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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 III (7/9)

SUPPORTING REPORT

(A7; FMP/BABAI RIVER)

MAY 1999

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

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FINAL REPORT

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A7. FLOOD MITIGATION PLAN:

BABAI RIVER BASIN

SUPPORTING REPORT
A7. FLOOD MITIGATION PLAN: BABAI RIVER BASIN

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PART-I: MASTER PLAN STUDY

1. EXISTING CONDITIONS

1.1 Topography and Geology

The topography and geology of Nepal can be divided into the following zones (Fig. A1.1):

1) Inner Himalayan valleys
2) Higher Himalayan zone
3) Lesser Himalayan zone
   - Midland range
   - Mahabharat range
4) Siwalik (Churia) hills
5) Dun valleys
6) Terai plain

The Babai river basin falls under the topographical and geological zones of Mahabharat range, Siwalik hills and Terai plain. Principal features of these zones are presented below.

(1) Mahabharat Range

Lesser Himalayan zone occupies the central part of the Himalayan Mountains. It consists of a series of mountain ranges rising abruptly above its low rolling hills. The Lesser Himalayan zone is divided into two sub-ranges, namely the Midland and Mahabharat ranges from north.

The Mahabharat range consists of comparatively harder rock than the midland range. The number of slides is found to be less even though the topography is steep. The topography is steeper on the southern slope comparing to the northern one of about 100 to 200 m/km. Slides take place on the northern slope and rock falls on the southern slope. The steep of the topography can be attributed to the Main Boundary Fault (MBF) which lies mostly at the southern foot of these ranges.

The Mahabharat range is the first set of high mountains facing the Terai plain, and affects much to the climate of Nepal during the monsoon.

(2) Siwalik (Churia) Hills

The Siwalik (Churia) hills are the lowest hills bordering the Indo-Gangetic plain in the north. Mostly it consists of rocks of alternating beds of clay, sandstone, sand and pebble. The rocks generally dip northwards. Alternately loose and hard rock beds have produced the escarpment feature. In many places rugged land with numerous gullies and mound of talus are found. The topographic slope varies from 200 to 400 m/km on the average. The Siwalik hills are divided into three layers, i.e., upper, middle and lower Siwaliks.

Upper Siwalik

The upper Siwalik is mainly conglomerate with pebbles and boulders of pale schistose quartzite, purple and white quartzite; dark phyllites; purple and dark pebbly quartzite and silt brown sandstone. The depth of upper Siwalik is about 2000 to 3000 meters.

Middle Siwalik

The layer of middle Siwalik is found in the form of thick deposits of sandstone. These are characterized by their feldspar and mica content. Apparently the sandstone has been derived from granite rocks. Calcareous concretions and seams of coal are found in the basal part. In many sections, the sandstone forms vertical cliffs. The depth of middle Siwalik is about 2000 to 2500 meters.

Lower Siwalik

The lower Siwalik is an alteration of brown, weathered sandstone and chocolate colored clays. The alternation of beds is not thick as the sandstone. Beds of impure limestone also occur within the lower Siwalik. The depth of lower Siwalik is about 1200 to 1500 meters. All pebbles except those found in the brown sandstone are derived from rocks of Pre-tertiary age.

(3) Terai Plain

The Terai plain is the continuation of Indo-Gangetic plain having an elevation from 50 to 300 m,MSL. Its width varies between 10 to 30 km with one exception at Koilabash narrow, and extends from east to west Nepal for about 900 km.

The Terai slopes toward south with steeper slope at the foot hill region and nearly flat at

the southern end.

In the Terai plain the changes of river stream are often seen in places by the lateral erosion incorporated by much sediment from the mountainous area. On such rivers, artificial structure works such as bridge, roads and irrigation facilities have to be given careful consideration.

The Terai plain is divided into three zones, i.e., (1) Bhabhar zone (foot of hill), (2) Marshy area (spring line), and (3) Southern Terai (Indian border).

Bhabhar Zone

The Bhabhar zone lies at the foot of Siwalik hills and is about 12 km wide (Charkose Jhadi). It is composed of boulder, pebble, cobble and sand of Siwalik hills or Mahabharat range deposited by the present rivers. In most cases the rocks are sandstone, quartz or charty dolomite. The foot of hills is covered with evergreen forest.

Soils are mainly alluvium consisting of sand, silt, clay looms and silty clay. In the dry season almost all rivers in this zone have no flow on the surface and water flow underground only.

Marshy Area

The marshy area is found in the south of Bhabhar zone where two lithological units having different porosity and permeability meet or inter finger along with the change of elevation mainly resulting in spring lines, ponds, lakes, etc. The lithology is mostly composed of pebbles and sandy bed with a few clay partings. The lithology of the pebbles is similar to the boulder zone and sand beds are loose, brownish to greenish with black and red shale fragments. The clay is mostly blackish gray where a thick sequence is found, but yellow one is also observed at some places where there was a temporary hiatus in its deposition or because of a flood at that time. This is particularly true in Lumbini zone.

Southern Terai

This nearly flat and not well-drained area is found between middle Terai and the Indo-Nepal border. The area is composed of sand, clay and silt with less pebble.

(4) Babai River Basin

The Babai river basin originates in the Mahabharat ranges. In the upper basin, the river is forced to bend its course by Main Boundary Thrust (MBT) and other faults. The channel is forced to flow to the northwest direction due to the Siwalik hills before it reaches to the Terai plain.

Geological map of the Babai river basin is shown in Fig. A1.2.

1.2 Meteorology and Hydrology

1.2.1 Meteo-Hydrological Observation

Responsibilities for meteo-hydrological data collection and analysis in Nepal have been born mainly by the Department of Hydrology and Meteorology (DHM), the Ministry of Science and Technology. Other authorities such as the Department of Irrigation (DOI), Nepal Electricity Authority (NEA), and International Center for Integrated Mountain Development (ICIMOD) also conduct meteo-hydrological observations. In principle, all of these data observed by other authorities are also sent to the DHM. The DHM publishes data in yearbooks after basic checking has been completed.

The Meteorology Section of DHM is responsible for compilation and analysis of meteorological observation records such as precipitation, temperature, humidity, vapor pressure, sunshine, wind, evaporation and soil temperature. And the Hydrology Section of DHM is responsible for compilation and analysis of hydrological observation records such as water level and sediment.

Based on the DHM's data, a list of meteorological and hydrometric stations in the mid-Western Development Region is shown in Tables A1.1 and A1.2, and their locations in Figs. A1.3 and A1.4.

In order to supplement the existing observatory, the Study Team installed new gauges at the following sites:

1) Recording rain gauge: At Banke District Irrigation Office in Nepalganj (1 site) for the lower Babai and West Rapti river basins. This office is under the direct control of DOI. An ordinary rain gauge (sta. No.0416 under DHM) is

installed here.

River basin	Caretaker	Serial Number
Babai/West Rapti	Banke District Irrigation Office (Nepalganj)	Gauge: 232717 Recorder: 244189

2) Water level gauge (staff gauge): Downstream of Babai barrage for rehabilitation of existing staff gauge.

River	Caretaker	Remarks
Babai	Babai Irrigation Project Office (Babai, Bardiya)	Repair of downstream staff gauge: 8 m

1.2.2 Meteo-Hydrological Features of Basin

Climate of the Babai river basin falls under monsoon subtropical zone (Terai plain and Siwalik hills) and temperate zone (Mahabharat range). The dry season (from October to May) and rainy season (from June to September) are clear. The dry and rainy seasons due to monsoon are the major cause of climatic contrasts in the Babai river basin. Figure A1.5 shows the meteo-hydrological features of the basin based on the monthly average data at Rani Jaruwa nursery (sta. code: 0417).

(1) Temperature

Altitude affects much the temperature. The annual average temperature is 24.4℃, ranging from 15.0℃ in the coldest month to 31.1℃ in the hottest month. The coldest month is in January and the hottest falls in between May and August. The temperature rises from March to June-July while it decreases from October to January.

(2) Relative Humidity

According to Fig. A1.5, annual average relative humidity is 82.7%, ranging from 62.1% in April to 92.1% in January.

(3) Rainfall

The study area receives the southeast monsoon during the months from June to September. The monsoon air-stream is forced to rise as it meets the Himalayas and causes heavy rainfall on the south facing slopes (Fig. A1.6).

According to Fig. A1.5, annual rainfall at Rani Jaruwa nursery is 1,279mm on average ranging from 569 to 1,849mm depending on the year. The maximum rainfall is 1,849mm in 1988. The 87% of annual rainfall is concentrated in rainy season from June to September.

(4) Runoff

Figure A1.7 shows the monthly average flow of the Babai river at Bargadha station (No.290).

According to Fig. A1.7, The runoff increases from May to August while it decreases from August to November and the most of runoff is concentrated in rainy season from June to September. The annual average runoff at Bargadha station is approximately $90m^3/s$. The maximum monthly average flow is approximately $260m^3/s$ in August. The monthly average flow exceeds the annual average during the period from July to October.

1.3 Environment

1.3.1 Environmental Organizations and Institutions

The Environmental Division of the Ministry of Population and Environment has overall responsibility for environmental matters in Nepal. In June of 1997, Environmental Conservation Rules were issued under section 24 of the 1997 Environmental Conservation Act. These rules lay down procedure to be followed when new projects are proposed or existing projects extended.

1.3.2 Environmental Overview

The Babai is a class-II river originating in the Mahabharat ranges. Its length is about 150 km. and it has a total basin area of some 3425 km^2 (342,500 hectares). Several tributaries join the Babai river upstream, but there are no major rivers joining it in the Terai. The distance from the E-W highway (the boundary of the Royal Bardiya National Park) to the Indian border is about 30 km, but it meanders considerably and its length is 48 km. The basin area in the Terai is 371 km^2 (37,100 ha).

The Babai river passes through the Royal Bardiya National Park. This park has an area of 96,800 ha., about 85% being forest and 15% grassland. Only when the river

emerges from the park at its southern end are flood mitigation measures contemplated. However, there is a Buffer zone that surrounds the park to a depth of about 5-km. Some of the proposed mitigation measures are within this buffer zone, therefore such measures have to be approved by the Buffer Zone Users' Committee, (Nepal Gazette Part 45, No 47, Section 3 [11 March 1996]). It is also possible that stones and gravel could be used from the riverbed within the park for gabions and dyke work. The rules about removing riverbed material from National Parks are very strict and include a clause specifying that no more than the previous year's deposits may be removed. An Environmental Impact Assessment has to be undertaken as well. But provided this EIA is favorable, permission could be granted to use the riverbed material.

The flora and fauna found in the buffer zone close to the river are similar to those found in the park. It includes *Saccharum spontaneum* (elephant grass), *Imperata cylindrica* (imperata grass), *Bombax ceiba* (simal), *Dalbergia sissoo* (sisoo) and *Acacia catechu* (khair). There are several migratory birds and large animals such as the Rhino.

There are no floodplains in the vicinity of the Babai river within the Terai, but there is the Black Buck Conservation Area very close to one of the proposed bank protection measures along the Babai river. A special study was undertaken at this site. The existing land use and population in the Terai along this river is given below.

(Land Area, Land Use and Population: 1998)

Items	Agri-culture	Forest	Barren/ Sand	Other	Total	Population
Area (ha)	14,880	17,840	4,120	260	37,100	(88,600)*
Ratio (%)	40.1	48.1	11.1	0.7	100	(2.7)**

(Note)*: Population, **: Population density (her/ha)

The Babai basin is one of two rivers in the FMMP that contains more forest area than agricultural land. The other basin is along the Khutiya river to the west of the Babai. Thus there is considerable natural vegetation remaining along this river. However, the population is growing faster than the national average, indicating that migration is occurring. Unless agricultural productivity can be increased, some forest areas will be cleared to cater for the increased needs of this expanding population.

This is why it is vital to undertake a comprehensive flood mitigation program, so that farmers can invest in irrigation systems etc. This may relieve the pressure on the remaining forest area and boost grain production.

1.4 Socio Economy

(1) Economic Activities

Land Use: The Babai river flows in Bardiya district. According to the district data, agricultural and forestland makes up 61.5% of the total plain area.

unit: hectare

District	Agriculture	Forest	Sand/Gravel /Boulder	Others
BARDIYA	62,281 44.5%	38,529 27.5%	8,635 6.2%	30,527 21.8%
10 Districts (where M/P rivers flow)	800,591 64.1%	352,508 28.2%	43095 3.5%	52,449 4.2%

Source: Land Resources Mapping Project 1986, Department of Survey
Forest Survey 1993, Department of Forest

Economically Active Population (10 Years of Age and Over) by Major Occupation: A ratio of 82.8% of the labor force is engaged in agriculture, as opposed to 3.8% in manufacturing and 9.2% in service sectors.

District	Agriculture Worker	Service Worker	Production Worker	Sales Worker and Others
BARDIYA	82,399 82.8%	9,117 9.2%	3,767 3.8%	4278 4.3%
10 Districts (where M/P rivers flow)	1,123,328 73.9%	215,393 14.2%	73,937 4.9%	107522 7%

Source: Population Census 1991, Central Bureau of Statistics

Crop Area and Productively of Agriculture Crop: Bardiya district produces a wide range of crops, with major crops of paddy, wheat, and pulse. These major crops but wheat and pulse are grown during the monsoon. Although there are also winter paddy and maize, most of the paddy and maize are grown in summer.

unit: hectare. (metric ton/ha.)

District	Paddy	Maize	Wheat	Pulses	Oilseeds	Sugarcane	Vegetables
BARDIYA	33,095 (4.91)	9,920 (2.27)	20,000 (2.25)	12,400 (0.75)	12,250 (0.81)	55 (25)	800 (12.01)
10 Districts (where M/P rivers flow)	537671 (27.79)	145489 (18.14)	174589 (19)	98536 (4.9)	102720 (7.92)	17331 (233.06)	11930 (52.58)

Source: Annual Agricultural Development Program 1995/96, District

(2) Land Holding

Land Ownership & Holding: In Bardiya district, the average land holding size has declined in recent years like other districts in the Terai plain. The average size is far

below the 16.4-hectare ceiling imposed by the 1964 Lands Act. About 90 % of the agricultural land is under owner-cultivation. With regard to the agricultural land under "formal" tenancy, the most dominant form is sharecropping.

District	Owner-Cultivated (%)		Average Holding Size (ha.)	
	1981/82	1991/92	1981/82	1991/92
BARDIYA	92.2	84.6	2.73	1.61
Terai	91.8	87.6	1.47	1.22

Tenure Arrangements: However, that since informal arrangements of land tenancy are not recorded in the official census, the above figure of owner-cultivation should be treated with caution. Underlying the sharecropping category is a commonly known phenomenon of "dual ownership". To undertake flood mitigation works for land under "dual ownership", it will be imperative to involve both land owners and tenants, both of whom are entitled to certain shares of the proceeds of the land.

District	Tenure Arrangement – 1991/92 (%)		
	Fixed Rent	Share Crop	Others
BARDIYA	14.6	82.2	32.0
Terai	30.6	62.7	6.7

Source: Nepal Sample Census of Agriculture 1991/92, Department of Agriculture

(3) Population

From nation-wide viewpoint, in-migration in the east is approaching to zero, as new lands available for cultivation are being closed. On the other hand, the western districts continue to exhibit high population growth, since the land frontiers are relatively open. In a similar vein, the original inhabitants of the Terai constitute nearly or more than half the population towards the west, while the proportion of indigenous groups makes up less than half in most of the eastern districts.

Population of Bardiya district is 290,000 as of 1991 with population growth rate of 3.8% (1981-1991). The population growth ratio was markedly high during 1970s and, since then, it has declined. However, the current pace of population growth is much higher than the national average, i.e., 2.3% (1981-1991).

Demographic Records of Flood-Prone VDCs: The following table shows the population trends of the VDCs/Municipality affected by Babai floods. The 1981-91 population growth rate of the affected areas is 3.7%.

District	VDC/Municipality	1971	1981	1991	1996
Bardiya	Baniyabhar	4,563	6,530	10,652	12,817
	Padnaha	3,825	6,628	7,186	8,647
	Mahamadpur	3,270	5,657	8,191	9,856
	Baganaha	4,918	7,938	8,975	10,799
	Gularia	4,905	8,937	14,999	52,893
	Dhadhawar	5,585	7,503	12,693	15,273
Total		27,066	52,462	75,238	110,285

Source: Population Census 1991, Central Bureau of Statistics
Nepal District Profile 1997, National Research Associates

(4) Human Development Index (HDI)

In terms of the Human Development Index (which is a development indicator based on life expectancy, adult literacy, and GDP), the districts in eastern areas of the country receive, in general, higher performance, and become lower toward the west. Accordingly, the HDI of Bardiya district is also ranked among the lower strata (50th among all 75 districts).

1.5 River and Basin Conditions

1.5.1 Principal Basin Features

The Babai river basin extends from 27°56′N to 28°27′N and from 81°16′E to 82°42′E. The Babai river originates in Mahabharat range and is classified as a class II river. Administratively it is located in Bardiya district of Mid-Western Development Region.

Basin area of the Babai river is 3,425 km^2 in total, consisting of 3,054 km^2 of mountainous area and 371 km^2 of plain area. Boundaries of the river basin and sub-basins were drawn on the basin map. Basin boundary in the Terai plain was delineated in consideration of existing drainage channels, irrigation canals, road networks and other ground objects.

