JAPAN INTERNATIONAL COOPERATION AGENCY

DEPARTMENT OF IRRIGATION
MINISTRY OF WATER RESOURCES
THE KINGDOM OF NEPAL

THE STUDY
ON
FLOOD MITIGATION PLAN
FOR
SELECTED RIVERS IN THE TERAI PLAIN
IN
THE KINGDOM OF NEPAL

FINAL REPORT

VOLUME IV

DATA BOOK

MAY 1999

NIKKEN Consultants, Inc.
NIPPON KOEI CO., LTD.

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FINAL REPORT

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The costs are estimated based on the price and average exchange rate in October 1998.

The average exchange rate is as follows:

US$ 1.00=NRs.67.93

¥ 1.00 =NRs.0.59

DATA BOOK

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ON

RIVERBED MATERIAL INVESTIGATION

FOR

THE STUDY ON FLOOD MITIGATION PLAN

FOR

SELECTED RIVERS IN THE TERAI PLAIN

IN

THE KINGDOM OF NEPAL

March 1998

MEH Consultants (P) Ltd, Kathmandu

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INTRODUCTION

Introduction

This report is being presented as per the contract between JICA Study team and MEH Consultants (P) Ltd. as a part of "The Study on Flood Mitigation Plan for Selected Rivers in the Terai Plain in The Kingdom of Nepal". The main objectives of the contract were the "The Investigation of River and River Basin Conditions" and Investigation on Riverbed Material. The study area covered the selected eight rivers in the Terai Plain in The Kingdom of Nepal, namely, Ratuwa, Lohendra, Lakhandehi, Narayani of the eastern belt and Tinau, West Rapti, Babai and Khutiya of the western belt.

The Investigation of River and River Basin Conditions included the investigation of river facilities for flood mitigation, riverbank protection, irrigation and other purposes. The investigation in detail included their GPS location, existing condition, type of structure and damaged conditions with required photographs. These are compiled in separate volumes for each river and are submitted along with this report.

The Investigation on Riverbed Material included the GPS location of the sample site, outdoor grain size analysis, laboratory tests for indoor grain size analysis and specific gravity tests. The reports on results of Outdoor Grain Size Analysis, Indoor Grain Size Analysis, Specific Gravity tests along with the photographs are compiled in separate volumes for each river and are submitted along with this report. Altogether 121 samples were collected from the selected eight rivers for this study. The details of these are tabulated below:

SN	Name of River	Code	District	No. of Samples
1	Ratuwa	Ra	Jhapa	13
2	Lohendra	Lo	Morang	13
3	Lakhandehi	La	Sarlahi	13
4	Narayani	Na	Chitwan/Nawalparasi	22+1(extra)
5	Tinau	Ti	Rupandehi	13
6	West Rapti	WR	Banke/Dang	23
7	Babai	Ba	Banke	13
8	Khutiya	Kh	Kailali	10

In addition to these, all necessary relevant data including the District rates were collected from various district offices and are submitted with this report.

Methodology

To fulfill the set objective as stated in the TOR, proven standard methodologies have been followed during the investigation process. The brief outline of the investigation work comprised of:

- Investigation on Riverbed Material
  - Out door grain size analysis

- Indoor grain size analysis
- Specific gravity test

The procedures for each of the work is described in brief in the following subsequent paragraphs.

Procedure for Outdoor Grain Size Analysis

- Locate the Sampling Site near the shore where riverbed materials are exposed out of water.
- From the Sampling Site, take a photo of river channel for its upstream and downstream views.
- After removing the surface materials by about 30 cm, take a photo of the sampling spot **with scale to show the grain size.**
- Take out bed materials upto 80 cm deep (50 cm more) for a pit so that the quantity of materials taken out are as follows according to the grain size:

Grain Size (mm)	Materials to be taken out (kg)	Quantity of materials for sampling (kg)	Remarks
Less than 10	4	1	Indoor Analysis
10 to 20	20	5	Outdoor Analysis
20 to 40	60	15	Outdoor Analysis
40 to 60	80	20	Outdoor Analysis
60 to 80	120	30	Outdoor Analysis
More than 80	140	35	Outdoor Analysis

- Spread the clean vinyl sheet over the ground and place the materials taken out and mix well.
- Take a quarter of sample for Grain Size Analysis.
- If the maximum grain size is smaller than 10 mm, place 1 kg of sample for Indoor Sieve Analysis and Specific Gravity Test with the identification of site and tie it well.
- If the maximum grain size is larger than 10 mm, let the sample get dried up to surface dry conditions in the air.
- Weigh the sample to be placed in the sieve as indicated in the above table.
- Place the sample in the largest sieve with lid and receiver and shake gently.
- Weigh the weight of the materials remained on the sieve and the receiver.
- Repeat steps 9 to 11 with the remaining sieves. (Sieve upto 9.52 mm)
- Place around 1 kg of the remaining sample for Indoor Sieve Analysis in the sampling bag with the identification tag and tie it well.

Procedure for Indoor Grain Size Analysis

- The sample that was brought from the site is weighed to 1 kg
- The sample is placed on a sieve of the largest opening on a set of sieves ranging from 9.50 mm to 75μmm.

- The set of sieves is then placed in a sieve shaker and shaked for 10 minutes.
- The set of sieves is then removed from the sieve shaker and sieved manually for a couple of minutes.
- The residue on each sieve is placed on to a receiver pan individually and weighed.

Specific gravity of fine aggregate

- The specific gravity of the fine aggregate is the ratio of the unit weight of the sand to the unit weight of water.
- The sand sample had been immersed in clean water for 24 hours and dried to saturated and surface dry condition.
- A representative sample of the above saturated surface-dry material is obtained by a sample splitter. The sample is divided into approximately equal parts from which two samples are weighed having identical weight 500 grams. The weight of saturated and surface-dry sand is recorded as B.
- One sample is placed in an oven and dried to constant weight and the weight is recorded as A.
- The pycnometer is filled about three-quarters full of water and the saturated surface dry sand sample B is added. Entrapped air is removed by boiling the sample pycnometer by 15 minutes. The jar is then filled with water and cooling up to room temperature. The pycnometer is weighed and the weight recorded as W. The value of specific gravity of the sand had been calculated

$$\text{Specific gravity} = \frac{A}{W_c + B - W}$$

as:

Where,

W_c = weight of pycnometer filled with water at same temperature as water used in test.

W = weight of pycnometer with water and sample.

Apparatus required:

- Pycnometer of 500 ml capacity;
- Balance having a capacity of 2 kg and sensitivity 0.1 gm.
- Water bath.
- Sample splitter.
- Water storage jar of about 20 lit. capacity for maintaining the water at room temperature.
- Oven.

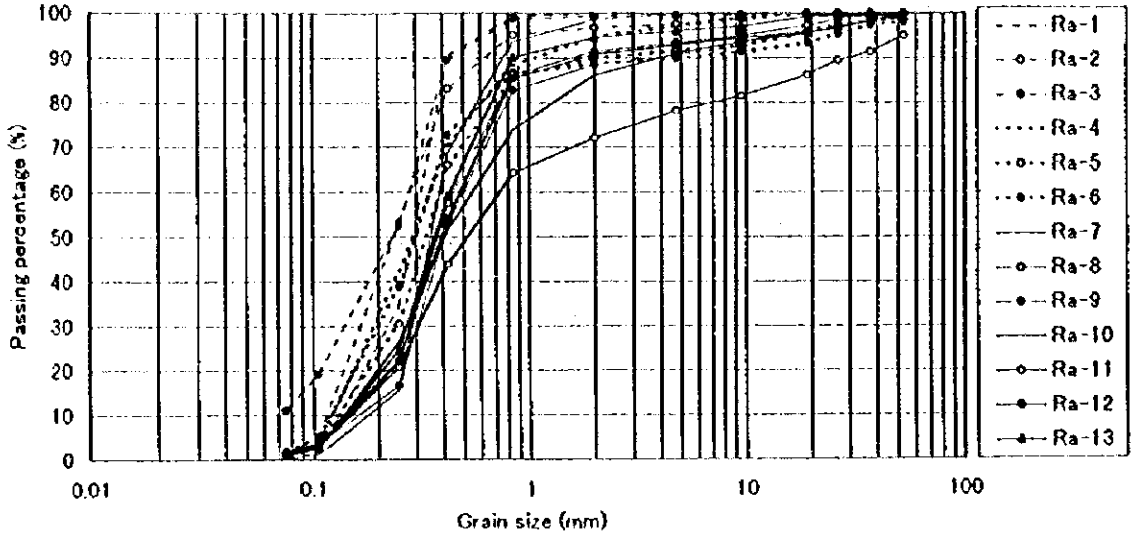
1. RATUWA RIVER

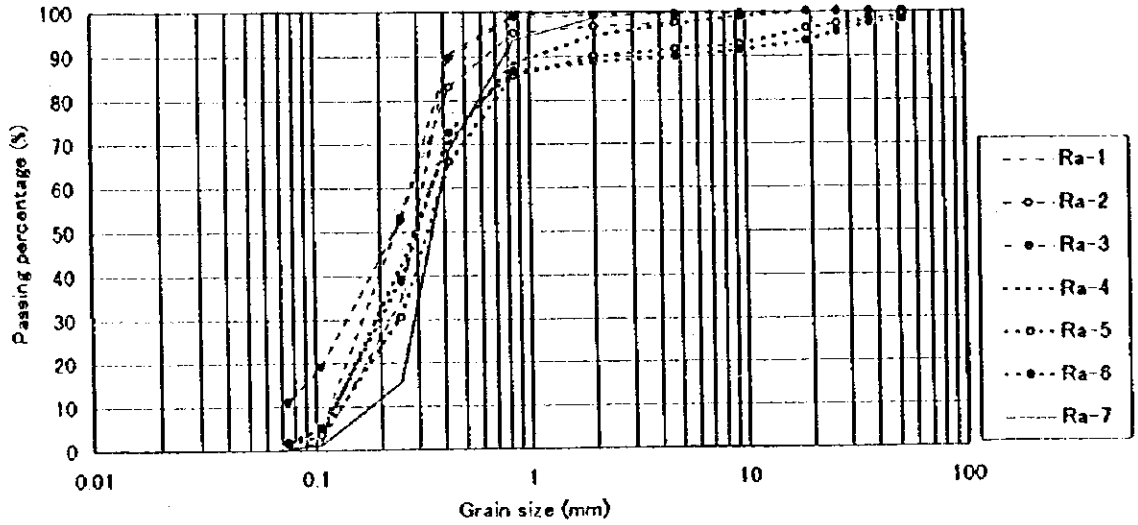
INVESTIGATION REPORT OF RIVERBED MATERIALS
SAMPLING DESCRIPTION

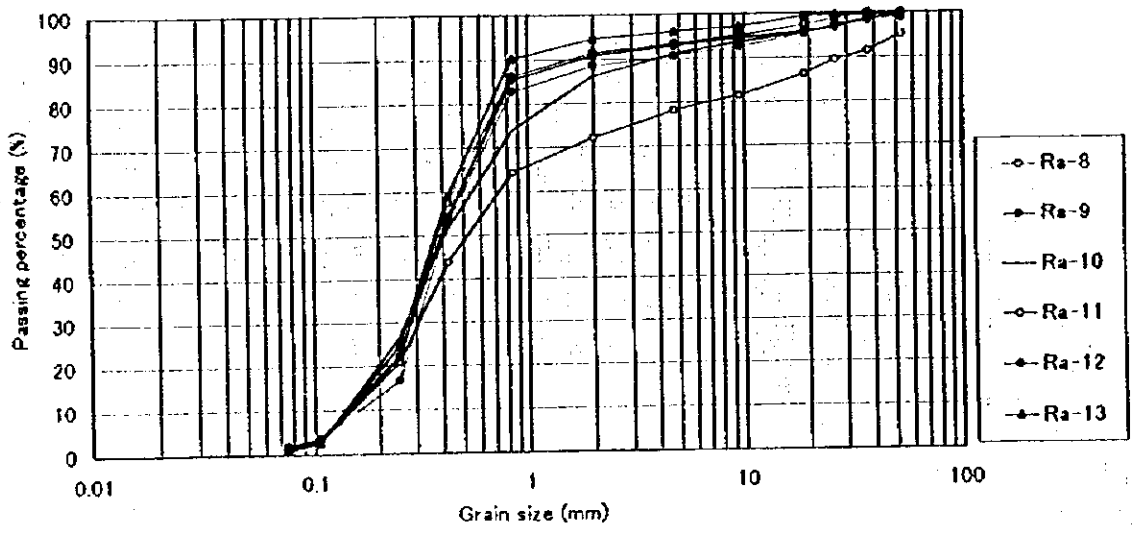
Ratuwa River

SN	Sample Code	Soil Classification by eye	Description of Sampling Place	GPS Reading		FGA (Y/N)	Remarks
				N	E		
1	Ra-1	Silty sand		26°27.476′	087°39.660′	N	
2	Ra-2	Silty sand	Sijuwa WN 3	26°29.471′	087°38.979′	N	
3	Ra-3	Silty sand	Itahara WN 9	26°30.845′	087°38.455′	N	
4	Ra-4	Silty sand	Itahara WN 8	26°33.730′	087°38.508′	N	
5	Ra-5	Boulder mixed sand	Damak Municipality WN 19, Setomadi	26°35.661′	087°39.547′	Y	
6	Ra-6	Boulder mixed sand	Damak Municipality WN 18, Dharane Tole	26°36.407′	087°40.413′	Y	
7	Ra-7	Silty sand	Damak Municipality WN 19, Parewadangi	26°36.094′	087°39.007′	N	
8	Ra-8	Gravel mixed sand	Damak Municipality WN 15	26°38.302′	087°41.187′	Y	
9	Ra-9	Gravel mixed sand	Damak Municipality WN 12	26°39.599′	087°42.517′	Y	
10	Ra-10	Boulder mixed sand	Damak Municipality WN 8	26°39.804′	087°38.747′	Y	
11	Ra-11	Boulder mixed sand	Damak Municipality WN 3	26°41.272′	087°42.725′	Y	
12	Ra-12	Gravel mixed sand	Barakothe WN 2	26°40.830′	087°44.505′	Y	
13	Ra-13	Gravel mixed sand	Barakothe WN 4	26°41.848′	087°45.670′	Y	

RATUWA RIVER







GRAIDING OF RIVERBED MATERIALS

Sample code	Cumulative percentage of passing materials (%)												dm(%) 65 (mm)	Specific gravity(g/cc)		
	<0.075 (mm)	<0.106 (mm)	<0.25 (mm)	<0.425 (mm)	<0.85 (mm)	<2 (mm)	<4.75 (mm)	<9.5 (mm)	<19 (mm)	<26.5 (mm)	<37.5 (mm)	<53 (mm)		S.G.1	S.G.2	Ave.
	0.075	0.106	0.250	0.425	0.850	2.00	4.75	9.50	19.0	26.5	37.5	53.0				
Ratuwa River																
Ra-1	0.3	1.7	34.3	90.4	99.2	99.8	100.0	100.0	100.0	100.0	100.0	100.0	0.35	2.59	2.59	2.59
Ra-2	1.5	4.9	53.0	83.0	95.1	96.7	97.5	98.8	100.0	100.0	100.0	100.0	0.32	2.65	2.68	2.67
Ra-3	11.0	19.1	52.5	89.5	98.7	99.3	99.4	99.6	100.0	100.0	100.0	100.0	0.31	2.67	2.66	2.67
Ra-4	1.2	3.7	42.2	70.5	88.3	94.7	97.3	99.1	100.0	100.0	100.0	100.0	0.39	2.68	2.66	2.67
Ra-5	1.4	3.5	30.5	65.9	85.6	89.9	91.7	92.7	96.3	97.3	98.1	99.3	0.42	2.63	2.67	2.65
Ra-6	1.7	5.1	38.7	72.5	86.6	88.7	89.9	91.4	93.4	95.4	97.4	98.1	0.39	2.59	2.60	2.60
Ra-7	0.3	1.1	15.7	68.7	93.6	98.6	99.8	100.0	100.0	100.0	100.0	100.0	0.41	2.65	2.63	2.64
Ra-8	1.1	2.4	22.1	57.5	86.2	91.4	93.4	95.0	97.3	98.7	100.0	100.0	0.54	2.63	2.63	2.63
Ra-9	1.2	3.6	16.7	52.9	82.6	88.4	90.6	92.5	95.3	97.3	98.7	98.7	0.60	2.63	2.65	2.64
Ra-10	0.8	2.5	26.4	51.6	73.8	86.0	91.0	93.5	95.6	96.6	98.6	99.3	0.68	2.66	2.68	2.67
Ra-11	1.3	2.8	20.7	43.8	64.3	72.0	78.1	81.3	86.2	89.4	91.4	95.0	0.95	2.65	2.68	2.67
Ra-12	1.7	3.3	22.1	54.1	85.3	90.7	92.8	94.5	95.8	96.8	98.3	100.0	0.57	2.66	2.65	2.66
Ra-13	1.1	2.5	24.6	59.1	90.2	94.5	96.0	97.1	99.3	99.4	99.4	100.0	0.51	2.60	2.59	2.60

