JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF COMMUNICATIONS
PUBLIC WORKS AND TRANSPORTATION
THE REPUBLIC OF HONDURAS

THE MASTER PLAN STUDY
ON
THE EROSION AND SEDIMENT CONTROL
IN
THE PILOT RIVER BASIN, CHOLOMA, SAN PEDRO SULA, CORTES
IN
THE REPUBLIC OF HONDURAS

FINAL REPORT

MAIN REPORT

JANUARY 1994

PACIFIC CONSULTANTS INTERNATIONAL, TOKYO
IN ASSOCIATION WITH
KOKUSAI KOGYO CO., LTD., TOKYO

The cost estimate was made based on prevailing market price in June 1993 and expresses in Lempiras according to the following exchange rate.

US$ 1.00 = Lps. 6.20 = Yen 110.00

(As of June, 1993)

PREFACE

In response to a request from the Government of the Republic of Honduras, the Government of Japan decided to conduct a master plan study on Erosion and Sediment Control in the Pilot River Basin, Choloma, San Pedro Sula, Cortes and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Honduras a study team headed by Mr. Hajime Tanaka, Pacific Consultants International and composed of members from Pacific Consultants International and Kokusai Kogyo Co., Ltd., 4 times between August 1992 and November 1993.

The team held discussions with officials concerned of the Government of Honduras and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Honduras for their close cooperation extended to the team.

January 1994

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

THE MASTER PLAN STUDY ON THE EROSION AND SEDIMENT CONTROL IN THE PILOT RIVER BASIN, CHOLOMA, SAN PEDRO SULA, CORTES IN THE REPUBLIC OF HONDURAS

OUTLINE OF THE STUDY

1 The study area (approximately 717 square km) is situated in the north-western part of the Sula Valley located in the north-western part of Honduras. The Sula Valley is the most important agricultural and industrial area in the country. However the area is vulnerable to the sediment and flood problems. The most severe damages in record were caused by the hurricane Fifi in 1974. Since then the study area, especially the pilot river basins (Rio Choloma, Rio Blanco and Rio El Sauce), has suffered from a heavy sediment problem. This study has formulated a master plan for control of erosion, sediment and flood in this area.

2 Master Plan for Erosion and Sediment Control

2.1 The design sediment yields and discharges are planned based on a scale of the sediment yields caused by the hurricane Fifi in 1974. The facility plan for erosion and sediment control consists of the facilities such as check dams, consolidation dams, channel works, sand retarding areas and training levees.

The design floods are planned based on a flood of once in 50-year return period. The facility plan for flood mitigation consists of channel works, embankment and protection works.

As non-structural measures for erosion and flood control, it is necessary to establish the flood and debris flow warning and evacuation system. In order to formulate the basis of this system, the maps of potential debris flow and flood hazard areas for the study area were prepared.

2.2 The target year of the master plan is 2005.

The project costs are composed of direct costs, indirect costs and physical contingency, including land acquisition and compensation costs, administration cost and engineering cost. The exchange rates of foreign currencies are Lps. 6.20 = US$ 1.0 = Yen 110.0 (as of June 1993).

1) Rio Choloma

(Unit : million Lps.)

	Item	F/C	L/C	Total
A	Direct Cost	227.68	124.29	351.97
B	Indirect Cost	27.32	33.59	60.91
C	Physical Contingency	45.54	24.86	70.40
D	Total	300.54	182.74	483.28

2) Rio El Sauce with Rio Blanco

(Unit : million Lps.)

	Item	F/C	L/C	Total
A	Direct Cost	266.48	152.10	418.58
B	Indirect Cost	31.98	40.25	72.23
C	Physical Contingency	53.30	30.42	83.72
D	Total	351.76	222.77	574.53

2.3 The implementation period for the project is proposed to be ten (10) years from 1996 to 2005.

2.4 The EIRR values of the pilot projects are estimated as follows:

Pilot Projects	Rio Choloma	Rio Blanco	Rio El Sauce	Rio El Sauce & Blanco
EIRR (%)	15.3	4.3	14.3	13.0

2.5 The environmental impacts by the project will be mostly beneficial as the project is aimed at disaster mitigation of flood, erosion and sediment control. The facilities of flood and sediment control will contribute to the environmental improvement of the area. Therefore, no significant adverse effect by the project is anticipated.

2.6 According to the result of the project evaluation, the Rio Choloma has been concluded to be the most effective and identified as the priority area for a Feasibility Study.

3 Feasibility Study on the Rio Choloma

3.1 The long term and urgent plans are planned as follows;

Facilities (Target Year)	Long term plan (2005)	Urgent plan (1997)
(Erosion and sediment control)		
- Check dam (site)	10	2
- Consolidation dam (site)	17	2
- Training levee (site)	1	1
(River improvement)		
- Channel improvement (km)	7.57	3.43
- Embankment (km)	15.13	6.86
- Revetment (km)	4.80	3.43
- Foot protection for the national road bridge (sq. m)	16,800.00	11,400.00
- Reconstruction of the national road bridge (site)	1	0
- Reconstruction of the railway bridge (site)	1	1

3.2 Project Cost

(1) Long Term Plan

(Unit : million Lps.)

	Item	F/C	L/C	Total
A	Direct Cost	227.82	138.10	365.92
B	Indirect Cost	27.34	35.43	62.77
C	Physical Contingency	45.56	27.62	73.18
D	Total	300.72	201.15	501.87

(2) Urgent Plan

(Unit : million Lps.)

	Item	F/C	L/C	Total
A	Direct Cost	66.68	36.65	103.33
B	Indirect Cost	8.00	9.92	17.92
C	Physical Contingency	13.34	7.33	20.67
D	Total	88.02	53.90	141.92

3.3 For implementation of the project, the overall coordination will be provided by the Ministry of Communications, Public Works and Transportation (SECOPT) and the project execution will be under the responsibility of General Direction of Public Works (DGOP).

- The urgent plan will be commenced in the year of 1995 and completed by the year of 1977.
- The long term plan will be completed by the year of 2005.

3.4 The project evaluation is based on effectiveness in economic, social and environmental terms.

The flood and debris flow of hurricane Fifi in 1974 caused tremendous damages to the villages and town of the Choloma area as well as many casualities (killed : 2500 people, wounded : 20,000 people). Furthermore, the national road bridge of the Choloma river was washed away, thereby demoralizing the vital transportation system. Therefore, the social effect of the damage was very severe.

By the implementation of the project, the villages and town of the Choloma area will be safe against the same scale of sediment and flood of Fifi. Hence the social benefit of the direct and indirect mitigation of the damage will be very high.

Furthermore, the environment along the Rio Choloma will be improved, thereby enhancing the natural and living environment.

The EIRR value for the long term plan is as high as 15.3 %. The urgent plan will produce a higher economic efficiency, because it is planned to eliminate sediment and flood disasters from the urban area of Choloma, the most densely populated area in the Rio Choloma basin.

4 Conclusion and Recommendation

4.1 Conclusion

1) The facility plan proposed in the Master Plan for the pilot river basins is feasible in technical, economical and environmental terms.

2) The urgent plan proposed for the Rio Choloma is concluded to be feasible in technical, economical, social and environmental terms. An early implementation of the urgent plan will surely provide many socio-economically beneficial impacts that are not limited to Choloma area.

4.2 Recommendation

1) The Rio Choloma should be given a high priority by the Government for an early implementation of the urgent plan.

2) Further studies on the Rio El Sauce and the Rio Blanco should be carried out.

3) The hydrological observation network both in the study area and the Sula Valley should be improved and reinforced not only for flood mitigation, but also for water resources development.

4) The maps of debris flow and flood hazard areas that are prepared in the Master Plan Study, should be referred by the authorities who are responsible for land management and development.

5) The existing downstream canals of the Rio Choloma such as the Canal Copen - Higuero - Cuabanos and also that of the Rio Chamelecon should be improved in order to protect the area at downstream of the Rio Choloma from flood, because their conveyance capacities may be too small to meet the flood discharges anticipated.

6) Engineering staff of SECOPT should be reinforced in the field of sediment and flood control in order to cope with sediment and flood mitigation problems in the country and the respective O & M activities.

SUMMARY

SUMMARY

1 INTRODUCTION

1.1 This is a summary of the Final Report for a Master Plan Study on the Erosion and Sediment Control in the Pilot River Basin, Choloma, San Pedro Sula, Cortes in the Republic of Honduras (ROH), consisting of a master plan for the study area and a feasibility study on the priority area identified in the master plan.

1.2 The study area (approximately 717 square km) is situated in the north-western part of the Sula Valley located in the north-western part of the country. The Sula Valley, which lies in the northernmost part of the Rio Ulua basin (Catchment area: 19,900 square km) and the Rio Chamelecon basin (Catchment area: 3,200 square km), is the most important area of agricultural and industrial production in the country. The Government of Honduras (GOH) gives high priority to the stability of the Sula Valley.

1.3 In 1974 the hurricane Fifi caused severe flood damages to the Sula Valley. It caused thousands of hill slope collapses in the Merendon mountains of the study area. The debris flows and floods resulted in a heavy loss of human lives and severe flood and debris related damages to the study area. During the flood no less than 10,000 casualties were reported in the study area. After the hurricane Fifi the study area has been suffered from heavy sediment and flood problems.

1.4 In response to the request of GOH, the Government of Japan (GOJ) has decided to conduct a Maser Plan Study on Erosion and Sediment Control in the Pilot River Basin. The Japan International Cooperation Agency (JICA), an official agency responsible for technical cooperation programs of the GOJ, was assigned to undertake the study in cooperation with authorities concerned of the GOH. The study was commenced in August 1992. The study consists of two phases as follows:

Phase 1: Master Plan Study (from August 1992 to March 1993)

The objectives of the study are as follows:

- To carry out a Master Plan Study on erosion and sediment control measures for the pilot river basins, i.e., the Rio Choloma, the Rio Blanco and the Rio El Sauce, and to recommend what to do for the remaining area in the study area,
- To identify a priority area for a Feasibility Study,
- To pursue technology transfer to the counterpart personnel through on the job training in the course of the study.

Phase 2: Feasibility Study (from April 1993 to December 1993)

- To carry out a Feasibility Study on erosion and sediment control measures for the priority area identified in the phase 1,
- To carry out on the job training to the counterpart personnel.

SECOPT has assigned to the study team five full time counterparts in the phase 1 and four full time counterparts in phase 2.

2 STUDY AREA AND FLOOD DAMAGE

2.1 The study area consists of the Merendon mountain range and the valley floor of the Sula Valley. The Merendon mountains rise from the Sula Valley to a maximum height of 1,700 meters above mean sea level and develop a very steep topography. The landform of the study area is composed of steep mountain slopes, steep streams, alluvial fans and cones at the valley mouths, and alluvial plains.

2.2 The geology of the study area is composed of the Paleozoic metamorphic rock and the Cretaceous-Neocene granite that interpenetrate the Paleozoic rock. Alluvial cones and diluvial fans are widely developed at the piedmont areas and also a thin layer of volcanic pyrocrastic deposits distributes over the gentle slopes and the top of the southern part of the Merendon Mountains, but in very limited areas.

