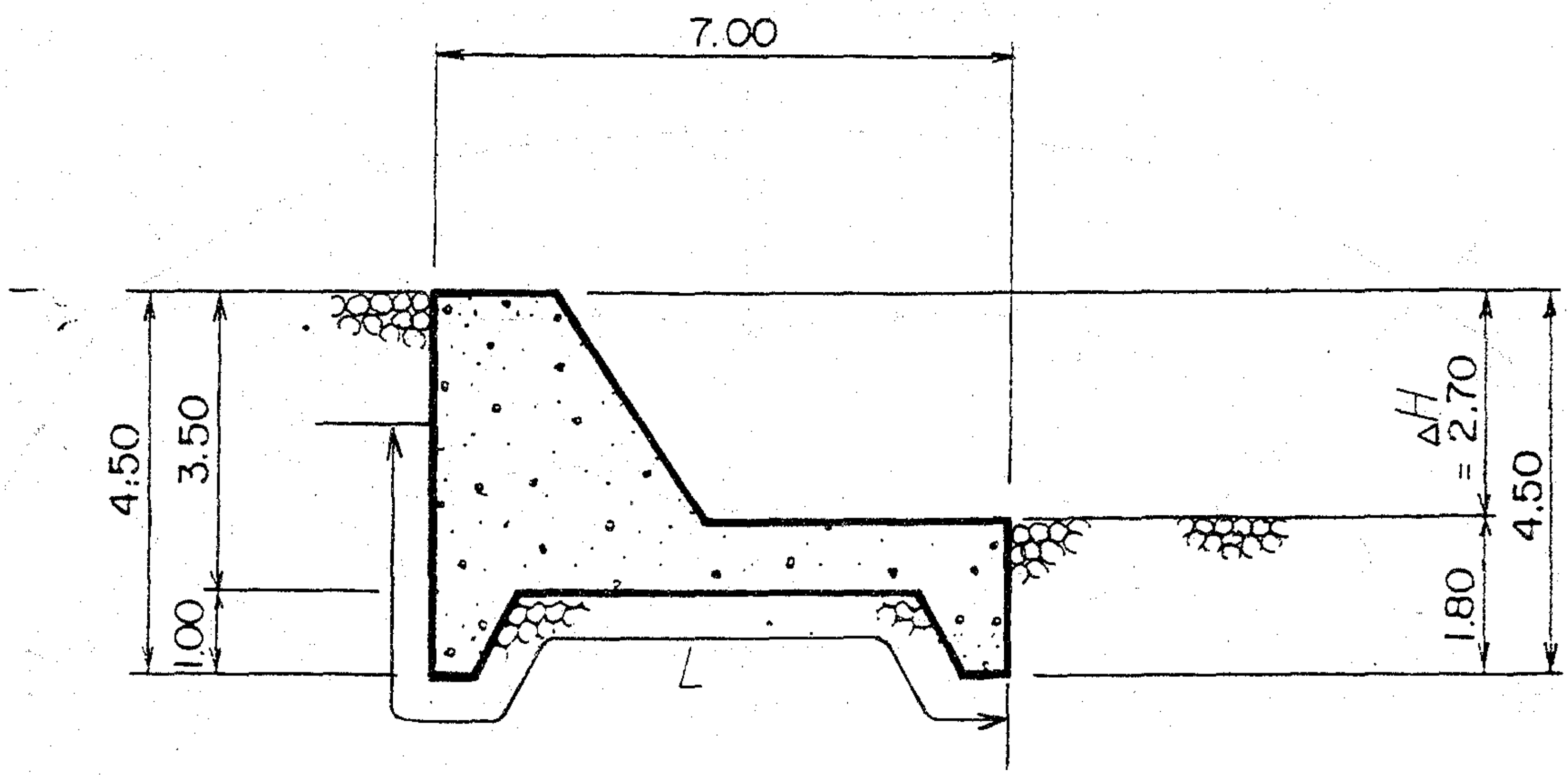

SMALL SCALE HYDROELECTRIC
POWER DEVELOPMENT PROJECT
AT UPPER LIWAGU RIVER BASIN
NARADAW PROJECT
ALTERNATIVE WATERWAY (A)
FIGURE
0
500 m
N
Masilau Intake Dam
Masilau Pipeline
Spillway
Headpond
Penstock
Powerhouse
Liwagu Headrace Pipeline
Liwagu Intake Dam


SMALL SCALE HYDROELECTRIC
POWER DEVELOPMENT PROJECT
AT UPPER LIWAGU RIVER BASIN
NARADAW PROJECT
ALTERNATIVE WATERWAY
FIGURE
Mesilau Intake
Mesilau Headpond
Mesilau Pipeline
Penstock
Powerhouse
Liwagu Pipeline
Liwagu Headpond
Liwagu Intake Dam