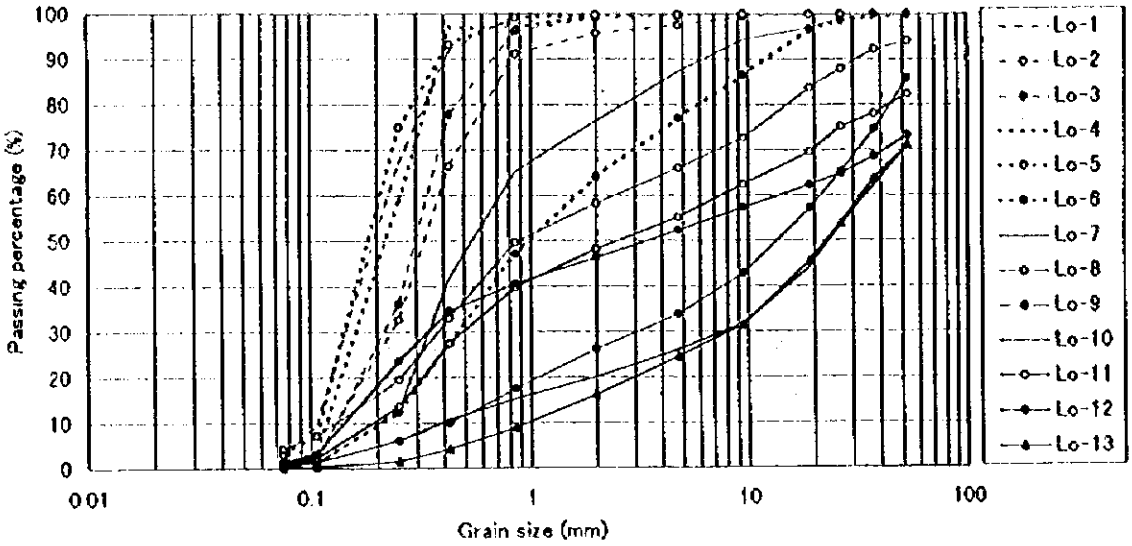
2. LOHANDRA RIVER

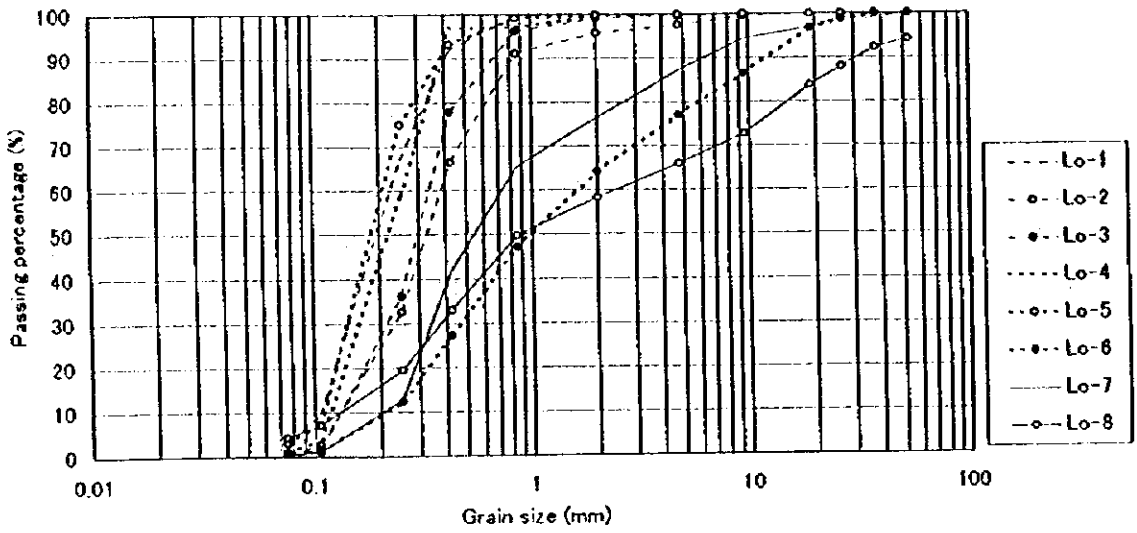
INVESTIGATION REPORT OF RIVERBED MATERIALS
SAMPLING DESCRIPTION

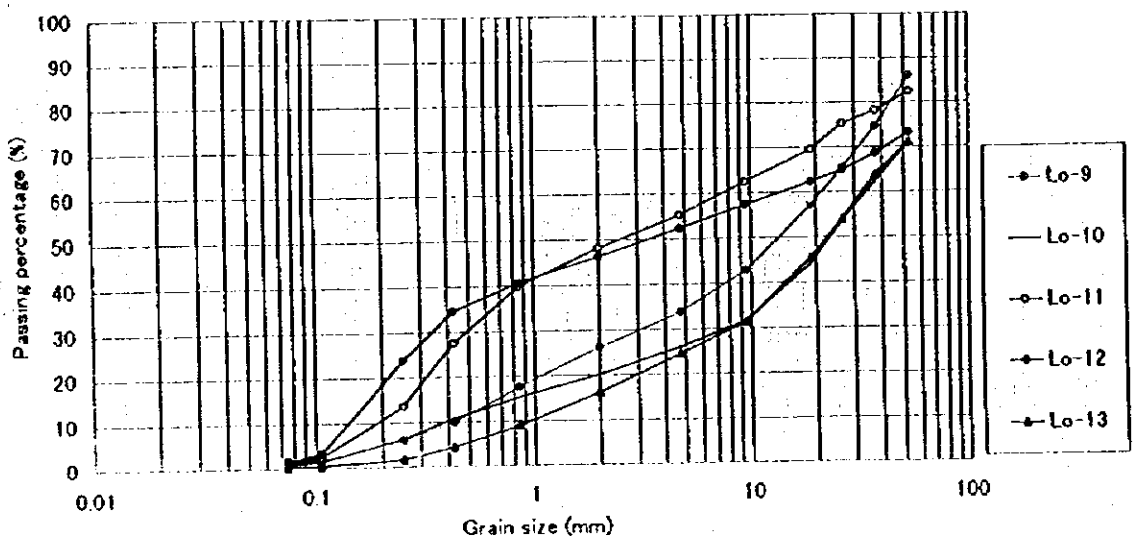
Lohendra River

SN	Sample Code	Soil Classification by eye	Description of Sampling Place	GPS Reading		FGA (Y/N)	Remarks
				N	E		
1	Lo-1	Silty sand	Majhare WN 7	26°24.467′	087°20.190′	N	
2	Lo-2	Silty sand	Siswani WN 8	26°26.669′	087°19.745′	N	
3	Lo-3	Silty sand	Lohendra WN 9, Naya Bazar	26°28.247′	087°21.416′	N	
4	Lo-4	Silty sand	Thalaha WN 8	26°29.465′	087°22.830′	N	
5	Lo-5	Silty sand	Thalaha WN 7, Hurhuriya	26°31.019′	087°23.999′	N	
6	Lo-6	Aggregate mixed sand	Motipur WN 2	26°33.274′	087°24.158′	Y	
7	Lo-7	Aggregate mixed sand	Near Chhatra Main Canal Syphon	26°35.478′	087°23.704′	Y	
8	Lo-8	Boulder mixed sand	Belbari WN 3, WN 5	26°37.753′	087°24.674′	Y	
9	Lo-9	Boulder mixed sand	Belbari	26°39.707′	087°24.739′	Y	
10	Lo-10	Boulder mixed sand	Kerabari WN 9	26°41.829′	087°25.586′	Y	
11	Lo-11	Boulder mixed sand	Bhaluwa WN 9	26°43.048′	087°26.462′	Y	
12	Lo-12	Boulder mixed sand		26°42.958′	087°26.401′	Y	
13	Lo-13	Boulder mixed sand	Letang WN 2	26°44.342′	087°29.953′	Y	

LOHANDRA RIVER







GRAIDING OF RIVERBED MATERIALS

Sample code	Cumulative percentage of passing materials (%)												dm(%) 65 (mm)	Specific gravity(g/cc)		
	<0.075 (mm)	<0.106 (mm)	<0.25 (mm)	<0.425 (mm)	<0.85 (mm)	<2 (mm)	<4.75 (mm)	<9.5 (mm)	<19 (mm)	<26.5 (mm)	<37.5 (mm)	<53 (mm)		S.G.1	S.G.2	Ave.
	0.075	0.106	0.250	0.425	0.850	2.00	4.75	9.50	19.0	26.5	37.5	53.0				
Lohandra River																
Lo-1	3.0	9.3	67.0	91.8	99.5	99.8	100.0	100.0	100.0	100.0	100.0	100.0	0.24	2.59	2.60	2.60
Lo-2	0.8	2.6	32.6	66.5	91.1	95.8	97.6	99.4	100.0	100.0	100.0	100.0	0.42	2.63	2.65	2.64
Lo-3	0.9	1.5	36.0	77.8	96.2	99.0	99.6	100.0	100.0	100.0	100.0	100.0	0.37	2.68	2.65	2.67
Lo-4	1.2	3.6	58.7	97.0	97.1	99.4	100.0	100.0	100.0	100.0	100.0	100.0	0.28	2.70	2.68	2.69
Lo-5	3.1	7.2	75.0	93.1	99.2	99.8	99.9	100.0	100.0	100.0	100.0	100.0	0.23	2.64	2.63	2.64
Lo-6	0.6	1.2	12.3	27.2	47.1	64.1	77.0	86.4	96.7	98.7	100.0	100.0	2.20	2.68	2.67	2.68
Lo-7	0.6	1.1	12.9	41.6	65.3	76.4	87.2	94.3	97.0	99.0	99.0	100.0	0.85	2.65	2.61	2.63
Lo-8	4.3	7.1	19.4	32.8	49.7	58.3	66.0	72.7	83.7	88.0	92.3	94.1	4.38	2.60	2.65	2.63
Lo-9	1.5	1.5	6.0	9.9	17.4	26.0	33.8	42.7	57.2	65.2	74.6	85.9	26.32	2.67	2.67	2.67
Lo-10	0.6	1.3	6.2	10.6	15.2	20.0	25.9	31.7	44.1	53.5	62.3	71.0	42.24	2.63	2.60	2.62
Lo-11	1.1	2.2	13.5	27.3	39.7	48.1	55.2	62.5	69.5	75.2	78.0	82.5	12.92	2.68	2.63	2.66
Lo-12	1.2	3.0	23.6	34.4	40.6	46.2	52.3	57.2	62.2	64.8	68.5	73.2	27.07	2.63	2.59	2.61
Lo-13	0.2	0.3	1.6	4.1	8.9	16.2	24.3	31.4	45.5	53.8	63.8	71.0	40.13	2.63	2.68	2.66

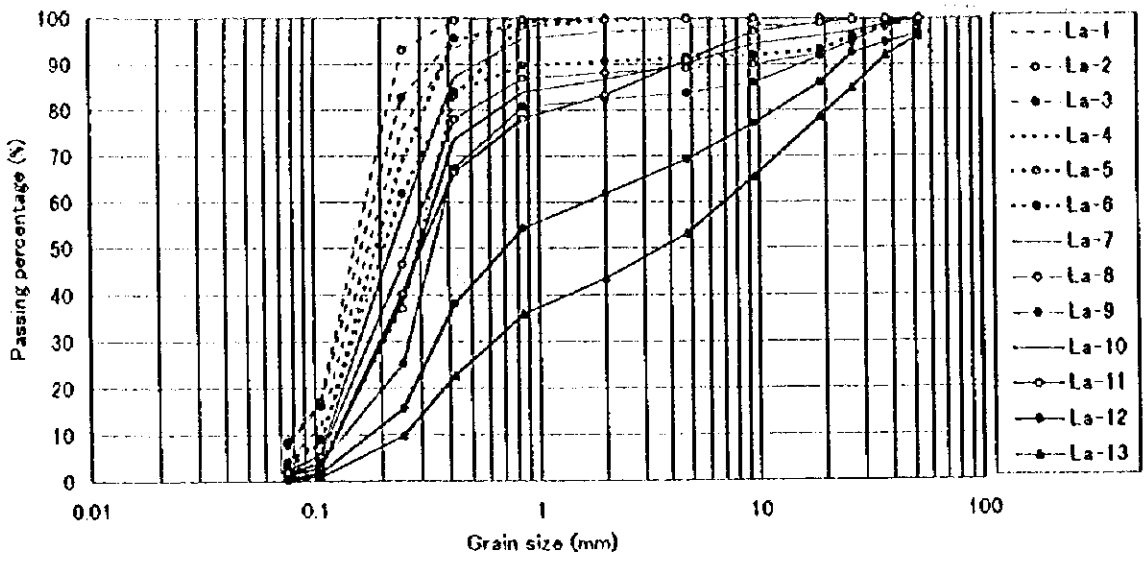
3. LAKHANDEI RIVER

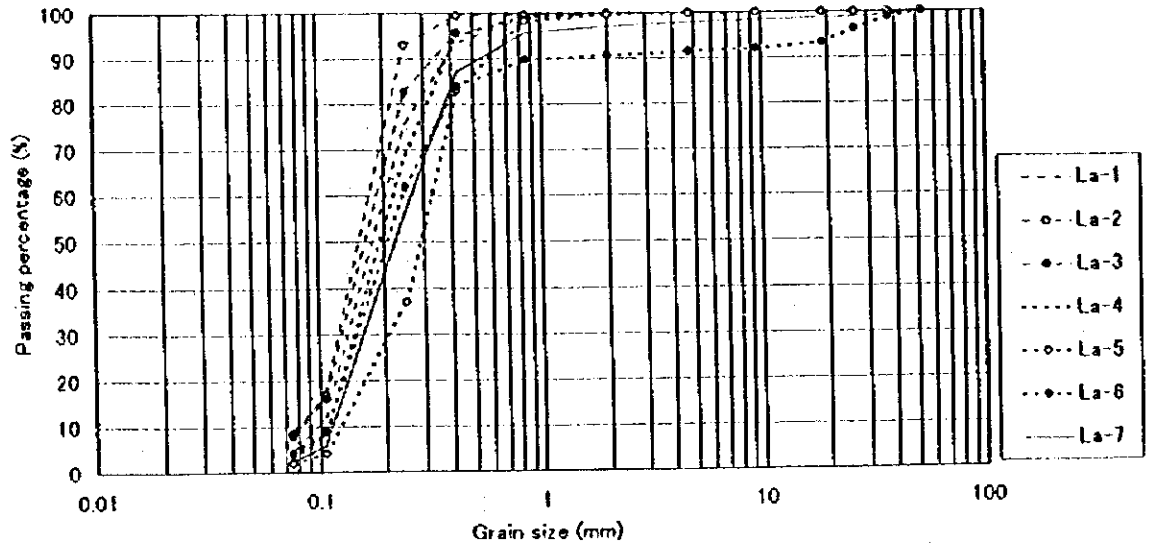
INVESTIGATION REPORT OF RIVERBED MATERIALS
SAMPLING DESCRIPTION

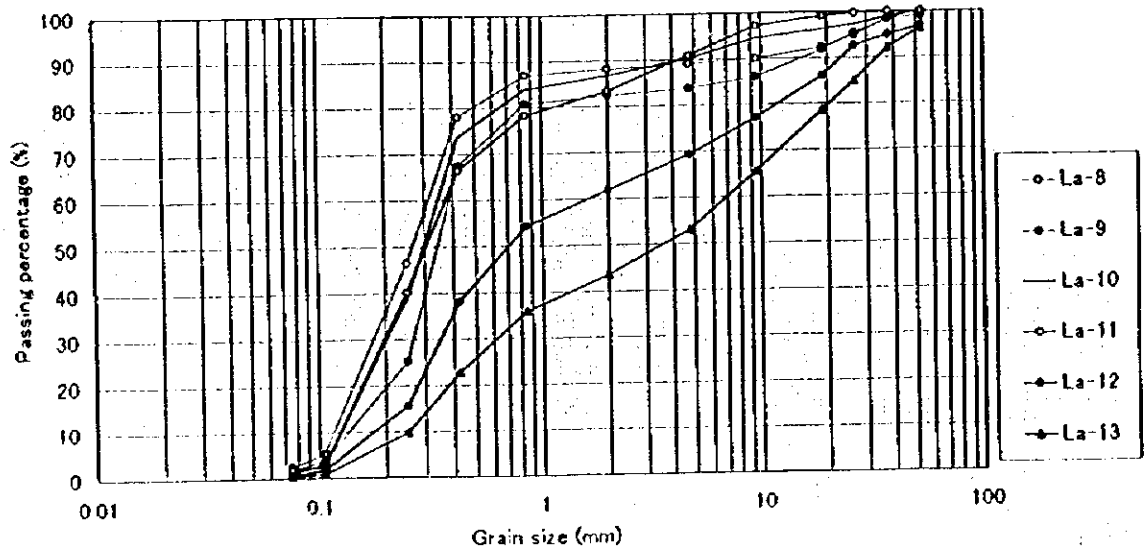
Lakhandehi River

SN	Sample Code	Soil Classification by eye	Description of Sampling Place	GPS Reading		FGA (Y/N)	Remarks
				N	E		
1	La-1	Silty sand	Near bridge on Hulaki road	26°51.776′	085°29.636′	N	
2	La-2	Silty sand	Sundarpur WN 9	26°53.259′	085°29.641′	N	
3	La-3	Silty sand	Padari WN 5	26°55.009′	085°30.026′	N	
4	La-4	Silty sand	Shreepur WN 1	26°57.020′	085°30.081′	N	
5	La-5	Silty sand	Hempur WN 5	26°58.005′	085°30.454′	N	
6	La-6	Gravel mixed sand	Pipariya WN 3	26°59.349′	085°31.589′	Y	
7	La-7	Gravel mixed sand		27°00.644′	085°33.094′	Y	
8	La-8	Gravel mixed sand	Haripur WN 8	27°01.377′	085°34.124′	Y	
9	La-9	Boulder mixed sand	Netragunj WN 4	27°02.953′	085°34.472′	Y	
10	La-10	Gravel mixed sand	Nawalpur WN 6	27°04.466′	085°34.240′	Y	
11	La-11	Gravel mixed sand	Sashapur WN 1	27°05.203′	085°34.558′	Y	
12	La-12	Boulder mixed sand	Nawalpur WN 9	27°04.683′	085°36.642′	Y	
13	La-13	Boulder mixed sand	Patharkot WN 5	27°05.069′	085°38.406′	Y	

LAKHANDEI RIVER







GRAIDING OF RIVERBED MATERIALS

Sample code	Cumulative percentage of passing materials (%)												dm(%) 65 (mm)	Specific gravity(g/cc)		
	<0.075 (mm)	<0.106 (mm)	<0.25 (mm)	<0.425 (mm)	<0.85 (mm)	<2 (mm)	<4.75 (mm)	<9.5 (mm)	<19 (mm)	<26.5 (mm)	<37.5 (mm)	<53 (mm)		S.G.1	S.G.2	Ave.
	0.075	0.106	0.250	0.425	0.850	2.00	4.75	9.50	19.0	26.5	37.5	53.0				
Lakhandei River																
La-1	4.4	11.6	75.6	93.6	98.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	0.23	2.65	2.63	2.64
La-2	8.3	16.8	92.9	99.4	99.6	99.8	100.0	100.0	100.0	100.0	100.0	100.0	0.20	2.63	2.66	2.65
La-3	7.7	15.9	82.5	95.7	98.3	99.9	99.9	100.0	100.0	100.0	100.0	100.0	0.21	2.63	2.67	2.65
La-4	2.9	8.5	68.8	95.0	99.3	99.7	99.9	100.0	100.0	100.0	100.0	100.0	0.24	2.67	2.63	2.65
La-5	2.0	4.0	37.0	83.1	98.2	99.6	99.8	100.0	100.0	100.0	100.0	100.0	0.36	2.69	2.65	2.67
La-6	4.0	8.8	61.8	84.0	89.7	90.7	91.5	92.0	93.3	96.3	98.8	100.0	0.28	2.61	2.58	2.60
La-7	2.3	5.8	56.6	87.2	95.7	97.1	97.8	98.3	98.7	98.9	99.4	100.0	0.30	2.59	2.63	2.61
La-8	2.4	5.2	46.4	77.9	86.9	88.2	89.0	90.0	92.3	94.9	98.5	98.9	0.35	2.63	2.60	2.62
La-9	2.0	3.7	25.2	67.3	80.8	82.3	83.6	86.0	91.7	95.4	98.3	99.1	0.42	2.68	2.70	2.69
La-10	1.2	3.0	38.5	73.5	83.8	86.6	90.1	94.5	96.3	97.3	98.8	100.0	0.38	2.63	2.68	2.66
La-11	1.7	2.6	40.1	66.4	78.2	83.3	90.9	97.2	99.0	99.7	100.0	100.0	0.42	2.63	2.65	2.64
La-12	0.6	1.8	15.5	38.0	54.2	61.8	69.2	77.0	86.0	92.6	94.9	96.7	3.19	2.66	2.69	2.68
La-13	0.4	0.8	9.7	22.7	35.8	43.4	53.0	65.4	78.6	84.9	92.0	96.3	9.34	2.59	2.63	2.61

