HIS MAJESTY'S GOVERNMENT OF NEPAL

FEASIBILITY REPORT ON SAPT GANDAKI HYDROELECTRIC POWER DEVELOPMENT PROJECT

VOL. II

ANNEX

JANUARY 1983

JAPAN INTERNATIONAL COOPERATION AGENCY

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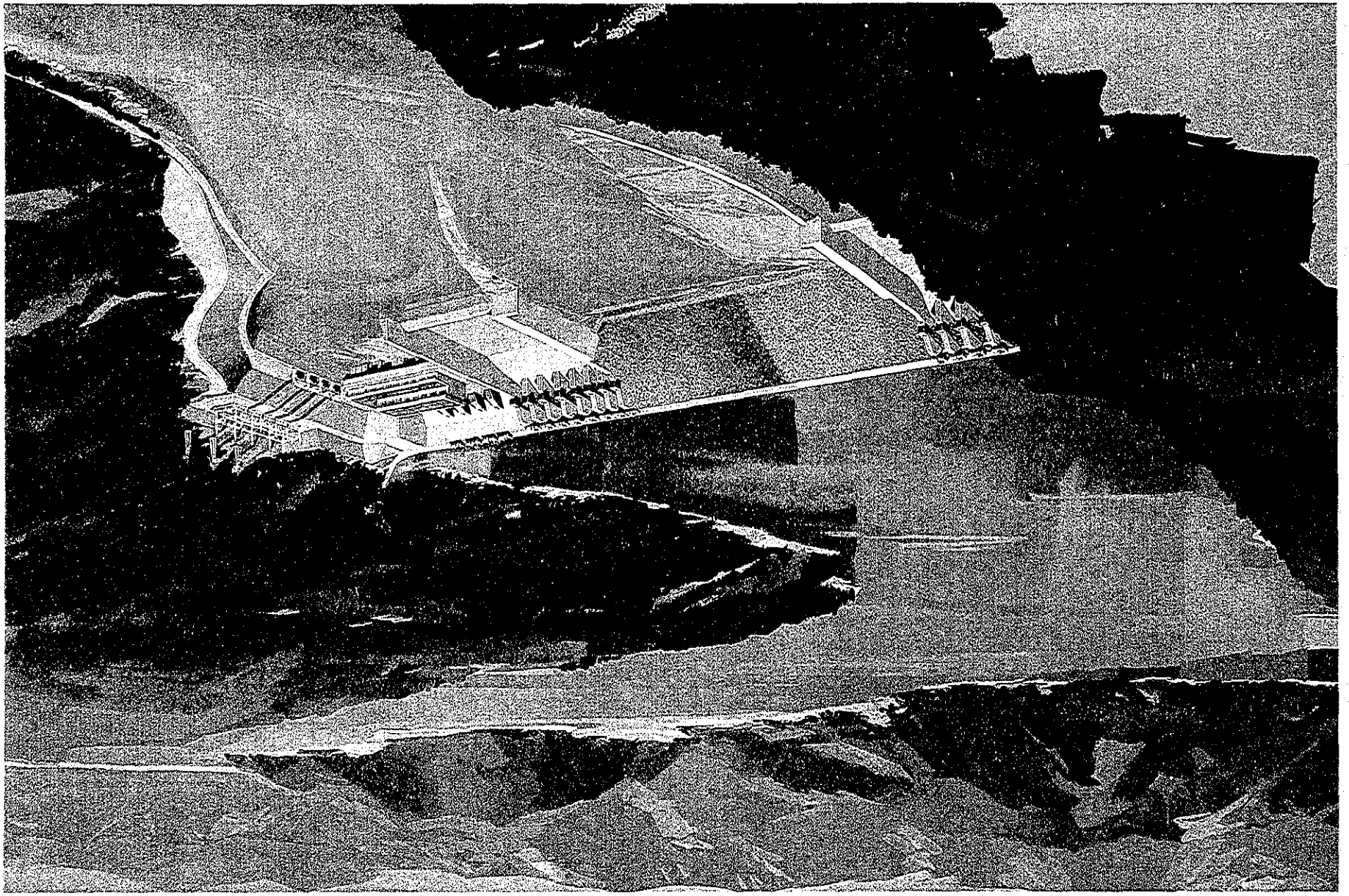
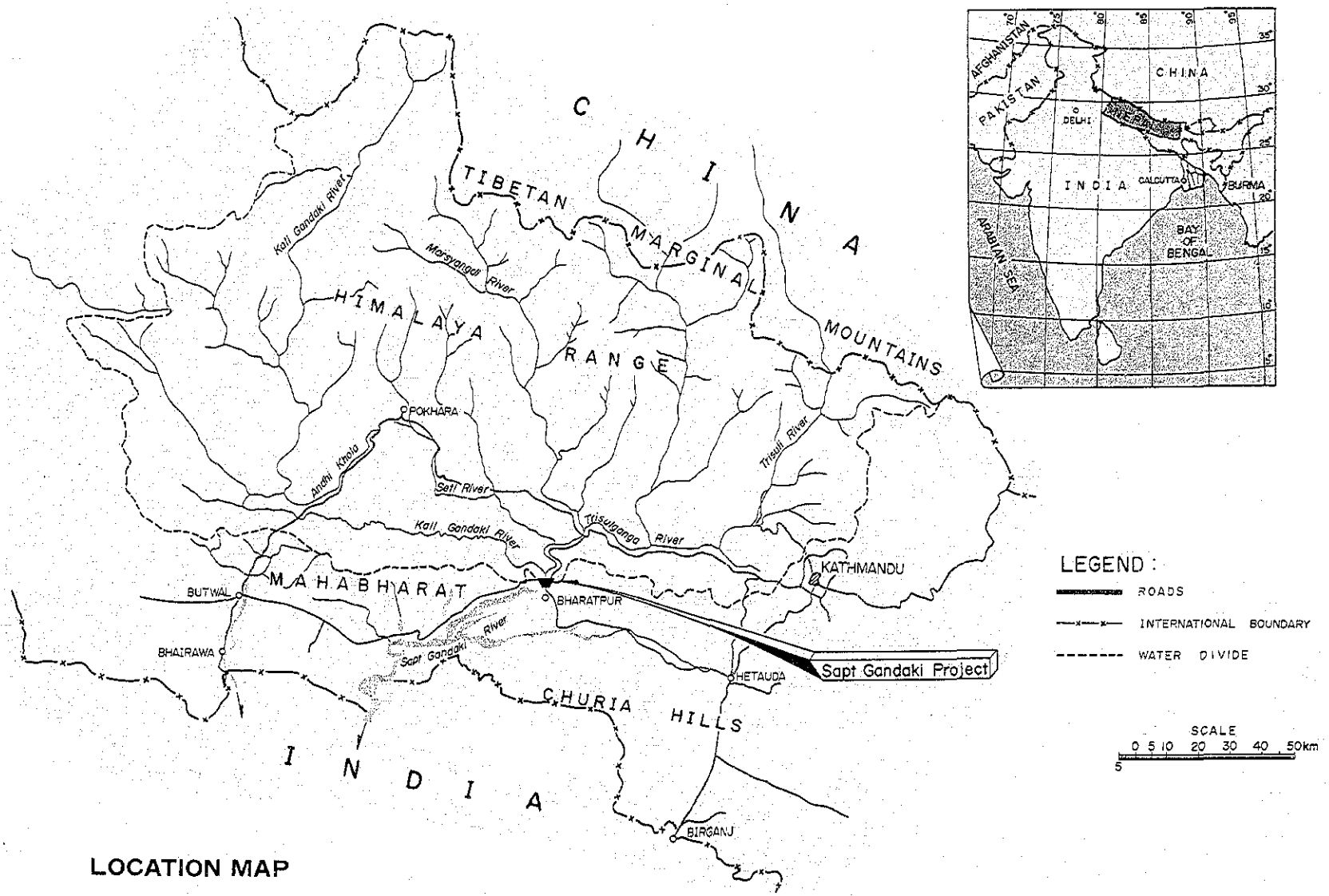
LIST OF REPORTS





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I. INTRODUCTION

The following data were collected during the Stage-I and Stage II survey period.

(i) Aerial photographs covering the project area.

(ii) Topographic map of 1 to 10,000 in scale covering the Sapt Gandaki River basin.

(iii) Topographic map of 1 to 63,360 in scale covering the whole Nepal.

(iv) Data of the Indian Survey Triangulation Stations near the project area.

(v) Data of the existing bench marks which are used in the Chitwan Valley Development Project and the Road Department, HMG.

In order to carry out the detailed study of the project, it is necessary to prepare more accurate topographic maps in the project area including the borrow area of construction materials and effectuate various checkings of elevations, coordinates or of the existing topographic maps, etc. To carry out those activities, the following topographic surveys were planned and executed in the Stage-II field investigation.

(i) Levelling:

- For the installation of new bench marks near the damsite ..... 10 km
- For the control points survey ..... 50 km
- For the checking of Mugling Road elevation ..... 30 km
- For the checking of elevation at the Kali Gandaki No.2 project site ..... 30 km
- For the checking of accuracy of the existing topographic map of 1 to 10,000 in scale ..... 10 km

(ii) Control points survey by the traverse survey from the existing triangulation points for the preparation of topographic maps of 1 to 500 in scale around the damsite.

(iii) Ground control points survey by the traverse survey from the existing triangulation points for aero-photo mapping of 1 to 2,000 in scale using the existing aerial photographs.

(iv) Plane table survey

- For the preparation of topographic maps of 1 to 500 in scale around the damsite ..... 169 ha.
- For the preparation of topographic maps of 1 to 1,000 in scale in the borrow area of sand and gravel ..... 30 ha.

(v) River cross section survey from the damsite to about 4 km downstream at the interval of 250 meter ..... 20 sections

(vi) Aero-photo mapping of 1 to 2,000 in scale using the existing aerial photograph ..... 4 km^2

The topographic survey in the Stage-II were carried out during the period from mid October, 1981 to end March, 1982. All the survey works including the summarization of the survey data, calculations and preparation of the topographic maps, etc. were satisfactorily completed in the allocated period. The detailed descriptions of the topographic survey works executed in the Stage-II are presented in the succeeding Chapter.

II. SURVEY WORKS CARRIED OUT

2.1 Instalaltion of New Bench Marks

The installation of the new bench marks near the project site was essential in consideration of its use as the base control points in topographic survey work of the Stage-II. Thus, first of all, the installation of the bench marks near the project site was carried out.

New bench marks (four near the dam site and one near the borrow area of concrete aggregates) were installed at the positions shown in Fig.-A.1 of which selection was made, taking into consideration not only the suitability for the topographic survey works in the Stage-II but also the convenience in the future use at the detailed design and the construction work stages. These bench marks were all connected with the traverse route of the control point survey so as to be used as control points.

The elevation of each bench mark was surveyed by the direct levelling from the existing bench mark (BM35 in Fig.-A.1). The elevation of the existing bench mark BM35 which is fixed at EL.193.586 m is now being used in the Chitwan Irrigation Project and its accuracy was confirmed through the indirect levelling (trigonometry) from the Indian Survey Triangulation Stations of which data were obtained from the Geodetic Department, HMG.

The elevation of each new bench mark was surveyed as shown in Table-A.1. A stone post made of concrete and provided with its elevation was embedded at each position so as to be durable permanently.

2.2 Control Points Survey

The control points survey was carried out by means of traverse survey for the purpose of establishing the base points for all necessary topographic survey works.

Fig.-A.1 shows the traverse route of the control points survey executed. The traverse route was arranged so as to connect the Indian Survey Triangulation Stations near the project area (No.1, No.2 and No.36), the selected control points in the project area (T1 to T11), the ground control points required for the aero-photo mapping (GC1 to GC4) and the newly installed bench marks (BM1 to BM6).

The traverse survey was carried out using an electro-optical distance meter for distance measurement and two transits of 1" reading for angle measurement. The coordinate of each control point was worked out based on the surveyed distance and angle, the coordinates of the Indian Survey Triangulation Stations and the azimuth measured by astronomic observation (sun observation). The elevation of each control point was worked out by the indirect levelling because of difficulty of the direct levelling due to the topographic condition. The above traverse was closed with a satisfactory accuracy, satisfying sufficiently the following standard required for the control point survey.

- Coordinate : Within 1/5,000 and 10.0 cm + 20 cm $\sqrt{S}$
  (S: survey distance in km)
- Elevation : Within 10.0 cm + 3.0 cm $\sqrt{n}$
  (n: number of points surveyed)

The results of the above control points survey are summarized in Table-A.2.

2.3 Topographic Map of 1 to 500 in Scale around the Damsite

The preparation of the topographic map of 1 to 500 in scale around the damsite was considered necessary for the design of the main structures such as the dam, power station, diversion channels and auxiliary facilities, which would be essential for the examination of the technical and economic feasibility of the project. Further, it was considered that the preparation of the above topographic map should cover the area including the alternative damsites for the comparative study of the damsites of which necessity occurred due to the unexpected unfavourable geological conditions of the damsite-A proposed in the Prefeasibility Report. Thus, the topographic survey for preparation

of the above map of 1 to 500 in scale was carried out for the area as shown in Fig.-A.2.

The survey work included the minor control point survey for horizontal and vertical control and the successive plane table survey. The minor control point survey was made by the traverse survey on the traverse route connected with the base control points established by the mentioned control point survey, as seen in Fig.-A.2. The measurement of distance and angle on the traverse route was made using the same survey equipment as the control point survey mentioned in Chapter 2.2. The indirect levelling was applied for the vertical control in view of the extreme inefficiency of the direct levelling due to the topographic condition at the site. A satisfactory accuracy was indicated in the traverse survey, satisfying the standard required in its closing error. The results of the traverse survey for the minor control points are given in Table-A.3.

In the plane table survey, attention was paid to plot the change of the topography as accurately as possible. Thus, the survey procedure, in which ridges, gullies or sharp changes of slope are checked and plotted firstly, was adopted. The horizontal and vertical control of the plane table survey were strictly made by referring to the minor control points set prior to the plane table survey.

2.4 Aero-photo Mapping

The topographic map which will make the overall project planning possible was prepared. Since aerial photographs covering the project area were available, the preparation of the topographic map of 1 to 2,000 was carried out by aero-photo mapping from the available photographs for the area shown in Fig.-A.3.

The available aerial photographs were prepared in 1974 and had the following characteristics;

- Used camera : Wild RC8 f = 152.10 mm
- Photographing height : 1,700 m
- Scale : 1/10,000

Eight years elapsed after the air photosurveying, and therefore, some slight changes from the photograph such as the suspension bridge constructed after the preparation of the photograph were recognized in the present condition. However, no substantial change of the topography and no major targets were found and the photograph was sufficiently accurate for the preparation of the topographic map of 1 to 2,000 in scale.