2.3 The climate of this study area is characterized by two season, i.e., wet season and dry season. Annual rainfall is about 1,200 mm at La Mesa of La Lima which is located in the southern border of the study area and 2,800 mm at Puerto Cortes in the coastal area located at outskirt of its northern border. Although the rainfall amount in the study area is likely vary very much locally, the available hydrological data are still very limited.

There are several rainfall and river stage gauging stations in and around the study area, but the rainfall gauging station at La Mesa is the only one which has comparatively a long observation period from 1944 to 1991 and no river gauge data are available in the pilot river basins.

2.4 The disastrous floods have been caused by hurricane or tropical depression. Currently remarkable floods were reported in 1897, 1916, 1935, 1945, 1954, 1969, 1974, 1976, 1979, 1988,1990 and 1993. The hurricane Fifi of 1974 caused the most catastrophic damages to the study area. According to the field study, by the hurricane Fifi, the most part of the valley floor was submerged for about 10 days in average. The flood areas

of the hurricane Fifi as the largest flood, the 1990 flood as a current large flood and yearly floods are studied based on the available data and the field investigation, including questionnaire surveys. According to the study, the hazard areas of the 1974 and 1990 floods are 340 square km and 190 square km respectively.

2.5 During the hurricane Fifi from September 18 to 19, 1974, La Mesa and Puerto Cortes recorded the maximum daily rainfalls of 340 mm and 280 mm respectively. The daily rainfall of 340 mm is estimated to be a storm larger than once in 200-year return period, but that of 280 mm at Puerto Cortes is estimated to be a storm with once in 20 to 30-year return period.

However the rainfall intensities in short duration were comparatively low. The available six (6) hour's rainfall amount at La Mesa was 140 mm that is assessed to be once in 50-70 year return period and also the maximum hourly rainfall intensity at La Mesa is estimated to be about 66 mm which is a storm of once in 30-year frequency.

The peak discharge by the simulation on the hurricane Fifi are assessed as the same scale of the flood that would be caused by the daily rainfall of once in 50-year return period in the whole basin.

3 POPULATION AND LAND USE

3.1 The Honduran population amounted to 4,443,721 in 1988, that increased from 2,656,948 in 1974 and 1,884,765 in 1961. The average annual growth rate was 2.68 % and 3.74 %, respectively for the period 1961-1974 and 1974-1988. The average population density in the country as a whole came to 40 persons per square km.

The study area has been developed very rapidly. The total population of San Pedro Sula, Choloma, La Lima and Puerto Cortes municipalities amounted to 500,886 in 1988 from 281,247 in 1974 and 137,988 in 1961, at the average annual growth rate of 5.63 % for the period 1961-1974 and 4.21 % for the period 1974-1988. The urban population accounted for 77 % of the total population in 1988.

The average family size per house was 4.71 persons per house in the whole area of the four municipalities.

3.2 The land use of the Study Area is characterized by ample and fertile valley and forest mountain, and provides favorable conditions for agriculture, cattle breeding and forestry.

The highland zone, located in the western part of the study area, is covered by tropical rain forest which consists of pine, cedar and wide leaves trees (mahogany, mango, almond, palm, avocado,etc.). The area of the whole highland zone is estimated at about 304 square km or 42 % of the study area. The forest area covers 67 % to 77 % of the mountain area of San Pedro Sula, but only 9 % of that of Choloma. The mountain area of San Pedro Sula has been conserved by the municipality for water resources and erosion control purposes, while the mountain area of Choloma is rather extensively used for agricultural purposes. On the other hand, in the lowland zone, where lies the eastern part of the study area, the dominant use is natural and cultivated pastures for cattle breeding, except urban areas.

Out of the lowland zone, the area along the Rio Chamelecon form a mixed agricultural land which is composed of small-scale villages and fields of sugar cane, pasture, bananas, maize, rice, various vegetables and brushwood, etc. The total area of the lowland zone is estimated at about 413 square km or 58 % of the study area.

The major urban areas are located in the three cities of San Pedro Sula, Choloma and La Lima. The city of San Pedro Sula and its surrounding areas form a large industrial zone as well as commercial and residential zones.

4 EXISTING FACILITIES

4.1 As for erosion and sediment control facilities, SECOPT made a facility plan for the Rio Choloma basin in 1980s and constructed one check dam (Takemoto Dam) in 1984 in the Rio Choloma basin.

4.2 As for flood mitigation facilities, there are several types of structures constructed in the study area. They are as follows:

(1) Embankment along the Rio Chamelecon

There is a 54.1 km of flood embankments along the left bank of the Rio Chamelecon. They have been constructed locally by different agencies such as the municipality of San Pedro Sula and SECOPT.

(2) Embankment along the Tributaries

After the hurricane Fifi about 5 km of embankment was constructed along the Rio Choloma. The embanked channels in the Rio Blanco (21.2 km) and in the Rio El Sauce (44.1 km) were constructed by the municipality of San Pedro Sula and SECOPT

in order to protect the urban area of San Pedro Sula. The embanked channels are evaluated to have sufficient flow capacities against the design flood discharges. Also there is a ring dike around the Lima Airport constructed by SECOPT.

5 DESIGN RAINFALL AND FLOOD RUN -OFF

5.1 The rainfall pattern is studied based on the collected data from the two stations of La Mesa and El Modelo which are located nearby each other and their average annual rainfall amounts are similar. The rainfall pattern in which the maximum rainfall intensity occurs at the final stage of rainfall is applied for the runoff analysis, because it gives the largest discharge among the three patterns studied.

5.2 For flood run-off analysis, the Rational Formula and the Nakayasu's Unit Hydrograph Method are applied due to the following reasons:

(1) The Rational Formula is proper to estimate a peak discharge from a comparatively small basin of less than 200 square km. The method is applied for estimating peak discharge in designing the erosion and debris control works.

(2) The Nakayasu's Unit Hydrograph Method is widely used for planning river works in Japan. The method is applied for the flood runoff analysis of the pilot river basins that have a similar topographic condition as those in Japan. By this method, it is possible to estimate not only a peak discharge, but also a shape of flood hydrograph.

(3) The storage function method is also useful for the study, but there are no discharge data necessary to calibrate the hydrograph estimated by the method.

6 SEDIMENT YIELD AND DISCHARGE

6.1 The hurricane Fifi caused thousands of hill slope collapses and debris flows both in the Rio Choloma basin and in the Rio Blanco basin. Debris flow marks are identified at most of the streams of second order. Based on study in a sample area of 16.4 square km, that was selected in the Rio Choloma basin, the collapsed slope areas were identified to be 9.68 % of the whole slope area during the hurricane Fifi and the depth of collapse was estimated about 1.0~2.0 meters at the Rio La Jutosa, but less at the Rio

Choloma. However the collapsed materials seem to have already been discharged downstream as debris flows or sediment flows.

Based on the aerial photographs and the field investigation conducted, the sediment deposit area and the sedimentation depth caused by the hurricane Fifi are identified for the Rio Choloma and the Rio Blanco. The sediment balance of the hurricane Fifi was estimated for the Rio Choloma.

The sediment balance of each pilot river basin was estimated based on the followings:

- Produced sediment volume from collapsed area,
- Eroded sediment volume of the river course,
- Unstable deposits related to sediment yield.

Also the areas likely have a high potential of sediment yield are identified through aerial photographs and field investigation.

7 MASTER PLAN FOR EROSION, SEDIMENT AND FLOOD CONTROL

7.1 The Master Plan for erosion and sediment control facilities are planned based on the scale of the hurricane Fifi of 1974. The proposed facility plan aims to reduce the excessive sediment discharge to the allowable sediment discharge at the design control point, by controlling the amount of sediment yields and discharges by optimum erosion and sediment control facilities such as check dams, consolidation dams, channel works, sand retarding areas and training levees. The proposed facilities and their locations are shown in Fig. S. 1.

As a part of the non-structural measures, possible hazard areas are identified for the study area.

7.2 The Master Plan for flood mitigation facilities are planned based on a flood discharge once in 50-year return period that is approximately the same scale as the hurricane Fifi's flood. The pilot river channels are assessed for their flow capacities and optimum flood mitigation works are studied. For channel improvement, a compound cross section is planned by considering easy maintenance. The low water channel section is designed to have a flow capacity once in 2 to 3-year flood return period. The Rio Blanco is proposed to flow into the Rio El Sauce and resume its former course. The proposed facilities are shown in Fig. S.1.

7.3 Simulation of sediment discharge and river bed variation for the pilot rivers is conducted for the river reaches under the conditions of with and without the project. According to the results of the simulation, the balance of sediment discharge of the Rio Choloma will be improved and become almost in the dynamic stability condition by the river improvement. The Rio Blanco will need a proper management on sand excavation from the river bed. The Rio El Sauce, under either condition of with or without the Rio Blanco, will need periodical observation of the downstream reach, because there is a tendency of sediment deposition in the downstream reach.

7.4 Non-structural measures such as flood warning and evacuation systems will be required for the people who live in outside the pilot river basins, to be protected from debris flows and floods. As a part of the non-structure measures, the debris flow hazard areas are identified in the study area. The hazard map shows that the hazard area by debris flows covers some part of the built-up area of San Pedro Sula.

7.5 The project costs are composed of direct cost, indirect costs and physical contingency, including land acquisition and compensation costs, administration costs, O&M and engineering costs. The direct costs of base construction costs are estimated based on the preliminary design of proposed facilities and the tentative construction schedule. The indirect costs are estimated as percentages of the base construction costs. Physical contingencies are also calculated as percentages of base construction costs. The unit price and cost are estimated based on prevailing market price in June 1993 and the exchange rates of foreign currencies are Lps. 6.20 = US$ 1.0 = Yen 110.0.

The project costs are summarized as follows:

1) Rio Choloma

(Unit: million Lps)

Item	F/C	L/C	Total
A Direct Cost			
1) River Improvement	46.06	12.87	58.93
2) Sediment Control	181.62	111.42	293.04
3) Sub Total	227.68	124.29	351.97
B Indirect Cost			
1) Land Acquisition	0.00	1.07	1.07
2) Administration	0.00	17.60	17.60
3) Engineering Service	27.32	14.92	42.24
4) Sub Total	27.32	33.59	60.91

C	Physical Contingency	45.54	24.86	70.40
D	Total	300.54	182.74	483.28

2) Rio El Sauce with Rio Blanco

(Unit: million Lps.)

	Item	F/C	L/C	Total
A	Direct Cost			
	1) River Improvement	64.61	30.52	95.13
	2) Sediment Control	201.87	121.58	323.45
	3) Sub Total	266.48	152.10	418.58
B	Indirect Cost			
	1) Land Acquisition	0.00	1.07	1.07
	2) Administration	0.00	20.93	20.93
	3) Engineering Services	31.98	18.25	50.23
	4) Sub Total	31.98	40.25	72.23
C	Physical Contingency	53.30	30.42	83.72
D	Total	351.76	222.77	574.53

7.6 The implementation program for the project is based on the construction plan from 1996 to 2005.

7.7 The project evaluation is mainly based on the economic evaluation. In the Master Plan Study, the economic evaluation is made with aim at finding out an economic optimum plan out of alternative plans for the erosion and sediment control projects of the pilot rivers. The economic effects of the project are examined by making a comparison between both present values of the economic cost and benefit, by means of the Economic Internal Rate of Return (EIRR).