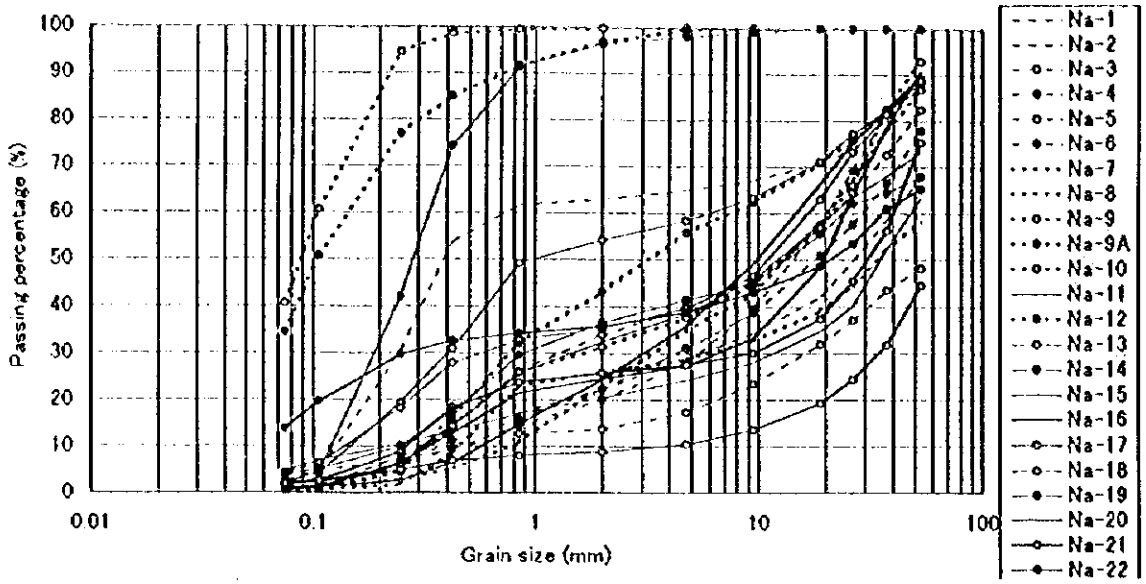
4. NARAYANI RIVER

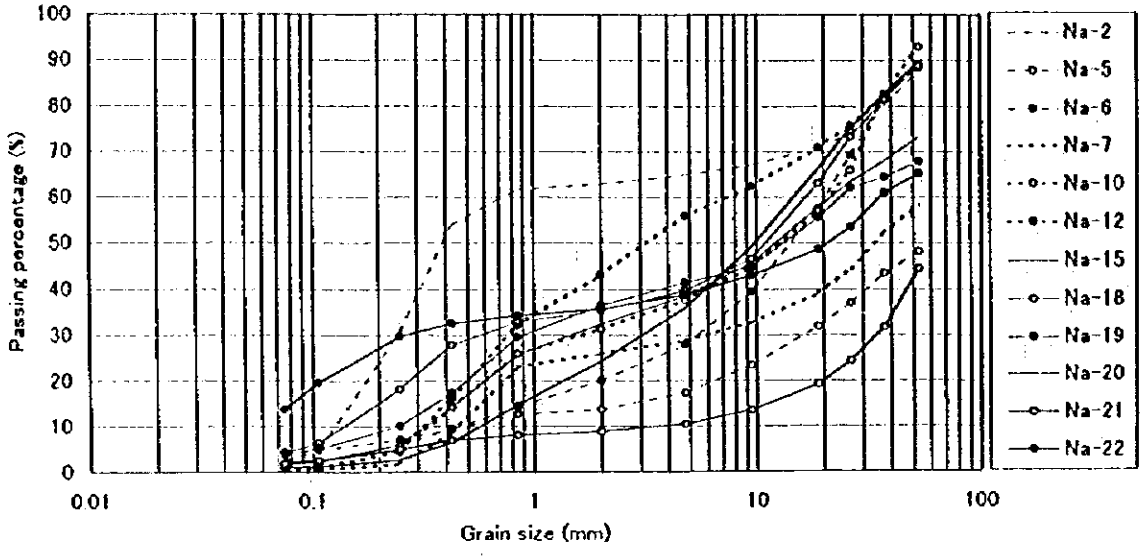
INVESTIGATION REPORT OF RIVERBED MATERIALS
SAMPLING DESCRIPTION

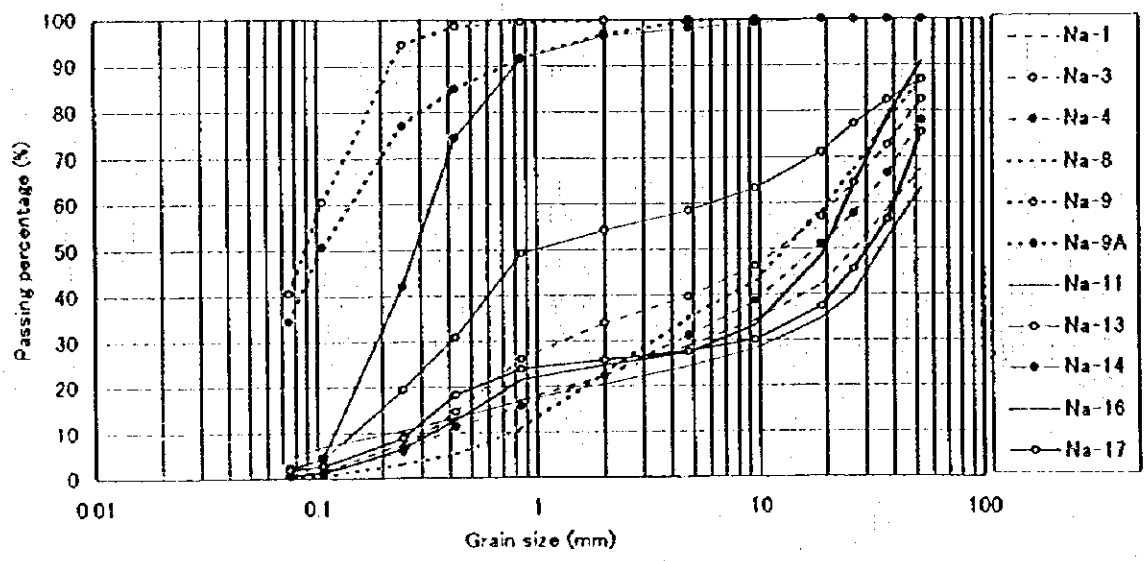
Narayani River

SN	Sample Code	Soil Classification by eye	Description of Sampling Place	GPS Reading		FGA (Y/N)	Remarks
				N	E		
1	Na-1	Boulder mixed sand	Dumkibas WN 6	27°34.057′	083°53.203′	Y	
2	Na-2	Boulder mixed sand	Naya Belani WN 2	27°32.802′	083°56.756′	Y	
3	Na-3	Boulder mixed sand	Belani WN 8	27°36.882′	084°57.428′	Y	
4	Na-4	Boulder mixed sand	Tamasaria WN 7	27°36.943′	084°00.971′	Y	
5	Na-5	Boulder mixed sand	Narayani WN 3	27°33.274′	084°00.607′	Y	
6	Na-6	Boulder mixed sand	Kumarwarti	27°33.126′	084°06.017′	Y	
7	Na-7	Boulder mixed sand	Kumarwarti, Amaltari	27°33.229′	084°06.008′	Y	
8	Na-8	Boulder mixed sand	Agauli WN 9	27°37.427′	084°06.189′	Y	
9	Na-9	Silty sand	Kawaswoti WN 1	27°36.771′	084°90.421′	N	
9a	Na-9a	Silty sand	Kawaswoti WN 1	27°37.055′	084°09.001′	N	
10	Na-10	Boulder mixed sand		27°34.442′	084°10.186′	Y	
11	Na-11	Boulder mixed sand		27°33.848′	084°11.643′	Y	
12	Na-12	Boulder mixed sand		27°36.781′	084°13.507′	Y	
13	Na-13	Boulder mixed sand	Pithauli	27°38.547′	084°10.964′	Y	
14	Na-14	Silty sand	Rajaur WN 2	27°39.762′	084°14.094′	N	
15	Na-15	Boulder mixed sand		27°38.502′	084°16.296′	Y	
16	Na-16	Boulder mixed sand		27°33.686′	084°16.241′	Y	
17	Na-17	Boulder mixed sand		27°34.023′	084°21.434′	Y	
18	Na-18	Boulder mixed sand	Mangalpur WN 8, Magargaon	27°40.403′	084°18.882′	Y	
19	Na-19	Boulder mixed sand	Mukundpur WN 8	27°41.016′	084°18.578′	Y	
20	Na-20	Boulder mixed sand	Gaindakot WN 5,	27°42.239′	084°21.823′	Y	
21	Na-21	Boulder mixed sand	Mangalpur WN 5, Barampur	27°41.694′	084°21.663′	Y	
22	Na-22	Boulder mixed sand	Near highway bridge	27°42.074′	084°25.259′	Y	

NARAYANI RIVER







GRAIDING OF RIVERBED MATERIALS

Sample code	Cumulative percentage of passing materials (%)												dm(%) 65 (mm)	Specific gravity(g/cc)		
	<0.075 (mm)	<0.106 (mm)	<0.25 (mm)	<0.425 (mm)	<0.85 (mm)	<2 (mm)	<4.75 (mm)	<9.5 (mm)	<19 (mm)	<26.5 (mm)	<37.5 (mm)	<53 (mm)		S.G.1	S.G.2	Ave.
	0.075	0.106	0.250	0.425	0.850	2.00	4.75	9.50	19.0	26.5	37.5	53.0				
Narayani River																
Na-1	0.8	1.7	7.6	13.3	17.0	22.1	28.7	34.3	41.9	49.6	58.5	67.5	48.66	2.61	2.65	2.63
Na-2	2.4	4.8	30.3	53.8	61.7	62.8	64.9	67.0	70.9	73.8	80.3	87.6	4.93	2.68	2.63	2.66
Na-3	0.4	0.9	6.4	14.5	25.9	33.9	39.5	46.2	56.9	64.3	72.6	82.5	27.38	2.68	2.68	2.68
Na-4	0.4	1.0	5.8	11.2	15.6	22.1	31.0	38.5	51.0	57.6	66.4	77.9	35.73	2.68	2.70	2.69
Na-5	1.4	2.4	5.8	9.5	12.5	13.7	17.3	23.4	31.8	36.9	43.5	48.2	58.40	2.66	2.65	2.66
Na-6	3.8	4.9	7.0	9.4	14.3	20.0	27.8	39.4	57.5	69.2	82.0	88.4	23.82	2.69	2.70	2.70
Na-7	0.5	0.7	1.7	8.5	23.0	25.8	28.7	32.8	38.9	44.4	52.1	58.5	54.73	2.59	2.63	2.61
Na-8	0.3	0.6	2.9	5.3	10.7	22.6	34.8	42.9	58.2	67.4	78.0	86.7	24.55	2.68	2.63	2.66
Na-9	40.5	60.6	94.6	98.7	99.5	99.9	100.0	100.0	100.0	100.0	100.0	100.0	0.12	2.65	2.63	2.64
Na-9A	34.3	50.8	77.0	85.0	91.6	96.9	99.7	100.0	100.0	100.0	100.0	100.0	0.18	2.68	2.63	2.66
Na-10	0.7	1.1	4.5	14.2	25.8	31.4	37.7	44.8	56.9	66.0	82.6	93.0	25.64	2.68	2.65	2.67
Na-11	4.6	7.0	10.4	13.2	16.9	20.3	24.2	28.0	34.7	40.1	52.4	63.3	53.41	2.64	2.61	2.63
Na-12	0.5	0.8	4.7	16.2	32.0	43.1	55.8	62.4	70.8	75.7	82.0	89.0	12.45	2.63	2.65	2.64
Na-13	2.3	4.3	19.3	30.9	49.1	54.3	58.4	63.3	71.2	77.2	82.3	86.7	11.51	2.65	2.68	2.67
Na-14	1.7	4.6	42.0	74.4	91.4	96.5	98.1	99.2	100.0	100.0	100.0	100.0	0.37	2.59	2.63	2.61
Na-15	2.1	2.5	5.8	14.4	25.5	32.4	38.5	45.6	57.8	63.5	68.0	73.3	30.16	2.68	2.65	2.67
Na-16	0.7	1.3	6.4	12.7	21.3	24.5	27.1	33.2	48.4	63.9	78.5	90.7	27.29	2.59	2.61	2.60
Na-17	1.8	2.7	8.8	18.2	23.6	25.7	27.4	30.0	37.3	45.4	56.3	75.3	44.61	2.63	2.59	2.61
Na-18	4.2	6.3	18.0	27.8	32.8	35.3	39.7	46.6	63.0	73.3	81.6	88.9	20.46	2.68	2.63	2.66
Na-19	3.9	5.1	10.0	17.3	29.5	36.5	41.4	44.8	55.5	62.1	64.3	67.9	40.38	2.68	2.70	2.69
Na-20	0.9	1.3	2.6	6.4	14.5	24.1	35.8	49.1	66.3	75.1	82.6	89.6	18.29	2.65	2.68	2.67
Na-21	1.8	2.4	4.9	6.9	8.0	8.8	10.4	13.5	19.1	24.3	31.7	44.4	60.18	2.63	2.58	2.61
Na-22	13.6	19.5	29.6	32.5	34.1	35.6	38.8	42.9	48.6	53.4	61.0	65.1	52.47	2.58	2.61	2.60

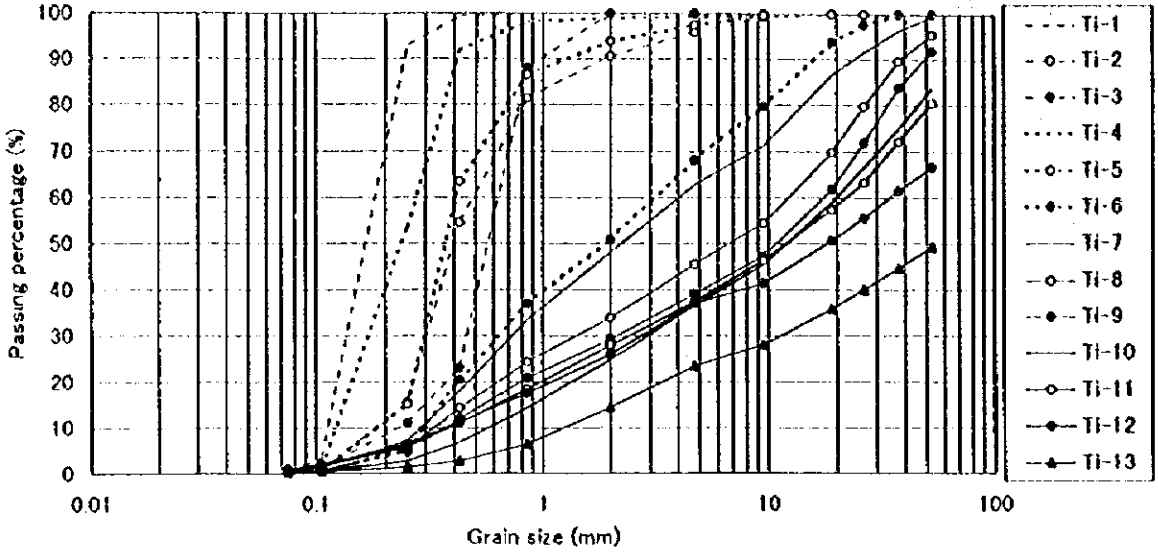
5. TINAU RIVER

INVESTIGATION REPORT OF RIVERBED MATERIALS
SAMPLING DESCRIPTION

Tinau River

SN	Sample code	Soil classification by eye	Description of sampling place	GPS Reading		FGA (Y/N)
				N	E	
1	Ti-1	Silt		27° 42.413′	83° 27.762′	N
2	Ti-2	Medium sand		27° 28.377′	83° 20.735′	N
3	Ti-3	Silty sand		27° 28.088′	83° 19.987′	N
4	Ti-4	Fine sand		27° 29.452′	83° 22.082′	N
5	Ti-5	Coarse to medium sand		27° 30.856′	83° 24.047′	N
6	Ti-6	Gravel mixed gravel		27° 32.599′	83° 25.746′	Y
7	Ti-7	Mixed gravel		27° 34.341′	83° 25.125′	Y
8	Ti-8	Mixed gravel		27° 36.618′	83° 25.897′	Y
9	Ti-9	Mixed gravel		27° 37.876′	83° 26.602′	Y
10	Ti-10	Mixed gravel		27° 41.058′	83° 27.165′	Y
11	Ti-11	Mixed gravel		27° 41.058′	83° 27.165′	Y
12	Ti-12	Mixed gravel		27° 41.534′	83° 27.223′	Y
13	Ti-13	Coarse Aggregate		27° 42.467′	83° 27.824′	Y

TINAU RIVER


Passing percentage (%)
Grain size (mm)
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1
10
100
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Ti-2
Ti-3
Ti-4
Ti-5
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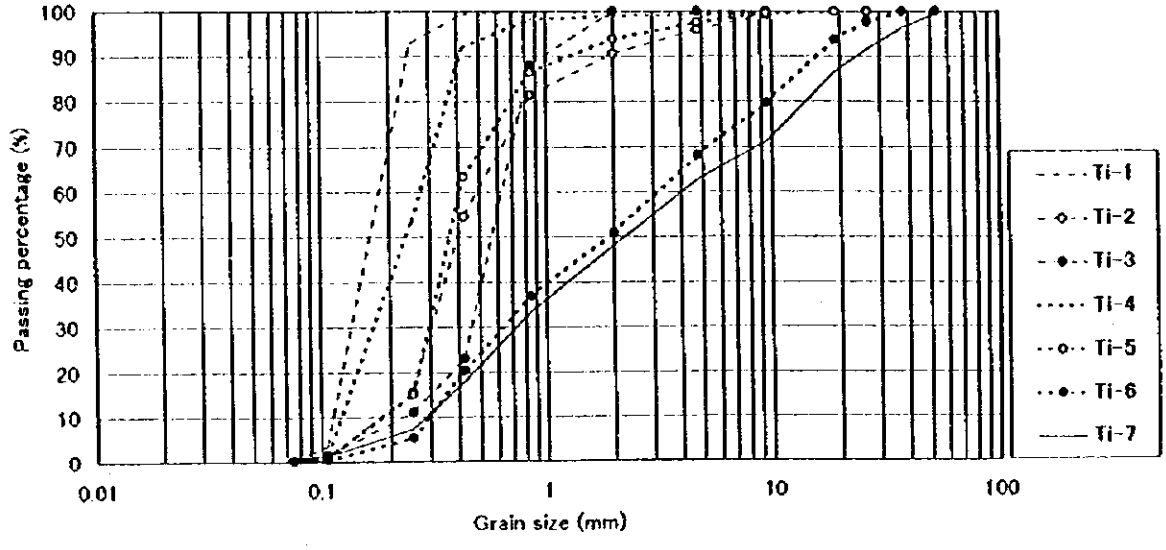
Ti-8
Ti-9
Ti-10
Ti-11
Ti-12
Ti-13


Passing percentage (%)
Grain size (mm)
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0.1
1
10
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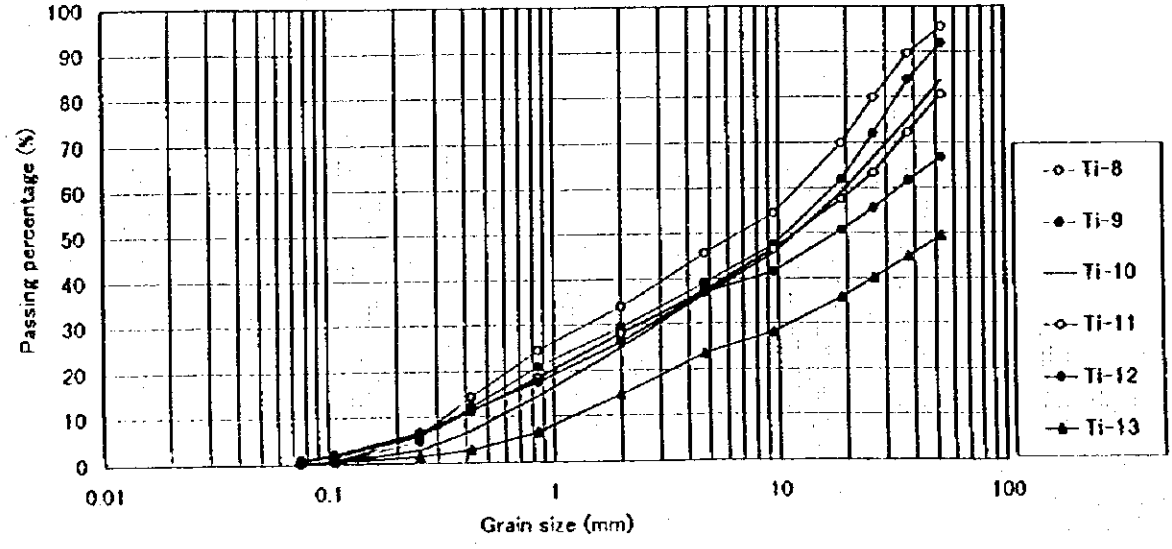
Ti-2
Ti-3
Ti-4
Ti-5
Ti-6
Ti-7


Passing percentage (%)
Grain size (mm)
0.01
0.1
1
10
100
Ti-8
Ti-9
Ti-10
Ti-11
Ti-12
Ti-13