General basin maps of the Babai river is shown in Fig. A1.8. Topographic maps of 1/25,000 for the western part of Nepal are under preparation in Department of Survey and not yet available. Topographic maps of 1/50,000 were used to prepare overall basin maps of the Babai river. Lower basin of the Babai river was prepared based on the draft topographic maps of 1/25,000. Aerial photos of approximately 1/50,000 were also used to supplement the topographic maps.

Notable features of the Babai river basin are as follows:

1) The Babai river flows through the mountain valley in the upstream reaches. In the lower reaches from E-W highway, the river expands its width abruptly and forms a braided river channel.
2) At the E-W highway, Babai barrage exists supplying water to the left bank (east side) areas including flood prone area of the Babai.
3) There is a scheme to convey irrigation water from the east canal to west side area crossing the Babai river by siphon. This scheme will be implemented soon.
4) A study is being made by JICA to divert a part of water from the Bheli river to the Babai river for power generation and irrigation purposes. This scheme would not affect significantly the flood flows of the Babai river.

1.5.2 Characteristics of River Channel

Channel slope and width of the existing river are shown in Fig. A1.9 for the plain reaches. These were prepared based on the topographic map of scale 1/25,000, since river survey results were not available. In order to obtain the river profile, spot elevation data on the topographic map were used and the river width was measured on the map at the intervals of 1 km along the river. The river width includes perennial river sections and sandbars of the meandering and braided river section.

According to the figure, principal features of the existing river in the Terai plain are summarized below.

River	Class	Length(km)	Slope	Width(m)
Babai R.	II	48.0(48.0)	1/320～3000	200～1300

(Note) River length in ( ) indicates that downstream from E-W Highway

1.5.3 River Course Shifting

It is generally said that rivers in the Terai plain have tendency to shift westwards. If it is true the existing talweg might take closer to west or right side bank as a whole. To confirm this hypothesis, the location of talweg in the river section was measured at every 1 km and shown in the Fig. A1.9. The clear tendency of westward shifting was not seen.

In order to look into the actual shifting of river course in the past, topographic maps prepared in 1953/54 (scale: 1/50,000) and those in 1996 (scale: 1/25,000) were superimposed and shown in Fig. A1.10. Figure A1.11 also shows historical river course shifting of the Babai river.

According to the these data showing river course changes during the past 42 years, the following features are considered:

1) Meander of river course is not sever in the upper reaches of large channel bend near Kusumba Bajar, and the river course shifting remains within the meander belt.
2) In the lower reaches of the bend, the Babai river meanders more severely, but the shifting of river course seems to remain within the meandering belt.
3) In the old map, a branch channel diverts from the Babai at about 19 km from the Indian border. According to the information obtained at site, this branch channel was the main channel of the Babai river around 40 years ago.

1.5.4 Riverbed Materials

The Study Team investigated riverbed materials along the plain reaches of the river. The investigation includes the following outdoor and indoor works:

1) Sampling of river bed materials at site
2) Grain size analysis at site field and in laboratory
3) Specific gravity test in laboratory

Bed materials of the Babai river were sampled at 13 sites (Fig. A1.12) among which outdoor analyses were carried out at 6 sites.

Results of riverbed material tests are shown in Table A1.3 and the grading curves in Fig. A1.13.

Principal features of the riverbed materials are summarized below. In the descriptions below, UI denotes uniformity index defined as a ratio of d_{84} to d_{16}, SG stands for specific gravity, and classification of grain size is principally based on classification by AGU.

1) Samples: All samples are from the main course of the Babai river.

2) Grain size: It is note worthy that the grading curves of the Babai river are clearly classified into two types.
   - d_{60} = 0.19 to 0.35 mm (fine to medium sand): downstream from Ba-7 site
   - d_{60} = 28.01 to 50.47 mm (coarse to very coarse gravel): upstream from Ba-8 site
3) Uniformity index: Riverbed materials are well sorted and uniform in the downstream reaches from Ba-7 site.
   - UI = 2.1 to 3.0: downstream from WR-7
   - UI = 95 to 300: upstream from WR-8
4) Specific gravity:
   - SG = 2.65 g/cc on average ranging from 2.59 to 2.68
5) Longitudinal distribution: Significant change in grain size is observed between WR-7 and WR-8 sites

Based on the investigation result, grain size distribution along the river is shown in the Fig. A1.9.

1.5.5 Land Use

Land utilization map and land capability map (scale: 1/50,000) are available. These maps have been prepared by Topographic Survey Section of Survey Department under the Canadian assistance program.

Mapping details are based on aerial photos taken in 1978 and 1979 and extensive field truthing and sampling during the year 1980 and 1981. The maps were published in 1982.

Existing land use of the plain area is shown in Fig. A1.14 based on the land utilization map. These maps were prepared rearranging the classifications into five categories, i.e., (1) rice field, (2) diversified cropland, (3) grazing land, (4) forest, and (5) settlement.

Land capability map is also available, which shows the land capability for agricultural development mainly based on the land system such as topography, land slope, soil and drainage conditions. Future land use would be prospected from the land capability.

1.5.6 Existing Basin Development Projects and Plans

(1) Babai Irrigation Project

Back Ground: The perennial flow of Babai River as well as the flood water of local drainage has been taken through several farmers managed canals by making temporary bunds at several places across each of these sources. However, those drains that principally carry flash floods are very unreliable source of water. Thus, if a reliable irrigation is given to these farmlands utilizing the perennial discharge of Babai River, a significant increase in crop yield can obviously be expected.

Phase-wise Construction Works: The total works of the Babai Irrigation Project is planned to be constructed in three phases as follows (Fig. A1.15):

1) 1st Phase: Construction and development of 13240 ha of command area on right bank of Babai River.
2) 2nd Phase: Construction and development of 5760 ha of command area on left bank as well as 21000 ha of command area on right bank of Babai River. The works of 2nd phase is proposed after Bheri-Babai Diversion Project, if 35 cumecs discharge is diverted to Babai river from Bheri river.
3) 3rd Phase: Construction and development of additional 32000 ha of command area on left bank of Babai river, if 60 cumecs discharge is diverted to Babai river from Bheri river.

Progress: Using the available funds from HMG the 1st Phase works are now under construction. Main canal is being constructed to feed the local canals in very early stage and provide immediate benefits from the investment made so far. The construction of diversion weir with bridge and the construction of Main Canal except earthwork between No.23+000 to 27+500 have been completed.

Project in the larger Perspective: The project is suitably located and configured for the later incorporation into the Bheri-Babai Multipurpose Project. Flows originating in the Bheri river, a major tributary of the Karnali river, can be diverted to the adjacent Babai basin via a short tunnel of length about 8.5 km with an elevation difference between the two rivers of over 140 m. The project would permit the generation of low cost hydra-electric energy. It is estimated that about 24 MW of electricity will be generated utilizing 100 m of the available head and 35 m^3/s of the diverted flow needed for the full development of the project.
(Source: Project Information Summary, Babai Irrigation Project)

(2) Bheri-Babai Diversion Scheme

Background: During the master plan study of water resources development of Upper Karnali and Mahakali river basins, conducted by JICA in 1993, Bheri-Babai Diversion Project was identified as the top priority scheme in these basins.

Project Description: Bheri-Babai Diversion Project has been conceived to be developed as a diversion scheme with a 35 m high dam at Bheri river and underground power house near Bheri river with a generating capacity of 83 MW. The tailrace tunnel is 9 km long that discharges the water to Babai river about 20 km upstream of the existing Babai Irrigation Project. The Bheri diversion water discharge of 58 m^3/s along with the Babai discharge would be sufficient to irrigate the command area of 74,000 ha in Bardiya and Banke districts.

Location: Bheri dam is located in Surkhet district approximately 5 km downstream of the Bheri bridge on Kohalpur-Surkhet road.
(Source: A Brief Note on Bheri-Babai Diversion Project, Electricity Development Center; Jan. 1995)

1.6 Vegetation in Watershed Area

General features of vegetation in the watershed area are presented here. Sediment yield from the watershed was not estimated for the Babai river, since the watershed area is large and the sediment yield in the watershed does not directly affect the sediment flows in the plain area. Most of the sediments in the plain area are secondary or tertiary sediment deposit transported by river flows.

Watershed of the Babai river is classified as the climate and vegetation divisions of Middle Mountain and Terai and Outer Himalaya.

(1) Terai and Outer Himalaya

The Terai plain is composed of an alluvial fan and an alluvial plain of elevation ranging from 50 m to 300 m,MSL extending from the foot of Siwalik hills to the Indian border. The climate of this area belongs to the monsoon subtropical zone, and the dry season is from October to May with the rainy season from June to September. The Terai plain was covered widely by Sal forests (*Shorea robusta*). But, recently farmers from

Middle Mountains cleared the forests rapidly for agricultural land and villages.

The Siwalik hills were formed by upheaval of sediment bed carried from Himalaya. Forests are left in the Siwalik hills, because of too steep inclination for settlement and farming. But, clearing forest takes place recently even in the Siwalik hills.

(2) Middle Mountain

The Middle Mountain is the area of 1000 to 2500 m,MSL between the Mahabharat and High Himalaya mountain. The Middle Mountain is the central place of Himalayan mountain residents. In the eastern and central part of the Middle Mountain, population is large and forest changed to cultivated lands and residential areas.

Large forest area shall remain in the western part of the country where population is sparse. Generally the forests are left in the areas such as (1) steep slope area which is hard to approach, (2) community forest managed by village, (3) forest with small shrine of native belief, and (4) northern slope which is not suitable for agriculture.

Vegetation changes according to the changes of elevation. Sal forest continues from the Terai plain up to 1000 to 1200 m,MSL, followed by laurel forest from 1000 to 2500 m,MSL. These vegetation zones are recognized throughout the Middle Mountain, and forest species changes from humid type in eastern part to dry type in western part.

1.7 Past Flood and Sediment Disasters

The Study Team investigated conditions of past flood and sediment disasters in January 1998. On the basis of the information obtained from the District Irrigation offices and District Development Committee offices, a total of 6 VDC/Municipality offices were selected for the investigation. Furthermore, a total of 129 residents in the flood prone areas were selected for the interview using questionnaire form.

Questionnaires to the residents are summarized and shown in Table A1.4. The biggest flood over the last 10 years took place in 1995 followed by floods in 1987 and 1996.

Wards No. 2, 5 and 6 of Gulariya municipality and Mahamadpur VDC suffer from inundation almost every year. Wards No. 8, 10, 13 and 14 of the Gulariya municipality and VDCs of Dhadhawar, Padanaha and Baganaha suffer once in 3 to 4 years.

During the 1995-flood, 174 families in ward No. 5 of Gulariya municipality were evacuated to schools and about 300 families from other wards of the municipality were evacuated to other public facilities. After the flood, epidemic disease occurred in wards No. 5, 6, 8, 10, 13 and 14 of Gulariya municipality and Mahamapur and Baganaha VDCs, and 12 lives were lost in wards No. 13 and 14.

Bank erosion, flooding over farmland and sedimentation are the major types of disasters. According to the data and information obtained from DDC and DIO of Bardiya district. The extent of loss of life and damage to property are shown in Table A1.5, mainly based on data during 1995 flood.

According to field investigations and interviews with residents, flood-affected areas during the 1995-flood are shown in Fig. A1.16.

1.8 Flood Mitigation Activities

1.8.1 Existing River Facilities

According to the result of investigation conducted by the Study Team in January 1998, major river facilities of the Lakhandei river are as follows:

1) Embankment : 2 sites
2) Spur : 54 sites
3) Revetment : 10 sites
4) Head work : none
5) Bridge : 2 sites

Location of these facilities is shown in Fig. A1.17. As seen in the above, spur (groin) works share by far the majority of the facilities followed by revetment works. Almost all the spur and revetment works are made of gabion by boulder and galvanized iron (G.I.) wire net.

The existing facilities are located sporadically along the river course. Some of these spur and revetment works are damaged already probably due to inappropriate foot protection. In some sites single spur was seen, though the spur works can function effectively, in general, when they are installed as a series. The types of existing spur or bank protection works are monotonous. Variety of works should be introduced taking account the river condition and availability of materials. Photos of typical river facilities are shown in Fig. A1.18.

1.8.2 Policy Framework

There are various laws and policies governing and orientating the flood mitigation activities. The followings are the major ones, among others:

1) Approach to the Ninth Plan (1997-2002)
2) National Action Plan on Disaster Management
3) Draft Flood Mitigation Policy
4) Watershed Development Policy

1.8.3 Organizations Involved in Flood Mitigation

The Department of Irrigation (DOI) is responsible for flood mitigation in the downstream areas. At the same time, there are other agencies that can make significant contributions to the implementation of flood mitigation project, both within and outside the central Government.

The Water-induced Disaster Prevention Technical Center (DPTC) has developed technologies and methodologies which can be applied to the project.

The Department of Soil Conservation and Watershed Management (DOSCWM), with an increasing number of branch offices in the Terai plain, also contributes to the project implementation through soil conservation which is also a crucial factor in promoting flood mitigation in the target areas.

As indicated by the experience of the efforts for small-scale infrastructure development by the Ministry of Local Development (MLD), the local governing institutions (LGIs) can play a significant role in facilitating community mobilization and also in coordinating different organizations operating in their own jurisdictions. There exists an NGO-led disaster preparedness network (DPNET), an association of organizations concerned with community-based disaster management can participate in implementing community development components of the flood mitigation project.

Table A1.1

LIST OF METEOROLOGICAL STATIONS

Station No.	Station Name	Type of Station	Reg.	Latitude			Longitude			Elevation (m)	Start of Record	Remarks
				°	'	"	°	'	"			
0301	Muga	Precipitation	MW	29	45	00	82	33	00	3,803	06-1958	
0302	Thirpu	Precipitation	MW	29	19	00	81	46	00	1,006	12-1956	
0303	Jumla	Synoptic	MW	29	17	00	82	10	00	2,300	12-1956	
0304	Guti Chaur	Precipitation	MW	29	17	00	82	19	00	3,080	06-1976	
0305	Sheri Ghat	Precipitation	MW	29	08	00	81	36	00	1,210	02-1966	
0306	Gam Shree Nagar	Precipitation	MW	29	33	00	82	09	00	2,133	10-1970	
0307	Rara	Climatology	MW	29	33	00	82	07	00	3,048	10-1970	
0308	Nagma	Precipitation	MW	29	12	00	81	54	00	1,905	10-1970	
0309	Bijayapur (Raskot)	Precipitation	MW	29	14	00	81	38	00	1,814	12-1956	
0310	Dipayal Gaun	Climatology	MW	29	16	00	82	13	00	2,310	06-1974	
0311	Simikot	Climatology	MW	29	58	00	81	50	00	2,800	05-1976	
0312	Dunai	Climatology	MW	28	56	00	82	55	00	2,058	06-1958	
0313	Darma	Precipitation	MW	29	44	00	82	06	00	1,950	09-1979	
0401	Pusma Camp	Climatology	MW	28	53	00	81	15	00	950	03-1963	
0402	Dailekh	Climatology	MW	28	51	00	81	43	00	1,402	01-1957	
0403	Jamu (Tikuwa Kuna)	Precipitation	MW	28	47	00	81	20	00	260	05-1963	
0404	Jajarkot	Precipitation	MW	28	42	00	82	12	00	1,231	12-1956	
0405	Chisapani (Karnali)	Climatology	MW	28	39	00	81	16	00	225	01-1963	
0406	Surkhet (Birendra Nagar)	Synoptic	MW	28	36	00	81	37	00	720	01-1957	
0407	Kusum	Precipitation	MW	28	01	00	82	07	00	235	11-1956	West Rapti
0408	Gulariya	Precipitation	MW	28	10	00	81	21	00	215	01-1957	Babai
0409	Khajura (Nepalgunj)	Agrometeology	MW	28	06	00	81	34	00	190	01-1968	West Rapti
0410	Bale Budha	Precipitation	MW	28	47	00	81	45	00	610	05-1965	
0411	Rajapur	Precipitation	MW	28	26	00	81	06	00	129	02-1971	
0412	Naubasta	Precipitation	MW	28	16	00	81	43	00	135	02-1971	West Rapti
0413	Shyalo Shree	Precipitation	MW	28	27	00	81	35	00	302	02-1971	Babai
0414	Baijapur	Precipitation	MW	28	03	00	81	54	00	226	02-1971	West Rapti
0415	Bargadaha	Precipitation	MW	28	26	00	81	21	00	200	11-1967	Babai
0416	Nepalgunj (Reg Off.)	Climatology	MW	28	04	00	81	37	00	144	02-1973	West Rapti
0417	Rani Jaruwa Nursery	Climatology	MW	28	23	00	81	21	00	200	12-1975	Babai
0418	Maina Gaun (D.bas)	Precipitation	MW	28	59	00	82	17	00	2,000	05-1975	
0419	Sikta	Agrometeology	MW	28	02	00	81	47	00	195	05-1978	West Rapti
0501	Rukumkot	Precipitation	MW	28	36	00	82	38	00	1,560	07-1957	
0502	Shera Gaun	Precipitation	MW	28	35	00	82	49	00	2,150	07-1957	
0504	Libang Gaun	Precipitation	MW	28	18	00	82	38	00	1,270	07-1957	West Rapti
0505	Bijuwar Tar	Precipitation	MW	28	06	00	82	52	00	823	08-1957	West Rapti
0507	Nayabasti (Dang)	Precipitation	MW	28	33	00	82	07	00	698	12-1970	Babai
0508	Tulsipur	Climatology	MW	28	08	00	82	18	00	725	12-1970	Babai
0509	Ghorahi (Masina)	Precipitation	MW	28	03	00	82	30	00	725	12-1970	Babai
0510	Loilabas	Precipitation	MW	27	42	00	82	32	00	320	02-1971	
0511	Salyan Bazar	Climatology	MW	28	23	00	82	20	00	1,457	11-1956	Babai
0512	Luwamjula Bazar	Precipitation	MW	28	18	00	82	17	00	885	11-1971	Babai
0513	Chaur Jhari Tar	Climatology	MW	28	32	00	82	01	00	910	06-1975	
0514	Musikot (Rukumkot)	Climatology	MW	28	38	00	82	29	00	2,100	07-1973	
0515	Ghorai	Synoptic	MW	28	03	00	82	30	00	725	*	

(Note) Reg. MW: Mid Western Region (All the stations of this region are listed.)

