APPENDIX IV

RIVER AND RIVER BASIN FEATURES

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1. FEATURES OF RIVER AND RIVER BASIN

1.1 Catchment Area

It is difficult to measure the total catchment area of the Rimac river basin since the basin's boundary in the downstream area is not clear by the maps available at present. However the total catchment area is measured by the map of 1/100,000 in scale by assuming basin's boundary of downstream area. The results are obtained as follows.

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

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

(a) The Rimac river: 1,230 Km^2
(b) The Sta. Eulalia river: 1,020 Km^2

1.2 River Length

In regard to the river length, it is also difficult to measure the accumulate length as the river meanders and the river channel course is frequently changed in some stretches with comparatively wide river course. However, the river length was measured by using the map of 1/25,000 in scale. The approximate river length from the river mouth at major points is shown in Fig. IV-1-1 and the distances at major points are as follows:

(A) At Confluence of the Rimac river and the Sta. Eulalia river: Approx. 56 Km.

(B) At Cocachacla: Approx. 71 Km.

(C) At Surco: Approx. 84 Km.

(D) At Matucana: Approx. 91 Km.

(E) At San Mateo: Approx. 107 Km.

(F) At Chicla: Approx. 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 river and the Acobamba river: Approx. 39 Km. (from the confluence with the Rimac river)

(I) Total length of the Sta. Eulalia river (from the confluence with the Rimac river): Approx. 56 Km*

* Up to the outlet of the diversion tunnel from the Mantaro river.

1.3 River Cross Sections

The river width is generally narrow except Chaclacayo-Atarjea stretch of about 20 Km long due to the comparatively high velocity of river flow. It is difficult to mention about the river width of every representative stretches as the river width changes distance by distance. However, the river width with the ordinary flow is roughly introduced 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

Note: The width shown above is not obtained by the drawings or calculation but by the judgement by sight.
The width of the Sta. Eulalia is not shown but similar to the upstream stretches from Chosica in the Rimac river.

The shape of river cross section is remarkably changed even in a short stretch. Where the river is wide, the banks are usually low and where the river channel is narrow, the banks are usually high. In other words, it seems that the river cross sections are generally balanced from the viewpoint of flow capacity. However, the remarkable variations of river cross section seem to be not desirable for the balance of sediments transportation and also for the flow capacity at the time of flood.

In Lima city, in the most downstream stretch of less than 15 Km, there are some narrow stretches caused by natural force as well as actions of inhabitants. The typical case is seen at about 10 Km from the river mouth. This gorge has the width of only 15-20 m between both banks and the steep cliffs on both banks have the height of about or more than 15 m.

As far as seen in old maps, the Rimac river was pretty wide in the stretch of present city area. It can be imaginable that the people embanked the river channel little by little and consequently the river width became narrow. The deep cliffs were possibly created by the natural action of river flow. The action to make narrow the river channel seems to be continued even at present. Such case can be seen in some places where the large piles of earths with rubbish are dumped to the river channel.

The Plans of river channel in Lima city area shown in some old maps as well as in the latest map are to be attached as follows:

(a)	Map of 1821	(Fig. IV-1-2)
(b)	Map of 1881	(Fig. IV-1-3)
(c)	Map of 1907	(Fig. IV-1-4)
(d)	Map of 1935	(Fig. IV-1-5)
(4)	Latest map	(Fig. IV-1-6)

1.4 River Profile

The gradient of river bed is remarkably steep as upstream ends of river and tributaries are surrounded by the mountains of which top is higher than EL.5,000 m and the river length is only 130-140 Km at the longest stream. The gradient of river bed is not constant. That is, even in the mountain area there are stretches with comparatively gentle slope and in the downstream areas there are stretches with comparatively steep slope. However, the gradient is naturally steeper in the upstream stretches. The average gradient of river bed of the Rimac river obtained from the results of the past river survey is summarized as follows.

(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	-----	

The river profiles obtained from the existing report are shown in Fig. IV-1-7. The detailed river profiles based on the drawings of river survey prepared in 1983 are to be attached in Section 3 as the data are used for hydraulic analysis of river channel.

As the gradient of river bed is steep, the river generally does not meander remarkably though the gentle meandering is seen in almost every stretch.

As one of the particular feature of the river basin, there are many lakes in the upstream areas, generally on the high land of EL. 4,500-5,000 m and some of them are the origins of the tributaries.

2. TRIBUTARIES AND SUB-BASINS

As seen in the map of the Rimac river basin, there are many tributaries joining into the main stream. There are generally two kinds of tributaries classified by the size as follows.

(a) Rio : Big catchment area with much discharge; generally there is flowing water all year long.

(b) Quebrada : Small catchment area or big catchment area with less discharge; generally, there is no flow in the dry season.

There are only five tributaries which are called Rio.

(a) Rio Sta. Eulalia +
(b) Rio Acobamba (Rio Sacsa) ++
(c) Rio Blanco
(d) Rio Pillihua ++
(e) Rio Suncha ++

+ Main stream of Rio Sta. Eulalia changes its name at the upstream; Rio Macao and Rio Pallca.
++ Tributary of Rio Sta. Eulalia.

Though the tributary with catchment area of almost two times of that of Rio Blanco flows into the Rimac river at the downstream stretch from the left bank, it is called as Quebrada Jicamarca due to its comparatively small discharge.

Among the above big tributaries, the Rio Sta. Eulalia, joining into the Rio Rimac at the upstream end of Chosica town, is the tributary of which catchment area is equivalent to the upstream basin of the Rimac river in scale.

The river basin can be divided by sub-basins of tributaries. However, it is difficult and too much complicated to divide the basin by the very small tributaries including gullies. Therefore it is decided to classify the basin into the following two types.

(a) Tributary type area (Qda Area)
(b) Mountain slope area (Spe Area)

The detailed descriptions for the classification are to be made in Appendix X as the division of basin is required for the study of structural plan including the estimation of probable disaster.

As shown in Appendix X, the division is made as follows:

(A) Qda Area: 76 areas
(B) Spe Area: 71 areas

The features of Qda Areas as well as Spe Areas are also shown in Appendix X. However the distribution of main features is to be summarized as follows:

(A) Distribution of Catchment Area

Range	Number of of Oda Area	Number of Spe Area
CA < 5 km^2	11	36
5 ≤ CA < 10	22	22
10 ≤ CA < 15	12	7
15 ≤ CA < 20	8	1
20 ≤ CA < 25	3	2
25 ≤ CA < 30	3	0
30 ≤ CA < 50	6	0
50 ≤ CA <100	5	1
100 ≤ CA	6	2
Total	76	71

(B) Distribution of Height

Range	Number of Oda Area	Number of Spe Area
H < 500 m	0	2
500 ≤ H < 1,000	7	23
1,000 ≤ H < 1,500	15	25
1,500 ≤ H < 2,000	14	12
2,000 ≤ H < 2,500	23	6
2,500 ≤ H < 3,000	12	0
3,000 ≤ H < 3,500	3	0
3,500 ≤ H	2	0
Total	76	68*

(C) Distribution of Slope

Range	Number of Oda Area	Number of Spe Area
$S < 5°$	2	0
$5 \leq S < 10°$	9	0
$10 \leq S < 15°$	16	0
$15 \leq S < 20°$	20	11
$20 \leq S < 25°$	9	15
$25 \leq S < 30°$	8	22
$30 \leq S < 35°$	6	17
$35 \leq S < 40°$	6	3
Total	76	68*

* Downstream 3 Spe Areas are not counted.

(D) Distribution of Horizontal Length* of River

Range	Number of Oda Area
$L < 5$ Km	30
$5 \leq L < 10$	33
$10 \leq L < 15$	4
$15 \leq L < 20$	5
$20 \leq L$	4
Total	76

* From the confluence to the end of river-like section.

(E) Distribution of Horizontal Length of Slope

Range	Number of Spe Area
L < 500 m	0
500 ≤ L < 1,000	4
1,000 ≤ L < 1,500	6
1,500 ≤ L < 2,000	12
2,000 ≤ L < 3,000	28
3,000 ≤ L	18
Total	68

(F) Distribution of Highest Elevation

Range	Number of Oda Area	Number of Spe Area
EL <1,000 m	0	0
1,000 ≤ EL <2,000	5	16
2,000 ≤ EL <3,000	11	12
3,000 ≤ EL <4,000	8	18
4,000 ≤ EL	52	25
Total	76	71

3. CAPACITY OF RIVER CHANNEL

3.1 River Survey in 1987

In accordance with the agreement on the condition of the undertaking by the Peruvian Government, a river survey of the Rimac river was carried out by the Peruvian side. Main purpose of this survey was to search the present river condition to establish a proper river improvement plan which would be formulated as a part of the Disaster Prevention Master Plan of the Rimac river.

The survey result consisting of 10 sheets of drawings (50 river cross sections in total) were handed over the Study Team at the end of August, 1987. Although the specification of the survey given by the Study Team instructed the survey range from the river mouth to Matucana, the location of cross sections prepared by the Peruvian side ranges from 3.5 km upstream of the river mouth to 1.5 km downstream of Pte. Los Angeles in Chacracayo.

While the Study Team stayed in Lima in September 1987 for submittal of the Interim Report, the Study Team requested to expedite the survey for remaining sections and time limit of handing over the survey result to the Study Team was discussed and accepted to be at the end of October, 1987. However, the drawings in the remaining stretch had not been taken over to the Study Team.

After checking the drawings, it was concluded that the river survey result in 1983 by P & V Ingenieros could be utilized for computation of carrying capacity and making river improvement plan. The reasons are as follows:

(1) Number of cross sections and covering range of the river channel obtained by the survey in 1987 is judged insufficient to estimate the carrying capacity and to make a river improvement plan.

(2) It was confirmed by the checking inspection in June and July 1987 that the result of survey in 1983 are still available to use except several sections where a disordered disposal of garbage/soil is seen.

3.2 Comparison of the Cross Sections in 1983 and 1987

The location of the cross sections in 1987 can be accurately identified on the topological maps of scale 1 to 5,000 because the coordinates (X, Y values) of the end points of respective line are noted on the drawings. On the other hand, the location of survey line on the drawings prepared in 1983 is shown in the same scale map without any description of coordinates.

Therefore, a strict comparison of the two results for cross sections at the same location is difficult.

However, the river bed elevations of two survey results can be compared each other by longitudinal profiles along the river channel. The result of the comparison is summarized as follows:

(1) Upstream reach of La Atarjea intake site
River bottom elevation between the both sections is more or less similar and the difference is within several ten centimeters.

(2) From Pte. Ejercito to Pte. Huascar
The difference of the elevations of the lowest river bed between the two surveys varies within 2.5 m.

(3) From Pte. Dueñas to Pte. Ejercito
This stretch includes narrow portion in the central part of Lima. The lowest river bed elevation by the survey in 1987 is higher than that in 1983 by around 1.5 m to 3.0 m in this stretch. However, it can be said that large deposit in such a short period of some 4 years can be hardly considered as flow velocity seems comparatively high in the narrow portion. Thus, it is deemed that a difference of the base point of the two surveys brought about such a discrepancy.

(4) Downstream reach of Pte. Faucett
(Around 1.5 km reach)
The profile of 1987 is about 1.0 m to 2.0 m higher than that of 1983.

As a whole, it is considered that the river bed at downstream reach in Lima metropolitan area rose up about 2.0 m at the most. Although the result of two river surveys has differences as mentioned above, the carrying capacity of the main stream was estimated based on the cross sectional profiles in 1983. The reduction of the flow area due to the deposit in the stretch at downstream of Pte. Faucett was taken into consideration for the estimation of work quantity (for dredging work) described in Appendix XI, Supporting Report III.

The location of the survey line in 1983 and 1987 are shown in the Data Book. All the profiles of cross section is attached behind the location maps of survey line in the Data Book as well.

Anyhow, further detailed survey is recommendable for next stage planning of river improvement in the Rimac river. The periodical survey will be required to understand the deposit/erosion condition which is essential information for the planning.

3.3 Method of Analysis

The carrying capacity of the Rimac river in the stretch downstream from Chosica to the river mouth is estimated by non-uniform flow calculation by using cross sectional profiles made by P y V Ingenieros in 1983.

Available cross sectional profiles cover the river channel from near Pte. del Emisor (1.1 Km upstream from the river mouth) to Moyopampa in Chosica and 199 profiles in total are available. The average interval of neighboring sections is approximately 200 m. Longitudinal profile along the main stream is shown in Fig. IV-3-1.

Within the second field investigation period in June and July 1987, the profiles were roughly checked and, as a result, the shape of some profiles were modified. Major changes were identified at some locations as below:

(a) Downstream of narrow sections between Pte. Faucete and Pte. Universitario (at Section No. 25, 26 and 27, disordered disposal of garbage reduces the section).

(b) Between Pte. Ejercito and Pte. Piedra (at Section No. 44 and 47, same condition as (a))

(c) Between Pte. Piedra and Pte. Huascar (at Section No. 52, 53, 55, 57, 58 and 59, existing parapet wall is added in those sections).

(d) At approximately 1 Km downstream of Pte. Peatonal (at Section No. 69, a large-scale disordered disposal of garbage at right bank can be seen).

(e) Between La Atarjea intake weir site and Pte. Huachipa (at Section No. 86, 87, 88, 89, 90 and 91, a continuous levee has been constructed at right bank with extension of highway road).

For the upstream reach of Chosica town, typical cross sectional profiles are available at 12 locations between Pte. Ricardo Palma and Matucana town. The length along the river channel is approximately 35 Km. By means of the typical profiles, the carrying capacity along the stretch upstream of Chosica was estimated by uniform flow calculation. Longitudinal profile along the Rimac river from Chosica to Matucana is shown in Fig. IV-3-2. In the profiles above, the line of river bed was drawn based on the topographical map of 1 to 5,000 in scale.

Considering the condition of the river channel, roughness coefficient, n, was assumed at 0.035 for the sections between the river mouth and La Atarjea intake weir site, and at 0.040 between La Atarjea intake weir site and the upstream end in Chosica town. On the other hand, 0.06 was applied for the river channel of upstream of Chosica as comparatively large boulders lie in the river bed. It is deemed that average size of river bed materials in upstream reach is bigger than that in downstream reach of Chosica. At each section, same value was applied along the perimeter of low and high water river beds.

It is judged that the tidal fluctuation of the sea water level near the river mouth can be neglected for non-uniform flow calculation. That is, the back water calculation is not required in the Rímac river of which profile is very steep as about one to 100 even at the river mouth.

3.4 Capacity of Present River Channel

3.4.1 Downstream of Chosica

Based on the non-uniform flow calculation, discharge - water level curves were prepared at all points where cross sections are available. By means of these curves, the carrying capacity along the main stream between the river mouth and Chosica was obtained. The results are tabulated in Table IV-3-1. Further, width, depth and the capacity in the channel are graphically shown in Fig. IV-3-2. The capacity can be approximately summarized as below.

	Stretches	Range of capacity (m^3/sec)
1.	River mouth - Pte. Piedra	250* - 800 +
2.	Pte. Piedra - La Atarjea intake	570 - 800 +
3.	La Atarjea intake - Pte. Ñaña	400* - 800 +
4.	Pte. Ñaña - Pte. Huampani	350* - 800 +
5.	Pte. Huampani - Pte. La Cantuta	150* - 600
6.	Pte. La Cantuta - Moyopampa (Chosica)	150* - 400

Remarks: *, Including a short stretch having less capacity
+, Including a short stretch having more capacity

A water level profile in case of 100 year probable flood of 660 m^3/sec at Chosica is shown in Fig. IV-3-3 with profiles of the river bed and profiles of right and left banks.

3.4.2 Upstream of Chosica

In the stretches upstream side from Chosica, the typical profiles at some representative stretches are available. Therefore, the capacity can be roughly confirmed by uniform flow calculation.

The water levels of 100 year probable flood (Q = 310 m^3/sec) are calculated in the stretches where the typical cross section is available. The results are shown in Fig. IV-3-4. The capacity in the channel is summarized as follows:

No.	Distance from Pte. Ricardo Palma	Range of carrying capacity (m^3/sec)
1.	0.1 - 2.0 km	800 +
2.	6.0 - 7.5 km	800 +
3.	7.5 - 8.0 km	800 +
4.	8.0 - 9.0 km	330
5.	9.0 - 10.5 km	800 +
6.	15.0 - 16.5 km	650
7.	25.0 - 26.5 km	800 +
8.	26.0 - 27.0 km	800 +
9.	27.0 - 29.0 km	800 +
10.	32.8 - 33.0 km	560
11.	33.0 - 33.6 km	800 +
12.	34.0 - 35.0 km	800 +

Remarks : +, Having capacity over 800 m^3/sec.

Tables

Table IV-3-1 CARRYING CAPACITY OF EXISTING RIVER CHANNEL (1/2)

Sec No.	Distance (m)	Width (m)	Depth (m)	Elevation of bankfull (m) Left	Elevation of bankfull (m) Right	Carrying capacity (m3/sec)
1	0	50	5.8	13.0	13.0	800+
2	270	64	2.9	13.0	12.3	400
3	615	67	4.6	16.2	16.2	800+
4	920	62	2.5	16.5	18.7	350
5	1050	60	4.0	22.2	19.0	800+
6	1205	26	3.5	22.5	19.9	330
7	1480	102	3.1	21.3	26.2	260
8	1765	35	3.5	25.4	24.2	480
9	2000	113	2.6	26.0	25.8	330
10	2280	141	2.1	28.8	27.0	450
11	2515	126	2.9	31.1	30.2	800+
12	2800	125	3.0	35.5	33.0	800+
13	3020	130	2.5	38.3	36.3	800+
14	3215	120	4.3	40.1	41.2	800+
15	3420	97	3.6	43.4	42.0	800+
16	3655	82	3.3	47.4	43.1	610
17	3745	62	2.9	44.7	44.7	280
18	3850	59	4.0	47.4	47.4	800+
19	3990	47	1.2	49.5	45.8	150
20	4220	82	5.0	51.3	52.4	800+
21	4395	65	5.0	56.0	53.1	800+
22	4690	93	4.4	55.6	55.7	800+
23	4920	64	5.3	61.3	59.0	800+
24	5160	57	5.5	64.0	62.0	800+
25	5430	47	8.6	67.7	69.7	800+
26	5665	35	6.2	67.0	67.8	800+
27	5970	55	7.3	70.6	70.6	800+
28	6110	38	5.6	71.7	71.1	800+
29	6240	45	7.3	77.2	75.5	800+
30	6530	53	9.8	80.5	80.7	800+
31	6870	41	9.5	83.6	84.0	800+
32	7140	23	13.1	87.9	88.7	800+
33	7410	46	7.0	90.7	90.7	800+
34	7690	36	9.0	98.1	94.1	800+
35	8075	17	11.9	99.5	100.2	660
36	8230	27	14.5	108.0	103.2	550
37	8510	31	15.1	105.7	107.4	800+
38	8720	18	15.9	108.5	109.2	800+
39	9120	25	19.3	114.8	114.8	800+
40	9400	16	17.6	115.3	115.3	800+
41	9700	31	24.8	126.8	126.8	800+
42	9785	29	21.0	124.4	124.4	800+
43	9965	50	4.8	127.8	127.8	800+
44	10145	26	2.3	131.6	127.6	190
45	10365	27	3.0	131.4	131.0	320
46	10680	26	2.9	135.7	133.6	230
47	11025	53	8.6	143.3	143.8	800+
48	11155	27	4.3	140.8	144.4	540
49	11350	47	3.1	141.4	147.2	260
50						
51	11540	78	7.9	154.3	154.3	800+
52	11760	41	4.0	153.3	153.3	800+
53	12105	50	5.1	158.7	158.7	800+
54	12255	100	8.4	164.8	164.8	800+
55	12515	46	3.0	162.0	164.6	570
56	12675	89	7.7	168.2	168.2	800+
57	12825	68	3.9	165.8	165.7	800+
58	13115	70	3.9	168.3	173.8	800+
59	13515	60	4.1	172.4	178.1	800+
60	13825	78	5.8	179.0	179.0	800+
61	14435	75	3.8	184.1	189.2	800+
62	14695	73	3.9	188.8	188.3	800+
63	15150	70	4.0	194.1	196.7	800+
64	15465	74	4.0	198.5	200.2	800+
65	15715	80	5.4	202.9	202.9	800+
66	16065	72	6.8	210.5	208.6	800+
67	16365	71	7.9	213.6	214.2	800+
68	16575	49	4.1	212.7	215.0	800+
69	16790	55	7.2	220.0	225.0	800+
70	16985	68	8.3	225.4	226.7	800+
71	17585	70	7.3	230.0	231.4	800+
72	17835	62	8.3	237.0	236.0	800+
73	18155	90	5.8	240.0	238.8	800+
74	18395	104	5.4	242.0	244.5	800+
75	18685	163	7.0	249.0	249.0	800+
76	18785	208	5.4	248.4	249.0	800+
77	18850	163	5.1	249.4	249.1	800+
78	18955	206	7.1	260.7	252.4	800+
79	19050	209	6.2	262.0	252.2	800+
80	19145	141	7.3	257.2	254.8	800+
81	19240	91	5.8	258.0	254.8	800+
82	19350	90	6.1	261.0	258.0	800+
83	19460	70	7.6	264.6	264.6	800+
84	19555	81	6.0	265.0	265.4	800+
85	19665	79	3.1	265.8	264.0	800+
86	20165	237	2.3	275.1	269.5	570
87	20665	235	3.3	283.6	277.8	800+
88	21145	300	2.6	285.0	285.2	800+
89	21615	232	2.3	291.2	292.0	800+
90	22105	200	2.8	302.0	301.8	800+
91	22595	229	3.4	312.0	308.4	800+
92	23095	243	3.7	323.1	318.2	800+
93	23615	246	3.1	330.1	326.1	800+
94	24125	315	1.2	338.9	331.7	530
95	24645	300	1.2	341.0	340.2	540
96	25165	320	1.0	350.0	348.8	150
97	25690	123	1.2	361.0	360.0	490
98	26180	97	2.9	368.5	368.5	520
99	26690	209	2.2	379.0	375.0	640
100	27160	166	4.1	384.0	383.8	800+

Table IV-3-1 CARRYING CAPACITY OF EXISTING RIVER CHANNEL (2/2)

Sec No.	Distance (m)	Width (m)	Depth (m)	Elevation of bankfull (m) Left	Elevation of bankfull (m) Right	Carrying capacity (m3/sec)
101	27630	151	4.4	393.0	392.4	800+
102	28160	172	1.7	404.5	399.5	500
103	28675	197	1.4	410.5	407.3	150
104	29175	257	2.6	419.7	418.2	800+
105	29665	259	2.7	426.5	426.0	800+
106	30155	220	1.4	439.0	434.0	800+
107	30655	234	2.6	447.8	444.0	800+
108	31145	103	1.5	451.8	452.0	150
109	31665	175	2.8	463.1	460.0	740
110	32165	261	4.3	470.0	470.0	800+
111	32665	319	1.3	480.0	476.9	550
112	33165	283	1.5	489.9	486.6	410
113	33775	160	1.5	495.9	495.9	360
114	34240	126	2.1	505.0	505.0	800+
115	34650	167	1.5	510.0	510.0	480
116	35130	100	1	518.1	518.1	300
117	35630	167	1	525.0	524.9	150
118	36140	114	1.3	535.0	535.0	560
119	36650	76	1.8	544.7	544.6	570
120	37120	60	2	553.2	560.3	800+
121	37570	120	2.1	561.1	562.9	800+
122	38070	120	1.2	572.5	568.1	150
123	38770	130	2.4	584.4	587.6	800+
124	39080	151	3.2	589.5	592.4	800+
125	39280	140	0.8	590.7	595.7	170
126	39360	110	2.5	594.4	599.0	800+
127	39520	100	1.2	597.2	602.0	650
128	39820	100	1.5	602.7	607.8	350
129	40040	90	2.5	605.5	609.5	430
130	40240	110	2.8	609.1	612.6	800+
131	40530	90	2.2	614.5	615.2	800+
132	40730	110	1.3	619.3	619.0	370
133	40945	100	0.8	623.7	622.8	150
134	41165	60	1.3	626.5	625.1	150
135	41275	80	0.7	629.9	628.2	150
136	41485	40	2.5	635.1	635.4	500
137	41930	25	1.2	642.5	642.5	150
138	43090	40	1.8	662.6	665.5	180
139	43190	40	1.1	666.3	663.1	150
140	43375	30	1.1	666.5	668.7	180
141	43475	25	1	667.2	668.0	150
142	44085	25	3.1	681.1	680.2	200
143	44560	45	1.1	690.0	690.1	150
144	44820	20	2.2	695.1	695.0	180
145	44960	20	1.8	699.5	698.0	150
146	45455	20	1.7	703.4	706.0	150
147	45640	15	2.7	710.5	710.4	400
148	46070	20	2.2	717.4	716.3	150
149	46290	20	2.9	722.4	722.4	170
150	46485	30	1.8	723.8	724.5	150
151	46695	25	1.2	731.0	731.3	150
152	46890	25	3.0	734.8	734.9	190
153	47075	25	3.0	737.2	737.2	550
154	47270	35	1.0	738.3	739.1	150
155	47480	40	3.0	745.4	746.0	800+
156	47955	25	1.1	754.3	752.5	150
157	48115	25	1.9	756.6	756.6	180
158	48340	25	1.0	760.8	760.0	150
159	48416	45	1.9	762.5	762.8	300
160	48464	50	1.2	763.8	765.5	390
161	48515	30	2.6	765.8	766.0	440
162	48561	30	1.9	766.2	767.6	150
163	48610	50	1.8	767.0	767.6	150
164	48659	60	2.1	770.5	768.2	320
165	48711	50	2.2	769.1	770.6	500
166	48762	50	1.8	770.6	769.1	210
167	48818	40	2.0	772.0	771.0	300
168	48881	50	1.2	772.8	771.8	180
169	48937	40	1.1	772.8	772.8	270
170	48991	40	1.1	775.3	774.3	220
171	49044	70	1.3	776.7	775.5	230
172	49097	70	1.4	778.8	777.3	390
173	49149	70	2.7	780.4	780.7	800+
174	49198	40	1.3	779.5	779.5	200
175	49238	25	3.6	781.8	789.6	800+
176	49291	30	4.8	784.3	794.5	800+
177	49333	30	4.8	785.8	785.2	800+
178	49392	40	2.2	784.4	785.3	590
179	49430	40	2.8	789.5	786.1	400
180	49475	30	1.3	786.3	787.0	150
181	49507	20	2.3	788.4	787.7	450
182	49544	20	2.2	789.3	789.9	410
183	49585	25	1.5	789.4	788.7	190
184	49629	25	1.2	789.4	789.0	150
185	49678	25	3.8	792.4	793.7	800+
186	50488	25	1.0	808.2	808.0	180
187	50788	50	3.0	816.6	818.4	800+
188	50973	70	1.3	818.3	818.7	180
189	51113	70	3.1	822.1	822.7	320
190	51283	25	1.5	825.5	830.2	320
191	51543	25	2.7	830.6	830.9	590
192	51973	20	2.1	838.3	837.8	170
193	52193	20	2.4	849.0	845.9	170
194	52443	25	1.9	849.5	849.5	150
195	52643	25	2.0	854.9	853.5	150
196	52853	35	1.2	859.6	858.1	150
197	53193	20	0.8	862.6	863.8	150
198	53713	20	2.0	876.6	878.8	360
199	54003	30	2.5	887.6	886.4	500