GRAIDING OF RIVERBED MATERIALS

Sample code	Cumulative percentage of passing materials (%)												dm(%) 65 (mm)	Specific gravity(g/cc)		
	<0.075 (mm)	<0.106 (mm)	<0.25 (mm)	<0.425 (mm)	<0.85 (mm)	<2 (mm)	<4.75 (mm)	<9.5 (mm)	<19 (mm)	<26.5 (mm)	<37.5 (mm)	<53 (mm)		S.G.1	S.G.2	Ave.
	0.075	0.106	0.250	0.425	0.850	2.00	4.75	9.50	19.0	26.5	37.5	53.0				
Tinau River																
Ti-1	0.5	3.2	92.9	99.3	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.21	2.59	2.63	2.61
Ti-2	0.3	0.7	15.4	54.5	81.4	90.6	95.9	99.1	100.0	100.0	100.0	100.0	0.59	2.68	2.63	2.66
Ti-3	0.3	1.3	10.9	22.9	87.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.70	2.68	2.63	2.66
Ti-4	0.3	1.6	53.6	92.0	98.2	99.1	99.3	99.8	100.0	100.0	100.0	100.0	0.30	2.63	2.63	2.63
Ti-5	0.1	0.6	15.1	63.4	86.4	93.8	97.5	99.6	100.0	100.0	100.0	100.0	0.46	2.59	2.63	2.61
Ti-6	0.2	0.4	5.2	20.4	36.9	50.8	68.1	79.7	93.7	97.7	100.0	100.0	4.26	2.68	2.63	2.66
Ti-7	0.7	1.2	7.3	17.9	33.4	48.1	62.7	71.2	86.6	91.5	96.3	99.5	6.02	2.63	2.65	2.64
Ti-8	0.3	0.7	5.7	14.3	24.3	33.9	45.5	54.3	69.8	79.8	89.6	95.5	16.06	2.67	2.65	2.66
Ti-9	0.3	0.5	4.7	11.8	20.8	29.2	39.1	47.3	61.8	71.8	83.7	91.8	21.39	2.68	2.66	2.67
Ti-10	0.3	0.5	2.7	6.8	14.2	24.7	36.5	45.3	58.9	66.6	74.9	83.6	24.97	2.68	2.65	2.67
Ti-11	1.0	1.7	5.9	11.0	18.4	27.8	37.2	46.3	57.4	63.3	72.1	80.4	28.63	2.59	2.63	2.61
Ti-12	0.9	1.8	6.4	11.2	17.3	26.0	36.9	41.3	50.5	55.5	61.5	66.5	48.28	2.68	2.67	2.68
Ti-13	0.3	0.5	1.4	2.8	6.4	14.4	23.3	28.1	35.8	40.1	44.6	49.2	57.97	2.65	2.67	2.66

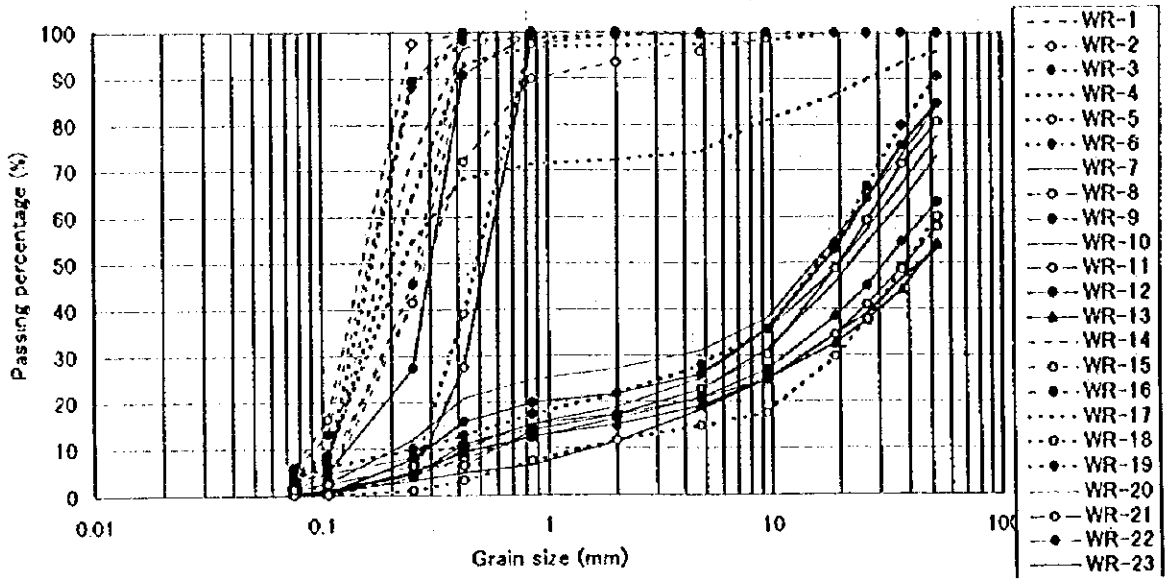
6. WEST RAPTI RIVER

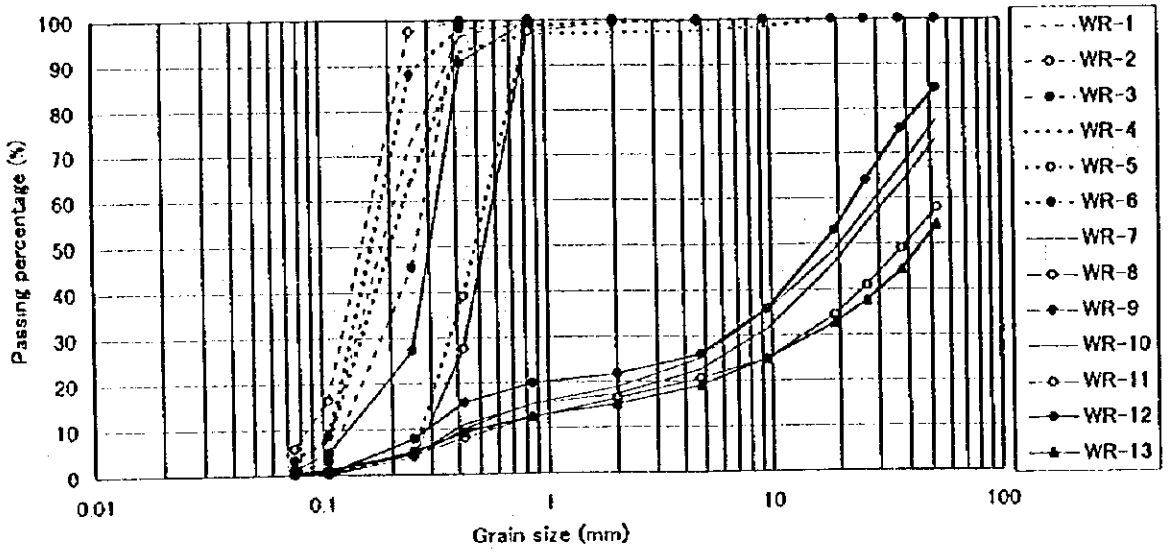
INVESTIGATION REPORT OF RIVERBED MATERIALS
SAMPLING DESCRIPTION

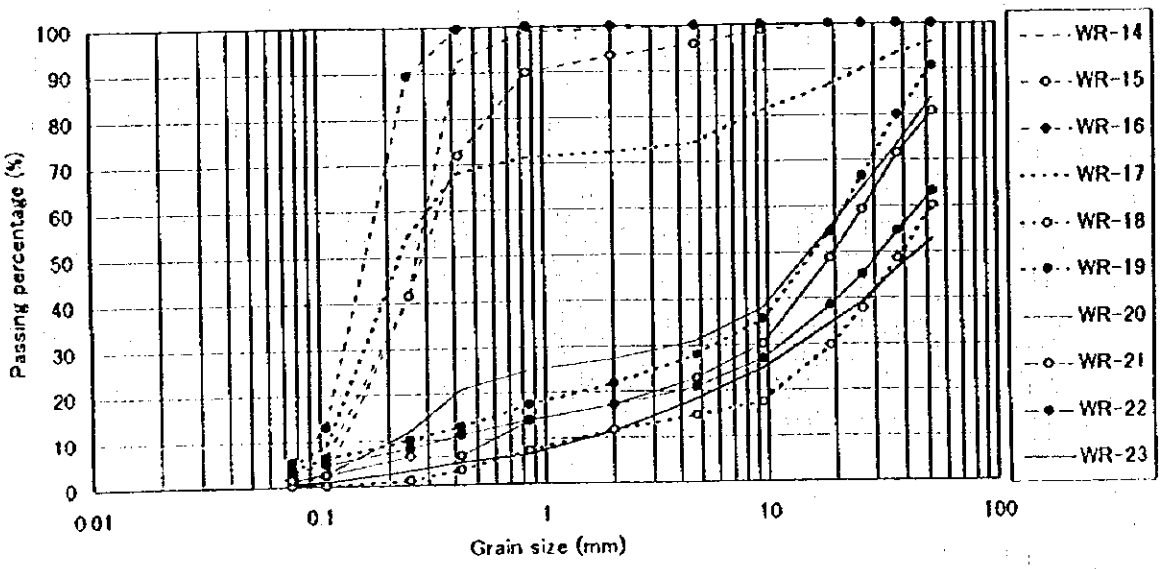
West Rapti River

SN	Sample code	Soil classification by eye	Description of sampling place	GPS Reading		FGA (Y/N)
				N	E	
1	WR-1	Fine sand		27° 58.593′	81° 43.786′	N
2	WR-2	Fine sand with silt		28° 00.278′	81° 43.284′	N
3	WR-3	Fine sand with silt		28° 01.125′	81° 43.548′	N
4	WR-4	Fine sand with silt		28° 02.974′	81° 44.172′	N
5	WR-5	Fine Silt		28° 03.777′	81° 43.171′	N
6	WR-6	Silty sand		28° 04.019′	81° 42.329′	N
7	WR-7	Mixed gravel		28° 05.269′	81° 45.811	Y
8	WR-8	Fine to medium sand		28° 06.711′	81° 46.023′	N
9	WR-9	Fine sand		28° 06.175′	81° 47.510′	N
10	WR-10	Mixed gravel		28° 04.947′	81° 49.110′	Y
11	WR-11	Mixed gravel(Large size)		28° 04.733′	81° 51.026′	Y
12	WR-12	Mixed gravel(Medium size)		28° 03.496′	81° 52.900′	Y
13	WR-13	Mixed gravel(Large size)		28° 03.328′	81° 55.593′	Y
14	WR-14	Fine sand		28° 00.480′	82° 05.914′	N
15	WR-15	Medium to fine sand		27° 58.510′	82° 11.866′	N
16	WR-16	Fine sand and silt		27° 53.537′	82° 21.447′	N
17	WR-17	Mixed gravel		27° 51.824′	82° 26.679′	Y
18	WR-18	Mixed gravel		27° 53.041′	82° 30.540′	Y
19	WR-19	Mixed gravel(Medium sand)		27° 50.501′	82° 32.105′	Y
20	WR-20	Mixed gravel with loosed medium sand		27° 49.440′	82° 38.256′	Y
21	WR 21	Mixed gravel(Medium)size		27° 49.506′	82° 43.059′	Y
22	WR-22	Mixed gravel with sand (Large size)		27° 50.420′	82° 46.157′	Y
23	WR-23			27° 48.657′	82° 45.881′	Y

WEST RAPTI RIVER







GRAIDING OF RIVERBED MATERIALS

Sample code	Cumulative percentage of passing materials (%)												dm(%) 65 (mm)	Specific gravity(g/cc)		
	<0.075 (mm)	<0.106 (mm)	<0.25 (mm)	<0.425 (mm)	<0.85 (mm)	<2 (mm)	<4.75 (mm)	<9.5 (mm)	<19 (mm)	<26.5 (mm)	<37.5 (mm)	<53 (mm)		S.G.1	S.G.2	Ave.
	0.075	0.106	0.250	0.425	0.850	2.00	4.75	9.50	19.0	26.5	37.5	53.0				
West Rapti River																
WR-1	2.7	7.9	72.6	96.5	99.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	0.23	2.67	2.69	2.68
WR-2	5.9	16.2	97.5	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.19	2.56	2.60	2.58
WR-3	0.6	3.1	45.5	99.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.31	2.66	2.60	2.63
WR-4	3.3	7.8	64.4	93.1	96.8	97.1	97.6	98.4	100.0	100.0	100.0	100.0	0.25	2.59	2.60	2.60
WR-5	0.0	0.1	5.2	39.0	98.7	99.3	99.7	100.0	100.0	100.0	100.0	100.0	0.61	2.56	2.60	2.58
WR-6	3.3	8.6	88.1	98.2	98.9	99.3	99.8	100.0	100.0	100.0	100.0	100.0	0.21	2.66	2.63	2.65
WR-7	0.7	1.2	4.3	11.0	15.2	17.4	22.6	31.2	45.7	54.4	63.1	73.1	40.38	2.65	2.68	2.67
WR-8	0.0	0.1	4.0	27.4	97.5	99.3	99.7	100.0	100.0	100.0	100.0	100.0	0.65	2.63	2.66	2.65
WR-9	1.3	4.9	27.2	90.7	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.35	2.59	2.60	2.60
WR-10	0.1	0.4	3.8	10.1	15.4	18.9	25.1	35.3	48.5	57.4	67.0	77.5	35.26	2.68	2.70	2.69
WR-11	0.5	1.0	4.4	8.1	12.3	16.4	20.7	24.8	34.5	40.9	48.9	57.8	54.93	2.59	2.63	2.61
WR-12	0.3	0.6	7.8	15.7	19.7	21.7	25.8	35.6	52.8	63.9	75.5	84.5	27.50	2.66	2.68	2.67
WR-13	0.4	0.9	5.1	9.3	12.4	15.1	19.2	24.7	32.5	37.5	44.2	54.1	56.13	2.64	2.61	2.63
WR-14	0.8	2.2	41.3	92.4	99.0	99.3	99.7	100.0	100.0	100.0	100.0	100.0	0.33	2.67	2.68	2.68
WR-15	1.9	6.2	41.5	72.0	89.9	93.3	95.9	98.7	100.0	100.0	100.0	100.0	0.38	2.63	2.67	2.65
WR-16	5.3	12.8	89.3	99.6	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.20	2.65	2.63	2.64
WR-17	4.4	9.1	54.7	68.2	71.5	72.3	74.3	81.0	86.4	89.8	93.4	96.0	0.38	2.65	2.67	2.66
WR-18	0.1	0.2	1.1	3.3	7.3	11.7	14.7	17.5	29.6	37.6	48.5	60.1	54.27	2.67	2.63	2.65
WR-19	3.7	6.1	10.1	12.9	17.3	21.6	27.9	35.5	54.4	66.5	79.8	90.6	25.56	2.60	2.59	2.60
WR-20	1.3	2.7	11.9	20.9	24.8	27.1	31.0	38.0	55.3	63.9	73.3	83.7	27.83	2.66	2.69	2.68
WR-21	1.3	2.4	6.4	6.4	13.9	17.2	22.8	30.0	48.6	59.2	71.4	80.7	31.72	2.67	2.70	2.69
WR-22	3.1	4.7	8.2	11.0	14.0	17.0	20.8	26.9	38.3	45.0	54.6	63.1	53.46	2.60	2.63	2.62
WR-23	0.4	0.8	3.1	4.8	6.4	11.4	18.2	24.7	34.4	39.0	46.4	52.9	56.56	2.63	2.67	2.65

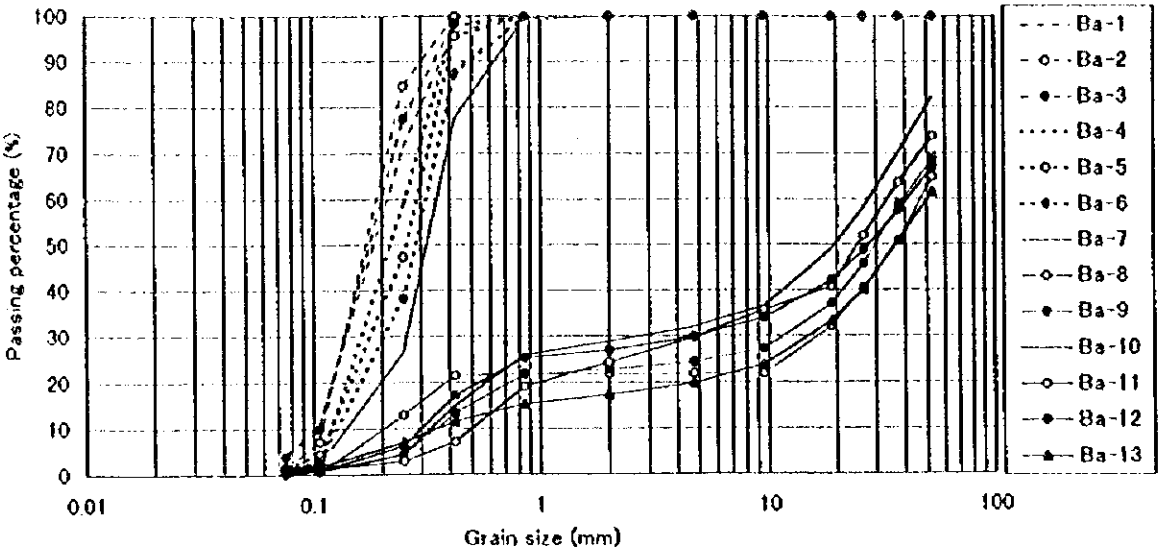
7. BABAI RIVER

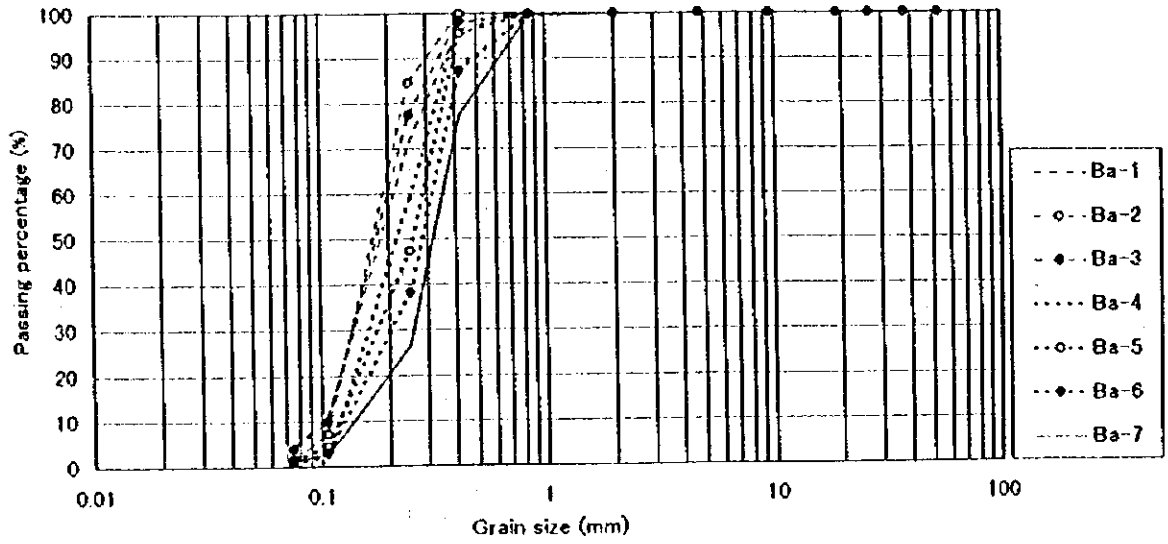
INVESTIGATION REPORT OF RIVERBED MATERIALS
SAMPLING DESCRIPTION

Babai River

SN	Sample code	Soil classification by eye	Description of sampling place	GPS Reading		FGA (Y/N)
				N	E	
1	Ba-1	Silt		28°11.464′	81°22.147′	N
2	Ba-2	Silty sand		28°13.404′	81°22.376′	N
3	Ba-3	Silty sand		28°15.062′	81°22.271′	N
4	Ba-4	Fine sand		28°15.951′	81°21.840′	N
5	Ba-5	Fine sand		28°15.951′	81°21.840′	N
6	Ba-6	Medium sand		28°16.737′	81°19.340′	N
7	Ba-7	Medium sand				N
8	Ba-8	Mixed gravel		28°20.638′	81°18.559′	Y
9	Ba-9	Mixed gravel (Large size)		28°22.127′	81°18.240′	Y
10	Ba-10	Mixed gravel		28°22.942′	81°18.951′	Y
11	Ba-11	Mixed gravel (Medium size)		28°24.722′	81°20.126′	Y
12	Ba-12			28°25.353′	81°20.507′	Y
13	Ba-13	Mixed gravel		28°25.464′	81°22.214′	Y