LIST OF HYDROMETRIC STATIONS

Station No.	Name of River	Name of Site	Latitude	Longitude	Elevation (m)	Drainage Area (km^2)	Instrument			Start of Record	End of Record	Remarks
			° ' "	° ' "								
120.	Chamelia	Karkale Gaon	29 40 20	80 33 30	-	1,150				01/01/65		
150.	Mahakali	Pancheshwor	29 26 45	80 15 30	-	12,236	C	R		01/01/62		
169.8	Surnagad	Gujar Gaon	29 31 00	80 35 00	-	(66)	C			-		
170.	Surnagad	Patan near Baitadi	29 27 30	80 33 10	1,110	118	C			01/01/66	01/04/88	
190.5	Kandr Khola	Amsara	28 36 00	80 56 00	-	(313)				-		
190.8	Khutiya Khola	Boladevi Gaon	28 53 00	80 44 00	-	-				-		Khutiya
205.	Kharpu Khola	Kharpu	29 57 00	81 52 00	-	1,310				14/05/78		
206.	Humla Karnali	Bihi Chhara	29 38 00	81 52 00	-	(8,447)				17/06/79		
208.	Mugu Karnali	Surkhet	29 37 00	81 52 00	-	5,300	C	.		13/06/79		
209.	Kawadi Khola	Kawadi Ghat	29 36 16	81 45 28	-	795				17/01/89		
210.	Rara Daha	Nizal	29 31 00	82 04 00	-	1,150				08/11/65		
215.	Humla Karnali	Thuldada	29 09 00	81 36 00	-	15,200	C			06/02/66		
220.	Tila Nala	Nagina	29 12 00	81 55 00	-	1,870	C			19/03/64		
225.	Sinja Khola	Diware	29 12 00	81 55 00	-	824	C			17/03/64		
230.	Tila Nadi	Seti Ghat	29 08 00	81 36 00	-	3,470	C			08/03/64		
240.	Karnali	Asara Ghat	28 57 10	81 26 30	629	19,260	C	R	S	01/01/61		
241.	Lohare Khola	Tallo Dungeswat	28 41 00	81 36 00	-	1,060	C			24/05/65		
245.	Chhamghat Khola	Gitachaur	28 56 00	81 41 30	-	(108)	C			20/03/78		
250.	Karnali	Benighat	28 57 40	81 07 10	320	21,240	C	R		01/02/63		
251.	Seit	Chainpur	29 33 30	80 12 40	-	2,040	C			-		
255.	Bhdhi Ganga	Kakarsant	29 11 00	81 13 00	-	1,340	C			28/04/78		
259.2	Seit	Gopaghat Gaon	29 18 00	80 46 30	-	4,420	C			-		
260.	Seit	Banga near Belgaon	28 58 40	81 08 40	328	7,460	C	R	S	06/02/63		
262.	Tuli Gad	Khanayatal	28 56 00	80 54 00	314	896	C	R		17/06/65		
265.	Thulo Bheri	Rimna	28 42 30	82 17 30	-	6,720	C			18/06/72		
267.	Sano Bheri	Simli Ghat	28 39 30	82 21 30	-	2,620	C			18/06/76		
269.5	Bheri Nadi	Samaiji Ghar			-	-	C	PR		16/12/89		
270.	Bheri	Jamu	28 45 20	81 21 00	246	12,290	C	R	S	23/01/63		
280.	Karnali	Chisapani	28 38 40	81 17 30	191	42,890	C	R	S	01/01/62		

LIST OF HYDROMETRIC STATIONS

Station No.	Name of River	Name of Site	Latitude	Longitude	Elevation (m)	Drainage Area (km^2)	Instrument			Start of Record	End of Record	Remarks
			° ' "	° ' "								
284.	Sarda Khola	Shyalpani-Sita Pall	28 22 30	82 11 45	-	295				17/06/77		Babai
285.	Mohana	Kalakunta	28 27 00	81 00 30	-	(623)				22/04/76		
286.	Sarada Khola	Daradhunga	28 17 58	82 01 30	-	816	C	R	S	01/01/72		Babai
287.	Kauriala Karnali	Sattar Farm	28 24 30	81 05 00	-	-				17/03/80		
288.	Geruwa Karnali	Kothiya Ghat	28 22 30	81 12 00	-	(14,853)				18/03/80		
289.	Babai River	Gangate Gaon	28 15 00	81 57 00						06/01/72		
289.5	Gohar Khola	Sirchaur Gaon	28 09 15	82 22 45	-	-	C			21/06/77		Babai
289.9	Babai Nadi	Gangata			-	-				-		Babai
289.95	Babai Nadi	Chepang			-	-	C	R		01/10/89		Babai
290.	Babai	Bargadha	28 25 20	81 22 10	192	3,000	C	R		16/07/66	13/04/89	Babai
291.	Babai Nadi	Bhada			-	-				-		Babai
327.	Lungri Khola	Khungree Gaon	28 13 30	82 42 30	-	467	C			26/12/76		West Rapti
330.	Mari Khola	Nayagaon	28 04 20	82 48 00	536	1,980	C			01/01/64		West Rapti
333.	Arun Khola	Devistan	28 02 00	82 45 30	-	136	C			--/--/68		West Rapti
339.5	Jhimruk Khola	Tigra Gaon	28 03 00	82 49 40	-	683	C			22/05/71		West Rapti
340.	Jhimruk Khola	Kalimati Ghat	28 02 10	82 53 00	692	696	C			01/01/65	21/05/71	
350.	Rapti	Bagasoti Gaon	27 54 00	82 51 00	381	3,380	C	R	S	08/05/75		West Rapti
350.5	Rangsing Khola	Tinkhanne Gaon	27 47 30	82 49 00	-	(92)	C			03/01/83		West Rapti
360.	Rapri	Jalkundi	27 56 50	82 13 30	218	5,150	C	R	S	08/04/64		West Rapti
380.	Rapti River	Sindhania	28 01 00	81 44 45						06/03/83		
385.2	Rapti River	Farinda			-	-				-		West Rapti
387.4	Dumre Khola	Kalimati	27 47 47	83 32 09	595	90	C			18/06/80		Tinau
387.5	Madi Tinau	Charchare	27 47 29	83 33 08	570	103	C	R		17/06/80		Tinau
387.8	Jhumsa Khola	Dumahi Bari	27 45 00	83 30 46	335	99	C			15/02/85		Tinau
390.	Tinau Khola	Butwal	27 42 10	83 27 50	184	554	C			09/12/63		Tinau
403.	Kali Gandaki	Jomsom	28 47 30	83 45 00	-	(3,060)				07/06/69		Narayani
403.5	Kali Gandaki	Tatopani	28 29 00	83 39 00	1,239	-		R		--/03/92		
404.6	Kali Gandaki	Kalipul Beni	28 21 30	83 34 30	-	(4,581)				05/04/71		Narayani
404.7	Myagdi Khola	Mangla Ghat	28 21 30	83 32 00	-	(1,112)	C			19/05/75		Narayani

LIST OF HYDROMETRIC STATIONS

Station No.	Name of River	Name of Site	Latitude	Longitude	Elevation (m)	Drainage Area (km^2)	Instrument			Start of Record	End of Record	Remarks
			° ' "	° ' "								
406.	Kali Gandaki	Modi Beni	28 12 00	83 42 00	667	-		R		--/03/92		
406.5	Modi Khola	Nayapul	28 13 30	83 42 15	-	(635)	C			25/05/75		Narayani
409.5	Seti Khola	Seti Beni	28 00 40	83 37 10	-	(138)				22/02/76		Narayani
410.	Kali Gandaki	Seti Beni	28 00 30	83 36 10	546	6,630	C	R	S	21/02/64		Narayani
413.2	Danab Khola				-	-	C			27/05/90		
414.1	Dararun Khola	Arjun Chaupari			-	-				01/01/90		
415.	Andhi Khola	Dumrichaur Andhimuhan	27 58 20	83 35 20	543	476	C			06/04/89		Narayani
416.2	Daram Khola	Wamitaksar	28 11 45	83 18 15	-	(239)	C			18/12/78		Narayani
417.	Badigad Khola	Rudrabeni Gulmi	27 58 20	83 28 10	-	1,990	C			24/05/67		Narayani
419.1	Kali Gandaki	Ansigh-AndhiGhat			-	-	C			13/04/89		Narayani
420.	Kali Gandaki	Kotagaon Shringe	27 45 00	84 20 50	198	11,400	C	R		15/04/64		Narayani
428.	Mardi Khola	Lahachok	28 18 30	83 55 30	-	160	C			07/06/70		Narayani
430.	Seti Khola	Phoolbari	28 14 00	84 00 00	830	582	C			01/01/89		Narayani
438.	Madi	Shisa Ghat	28 06 00	84 14 00	-	858	C			08/02/73		Narayani
439.3	Khudi Khola	Khudi Bazar	28 17 15	84 21 45	-	(151)	C			04/07/81		Narayani
439.4	Dordi Khola	Amote Bazar-Sera Besi	28 10 45	84 27 30	-	(341)	C			09/02/76		Narayani
439.7	Marsyangdi	Bimal Nagar	27 57 00	84 25 48	354	(4,088)	C	R	S	31/03/87		Narayani
439.8	Marsyangdi	Gopling Ghat	27 55 35	84 29 42	320	3,850	C	R	S	01/06/73	21/05/88	
440.	Chepe Khola	Garam Besi	28 03 41	84 29 23	442	308	C	PR		20/11/63		Narayani
441.	Daraundi Khola	Navasanghu Gorkha	28 01 00	84 35 15	-	386	C			13/10/67		Narayani
441.5	Daraundi Khola	Ramdi								26/12/86		
445.	Burhi Gandaki	Arughat	28 02 37	84 48 59	485	4,270	C	R	S	28/11/63		Narayani
445.3	Ankhu Khola	Ankhu Bridge	27 58 20	84 49 10	-	768	C			--/--/67		Narayani
446.15	Lirung Khola	Kyangjin								-		
446.2	Langtang Khola	Shyaprubesi	28 09 30	85 20 45	-	(540)	C			-		Narayani
446.25	Bhote Kosi	Syaprubesi			-	-				-		
446.3	Trisuli Khola	Dhunche	28 07 10	85 17 40	-	49	C	R		--/--/63		Narayani
446.8	Phalankhu Khola	Betrawati	27 58 25	85 11 15	630	162				24/04/69		Narayani
447.	Trisuli	Betrawati	27 58 08	85 11 00	600	4,110	C	R	S	01/04/67		Narayani

LIST OF HYDROMETRIC STATIONS

Station No.	Name of River	Name of Site	Latitude	Longitude	Elevation (m)	Drainage Area (km^2)	Instrument			Start of Record	End of Record	Remarks
			° ' "	° ' "								
447.4	Tadi Khola	Rautar Nuwakot	27 55 00	85 17 10	-	254				-		Narayani
447.9	Likhu Khola	Pattawari Nuwakot	27 53 30	85 14 45	-	(145)				-		Narayani
448.	Tadi Khola	Tadipul Belkot	27 51 35	85 08 18	475	653				14/06/68		Narayani
449.9	Trisuli	Mugling	27 51 00	84 34 30	-	-				-		Narayani
449.91	Trishuli	-			-	-				-		
449.95	Trisuli	Bhorletar	27 49 00	84 26 45	-	(14,500)	C			26/02/82		Narayani
450.	Narayani	Narayan Ghat	27 42 30	84 25 50	180	31,100	C	R	S	10/02/62		Narayani
460.	Rapti	Rajaiya	27 26 30	84 58 15	332	579	C			01/01/63		Narayani
465.	Manahari Khola	Manahari	27 33 00	84 48 10	305	427	C	R		13/06/63		Narayani
470.	Lothar Khola	Lothar	27 35 40	84 43 00	336	169	C			30/11/63		Narayani
505.	Bagmati	Sundarijal	27 46 30	85 25 40	1,600	17	C	R		07/12/62		
507.	Nagmati	Sundarijal	27 46 20	85 26 10	1,660	13				00/11/63		
510.	Sialmati	Syamdado	27 46 10	85 25 10	1,660	3				00/11/63		
511.	Dhakal Khola	Gagalgau	27 44 45	85 26 15	-	-				-		
520.	Bagmati River	Gokarna	27 43 45	85 23 30		56				-		
525.5	Manahara River	Shakyu Salmutar			-	-				04/03/00		
530.	Bagmati	Gauri Ghat	27 42 30	85 21 00	1,300	68				15/11/64		
536.2	Bishnumati Khola	Budhanilkantha	27 46 49	85 21 32	1,454	4				27/05/68	27/08/98	
540.	Nakhu Khola	Tika Bhairab	27 34 30	85 18 50	1,400	43				23/11/62		
548.	Nakhu Khola	Nakhu Jail Near Patan	27 39 40	85 18 30	-	56				01/01/87		
550.	Bagmati River	Chovar	27 39 40	85 17 50	1,280	585	C	R	S	01/07/62	--/--/80	
550.05	Bagmati	Khokana	27 16 00	85 13 00	1,255	607		PR		01/06/91		
550.1	Bagmati River	Sampkhel	27 33 30	85 15 45	-	-	C	R	S	15/06/85		
565.	Kulekhani Khola	Lamichaur	27 36 13	85 09 39	1,514	122	C	R		01/07/75	09/12/78	
570.	Kulekhani Khola	Kulekhani	27 35 10	85 09 30	1,480	126	C	R	S	01/12/62	15/11/77	
586.	Bagmati	Rai Gaon			-	-				01/02/88		
589.	Bagmati	Pandhera Dobhan	27 06 20	85 28 30	180	2,700	C	R	S	28/01/79		
590.	Bagmati	Karmaiya - Mangalpur	27 06 20	85 28 30	177	2,720		R	S	21/06/64	17/10/84	
592.	Bagmati	Bramhapuri	26 45 30	85 20 00	-	(13,790)				-		

LIST OF HYDROMETRIC STATIONS

Station No.	Name of River	Name of Site	Latitude	Longitude	Elevation (m)	Drainage Area (km^2)	Instrument			Start of Record	End of Record	Remarks
			° ' "	° ' "								
595.	Jamuni	Chyutaha	26 57 00	85 20 00	-	-				19/03/92		
598.	Kamala	Chisapani	26 55 15	86 10 30	-	(1.595)				-		
599.	Kamala	Inarawa	26 36 45	86 09 00	-	-				-		
600.05	Barun Khola	Seksila Hatiya	27 41 00	87 21 00	1.500	352				22/12/86		
600.1	Arun	Uwa Gaon	27 36 00	87 20 06	1.294	26.750	C	R	S	11/05/72		
601.8	Pangtha Khola	Kurle Besi	27 24 00	87 13 30	-	(26)				01/09/98		
601.9	Pangma Khola	Kurle Besi	27 24 00	87 12 45	-	(38)				01/09/98		
602.	Sabhaya Khola	Tumlingtar	27 18 20	87 13 15	-	375	C	R		02/01/74		
602.5	Hinwa Khola	Pipletar	27 17 45	87 13 30	-	110	C			-		
604.	Arun	Leguwa Ghat	27 09 00	87 16 30	-	(4.183)				01/06/68		
604.5	Arun	Turkeghat	27 20 00	87 11 30	414	28.200	C	R		23/05/75		
605.	Pikhuwa Khola	Parapani Phedi	27 05 00	87 07 00		337				0/0/64		
606.	Arun	Simle	26 55 30	87 09 30	-	30.380	Br			-		
610.	Bhote Kosi	Barabise	27 47 10	85 53 20	840	2.410				17/02/65		
612.	Sun Kosi	Barabise	27 46 30	85 54 30	-	(84)				-		
620.	Balephi Khola	Jalbire	27 48 20	85 46 10	793	629	C			25/12/63		
625.	Sun Kosi	Dolalghat	27 38 30	85 43 00	-	(1.375)	C			-		
627.5	Melamchi Khola	Helambu	28 02 30	85 32 00	-	-				-		
627.55	Melamchi Khola	Sajhaya			-	-				-		
629.1	Indrawati	Dolalghat	27 38 20	85 42 30	-	1.225	C			17/09/72		
630.	Sunkosi	Pachuwar Ghat	27 33 30	85 45 10	589	4.920	C			26/03/64		
640.	Rosi Khola	Panauti	27 34 50	85 30 50	1.480	87				17/10/63		
641.	Rosi Khola	Lold Khola			-	-				-		
647.	Tamakosi	Busti	27 38 05	86 05 12	849	2.753	C	R		14/01/70		
650.	Khimti Khola	Rasnalu Village	27 34 30	86 11 50	1.520	313	C			06/04/64		
652.	Sunkosi	Khurkot	27 20 00	86 00 00	455	10.000	C			01/07/67		
660.	Likhu Khola	Sanghu Khola	27 20 10	86 13 10	543	823	C			24/03/64		
665.	Sun Kosi	Ahrkapur (Tokselghat)	27 10 30	86 22 00	-	(8.736)	C			20/02/86		
668.4	Taktor Khola	Beni	27 31 45	86 33 30	2.350	(87)	Br			-		