Figures

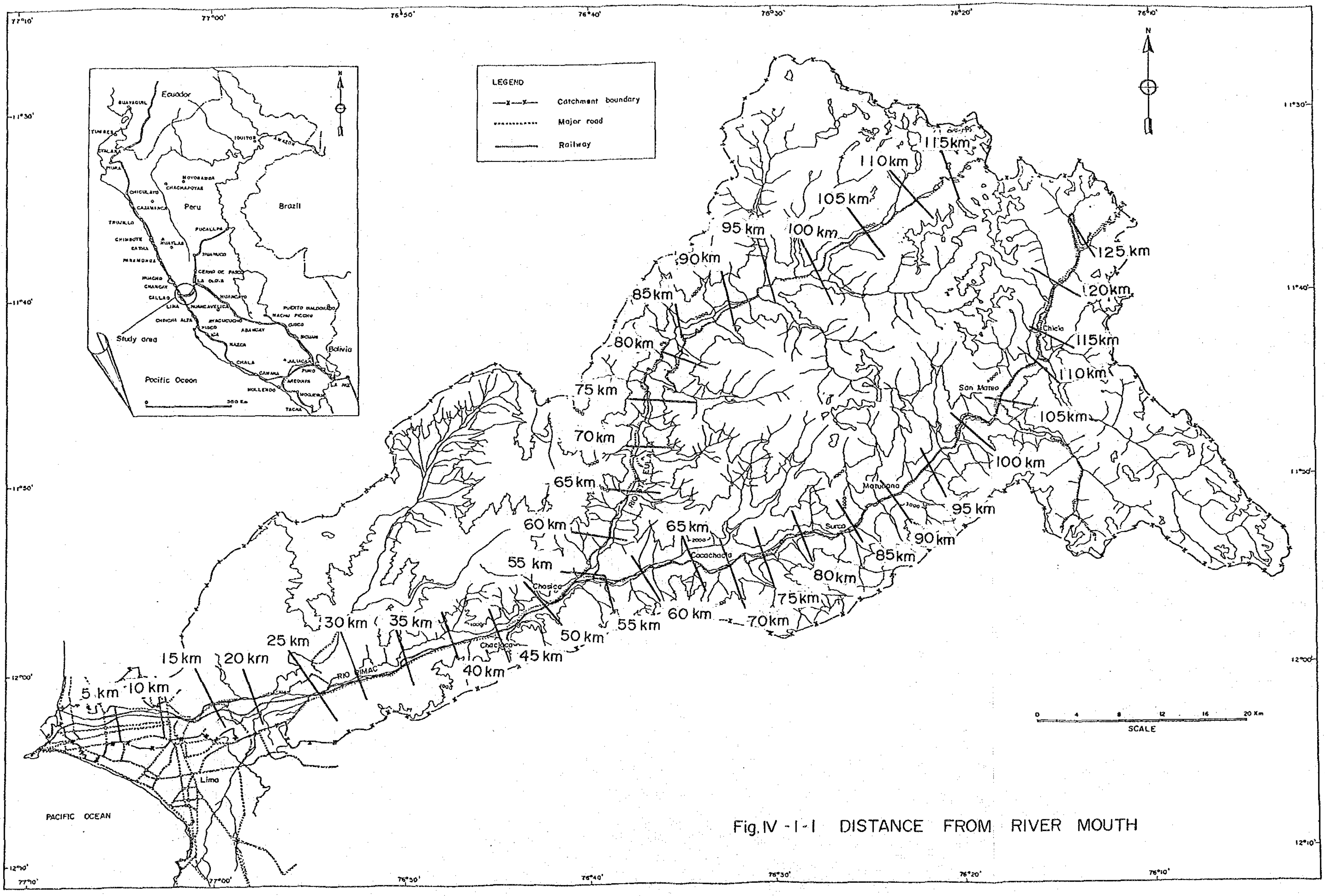


Fig. IV -1-1 DISTANCE FROM RIVER MOUTH

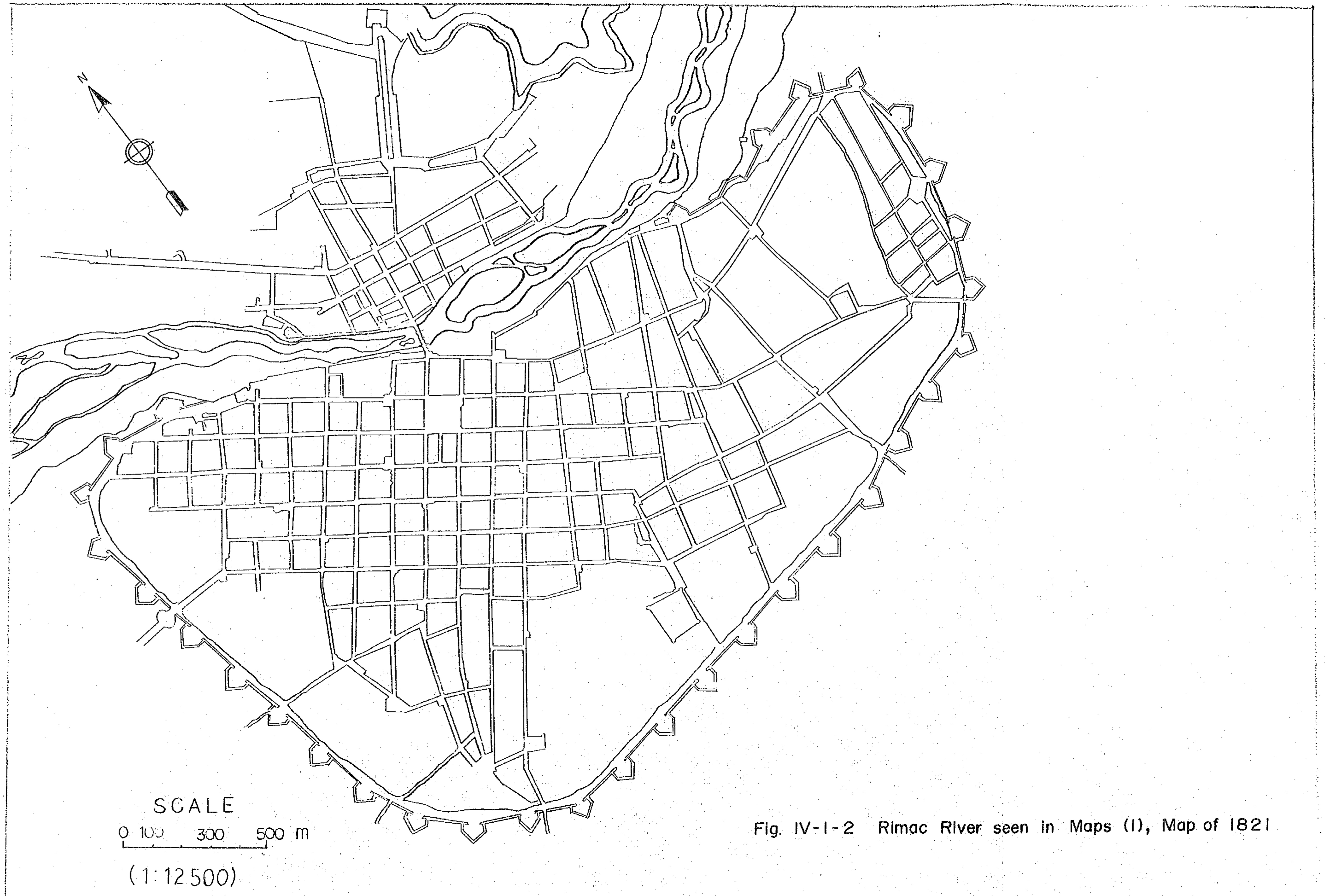


Fig. IV-1-2 Rimac River seen in Maps (I), Map of 1821

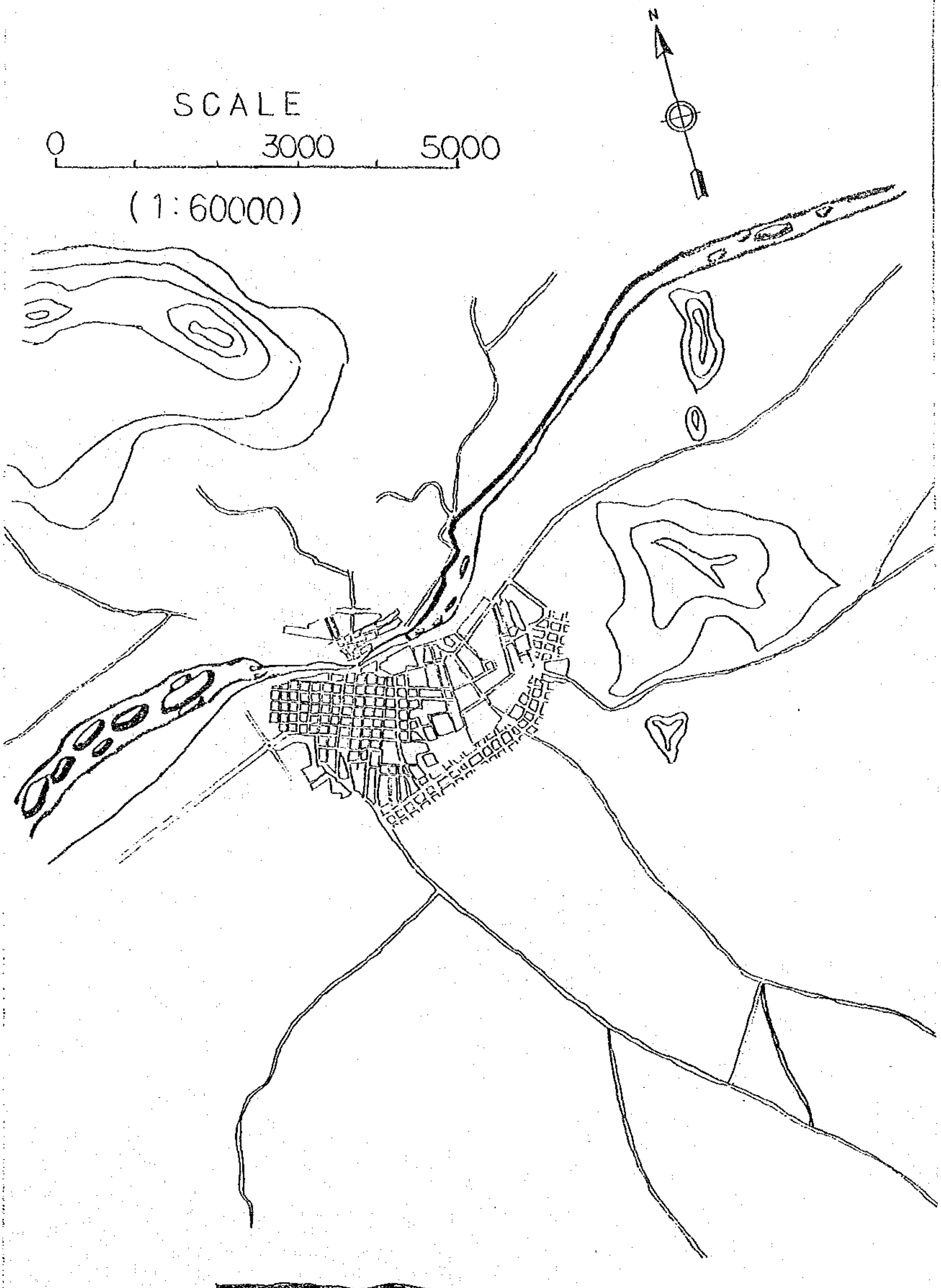


Fig. IV-1-3 Rimac River seen in Maps (2), Map of 1881

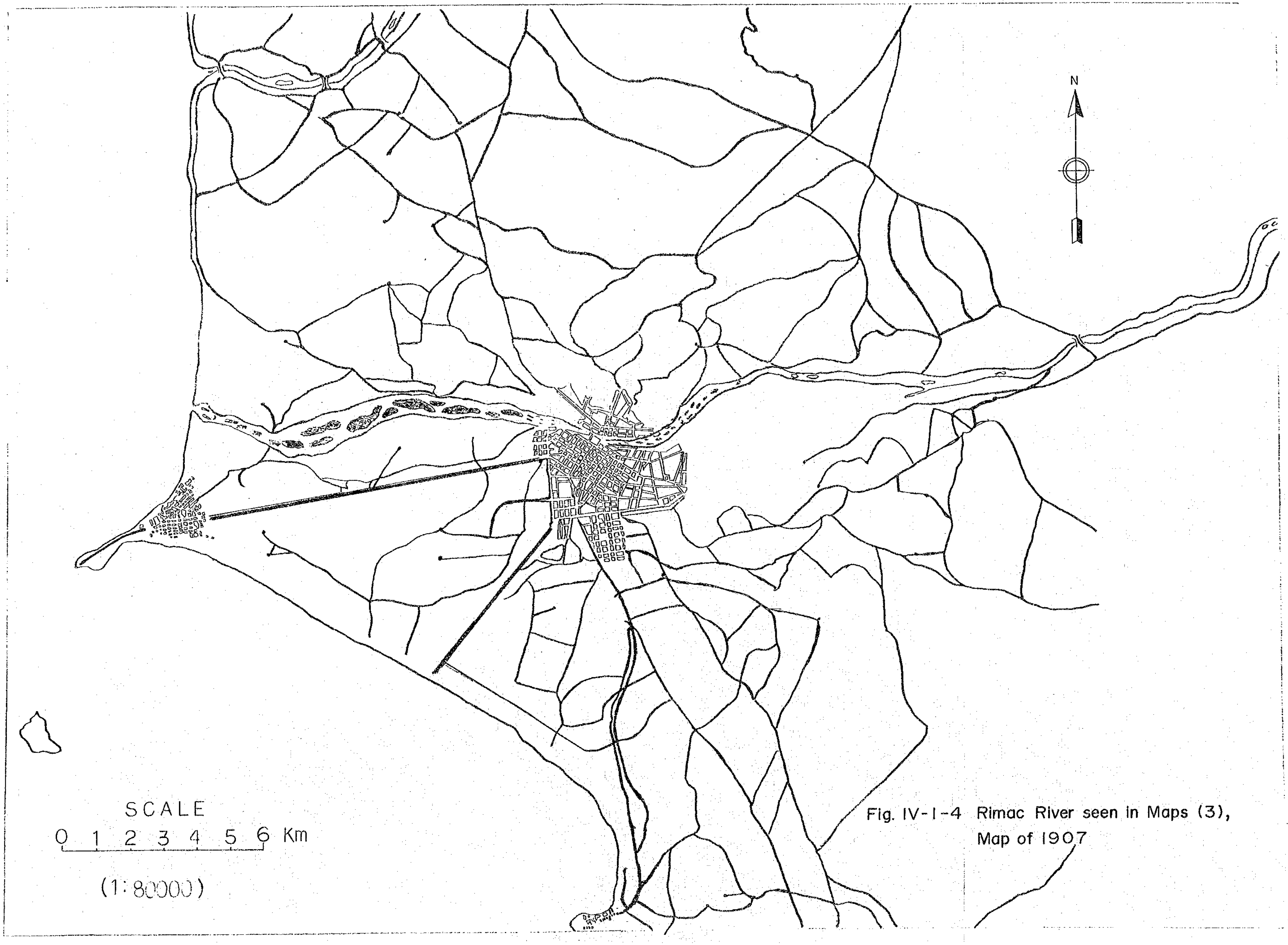


Fig. IV-1-4 Rimac River seen in Maps (3), Map of 1907

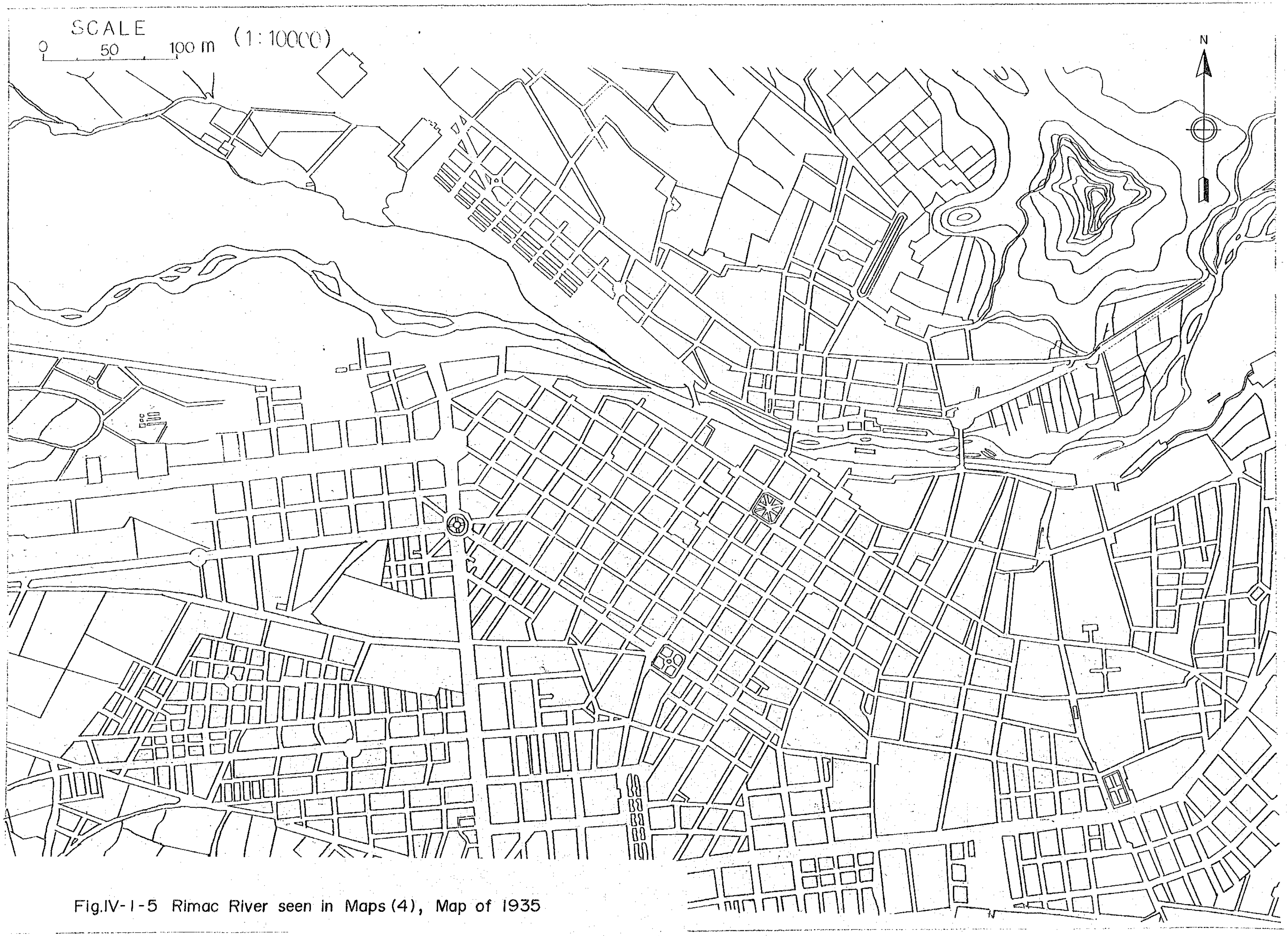


Fig.IV-1-5 Rimac River seen in Maps (4), Map of 1935

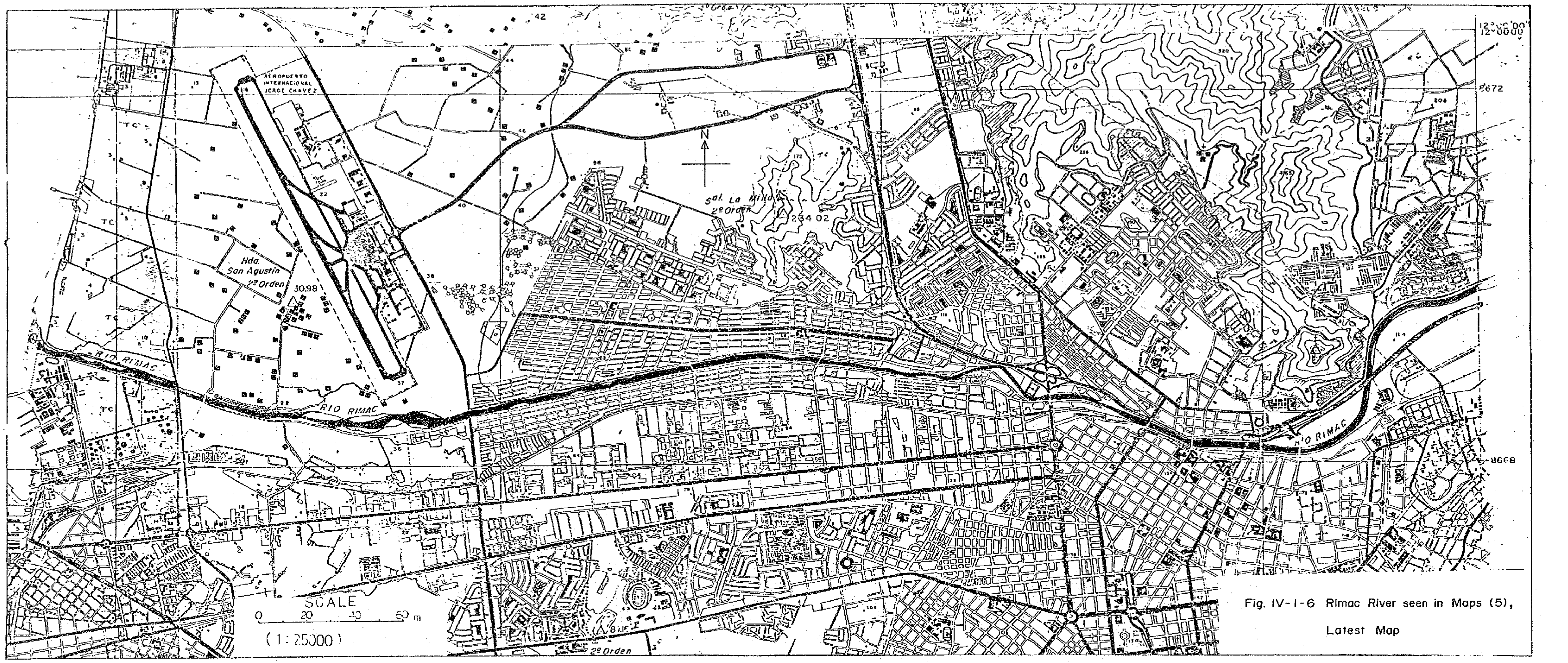


Fig. IV-1-6 Rimac River seen in Maps (5), Latest Map

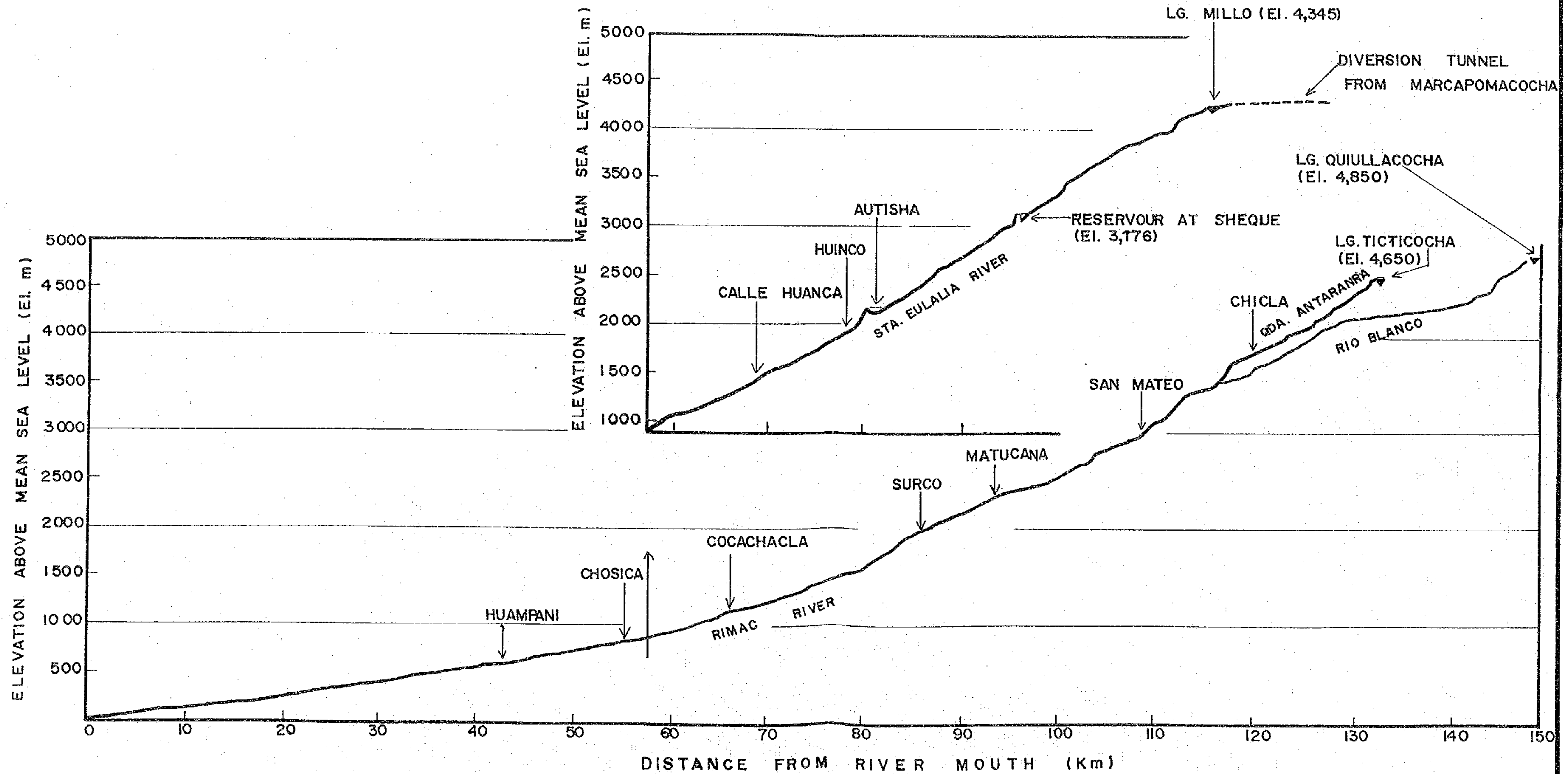
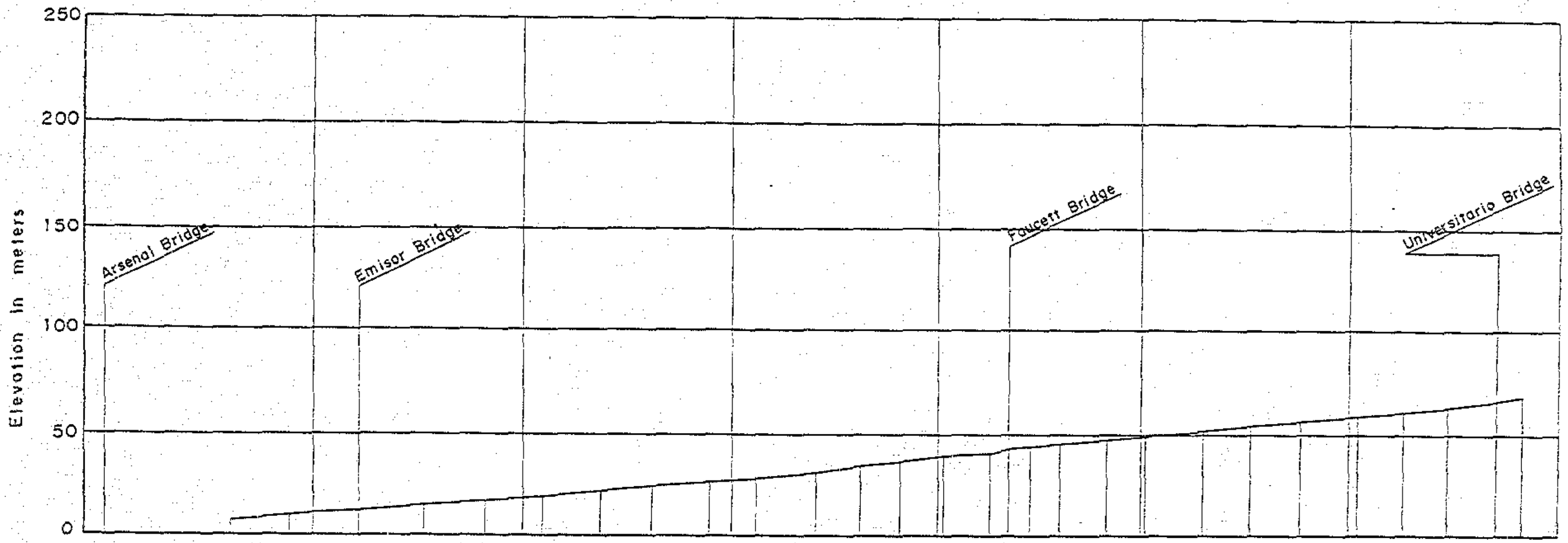


