3.1.3 Other Meteorological Conditions

The meteorological conditions other than the rainfall, such as the temperature, humidity, evaporation, wind, sunshine and so on in the basin are also investigated, and are detailed in Appendix II, Supporting Report I.

3.2 Hydrological Conditions

3.2.1 General

The Rimac river basin is formulated by two major tributaries: that is, the Rimac and the Santa Eulalia rivers, and many small tributaries (called "Quebrada"). The two major rivers meet at just upstream of Chosica which is one of the satellite town of Lima. The catchment areas of the Rimac and the Santa Eulalia rivers at upstream of this confluence are 1,228 km^2 and 1,085 km^2 respectively.

In the most upstream area higher than EL. 4,500 m above mean sea level, glaciated valleys remain in the skirt of the mountains. In those valleys, a lot of small lakes (called "Laguna") can be seen. The principal feature of major Lagunas is summarized in Table II-3-6.

The runoff of the Rimac river is mainly dominated by the rainfall pattern in the upstream area. At Chosica gaging station, annual average runoff is 32 m^3/sec according to the record in the period from 1969 to 1987. Between four months from January to April, around 65% of annual volume was recorded.

Besides the water resources of the Rimac river, water in the Laguna Marcapomacocha diverted by an open canal and a tunnel to the Santa Eulalia river is also utilized in the basin. The annual average diverted water volume is about 4 m^3/sec. The length and capacity of the tunnel are 10 km and 12 m^3/sec. respectively.

Development of hydropower in the Rimac river started in 1920'. Integrated system of five power stations (three in the Rimac and two in the Santa Eulalia rivers) supplies electricity to the metropolitan area. Total capacity of generation in peak time is 540 MW.

At Atarjea about 21 km upstream from the river mouth, a intake weir and treatment plant with storage pond are operated by SEDAPAL. About 70% of urban population is served water from this plant by SEDAPAL at present.

Nowadays, pollution of the Rimac river becomes a serious problem in parallel with the growth of the metropolitan area. SEDAPAL and DGASI conduct water quality analysis of the samples at several locations along the river.

3.2.2 Runoff

SENAMHI operates three stream flow gaging stations at present, that is, Rio Blanco, San Mateo and Chosica. Automatic water level recorders are installed at these stations. On the other hand, ELECTROLIMA manages four stations at Tamboraque, Milloc, Sheque and Autisha which are key locations of hydropower generation by ELECTROLIMA. At the outlet of the diversion tunnel at Milloc, a water level recorder is functioned to observe the discharge quantity from the Mantaro river basin. At other ELECTROLIMA stations only staff gages are installed.

At Chosica gaging station, around 2.5 Km downstream of the confluence between the Rimac and the Santa Eulalia rivers, a cableway is equipped with a cage for discharge measurement. Rating curves are made periodically. Within three or four months, the curve is renewed based on the latest measuring result.

According to the record of monthly maximum discharge mean daily values at Chosica, the largest value is 276 m^3/sec in February 1981. Hydrographs at Chosica in characteristic hydrological years of three typical patterns are shown in Fig. II-3-3. Table II-3-7 to II-3-9 show major run-off data in the basin. In addition, annual maximum discharge at Chosica is tabulated in Table II-3-10.

The probable flood peak discharge is analyzed as follows:

Return Period (Year)	Flood Peak Discharge (m^3/sec)
2	150
5	290
10	380
25	490
50	580
100	660
200	740
500	820
1,000	920

The analysis for the above is given in detail in Appendix II, Supporting Report I.

3.2.3 Other Hydrological Conditions

The condition of water utilization in the basin such as the water use for hydropower generation, agriculture, municipal water, etc. is related to the hydrology of the basin. The investigation results for the present conditions of water utilization in the basin are all given in Appendix II, Supporting Report I as well as those for the water quality, sediments and tide, etc.

4. LAND USE AND VEGETATION

4.1 Land Use

The general land use conditions of the whole basin are shown in Fig. II-4-1 which was processed from the land use classification map prepared in 1/100,000 scale.

The ratio of land use is roughly measured as follows:

(a)	Town/Village	4.6%
(b)	Farm (flat land)	1.7%
(c)	Farm (mountain slope)	7.1%
(d)	Mountain (without vegetation)	30.0%
(e)	Mountain (with vegetation)	34.6%
(f)	Swamp	0.8%
(g)	Glacier/Perpetual snow	0.9%
(h)	Lake	0.3%

Note: The areas for river, road and railway are not counted.

In general, almost 90% of the basin is mountain area. The flat plain is developed only in the lower reach area which includes the Lima-Callao metropolitan district and in a part of middle reach area which is located along the main streams, the Rimac river and the Sta. Eulalia river.

In the mountain area, the most parts are bare land without vegetation or with very limited vegetation of some grasses, scattered cactuses, some low trees. The vegetation is seen in the mountain slopes and wide U-shape valleys of the upper reach area where the land is used for vegetable cultivation or pasturage. Many small mines with its villages are located in the mountain of middle and upper reach areas. In the area along the main streams, some towns such as Chosica, San Mateo, Surco, and Matucana are located and farm lands are developed. The main national roads and national railway are also running along this valley of main stream. That is, the main traffic trunk which contribute much to the Peruvian economy and society forms a part of the mountain area.

In the flat plain located in the lower reach, various kinds of building, facility, and structure are seen. The area is developed as the metropolitan district. That is, the level of land use is very high. Even in the suburb area of metropolitan district, the town areas are continuously adjacent and some main roads and a railway are located there. Farm lands and resort areas are also seen in the suburb zone.

More specific descriptions for the land use condition in the areas along the Rimac river and the Sta. Eulalia river as well as in some disaster prone areas are made in the Supporting Report I.

4.2 Vegetation

The condition of vegetation in the basin is approximately shown in Fig. II-4-2. The ratio of each classification is obtained as follows:

(a) Town/Village*	4.7%
(b) Farm land/Forest	9.0%
(c) Grass land/Shrub (high and low)	21.8%
(d) Grass land/Shrub (low)	30.4%
(e) Almost no vegetation (only cactus)	14.1%
(f) No vegetation	19.1%
(g) Lake/Swamp/Perpetual snow	0.9%

* There are many vegetation areas in parks, roads, house-yards, etc. in the town and village area.

As seen in the table above, the area of about 35% of the basin has no vegetation and the area of 50% is covered with grasses and shrubs. However, the vegetation in this area is not so thick and the share of bare land is much larger than the actual vegetation land. Farm land and forest area are located in and along the valleys of main streams.

Various vegetations have been cultivated in the riverside along the Rimac river and the Santa Eulalia river. Various types of verdure are cultivated in the lower reaches. They are tomato, carrot, lettuce, alfalfa, etc. Many fruits are also cultivated in the middle reaches. They are banana, avocado, apple, etc. A species of cactus is also cultivated as a material of toilet articles. Cultivation of maizes and potatoes is found on many slopes in the natural vegetation area. Forestation of pinetree and eucalyptus is seen on the river sides of the middle and upper reaches.

5. RIVER AND RIVER BASIN FEATURES

Major features of the river and river basin are summarized below. More detailed features are presented in Appendix IV, Supporting Report I.

(1) Catchment Area

(A) Total catchment area :3,230 Km^2

(B) At confluence of the Rimac and Sta. Eulalia rivers : 2,250 Km^2

(a) The Rimac river : 1,230 Km^2

(b) The Sta. Eulalia river : 1,020 Km^2

(2) River Length

The river length from the river mouth is measured at several major points as follows;

(A)	At confluence of the Rimac and Sta. Eulalia rivers	: 56 Km
(B)	At Cocachacla	: 71 Km
(C)	At Surco	: 84 Km
(D)	At Matucana	: 91 Km
(E)	At San Mateo	: 107 Km
(F)	At Chicla	: 115 Km
(G)	Total length of the Rimac river	
	(a) Quebrada Antaranra	: 129 Km
	(b) Quebrada Pucacocha	: 132 Km
(H)	At confluence of the Sta. Eulalia and Acobamba rivers (from the confluence with the Rimac river)	: 39 Km
(I)	Total length of the Sta. Eulalia river (from the confluence with the Rimac river)	: 56 Km

(3) River Width

Regarding the river width, it is noted that the variation of width is remarkable as follows;

(A)	Upstream Stretch from Matucana	: 3- 10 m
(B)	Matucana - Chosica	: 10- 40 m
(C)	Chosica - Chaclacayo	: 25-100 m
(D)	Chaclacayo - Atarjea	: 50-300 m
(E)	Atarjea - River Mouth	: 10-200 m

(4) River Profile

The river profile is considerably steep as shown below:

	River Reaches	Gradient	
(A)	0 - 10 Km (Lima)	0.010	(=1/104)
(B)	10 - 20 Km	0.016	(=1/ 64)
(C)	20 - 30 Km	0.016	(=1/ 61)
(D)	30 - 40 Km	0.017	(=1/ 59)
(E)	40 - 50 Km	0.018	(=1/ 55)
(F)	50 - 60 Km (Chosica)	0.026	(=1/ 38)
(G)	60 - 70 Km	0.031	(=1/ 32)
(H)	70 - 80 Km	0.039	(=1/ 26)
(I)	80 - 90 Km	0.054	(=1/ 19)
(J)	90 Km up	-----	

Fig. II-5-1 and II-5-2 indicate the distance from the river mouth at the respective point and the longitudinal profile of river, respectively.

6. DISASTER MANAGEMENT

6.1 General

The present management of river and disaster in the basin is not sufficient, which causes the various disasters or increases the damage.

This section investigates the present situation of the management, aiming at duly reflecting on the planning of the disaster prevention measure in the basin.

6.2 Present Structural Management

6.2.1 Existing Structures

There are various structures in or along the Rimac river as listed below.

(a) Road
(b) Railway
(c) Bridge
(d) Levee
(e) Parapet wall
(f) Channel works, Revetment, Ground sill
(g) Intake structure for city water supply
(h) Intake structure for irrigation water supply
(i) Intake and outlet structures for power generation, including dam
(j) Groyne
(k) Intake for water supply to refinery plant
(l) Houses
(m) Others

Most of them are located along the main stream. In tributaries, the scale of structure is relatively small.

Though there are many river structures, the following structures are mainly constructed for preventing the disaster.

(a) Levee
(b) Parapet wall
(c) Channel works
(d) Groyne

The other structures are constructed for individual purpose. Some of them are considered to be undesirable structures for disaster prevention as they would obstruct the smooth flow and reduce the flow capacity of river channel.

No overall structural plan in the whole basin has been prepared. The structures have been constructed for a limited point or section and for a limited purpose. As for the disaster prevention, the structures were constructed almost always after suffering disaster. In this case, it is expected that the area protected by new structures will not suffer the disaster at the time of flood for some years. However, the other areas will suffer instead.

In addition, it seems that the quality including design, materials and construction of some structures is not good enough as permanent structures. Especially, the design and construction of levee will need improvement in the future.

6.2.2 Operation and Maintenance of Structures

As far as the information obtained by the Study Team, there is no unified standard or rule for operation and maintenance of all the structures in and along the Rimac river as well as the Santa Eulalia river. However, the structures in the same group are controlled and managed by a certain body or office. The structures classified by the administrative office are generally as follows:

(a) Hydro-electric power generation structures including intake and outlet of waterway : ELECTRO LIMA.
(b) Irrigation water intake : MINIS. AGRICUL.
(c) City Water supply intake : SEDAPAL
(d) Railway and Railway bridge : ENAFER
(e) Road and roadway bridge : MINIS. TRANSP.

The other structures such as levee, parapet wall, and channel works can not be classified by the administrative office as the administrative office or body is different by the location as well as by the owner. For example, the levee in Corcona was constructed by the mining company nearby Corcona, the levee on the left bank in Nana district was constructed by COOPOP and the levee constructed in the downstream stretch nearby the river mouth was constructed by Peruvian Navy. The parapet walls are also constructed by the different offices and bodies. The parapet walls located in the partial portion along the river are usually constructed by a private person or a group of inhabitants/village nearby the river.

It can be said that the office or persons who need such structure or the office related to the structure are generally in charge of construction as well as operation and maintenance. If there are some offices related to the structure, the construction is generally carried out on shares.

In regard to the cooperation and regulation between or among the different offices, it seems that there is no authorized system for operation and maintenance. However, they usually assist the other offices if requested. For example, ELECTRO LIMA opens the gate of reservoir wider than its requirement when the downstream offices, specially SEDAPAL, request more water for their necessity.

6.3 Present Non-structural Management

6.3.1 Laws

There are many laws established by the Peruvian Government. However, there is no specific law limited for river or disaster. It is necessary to refer to some related laws if required to check any regulations for disaster prevention or for utilization of river, making it difficult to put into execution the regulations.

The laws and norms related to management of river and disaster are introduced in Appendix VII, Supporting Report I.

6.3.2 Relief of Inhabitants

Though no special measures are taken to reduce the damage due to disaster, some activities after the disaster are carried out for the relief of inhabitants. The assistance for relief is mainly provided by the governmental offices concerned. Generally, several different offices start their work at the disaster area. For example, the following work is carried out.

(a) TRANSP. MINISTRY repairs the road and bridges.

(b) HOUSING MINISTRY takes care of the houses of the inhabitants.

(c) HEALTH MINISTRY serves the medical and health care of the inhabitants.

(d) Municipality office tries to obtain the relief goods and provide the necessary information to the inhabitants.

(e) SE/INDC collects the informations of disaster and damage and announces in public. The coordination of each government office is also performed by SE/INDC.

Note: It is noted that the name of CNDC was changed to INDC (Instituto Nacional de Defensa Civil) due to the reorganization in August 1987.

6.3.3 Training and Education for the Disaster Prevention

SE/INDC arranges the ordinary meeting as well as the occasional meeting of which members consist of the staff of the government offices and agencies related to the disaster. In the meeting, the information and data in respect of the recent disaster are made. Besides SE/INDC occasionally announces the importance and necessity of disaster prevention.

6.4 Related Offices for Management of River and Disaster

6.4.1 General

There is no unified organization which controls the whole river basin with responsibility in regard to the disaster prevention. That is, all the government offices and agencies individually carry out their activities for structures and facilities to be constructed or established by the budget of their offices.

However, Committee Nacional de Defensa Civil (CNDC) was established in 1972 as a coordinating authority for the inter-agencies at emergency, expecting that CNDC would control all the matters at the occurrence of disaster. The name of CNDC which has continued his activities since then was recently changed to INDC (Instituto Nacional de Defensa Civil).

In addition to the above INDC, there are many other offices relating to the disaster prevention more or less.

INDC, which is the main related office, is introduced hereunder. *Other relevant offices are introduced in* Appendix VII, Supporting Report I.

6.4.2 INDC

As mentioned above, CNDC was established in 1972 as a coordinating authority for the interagencies at emergency after the great earthquake in Huaraz which killed more than 50,000 persons. Since then, CNDC has continued his activities: that is, CNDC has been accumulating the experience for disaster and improving the consciousness for the importance of disaster prevention. However, in view that the function of CNDC is required to be further reinforced, CNDC was recently reorganized to INDC which is newly provided with the autonomy.

The details of new organization in INDC are not definitively established yet, since the reorganization was just made in August 1987. Thus, the present organization is still as presented below without any substantial change from that of CNDC.

The general organizations of INDC and SE/INDC which is an executive office of INDC are shown in Fig. II-6-1 and II-6-2. Its organization and major activities are detailed as follows:

(A) Organization

<u>Main Composition</u> :

Under the original law, the Sistema de Defensa Civil was composed by the following organizations:

- Ministry of Interior
- Ministry of Health
- Ministry of Agriculture
- Ministry of Energy and Mining
- Ministry of Transport and Communication
- Ministry of Housing and Construction
- Ministry of Education
- President of the United Armed Force

<u>Levels of Committee</u> :

The organization also provides Defensa Civil Committees of different level by scale. A set of people gathers regularly to perform a definite purpose in each level of Committee.

There are 5 levels of Committees.

(a) National : For the whole nation. It is directed by the Minister of Interior. It has a Secretaria Ejecutive Nacional in Lima.

(b) Regional : For each of five regions with headquarters in Piura, Lima, Arequipa, Cuzco and Iquitos. Each one of the regions has a Secretaria Ejecutive Regional.

(c) Department: For each of the department of Peru.

(d) Province : For each of the province of Peru.

(e) District : For each of the district of Peru.

Note: For the last 3 levels, there is not Secretaria Ejecutive.

<u>Regional Committee</u> :

Each region covers the following departments:

(a) First Region

- Piura
- Tumbes
- Lambayeque
- La Libertad
- Cajamarca
- Amazonas

(b) Second Region

- Lima
- Ancash
- Ica
- Pasco
- Huancavelica
- Junin
- Huanuco
- Ayacucho
- Provincia Constitucional del Callao
- Ucayali

(c) Third Region

- Arequipa
- Moquegua
- Tacna
- Puno

(d) Fourth Region

- Cuzco
- Apurimac
- Madre de Dios

(e) Fifth Region

- San Martin
- Loreto

(B) Activities

The major activities of INDC are (i) to act as the coordinating body of all the related offices at emergency, (ii) to investigate and prepare the reports for the disasters, (iii) to collect informations and data in relation to the disasters and (iv) to educate the public for the disaster prevention, etc. However, it cannot be said that a sufficient function necessary for the mentioned activities is provided to INDC. The detailed situation of present activities are presented in Appendix VII, Supporting Report I.

7. PAST DISASTER AND DAMAGE

7.1 General

According to the records and informations in regard to the past disaster, the disasters caused by debris flow, inundation, slope failure, etc. occurred almost every year in the Rimac river basin. The locations of past disaster are shown in Fig. II-7-1. However, it was found that the disaster happened in 1983 and 1987 was remarkably serious. Therefore, a special attention was paid on the disasters happened in 1983 and 1987. Especially, the investigation on the disaster happened in March 1987 was made in detail as the disaster happened when the Study Team stationed in Lima.