LIST OF HYDROMETRIC STATIONS

Station No.	Name of River	Name of Site	Latitude	Longitude	Elevation (m)	Drainage Area (km^2)	Instrument			Start of Record	End of Record	Remarks
			° ' "	° ' "								
668.5	Solua Khola	Saime	27 30 30	86 33 15	1,800	(324)	Br			-		
669.5	Rawa Khola	Gaikhure	27 16 00	86 40 30						-		
670.	Dudh Kosi	Rabuwa Bazar	27 16 00	86 39 50	460	4,100	C	R	S	10/03/64		
680.	Sun Kosi	Kampughat	26 52 30	86 49 20	200	17,600				28/06/65		
681.	Sun Kosi	Hampuachuwar	26 55 15	87 08 45	-	-	C			-		
684.	Tamur	Majhitar	27 09 30	87 42 45	-	-	C			-		
685.3	Maiwa Khola	Maiwa Dovan	27 22 10	87 36 50		194				-		
685.9	Hima Khola	Thapatar (Phidim)	27 09 45	87 46 15						0/0/74		
688.5	Madhu Khola	Dhankuta	26 59 30	87 22 15						-		
688.6	Banchare Khola	Dhankuta	26 59 00	87 22 30		13				-		
688.7	Nibuwa Khola	Dhankuta	26 59 00	87 23 15	-	(28)				-		
689.	Tankhuwa Khola	Biretar Near Dhankuta	26 58 30	87 22 15	-	51				--/--/64		
690.	Tamur	Mulghat	26 55 50	87 19 45	276	5,640	Br	PR	S	11/03/65		
691.	Tamur	Tribeni	26 55 00	87 10 00	-	(6,146)	C			-		
695.	Sapta Koshi	Chatara-Kothu	26 52 00	87 09 30	140	54,100	C		S	01/01/77		
698.	Sardu Khola	Mathilo Sardu-Dharan	26 51 00	87 18 05		7				0/0/71		
715.	Mai Khola	Mai Beni	26 53 25	87 57 20		210				0/0/71		
720.	Jog Mai Khola	Mai Beni	27 53 40	87 59 20		140				0/0/67		
728.	Mai Khola	Rajdwail	26 52 45	87 55 45	-	377	C		S	01/01/83		
730.	Puwa Khola	Sajbote (Ilam)	26 55 00	87 54 40	802	107	C			18/01/65		
738.	Deo Mai Khola	Angdang	26 54 00	87 46 15	-	(199)	C			-		Ratuwa ?
795.	Kankai Mai	Mainachuli	26 41 12	87 52 44	125	1,148	C	R		01/05/71		
799.	Kankai	Kumarkhod-Jhapa			-	-				30/10/87		
848.4	Siddhi Khola	Kajeni	26 51 15	88 07 00	-	-				-		

Note:

C: Cable way for discharge measurement
Br: Bridge available for discharge measurement
R: Recording gauge for water level observation
PR: Pressure type gauge for water level observation

GRAIDING OF RIVERBED MATERIALS

Sample code	Cumulative percentage of passing materials (%)														
	<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)	<100 (mm)	<200 (mm)	<400 (mm)
	0.075	0.106	0.250	0.425	0.850	2.00	4.75	9.50	19.0	26.5	37.5	53.0	100.0	200.0	400.0
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	100.0	100.0	100.0
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	100.0	100.0	100.0
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	100.0	100.0	100.0
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	100.0	100.0	100.0
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	100.0	100.0	100.0
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	100.0	100.0	100.0
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	100.0	100.0	100.0
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	91.6	100.0	100.0
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	93.3	100.0	100.0
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	92.8	100.0	100.0
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	100.0	100.0	100.0
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	78.0	100.0	100.0
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	77.8	100.0	100.0

REPRESENTATIVE GRAIN SIZES AND SPECIFIC GRAVITY

Sample code	Representative grain size					Specific gravity (g/cc)		
	16 (%)	60 (%)	65 (%)	84 (%)	d84/d16	S.G.1 (g/cc)	S.G.2 (g/cc)	S.Gave (g/cc)
Babai River								
Ba-1	0.11	0.21	0.23	0.33	2.86	2.65	2.68	2.67
Ba-2	0.12	0.19	0.20	0.25	2.12	2.66	2.69	2.68
Ba-3	0.11	0.20	0.21	0.30	2.58	2.60	2.65	2.63
Ba-4	0.13	0.25	0.27	0.35	2.69	2.63	2.67	2.65
Ba-5	0.13	0.29	0.30	0.37	2.80	2.68	2.65	2.67
Ba-6	0.15	0.32	0.33	0.41	2.81	2.67	2.63	2.65
Ba-7	0.17	0.35	0.37	0.52	3.03	2.67	2.65	2.66
Ba-8	0.30	47.13	53.24	83.52	275.52	2.69	2.63	2.66
Ba-9	0.53	39.45	46.77	78.68	147.97	2.69	2.66	2.68
Ba-10	0.45	28.01	32.36	58.86	129.43	2.58	2.60	2.59
Ba-11	0.72	33.75	39.44	67.98	94.91	2.60	2.65	2.63
Ba-12	0.40	41.24	49.39	120.81	299.79	2.59	2.61	2.60
Ba-13	1.22	50.47	60.71	121.36	99.43	2.65	2.67	2.66
							Average	2.65

SUMMARY OF QUESTIONNAIRES BY RIVER

Name of river: **BABAI RIVER(1/2)**

No.	Questions/items	Summary of answers
1. FLOOD EVENTS		
1.1	Year of most severe flood in past 10 years (nop)	1995(127)
1.2	Floods in a year (times)	Average(3) ranging(2 to 8)
1.3	Severe floods in past 10 years (times)	Average(2) ranging(1 to 4)
1.4	(Cancelled)	(Cancelled)
1.5	Cause of flood (nop)	• Too much rain(61) • Sediment flow(2) • Bank erosion(83) • Others(0)
2. EFFECT DUE TO SEVERE FLOOD IN PAST		
2.1	Loss of human life (nop)	1 (excluding those due to epidemic disease)
2.2	Loss of livestock/husbandry (nos)	• Cow(46) • Buffalo(10) • Sheep/Goat(142) • Poultry(848)
2.3	Damage to farm land (ha)	• Irrigated land: Average(4.8) ranging(0.3 to 16.0) • Non-irrigated land: Average(7.6) ranging(0.2 to 23.0)
2.4	Extent of damage to farm land	• Simple inundation (nop): 99 • Loss of crops (nop): Paddy(71), Sugarcane(1), Maize(84), Others(18) • Total washout (ha): Average(1.1) ranging(0.7 to 1.9)
2.5	Extent of damage to dwelling and asset	• Flooding duration (days): Average(3.9) ranging(2 to 7) • Flooding depth in (m): Average(1.6) ranging(0.8 to 1.7) • Damage to house (nop): Severe(35), Moderate(31), Ordinary(33) • Loss of cash (Rs): Average(1,125) ranging(0 to 5,000) • Loss of food grains (kg): Paddy: Average(2,370) ranging(0 to 3,900) • Clothing (nos): Average(1) ranging(0 to 1) • Other valuables: Average(1) ranging(0 to 1)
2.6	Problems during flood (nop)	• Erosion of river bank(118) • Sediment in the river(50) • Sediment in irrigation canal(35) • Drinking water problem(55) • Sanitary problem(41) • Salinity(0) • Flooding over farm land(109) • Others(9)
2.7	Epidemic disease after flood? (nop)	• Yes(63) • No(65)
2.8	If yes, kind of epidemic disease (nop)	• Cholera(6) • Dysentery(53) • Typhoid(44) • Others(23)
2.9	Fatal causality? (nop)	• Yes(5) • No(107)
2.10	Reason of flood(nop)	• Too much rain(37) • Lack of flood protection works(93) • Weak river training works(19) • Sediment load in the flood water(2) • Flood from adjoining rivers(4)
2.11	Total amount of damage (Rs)	Average(174,000) ranging(0 to 1,100,000)

(Remarks) nop: Number of persons who answer to the item.

SUMMARY OF QUESTIONNAIRES BY RIVER

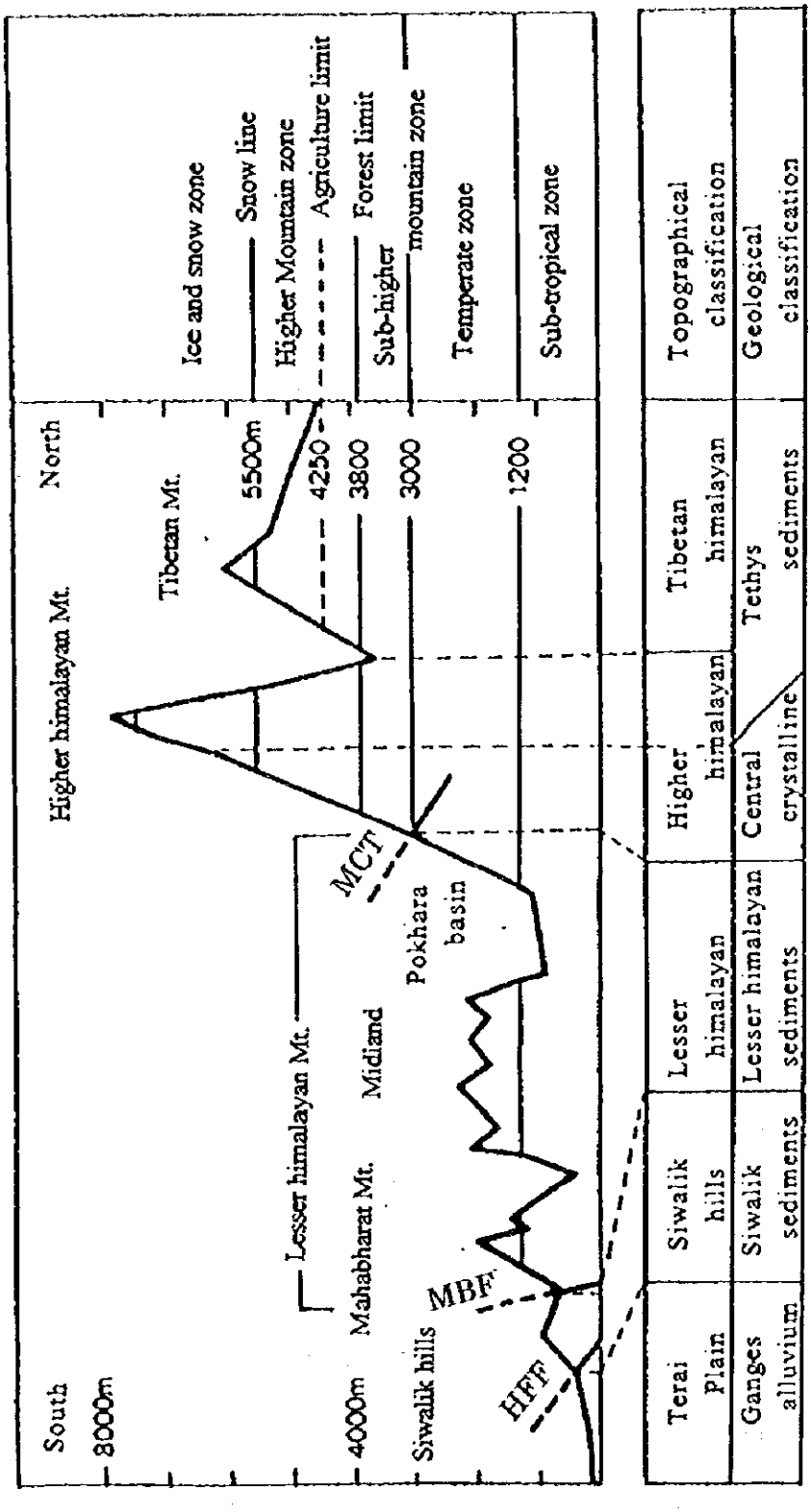
Name of river: BABAI RIVER(2/2)

No.	Questions/items	Summary of answers
3. FLOOD WARNING SYSTEM		
3.1	(Cancelled)	(Cancelled)
3.2	Self warning (nop)	• Heavy rain/High flood level(55) • Bank erosion(8) • Smelled mud(0) • Unusual sound(0) • Others(2)
3.3	Warning by others (nop)	• Neighbors(0) • Institutions(0) • Others(0)
4. FLOOD RELIEF MEASURES		
4.1	Evacuation experience? (nop)	• Yes(61) • No(68)
4.2	If yes, place of evacuation (nop)	• High ground(17) • Public building(11) • Others houses(24) • Other sites(2)
4.3	Being relieved? (nop)	• Yes(62) • No(60)
4.4	If yes, how?(nop)	• In cash(15) • Kind(62)
4.5	Organization/individual giving relief (nop)	• Central government(5) • DDC(17) • VDC(6) • Other institutions(10) • NGO(41) • Individuals(0)
4.6	(Cancelled)	(Cancelled)
5. PREVENTIVE MEASURES AGAINST FLOOD		
5.1a	Current preparedness/ measures (nop)	• Warning(0) • Evacuation(51) • Settlement(12)
5.1b	Proposed preparedness/ measures (nop)	• Warning(39) • Evacuation(72) • Settlement(48)
5.2a	Current non-structural measures (nop)	• Seed storage(0) • Cash pools(13) • Informal insurance(0) • Others(0)
5.2b	Proposed non-structural measures (nop)	• Seed storage(85) • Cash pools(33) • Informal insurance(10) • Others(0)
5.3a	Current structural measures (nop)	• Embankment(8) • Spur(15) • Simple gabion(25) • Plantation(5) • Others(2)
5.3b	Proposed structural measures(nop)	• Embankment(103) • Spur(36) • Simple gabion(91) • Plantation(0) • Others(3)
6. PARTICIPATION ACTIVITIES		
6.1	Experience of Participation in activities? (nop)	• Yes(51) • No(78)
6.2	If yes, type (nop)	• Cash(3) • Labor(37) • Kind(11) • Care taker(4) • Others(7)
6.3	If no, reason (nop)	• Being affected badly(64) • Financially weak(4) • Being out of the area(1) • No willingness(10) • Others(19)
6.4	Willing to participate in future? (nop)	• Yes(99) • No(29)
6.5	If yes, type (nop)	• Cash(8) • Labor(93) • Kind(2) • Care taker(9) • Others(0)
6.6	If no, reasons (nop)	• No time(0) • No benefit(0) • No Willingness(1) • Not known how to participate(0) • Others(29)

(Remarks) nop: Number of persons who answer to the item.

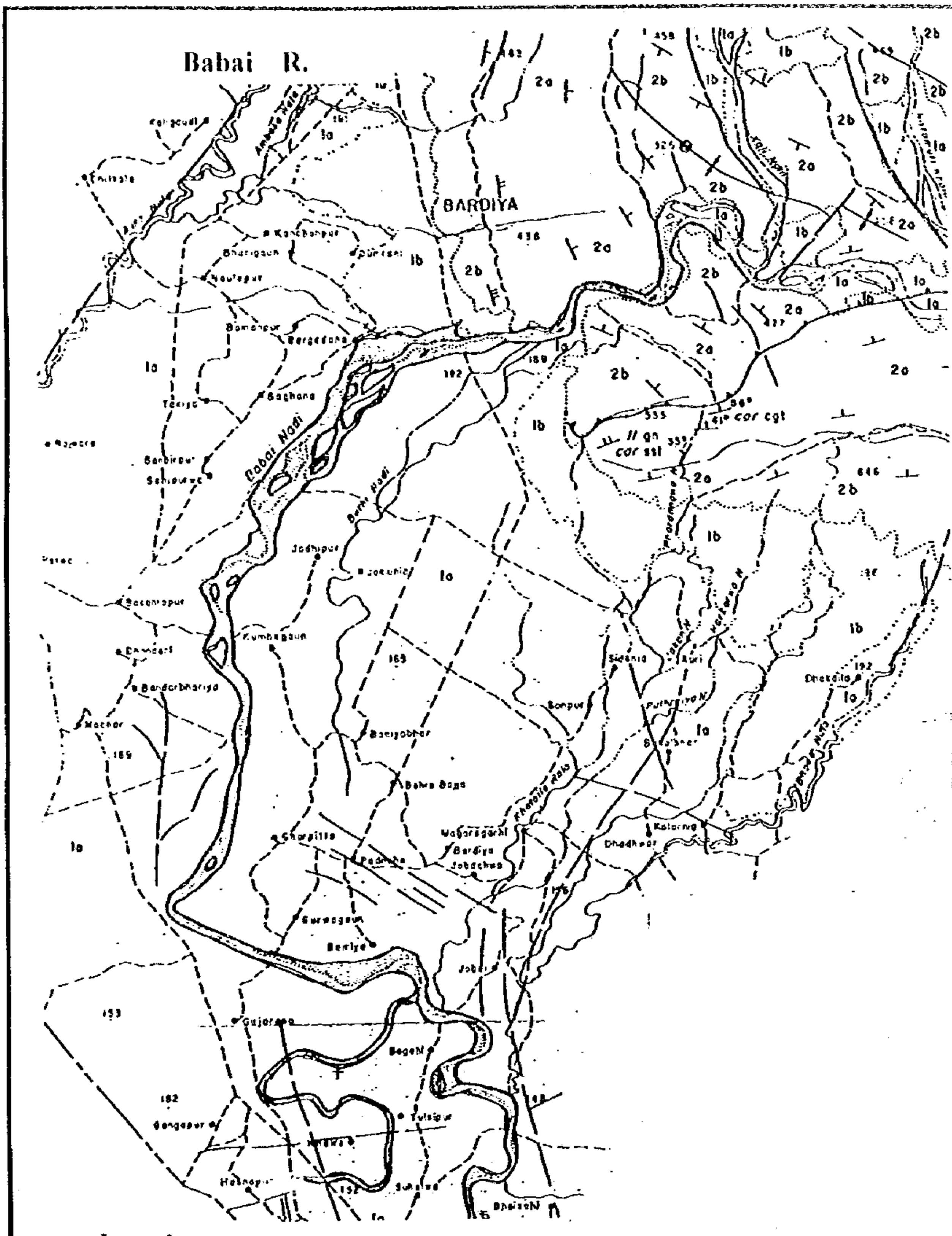
LOSS OF LIFE AND DAMAGE TO PROPERTIES (BABAI RIVER)
(1995-FLOOD)