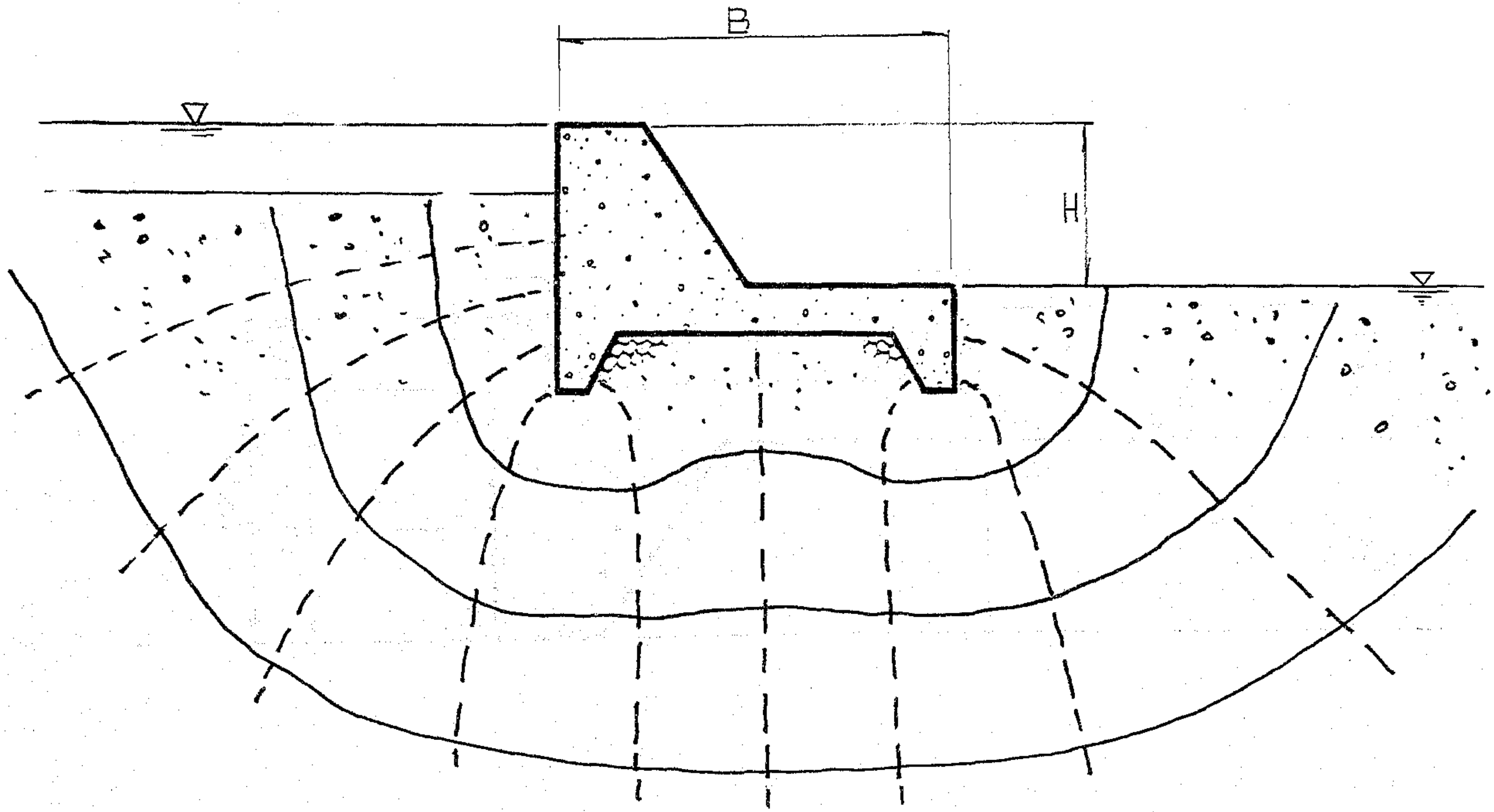


Rating Curve
Overflow Crest of Liwagu
L=24m
200 m³/s
Design Flood Discharge
Discharge Q (m^3/s)
Depth H m
0
0.5
1
1.5
2
2.5
3
0
100
200
300


4.50
2.70
1.80
MESILAU
LIWAGU
Original ground surface
K = 1×10⁻² cm/s
DEPOSIT
PINOSUK
K = 4×10⁻³ cm/s
K = 1×10⁻² cm/s
CROCKER
K = 1×10⁻² cm/s
K = 7×10⁻⁴ cm/s



Bligh's Method $L = L_h + L_v = C \times \Delta H = 5 \times 2.70 = 13.50\,m$



$$q = K H \frac{1}{\pi} \log_e \left(\frac{2x}{B} + \sqrt{\left(\frac{2x}{B}\right)^2 - 1} \right) \quad m^3/s/m$$

the Optimum Diameter of waterway

$$B_e - C_g = (B_g - B) - (C + C_o) = (B_g - C_o) - (B + C)$$

B_e; Annual benefit in effective head

B_g; Annual benefit in gross head

B ; Annual benefit loss due to head loss

C_g; Annual cost for the construction cost

C_o; Annual cost for the construction cost except for waterway

C ; Annual cost for the construction cost of waterway

Table Optimum Diameter of Pipeline at Liwagu Site

	ITEM	D 1 0.5	D 2 0.55	D 3 0.6	D 4 0.65	D 5 0.7	D 6 0.75
Annual Benifit Loss B	Head Loss Δ H (m)	0.03438	0.02068	0.013	0.00849	0.00571	0.00396
	Output for Head Loss Δ P (kw)	0.2005	0.1206	0.0758	0.0495	0.0333	0.0231
	Energy for Head Loss Δ E (kwh)	1170.6	704.1	442.6	289.1	194.4	134.8
	Benifit for Firm Peak Power: B kw(M$)	47.52	28.58	17.96	11.73	7.89	5.47
	Benifit for Energy B kwh(M$)	200.17	120.4	75.68	49.44	33.24	23.05
	Total Benifit B (M$)	247.69	148.98	93.64	61.17	41.13	28.52
Equalized Annual Cost C	Construction Cost C con(M$)	370	420	460	580	710	860
	Annual Cost C (M$)	42.55	48.3	52.9	66.7	81.65	98.9
Total B + C	B + C (M$)	290.24	197.28	146.54	127.87	122.78	127.42

Q(m3) = 0.7

n = 0.013

Δ H (m) = 10.298*n^2*Q^2/D^(16/3)