The ground control points required for the aero-photo mapping were located at clear visible places near the traverse route of the control point survey as shown in Fig.-A.1. They were all connected with the traverse route of the control point survey and surveyed together with the control points. For the ground control points, the direct levelling from the bench marks was also carried out. Further, two or three clear targets near each ground control point were surveyed to use as the photo control points in the mapping.

Pricking on the photograph was made for 3 bench marks of BM1, BM3 and BM4.

The results of the ground control points survey are summarized in Table-A.4. Applying this results, the aero-photo mapping for preparing the topographic map of 1 to 2,000 in scale was carried out in Tokyo by using the stereo plotting instrument, Stereo Plotter A8 (wild). The map prepared by the stereo plotting instrument was checked in detail and finalized referring to the result of the plane table survey carried out for the preparation of the topographic map of 1 to 500 in scale.

2.5 Levelling of Mugling Road

The Gorkha-Mugling-Narayangar Road (referred to as the "Mugling Road") passes along the Trisulganga river. This road will partially be submerged by the proposed reservoir when the project will be realized. This road is one of the main national roads, and the road in the submerged portion will have to be relocated. Thus, the investigation of the elevation of the existing Mugling Road for the estimation of the necessary road relocation cost was carried out in the Stage-II field investigation.

In order to assess the road length to be submerged and to make arrangement for the relocation road, it was considered necessary to prepare the plan and longitudinal section of the Mugling Road including the surrounding topography. Thus, for such preparation, the survey works consisted of the direct levelling from the existing bench mark BM35 to the bench mark BM6 which was installed as the base point for the Mugling Road investigation, minor control point survey along the Mugling Road as shown in Fig.-A.4, stadia and plane table survey from the minor control points for the preparation of the road plan.

The survey results are as summarized in Table-A.5 and Table-A.6.

The plan and longitudinal section of the Mugling Road were prepared as presented in Table-A.5 and in the end of this Annex (A) respectively, based on the above survey results. The incorporation of the surrounding topography was made by utilizing the existing topographic map of 1 to 10,000 in scale. This existing topographic map was enlarged to the scale of 1 to 5,000 and duly combined with the road plan.

Based on the above survey results, it was found that about 8 km of the Mugling Road would be submerged by the future reservoir of which the full supply level is set at EL.230.0 m in the feasibility study.

2.6 Investigation of the Elevation at Kali Gandaki No.2 Project Site

At about 20 km upstream of the Kali Gandaki river from the Sapt Gandaki project site, there is a project site where a hydroelectric power project named as the Kali Gandaki No.2 project is proposed. There is a possibility that it will be realized in accordance with the increase of the power demand although its realization may be in a far future.

The development scale of the Sapt Gandaki project should be determined in due consideration of the combination with this upstream project, and the tailwater level at this upstream project is closely related to the development scale of the Sapt Gandaki project. Thus, it was considered that the exact elevation at the upstream project site should be investigated.

The investigation of the elevation of the Kali Gandaki No.2 project was made by the traverse survey from the control point, T7 as shown in Fig.-A.6. The elevation of the water level and the riverbed at the three conceivable sites were surveyed, of which results are given in Fig.-A.7 and Table-A.7. The position of the point, K20 was clearly marked on the firm exposed rock together with its elevation.

As seen in Fig.-A.7, the riverbed at the Kali Gandaki No.2 project site was investigated at EL.218.5 to EL.219.9 m. The river water level (water level in early February, 1982) was investigated at EL.219.9 to EL.222.1 m.

The tailwater level of the Kali Gandaki No.2 project is assumed at EL.220.0 m in the Prefeasibility Report by SMEC. Thus, the above investigation result revealed that EL.220.0 as the tailwater level of the Kali Gandaki No.2 project in the Prefeasibility Report is a proper assumption.

2.7 River Cross Section Survey

The river cross section survey was carried out at about 250 m interval from the damsite to about 4 km downstream as shown in Fig.-A.8. It aims to investigate the exact topography of the riverbed and also to make it possible to measure the future riverbed change, if any, which is concerned with the future necessary adjustment of the rating curve established.

The arrangement so as to make it possible to measure the future riverbed change at the same cross section was necessary as stated. Thus, the river cross section survey works consisted of the establishment of the control points for the river cross section survey, the establishment of the coordinates at each cross section and levelling along each cross section.

The control point survey for the river cross section survey in which two bench marks were newly installed was also made by the traverse survey along the traverse route shown in Fig.-A.8.

The coordinates and elevations of the fixed points on both banks of each cross section were established as shown in Table-A.7. A durable clear mark was installed at the position in the field so that the mark will be found easily in future whenever necessary.

The levelling along each cross section was done at around 5 m intervals, properly adjusted to closer intervals in the abrupt change of the slope and to larger intervals in the flat portion. The direct levelling was carried out in both banks. The levelling in the riverbed portion where water is flowing, was carried out by wiring a rope across the river and measuring the water depth from the boat. In measuring the water depth in which a rope with measure and 7 kg weight was used, the adjustment of the error caused due to river flow became necessary. The adjustment was duly made by measuring the skewed angle against the gravity direction.

The river cross sections prepared based on the mentioned survey are given in the end of this Annex (A).

2.8 Topographic Map of 1 to 1,000 in Scale for Sand and Gravel Deposit

There is a major gravel deposit for the concrete aggregates at a location about 4 km downstream from the damsite. For the estimation of the available quantity of gravel, the excavation of test pits and seismic exploration were carried out in the deposit. In addition to the above, the topographic map of the area was prepared for more accurate estimation of the available quantity.

For the sand and gravel deposit, the results of the river cross section survey and the survey carried out for the seismic exploration were available. The existing aerial photograph taken in 1974 was also available in preparing the topographic map of the area. Thus, the preparation of the topographic map for the sand and gravel deposit was conducted by fully utilizing the above available data.

The ground control point survey for the aero-photo mapping from the existing aerial photograph and the plane table survey to supplement the available data were performed as shown in Fig.-A.9.

The topographic map prepared by the aero-photo mapping and duly modified based on the available data and the supplemental field survey results are provided in the end of this Annex (A).

2.9 Checking on the Accuracy of the Existing Topographic Map of 1 to 10,000 in Scale

The existing topographic map of 1 to 10,000 in scale which was obtained in Stage-I and covering the whole project area including the future reservoir area was to be used for measuring the storage volume of the reservoir and the necessary compensation area to be submerged by the reservoir, etc. This existing topographic map had been prepared by aerial survey and was considered to involve some errors in it. Thus, checking on its accuracy was carried out by comparing the differences between elevation and coordinate worked out through the actual survey in Stage II and those read on the existing topographic map regarding each of the selected bench marks and control points.

The results of the above checking are summarized in Table-A.9. It was found through the above checking that there is an error of 8.5 m in average in its elevation and that the coordinates are acceptable. Thus, it is considered practical to utilize this existing topographic map by shifting the contour line by 10 m (For example, the contour line of EL.200 in the existing topographic map will be assumed as EL.190).

TABLES

TABLE-A.1: ELEVATION OF NEW BENCH MARKS

Bench Mark No.	Elevation in m	Remarks
BM35	193.586	Existing bench mark
BM1	207.954	Position is shown in Fig.-A.1
BM2	209.174	"
BM3	194.548	"
BM4	193.832	"
BM5	194.119	"
BM6	254.560	Position is shown in Fig.-A.4
BM101	189.401	Position is shown in Fig.-A.8
BM102	190.769	"

Note: (i) The above elevations of the new bench marks were obtained by direct levelling from the existing bench mark, BM35.

(ii) The coordinate of each bench mark was obtained by the control point survey. It is given in Table-A.2.

Table-A.2 RESULTS OF CONTROL POINT SURVEY

Station No.	Northing (X) in m	Easting (Y) in m	Elevation in m
T1	3,070,126.70	545,160.20	240.41
T2	3,070,773.55	544,040.93	225.36
T3	3,069,559.47	543,601.83	201.63
T4	3,069,110.10	541,685.31	251.89
T5	3,066,527.49	541,539.91	234.45
T6	3,065,861.20	538,609.60	191.23
T7	3,066,631.85	537,284.34	212.58
T8	3,065,126.74	535,994.56	182.20
T9	3,064,181.47	531,658.97	182.54
T10	3,063,069.69	530,808.96	174.62
T11	3,063,719.28	530,251.29	187.00
T5-1	3,065,212.86	540,704.49	196.07
T5-2	3,067,728.86	540,531.94	572.53
EM1	3,068,493.54	542,209.74	207.954
BM2	3,068,303.61	541,968.17	209.174
BM3	3,067,568.23	542,368.10	194.548
BM4	3,067,502.03	542,176.35	193.832
BM5	3,065,649.49	543,002.87	194.119
BM6	3,072,423.24	546,657.38	254.560

Table-A.3: RESULTS OF MINOR CONTROL POINT SURVEY

A.3(1)

Station No.	Northing (X) in m	Easting (Y) in m	Elevation in m
BM 1	3,068,493.54	542,209.74	207.954
2	8,303.61	1,968.17	209.174
3	7,568.23	2,368.10	194.548
4	7,502.03	2,176.35	193.832
CL-L- 1	8,598.54	2,138.27	186.61
2	8,379.92	2,248.90	186.50
3	8,100.97	2,300.12	185.70
4	7,809.90	2,349.99	187.53
5	7,354.94	2,442.17	185.06
CS-R- 1	8,552.05	1,936.55	186.16
2	8,324.40	2,041.91	185.90
3	8,066.79	2,100.22	187.44
4	7,812.24	2,129.94	187.06
5	7,290.19	2,274.19	185.18
L 1	8,468.42	2,264.60	214.53
2	8,492.91	2,332.13	221.43
3	8,432.35	2,414.08	231.21
4	8,452.99	2,486.00	236.37
5	8,484.45	2,596.47	240.93
6	8,494.22	2,716.39	267.85
15	8,361.76	1,711.65	287.87
16	8,315.09	1,732.75	280.30
17	8,273.51	1,761.46	276.64
18	8,429.48	2,755.63	271.86
19	8,398.81	2,832.59	272.73
20	8,276.30	2,893.66	271.77
21	8,172.66	2,856.81	264.07
22	8,121.39	2,693.32	256.15
23	8,074.89	2,710.67	256.20
24	8,014.56	2,682.76	254.71
L 25	8,029.15	2,596.36	251.72

- to be continued -

Station No.	Northing (X) in m	Easting (Y) in m	Elevation in m
L 26	8,033.95	2,542.94	238.14
27	8,030.47	2,474.89	233.56
28	8,023.01	2,391.37	200.06
50	8,130.68	2,860.11	262.86
51	8,006.07	2,869.45	256.66
52	7,984.14	2,946.45	261.36
53	7,903.92	2,942.34	259.10
54	7,812.83	2,946.58	257.93
55	7,712.06	3,004.42	257.84
56	7,623.16	3,039.19	257.18
57	7,524.70	2,974.24	254.44
58	7,558.48	2,831.35	249.63
59	7,450.74	2,779.72	245.39
60	7,286.97	2,552.98	203.03
61	7,419.99	2,493.38	200.44
62	7,518.12	2,480.36	199.82
63	7,592.81	2,444.76	200.27
64	7,721.21	2,560.06	232.60
65	7,753.31	2,679.85	249.77
66	7,757.33	2,797.32	254.82
67	7,825.62	2,896.71	255.49
68	7,786.45	2,907.41	254.06
L56-1	7,436.24	3,021.38	246.74
59-1	7,511.96	2,666.37	230.98
65-1	7,805.85	2,615.61	241.83
66-1	7,662.24	2,811.93	252.77
68-1	7,720.75	2,877.29	235.62
R 1	8,302.59	1,898.82	224.17
2	8,203.80	1,812.80	284.00
3	7,946.68	2,072.08	206.34
4	7,921.79	1,962.32	251.54
5	8,101.95	1,903.48	258.90
6	8,132.27	1,876.53	273.55
R 7	8,178.59	1,968.78	219.50

- to be continued -

Station No.	Northing (X) in m	Easting (Y) in m	Elevation in m
R 14	8,411.00	1,705.42	284.34
15	8,361.76	1,711.65	287.87
16	8,315.09	1,732.75	280.30
17	8,273.51	1,761.46	276.64
70	7,398.27	2,210.73	192.16
71	7,237.00	2,123.51	241.27
72	7,242.19	2,021.50	258.45
73	7,320.55	1,881.00	287.66
74	7,420.56	1,927.39	275.52
75	7,488.94	1,943.50	269.45
76	7,596.58	1,845.17	286.34
77	7,713.90	1,834.40	278.16
78	7,762.37	1,910.36	251.34
79	7,889.99	1,940.75	268.00
R 3-1	7,747.60	2,062.36	212.37
R 3-2	7,820.40	1,936.74	214.08
BM4-1	7,581.27	2,065.78	248.74
R77-1	7,662.16	1,892.88	287.31
74-1	7,452.15	2,038.47	253.04

Table-A.4: RESULTS OF SURVEY FOR GROUND CONTROL POINTS FOR 1/2,000 AERO-PHOTO MAPPING

Station No.	Northing (X) in m	Easting (Y) in m	Elevation in m
GC1	3,069,718.94	542,447.82	223.85
P_1	686.81	453.33	222.99
P_2	721.86	433.41	223.76
P_3	696.14	397.22	222.75
GC2	3,069,296.88	541,511.26	254.51
P_1	293.74	496.90	255.52
P_2	290.86	494.83	255.55
P_3	289.47	483.02	254.73
BM1	3,068,493.54	542,209.74	207.95
P_1	486.88	203.10	207.52
P_2	476.64	211.55	207.16
BM3	3,067,568.23	542,368.10	194.55
P_1	578.72	370.23	193.75
P_2	567.50	388.79	196.06
BM4	3,067,502.03	542,176.35	193.83
P_1	524.29	164.97	196.07
P_2	499.30	170.23	192.43
GC3	3,065,687.72	543,223.25	212.12
P_1	794.54	256.73	212.70
P_2	792.33	317.79	212.93
P_3	723.58	285.42	212.69
GC4	3,066,336.66	541,736.93	208.73
P_1	386.18	777.95	210.44
P_2	335.95	688.94	208.67

Note: P_1, P_2 and P_3 above are photo control points to be used as supplemental control points in mapping

Table-A.5: RESULTS OF CONTROL POINT SURVEY FOR MUGLING ROAD

Station No.	Northing (X) in m	Easting (Y) in m	Elevation in m
BM6	3,072,423.24	546,657.38	254.56
M 0	3,071,994.32	546,572.90	212.41
M-2	3,070,607.94	547,165.11	241.373
M+2	3,072,679.88	546,054.29	221.02
3	3,072,789.00	545,906.60	219.34
4	3,072,847.27	545,802.49	212.50
5	3,073,463.24	544,186.68	219.51
6	3,073,498.55	544,001.70	227.01
7	3,073,479.03	543,894.66	229.52
8	3,073,499.02	543,488.71	220.30
9	3,073,541.83	543,415.51	221.07
10	3,073,779.81	543,274.82	221.34
11	3,073,280.01	542,967.06	219.68
12	3,074,666.06	542,764.68	217.06
13	3,075,041.13	542,710.72	231.06
14	3,076,025.87	542,746.76	228.70
15	3,076,429.75	542,771.89	223.99
16	3,076,934.81	542,877.63	226.07
17	3,077,049.27	542,916.91	223.87
18	3,077,172.70	542,999.23	231.22
19	3,077,901.87	543,957.68	246.60
20	3,078,105.90	544,091.02	247.30
20-1	3,078,157.44	544,223.08	253.67
21	3,077,824.32	546,120.41	232.68

