Table-B.4: SIEVING ANALYSIS RESULT FOR FINE AGGREGATE

Sieve (mm)	Passing (Remaining) Rate of Each Sieve in %						Remarks
	Test Pit No.					Average	
	FTP-1	FTP-2	FTP-3	FTP-4	FTP-5		
5	85(15)	38(62)	87(13)	63(37)	44.5(55.5)	63.5(36.5)	
2.5	80(20)	31.5(68.5)	84(16)	57(43)	38(62)	58.1(41.9)	
1.2	76(24)	26.5(73.5)	82.5(17.5)	53.5(46.5)	33(67)	54.3(45.7)	
0.6	53.5(46.5)	13(87)	77.5(22.5)	38.5(61.5)	20(80)	40.5(59.5)	
0.3	15.5(84.5)	3.5(96.5)	14(86)	10(90)	4(96)	9.4(90.6)	
0.15	2(98)	1.0(99)	2(98)	2(98)	2(98)	1.8(98.2)	

Sieve (mm)	Remaining Rate in Each Sieve in % (Excl. size larger than 5 mm)						Remarks
	Test Pit No.					Average	
	FTP-1	FTP-2	FTP-3	FTP-4	FTP-5		
5	0	0	0	0	0	0	
2.5	5.88	17.11	3.45	9.52	14.61	10.11	
1.2	10.59	30.26	5.17	15.08	25.84	17.39	
0.6	37.06	65.79	10.92	38.89	55.06	41.54	
0.3	81.76	90.79	83.91	84.13	91.01	86.32	
0.15	97.65	97.37	97.70	96.83	95.51	97.01	
F.M.	2.33	3.01	2.01	2.44	2.82	2.52	

Table-B.5: QUALITY TEST RESULT FOR FINE AGGREGATE

Test Pit No.	Specific Gravity and Absorption		Washing Test	Abrasion Test	Soundness Test	Weight of Unit Volume
	Specific Gravity	Absorption (%)	Rate of Passing 0.088 mm Sieve (%)	Weight Reduction (%)	Weight Reduction (%)	(t/m^3)
FTP – 1	2.67	1.93	10.09	–	9.58	1.283
– 2	2.65	1.94	1.93	–	–	1.891
– 3	2.68	2.63	2.20	–	12.03	1.295
– 4	2.63	1.84	1.07	–	–	1.615
– 5	2.54	2.28	6.14	–	–	1.800

Table-B.6: QUALITY TEST RESULT FOR CORE MATERIAL (1)

Samples		Soil	Field Moisture	Specific	Consistency			Gradation							
								Passed Percentage (%)					Particle Size (mm)		
Test Pit No.	Depth (m)	Classification	Content Wf, (%)	Gravity, Gs(g/cm^3)	L.L. (%)	P.L. (%)	P.I. (%)	mm 4.76	mm 2.00	mm 0.42	mm 0.074	mm 0.005	D60	D30	D10
TP-1	2	CL	17.8	2.656	35.2	25.3	9.9	100	99.1	97.5	86.1	51.0	0.01	–	–
TP-2	2	CH	26.9	2.659	52.9	36.4	16.5	100	100	99.1	94.2	53.0	0.008	–	–
	4	CL	12.6	2.710	41.5	20.1	21.4	100	98.9	97.5	82.0	28.0	0.035	0.0063	–
TP-3	2	CL	20.2	2.688	44.8	18.7	26.1	100	100	96.9	85.0	48.0	0.013	–	–
	4	CL	10.1	2.699	33.5	23.6	9.9	96.9	95.6	87.6	67.8	22.0	0.065	0.012	–
TP-4	2	CL	20.5	2.677	40.5	24.3	16.2	100	99.8	96.8	85.0	44.0	0.017	0.0035	–
TP-5	2	CL	23.6	2.663	37.9	20.3	17.6	100	100	97.9	88.8	46.0	0.024	0.001	–
TP-6	2	CL	23.4	2.663	46.7	27.2	19.5	100	100	96.9	85.8	50.0	0.007	0.0015	–
TP-7	2	CL	24.0	2.659	41.6	28.7	12.9	100	100	98.4	91.2	65.0	0.0042	–	–

Table-B.7: QUALITY TEST RESULT FOR CORE MATERIAL (2)

Samples	Condition of Test	Dry Density, rd (g/cm^3)	Mositure Content, W (%)	Wet Density, rt (g/cm^3)	Void Ratio, e	Degree of Saturation, Sr (%)	Triaxial Compression Test U-U Cohesion, C (kg/cm^2)	Triaxial Compression Test U-U Friction Angle, ϕ (°)	Triaxial Compression Test C-U Cohesion, C (kg/cm^2)	Triaxial Compression Test C-U Friction Angle, ϕ (°)	Permeability Test Permeability Coefficient, k (cm/s)
TP-3 (at 2 m depth)	Max. dry density and optimum moisutre content	1.560	22.6	1.913	0.723	84.0	1.9 (-)	15°00' (-)	- (-)	- (-)	2.78×10^{-7}
	95% dry density and 80% of degree of saturation	1.482	24.2	1.841	0.814	80.0	1.2 (-)	12°00' (-)	0.3 (0.08)	15°30' (35°30')	3.63×10^{-6}
TP-4 (at 2 m depth)	Max. dry density and optimum moisture content	1.485	26.2	1.868	0.803	87.3	1.4 (-)	15°00' (-)	- (-)	- (-)	4.87×10^{-7}
	95% dry density and 80% of degree of saturation	1.411	26.8	1.789	0,897	80.0	1.3 (-)	13°30' (-)	0.42 (0.15)	11°30' (33°30')	2.29×10^{-6}

Samples	Compaction Test Compaction Energy, Ec (%)	Max. Dry Density, rd Max. (g/cm^3)	Optimum Moisture Content Wopt (%)	Wf - Wopt (%)	Allowable Maximum Grain Size (mm)	Diameter of Mold (mm)	Weight of Rammer (kg)
TP-1 (at 2 m depth)	100 (5.625 m.kg/m^3)	1.555	24.0	-6.2	4.76	100	2.5
TP-3 (")	"	1.560	22.6	-2.4	"	"	"
TP-4 (")	"	1.485	26.2	-5.7	"	"	"
TP-7 (")	"	1.510	25.8	-1.8	"	"	"

Notes: (i) WF = Moisture content at field.
(ii) ( ) shows the effective stress analysis.

Table-B.8: QUALITY TEST RESULT FOR QUARRY ROCK

Sample No.	Specific Gravity and Absorption		Abrasion	Soundness
	Specific Gravity	Absorption (%)	Weight Reduction (%)	Weight Reduction (%)
R-1	2.934	0.24	29.48	0
R-2	2.880	0.52	23.88	0
R-3	2.907	0.41	16.97	0
R-4	2.845	0.97	32.50	0

FIGURES

FIG- B.1

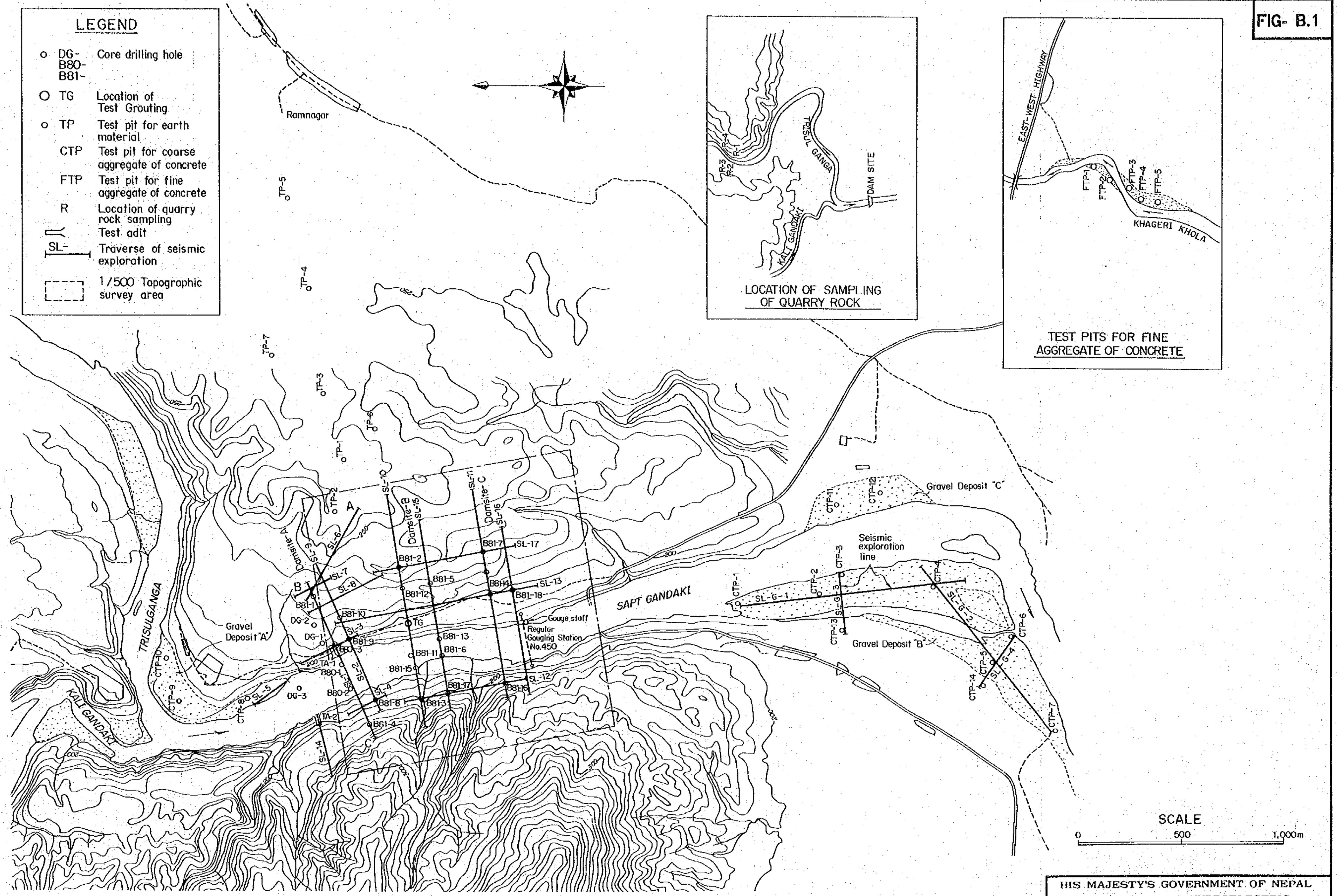


FIG- B.1 : LOCATION MAP OF INVESTIGATION

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT
JAPAN INTERNATIONAL COOPERATION AGENCY

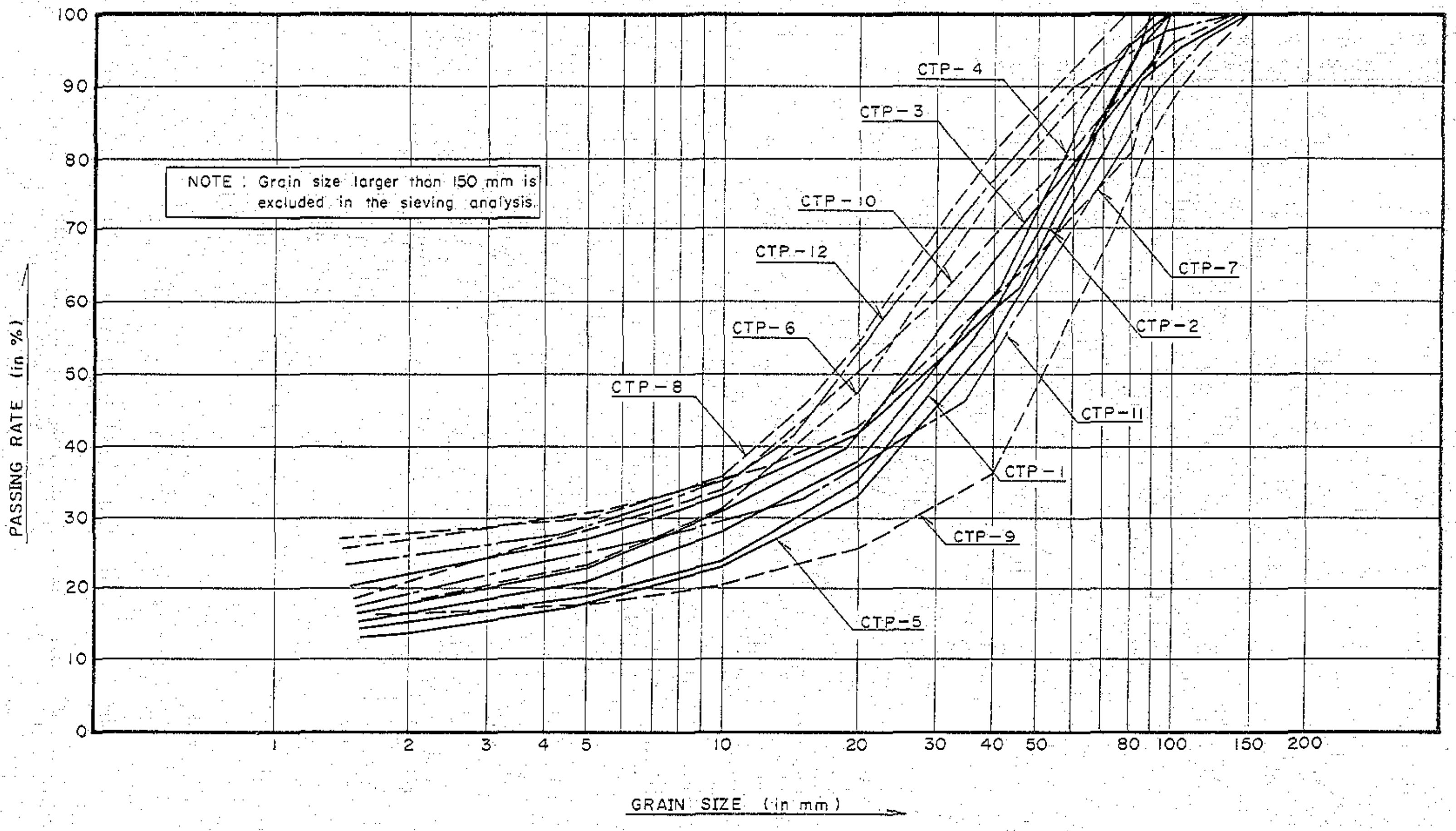


FIG- B.2 : SIEVING ANALYSIS RESULT (COARSE AGGREGATE)

HIS MAJESTY'S GOVERNMENT OF NEPAL SAPT GANDAKI HYDROELECTRIC POWER DEVELOPMENT PROJECT FEASIBILITY REPORT	FIG- B.2
JAPAN INTERNATIONAL COOPERATION AGENCY	

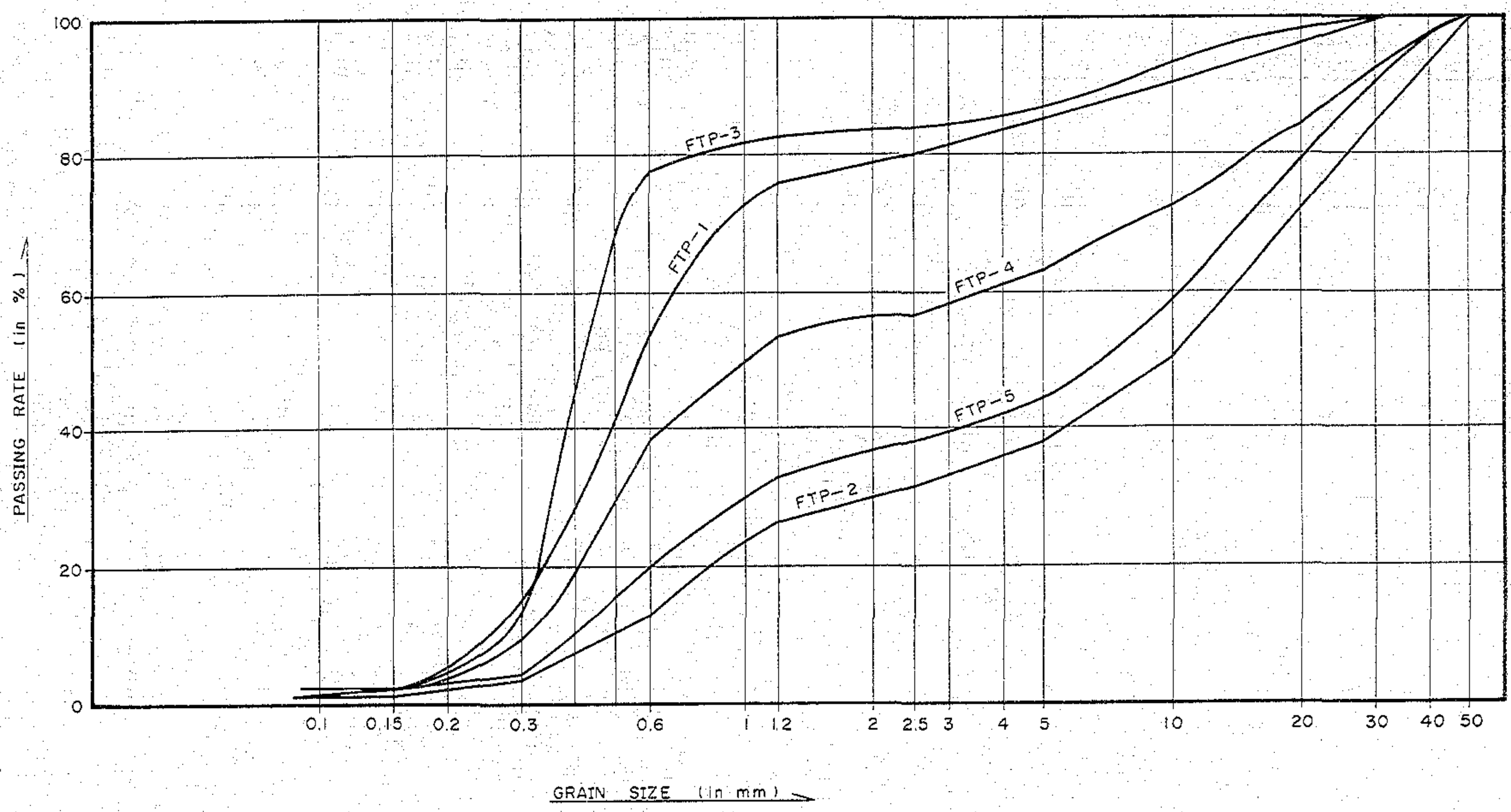


FIG- B.3 : SIEVING ANALYSIS RESULT
(FINE AGGREGATE)

HIS MAJESTY'S GOVERNMENT OF NEPAL SAPT GANDAKI HYDROELECTRIC POWER DEVELOPMENT PROJECT FEASIBILITY REPORT	FIG- B.3
JAPAN INTERNATIONAL COOPERATION AGENCY	

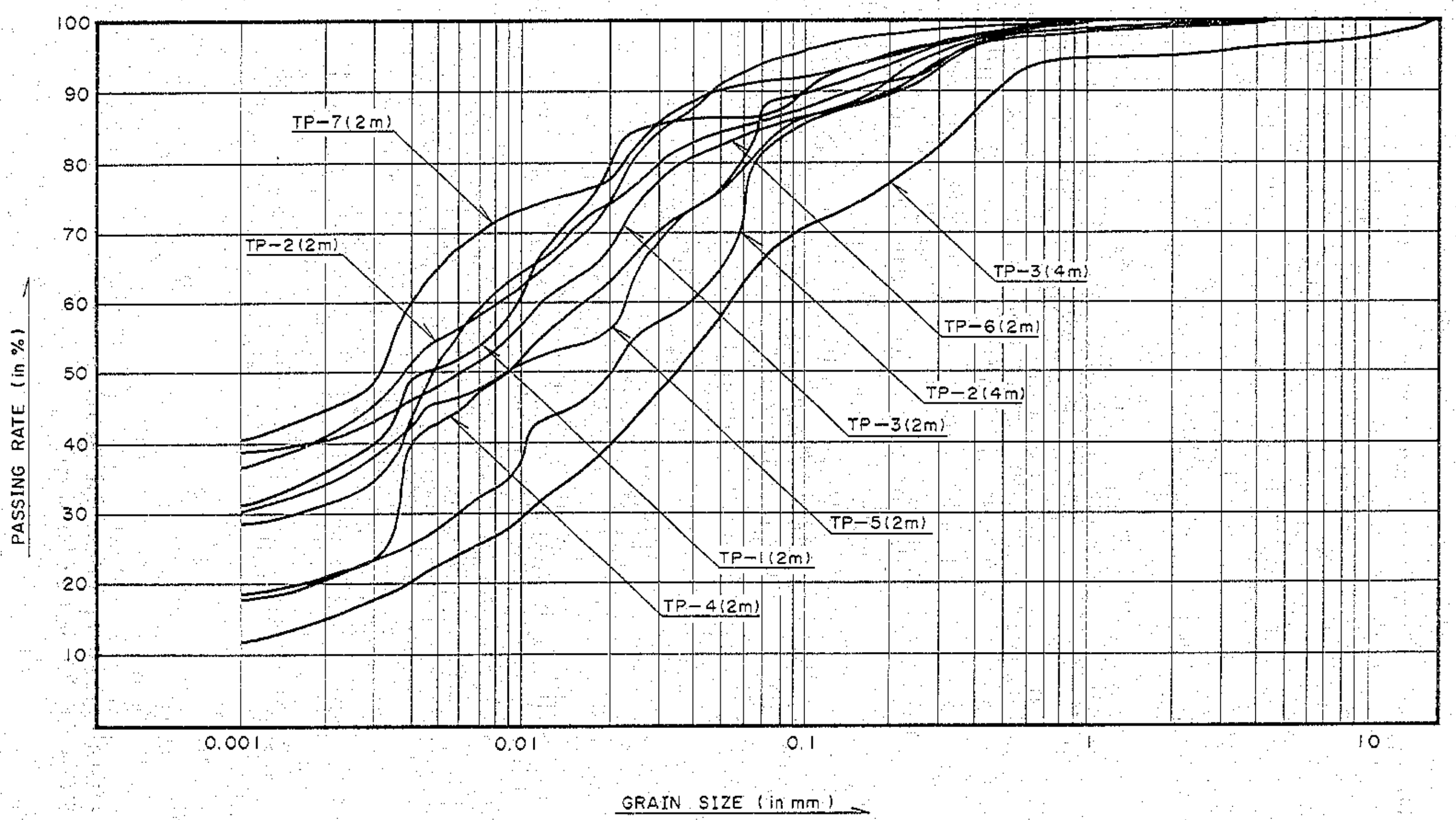
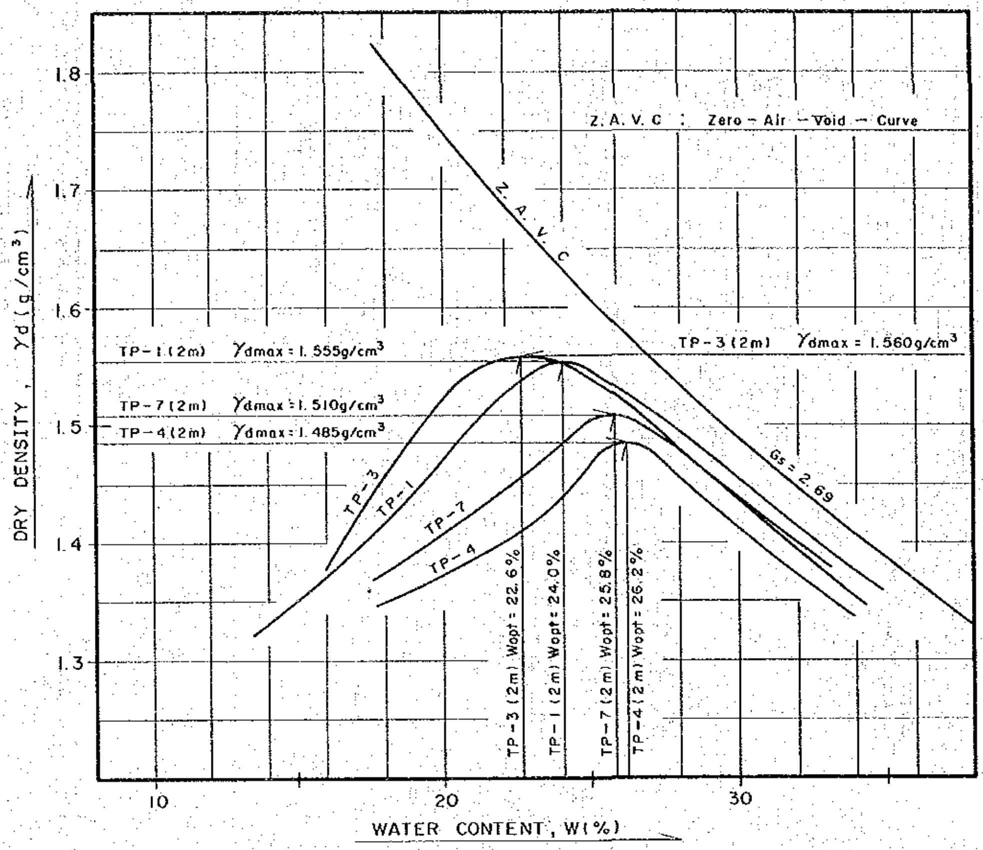