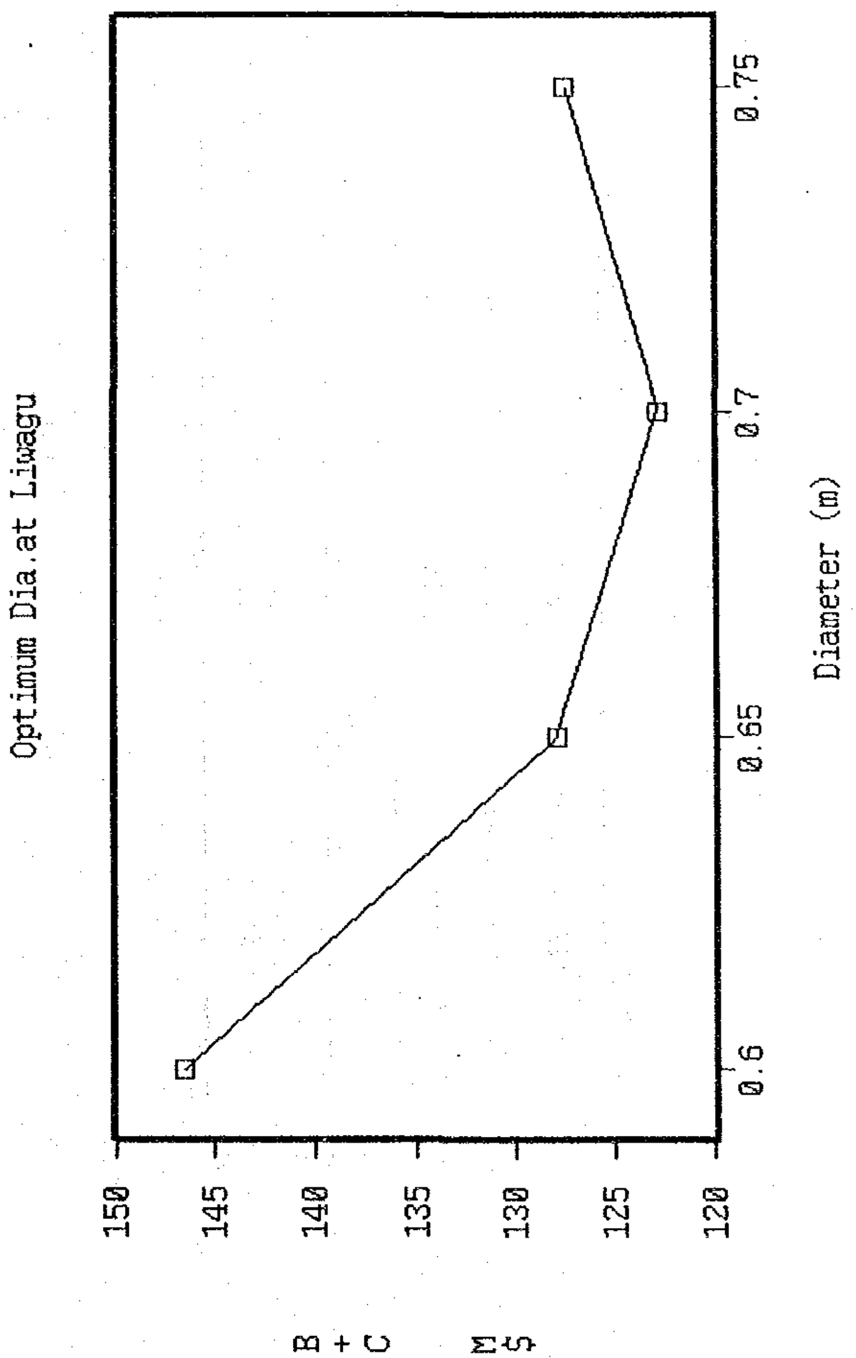
Δ P (kw) = 9.8*η*Q*h

Δ E (kwh) = E*(Q/Qmax)*(Hloss/He) = 9.7*10^6*(Q/1.18)*(Δ H/169)

B kw(M$) = Δ P * Unit kw benifit = 240M$/kw*Δ P

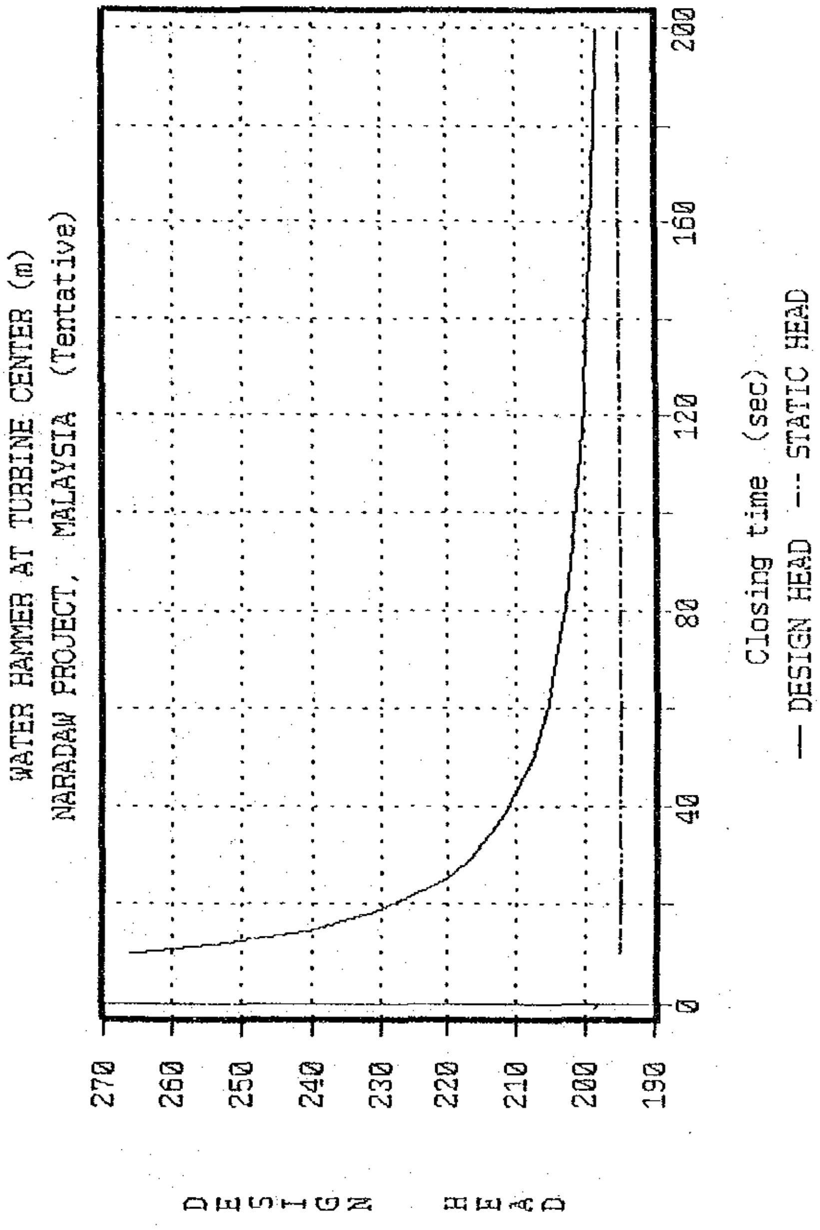
B kwh(M$) = Δ E * Unit kwh benifit = 0.18M$/kwh*Δ E