Table-A.6: ELEVATION OF MUGLING ROAD

A.6(1)

Station No.	Distance	Elevation	Accumulated Distance	Remarks
M-2	0.0	241.37	0.0	
	181.5	233.22	181.5	
	66.5	231.64	248.0	
	482.0	219.56	730.0	
	147.5	219.28	877.5	
	99.0	219.11	976.5	
	181.5	217.89	1,158.0	
	78.0	215.23	1,236.0	
	42.0	213.98	1,278.0	
	299.0	212.15	1,577.0	
	36.0	211.78	1,613.0	Bridge L = 50.0 m
	50.0	211.76	1,663.0	
	67.0	211.71	1,730.0	
	293.5	219.99	2,023.5	
	208.0	221.79	2,231.5	
	126.5	223.51	2,358.0	
M+2	94.0	221.02	2,452.0	
	71.5	219.96	2,523.5	Bridge L = 38.0 m
	38.0	219.97	2,561.5	
	59.0	219.82	2,620.5	
M+3	14.5	219.34	2,635.0	
	69.0	215.60	2,704.0	
M+4	51.0	212.50	2,755.0	
	88.5	209.37	2,843.5	
	52.5	209.44	2,896.0	Bridge L = 4.0 m
	155.0	210.66	3,051.0	
	113.0	212.34	3,164.0	Bridge L = 4.0 m
	115.0	217.39	3,279.0	
	162.0	218.24	3,441.0	
	92.0	219.72	3,533.0	
	331.0	219.96	3,864.0	Bridge L = 14.0 m

- to be continued -

Station No.	Distance	Elevation	Accumulated Distance	Remarks
M+4	14.0	219.96	3,878.0	
	94.0	221.16	3,972.0	
	32.0	221.52	4,004.0	
	106.5	210.61	4,110.5	
	121.0	221.12	4,231.5	
	24.0	-	4,255.5	
	47.0	221.37	4,302.5	
	60.5	221.40	4,363.0	
	118.0	216.56	4,481.0	
M+5	94.0	219.51	4,575.0	
	42.0	221.44	4,617.0	Bridge L = 4.0 m
	64.0	223.74	4,681.0	
M+6	88.5	227.01	4,769.5	
	80.5	229.68	4,850.0	
M+7	31.0	229.52	4,881.0	
	26.0	228.43	4,907.0	
	39.5	225.56	4,946.5	
	110.5	219.10	5,057.0	Bridge L = 38.5 m
M+8	229.0	220.30	5,286.0	
M+9	84.0	221.07	5,370.0	
	36.0	221.30	5,406.0	
	46.5	221.30	5,452.5	Bridge L = 4.0 m
	154.5	221.22	5,607.0	
M+10	41.5	221.34	5,648.5	
	69.0	220.76	5,717.5	
	62.0	217.76	5,779.5	
	111.0	214.89	5,890.5	
	94.5	215.66	5,985.0	
	170.5	218.76	6,155.5	
M+11	89.5	219.68	6,245.0	
	159.0	219.66	6,404.0	
M+12	279.0	217.06	6,683.0	
	147.5	223.20	6,830.5	
	144.0	228.27	6,974.5	

- to be continued -

Station No.	Distance	Elevation	Accumulated Distance	Remarks
M+12	44.5	-	7,019.0	
M+13	42.0	231.06	7,061.0	
	172.0	226.78	7,233.0	
	102.0	230.21	7,335.0	
	52.0	230.98	7,387.0	
	141.0	230.40	7,528.0	
	45.0	229.78	7,573.0	
	37.5	228.60	7,610.5	Bridge L = 27.5 m
	27.5	228.60	7,638.0	
	29.0	228.40	7,667.0	
	153.0	228.52	7,820.0	
	83.0	228.64	7,903.0	
	53.0	228.41	7,956.0	
	85.0	228.50	8,041.0	Bridge L = 24.0 m
	24.0	228.50	8,065.0	
M+14	5.0	228.70	8,070.0	
	29.0	228.65	8,099.0	
	90.0	226.44	8,189.0	
	94.0	224.11	8,283.0	
	73.0	223.96	8,356.0	
M+15	138.0	223.99	8,494.0	
	122.0	223.63	8,616.0	
	76.5	220.98	8,692.5	
	84.0	223.55	8,776.5	
	43.0	225.73	8,819.5	Bridge L = 4.0 m
	4.0	225.73	8,823.5	
	63.0	226.79	8,886.5	
	116.0	226.70	9,002.5	
M+16	38.0	226.07	9,040.5	
	70.0	223.57	9,110.5	
M+17	51.5	223.87	9,162.0	
M+18	149.0	231.22	9,311.0	
	32.0	230.34	9,343.0	
	67.0	228.36	9,410.0	

- to be continued -

Station No.	Distance	Elevation	Accumulated Distance	Remarks
M+18	176.0	223.38	9,586.0	
	89.7	224.96	9,675.7	Bridge L = 4.3 m
	4.3	224.96	9,680.0	
	69.0	228.16	9,749.0	
	76.5	234.75	9,825.5	
	18.5	236.35	9,844.0	
	174.5	246.78	10,018.5	
	52.0	249.45	10,070.5	
	243.0	252.13	10,313.5	
	141.0	252.11	10,454.5	
M+19	123.5	246.60	10,578.0	
	51.0	244.32	10,629.0	
	52.0	243.81	10,681.0	Bridge L = 56.0 m
	56.0	243.81	10,737.0	
M+20	98.0	247.30	10,835.0	
	134.0	254.37	10,969.0	
	281.0	-	11,250.0	
	154.0	245.05	11,404.0	
	562.0	261.78	11,966.0	
	455.0	245.60	12,421.0	
	89.0	246.59	12,510.0	
	332.0	-	12,842.0	Bridge L = 15.0 m
	15.0	-	12,857.0	
	20.0	246.54	12,877.0	
M+21	292.0	232.68	13,169.0	
	72.0	231.30	13,241.0	Bridge L = 32.0 m
	32.0	231.30	13,273.0	
	325.0	247.80	13,598.0	

Table-A.7: SURVEY RESULTS FOR KALI GANDAKI NO.2 PROJECT SITE

Station No.	Northing (X) in m	Easting (Y) in m	Elevation in m
DS-1	3,076,985.36	529,966.93	223.51
River bed			218.70
River water			222.00
DS-2	3,077,161.29	529,906.41	222.78
River bed			219.90
River water			222.10
K20	3,076,728.37	529,972.99	227.42
River bed			218.50
River water			219.90

ON THE RIVER CROSS SECTION

Station No.	Right Bank Northing (X) in m	Right Bank Easting (Y) in m	Right Bank Elevation in m	Left Bank Northing (X) in m	Left Bank Easting (Y) in m	Left Bank Elevation in m
CS-1	3,068,552.05	541,936.55	186.16	3,068,598.54	542,138.27	186.61
CS-2	3,068,324.40	542,041.91	185.90	3,068,379.92	542,248.90	186.50
CS-3	3,068,063.85	542,116.20	186.61	3,068,088.54	542,295.72	185.06
CS-4	3,067,803.89	542,131.80	186.62	3,067,817.21	542,345.45	184.47
CS-0	3,067,526.39	542,166.85	195.88	3,067,562.90	542,364.15	191.54
CS-5	3,067,284.90	542,273.69	186.80	3,067,343.51	542,440.20	183.91
CS-6	3,067,058.27	542,349.03	189.45	3,067,098.11	542,533.17	185.59
CS-7	3,066,844.60	542,365.47	190.22	3,066,867.27	542,613.39	184.20
CS-8	3,066,611.74	542,454.75	184.45	3,066,634.54	542,653.19	185.25
CS-9	3,066,365.67	542,496.14	185.79	3,066,393.42	542,688.06	185.17
CS-10	3,066,115.75	542,572.11	185.12	3,066,174.76	542,795.25	183.77
CS-11	3,065,871.42	542,632.97	183.77	3,065,888.24	542,834.82	184.51
CS-12	3,065,621.12	542,620.30	184.92	3,065,624.80	542,888.04	183.92
CS-13	3,065,360.73	542,547.88	186.22	3,065,149.07	542,770.96	182.88
CS-14	3,065,221.42	542,386.65	189.43	3,065,041.60	542,460.87	183.30
CS-15	3,065,043.10	542,092.59	183.63	3,064,873.10	542,212.12	184.82
CS-16	3,064,954.08	541,901.62	182.31	3,064,769.86	542,024.91	183.20
CS-17	3,064,907.40	541,713.45	184.74	3,064,627.22	541,868.05	184.38
CS-18	3,064,724.90	541,416.00	181.75	3,064,498.52	541,576.61	181.87
CS-19	3,064,665.32	541,158.06	181.39	3,064,429.62	541,299.32	183.13

Table-A.9 RESULT OF ACCURACY CHECK OF EXISTING 1/10,000 TOPOGRAPHIC MAP

Checked Station No.	Map Sheet No.	Difference in Northing in m	Difference in Easting in m	Difference in Elevation in m
No.2	M18	0	0	-2.8
EM6	N18	"	"	-9
M0	"	"	"	-8
M+2	"	"	"	-3
T1	"	"	"	-3
T2	"	"	"	-4
T3	$\bar{0}$18	"	"	-12
T4	"	"	"	-5
BM1	"	"	"	-4
BM2	"	"	"	-9
BM3	"	"	"	-14
BM4	"	"	"	-10
BM5	"	"	"	-14
GC3	"	"	"	-11
T5	"	"	"	-11
T6	$\bar{0}$17	"	"	-10
T7	"	"	"	-10
T8	"	"	"	-12
T9	P16	"	"	-6
T10	"	"	"	-10
T11	"	"	"	-12
No.39	"	"	"	-8
Mean		0	0	-8.54

FIGURES

INDIAN TRIANGULATION COORDINATES :

Station No.	Easting	Northing	Height	Remarks
1	540 525.5	3 067 729.7	568.2	Gaindakot
2	542 436.1	3 075 919.5	1 184.2	Kapilas
36	529 932.7	3 063 640.8		Bherabari

NOTE :
All coordinates are expressed in meters and Universal Transverse Mercator (U T M) coordinates in Grid Zone 44.5 with Central meridian of 84° East reading 500,000 meters.

LEGEND :
- △ No. i : Indian Survey Triangulation Points
- ⊙ BM i : New bench marks
- ● BM i : Existing bench marks
- ⊙ GC i : Ground control points for aero-photo mapping
- ⊙ T i : Main traverse stations

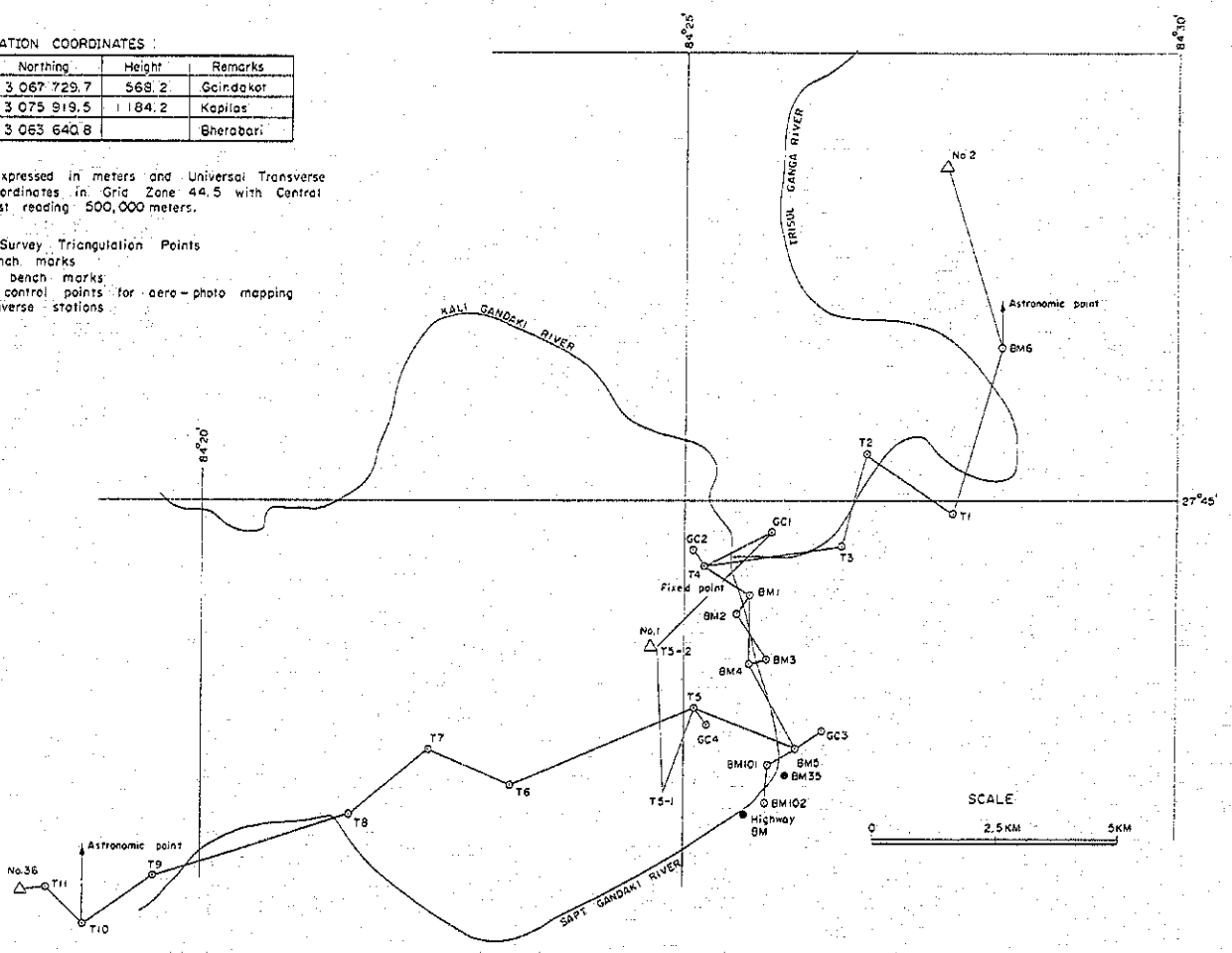
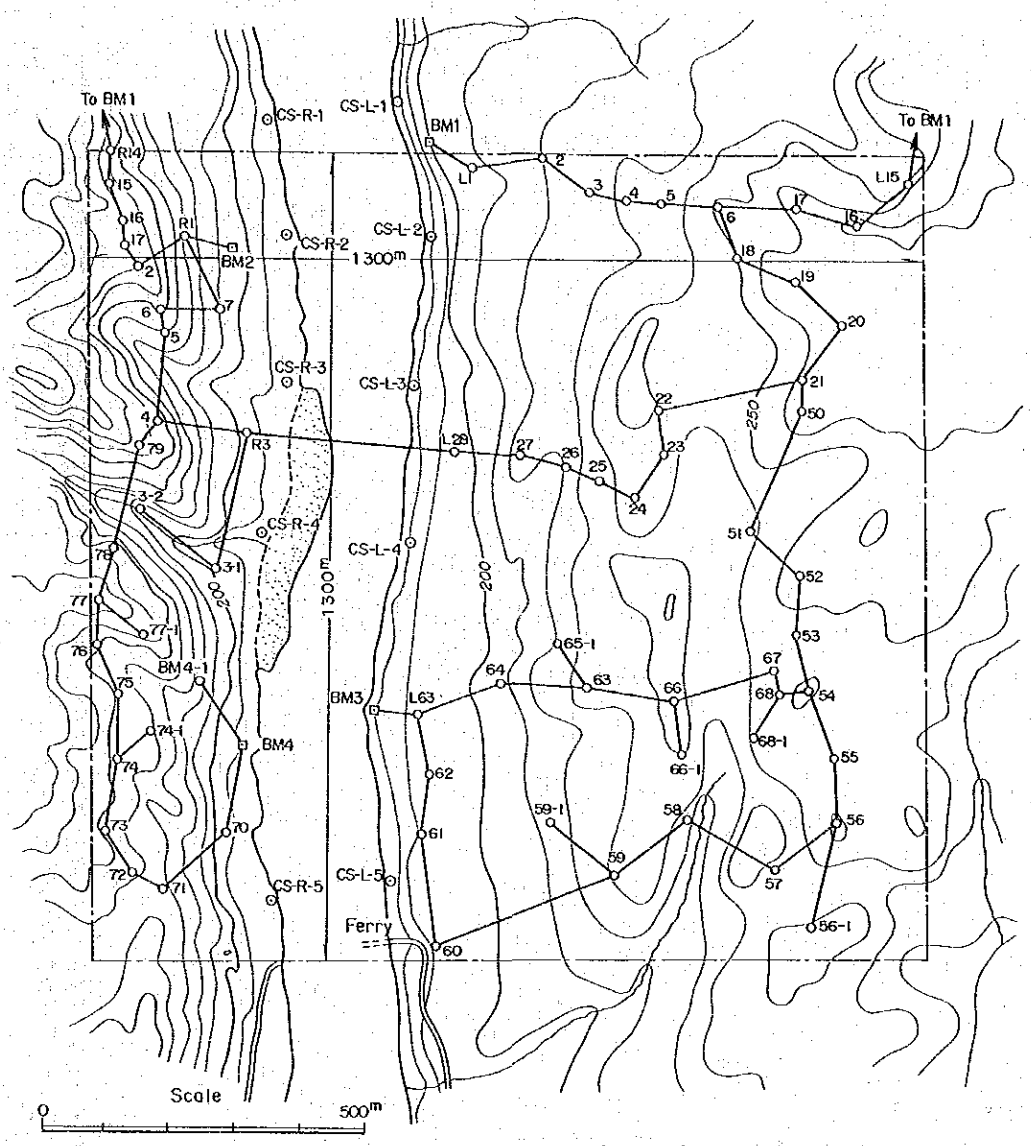