VDC/Municipality	Loss of Life (nos.)	Loss of cattle (nos.)		Damage of crops (ha)				Damage of crops (ton)			Wash out land (ha)		Damage of houses (nos.)		Remarks
		Cow	Goat	Poultry	Paddy	Maize	Cotton, Pulse, Vegetable	Paddy	Maize	Cotton, Pulse, Vegetable	Agricultural	Barren	Damage	Washout	
Gulariya	-	112	613	1,850	588	1,687	20 (C) 20 (P) 80 (V)	1,430	3,033	30 (C) 6 (P) 1,200 (V)	184	265	1,221	92	
Muhamadpur	3	24	25	150	50	180	37 (P)	150	270	37 (P)	42	2	400	150	
Dhadhawar	-	-	5	150	18	9	-	54	11	-	7	-	35	-	
Padanaha	-	-	25	150	250	50	-	750	100	-	67	133	2	35	
Baniyabhar	-	45	20	-	25	5	-	75	8	-	20	15	-	20	
Bagahaha	2	150	10	200	100	-	-	400	-	-	10	-	130	5	
Total	5	331	698	2,500	1,031	1,931	20 (C) 57 (P) 80 (V)	2,859	3,422	30 (C) 43 (P) 1,200 (V)	330	415	1,788	302	



TOPOGRAPHICAL AND GEOLOGICAL CLASSIFICATION(N-S PROFILE)

His Majesty's Government of Nepal Department of Irrigation, Ministry of Water Resources
THE STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL
JAPAN INTERNATIONAL COOPERATION AGENCY



Legend

1. Unconsolidated sediments, chiefly in the Terai plain
   - 1a. alluvium, deposited or reworked by water
   - 1b. alluvial fans, talus, colluvium
2. Siwalik sedimentary system
   - 2a Upper formation-generally coarser clastics
   - 2b. Lower formation-generally finer clastics

GEOLOGICAL MAP (BABAI R.)

His Majesty's Government of Nepal
Department of Irrigation, Ministry of Water Resources

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

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. A1.3

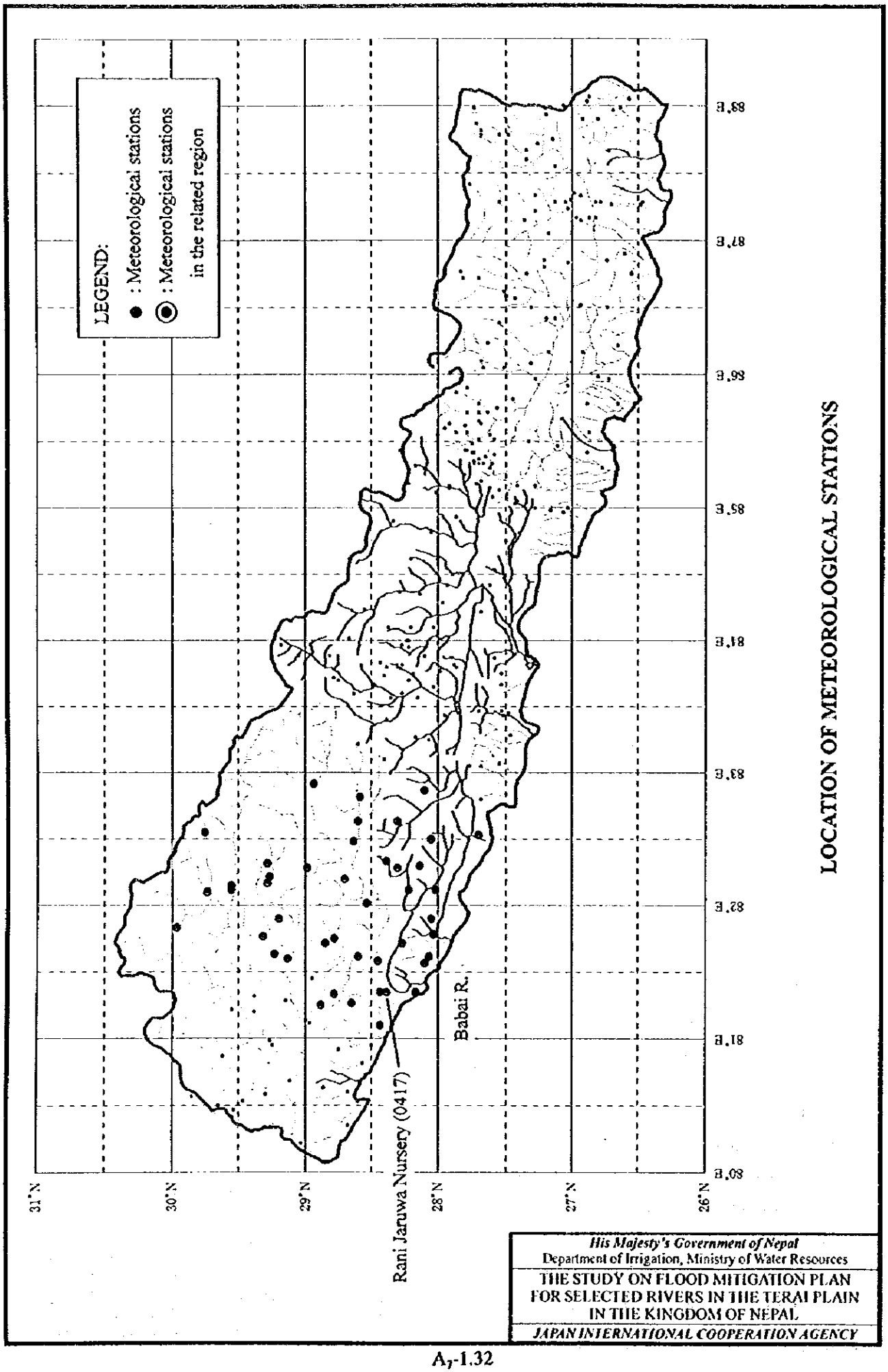
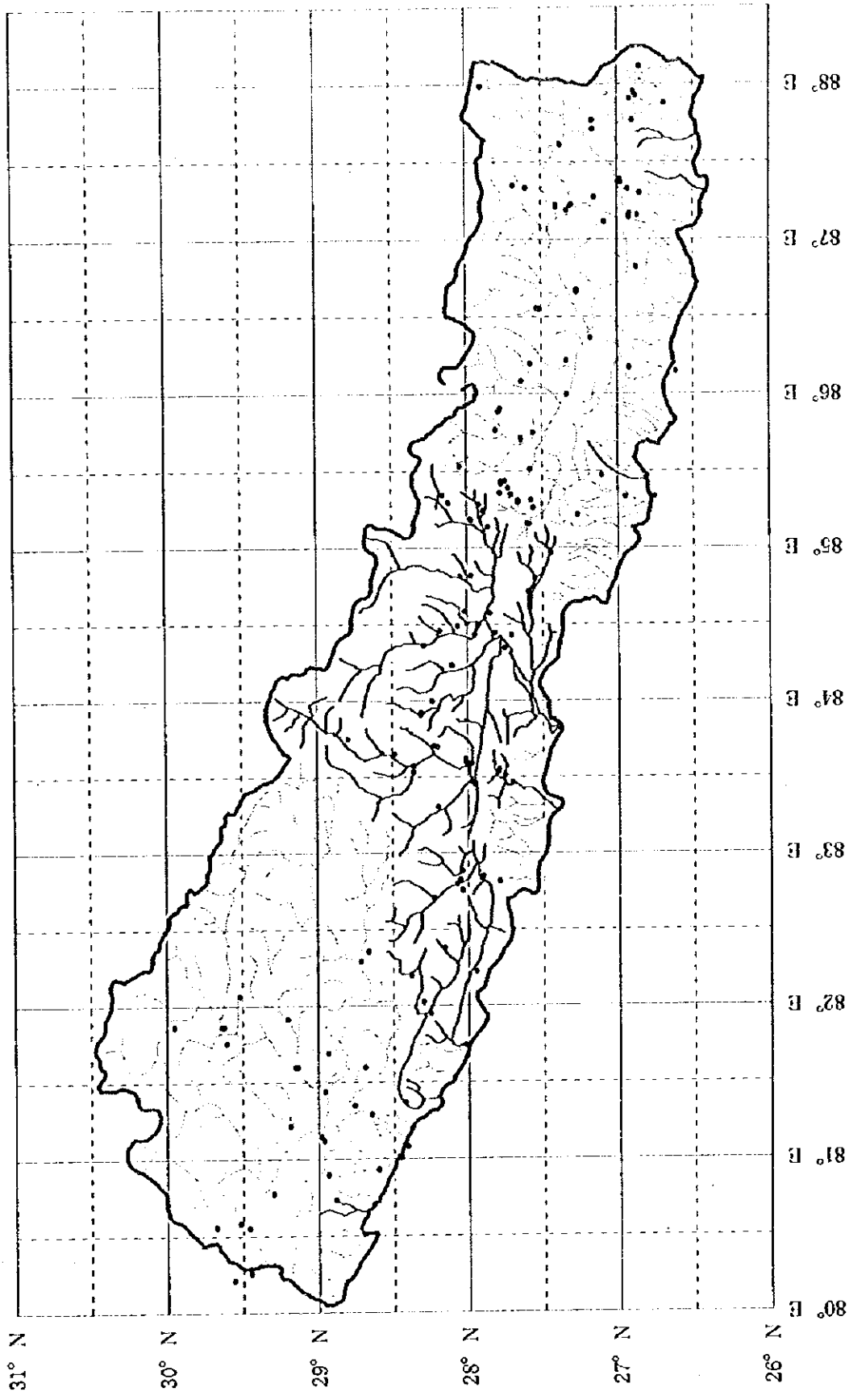

LEGEND:
● : Meteorological stations
◉ : Meteorological stations in the related region
Babai R.
Rani Jaruwa Nursery (0417)
31°N
30°N
29°N
28°N
27°N
26°N
LOCATION OF METEOROLOGICAL STATIONS
His Majesty's Government of Nepal
Department of Irrigation, Ministry of Water Resources
THE STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. A1.4



His Majesty's Government of Nepal
Department of Irrigation, Ministry of Water Resources

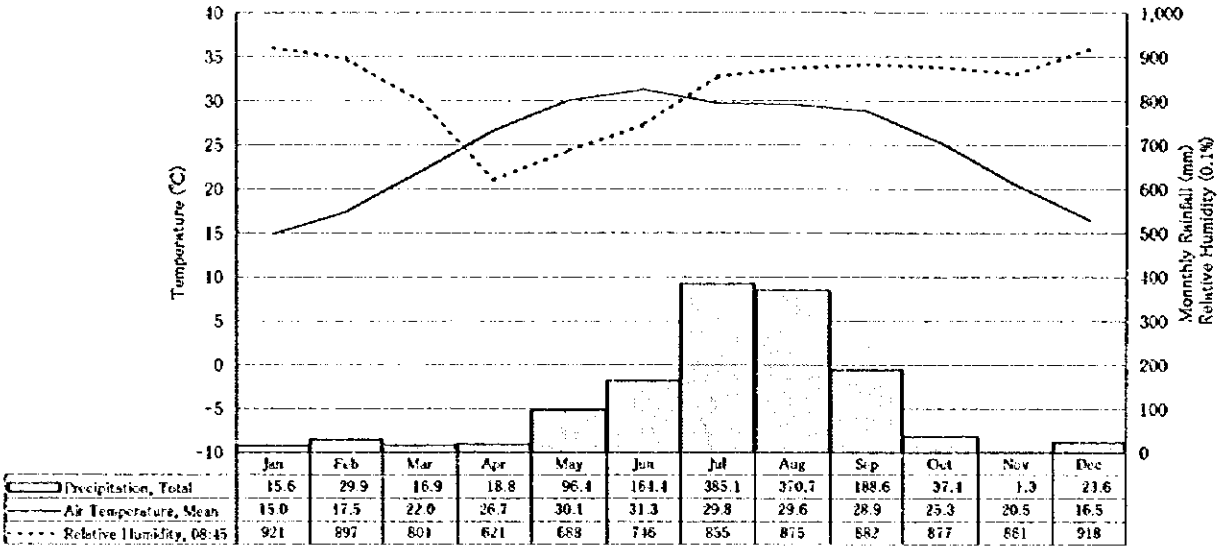
THE STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL

JAPAN INTERNATIONAL COOPERATION AGENCY

Code: 0417
Station: Rani Jaruwa Nursery

Latitude: 28°23'
Longitude: 81°21'
Elevation: 200 m

Rani Jaruwa Nursery (0417)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation, Total	15.6	29.9	16.9	18.8	96.4	164.4	385.1	370.7	188.6	37.4	1.3	23.6
Air Temperature, Mean	15.0	17.5	22.0	26.7	30.1	31.3	29.8	29.6	28.9	25.3	20.5	16.5
Relative Humidity, 08:45	921	897	801	621	688	746	855	875	882	877	861	918

Air Temperature, Mean (Unit: °C)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1985	-	-	-	-	-	31.9	28.8	29.5	-	-	-	16.3	-
1986	15.1	17.2	22.4	25.9	26.8	30.3	29.0	29.7	28.6	25.4	20.8	16.9	24.0
1987	15.5	-	-	-	30.0	32.4	29.5	29.5	29.5	25.8	21.3	17.2	-
1988	16.5	18.7	22.0	27.1	33.2	31.1	30.3	29.4	29.3	25.7	20.2	17.7	24.9
1989	14.1	16.3	21.5	26.1	30.9	29.7	29.7	29.9	29.1	25.9	20.3	15.7	24.1
1990	15.8	17.2	22.1	27.2	29.3	31.3	29.2	29.9	29.3	25.0	20.9	16.7	24.5
1991	14.2	18.3	22.7	27.7	31.3	31.5	30.6	29.6	28.5	24.8	19.1	15.9	24.5
1992	14.5	16.0	21.5	27.8	29.7	31.2	30.0	29.5	28.9	25.2	20.8	16.0	24.2
1993	13.9	19.4	20.3	25.7	30.5	31.0	29.8	29.4	28.2	25.4	20.6	16.6	24.2
1994	15.3	16.9	23.6	26.0	31.1	32.9	30.7	29.8	28.8	24.9	20.4	16.2	24.7
Ave.	15.0	17.5	22.0	26.7	30.1	31.3	29.8	29.6	28.9	25.3	20.5	16.5	24.4

Relative Humidity, 08:45 (Unit: %)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1985	-	-	-	-	-	76	88	90	92	90	91	95	-
1986	95	92	79	63	78	76	91	88	88	89	89	92	85.0
1987	94	91	82	68	63	65	88	84	90	90	87	89	82.6
1988	86	87	80	73	66	78	87	92	89	89	85	92	83.7
1989	96	93	90	75	79	80	89	87	89	89	82	92	86.8
1990	96	92	83	74	90	90	88	88	87	88	81	92	87.4
1991	95	89	70	56	68	77	82	88	89	84	87	92	81.4
1992	92	89	78	47	70	69	82	88	68	91	87	90	80.9
1993	87	85	84	57	60	71	79	87	87	85	87	92	80.2
1994	88	88	75	46	45	64	81	83	83	82	85	92	76.0
Ave.	92.1	89.7	80.1	62.1	68.8	74.6	85.5	87.5	88.2	87.7	86.1	91.8	82.7

Precipitation, Total (Unit: mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1985	-	-	-	-	-	96	519	532	448	195	0	7	-
1986	3	36	2	43	83	217	372	335	227	27	6	34	1,385
1987	13	7	0	30	123	56	552	245	147	22	0	26	1,221
1988	0	20	30	56	80	341	638	573	75	10	0	26	1,849
1989	60	15	0	0	40	298	433	323	336	14	3	39	1,561
1990	0	75	55	2	311	217	473	299	171	46	1	17	1,667
1991	5	39	16	17	40	113	159	340	100	0	2	49	880
1992	16	14	0	2	77	162	204	315	250	60	1	38	1,139
1993	16	12	49	19	98	101	289	551	106	0	0	0	1,241
1994	27	51	0	0	16	43	212	194	26	0	0	0	569
Ave.	15.6	29.9	16.9	18.8	96.4	164.4	385.1	370.7	188.6	37.4	1.3	23.6	1,279