7.2 Disaster in 1983

In 1983, the natural disaster was remarkable not only in the Rimac river basin but also in the other districts of Peru. According to CNDC's data covering January through June in 1983, the total toll in provinces of Huarochiri and Lima was recorded at 285 consisting of the dead 52 and the injured 233. It is considered that most of them are happened in the Rimac river basin. The precipitation from February to March increased remarkably due to intense rainfall caused by El Niño event. Monthly rainfall records indicate 62.8 mm of Feb. and 189.2 mm of March in Matucana. As a result, an intensive damages were inflicted on settlement area in the middle reaches between Chosica and San Mateo, and central highway of Route 20 and railway connecting Metropolitan Lima and mountainous area. The traffic system was interrupted for a long time.

7.3 Disaster in March 1987

A large scale disaster due to debris flow, inundation and slope failure happened on and around March 9, 1987 as summarized in Table II-7-1. Its locations are shown in Figure II-7-2.

The disaster is classified into the following three categories.

(a) Debris flow happened in five Quebradas located in Chosica district.

(b) Inundation happened in Campoy/Zarate district located on the right bank area along the Rimac river. The cause was the overflow from Qda Jicamarca, the major tributary located in the lower reaches of the Rimac river.

(c) Other disasters such as debris flow in Qda La Cantuta, slope failure at Santa Rosa de Palle Bajo village and Inundation from the Rimac river in Huachipa area. The damage of these disaster was comparatively small.

The particular features of debris flow disaster in March 1987 are summarized below.

7.3.1 Rainfall

The rainfall duration is judged from the hearing investigation to be generally from PM 3:00 to PM 7:00. In Chosica district, light rainfall came at around PM 3:00 and heavy rainfall of 15 - 30 minutes came at around PM 4:00 and then misty rain continued from PM 5:00 until PM 7:00. The total rainfall on March 9 in Chosica is considered to be 20 - 50 mm judging from the hearing information, the record at Autisha gaging station, and etc. This value seems to be reasonable as the past maximum daily rainfall of 8 years records in Chosica (La Cantuta station) is 32.2 mm and the estimated total rainfall from the distribution obtained from the hearing.

7.3.2 Runoff

The maximum discharge at the time of debris flow on March 9, 1987 is estimated from the assumed velocity and the flood marks or the maximum water level obtained by hearing in each Quebrada as follows.

Location	Catchment area	Max. discharge
Qda Quirio	10.4 km^2	50 m^3/s
Qda Pedregal	10.6 km^2	160 m^3/s
Qda Cashahuacra	15.1 km^2	140 m^3/s

The discharge at small Quebradas, Qda Carosio and Qda Corrales, was difficult to estimate as the information and data were not enough.

7.3.3 Condition of Debris Flow Disaster

The disaster conditions are more or less different in each Quebrada. The deposit conditions in each Quebrada are summarized in Table II-7-2. The main points obtained by hearing from the inhabitants in Qda Pedregal are mentioned below:

(a) Debris flow with step-wave occurred several times.
(b) Discharge of debris flow increased gradually.
(c) Big sound and ground rumbling were accompanied.

(d) The size and volume of debris were increased in accordance with the increase of flow level.
(e) Big boulders flowed down by rolling.
(f) In the sediment area, big boulders repeated the action of deposit and movement.
(g) The direction of main flow was changed due to the deposits of boulders.
(h) The damage became serious by the impact of boulders.
(i) The content of debris became small when the water level became low.

The conditions of damage are as follows:

The human damage is reported that 38 persons were dead and 12,414 persons are wounded. Though the details of human damage are not shown, the police (PIP) reported the location of 19 dead bodies of which identity were confirmed as follows:

(a) Qda Corrales	4 people
(b) Qda Pedregal	15 people

The damage on houses was counted at 700 - 1000 in number which include complete destruction and semi-destruction. About 60% of them were located in Qda Pedregal. Most houses were destroyed in the area where the debris flow made deposits. Especially in the main route of debris flow, the level of destruction was almost completely destroyed. However in the surrounding area of main route, the level of destruction was different by the type and location of house.

Besides the above, the damages were reported in power-generating facilities/structures, transportation structures, water supply facilities and etc.

Further, the indirect damage was also remarkable. Though the reports of SE/CNDC don't describe the matter, it seems that the indirect damage made serious effect on the Peruvian economy. The most serious damage was the traffic blockade of Carretera Central (National road No. 20). The stop of electric generation at Huampani power station due to the sediments in the waterway and the stop of water-supply due to the destruction of pipes and facilities are also considered serious.

7.3.4 Condition of Inundation Disaster

(A) Conditions of inundation

Though Qda Jicamarca has usually very little flow, the flood flow caused by heavy rainfall in the upstream areas induced the inundation from two places at around PM 5:00 on March 9, 1987.

At the crossing point of road and Qda Jicamarca located 5 km upstream from the confluence, the driftwood blocked the culvert for about an hour from PM 5:00 until PM 6:00 as the section of culvert was too small to pass through the driftwood and the channel was sharply bent at this portion as well. Then the inundation occurred on the upstream left bank zone along Qda Jicamarca. The farm lands, some houses and a part of road suffered the damage. The traffic blockade was only temporary. The driftwood could naturally flow through the culvert later and then the water level lowered.

On the other hand, at the confluence, the corrugate pipes under the new highway were blocked by driftwood at around PM 5:00, accompanied with the water level suddenly raised. The water overflowed from the right bank of Qda Jicamarca flowed into the Campoy district along the right bank of the Rimac river. The water depth in the area nearby the overflowed portion reached to 1.0 - 1.5 m at the maximum which continued for about 3 hours. Then the water level lowered gradually and almost no inundation area remained at around PM 10:00 or PM 11:00. The flow went down along the right bank of Rimac river mainly through the roads. The water depth became shallow as the distance from the overflowed portion became far. The inundation area reached a part of central zone in old Lima which is about 10 km from the confluence. It was about 1 km at the wide area but only 30 m at the narrow area. The inundation flow included plenty of mud but did not include boulders as well as stones. The sediment depth was much different by the place. The depth on the road was as shallow as only 10 - 20 cm at the place nearby the overflowed portion as the velocity was comparatively high. However, the sediment depth in the housing zone was so deep that the sediments of over 1 m deep were seen in some places.

(B) Conditions of damage

In accordance with the report prepared by SE/CNDC, the damage of inundation disaster was as follows:

(a) Houses

Totally destroyed	:	149 houses
Semi-destroyed	:	50 houses
Washed away	:	46 houses

(b) Well

Among 1,300 wells located in Huachipa, Campoy and Zarate districts, 316 wells (about 25%) lost its function. Many other wells suffered the muddiness.

(c) School

2 colleges suffered the inundation.

(d) Traffic

In Zarate district the roads of about 20 km in total were buried with sediments of 7,000 m^3.
In Campoy district, about 2 km section of main road was buried with mud.

(e) Power

A substation suffered the damage.

(f) Agriculture

Farm land of 80 ha was inundated in Cajamarquilla.
About 5,000 chickens were dead.
Secondary irrigation canal of 1,500 m long was buried.
Others.

(g) Public Park

60% of public green zone was buried with water and mud. A park in Zarate was buried with mud of 50 cm deep.
Planting farm of 14 ha was buried.
Others.

The destruction of houses mainly occurred in the area located within about 500 m from the confluence due to the high flow velocity and depth. Especially in the border area of Campoy and Zarate where a part of inundation flow returned to the main river, the degree of destruction was remarkable to such an extent that the mud piled at about 0.3 - 1.0 m deep in these houses and the most household goods were flowed away. The number of houses affected by inundation was large as the inundation was widely spread.

Though the sediments on the roads were shallow, the damage due to traffic blockade was serious as the area was located in a densely populated zone.

8. INVENTORY OF DAMAGEABLE VALUE

8.1 General

The estimate of probable damage by different magnitude of disaster will be required to count the disaster control benefit which is derived from damage amount to be mitigated by proposed structural plans. This sub-chapter provides the inventory of damageable value which is necessary for simulation of probable flood or debris flow damage.

The inventory of damageable value starts with identification of various types of properties in disaster area caused by flooding or debris flow. The list of damageable properties to be directly spoiled are the following items:

(a) Residential house according to qualitative type such as upper, middle, and lower class.

(b) Building and factory consisting of the market facility, school, government office, factory, and others.

(c) Farm crops and cattle.

(d) Public structure such as the road, bridge, well, park and others.

Furthermore, the rehabilitation cost of removing debris, mud and destroyed structure is added to the above items from (a) to (d) in order to formulate direct damage category. Indirect damage due to interruption of economic activities caused by disaster is also estimated in terms of to what extent the stoppage of transportation system in principal road affects economic activities of industrial sectors.

The damageable value of all properties is assessed at price level of June, 1987.

8.2 House and Building

Building costs by type and quality of buildings are estimated on the basis of unit cost per m^2, the standard size of buildings, and their salvage value.

(1) Unit Cost per m^2

(A) Residential house

Since housing cost is much different by quality of house, residential house is classified into three classes.

(a) Upper class
(b) Middle class
(c) Lower class

(B) Other buildings

As far as other buildings are concerned, the average unit cost of each type of building per m^2 is used.

(C) Unit cost per m^2

The results of unit cost per m^2 by type and quality of buildings are shown below.

(a) Residential house	
upper class	I./10,000 per m^2
middle class	I./ 5,000 per m^2
lower class	I./ 2,000 per m^2
(b) Market facility	I./ 4,000 per m^2
(c) School	I./ 5,000 per m^2
(d) Government office	I./ 7,000 per m^2
(e) Factory	I./ 5,000 per m^2
(f) Commercial building	I./ 8,000 per m^2

(2) Standard Size of Buildings

The standard size of buildings by type and quality shows the average size of them. The average size of houses is estimated based on informations of inhabitants and site inspection.

(A) Residential house	
upper class	200 m^2
middle class	120 m^2
lower class	60 m^2
(B) Market facility	1,000 m^2
(C) School	500 m^2
(D) Government office	500 m^2
(E) Factory	2,000 m^2
(F) Commercial building	500 m^2

(3) Building Cost

Building costs by type and quality of buildings are estimated as the average cost between purchasing value and salvage one. The ratios of salvage value to purchasing cost based on official data are shown below.

(A) Residential house	
upper class	0.9
middle class	0.8
lower class	0.7
(B) Other buildings	0.8

Building costs are estimated with the following equation:

$$\text{Building cost} = (\text{unit cost per } m^2 \times \text{standard size} + \text{salvage value}) \times 0.5$$

The results of them are shown in Table II-8-1.

8.3 Indoor Movables

Indoor movables are estimated as stock value which is typical inventory belonging to each type of building. As far as indoor movables of a middle class family are concerned, an approximate estimate of household effect was conducted by assuming the number of their holdings. Household effects in upper and lower classes are estimated on the assumption that those are in proportion to the difference of building cost.

In case of other types of establishment, statistical data are available only for factory of manufacturing industry. Assuming that inventory of manufacturing factory is final products, input material, and capital equipments, its stock value per establishment is estimated by considering stock period of respective inventory. Since there are insufficient data on estimating for stock value of other types of building, stock value of them is estimated by referring to the ratio of respective inventory value to building cost in case of manufacturing establishment. The results of indoor movables are shown in Table II-8-2.

8.4 Farm Crops

Farm lands in the disaster area produce various kinds of vegetable, cereals, and fruits. Among them, tomato and maize are represented as typical crops in disaster area. Farm land is classified into good harvest and poor harvest land. Net income of above two crops is taken as damageable value, assuming that crops are spoiled at the time of harvest. The results of damageable value of two crops are shown in Table II-8-3.

8.5 Public Structures and Rehabilitation Works

Unit construction cost is estimated for the major public structures to be damaged by typical disaster such as the road, bridge and well. The unit cost by items is shown below:

(A) Road

- Paved highway with its width ranging from 7 to 20 m — 3,000 Intis/m^2
- Non-paved road having its width of around 6 m — 100 Intis/m^2

(B) Bridge

- Concrete bridge in highway with span from 30 to 40 m — 8,000 Intis/m^2*
- Concrete bridge in non-paved road with span of about 10 m — 3,000 Intis/m^2*

* Cost per area of top surface

(C) Well excavated in gravel layer with 6.6 cm in diameter and 100 m in depth — 1,200 Intis/m

After disaster, a large quantity of deposits remains in the disaster area. The cost for removal of those deposits to recover to the condition before disaster is considered as a value of damage. The costs of removal works by bulldozer are shown below.

(D) Rock with cobble stone/ structures destroyed — 200 $Intis/m^3$
(E) Common/mud — 70 $Intis/m^3$

8.6 Interruption of Traffic

When the traffic is interrupted by inundation or deposits of debris/mud flow, the indirect damage affecting social and economic fields is a serious problem. Since there is a national road of No. 20 called Carretera Central and railway connecting Metropolitan Lima with Sierra in the Rimac river basin, the indirect damage caused by traffic blockade in this transportation was the most concerned matter among various damages. Actually, disasters occurred in Quebradas along this principal road cause the traffic blockade with a long duration, resulting in the loss in economic sectors, in particular, manufacturing one faced with the opportunity loss of selling or producing final products since major intermediate materials or semi-finished products are transported from Sierra area through the route 20 and railway.

Although there is no actual or specific damage records concerning to these indirect damage, the indirect damage is estimated as economic loss of value added due to inability of selling final products of industrial sectors. Assumptions for counting indirect damages affecting the economy of Metropolitan Lima are as follows:

(A) In case of consignment from Sierra to Lima area, mineral materials conveyed to Lima area are mostly transported through a route of 20 or by railway, whereas other consignment transported to Lima through the above traffic route is assumed to be a quarter based on historical traffic volume in principal roads to Lima. In this respect, the ferrous metal industry in Lima area to which minerals are supplied as intermediate material is the sole sector to be affected by disaster in full if the said traffic route is interrupted. As to other industrial sectors to which consignments other than minerals are supplied, the probability to be affected is considered around 25% if the same traffic route is interrupted.

(B) As far as the consignment from Lima to Sierra is concerned, these consignments transported to Junin and Pasco are mostly conveyed through the route of 20 or by railway. So, industrial sectors in Junin and Pasco are to be affected fully if the said traffic route is interrupted.

(C) Assuming that the duration of interruption is about 1 day, the indirect damage in Lima economy is estimated by the following equation.

(GRDP of ferrous metal x 1.0 + GRDP of other sectors x 0.25) x 1/365

Indirect damage in Sierra area is

GRDP of selected industries x 1/365

Then, the total indirect damage due to traffic blockade is estimated to be around 50 million Intis per day.

Note: GRDP of industrial sectors at 1987 price level is estimated as shown in Table II-8-4.

8.7 Summary of Damageable Value

In accordance with the explanation described in the previous sections, the damageable value of each item is decided as follows:

(A) House (including indoor movables)	
Upper class	I./2.45 x 10^6/no.
Middle class	I./0.75 x 10^6/no.
Lower class	I./0.13 x 10^6/no.
(B) Public Building (including indoor movables)	
Market	I./3.76 x 10^6/no.
School	I./2.50 x 10^6/no.
Government office and others	I./3.50 x 10^6/no.
(C) Farm Land	
Good harvest	I./0.03 x 10^6/ha.
Poor harvest	I./0.01 x 10^6/ha.
(D) Public Structures	
Paved road	I./0.003 x $10^6/m^2$.
Non-paved road	I./0.0001 x $10^6/m^2$.
Main bridge	I./0.008 x $10^6/m^2$.
Common bridge	I./0.003 x $10^6/m^2$.
Park	I./0.0005 x $10^6/m^2$.

Others (Waterway etc.) L.S.

(E) Rehabilitation Works

Removal of debris I./0.00020 x $10^6/m^3$.

Removal of mud I./0.000070 x $10^6/m^3$.

(F) Traffic Block

National road No.20 I./50/day

Sta Eulalia main road I./5 /day

8.8 Estimate of Enhancement of Land Use and Economic Activity

The land use in the study area is being enhanced every year: that is, the inhabitants and protective properties, etc. in the study areas are being increased. The economic activities, which is made mainly by using the Central highway, is also more active every year, resulting in more damage at the occurrence of disaster in the future.

The increase rate of the land use and economic activities is estimated at 3.0% per annum in average based on the past records of population, the Gross Domestic Product (GDP) and the Gross Regional Domestic Product (GRDP) as follows:

(1) Population

The following shows the records of population in Peru and the basin.

(Unit: 10^3)

	1980	1981	1982	1983	1984
1. Peru	17,295.3	17,754.8	18,225.7	18,707.0	19,197.9
(Increase Rate)	-	2.66%	2.65%	2.65%	2.62%
2. Basin	4,668.6	4,836.3	5,005.6	5,176.8	5,349.1
(Increase Rate)	-	3.59%	3.50%	3.42%	3.33%

As seen above, the population in the whole Peru and the basin is being increased at the annual increase rate of 2.6 to 2.65% and 3.3 to 3.6% respectively. As such, it is considered reasonable to assume the annual increase rate of 3% for the inhabitants and assets in the study area of the basin.

(2) GDP and GRDP

The following shows the records of GDP and GRDP of the basin at 1979 price level:

(Unit: 10^6 US$)

	1970	1980	1981	1982	1983	1984
1. GDP	2,596.4	3,646.7	3,807.7	3,817.3	3,346.0	3,478.3
(Increase Rate)	-	3.5%	4.4%	2.5%	-12.3%	4%
2. GRDP	-	1,666.2	1,752.6	1,734.5	1,501.3	1,530.7
(Increase Rate)	-	-	5.2%	-1.0%	-13.4%	2.0%

As seen above, the GDP during ten (10) years from 1970 to 1980 was increased at the annual average increase rate of 3.5%. Although a negative increase is shown in 1983, its reason is said to be due to the disaster occurred in 1983, as evidenced by the fact that the increase rate is recovered to 4% in the next year. Based on the past records as mentioned, it is considered reasonable to assume the annual average increase rate of 3% for the future growth of national economic activities.