The economic evaluation of the project is based on the comparison of costs with the benefits. Benefits are derived from the reduction of annual flood damages. Such reduction of annual flood damage was evaluated for the return periods of 2, 5, 30, 50, and 100 year, with respect to the following items:

- Damage to buildings and household effects,
- Damage to public facilities,
- Economic loss due to business suspension,

- Emergency expenses.

The project life is economically taken as 50 years after commencement of the construction works.

7.8 Economic Evaluation for the Rio Choloma basin was conducted with each of the above five (5) return periods. As the result, a 50-year design return period was selected since it produced the highest economic efficiency.

According to the economic evaluation of the project with 50-year return period, the EIRR values of the projects were estimated for the pilot rivers, including the combined project of the Rio Blanco and the Rio El Sauce. They are as follows:

Economic Internal Rate of Return (EIRR)

Return Period(years)

	Rio Choloma	Rio Blanco	Rio El Sauce	Rio El Sauce & Blanco
EIRR (%)	15.3	4.3	14.3	13.0

(1) Regarding the Rio Choloma and the Rio El Sauce projects, the EIRR values of the projects with the 50-year return period indicate 15.3 % and 14.5 % respectively, which are a comparatively high rate as flood protection project, i.e., these projects are regarded to be viable economically.

(2) The Rio Blanco project with 50-year return period shows an EIRR of 4.3 % which is little viable economically, due to a low potential of assets inundated.

(3) However, the EIRR of the combined flood protection project of both the Rio Blanco and the Rio El Sauce would come to 13.0 %. It shows that the combined project is economically feasible, considering that the opportunity cost of capital in Honduras would be between 10 % and 12 %.

7.9 The environmental impacts by the project will be mostly beneficial as the project is aimed at disaster mitigation of flood, erosion and sediment control. The facilities of flood and sediment control will contribute to the environmental improvement of the area. The mitigation of flooding will enhance the land use potential of the area to a variety of beneficial uses like urban, industrial and agricultural development. Moreover, enhanced protection to such existing land utilization will be obtained. No significant direct adverse effect by the project is anticipated.

As indirect effect due to enhanced land use potential, increased pollution load discharge by progressing urban, industrial and agricultural development to the surrounding water bodies is anticipated. Therefore water quality improvement measures will be necessary.

7.10 According to the result of the project evaluation on the measures that are required in each river basin, the Master Plan for the Rio Choloma will be the most effective and identified as the priority area for a Feasibility Study.

8 F/S ON THE URGENT FACILITIES FOR THE RIO CHOLOMA

8.1 The urgent facilities for erosion and sediment control are selected from the Master Plan which consists of ten (10) check dams, three consolidation works and one training levee. Among these facilities, the facilities selected for an early implementation are listed as follows:

- Check dam (No. 1) at 25.72 km of the Rio Majaine,
- Check dam (No. 9) at 26.535 km of the Rio La Jutosa,
- Consolidation dam (No. 1) at 18.885 km of the Rio Choloma,
- Consolidation dam (No. 7) at 21.235 km of the Rio Choloma,
- Training levee at the consolidation dam (No. 1).

The location map of the proposed urgent facilities is shown in *Fig.* S.2.

The effects of the urgent facilities are assessed on the sediment balance. The urgent facilities would control 34 % of the design sediment discharge.

8.2 The urgent facilities for flood mitigation, selected from the master plan, which is planned for the reach from the junction of the Canal San Roque to the consolidation dam (No. 1), consist of channel improvement (7.57 km), embankment (15.13 km), revetment (4.8 km), rehabilitation of two bridges and protection works.

The urgent plan is formulated for the reach between the Sta. CH-023 and the proposed consolidation dam No. 1. The urgent plan aims to protect the urban area of Choloma, including the future urban area planned by the municipality of Choloma city. The design concept is same as the master plan. The proposed urgent facilities are summarized as follows:

- Channel improvement : 3.43 km
- Embankment : 6. 86 km
- Revetment : 3.43 km
- Foot protection for the national road bridge : 11.400 sq. m
- Reconstruction of the railway bridge : one (160 m x 5.0 m)

8.3 Project Cost

The project cost has been estimated based on the preliminary designs under the same conditions as the master plan. The exchange rates of the foreign currencies applied are Lps. 6.20 = US$ 1 = Yen 110.0. The project costs for both the whole project (long term) and the urgent project are estimated as follows:

1) PROJECT COST FOR THE LONG TERM PLAN

(unit: million Lps.)

Item	F/C	L/C	Total
A. Direct Cost			
1)River Improvement	48.65	29.31	77.96
2)Sediment Control Facilities	179.17	108.79	287.96
3)Sub-total	227.82	138.10	365.92
B Indirect Cost			
1)Land Acquisition Cost	0.00	0.54	0.54
2)Administration Cost	0.00	18.32	18.32
3)Engineering Service Cost	27.34	16.57	43.91
4)Sub-total	27.34	35.43	62.77
C Physical Contingency A x 20 %	45.56	27.62	73.18
D Total	300.72	201.15	501.87

2) PROJECT COST FOR THE URGENT PLAN

(Unit: million Lps.)

	Item	F/C	L/C	Total
A	Construction Cost			
	1)River Improvement	24.82	13.24	38.06
	2) Sediment Control Facilities	41.86	23.41	65.27
	3) Sub-total	66.68	36.65	103.33
B	Indirect Cost			
	1)Land Acquisition	0.00	0.33	0.33
	2)Administration Cost	0.00	5.19	5.19
	3)Engineering Service	8.00	4.40	12.40
	4)Sub-total	8.00	9.92	17.92
C	Physical Contingency A x 20 %	13.34	7.33	20.67
D	Total	88.02	53.90	141.92

8.4 For implementation of the project, the overall coordination will be provided by the SECOPT and the project execution will be under the responsibility of the DGOP. The other implementing agency will be the Municipality of Choloma. The implementation program for the project is based on the following:

- The urgent works will be commenced in the year of 1995 and completed by the year of 1977,
- The remaining works will be completed by the year of 2,005.

8.5 Project

The project evaluation is based on effectiveness in economic, social and environmental terms. However the social and environmental benefits will be high as stated in the master plan.

According to the economic evaluation, the proposed long term project for the Rio Choloma will be feasible in relation to sediment control and flood mitigation benefits. The EIRR value for the project is as high as 15.3 %.

According to the sensitivity test of EIRR, even the case with a 10% increase in the economic cost and a 10% decrease in the economic benefit, produced an EIRR value more than 12%, which exceeds the opportunity cost of capital in Honduras, estimated to be between 10% and 12%. Accordingly, it is concluded that the project will have a high economic efficiency.

The urgent facility plan will give a higher economic efficiency, because it is planned to eliminate sediment and flood disasters from the urban area of Choloma, the most densely populated area in the Rio Choloma basin.

Also the plan will produce a high social benefit. Choloma area suffered a severe damage caused by the hurricane Fifi in 1974.

At that time, the number of population in Choloma was about 30,000, of which 2,500 people were killed and 20,000 people were injured during the flood caused by the hurricane. Also the national road bridge was washed away and the vital transportation system was demoralized.

According to the national census in 1988, the number of population in Choloma was increased to be about 67,000, which is expected to be about 100,000 in 1993.

By implementation of the urgent facilities, the urban area of Choloma will be safe from sediment and flood damages. Also the national road bridge will be safe and the transportation between the major port of Puerto Cortes and the major cities, including the capital city, will be secured. The social benefits will be very high.

Through implementation of the project, besides the foregoing tangible direct benefits, many intangible benefits could be expected. Among them an imprint intangible benefit would be elimination of various negative intangible factors for social and economic development in and around the flooded area and enhancement of the development potential of the area.

9 CONCLUSION AND RECOMMENDATION

9.1 Conclusion

1) It is concluded that the facility plan proposed in the Master Plan for erosion and sediment control will be feasible in technical, economical and environmental terms. With the project the three pilot river basins will be safe from the debris and flood damages of a scale of the hurricane Fifi of 1974 that is assessed to be the most severe

debris flows and floods in record. According to the economic evaluation, the EIRR values of the Rio Choloma, the Rio El Sauce and the Rio Blanco projects are 15.3 %, 14.5 % and 4.3 %. Though the EIRR value of the Rio Blanco is low, it becomes 13.0 %, when the Rio Blanco resumes its original river course and flows into the existing Rio El Sauce as proposed in the Master Plan. Due to the preliminary environmental impact assessment the adverse effects by the project are anticipated to be insignificant, because the proposed plan in itself is an environmental improvement plan aimed at disaster mitigation.

2) The urgent plan proposed in the Feasibility Study is also concluded to be feasible in technical, economical, social and environmental terms. The EIRR value of the facility plan with urgent facilities is 15.3 %. Simultaneously the proposed urgent facilities will likely have a strong social impact, because an early implementation of the urgent facilities will surely provide many socio-economically beneficial intangible impacts that are not limited to Choloma area. The proposed urgent facilities are composed of two check dams, consolidation works, training levee and river improvement works.

9.2 Recommendation

Recommendations from the study are summarized as follows:

1) The urgent plan proposed in the Feasibility Study for the Rio Choloma basin should be given a high priority by the Government for an early implementation.

2) Further studies on the Rio El Sauce and the Rio Blanco will be important for an early implementation. According to the project evaluation, the Rio El Sauce with the Rio Blanco project will be feasible in technical, economical, social and environmental terms. The project will have a strong social impact, because San Pedro Sula city and a part of La Lima city that have a high population density and a high socio-economic importance, are located in these two river basins.

3) Improvement of the hydrological observation net work will be a fundamental action not only for flood mitigation, but also for water resources management and development. Hydrological data will be basis for planning optimum countermeasures against sediment and flood damages. The numbers of rainfall and water level gauging stations are still very limited not only in the pilot river basins, but also in the Sula Valley. The hydrological gauging stations both in the Rio Chamelecon and in the Rio Ulua are necessary to be increased.