METEOROLOGICAL CONDITIONS

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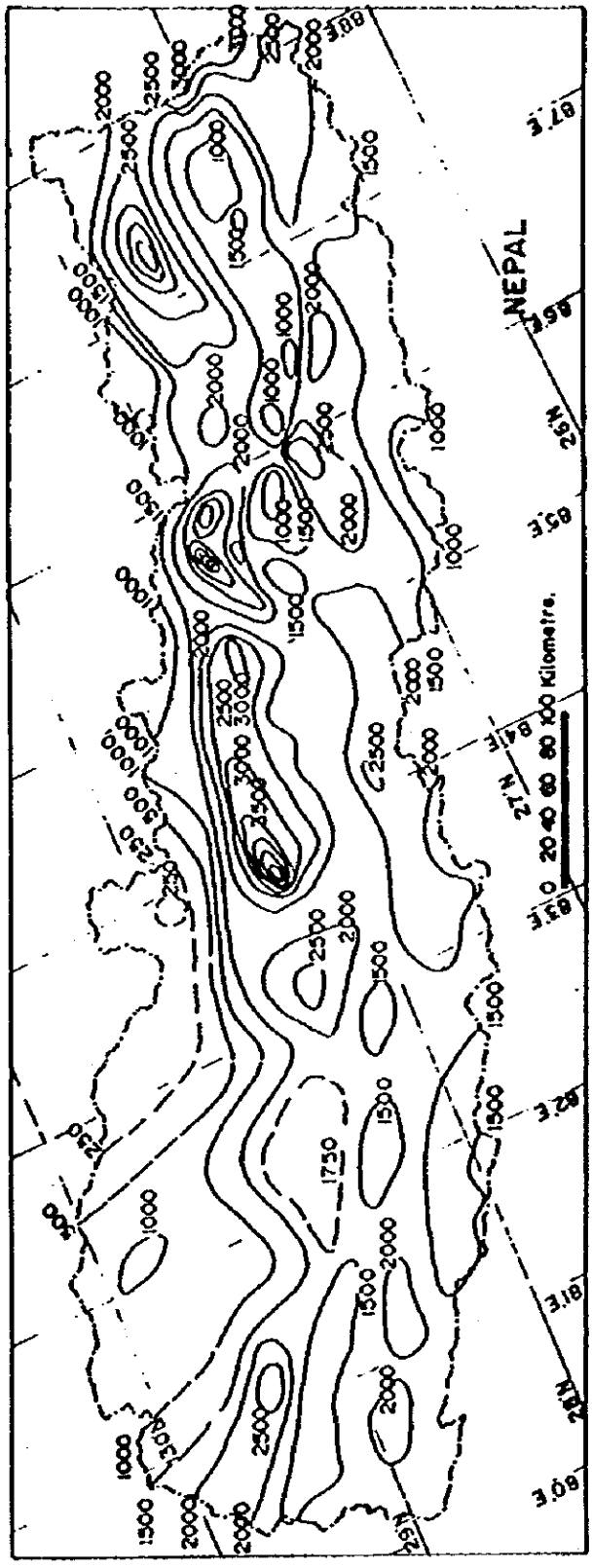
MEAN ANNUAL PRECIPITATION (mm) 1971-1985



Source: Natural Hazards and Man Made Impacts in The Nepal Himalaya, C.K.Sharman, 1988

ANNUAL RAINFALL DISTRIBUTION OF NEPAL

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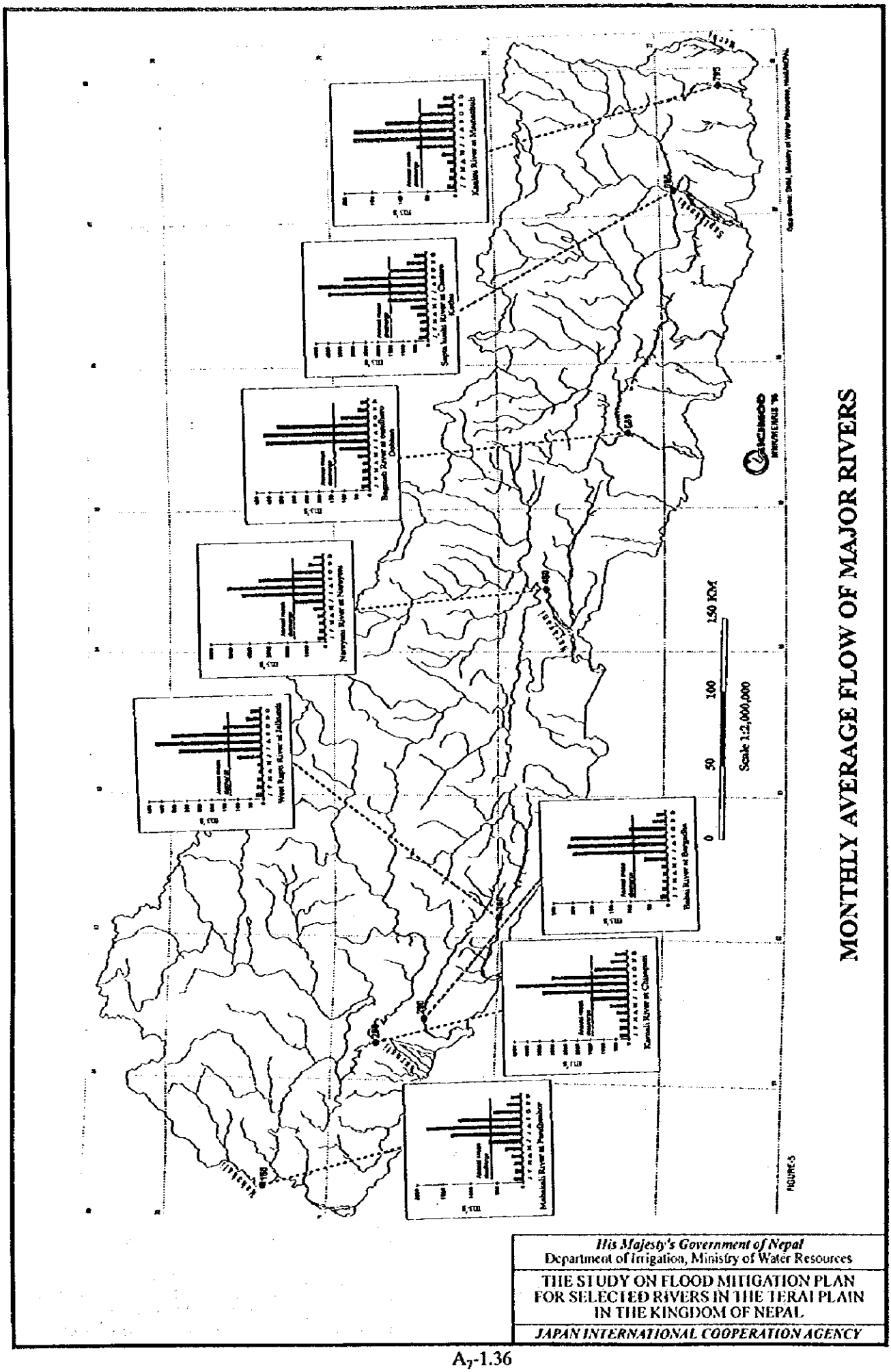
MONTHLY AVERAGE FLOW OF MAJOR RIVERS
Scale 1:2,000,000
0
50
100
150 KM
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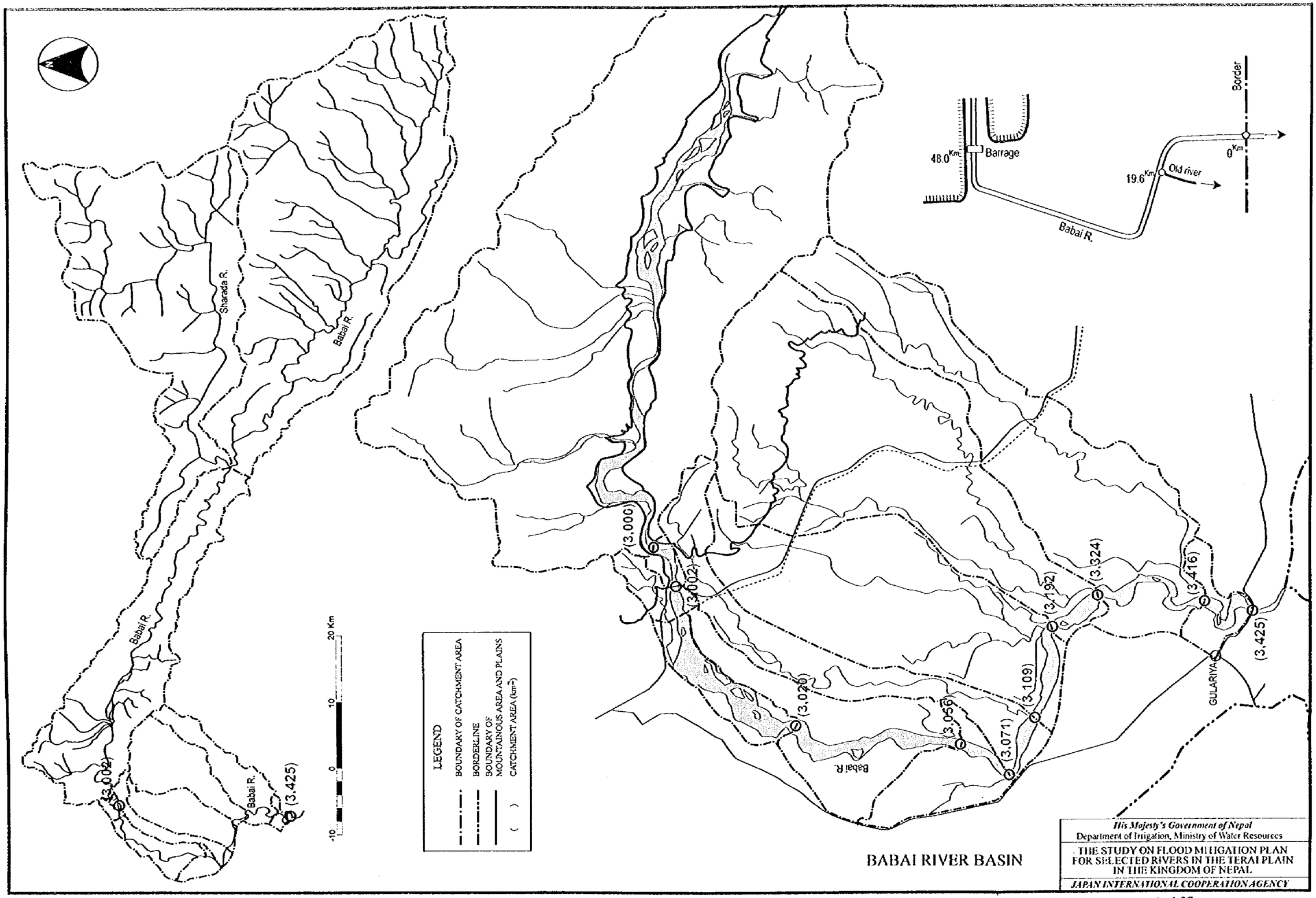
Fig. A1.8


Sharada R.
Babai R.
Babai R
Babai R.
(3.425)
(3.002)
(3.000)
(3.002)
(3.020)
(3.056)
(3.071)
(3.109)
(3.192)
(3.324)
(3.416)
(3.425)
GULARIYA
Babai R.
48.0Km
Barrage
19.6Km
Old river
0Km
Border
LEGEND
BOUNDARY OF CATCHMENT AREA
BORDERLINE
BOUNDARY OF MOUNTAINOUS AREA AND PLAINS
( ) CATCHMENT AREA (km²)
20 Km
10
0
-10
BABAI RIVER BASIN
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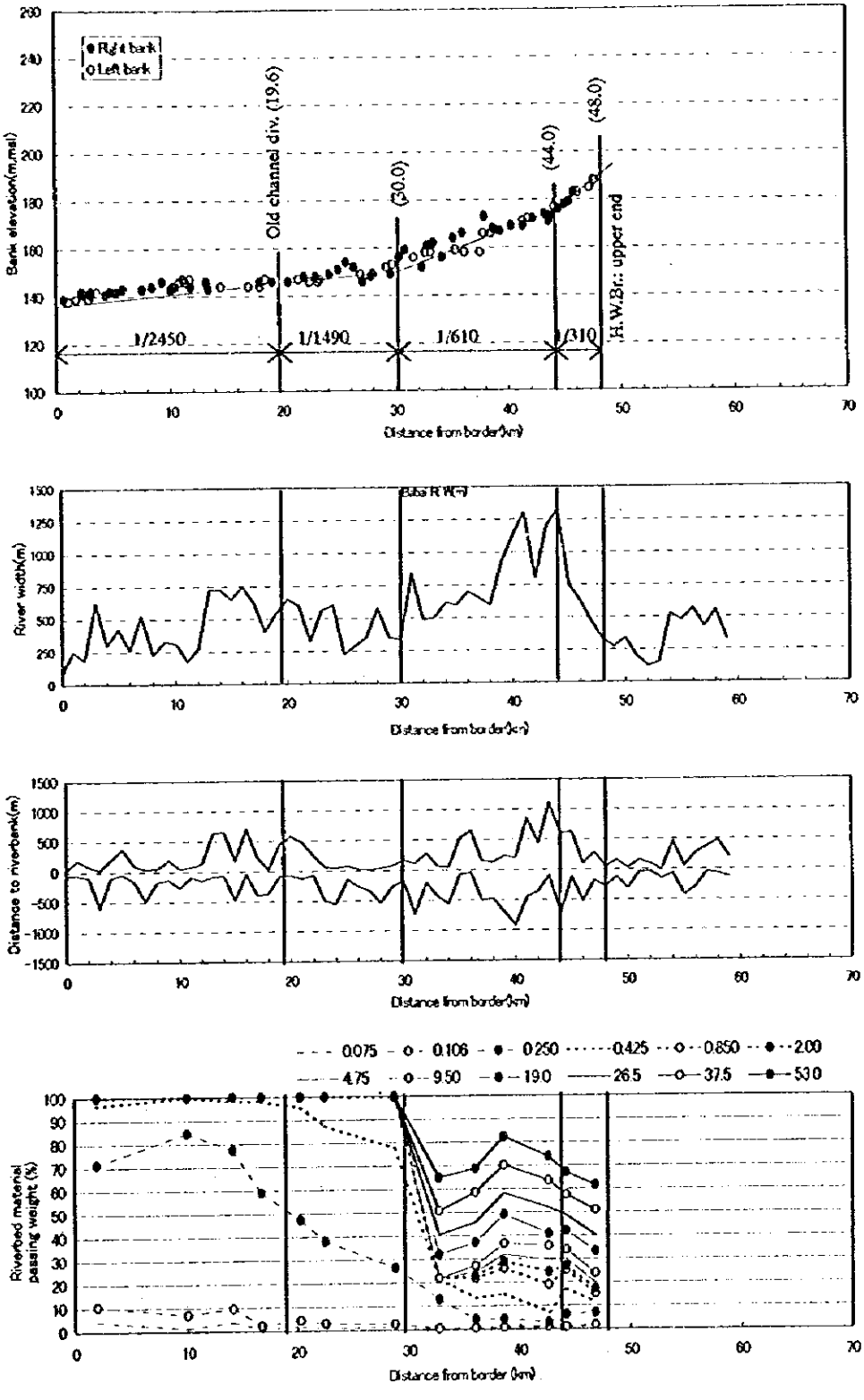
BABAI RIVER



CHARACTERISTICS OF EXISTING CHANNEL

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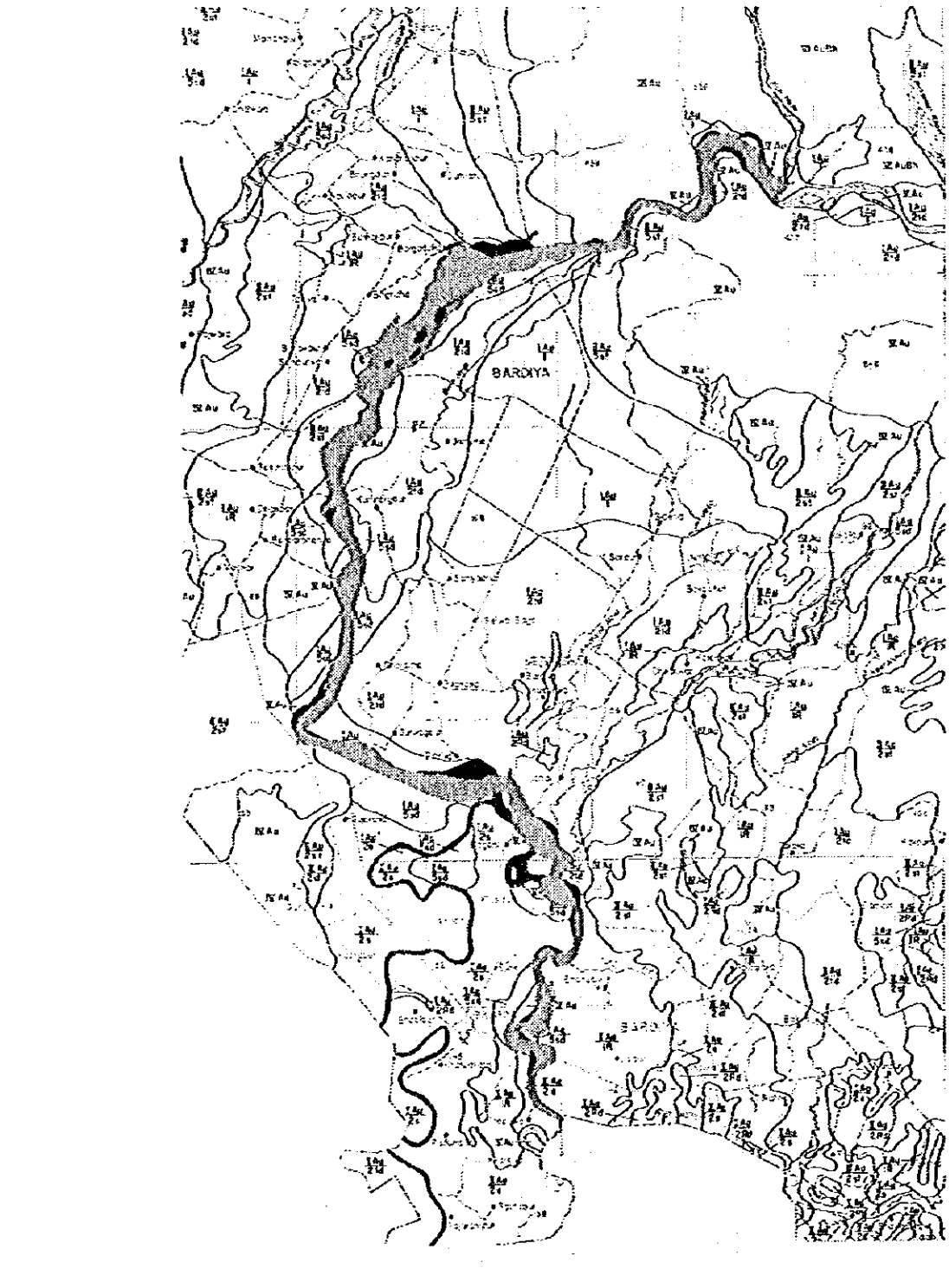