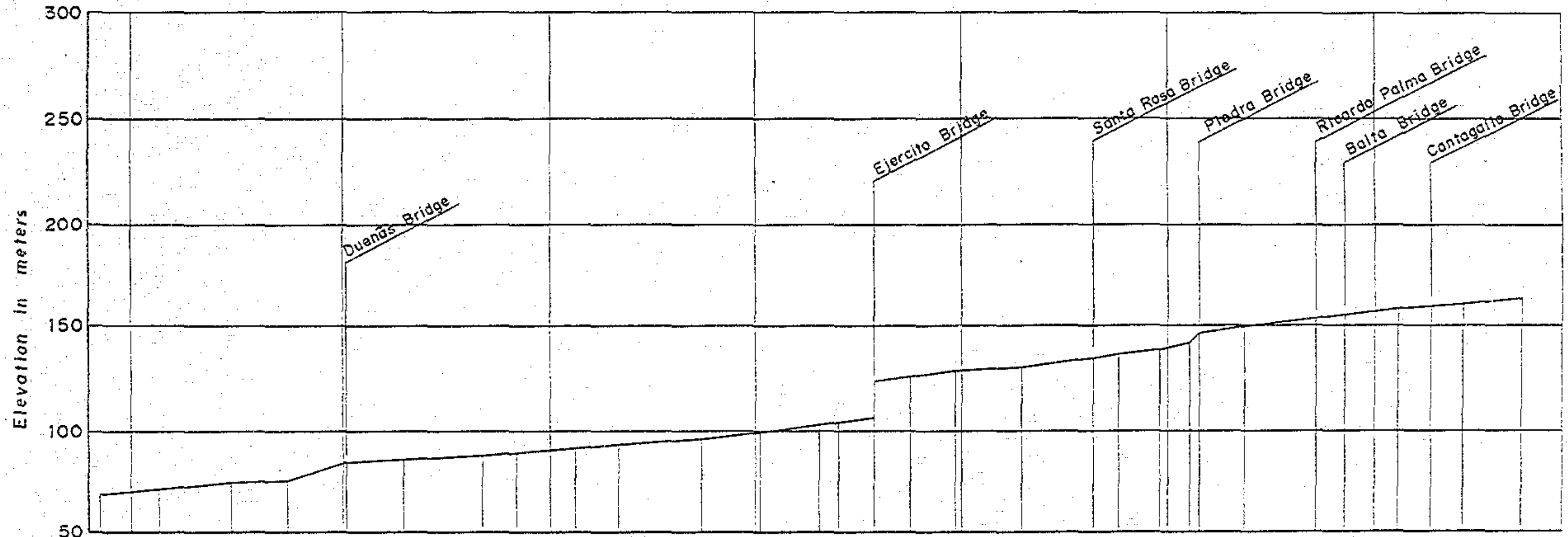
Fig. IV-1-7 LONGITUDINAL PROFILES OF THE RIMAC RIVER AND THE STA. EULALIA RIVER



CROSS SECTION NO.	Sec.0	1	2		3	4	5	6	7	8	9	10		11	12	13	14	15
STATION NO.	STA.0	+610	+880	STA.1	+225	+530	+660	+815	STA.2 + 90	+375	+610	+890	STA.3	+125	+410	+630	+825	STA.4 + 30
ACCUMU DISTANCE (m)	0	610	880	1,000	1,225	1,530	1,660	1,815	2,000 2,090	2,375	2,610	2,890	3,000	3,125	3,410	3,630	3,825	4,000 4,030
DISTANCE (m)	0	610	270		345	305	130	155	275	285	235	280		235	285	220	195	205
EXISTING RIVERBED ELEVATION (m)		7.19	9.36		11.61	14.00	14.90	16.36	18.18	20.65	23.16	24.93		27.28	30.00	33.76	35.82	38.43

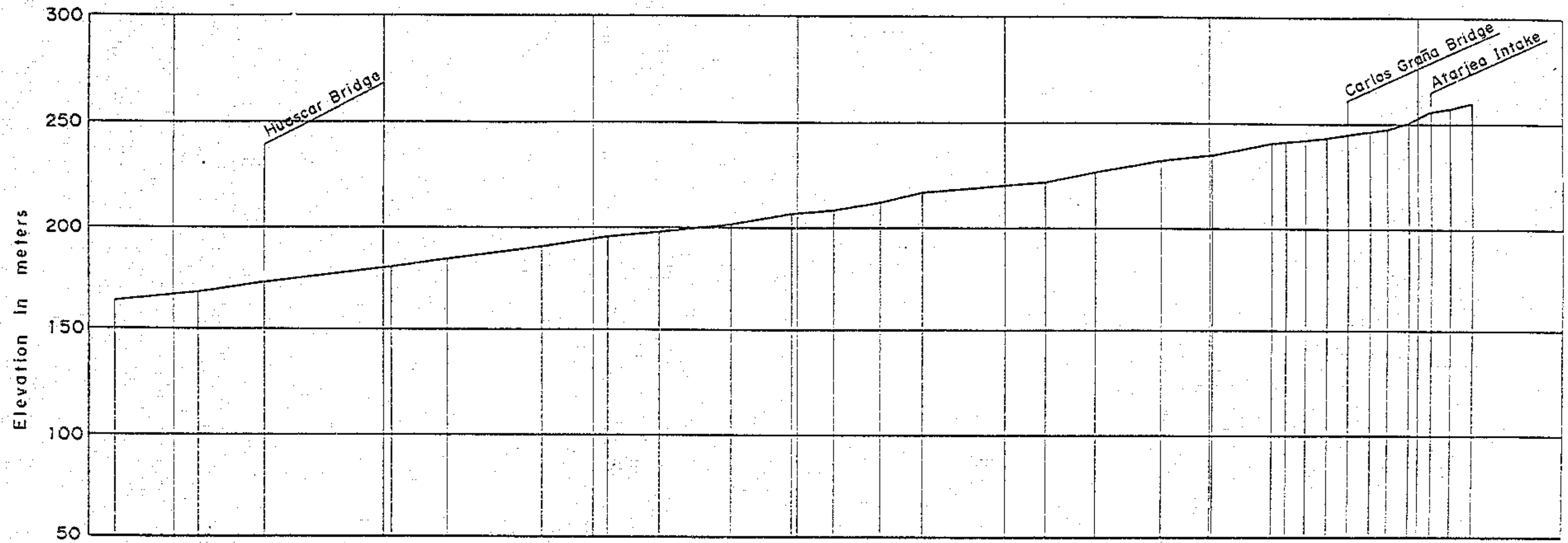
CROSS SECTION NO.	16	17	18	19	20	21	22	23	24	25	26	27	28	29
STATION NO.	+265	+355	+460	+600	+830	STA.5 + 5	+300	+530	+770	STA.6 +40	+275	+480	+720	+850
ACCUMU DISTANCE (m)	4,265	4,355	4,460	4,600	4,830	5,000 5,005	5,300	5,530	5,770	6,000 6,040	6,275	6,480	6,720	6,850
DISTANCE (m)	235	90	105	140	230	175	295	230	240	270	235	205	240	130
EXISTING RIVERBED ELEVATION (m)	39.83	41.79	43.36	44.63	46.34	48.15	51.24	53.67	56.54	59.09	60.80	63.30	66.13	68.16

Fig.IV-3-1 Longitudinal Profile of the Rimac River (1/9)



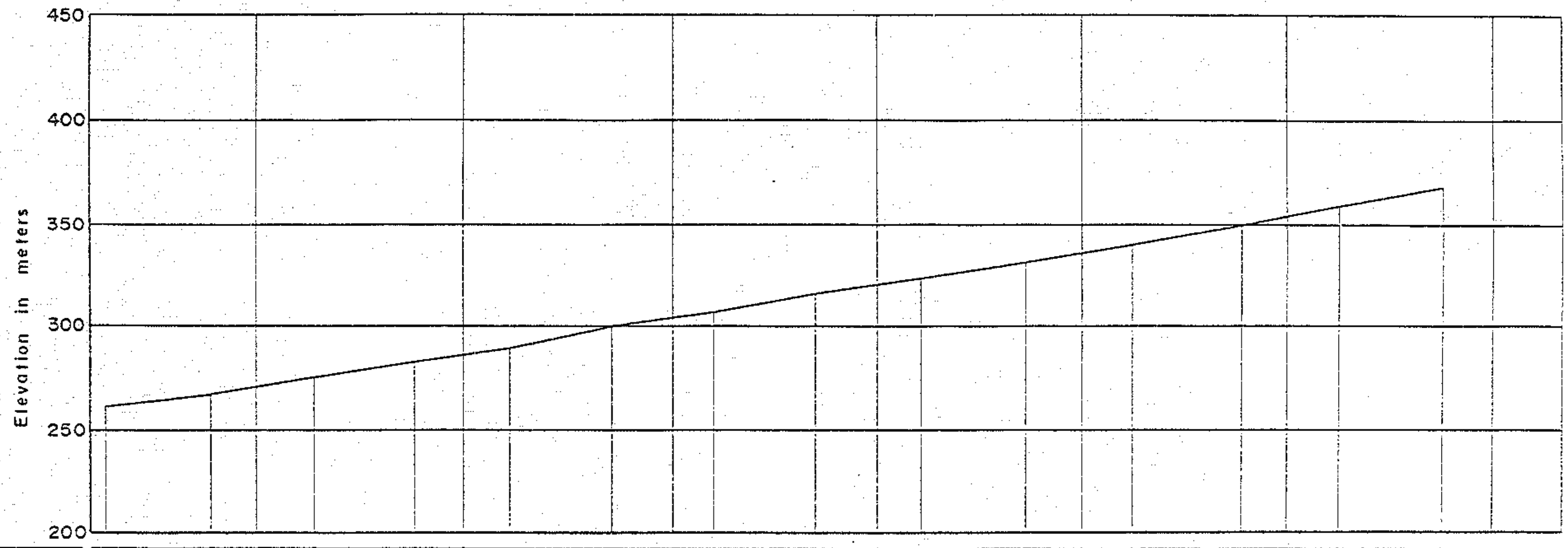
CROSS SECTION NO.	EXISTING RIVERBED ELEVATION (m)	DISTANCE (m)	ACCUMU DISTANCE (m)	STATION NO.
Sec.29	68.16	130	6,850	+850
			7,000	STA.7
30	70.65	290	7,140	+140
31	74.07	340	7,480	+480
32	74.81	(325) 270	7,750	+750
33	83.66	270	8,000 8,020	STA.8 +20
34	85.06	280	8,300	+300
35	87.58	385	8,685	+685
36	88.75	155	8,840	+840
			9,000	STA.9
37	90.65	280	9,120	+120
38	92.58	210	9,330	+330
39	95.54	400	9,730	+730
40	97.70	280	10,000 10,010	STA.10 +10
41	101.96	300	10,310	+310
42	103.35	85	10,395	+395
43	(105.50) 123.00	180	10,575	+575
44	125.26	180	10,755	+755
45	128.02	220	10,975 11,000	+975 STA.11
46	130.90	315	11,290	+290
47	134.70	345	11,635	+635
48	136.54	130	11,765	+765
49	138.30	195	11,960 12,000	+960 STA.12
50	140.82	140	12,100	+100
51	146.40	50	12,150	+150
52	149.26	220	12,370	+370
53	153.64	345	12,715	+715
54	156.37	150	12,865	+865
			13,000	STA.13
55	158.99	260	13,125	+125
56	160.50	160	13,285	+285
57	161.77	150	13,435	+435
58	164.44	290	13,725	+725

Fig.IV-3-1 Longitudinal Profile of the Rimac River (2/9)



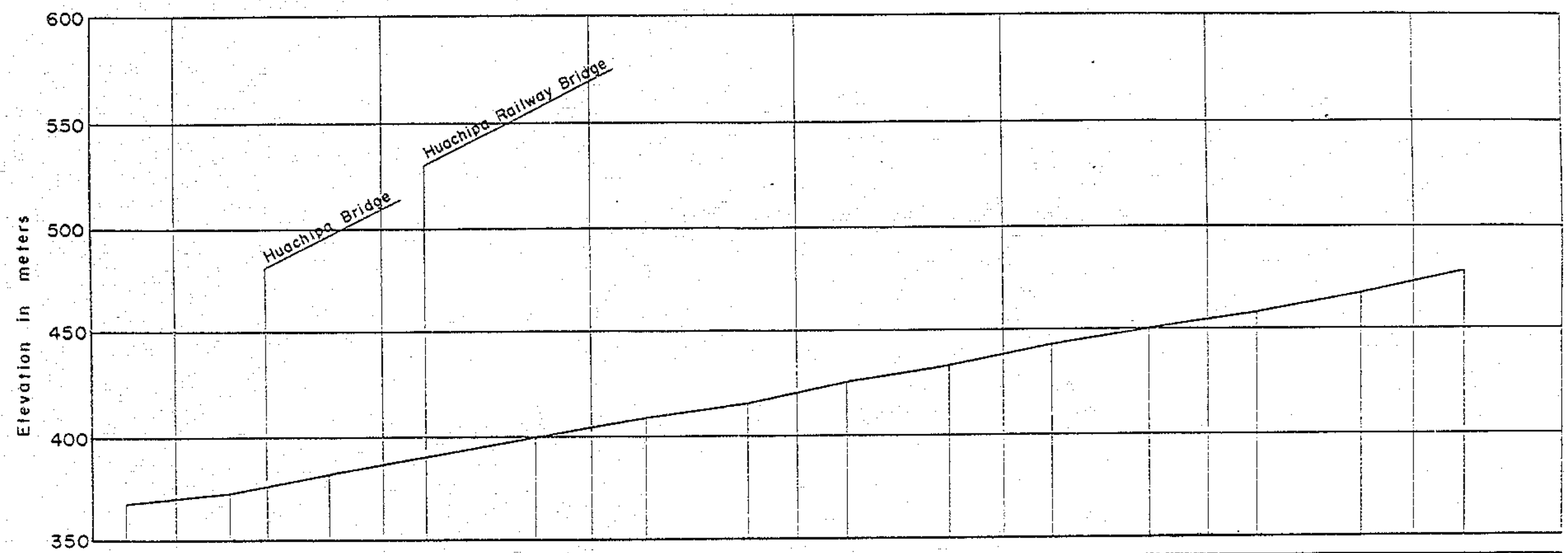
CROSS SECTION NO.	STATION NO.	ACCUMU DISTANCE (m)	DISTANCE (m)	EXISTING RIVERBED ELEVATION (m)
Sec.58	+725	13,725	290	164.44
	STA.14	14,000		
59	+125	14,125	400	168.30
60	+435	14,435	310	173.17
	STA.15	15,000		
61	+ 45	15,045	610	180.26
62	+305	15,305	260	184.38
63	+760	15,760	455	190.13
	STA.16	16,000		
64	+ 75	16,075	315	194.48
65	+325	16,325	250	197.50
66	+675	16,675	350	201.81
67	+975	16,975	300	205.65
	STA.17	17,000		
68	+185	17,185	210	208.58
69	+400	17,400	215	212.81
70	+595	17,595	195	217.09
	STA.18	18,000		
71	+195	18,195	600	222.65
72	+445	18,445	250	227.69
73	+765	18,765	320	233.00
	STA.19	19,000		
74	+ 5	19,005	240	236.63
75	+295	19,295	290	242.00
76	+395	19,395	100	243.00
77	+460	19,460	65	244.00
78	+565	19,565	105	245.00
79	+660	19,660	95	246.00
80	+755	19,755	95	247.50
81	+850	19,850	95	249.00
82	+960	19,960	110	251.90
	STA.20	20,000		
83	+ 70	20,070	110	257.00
84	+165	20,165	95	259.00
85	+275	20,275	110	260.90

Fig.IV-3-1 Longitudinal Profile of the Rimac River (3/9)



EXISTING RIVERBED ELEVATION (m)	DISTANCE (m)	ACCUMU DISTANCE (m)	STATION NO.	CROSS SECTION NO.
260.90	110	20,275	+275	Sec.85
267.00	500	20,775	+775	86
		21,000	STA.21	
274.80	500	21,275	+275	87
282.50	480	21,755	+755	88
		22,000	STA.22	
288.30	470	22,275	+225	89
298.90	490	22,715	+715	90
		23,000	STA.23	
306.40	490	23,205	+205	91
314.90	500	23,705	+705	92
		24,000	STA.24	
322.70	520	24,225	+225	93
330.80	510	24,735	+735	94
		25,000	STA.25	
339.00	520	25,255	+255	95
347.90	520	25,775	+775	96
		26,000	STA.26	
358.00	515	26,290	+290	97
368.00	500	26,790	+790	98
		27,000	STA.27	

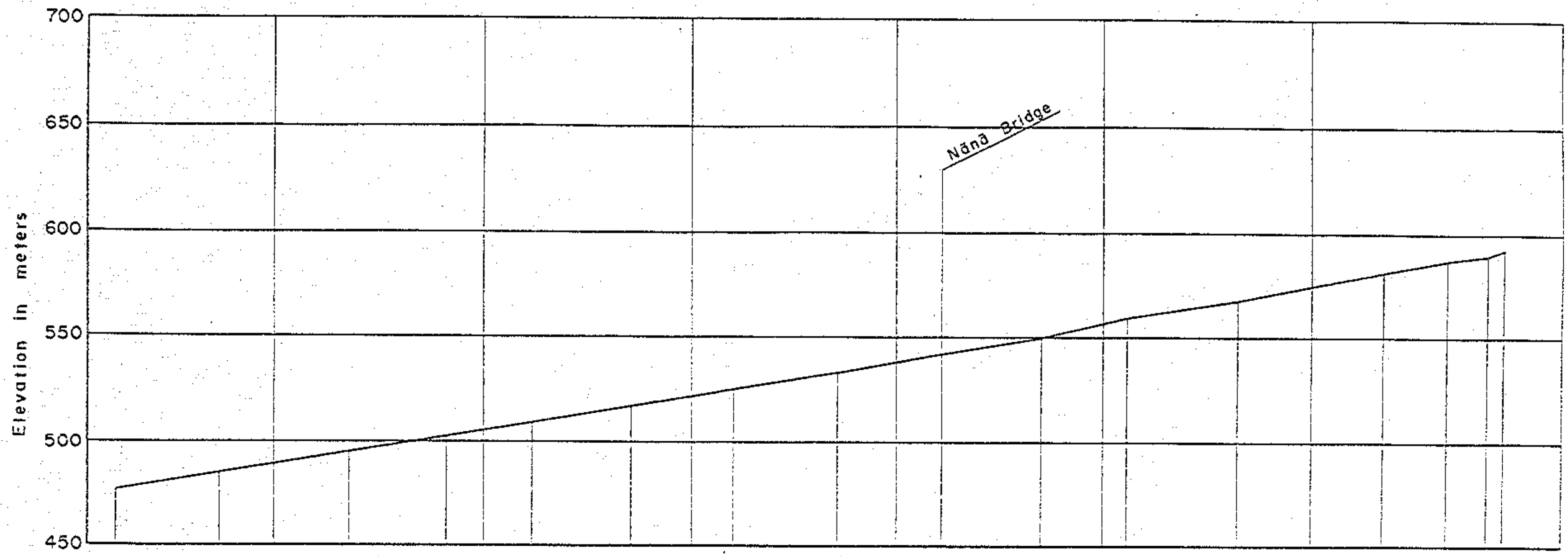
Fig.IV-3-1 Longitudinal Profile of the Rimac River (4/9)



EXISTING RIVERBED ELEVATION (m)	368.00		372.80	(376.06)	381.50		390.40	399.00		407.80	415.40
DISTANCE (m)	500		500	(180)	480		470	530		515	500
ACCUMU DISTANCE (m)	26,790	27,000	27,290	27,470	27,770	28,000	28,240	28,770	29,000	29,285	29,785
STATION NO.	+790	STA.27	+290	+470	+770	STA.28	+240	+770	STA.29	+285	+785
CROSS SECTION NO.	Sec.98		99		100		101	102		103	104

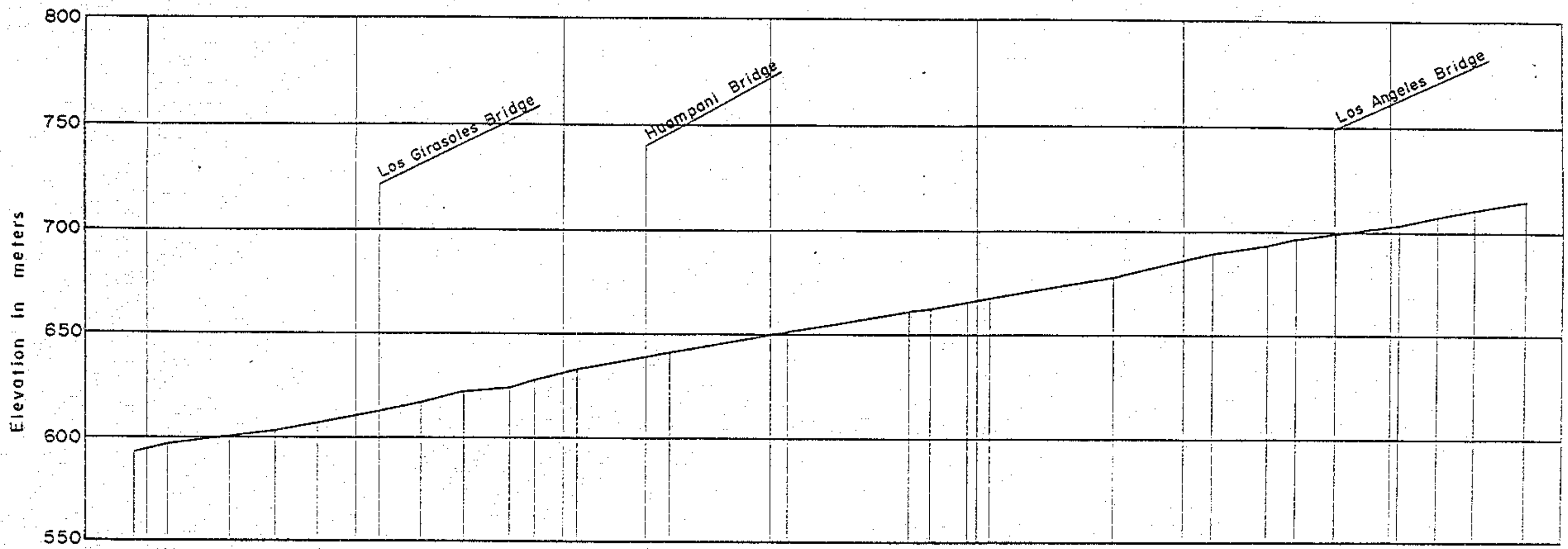
EXISTING RIVERBED ELEVATION (m)		424.70	433.40		442.60	450.80		458.50	467.70		476.80
DISTANCE (m)		490	490		500	490		520	500		500
ACCUMU DISTANCE (m)	30,000	30,275	30,765	31,000	31,265	31,755	32,000	32,275	32,775	33,000	33,275
STATION NO.	STA.30	+275	+765	STA.31	+265	+755	STA.32	+275	+775	STA.33	+275
CROSS SECTION NO.		105	106		107	108		109	110		111