FIG- A.1 : LOCATION MAP OF BENCH MARKS AND CONTROL POINTS

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

FIG- A.1

FIG- A.2



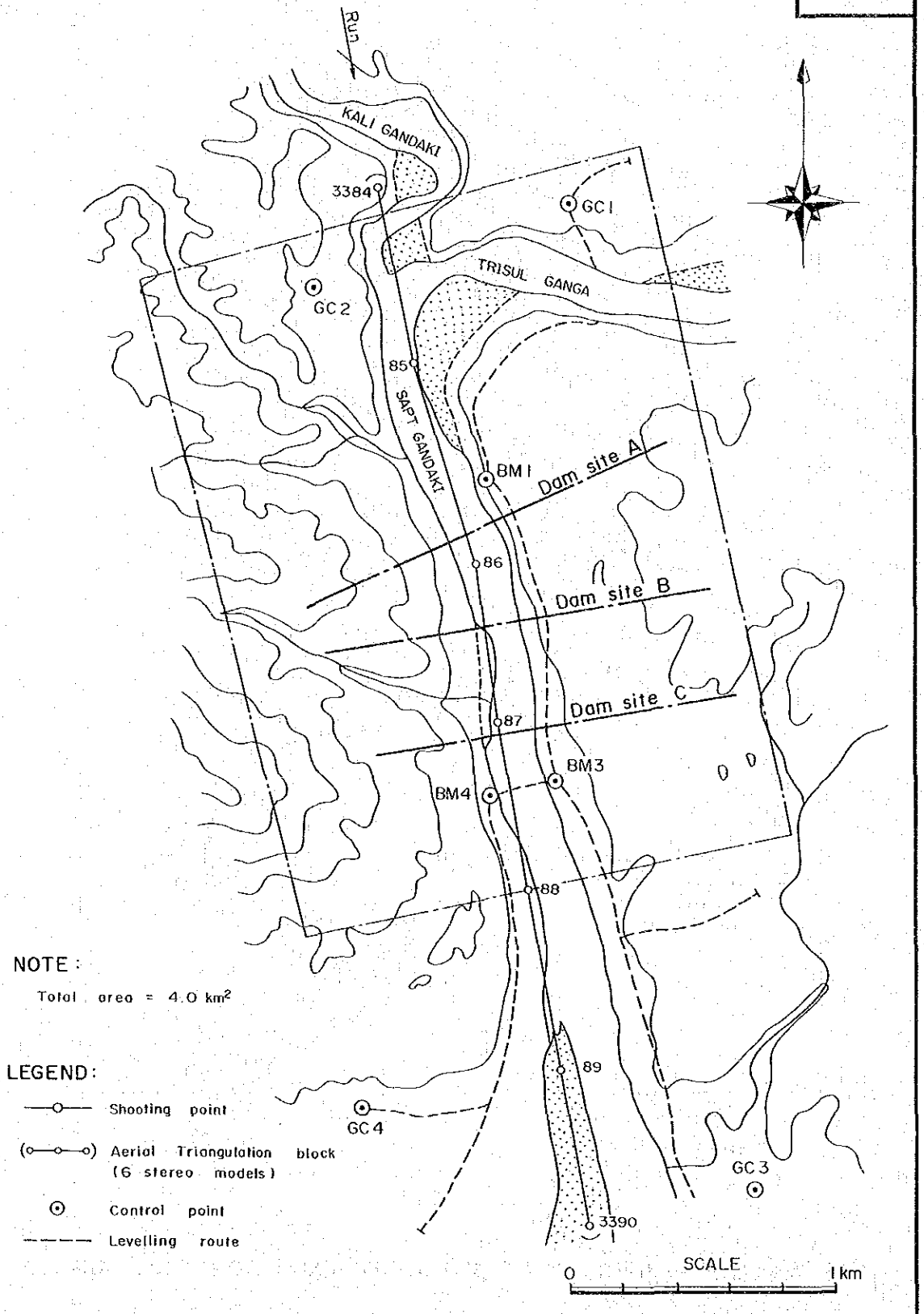
Legend :

- ⊡ : Bench marks
- o : Minor control points
- ⊙ : Control points of river cross section survey
- o—o : Traverse route
- ⬚ : Area of 1/500 topographic Map (Total area = 169 ha)

FIG-A.2 : AREA OF PREPARATION OF 1/500 TOPOGRAPHIC MAP AND LOCATION OF MINOR CONTROL POINTS AROUND DAMSITE

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

FIG- A.3



NOTE :

Total area = 4.0 km²

LEGEND :

- Shooting point
- Aerial Triangulation block (6 stereo models)
- Control point
- Levelling route

FIG- A.3 : AREA OF 1/2000 AERO-PHOTO MAPPING

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

FIG- A.4

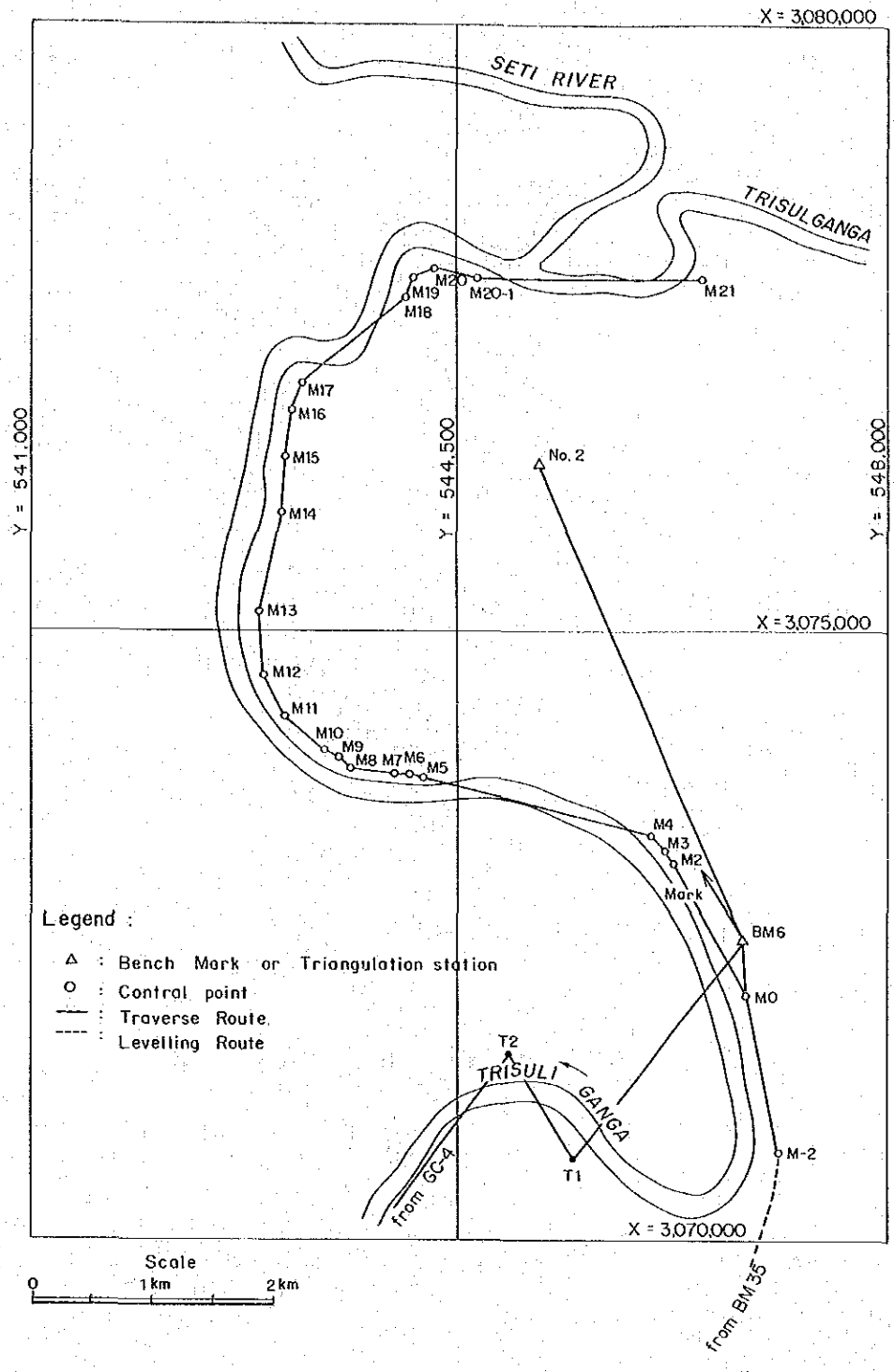
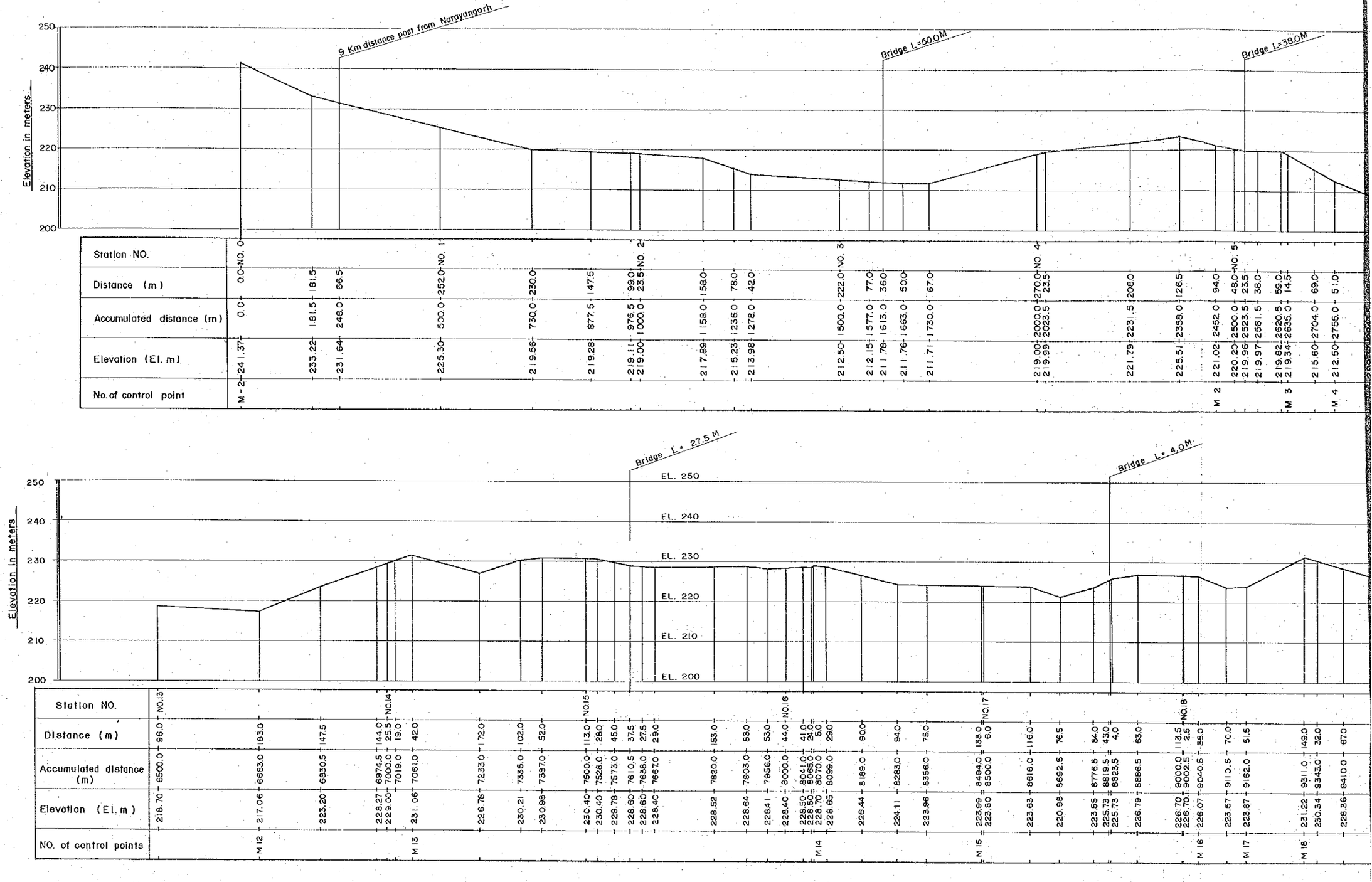