FIG- B.4 : SIEVING ANALYSIS RESULT (CORE MATERIAL)

FIG- B.4
HIS MAJESTY'S GOVERNMENT OF NEPAL SAPT GANDAKI HYDROELECTRIC POWER DEVELOPMENT PROJECT FEASIBILITY REPORT
JAPAN INTERNATIONAL COOPERATION AGENCY



	Energy Ec (%)	γd max (g/cm³)	Wopt (%)	Wf − Wopt (%)
TP-1 (2m)	100	1.555	24.0	−6.2
TP-3 (2m)	"	1.560	22.6	−2.4
TP-4 (2m)	"	1.485	26.2	−5.7
TP-7 (2m)	"	1.510	25.8	−1.8

FIG- B.5 : COMPACTION TEST RESULT FOR CORE MATERIALS

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT

JAPAN INTERNATIONAL COOPERATION AGENCY

FIG- B.6

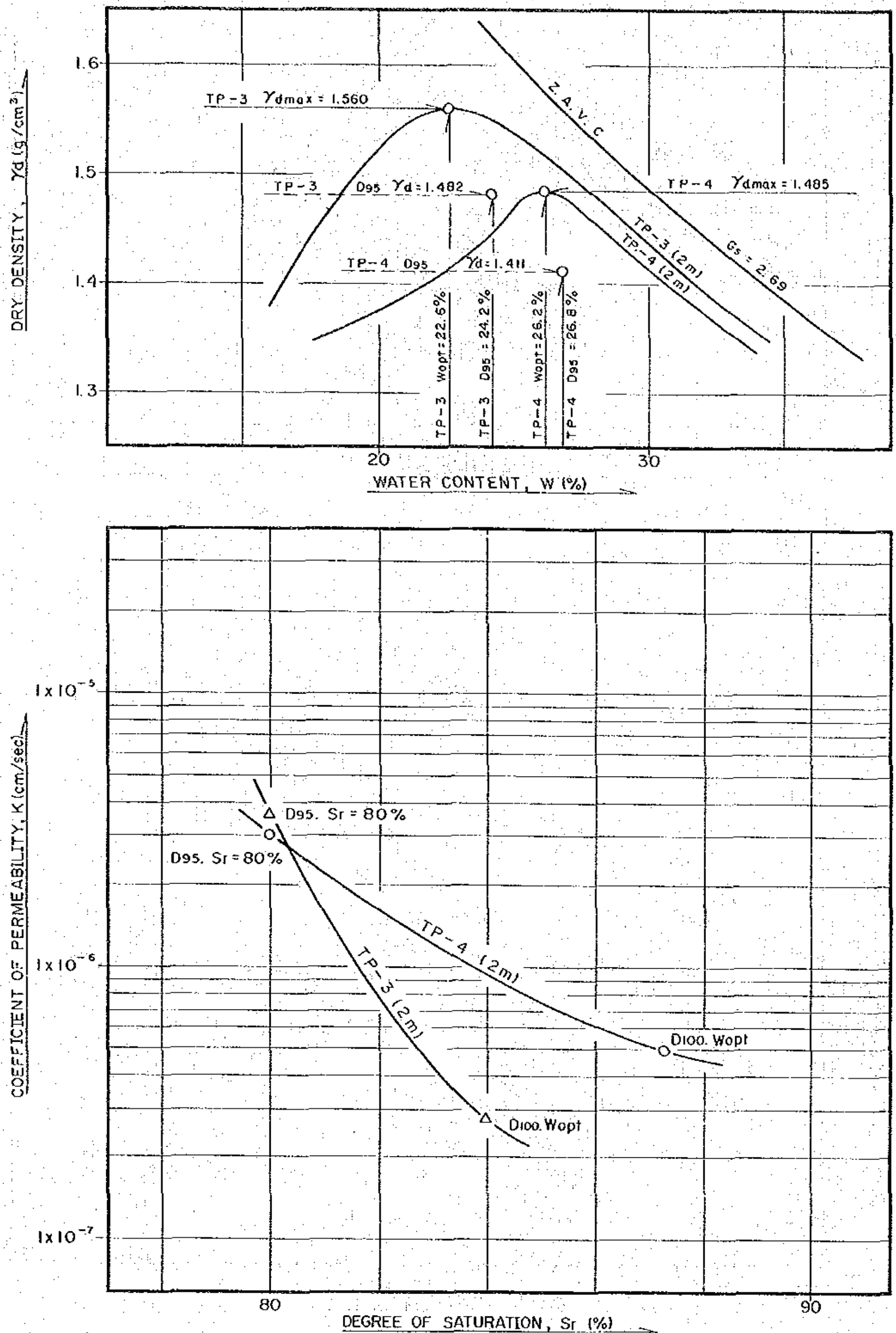


FIG- B.6 : PERMEABILITY TEST RESULT FOR CORE MATERIALS

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT
JAPAN INTERNATIONAL COOPERATION AGENCY

FIG- B.7

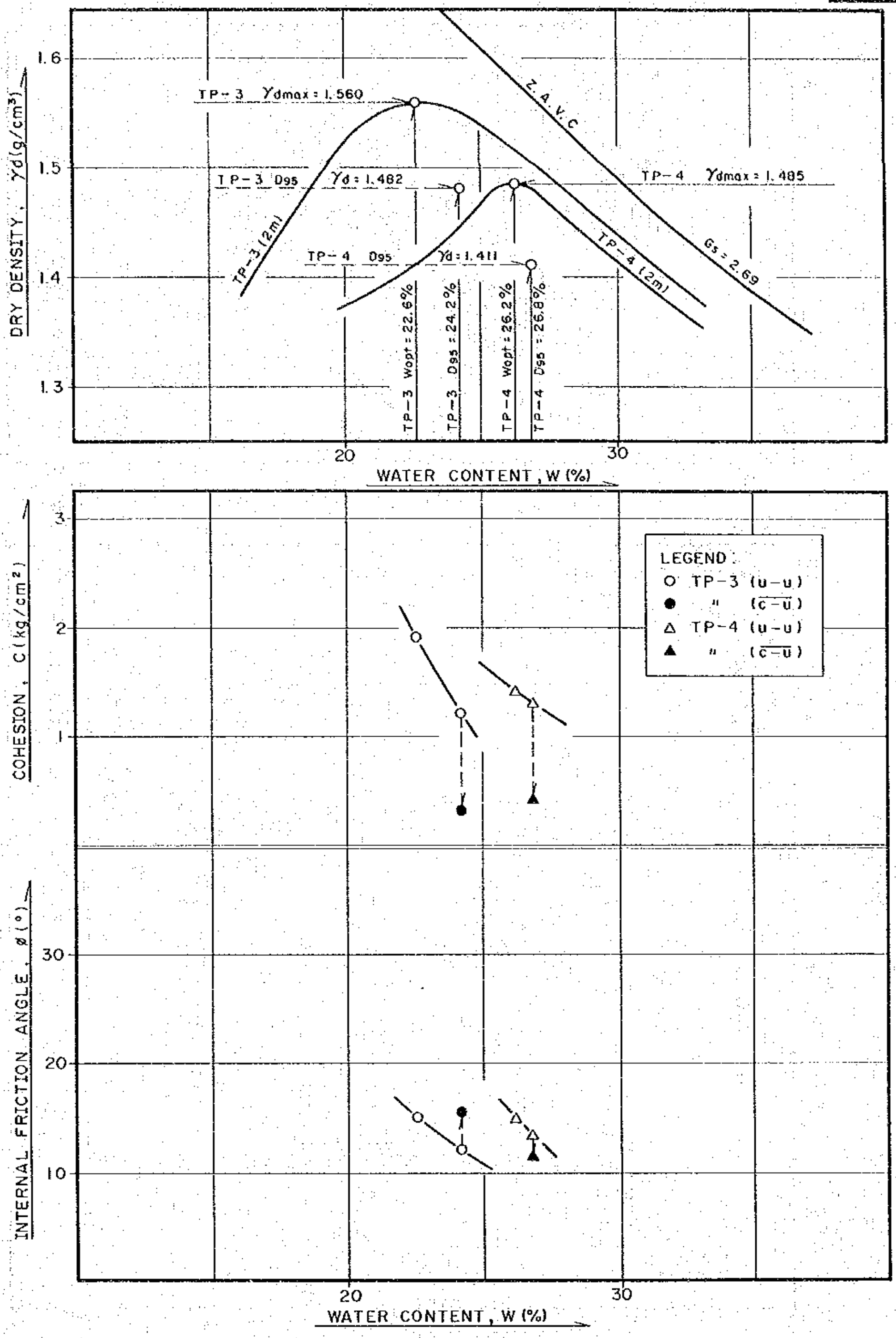


FIG- B.7 : TRIAXIAL COMPRESSION TEST RESULT FOR CORE MATERIALS

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT
JAPAN INTERNATIONAL COOPERATION AGENCY

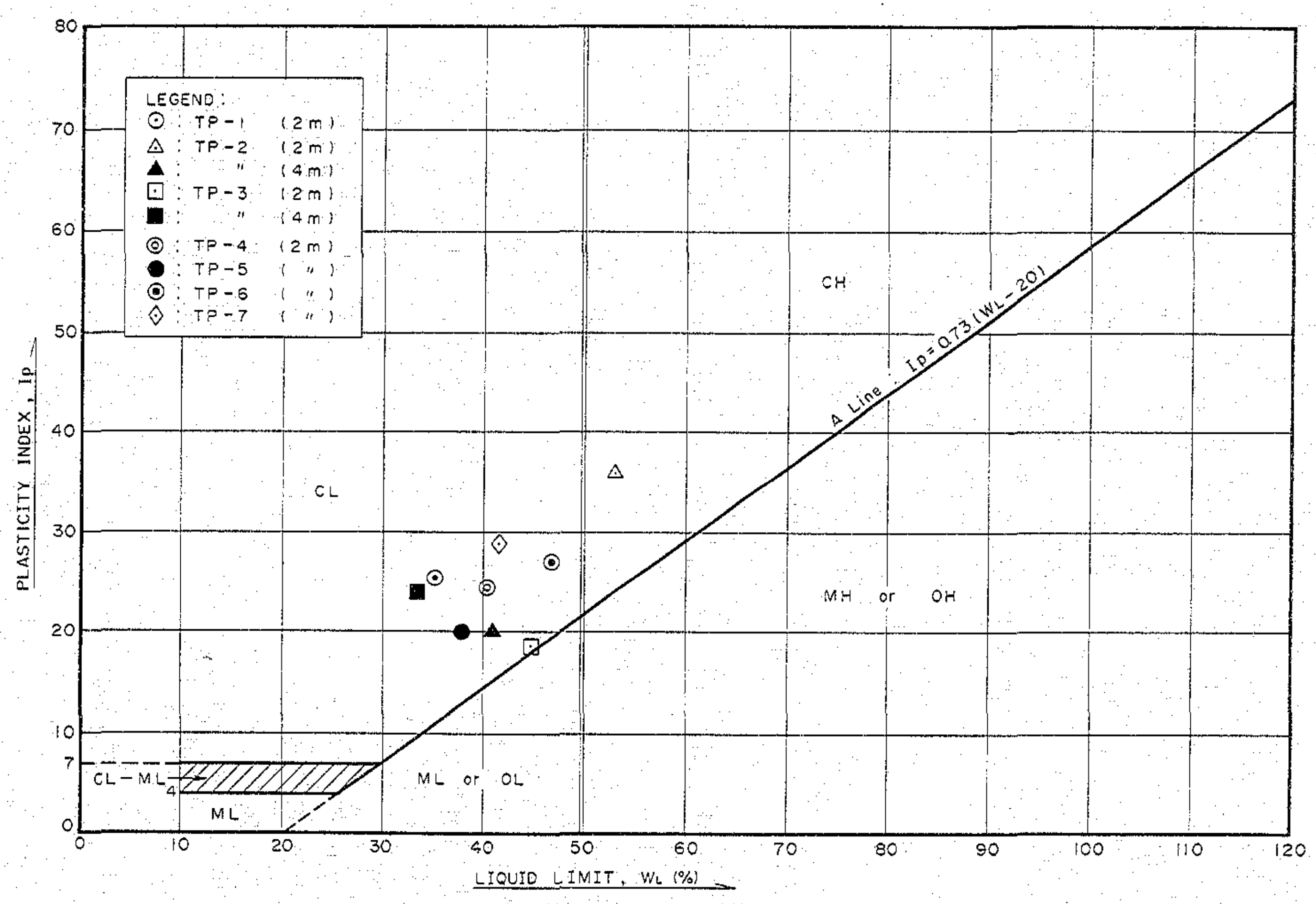


FIG- B.8 : PLASTICITY CHART FOR CORE MATERIAL

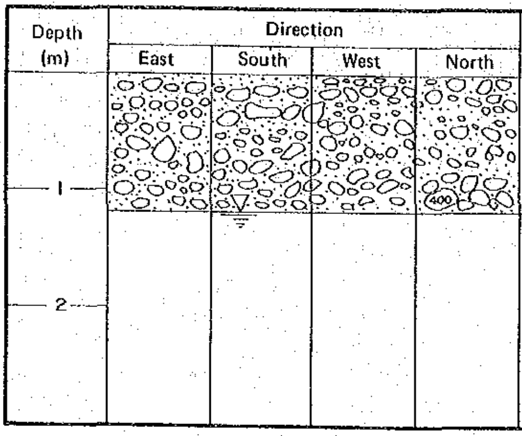
HIS MAJESTY'S GOVERNMENT OF NEPAL SAPT GANDAKI HYDROELECTRIC POWER DEVELOPMENT PROJECT FEASIBILITY REPORT	FIG- B.8
JAPAN INTERNATIONAL COOPERATION AGENCY	

ATTACHMENTS

SKETCH OF TEST PITS

FOR

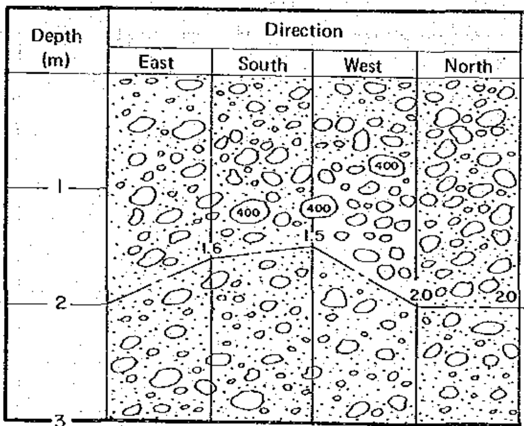
CONSTRUCTION MATERIAL SURVEY



Description

Max. size is about 400 mm in diameter.
There are many round gravels of medium size, assuming gray to grayish brown colour.
Ground water appears at 1.2 m depth.

Test Pit No. CTP–1 (1.2 m)



Description

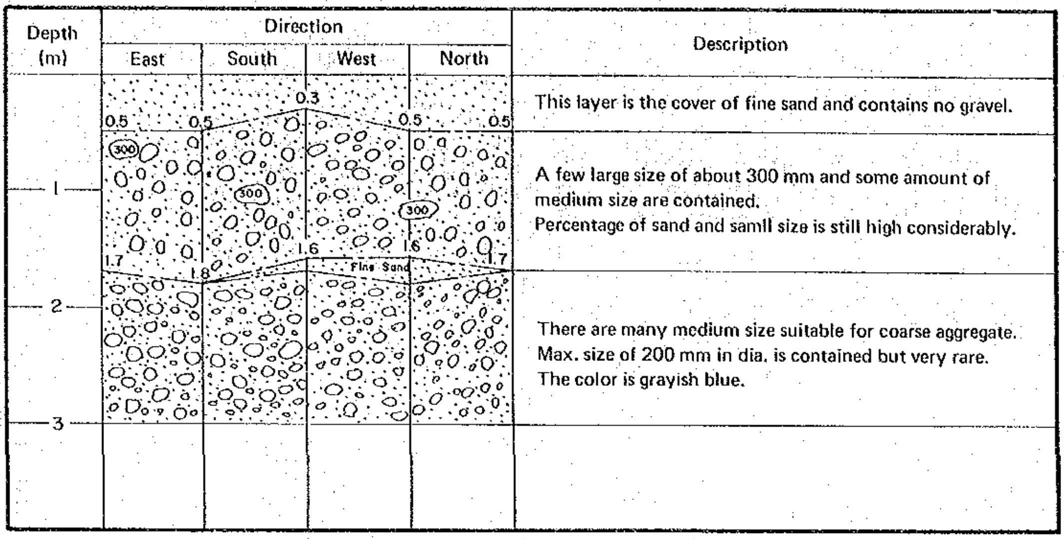
Max. size is about 400 mm in diameter (very rare. 2 to 3 nos. in number). Colour is grayish blue.
There are many gravels of dia. 10 mm to 60 mm.

Large size of 300 to 400 mm in dia. and samll size increase in its number. Gravels of 10 to 60 mm become less than the upper layer.
The materials in this layer assume grayish blue or grayish brown.