Fig.IV-3-1 Longitudinal Profile of the Rimac River (5/9)



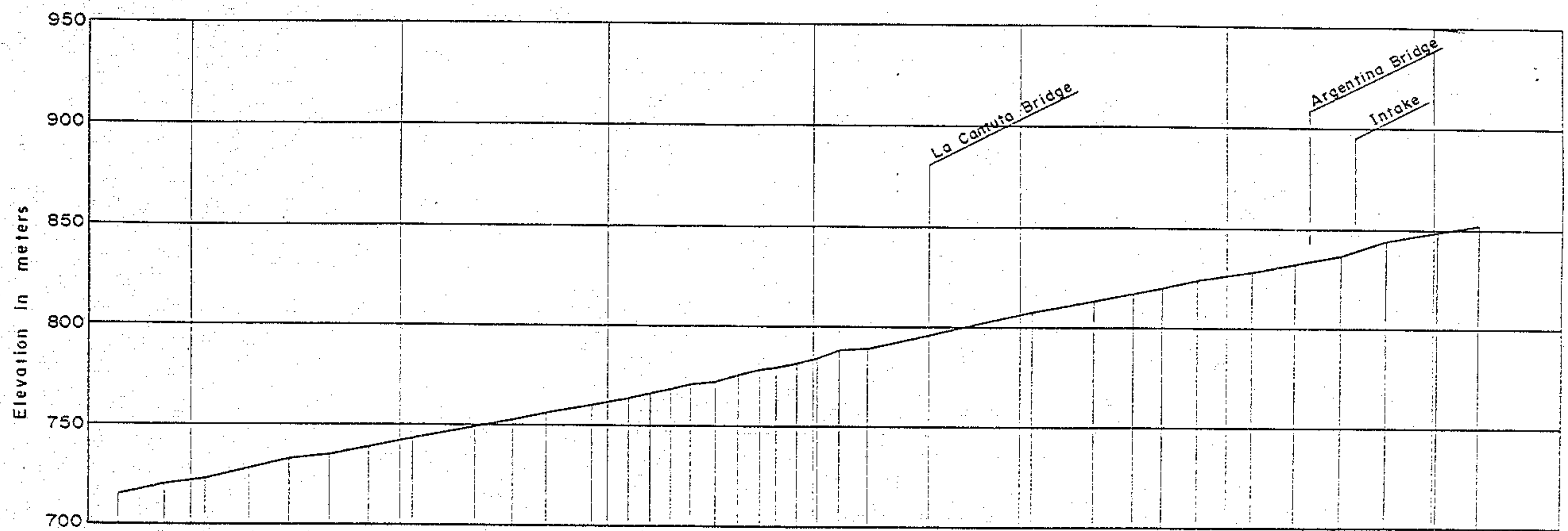
CROSS SECTION NO.	EXISTING RIVERBED ELEVATION (m)	DISTANCE (m)	ACCUMU. DISTANCE (m)	STATION NO.
Sec.111	476.80	500	33,275	+275
112	485.20	500	33,775	+775
			34,000	STA.34
113	495.10	610	34,395	+395
114	502.80	465	34,850	+850
			35,000	STA.35
115	509.00	410	35,260	+260
116	516.60	480	35,740	+740
			36,000	STA.36
117	525.50	500	36,240	+240
118	533.70	510	36,750	+750
			37,000	STA.37
119	542.50	510	37,260	+260
120	550.50	470	37,730	+730
			38,000	STA.38
121	560.00	450	38,180	+180
122	567.00	500	38,680	+680
			39,000	STA.39
123	582.50	700	39,380	+380
124	587.00	310	39,690	+690
125	590.00	200	39,890	+690
126	592.00	80	39,970	+970
			40,000	STA.40

Fig.IV-3-1 Longitudinal Profile of the Rimac River (6/9)



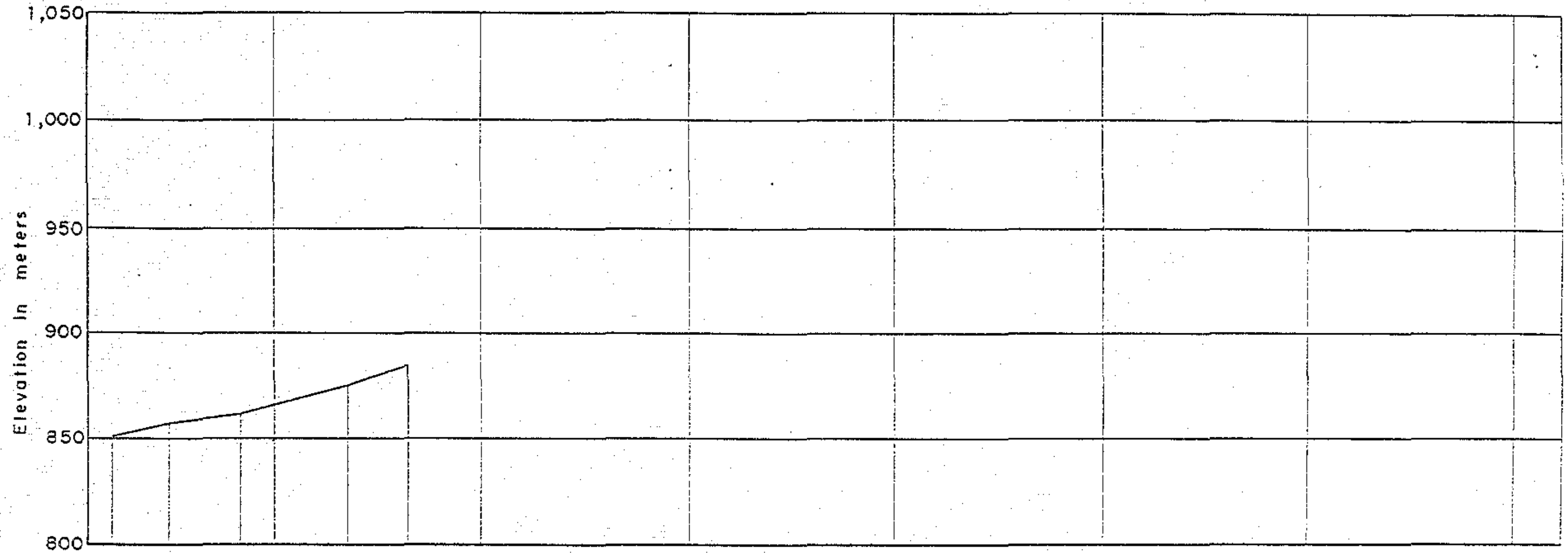
CROSS SECTION NO.	STATION NO.	ACCUMU DISTANCE (m)	DISTANCE (m)	EXISTING RIVERBED ELEVATION (m)
Sec.126	+970	39,970	80	593.00
	STA.40	40,000		
127	+130	40,130	160	596.00
128	+430	40,430	300	600.60
129	+650	40,650	220	603.50
130	+850	40,850	200	667.00
	STA.41	41,000		
131	+140	41,140	290	612.30
132	+340	41,340	200	617.45
133	+555	41,555	215	622.00
134	+775	41,775	220	623.80
135	+885	41,885	110	628.55
	STA.42	42,000		
136	+ 65	42,095	210	633.00
	+420	42,420	(325)	(638.84)
137	+540	42,540	445	641.00
	STA.43	43,000		
	+110	43,110	570	651.40
138	+700	43,700	590	661.00
139	+800	43,800	100	662.00
140	+985	43,985	185	665.50
	STA.44	44,000		
141	+ 85	44,085	100	667.50
142	+695	44,695	610	677.20
	STA.45	45,000		
143	+170	45,170	475	689.20
144	+430	45,430	260	693.00
145	+570	45,570	140	696.40
	+760	45,760	(190)	(698.43)
	STA.46	46,000		
146	+ 65	46,065	495	701.70
147	+250	46,250	185	707.60
	+440	46,440	190	711.20
148	+680	46,680	240	714.10

Fig.IV-3-1 Longitudinal Profile of the Rimac River (7/9)



CROSS SECTION NO.	STATION NO.	ACCUMU DISTANCE (m)	DISTANCE (m)	EXISTING RIVERBED ELEVATION (m)
Sec.148	(148) +680	46,680	240	714.10
149	+900	46,900	220	719.60
150	STA.47 + 95	47,000 47,095	195	722.00
151	+305	47,305	210	727.50
152	+500	47,500	195	731.80
153	+685	47,685	185	734.30
154	+880	47,880	195	737.30
155	STA.48 + 90	48,000 48,090	210	742.50
	+390	48,390	300	(748.50)
156	+565	48,565	175	751.50
157	+725	48,725	160	755.00
158	+950	48,950	225	759.00
159	STA.49	49,000		760.64
161	+125	49,125	175	762.50
163	+220	49,220	95	765.20
165	+321	49,321	101	766.90
167	+428	49,428	107	770.20
169	+547	49,547	119	771.85
171	+654	49,654	107	774.20
173	+759	49,759	105	777.70
175	+848	49,848	89	778.33
177	+943	49,943	95	780.38
179	STA.50 + 40	50,000 50,040	97	783.30
182	+154	50,154	114	787.30
185	+288	50,288	134	708.31
	+584	50,584	(296)	(795.20)
186	STA.51 + 98	51,000 51,098	810	807.00
187	+398	51,398	300	813.50
188	+583	51,583	185	817.00
189	+723	51,723	140	820.00
190	+893	51,893	170	824.00
	STA.52	52,000		
191	+153	52,153	26	828.00
	+363 +400	52,363 (52,400)	210 (280)	(833.20)
192	+583 (+653)	52,583 52,653	220 (70)	836.00 (838.40)
193	+803	52,803	220	843.50
194	STA.53 + 53	53,000 53,053	250	848.00
195	+253	53,253	200	851.50

Fig.IV-3-1 Longitudinal Profile of the Rimac River (8/9)



EXISTING RIVERBED ELEVATION (m)	851.50	857.00	861.80		87500	884.00					
DISTANCE (m)	200	210	340		520	290					
ACCUMU DISTANCE (m)	53,253	53,463	53,803	54,000	54,323	54,613					
STATION NO.	+253	+463	+803	STA.54	+323	+613	STA.55	STA.56	STA.57	STA.58	STA.59	STA.60
CROSS SECTION NO.	Sec.195	196	197		198	199					

Fig.IV-3-1 Longitudinal Profile of the Rimac River (9/9)

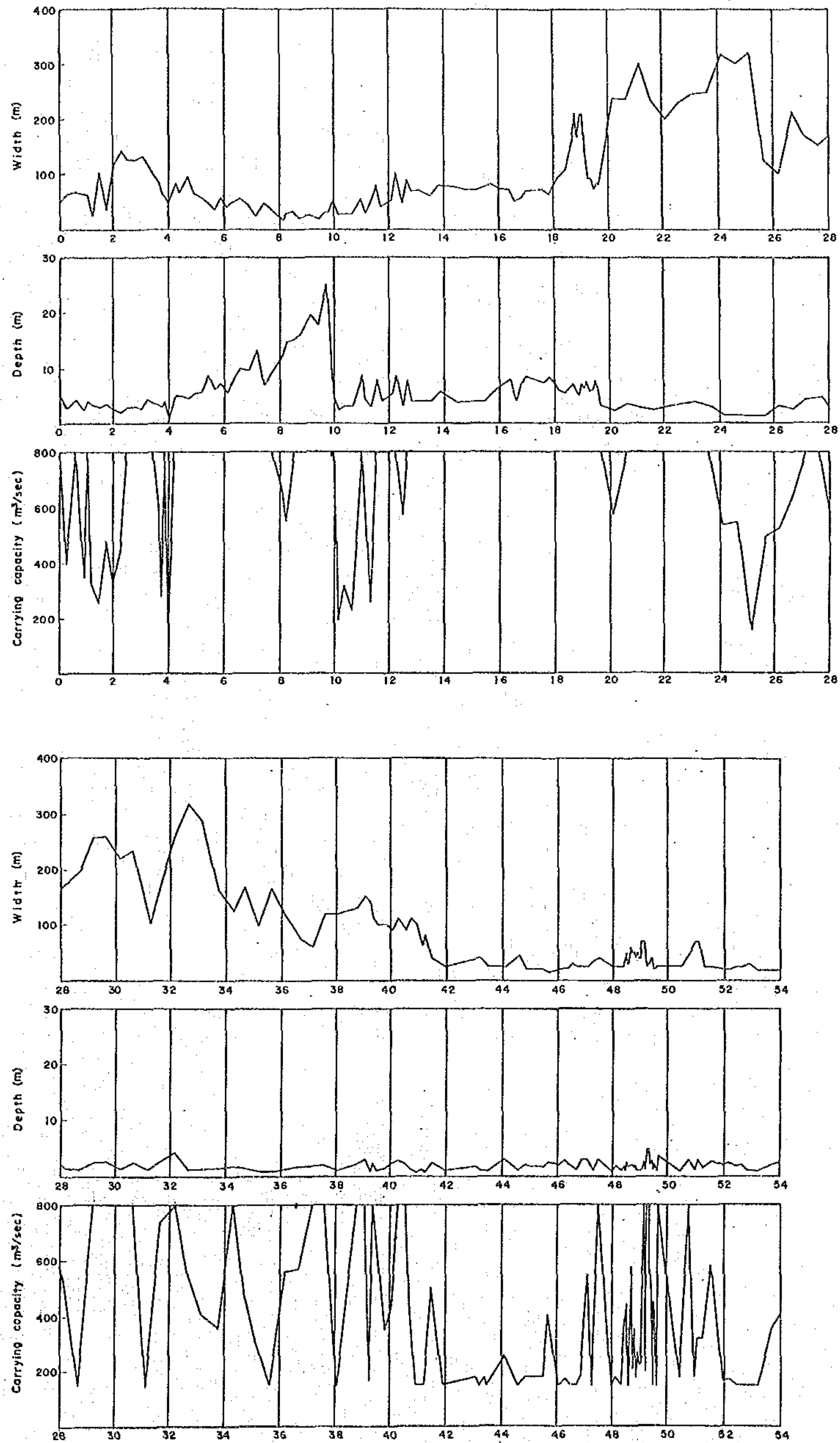


Fig.IV-3-2 Characteristics of Existing River Channel

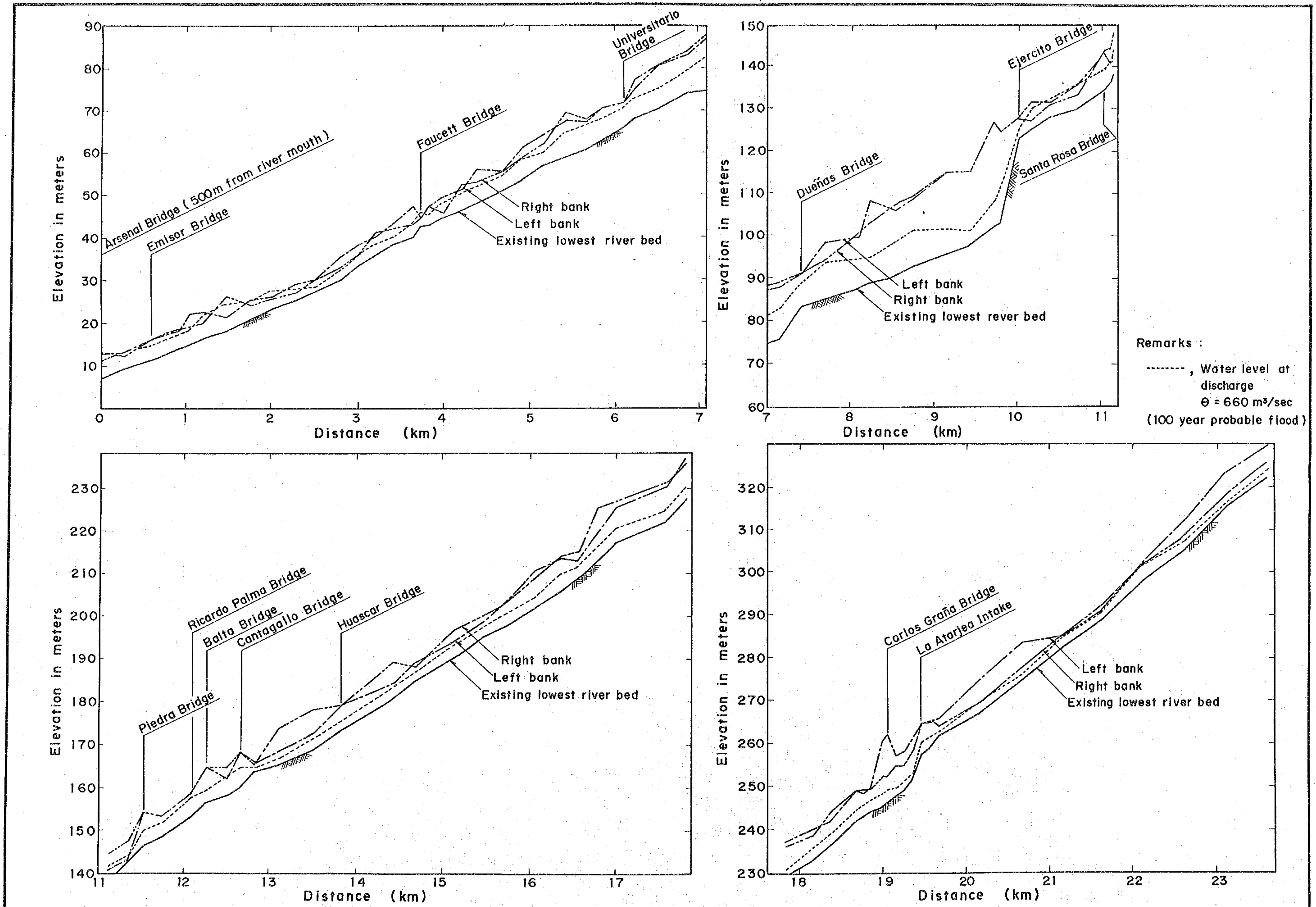


Fig. IV - 3 - 3 Longitudinal Profile of Water Level and River Channel (1/3)

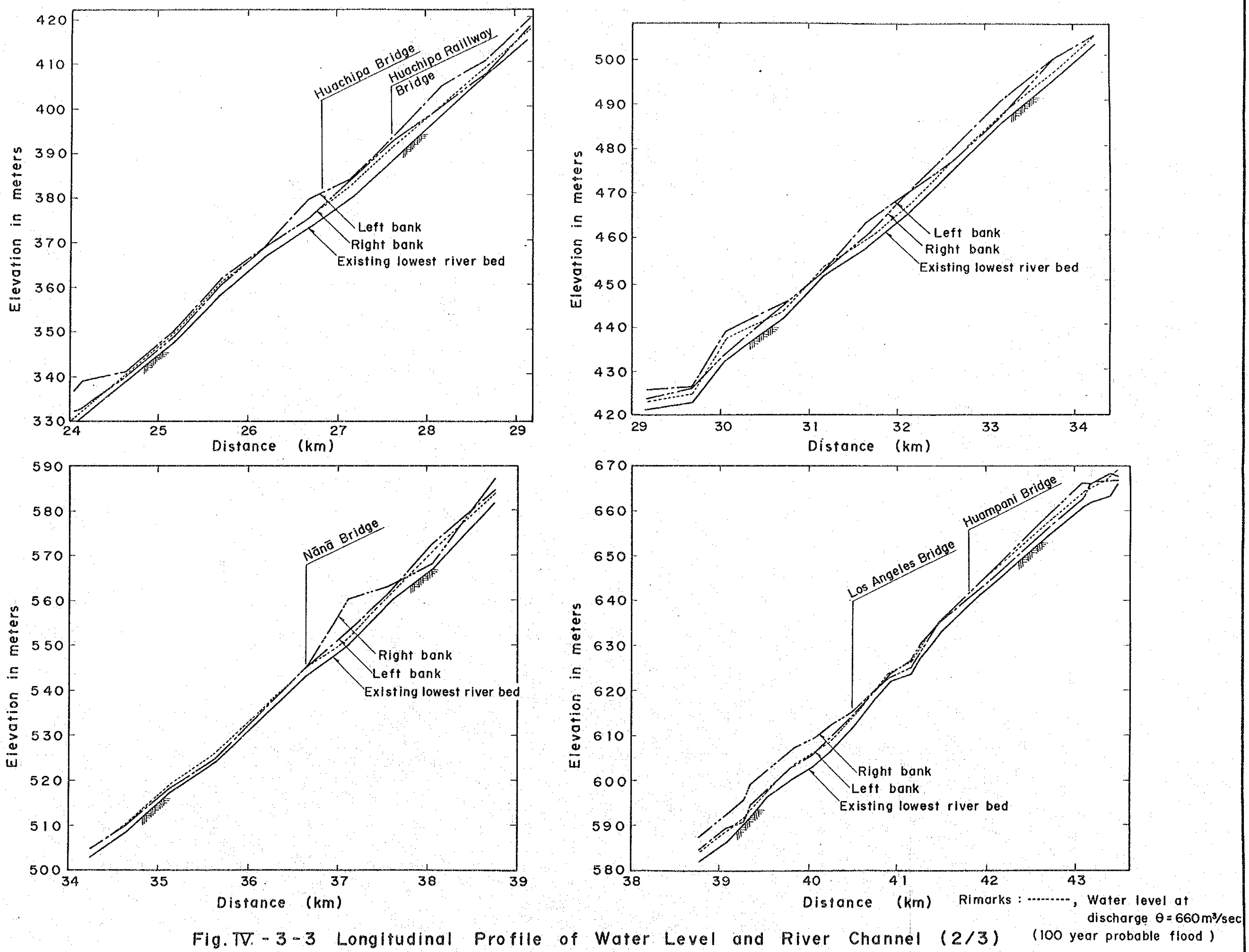
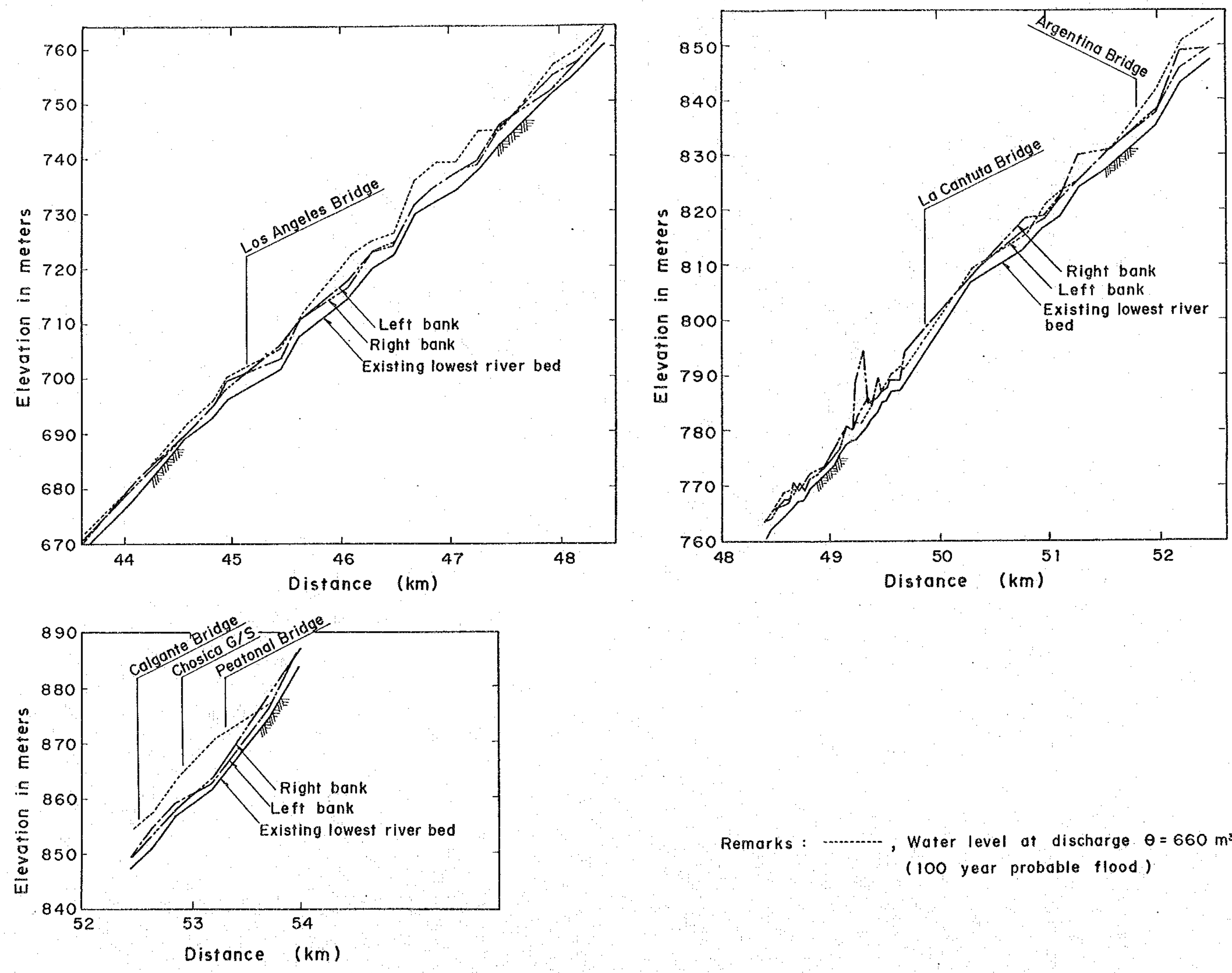
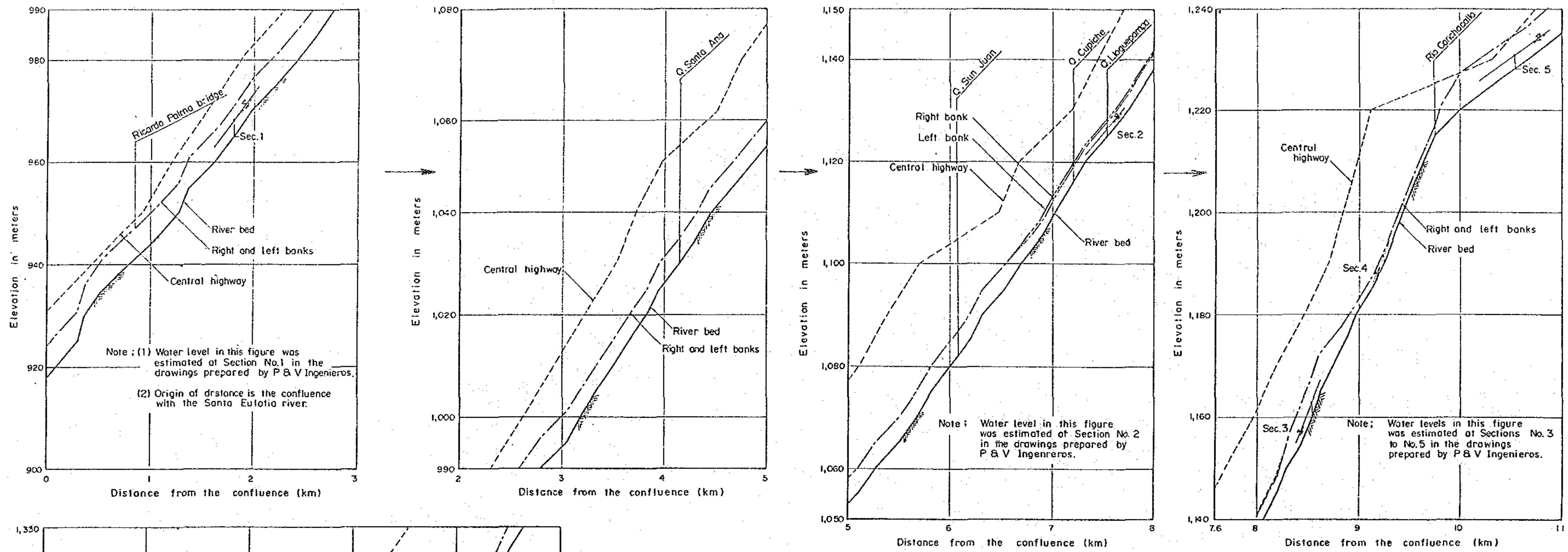