FIG-A.4 : LOCATION MAP OF MUGLING ROAD CONTROL SURVEY

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



Station NO.	0.0 NO. 0	181.5	66.5	252.0 NO. 1	230.0	147.5	99.0	23.5 NO. 2	158.0	78.0	42.0	222.0 NO. 3	77.0	36.0	50.0	67.0	270.0 NO. 4	23.5	208.0	126.5	94.0	48.0 NO. 5	23.5	38.0	59.0	14.5	69.0	51.0
Distance (m)	0.0	181.5	248.0	500.0	730.0	877.5	976.5	1000.0	1158.0	1236.0	1278.0	1500.0	1577.0	1613.0	1663.0	1730.0	2000.0	2023.5	2231.5	2358.0	2452.0	2500.0	2523.5	2561.5	2620.5	2635.0	2704.0	2755.0
Accumulated distance (m)	241.37	233.22	231.64	225.30	219.56	219.28	219.11	219.00	217.89	215.23	213.98	212.50	212.15	211.78	211.76	211.71	219.00	219.99	221.79	225.51	221.02	220.20	219.96	219.97	219.82	219.34	215.60	212.50
Elevation (El. m)	M-2																				M 2				M 3			M 4
No. of control point																												

Station NO.	NO.13	183.0	147.5	144.0	NO.14	42.0	72.0	102.0	52.0	113.0	NO.15	45.0	37.5	27.5	29.0	53.0	83.0	53.0	44.0	NO.16	41.0	24.0	5.0	29.0	90.0	94.0	75.0	138.0	NO.17	6.0	116.0	76.5	84.0	43.0	4.0	63.0	113.5	NO.18	2.5	39.0	70.0	51.5	149.0	32.0	67.0
Distance (m)	96.0	183.0	147.5	144.0	25.5	19.0	42.0	72.0	102.0	52.0	113.0	28.0	45.0	37.5	27.5	29.0	53.0	83.0	53.0	44.0	41.0	24.0	5.0	29.0	90.0	94.0	75.0	138.0	6.0	116.0	76.5	84.0	43.0	4.0	63.0	113.5	2.5	39.0	70.0	51.5	149.0	32.0	67.0
Accumulated distance (m)	6500.0	6683.0	6830.5	6974.5	7000.0	7019.0	7061.0	7233.0	7335.0	7387.0	7500.0	7528.0	7573.0	7610.5	7638.0	7667.0	7820.0	7903.0	7956.0	8000.0	8041.0	8065.0	8070.0	8099.0	8189.0	8283.0	8356.0	8494.0	8500.0	8616.0	8692.5	8776.5	8819.5	8823.5	8886.5	9000.0	9002.5	9040.5	9110.5	9162.0	9311.0	9343.0	9410.0
Elevation (El. m)	218.70	217.06	223.20	228.27	229.00	231.06	226.78	230.21	230.98	230.40	230.40	229.78	228.60	228.60	228.40	228.52	228.64	228.41	228.40	228.50	228.50	228.70	228.65	226.44	224.11	223.96	223.99	223.80	223.63	220.98	223.55	225.73	225.73	226.79	226.70	226.70	226.07	223.57	223.87	231.22	230.34	228.36
NO. of control points		M 12			M 13										M 14												M 15									M 16			M 17		M 18		

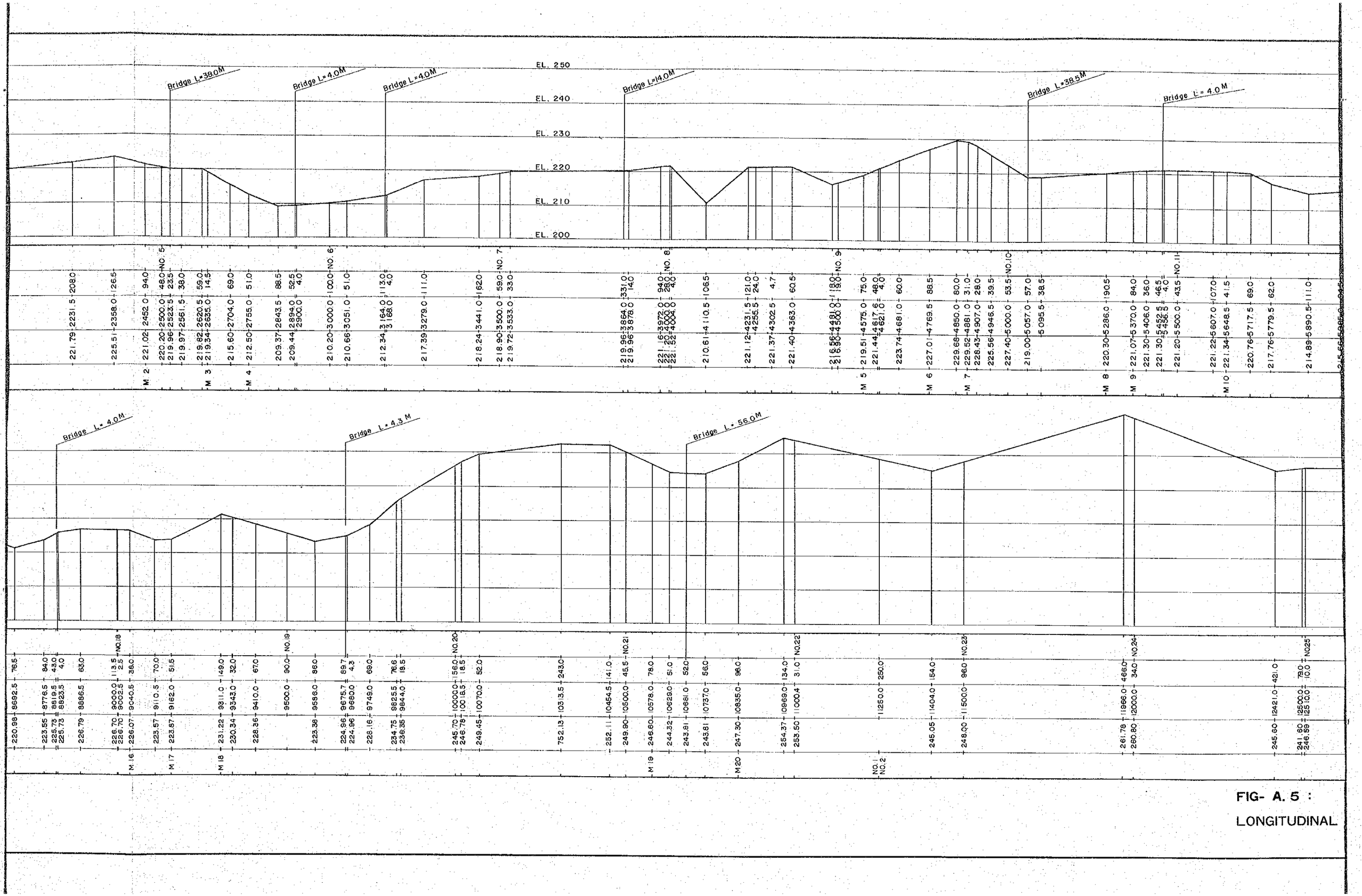


FIG- A. 5 :

LONGITUDINAL

FIG- A. 5

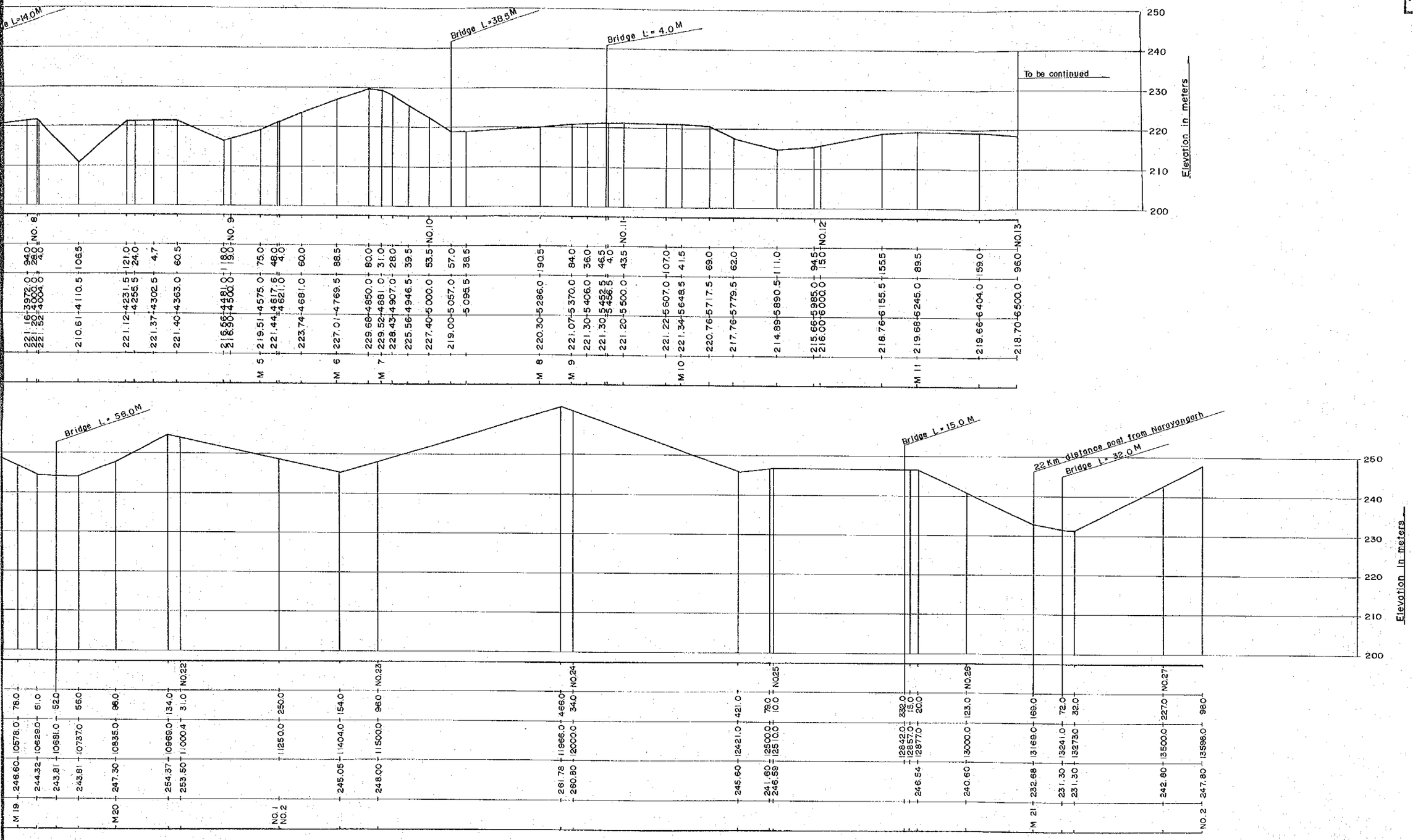


FIG- A. 5 :

LONGITUDINAL PROFILE OF MUGLING ROAD

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT
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FIG- A.6

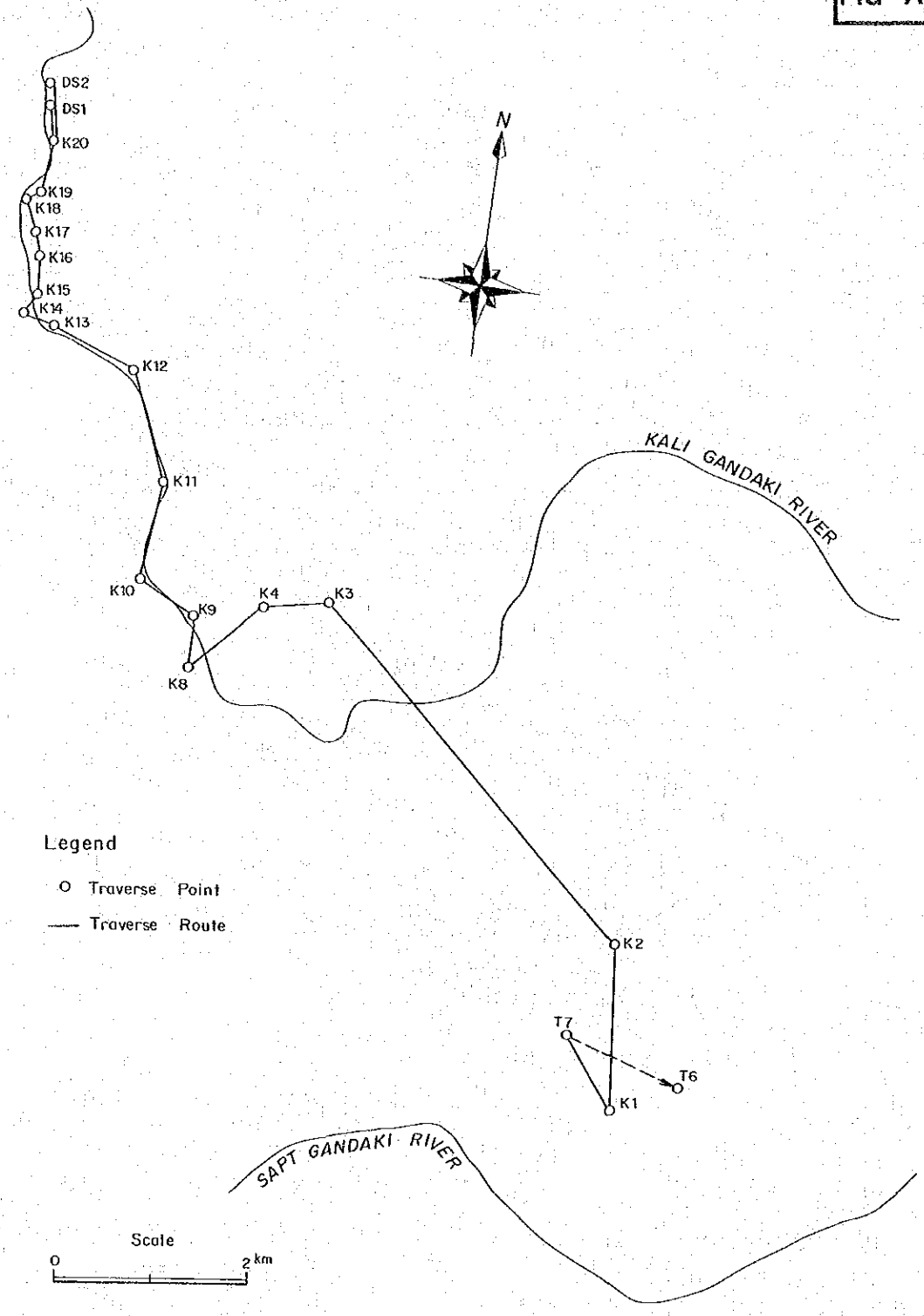

FIG-A.6 : LOCATION MAP OF KALI GANDAKI CONTROL SURVEY

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
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FIG- A.7