BABAI RIVER


Passing percentage (%)
Grain size (mm)
0.01
0.1
1
10
100
Ba-1
Ba-2
Ba-3
Ba-4
Ba-5
Ba-6
Ba-7
Ba-8
Ba-9
Ba-10
Ba-11
Ba-12
Ba-13


Passing percentage (%)
Grain size (mm)
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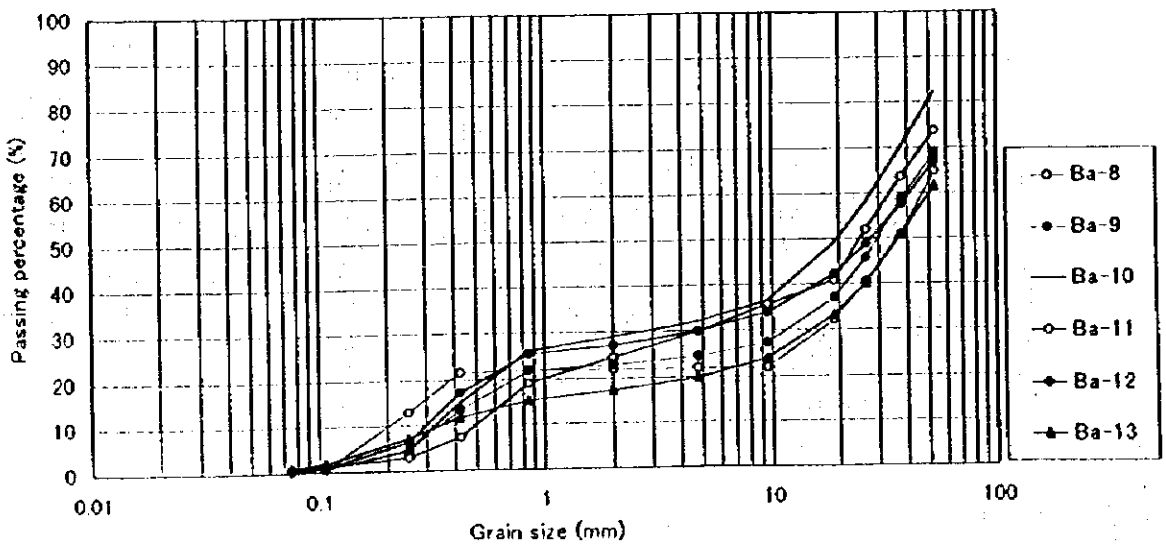
0.1
1
10
100
Ba-1
Ba-2
Ba-3
Ba-4
Ba-5
Ba-6
Ba-7


Passing percentage (%)
Grain size (mm)
0.01
0.1
1
10
100
Ba-8
Ba-9
Ba-10
Ba-11
Ba-12
Ba-13

GRAIDING OF RIVERBED MATERIALS

Sample code	Cumulative percentage of passing materials (%)												dm(%)	Specific gravity(g/cc)		
	<0.075 (mm)	<0.106 (mm)	<0.25 (mm)	<0.425 (mm)	<0.85 (mm)	<2 (mm)	<4.75 (mm)	<9.5 (mm)	<19 (mm)	<26.5 (mm)	<37.5 (mm)	<53 (mm)	65 (mm)	S.G.1	S.G.2	Ave.
	0.075	0.106	0.250	0.425	0.850	2.00	4.75	9.50	19.0	26.5	37.5	53.0				
Babai River																
Ba-1	4.2	10.7	71.2	96.5	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	0.24	2.65	2.68	2.67
Ba-2	1.3	7.1	84.6	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.21	2.66	2.69	2.68
Ba-3	3.8	9.7	77.4	98.3	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	0.22	2.60	2.65	2.63
Ba-4	0.8	2.2	58.9	98.0	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.28	2.63	2.67	2.65
Ba-5	1.6	4.4	47.3	95.4	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	0.31	2.68	2.65	2.67
Ba-6	0.9	2.9	38.1	87.3	99.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.35	2.67	2.63	2.65
Ba-7	1.2	2.5	26.5	77.7	99.4	99.7	99.9	100.0	100.0	100.0	100.0	100.0	0.38	2.67	2.65	2.66
Ba-8	0.2	0.5	12.9	21.5	21.9	21.9	21.9	21.9	32.0	40.5	50.6	64.8	53.05	2.69	2.63	2.66
Ba-9	0.3	0.6	4.2	13.3	21.7	22.9	24.3	27.2	37.1	45.6	58.5	68.7	47.40	2.69	2.66	2.68
Ba-10	0.5	0.8	4.3	14.9	25.9	28.8	32.0	36.5	49.1	58.1	70.1	82.3	32.83	2.58	2.60	2.59
Ba-11	0.6	1.1	2.9	7.1	18.9	24.3	29.6	35.6	40.8	51.9	63.5	73.7	39.76	2.60	2.65	2.63
Ba-12	0.6	1.0	6.2	17.1	25.2	26.9	29.7	33.9	42.1	48.6	57.4	67.0	49.84	2.59	2.61	2.60
Ba-13	0.8	1.7	7.0	11.5	15.1	17.2	19.7	23.7	33.2	40.1	50.8	61.5	53.88	2.65	2.67	2.66

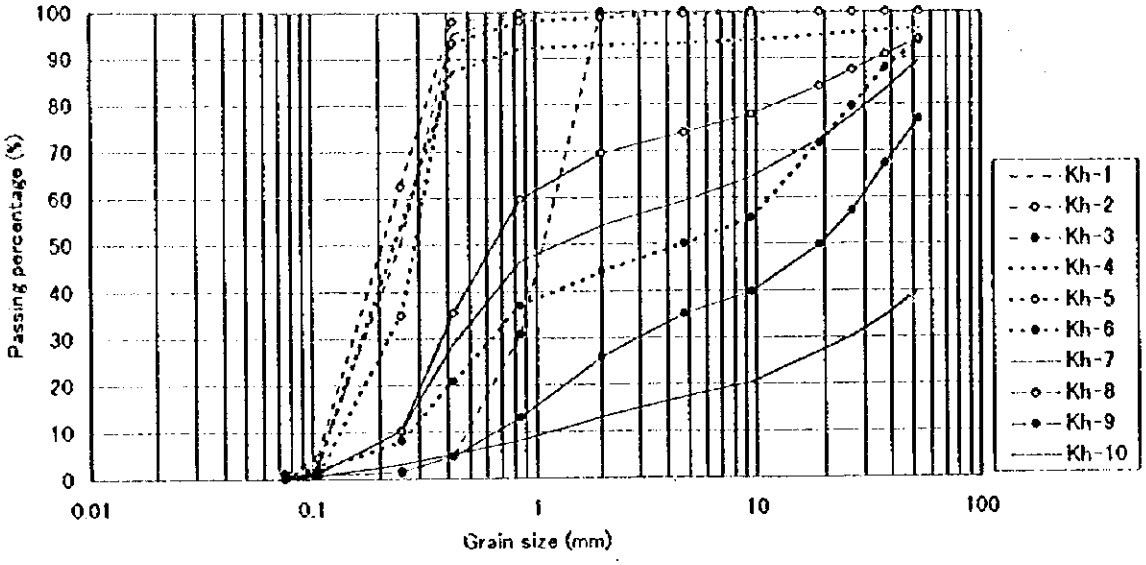
8. KHUTIYA RIVER

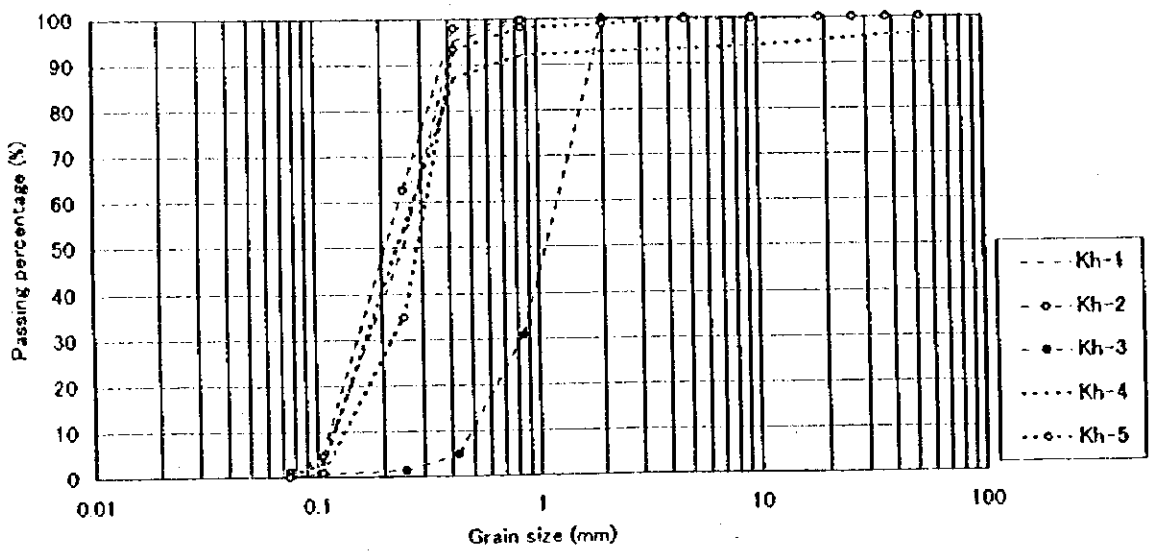
INVESTIGATION REPORT OF RIVERBED MATERIALS
SAMPLING DESCRIPTION

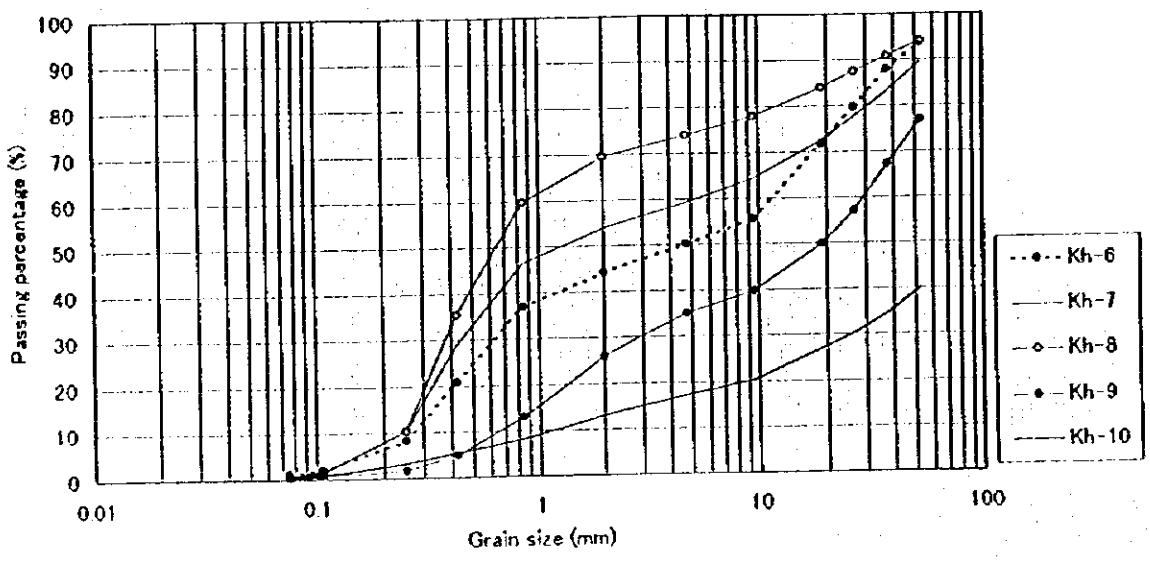
Khutiya River

SN	Sample code	Soil classification by eye	Description of sampling place	GPS Reading		FGA (Y/N)
				N	E	
1	Kh-1	Fine sand		28° 37.315′	80° 41.015′	N
2	Kh-2	Very fine silt		28° 38.669′	80° 39.664′	N
3	Kh-3	Fine sand		28° 40.239′	80° 40.115′	N
4	Kh-4	Coarse sand with 2% gravel		28° 41.002′	80° 40.120′	Y
5	Kh-5	Sitty sand		28° 41.994′	80° 40.780′	N
6	Kh-6	Mixed gravel		28° 42.455′	80° 40.536′	Y
7	Kh-7			28° 44.349′	80° 39.704′	Y
8	Kh-8			28° 45.870′	80° 39.717′	Y
9	Kh-9	Mixed gravel(Largr size)		28° 46.961′	80° 38.144′	Y
10	Kh-10	Mixed gravel		28° 48.267′	80° 38.197′	Y

KHUTIYA RIVER







GRAIDING OF RIVERBED MATERIALS

Sample code	Cumulative percentage of passing materials (%)												dm(%)	Specific gravity(g/cc)		
	<0.075 (mm)	<0.106 (mm)	<0.25 (mm)	<0.425 (mm)	<0.85 (mm)	<2 (mm)	<4.75 (mm)	<9.5 (mm)	<19 (mm)	<26.5 (mm)	<37.5 (mm)	<53 (mm)	65 (mm)	S.G.1 (g/cc)	S.G.2 (g/cc)	S.Gave (g/cc)
	0.075	0.106	0.250	0.425	0.850	2.00	4.75	9.50	19.0	26.5	37.5	53.0				
Khutiya River																
Kh-1	1.3	3.7	50.1	95.3	99.6	99.9	100.0	100.0	100.0	100.0	100.0	100.0	0.31	2.59	2.59	2.59
Kh-2	1.3	4.6	62.6	97.9	99.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.26	2.63	2.59	2.61
Kh-3	0.2	0.7	1.3	4.7	30.8	99.5	100.0	100.0	100.0	100.0	100.0	100.0	1.42	2.60	2.63	2.62
Kh-4	0.5	3.0	53.9	87.2	92.2	92.8	93.2	94.0	95.0	95.6	96.1	96.4	0.31	2.65	2.63	2.64
Kh-5	0.0	1.0	34.8	93.4	98.1	98.8	99.5	99.7	100.0	100.0	100.0	100.0	0.34	2.67	2.70	2.69
Kh-6	1.3	2.0	8.1	20.8	36.8	44.1	50.1	55.7	71.7	79.7	87.8	93.7	15.04	2.63	2.68	2.66
Kh-7	0.7	1.5	10.2	28.7	46.5	53.9	59.3	64.4	72.4	77.6	83.1	89.4	10.22	2.63	2.59	2.61
Kh-8	0.6	1.1	10.3	35.3	59.7	69.5	73.9	77.8	84.0	87.4	90.9	94.0	1.47	2.63	2.61	2.62
Kh-9	0.4	0.6	1.7	4.8	12.9	25.8	34.9	39.6	49.8	57.1	67.2	76.8	35.08	2.59	2.56	2.58
Kh-10	0.3	0.6	3.0	5.3	8.1	13.0	17.1	20.3	26.9	30.1	34.4	40.0	62.69	2.68	2.63	2.66

DATA BOOK
2. TOPOGRAPHICAL MAPPING

His Majesty's Government of Nepal
Department of Irrigation (DOI)
Japan International Co-operation Agency (JICA)

FINAL REPORT
ON
TOPOGRAPHICAL MAPPING
(LAKHANDEI AND BABAI)
FOR
THE STUDY ON FLOOD MITIGATION PLAN
FOR
SELECTED RIVERS IN THE TERAI PLAIN
IN
THE KINGDOM OF NEPAL

Prepared by

TAEC Consult P. Ltd.

PO Box: 2519, Kathmandu, Nepal
Tel.: 246563, 254923 & 247258
Fax: 244147, 225481
E-mail: taec@taecpl.mos.com.np

July 1998

TABLE OF CONTENTS

1. BACKGROUND

Maps needed for flood mitigation purposes are of large scales. Here the base of the map prepared has been taken from 1:25,000 scale topographic map recently produced and published by **HMG, Survey Department.** A request letter from DOI was forwarded to Topographic Survey Branch to produce 1:10,000 scale base map out of 1:25,000 scale map. This request was entertained with condition that the reproduction material has to be supplied. Requested material necessary to reproduce 1:10,000 scale base map of Lakhandei and Babai Rivers is supplied by **TAEC Consult P. Ltd.** After 3 weeks of request TAEC Consult received the base map i.e. preliminary map of 1:10,000 scale. Till now the maps of Babai area are not published for private use. This 1:25,000 scale topographic maps are produced by **HMG, Survey Department in co-operation with FM-International of Finland.** Lakhandei area map was produced and published during 1993-1995 and Babai area map is prepared during 1996-1997 and not yet published.

- This project is a part of Japan's Technical Assistance to Nepal under development program and JICA Study Team selected **TAEC Consult P. Ltd.** to participate in the Study on Flood Mitigation Plan for selected rivers in the Terai in the Kingdom of Nepal.

- A contract has been signed between JICA Study Team and TAEC Consult P. Ltd. on the day of 29th April, 1998 to complete the following tasks.

  - Preparation of 1:10,000 scale reproduced map using precise photomechanical process
  - Measurement of spot height and revision survey
  - Field verification
  - Editing with contour interpolation at each 2.5 m interval
  - Compilation map
  - Final map preparation by tracing with permanent ink.
  - Area defined is: Lakhandei 160 sq. km and Babai 145 sq. km (approx.).

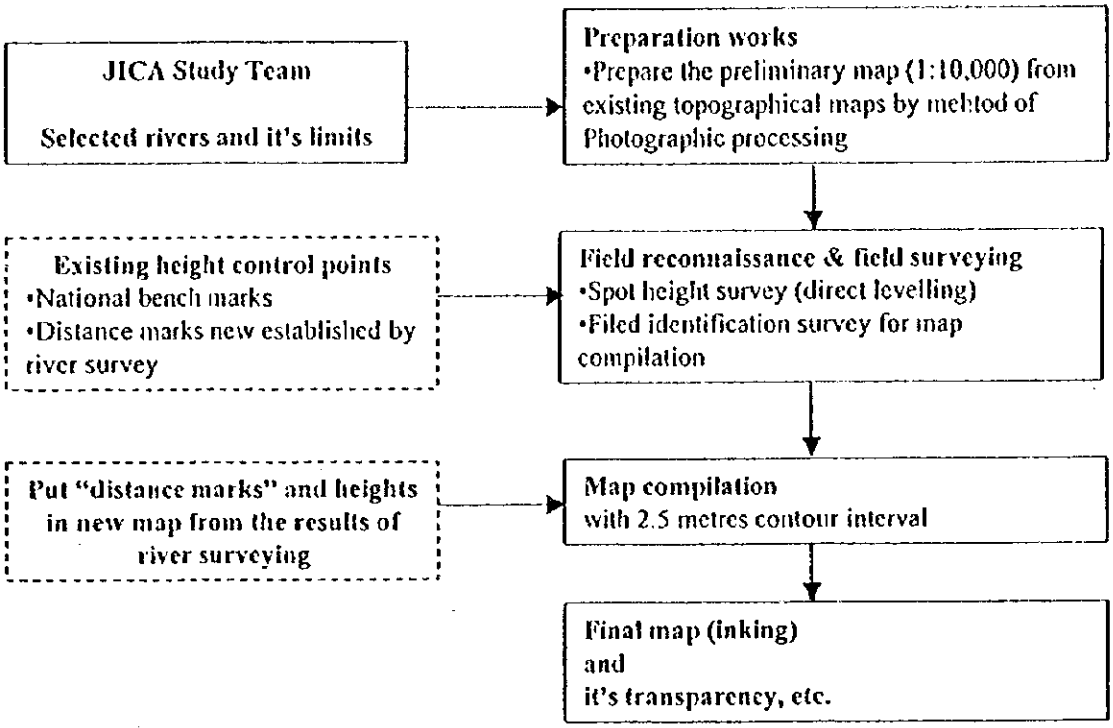
- Planning

  - Preliminary study was carried out in between 15th and 25th of April 1998.
  - Collection of old record and maps etc. of the area specified in the contract was carried out.
  - Babai areas do have 1:10,000 scale topographic map prepared by Karnali Multipurpose scheme during 1987 and Lakhandei have 1:5,000 scale topographic map prepared by Bagmati Irrigation Project 1987, but do not cover the whole area.