9. PAST STUDY

The following are found as the major past studies in relation to the disaster prevention in the basin:

(1) Estudio Geomorfologico aplicado al control de huaycos en la Cuenca del Rio Seco (ONERN)

The report presents a geomorphological study on the control of debris flow in Qda. Rio Seco.

(2) Sequridad Fisica contra huaycos, desbordes, deslizamientos-San Meteo-Prov. Huarochiri (PREDES)

The report presents a study on the physical safety against the debris flow, flood and land sliding in San Mateo, Prov. Huarochiri.

(3) Estudios de Sequridad Fisica contra huaycos, desbordes y deslizamientos-Distr. San Jeronimo de Surco, Prov. Huarochiri-Dpto. de Lima (PREDES)

The report presents a study on the physical safety against the debris flow, flood and land sliding in Surco, Prov. Huarochiri.

(4) Estudios de Sequridad Fisica de los poblados de San Jose Palles (PREDES)

The report presents a study on the physical safety for inhabitants in San Jose Palles.

(5) Estudios Geotecnicos de Sequridad Fisica de Obras de Ingenieria Ubicados en la cuenca del Rio Rimac (INGEMET)

The report presents a geotechnical study on the safety of structures in the Rimac river basin.

(6) Reconnaissance Report on Callao Naval Base, Rio Rimac Basin, Lima, Peru (US Army Corp of Engineers)

The report presents the investigation results on the inundation disaster occurred in the Callao naval base in February, 1984.

(7) Proyecto de Encauzamiento del Rio Rimac Sector : Puente Los Angeles - Puente Huachipa Estudio Especial (PREDES)

The report presents a river improvement plan for the river reaches between pte. Los Angeles and Pte. Huachipa.

As seen, the study on safety or investigation of disaster, etc. are individually made in a limited area. However, a comprehensive study on the planning for preventing the disaster in the basin has not been carried out yet.

Tables

Table II-1-1 POPULATION DISTRIBUTION BY GEOGRAPHIC CATEGORY

(Unit : thousand ha)

Land Use	costa	Sierra	Selva	Total
Urban	7,745.8 (67.0)	3,107.6 (27.0)	656.0 (6.0)	11,509.4 (100.0)
Rural	1,367.7 (21.9)	4,221.9 (67.5)	655.8 (10.6)	6,254.4 (100.0)
Total	9,113.5 (51.3)	7,329.5 (41.3)	1,311.8 (7.4)	17,754.8 (100.0)

Source : Direction General de Demografia
Remarks : Parentheses Indicates Distribution Percentage

Table II-1-2 MACRO-ECONOMIC INDICATORS

	1979	1980	1981	1982	1983
Government Finance				(Unit:million Intis)	
Revenue	552.2	1,019.3	1,522.5	2,493.3	3,732.0
Expenditure	570.2	1,159.3	1,938.4	3,050.2	6,083.0
Deficit	-18.0	-140.0	-415.9	-556.9	-2,351.0
Index Rate 1979=100	100	159	279	459	969
Exchange Rate Intis per US $	0.225	0.289	0.422	0.698	1.629
				(Unit:million US $)	
Trade Balance	1,598.9	762.7	-869.5	-744.0	39.4
Current Account	622.5	-72.3	-1,889.4	-1,777.0	-1,092.4
Capital Account	413.6	725.5	1,165.9	1,638.0	1,026.7
Balance of Payment	1,076.1	653.2	-723.5	-139.0	-65.7
				(Unit:million US $)	
Total Debt	9,334	9,594	9,638	11,097	12,632
Public	7,997	8,390	8,475	9,951	n.a.
Private	1,337	1,204	1,163	1,146	n.a.
Debt Service	919	1,501	1,895	1,536	779
Export Value	3,491	3,899	3,248	3,043	2,970
Debt Service Ratio (%)	26	38	58	50	26

Source : ECLAC IMF, Compendio Estadistico

Table II-1-3 POPULATION DATA OF PROVINCES RELATED TO THE RIMAC RIVER BASIN

Province	Area (km2)	1972	1981	Annual Growth Rate 1971-1981 (%)	Density 1981 Person/km2
Lima	3,701	2,981,292	4,164,597	3.8	1,125
Callao	148	321,231	443,413	3.6	2,996
Huarochiri	4,487	50,729	59,792	1.8	14

Table II-1-4 HISTORICAL PERFORMANCE OF GRDP BY SECTOR IN DEPARTMENTOS LIMA-CALLAO (AT 1979 CONSTANT PRICE)

(Unit:million intis)

Sector	Calender Year					
	1979	1980	1981	1982	1983	1984
Agriculture	53.4	54.3	51.2	52.8	50.1	45.4
Fishery	3.1	2.0	2.1	2.7	1.9	2.1
Mining	16.9	15.3	11.2	16.7	14.2	14.2
Manufacturing	472.2	517.0	528.1	510.9	416.1	424.3
Construction	60.4	66.6	79.0	81.4	62.9	64.0
Commerce	378.1	409.7	432.0	423.8	365.7	362.7
Lease Service	35.0	36.8	38.7	39.2	39.8	40.6
Public Service	110.1	120.6	124.3	125.8	135.0	143.6
Other Service	414.2	444.7	485.8	481.1	415.6	433.8
Total	1,543.5	1,666.2	1,752.6	1,734.5	1,501.3	1,530.7

Source : Producto Bruto Interno (National Statistical Office)

Table II-2-1 LITHOLOGY UNITS

LITHOLOGY UNITS

UNIT I	QUATERNARY DEPOSITS	
UNIT II	VOLCANIC ROCKS	
	II An	ANDESITE
	II rda	RHYOLITE
	II Ta	TRAQUYANDESITE
	II br	BRECCIA
UNIT III	VOLCANIC - SEDIMENTARY ROCKS	
	III A	VOLCANIC CONGLOMERATE, ANDESITIC EXTRUSIVES, SILT AND SANDSTONE
	III B	TUFF, TUFFACEAS SANDSTONE AND LIMESTONE
	III AB	INCLUDE ROCKS OF III A AND III B
	III C	SANDSTONE, ANDESITE AND CONGLOMERATE
	III D	TUFF, SANDSTONE AND SILSTONE
	III E	ANDESITE EXTRUSIVE
	III	ANDESITIC LAVAS, MUDSTONE, MARL CHERT
UNIT IV	SEDIMENTARY ROCKS	
	IV A	LIMESTONE
	IV B	SHALE, SANDSTONE, QUARZITE, SILSTONE
	IV C	SANDSTONE, SILSTONE, SHALE, CONGLOMERATE
	IV D	LIMESTONE, SILSTONE
UNIT V	INTRUSIVE ROCKS	
	V gr	GRANITE
	V Tgd	TONALITE - GRANODIORITE
	V MZ-gd	MONZONITE - GRANODIORITE
	V di	DIORITE
	V gd	GRANODIORITE
	V Tdi	TONALITE - DIORITE
	V gb-di	GABRO DIORITE

Table II-3-1 SUMMARY OF MONTHLY RAINFALL RECORD

(Unit : mm)

Station name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Hipolito Unanue 1969-72	4.1	0.0	0.3	0.2	0.4	2.2	3.0	3.1	2.8	0.5	1.1	0.3	18.0
Limatambo 1950-62	1.8	0.9	0.7	0.2	2.0	3.9	6.1	6.9	7.4	4.8	2.2	1.4	38.3
Campo de Marte 1927-82	1.0	0.5	0.5	0.2	1.8	3.3	4.1	5.0	4.6	1.8	0.9	0.6	24.3
A Von Humboldt 1966-72	2.8	0.8	0.8	0.3	1.1	2.3	2.4	2.3	1.7	1.7	0.8	0.7	17.7
La Molina 1930-61	0.8	0.7	0.7	0.8	1.8	2.9	3.0	2.8	2.4	1.1	0.6	0.6	18.2
Nana 1964-84	1.5	0.7	1.7	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.2	0.3	4.7
Chosica 1948-54	4.6	4.6	4.9	0.9	0.1	0.0	0.0	0.0	0.0	0.5	0.4	2.0	18.0
Santa Eulalia 1969-72	29.8	16.3	50.0	0.0	0.0	0.0	0.0	0.0	2.7	0.5	0.6	6.9	106.8
Carampoma 1966-72	85.2	85.6	84.0	24.8	3.5	0.2	0.2	1.2	13.0	29.8	2.5	29.1	359.1
Bellavista 1947-71	114.0	135.0	121.2	46.1	17.6	2.6	2.2	6.6	18.1	37.2	48.6	90.0	639.2
San Jose de Parac 1966-69	80.5	109.1	112.2	9.2	0.5	0.0	0.8	0.0	3.3	48.5	19.3	47.6	431.0
Casapalca 1947-71	117.8	131.8	119.3	59.6	25.8	12.6	8.0	11.8	35.4	51.8	54.5	91.0	719.4
Milloc 1965-86	125.6	149.3	141.2	64.8	22.7	14.9	13.3	16.5	42.7	73.3	76.8	117.1	858.2
Mina Colqui 1969-71	122.4	140.2	144.0	57.2	7.7	0.4	0.3	3.0	29.0	59.2	53.0	180.2	796.6
Lag.Quisha 1969-72	173.2	142.2	175.4	90.1	24.6	1.4	14.6	14.1	61.4	86.2	62.0	175.0	1020.2
Lag.Pirhua 1970-72	177.3	142.1	189.8	70.4	22.4	0.2	13.8	10.1	40.4	88.1	42.2	149.4	946.2
Ticlo 1956-67	92.7	128.3	101.9	58.6	29.7	8.0	10.5	20.6	43.5	61.2	50.8	82.1	687.9
Matucana 1964-85	44.6	64.8	93.7	14.3	2.0	0.2	0.0	0.1	3.5	7.8	7.4	33.8	272.2

Table II-3-2 MONTHLY PRECIPITATION AT CAMPO DE MARTE (1/2)

Year	Jan	Feb	Mar	Apr	Mar	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1927	-	-	2.4	1.0	1.3	6.4	5.0	9.4	11.2	2.0	3.5	0.2	-
1928	-	-	-	-	-	-	-	5.7	1.9	1.1	0.6	0.5	-
1929	0.8	0.0	2.0	0.0	4.5	6.5	3.5	6.9	7.3	2.0	2.2	1.7	37.4
1930	0.2	0.5	0.4	1.0	3.6	3.5	4.3	5.8	7.9	3.7	1.6	0.3	32.8
1931	0.0	0.0	0.2	0.0	1.5	6.6	13.9	10.2	7.6	2.5	1.8	1.0	45.3
1932	2.5	2.7	0.1	0.3	9.1	2.6	8.4	10.0	9.8	3.1	0.8	0.2	49.6
1933	0.5	0.0	0.4	0.0	0.8	2.1	4.4	11.4	7.1	1.5	0.2	0.2	28.6
1934	0.6	1.2	0.5	0.0	1.0	8.3	7.4	9.4	8.7	2.0	0.6	0.5	40.2
1935	3.6	0.2	0.5	0.0	0.3	6.4	8.8	5.3	8.9	1.6	2.4	0.1	38.1
1936	1.4	0.2	0.1	1.6	4.4	4.4	6.7	7.9	6.1	4.1	3.8	1.9	42.6
1937	0.3	0.1	0.4	0.4	3.2	4.9	9.6	8.1	10.4	0.8	0.6	2.0	40.8
1938	2.2	0.4	0.9	0.1	2.0	5.1	9.0	10.8	6.0	2.8	4.5	2.5	46.3
1939	0.4	0.0	0.5	0.1	3.7	6.0	3.8	4.1	1.3	2.4	0.7	0.0	23.0
1940	0.0	0.4	0.0	0.1	7.1	6.7	3.4	6.5	5.8	4.6	0.4	2.4	37.4
1941	1.0	0.8	1.0	3.0	11.1	11.2	4.3	8.3	5.1	6.9	4.8	1.5	59.0
1942	3.0	0.2	1.1	0.0	2.3	4.1	7.4	8.9	7.3	5.1	1.3	0.0	40.7
1943	1.3	0.0	0.5	0.1	0.7	9.2	12.2	14.1	12.1	1.2	0.1	-	-
1944	0.0	0.4	0.3	0.3	3.3	1.9	9.0	9.4	4.8	0.8	0.4	0.3	30.9
1945	0.0	0.0	0.0	0.0	0.0	0.2	3.8	4.2	2.5	0.5	0.0	0.2	11.4
1946	0.1	1.0	0.3	0.0	0.4	8.6	7.2	4.6	4.2	2.4	1.8	1.5	32.1
1947	0.7	0.0	0.0	0.0	0.2	1.5	2.7	4.0	3.2	2.1	0.4	0.1	14.9
1948	0.0	0.4	0.0	0.7	3.5	2.2	0.8	3.7	4.2	2.0	0.2	0.1	17.8
1949	0.0	0.0	2.1	0.0	0.2	6.3	5.7	5.1	4.1	0.0	0.7	0.0	24.2
1950	-	0.0	0.0	0.0	0.4	4.9	5.3	8.3	7.2	3.1	0.5	1.9	-
1951	0.0	0.0	3.5	0.0	0.0	0.9	1.5	4.1	3.4	4.4	3.2	0.7	21.7
1952	5.2	0.0	0.4	0.0	0.1	5.1	5.5	5.1	2.4	3.2	1.9	0.0	28.9
1953	0.0	0.0	0.0	0.0	10.6	9.2	14.8	12.0	6.4	1.7	2.4	0.7	57.8
1954	0.0	0.0	0.0	0.0	5.0	2.2	2.0	4.1	2.7	1.3	1.0	0.3	18.6
1955	0.5	0.2	0.4	0.0	0.3	2.8	3.6	4.4	3.7	2.3	0.3	0.1	18.6
1956	0.2	1.8	0.6	0.2	2.5	4.4	3.4	1.6	5.6	2.5	0.0	0.0	22.8
1957	0.1	1.5	0.5	0.0	1.0	0.2	2.7	2.7	5.5	3.1	0.7	1.0	19.0
1958	5.3	0.2	0.8	0.0	1.2	5.8	1.7	2.2	3.3	1.1	0.9	0.1	22.6
1959	0.1	0.5	0.0	1.0	2.1	2.4	5.0	6.9	1.5	1.0	0.8	2.4	23.7
1960	0.0	0.0	0.0	0.0	0.5	2.0	1.7	2.9	4.4	3.5	0.5	0.0	15.5
1961	0.0	1.4	0.9	0.2	0.0	3.3	3.8	3.2	8.1	1.3	0.0	0.0	22.2
1962	0.0	0.0	0.0	0.0	0.5	3.2	9.3	5.6	13.9	2.9	0.5	0.0	35.9
1963	0.0	1.5	0.0	0.3	1.4	0.9	0.2	2.5	6.1	2.3	0.8	0.0	16.0
1964	0.1	0.0	0.0	0.0	0.2	0.6	1.3	3.3	0.2	0.1	0.0	0.0	5.8
1965	0.0	0.6	0.0	0.0	3.0	0.2	1.3	0.5	6.5	2.4	0.2	0.1	14.8
1966	0.0	0.0	0.4	0.0	0.0	1.8	0.2	1.3	1.7	0.5	0.5	1.5	7.9
1967	0.9	0.6	1.6	0.0	0.4	0.4	2.3	1.2	1.4	0.3	0.2	0.5	9.8
1968	0.0	0.0	0.0	0.0	0.2	0.0	0.6	1.0	0.9	0.8	0.1	0.1	3.7
1969	0.0	0.0	0.0	0.6	0.5	3.5	1.8	2.9	0.9	0.0	2.3	0.5	13.0
1970	17.4	0.6	0.3	0.0	0.6	2.5	4.4	1.2	1.6	0.1	0.6	0.2	29.5

Table II-3-2 MONTHLY PRECIPITATION AT CAMPO DE MARTE (2/2)

Year	Jan	Feb	Mar	Apr	Mar	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1971	0.4	0.0	0.0	0.0	1.0	3.1	1.8	6.4	1.8	0.7	0.0	0.0	15.2
1972	0.2	0.0	0.9	0.0	0.0	0.0	0.9	0.6	5.3	1.9	0.3	0.6	10.7
1973	0.3	0.0	0.0	0.0	0.0	0.0	0.4	0.5	1.2	0.2	0.6	0.1	3.3
1974	0.0	5.0	0.0	0.1	0.5	2.5	1.4	3.1	0.3	0.3	0.0	1.8	15.0
1975	0.3	1.5	0.0	0.0	1.8	1.1	1.2	1.0	0.2	0.4	0.1	0.1	7.7
1976	0.0	–	–	0.0	1.4	0.3	0.0	0.4	2.5	1.4	0.0	0.2	–
1977	0.0	0.2	0.0	0.0	0.1	0.4	2.6	1.4	4.0	0.6	0.2	0.6	10.1
1978	0.0	0.0	0.4	0.2	0.1	0.1	0.3	1.6	1.2	0.6	0.0	0.0	4.5
1979	0.0	0.0	1.5	0.0	0.0	0.2	0.2	2.0	0.7	1.4	0.1	0.3	6.4
1980	0.0	0.0	0.0	0.0	0.1	1.3	1.3	0.7	1.2	0.1	0.0	0.1	4.8
1981	–	0.1	0.0	0.3	0.0	0.0	0.4	5.0	0.0	0.0	0.0	0.0	–
1982	0.0	0.0	0.0	0.0	0.0	0.2	1.5	–	–	–	–	–	–
Mean	1.0	0.5	0.5	0.2	1.8	3.3	4.1	5.0	4.6	1.8	0.9	0.6	24.1