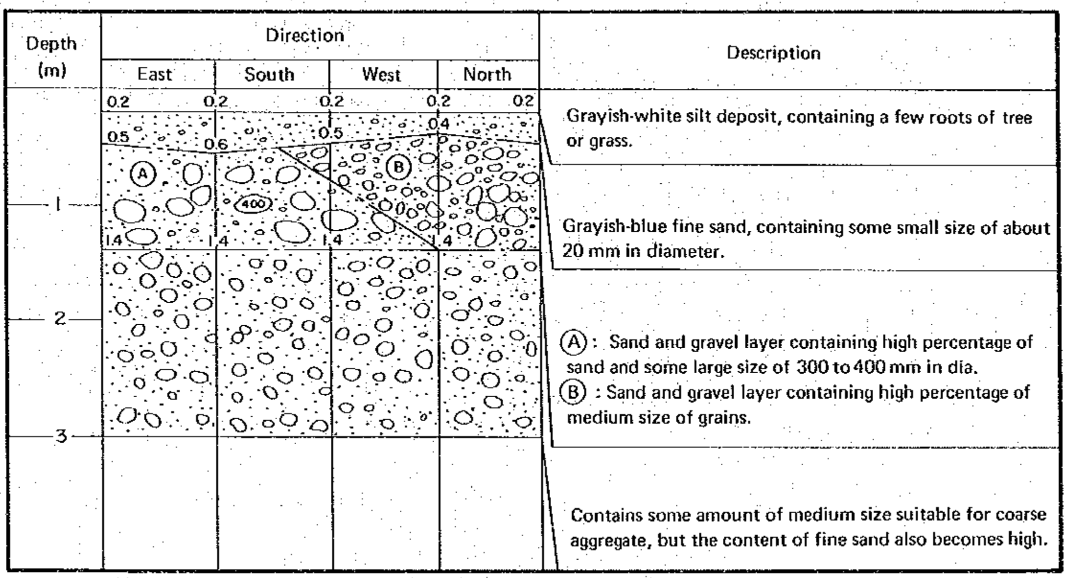
Test Pit No. CTP–2 (3.0 m)

SKETCH OF TEST PITS FOR CONSTRUCTION MATERIAL SURVEY (1)

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT
JAPAN INTERNATIONAL COOPERATION AGENCY



Test Pit No. CTP–3 (3.0 m)

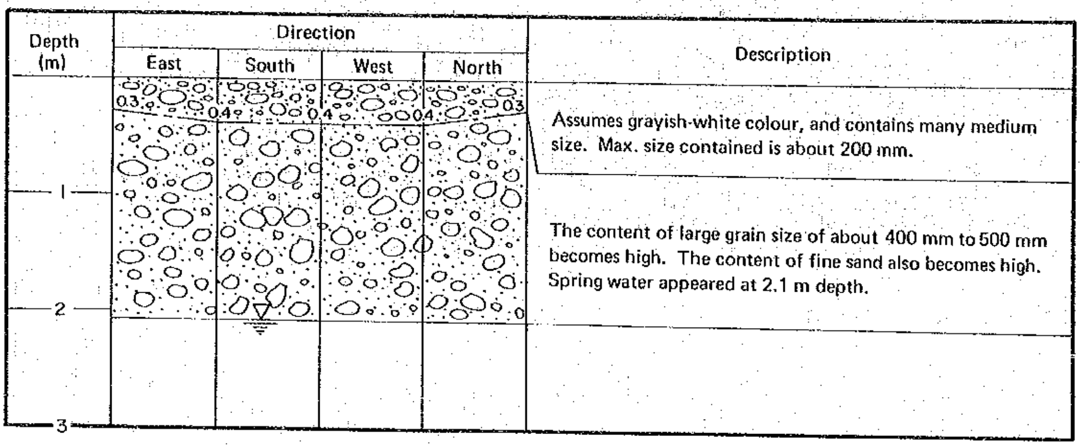


Test Pits No. CTP–4 (3.0 m)

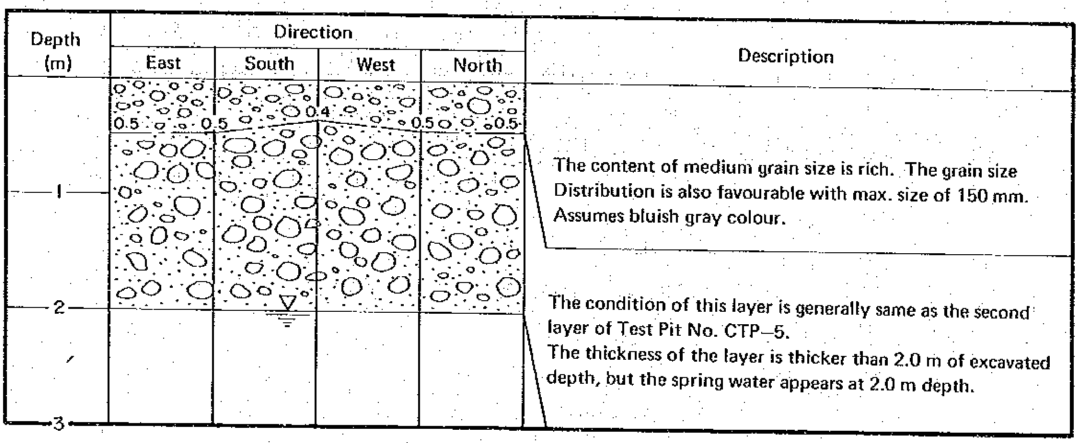
SKETCH OF TEST PITS FOR CONSTRUCTION MATERIAL SURVEY (2)

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT

JAPAN INTERNATIONAL COOPERATION AGENCY



Test Pits No. CTP–5 (2.2 m)



Test Pits No. CTP–6 (2.0 m)

SKETCH OF TEST PITS FOR CONSTRUCTION MATERIAL SURVEY (3)

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT
JAPAN INTERNATIONAL COOPERATION AGENCY

Depth (m)	Direction: East	South	West	North	Description
1					Grain size distribution is fabourable for concrete coarse aggregates with many medium grain size. The layer is thicker than 1.5 m of excavated depth, at which the pit excavation was stopped due to spring water.
	1.50	1.5	1.5	1.5	
2					Submerged condition
3					

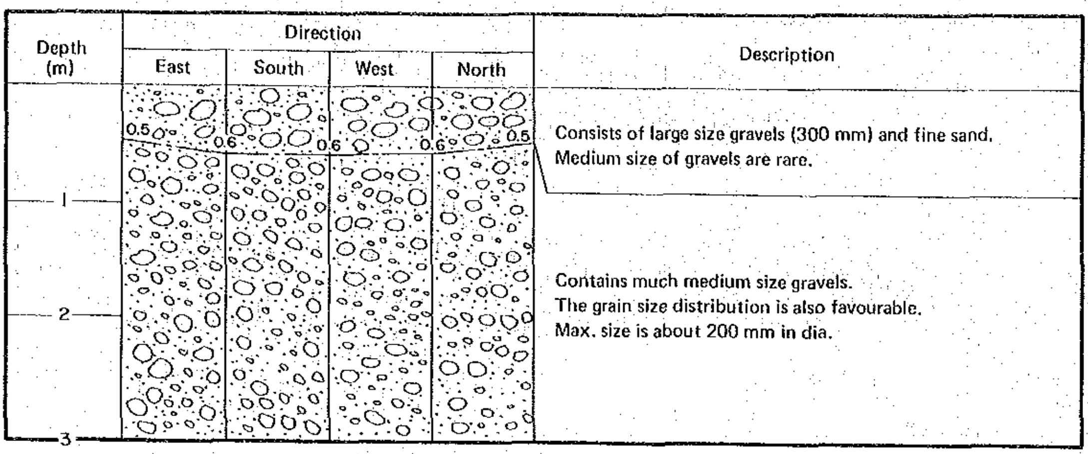
Test Pits No. CTP–7 (1.5 m)

Depth (m)	Direction: East	South	West	North	Description
					Consists of medium size gravels and sand, and contains many roots of tree of grass.
1					Consists of medium to small size of gravels. The content of sand is also high.
2					
3					

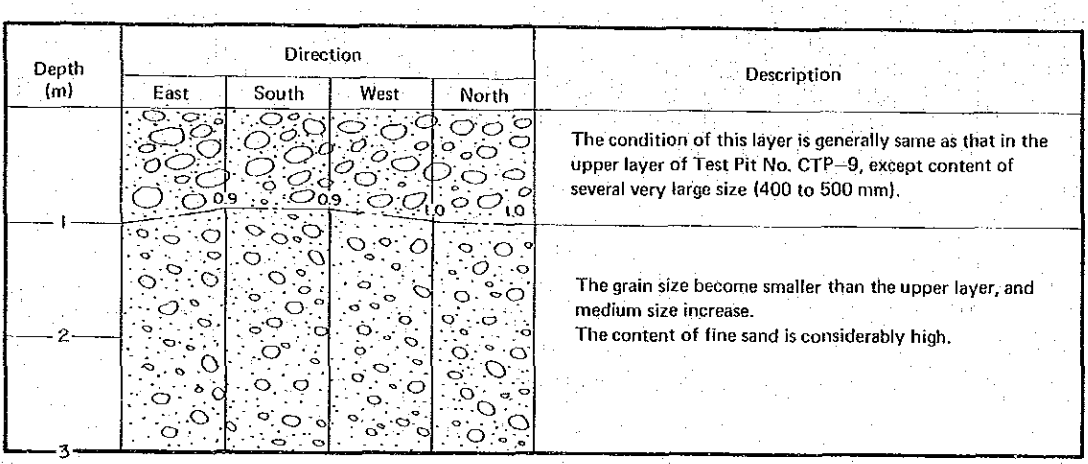
Test Pit No. CTP–8 (3.0 m)

SKETCH OF TEST PITS FOR CONSTRUCTION MATERIAL SURVEY (4)

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT
JAPAN INTERNATIONAL COOPERATION AGENCY



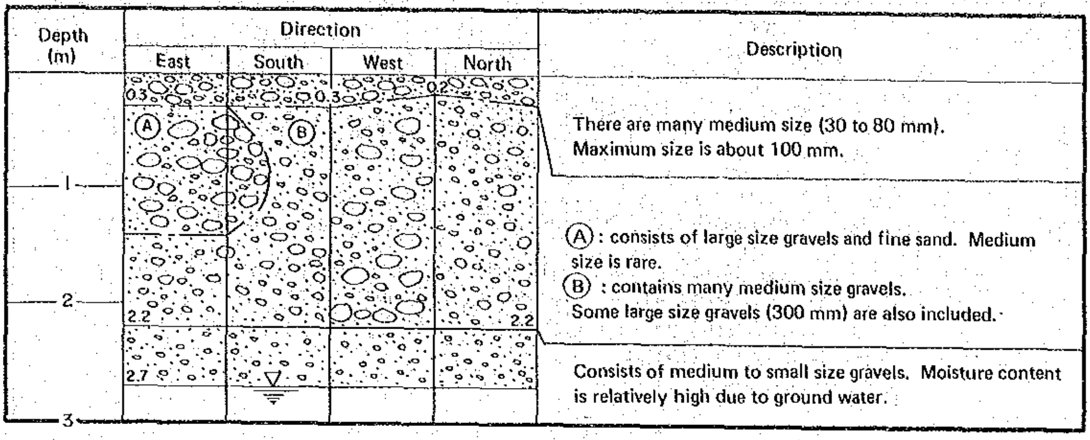
Test Pits No. CTP–9 (3.0 m)



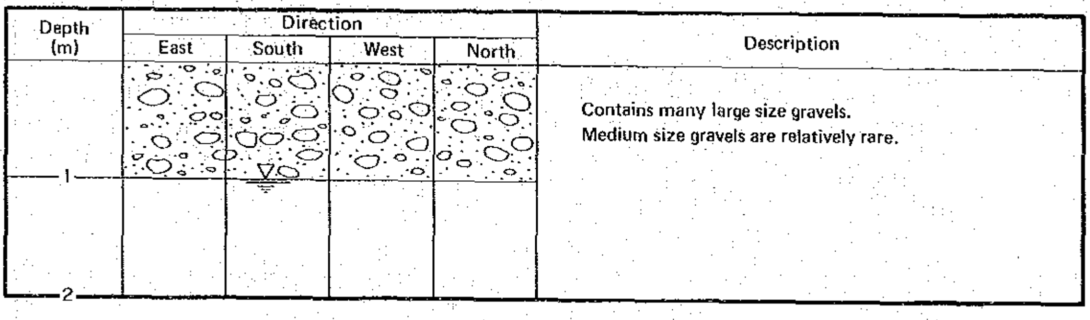
Test Pit No. CTP–10 (3.0 m)

SKETCH OF TEST PITS FOR CONSTRUCTION MATERIAL SURVEY (5)

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT
JAPAN INTERNATIONAL COOPERATION AGENCY



Test Pits No. CTP–11 (3.0 m)

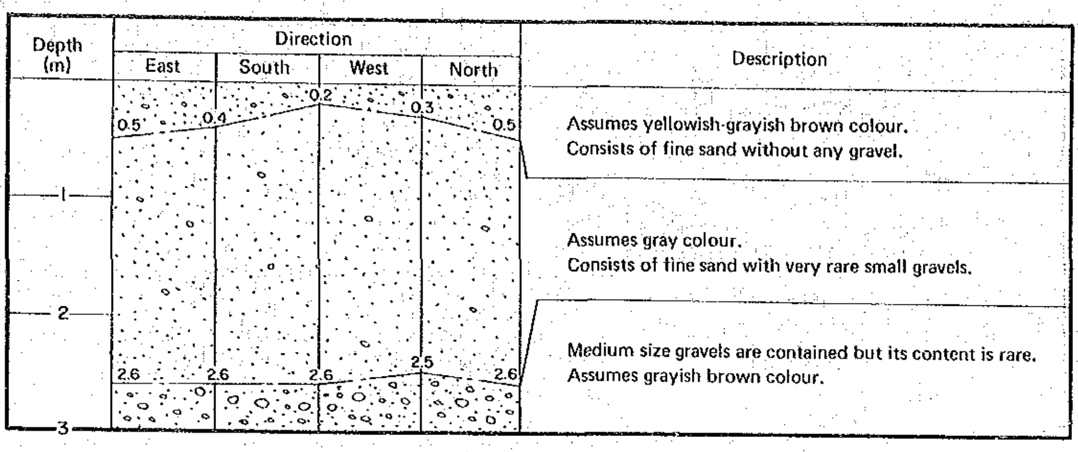


Test Pit No. CTP–12 (1.0 m)

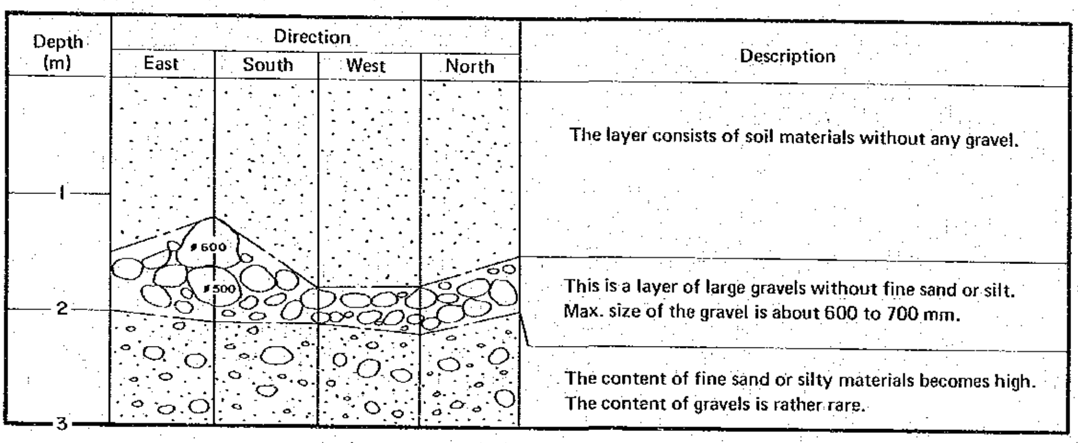
SKETCH OF TEST PITS FOR CONSTRUCTION MATERIAL SURVEY (6)

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT

JAPAN INTERNATIONAL COOPERATION AGENCY



Test Pits No. CTP–13 (3.0 m)

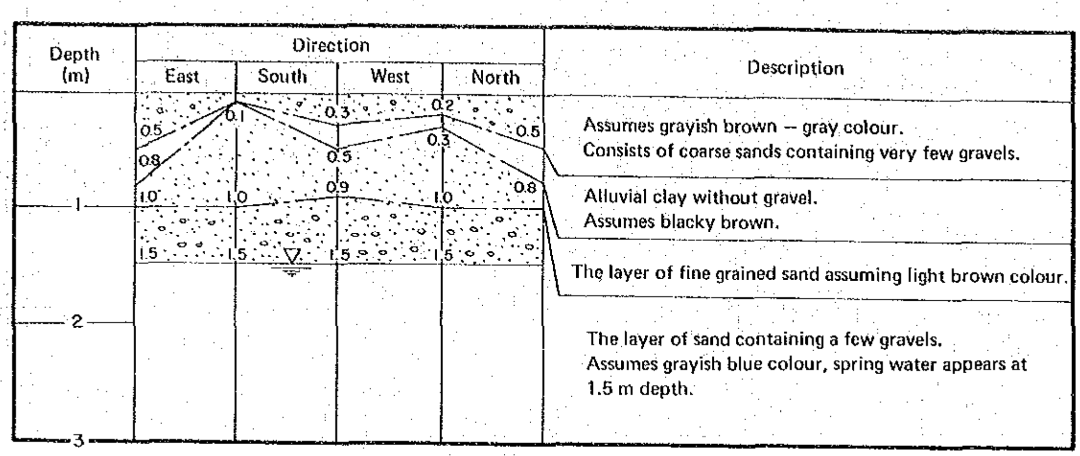


Test Pit No. CTP–14 (3.0 m)

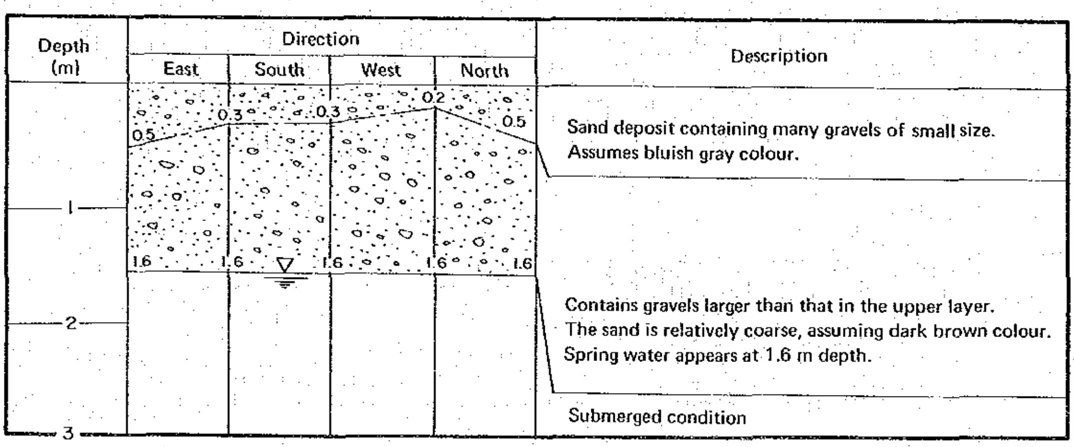
SKETCH OF TEST PITS FOR CONSTRUCTION MATERIAL SURVEY (7)

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT

JAPAN INTERNATIONAL COOPERATION AGENCY



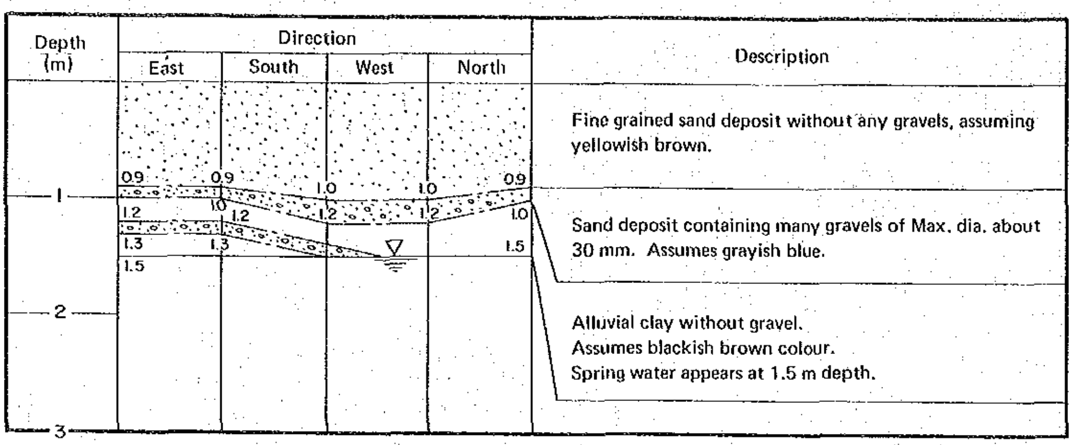
Test Pit No. FTP–1 (1.5 m)



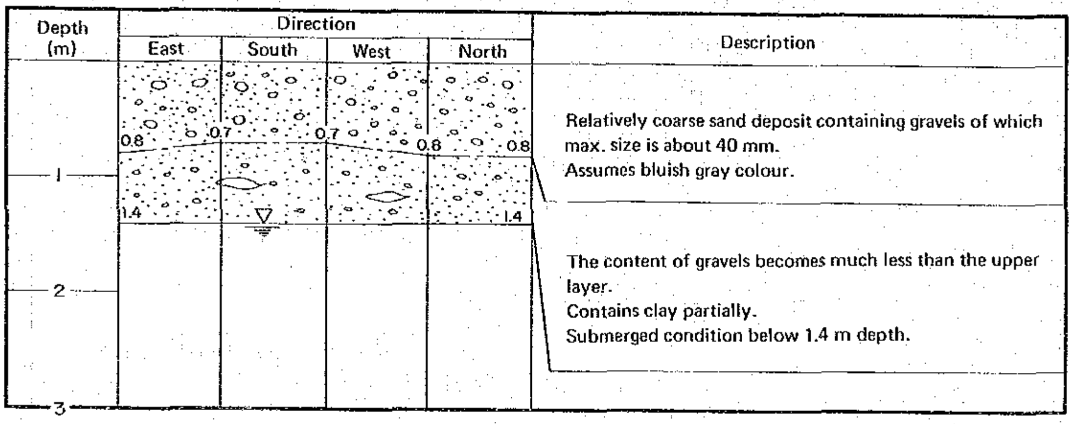
Test Pit No. FTP–2 (1.6 m)

SKETCH OF TEST PITS FOR CONSTRUCTION MATERIAL SURVEY (8)

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT
JAPAN INTERNATIONAL COOPERATION AGENCY



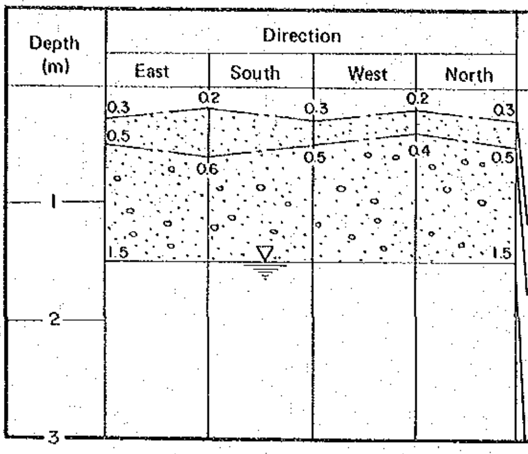
Test Pits No. FTP–3 (1.5 m)



Test Pits No. FTP–4 (1.4 m)

SKETCH OF TEST PITS FOR CONSTRUCTION MATERIAL SURVEY (9)

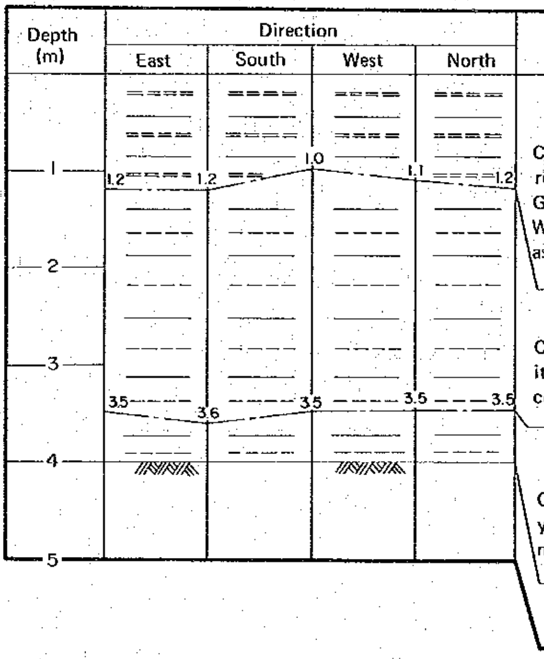
HIS MAJESTY'S GOVERNMENT OF NEPAL SAPT GANDAKI HYDROELECTRIC POWER DEVELOPMENT PROJECT FEASIBILITY REPORT
JAPAN INTERNATIONAL COOPERATION AGENCY



Description

- Alluvial clay layer without gravel, assuming blackish brown to brown. Fine sands are contained, but not available for fine aggregate.
- Deposit of very fine sand without any gravel.
- Deposit of relatively coarse sand containing some gravels. Assumes yellowish grayish brown colour. Spring water appears at 1.5 m depth.