C (M$) = Annual cost factor * Ccon = 0.115*Ccon

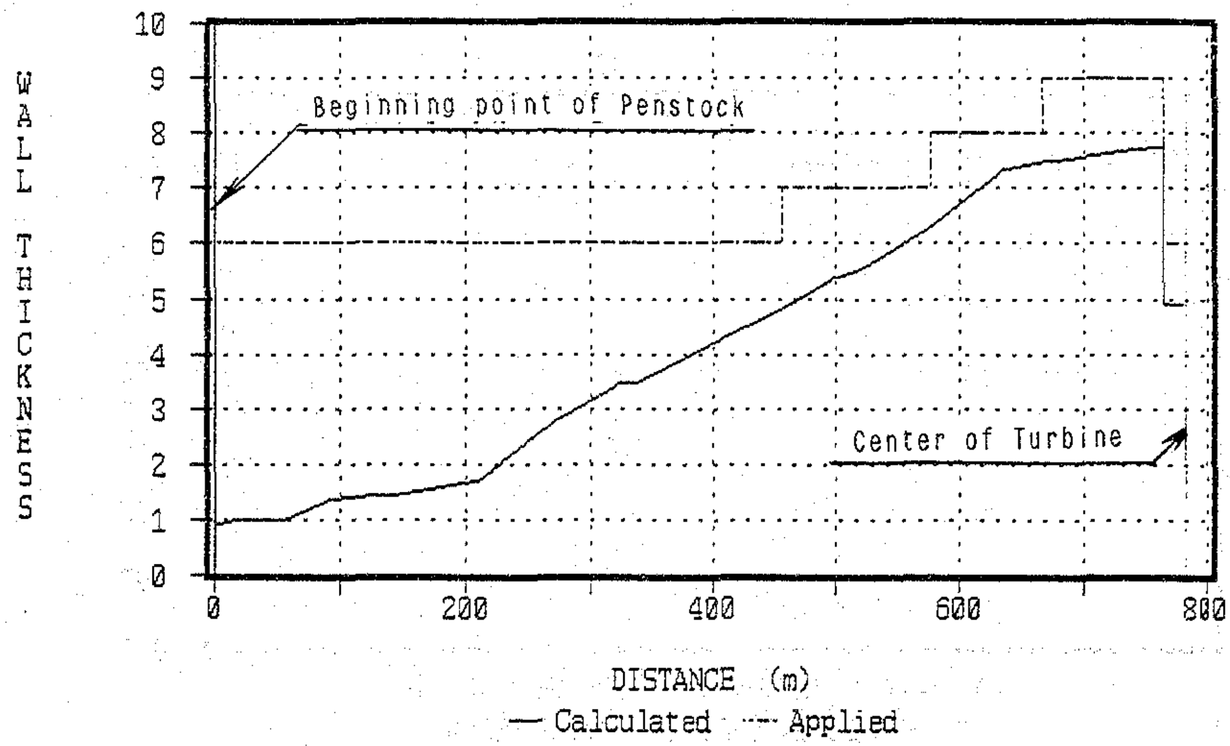

Optimum Dia.at Liwagu
Diameter (m)
0.6
0.65
0.7
0.75
150
145
140
135
130
125
120
B + C
M$

WATER HAMMER CALCULATION (TENTATIVE)

INTAKE	LIWAGU	LIWAGU + MESILAU
DISCHARGE (m3/sec)	0.7	1.2
STATIC HEAD (m)	195.00	184.00
WATER HAMMER (m) (closing time:20 sec)	32.90	19.44
WATER HAMMER (m) (rapid closing)	170.62 (t < 7.2 sec)	206.68 (t < 3.8 sec)