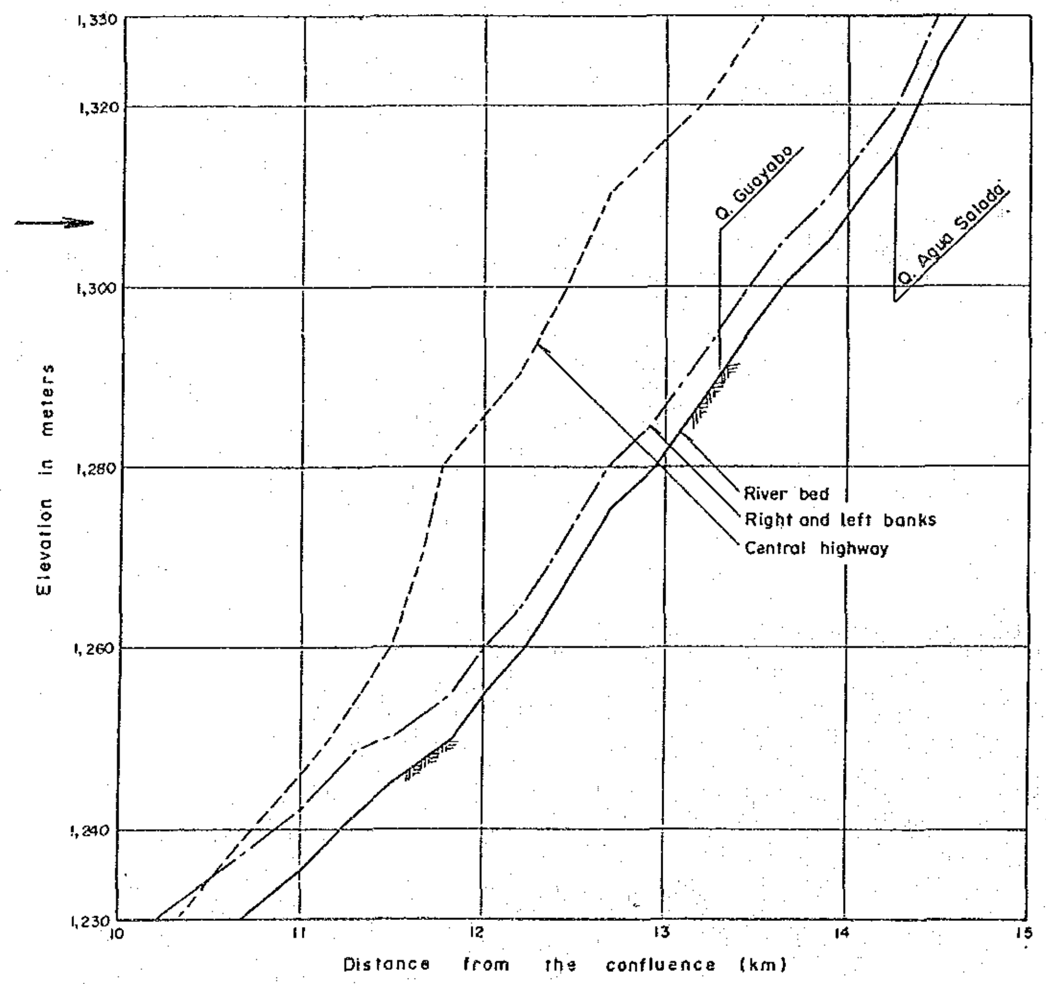
Fig. IV - 3 - 3 Longitudinal Profile of Water Level and River Channel (2/3)



Remarks : ---------- , Water level at discharge Θ = 660 m³/sec (100 year probable flood)

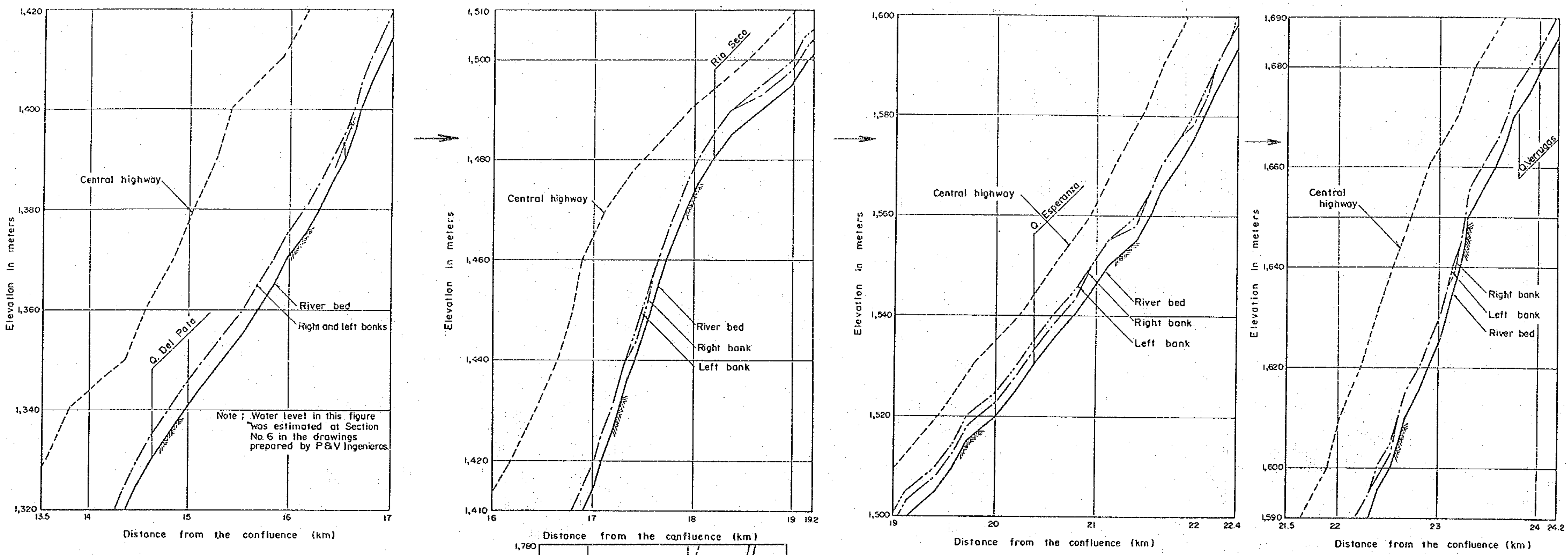
Fig. IV-3-3 Longitudinal Profile of Water Level and River Channel (3/3)

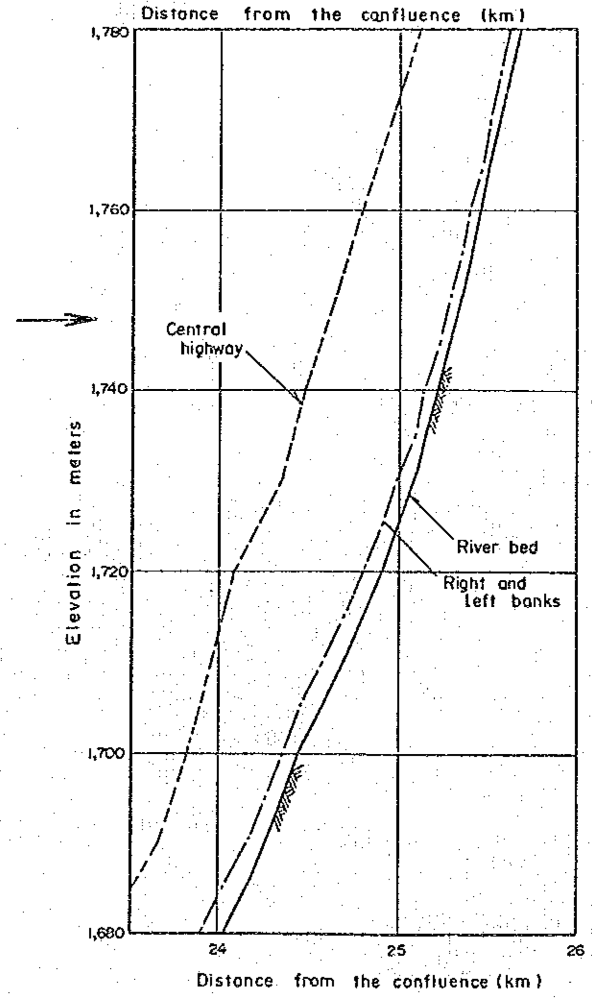


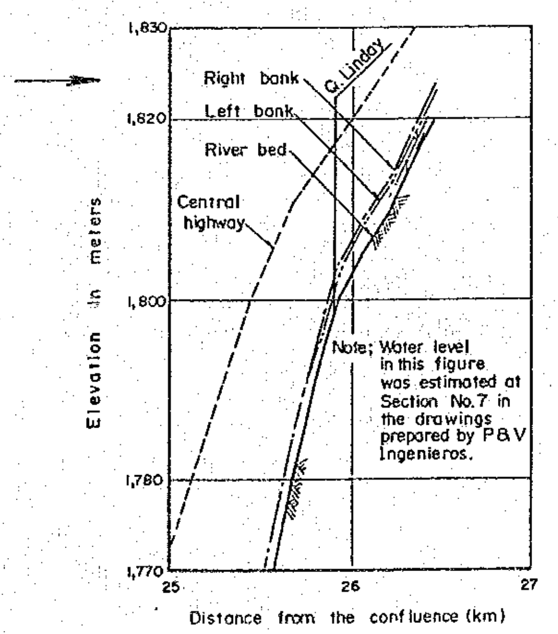


Note : Water levels mean 100 year probable flood peak discharge (310m3/sec)

Fig.IV-3-4 Longitudinal Profile from the Confluence to Songos (around 8km downstream of Matucana) (1/2)







Note : (1) Water levels mean 100 year probable flood peak discharge (310m3/sec)
(2) Topographical map of scale 1:5,000 is avaibable up to Songos

Fig.IV-3-4 Longitudinal Profile from the Confluence to Songos (around 8km downstream of Matucana) (2/2)

APPENDIX V

CONDITIONS OF RELATED STRUCTURES

Appendix V CONDITIONS OF RELATED STRUCTURES

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APPENDIX V
CONDITIONS OF RELATED STRUCTURES

1. GENERAL

There are various kind of structures in or along the Rimac river. They are classified generally as follows:

(a) Bridges (Road bridge and Railway bridge)
(b) Road
(c) Railway
(d) Levee
(e) Parapet wall
(f) Channel work (including revetment and 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) Others (groin, intake for water supply to refinery plant, pile of excavated materials, etc.)

The detailed survey for structures could not be carried out for this time as there are so many structures in the river basin. However, the inspection was carried out for major structures such as some main bridges, intake weir for city water supply, intake and outlet structures for power generation and levees in disaster areas. In addition, the data in respect of structures were collected from the government offices concerned. The general location of representative major structure is shown in Fig. VII-1-1.

In the following Sub-sections, the conditions and features of existing structures are to be described. Though the available data for each structure are different and generally insufficient, the following items are to be summarized for the major structures;

(a) Location
(b) Type/Kind
(c) Name
(d) Main dimensions
(e) Materials
(f) Present conditions
(g) Effect on disaster prevention
(h) Administrator
(i) Operation and maintenance method
(j) Others (function, using condition, etc.)

As the drawings of some major structures are obtained, the basic features are to be shown in the figures.

2. ROAD AND ROADWAY BRIDGE

In general, there are two major routes of road along the river as follows:

(a) Road along the Rimac river
(b) Road along the Sta. Eulalia river

The road, National Road No. 20, along the Rimac river is one of the most important trunk roads in Perú as it connects the metropolitan area of Lima-Callao and the eastern area of the mountain range which clearly separates the eastern area of Peru from the developed areas along the western coast. The traffic volume is comparatively large as many heavy big trucks run on the road even at night. This road comes to the highest point EL.4,840 m at Ticlio pass which is located about 131 Km from the center of Lima and then directs to the towns located in the eastern plateau such as La Oroya, Tarma, Junin and Huancayo. Most parts of this road in the Rimac river basin are paved with asphalt. There are some towns and villages along the road. They are Chaclacayo, Chosica, Cocachacla, Surco, Matucana, San Mateo, Chicla, etc.

On the other hand, the Road along the Sta. Eulalia river does not have much traffic. For example, when the Study Team carried out field reconnaissance from the upstream end of the Sta. Eulalia river to the downstream direction, the Study Team met only four or five cars until coming to the downstream end stretches of about 10 Km between Chosica and Callahuanca Power Station though the downstream stretch has more or less frequent traffic. The road is not yet paved except the section of downstream some kilometers and the width is only for one lane as the road is constructed on the steep slope of deep valley. It seems that the road along the Rimac river has very important function for the country of Peru, however, the road along the Sta. Eulalia is also important for the development of the upstream areas and for the access to the public structures such as the outlet of diversion tunnel from the Mantaro river and the structures for power generation. In addition, there are some villages along the river such as Laraos, San Juan de Iris, San Lorenzo de Huachupampa, San Pedro de Casta, etc. Though the road is connected to the towns of Marcapomachocha, Junin, etc. located on the high plateau, the road is important preferably for the inhabitants living along the Sta. Eulalia river and also for the supply of electric power to the Metropolitan area of Lima-Callao.

The routes of main roads along the main stream and typical section of road are respectively shown in Fig. V-2-1 and V-2-2.

In regard to the roadway bridge, there are so many bridges across the river as the main roads are running along the river. The number of road bridge crossing the main stream was counted as follows:

(A) Along the Rimac river

(a) River mouth - Atarjea intake: 12 nos.
(b) Atarjea - Chosica: 7 nos.
(c) Ricardo Palma - Ticlio: 15 nos.

Note: The number excludes the temporary or low grade bridges and also the bridge only for pedestrians.

(B) Along the Sta. Eulalia river: 6 nos.

There are also many bridges across the tributaries.

The location of bridges across the main stream are shown in Fig. VII-2-1 together with the route of main road. The main features of the major bridges are summarized in Table VII-2-1. Then the plan and section of a representative bridge are shown in Fig. V-2-3.

Besides the bridges, there are some other structures on the road. The following structures will be available for the disaster prevention against rock falling.

(a) Bypass of road
(b) Rockfall shed tunnel

There are some roads which will be available as the bypass at the time of traffic block, though the most of them would not be constructed only for the function of bypass.

There are two rockfall shed tunnels on the road between Surco and Matucana.

3. RAILWAY AND RAILWAY BRIDGE

There is a railway running along the Rímac river. This railway connects the metropolitan area of Lima-Callo and some central towns in the districts of high plateau. The railway has the branch at la Oroya. One of them directs to north-east and reach to Cerro de Pasco. Another way direct to south-east and reach to Huancayo. The total length of railway between Lima-Callao and Huancayo is approximately 346 Km. This railway is famous in the world as it passes the highest point at Ticlio pass of which elevation is about 4,840 m and the highest point of railway in the world. The Ticlio pass is located at about 171 Km from Lima by railway length and on the boundary line of the Rímac river basin.

The schematic plan and profile of railway line are shown in Fig. V-3-1.

On the way to Ticlio, the railway runs almost along the Rímac river and passes through some towns and villages. However, the railway is not so much used for the passengers. It is informed there is generally only one train for one way a day for the passengers. The railway is rather used for the transportation of minerals from mines located in the mountain areas.

The railway passes the main stream of the Rímac river at several portions where bridges are provided. The typical section of a representative railway bridge is shown in the Fig. V-3-2.

Further, the railway runs on the steep slope of mountains and crosses many tributaries where the bridge or tunnel is usually provided. However, it seems to be very fearful to take this train as the possibility of rockfall and debris flow to the railway will be not low, specially at the time of rainfall.

4. RIVER IMPROVEMENT WORKS

4.1 General

The structures for river improvement works are seen in a lot of places in and along the river. The river improvement works are generally classified as follows:

(a) Channel works
(b) Revetment
(c) Levee
(d) Parapet wall
(e) Ground sill
(f) Groin

The data of river improvement works are collected from some different offices and the field reconnaissance confirmed the actual conditions. As it is hard to confirm the small scale structures at this stage of study, the Study Team paid attention with much priority of investigation on the major structures which regulate, more or less, the river flow. The general locations of major river improvement works are shown in Fig. V-1-1.

4.2 Channel Works

The channel works which protect both river bed and bank slopes are seen in a stretch of Lima city and up and downstream portions of some weirs and bridges. The channel works are not seen in tributaries except some tributaries where the crossing points with railway or road are protected by the channel works. Generally it seems that the channel work are not taken so much as the measures for river improvement works.

4.3 Revetment

The typical type revetment which protects the slope of river bank is generally seen in the comparatively limited portions such as at up and down stream sides of bridges, at the confluence portion of tributaries to the main stream and at the stretches where the road runs along the stream and the height of road surface is low above the stream surface. In such portions, dry masonry revetment which simply piles up stones on the slope is generally used. In the stretch of about 18 Km from Chaclacayo, the revetment by gabion is seen on the left bank. The examples of gabion works in this stretch are shown in Fig. V-4-1.

4.4 Levee

It seems that the levee construction is one of the most commonly used method for the flood control. Most of the levees seen in the basin are made of stones, earths and sands which are obtained nearby places. The representative places of levee are listed below.

(a) Left bank at Matucana
(b) Left bank at Corcona
(c) Left bank at Ñaña district
(d) Right bank at Huachipa district

All the above levees were constructed after 1983 when the inundation due to flood happened in these areas. The typical sections of representative levees are shown in Fig. V-4-2.

4.5 Parapet Wall

The parapet wall are generally used in town areas though the partial wall are constructed at many places along the main streams. The representative places of parapet wall are listed below.

(a) San Mateo town
(b) Matucana town
(c) Chosica town
(d) Chaclacayo town
(e) Lima city
(f) Callao city

The parapet wall is generally constructed in the areas where the space for levee can hardly be found. Most of the parapet wall are made of reinforced concrete. However, it seems that the foundation of wall at some portions is not protected well. As the representative feature, the typical sections of parapet wall are shown in Fig. V-4-3.

4.6 Ground Sill

The ground sill is seen in some places. However, they are generally constructed as a part of structures such as irrigation intake, city water supply intake and intake or outlet for power generation water supply. It seems that the ground sill seen in the river channel of Lima city was also constructed for the protection of bridge foundation, though it is not yet confirmed.

4.7 Groin

The series of groin in large scale is not seen in the river. However, during the field reconnaissance the Study Team found some groins provided in the curved portion of river where the road runs along the river side and in the comparatively gentle and wide river stretch with the houses beside the river. The groins are constructed by wet-masonry, gabion or concrete.

5. INTAKE WEIR FOR CITY WATER SUPPLY

As the most representative structure in the river, there is a gated intake weir for city water supply in Atarjea district which is located at about 21 Km from the river mouth. The infiltration facilities are located beside the weir. The weir is equipped with seven (7) tenter gates. Five (5) of them are 10 m wide and 4 m high and two (2) of them are 5 m wide and 4 m high. The water is taken from the upstream pond stored by the gate operation. No function against flood is expected by this intake. The plan and typical section are shown in Fig. V-5-1.

6. INTAKE STRUCTURE FOR IRRIGATION WATER SUPPLY

On the both sides of the Rímac river, the agricultural lands are developed. As the rainfall is very limited and short for agriculture specially in the downstream stretches from Chosica district, the intake of water from the river is important. There are more than twenty intakes for irrigation water supply in the Rímac river. Among them, the downstream twenty (20) intakes are administrated by Ministry of Agriculture. The total maximum intake discharge of the twenty intakes is about 18 m^3/s for approximately 19,400 ha in total irrigation area.

The location of irrigation intake is shown in Fig. V-6-1 and the basic design of a representative intake is shown in Fig. V-6-2.

7. INTAKE AND OUTLET STRUCTURES FOR POWER GENERATION

There are 5 hydro-electric power stations in the Rímac river basin. Three (3) stations are located in the Rímac river basin and two (2) stations in the Sta. Eulalia river. Each power station takes the water from the intake structure located in the upstream stretch through the waterway tunnel. As the river gradient is very steep in the mountain area, it is possible to get high head for the power generation. The present power stations are listed as follows:

(A) The Rímac river

- (a) Pable Boner - Matucana (120,000 kW)
- (b) Carosio - Moyopampa (63,000 kW)
- (c) Bianchini - Huampaní (30,000 kW)

(B) The Sta. Eulalia river

- (a) Huinco (260,000 kW)
- (b) Carosio - Callahuanca (67,000 kW)

The location and system of hydro-electric power at present condition is shown in Fig. V-7-1. The intake and outlet structures are located in or beside the river. The main features of a intake , Sheque dam and Huinco dam are respectively shown in Fig. V-7-2, 3 and 4.

It seems that the Rímac river as well as the Sta. Eulalia river are utilized much for the power generation. And consequently, ELECTROLIMA practically control according to the electric demand in the Metropolitan area.

8. OTHER STRUCTURES

There is a weir with low height less than 1 m at about 150 m upstream of Huachipa bridge. The river width at this portion is approximately 100 m. The infiltration facilities with ponds are located at right bank of the weir. The intake structure with two gates located at the right end of weir controls the water level for intake.

The water after infiltration is transported to the refinery plant for Cajamarquilla mine.

At the upstream of the Santa Eulalia river, there is the outlet of tunnel from the Mantaro river, the tributary of the Amazon river. At present, it is informed that the discharge is about 4 m^3/sec, however, it will be increased up to 16 m^3/sec in the future if the Mantaro transfer project is completed.

The present and future system to transfer the water from the Mantaro river to the Rímac river basin is schematically shown in Fig. V-8-1.

There are many natural lakes in the valley of high mountain at EL.4500-5000 m. Some of these lakes have outlet facilities with gate(s) which control(s) the water level and outlet discharge.

There are waterway tunnels in the main stream as well as in the tributaries in the upstream stretches. In the stretch between Matucana and San Mateo, there are two tunnels from which very rapid flow is flushed out. In the very narrow valley at Autisha bridge in the Santa Eulalia river, there is tunnel passing below the valley. In addition, there are some tributaries of which water is guided by tunnel or culvert to the main stream. Usually the mining company constructs such tunnel in tributary.

There are big piles of excavated materials from mine at Qda. Sta. Rosa and Qda. Tacpin located at the upstream stretch of the Rímac river. The piles look like high earth dam and almost completely bury the valley of the tributaries. There are water way tunnels to divert the water from the tributary to the main stream.

It is not a structure, however, the piles of excavated materials from road construction are seen in the middle reach of the Rímac river, specially in the stretch of Surco and Matucana. In the downstream stretch, specially in the city area of Lima, piles of earth and rubbish are seen in the river channel. The flow capacity in such stretches will be much reduced and the sedimentation from the pile will rises the river bed height in the downstream stretches.

For the additional references, typical sections of revetment and retaining wall used at some places in the basin are respectively shown in Fig. V-8-2 and 3.