Test Pit No. FTP–5 (1.5 m)



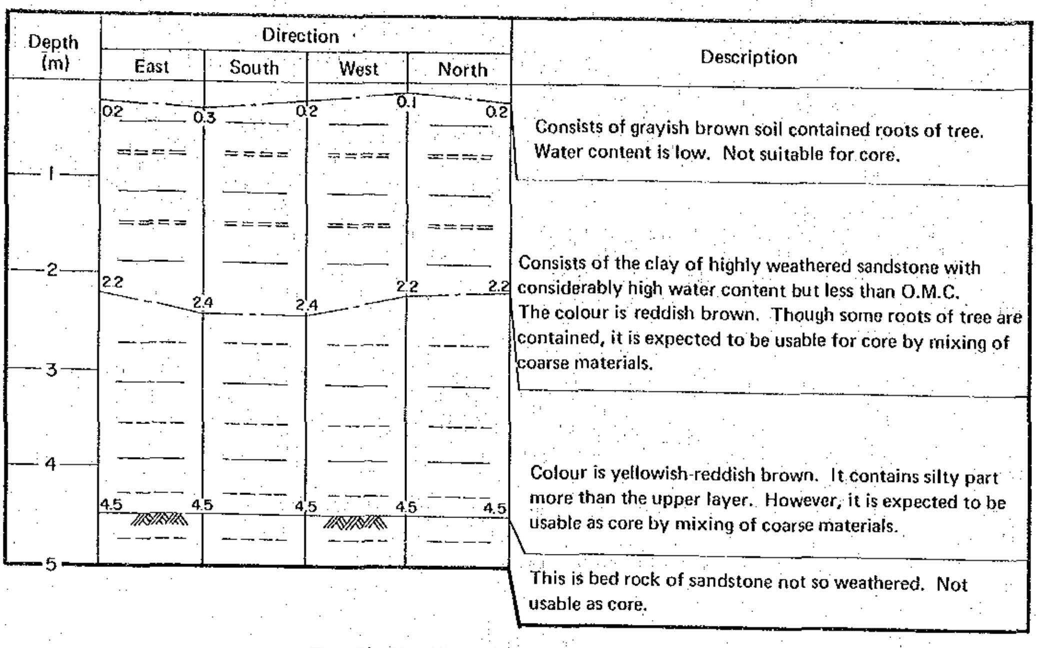
Description

- Consists of the clay of highly weathered sandstone with reddish brown colour. Some roots of tree are contained. Gravels contained are very rare. Water content is relatively high. It is expected to be usable as core material by mixing of some coarse materials.
- Contains silty part more than the upper layer. However, it is expected to be usable as core material by mixing of coarse materials.
- Consists of moderately weathered sandstone with whity yellowish gray colour. This is too hard to dig by hand and not suitable for core.
- This is bed rock and not suitable for core.

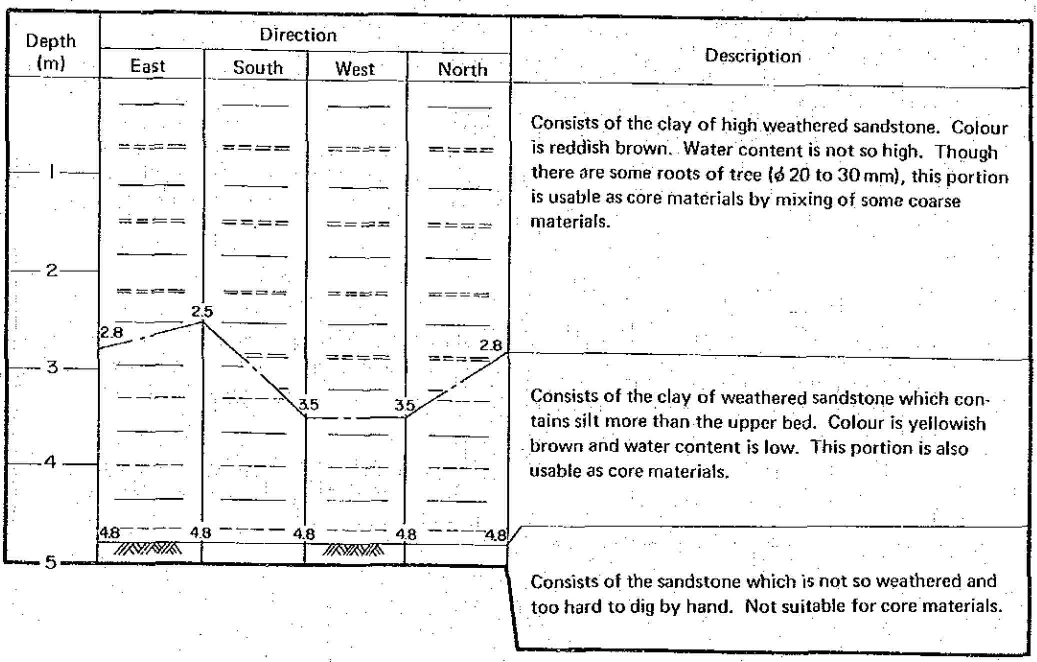
Test Pit No. TP–1 (4.0 m)

SKETCH OF TEST PITS FOR CONSTRUCTION MATERIAL SURVEY (10)

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT
JAPAN INTERNATIONAL COOPERATION AGENCY



Test Pit No. TP–2 (5.0 m)

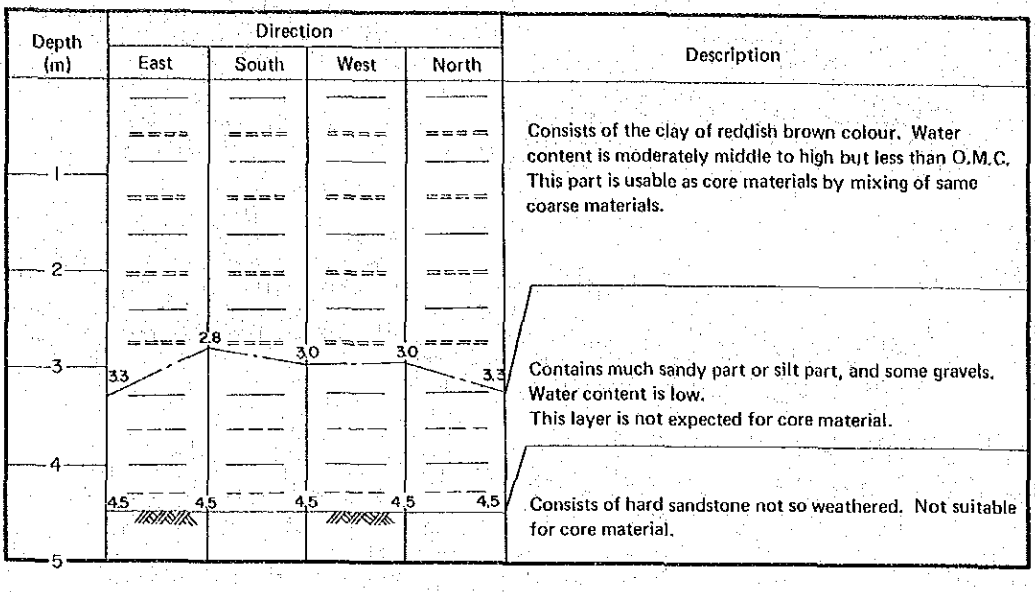


Test Pit No. TP–3 (4.8 m)

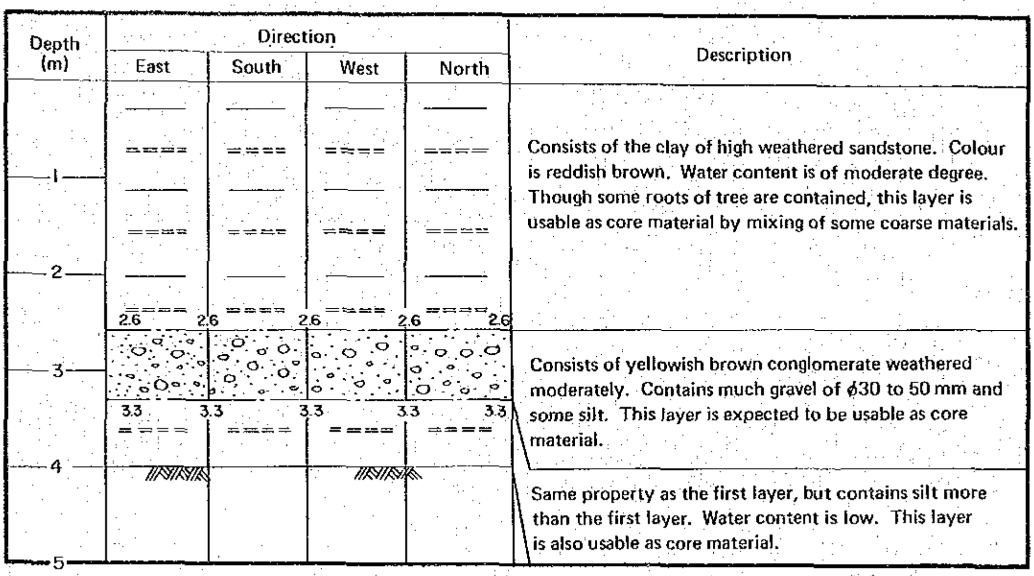
SKETCH OF TEST PITS FOR CONSTRUCTION MATERIAL SURVEY (11)

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT

JAPAN INTERNATIONAL COOPERATION AGENCY



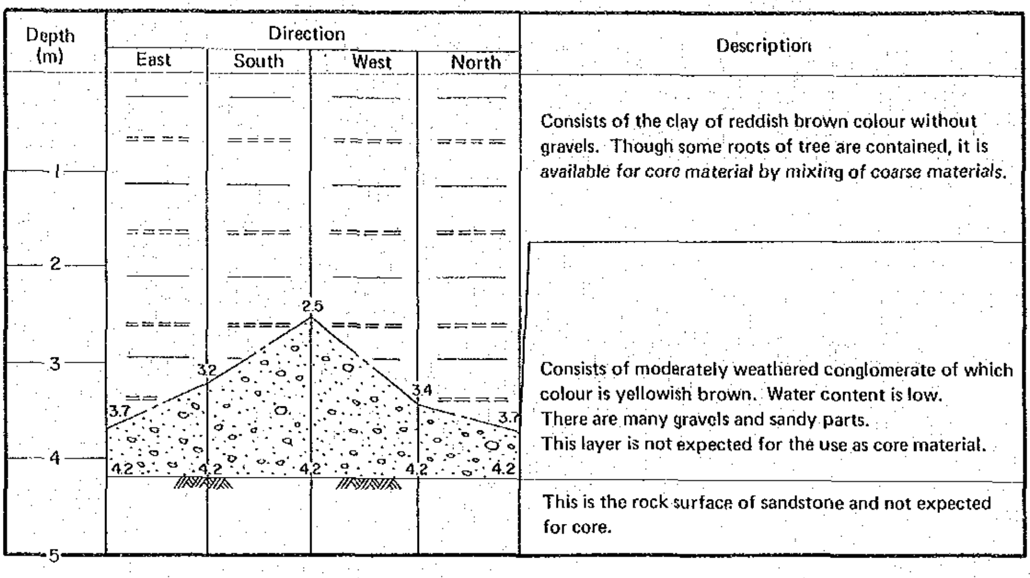
Test Pit No. TP–4 (4.5 m)



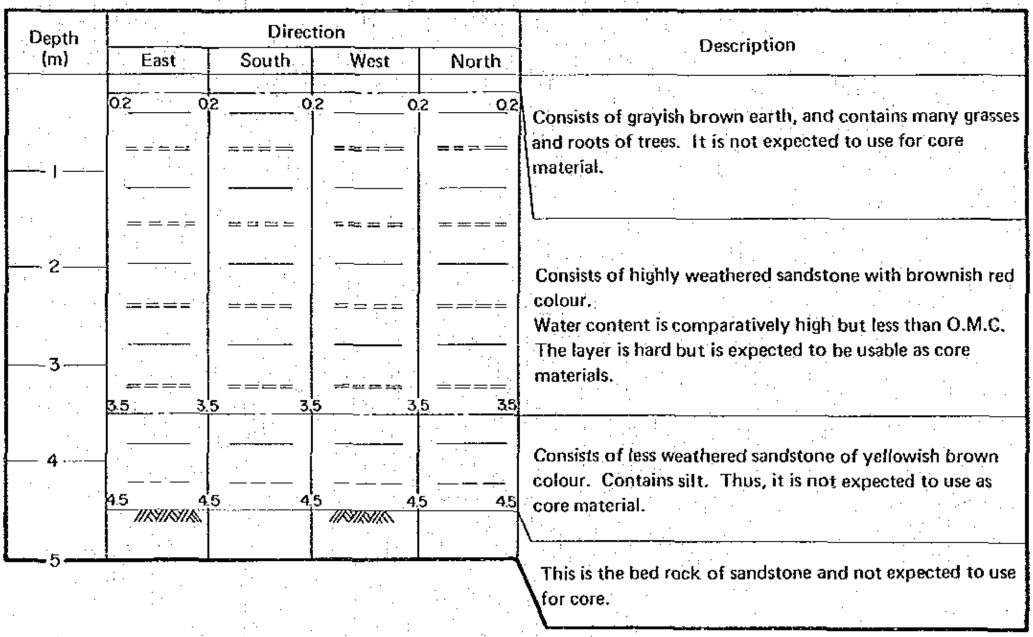
Test Pit No. TP–5 (4.0 m)

SKETCH OF TEST PITS FOR CONSTRUCTION MATERIAL SURVEY (12)

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT
JAPAN INTERNATIONAL COOPERATION AGENCY



Test Pit No. TP–6 (4.2 m)



Test Pit No. TP–7 (4.5 m)

SKETCH OF TEST PITS FOR CONSTRUCTION MATERIAL SURVEY (13)

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT
JAPAN INTERNATIONAL COOPERATION AGENCY

ANNEX (C)

HYDROLOGY AND METEOROLOGY

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ATTACHMENTS

TITLE

I. GENERAL

The overall hydrologic investigation for the Sapt Gandaki basin was carried out by Snowy Mountain Engineering Corporation (hereinafter called SMEC), an Australian consultant, in the course of the Basin Master Plan Study and the Prefeasibility Study of the Project.

For the Feasibility Study of the Project, further detailed hydrologic investigations and analysis as itemized below have been carried out.

(i) Collection and review of meteorological and hydrological data in and around the Sapt Gandaki River basin,

(ii) Check measurements of stream flow at the Gaging Station 450 (Narayangar) for the purpose of examining accuracy of the existing rating curve and establishing a new rating curve,

(iii) Determination of the long-term discharges at the proposed damsite using the above rating curve,

(iv) Estimation of the frequency and magnitude of the floods, and

(v) Estimation of the sediment load transported into the reservoir, grain size analysis of sediments and clarification of water quality of the Sapt Gandaki River for various uses such as hydropower, concrete mixing, drinking water and so on.

This ANNEX (C) presents the results of the mentioned hydrologic investigations and analysis.

II. METEOROLOGY

2.1 General

The climate of Nepal is much affected by the southeast monsoon during the wet season and the northwest monsoon during the dry season. The wet season lasts for four months from June to September, while the dry season is from November to April. May and October are transition period of these seasons. In general, it is humid and hot in the wet season or summer, while it is dry and cold in the dry season or winter. 60 to 80% of the yearly rainfall occurs in the wet season. This is due to the influence of the said southeast monsoon.

From the climatorological viewpoint, the Sapt Gandaki River basin can be devided into four zones in accordance with its altitude, namely Himarayan, Tibetan, Middle and Inner Terai zones. The Himarayan and Tibetan zones whose elevation is almost above 3,000 m with the peak over 8,000 m in the Great Himarayan Range is situated in the northern part of the basin. The high mountainous area exceeding around 6,000 m in elevation forms eternal glacier and snow cover, while the Tibetan mountainous area ranging between 3,000 and 6,000 m in elevation is characterized by the desert climate. In this zone, the vegetation is extremely poor, and it is apt to occur a large quantity of sediment transport to the project area in the wet season.

The Middle zone accounts for major part of the basin. Its elevation varies in a wide range from 600 to 3,000 m, and this zone is also subject to soil erosion due to the steep topography, deforestation resulting from development of new cultivated land in lowland area and even in the high mountainous area.

The Inner Terai zone situated in the south of the Mahabharat Range consists of low lands of around 200 m in elevation. The project site is located at the most northern part of this zone where the Sapt Gandaki River flows from north to south after its tributaries, Kali Gandaki and Trisulganga, traverse the Mahabharat Range and meet.

Due to the said variable topography, the climate of Nepal varies from subtropical in the Inner Terai zone to alpine in the Himarayan in accordance with their altitudes. Most of the Middle zone is characterized by the temperate climate.

2.2 Data Available

The meteorological records observed in Nepal has been compiled in "CLIMATOROLOGICAL RECORDS OF NEPAL" which was published by the Department of Irrigation, Hydrology and Meteorology (hereinafter called DIHM). The publication usually includes monthly rainfall, air temperature and humidity records. Among the meteorological records, those for the period from 1971 to 1975 were issued in three separate volumes, namely Volume I, II and III. Volume I consists of the records for monthly rainfall, air temperature and relative humidity observed for the five years. Volume III includes the data on monthly sunshine, wind, evaporation and soil temperatures at 16 climatorological stations for the period from 1967 to 1975. Volume II presents weather statistics in the Kathmandu area.

In addition to the above, the daily rainfall records in and around the Sapt Gandaki river basin were collected from the DIHM office during the field investigation period in Stage I and II of the Feasibility Study. DIHM is, at present, carrying out the compilation work for the meteorological records for the period from 1976 to 1980.

2.3 Air Temperature

The air temperature in the Sapt Gandaki River basin is much influenced by the southeast and northwest monsoon prevailing in the wet season and in the dry season, respectively.

The annual mean monthly air temperature observed at Mustang, Pokhara and Rampur stations for the period from 1966 to 1975 are listed below.

Annual Mean Monthly Air Temperature

Month	Name of Sta. (Sta. No.)		
	Mustang (0612)	Pokhara (0803)	Rampur (0902)
Jan.	-4.7	13.4	15.8
Feb.	-2.7	15.9	17.7
Mar.	1.6	20.3	22.8
Apr.	6.7	23.9	27.9
May	9.1	25.1	30.2
Jun.	12.5	25.4	29.0
Jul.	13.7	25.5	28.4
Aug.	13.2	25.4	28.3
Sept.	11.4	24.3	27.5
Oct.	8.8	21.5	25.2
Nov.	2.2	17.6	19.6
Dec.	3.5	14.2	15.9
Mean	6.2	21.0	24.0

The Mustang station is situated in the foothill of the Great Himarayan Range on the main stream of the Kali Gandaki River and its elevation is around 3,700 m so that it is considered to be influenced to some extent by the alpine climate of the Great Himarayan Range. The air temperature at the Mustang station is 6.2°C on the average and lowers below a freezing point during the period of January and February.

The Pokhara station is located in the said middle zone and its climate is comparatively temperate. The annual mean air temperature at the Pokhara station is 21°C. The records represent an air temperature in the Middle zone.

In the Rampur station, the subtropics is predominant. Its mean air temperature is 24°C. There is a difference of 24°C between the maximum and minimum of annual mean monthly air temperatures. In addition, there is a considerable difference between the daily maximum and minimum air temperatures in the dry season.

2.4 Relative Humidity

The relative humidity in the Sapt Gandari River basin is also subject to the influence of the southeast monsoon during the wet season and the northwest monsoon during the dry season. In general, the relative humidity is high in the wet season, compared with that in the dry season, and it becomes higher in nighttime than that in the daytime in the wet season.

The annual monthly mean relative humidities at the said three climatorological stations are shown in the following.

Annual Mean Monthly Relative Humidity

(Unit: %)

Month	Station (Period)		
	Mustang (1974 & 75)	Pokhara (1967 - 74)	Rampur (1967 - 75)
Jan.	61	67	82
Feb.	58	58	75
Mar.	57	50	60
Apr.	56	51	48
May	59	62	56
Jun.	64	78	76
Jul.	66	83	83
Aug.	66	83	84
Sept.	67	82	83
Oct.	60	75	82
Nov.	53	71	79
Dec.	55	70	82
Mean	60	69	74

As shown in the above table, the maximum and minimum of annual mean monthly relative humidities were observed in the wet season of June to September and in the dry season of November to April, respectively.

The annual mean relative humidity at the Rampur station is higher than those at other two stations due to the subtropical climate. The seasonal variation of relative humidity at the Mustang station is little compared with those at other two stations. This is due to less influence of southeast monsoon in the wet season.

2.5 Evaporation

The evaporation usually varies from day to day and from place to place under the influence of air temperature, relative humidity and rainfall, etc. In Nepal, the rate of evaporation for the period from March to October is high due to high air temperature, while that in the period from November to February is relatively low due to the northwest wind with low temperautre.

In Nepal, the evaporation is being observed at sixteen climatorological stations by means of Class A pan. The observation of evaporation is usually made daily at 8:40 in the morning.

The annual mean Class A pan evaporation amounts at these climatorological stations for the period from 1967 to 1975 are plotted against their altitudes as shwon in Fig.-C.1. These evaporation amounts range from 949 mm at the Jiri station in the minimum to 2,519 mm at the Dum Kauli station in the maximum. From the Figure, the evaporation appears to have a tendency that it decreases with increase of altitude.

In estimating the evaporation amount from the reservoir surface, 60 to 70% of Class A pan evaporation amount is adopted as the actual reservoir evaporation. For the purpose of computing the monthly evaporation amounts for the Sapt Gandaki reservoir, it is determined that 70% of annual monthly mean Pan A evaporation at the Pokhara station is adopted.

The monthly mean evaporation amount of the Sapt Gandaki reservoir so obtained are shown in the following.