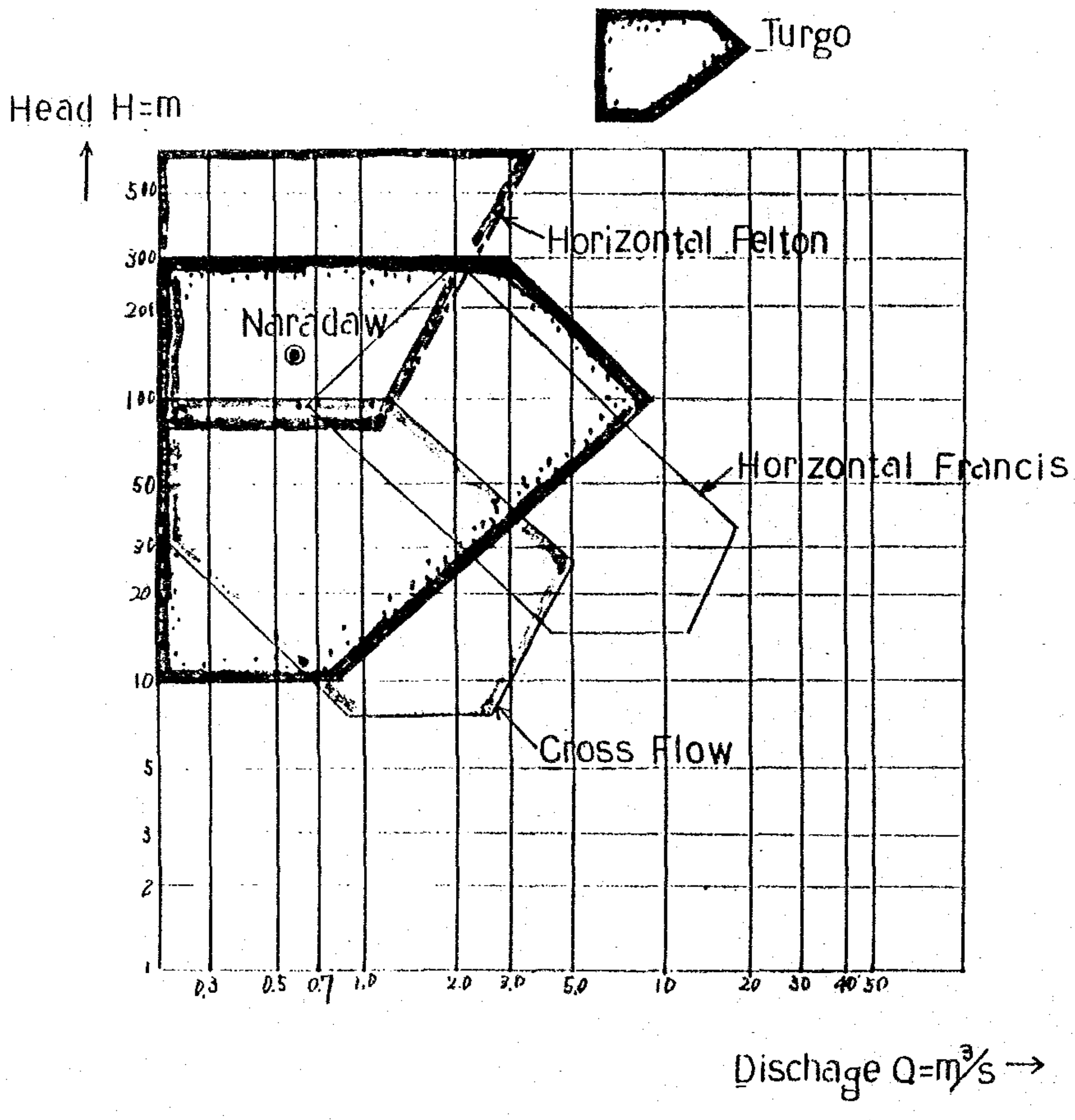

WATER HAMMER AT TURBINE CENTER (m)
NARADAW PROJECT, MALAYSIA (Tentative)
DESIGN HEAD
270
260
250
240
230
220
210
200
190
0
40
80
120
160
200
Closing time (sec)
— DESIGN HEAD --- STATIC HEAD

WALL THICKNESS OF PENSTOCK (mm)
NARADAW PROJECT, MALAYSIA (Tentative)



6 PRELIMINARY DESIGN OF ELECTRICAL AND MECHANICAL EQUIPMENT

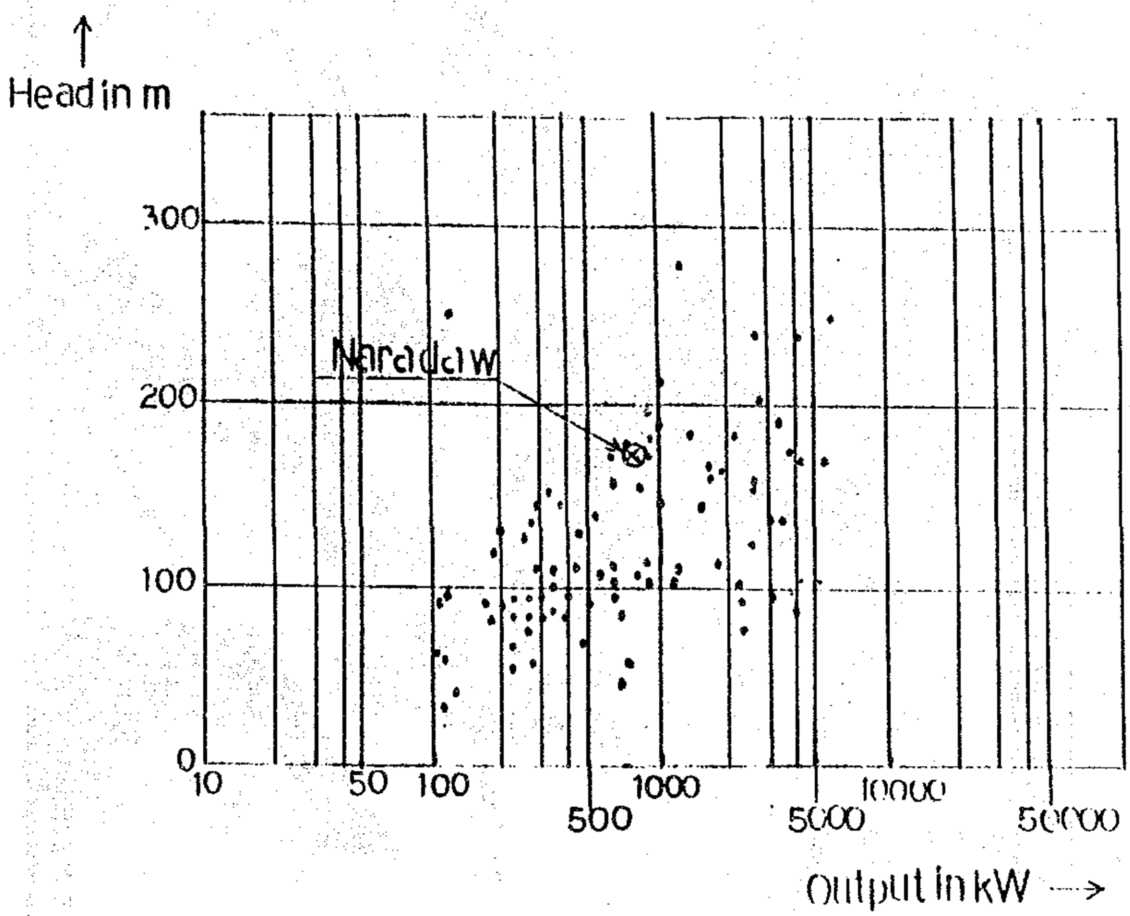
TURBIN TO BE SELECTED



SUPPLUY RECORDS OF TURGO IMPULSE

TURBINS MADE BY GILKES, ENGLAND

FROM 1982 TO 1991 (10 YEARS)