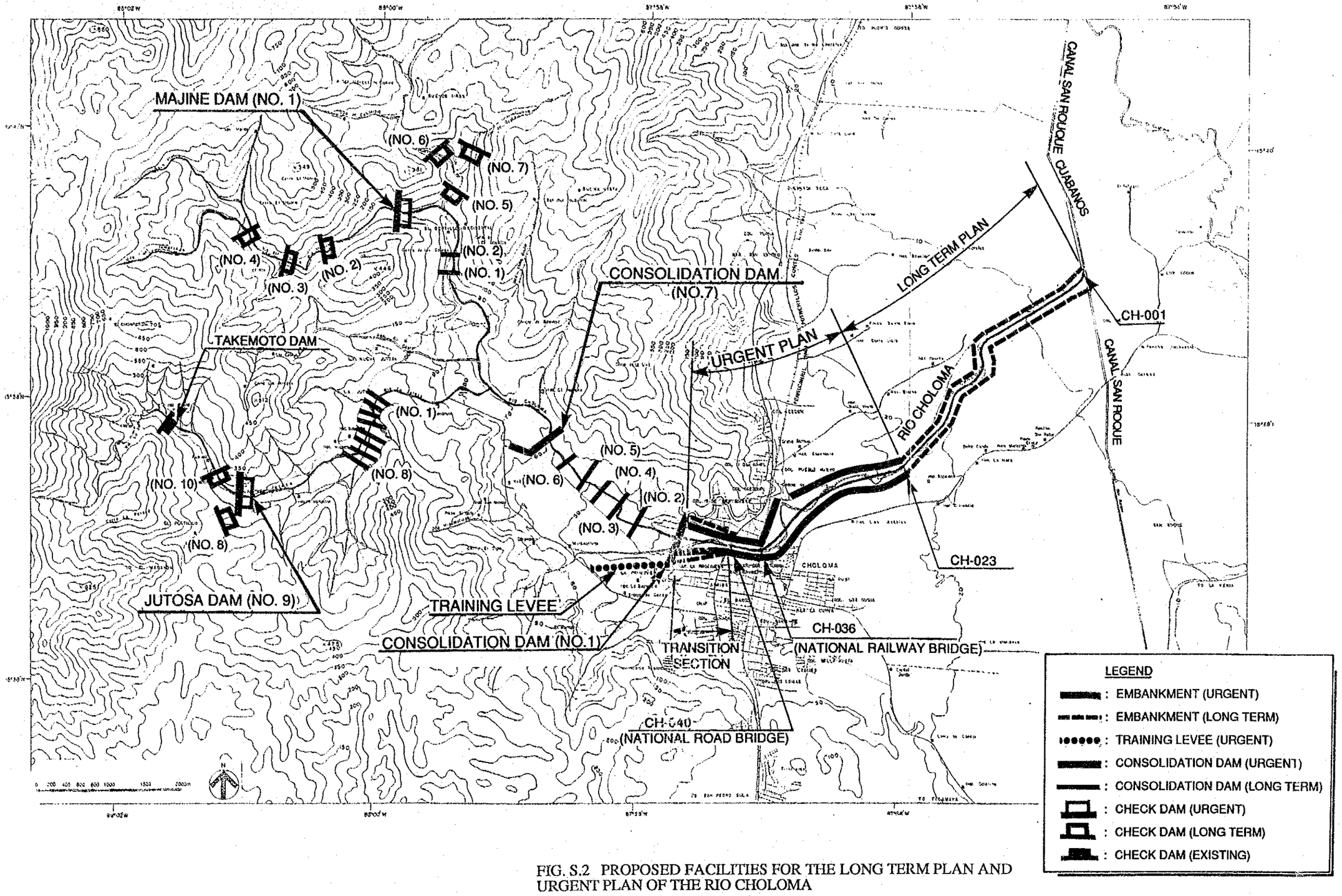
4) As a part of the non-structural measures for sediment and flood mitigation, the hazard areas of future debris flows and past floods that are prepared in the Master Plan Study, should be referred by the responsible authorities for land management and development.

5) Improvement of the existing downstream canals of the Rio Choloma such as the Canal Copen-Higuero-Cuabanos and also that of the Rio Chamelecon will be required for elimination of flood damages from the area downstream of the Rio Choloma, because their conveyance capacities may be extremely small to meet the anticipated flood discharges.

6) Institutional improvement of SECOPT is recommended in the field of sediment and flood control in order to cope with sediment and flood mitigation problems in the country. Also proper operation and maintenance (O&M) activities for sediment and flood control facilities will be essential after implementation of facilities. Among the existing sediment and flood control facilities of the pilot rivers, there are many sites that need proper O&M activities locally.

Area/River	Flood Control Facilities/Works	Main Feature	Area/River	Sediment Control Facilities/Works	Main Feature	Remarks
1.Río Choloma	1).Embankment	15.6 km	1.Río Choloma *Río Majore & Río La Juicea	1) Sabo (Check) Dam	10 pls	
	2).Revetment	4.8 km		2) Consolidation Dam	17 pls	
	3). Channel Improvement	7.8 km		3) Training Levee	1,325 m	
	4).Bridge Improvement	2pls				
	5).Land Acquision	91.0 ha				
2.Río Blanco-Canal San Roqe With Río El Sauce						
2.1. Río Blanco	1).Embankment *Left Bank Only	1.5 km	2.1 Río Blanco *Río Chiquito Río Del Zapotal & Río De Armenta	1) Sabo (Check) Dam	9 pls	
	2).Land Acquision	4.2 ha		2) Consolidation Dam	7 pls	
				3) Channel Works	1pls	
				4) Training Levee	4,050 m (6pls)	
2.2 Diversion Canal (2.6 km) *Río Blanco-El.Sauce	1).Embankment	5.2 km				
	2). Channel Improvement	2.6km				
	3).Diversion Weir	1 Pls				
	4).Land Acquision	56.7 ha				
2.3 El.Sauce 1).Left Bank	1).Embankment	5.5 km	2.3 El Sauce * Río Santa Ana & Río Piedras	1) Sabo (Check) Dam	14 pls	
2).Right Bank	1).Embankment *Heightning	7.5 km		2) Consolidation Dam	0	
	2). Channel Improvement	7.5km		3) Channel Works Ground Sill Riverbed Girdle	2 pls (12 pls) (4pls)	
	3).Revetment	2.0 km				
	4).Bridge	1				
	5).Land Acquision	117.8 ha				

FIG.S.1 PROPOSED MASTER PLAN



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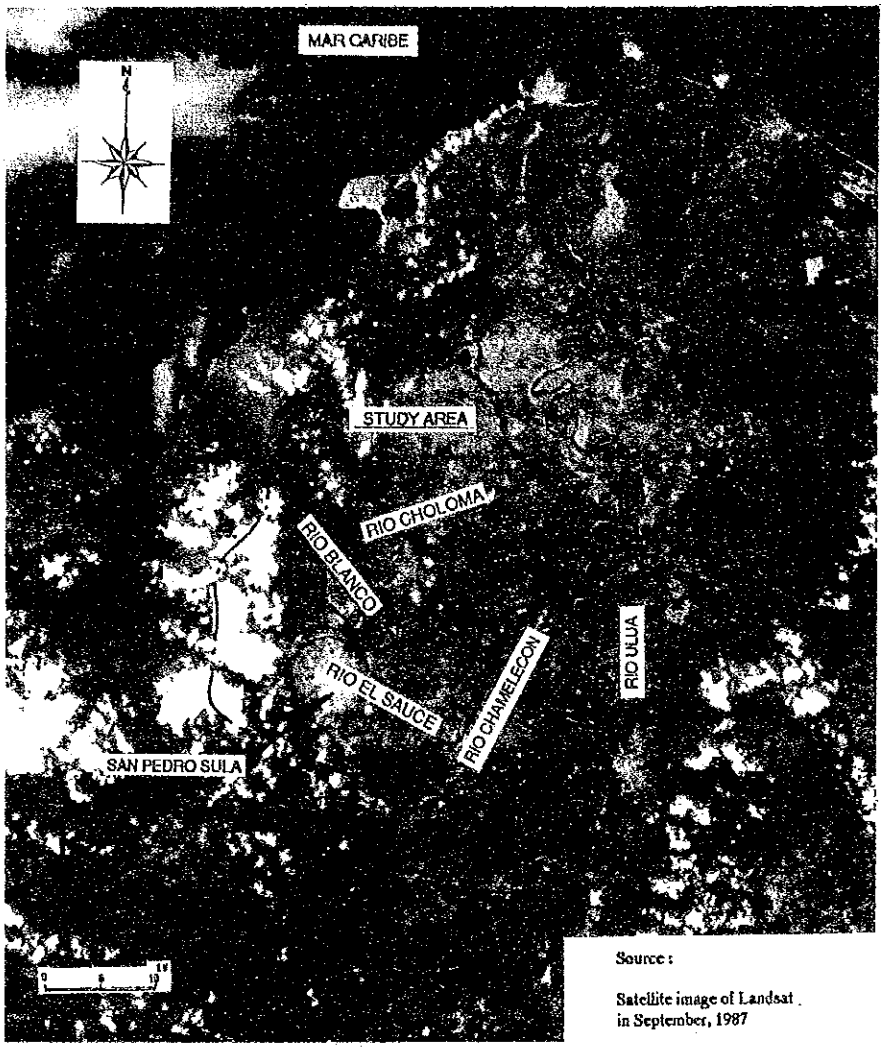
ABBREVIATIONS

CABEI	Central American Bank for Economic Integration
COHDEFOR	Corporation Hondurena de Desarrollo Forestal (Honduran Forestry Development Corporation)
COPECO	Comite Permanente de Emergencia y Contingencia (Permanent Committee of Emergency and Contingency)
DGOP	Direccion General de Obras Publicas de SECOPT (General Direction of Public Works of SECOPT)
DIMA	Division Municipal de Aguas de San Pedro Sula (Municipal Water Division of San Pedro Sula)
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GNP	Gross National Product
GOH	Government of Honduras
GOJ	Government of Japan
HARZA-CINSA	Consortium of consultants that carried out the Master Plan for the Sula Valley from 1976 to 1979
INA	Instituto Nacional Agrario (National Agricultural Institute)
IDB	Inter-American Development Bank
JICA	Japan International Cooperation Agency
JRD	Junta Regional de Desarrollo (Regional Development Committee)
SECPLAN	Secretaría de Planificacion, Coodinacion y Presupuesto (Ministry of Planification, Coordination and Budget)

SECOPT	Secretaría de Comunicaciones, Obras Publicas y Transporte (Ministry of Communications, Public Works and Transportation)
SHC	Servicio Hidrologico Climatologico (Climatic, Hydrologic Division)
SMN	Servicio Meteorologico Nacional (National Meteorological Division)
TRRC	Tela Railroad Co.
UNDP	United Nations Development Program



Source :

Satellite image of Landsat
in September, 1987

STUDY AREA AND SULA VALLEY

CHAPTER 1
INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Background

This is the Final Report for a Master Plan Study on the Erosion and Sediment Control in the Pilot River Basin, Choloma, San Pedro Sula, Cortes in the Republic of Honduras. This report covers the results of the study conducted from August 1992 to October 1993.

The study area is located in the northern part of Honduras. It covers an area of 717 square km in the Sula Valley and spreads over four Municipalities: San Pedro Sula, Choloma, La Lima and Puerto Cortes which are included in the Department of Cortes. The study area is characterized by ample and fertile valleys surrounded by steep mountains and provide a favorable condition for agriculture production. In fact, agriculture is well developed, especially on banana and sugar cane plantations and cattle farming.

San Pedro Sula is the second largest city of Honduras and forms the greatest industrial and commercial zones in the country. Also the Choloma city and its surrounding area have rapidly developed in recent years as a large industrial zone. The area produce various daily necessities and industrial raw materials at small- and middle-scale factories, which are estimated at around 1,500 in number in 1992. The total population of the four municipalities was 500,866 in 1988, increased rapidly from 281,247 in 1974.

Further, in the study area the national roads (CA-5, CA-13) and the national railway run through and several regional roads distributes in the study area. The daily traffic volume was estimated at about 7,400 vehicles between San Pedro Sula and Choloma and about 8,200 vehicles between San Pedro Sula and La lima, according to the traffic survey in 1991. The route CA-5 connects Tegucigalpa and Puerto Cortes through San Pedro Sula and Choloma. It is a trunk road for transporting business and tourism passengers, export and import goods at Puerto Cortes and commodities for domestic use.

However the study area is extremely vulnerable to erosion, sedimentation and flood problems. Due to sediment and flood disasters, the study area has suffered from severe sediment and flood flows of the pilot rivers.