Monthly Evaporation Record at Pokhara (0804)

(Unit: mm)

Month	Year 1972	1973	1974	1975	Daily Mean	Reservoir Evaporation
Jan.	-	65.1	74.4	-	2.3	49.9
Feb.	-	95.2	98.0	-	3.5	68.6
Mar.	-	130.2	167.4	173.6	5.1	110.7
Apr.	-	180.0	156.0	195.0	5.9	123.9
May	-	161.2	167.4	192.2	5.6	121.5
Jun.	-	141.0	-	174.0	5.3	111.3
Jul.	164.3	167.4	173.6	142.6	5.2	112.8
Aug.	136.4	173.6	167.4	186.0	5.4	117.2
Sept.	126.0	138.0	-	168.0	4.8	100.8
Oct.	120.9	127.1	-	120.9	4.0	86.8
Nov.	81.0	90.0	-	81.0	2.8	58.8
Dec.	68.2	68.2	-	68.2	2.2	47.7

2.6 Rainfall

In Nepal, the rainfall concentratedly occurs during the period of June to October owing to the influence of southeast monsoon, while the rainfall during the dry season from November to April is extremely little compared with that during the said period.

There are sixtyseven rainfall stations in and around the Sapt Gandaki River basin. The annual rainfalls recorded at these stations up to 1980 are listed in Table-C.1. Those annual mean rainfalls vary in a wide range from 257 mm at Jomsom station to 5,149 mm at Lumle station.

Among these rainfall stations, several have been abolished. On the other hand, as seen in the Table, there are many rainfall stations having the incomplete year of the rainfall record for the period from their established date to present. Sicne the project catchment area is measured to be 31,100 km^2 at the proposed damsite and there are twenty-nine rainfall stations in the basin, one station covers an area of more than 1,000 km^2 on the average. Taking into account the variable rainfall due to the complex topography in the basin, it can be said that the intensity of the rainfall stations in the basin is excessively low.

On the basis of the annual mean rainfalls at the said sixtyseven rainfall stations, the isohyetal map for the Sapt Gandaki River basin is established as shown in Fig.-C.2. In preparing the map, the annual rainfall in the high mountainous area of the Himarayan and Tibetan zones is determined taking into account the yearly isohyetal maps which are suggested in the said "CLIMATOROLOGICAL RECORDS OF NEPAL" as no rainfall data in the region are available.

The annual monthly mean rainfalls at the Pokhara, Jomsom and Rampur stations are tabulated below.

Annual Monthly Mean Rainfall

(Unit: mm)

Month	Station (Sta. No.)		
	Jomsom (601)	Pokhara (803)	Rampur (902)
	(1958 - 1980)	(1956 -1975)	(1967 - 1980)
Jan.	17.1	27.1	21.4
Feb.	13.8	31.2	14.5
Mar.	24.7	54.5	16.9
Apr.	18.6	87.5	41.1
May	9.6	246.9	109.2
Jun.	19.7	649.5	386.2
Jul.	39.6	886.0	526.6
Aug.	46.0	824.3	404.6
Sept.	31.8	575.7	330.7
Oct.	30.9	193.9	85.2
Nov.	6.2	19.3	8.0
Dec.	2.7	8.5	10.0
Annual	260.7	3,604.4	1,954.4

The above table indicates that around 90% of annual rainfall at the Rampur station occurs in the wet season from June to September due to the influence of southeast monsoon. The Rampur station which is located in the Inner Terai zone represents the climatorological features in the project area. In this zone, the subtropical climate is prevailing.

On the other hand, the annual rainfall amount at the Jomsom station is very little compared with those at the Pokhara and Rampur stations. This reveals that the Jomsom station which is located in the southern foothill of the Himarayan range on the Kaligandaki River is not so strongly influenced by the southeast monsoon as other two stations. As seen in Fig.-C.2, the annual mean rainfall in the Himarayan and Tibetan zone is considered to range between 200 and 1,000 mm.

The Pokhara station is situated in the Middle zone which forms major part of the Sapt Gandaki River basin. The seasonal rainfall pattern in this zone is relatively close to that in the Inner Terai zone. However, the annual mean rainfall in this region distributes in a wide range from 1,000 mm to 6,000 mm due to its variable topography.

In the Sapt Gandaki River basin, the maximum annual daily rainfall usually occurs in the period from July to October. On the basis of the available daily rainfall records up to 1980, the probable daily rainfalls at the above three stations are calculated assuming Gumbel's distribution as shown below.

Probable Daily Rainfall

(Unit: mm)

Recurrence Intervals in Years	Rainfall Station (Sta. No.)		
	Pokhara (601)	Rampur (803)	Jomsom (902)
5	211	183	54
10	242	217	68
50	310	292	100
100	338	323	114
200	367	355	127
1000	432	428	158

III. HYDROLOGY

3.1 General

The Sapt Gandaki River basin is blessed with rainfall by which the streamflow of the Sapt Gandaki river is feeded. On the other hand, snow cover in the high mountainous area which is located in the northern part of the basin contributes to yielding of runoff as the base flow. The snow melting which are affected by air temperature, humidity, wind and rainfalls, etc. occurs in a higher rate in the wet season than in the dry season.

In Nepal, the stream gaging stations were set up on almost all of the major streams. They are divided into two classes, namely partial and regular stream gaging stations. A gage stuff or water stage level recorder is installed at the regular stream gaging station and the stage height observation is continuously carried out by local inhabitants, usually two or three times a day in the dry season and more than three times a day in the wet season. The stage heights observed are converted into discharges using the stage height-discharge rating curve at DIHM office of Kathmandu. The discharge measurements at the regular stream gaging station are periodically made by the gaging staffs of DIHM in order to examine accuracy of the existing rating curve. On the other hand, the discharge measurements are limitedly made at the partial stream gaging station for the use in hydrological analysis.

In general, the major rivers of Nepal transport a large quantity of sediment during the wet season. As the above stream gaging stations are generally built on the alluvial deposit, the river floors are apt to vary after the large magnitude of flood flow. Accordingly, the stage height-discharge rating curves are required to be modified or newly established based on the results of the said periodical discharge measurements.

The monthly mean discharge records of major streams in Nepal up to 1974 which includes the maximum and minimum peak records were issued by the DIHM as "SURFACE WATER RECORDS OF NEPAL". The stage height records observed after 1975 are under processing to compile them in the publication.

3.2 Low Flow Analysis

3.2.1 Drainage System

The proposed project site is located on the Sapt Gandaki River around 1 km downstream from the confluence of the Kali Gandaki and Trisulganga rivers. Among these two main tributaries, the former drains a catchment area of around 11,000 km^2 which accounts for around 35% of catchment area of the project, 31,100 km^2. The Trisulganga river draining a catchment area of around 20,000 km^2 forms eastern part of the basin.

The Kali Gandaki River originates from the north of the Great Himarayan Range. In the upper reach, it generally flows from north to south and changes its course to the east after making a large loop at around 110 km downstream from the town Jomsom. Many tributaries including the Mayangdi, Modi and Andhi Rivers flow into the main stream until it combines with the Trisulganga River.

The longest course of the Trisulganga River which is called the Trisuli River originates from the Tibetan zone. The northern part of the Trisulganga River basin belongs to territory of China. The Trisuli River generally flows southwest and it meets many tributaries such as the Burhi Gandaki, Marsyangdi and Seti Rivers until it joins the Kali Gandaki River.

3.2.2 Streamflow at the Damsite

The regular stream gaging station 450 is located at around 0.9 km downstream from the project site. The water level observation was commenced in 1963 and the stage height records were converted into discharges for the period from 1963 to 1968 using the stage height-discharge rating curve established by HMG. The discharge records are summarized in the said "SURFACE WATER RECORDS OF NEPAL". Regarding the stage height records after 1969, however, no processing work was conducted.

Afterward, SMEC carried out the discharge measurements at the gaging station 450 for the period from July 21, 1972 to July 22, 1977 for the purpose of preparing the Prefeasibility Report. At that time, twentyfour discharge measurements were taken. In Fig.-C.3, the rating curves established by HMG and SMEC are illustrated. The results of the discharge measurements by SMEC were plotted in Fig.-C.4.

On the other hand, the JICA Team carried out the discharge measurements for the period of February to March and August to November in 1981 so as to examine accuracy of the existing rating curves. The measurements for low flow were concentratedly performed during the former period using a current meter, while the measurements for flood discharges were conducted during the latter period using floats in collaboration with counterpart personnel provided by HMG. The results of discharge measurements are shown in Table-C.2.

Based on the discharge measurements carried out by the JICA Team, it was found that the rating curve established by SMEC generally coincided with the measurements by JICA in the low flow discharges but excessively large estimate of discharge was made in the high flows. Thus, it was considered that both the rating curves prepared by SMEC and DIHM were required to be modified accordingly.

A new rating curve was established based on the discharge measurement results as shown in Fig.-C.4. In establishing the new rating curve, some of measurements by SMEC were incorporated.

Followings were considered for the application of the rating curves for converting into the stream flow;

As the Sapt Gandaki River causes much sedimentation by flood, there is a possibility that the riverbed topography changes by a large flood. The rating curve is also considered to be changed accordingly. DIHM carried out the discharge measurement and checking of the rating curve up to April 1967. Thus, DIHM's rating curve was considered right and should be applied during the period. From July 1972, SMEC carried out the discharge measurement and established a new rating curve which is considerably different from the DIHM's one and nearly same as in low flow the new one established at this time though there is some difference in the high flow portion. Such being the case, it may be reasonable to consider that the change of the rating curve to be applied occurred during the period of May 1967 to July 1972 while any discharge measurement and checking of the rating curve was not carried out. Thus, the application of the rating curves for conversion from the river water level into the stream flow was made on the assumption that the change of the rating curve from the DIHM's one to the newly established one occurred at the middle of the period of May 1967 to July 1972, i.e., DIHM's stream flow data which were derived applying the DIHM's rating curve, were used up to June 1970 and after then, the stream flow was derived by the application of the newly established rating curve.

The daily mean discharges so obtained for the period from 1963 to 1980 are compiled in the end of this ANNEX (C). The monthly mean discharges are summarized in Table-C.3. In addition, annual mean monthly discharges for the period are shown in Fig.-C.5 and in the following.

(Unit: m^3/sec)

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mean	376	303	283	373	572	1,548	3,576	4,231	2,967	1,578	795	520

The annual mean discharges of the Sapt Gandaki River at the damsite is calculated to be 1,436 m^3/sec. As shown in the above Table, around 85% of the annual runoff occurs in the wet and transition seasons from May to October.

3.2.3 Verification of Reliability of Runoff Data

As the density of rainfall stations in the basin is too low to accurately estimate the runoff coefficient and rainfall data in the Himarayan and Tibetan zones are hardly available, the reliability of the runoff data at the Gaging Station 450 is examined by double mass curve method and comparing specific runoff at the Gaging Station 450 with those at other gaging stations in the basin.

(1) Double mass curve

In order to examine consistency of the runoff records at the Gaging Station 450, the accumulated annual mean runoff at the Station is compared with that at the Gaging Station 420 on the Kali Gandaki River which covers a catchment area of 11,400 km^2. To represent the correlation between those, the double mass curve for the period of 1964 to 1978 is established as shown in Fig.-C.6.

Since the relation between those is given by a straight line in the Figure, it can be said that the runoff records at the Gaging Station 450 is well correlated with those at the Gaging Station 420 and that these records are consistent. In addition to the above, high correlation of these runoff data is indicated in Fig.-C.5 and Fig.-C.7 showing annual mean monthly runoffs and relation of monthly mean discharges at these gaging stations, respectively.

Fig.-C.6 also shows a well correlation between the runoff records at the damsite and those at Gaging Station 680 which is located on the Sapt Kosi River basin, being adjacent to the Sapt Gandaki River basin in the east and at which a catchment area is measured to be around 18,000 km^2.

(2) Specific runoff

The annual mean specific runoff at the project site is estimated at 4.52 $m^3/sec/100\ km^2$ based on the runoff data for the period from 1964 to 1980. On the other hand, the annual mean specific runoff at five stream flow gaging stations in the Sapt Gandaki basin are shown in the following.

No. of G.S.	Name of River	Available Period of Runoff Data	Annual Mean Specific Runoff ($m^3/sec/100\ km^2$)
420	Kali Gandaki	1964 - 1977	4.30
430	Seti	1964 - 1978	8.88
439.8	Marsyangdi	1974 - 1979	5.57
445	Burhi Gandaki	1964 - 1978	3.62
447	Trisuli	1967 - 1974	4.22

The above table shows that the specific runoffs of the tributaries of the Sapt Gandaki River range so widely from 3.62 to 8.88. The value of 4.52 m^3/sec/100 km^2 of the Gaging Station 450 is considered to be reasonable in comparison with specific runoff of 4.30 m^3/sec/100 km^2 of the Gaging Station 420. Though the specific runoff at Gaging Station 420 is slightly less than that at Gaging Station 450, this results from the small rainfall amount in the upper reach of the Kali Gandaki River as seen in Fig.-C.2. Thus, the runoff records at the Sapt Gandaki damsite are judged to be reasonable.

3.2.4 Frequency of Low Flow

Since the project is planned to be of run-of-river scheme, the frequency of low flow discharges has a significant effect on the dependability of the power plants. As shown in Table-C.3, the daily mean discharge records at the damsite are incomplete for the nine years of 1963, 1971, 1972, 1974 to 1978 and 1980. For the purpose of establishing the discharge duration curve at the damsite, the daily discharges in the wet season are simply generated by applying discharge records at the Gaging Station 420 and a catchment ratio of Gaging Station 450 to Gaging Station 420. The discharge records for the period of 14 years exclusive of those in 1971, 1972 and 1976 became available for the purpose of examining the frequency of the low flow at the damsite. The discharge duration curve at the damsite is illustrated as shown in Fig.-C.8 and the daily discharges for selected exceedance probability are as follows.

	Percentage of time when daily discharge is exceeded									
	10	20	30	40	50	60	70	80	90	100
Discharge (m^3/sec.)	3,890	2,730	1,620	982	684	523	424	343	290	150

3.3 Flood Analysis

3.3.1 General Feature of Flood Frequency of the Basin

In the Hydrology Report for the Basin Master Plan Study prepared by SMEC in 1979, it was stated that the log-normal distribution is well fit for the flood records in the Sapt Gandaki River basin. This hydrologic characteristic was confirmed by examining distribution of annual maximum peak discharges observed at each gaging station in the basin.

Table-C.5 shows the annual maximum peak discharges observed at the Gaging Station 420 (on the Kali Gandaki River), 430 (on the Seti River), 445 (on the Burhi Gandaki River) and 447 (on the Trisuli River) which are major tributaries of the Sapt Gandaki River. These peak discharge records were plotted on log-normal paper for each gaging station as shown in Fig.-C.9. From the Figure, it can be said that the log-normal distribution shows a good fit for the flood records in the basin as a whole.

On the other hand, a skewness of the samples was calculated for each of the above gaging stations as shown in Table-C.5. The skewnesses of samples in the basin are less than 1.1935 which is given as that of Gumbel's extreme distribution. This means that the curve derived from the sample is skewed to the left with increase of discharge on the Gumbel's paper. Thus, it is considered that an application of log-normal or Gumbel's distribution rather than log extreme value distribution is suitable for frequency analysis for flood records in the basin.

3.3.2 Flood Frequency Analysis

The annual maximum peak discharges at the Gaging Station 450 for the period from 1963 to 1981 are shown in Table-C.6. As seen in the Table, the annual maximum peak discharges range approximately between 6,000 and 16,500 m^3/sec, and it is noted that they mostly occurred for the period from the beginning of July to the end of September in the wet season.

The flood frequency analysis was made using the log-normal, Gumbel's and Iwai's method as shown in the following table.

Estimated Peak Discharge

(Unit: m^3/sec)

Recurrence Interval in Year	Log Normal	Gumbel's	Iwai's
2	9,100	9,000	8,700
5	10,900	11,300	10,400
10	12,100	12,900	11,500
20	13,100	14,400	12,400
50	14,300	16,300	13,500
100	15,200	17,800	14,400
200	16,100	19,200	15,200
1,000	18,000	22,600	16,900
10,000	20,700	27,400	19,400

As shown in the above table, the peak discharges estimated by the Gumbel's method are larger than those by the other methods for recurrence intervals of more than 5 years. Taking into consideration uncertainties involved in the extreme huge catchment area of 31,100 km^2, it is recommended to adopt the results by the Gumbel's method for the purpose of project planning and design.

In order to check the reliability of the above result of the flood frequency analysis, the estimated peak discharges for the Gaging Station 450 are compared with those for Gaging Station 420 on the Kali Gandaki River and unusual floods in the whole Nepal by using the following Creager's formula.

$$Q = 46CA^b$$

$$b = 0.89A^{-0.048} - 1$$

where, Q: flood peak in second-feet

A: catchment area in square miles

C: Coefficient

The frequency analysis for the Gaging Station 420 was made for the annual maximum water levels for the period from 1964 to 1977 using the Gumbel's method. The results are shown in Table-C.7. The above

Creager's C corresponding to the peak discharges estimated by Gumbel's method for the Gaging Station 420 and 450 are tabulated below.

Recurrence Interval in Year	Creager's C	
	Gaging Station 420 (C.A. = 11,400 km^2)	Gaging Station 450 (C.A. = 31,100 km^2)
200	62	71
10,000	94	100

As shown in the above table, the values of Creager's C for the 200 year and 10,000 year flood for the Gaging Station 450 resulted in generally same as those for the Gaging Station 420. The value of C is considered to depend on the characteristics of the drainage basin such as rainfall intensity, topography and so on. Therefore, taking into account the similarity of both basins, the results of the frequency analysis for the Gaging Station 450 are judged to be reasonable.

In Fig.-C.11, the recorded maximum peak discharges at the respective gaging stations in Nepal are plotted against their catchment areas using the said C value. The highest C value, as shown in the Figure, is derived to be 66. Accordingly, the 10,000 year flood of 27,400 m^3/sec at the damsite which corresponds to C = 100 has a considerable allowance for the recorded unusual floods in Nepal. Furthermore, it is generally accepted that the value of C = 100 gives the largest peak flood at any part of the world.

From the above hydrological viewpoints, it is recommended that the spillway has a capacity of discharging the estimated 10,000 year flood at the damsite with an allowance to some extent.

IV. SEDIMENTATION STUDY AND WATER QUALITY

4.1 Sedimentation Study

4.1.1 General

The rivers of Nepal generally transport high sediment load due to the highly deforested land, steep slope and high intensity of rainfall during the wet season. On the other hand, the characteristic appears to be comparatively remarkable in the rivers which originates from the Tibetan zone. The Sapt Gandaki River water seems to be very clear in the dry season, while it becomes muddy in the wet season due to a large quantity of sediment transports from the basin. It is observed that the sediment rate of the Kali Gandaki River is higher than that of the Trisuli River.

The sedimentaion studies were made for the whole Sapt Gandaki basin based on the data on the suspended load at Gaging Station 450 which were carried out by DIHM for the period from 1975 to 1978. In addition to those, the suspended sediment data collected by the JICA Team during the field investigation period, as shown in Table-C.8, were incorporated in assessing the sedimentation of the Sapt Gandaki River basin.

As the Sapt Gandaki project is planned to be developed as a run-of-river scheme, the studies are focused on estimate of time when the reservoir below the spillway crest level is filled up with the sediment.

4.1.2 Estimate of Long-term Suspended Load Transport

The ultimate objective of sedimentation study is to estimate the sediment rate of the basin based on the relationship between daily mean discharge and sediment load concentration. The sediment load consists of suspended and bed loads. In general, it is not possible to accurately measure the bed load in the natural river. In addition, any data on bed load are not available in Nepal. Accordingly, the rate of bed load transport is simply assumed to be 15% of that of the suspended one.

On the basis of the said data on the suspended load at the Gaging Station 450, the concentrations are plotted against discharges as shown in Fig.-C.12. It reveals that the values of the suspended load concentration scatter in a wide range. From the figure, it appears that the sediment yield in low flow season is influenced by other factors than the magnitude of runoff discharge and that concerning flood season there is comparatively a large difference of the suspended load concentration between rising and descending time of the flood.

On the basis of the results of the suspended load measurements, the relationship between daily mean discharge and suspended load transport is established as shown in the following.

$$Qs = 7.53408 \times 10^{-4} \times Q^{2.54267}$$

where Q and Qs are daily mean discharge in m^3/sec and suspended load transport in ton/day, respectively. As the exponent of the above expression generally ranges between 2.0 and 3.0 in the rivers of Nepal, it is judged to be adequate.

The long term suspended transports at the damsite are estimated using the daily mean runoff records at the Gaging Station 450. The monthly suspended load transports for the period from 1964 to 1980 are shown in Table-C.9. As seen in the Table, more than 90% of annual suspended load transport occurs in the wet season of June to September.

4.1.3 Reservoir sedimentation

For the purpose of converting the unit of sediment load from weight into volume, a density of sediment material is assumed to be 1.4 ton/m^3. By adding the bed load, the annual mean sediment yield of the Sapt Gandaki basin is estimate to be around 88 x 10^6 m^3/year as shown below.

Annual Monthly Mean Sediment Yield

(Unit: 10^3 m^3)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
76	39	36	78	244	3,646	26,356	35,791	15,990	4,877	498	168	87,799

The specific sediment transport of the Sapt Gandaki River basin expressed in m^3/km^2/year is determined to be 2,800 which is slightly smaller than a 3,000 m^3/km^2/year recommended in the SMEC's Prefeasibility Report.

In case of developing the Project as a storage type, the Sapt Gandaki reservoir needs to have a dead storage capacity of more than 9 x 10^9 m^3 which is equivalent to the 100 year sediment transport volume. Since it is not possible to raise up the dam crest to such a level taking into consideration of topography at the damsite, the project is proposed as a run-of-river scheme. Hence, the sediment inflow into the reservoir is required to be discharged downstream through the spillway gates after it is filled with the sediment.

In order to estimate the time when the reservoir below the spillway crest level is to be filled with sediment, it is necessary to determine the trap efficiency of the reservoir. The trap efficiency is considered to be a function of the ratio of gross reservoir storage capacity to annual inflow discharge volume. Usually, the trap efficiency becomes small if annual inflow volume is large compared with gross storage capacity. Since the ratio for the Project is calculated around 0.07, the value of trap efficiency is estimated to range between 20% and 50% based on data obtained by surveying the existing reservoirs in U.S.A. On the other hand, the flood discharge in wet season during which a large sediment transport occurs is planned to be mostly discharged downstream through the spillway gate without retarding. Accordingly, as the trap efficiency is considered to be very low as a whole, 30% is adopted as the trap efficiency for the Project.