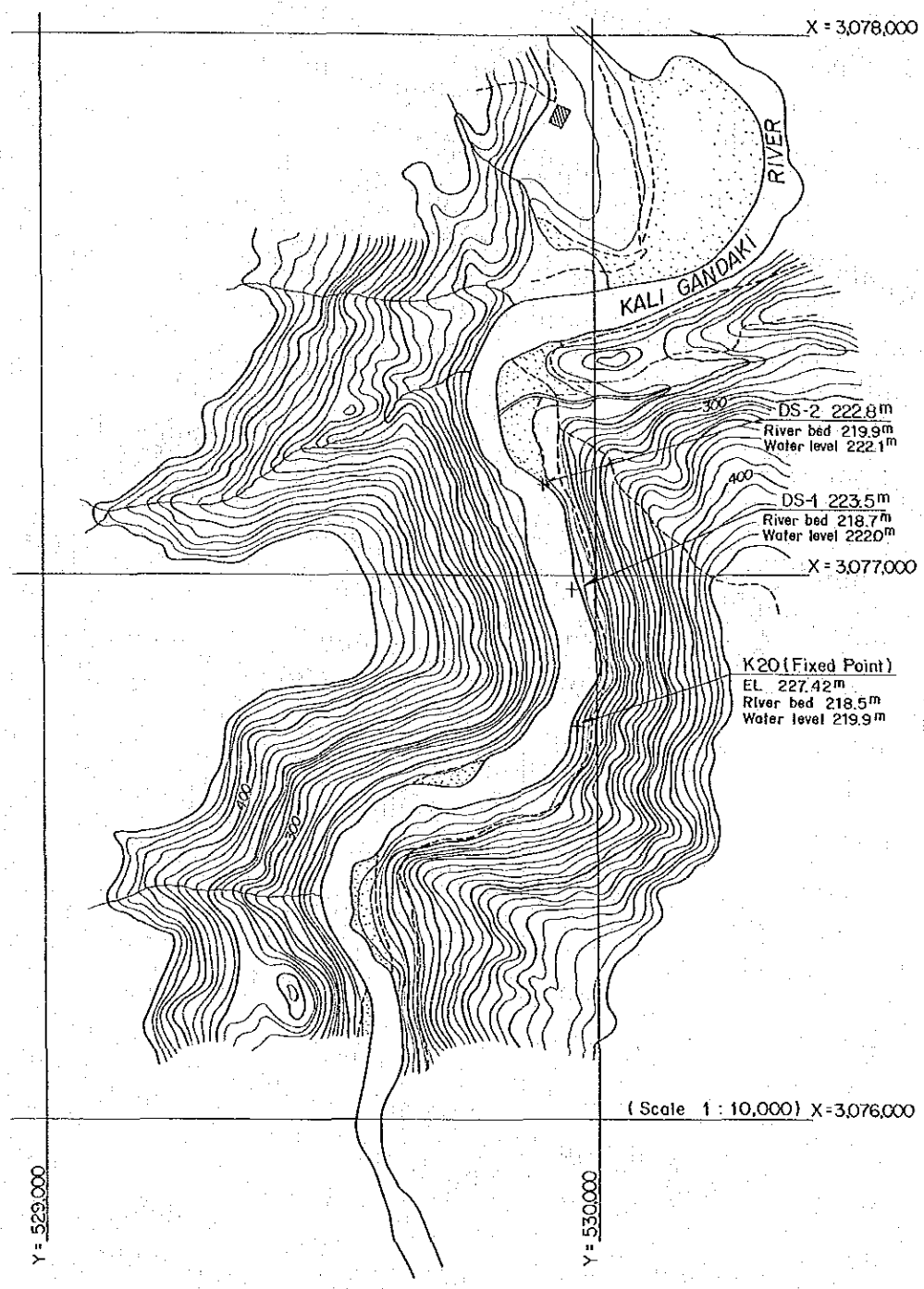

FIG-A.7 : LOCATION AND SURVEY RESULT FOR KALI GANDAKI NO.2 PROJECT SITE

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT
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FIG- A.8

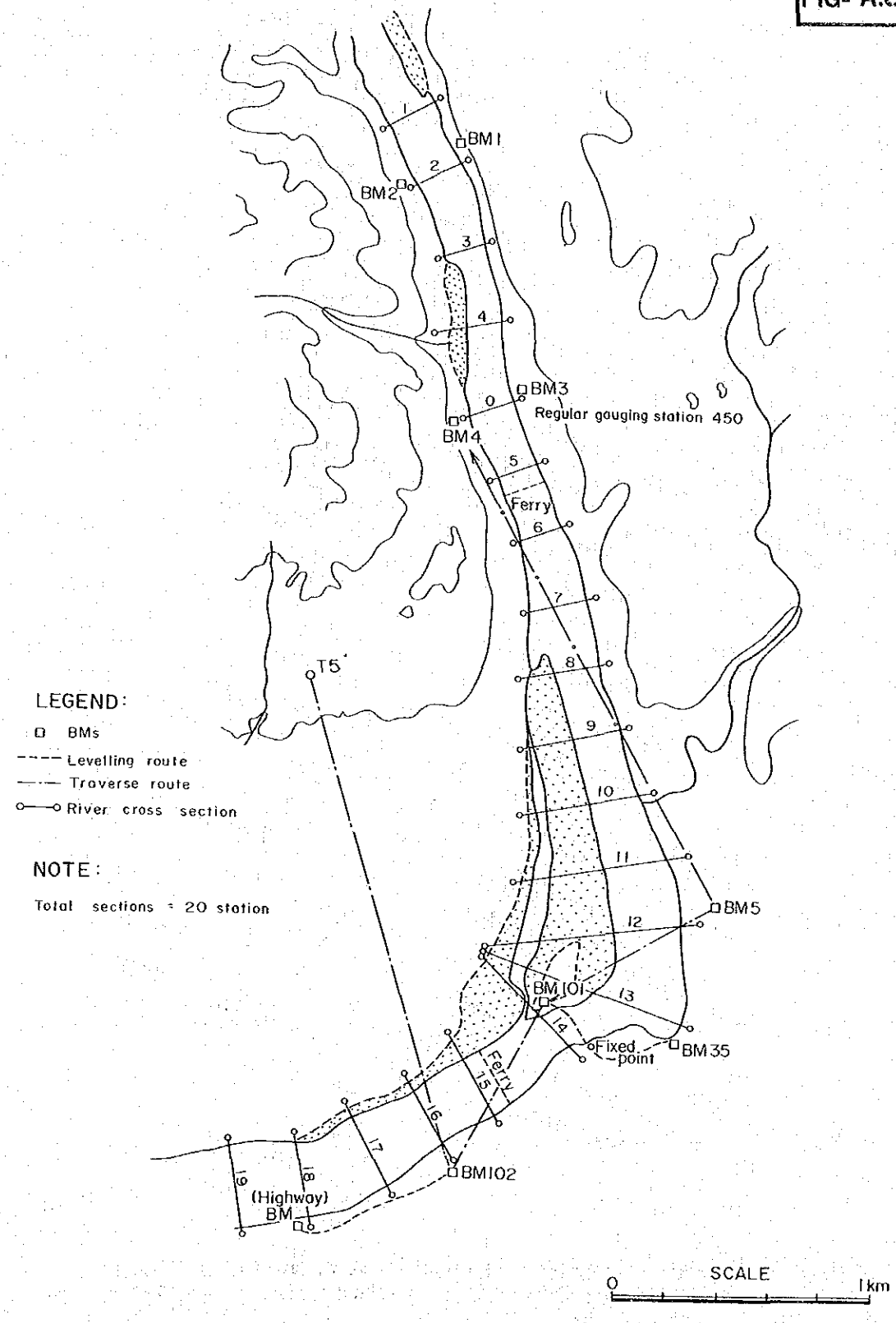


FIG- A.8 : LOCATION MAP OF RIVER CROSS SECTIONS

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

FIG- A.9

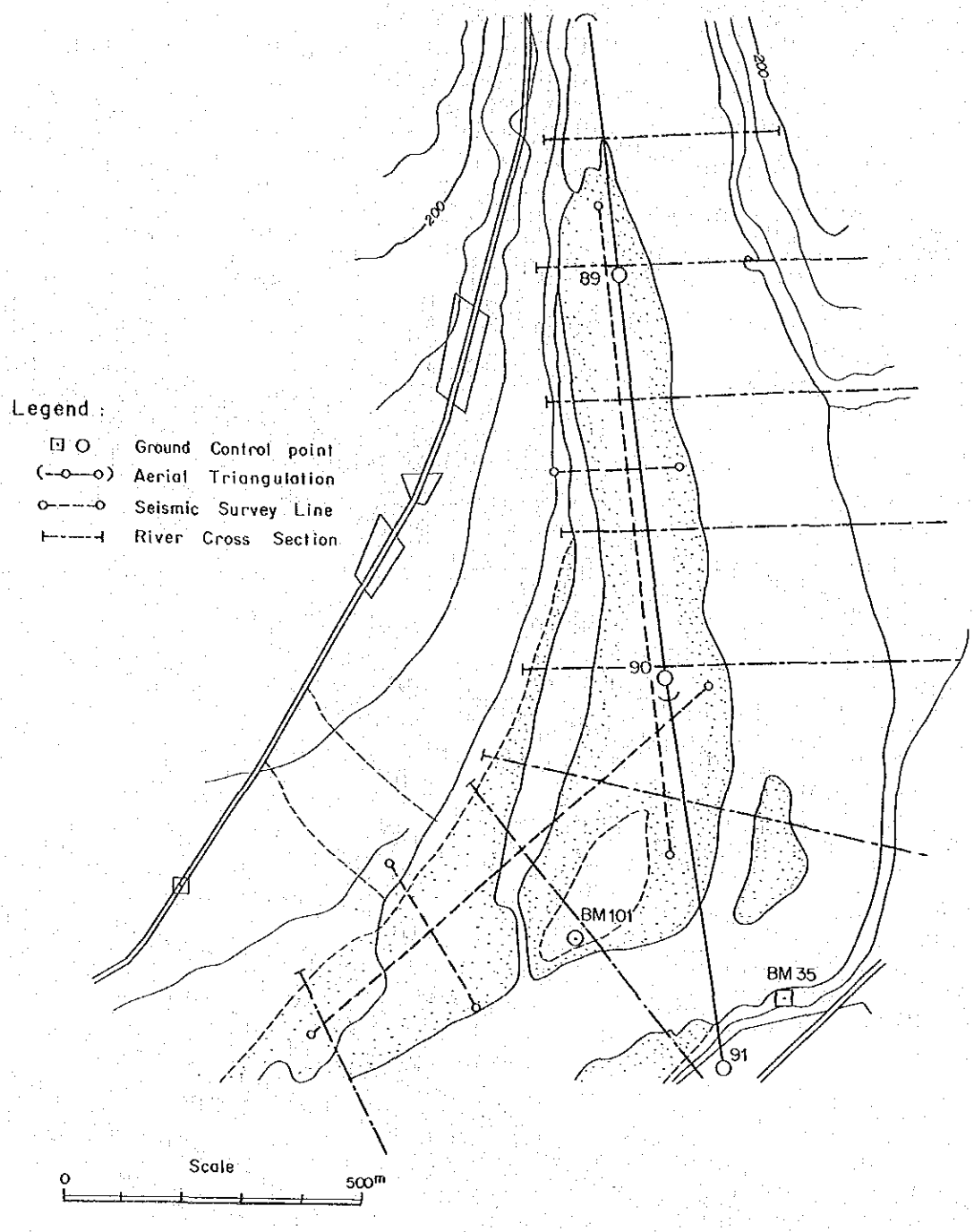


FIG-A.9 : SURVEYS CARRIED OUT FOR GRAVEL DEPOSIT IN 4 KM DOWNSTREAM FROM THE DAMSITE

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

ATTACHMENTS

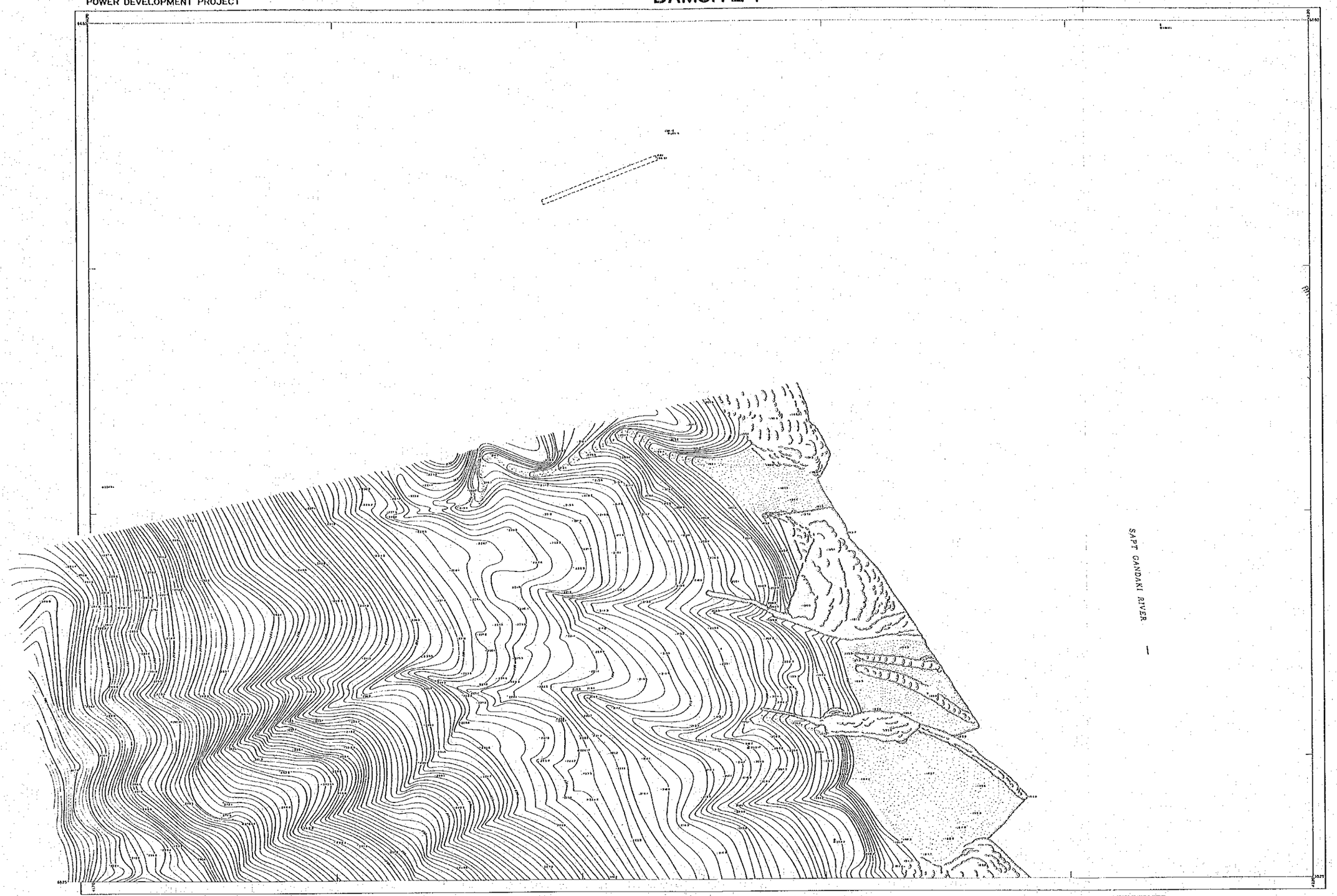
I

TOPOGRAPHIC MAP AROUND DAMSITE

OF 1 TO 500 IN SCALE (14 SHEETS)

SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT

DAMSITE I



Mapped by Japan International Corporation
Agency for the purpose of Sapt Gandaki Hydroelectric
Power Development Project Feasibility Study

LEGEND

SCALE 1:500

CONTOUR INTERVAL 1 METRES

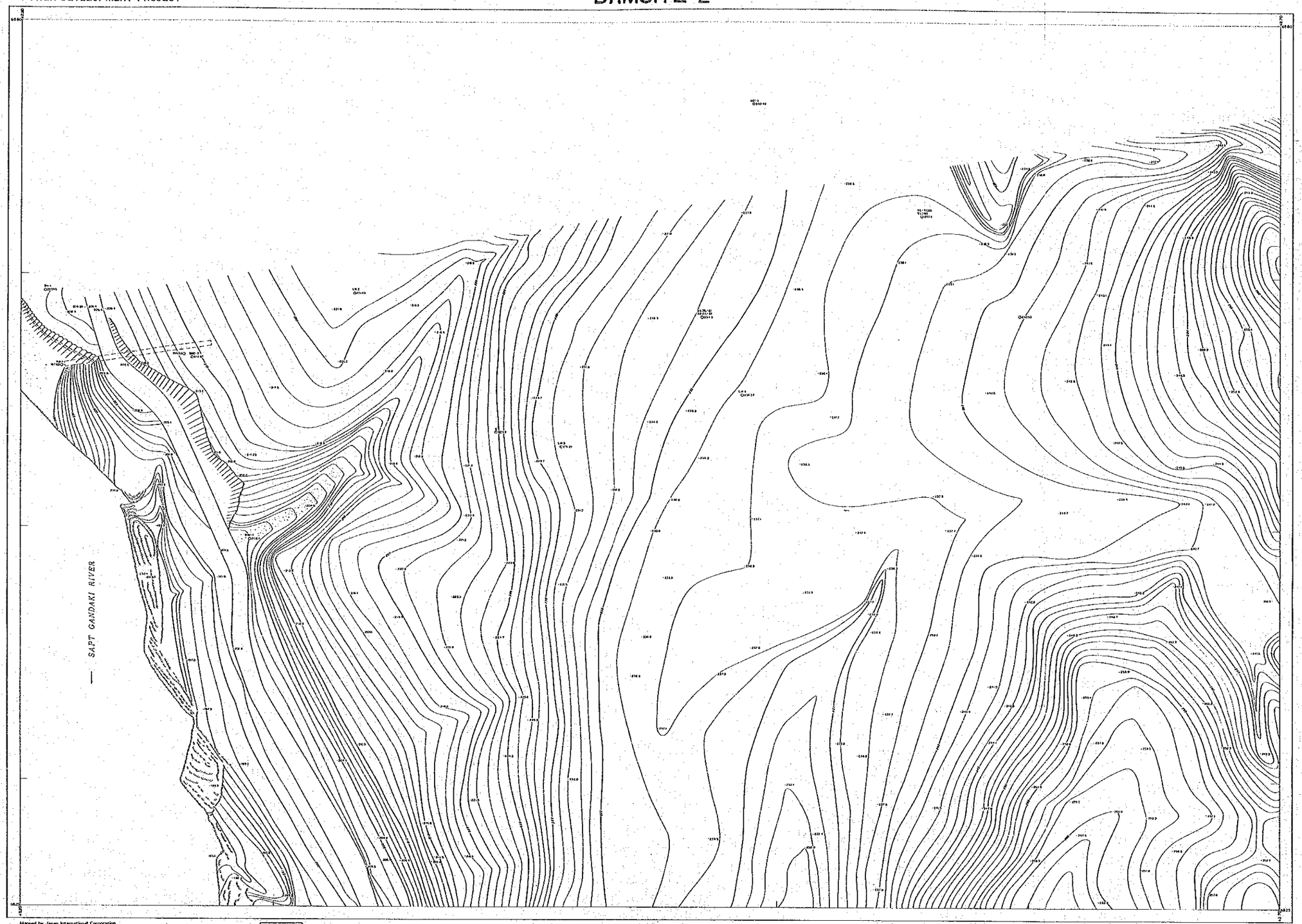
UNIVERSAL TRANSVERSE MERCATOR PROJECTION

INDEX TO ADJOINING SHEETS

1	2	3
4	5	6
7	8	9
10	11	12
13	14	

SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT

DAMSITE 2



Mapped by Japan International Corporation Agency for the purpose of Sapt Gandaki Hydroelectric Power Development Project Feasibility Study.

LEGEND

Control station (BM)		River System	
Bolt Elevation		Flow Arrow	
Formed Roads		Cutting	
Trail		Embankment	
Buildings		Depression	
Bridges		Cliff	
Ferry		Bare rock	
		Sand	
		Slope	
		Small Leaf	
		Grass	
		Paddy	

SCALE 1:500

CONTOUR INTERVAL 5 METRES

UNIVERSAL TRANSVERSE MERCATOR PROJECTION

Latitude of origin : Equator
Longitude of origin : 81° East
False northing : 0 meters
False Easting : 500,000 meters
Scale factor at the central meridian : 0.9996
Zone number : 44 S Std Zone
Spheroid : Everest

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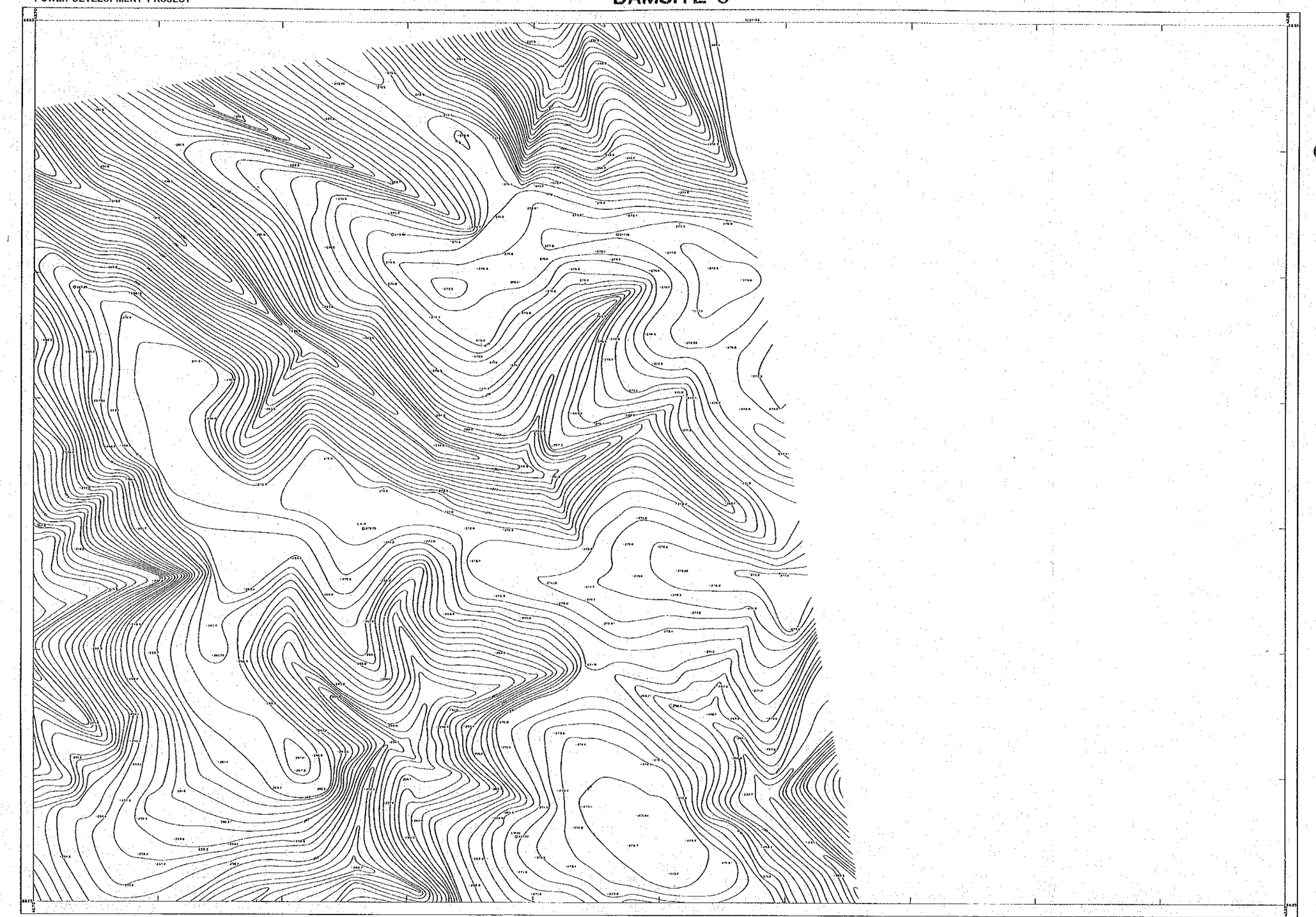
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT

DAMSITE 3



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Power Development Project Feasibility Study

LEGEND

Control station (BM)	⊡	River Stream		Shown	
Spot Elevations	+414	Flow Arrow		Broad Leaf	B B
Formed Roads		Cutting		Grass	A A
Trail		Embankment		Fields	
Buildings		Depression			
Bridges		Cliff			
Ferry		Rock / Rock			
		Sand			

SCALE 1:500

CONTOUR INTERVAL 1 METRES

UNIVERSAL TRANSVERSE MERCATOL PROJECTION

Longitude of origin : Central meridian 84°East
Latitude of origin : 0° (Equator)
False northing : 0 meter
False Easting : 500,000 meters
Scale factor at the central meridian : 0.9999
Zone number : 44N (N-N Zone)
Spheroid : Everest

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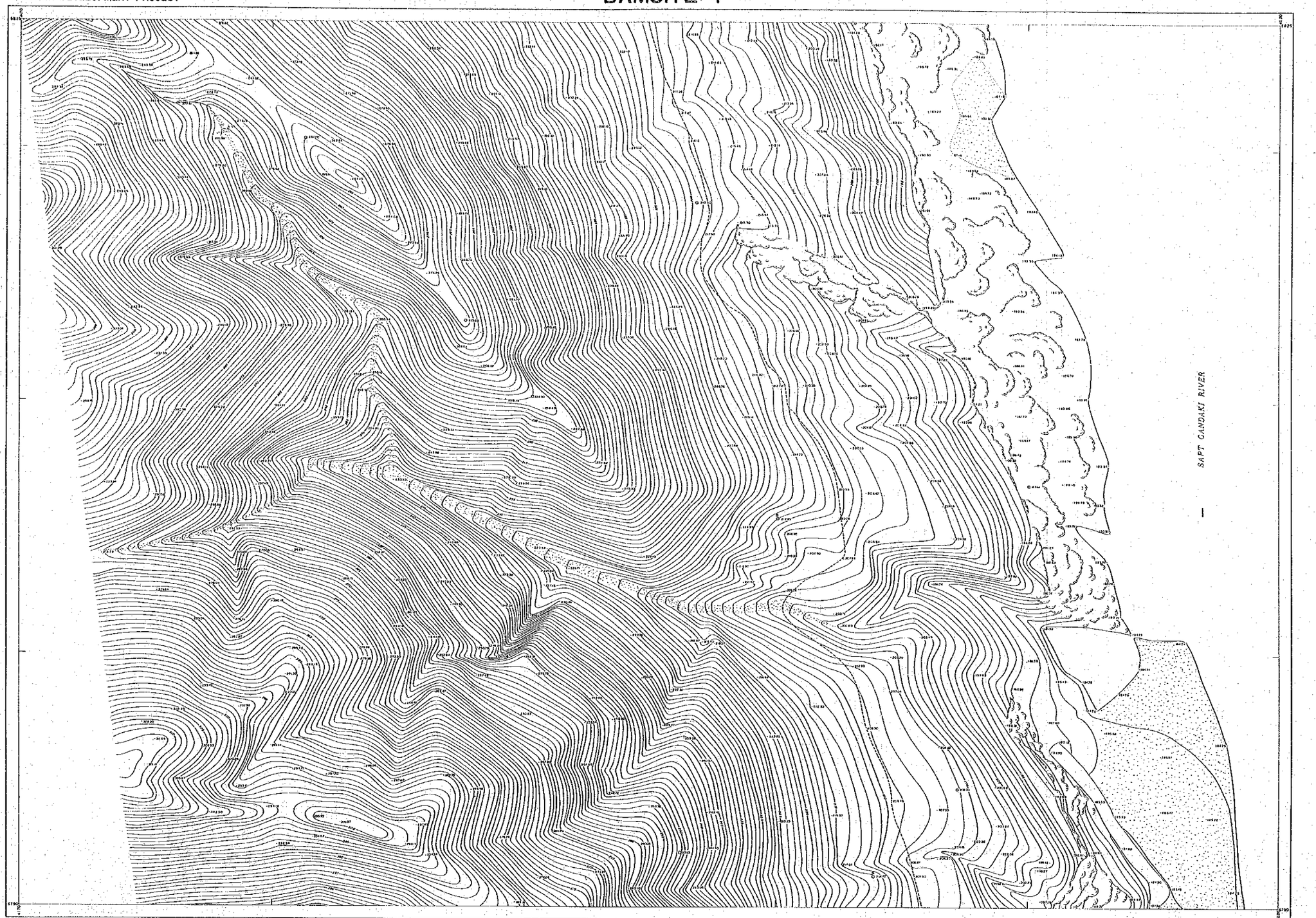
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT

DAMSITE 4



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LEGEND

SCALE 1:5000

CONTOUR INTERVAL 5 METRES

UNIVERSAL TRANSVERSE MERCATOR PROJECTION

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SAPT GANDAKI HYDROELECTRIC
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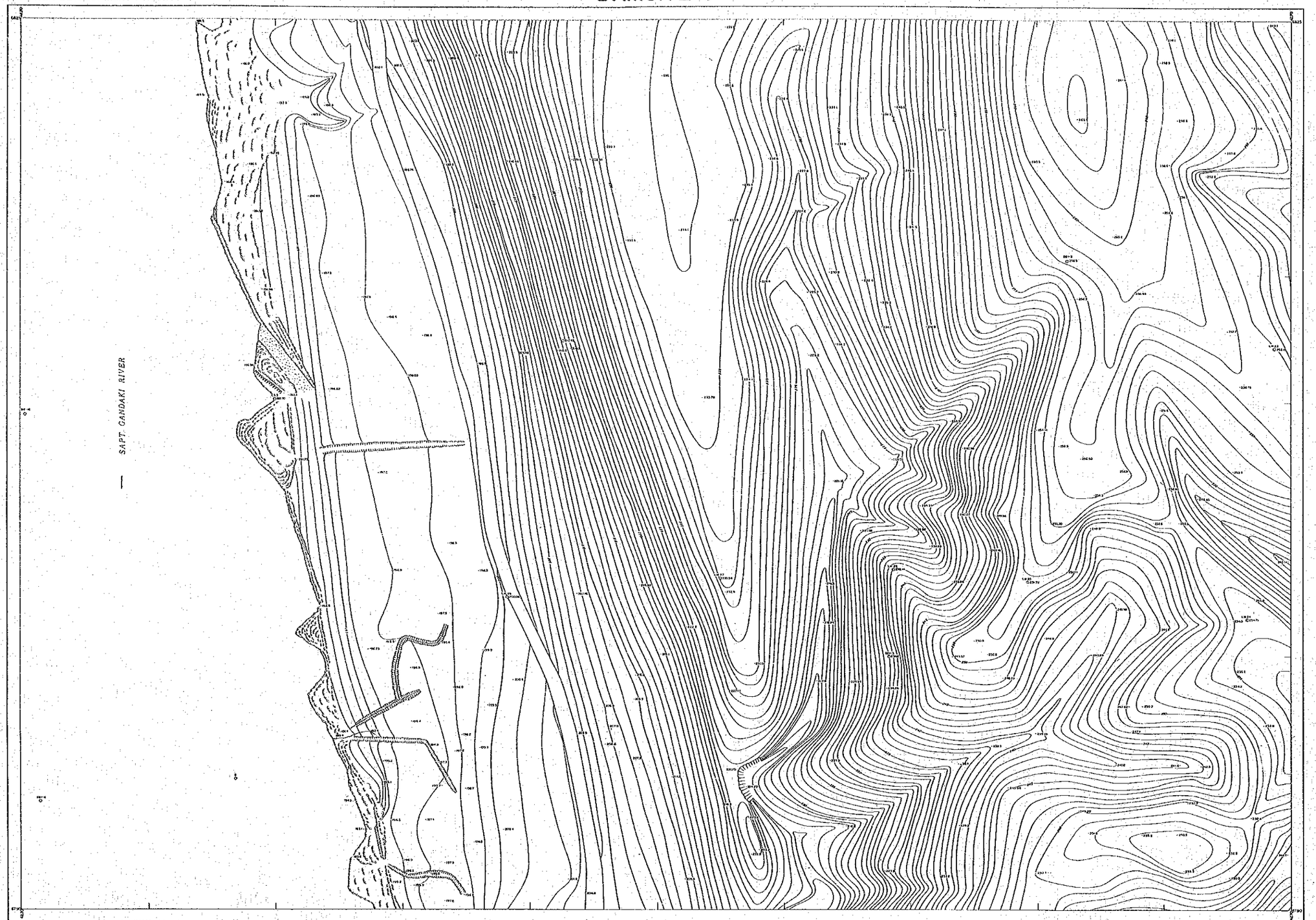
DAMSITE 5



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Agency for the purpose of Sapt Gandaki Hydroelectric
Power Development Project Feasibility Study.

LEGEND

Control station (BM)	⊡	River Stream		Slopes	
Spot Elevations	+ 619	Flow Arrow		Broad Leaf	
Formed Road		Cutting		Grass	
Trail		Embankment		Fields	
Buildings		Depression			
Bridges		Cliff			
Ferry		Bare rock			
		Sand			

SCALE 1:500

CONTOUR INTERVAL 1 METRES

UNIVERSAL TRANSVERSE MERCATOR PROJECTION

Longitude of origin : Central meridian 84°East
Latitude of origin : 0° (Equator)
False easting : 10 meter
False Northing : 2,500,000 meters
Scale Factor at the central meridian : 0.9995
Zone number : 44 S (44 Zone)
Sphe'oid : Everest

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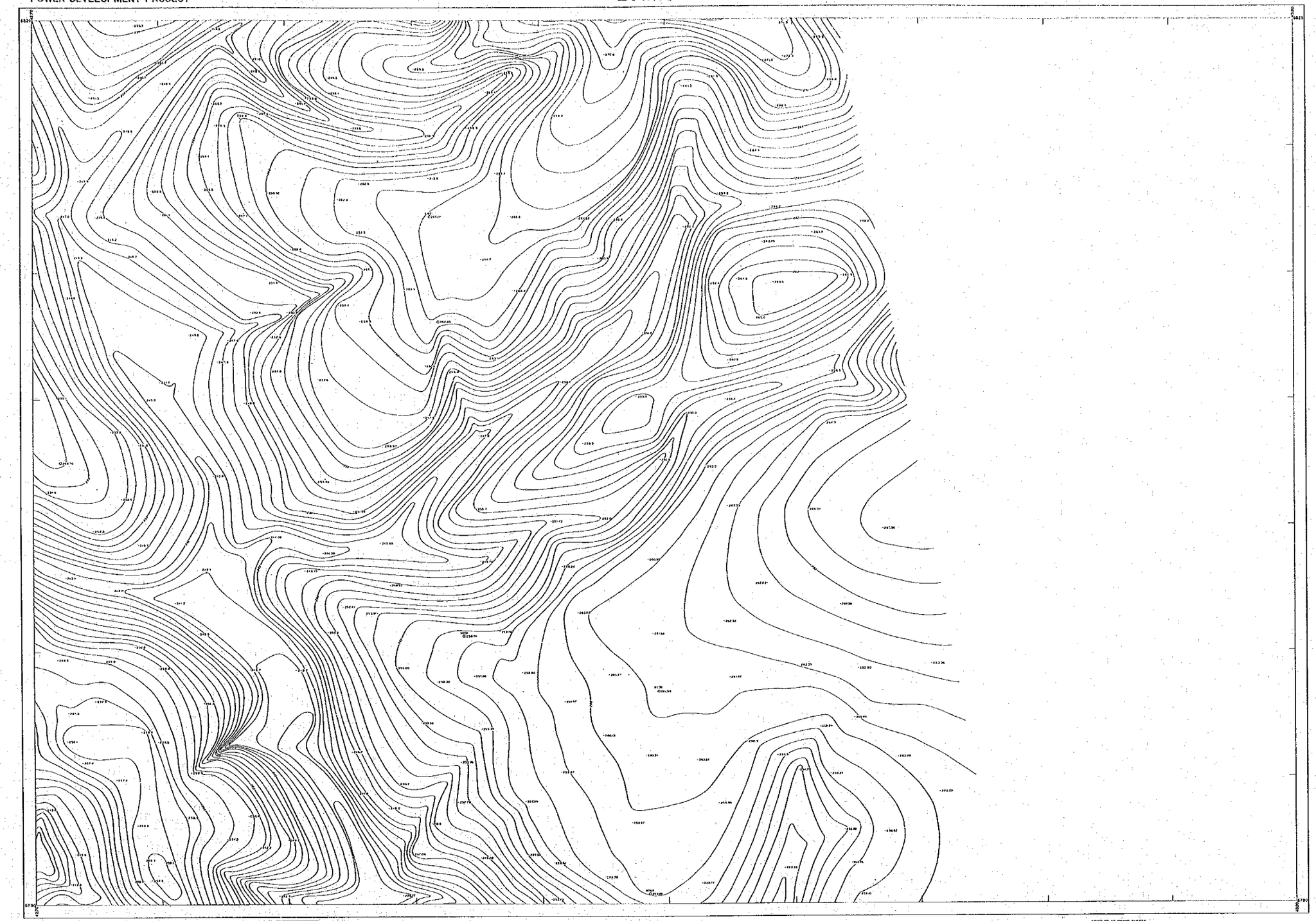
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT

DAMSITE 6



Mapped by Japan International Corporation
Agency for the purpose of Sapt Gandaki Hydroelectric
Power Development Project Feasibility Study.

LEGEND

Control station (BM's)	⊡	River Stream		Slope	
Spot Elevations	419	Flow Arrow		Broad Leaf	
Formed Roads		Cutting		Grass	
Trail		Embankment		Fields	
Buildings		Depression			
Bridges		Cliff			
Ferry		Bare rock			
		Sand			

SCALE 1:500

CONTOUR INTERVAL 1 METRES

UNIVERSAL TRANSVERSE MERCATOR PROJECTION

Longitude of origin : Central meridian 84°East
Latitude of origin : 0° (Equator)
False northing : 0 meter
False Easting : 500,000 meters
Scale factor at the central meridian : 0.9996
Zone number : 44 E Grid Zone
Spheroid : Everest

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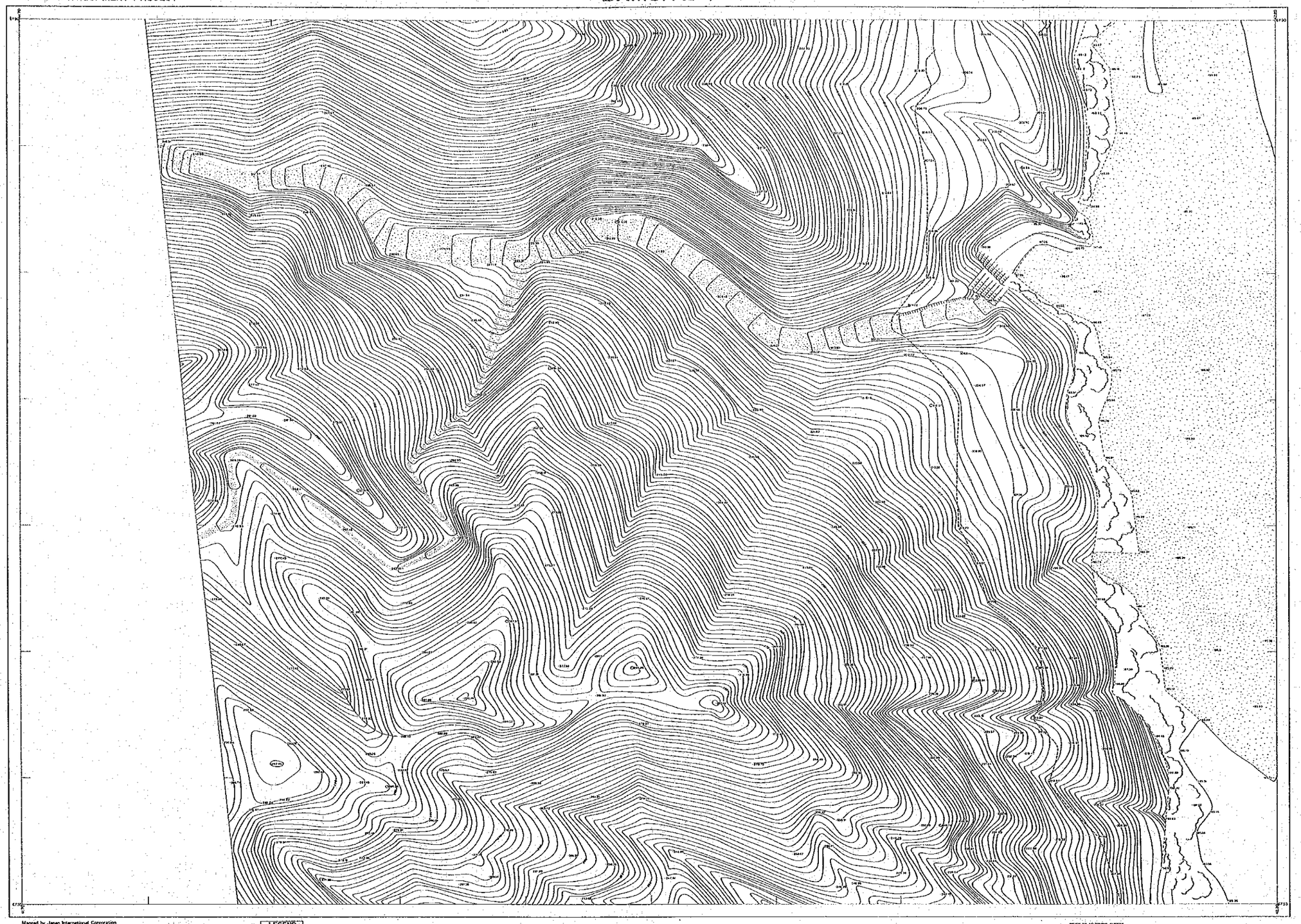
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT

DAMSITE 7



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Power Development Project Feasibility Study

LEGEND

Control station (BMs)	⊡	River Stream		Slopes	
Spot Elevations	+918	Flow Arrow		Broad Leaf	
Formed Roads		Cutting		Grass	
Trail		Embankment		Fields	
Buildings		Depression			
Bridges		Cliff			
Ferry		Bare rock			
		Sand			

SCALE 1:500

CONTOUR INTERVAL 1 METRES

UNIVERSAL TRANSVERSE MERCATOL PROJECTION

Longitude of origin	: Central meridian 84°East
Latitude of origin	: 0° (Equator)
False northing	: 0 meter
False Easting	: 500,000 meters
Scale factor on the central meridian	: 0.9999
Zone number	: 44 S Grid Zone
Spheroid	: Everest

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