Due to the hurricane Fifi, also major infrastructures such as the national road, connecting the major port of Puerto Cortes to the major cities, including Tegucigalpa, were damaged for a while.

In 1974, the hurricane Fifi caused catastrophic sediment and flood damages to the Sula Valley. Most of the valley floor were submerged for about 10 days in average. Numbers of houses were swept away by the flood and no less than 10,000 casualties were recorded in San Pedro Sula and Choloma areas. Also it caused thousands of hill slope collapses in the Merendon mountain areas and the areas of San Pedro Sula and Choloma.

The hurricane Fifi caused sever debris and sediment flows which buried villages, swept the national road bridge and the railway bridge and damaged the urban area. It is reported that as many as 2,500 people were lost in those debris flows and 20,000 people were injured or damaged by floods in Choloma area.

According to the interpretation of the aerial photographs taken soon after the hurricane Fifi and the field investigation, it is identified that the hurricane Fifi caused collapse of approximately 10 percent of the mountain slopes in the Rio Choloma basin. The sediment deposits caused by the hurricane floods were estimated to be about 6,500,000 cubic meters in the Rio Choloma basin. Since then a large amount of sediment run-off from the mountains has been blocking the river channels and causing floods downstream.

The Government of Honduras(GOH) gives a high priority to the stabilization and development of the Sula Valley. The President Rafael Leonaldo Callejas established the Sula Valley Commission in 1990 by executive order in order to enhance the development of the Sula Valley. The president is also supporting legislation that would establish an Authority.

GOH requested the Government of Japan (GOJ) to carry out a development study on comprehensive erosion and sediment control measures. In response to the request of GOH, GOJ has decided to conduct a Master Plan Study on Erosion and Sediment Control in the Pilot River Basin; Choloma, San Pedro Sula, Cortes. The Japan International Cooperation Agency (JICA) which is the official agency responsible for the implementation of technical cooperation programs of GOJ, was assigned to undertake the study in close cooperation with SECOPT and other concerned authorities of GOH. The Scope of work was agreed upon between SECOPT and the JICA mission on December 16, 1991.

The study consists of two phases and the respective period and objectives are as follows;

Phase 1: Master Plan Study (from August 1992 to March 1993)

The master plan study on erosion and sediment control for the pilot river basins of the Rio Choloma, the Rio Blanco and the Rio El Sauce was conducted and an optimum plan for mitigation of sedimentation and flooding problems in the study area, was proposed in the Interim Report (March 1993). Among the three pilot river basins the Rio Choloma was identified as the priority area for a feasibility study.

General Direction of Public Works (DGOP) of SECOPT assigned to the study team five full time counterparts during the study in Honduras.

Phase 2: Feasibility Study (from May to December 1993)

The feasibility study for the Rio Choloma has been conducted since May 1993. During the study an urgent plan has been proposed for an early implementation.

DGOP assigned to the study team four full time counterparts during the study in Honduras.

1.2 Objectives of the Study

The objectives of the study are summarized as follows:

(1) To formulate a Master Plan on erosion and sedimentation control measures for the pilot river basins and their flooding areas, and recommend possible measures for the remaining area in the study area,

(2) To conduct a Feasibility Study on urgent erosion and sediment control measures for the priority river basin identified in the Master Plan, and

(3) To pursue technology transfer to the counterpart personal through on the job training in the course of the study.

1.3 Study Area

The study area covers approximately 717 square km of the western part of the Sula Valley. The area is mainly composed of tributary basins of the Rio Chamelecon, including the Rio Choloma, the Rio Blanco and the Rio El Sauce.

The study area consists of the Merendon mountain range and the valley floor of the Sula Valley. The major cities are San Pedro Sula, La lima and Choloma that are major centers of agricultural, industrial and commercial activities in the Sula Valley. The study area is shown in *Fig.* 1.1.

1.4 General Approach

The study has been carried out in collaboration with the counterparts of DGOP and other related government authorities. In order to make an optimum plan for elimination of sedimentation and flood damages from the study area, necessary field surveys and studies have been carried out on the actual situation of the debris flow and flood damages caused by the hurricane Fifi and the other floods.

1.5 Supplementary Field Works

In order to supplement the available data and information, along with the field investigation, the following field surveys have been conducted:

(1) Master Plan Stage (Phase-1)

- River longitudinal and cross-sectional surveys in the Rio Choloma, The Rio Blanco and the Rio El Sauce,
- River bed material survey at three sites each along the Rio Choloma, the Rio Blanco and the Rio El Sauce,
- Questionnaire survey on flood damages caused by current debris flows and floods,

The river reaches where the river surveys were conducted, are shown in *Figs.* 1.2 and 1.3 respectively.

(2) Feasibility Study Stage (Phase-2)

- Topographic survey on the urgent facilities in the Rio Choloma basin,
- River longitudinal and cross-sectional surveys on the urgent facility plan in the Rio Choloma basin,
- Spot leveling survey in the inundation area downstream of the Rio Choloma,
- Geological investigation on the urgent facilities in the Rio Choloma basin,
- Ecological and water quality survey in the study area.

The topographic survey areas, the river survey areas and the spot leveling survey areas are shown in *Figs.* 1.4~1.6 respectively. The datum for the survey is based on the bench-mark J - 159 (EL. 37.4337 m) which is located at the south west corner of the

national road bridge (Choloma bridge). The geological investigation sites are shown in *Fig.* 1.7.

The results of the surveys are compiled in the Data Book.

1.6 Installation of River Stages and Automatic Rain Gauges

In order to improve the existing hydrological observation network, nine (9) river stages and six (6) automatic rain gauges were installed in the Master Plan Study stage. Their locations are shown in *Fig.* 1.8.