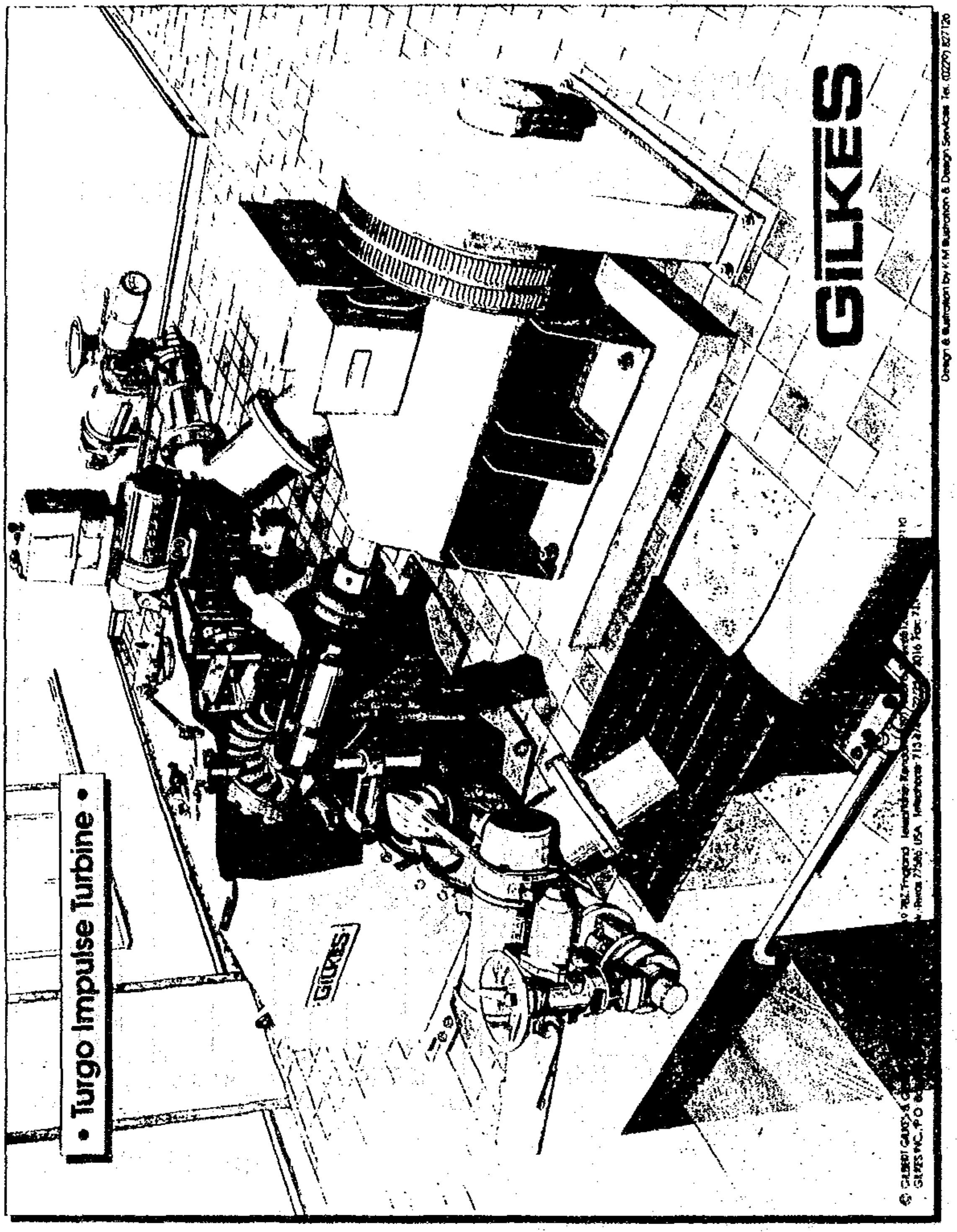

• Turgo Impulse Turbine •
GILKES

Table 11-3-1 Major Equipment Parameters of Naradaw Small Hydroelectric Power Plant

Water Turbine

Type	Turgo-Impulse Turbine
Number of Units	2
Effective Head	170 m
Maximum Discharge	0.60 m^3/s
Speed	1,000 rpm

Generator

Type	3-phase Synchronous Generator
Number of Units	2
Capacity	890 kVA
Voltage	3,300 V
Current	156 A
Speed	1,000 rpm

Transformer

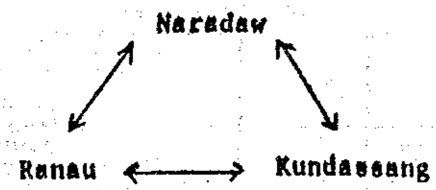
Type	Self-Cooled, 3-phase Transformer
Number of Units	1
Capacity	1,780 kVA
Voltage	11,000 V/3,150 V

Power Plant Control System

Manned Monitoring Control System (One-man Control System)

Communication System

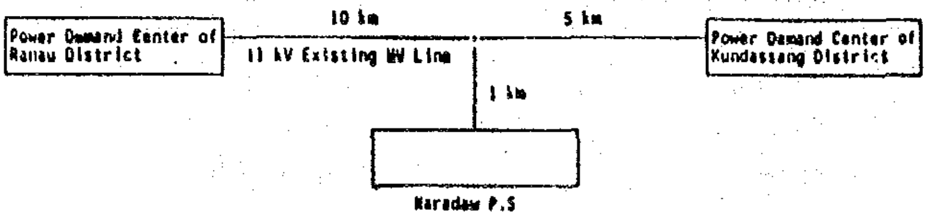
Radio Telephone Channel



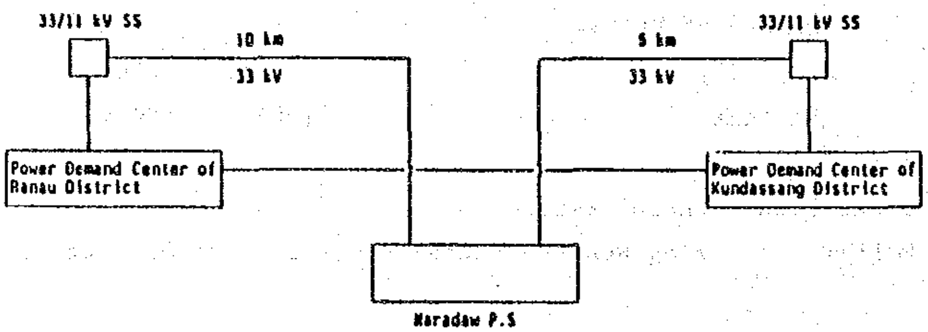
Comparison of Power Transmission Pattern

	Transmission Pattern A	Transmission Pattern B	Transmission Pattern C
Construction cost comparison	M$43,500	M$1,605,000	M$852,500
Supply reliability	Poor	Good	Good
Transmission loss	3.0%	1.4%	3.0%
Order of selection	1	3	2