Table II-3-3 MONTHLY PRECIPITATION AT NANA

Year	Jan	Feb	Mar	Apr	Mar	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1964	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6
1965	0.0	0.6	0.7	0.0	0.8	0.0	0.0	0.0	0.8	0.0	0.0	0.7	3.6
1966	2.9	0.0	0.3	0.0	0.0	0.0	0.5	0.0	0.0	1.5	1.5	2.0	8.7
1967	5.0	6.1	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.2
1968	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–
1969	4.5	0.0	0.0	0.0	0.0	–	0.0	–	0.0	0.0	0.0	–	–
1970	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	0.0	0.0	0.0	0.0	–
1971	–	–	–	–	–	–	–	–	0.0	0.0	0.0	0.0	–
1972	–	–	–	–	–	–	–	0.0	–	0.0	0.0	–	–
1973	–	–	–	0.0	–	–	–	–	–	0.0	0.0	0.0	–
1974	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.4
1975	0.8	0.0	7.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.7
1976	8.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	10.8
1977	1.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	2.9
1978	0.0	0.0	1.5	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7
1979	0.0	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0
1980	–	–	–	–	–	–	0.0	0.0	0.0	0.0	0.0	0.0	–
1981	–	–	–	–	–	0.0	0.0	0.0	0.0	–	–	0.0	–
1982	0.0	–	–	–	–	–	–	–	–	–	–	–	–
1983	–	–	–	–	0.0	0.0	0.0	–	0.0	0.0	–	–	–
1984	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–	–
Mean	1.5	0.7	1.7	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.2	0.3	4.6

Table II-3-4 MONTHLY PRECIPITATION AT MATUCANA

Unit:mm

Year	Jan	Feb	Mar	Apr	Mar	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1964	-	64.6	57.6	61.1	5.1	0.0	0.0	0.0	0.0	4.6	6.0	33.2	-
1965	55.4	82.8	69.8	10.5	2.6	0.0	0.0	0.0	3.8	13.7	6.7	24.8	270.1
1966	61.6	38.7	52.5	22.3	0.2	0.0	0.0	0.0	0.0	18.0	0.0	37.0	230.3
1967	77.3	147.7	97.1	17.2	3.7	0.0	-	-	2.1	15.2	4.3	8.4	-
1968	24.9	24.9	33.3	11.2	7.7	-	-	-	-	-	-	-	-
1969	11.4	54.6	73.3	26.3	0.0	0.0	0.0	0.0	0.9	18.1	24.1	55.2	263.9
1970	106.9	8.9	35.4	29.1	9.1	0.0	0.0	0.0	21.8	14.5	5.4	53.8	284.9
1971	57.4	72.6	116.0	27.4	0.0	0.0	0.0	0.0	0.0	6.6	1.2	43.0	324.2
1972	63.5	106.2	144.8	13.8	0.0	0.0	0.0	0.0	1.5	12.6	5.0	48.2	395.6
1973	82.3	80.8	58.7	5.7	0.0	0.0	0.0	0.0	33.9	8.3	7.5	56.9	334.1
1974	45.3	76.4	75.8	9.4	0.0	0.0	0.0	0.0	0.4	0.6	4.6	21.3	233.8
1975	33.4	59.0	118.3	8.9	6.2	0.8	0.0	0.0	1.3	7.0	12.4	40.1	287.4
1976	70.3	73.4	58.1	0.5	0.5	0.9	0.0	0.0	0.8	0.0	0.0	26.2	230.7
1977	32.9	69.5	37.8	2.7	5.9	0.0	0.0	0.0	2.5	0.6	28.7	26.2	206.8
1978	29.1	29.8	21.0	5.4	0.0	0.0	0.0	0.0	1.5	0.0	7.8	12.6	107.2
1979	15.1	43.2	65.5	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.9	-	-
1980	18.0	8.3	21.0	18.8	0.0	0.0	0.0	0.0	0.0	14.1	0.0	13.7	93.9
1981	62.0	43.4	72.8	0.0	0.0	0.0	0.0	0.0	0.0	4.2	1.5	33.9	217.8
1982	28.2	25.3	29.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.3	0.9	93.7
1983	9.5	62.0	169.2	25.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.7	299.3
1984	34.1	196.8	86.5	10.5	1.0	1.8	0.0	0.0	0.0	20.5	29.2	73.4	453.8
1985	17.9	55.7	67.7	8.7	2.2	0.0	0.0	1.6	2.7	1.7	0.0	-	-
Mean	44.6	64.8	71.0	14.3	2.0	0.2	0.0	0.1	3.5	7.8	7.4	33.8	249.3

Table II-3-5 MONTHLY PRECIPITATION AT MILLOC

Unit:mm

Year	Jan	Feb	Mar	Apr	Mar	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1965	-	-	-	-	-	-	-	-	-	76.0	37.0	146.0	-
1966	196.0	108.0	130.0	72.0	25.0	-	7.0	5.0	68.0	181.0	181.0	146.0	-
1967	177.0	229.0	199.0	60.0	45.0	9.0	27.0	25.0	51.0	138.0	55.0	80.0	1095.0
1968	132.0	108.5	112.0	37.2	27.0	13.5	9.0	38.0	35.5	89.5	80.0	59.0	741.2
1969	68.5	122.0	107.0	117.5	6.0	6.0	19.1	14.5	60.0	55.5	74.5	190.0	840.6
1970	175.0	60.0	100.5	86.0	46.0	3.0	15.5	10.5	97.0	78.0	57.0	171.0	899.5
1971	112.0	177.7	183.0	66.5	20.5	-	-	22.5	15.0	48.5	64.0	183.0	-
1972	129.0	125.0	222.0	76.5	5.0	-	20.5	-	46.5	67.0	34.0	142.0	-
1973	161.7	191.7	175.1	125.6	31.5	4.5	24.4	23.5	61.0	105.2	69.4	156.3	1129.9
1974	167.1	107.0	154.7	49.2	8.0	6.6	3.7	20.6	34.9	47.9	66.9	51.4	718.0
1975	30.8	115.5	171.4	53.6	68.6	15.2	-	21.3	54.4	40.2	59.3	96.1	-
1976	128.7	145.8	95.2	42.8	23.2	48.2	2.7	28.3	27.8	15.9	24.5	68.7	651.8
1977	106.8	166.2	83.7	29.1	44.6	-	2.3	3.5	32.0	24.3	125.8	95.0	-
1978	119.4	155.9	83.3	29.3	2.0	19.1	17.2	5.2	37.2	59.3	69.8	69.0	666.7
1979	53.3	165.9	155.7	55.2	16.0	7.6	14.4	0.0	25.1	36.6	48.4	71.4	649.6
1980	162.0	76.6	130.3	45.0	7.2	20.2	37.0	5.2	16.2	170.1	131.9	122.0	923.7
1981	139.6	219.6	128.8	52.0	3.2	1.2	1.4	22.0	39.4	89.6	152.0	113.0	961.8
1982	145.6	241.0	98.4	68.4	0.0	-	13.2	51.8	41.2	81.2	125.0	103.8	-
1983	97.0	89.6	133.8	97.6	9.0	18.4	2.4	3.6	38.2	65.8	33.2	124.8	713.4
1984	77.2	203.8	131.2	37.0	12.2	29.8	0.0	2.4	-	112.4	112.0	159.6	-
1985	52.5	113.8	143.8	96.4	29.2	21.8	2.4	2.0	30.8	7.2	52.4	111.1	663.4
1986	206.7	212.6	226.7	-	46.9	-	34.2	25.6	-	23.2	36.5	-	-
Mean	125.6	149.3	141.2	64.8	22.7	14.9	13.3	16.5	42.7	73.3	76.8	117.1	819.6

Table II-3-6 PRINCIPAL FEATURE OF MAJOR LAGUNAS

Name of Lagunas	Altitude (El.m)	Effective storage volume (MCM)
Santa Eulalia river basin		
Quisha	4,648	8.7
Carpa	4,544	17.8
Huansa	4,361	6.3
Sacsa	4,382	14.9
Quila	4,530	1.8
Piti-Piti	4,625	6.5
Huamper	4,628	3.3
Huachua	4,570	5.0
Chiche	4,491	2.2
Pucro	4,435	2.0
Misha	4,650	0.7
Canchis	4,421	2.1
Huallunca	4,510	1.6
Pirhua	4,740	0.9
Manca	4,530	1.6
Sub-total		75.4
Marcapomacocha river basin		
Antacoto		62.5
Marcacocha		10.7
Marcapomacocha		14.8
Sangarar		9.0
Sub-total		97.0
Grand total		172.4

Source : ELECTROLIMA

Table II-3-7 MEAN MONTHLY DISCHARGE AT RIO BLANCO

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Mean
1968-69	-	1.2	2.0	4.1	1.8	6.0	7.1	5.2	1.5	1.1	0.8	0.8	-
69-70	0.8	1.4	1.8	7.2	10.5	6.5	5.4	4.2	2.7	1.1	0.7	0.6	3.6
70-71	1.5	1.9	1.4	4.6	6.1	7.8	9.1	5.2	1.8	1.0	0.7	0.6	3.5
71-72	0.7	0.8	0.8	4.2	5.8	7.5	11.9	7.1	2.2	1.1	0.8	0.7	3.6
72-73	0.8	1.6	1.2	3.0	7.5	8.4	8.3	5.7	1.6	0.7	0.5	0.4	3.3
73-74	0.5	0.9	1.4	3.9	6.1	7.6	7.0	4.1	1.3	0.8	0.5	0.5	2.9
74-75	0.5	0.7	0.8	2.1	4.3	4.6	9.1	4.8	3.4	1.5	1.0	0.9	2.8
75-76	1.4	1.4	1.8	3.3	8.6	12.8	11.2	4.7	2.6	1.0	0.7	0.7	4.2
76-77	-	-	-	-	-	-	-	-	-	-	-	-	-
77-78	-	-	-	-	-	-	-	-	-	-	-	-	-
78-79	0.8	1.1	-	3.6	2.3	13.7	14.7	5.7	2.2	1.0	0.8	0.8	-
79-80	0.8	0.9	1.2	1.3	6.1	5.3	6.7	3.6	1.2	0.9	0.8	0.7	2.5
80-81	0.8	3.8	5.7	9.2	14.3	30.3	23.6	7.5	6.5	-	-	-	-
Mean	0.9	1.4	1.8	4.2	6.7	10.0	10.4	5.3	2.5	1.0	0.7	0.7	3.3

Table II-3-8 MEAN MONTHLY DISCHARGE AT SAN MATEO

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Mean
1968-69	-	6.9	9.2	11.3	9.8	14.5	18.3	17.8	10.1	7.6	5.9	6.4	-
69-70	6.9	7.8	9.4	16.8	27.3	20.0	17.3	15.9	13.2	9.1	7.5	6.6	13.2
70-71	8.0	8.8	8.9	13.8	16.6	21.9	26.8	16.5	10.6	8.0	6.7	6.1	12.7
71-72	5.9	7.6	7.2	12.7	15.8	18.6	31.1	22.9	12.7	9.0	8.1	6.8	13.2
72-73	7.5	9.1	8.5	12.2	21.0	27.1	26.2	20.5	11.6	7.7	5.6	4.6	13.5
73-74	4.6	6.1	7.4	13.8	20.0	24.2	24.8	16.8	9.1	6.9	5.0	4.2	11.9
74-75	4.5	6.0	7.8	10.3	14.1	15.3	26.7	16.4	13.4	8.8	7.3	7.0	11.5
75-76	7.5	8.8	14.6	15.5	19.5	26.4	23.9	16.8	12.1	9.3	8.2	7.2	14.2
76-77	-	-	-	-	-	-	-	-	-	-	-	-	-
77-78	-	-	-	-	-	-	-	-	-	-	-	-	-
78-79	9.7	10.8	-	-	16.3	23.2	25.4	19.0	13.5	10.4	8.8	8.0	-
79-80	8.5	9.2	10.3	10.9	15.6	16.3	17.3	14.3	10.1	8.8	8.4	7.2	11.4
80-81	7.6	11.9	12.5	14.5	18.0	29.2	25.9	16.8	11.8	9.1	7.4	7.0	14.3
81-82	6.1	9.0	11.9	14.5	17.4	29.1	21.4	16.4	11.7	9.3	6.9	6.4	13.3
Mean	7.0	8.5	9.8	13.3	17.6	22.2	23.8	17.5	11.7	8.7	7.2	6.5	12.9

Table II-3-9 MEAN MONTHLY DISCHARGE AT CHOSICA R-2

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Mean
1969-70	15.6	15.9	17.3	43.2	85.6	36.4	45.6	37.5	25.2	20.8	18.7	17.4	31.6
70-71	18.7	18.2	17.5	23.7	40.2	48.1	78.0	40.4	22.3	21.8	20.1	20.2	30.8
71-72	19.7	18.7	15.9	26.7	48.0	65.3	140.6	66.3	22.4	17.0	15.3	15.6	39.3
72-73	13.3	14.5	16.6	26.0	56.8	61.8	76.0	59.5	20.7	12.9	11.8	11.0	31.7
73-74	9.6	11.6	13.1	23.3	36.8	47.1	56.2	32.2	15.1	11.6	9.6	11.2	23.1
74-75	13.1	15.6	15.1	11.6	18.7	18.7	100.4	39.3	28.5	23.6	21.3	22.3	27.4
75-76	21.6	20.4	21.9	22.9	41.4	76.1	65.0	36.8	20.9	19.3	16.6	16.8	31.6
76-77	17.5	17.6	18.6	18.2	20.8	71.0	57.0	33.8	25.0	19.4	19.0	19.3	28.1
77-78	19.2	19.6	29.9	31.1	37.8	78.1	45.3	30.3	18.4	17.2	18.3	17.0	30.2
78-79	16.4	17.6	17.8	21.1	19.8	75.3	96.2	36.3	18.1	17.9	16.7	17.1	30.9
79-80	18.3	18.4	18.3	18.6	28.7	29.1	39.2	31.9	17.5	18.0	14.8	14.7	22.3
80-81	18.1	17.6	18.3	22.7	36.9	86.8	72.6	43.7	21.9	21.3	19.8	21.1	33.4
81-82	21.0	14.6	16.7	23.0	29.0	53.6	51.0	45.4	38.8	33.4	29.7	30.6	32.2
82-83	23.3	23.6	28.1	26.3	31.3	28.9	58.6	71.4	28.9	28.2	22.9	19.0	32.5
83-84	15.5	26.3	25.5	35.3	32.0	67.6	53.7	34.4	25.2	31.1	28.8	27.8	33.6
84-85	25.7	26.9	27.2	-	-	-	-	-	-	36.6	26.9	30.6	-
85-86	24.8	24.3	27.9	39.7	84.0	92.4	103.5	74.1	55.3	23.9	24.1	23.8	49.8
86-87	21.6	18.8	23.5	-	-	-	-	-	-	-	-	-	-
Mean	18.5	18.9	20.5	25.8	40.5	58.5	71.2	44.6	25.3	22.0	19.7	19.7	31.8

Table II-3-10 ANNUAL MAXIMUM DISCHARGE AT CHOSICA R-2 STATION

Hydro-logical year	Date	Gage height (m) /1 Hmax	Gage height (m) /2 Hmed	Gage height (m) /3 Hinst	Discharge (m3/sec) /4 Qmax	Discharge (m3/sec) /5 Qinst
1968-69	Mar. 3	1.57	1.56	1.72	81.4	113.2
69-70	Jan.16	2.13	2.06	2.17	158.0	161.0
70-71	Mar.17	1.87	1.82	1.96	139.0	138.0
71-72	Mar.11	1.38	1.35	1.56	210.0	95.6
72-73	Feb. 5	1.75	1.72	1.86	115.0	128.0
73-74	Mar. 3	1.60	1.56	1.74	79.1	115.4
74-75	Mar.24	1.70	1.66	1.82	144.0	124.0
75-76	Feb. 7	1.50	1.41	1.66	116.0	106.6
76-77	Feb.19	1.72	1.62	1.84	162.0	126.0
77-78	Feb.24	1.70	1.66	1.82	151.0	124.0
78-79	Mar. 8	1.69	1.66	1.81	144.0	123.0
79-80	Jan.27	1.44	1.31	1.61	91.5	101.1
80-81	Feb. 7	1.80	1.74	1.90	216.0	132.0
81-82	Feb. 5	1.16	1.14	1.38	72.0	76.2
82-83	Apr. 8	1.32	1.30	1.51	108.0	90.1
83-84	Feb.13	2.20	2.08	2.23	103.5	167.3
84-85	-	-	-	-	-	-
85-86	Jan.29	1.41	1.24	1.59	164.2	98.9

Remarks :
- /1 Maximun gage reading record on the day when mean discharge is the largest in certain year.
- /2 Mean gage height on the day when mean discharge is the largest in certain year.
- /3 Instaneous peak water level estimated from Hmax.
- /4 Annual maxmum mean daily discharge.
- /5 Instantaneous peak discharge estimated by the rating curve established in 1984. (Rating table No. 02909 in SENAMHI)

Source : SENAMHI

Table II-7-1 LIST OF DISASTER IN THE RIMAC RIVER BASIN (MARCH 1987)

Place	Date	Disaster	Damage					Note
			dead person	injur. person	broken houses	high way	other	
Qda La Cantuta	March 2	Debris flow			(2)		Club facilities	
Santa Rosa de Palle Bajo	March 8	Slope failure			14			Downstream area of Santa Eulalia
Huachipa, Campoy, Zarate, Rimac	March 9	Inundation			245		Road: 22 Km Farm land: 80 ha College: 2	
Qda Quirio Qda Pedregal Qda Corosio Qda Corrales Qda Cashahuacra	March 9	Debris flow	38	12,414	650	x	School: 4 Farm land: 0.5 ha Waterway for power: 2 Km	Over I./222,000,000
Huachipa (Santa Rosa)	March 9	Inundation			(2)			
Total			38	12,414	913			

Note: Data from SE/CNDC

Table II-7-2 DEPOSIT VOLUME OF DEBRIS FLOW IN EACH QUEBRADA

NAME OF QDA	TYPE	CATHMENT AREA	AVERAGE SLOPE	SLOPE TRANSPORTATION SECTION	SLOPE DEPOSIT SECTION	DEPOSIT AREA	DEPOSIT VOLUME	DEPOSIT VOLUME PER 1 KM²	AVERAGE DIAMETER OF DEPOSITING BOULDERS
		km²	%	%	%	ha	m³	m³	m
Qda Quirio (R-6)	Valley	10.4	23	9-15	5-7	4.1	14,100	1,400	0.5
Qda Pedregal (R-7)	"	10.6	25	9-14	3-11	30.0	157,200	14,800	1.0-2.0
Qda Corosio (R-8)	Slope	0.4	76	45-60	13-26	2.3	4,400	8,800	0.5
Qda Corrales (R-9)	"	1.4	72	22-45	12-18	5.2	21,700	15,500	0.5
Qda Cashahacra	"	15.1	31	9-16	7-9	21.0	102,000	6,800	1.0
Total		37.9	-	-	-	62.6	299,400	7,900	-

Table II-8-1 BUILDING COST PER ESTABLISHMENT

Item	Building Cost (Million Intis)
Residential house	
upper class	1.90
middle class	0.54
lower class	0.10
Market facility	3.60
School	2.25
Government office	3.15
Factory	9.00
Commercial building	3.60

Source: Official data from several government institutions.