Tables

TABLE V-2-1 MAIN FEATURES OF MAJOR ROADWAY BRIDGES (1/2)

No.	Name of bridge	Location (Km)	Length (m)	Width (m)	Height from a girder to riverbed	Type	Year of construction
1.	Arsenal	0.59	50.0	8.0	-	-	-
2.	Emisor	1.81	50.0	6.0	-	C.G.	-
3.	Elmer Faucett	4.94	55.0	16.0	-	C.G.	-
4.	Universitario	7.31	70.0	20.0	2.5	C.G.	1966
5.	Dueñas	8.65	71.8	20.6	4.0	C.G.	1965
6.	Ejercito	11.16	92.5	26.8	6.5	C.B.G.	1964
7.	Santa Rosa	12.22	140.0	22.6	2.8	C.G.	-
8.	Piedra	12.74	50.0	12.0	-	-	-
9.	Abancay	13.30	55.0	25.0	-	C.G.	-
10.	Balta	13.45	90.0	12.0	-	C.G.	-
11.	Cantagallo	13.87	90.0	20.2	7.5	C.G.	-
12.	Huascar	15.32	198.0	32.8	7.0	C.B.G.	-
13.	Carlos Graña	20.20	220.0	35.0	4.5	C.G.	1985
14.	Huachipa	28.03	78.0	9.2	3.0	C.G.	-
15.	Ñaña	37.82	82.5	8.0	3.5	.G.	-
16.	Los Girasoles	41.73	126.5	3.9	2.0	C.G.	-
17.	Huanpani	42.98	47.0	4.0	2.0	T.	-
18.	Los Angeles	46.30	63.0	11.6	10.0	C.A.	-
19.	La Cantuta	51.23	41.0	4.0	2.5	C.G.	-
20.	Argen	52.99	23.0	4.0	-	C.G.	-
21.	Ricado Palma	57.71	60.0	7.2	10.0	C.A.	1950
22.	Baritina*	69.16	26.5	4.0	4.0	C.G.	-
23.	Agua Salada	71.49	40.0	9.6	6.5	C.G.	1984
24.	Esperanza	77.44	50.0	4.9	7.5	C.G.	1984
25.	La Cascada	78.84	30.0	9.4	12.0	C.G.	1984
26.	Verrugas	80.44	20.0	4.9	8.0	C.G.	1984
27.	San Juan	88.6	48.0	3.7	6.0	T.	-

(to be continued)

TABLE V-2-1 MAIN FEATURES OF MAJOR ROADWAY BRIDGES (2/2)

No.	Name of bridge	Location (Km)	Length (m)	Width (m)	Height from a girder to riverbed	Type	Year of construction
28.	Huaripachi	93.2	38.8	9.7	4.0	C.G.	1963
29.	Llican	94.5	30.0	9.7	7.5	C.G.	1960
30.	Chacahuaro	98.8	20.2	10.8	8.0	C.G.	1960
31.	Tamboraque No.3	107.9	45.0	8.8	12.5	C.G	1959
32.	Rio Blanco	116.5	12.0	9.0	7.0	C.G.	1958
33.	Young Bazo	116.6	19.2	9.4	10.0	C.G.	1964
34.	Anche	116.9	24.5	11.3	5.0	C.G.	1959
35.	Chicla No.1	121.8	20.5	9.5	7.5	C.G.	1954
36.	Chicla No.2	122.6	18.2	10.4	6.0	C.G.	1957
37.	Bellavista No.1	124.3	14.0	11.8	5.0	C.G.	1958
38.	Bellavista No.2	124.5	14.8	9.3	4.8	C.G.	1958
39.	Tablachaca	128.1	14.0	11.6	4.5	C.G.	1959
40.	Chinchan	136.2	14.6	11.4	4.5	C.G.	1960
	(Along the Santa Eulalia river)						
41.	Palomar	57.3	20.0	6.0	-	-	-
42.	Parca	60.1	20.0	5.0	-	-	-
43.	Juan Carossio	65.4	24.0	6.0	-	-	-
44.	Santa Rosa	67.0	20.0	8.0	-	-	-
45.	Verde	72.7	20.0	4.0	-	-	-
46.	Huinco	75.2	15.0	6.0	-	-	-

Note: C.A.: Concrete Arch
C.C.: Concrete Girder
C.B.G.: Concrete Box Girder
T. : Truss
* : Private Bridge

Figures

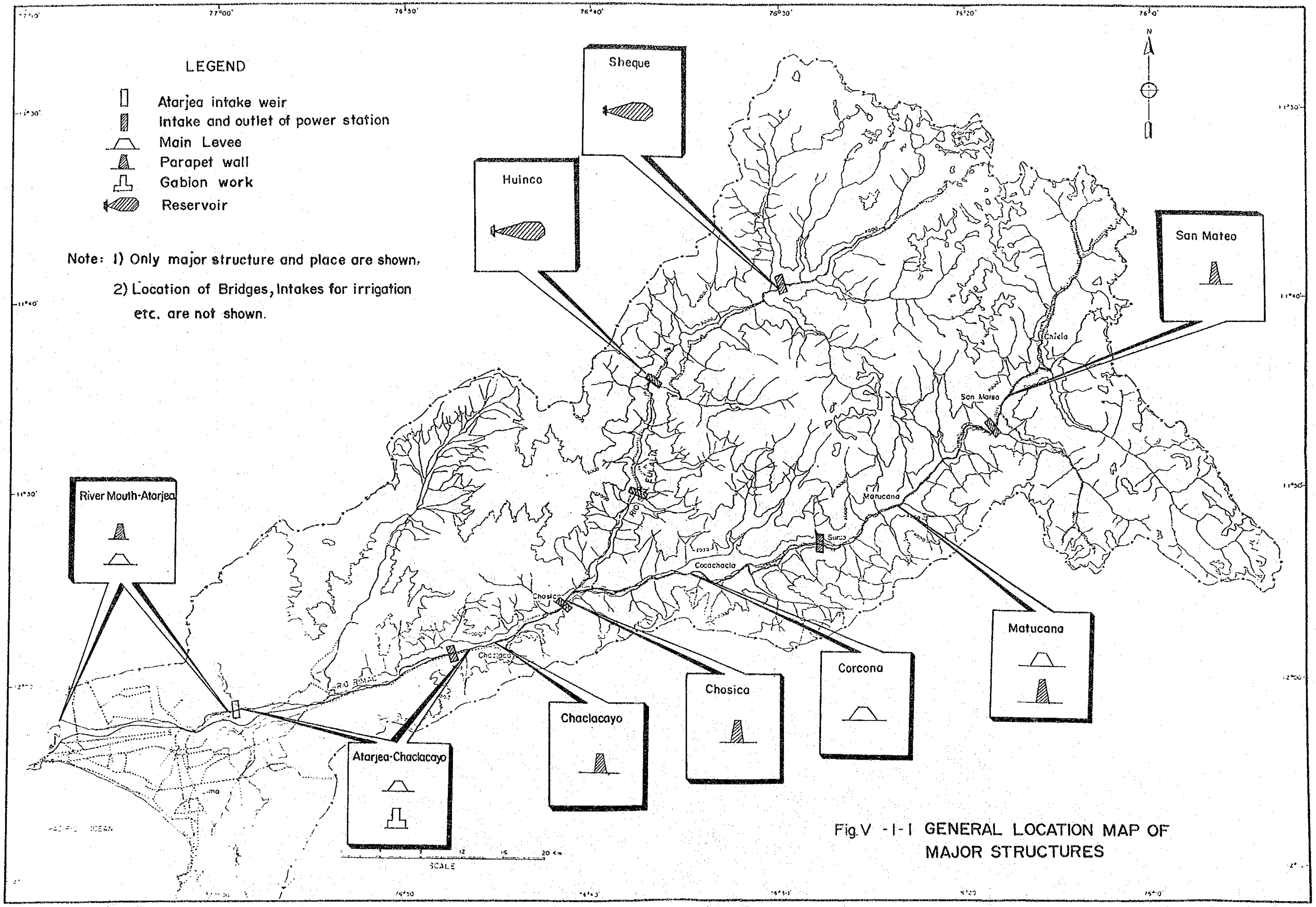


Fig.V -1-1 GENERAL LOCATION MAP OF MAJOR STRUCTURES

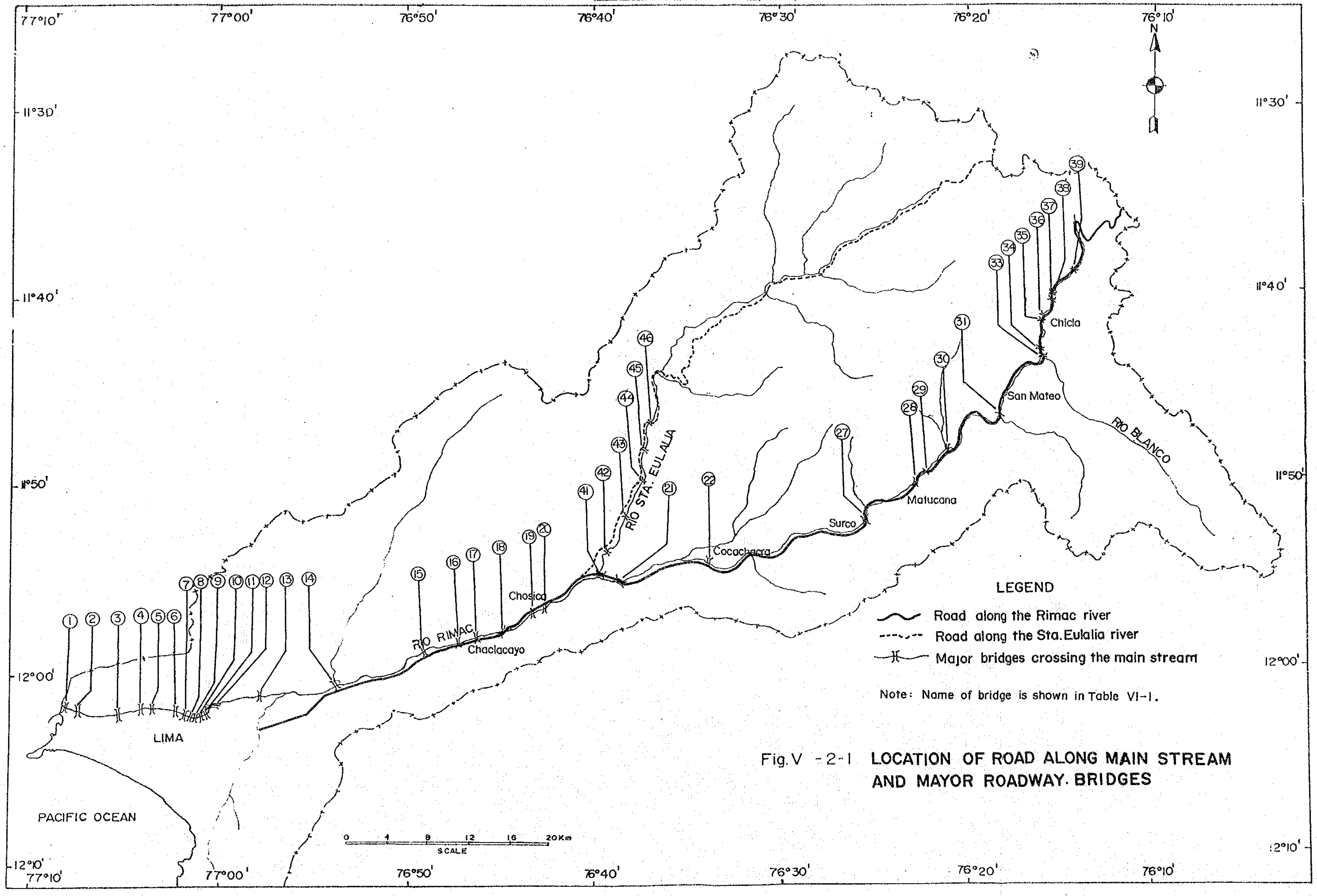
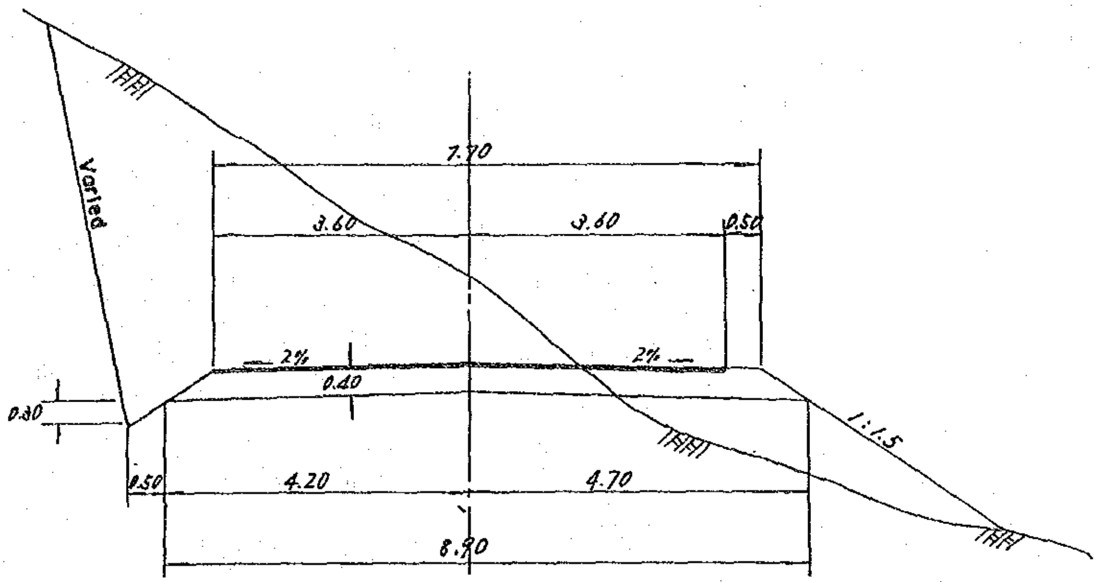
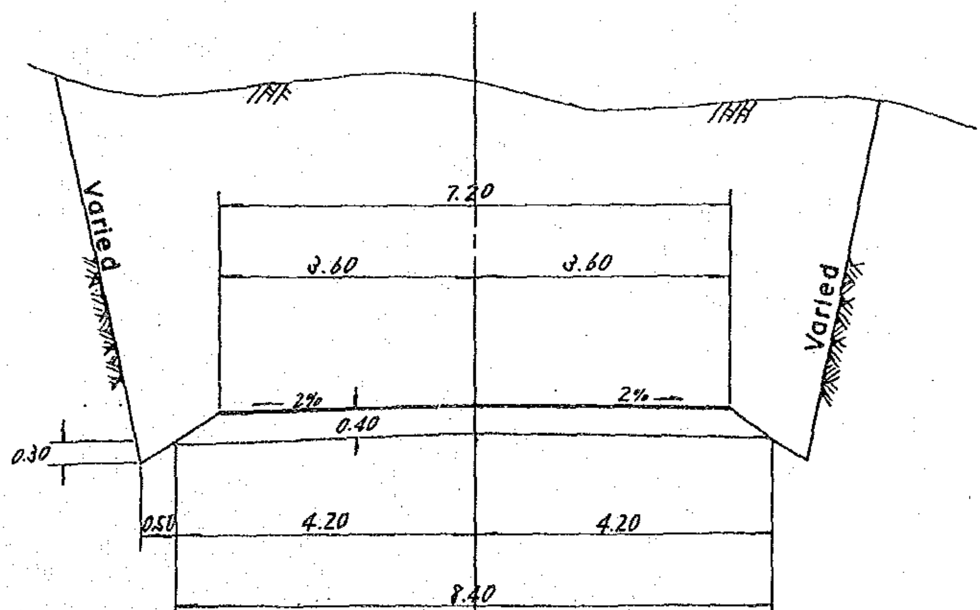


Fig. V -2-1 LOCATION OF ROAD ALONG MAIN STREAM AND MAYOR ROADWAY BRIDGES



TIPICAL SECTION , TYPE 'A'



TIPICAL SECTION , TYPE 'B'

Fig.V -2-2 TIPICAL SECTIONS OF ROADWAY

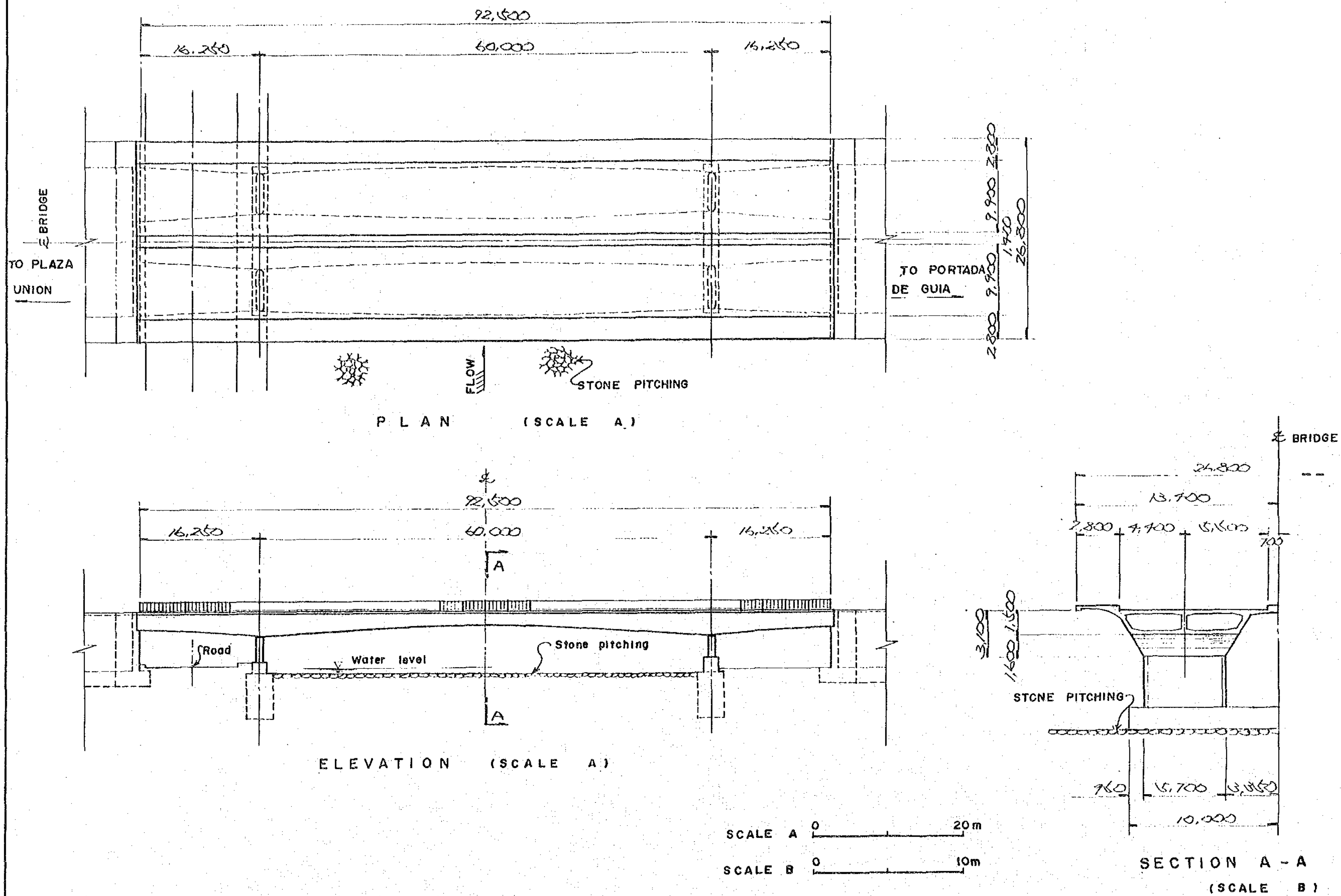


Fig.V -2-3 PLAN, ELEVATION AND CROSS SECTION ROADWAY BRIDGE (Ejercito Bridge)

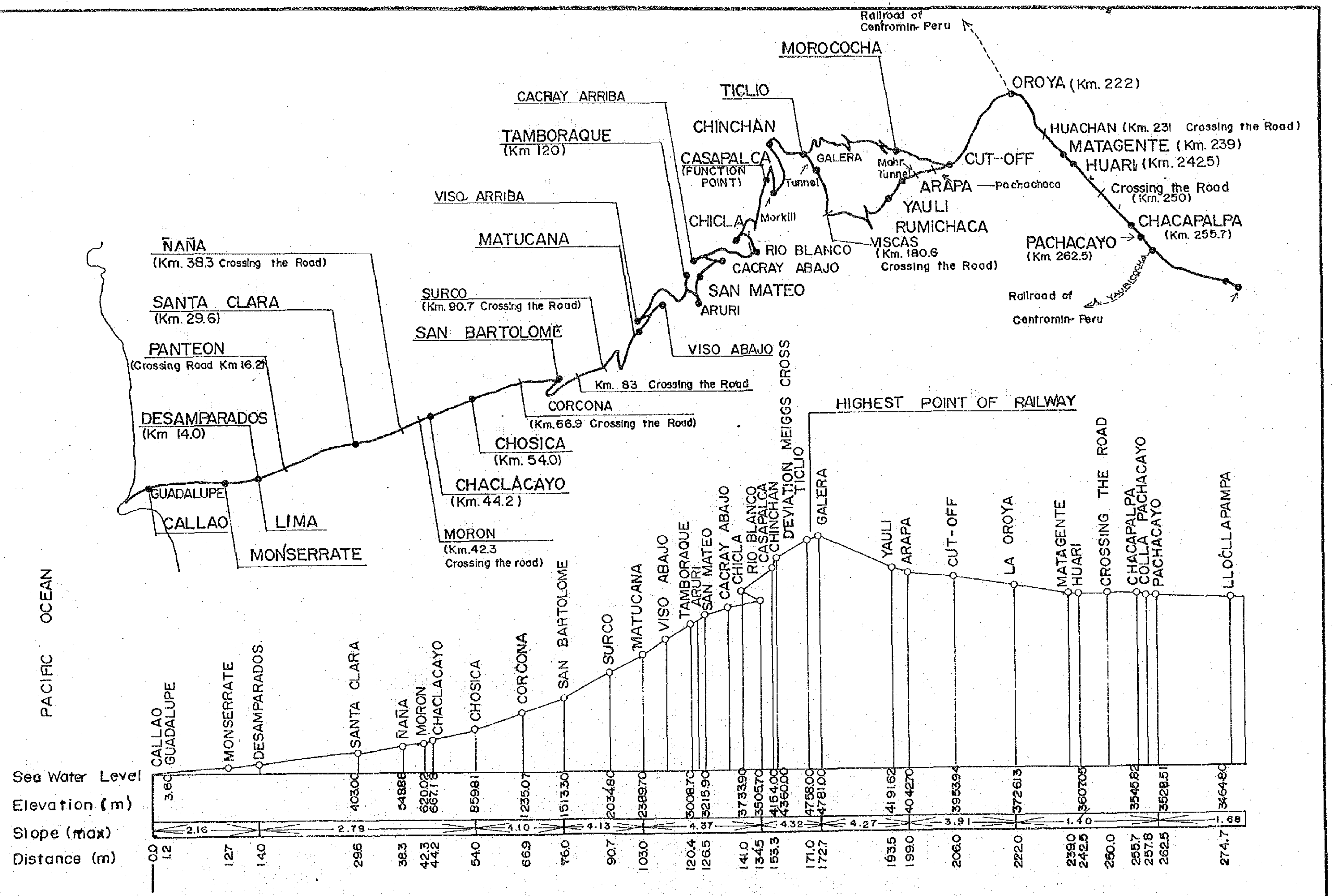


Fig.V.-3-1 PLAN AND PROFILE OF RAILWAY

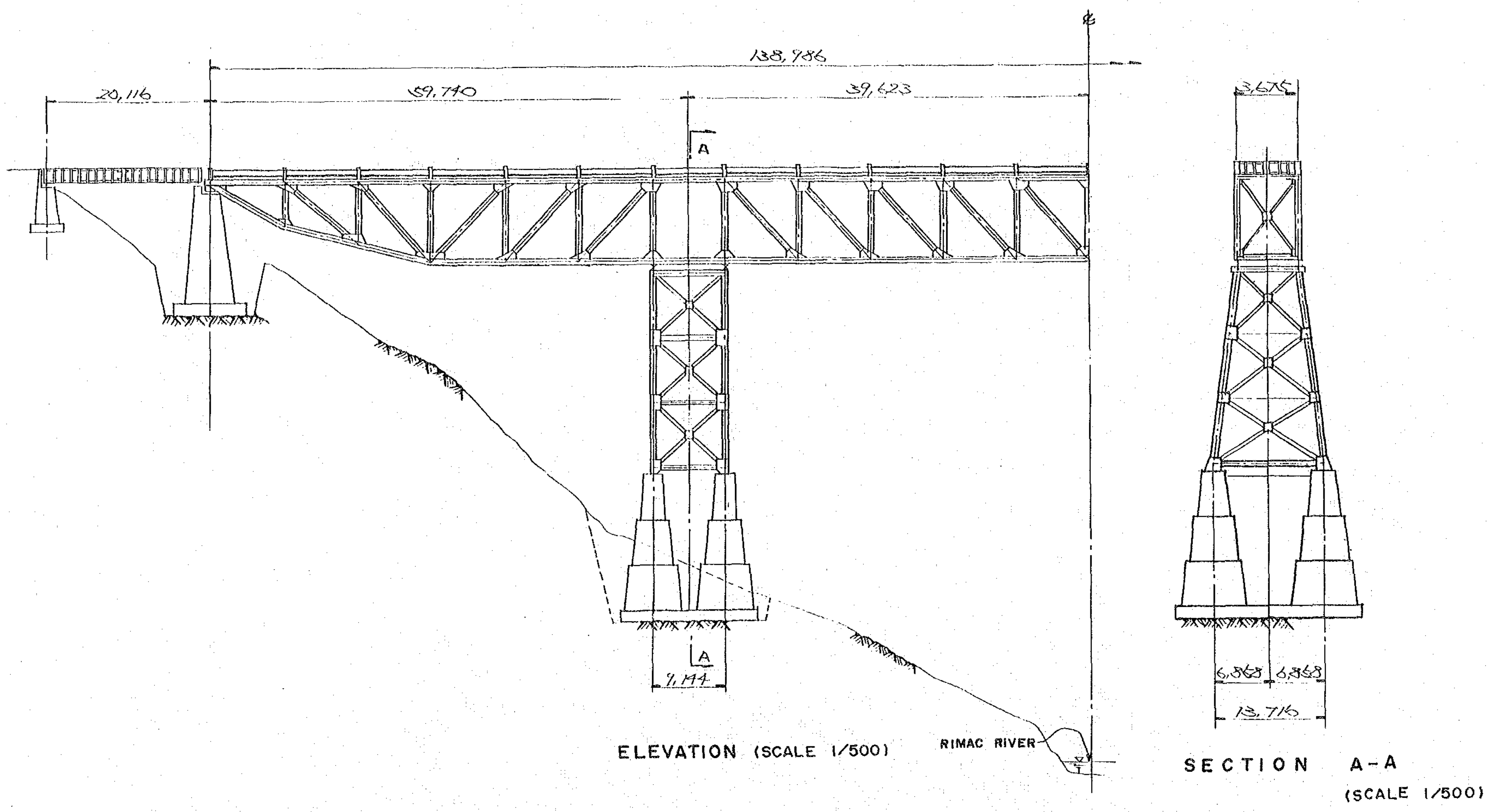


Fig. V-3-2 ELEVATION AND SECTION OF RAILWAY BRIDGE (Carrion Bridge)