With this trap efficiency, the annual sedimentation in the reservoir will be about 26 x 10^6 m^3 and the reservoir below the spillway crest, which capacity is about 130 x 10^6 m^3, will be filled up with sediment in several years.

4.1.4 Grain Size of Sediments

The grain size analysis of the sediments is made as shown in Table-C.10. As seen in the Table, the grain size of the sediments at the proposed damsite is very fine. It seems such fine particles will not be so harmful for the turbine blades.

4.2 Quality of the River Water

The laboratory tests for water quality analysis were carried out in order to examine the content of various chemical elements of the River water. The water samples were taken at the Gaging Station 450 not only in the dry season, but also in the wet season. These chemical analysis were made in DIHM laboratory of Kathmandu. The results of water quality analysis are tabulated in Table-C.11.

As shown in the Table, the River water is usable for drinking water and irrigation purposes and it also has no adverse effect on turbine and metal for hydropower use. The content of calcium for the River water is high compared with those of other elements. This shows that some of upstream area consists of limestone.

TABLES

Table-C.1: ANNUAL RAINFALL IN AND AROUND THE BASIN

C.1(1)

No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Name of sta.	Rukumkot	Shera Gaun	Libang Gaun	Bijuwar Tar	Musikot	Jomsom	Thakmarpha	Baglung	Tatopani	Lete	Mukutinath	Beni Bazar	Kushma
Sta. No.	0501	0502	0504	0505	0514	0601	0604	0605	0606	0607	0608	0609	0614
Elevation (El.m)	1,560	2,152	1,270	832	2,100	2,744	2,566	984	1,243	2,384	3,609	835	
Year 1957												1,332.7	
1958	1,933.3	1,124.0	1,132.5			259.6						1,401.5	
1959	1,839.8	1,103.6	1,317.3			252.0						1,331.8	
1960	1,634.9	1,358.5	974.2			327.0						1,316.4	
1961	3,395.3	1,539.1	2,319.7			317.3						1,634.6	
1962	3,268.9	1,533.6	1,294.7			244.1						1,322.9	
1963	4,748.3	1,604.0	1,295.4			346.7						1,532.7	
1964	3,171.0	1,381.4	892.7			284.7						1,567.8	
1965	1,645.3	1,171.3	755.1			284.8						1,164.7	
1966	1,956.4	1,302.4	725.2			157.3						1,440.8	
1967	2,384.6	981.5	942.3			141.3						1,044.2	
1968	3,504.6	1,275.6	1,058.9			347.0						1,406.2	
1969	-	1,386.1	1,064.8			324.2						1,314.0	
1970	4,729.8	1,444.5	-	1,292.7	-	189.3	499.4	2,354.8	1,321.7	821.8	-	1,448.2	1,920.5
1971	3,119.3	-	-	1,216.5	-	-	370.0	1,695.8	1,445.8	1,053.0	177.8	-	1,524.8
1972	6,922.0	-	-	892.7	-	-	398.4	1,033.2	1,199.5	1,202.0	432.8	-	1,790.5
1973	-	1,457.1	-	1,753.8	-	450.7	392.0	-	1,445.5	1,005.8	450.8	1,796.5	2,202.0
1974	-	1,293.6	1,515.3	897.9	1,339.4	301.4	264.8	1,901.6	-	1,062.4	412.7	1,306.5	2,420.0
1975	-	1,345.8	1,704.2	1,479.6	1,899.2	259.9	329.2	1,885.3	-	1,080.0	372.0	1,766.2	2,658.8
1976	-	1,334.4	-	836.8	1,668.0	214.7	253.2	1,689.0	1,605.5	1,015.7	341.5	1,432.8	-
1977	-	1,351.8	-	912.2	1,331.5	91.2	361.5	1,678.5	1,907.2	1,060.1	327.9	1,436.0	-
1978	1,346.5	1,725.6	1,925.9	1,531.1	1,489.0	64.0	-	1,463.2	1,143.1	1,084.1	936.2	1,252.8	-
1979	-	1,357.8	2,635.2	1,373.5	-	-	-	1,650.7	1,336.3	961.6	303.7	1,212.4	-
1980	-	1,580.0	1,852.7	1,415.3	2,538.2	-	475.3	2,148.2	1,626.2	1,167.9	472.6	1,430.2	-
Mean	3,040.0	1,364.4	1,376.8	1,236.6	1,710.9	256.7	371.8	1,750.0	1,447.9	1,046.8	422.8	1,404.5	2,086.1

- To be continued -

No.	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Name of sta.	Ridi Bazar	Tansen	Butwal	Beluwa	Dumkali	RAMBAS	Kirtipur Churi	Musikot	Jagat Setibas	Khudi Bazar	Pokhara Hosp.	Pokhara Airp.	Syanja	Kuncha
Sta. No.	0701	0702	0703	0704	0706	0713	0714	0722	0801	0802	0803	0804	0805	0807
Elevation (El.m)	442	1,067	205	150	154		842	1,280	1,334	823	918	845	860	855
Year 1957	1,003.8	1,415.0	2,678.4					1,658.4			3,215.9			1,805.6
1958	1,112.3	1,487.0	2,333.8	1,856.3				1,989.0	1,475.5	3,325.1	3,920.7			2,113.6
1959	1,568.7	2,219.7	2,328.7	2,362.5				2,050.5	1,519.5	3,398.1	3,268.8			2,758.8
1960	1,458.5	1,661.6	2,391.7	1,532.0				2,010.8	1,401.5	2,787.0	3,131.1			2,757.8
1961	1,727.5	2,009.5	1,966.3	2,352.3				551.5	1,518.3	3,579.8	3,936.3			2,398.6
1962	1,512.9	1,916.8	2,791.8	3,168.1				1,391.7	1,373.8	3,256.9	4,004.4			3,143.3
1963	1,144.4	1,611.8	2,239.0	2,924.4				1,815.7	1,328.3	3,382.3	3,233.5			2,089.8
1964	1,143.2	1,211.0	2,733.7	2,612.9				577.7	1,013.2	3,064.1	3,515.4			2,077.4
1965	1,019.4	1,400.8	2,374.5	2,151.9				1,440.2	1,287.9	3,237.4	3,312.9			2,349.5
1966	1,021.2	1,004.2	2,963.1	2,686.2				1,428.8	835.4	3,201.8	3,245.9			1,941.9
1967	1,046.3	1,007.0	2,140.4	2,079.8				1,312.9	1,003.1	3,392.2	3,332.6			2,098.3
1968	1,302.8	1,479.2	2,176.0	2,453.8				1,818.1	1,002.0	2,936.1	3,609.1			2,081.9
1969	1,251.0	1,042.2	1,895.8	2,052.4				1,544.1	1,284.6	2,484.7	2,752.8			1,821.6
1970	1,516.6	1,951.8	3,693.1	2,703.2	-	2,817.9	-	1,742.3	1,354.8	3,510.9	3,877.3	3,731.6	-	2,057.8
1971	1,547.6	951.7	3,245.0	2,595.5	2,604.2	1,952.1	3,811.2	1,666.2	-	3,441.2	4,063.0	3,275.6	-	2,629.4
1972	1,021.2	-	2,104.0	1,753.7	-	-	2,929.1	1,398.7	1,559.5	3,146.7	3,270.7	3,208.5	-	2,871.5
1973	2,271.0	-	3,128.7	2,781.1	-	-	-	2,819.4	1,649.6	3,738.2	4,072.6	4,096.4	3,357.7	3,648.1
1974	1,036.6	-	2,807.5	3,212.6	-	-	-	1,861.7	1,288.8	3,560.7	4,641.6	4,605.0	3,458.3	3,294.9
1975	1,895.6	-	3,240.8	2,903.3	2,264.3	-	-	1,952.5	1,909.3	3,453.9	4,388.5	4,666.0	3,828.4	2,922.0
1976	980.8	-	-	2,178.8	1,927.0	-	-	2,106.9	1,453.6	3,145.7	-	4,249.9	3,102.3	2,674.3
1977	1,241.2	993.0	-	1,815.6	1,715.8	-	-	2,060.8	1,629.2	3,381.4	-	3,810.0	-	2,433.0
1978	1,870.1	1,523.1	-	2,420.1	2,555.3	-	-	2,657.5	1,605.6	2,829.8	-	3,960.0	3,103.4	2,973.1
1979	1,167.5	1,167.6	-	1,869.5	1,929.5	-	-	1,786.1	1,331.3	3,343.2	-	4,010.7	2,936.9	3,095.6
1980	1,583.6	1,809.3	-	2,271.8	1,893.3	-	-	1,966.6	1,239.9	3,059.7	-	3,843.0	2,880.5	2,303.2
Mean	1,351.8	1,466.4	2,591.2	2,379.9	2,127.1	2,385.0	3,370.2	1,733.7	1,366.6	3,245.9	3,620.7	3,950.6	3,238.2	2,514.2

- To be continued -

No.	28	29	30	31	32	33	34	35	36	37	38	39	40
Name of sta.	Bandipur	Gorkha	Chapkot	Malepatan	Lumle	Khairani	Chame	Rampur	Jhawani	Chisapani Gadhi	Daman	Hetauda(N.F.I.)	Amlekhganj
Sta. No.	0808	0809	0810	0811	0814	0815	0816	0902	0903	0904	0905	0906	0907
Elevation (El.m)	965	1,097	400	856	1,642	500	2,680	256	270	1,706	2,314	474	359
Year 1956													2,399.1
1957	1,312.4	1,731.0											1,485.2
1958	1,390.2	1,585.7	1,439.0						1,283.0	1,449.8			2,324.3
1959	1,511.0	1,720.0	1,828.3						1,478.3	1,878.3			2,161.0
1960	1,924.2	-	2,494.0						1,830.6	1,873.4			1,910.5
1961	2,341.8	-	3,267.2						1,978.8	2,545.9			2,060.4
1962	2,514.4	-	3,271.0						2,458.7	2,340.9			2,555.8
1963	1,838.7	-	1,167.6						1,300.0	1,815.1			2,099.9
1964	1,866.8	1,606.5	1,271.0						1,854.0	1,382.3			2,057.4
1965	1,852.9	1,972.9	1,474.1						1,838.9	2,640.0			2,412.1
1966	1,765.0	1,494.2	1,237.3						1,916.9	2,457.0			2,543.4
1967	1,601.0	1,537.5	1,187.1	3,364.2	-	-	-	-	1,247.7	2,095.9	-	2,575.0	2,298.0
1968	1,927.2	1,594.7	1,651.2	-	-	-	-	1,953.6	1,616.4	2,187.8	1,251.8	2,275.1	-
1969	1,219.6	1,362.1	1,098.7	3,770.2	-	-	-	1,376.3	1,656.3	1,560.9	1,427.5	-	1,892.3
1970	2,385.3	1,467.3	1,462.2	3,960.1	5,610.6	-	-	1,943.6	1,512.3	2,514.3	1,259.2	-	1,581.6
1971	1,942.0	1,969.6	1,405.6	3,106.8	5,963.5	-	-	2,202.5	2,771.5	2,267.6	1,716.7	-	3,275.0
1972	2,139.0	1,940.5	1,632.8	-	5,368.4	2,516.5	-	1,648.3	1,445.6	2,510.3	2,084.0	1,601.8	1,584.7
1973	1,963.7	-	2,401.2	4,258.4	5,757.0	1,965.0	-	2,341.0	1,865.5	2,719.2	2,426.6	2,709.3	2,445.1
1974	2,170.4	1,939.1	1,832.6	-	-	2,202.9	-	2,532.4	2,297.9	2,889.8	2,308.1	2,397.4	2,440.4
1975	1,794.8	1,794.3	2,644.8	-	5,355.6	-	751.3	2,314.0	2,023.4	2,676.2	2,159.9	2,525.9	3,017.5
1976	1,373.1	2,312.0	-	-	4,713.1	-	665.4	1,824.8	1,560.3	2,173.1	1,929.4	2,359.9	1,972.5
1977	1,599.5	1,333.7	1,578.7	3,832.4	4,863.1	2,433.6	862.2	1,725.9	1,571.1	1,815.1	1,528.5	1,947.6	1,583.0
1978	1,908.8	2,288.4	1,894.7	3,499.1	4,951.9	2,622.5	667.7	2,287.8	2,058.5	2,544.4	2,311.2	2,431.8	1,985.1
1979	1,766.4	1,826.8	1,480.6	3,619.9	3,946.1	2,405.9	-	1,825.3	2,323.1	1,806.3	1,854.8	1,788.5	2,117.7
1980	1,794.4	1,522.8	1,981.3	3,501.3	4,959.7	1,965.9	1,461.2	1,584.0	1,740.1	1,560.5	1,111.6	-	1,757.2
Mean	1,829.3	1,736.8	1,804.6	3,656.9	5,148.9	2,301.8	881.6	1,966.1	1,810.0	2,161.0	1,797.6	2,261.2	2,165.0

- To be contineud -

No.	41	42	43	44	45	46	47	48	49	50	51	52	53
Name of sta.	Parvanipur	Bhartpur	Chitlang	Hetauda	Birganj	Makavampur	Beluwa	Timule	Aru Ghat	Nuvakot	Dhading	Kakani	Navalpur
Sta. No.	0911	0914	0915	0917	0918	0919	0920	1001	1002	1004	1005	1007	1008
Elevation (El.m)	115	223	1,530	466	91	1,030	274	1.900	518	1,003	1,420	2,064	1,592
Year 1957										1,759.8			
1958								1,017.6	2,331.4	-	1,303.4		
1959								961.4	2,286.4	1,839.0	2,018.4		
1960								968.1	1,328.2	1,650.0	2,846.8		2,220.1
1961								1,091.6	3,019.5	-	4,013.6		2,307.1
1962								1,089.0	3,042.2	2,116.1	4,182.9		2,720.6
1963								1,001.5	2,767.0	-	3,605.3		2,256.4
1964								1,007.5	1,916.1	1,727.0	1,615.0		2,639.2
1965								915.3	2,615.7	-	1,999.4		2,115.6
1966								956.6	2,008.4	-	2,043.0		1,946.6
1967	865.2							991.6	1,653.5	-	1,534.6		2,389.7
1968	881.9							1,069.1	1,791.9	1,187.8	1,526.0		2,475.0
1969	1,060.3							1,045.9	2,056.2	1,431.0	1,690.4		2,011.7
1970	1,760.4							879.7	2,759.3	1,952.4	2,021.1		2,242.9
1971	1,352.3	2,993.5						-	2,921.0	1,873.4	2,194.0		2,942.5
1972	893.4	-	1,473.7					758.8	3,133.5	1,702.6	1,930.4		1,950.9
1973	1,851.3	-	1,865.0					885.7	3,942.5	2,015.2	2,507.9		2,585.6
1974	1,939.5	-	1,829.0	2,591.0				660.4	3,252.9	2,065.0	2,013.2		2,424.4
1975	1,716.8	-	1,865.1	2,673.3	988.0	3,178.6	2,687.2	890.7	2,626.6	2,076.2	2,044.7		2,682.2
1976	1,026.8	-	1,706.4	1,963.7	907.4	2,689.0	2,264.2	256.5	2,987.2	1,741.8	2,269.5	2,652.4	2,857.5
1977	1,146.6	-	1,370.3	2,097.5	934.0	2,220.4	2,133.6	986.4	3,048.8	2,033.5	2,098.2	2,393.2	2,392.0
1978	1,809.2	-	2,960.3	2,613.9	1,276.9	2,970.4	2,737.7	1,122.6	3,060.5	2,541.6	2,301.4	3,239.6	3,008.7
1979	1,549.8	-	1,079.0	2,004.9	1,388.2	1,624.9	2,189.3	760.9	2,366.8	1,603.2	1,555.6	1,734.1	2,114.3
1980	1,161.0	-	1,095.8	1,569.2	1,036.8	919.7	2,440.0	1,345.8	2,557.2	1,732.7	1,915.3	2,842.1	2,357.6
Mean	1,358.2	2,993.5	1,693.8	2,216.2	1,088.6	2,268.7	2,408.7	939.2	2,585.8	1,836.0	2,227.4	2,572.3	2,411.5

- To be continued -

	54	55	56	57	58	59	60	61	62	63	64	65	66	67
Name of sta.	Chautra	Sundarijar Powerhouse	Sundarijar Reservoir	Kathmandu	Thankot	Sarmathang	Baunepati	Ranipauwa	Godavari	Kathmandu Airport	Thamachit	Dhunche	Tarke Ghyang	Changu Narayan
Sta. No.	1009	1012	1013	1014	1015	1016	1018	1019	1022	1030	1054	1055	1058	1059
Elevation (El.m)	1,660	1,364	1,576	1,324	1,630	2,625	845	1,828	1,400	1,336	1,847	1,982	2,480	1,543
Year 1941			2,525.1											
1942			2,808.9											
1943			3,010.0	1,009.6										
1944			2,425.1	1,185.7										
1945			2,909.3	1,585.6										
1946			3,259.9	1,395.6										
1947			-	-										
1948	2,154.1	2,755.0	3,125.6	1,793.4										
1949	2,151.5	2,445.9	2,478.2	1,368.9										
1950	2,131.9	2,406.6	1,439.4	1,536.1										
1951	1,847.9	2,037.6	1,692.3	1,224.4										
1952	-	1,967.5	2,302.4	1,280.4										
1953	-	2,007.1	2,224.9	1,363.6					1,764.4					
1954	-	2,525.4	2,553.4	1,593.7					2,083.6					
1955	1,918.8	-	-	1,130.6					2,063.9					
1956	3,061.9	2,455.8	2,309.0	1,776.4					2,393.9					
1957	1,540.7	1,641.3	1,512.4	1,000.7					1,397.9					
1958	1,664.9	-	-	1,134.3					1,455.7					
1959	2,023.1	2,062.7	1,994.5	1,195.3					1,633.0					
1960	980.0	1,393.0	1,691.7	1,201.5					1,766.2					
1961	2,048.4	1,674.5	1,947.4	1,704.7					-					
1962	2,330.4	2,482.8	2,366.7	1,261.5					2,337.2					
1963	1,853.7	2,111.8	2,263.1	1,313.5					-					
1964	2,143.1	1,762.2	1,904.1	1,384.8					-					
1965	1,648.6	1,450.2	1,649.3	1,333.2					-					
1966	-	1,655.8	1,728.8	1,223.8					-					
1967	-	1,992.0	2,061.7	1,348.6					-					
1968	2,049.5	-	2,445.1	1,539.2				2,748.0	-					
1969	-	-	1,929.0	1,131.2	1,189.0			2,624.0	-					
1970	-	-	2,267.8	1,439.9	1,589.6				-	1,362.3				
1971	-	-	2,382.5	1,601.0	1,811.0		2,066.6	-	1,992.8	1,511.3				
1972	2,994.4	-	1,779.2	1,509.5	1,851.6		1,604.9	-	1,927.2	1,261.4	1,196.0	1,681.5		
1973	2,994.4	-	-	1,969.2	2,632.6	2,353.3	1,920.2	-	2,430.4	1,799.8	1,497.6	1,820.0		
1974	1,491.1	-	2,007.1	1,135.5	2,206.6	3,470.3	1,360.9	-	-	1,225.1	1,498.0	1,712.6	2,434.7	
1975	1,519.9	-	2,540.8	1,526.7	2,091.8	3,856.6	1,691.2	-	-	1,424.5	1,668.3	2,090.6	772.1	1,644.5
1976	1,810.6	-	2,333.0	-	2,643.2	4,799.2	1,642.7	-	-	1,490.6	-	1,910.2	1,118.6	1,795.2
1977	1,958.0	-	-	-	2,287.6	3,535.5	1,480.8	-	-	1,297.3	2,524.0	1,661.5	584.8	-
1978	3,150.4	-	-	-	2,911.1	4,976.0	2,253.7	-	-	1,556.0	1,919.0	2,215.2	2,667.3	2,043.6
1979	1,723.2	-	-	-	2,576.8	4,012.4	1,483.2	-	-	1,356.4	913.0	2,432.7	849.6	1,144.4
1980	2,242.1	-	-	-	2,216.3	4,422.0	1,582.0	-	-	1,340.9	1,924.0	2,636.5	-	1,259.7
Mean	2,018.3	2,108.9	2,245.9	1,381.2	2,167.3	3,928.2	1,708.6	2,686.3	1,937.2	1,398.8	1,642.5	2,107.9	1,404.5	1,577.5

Table-C.2: RESULTS OF DISCHARGE MEASUREMENTS

Observed Date	Stage Height (m)	Observed Discharge (m^3/sec)
February 27, 1981	0.54	242
February 28, 1981	0.55	230
March 1, 1981	0.60	257
March 7, 1981	0.57	254
March 10, 1981	0.51	221
March 16, 1981	0.47	185
March 18, 1981	0.55	248
March 19, 1981	0.52	205
March 22, 1981	0.88	286
August 16, 1981	4.92	3,427
August 17, 1981	4.95	3,534
August 18, 1981	4.76	3,189
August 19, 1981	5.64	4,250
August 20, 1981	6.37	6,269
September 7, 1981	4.30	2,913
September 8, 1981	4.44	2,610
September 9, 1981	4.77	3,476
September 11, 1981	5.71	5,285
September 15, 1981	4.04	2,711
September 16, 1981	4.00	2,688
September 29, 1981	8.52	11,159
October 18, 1981	2.57	1,190
October 19, 1981	2.55	1,153
October 20, 1981	2.53	1,115
November 1, 1981	2.11	880
November 2, 1981	2.08	850
November 3, 1981	2.07	849
November 4, 1981	2.15	922
November 14, 1981	1.84	694
November 15, 1981	1.82	611
November 16, 1981	1.78	702

Table-C.3: MONTHLY MEAN DISCHARGES AT GAGING STATION 450 ON THE SAPT GANDAKI RIVER (NARAYANGAHR)