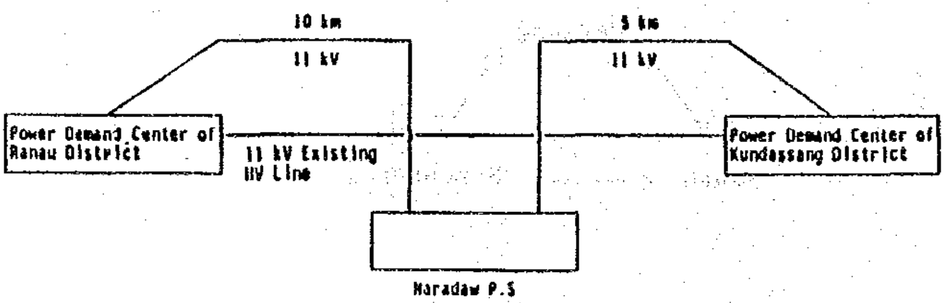
— Power Transmission Pattern A



— Power Transmission Pattern B



— Power Transmission Pattern C



7 ECONOMIC AND FINANCIAL ANALYSIS

7-1

ECONOMIC EVALUATION

1. Method of Economic Evaluation

2. Preparation of Parameters for Economic Evaluation

   (1) Confirmation of A Social Discount Rate

   (2) Parameters

      a. Determination of Alternative

      b. Technical Parameters of Project and Alternative

3. Benefit and Cost

   (1) Cost = Total Costs of Project

   Benefit = Total Costs of Alternative

   (2) Comparison of Discounted Cost and Discounted Benefit

4. Computation of EEDR (EIRR) to Assess whether to Accept the Project

FINANCIAL ANALYSIS

1. Methods of Financial Analysis

   Method One - Analysis of value of Investment in Implementation of Project

   Method Two - Analysis on Feasibility of Implementation of Project Viewed from the Standpoint of Power Utilities

2. Method One

   (1) Benefit - Gross Revenue from Sales of Electricity to Consumers

   Cost - Investment Cost and OM Cost

   (2) Comparison of A Stream Of Discounted Benefit and That of Discounted Cost

   (3) Assessment of Project, Compared with A Social Discount Rate

   (4) Computation of FEDR (FIRR)

3. Method Two

   (1) Preparation of Fund(s) Raising Program

   (2) Amortization Schedule

   (3) Profit and Los Statement

   (4) Cash Flow Sheet

   (5) Computation of Debt-Service Ratio

Tentative

Table 15.1.1

Descript.	Hydro	Diesel
(1) Installed Capacity(kW)	1600	514
(2) Firm Peak Capacity(kW)	460	
Actual Capa.of D/G(kW)		550
(3) Station Service Rate (%)		
kW Service Rate	1.0%	4.0%
kWh Service Rate	1.0%	4.0%
(4) T/L Loss Rate (%)	3.0%	0
(5) Scheduled Outage Rate (%)	1.0%	10.0%
(6) Forced Outage Rate (%)	5.0%	5.0%
(7) Annual Output Declining Rate (%)	0.4%	2.0%
(8) kW Adj.Factor(%)	1	1.12
(9) Unit Investment Cost of D/G per kW (Thous. M$)		1.560
(10) Service Life (Yr)	25	15
(11) Kind of Fuel		Diesel Oil
(12) Ther.Effici. (%)		28.0%
(13) Calorific Value (Kcal/Kg)		10000
(14) Specific Gravity (Kg/Liter)		0.81
(15) Fuel Consumption (Liter/kWh)		0.379
(16) Fuel Unit Price (M$/Liter)		0.500
(17) Fuel Cost per kWh (M$/kWh)		0.19
(18) OM Cost Ratio to Total Cons.Cost	1.1%	5.0%

Tentative

Table 15.1.2 Required Quantity of Energy to Be Generated At Alternative Diesel Power Plant

Year	Annual Energy Generati. (MWh)	Firm Usable Energy (MWh)	Non-firm Usable Energy (MWh)	Firm Saleable Energy (MWh) (a)	Non-firm Saleable Energy (MWh) (b)	Energy Generated at D/G for (a) (MWh)	Energy Generated at D/G for (b) (MWh)
1997	14267	2314	2186	2245	2120	2267	2142
1998	15715	2314	3051	2245	2959	2267	2989
1999	17201	2314	3919	2245	3801	2267	3840
2000	18958	2314	4863	2245	4717	2267	4765
2001	20320	2314	5499	2245	5334	2267	5388
2002	21843	2314	5962	2245	5783	2267	5842
2003	23494	2314	6281	2245	6093	2267	6154
2004	25204	2314	6525	2245	6329	2267	6393
2005	27064	2314	6733	2245	6531	2267	6597
2006	28715	2314	6881	2245	6675	2267	6742
2007	30467	2314	7003	2245	6793	2267	6862
2008	30467	2314	7158	2245	6943	2267	7013
2009	30467	2314	7158	2245	6943	2267	7013
2010	30467	2314	7158	2245	6943	2267	7013
2011	30467	2314	7158	2245	6943	2267	7013
2012	30467	2314	7158	2245	6943	2267	7013
2013	30467	2314	7158	2245	6943	2267	7013
2014	30467	2314	7158	2245	6943	2267	7013
2015	30467	2314	7158	2245	6943	2267	7013
2016	30467	2314	7158	2245	6943	2267	7013
2017	30467	2314	7158	2245	6943	2267	7013
2018	30467	2314	7158	2245	6943	2267	7013
2019	30467	2314	7158	2245	6943	2267	7013
2020	30467	2314	7158	2245	6943	2267	7013
2021	30467	2314	7158	2245	6943	2267	7013
Total	669786	57850	159115	56114	154342	56681	155901

Tentative

Table 15.1.3 Economic Evaluation

(In Thousand Malaysian Dollars)