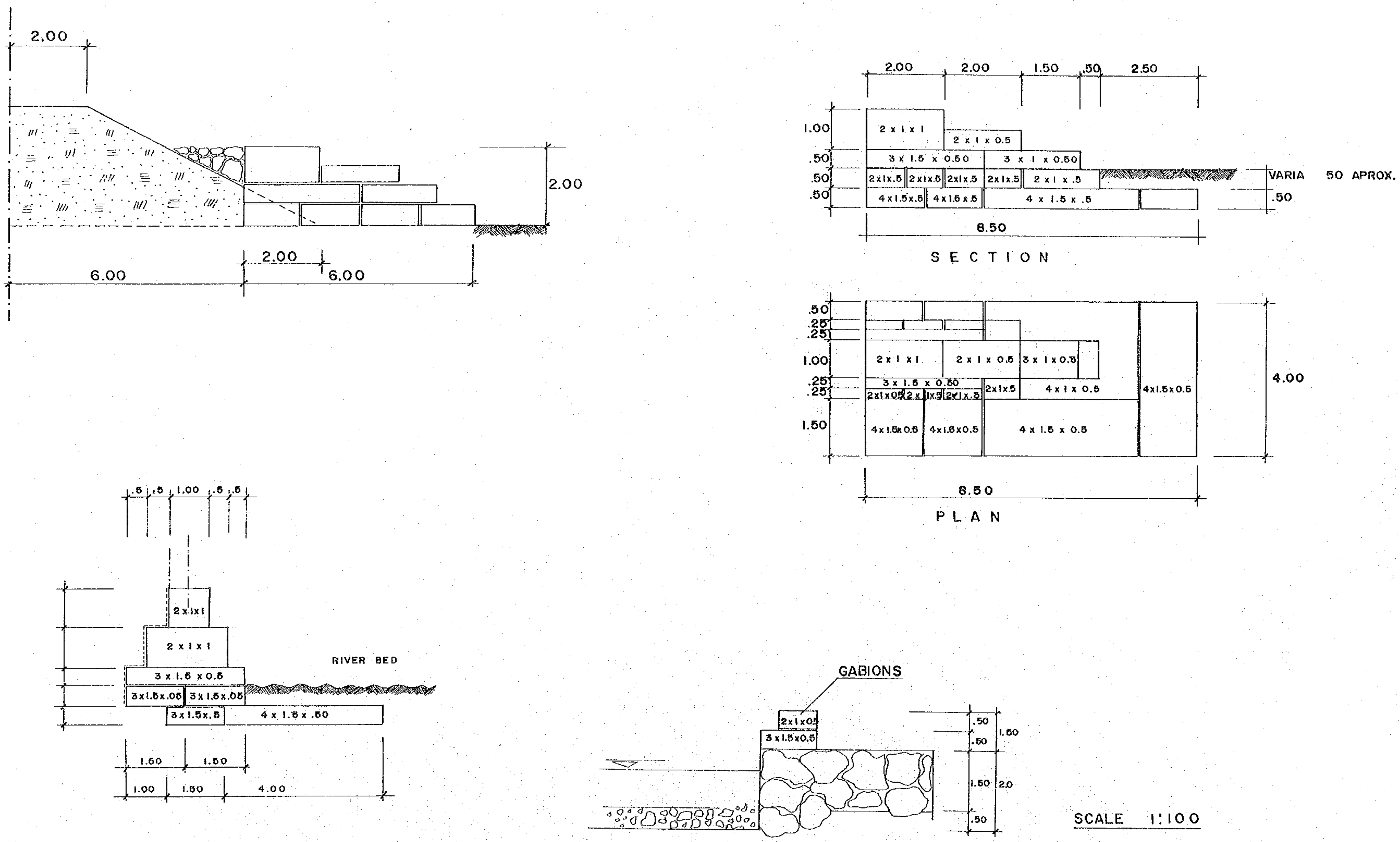
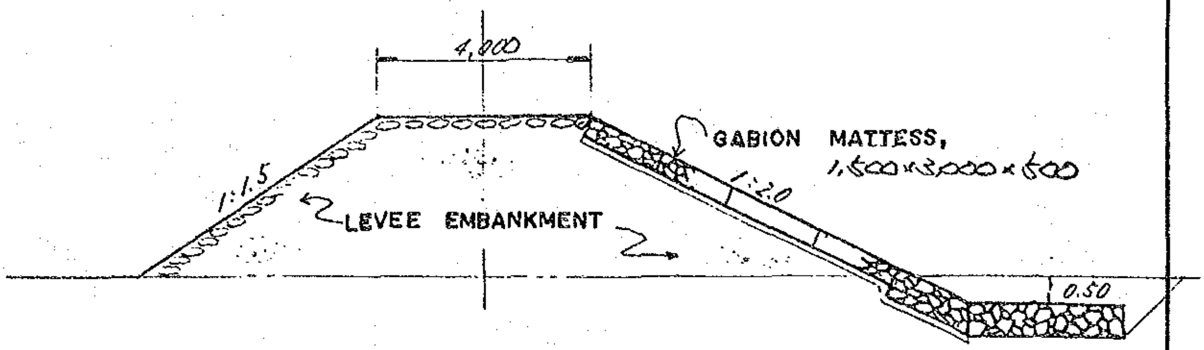


Fig.V-4-1 EXAMPLES OF GABION WORKS



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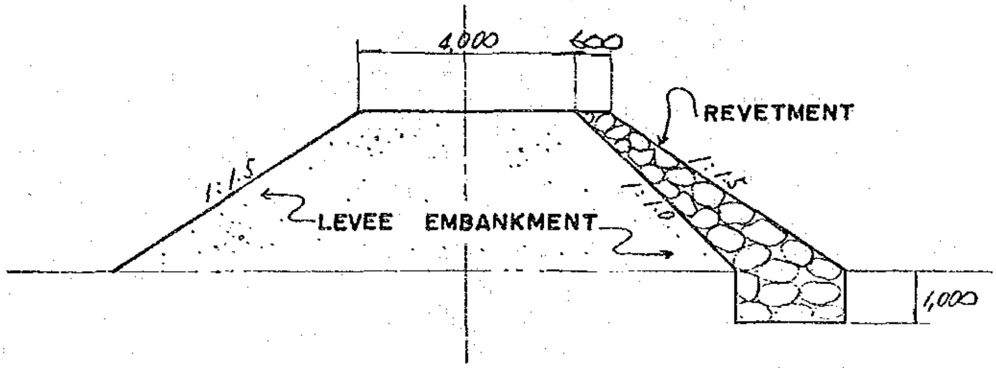
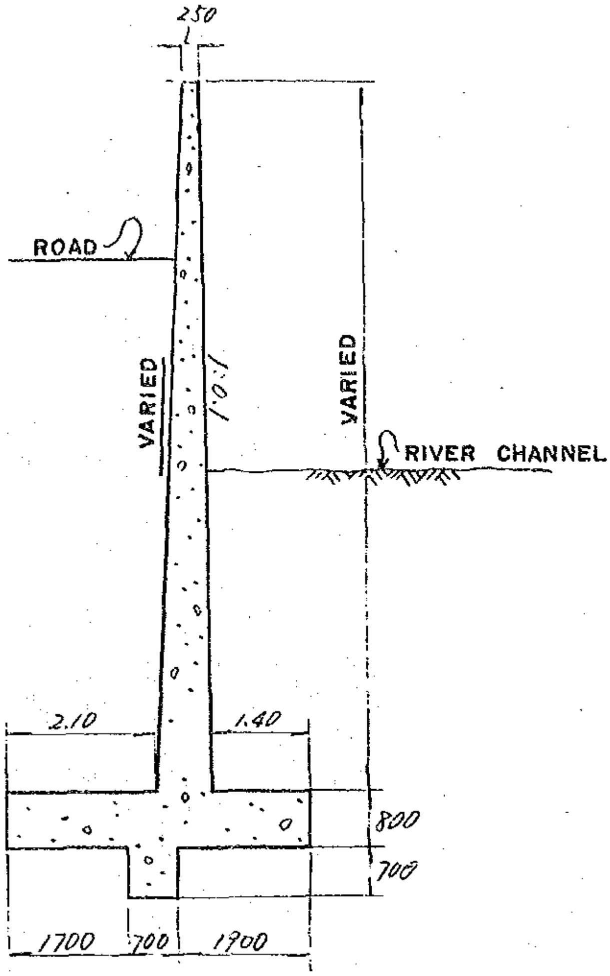
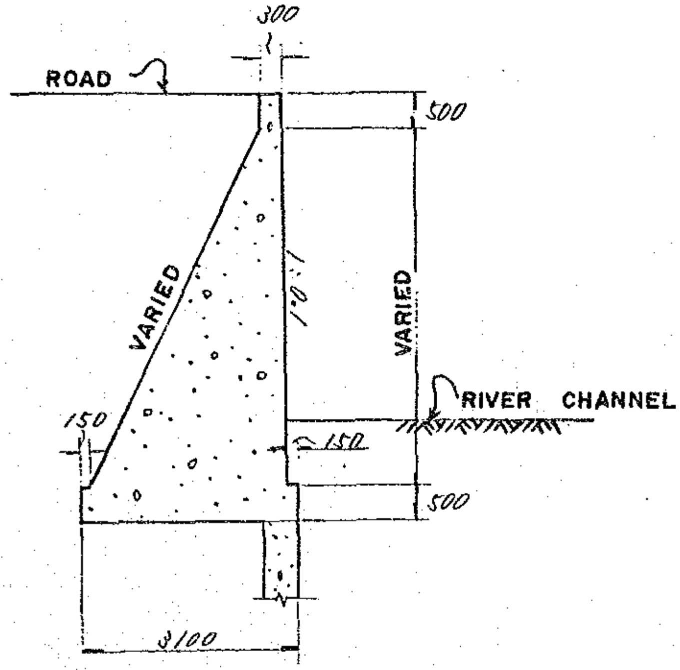


TIPICAL SECTION, TYPE 'B'

Fig.V-4-2 TIPICAL SECTIONS OF LEVEE



TIPICAL SECTION , TYPE A



TIPICAL SECTION , TYPE B

Fig.V -4-3 TIPICAL SECTION OF PARAPET WALL

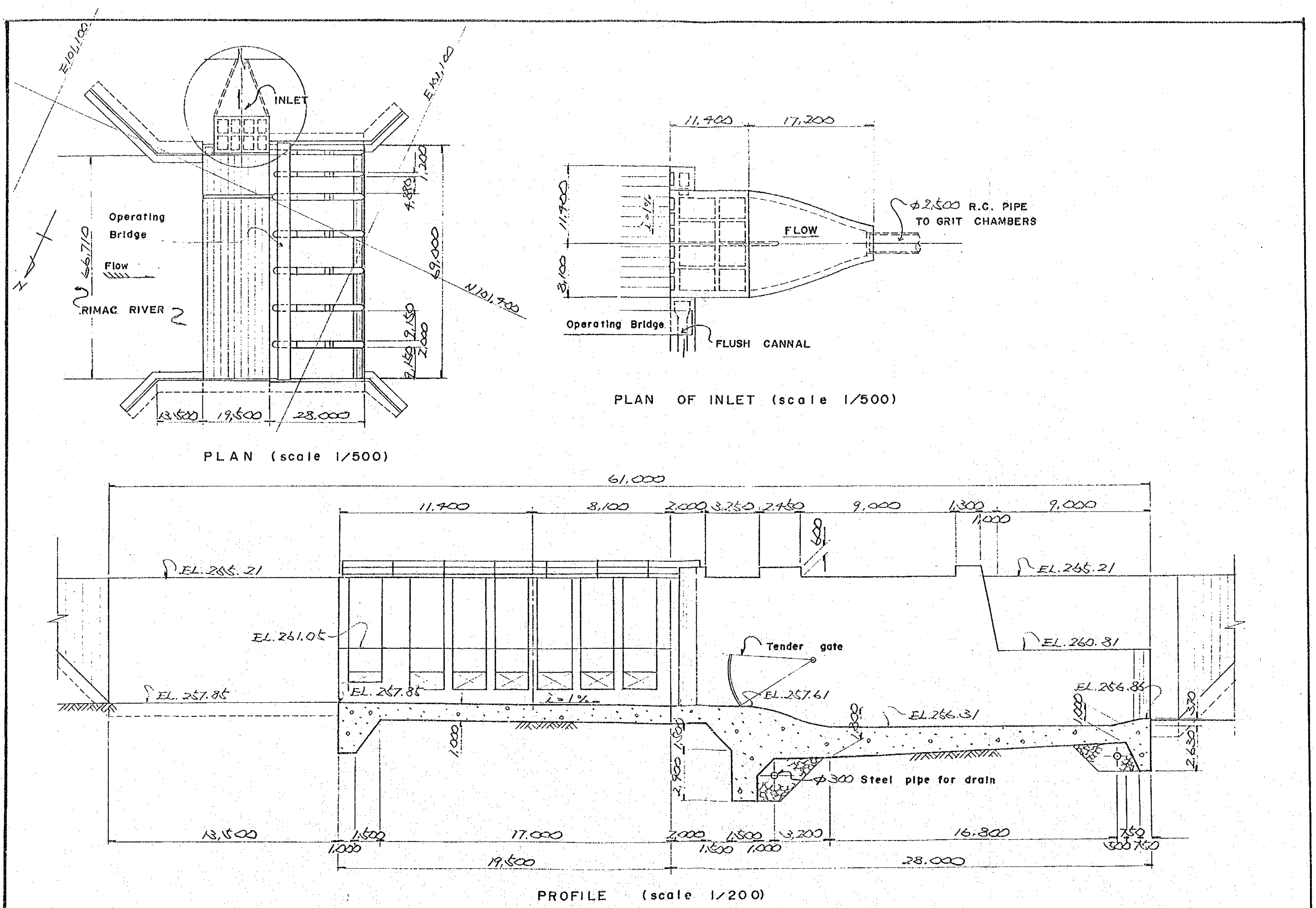


Fig.V -5-1 PLAN AND PROFILE OF INTAKE WEIR AT ATARJEA

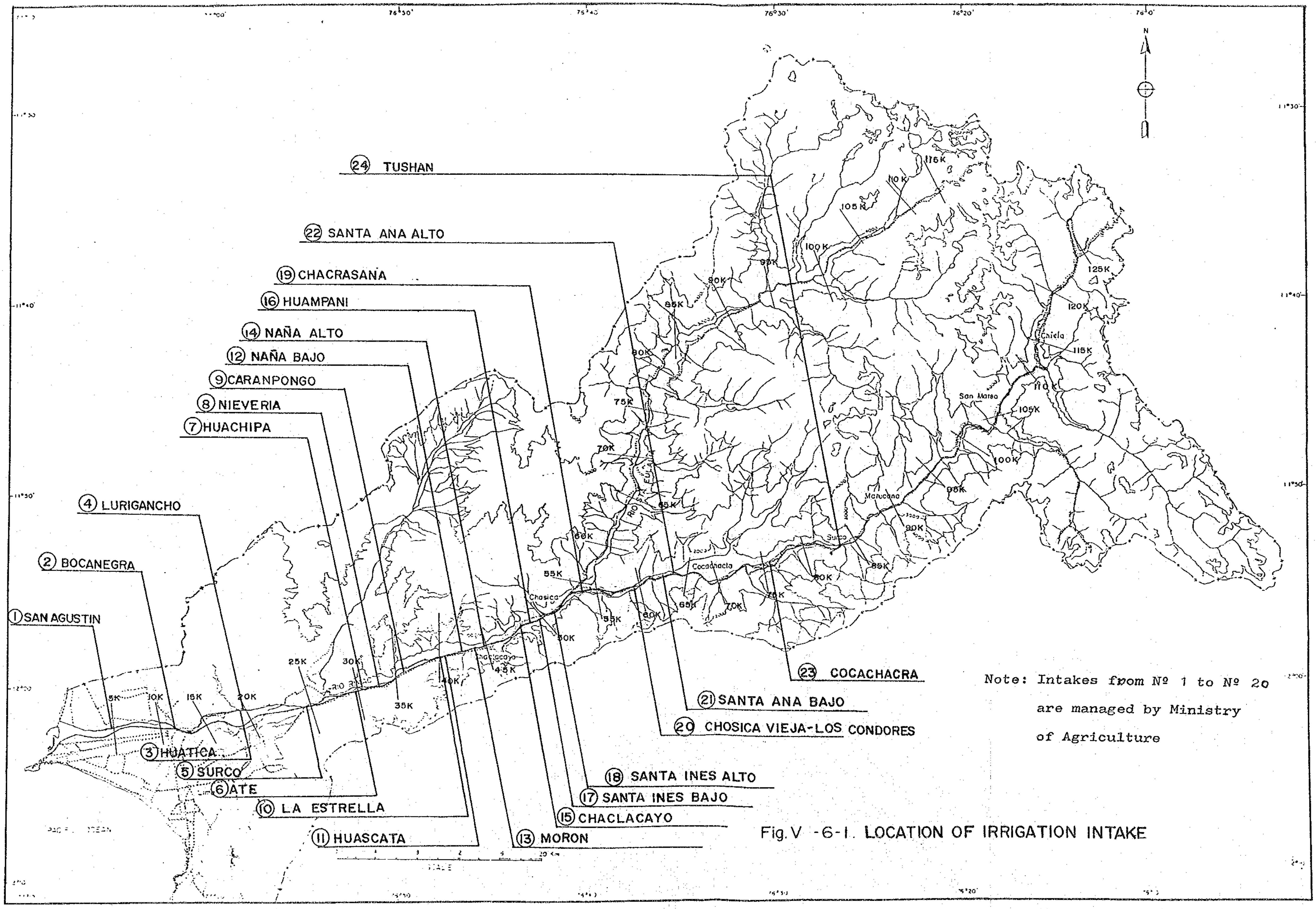
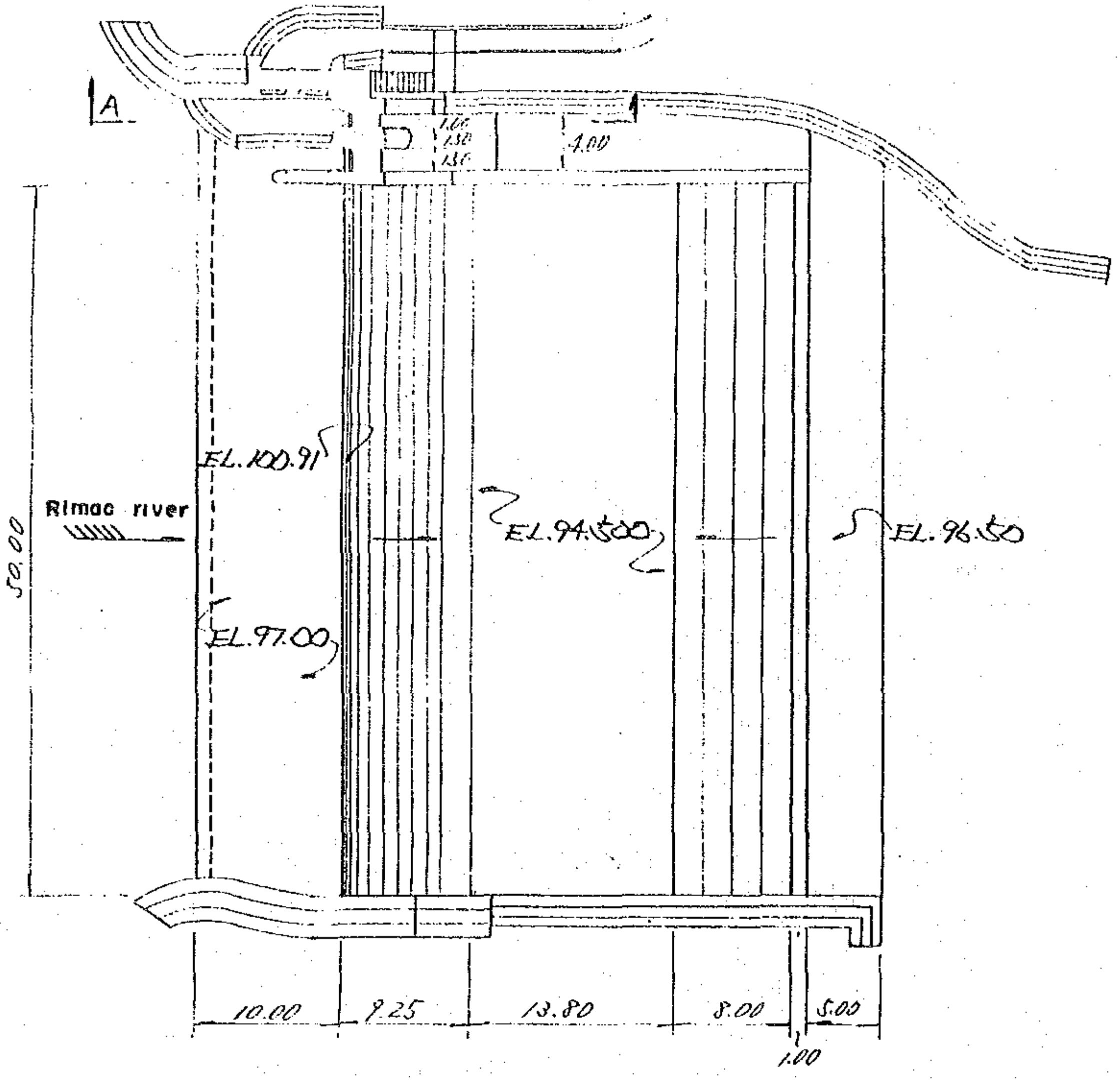
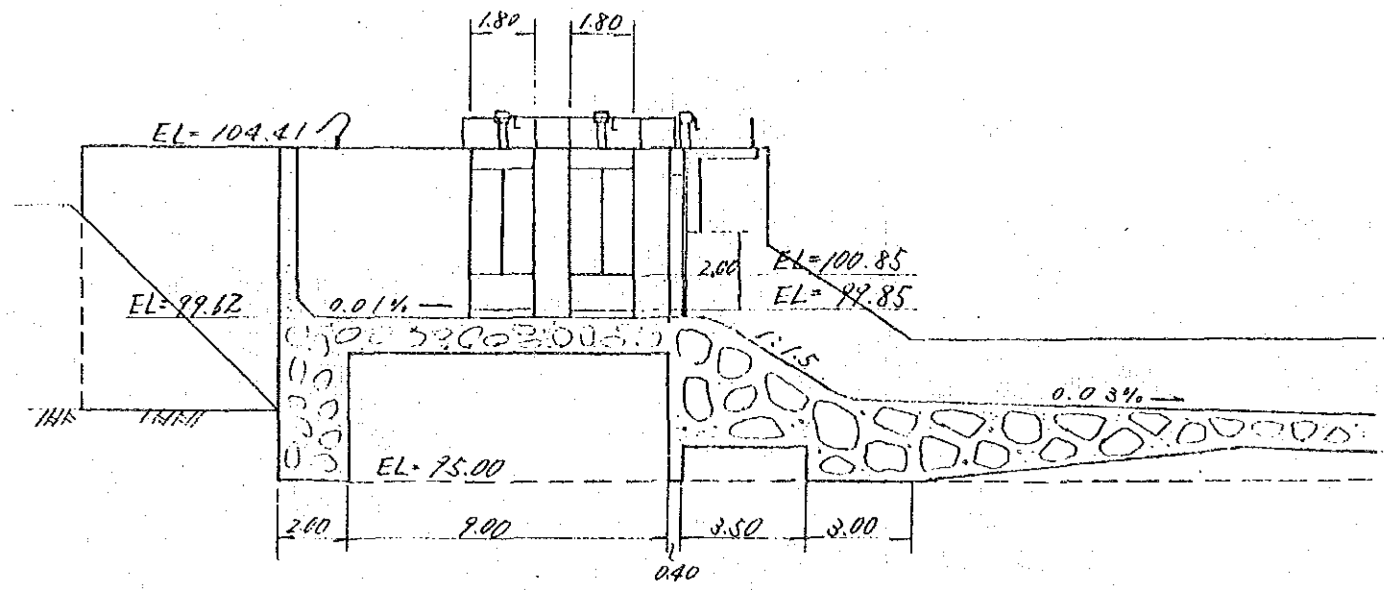


Fig. V -6-1. LOCATION OF IRRIGATION INTAKE

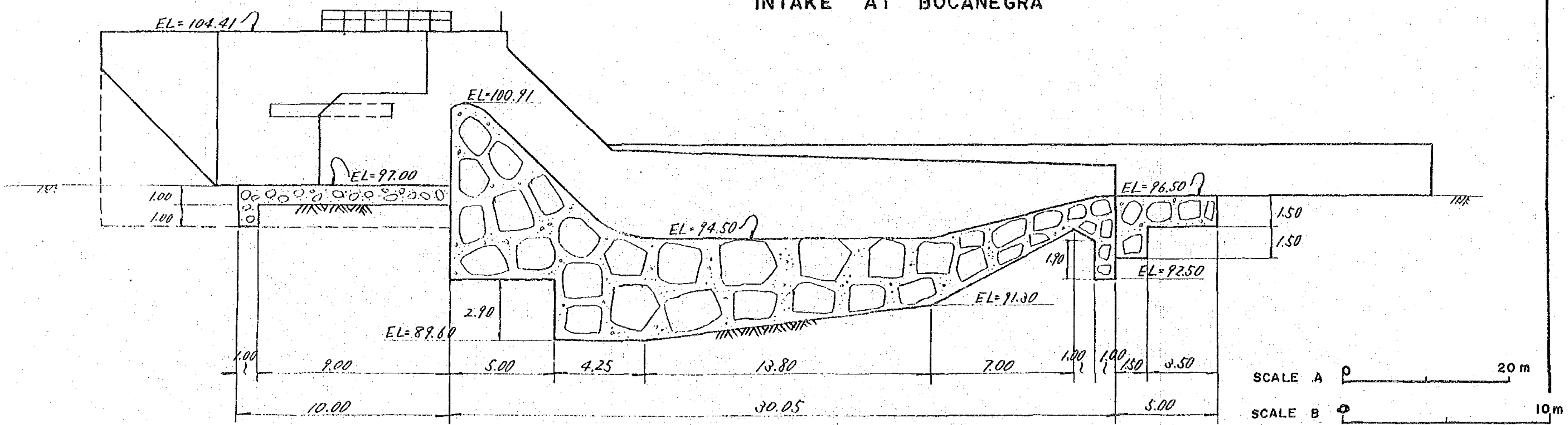


PLAN (Scale A.)