(Unit: m^3/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
1963	-	-	-	-	-	1,656	3,781	5,165	-	-	-	-	-
1964	452	377	310	412	444	1,180	4,061	4,451	3,510	1,764	987	638	1,561
1965	472	323	268	470	642	1,524	3,133	4,606	2,816	1,312	953	592	1,435
1966	387	313	245	285	615	1,328	3,490	5,325	3,379	1,322	852	583	1,521
1967	431	328	309	422	578	1,402	3,795	4,059	2,985	1,385	806	541	1,429
1968	407	308	320	366	637	1,920	4,471	4,176	3,147	2,822	1,043	670	1,699
1969	495	380	368	399	591	1,307	3,117	4,083	3,721	1,513	851	542	1,455
1970	378	278	236	372	588	1,828	4,382	4,412	2,175	1,213	606	371	1,414
1971	269	214	204	319	489	-	3,551	4,046	2,309	1,546	-	-	-
1972	-	-	233	239	542	1,165	-	3,408	2,388	1,086	656	-	-
1973	303	244	259	360	607	1,816	2,512	3,919	3,372	2,843	939	553	1,486
1974	416	327	288	379	502	1,020	3,388	-	-	-	781	540	-
1975	454	398	338	421	619	2,518	-	3,662	4,072	1,629	871	575	-
1976	-	-	374	396	347	1,891	2,465	3,298	2,625	-	-	-	-
1977	228	261	317	505	664	1,312	3,754	-	-	-	675	446	-
1978	374	304	313	431	976	2,110	4,742	4,690	2,527	1,426	702	435	1,598
1979	310	266	217	289	441	902	3,011	4,168	2,085	1,060	577	405	1,153
1980	278	225	223	286	446	1,452	-	-	3,340	1,172	629	390	-
Mean	376	303	283	373	572	1,548	3,576	4,231	2,967	1,578	795	520	1,436

Table-C.4: MONTHLY MEAN RUNOFF AT GAGING STATION 420 ON THE KALI GANDAKI RIVER
(C.A. = 11,400 km^2)

(Unit: m^3/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
1964	144	122	89.2	98.2	116	281	1,361	1,831	1,625	771	379	219	589
1965	146	155	86.1	118	129	481	1,180	1,742	1,092	525	356	225	513
1966	170	142	116	103	175	484	1,258	1,936	1,256	503	311	201	558
1967	131	94.3	76.9	101	138	459	1,212	1,433	1,123	489	236	137	472
1968	94.3	66.7	64.0	70.5	128	590	1,671	1,757	1,256	1,107	321	194	614
1969	143	107	98.2	92.8	133	304	850	1,148	1,190	448	231	126	408
1970	88.5	65.7	48.9	71.7	114	657	1,607	1,718	906	495	256	154	519
1971	105	73.9	75.0	128	213	764	1,133	1,461	848	573	274	153	486
1972	104	81.5	70.0	63.6	108	282	1,158	1,075	893	307	176	102	370
1973	75.2	59.3	58.7	76.0	143	496	914	1,452	1,469	1,394	334	192	550
1974	144	112	98.9	116	159	245	1,124	1,640	785	343	175	109	424
1975	84.9	66.6	57.4	71.7	108	397	1,761	1,477	1,382	512	225	143	528
1976	110	91.3	75.9	80.4	126	360	945	1,072	966	399	237	148	376
1977	112	89.0	76.2	102	142	251	1,006	1,857	917	413	249	158	451
Mean	118.0	91.9	78.0	92.4	138.0	432.2	1,222.0	1,542.8	1,122.0	591.4	268.6	161.5	491.6

Table-C.5: ANNUAL MAXIMUM PEAK DISCHARGES OF MAJOR TRIBUTARIES OF THE SAPT GANDAKI RIVER

(Unit: m^3/sec)

Year	GAGING STATION				
	No.	420	430	445	447
	River of Name	Kali Gandaki	Seti	Burhi Gandaki	Trisuli
	Catchment Area (km^2)	11,400	582	4,270	4,110
1964		3,730	346	650	-
1965		5,150	236	693	-
1966		3,210	268	735	-
1967		2,490	221	823	650
1968		6,720	599	570	605
1969		2,300	258	500	605
1970		5,650	500	528	690
1971		2,600	258	452	726
1972		3,730	433	574	850
1973		5,880	536	700	1,270
1974		4,480	555	805	1,170
1975		7,400	372	590	-
1976		2,820	420	494	-
1977		5,700	425	546	-
1978		-	218	518	-
Skewness		0.278	0.256	0.492	0.855

Table-C.6: ANNUAL MAXIMUM PEAK DISCHARGES AT THE DAMSITE

Date	Peak Discharges (m^3/sec)	Date	Peak Discharges (m^3/sec)
Aug. 8, 1963	7,970	Sep. 12, 1973	8,620
Aug. 4, 1964	8,400	Aug. 5, 1974	16,350
Aug. 12, 1965	7,940	Jul. 23, 1975	11,450
Aug. 24, 1966	9,480	Aug. 24, 1976	6,690
Jul. 10, 1967	8,790	Aug. 14, 1977	9,990
Oct. 5, 1968	10,160	Aug. 12, 1978	7,920
Jul. 26, 1969	6,160	Aug. 21, 1979	9,480
Jul. 16, 1970	9,230	Sep. 6, 1980	9,350
Aug. 8, 1971	7,030	Sep. 29, 1981	11,900
Jul. 28, 1972	9,990		

Table-C.7: RESULTS OF FREQUENCY ANALYSIS FOR ANNUAL MAXIMUM PEAK DISCHARGES OBSERVED AT GAGING STATION 420

Recurrence Interval in Year	Estimated Peak Discharges (m^3/sec)		
	Log Normal	Gumbel's	Iwai's
2	4,100	4,200	4,100
5	5,700	6,000	5,700
10	6,800	7,200	6,800
20	7,800	8,300	7,800
50	9,100	9,800	9,200
100	10,200	11,000	10,300
200	11,200	12,100	11,400
1,000	13,700	14,600	13,900
10,000	17,500	18,300	18,600

Table-C.8: RESULTS OF SUSPENDED LOAD MEASUREMENTS

Ovserved Date	Observed Streamflow (m^3/sec)	Suspended Load (mg/ℓ)
March 5, 1981	210	29
March 6, 1981	213	27
March 7, 1981	215	31
March 8, 1981	229	35
March 9, 1981	232	681
March 10, 1981	210	207
August 20, 1981	5,352	2,503
August 25, 1981	4,384	1,340
August 28, 1981	3,257	2,098
September 12, 1981	3,361	2,483
September 14, 1981	2,423	2,302
September 15, 1981	2,347	3,743
September 16, 1981	2,474	2,787
September 30, 1981	4,573	7,186
October 18, 1981	933	2,209
October 20, 1981	910	760

Table-C.9: LONG-TERM SUSPENDED LOAD AT THE DAMSITE

(Unit: 10^3 ton)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1964	135.6	78.5	50.8	105.5	137.3	2,496.3	43,118.2	47,483.7	25,747.7	4,493.1	982.5	320.5	
1965	149.9	51.7	35.4	158.3	336.1	3,921.2	19,764.9	53,039.6	15,015.2	2,068.5	909.9	265.6	
1966	93.0	49.1	28.5	44.2	314.1	2,744.3	27,002.3	74,275.3	27,367.6	2,124.8	652.8	255.7	
1967	120.2	53.3	51.7	129.2	262.3	2,707.7	34,273.2	35,845.5	15,937.3	2,493.7	568.9	212.5	
1968	102.1	47.8	57.8	78.2	327.3	6,994.6	52,333.5	38,217.8	18,620.0	24,356.1	1,111.6	365.4	
1969	169.0	77.6	81.2	100.5	305.6	2,041.8	20,646.1	36,986.8	28,062.9	3,165.2	661.1	214.6	
1970	84.3	35.0	25.8	112.6	277.5	9,423.8	54,457.1	49,963.9	7,226.3	1,822.4	291.6	81.5	
1971	35.7	17.8	17.0	58.4	168.0	-	26,723.7	38,765.8	9,377.3	3,182.2	-	-	
1972	-	-	24.9	25.7	298.3	2,847.0	-	26,372.7	11,652.0	1,558.8	448.8	-	
1973	48.0	25.3	32.6	78.4	325.6	7,313.1	13,225.7	36,925.6	26,174.2	28,427.6	863.5	226.4	
1974	107.7	52.4	42.4	87.1	177.9	1,390.7	32,058.8	-	-	-	536.8	212.1	
1975	135.8	86.4	63.6	118.1	309.2	-	-	42,003.8	43,128.5	3,787.5	698.8	245.8	
1976	-	-	82.4	92.8	88.7	8,269.7	13,153.9	22,641.8	13,969.6	-	-	-	
1977	23.8	35.3	54.6	211.8	420.8	2,360.5	31,428.2	-	-	-	383.1	129.6	
1978	90.7	43.7	52.8	125.9	1,019.1	8,456.7	57,031.1	62,941.3	10,857.1	2,765.4	426.4	123.9	
1979	51.1	31.3	20.6	42.8	149.6	1,339.2	23,978.6	44,541.4	8,725.2	1,248.2	245.1	108.4	
1980	39.2	21.0	22.2	47.7	134.5	4,265.9	-	-	30,126.9	1,635.2	306.7	93.3	
Mean	92.4	47.1	43.8	95.1	297.2	4,438.2	32,085.4	43,571.8	19,465.5	5,937.8	605.8	204.0	106,884.1

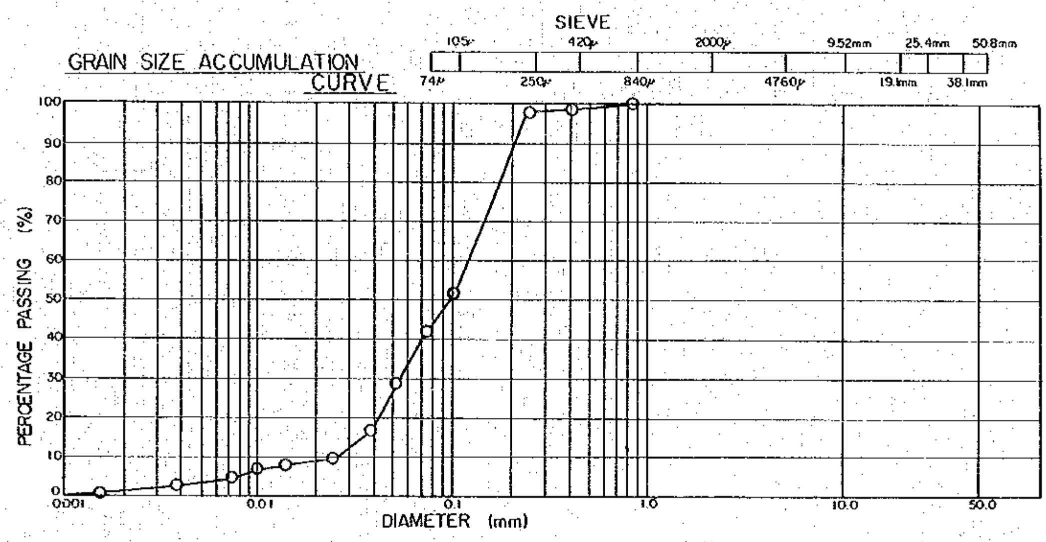
Table-C.10: RESULT OF GRAIN SIZE ANALYSIS FOR SEDIMENTS

PARTICLE SIZE & WEIGHT PERCENTAGE OF PARTICLES UNDER THE SIZE

SPECIFIC GRAVITY Gs 2.732

SIEVE	GRAIN SIZE (mm)	50.8	38.1	25.4	19.1	9.52	4.76	2.00	0.84	0.42	0.25	0.105	0.074
SIEVE	TOTAL PASSING(%)								100	99.8	98.3	51.9	42.0
HYDROMETER	GRAIN SIZE (mm)	0.0527	0.0386	0.0249	0.0144	0.0102	0.0073	0.0037	0.0015				
HYDROMETER	TOTAL PASSING(%)	29.1	17.3	10.2	8.2	7.4	5.4	3.1	0.7				

GRAIN SIZE ACCUMULATION CURVE



※ CLAY	SILT	SAND	GRAVEL
0.001	0.005	0.074	2.0

※ COLLOID

PROPORTION				
4.76mm <	0 %	MAXMUM DIAMETER	0.84 mm
4.76~2.00mm	0 %	60% DIAMETER	0.12 mm
2.00~0.42mm	0 %	30% DIAMETER	0.055 mm
0.42~0.074mm	58 %	10% DIAMETER	0.024 mm
0.074~0.005mm	38 %	COEFFICIENT OF UNIFORMITY	5.0
0.005mm >	4 %	COEFFICIENT OF CURVATURE	1.1

Table-C.11: RESULTS OF WATER QUALITY ANALYSIS

Chemical Element	Dry Season Sample No. 1	Dry Season Sample No. 2	Dry Season Mean	Wet Season Sample No. 1	2	3	4	5	6	Wet Season Mean
1. Cation										
Ca	32	31	32	23	24	24	24	24	27	24
Mg	10	11	11	4	8	5	6	7	11	7
Na + K	3	3	3	6	–	–	5	5	–	5
2. Anion										
CO_3	112	104	108	90	88	80	96	90	120	94
SO_4	20	34	27	6	16	5	6	18	–	10
CI	10	10	10	4	4	6	7	6	9	6
3. PH	7.9	7.9	7.9	8.1	8.1	8.0	–	8.2	8.2	8.1

FIGURES

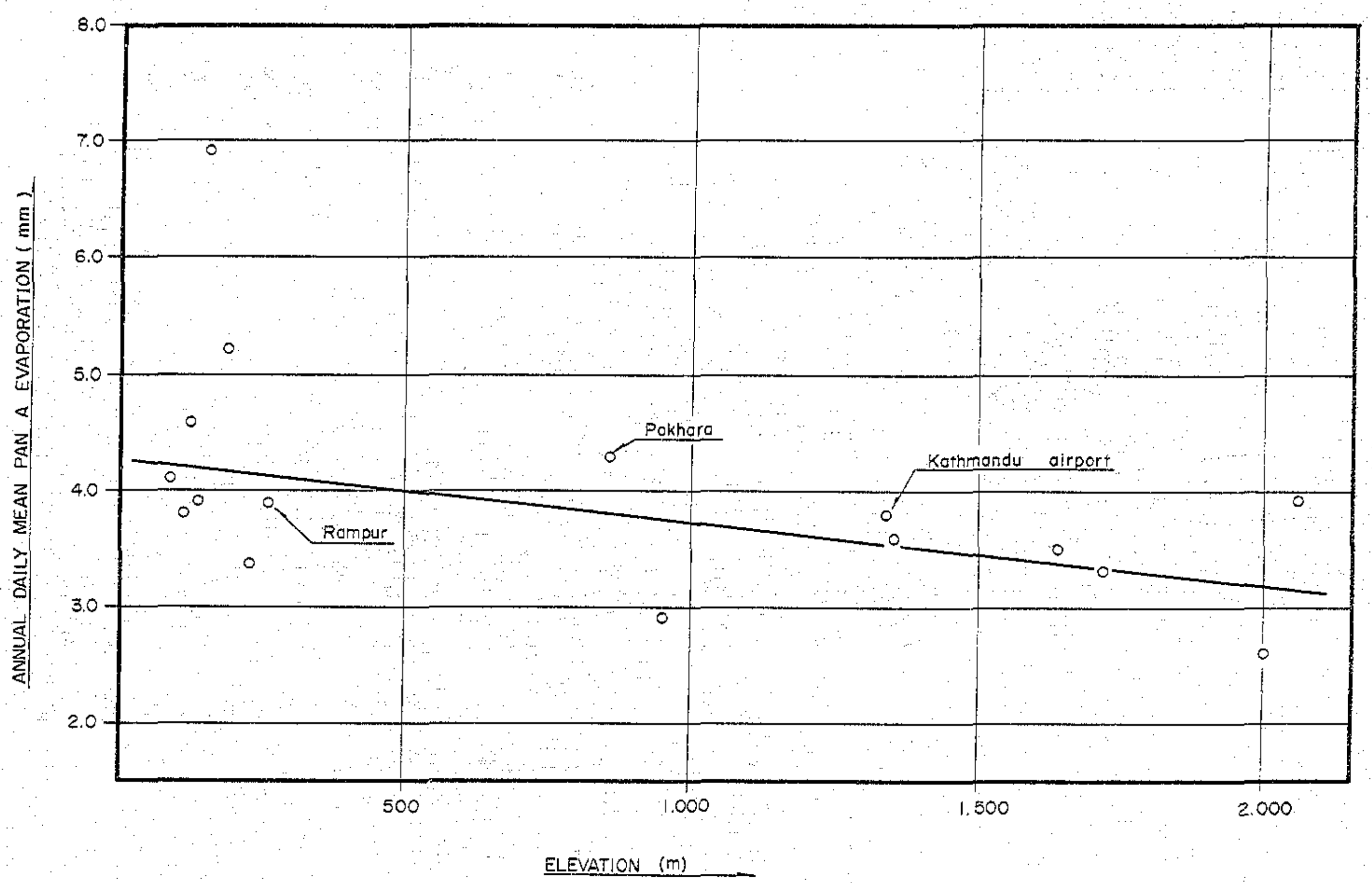


FIG- C.1 : RELATION BETWEEN ALTITUDE AND PAN A EVAPORATION

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT
JAPAN INTERNATIONAL COOPERATION AGENCY

FIG- C.1

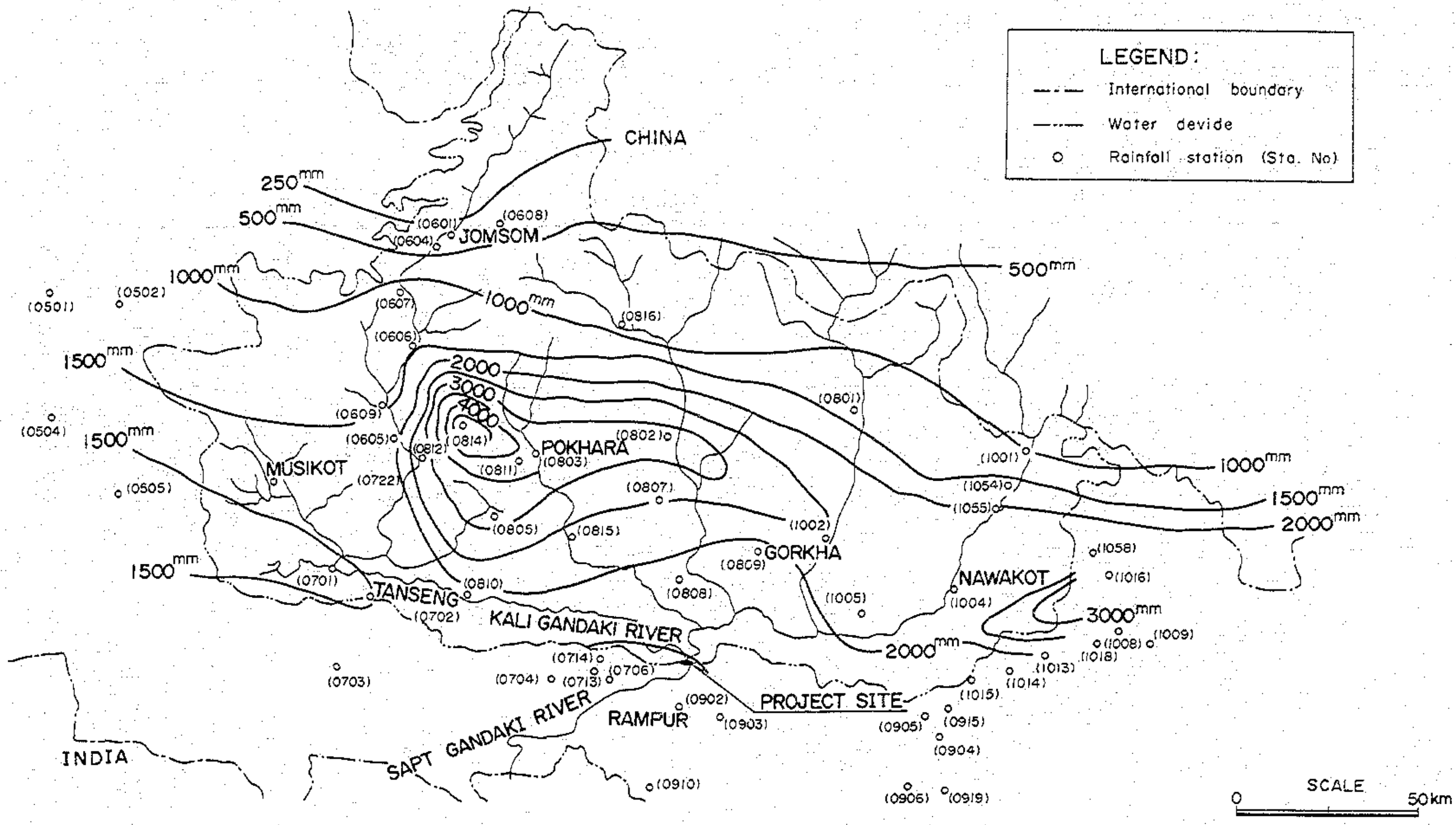


FIG- C.2 : ISOHYETAL MAP

HIS MAJESTY'S GOVERNMENT OF NEPAL SAPT GANDAKI HYDROELECTRIC POWER DEVELOPMENT PROJECT FEASIBILITY REPORT
JAPAN INTERNATIONAL COOPERATION AGENCY