CHANGE OF BABAI RIVER COURSE

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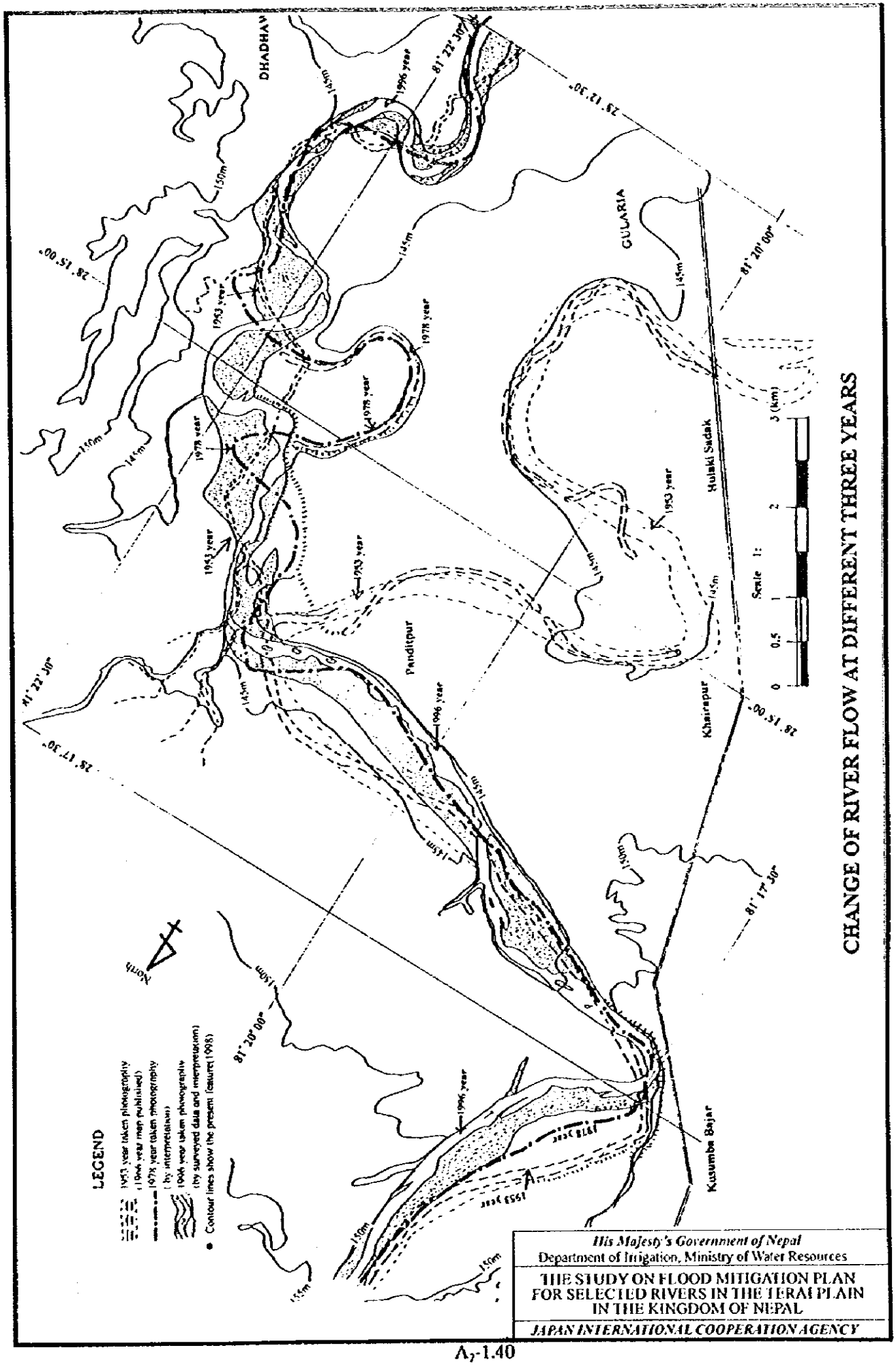

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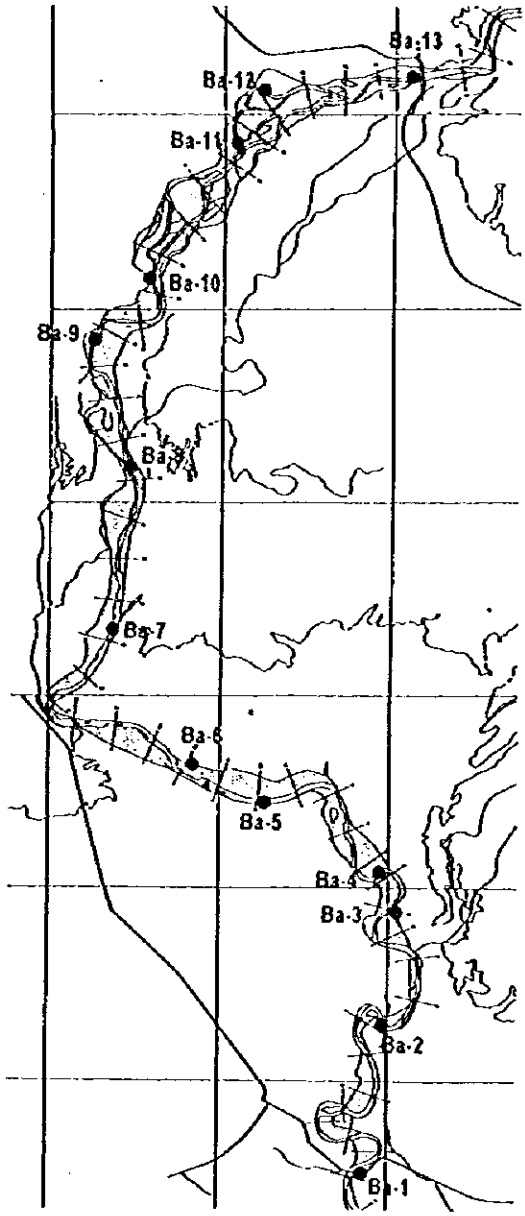

SN	Sample code	Soil classification by eye	Description of sampling place	GPS Reading		FGA (Y/N)
				N	E	
1	Ba-1	Silt		28° 11.464'	81° 22.147'	N
2	Ba-2	Silty sand		28° 13.404'	81° 22.376'	N
3	Ba-3	Silty sand		28° 15.062'	81° 22.271'	N
4	Ba-4	Fine sand		28° 15.951'	81° 21.840'	N
5	Ba-5	Fine sand		28° 15.951'	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

SAMPLING SITES OF RIVERBED MATERIALS (BABAI RIVER)

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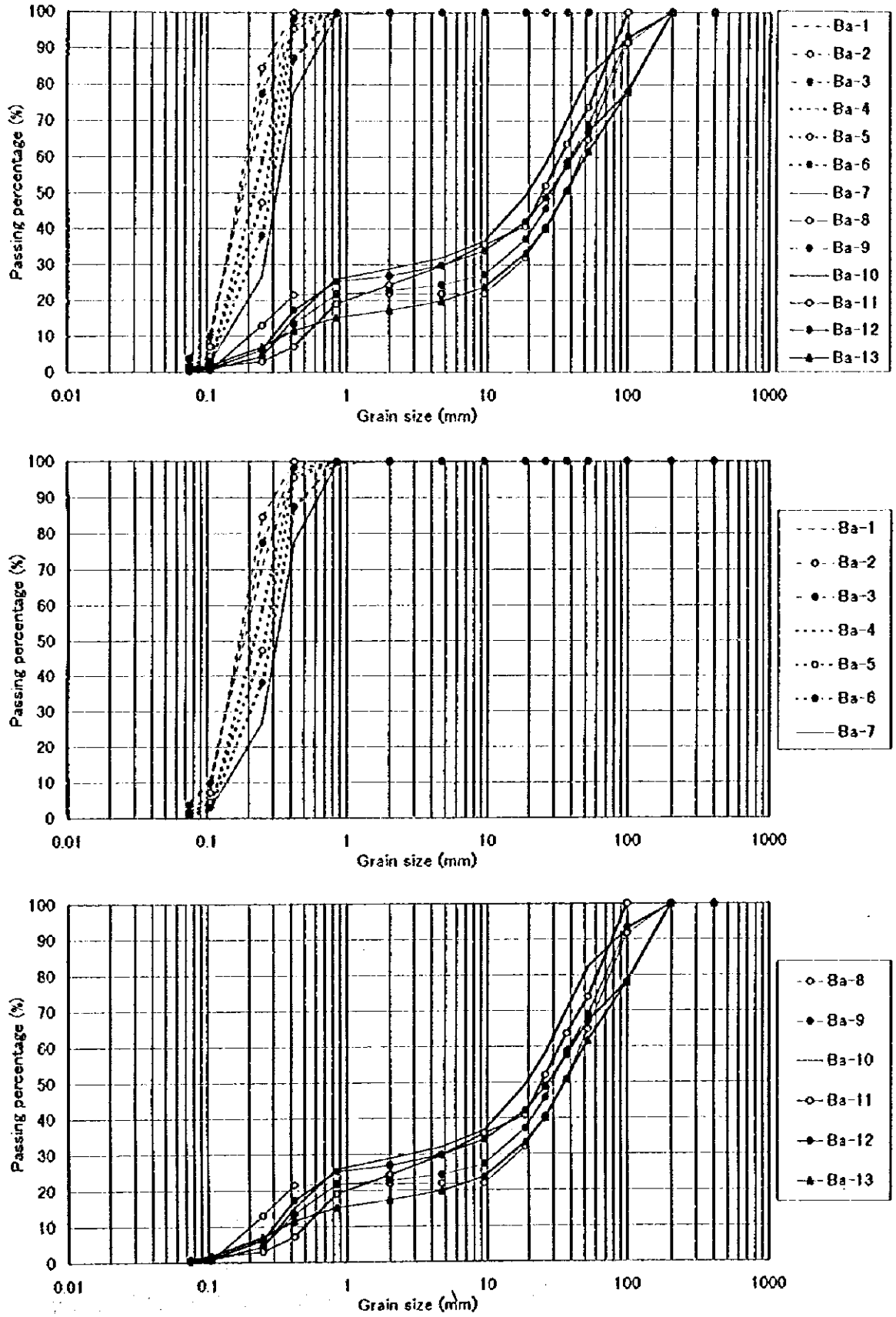

GRADING CURVES OF RIVERBED MATERIALS (BABAI R.)

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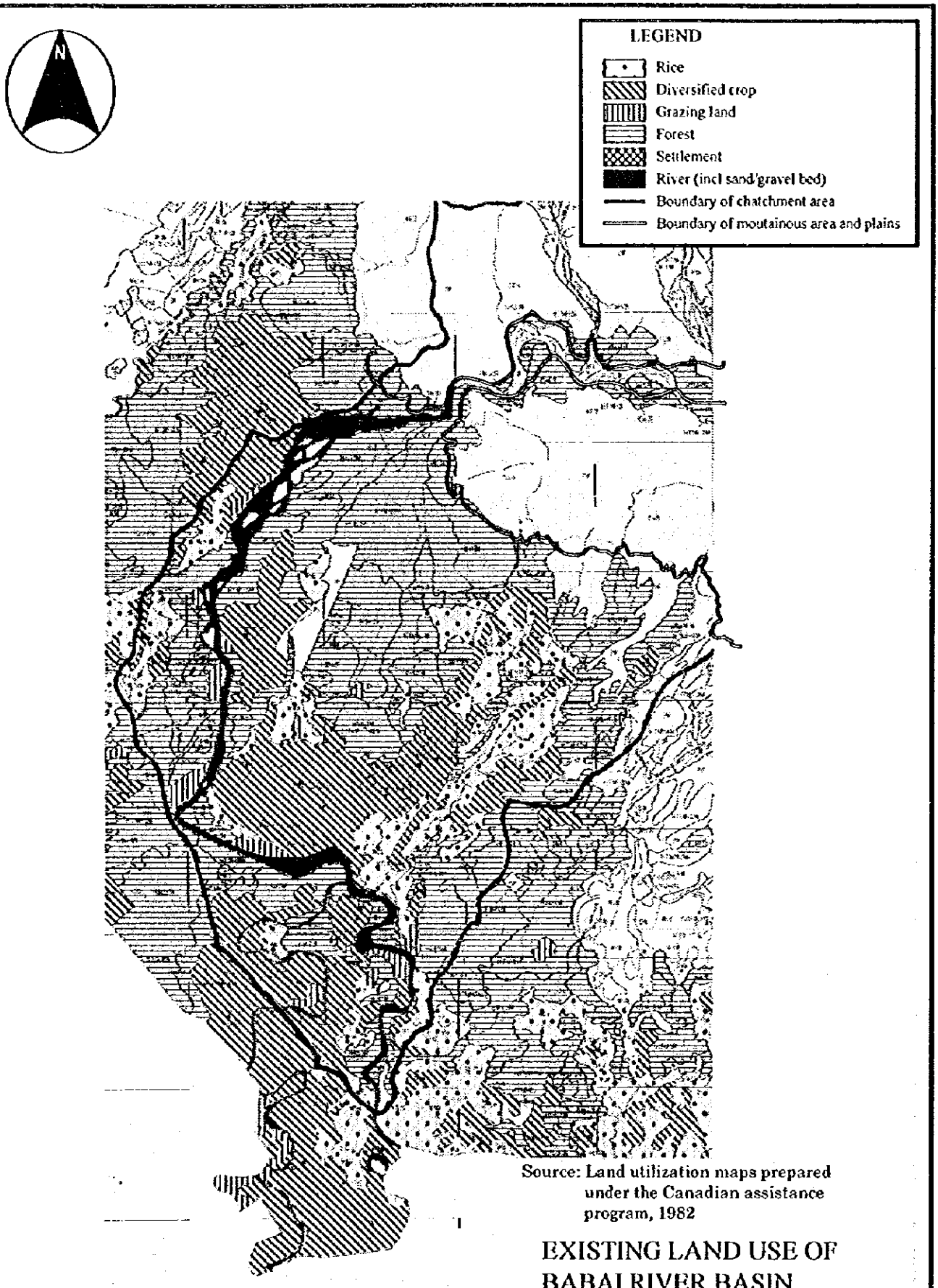
Fig. A1.14