FIGURES

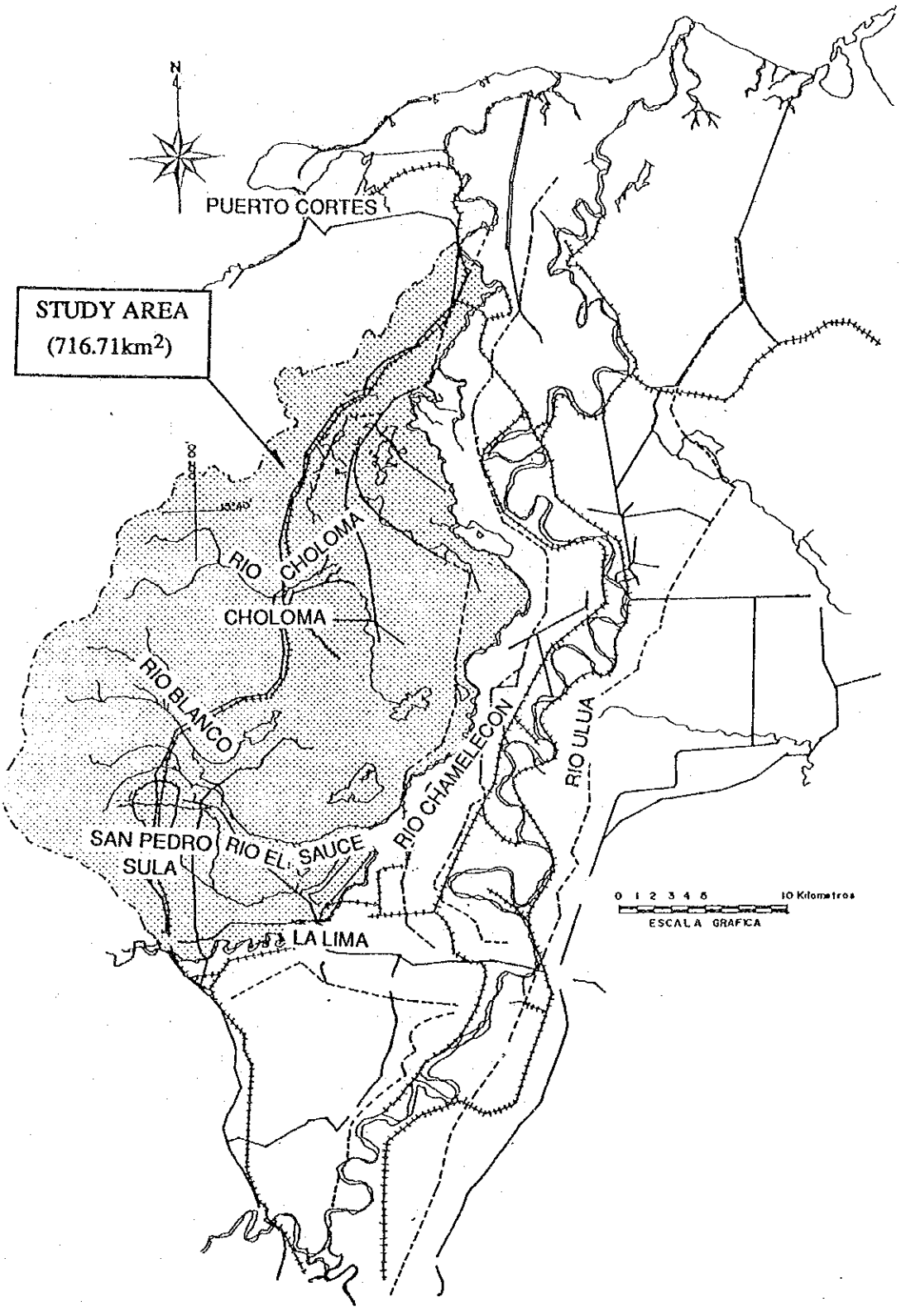


FIG. 1.1 THE STUDY AREA

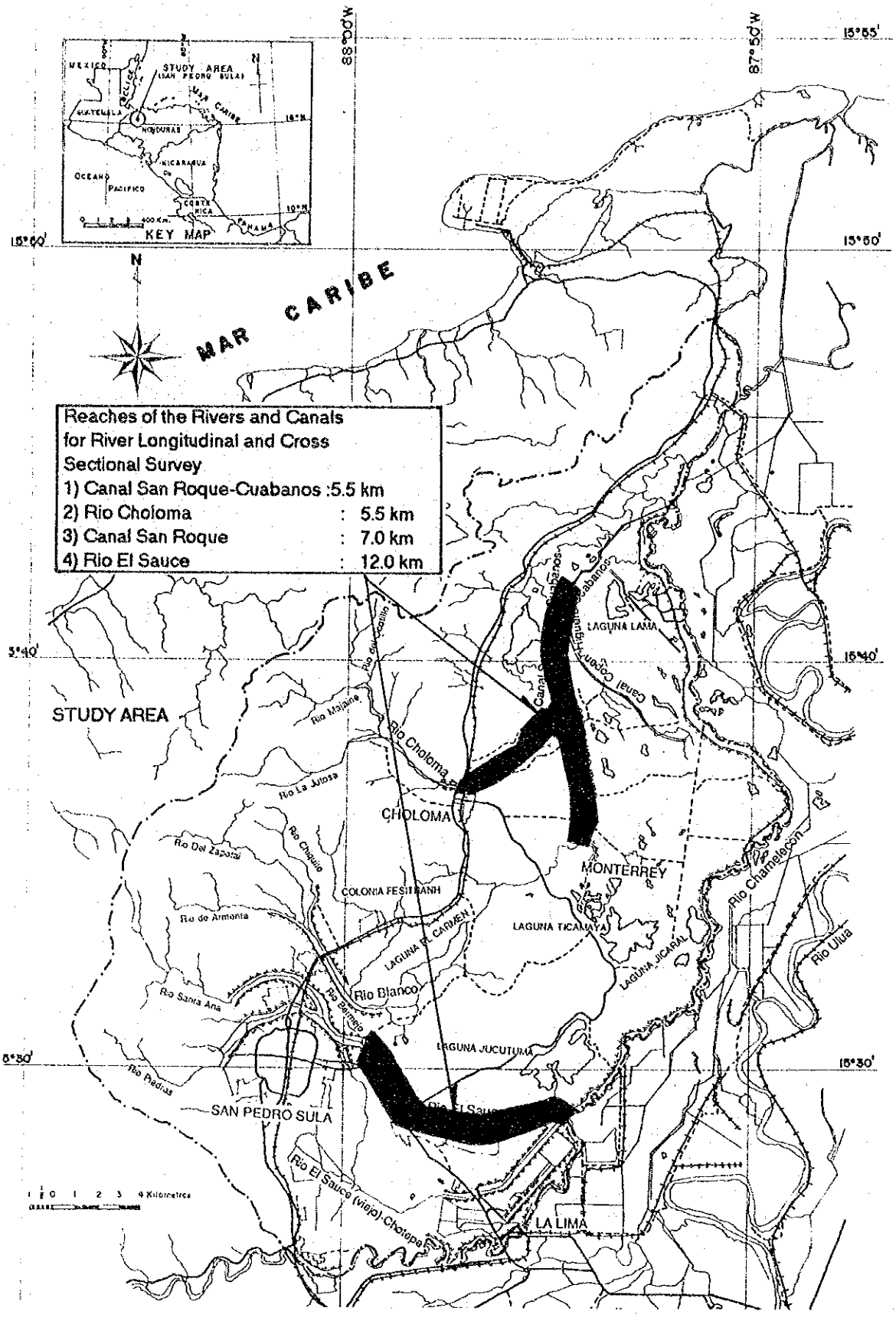


FIG. 1.2 LOCATION MAP OF THE RIVER LONGITUDINAL AND CROSS SECTIONAL SURVEY

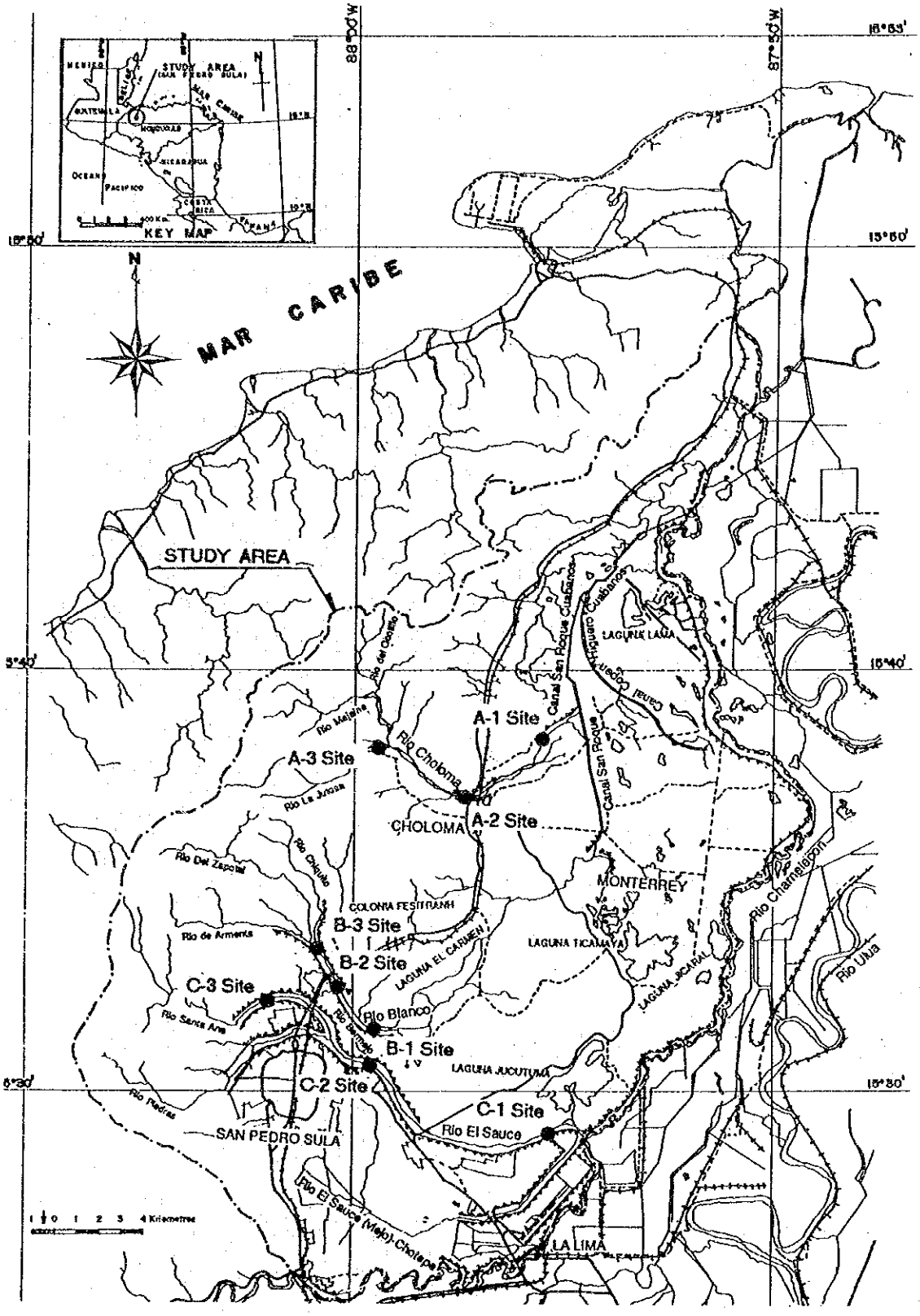


FIG. 1.3 **SAMPLING SITES OF THE RIVER BED MATERIALS INVESTIGATIONS FOR THE RIO CHOLOMA, RIO BLANCO AND RIO EL SAUCE**

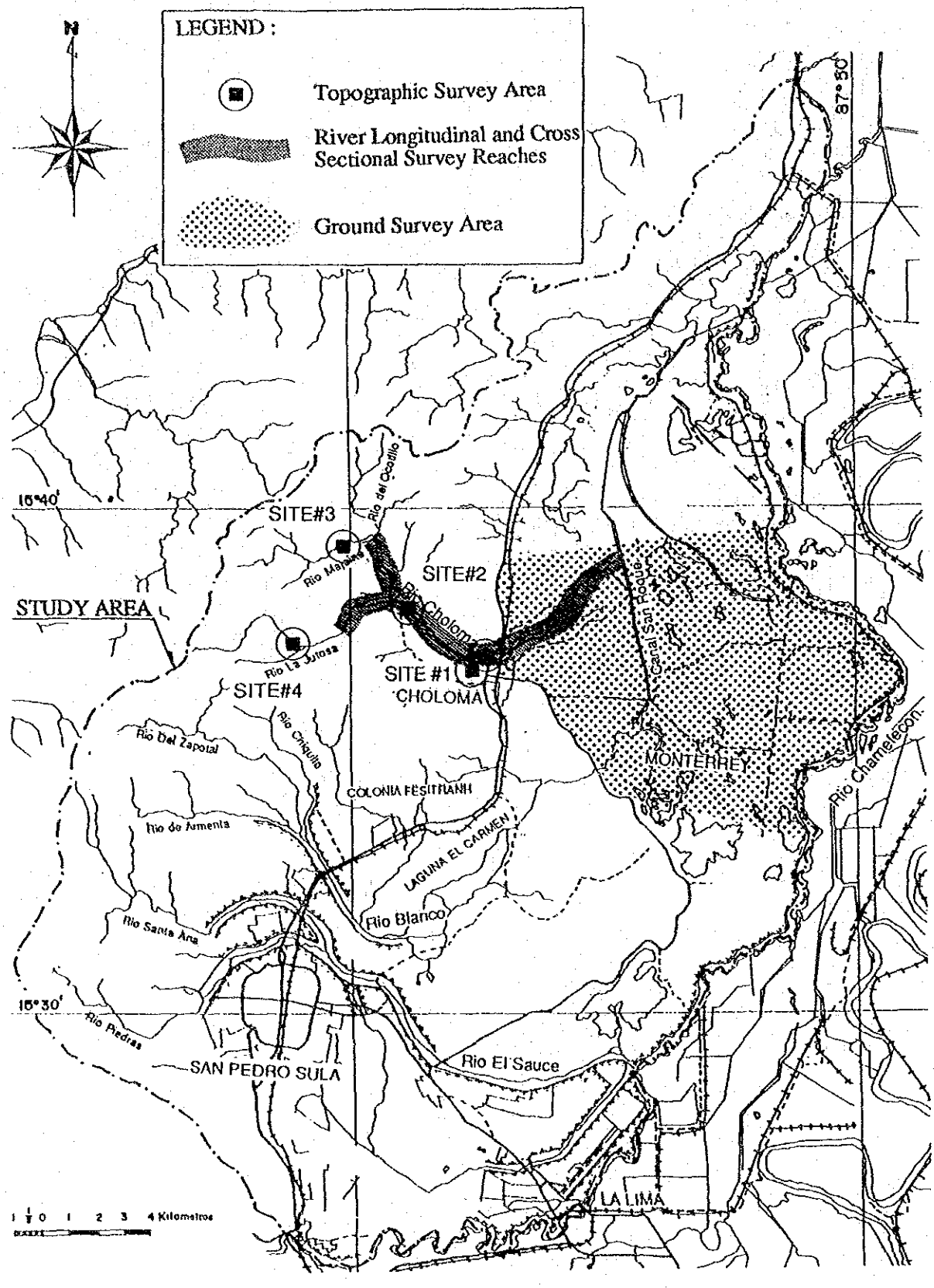


FIG. 1.4 LOCATION MAP OF THE TOPOGRAPHIC SURVEY, RIVER LONGITUDINAL AND CROSS SECTIONAL SURVEY AND GROUND SURVEY

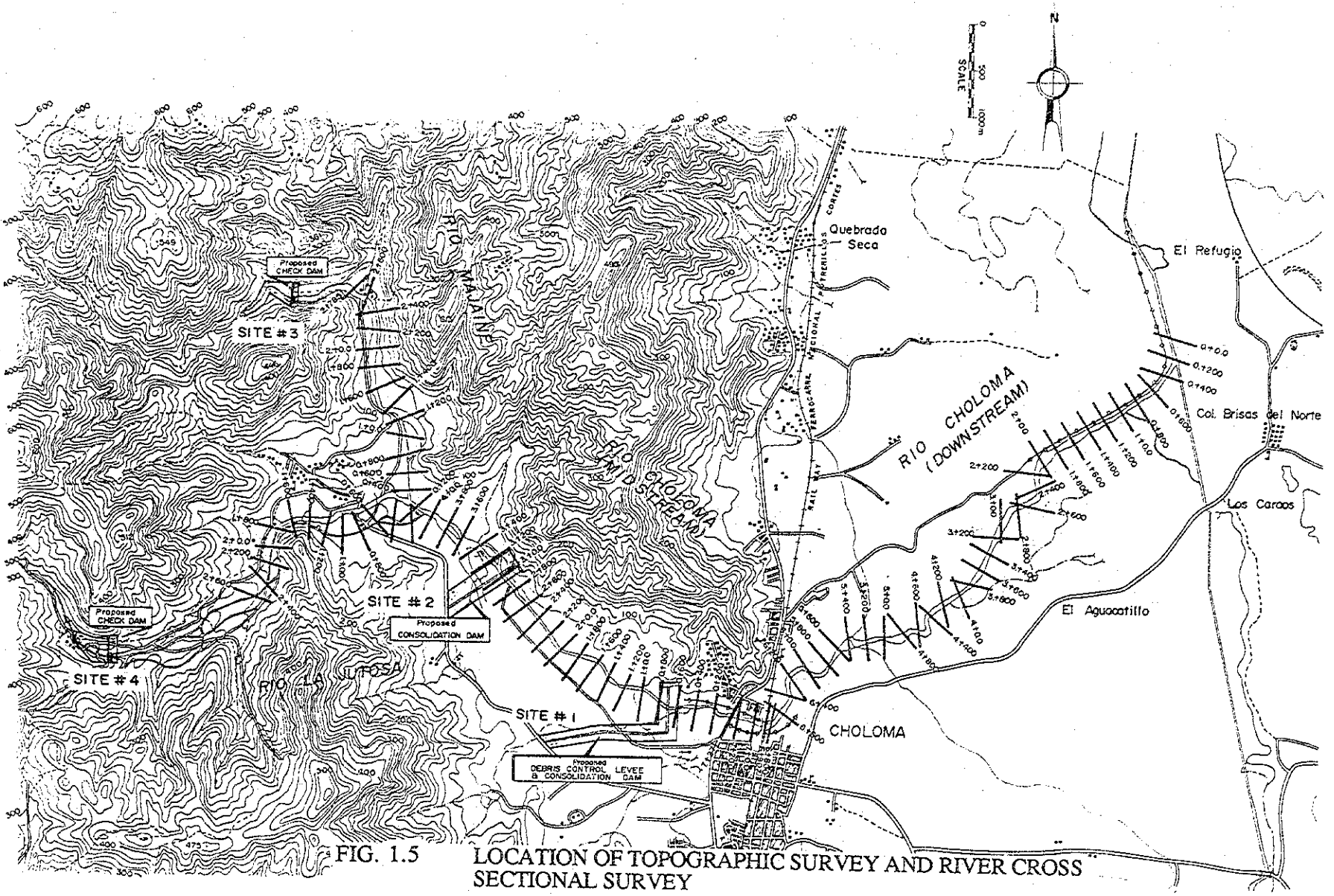


FIG. 1.5 LOCATION OF TOPOGRAPHIC SURVEY AND RIVER CROSS SECTIONAL SURVEY

JICA

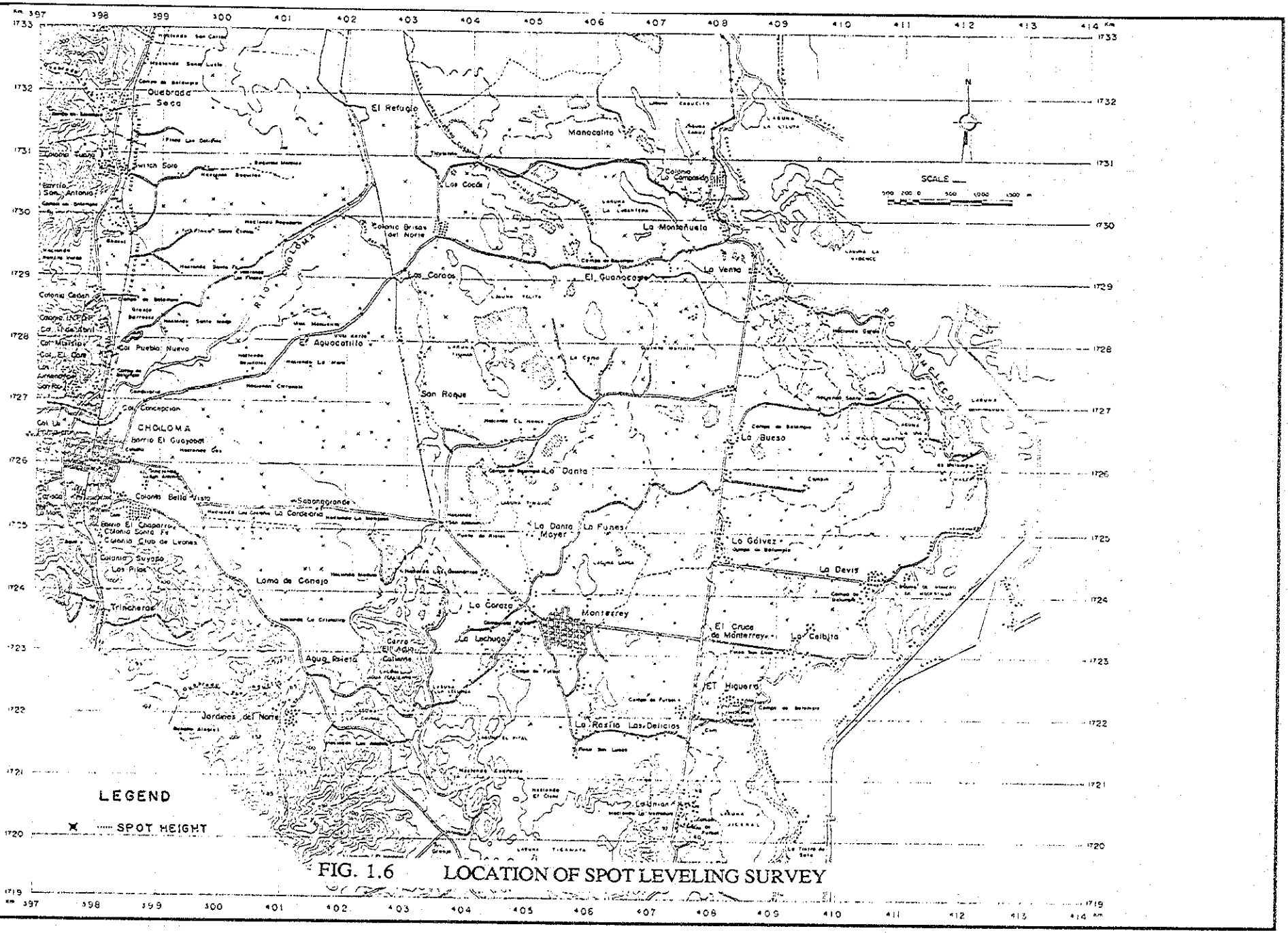


FIG. 1.6 LOCATION OF SPOT LEVELING SURVEY

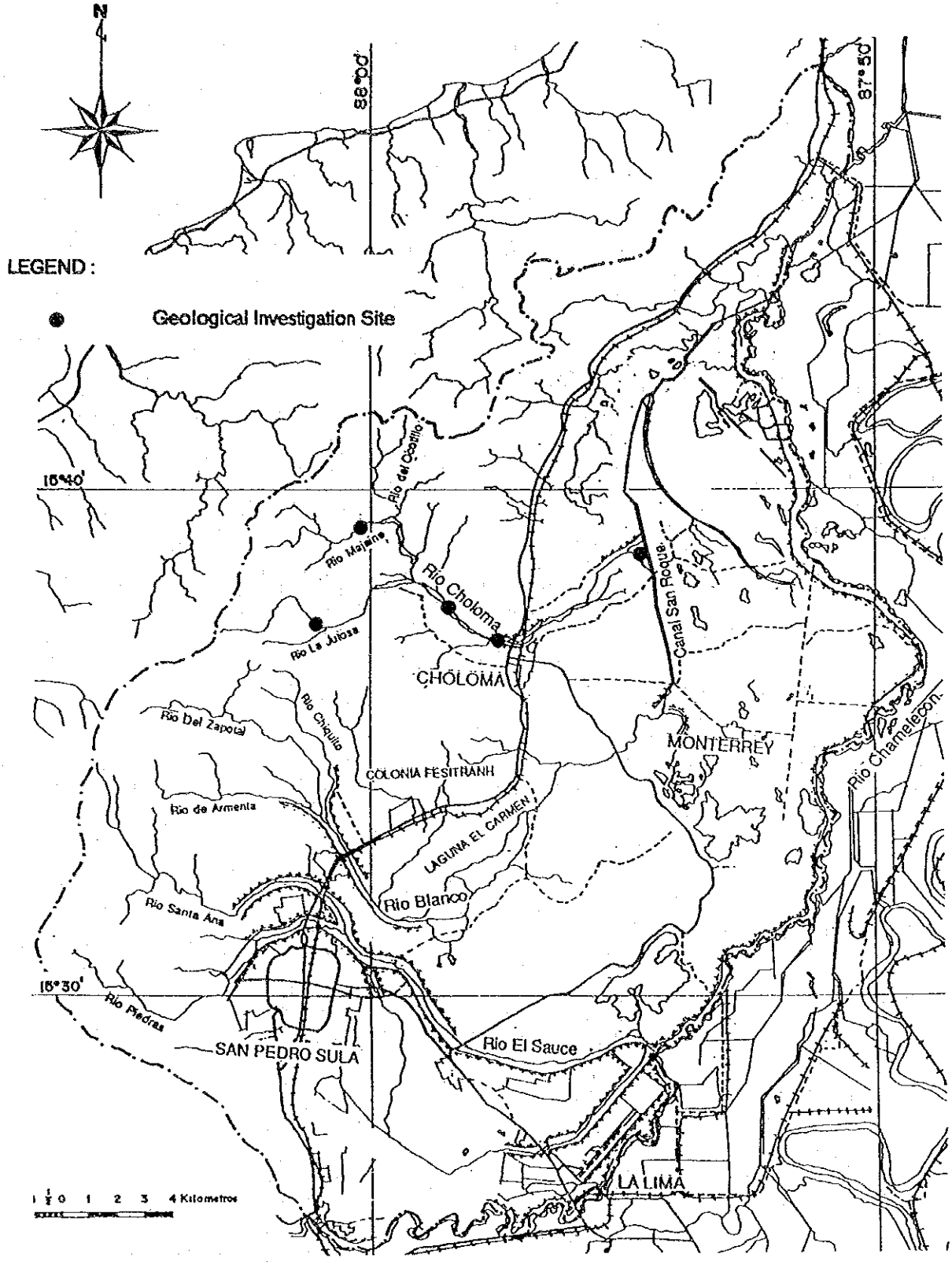


FIG. 1.7 LOCATION MAP OF THE GEOLOGICAL INVESTIGATION SITES

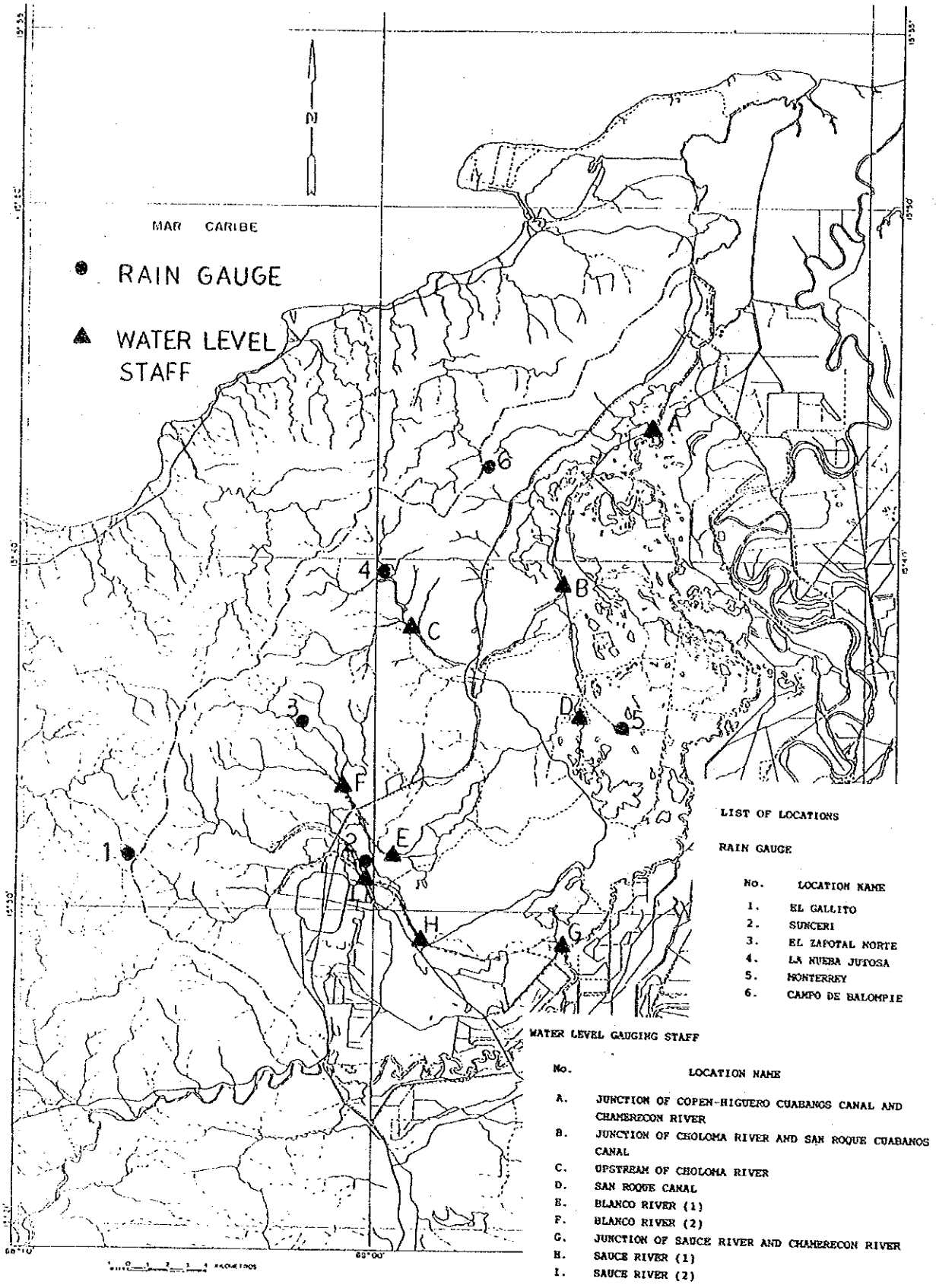
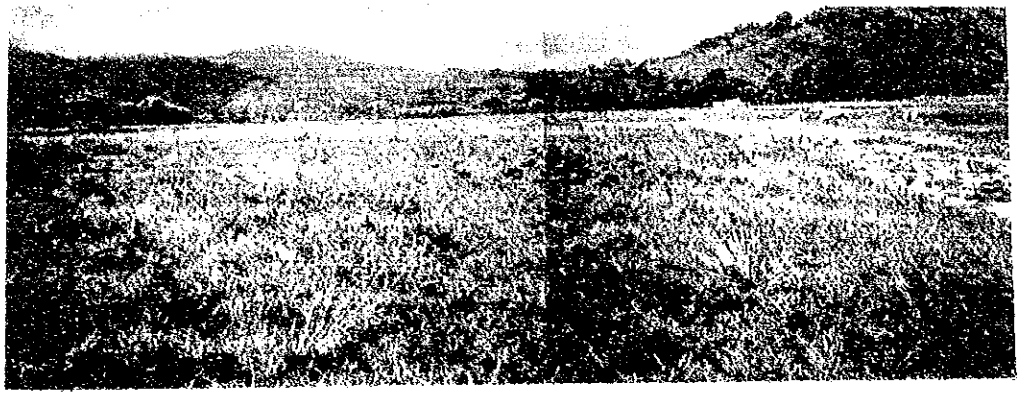


FIG.1.8 INSTALLATION SITES OF THE AUTOMATIC RAIN GAUGES AND THE RIVER STAFF GAUGES



RIO CHOLOMA (1992)

RIO SANTA ANA (1992)

CHAPTER 2
GENERAL CONDITION

CHAPTER 2 GENERAL CONDITION

2.1 Geography

The study area covers a part of the northwestern part of the Sula Valley, consisting of steep mountain areas, alluvial fans/cones and alluvial plains. The Merendon mountains rise from the Sula Valley to a maximum height of 1,700 meters above mean sea level and develop steep slopes. According to this topographic condition the streams are very steep in the mountains, but become gentle in the alluvial plain. Alluvial terraces are developed along streams in the mountains. Alluvial cones and fans are developed at the valley mouths.

The alluvial plain consists of piedmont alluvial plains, old low hills and alluvial plains. The alluvial fans merge gently into the sloping alluvial plains. The low hills of granite are located between the Rio Chamelecon and the urban areas of San Pedro Sula and Choloma. Those urban areas are located on upper sides of the alluvial fans, bounded by the Merendon mountains to the west and north.

The river system is composed of the Rio Chamelecon and its tributaries in the study area. The major tributaries among them are the Rio Choloma, the Rio Blanco and the Rio El Sauce (*Fig* 2.1).

2.2 Geological Conditions

The study area is composed of the Paleozoic metamorphic rock. The Cretaceous~Neogene granite that interpenetrated the Paleozoic rocks. Alluvial cones and diluvial alluvial fans are widely developing at the piedmont areas. Also a thin layer of volcanic pyrocrastic deposits distributes partly over the gentle slopes and the southern tops of the Merendon mountains. The metamorphic rock that distributes in the northern part of the study area and in the upper reaches of the Rio Choloma, the Rio Zapotal and the Rio El Sauce, is mainly composed of granitic mylonite, migmatite and schist, and partly of gneiss and marble. The intrusive granite distributes over from the middle reaches of the Rio Choloma and the Rio Zapotal to the low hills of the west bank of the Rio Chamelecon that are located in the south-east part of the study area.