FIG- C.2

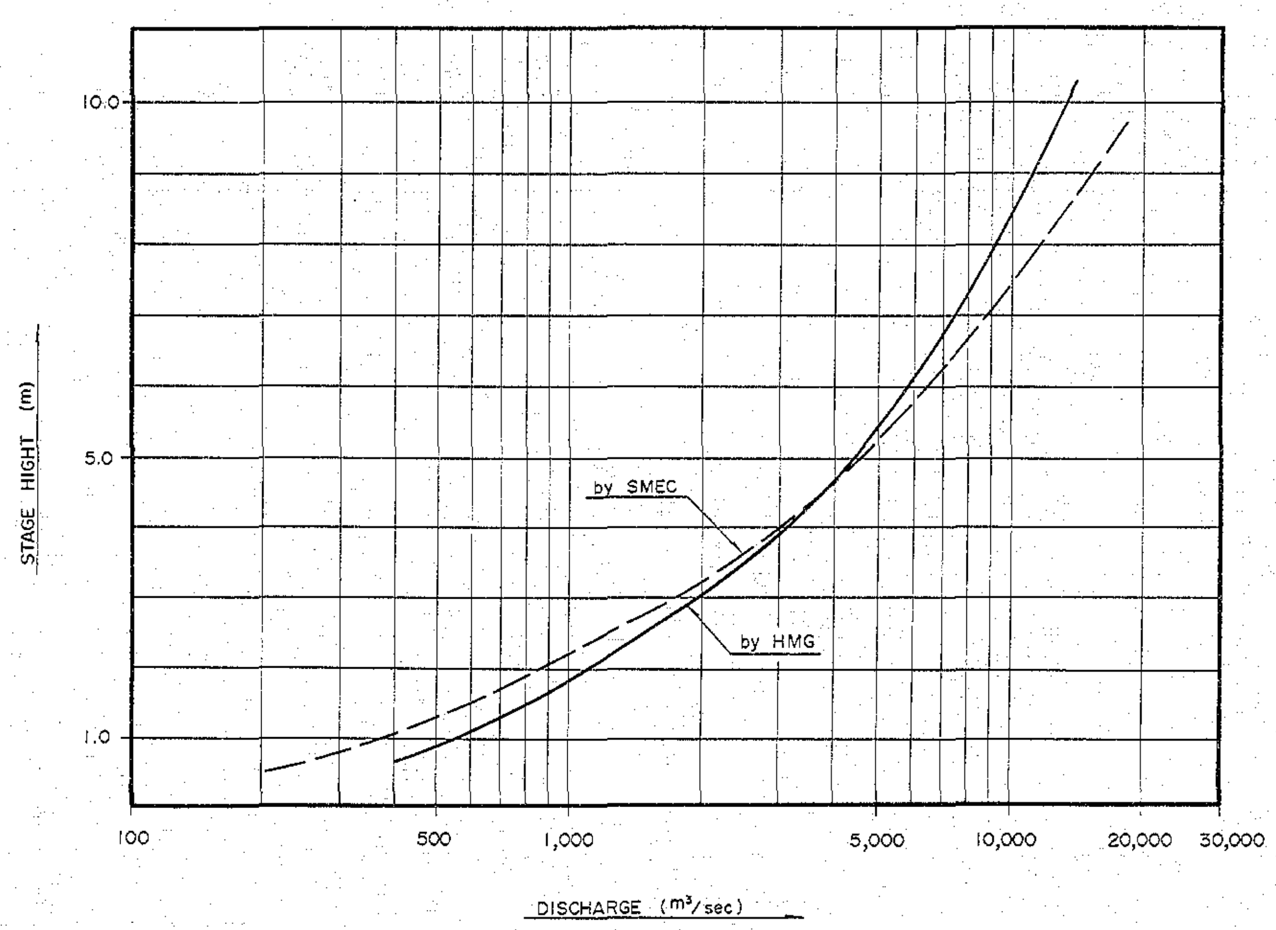


FIG- C.3 : DISCHARGE RATING CURVE AT GAGING STATION 450 (ESTABLISHED BY HMG & SMEC)

HIS MAJESTY'S GOVERNMENT OF NEPAL SAPT GANDAKI HYDROELECTRIC POWER DEVELOPMENT PROJECT FEASIBILITY REPORT	FIG- C.3
JAPAN INTERNATIONAL COOPERATION AGENCY	

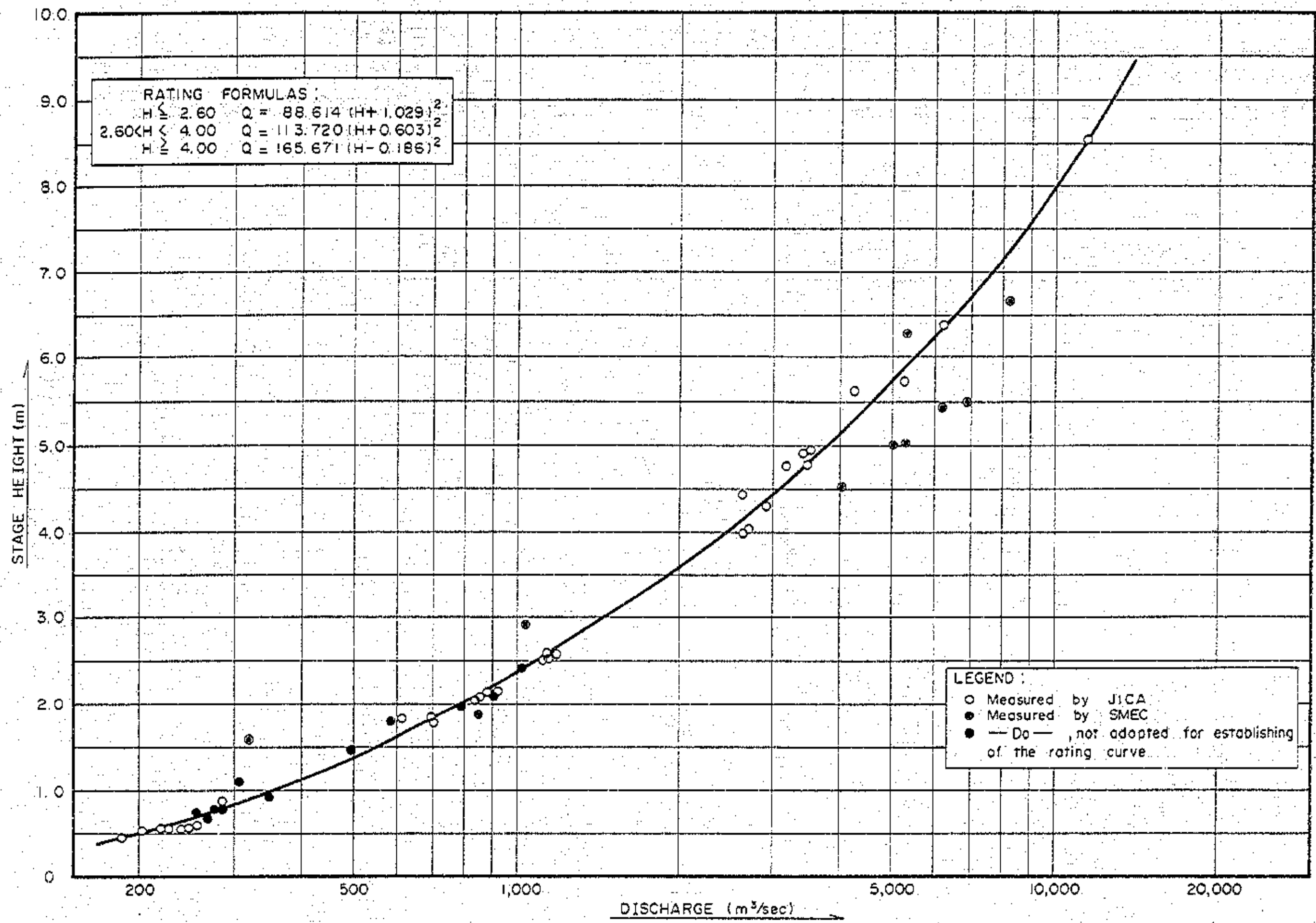


FIG- C.4 : DISCHARGE RATING CURVE AT GAGING STATION 450

HIS MAJESTY'S GOVERNMENT OF NEPAL SAPT GANDAKI HYDROELECTRIC POWER DEVELOPMENT PROJECT FEASIBILITY REPORT	FIG- C.4
JAPAN INTERNATIONAL COOPERATION AGENCY	

FIG- C.5

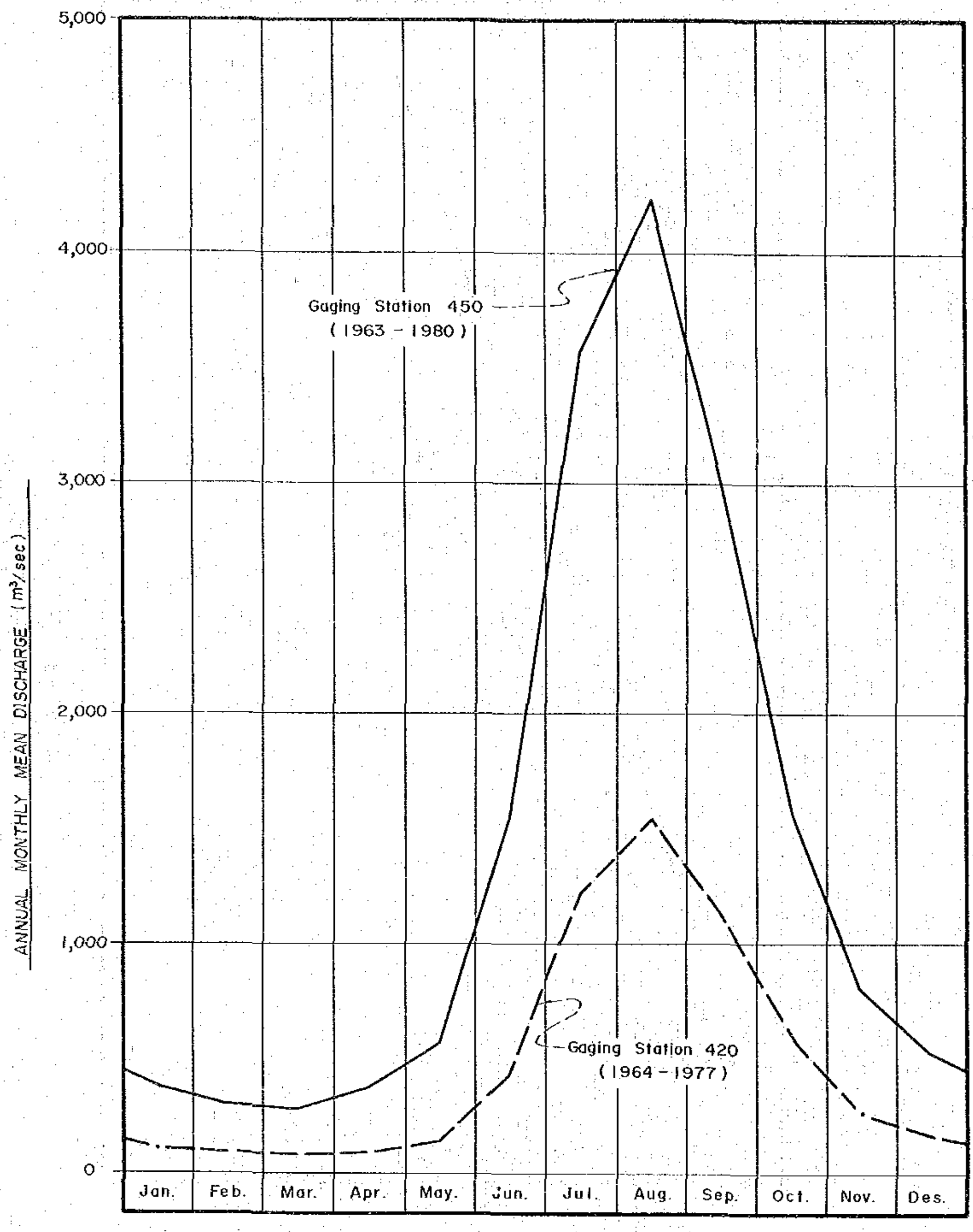


FIG- C.5 : ANNUAL MONTHLY MEAN DISCHARGES AT GAGING STATION 420 AND 450

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT

JAPAN INTERNATIONAL COOPERATION AGENCY

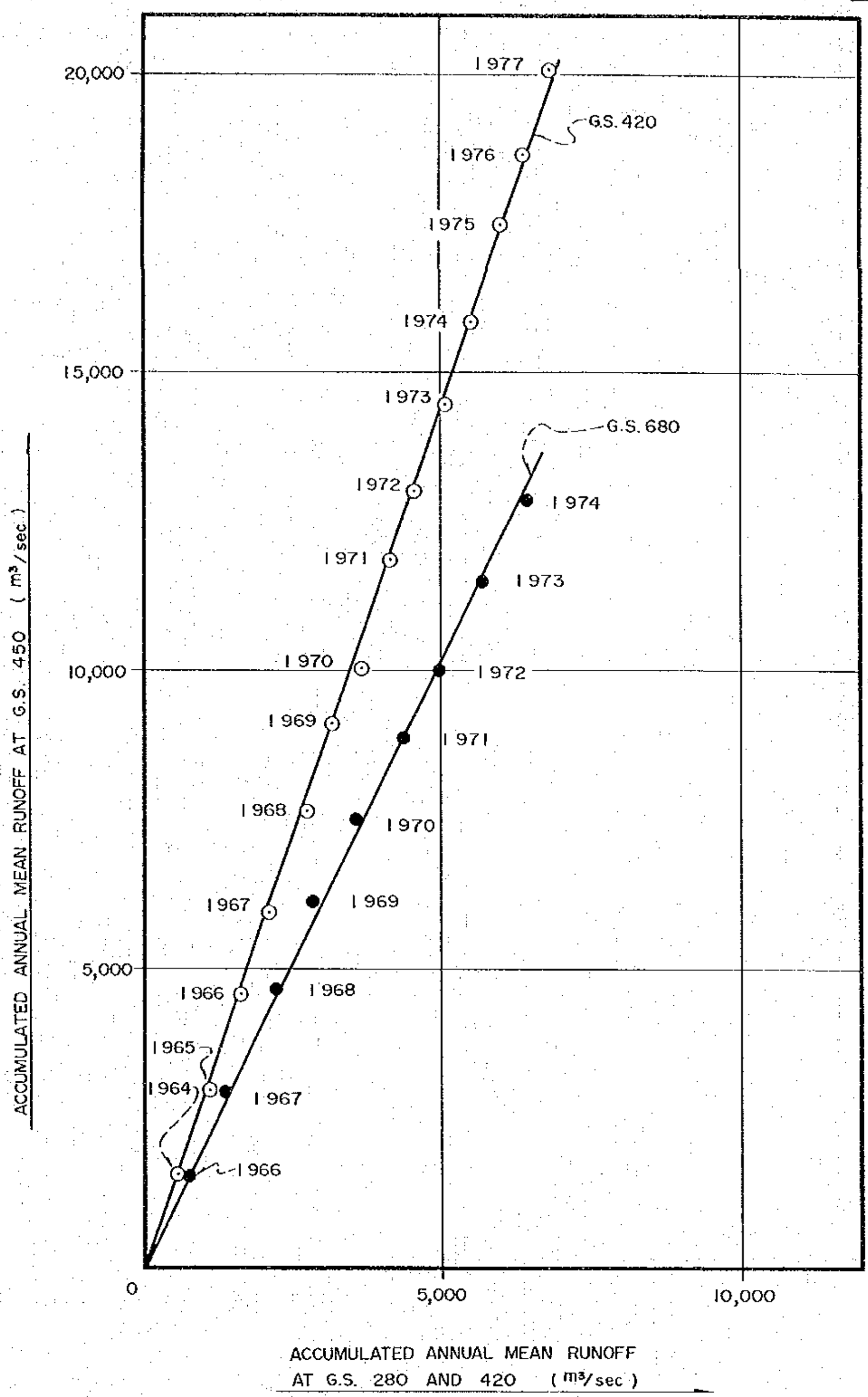


FIG- C.6 : DOUBLE MASS CURVE

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT
JAPAN INTERNATIONAL COOPERATION AGENCY

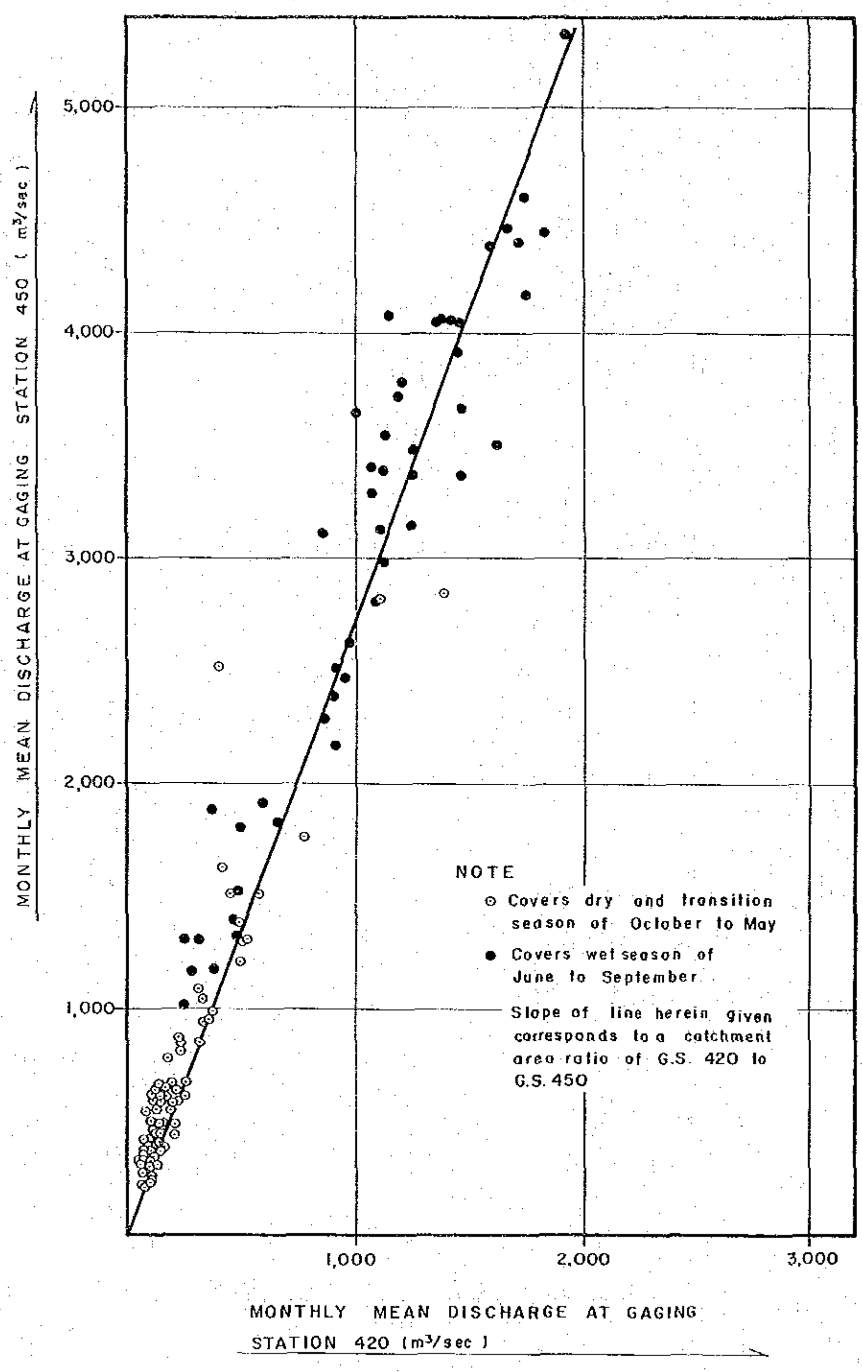


FIG- C.7 : RELATION BETWEEN MONTHLY MEAN DISCHARGES AT GAGING STATION 420 AND 450

HIS MAJESTY'S GOVERNMENT OF NEPAL SAPT GANDAKI HYDROELECTRIC POWER DEVELOPMENT PROJECT FEASIBILITY REPORT
JAPAN INTERNATIONAL COOPERATION AGENCY

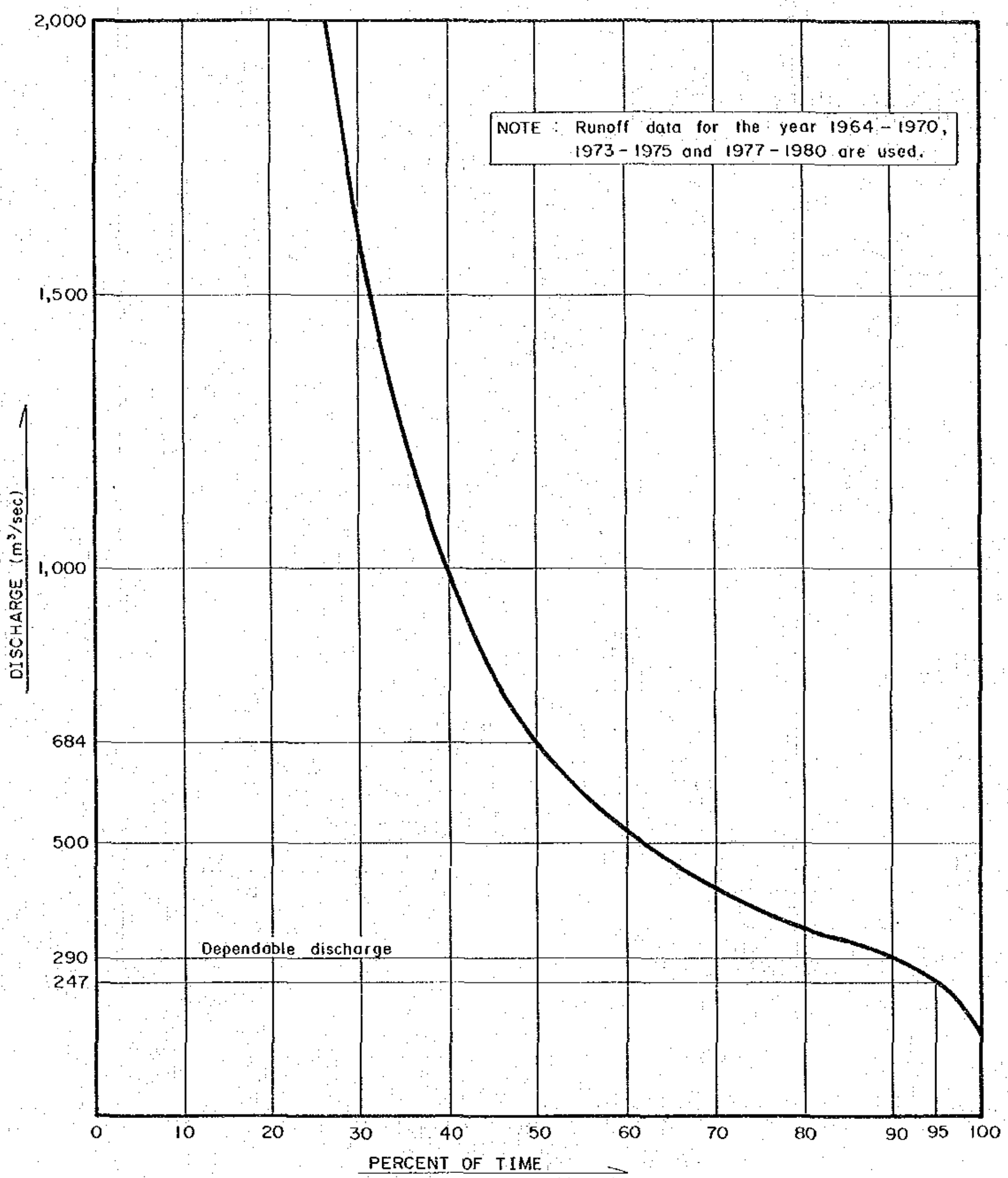


FIG- C.8 : FLOW DURATION CURVE AT THE DAMSITE

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT
JAPAN INTERNATIONAL COOPERATION AGENCY