N
LEGEND
Rice
Diversified crop
Grazing land
Forest
Settlement
River (incl sand/gravel bed)
Boundary of chatchment area
Boundary of moutainous area and plains
Source: Land utilization maps prepared under the Canadian assistance program, 1982
EXISTING LAND USE OF BABAI RIVER BASIN
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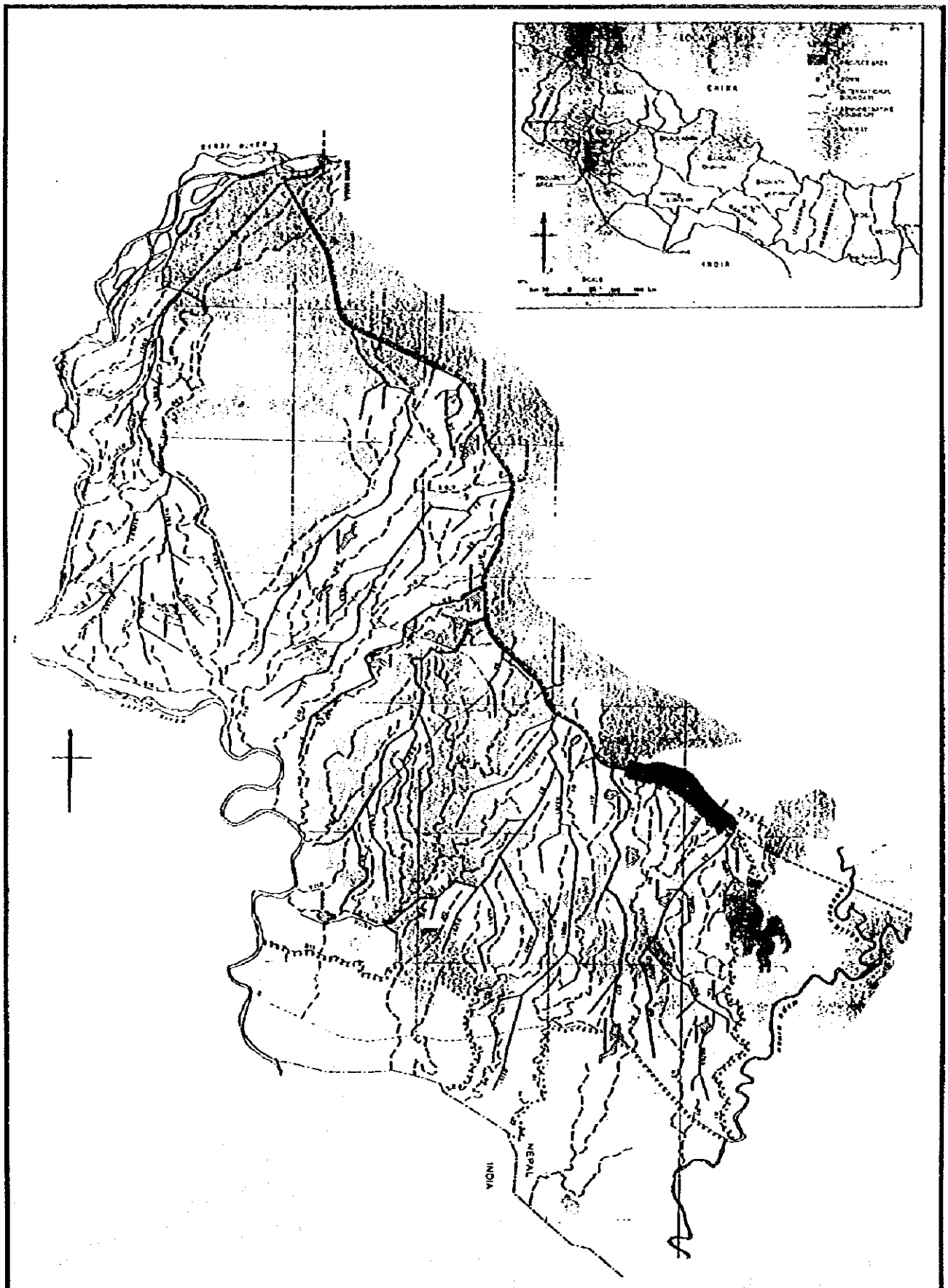
JAPAN INTERNATIONAL COOPERATION AGENCY
-5
0
5
10 Km

Fig. A1.15



BABAI IRRIGATION PROJECT

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FOR SELECTED RIVERS IN THE TERAI PLAIN
IN THE KINGDOM OF NEPAL

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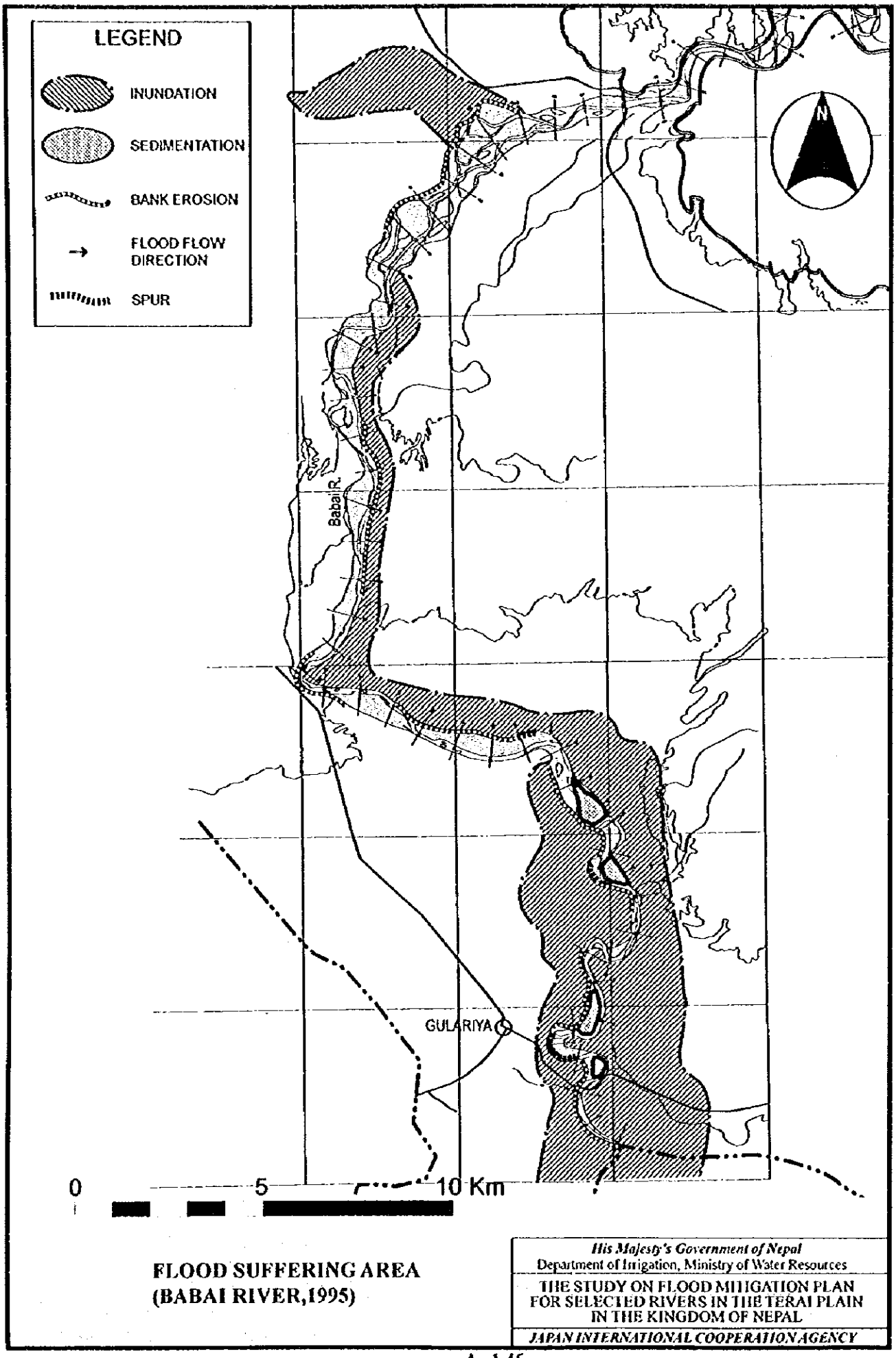
Fig. A1.16



FLOOD SUFFERING AREA (BABAI RIVER,1995)

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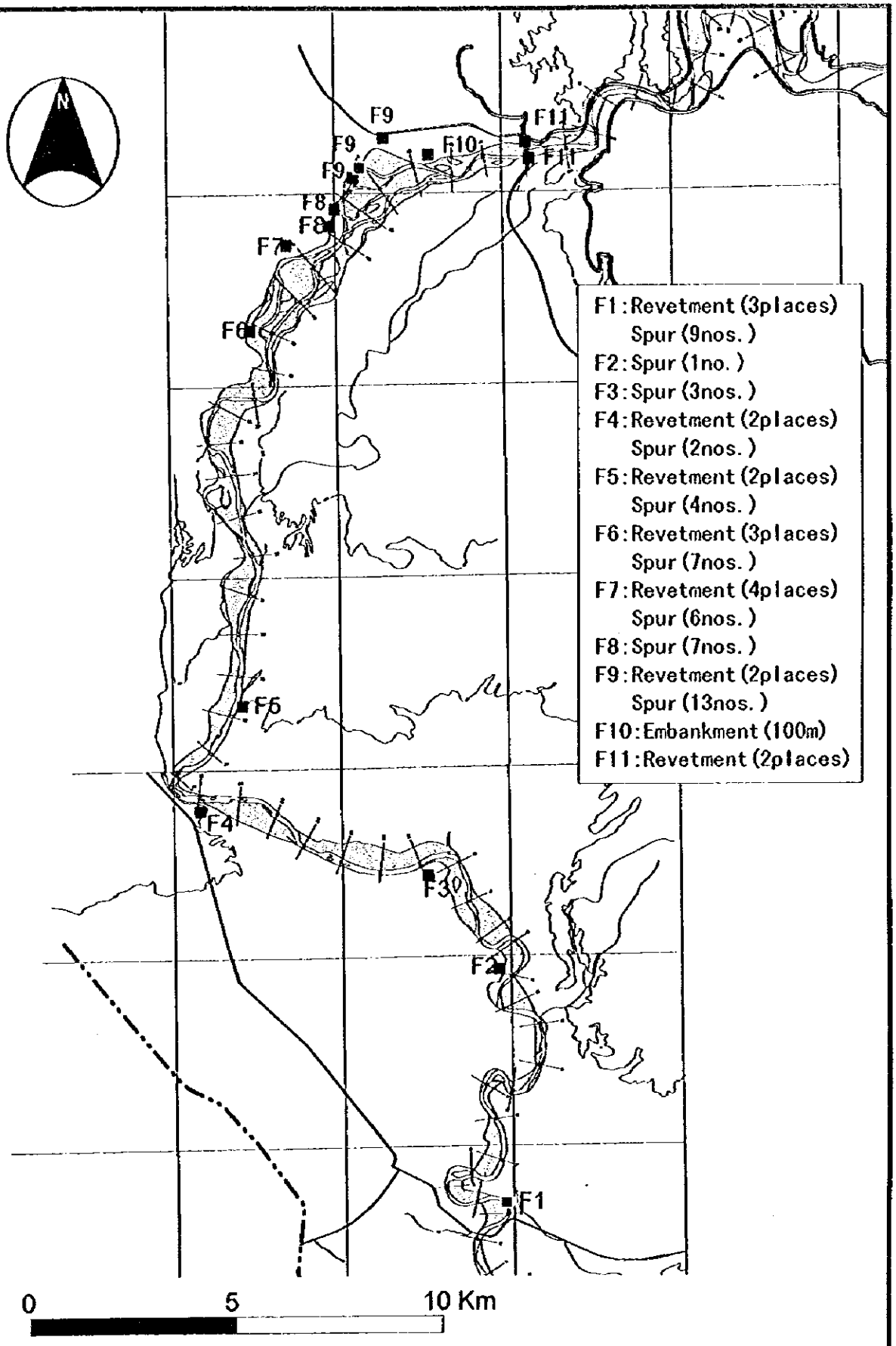
Fig. A1.17



LOCATIONS OF RIVER FACILITIES

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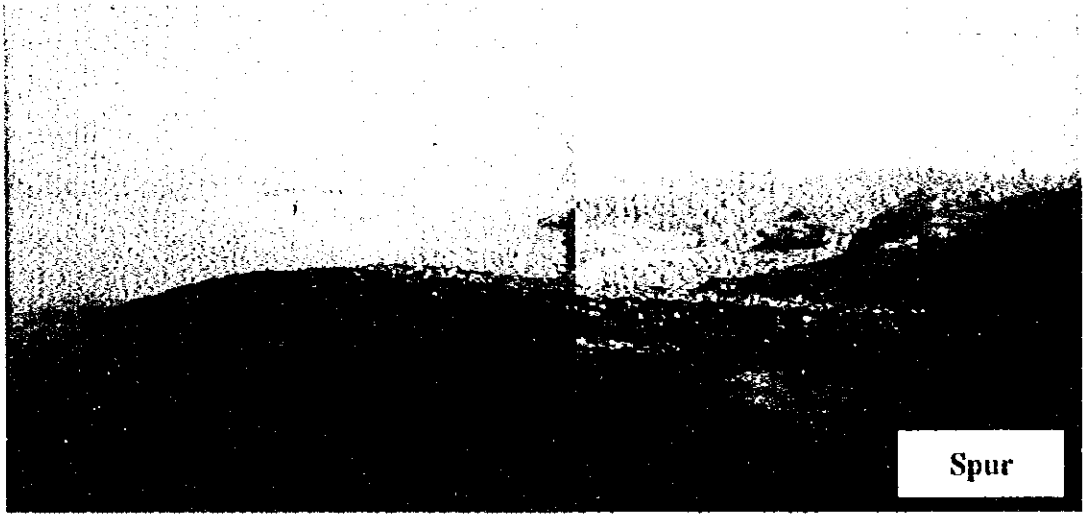

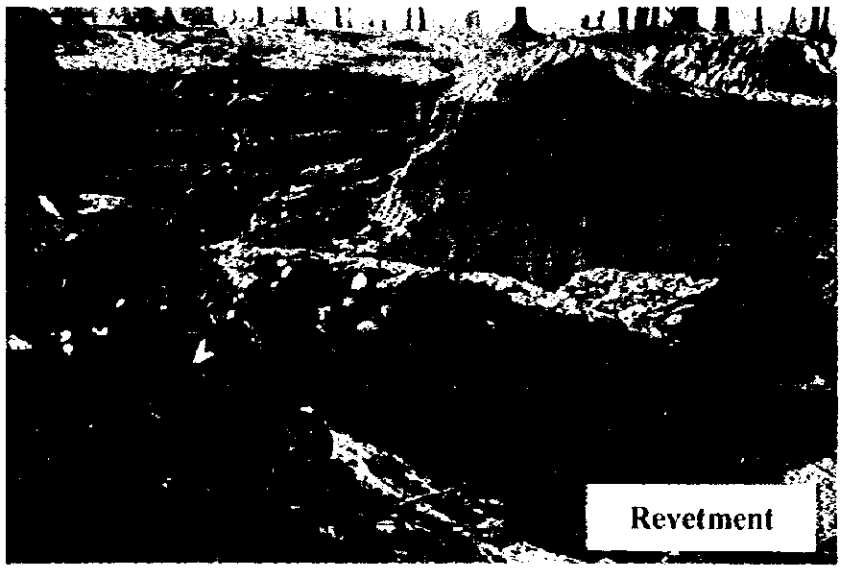

TYPICAL RIVER FACILITIES (1/2)

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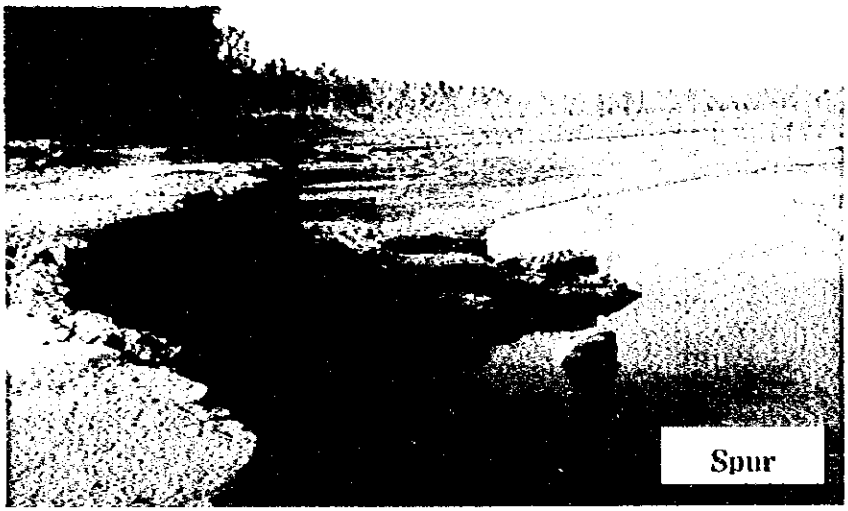

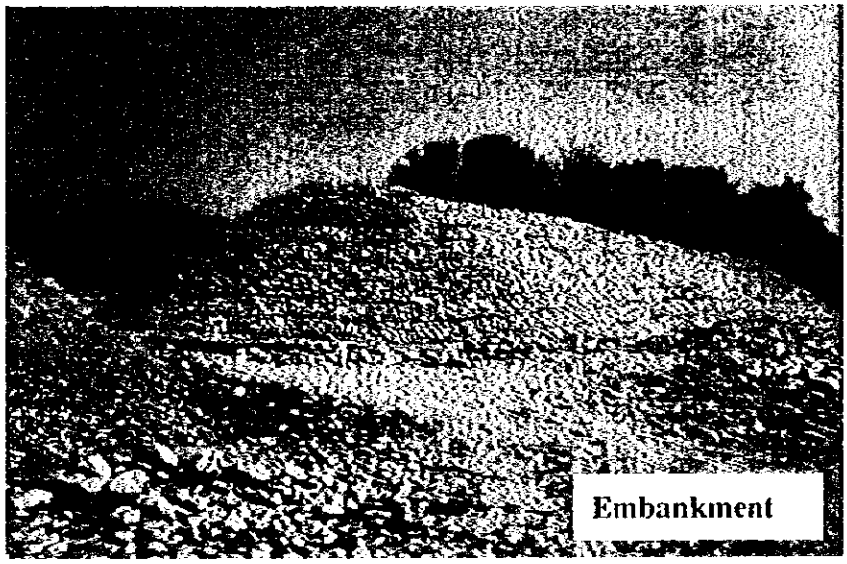

TYPICAL RIVER FACILITIES (2/2)

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