Table II-8-2 DAMAGEABLE VALUE OF INDOOR MOVABLES

Item	Value of Inventory (Million Intis)
Household effect	
upper class	0.55
middle class	0.15
lower class	0.03
Market facility*	0.16
School*	0.25
Government office*	0.35
Factory	1.80
Commercial building*	0.63

Note: Since data are not enough for estimating inventory value of buildings noted by (*), inventory value of them is calculated in such that building cost of them is multiplied with the ratio of stock value to building cost in manufacturing establishment.

Table II-8-3 AGRO-ECONOMIC INDICATORS

	Tomato		Maize	
	Good harvest	Poor harvest	Good harvest	Poor harvest
Yield (ton/ha)	17	10	4	3
Price (Intis/ton)	3,000	3,000	4,000	4,000
Gross income (I/ha)	51,000	30,000	16,000	12,000
Production cost (I/ha)	20,000	20,000	4,400	4,400
Net income (I/ha)	31,000	10,000	11,600	7,600

Source: Ministry of Agriculture

Table II-8-4 GRDP OF INDUSTRIAL SECTOR AT 1987 PRICE LEVEL

Unit: Million Intis

Lima + Callao Sector		Junion + Pasco Sector	
Food	13,493.2	Textile	190.0
Drink	10,298.1	Food	329.4
Ferrous metal	1,457.1	Drink	144.1
Furniture	1,760.0	Paper	-
Chemical	17,018.9	Platic	-
Construction	11,780.0	Chemical	-
Mineral	3,300.0	Petroleum Pro.	24.7
		Hotel/ Restaurant	1,160.0

Source: Basic statistics (Ministry of Industry)
National Census of Peru (Input-Output Table)
GRDP Statistics by Department

Figures

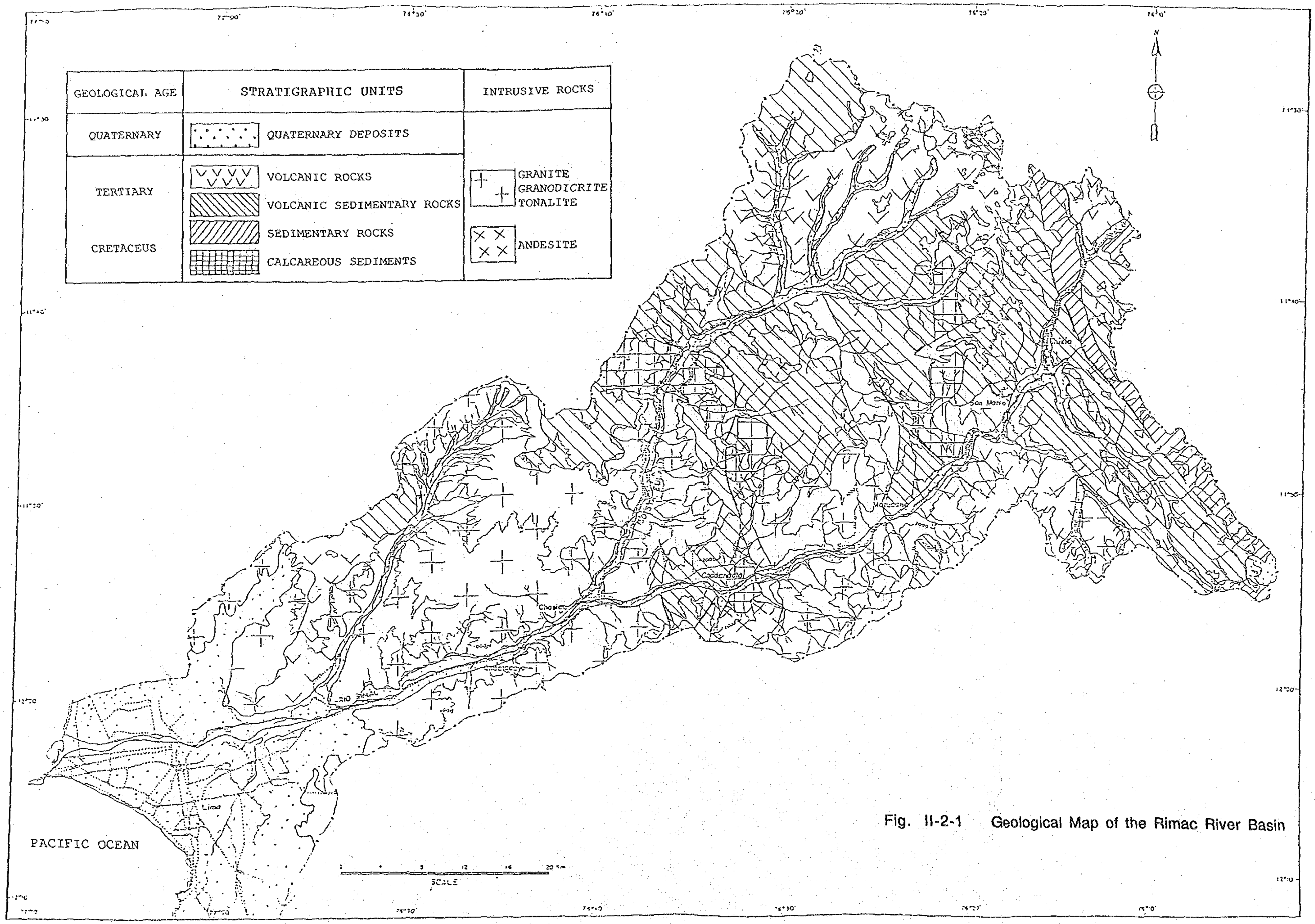


Fig. II-2-1 Geological Map of the Rimac River Basin

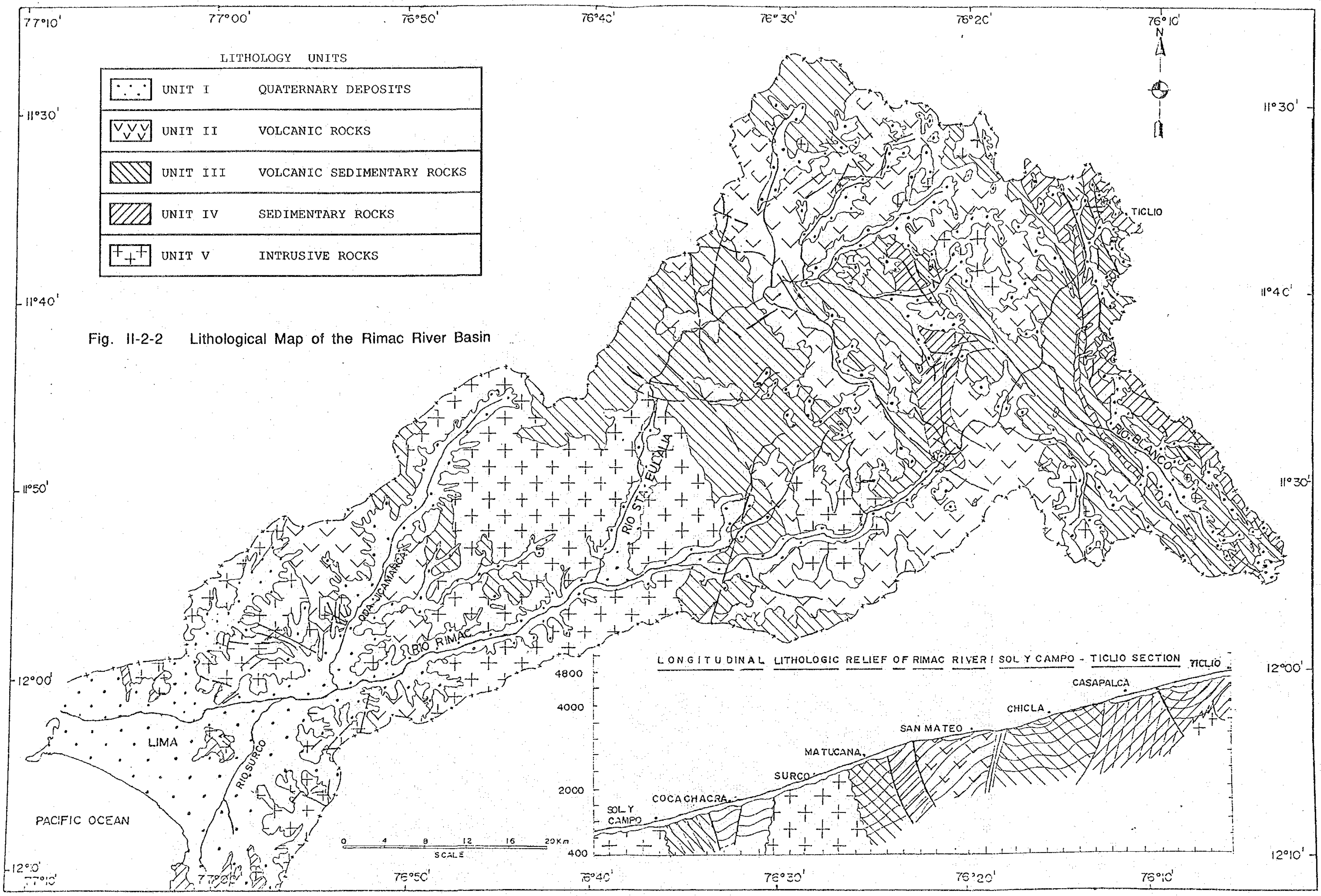


Fig. II-2-2 Lithological Map of the Rimac River Basin

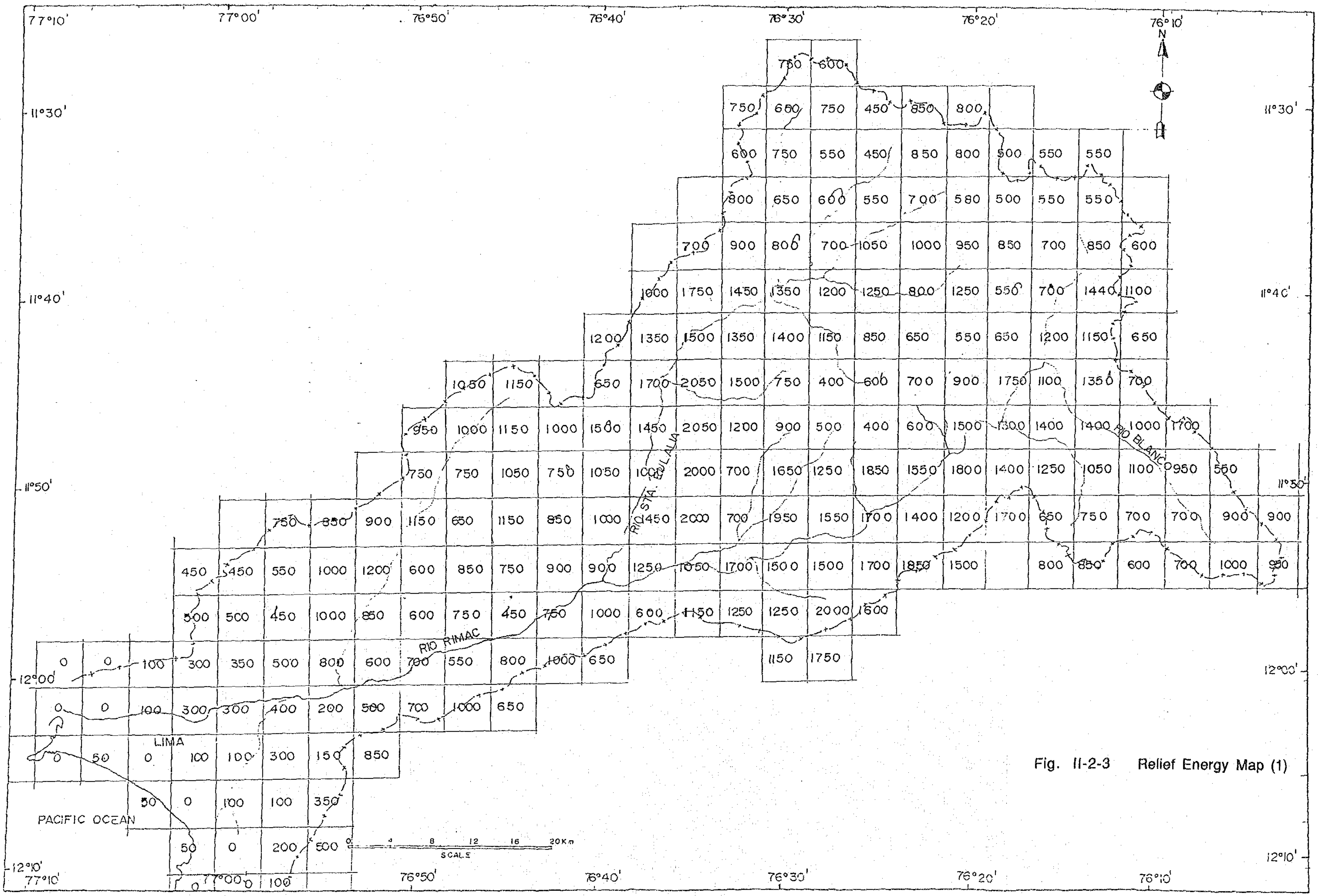


Fig. II-2-3 Relief Energy Map (1)

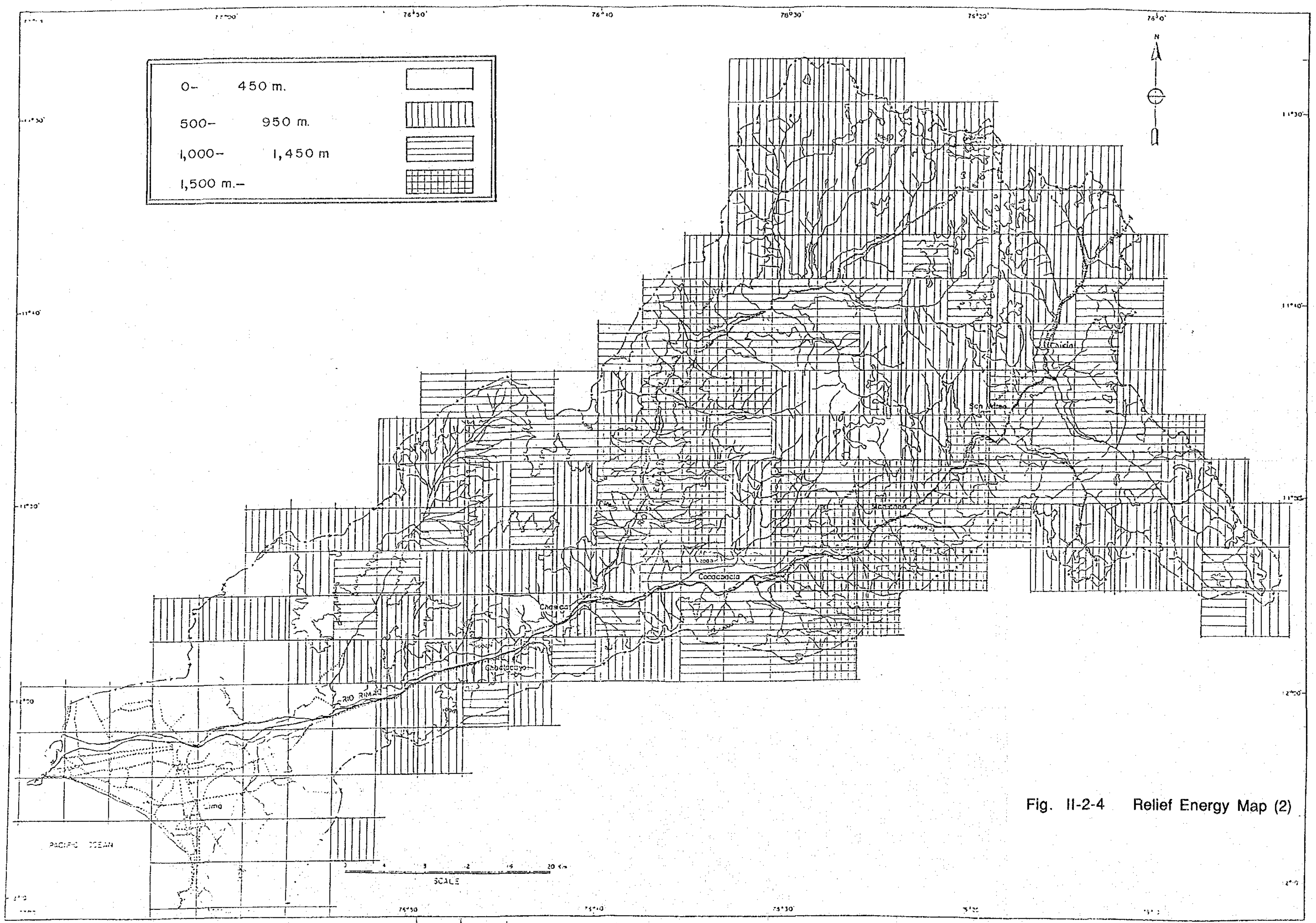


Fig. II-2-4 Relief Energy Map (2)