SECTION A-A (Scale B)

Fig.V -6-2 PLAN, PROFILE AND SECTION OF IRRIGATION INTAKE AT BOCANEGRA



PROFILE (Scale B)

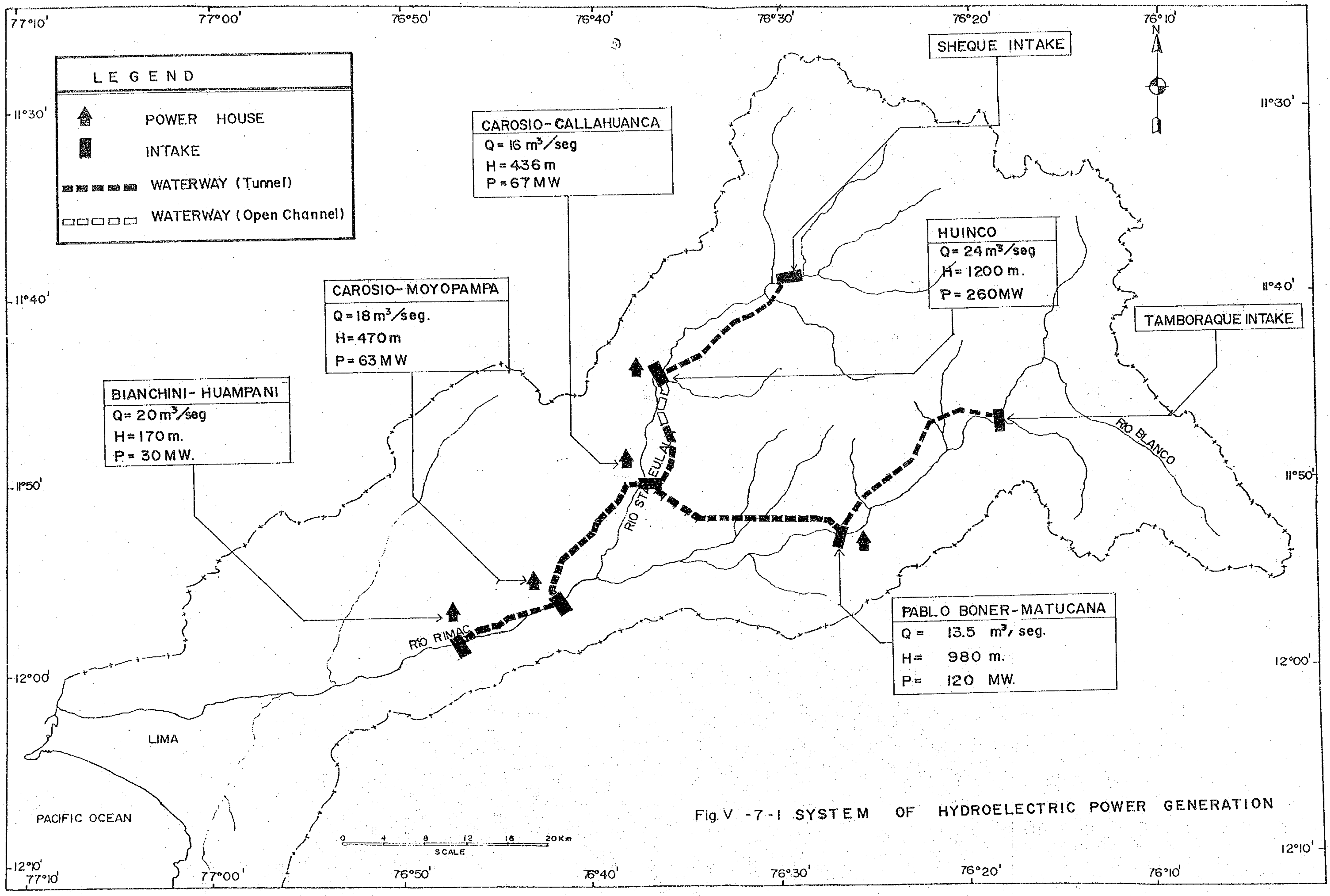


Fig. V -7-1 SYSTEM OF HYDROELECTRIC POWER GENERATION

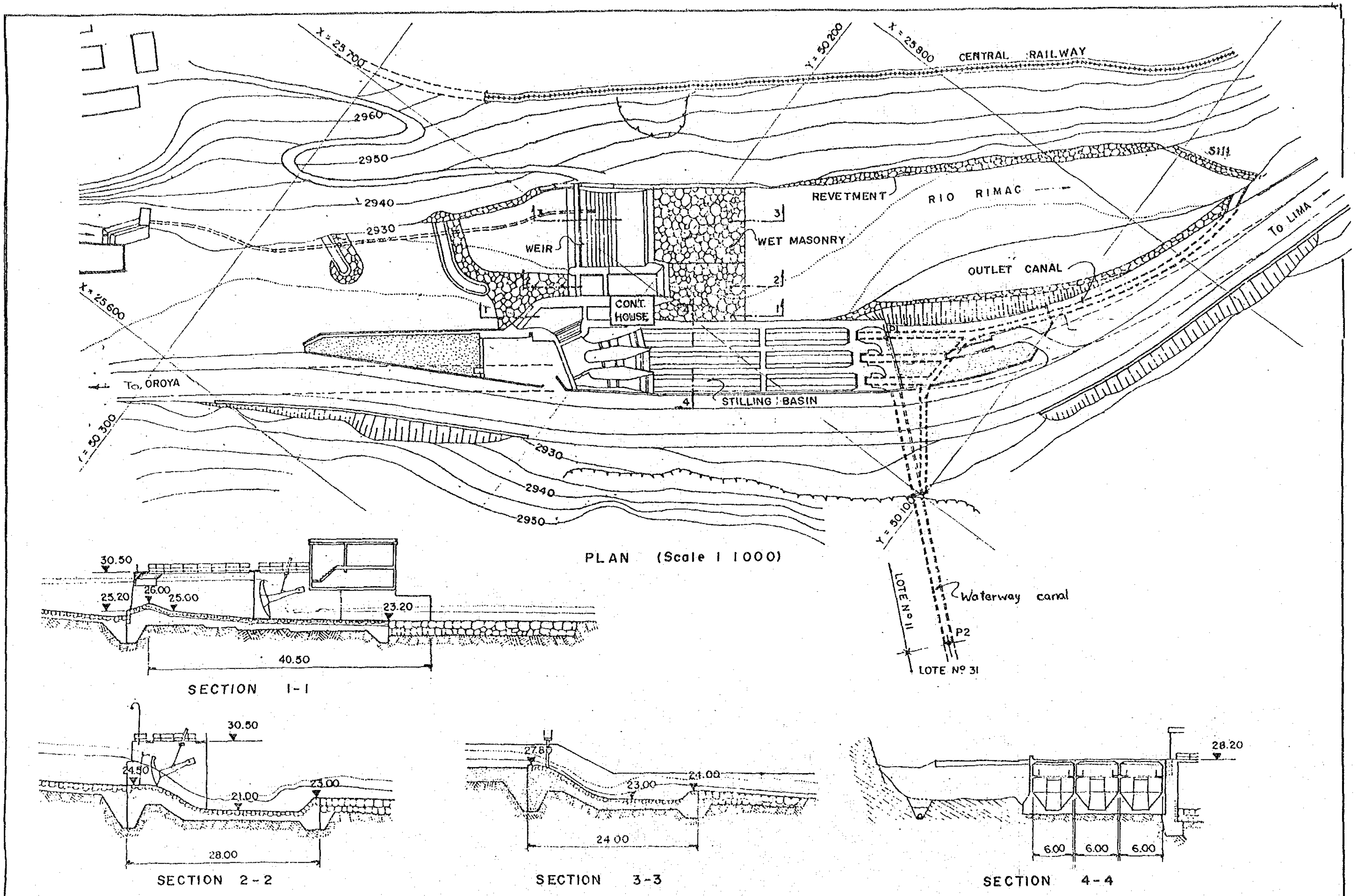


Fig. V ·7-2 PLAN AND SECTIONS OF INTAKE OF WATERWAY FOR POWER GENERATION (TAMBORAQUE INTAKE)

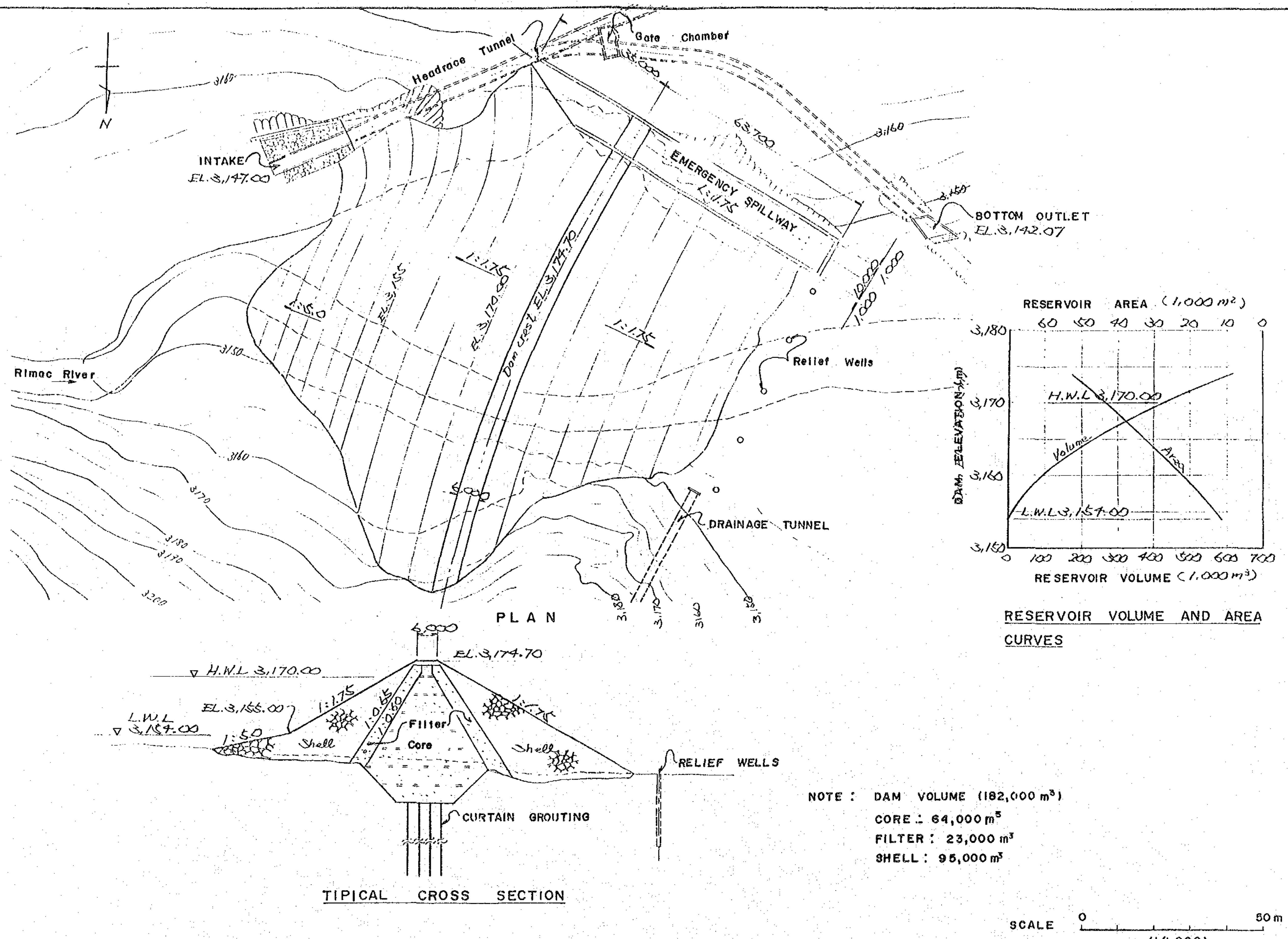


Fig.V-7-3 PLAN AND TIPICAL CROSS SECTION OF SHEQUE DAM

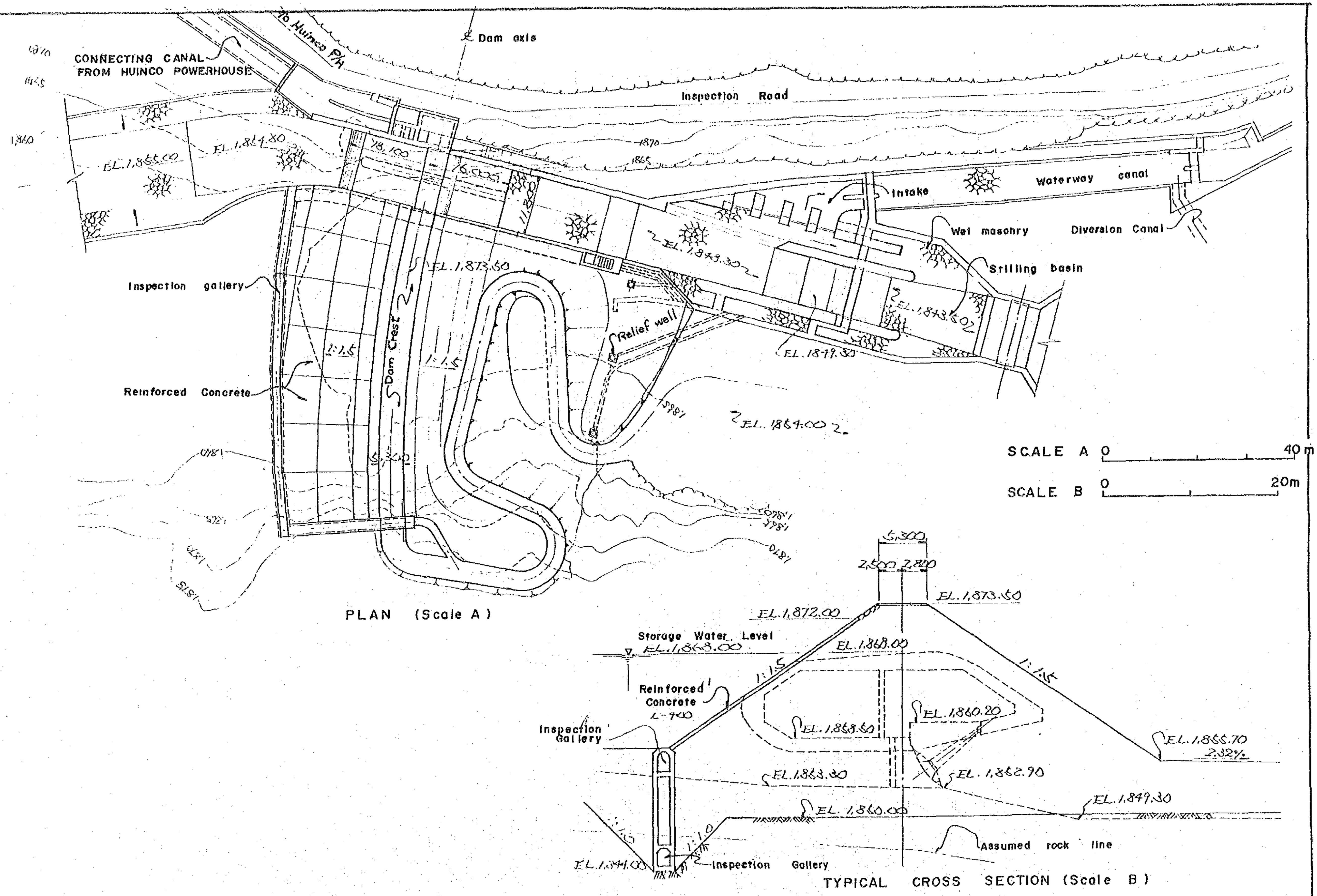


Fig. V-7-4 PLAN AND TYPICAL CROSS SECTION OF HUINCO DAM

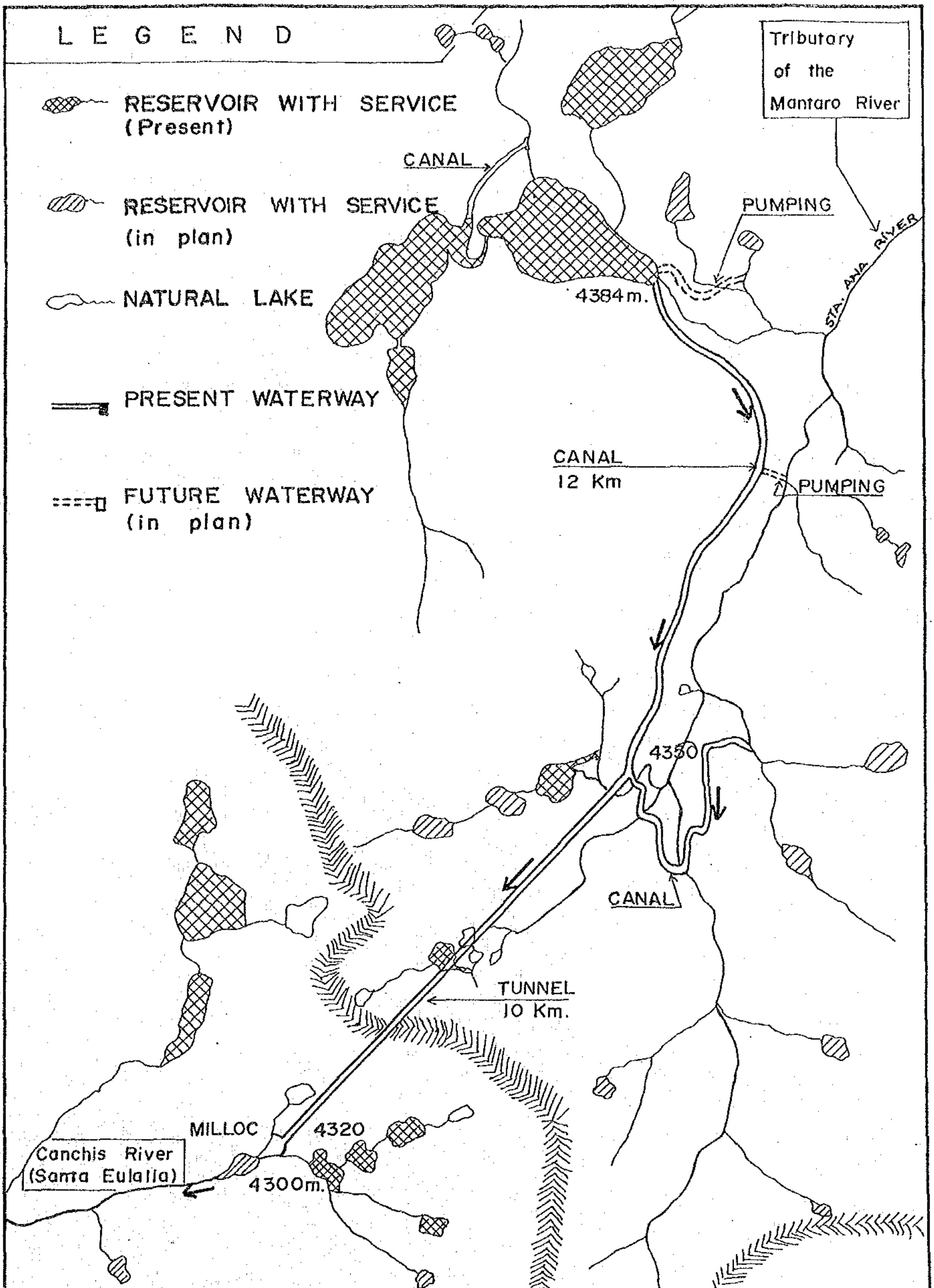
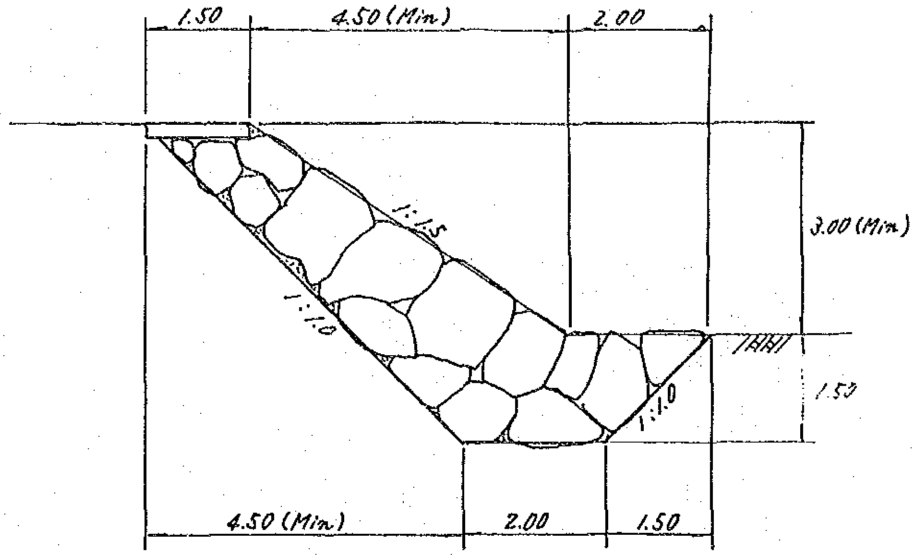
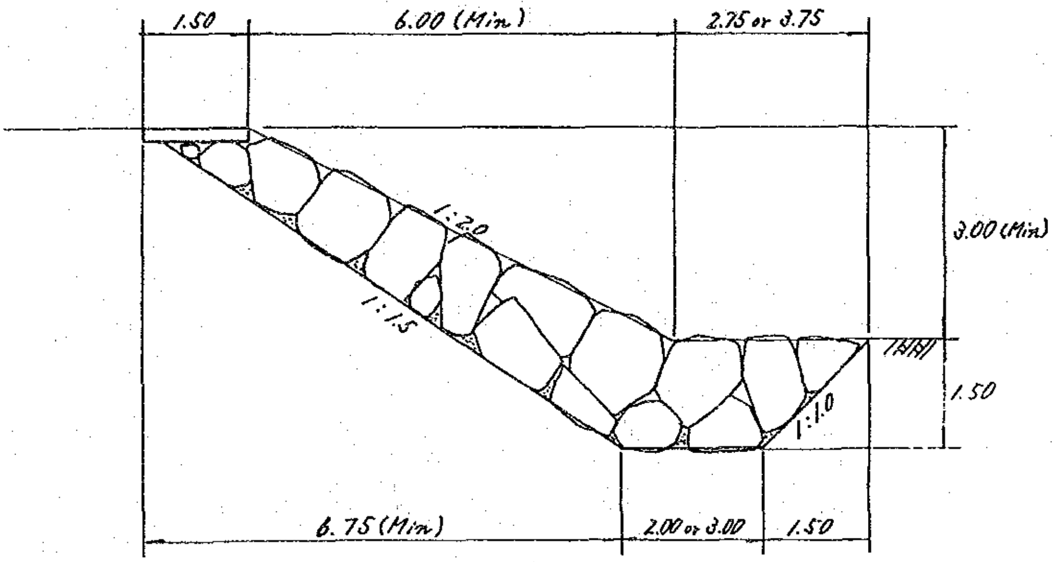


Fig.V-8-1 TRANSFER SYSTEM OF WATER FROM THE MANTARO RIVER TO THE RIMAC RIVER

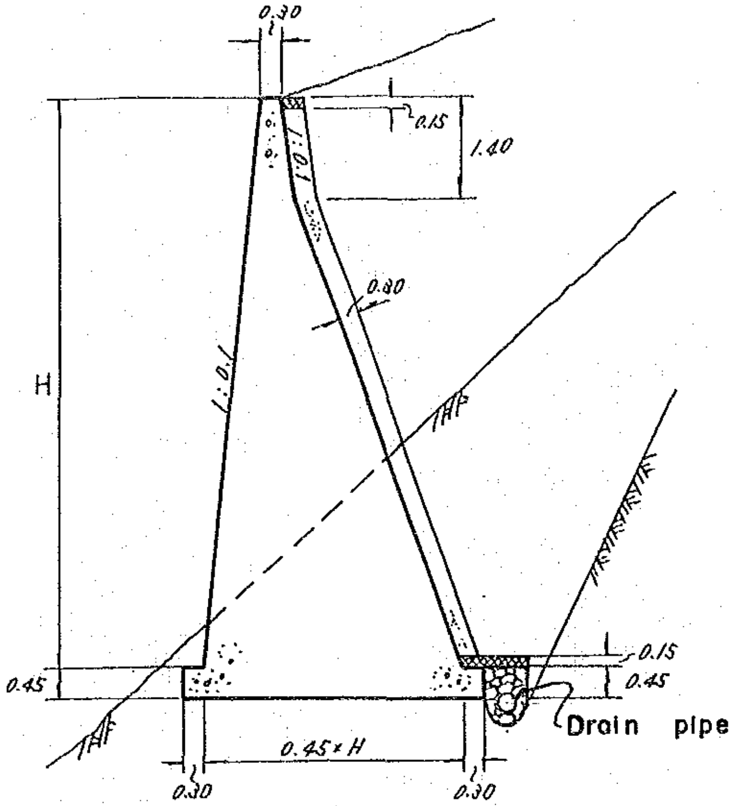


TYPICAL SECTION , TYPE A

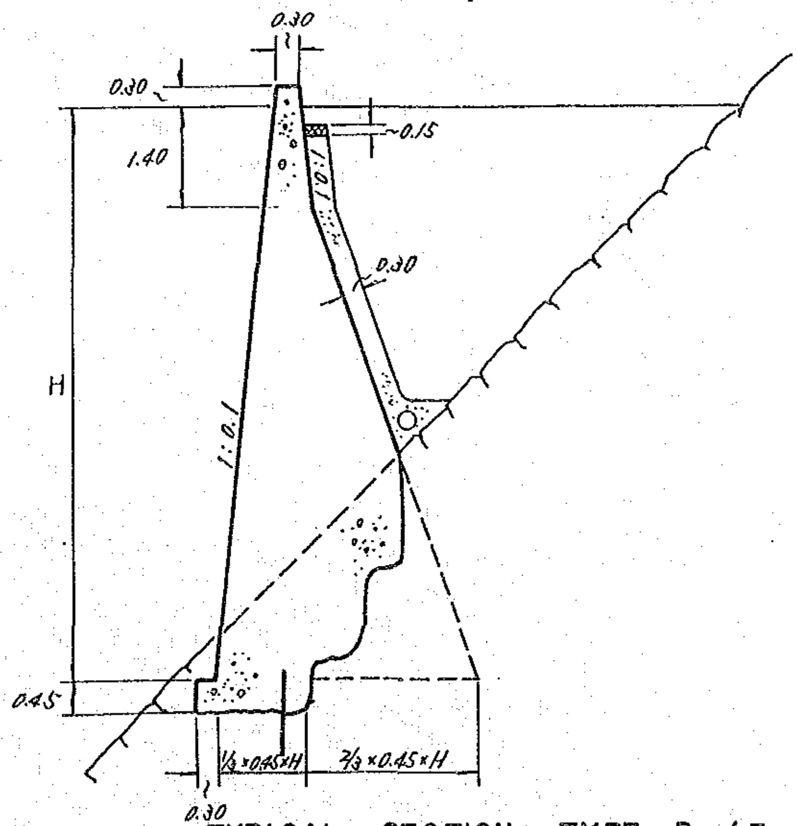


TYPICAL SECTION, TYPE B

Fig. V -8-2 TYPICAL SECTIONS OF REVETMENT



TYPICAL SECTION, TYPE A (For earth foundation)



TYPICAL SECTION, TYPE B (For rock foundation)

Fig. V-8-3 TYPICAL SECTIONS OF RETAINING WALL