SDR= 10.0%

Year	Serial No.	Project (as Cost) IR= 1 Invest.	OM Cost	Sub-Total	Gene. Ene at D/G (MWh)	Energy of Other D/G (MWh)	Diesel (as Benefit) FIR= 1 Invest.	OM Cost	Fuel Cost(a)	Fuel Cost(b)	Sub-Total	B-C	PV Factor	NPV Cost	NPV Benefit	NPV B-C
1994	1	2725		2725							0	-2725	0.909	2477	0	-2477
1995	2	5303		5303			343				343	-4960	0.826	4383	284	-4099
1996	3	3472		3472			515				515	-2957	0.751	2609	387	-2222
1	4		127	127	2267	2142		43	430	386	858	732	0.683	86	586	500
2	5		127	127	2267	2989		43	430	538	1011	884	0.621	79	628	549
3	6		127	127	2267	3840		43	430	691	1164	1037	0.564	71	657	586
4	7		127	127	2267	4765		43	430	858	1330	1204	0.513	65	683	618
5	8		127	127	2267	5388		43	430	970	1443	1316	0.467	59	673	614
6	9		127	127	2267	5842		43	430	1051	1524	1398	0.424	54	646	593
7	10		127	127	2267	6154		43	430	1108	1580	1454	0.386	49	609	561
8	11		127	127	2267	6393		43	430	1151	1624	1497	0.350	44	569	525
9	12		127	127	2267	6597		43	430	1187	1660	1534	0.319	40	529	489
10	13		127	127	2267	6742		43	430	1214	1686	1560	0.290	37	488	452
11	14		127	127	2267	6862		43	430	1235	1708	1581	0.263	33	450	416
12	15		127	127	2267	7013		43	430	1262	1735	1609	0.239	30	415	385
13	16		127	127	2267	7013		43	430	1262	1735	1609	0.218	28	378	350
14	17		127	127	2267	7013	343	43	430	1262	2078	1952	0.198	25	411	386
15	18		127	127	2267	7013	515	43	430	1262	2250	2123	0.180	23	405	382
16	19		127	127	2267	7013		43	430	1262	1735	1609	0.164	21	284	263
17	20		127	127	2267	7013		43	430	1262	1735	1609	0.149	19	258	239
18	21		127	127	2267	7013		43	430	1262	1735	1609	0.135	17	234	217
19	22		127	127	2267	7013		43	430	1262	1735	1609	0.123	16	213	198
20	23		127	127	2267	7013		43	430	1262	1735	1609	0.112	14	194	180
21	24		127	127	2267	7013		43	430	1262	1735	1609	0.102	13	176	163
22	25		127	127	2267	7013		43	430	1262	1735	1609	0.092	12	160	148
23	26		127	127	2267	7013		43	430	1262	1735	1609	0.084	11	146	135
24	27		127	127	2267	7013		43	430	1262	1735	1609	0.076	10	132	123
25	28		127	127	2267	7013	-286	43	430	1262	1449	1323	0.069	9	100	92
Total		11500	3163	14663	56681	155901	1430	1073	10746	28062	41311	26649		10331	10696	364

B-C= 364
B/C= 1.035
EEDR= 10.42%

Tentative

Table 15.2.1 Financial Analysis of Benefit and Cost

Sale Rate 0.26 M$

SDR= 10.0% IR= 1.00

Liwag(as Cost) Sale. Elect.(as Benefit) (In Thousand Malaysian Dollars)

Year	Serial No.	Invest.	OM Cost	Sub-Total	Energy (MWh)	Sale Revenue	B-C	PV Factor	NPV Cost	NPV Benefit	NPV B-C
1994	1	2725		2725			-2725	0.909	2477	0	-2477
1995	2	5303		5303			-5303	0.826	4383	0	-4383
1996	3	3472		3472			-3472	0.751	2609	0	-2609
1	4		127	127	4365	940	813	0.683	86	642	555
2	5		127	127	5204	1120	994	0.621	79	696	617
3	6		127	127	6046	1302	1175	0.564	71	735	663
4	7		127	127	6962	1499	1372	0.513	65	769	704
5	8		127	127	7579	1632	1505	0.467	59	761	702
6	9		127	127	8028	1728	1602	0.424	54	733	679
7	10		127	127	8337	1795	1668	0.386	49	692	643
8	11		127	127	8574	1846	1719	0.350	44	647	603
9	12		127	127	8776	1889	1763	0.319	40	602	562
10	13		127	127	8919	1920	1794	0.290	37	556	520
11	14		127	127	9037	1946	1819	0.263	33	512	479
12	15		127	127	9188	1978	1851	0.239	30	474	443
13	16		127	127	9188	1978	1851	0.218	28	430	403
14	17		127	127	9188	1978	1851	0.198	25	391	366
15	18		127	127	9188	1978	1851	0.180	23	356	333
16	19		127	127	9188	1978	1851	0.164	21	323	303
17	20		127	127	9188	1978	1851	0.149	19	294	275
18	21		127	127	9188	1978	1851	0.135	17	267	250
19	22		127	127	9188	1978	1851	0.123	16	243	227
20	23		127	127	9188	1978	1851	0.112	14	221	207
21	24		127	127	9188	1978	1851	0.102	13	201	188
22	25		127	127	9188	1978	1851	0.092	12	183	171
23	26		127	127	9188	1978	1851	0.084	11	166	155
24	27		127	127	9188	1978	1851	0.076	10	151	141
25	28		127	127	9188	1978	1851	0.069	9	137	128
Total		11500	3163	14663	210456	45307	30644		10331	11182	851

B-C= 851
B/C= 1.082
(FEDR= 10.30%)

8 CONSTRUCTION MANAGEMENT OF HYDROPOWER PROJECT

Construction Management of Hydropower Project

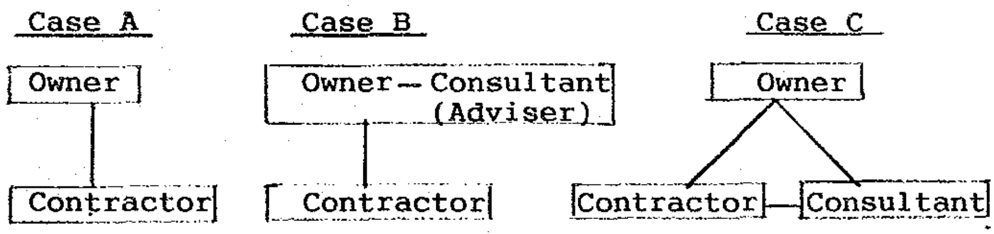
1. Detail Design and Tender Documents

   - Selection of Consultant
   - Detail design and Engineering Report
   - Preparation of Tender Documents

2. Selection of Contractor

   - Prequalification of Contractors
   - Tendering
   - Selection of Contractor

3. Formation of Construcion



4. Construction Works

	Contractor	Owner (Consultant)
Setting out of Structures (Survey)	Survey	Check
Construction Drawings	Preparation	Approval
Construction Works	Inspection	Inspection Approval

5. Completion

   Acceptance Test/ Final Inspection

   Guarantee Period

   Built-in Drawings

   Construction Report

4. Seminar on Small Scale Hydroelectric Power Development

The seminar was held under the joint sponsorship of SEB and JICA as follows.

Date : March 11 and 12, 1992

Venue: Hyatt Kinabalu Hotel, Kota Kinabalu


SEMINAR ON
SMALL HYDRO POWER DEVELOPMENT
BY SEB/JICA