- The base of the map which is being used in this project is prepared by HMG, Survey Department and the Finnish Consultant FM-International of Finland.

- Specified 1:25,000 topographic maps need to be reproduced in 1:10,000 scale map covering the project area marked by the study team and so it was requested to Topographic Survey Branch for reproduction. Thus the preliminary map of 1:10,000 scale is prepared.

Flow Chart of Topographical Mapping (1:10,000) from Existing Small Map



2. ORGANISATION

Survey & Mapping Expert

Traverse Survey Team	*Spot Height and Detail Revision Survey*	*Field Identification Team*	*Office Work*
River Survey Team Provide Ground control points/ BM's	Surveyor - 4 Asst. Surveyor - 4 Tacheometers - 4 Helpers – 16 4 WD Drive-car -2	Surveyor - 2 Helper - 4	Survey Engineer - 1 Draftsmen - 2

Time : Lakhandei River area 3rd May to 30th May 1998.
: Babai River area 1st June to 25th June 1998.

3. FIELD SURVEY

- A team of 4 Surveyors and 4 Assistant Surveyors was dispatched on 3rd May, 1998 from Kathmandu to Lakhandei area. This team has had worked for about a month in this area.

- Spot height whete necessary to interpolate contour, change of slope, physical features of terrain are taken during this phase of survey. Control points, for this spot height measurement and other details like river protection structure, secular change by the side of river, changes of waterways, and other man made structures, are the same section stakes on either side of river which are established by River Survey Team.

- River control facilities (existing and changes along the river side have been Surveyed by using Electronic Distance Meter and Theodolite. Section stakes are considered as Bench marks for this survey works.

- A few houses of riverside villages have been washed away and river has changed its course near by section 17 and 18 of Lakhandei.

- Many structures made for flood protection are incorporated in the revised map.

- A total of 300 sub control points are used for spot height and map revision detail survey such as change of river course etc. at Lakhandei area (about 160 sq. Km.)

- The same team of Lakhandei, after completion of spot height and map revision survey was dispatched to Babai on 1st June, 1998 from Lakhandei with their full sets to operate the spot height as well as revision survey. This team was able to complete about 145 sq. km. area of Babai spot height survey and map revision survey. About 250 sub control points were used together with the section stakes established by other consultants during this survey in Babai area.

- All the changes by the side of Rivers : Lakhandei and Babai are incorporated in the final maps.

- For contouring, all the necessary height points are plotted in the field in the preliminary maps and contour interpolation at each 2.5 m interval carried out.

- Change of details in the project area has been verified and incorporated during field identification. In this phase deletion/ addition of details and annotation was checked and corrected as necessary. Contours were checked with the help of nearby control points.

- After completion of field work the team prepared a compilation map incorporating all field data and then the final map is prepared and traced by permanent ink.

4. OFFICE WORKS

- Preliminary maps received from Survey Department after reproduction is traced for the preparation of base for final maps. 6 sheets of Lakhandei and 7 sheets of Babai area are traced from the 1:10,000 reproduced maps. All the section stakes flood marks, national (Bench Marks) datum points also are plotted in the compilation map.

- All field plotted spot heights and new details are transferred to the compilation maps from the field sheet. Contour interpolation has been carried out at each 2.5 m interval in this sheet.

- Cultivation, vegetation, Barren land, grazing land and river bed all are separated by different colour as much as possible.

- Final updating of preliminary map to make final maps is carried out by inking and tracing.

- Comparison of height is also studied. Photogrammetric height and direct level height are not found consistent. There is a difference of about 50 cm to 60 cm of height from place to place.

- Through the present survey of spot height has been carried out with 10 cm height accuracy, the Photogrammentry height in the base map is of metre accuracy. Existing contours of 10 m interval are kept as there are and 5 & 2.5 m contours are interpolated where there are sufficient spot height for contour interpolation.

- New contours and change noticed on compilation sheets are traced by ink in the final map sheets.

5. CONCLUDING REMARKS

- Control points or Bench Marks necessary to carry out surveys are established by River Survey Team. That is the section stakes are taken as the base for level height and location co-ordinates both in Lakhandei and Babai.

- Lists of section stakes of Lakhandei and Babai are attached in respective reports.

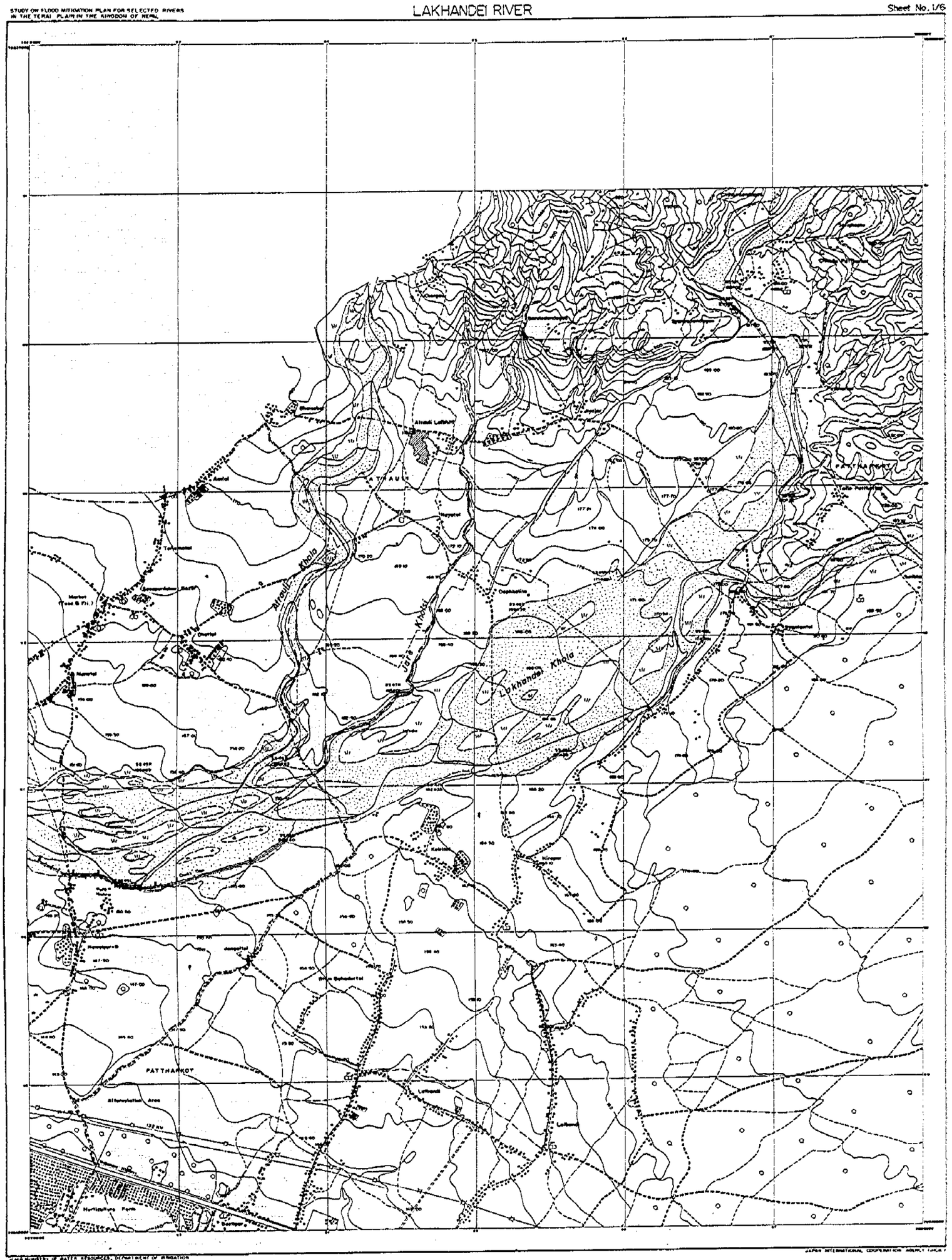
- Field data computation for spot height and revision of detail survey data are also submitted together with the report.

- Accuracy for spot height measured is 30 cm. The survey was carried out with direct 10 cm accuracy and the closing error is permissible upto 60 cm by specification.

STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL

LAKHANDEI RIVER

Sheet No. 1/6



HMG/Ministry of WATER RESOURCES, DEPARTMENT OF IRRIGATION

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

SCALE 1: 10,000

Contour Interval 2.5 Metres

LEGEND

SHEET HISTORY

- Date of Aerial Photography : November 1992
- Aerial Photographs by : Fotopac OY
- Date of Ground Survey : Feb - March 1993
- Date of Photogrammetric mapping (1:10,000 Original) : June - July 1995
- Date of Field Survey and Identification (1:10,000) : May 1996

Points are derived from existing control and supplemented during Field Identification.

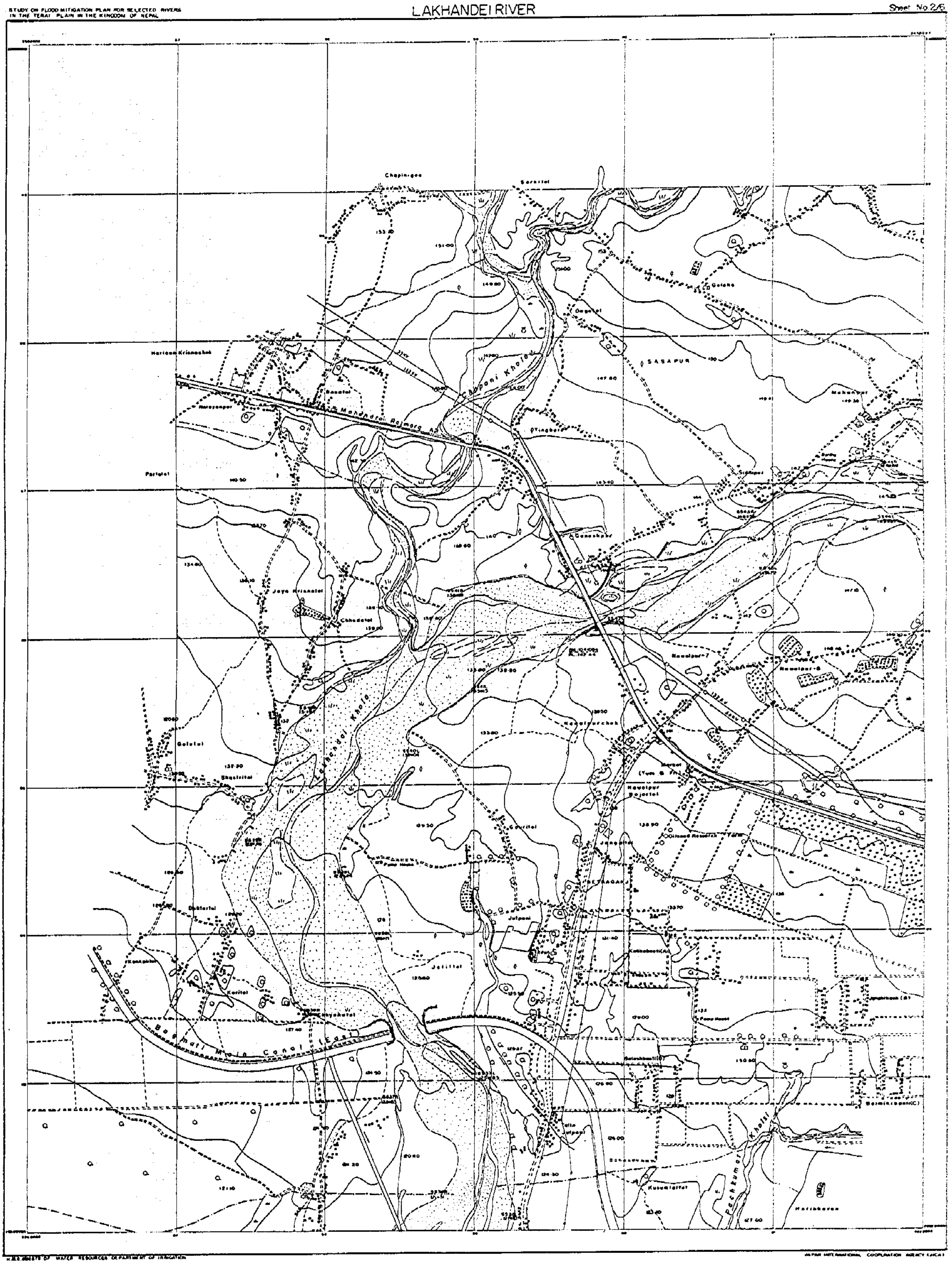
Map Prepared for JICA STUDY TEAM by TAEC Consult Pvt. Ltd.

Index to adjoining sheets

STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL

LAKHANDEI RIVER

Sheet No 2/6

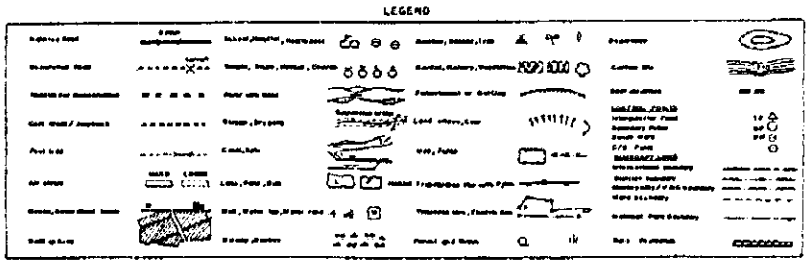


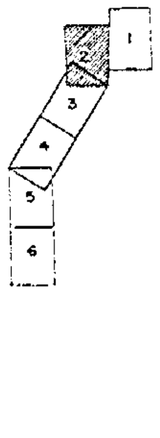
SHEET HISTORY

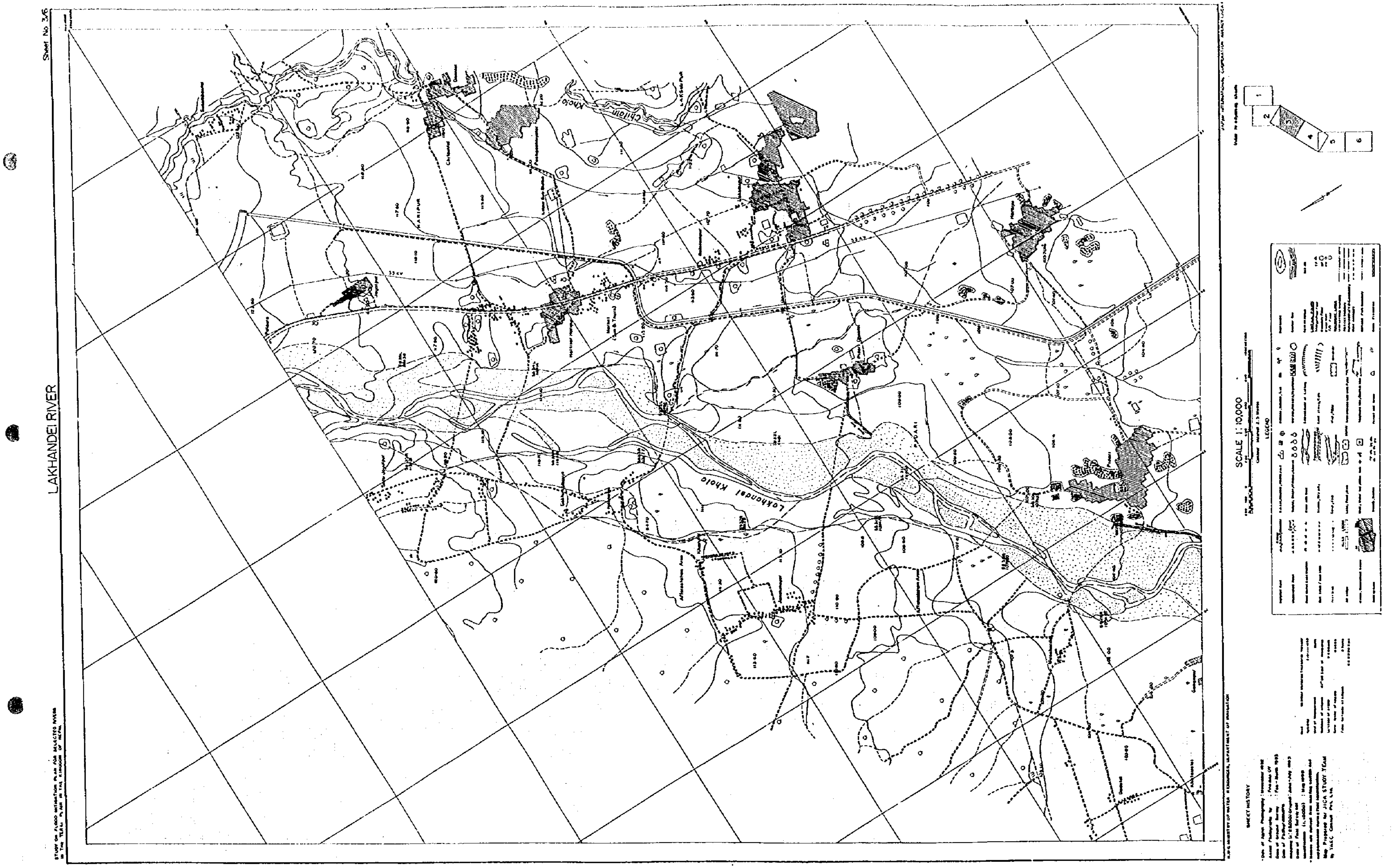
Map Prepared for JICA STUDY TEAM by TAEC Consult Pvt. Ltd.