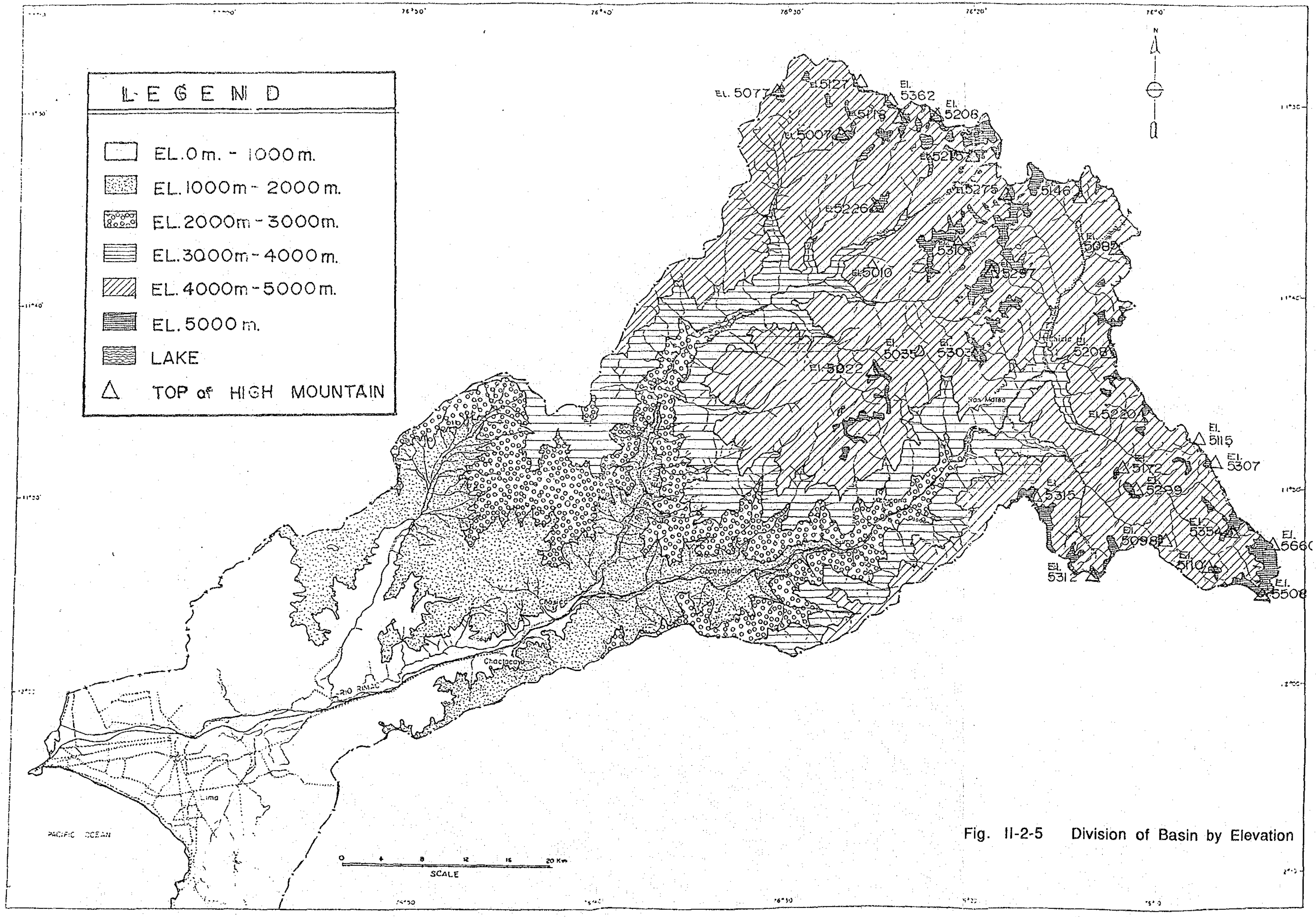


Fig. II-2-5 Division of Basin by Elevation

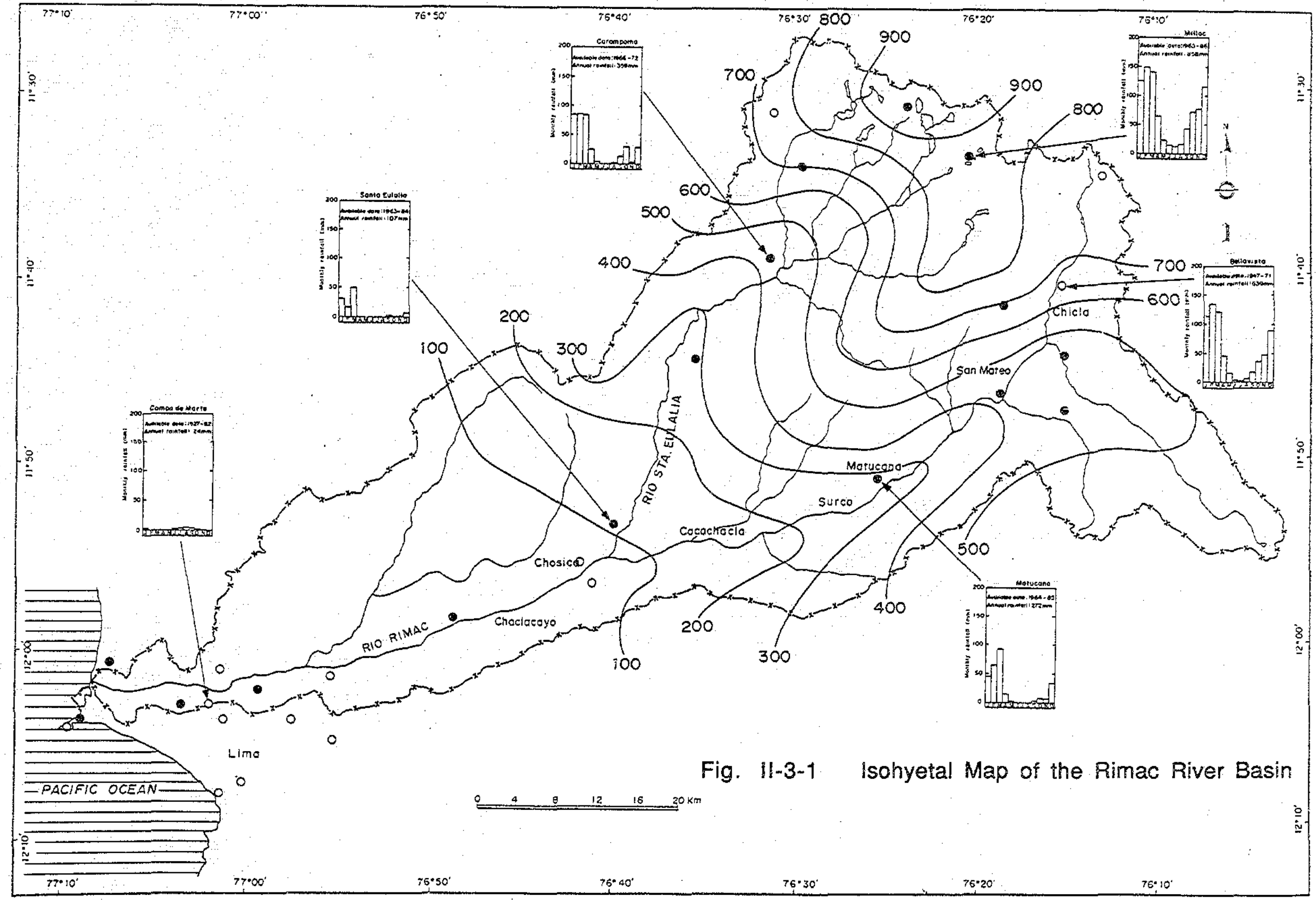


Fig. II-3-1 Isohyetal Map of the Rimac River Basin

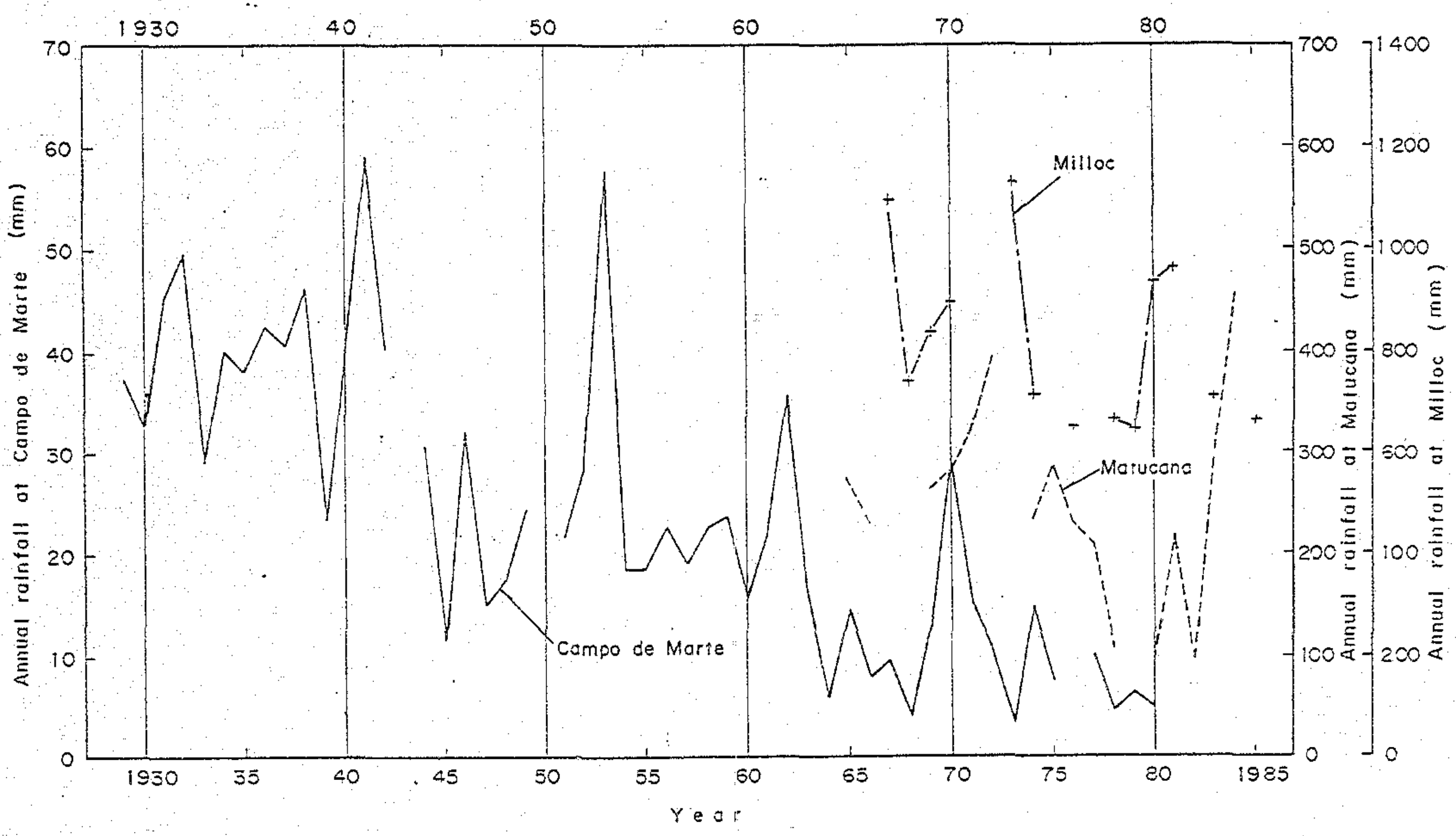


Fig. II-3-2 Annual Precipitation Record in the Rimac River Basin

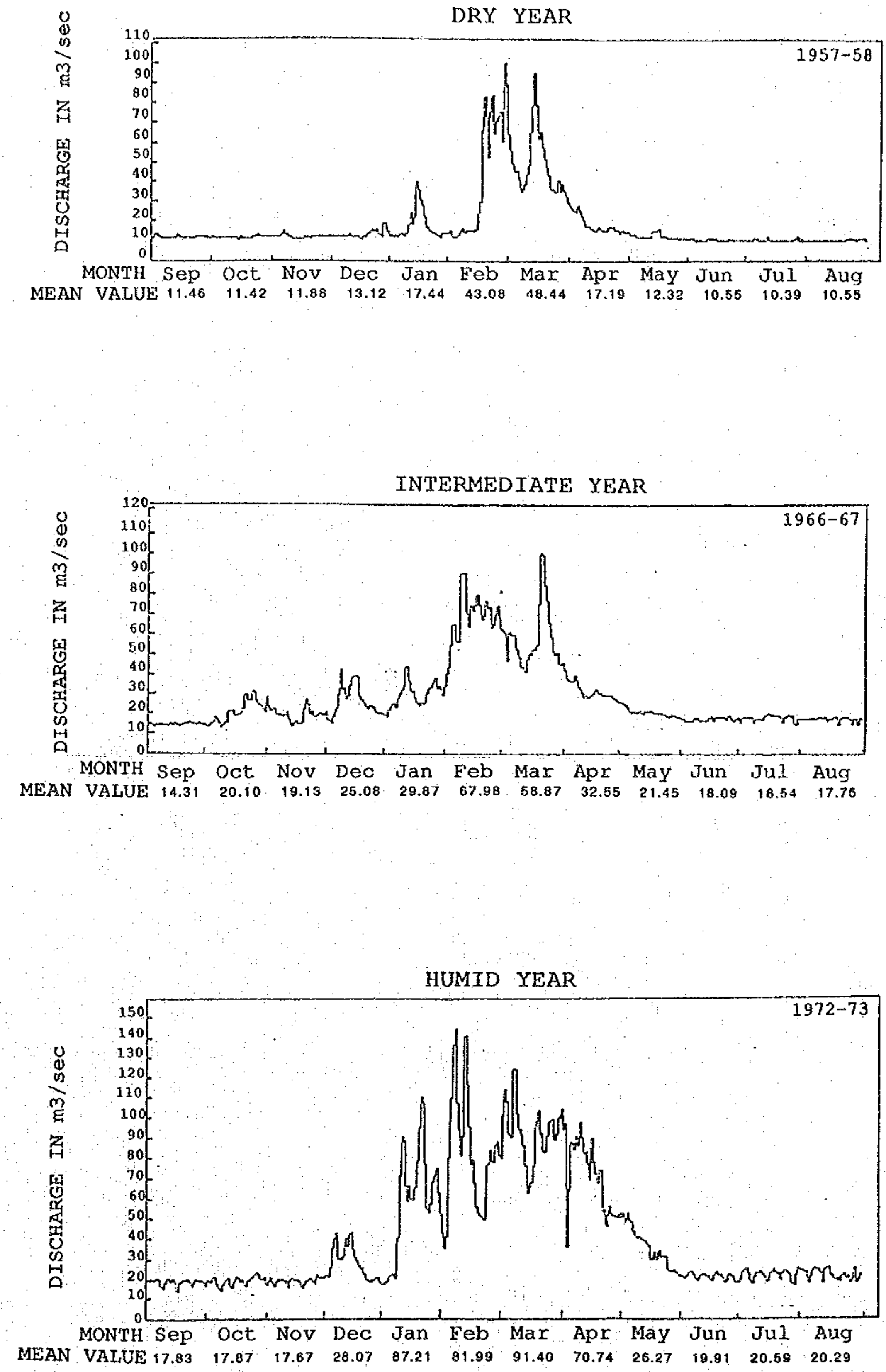


Fig. II-3-3 Hydrolographs in Characteristic Hydrological Years at Chosica

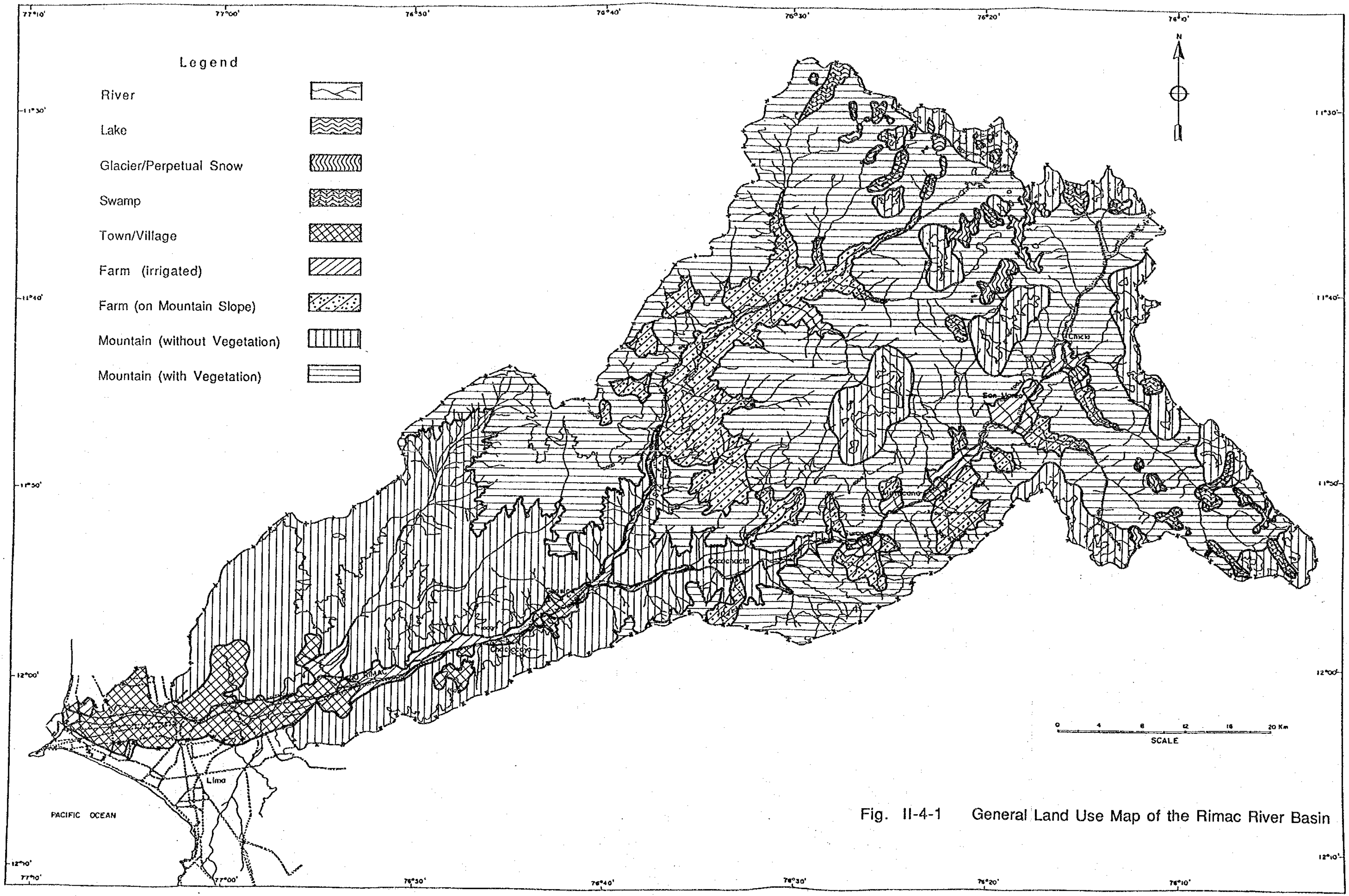