At the northwestern part of the study area, the Chamelecon fault tends to NE-SW and at between the western mountains of San Pedro Sula and the plain, there is a normal fault approximately in parallel with the Chamelecon fault According to the aerial photograph interpretation, stream lineaments of the upper basins both of the Rio Choloma and the Rio Blanco, are remarkably developed in parallel with those faults or crossing them at right angles. The stream lineaments develop a mosaic structure, likely by small faults.

The distribution of granitic rocks and a number of faults are likely the main reasons why the Rio Choloma and the Rio Blanco basins have yielded a larger amount of sediment than the other basins. Geological conditions of the study area are shown in *Fig.* 2.2.

2.3 Meteorology and Hydrology

The study area is sometimes subject to the influence of hurricanes because it is located in the southern extremity of the hurricane affecting area.

The climate is classified as a savanna type, characterized by two seasons, i e wet season and dry season. The wet season is from June to December. The annual rainfall is about 1,200 mm at La Mesa in La Lima, which is located in the valley floor of the southern border of the study area, but 2.800 mm at Puerto Cortes in the coastal area, which is near the outskirts of the northern border. The rainfall amount seems varied very much locally in the study area, especially among the valley floor and the coastal areas, but available meteorological and hydrological data are still very limited in the study area from technical aspect.

Average monthly temperatures are varied from 24 degrees centigrade in December~January to 28 degrees centigrade in May~June (*Table* 2.1).

2.4 Environmental Aspect

The overall environment in the Study Area comprises two (2) broad distinct environmental components of high lands, the Merendon mountain range and the low lands, including the associated aquatic environment of lagoons and wet lands. The line of demarcation between these two broad environments could be approximated as the national road across the study area from the north to the south, that links the San Pedro Sula with Choloma and Puerto Cortes. The Study Area of 717 square km is divided between the high land area of 304 square km and the low land area of 413 square km.

The high lands of the Merendon mountain range essentially belong to the three (3) ecological associations of wet low montane subtropical forest, wet subtropical forest and moist subtropical forest, while the most low lands of the Sula Valley belong to dry tropical forest transition to subtropical forest. The low hilly areas and the base of the Merendon mountain range, including the urban areas of San Pedro Sula, belong to the highly localized ecological association of moist tropical forest transition to subtropical forest.