SCALE 1: 10,000

LEGEND



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Sheet No 3/6
Lakhandei Khola
SCALE 1:10,000
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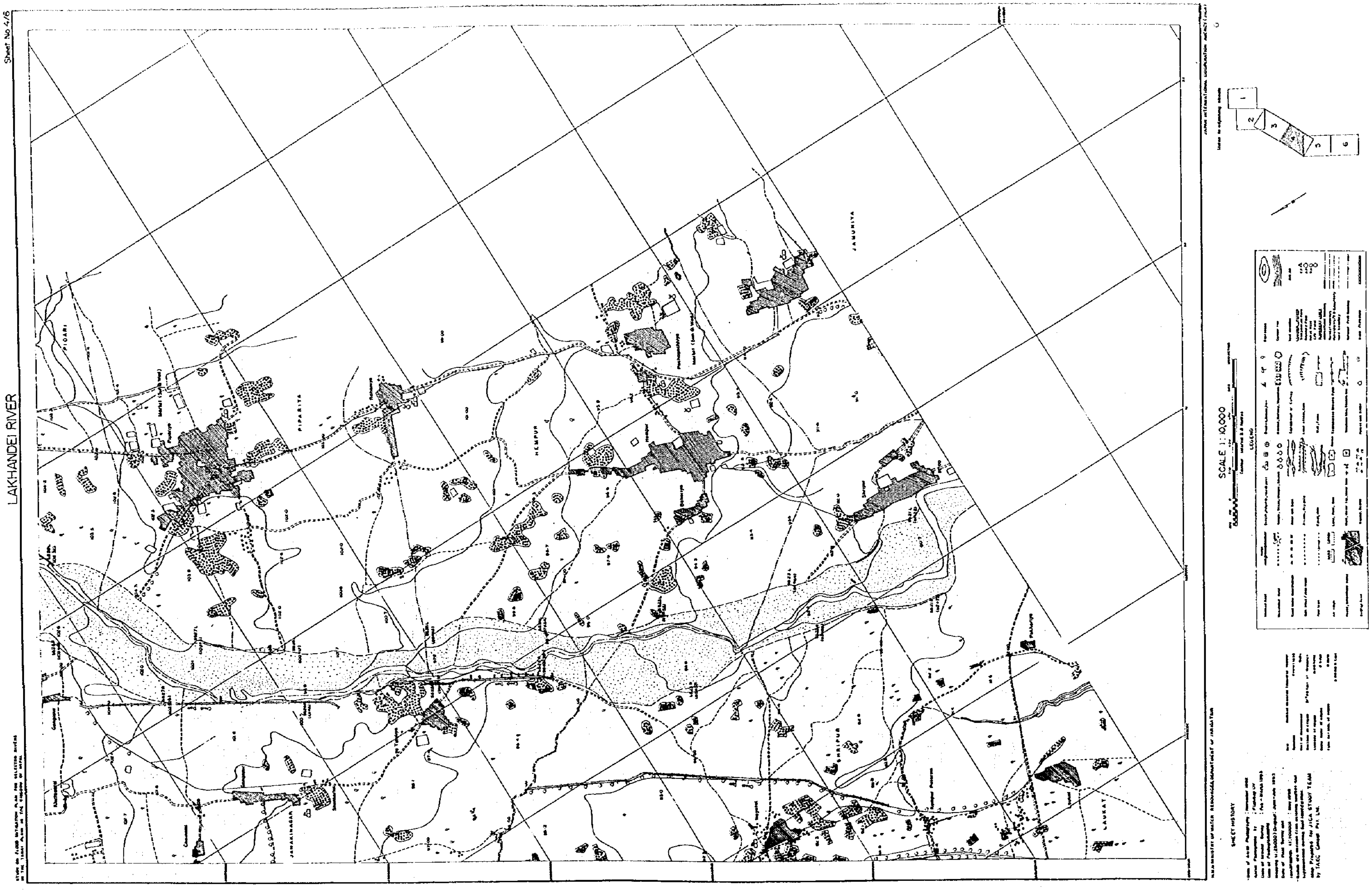
SHEET HISTORY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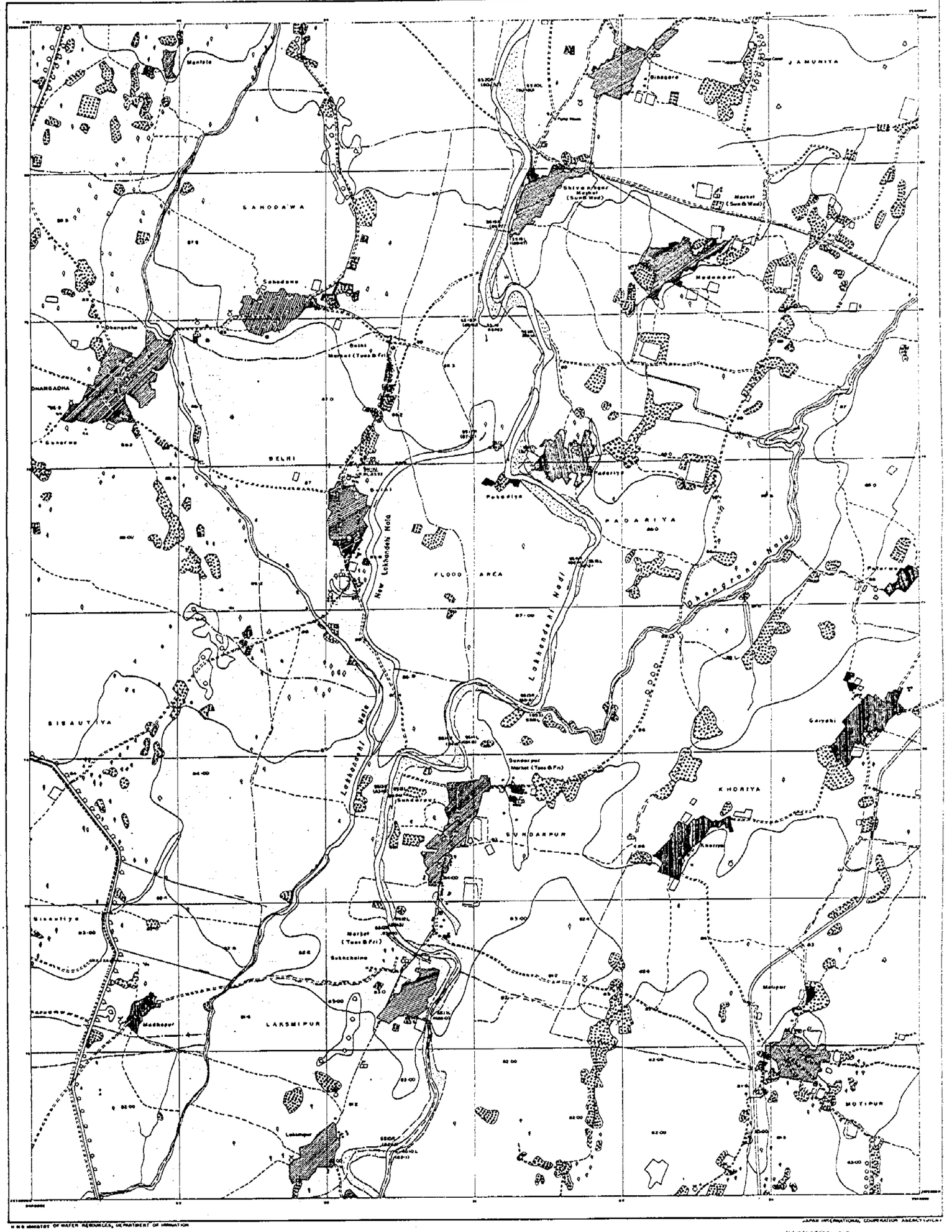
Sheet No 4/6
SCALE 1:10,000
LEGEND
SHEET HISTORY
PIPARIYA
HEMPUR
JAMUNIYA
JANAKINAGAR
SHRIPUR
LAUKAT

STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL

LAKHANDEI RIVER

Sheet No.5/6



SCALE 1 : 10,000

LEGEND

Index to adjoining sheets

1 2 3 4 5 6

SHEET HISTORY

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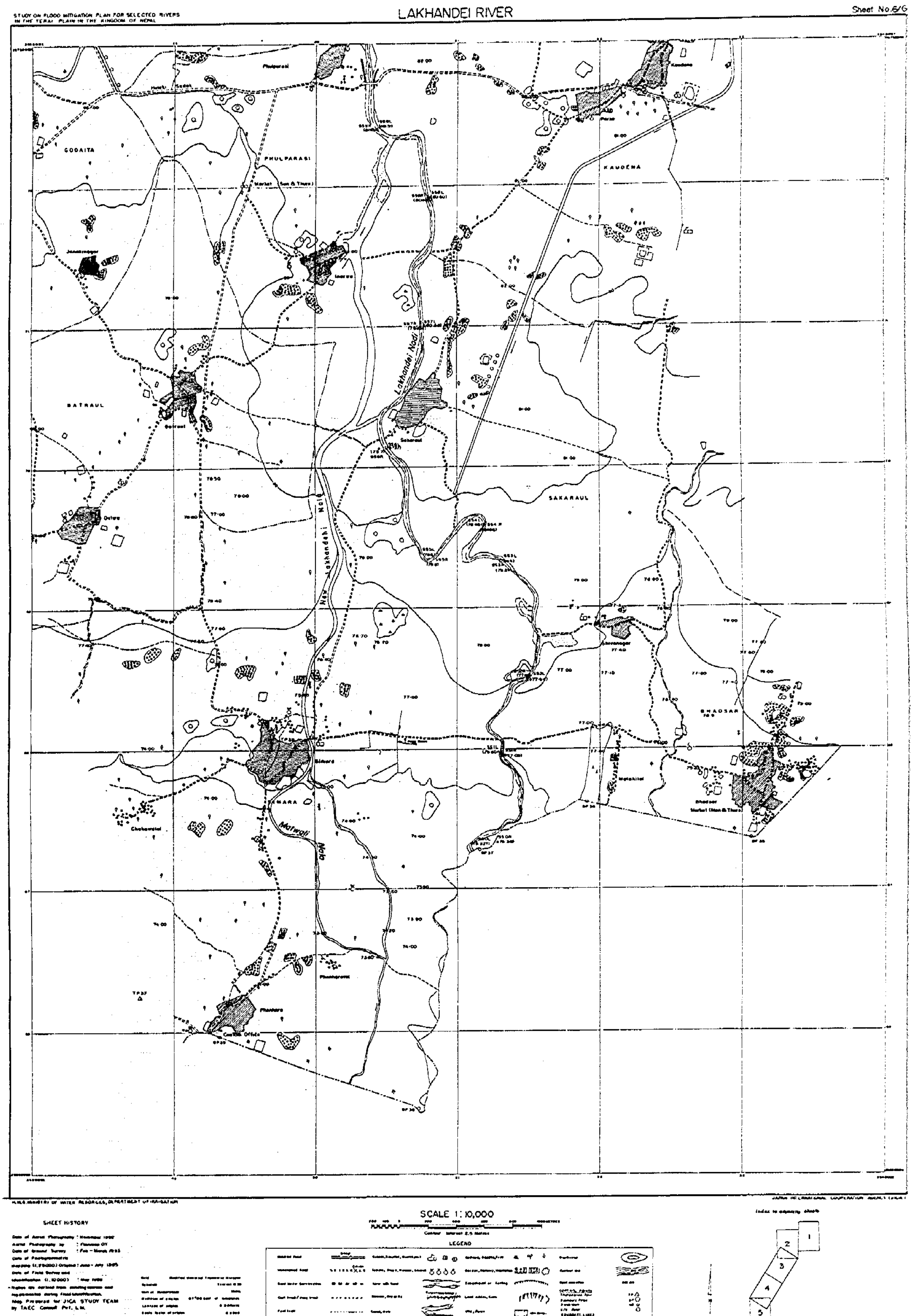
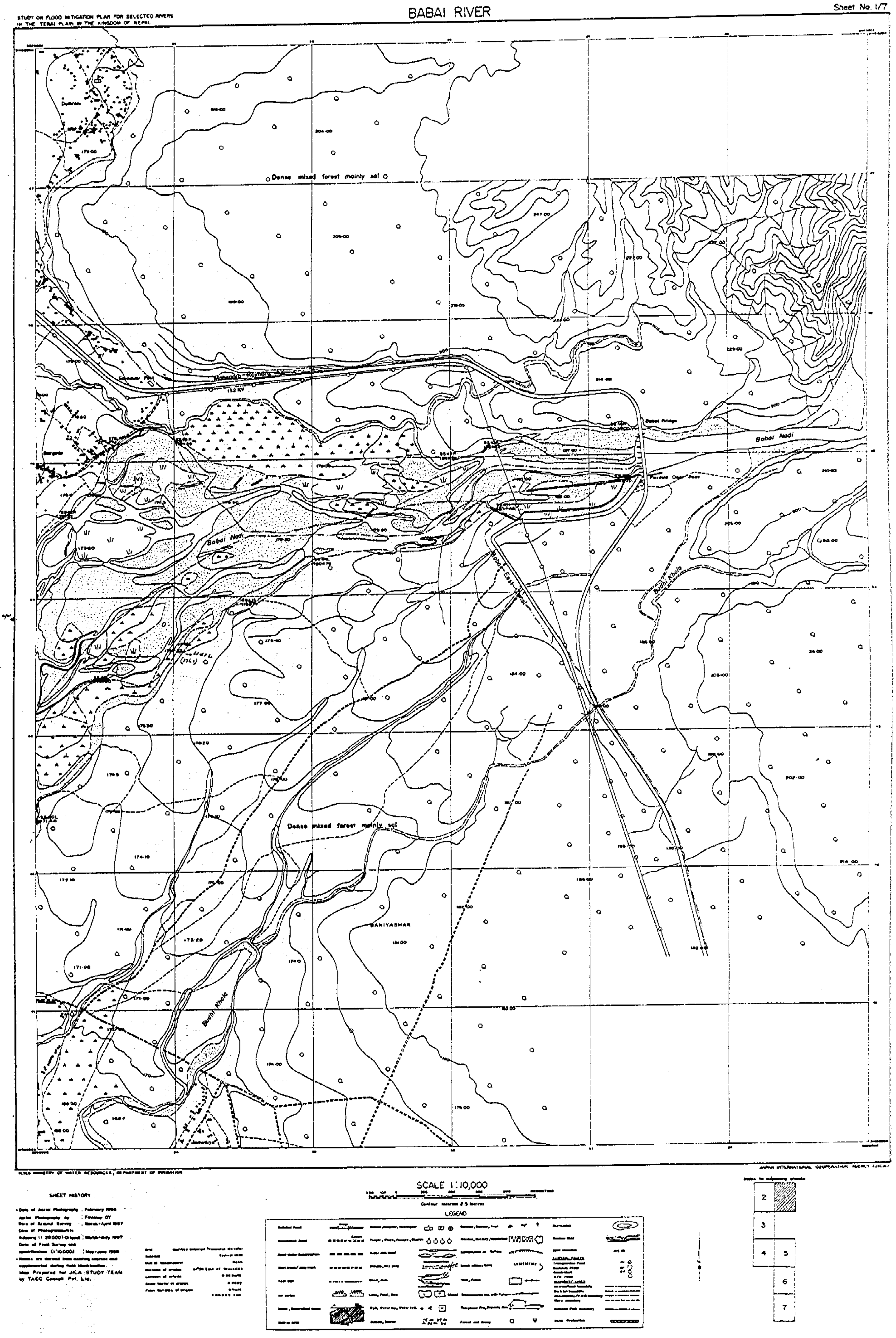
- Aerial photography by : Fleming OY
- Date of Ground Survey : Feb - March 1993
- Date of Photogrammetric mapping (1/25000) Original : June - July 1993
- Date of Field Survey and Identification (1/10000) : May 1993
- Names are started from existing names and improvements during field identification.

Map Prepared for JICA STUDY TEAM by TAEC Consult Pvt. Ltd.

HMG MINISTRY OF WATER RESOURCES, DEPARTMENT OF IRRIGATION

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)


STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL
LAKHANDEI RIVER
Sheet No.6/6
GODAITA
PHULPARASI
KAUDENA
BATRAUL
SAKARAUL
BHADSAR
Lakhandei Nadi
Lakhandei Nadi
Matwali Nala
SCALE 1:10,000
LEGEND
SHEET HISTORY


STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL
BABAI RIVER
Sheet No. 1/7
Dense mixed forest mainly sal
Mahendra Rajmarg
132 KV
Babai Bridge
Babai Nadi
Babai East Canal
Budhi Khola
BANIYABHAR
SCALE 1:10,000
Contour interval 2.5 Metres
LEGEND
SHEET HISTORY
Map Prepared for JICA STUDY TEAM by TAEC Consult Pvt. Ltd.
HMG MINISTRY OF WATER RESOURCES, DEPARTMENT OF IRRIGATION
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
Index to adjoining sheets
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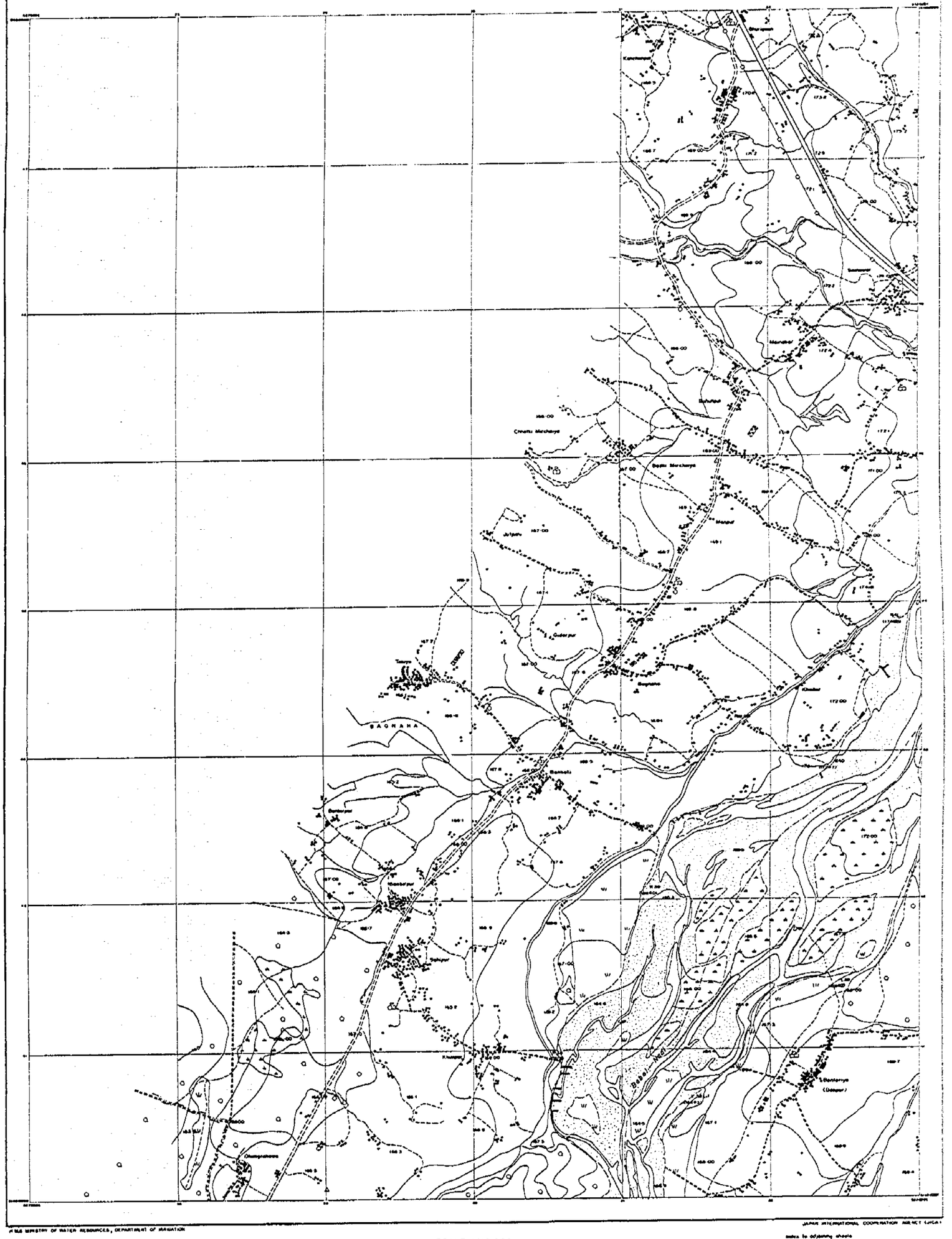
STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL

BABAI RIVER

Sheet No.2/7



HMG MINISTRY OF WATER RESOURCES, DEPARTMENT OF IRRIGATION

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

SCALE 1 : 10,000

Contour interval 2.5 Meters

LEGEND

Index to adjoining sheets

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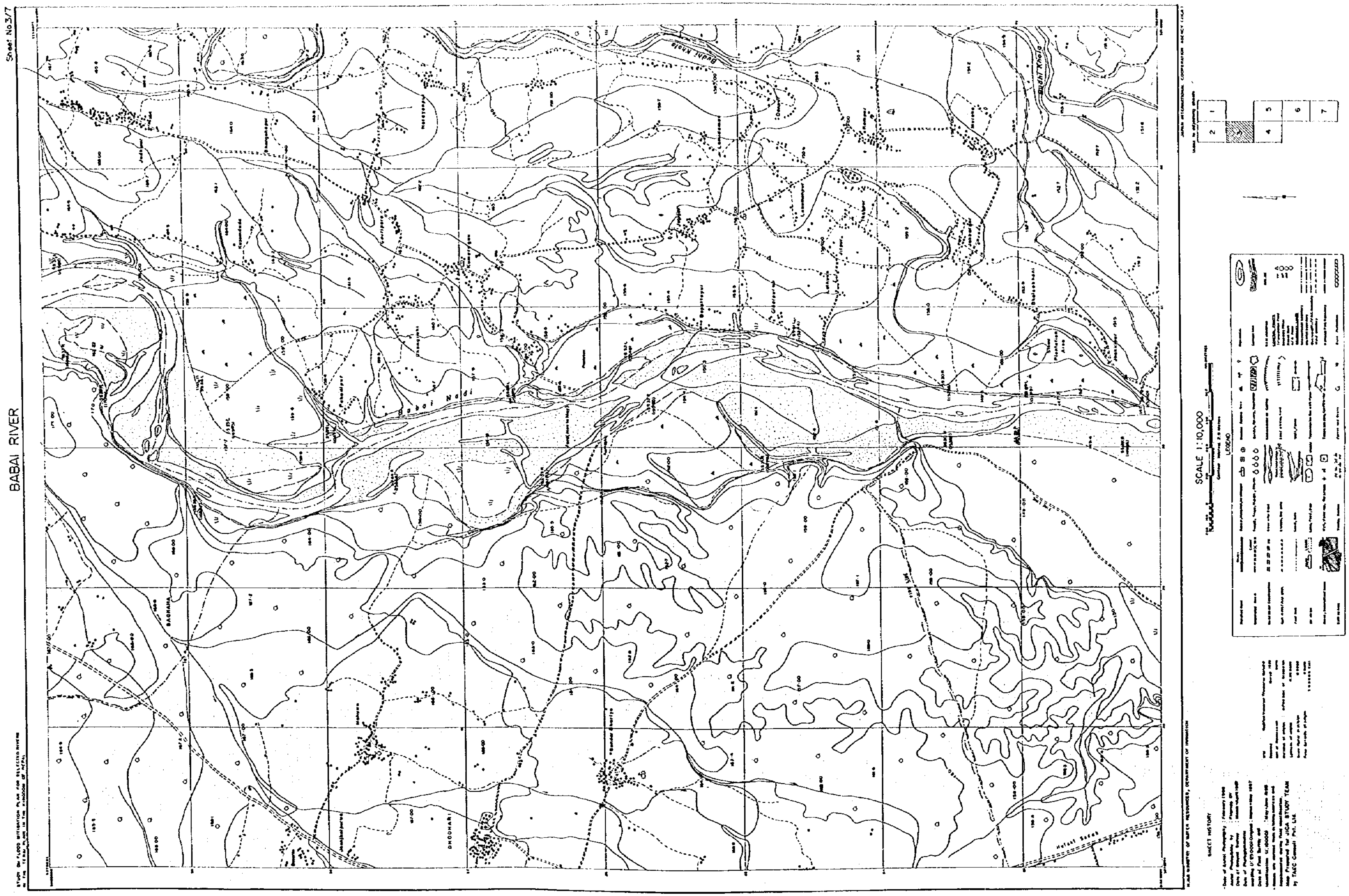
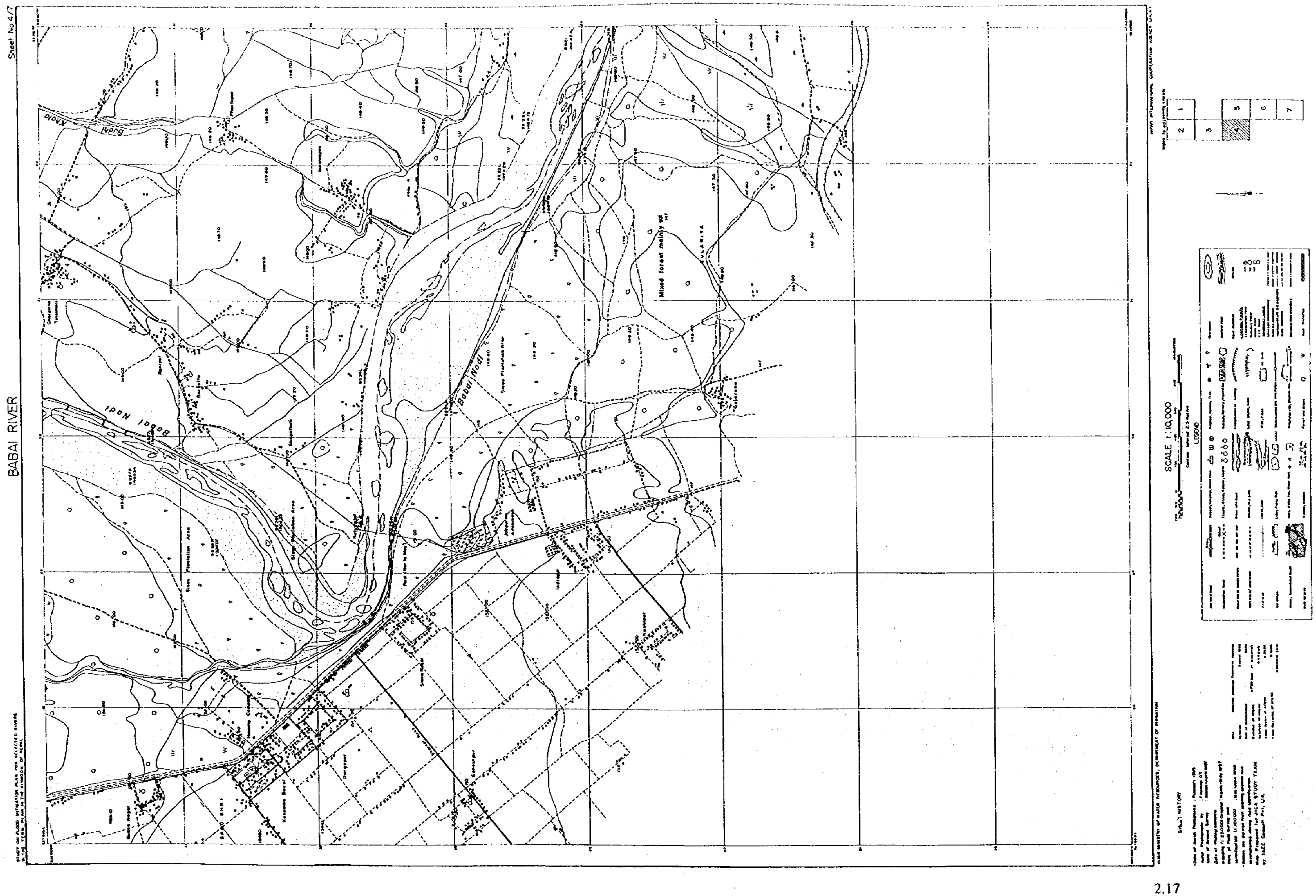
SHEET HISTORY

- Date of Aerial Photography : February 1996
- Aerial Photography by : Fairview OY
- Date of Ground Survey : March-April 1997
- Date of Photogrammetric mapping (1:25000) Original : March-May 1997
- Date of Field Survey and Identification (1, 10000) : May-June 1998
- Names are derived from existing sources and supplemented during field identification.

Map Prepared for JICA STUDY TEAM by TAEC Consult Pvt. Ltd.

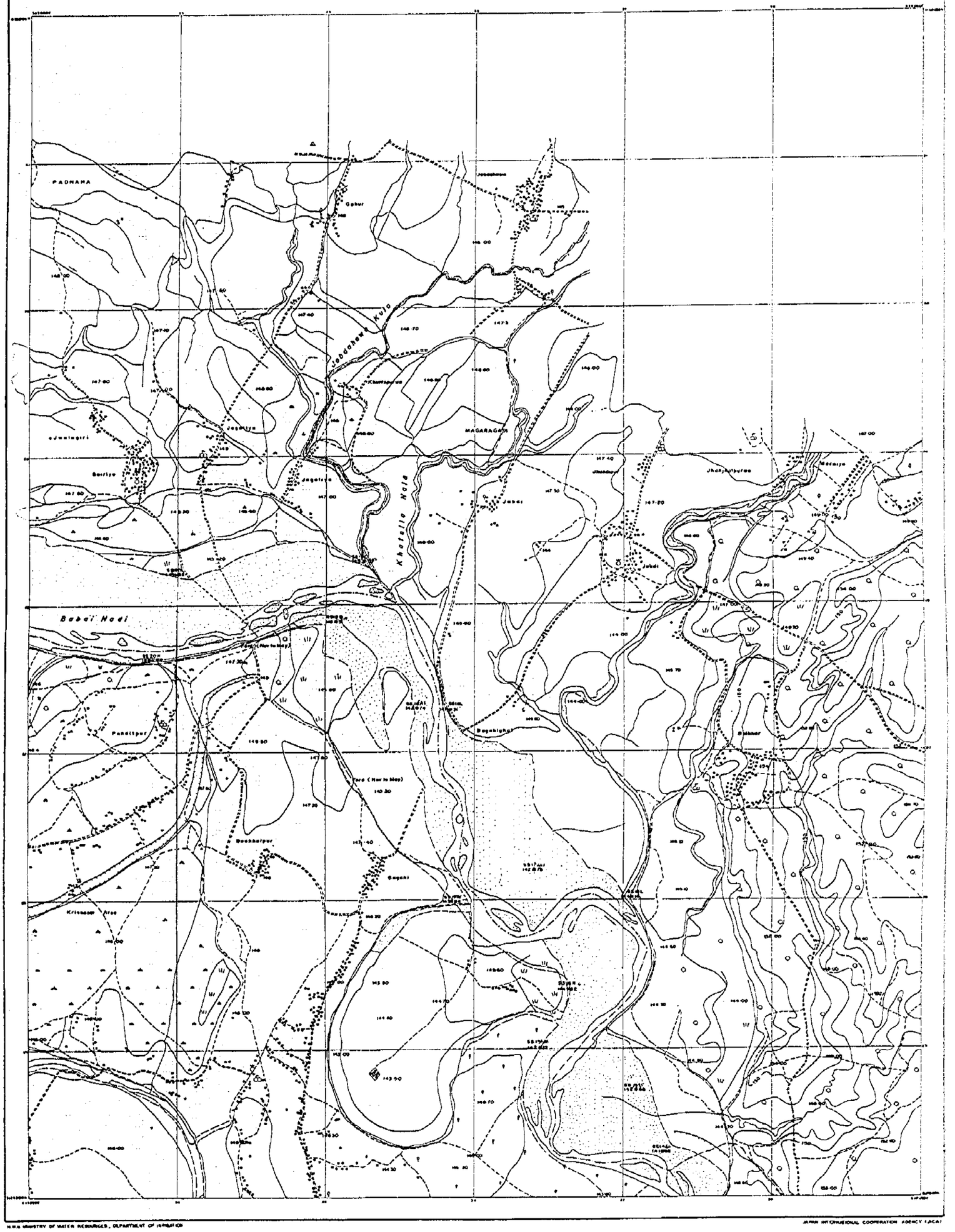

Sheet No.3/7
BABAI RIVER
Babai Nadi
SCALE 1:10,000
LEGEND
SHEET HISTORY


Sheet No 4/7
BABAI RIVER
Babai Nadi
Mixed forest mainly sal
SCALE 1:10,000
LEGEND
SHEET HISTORY

STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL

BABAI RIVER

Sheet No.5/7



H.M.G. MINISTRY OF WATER RESOURCES, DEPARTMENT OF IRRIGATION

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

SCALE 1:10,000

Contour Interval 2.5 Metres

LEGEND

INDEX TO ADJOINING SHEETS

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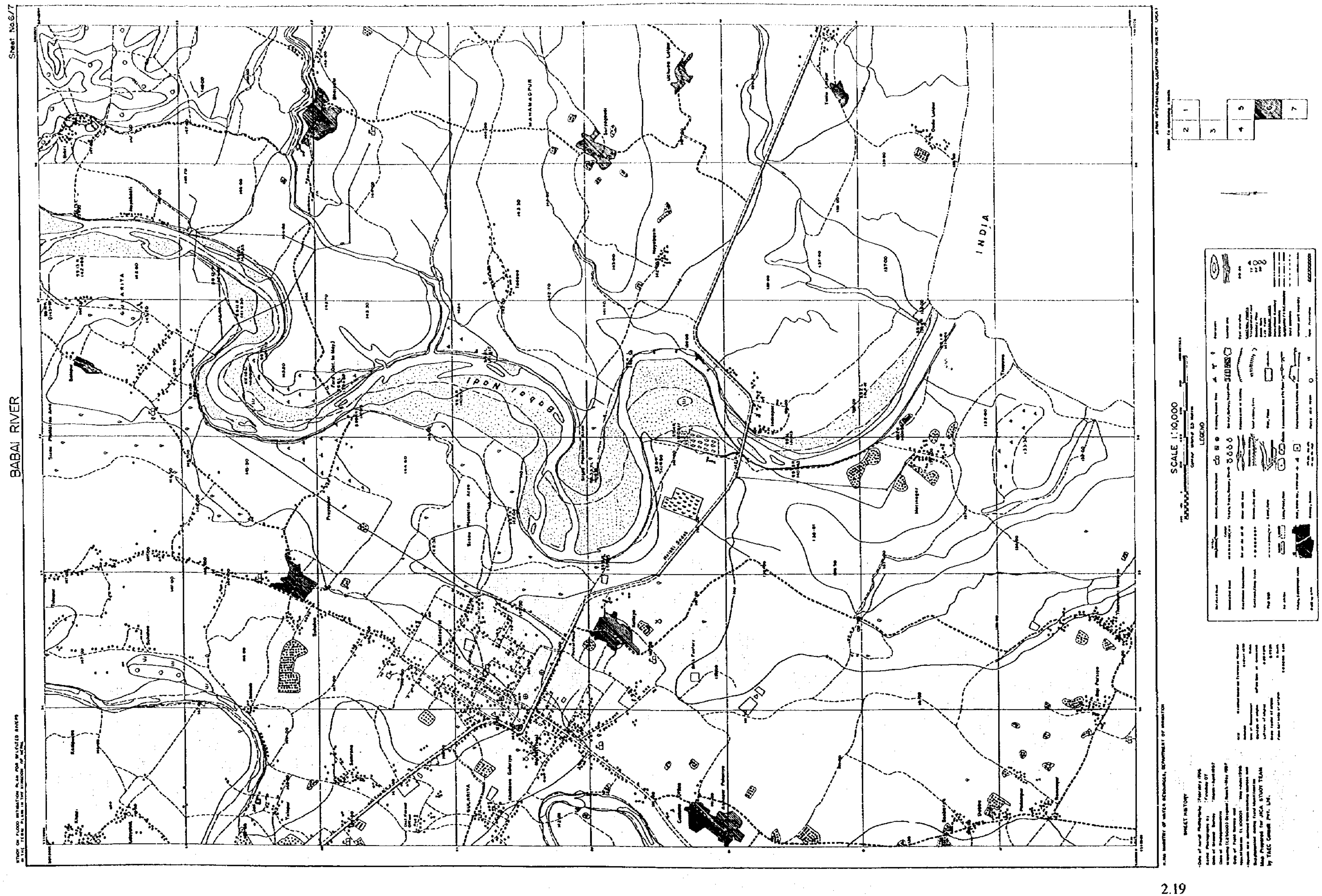
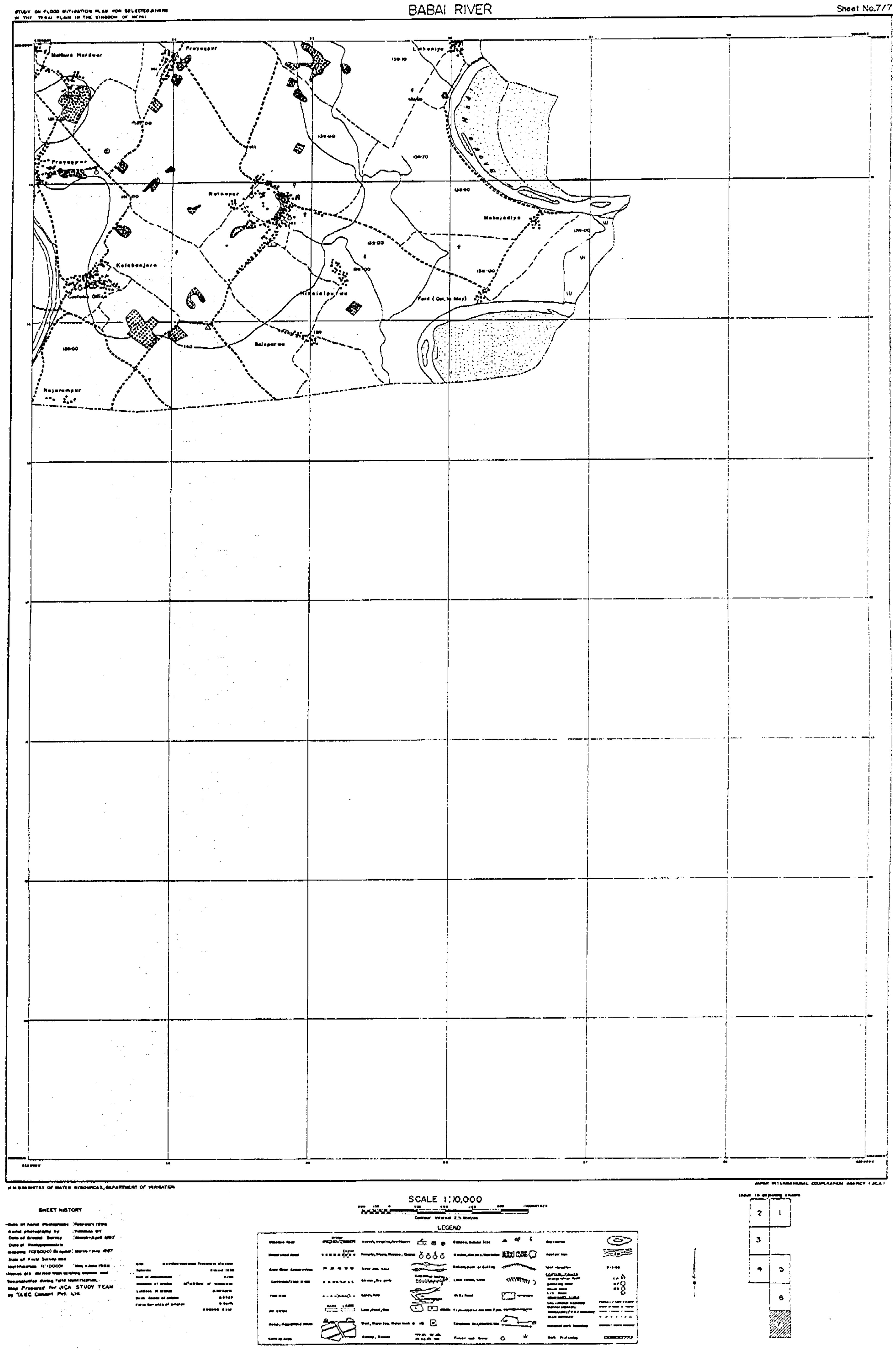
3
4 5
6
7

SHEET HISTORY

- Date of Aerial Photography : February 1988
- Aerial Photographs by : Fairchild OY
- Date of Ground Survey : March-April 1997
- Date of Photogrammetric mapping (1: 250000 Original) : March-May 1997
- Date of Field Survey and Identification (1: 100000) : May-June 1998
- Planes are defined from existing airfields and Implemented during flood identification.

Map Prepared for JICA STUDY TEAM by TAEC Consult Pvt. Ltd.


BABAI RIVER
Sheet No.6/7
SCALE 1:10,000
LEGEND
INDIA
SHEET HISTORY


BABAI RIVER
Sheet No.7/7
Mathura Hardwar
Prayagpur
Lathaniya
Ratanpur
Mahajodiya
Kalabanjara
Hiralalpurwa
Ford (Oct. to May)
Balaparwa
Rajarampur
SCALE 1:10,000
LEGEND
SHEET HISTORY