Fig. II-4-1 General Land Use Map of the Rimac River Basin

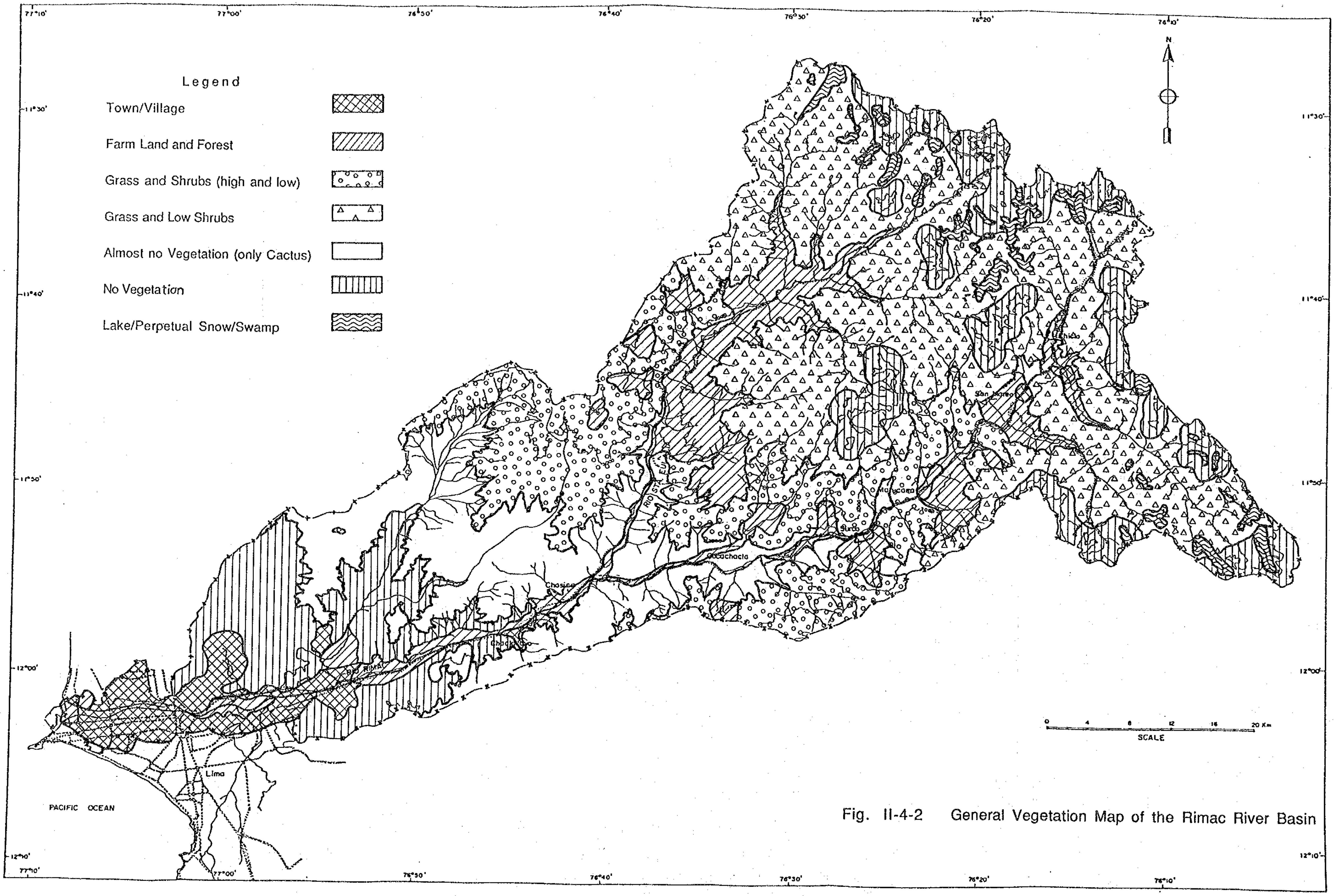


Fig. II-4-2 General Vegetation Map of the Rimac River Basin

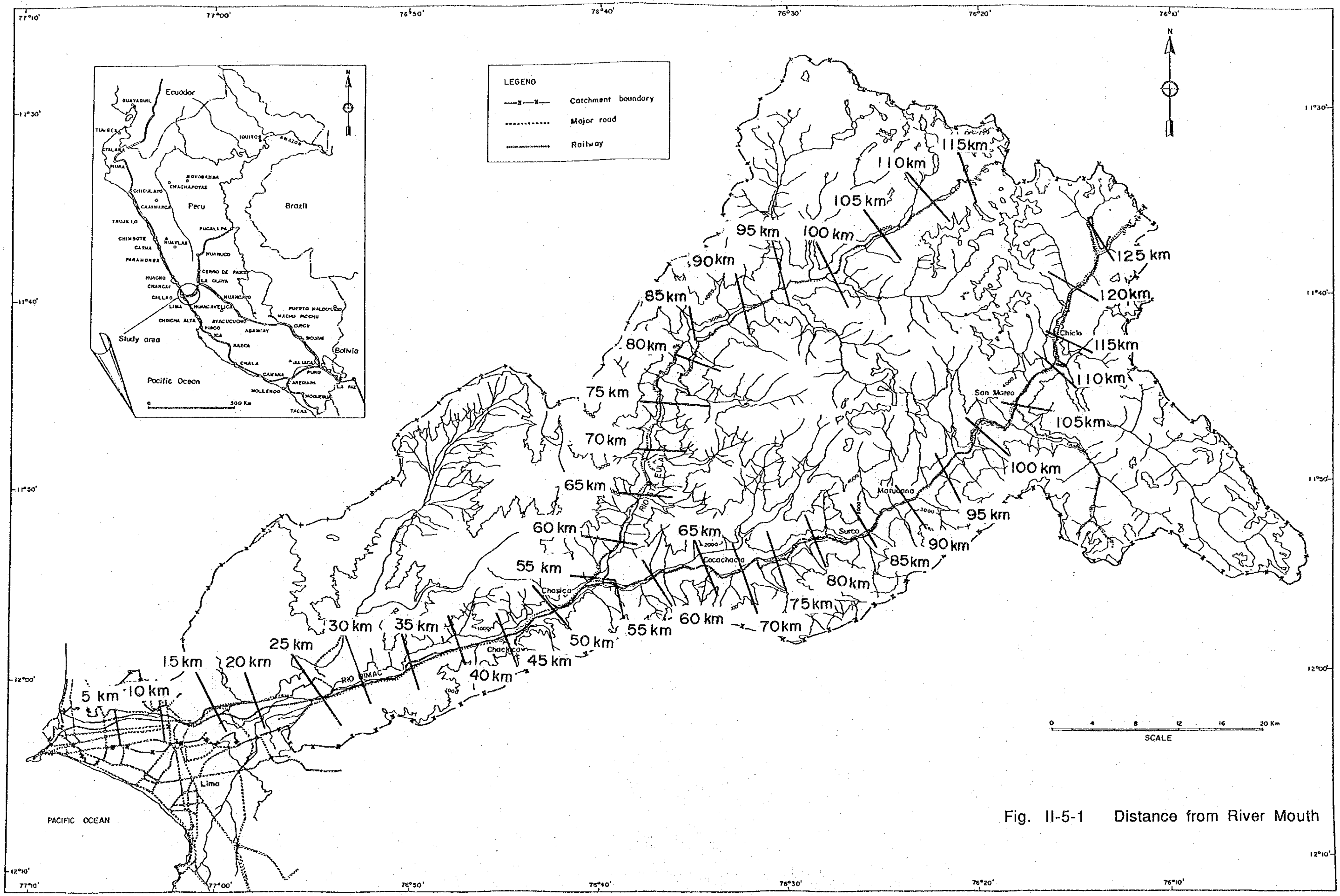


Fig. II-5-1 Distance from River Mouth

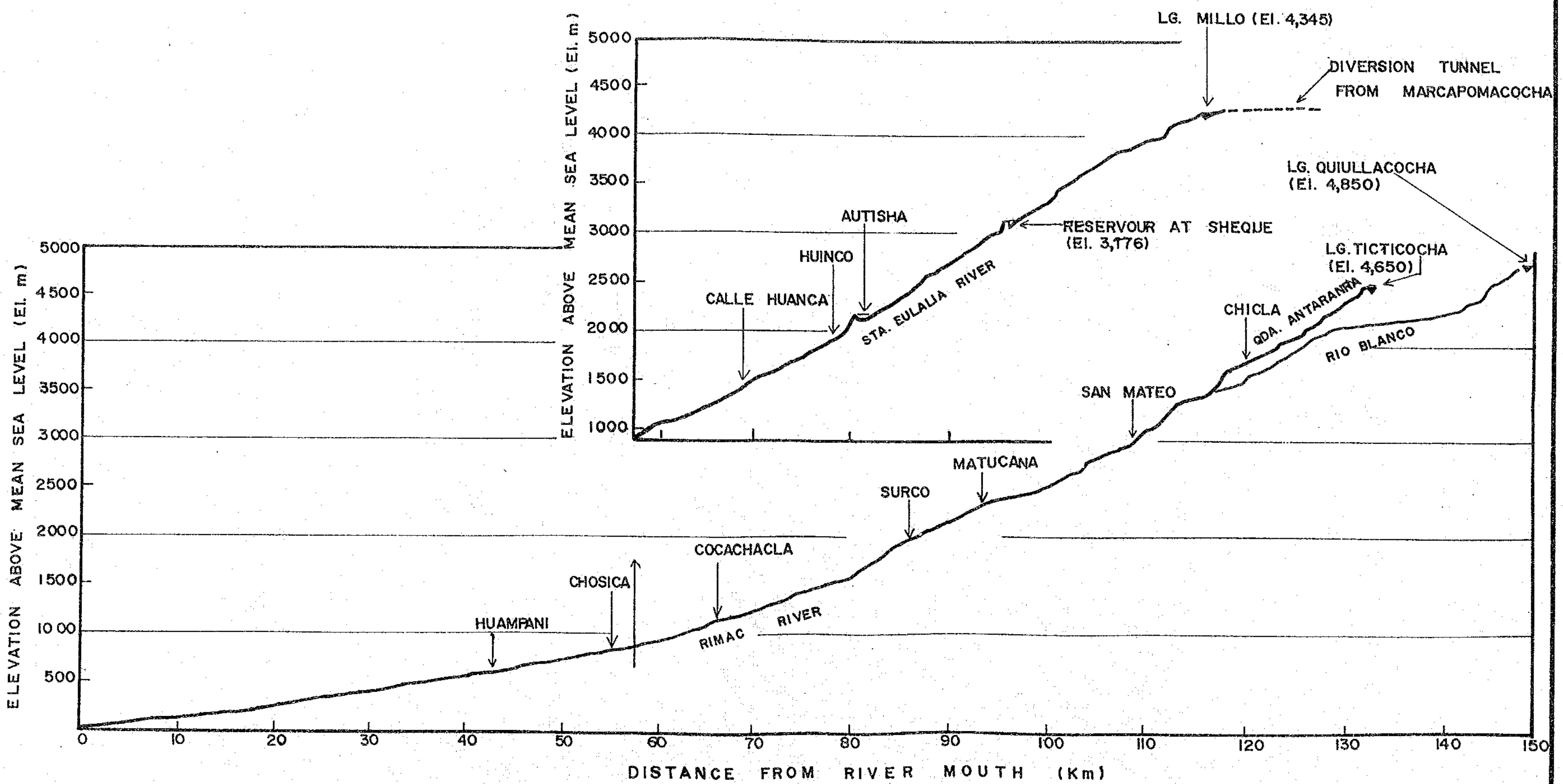


Fig. II-5-2 Longitudinal Profiles of the Rimac River and the Sta. Eulalia River

Fig. II-6-1 Organization Chart of INDC

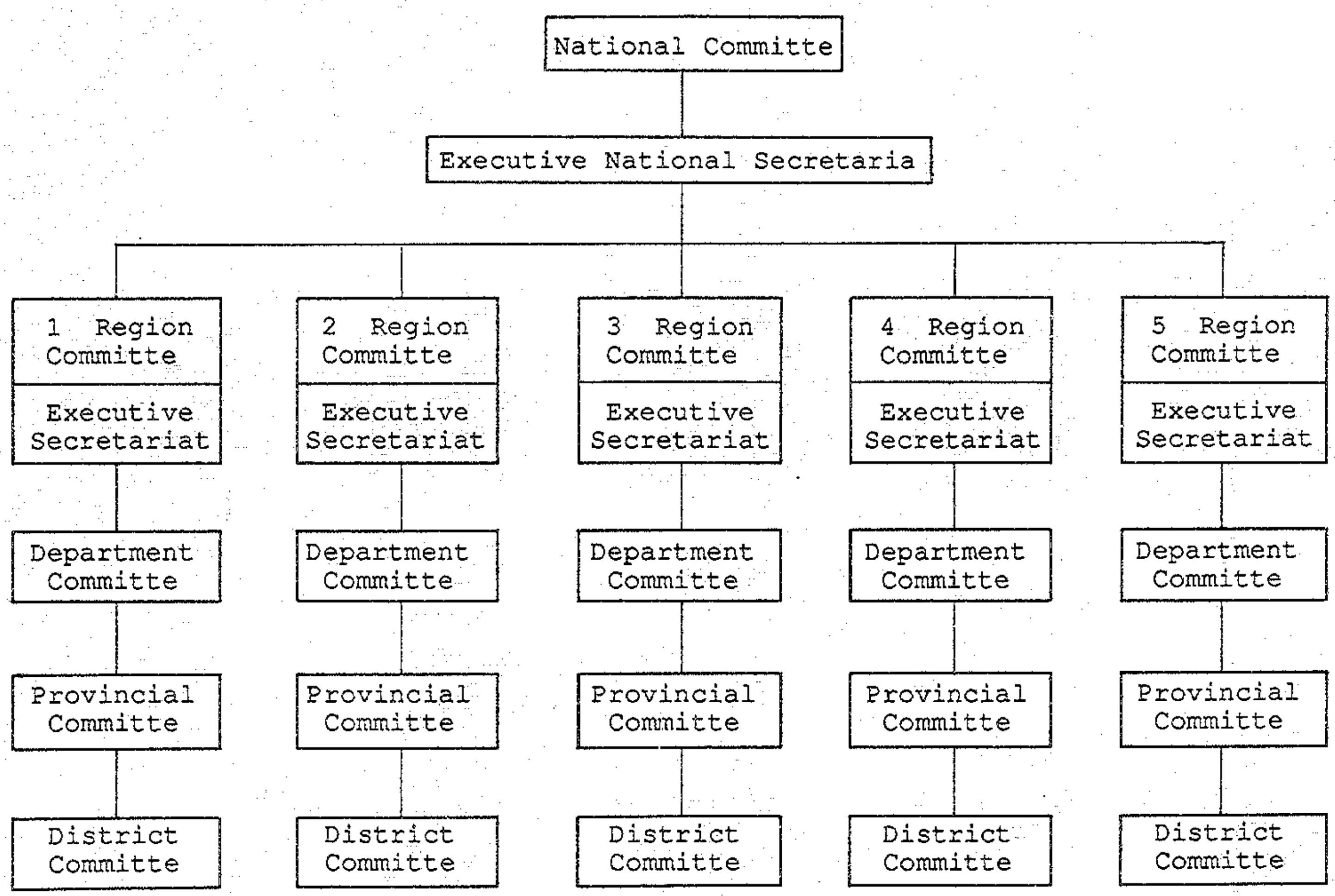
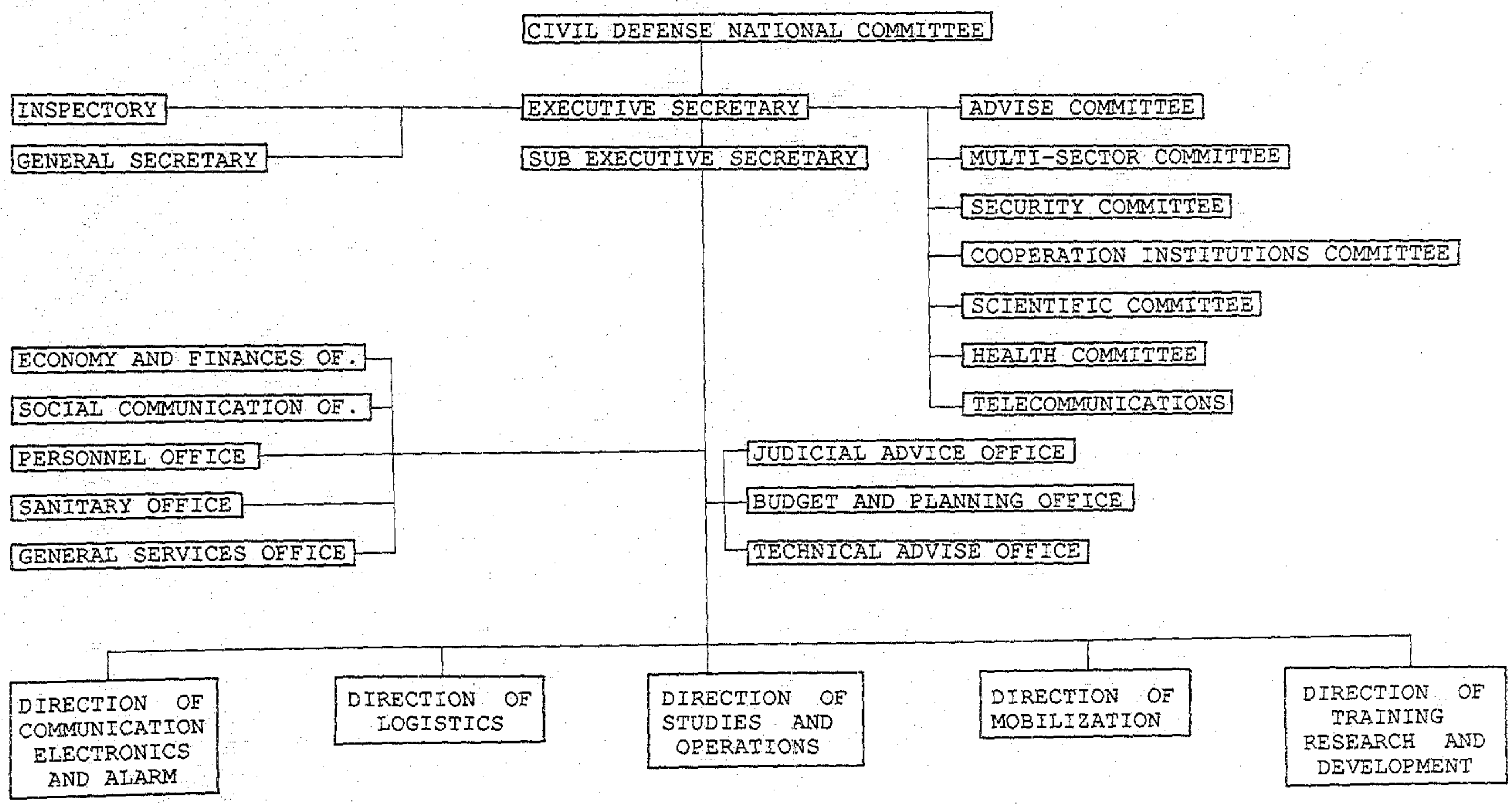