Both the above transitional associations have been highly modified with virtually no primary forest remaining. Most of urban, industrial, agricultural and animal husbandry developments in the Study Area occupy the areas of these two (2) transitional associations of dry tropical forest transition to subtropical forest and moist tropical forest transition to subtropical forest.

Other than these ecological associations, the distinct ecosystem that occupies the low land Sula Valley area is the lagoons and the associated wetlands of Jucutuma, Ticamaya, El Carmen, Lama and others.

In the low land area San Pedro Sula and other urban areas are located. Though San Pedro Sula city is the second largest on Honduras, next to the capital city of the nation, Tegucigalpa, San Pedro Sula city and its surroundings, including Choloma, are the most developed agricultural and industrial area and boast the largest industrial zones in the country.

The major environmental issues identified are deforestation, agriculture practice, water pollution and lack of any environmental management system. Destruction of forest for agricultural practice has been widespread in the Merendon mountain ranges of the Study Area. Deforestation for agriculture and pasture for animal husbandry in itself does not necessarily be a cause of soil erosion, even though it may cause other undesirable environmental consequences. It is the subsequent unsustainable agricultural practice, typically in sloping terrain, that lead to soil erosion and the resultant shifting of cultivated land.

San Pedro Sula city has become a major source of water pollution to its surroundings. The major cause of water pollution in these water bodies is the discharge of untreated domestic and industrial wastewater from the built-up areas of San Pedro Sula, Choloma and their surroundings. Pollution load run-off due to agriculture and animal husbandry activities like cattle ranches should also be a significant factor. As a result, the receiving surface water bodies at downstream of the city are severely polluted. The effect of untreated wastewater discharge to surrounding rivers and lakes is strikingly visual in the Rio El Sauce and the Rio Chotepe.

The basic framework concerned to environmental protection, was promulgated very recently at national level by the National Congress of the Government of Honduras. It is "The General Environmental Law." This law stipulates all basic requirement of environmental protection including environmental impact assessment (EIA).

There exist no environmental regulations or standards concerned to even the basic aspects of stream water quality or ambient air quality. Formulation of environmental