Fig. II-6-2 Organization Chart of SE/INDC



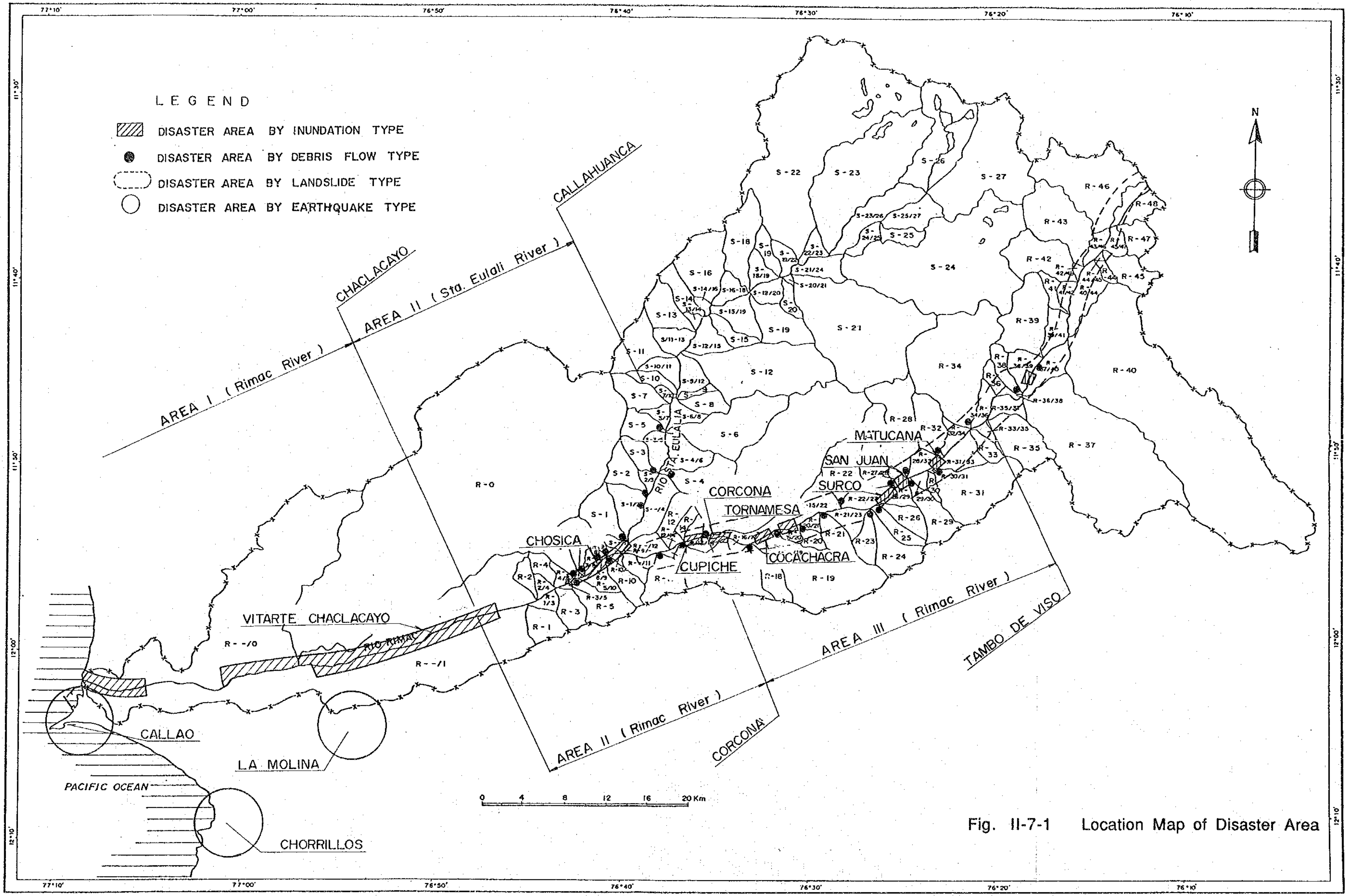


Fig. II-7-1 Location Map of Disaster Area

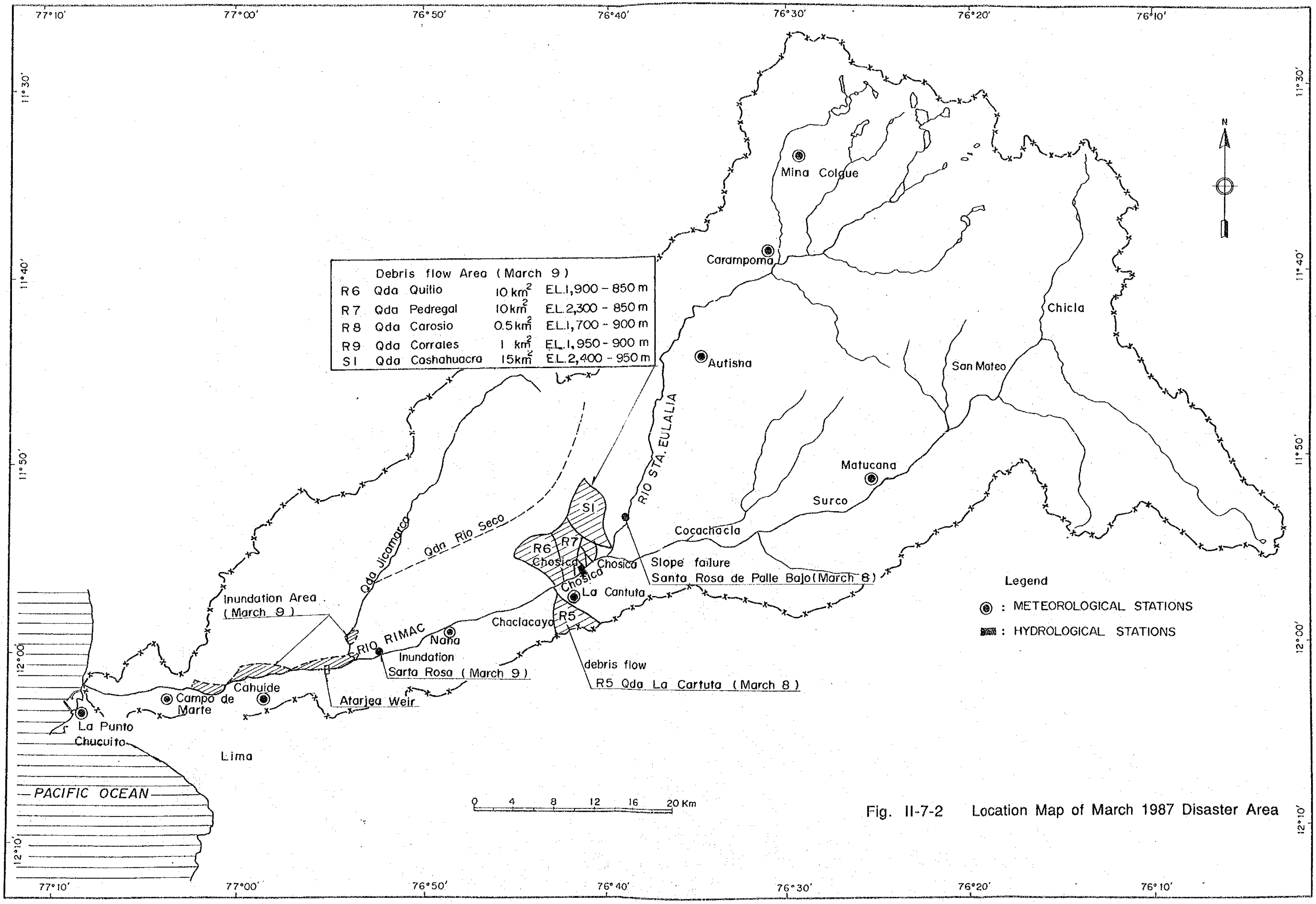


Fig. II-7-2 Location Map of March 1987 Disaster Area

III. BASIC CONCEPT AND CRITERIA FOR PLANNING DISASTER PREVENTION

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CHAPTER III BASIC CONCEPT AND CRITERIA FOR PLANNING DISASTER PREVENTION

1. BASIC CONCEPT

The study for planning disaster prevention will be based on the basic concepts described as follows:

(A) It is considered most important for the disaster prevention to control the basin consistently and comprehensively throughout the whole river basin. The study will make great account of the above point.

(B) Then, the master plan study for the disaster prevention will take into consideration the measures from both structural and non-structural aspects.

(C) The structural and non-structural measures will separately be examined, and then, combined into a comprehensive master plan finally.

(D) The structural measure will be examined by dividing the disaster into the following two types in consideration that the area, mechanism, damage, countermeasures, etc. of disaster are different between the both types.

(a) Debris flow type
(b) Inundation type

(E) The classification of study level in accordance with the degree of danger and protective properties in the respective areas will be made for effectively formulating the master plan.

(F) The disaster prevention plan will be established through a comparative study on the conceivable alternative plans.

(G) The comparative study will consist of the evaluations on the alternative plans both from the technical and economic aspects.

(H) The major objective of the master plan study is to present a basic guideline for the disaster prevention measure.

Thus, the alternative plans will take into consideration only the fundamental factors or functions in the planning; that is, the detailed alternatives such as the kinds, types, shapes or used material of each structure, etc. will not be dealt with in the study in principle.

(I) The objective scale for long-term plan of Debris flow type disaster will be a probable disaster of once in 100 years. The disaster with the scale equivalent to March 1987 disaster happened in Chosica district is assumed to be a disaster of once in 50-100 years, referring to the fact that the debris flow with an approximately same magnitude occurred in 1925.

Remarks: It is informed from the inhabitant that the similar scale of debris flow happened about 60 years ago (1925) in Qda Pedregal and Qda Quirio.

(J) The objective scale of long-term plan for the inundation type disaster will be the scale with probability of 100 years in accordance with the usual practice.

(K) The non-structural measure will especially emphasize the establishment of the administrative system to control the whole basin for preventing or mitigating the disaster.

2. CRITERIA FOR PLANNING AGAINST DEBRIS FLOW DISASTER

2.1 Division of Study Area

The disaster does not happen simultaneously in all the areas in the basin. The disaster usually happens individually in each area, requiring a proper division of study area.

The division will be too much complicated if the primary and secondary valleys of each tributary are included for the division. Then, the division will be made by every tributary which flows into the main streams.

In this case, the main stream means the Rimac river or Sta. Eulalia river. There are some big tributaries such as Rio Blanco, Rio Canchacalla, Qda Parac, Rio Acobamba, Rio Shucha, etc. In these big tributaries, no debris flow disaster is recorded in the past without any remarkable protective object in the upstream areas. Accordingly, it is not necessary to consider in the division the small tributaries entering into these big tributaries.

There are many tributaries which enter into the main stream. Their catchment area ranges from over 200 km^2 to the scale of 0.1 km^2. Small tributaries generally can not be classified as a tributary or a gully on mountain slope. The tributaries with catchment area over 5-10 km^2 generally have their names. However, the smaller tributaries have no name and the border line of the basin is sometimes not clear.

In due consideration of the above, the division of debris flow disaster area will be made as follows:

(A) Two kinds of division are made as follows.

(a) Tributary (Qda)
(b) Mountain slope (Spe)

(B) Qda is the tributary with a catchment area of over 5-10 km^2 in principle. But, the tributary with important protective objects and high danger factor will also be considered as a Qda even if the area is small.

(C) Spe is the area surrounded by the areas of Qda and the main stream. Each Spe area consists of a mountain slope with or without small tributaries and gullies.

2.2 Classification of Divided Area

2.2.1 Basis for Classification

There is a large difference in the priority level among the divided areas. As such, it is considered for an efficient formulation of the master plan to make a classification of the study level in accordance with the priority level.

The classification is made by dividing into three groups in accordance with the degree of danger and protective property as follows: that is, Group A, B and C (see 4, Chapter IV for detail).

The above classification will be based on the criteria detailed hereunder.

2.2.2 Criteria for Classification

The classification by three groups will be made by comprehensive judgement to features of each divided area in due consideration of the following two points;

(a) Level of Protective Object
(b) Level of Danger

Though more definite criteria for the classification will be described in the following sub-sections 2.2.3 and 2.2.4. Following is a general criterion for the classification:

(A) Level of Protective Object

Each area is classified into the following three (3) levels of protective object:

Level A: Damage will be big.
Level B: Damage will not be big remarkably.
Level C: Damage is small or nothing.

(B) Level of Danger

Each area is also classified into the following three (3) levels of danger:

Level A: Possibility of occurrence and scale level will be high.

Level B: Possibility of occurrence and scale will be comparatively high.

Level C: Possibility of occurrence and scale level will be low.

Then, the criteria for classification of area into the group based on the levels of protective object and danger are as follows:

(1) Only in the case that both levels of protective object and danger belong to Level A, the area will be classified into Group A.

(2) In the case that Level C is included either in protective object or in danger, the area will be classified into Group C.

(3) All other cases will be classified into Group B.

2.2.3 Criteria for Classification by Protective Objects

The comprehensive judgement is required for the classification of the level. However, the classification will, in principle, be made on the basis of the following criteria.

Level A
Importance is considered to be high by placing emphases on the number of houses (possibly more than 50 houses in a probable disaster area) and the location of road (especially main trunk road). The areas with serious disaster in the past will be selected with priority.

Level B
There are more than 5-10 houses or the important buildings or structures are located there.

Level C
Protective object does not exist or the damage is considered to be small if any.

In the above classification of level, the slope failure area (Spe area) is not to be included in Level A, since the scale of slope failure disaster is small in comparison with the debris flow disaster.

2.2.4 Criteria for Classification by Possible Danger

The comprehensive study based on meteo-hydrology, geology, topography, etc. is required for judging the probability and scale of disaster. Since it is hard to make the definite criteria, the classification of level will refer to the general criteria described below.

(A) Debris flow disaster area:

(a) Slope of downstream reach area:
Direct attack will be scarce in case of gentler slope than 1/30.

(b) Flow capacity and alignment:
Stream with small flow capacity and with large bending portion(s) has more opportunity of overflow.

(c) Past disaster:
Area with the experience of past disaster has more possibility of future disaster.

(d) Possible volume of unstable earth and rocks:
Probability of disaster is high in case possible volume of unstable earth and rocks is big judging from the conditions of upstream mountain slopes and river channels.

(e) River bed slope in the up-and-middle streams:
Debris flow generally occurs in case of slope steeper than 1/3 - 1/4.

(f) Catchment area of upstream zone:
Possibility is higher if the upstream catchment area is wide.

(g) Rainfall intensity and quantity:
Debris flow occurs at the time of rainfall with high intensity and much quantity.

(h) Vegetation: