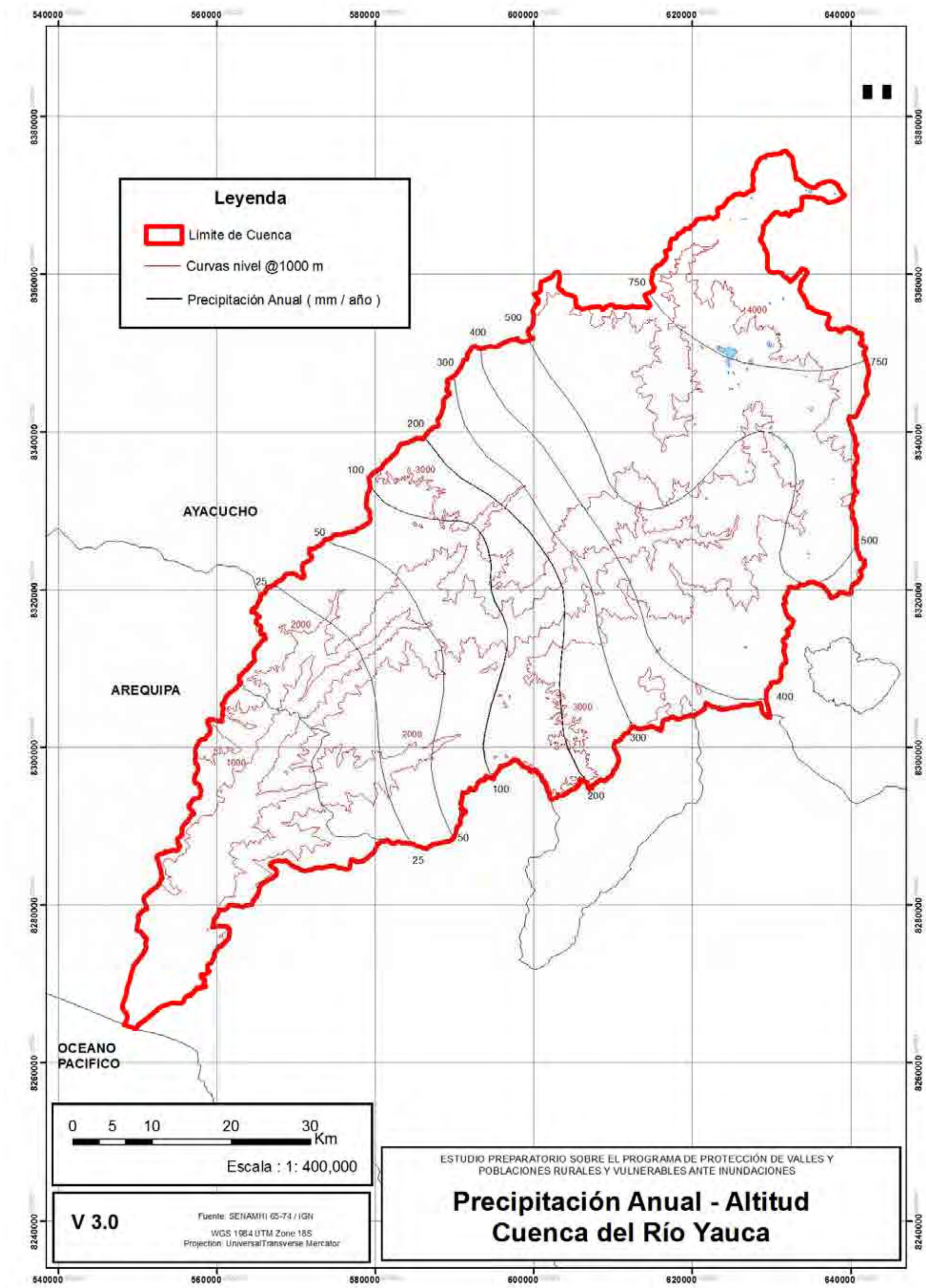


Figure 3.1.9-11 Isohyet Map (Yauca River watershed)

⑥ Majes-Camana River Watershed

Figure 3.1.9-12 shows a map of the isohyet of Majes-Camana River watershed. This watershed is characterized by the considerable variation of the annual rainfall depending on the zones, with a minimum of 50mm and a maximum of 750 mm approximately. The rainfall is lower when it is closer to the Pacific coast (low watershed), and it increases as the altitudes increase (high watershed).

The annual rainfall in the low watershed, subject to the control of floods, is reduced ranging from 50 to 200 mm.

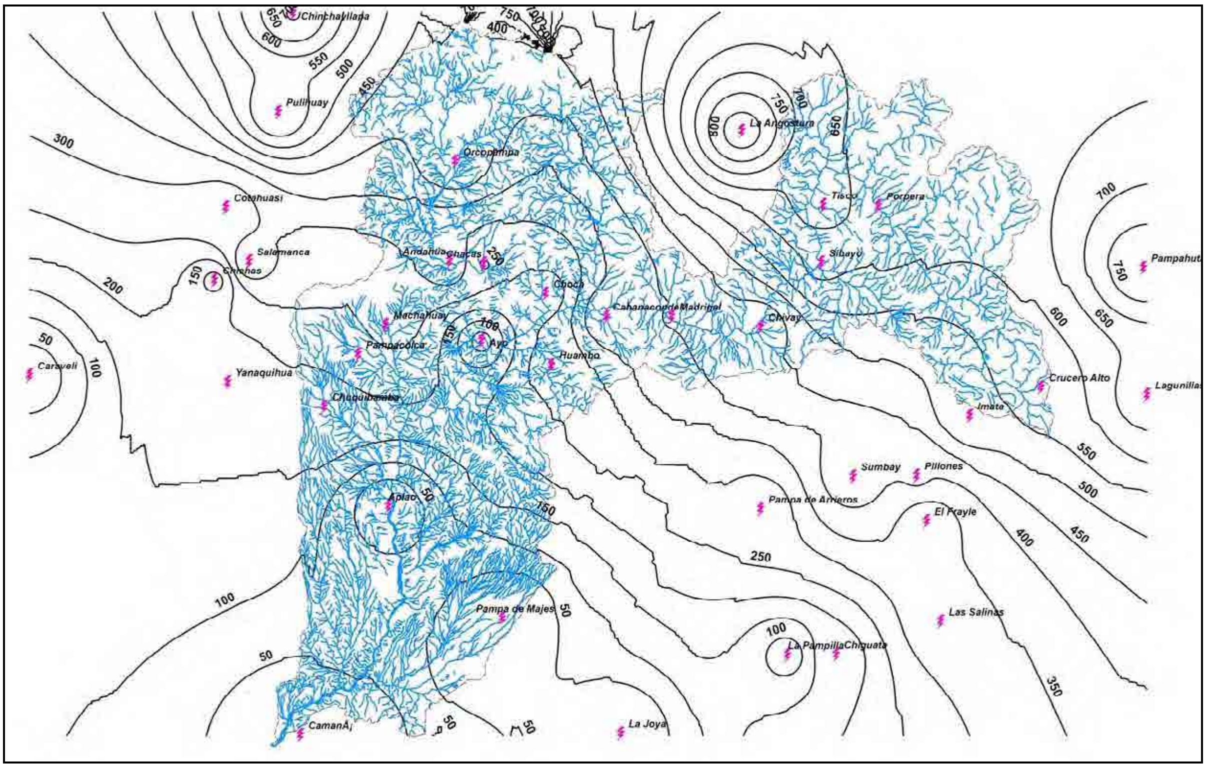


Figure 3.1.9-2 Isohyet Map (Majes-Camana River watershed)

(2) Rainfall analysis

1) Methodology

The statistic hydrologic calculation was made using the rainfall data collected from several stations, to determine the rainfall with 24 hour return period in every station.

Several models of distribution of return periods were tested and the most adequate one was adopted. Thus, the precipitation with 24 hours return period was determined with this model.
The statistic hydrologic models were.

- Normal distribution or Gaussian
- Log-Normal distribution of 3 parameters
- Log-Normal distribution of 2-parameters
- Log-Normal distribution of 2 or 3 parameters
- Log Pearson Type III distribution
- Gumbel distribution
- General distribution of extreme value

2) Results of the rainfall analysis of return period– t

The rainfall of several stations are shown below and the reference point of each watershed, according to return periods.

Comparing precipitations with a 50 years return period of each watershed it is obtained that in 5 watersheds (Except Chira), this vary only in millimetres, which means less than 100mm. Chira River is an specific case, rain with 50 year return period surpasses 100mm with a max of 339mm. This trend can also be seen in the isohyets map.

① Chira River Watershed

Table 3.1.9-13 shows the monitoring points and the rainfall with 24 hour return period in each station. Figure 3.1.9-13 shows the map of isohyets of rainfall with 50 year return period.

Table 3.1.9-13 Rainfall with 24 hour return period (Chira river watershed)

Nº	Station	Elevation (m.a.s.l.)	No. of Records	Return period (in years)					
				25	50	100	500	Registered	Assumed Distribution
1	Morropón	172	10	134,81	158,52	178,27	228,53	90,40 (*)	Gumbel
2	Malacasi	128	9	287,08	339,22	390,99	510,83	251,20	Gumbel
3	Virrey	230	27	231,55	290,51	347,08	464,48	230,70	Log Pearson III
4	Chignia	360	19	148,24	170,47	194,53	250,12	184,40	Gumbel
5	Barrios	310	19	135,34	153,85	172,23	214,89	119,70	Gumbel
6	Huarmaca	2180	43	112,54	128,58	140,48	172,84	111,40	Gumbel
7	Canchaque	1200	19	164,58	189,45	214,18	271,24	137,30	Gumbel

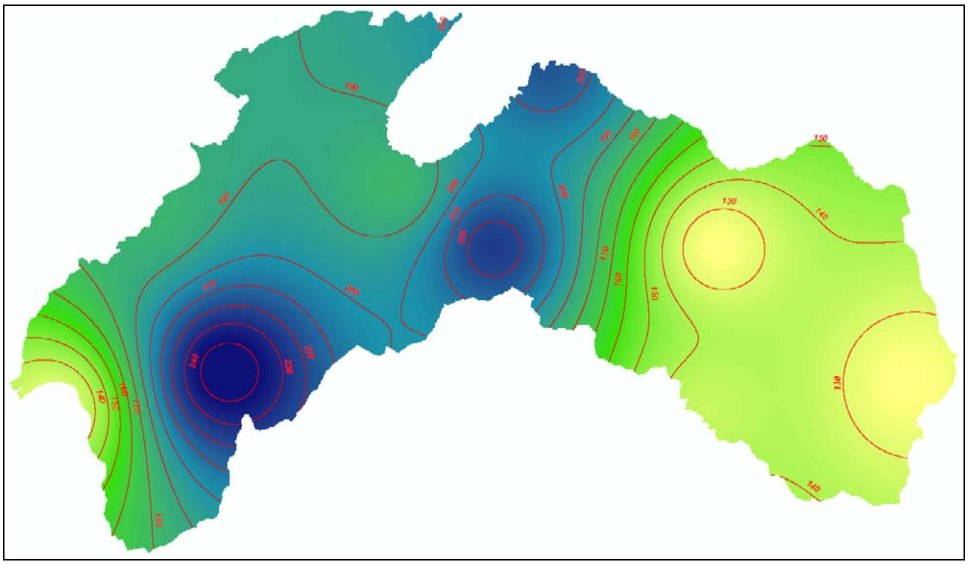


Figure 3.1.9-13 Map of isohyets of a 50 years period rainfall (Chira river watershed)

② Cañete River Watershed

Table 3.1.9-14, -15 shows the monitoring points and the rainfall with 24 hour return period in the reference point (Socsi Station). Figure 3.1.9-14 shows the map of isohyets of rainfall with 50 year return period.

Table 3.1.9-14 Rainfall with 24 hour return period (Cañete river watershed)

NOMBRE DE ESTACION	PERIODO DE RETORNO T [AÑOS]						
	PT_2	PT_5	PT_10	PT_25	PT_50	PT_100	PT_200
AYAVIRI	29.0	35.0	37.0	39.0	40.0	41.0	42.0
CARANIA	18.0	23.0	27.0	33.0	39.0	45.0	52.0
COLONIA	21.0	30.0	37.0	48.0	56.0	66.0	77.0
COSMOS	23.0	31.0	35.0	40.0	43.0	45.0	47.0
HUANGASCAR	20.0	29.0	35.0	44.0	51.0	59.0	67.0
HUANTAN	30.0	40.0	48.0	58.0	66.0	75.0	84.0
PACARAN	4.0	7.0	9.0	12.0	15.0	18.0	21.0
SOCSI CAÑETE	0.0	1.0	2.0	4.0	7.0	12.0	21.0
TANTA	23.0	32.0	38.0	46.0	52.0	58.0	65.0
TOMAS	14.0	18.0	20.0	21.0	22.0	23.0	24.0
YAURICOCHA	27.0	36.0	43.0	54.0	64.0	75.0	88.0
YAUYOS	18.0	23.0	27.0	31.0	34.0	37.0	40.0

Table 3.1.9-15 Rainfall with 24 hour return period
(Reference Point: Socsi Station)

T (Años)	PP Areal Max. 24 Horas(m
5.0	25.5
10.0	30.3
25.0	37.3
50.0	43.1
100.0	49.4

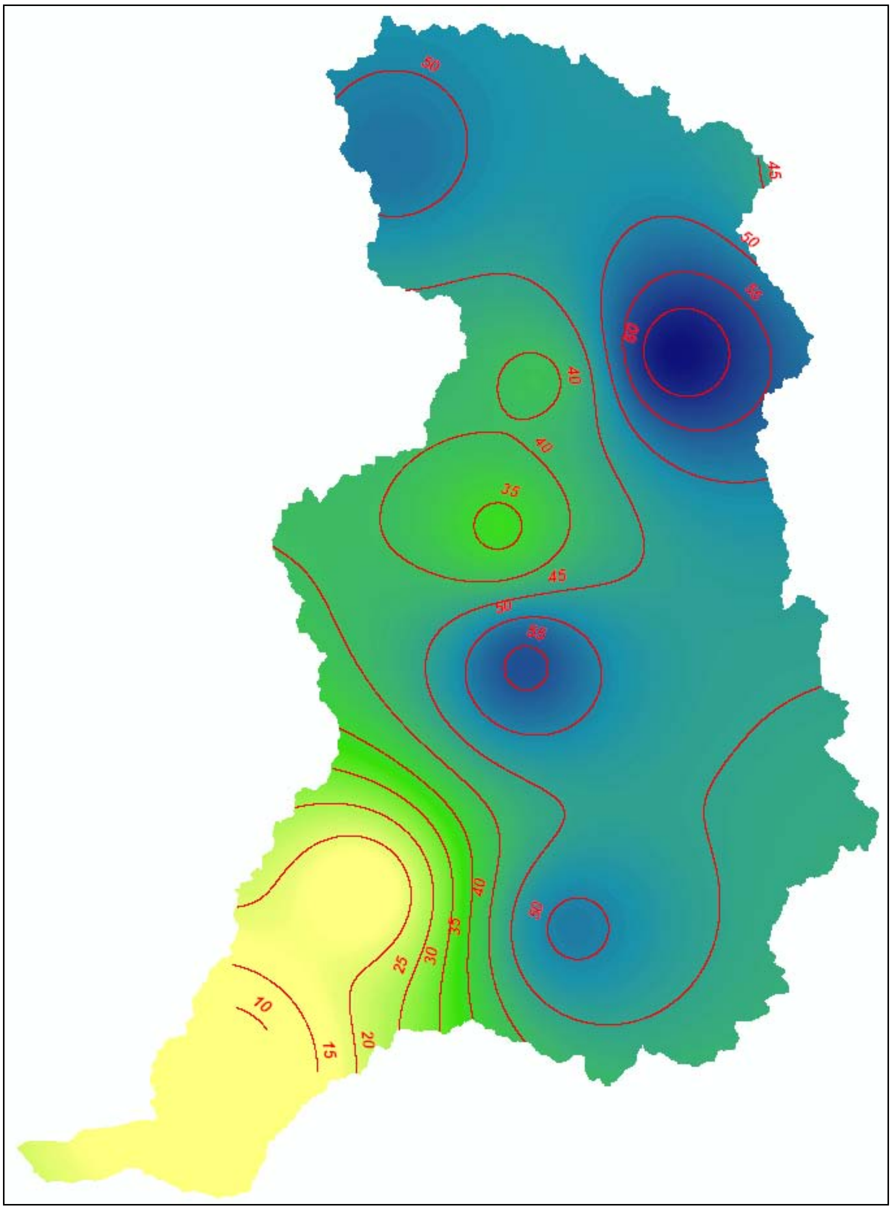


Figure 3.1.9-14 Map of isohyets of a 50 years period rainfall (Cañete river watershed)

Table 3.1.9-16 Probable rain Pluviograph

T (años) /Hora	1	2	3	4	5	6	7	8	9	10	PP total (mm)
5	1	2	3	4	3	3	2	2	1	1	23
10	1	2	4	5	4	3	3	2	2	1	27.4
25	2	3	4	6	5	4	3	3	2	1	33.7
50	2	4	5	7	5	5	4	3	2	2	38.9
100	2	4	6	8	6	5	4	4	3	2	44.6

③ Chincha River Watershed

Table 3.1.9-17, -18 shows the monitoring points and the rainfall with 24 hour return period in the reference point (Conta Station). Figure 3.1.9-15 shows the map of isohyets of rainfall with 50 year return period.

Table 3.1.9-17 Rainfall with 24 hour return period (Chincha river watershed)

Station Name	Return Period T [YEARS]						
	PT_2	PT_5	PT_10	PT_25	PT_50	PT_100	PT_200
COCAS	22.0	30.0	34.0	38.0	40.0	42.0	43.0
CONTA	1.0	2.0	4.0	6.0	9.0	13.0	18.0
FONAGRO	1.0	2.0	3.0	4.0	5.0	7.0	8.0
HUACHOS	24.0	31.0	36.0	42.0	48.0	53.0	59.0
SAN JUAN DE YANAC	11.0	18.0	23.0	30.0	34.0	39.0	44.0
SAN PEDRO DE HUACARPANA	23.0	29.0	32.0	35.0	36.0	37.0	38.0
TICRAPO	20.0	31.0	37.0	45.0	50.0	55.0	60.0
TOTORA	24.0	29.0	32.0	36.0	38.0	40.0	42.0
VILLA DE ARMAS	28.0	40.0	47.0	56.0	62.0	68.0	73.0

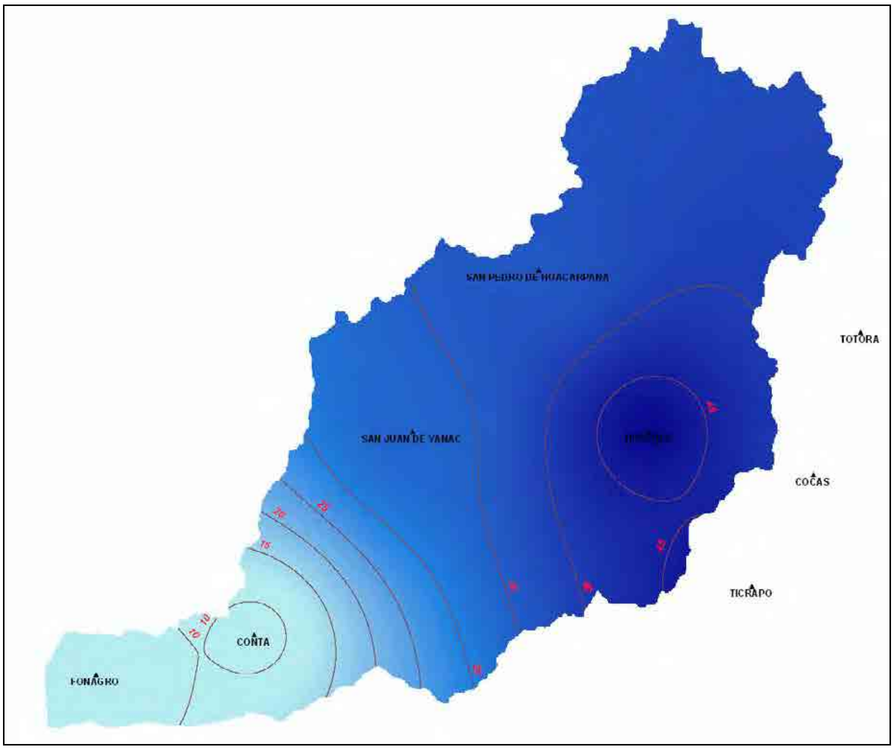


Figure 3.1.9-15 Map of isohyets of a 50 years period rainfall (Chincha river watershed)

Table 3.1.9-18 24 Hours rainfall for different return periods (Reference spot: Conta Station)

Return Period (years)	Maximum Precipitation of 24 hours (mm)
5	23,40
10	27,39
25	32,22
50	35,56
100	39,06

Table 3.1.9-19 Pluviograph of different return periods

Years	Hours										Total Precipitation (mm)
	1	2	3	4	5	6	7	8	9	10	
5	1	2	2	4	3	2	2	2	1	1	19
10	1	2	3	4	3	3	2	2	1	1	22,0
25	1	2	3	5	4	3	3	2	2	1	25,9
50	1	3	4	5	4	3	3	2	2	1	28,6
100	2	3	4	6	4	4	3	3	2	1	31,4

④ Pisco River Watershed

Table 3.1.9-20, -21 shows the monitoring points and the rainfall with 24 hour return period in the reference point (Letrayoc Station). Figure 3.1.9-16 shows the map of isohyets of rainfall with 50 year return period.

Table 3.1.9-20 Rainfall with 24 hour return period (Pisco river watershed)

NOMBRE DE ESTACION	PERIODO DE RETORNO T [AÑOS]						
	PT_2	PT_5	PT_10	PT_25	PT_50	PT_100	PT_200
ACNOCOCHA	27,0	30,0	32,0	34,0	35,0	36,0	37,0
CHOCLOCOCHA	30,0	43,0	51,0	60,0	66,0	71,0	76,0
COCAS	22,0	30,0	34,0	38,0	40,0	42,0	43,0
CUSICANCHA	19,0	26,0	29,0	33,0	35,0	37,0	39,0
HACIENDA BERNALES	0,0	1,0	3,0	6,0	11,0	19,0	34,0
HUAMANI	2,0	7,0	13,0	25,0	39,0	61,0	93,0
PARIONA	33,0	40,0	43,0	46,0	48,0	49,0	50,0
SAN JUAN DE CASTROVTIREYNA	17,0	23,0	29,0	36,0	42,0	49,0	56,0
TAMBO	26,0	35,0	40,0	46,0	49,0	52,0	55,0
TICRAPO	20,0	31,0	37,0	45,0	50,0	55,0	60,0
TOTORA	24,0	29,0	32,0	36,0	38,0	40,0	42,0
TUNEL CERO	29,0	36,0	41,0	48,0	54,0	61,0	67,0

Table 3.1.9-21 Rainfall with 24 hour for different return periods (Reference point: Letrayoc Station)

Return period (years)	Maximum 24 hours precipitation (mm)
5	28,90
10	33,23
25	38,78
50	42,59
100	46,92

Table 3.1.9-22 Different return periods of rainfall

Years	Hours										Total precipitation (mm)
	1	2	3	4	5	6	7	8	9	10	
5	1	2	3	4	3	3	2	2	1	1	22,6
10	1	2	3	5	4	3	3	2	2	1	26,0
25	2	3	4	6	4	4	3	2	2	1	30,3
50	2	3	4	6	5	4	3	3	2	1	33,3
100	2	3	5	7	5	4	4	3	2	1	36,7

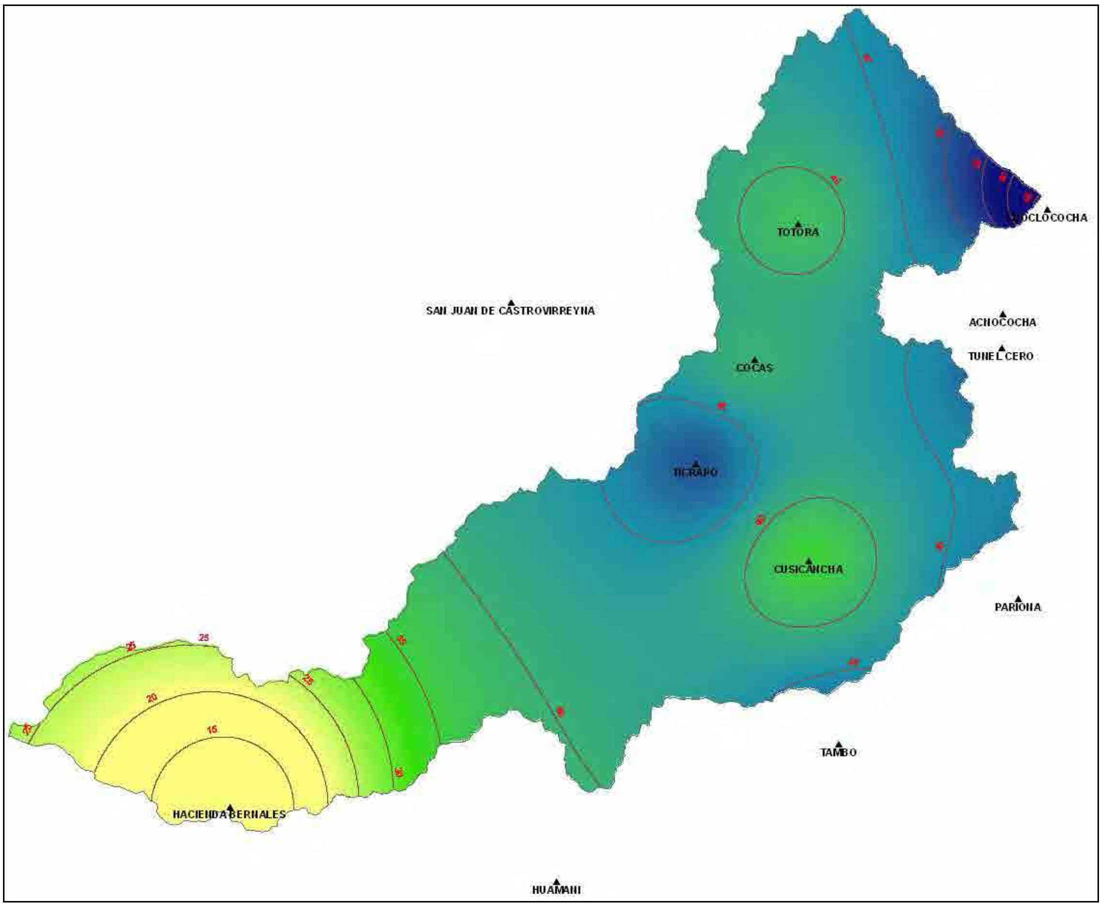


Figure 3.1.9-16 Map of isohyets of a 50 years period rainfall (Pisco river watershed)

⑤ Yauca River Watershed

Table 3.1.9-23, -24 shows the monitoring points and the rainfall with 24 hour return period in each station (San Francisco Alto Station). Figure 3.1.9-17 shows the map of isohyets of rainfall with 50 year return period.

Table 3.1.9-23 Rainfall with 24 hour return period (Yauca river watershed)

Station Name	Retunr Period T [YEARS]						
	PT_2	PT_5	PT_10	PT_25	PT_50	PT_100	PT_200
CARHUANILLAS	26.0	42.0	54.0	70.0	84.0	98.0	114.0
CHAVIÑA	32.0	42.0	48.0	54.0	59.0	62.0	66.0
CORA CORA	28.0	36.0	41.0	46.0	49.0	52.0	54.0
SANCOS	34.0	48.0	57.0	67.0	74.0	80.0	86.0
TARCO	20.0	32.0	41.0	54.0	65.0	77.0	91.0

Table 3.1.9-24 Rain of 24 hours for the different return periods (Reference Point: San Francisco Alto Station)

Return Period (years)	Maximum Precipitation in 24 hours (mm)
5	28
10	33
25	39
50	45
100	50

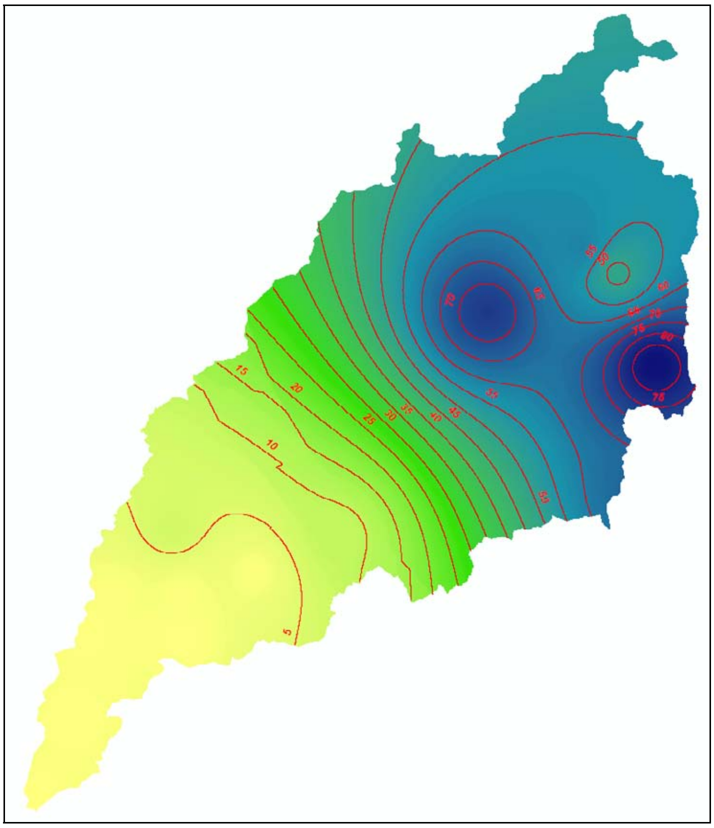


Figure 3.1.9-17 Map of isohyets of a 50 years period rainfall (Yauca river watershed)

Table 3.1.9-25 Pluviograph of the different return periods

Years	Hours										Total Precipitation (mm)
	1	2	3	4	5	6	7	8	9	10	
5	1	2	3	4	3	3	2	2	1	1	22
10	1	2	3	5	4	3	3	2	2	1	26.5
25	2	3	4	6	4	4	3	3	2	1	31.3
50	2	3	5	7	5	4	4	3	2	1	36.2
100	2	4	5	8	6	5	4	3	2	2	40.2

⑥ Majes-Camana River Watershed

Table 3.1.9-26 shows the monitoring points and the rainfall with 24 hour return period in the reference point (Socsi Station). Figure 3.1.9-26 shows the map of isohyets of rainfall with 50 year return period.

Table 3.1.9-26 Rainfall with 24 hour return period (Majes-Camana river watershed)

Station	Coordinates			Precipitation for T (years)						
	Latitude	Longitude	Altitude (masl)	2	5	10	25	50	100	200
Andahua	15° 29'37	72° 20'57	3538	24.30	31.33	34.83	38.29	40.33	42.02	43.43
Aplao	16° 04'10	72° 29'26	625	1.71	5.03	7.26	9.51	10.71	11.56	12.14
Ayo	15° 40'45	72° 16'13	1950	10.28	16.43	20.51	25.66	29.48	33.27	37.05
Cabanaconde	15° 37'7	71° 58'7	3369	26.58	37.88	45.89	56.58	64.95	73.67	82.79
Camaná	16° 36'24	72° 41'49	29	3.18	7.16	9.79	13.11	15.58	18.03	20.46
Caravelí	15° 46'17	73° 21'42	1757	7.67	16.07	22.60	31.46	38.30	45.21	52.15
Chachas	15° 29'56	72° 16'2	3130	22.21	28.60	32.08	35.83	38.24	40.37	42.30
Chichas	15° 32'41	72° 54'59.7	2120	16.28	23.47	27.01	30.37	32.23	33.67	34.80
Chiguata	16° 24'1	71° 24'1	2945	18.88	29.98	37.33	46.40	52.94	59.27	65.42
Chinchayllapa	14° 55'1	72° 44'1	4514	23.12	31.21	36.57	43.34	48.37	53.35	58.32
Chivay	15° 38'17	71° 35'49	3663	24.50	32.74	38.20	45.09	50.21	55.29	60.35
Choco	15° 34'1	72° 07'1	3160	16.10	22.92	27.45	33.16	37.39	41.60	45.79
Chuquibamba	15° 50'17	72° 38'55	2839	21.65	36.96	47.09	59.89	69.39	78.82	88.21
Cotahuasi	15° 22'29	72° 53'28	5086	21.20	29.97	35.78	43.12	48.56	53.96	59.35
Crucero Alto	15° 46'1	70° 55'1	4486	25.33	31.66	35.20	39.10	41.67	44.02	46.17
El Frayle	16° 05'5	71° 11'14	4110	22.33	29.95	35.43	42.89	48.83	55.12	61.82
Huambo	15° 44'1	72° 06'1	3500	22.87	30.14	34.96	41.05	45.57	50.05	54.52
Imata	15° 50'12	71° 05'16	4451	28.35	37.09	42.87	50.18	55.60	60.98	66.34
La Angostura	15° 10'47	71° 38'58	4260	35.90	45.89	53.22	63.31	71.46	80.18	89.57
La Joya	16°35'33	71°55'9	1279	1.22	4.74	7.89	11.93	14.65	16.98	18.92
La Pampilla	16° 24'12.2	71° 31'.6	2388	12.65	21.64	27.66	35.01	40.23	45.20	49.94
Lagunillas	15° 46'46	70° 39'38	4385	28.55	34.30	37.75	41.81	44.67	47.40	50.05
Las Salinas	16° 19'5	71° 08'54	3369	18.05	25.72	30.80	37.22	41.98	46.70	51.41
Machahuay	15° 38'43	72° 30'8	3000	21.06	29.80	34.71	40.03	43.45	46.46	49.14
Madrigal	15° 36'59.7	71° 48'42	3238	23.63	30.07	33.66	37.59	40.17	42.50	44.63
Orcopampa	15° 15'39	72° 20'20	3805	21.51	29.58	36.83	48.66	59.81	73.37	89.92
Pampa de Arrieros	16° 03'48	71° 35'21	3720	18.86	32.08	40.82	51.88	60.07	68.21	76.32
Pampa de Majes	16° 19'40	72° 12'39	1442	2.07	6.68	10.56	15.55	18.98	22.04	24.69
Pampacolca	15° 42'51	72° 34'3	2895	21.13	29.11	34.40	41.08	46.04	50.95	55.86
Pampahuta	15° 29'1	70° 40'33.3	4317	34.18	39.66	42.87	46.58	49.14	51.57	53.89
Pillones	15° 58'44	71° 12'49	4428	24.00	32.95	38.88	46.36	51.92	57.43	62.92
Porpera	15° 21'1	71° 19'1	4142	27.40	40.61	49.37	60.42	68.63	76.77	84.88
Pullhuay	15° 09'1	72° 46'1	3098	24.47	32.43	37.63	44.15	48.97	53.77	58.60
Salamanca	15° 30'1	72° 50'1	3153	19.86	26.64	31.13	36.81	41.02	45.20	49.36
Sibayo	15° 29'8	71° 27'11	3839	31.25	38.61	42.98	48.06	51.59	54.93	58.13
Sumbay	15° 59'1	71° 22'1	4300	25.43	35.57	43.10	53.56	62.08	71.26	81.17
Tisco	15° 21'1	71° 27'1	4198	33.41	42.74	51.24	65.12	78.15	93.95	113.15
Yanaquihua	15° 46'59.8	72° 52'57	2834	20.70	35.78	45.76	58.38	67.74	77.03	86.29

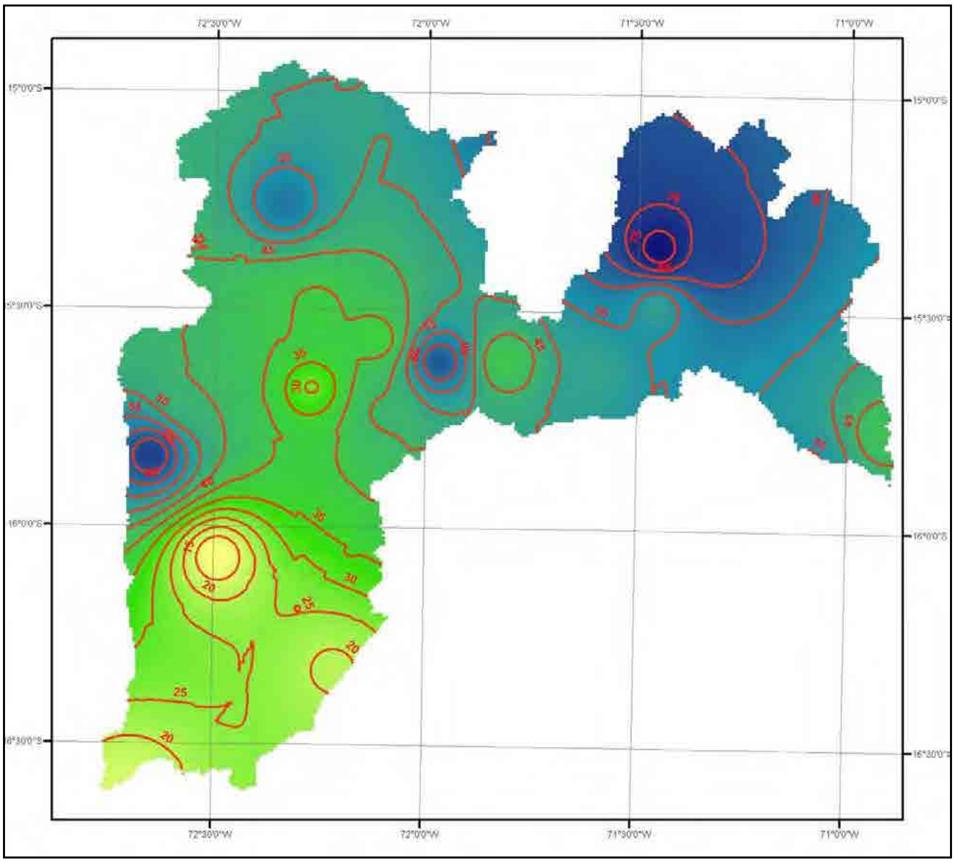


Figure 3.1.9-3 Map of isohyets of a 50 years period rainfall (Majes-Camana river watershed)

Table 3.1.9-27 Probable Flow in Control Points

(m^3/s)

Rivers	Return Periods					
	2 years	5 years	10 years	25 years	50 years	100 years
Río Chira Puente Sullana	888	1.726	2.281	2.983	3.503	4.019
Río Cañete Socsi	313	454	547	665	753	840
Río Chincha Conta	179	378	536	763	951	1.156
Río Pisco Letrayoc	267	398	500	648	774	914
Río Yauca San Francisco Alto	41	81	116	171	219	273
Majes-Camana Huatiapa	598	1.022	1.303	1.657	1.920	2.181

3) Analysis of flooding flow with t-years return periods

(a) Methodology

The probable flooding flow was analysed using the HEC-HMS model, with which the hyetograph or return periods was prepared, and the peak flow was calculated.

For the rainfall used in the analysis, the hyetograph of several periods prepared in the rainfall analysis was used. Hyetography was determined taking as reference the flow peak in the discharge analysis.

For the Chira River, the regulator effect of floods of Poechos Dam was taken into account, which is located in the upper watershed.

On Figures 3.1.9-19,-20 the HEC-HMS analysis output is shown.

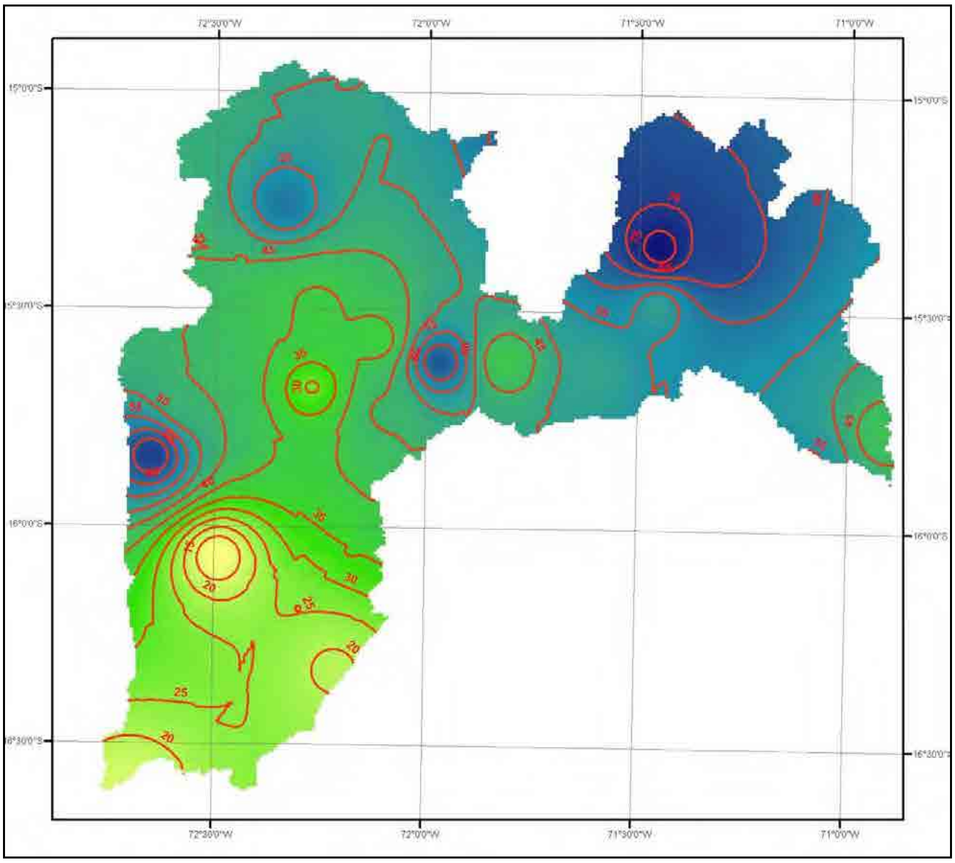


Figure 3.1.9-18 Rain Isohyets' map with 50 year return period (Majes-Camana River)

(3) Run off analysis

1) Flow monitoring

The current flow data collection system used in the discharge analysis was reviewed, and the necessary flow monitoring data were collected and processed for such analysis. The flow data have been obtained mainly from the DGIH, irrigation commissions, Water National Authority (ANA) and the Chira-Piura Special Project.

2) Analysis of Run off

The statistic hydrological calculation was made using the data of the maximum annual discharge collected and processed in the reference points, to determine the flow with different probabilities. Table 3.1.9-27 shows the probable flow with return periods between 2 and 100 years.

When comparing data of the 6 watersheds it can be seen that the greatest flow happens in Chira and Majes-Camana Rivers and the smallest flow is in Yauca.

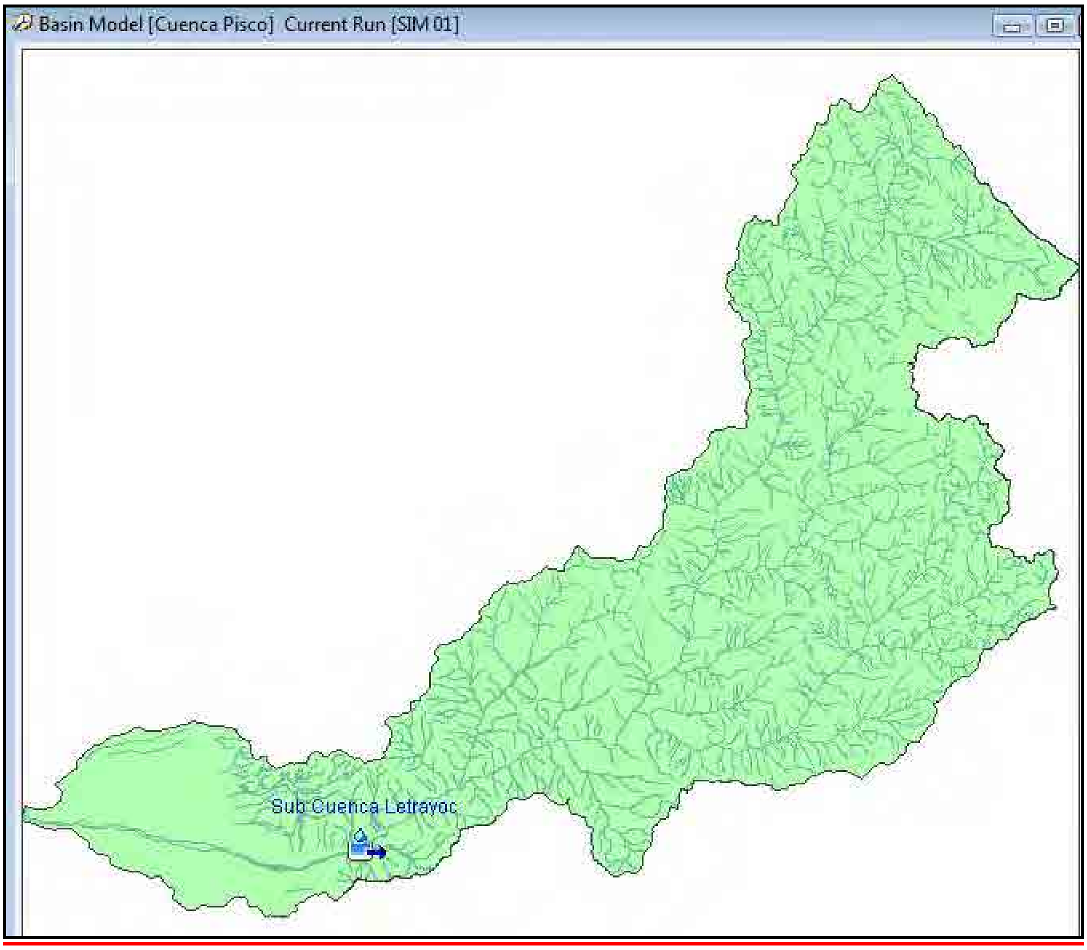
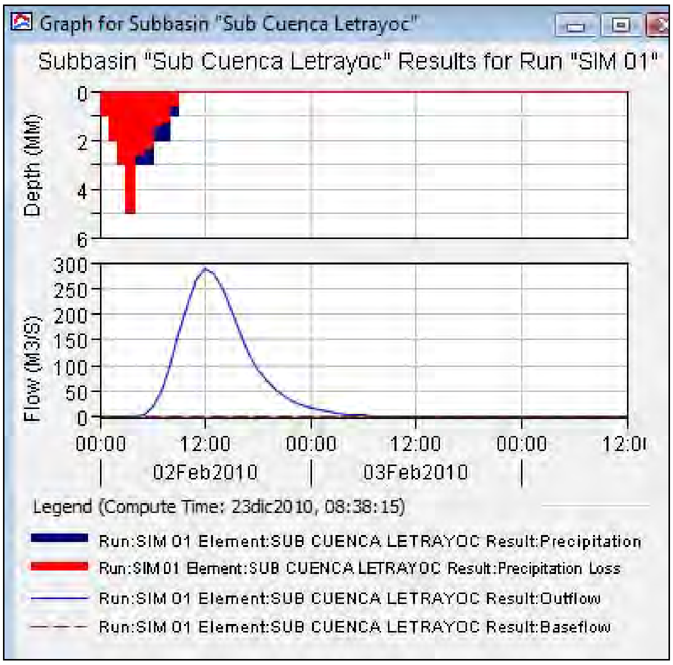
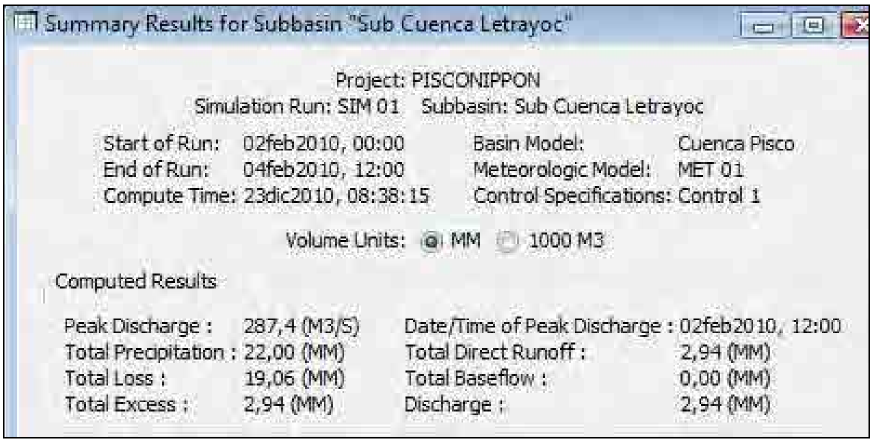


Figure 3.1.9-19 Result of Analysis 1 (analysis model and reference spot location: Pisco River)




Summary Results for Subbasin "Sub Cuenca Letrayoc"

Project: PISCONIPPON
Simulation Run: SIM 01 Subbasin: Sub Cuenca Letrayoc

Start of Run:	02feb2010, 00:00	Basin Model:	Cuenca Pisco
End of Run:	04feb2010, 12:00	Meteorologic Model:	MET 01
Compute Time:	23dic2010, 08:38:15	Control Specifications:	Control 1

Volume Units: MM 1000 M3

Computed Results

Peak Discharge :	287,4 (M3/S)	Date/Time of Peak Discharge :	02feb2010, 12:00
Total Precipitation :	22,00 (MM)	Total Direct Runoff :	2,94 (MM)
Total Loss :	19,06 (MM)	Total Baseflow :	0,00 (MM)
Total Excess :	2,94 (MM)	Discharge :	2,94 (MM)

Figure 3.1.9-20 Results of Analysis 2 (Calculation Results: Pisco River)

(b) Analysis results

Tables 3.1.9-28, -29 shows the flow of flooding with return periods between 2 and 100 years of the Chincha river watershed.

Likewise, Figures 3.1.9-28, -29 shows the hydrographical map of probable flood in the watersheds.

When comparing the specific discharge of the floods probable flow, it can be noticed that the lowest number refers to Chira River where there is more rain, compared to Cañete, Chincha and Pisco Rivers. This is due, because in the analysis a flood regulator effect was incorporated in Poechos Dam located upstream the reference point.

Table 3.1.9-28 Flood flow according to the return periods (Peak flow: Reference point)

(m^3/s)

Rivers	Return period					
	2 years	5 years	10 years	25 years	50 years	100 years
Río Chira Puente Sullana	890	1.727	2.276	2.995	3.540	4.058
Río Cañete Socsi	331	408	822	1.496	2.175	2.751
Río Chincha Conta	203	472	580	807	917	1.171
Río Pisco Letrayoc	213	287	451	688	855	962
Río Yauca San Francisco Alto	24	37	90	167	263	400
Majes-Camaná Huatiapa	270	728	1.166	1.921	2.659	3.586

Table 3.1.9-28 Flood flow according to the return periods (Peak flow: Reference point)

Rivers	Return Periods						
	2 years	5 years	10 years	25 years	50 years	100 years	Watershed area Km^2
Río Chira Puente Sullana	0,066	0,129	0,170	0,224	0,264	0,303	13.390
Río Cañete Socsi	0,058	0,072	0,145	0,264	0,383	0,485	5.676
Río Chincha Conta	0,068	0,158	0,195	0,271	0,308	0,393	2.981
Río Pisco Letrayoc	0,069	0,093	0,147	0,224	0,279	0,313	3.070
Río Yauca San Francisco Alto	0,008	0,012	0,028	0,052	0,082	0,125	3.198
マヘス/カマナ川 Huatiapa	0,021	0,057	0,091	0,149	0,207	0,279	12.854

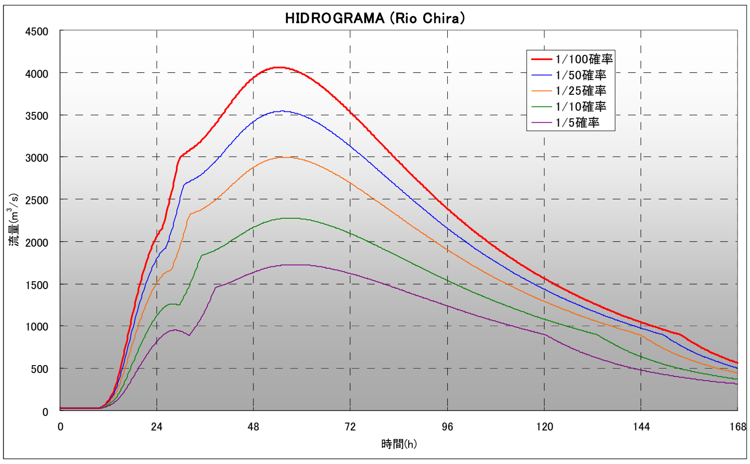


Figure 3.1.9-21 Hydrograph of Chira river

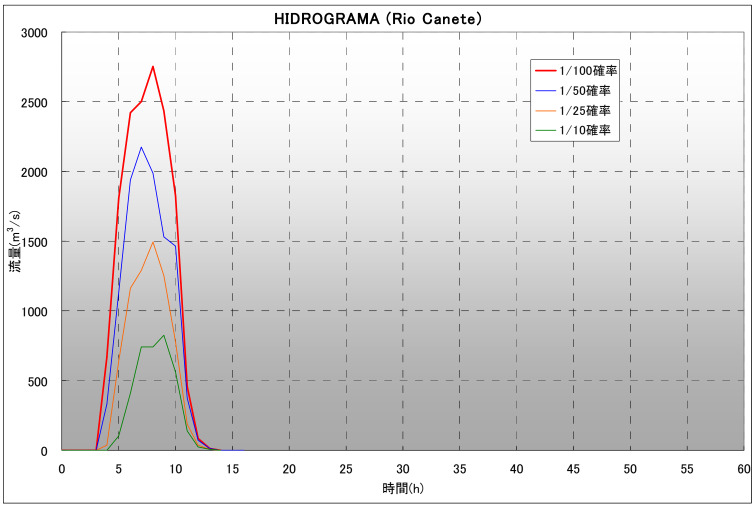


Figure 3.1.9-22 Hydrograph of Cañete river

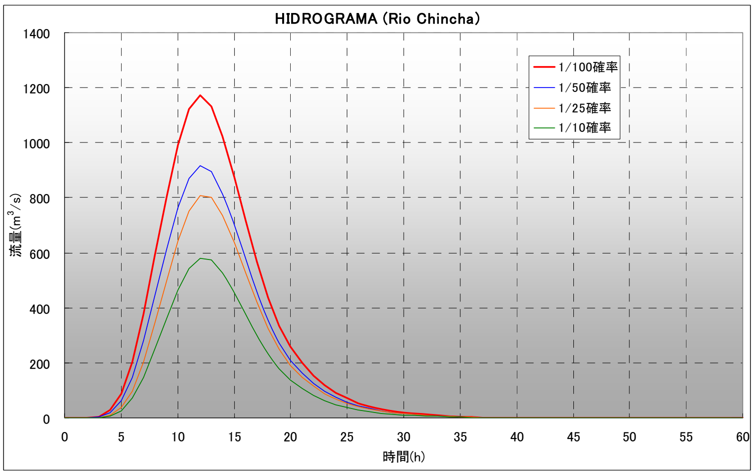


Figure 3.1.9-23 Hydrograph of Chincha river

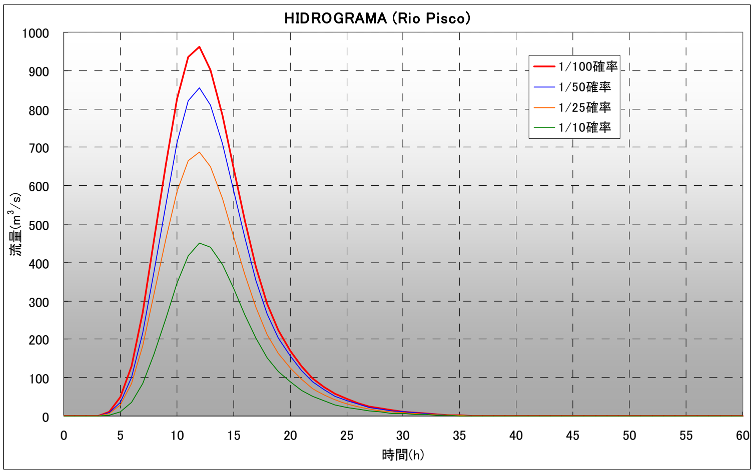


Figure 3.1.9-24 Hydrograph of Pisco river

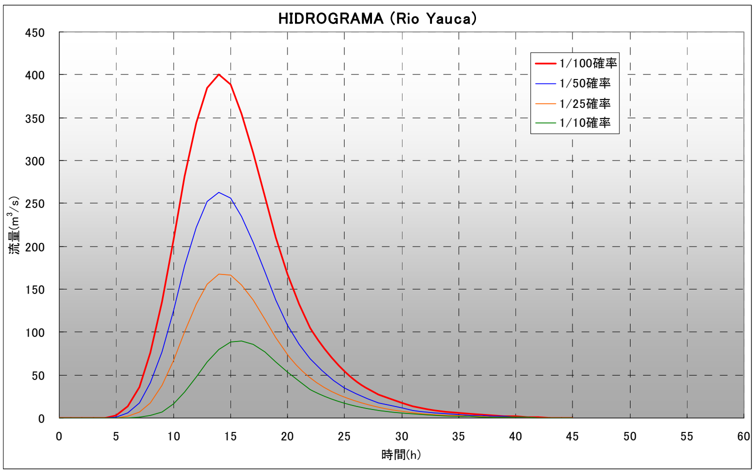


Figure 3.1.9-25 Hydrograph of Yauca river

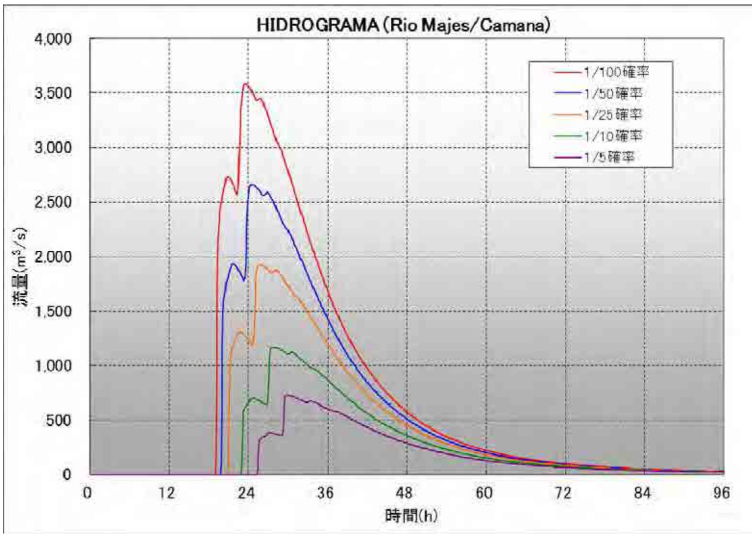


Figure 3.1.9-26 Hydrograph of Majes-Camana River

3.1.10 Analysis of inundation

（1） River surveys

Prior to the flood analysis, the transversal survey was performed as well as the longitudinal survey of dikes. Table 3.1.10-1 shows the results of the surveys in the five rivers subject of this Study.

In order to obtain the topographic data for the analysis of the inundation areas, the results of the true measurement results indicated in Table 3.1.10-1 were used as a complement, using the satellite Figures data.

Table 3.1.10-1 Basic data of the river surveys

Survey	Unit	Quantity	Notes
1. Control points survey			
Río Chira	No.	10	
Río Chincha	No.	6	
Río Pisco	No.	5	
Río Cañete	No.	4	
Río Yauca	No.	5	
Subtotal		30	
2. Dikes transversal survey			Intervalo de 250 m, solo una mergen
Río Chira	km	100	
Río Chincha	km	50	2 ríos x 25 km
Río Pisco	km	45	
Río Cañete	km	33	
Río Yauca	km	45	
Subtotal		273	
3. River transversal survey			Intervalo 500 m
Río Chira	km	120.0	200 líneas x 0.60 km (largo medio de línea)
Río Chincha	km	38.0	95 líneas x 0.4 km
Río Pisco	km	54.6	91 líneas 1x0.6 km
Río Cañete	km	46.9	67 líneas x 0.7 km
Río Yaucha	km	31.9	91 líneas x 0.35 km
Subtotal		291.4	
4. Benchmarks			
Tipo A	No.	30	Cada uno de los puntos de control
Tipo B	No.	273	Cada 273 km
Subtotal		303	

(2) Inundation analysis methods

Since the DGIH carried out the flood analysis of the profile study at a program level using the HEC-RAS model, for this Study, we decided to used this method, and review and modify it, if necessary.

1) Analysis basis

Normally, for the flooding analysis the following three methods are used.

① Varied flow unidimensional model
② Tank model
③ Varied flow horizontal bidimensional model

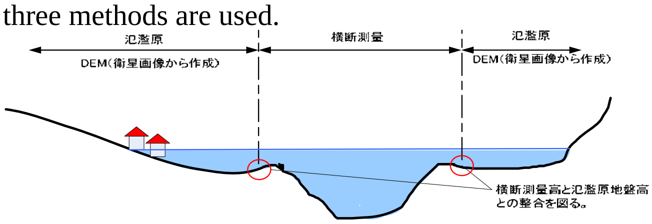
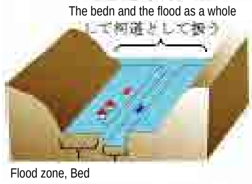
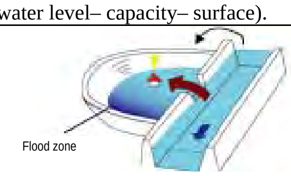
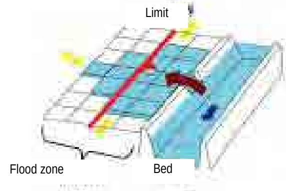


Figure 3.1.10-1 Idea of unidimensional model

The time and cost required by each method vary considerably, so only the most efficient method will be chosen, which guarantees the necessary accurateness degree for the preparation of the floodable zone maps.

Table 3.1.10-2 shows the characteristics of each analysis method. From the results of the simulation performed by DGIH, it is known that the rivers have a slope between 1/100 and 1/300, so initially the varied flow one-dimensional model was chosen assuming that the floods were serious. However, we considered the possibility that the overflowed water extends within the watershed in the lower watershed, so for this study the variable regimen horizontal bi-dimensional model was used to obtain more accurate results

Table 3.1.10-2 Methodology of flooding analysis

Analysis methods	Vary flow unidimensional model	Tank model	Varied flow bi-dimensional horizontal model
Basic concept of the flood zone definition	In this method, the flood zone is considered to be included in the river bed, and the flood zone is determined by calculating the water level of the bed in relation to the maximum flooding flow	This method manages the flood zone and bed separately, and considers the flooding zone as a closed body. This closed water body is called *pond* where the water level is uniform. The flood zone is determined in relation to the relationship between the overflowed water from the river and entered to the flood zone, and the topographic characteristics of such zone (water level– capacity– surface).	This method manages the flood zones and the bed separately, and the flood zone is determined by analyzing the bidimensional flow of the behaviour of water entered to the flood zone.
Approach			
Characteristics	It is applicable to the floods where the overflowed water runs by the flood zone by gravity; that means, current type floods. This method must manage the analysis area as a protected area (without dikes).	Applicable to blocked type floods where the overflowed water does not extend due to the presence of mountains, hills, embankments, etc. The water level within this closed body is uniform, without flow slope or speed. In case there are several embankments within the same flood zone, it may be necessary to apply the pond model in series distinguishing the internal region.	Basically, it is applicable to any kina of flood. Reside the flood maximum area and the water level, this method allows reproducing the flow speed and its temporary variation. It is considered as an accurate method compared with other methods, and as such, it is frequently applied in the preparation of flood irrigation maps. However, due to its nature, the analysis precision is subject to the size of the analysis model grids.

2） Inundation analysis method

Figure 3.1.10-2 shows the conceptual scheme of the variable regimen horizontal bi-dimensional model.

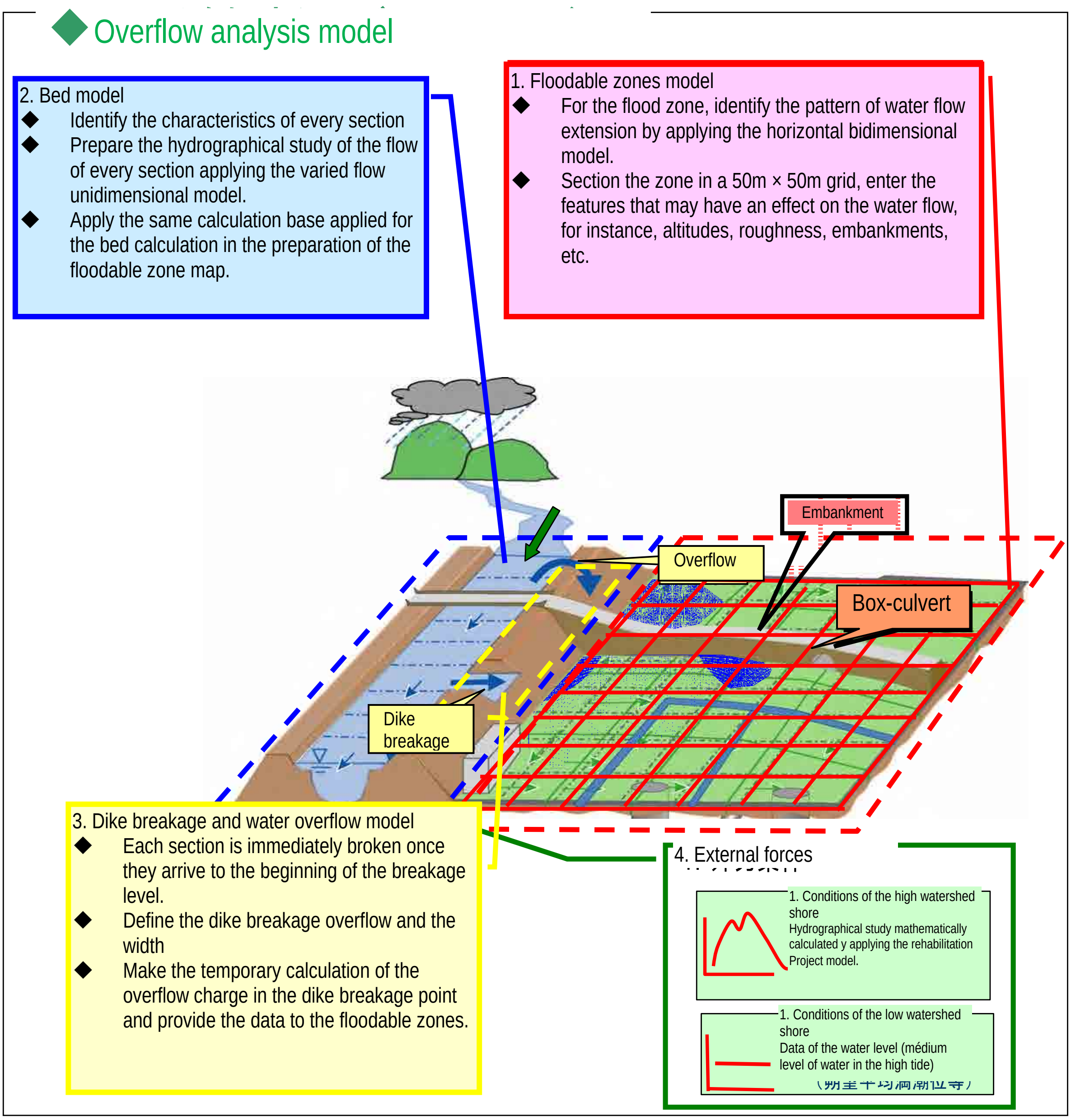


Figure 3.1.10-2 Conceptual scheme of the overflow analysis model

(3) Discharge flow analysis

The current discharge capacity of the beds was estimated based on the results of the river survey and applying the HEC-RAS method, which results appear in Figure 3.1.10-3. This Figure also shows the flooding flows of different return periods, which allow evaluating in what points of each watershed flood may happen and what magnitude of flood flow may they have.

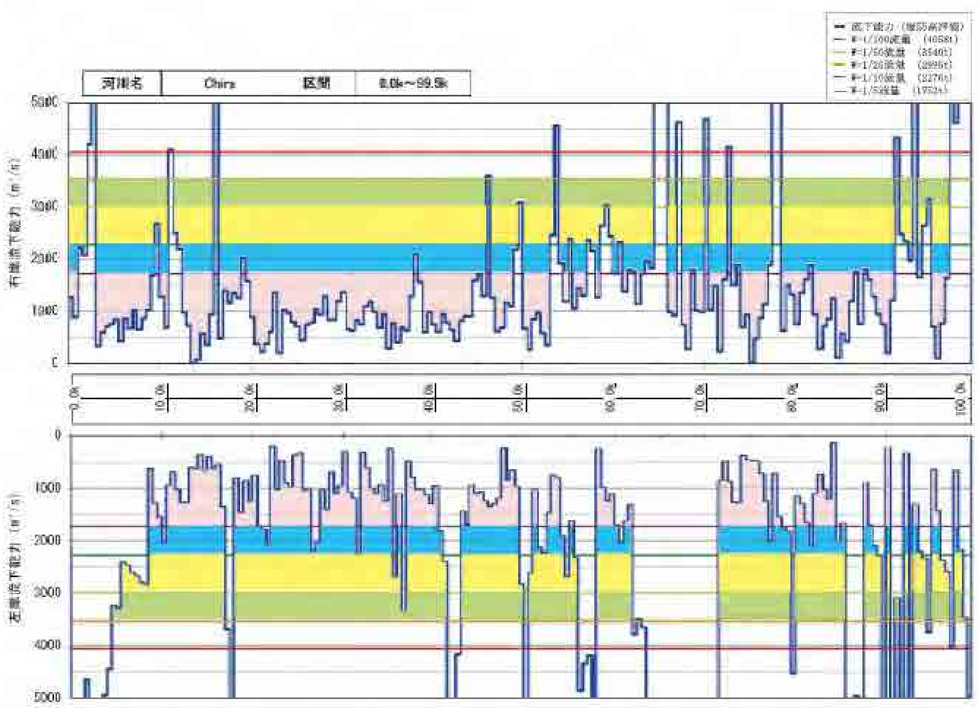


Figure 3.1.10-3 Current Discharge capacity of Chira River

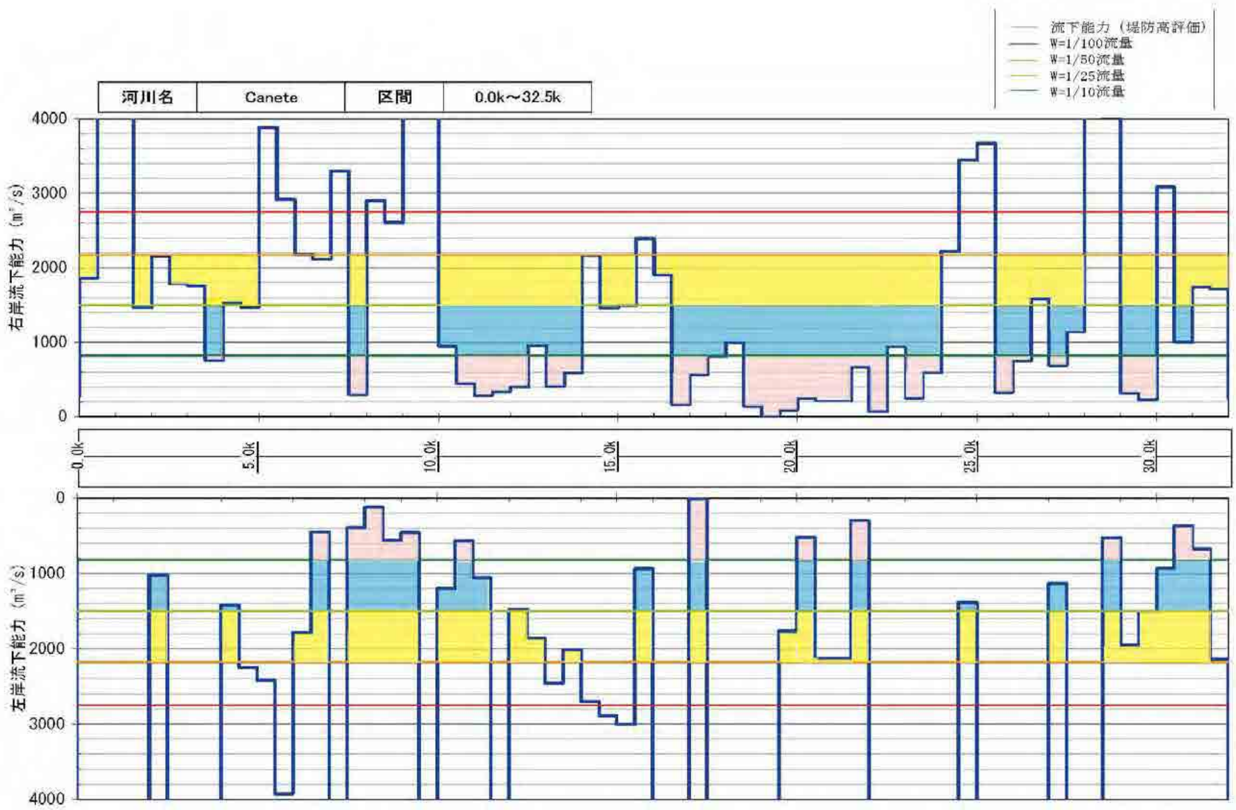


Figure 3.1.10-4 Current Discharge capacity of Cañete River

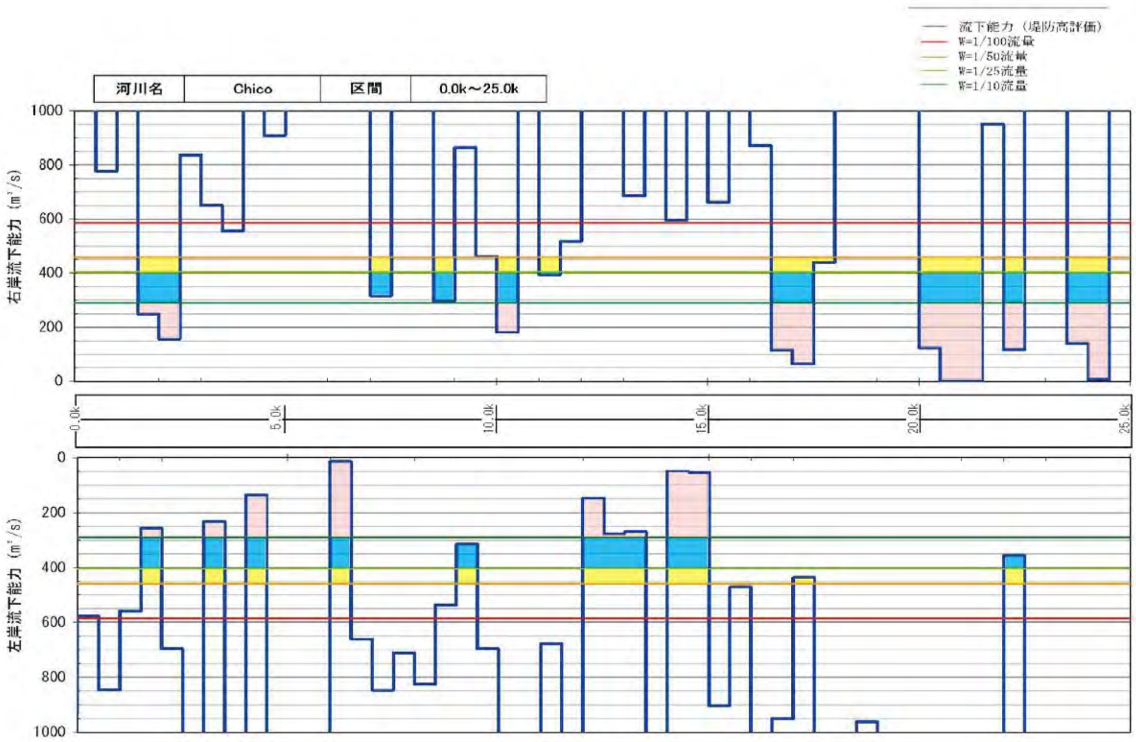


Figure 3.1.10-5 Current Discharge capacity of Chico River

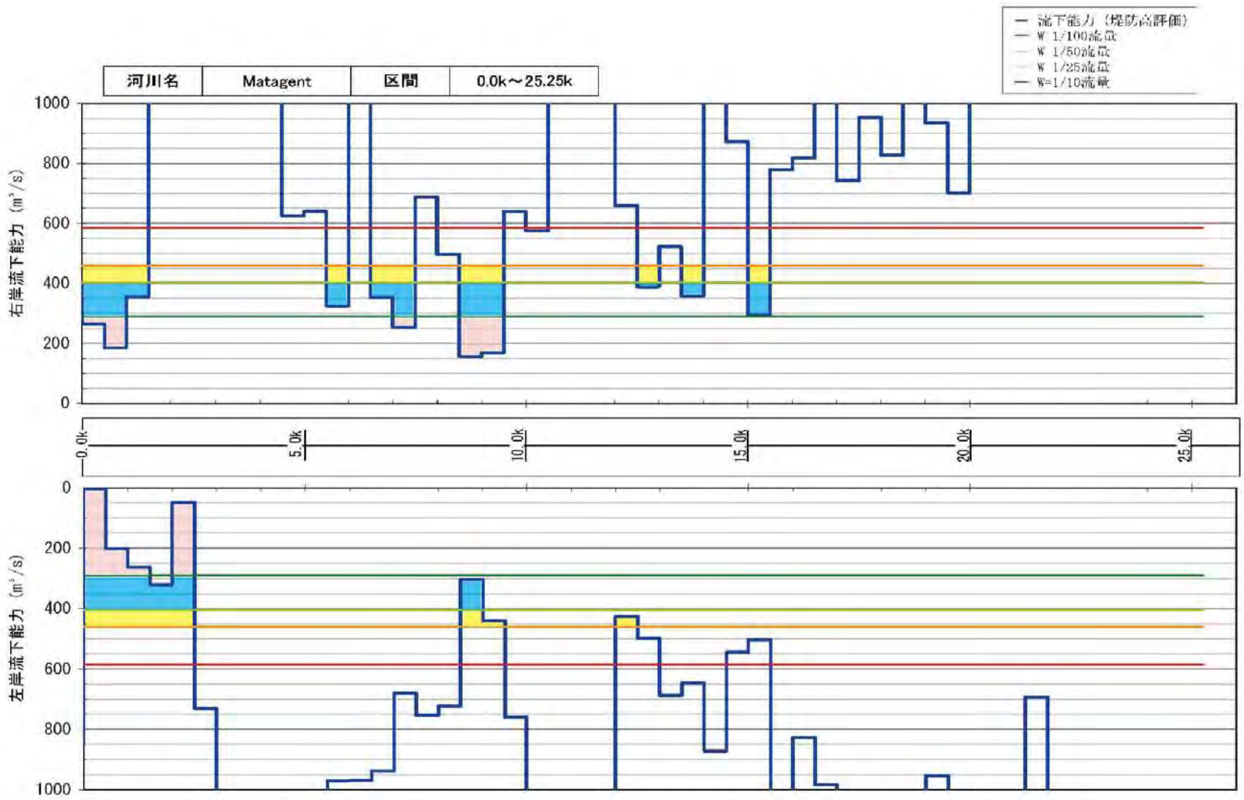


Figure 3.1.10-6 Current Discharge capacity of Matagente River

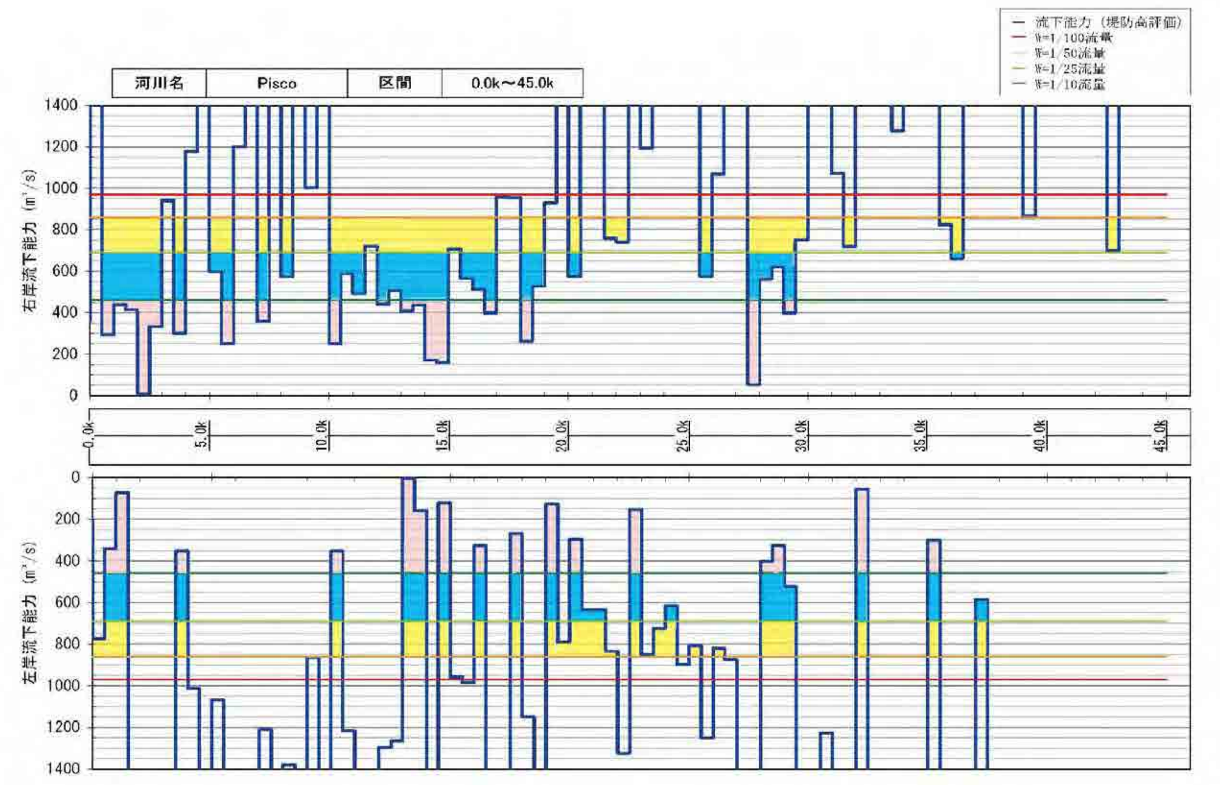


Figure 3.1.10-7 Current Discharge capacity of Pisco River

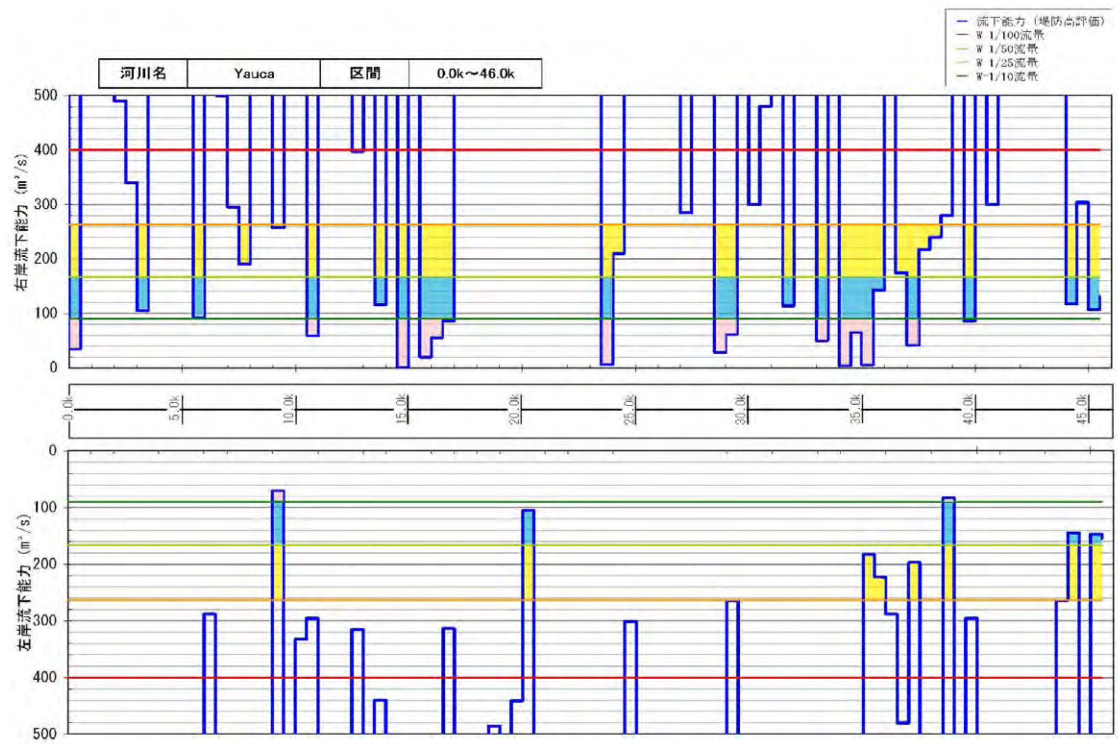


Figure 3.1.10-8 Current Discharge capacity of Yauca River

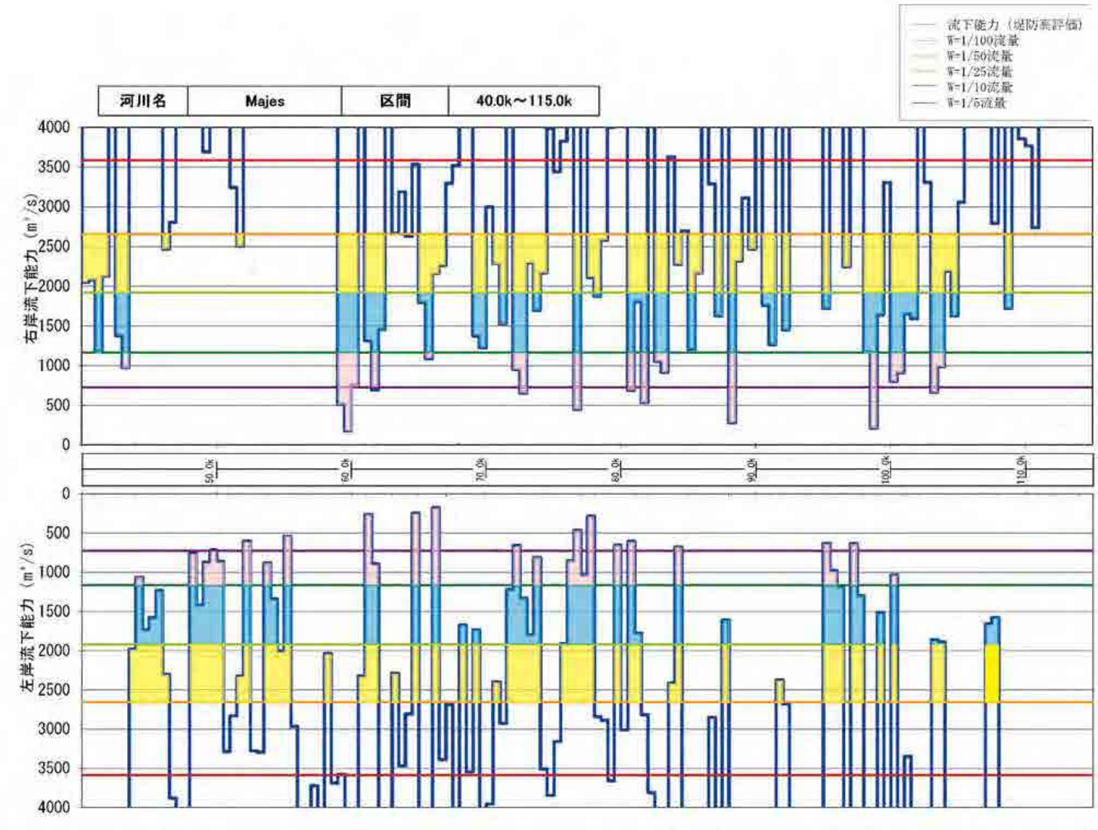


Figure 3.1.10-9 Current Discharge capacity of Majes River

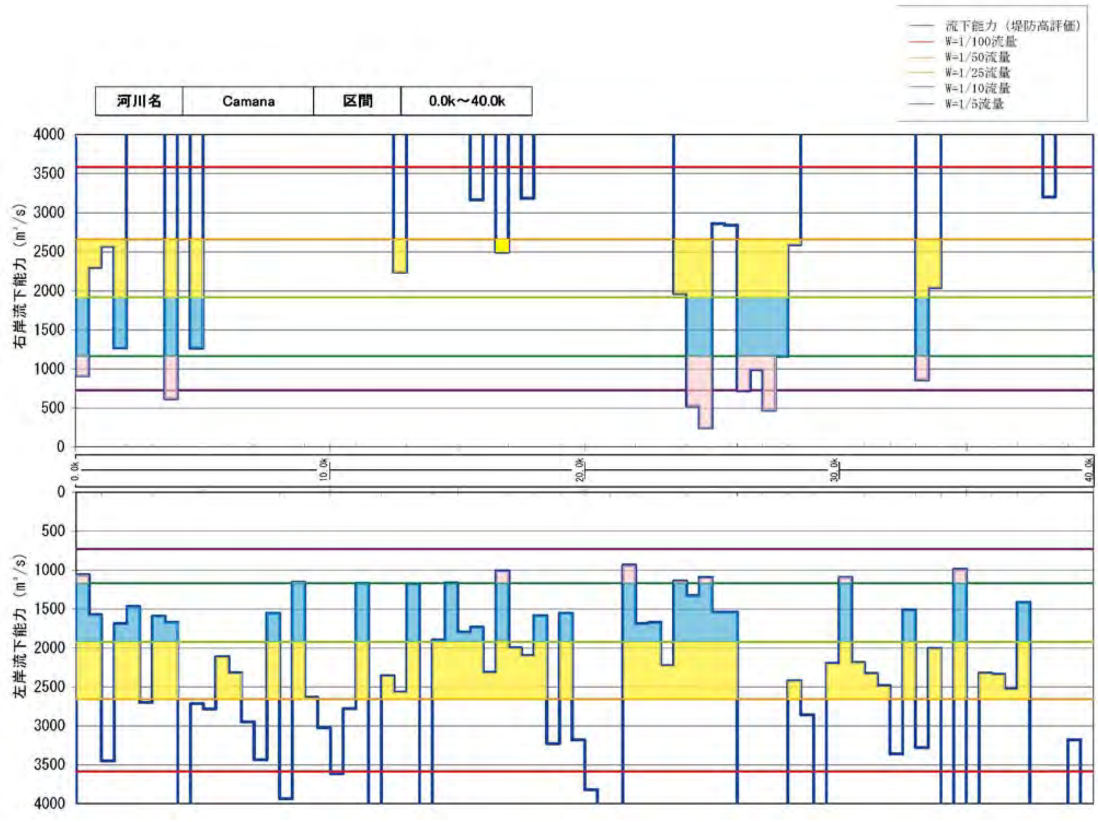


Figure 3.1.10-10 Current Discharge capacity of Camana River

(4) **Inundation area**

As a reference, Figures 3.1.10-11 and 3.1.10-18 show the results of the inundation area calculation in each watershed compared to the flooding flow with a 50 year return period.

Figure 3.1.10-11 Inundation area of Chira river (50 year period floods)

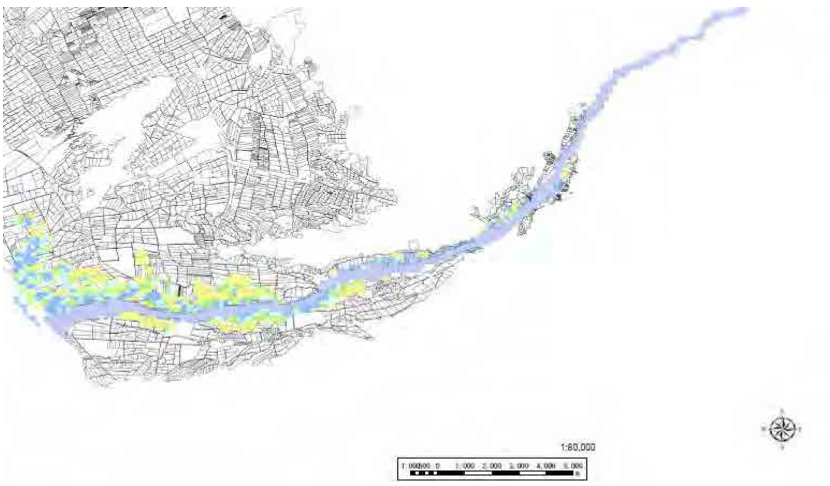


Figure 3.1.10-12 Inundation area scope of Cañete river (50 year period floods)

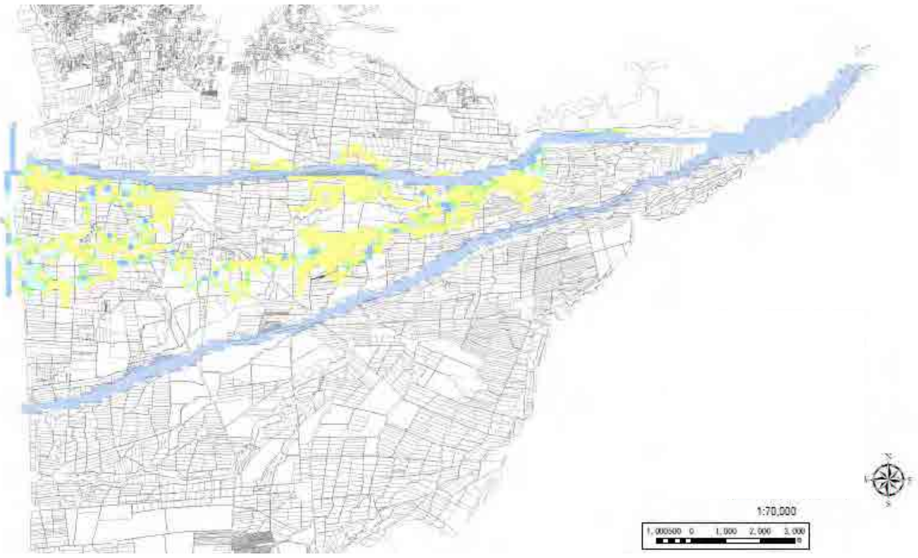


Figure 3.1.10-13 Inundation area of Chincha river (Chico) - (50 year period floods)

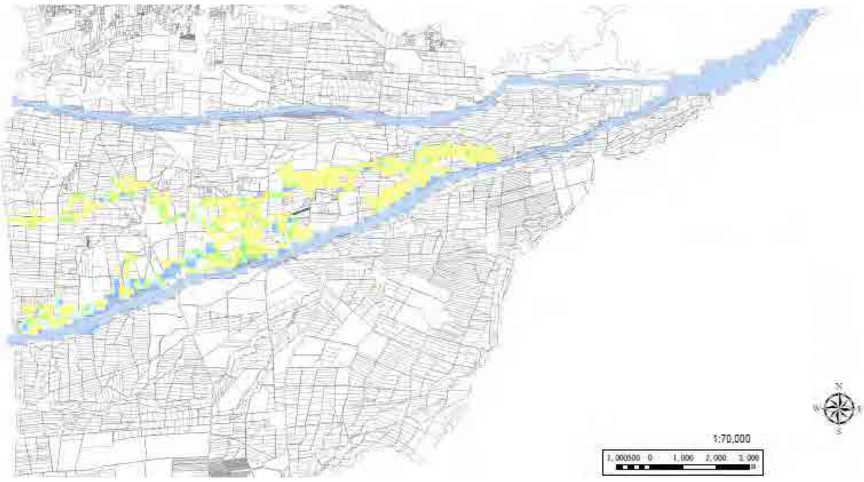


Figure 3.1.10-14 Inundation area of Chincha river (Matagente) - (50 year period floods)

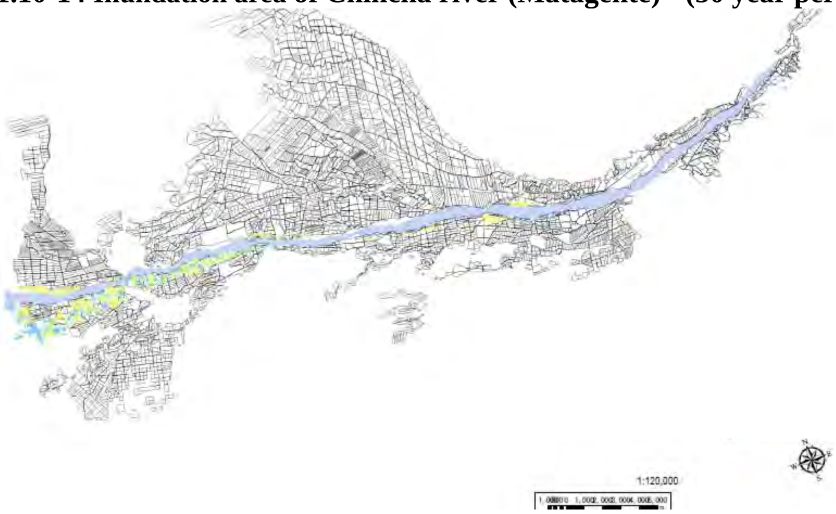


Figure 3.1.10-15 Inundation area of Pisco river - (50 year period floods)

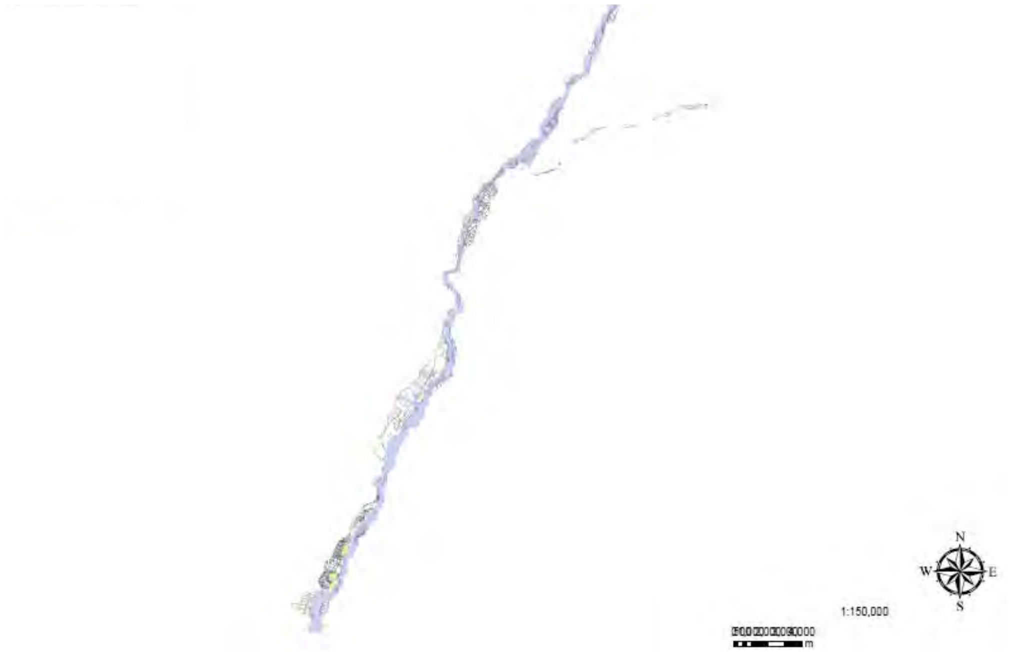


Figure 3.1.10-16 Inundation area of Yauca river - (50 year period floods)

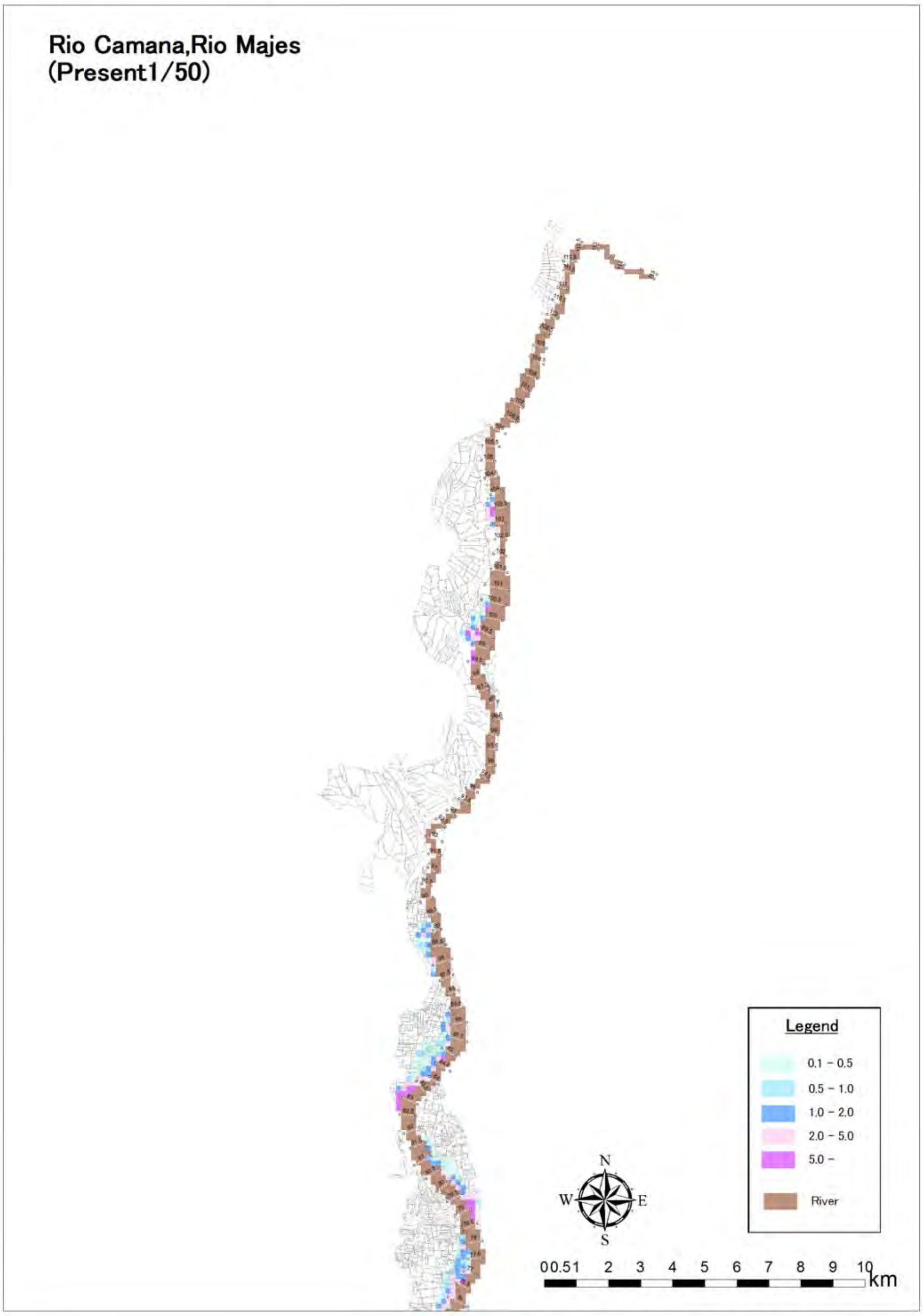


Figure 3.1.10-17 Inundation area of Majes-Camana river - (50 year period floods)

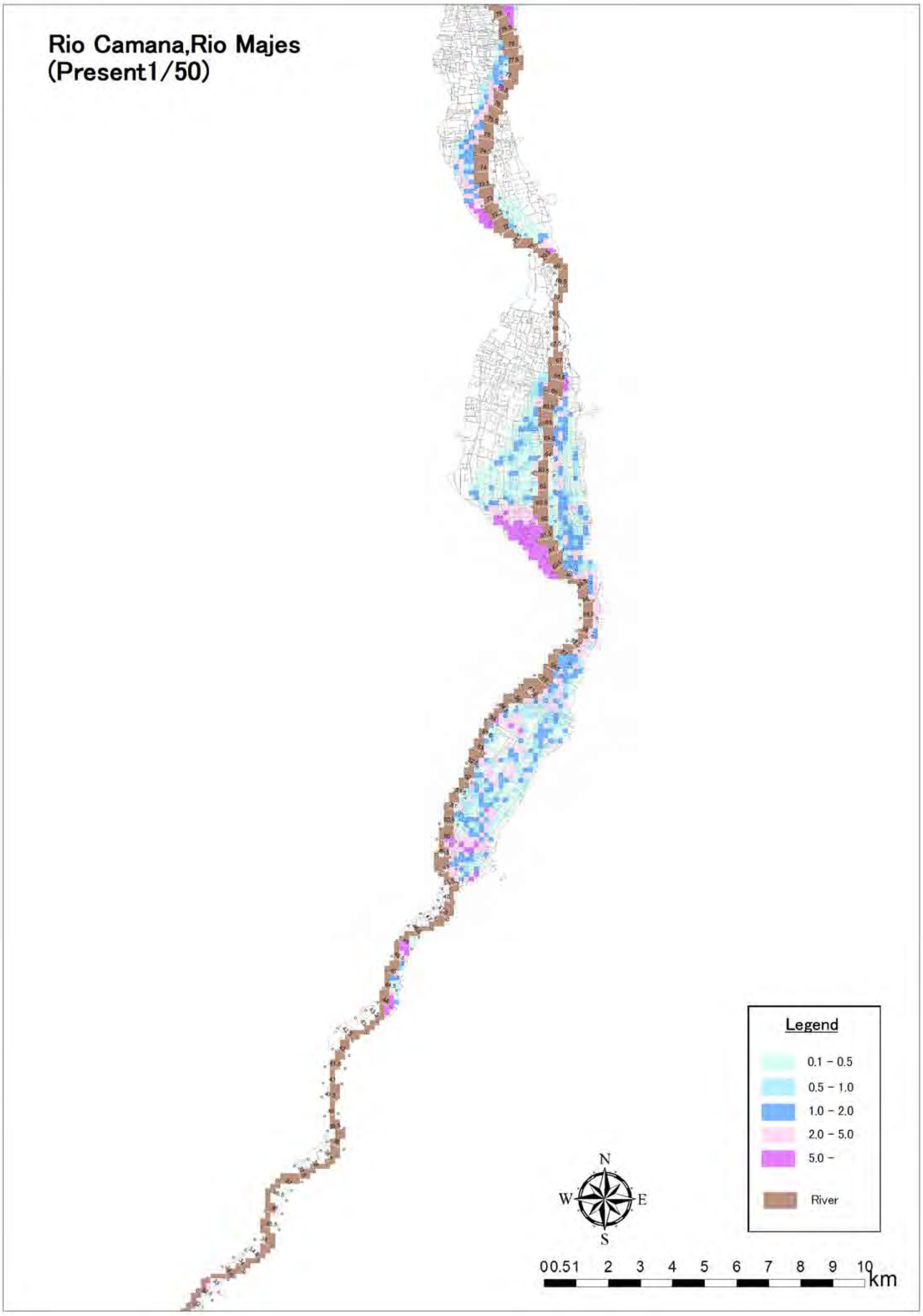


Figure 3.1.10-17(2) Inundation area of Majes-Camana river - (50 year period floods)

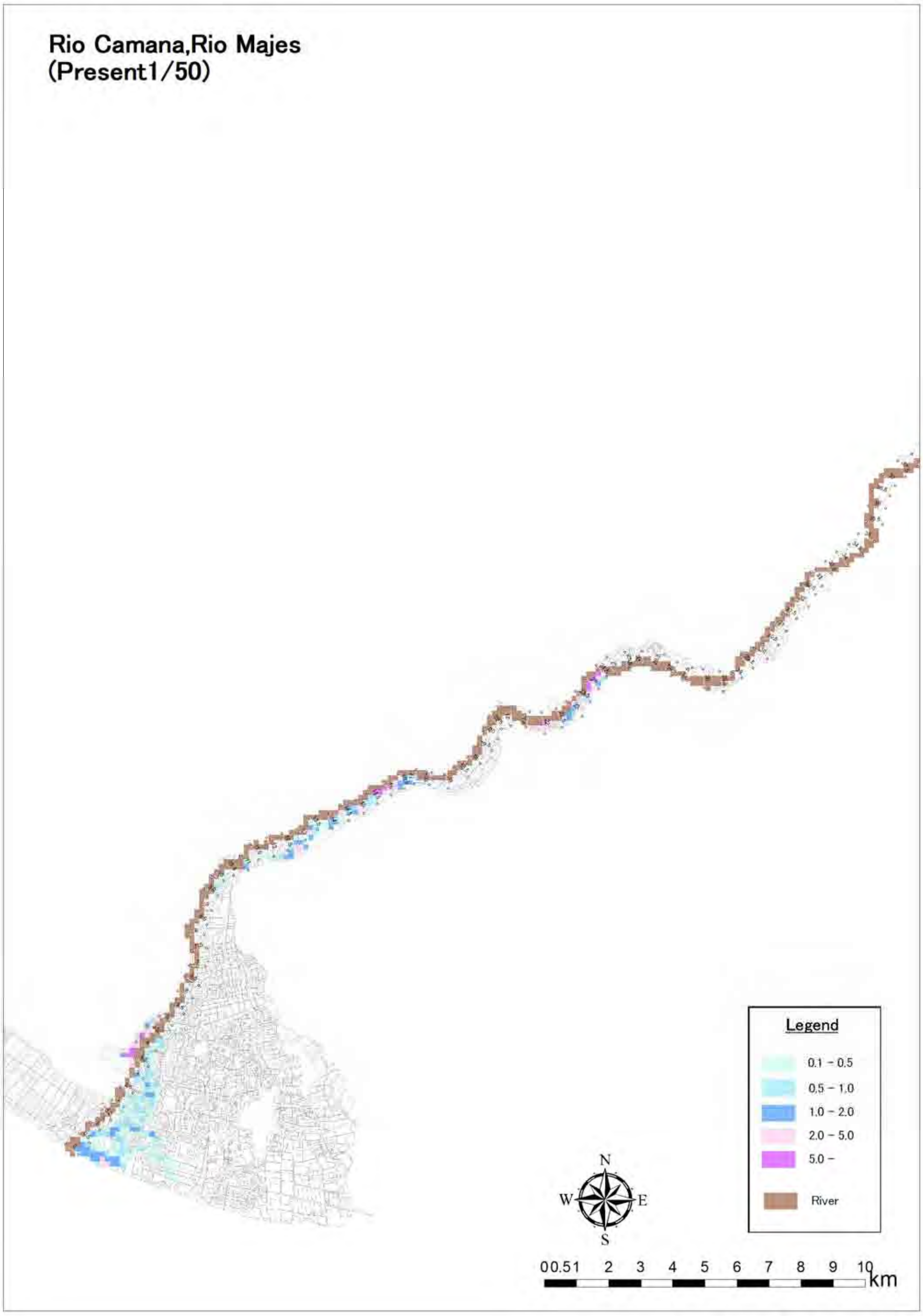


Figure 3.1.10-17(3) Inundation area of Majes-Camana river - (50 year period floods)

3.1.11 Early Alert Information System

(1) Piura River Watershed

There is an early alert system called **SIAT** (for its acronym in Spanish), for the Piura River Watershed. This was developed in the Reconstruction Definitive Study and Rehabilitation System for Flood Defense in Bajo Piura, which was installed in 2001 with financing of the German

Government trough GTZ and Piura Regional Administration Council CTAR-Piura.

The objectives of this project are:
- Plan and organize institutions work linked to the Early Alert System
- Install strategic points telemetry network of Piura River
- Implement and function Hydrologic Model NAXOS as base for flood forecast
- Investigation on the pluvial behavior of El Niño phenomenon of Piura River Watershed
- Technical and support assistance on the elaboration of Contingency Plans and Vulnerability Reduction at district level and on Health and Agriculture sectors

SIAT system operation and its functioning are done throughout a total of 30 Pluviometric and Hydrometric stations that operate together with SENAMHI, PECH and DIRESA. Data is sent in real time to the Operation Center installed in the Piura-Chira Project.
Rainfall data is received, analyzed and processed by NAXOS hydrologic model.
The results of this model allow Piura River flood forecasts. The alert is transmitted on time to the CIR (Regional Information Center) in CTAR – Piura, so their organisms and Civil Defense take decisions to mitigate the negative impact in most vulnerable areas.

SIAT execution is done throughout an inter-institutional agreement and the following take part in this agreement:

- Regional Government of Piura (GRP)
- Development German Cooperation (GTZ)
- National Service of Meteorology and Hydrology (SENAMHI)
- Regional Health Direction of Piura (DIRESA)
- University of Piura (UDEP)
- Scientific and Technologic Consultant Council of the Regional Government of Piura (CCCTEP)
- Especial Project Chira-Piura (PECHP)

SIAT network works throughout a communication system, which initially was telemetric and now is via satellite. In Figure 3.1.11-1, the Early Alert System installed in Piura River Watershed is shown, as its operation connections.

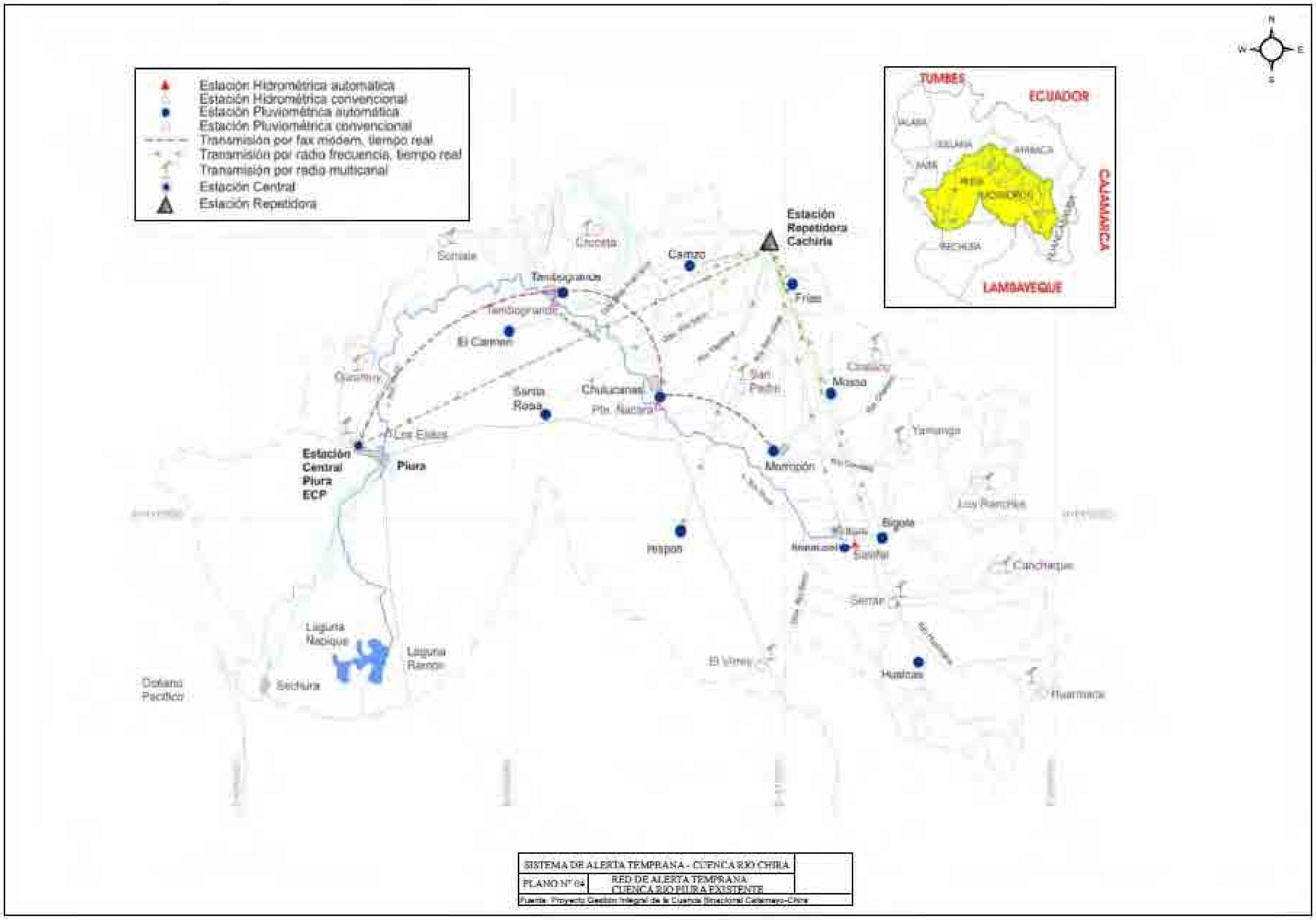


Figure 3.1.11-1 Early alert system of Piura River

(2) Chira River Watershed

Chira-Piura Project has a system to obtain information for the operation of the Chira-Piura system and especially for operating Poechos Dam. This is done based on a net built since 1971, which has 8 meteorological and 7 hydrometrical stations, all of them communicate through multi-channel radio and telephones; in Tables N%l 6 and 7 stations are indicated and on map N|5 the location of each station is detailed. This procedure of information gathering and data transfer is used since the first stage of the project's building process.

It is a preliminary process of the early alert information system that is currently being used. This transmits data through a daily multi-channel radial system at 7:00 and 19:00 hours to the Piura base station, which gathers all the Chira-Piura system's information and at the same time re-transmits to Poechos dam and Puente Sullana. The transmission sequence is as follows:

- Radio transceiver – Hydrometeorological Station
- Radio transceiver – Base Station
- Information entering to the PC – Data base

It does not have a rainfall run-off model for the watershed, but they use isochronous information for the upper watershed discharge values transfer and at the same time for the lower areas and sporadically they are using satellite information.

Table 3.1.11-1 Hydrometrical Stations currently operating in Chira-Piura River Watershed

Nº	Station	Coordinates UTM		RIVER	Condition
		N	E		
1	Paraje Grande	9488151	620548	Quiroz	Existent
2	Pte. Internacional	9515414	616512	Macara	Existent
3	Alamor	9529244	589330	Alamor	Existent
4	El Ciruelo	9524654	594327	Chira	Existent
5	Ardilla	9503620	567918	Chira	Existent
6	Poechos	9482714	552473	Chira	Existent
7	Pte. Sullana	9459530	534271	Chira	Existent

Table 3.1.11-2 Meteorological Stations currently operating in Chira River Watershed

N%l	STATION	PROV	DIST	SUB BASIN	Coordinates UTM		ALTITUD	CATEGORY	INSTITUCION QUE OPERA
					N	E			
1	Ayabaca	Ayabaca	Ayabaca	Quiroz	9487823	642699	2700	MAO	SENAMHI
2	Chilaco	Sullana	Sullana	Chira	9480963	554900	90	MAO	PECHP
3	El Ciruelo	Ayabaca	Suyo	Chira	9524654	594327	202	PV-PG	PECHP
4	Pte.Internac.	Ayabaca	Suyo	Macará	9515414	616512	408	PV-PG	PECHP
5	Paraje Grande	Ayabaca	Paimas	Quiroz	9488151	620548	555	PV	PECHP
6	Sapillica	Ayabaca	Sapillica	Chipillico	9471196	612750	1446	PV	SENAMHI
7	El Partidor	Piura	Las Lomas	Chipillico	9477296	580134	255	CO	SENAMHI
8	Alamor	Sullana	Lancones	Chira	9505457	566997	125	PV	SENAMHI

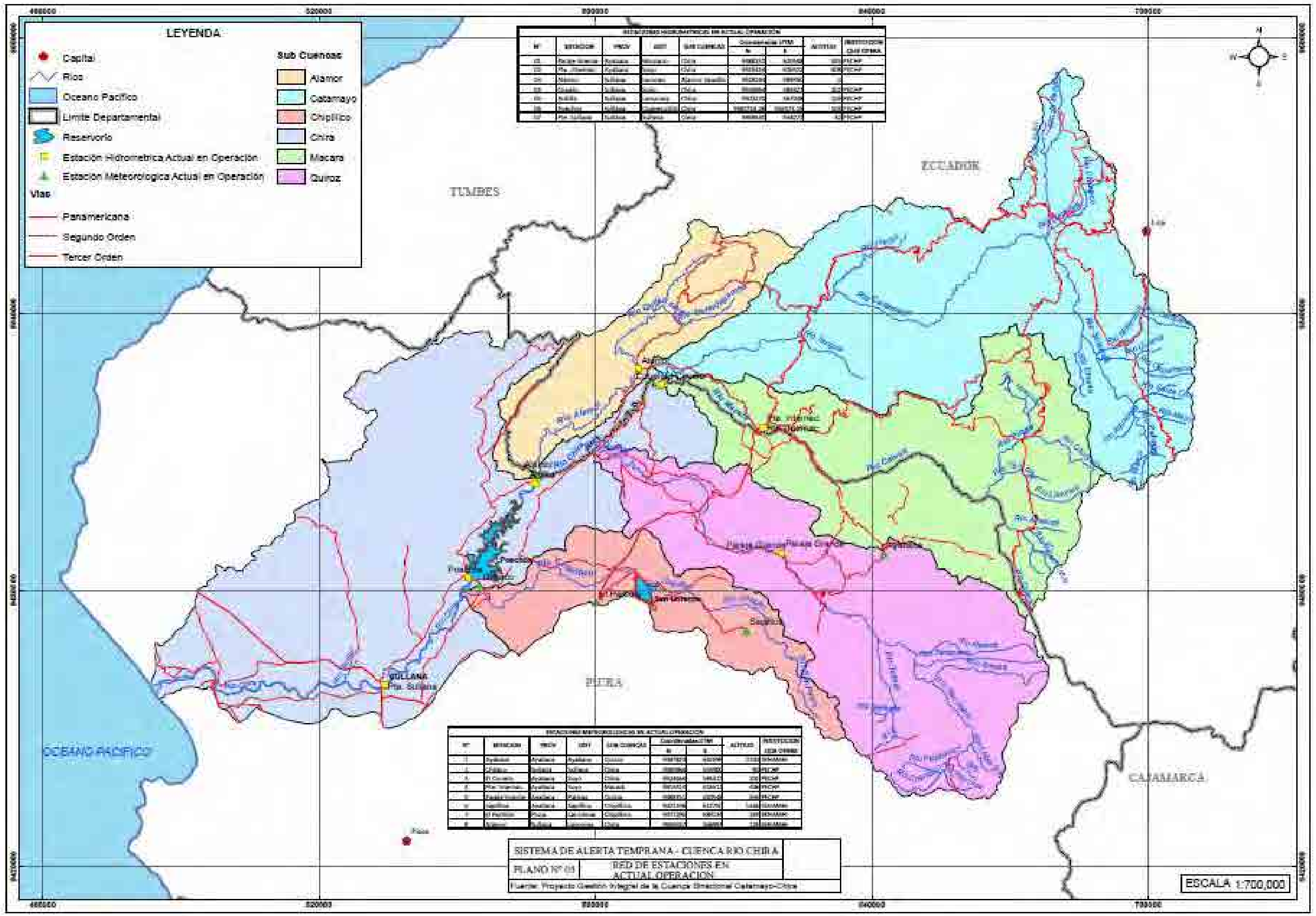


Figure 3.1.11-2 Location of monitoring stations of the Chira River Watershed

3.2 Definition of Problem and Causes

3.2.1 Problems of flood control measures in the Study Area

Based on the results of the six selected watersheds study, the main problem on flood control was identified, as well as the structures to be protected, which results are summarized in Table 3.2.1-1.

Table 3.2.1-1 Problems and conservation measures of flood control works

Problems		Overflowing			Dike erosion	Margins erosion	Non-working intake	Non-working derivation works
		Without dikes	Sediment in bed	Lack of width				
Structures to be protected	Agricultural lands	○	○	○	○	○	○	○
	Irrigation channels					○	○	
	Urban area	○		○				○
	Roads					○		
	Bridges		○					
	Dam Dikes					○		
	Natural gas deposit				○			

3.2.2 Problem causes

Next, the main problem and its direct and indirect causes for flood control in the Study Area are described:

(1) Main Problem

Valleys and local communities highly vulnerable to floods

(2) Direct and indirect causes

Table 3.2.2-2 shows the direct and indirect causes of the main problem

Table 3.2.2-2 Direct and indirect causes of the main problem

Direct cause	1. Excessive flood flow	2. Overflowing	3.Insufficient maintenance of control works	4. Insufficient communitarian activities for flood control
Indirect causes	1.1 Frequent occurrence of extraordinary weather (El Niño, etc..)	2. Lack of flood control works	3.1 Lack of maintenance knowledge and skills	4.1 Lack of knowledge and flood prevention techniques
	1.2 Extraordinary rains in the middle and upper basins	2.2 Lack of resources for the construction of works	3.2 Lack of training in maintenance	4.2 Lack of training in flood prevention
	1.3 Vegetation cover almost zero in the middle and upper basins	2.3 Lack of plans for flood control in basins	3.3 Lack of dikes and margins repair	4.3 Lack of early warning system
	1.4 Excessive sediment dragging from the upper and middle river levee	2.4 Lack of dikes	3.4 Lack of repair works and referral making	4.4 Lack of monitoring and collection of hydrological data
	1.5 Reduction of hydraulic capacity of rivers by altering slopes, etc.	2.5 Lack of bed channel width	3.5 Use of illegal bed for agricultural purposes	
		2.6 Accumulation of sediments in beds	3.6 Lack of maintenance budget	
		2.7 Lack of width at the point of the bridge construction		
		2.8 Elevation of the bed at the point of the bridge construction		
		2.9 Erosion of dikes and margins		
		2.10 Lack of capacity for the design of the works		

3.2.3 Problem Effects

(1) Main Problem

Valleys and local communities highly vulnerable to floods

(2) Direct and indirect effects

Table 3.2.3-1 shows the direct and indirect effects of the main problem

Table 3.2.3-1 Direct and indirect effects of the main problem

Direct Effects	1. Agriculture Damages	2. Direct damages to the community	3. Social infrastructure damages	4. Other economical damages
Indirect Effects	1.1 Agriculture and livestock damage	2.1 Private property and housing loss	3.1 Roads destruction	4.1 Traffic interruption
	1.2 Agricultural lands loss	2.2 Industries and facilities loss	3.2 Bridges loss	4.2 Flood and evacuations prevention costs
	1.3 Irrigation channels destruction	2.3 Human life loss and accidents	3.3 Running water, electricity, gas and communication infrastructures' damages	4.3 Reconstruction costs and emergency measures
	1.4 Work destruction and derivation	2.4 Commercial loss		4.4 Work loss by local inhabitants
	1.5 Dikes and margins erosion			4.5 Communities income reduction
				4.6 Life quality degradation
				4.7 Loss of economical dynamism

(3) Final effect

The main's problem final effect is the community socio-economic impediment development of the affected area.

3.2.4 Causes and effects diagram

Figure 3.2.4-1 shows the causes and effects diagram done based on the above analysis results.

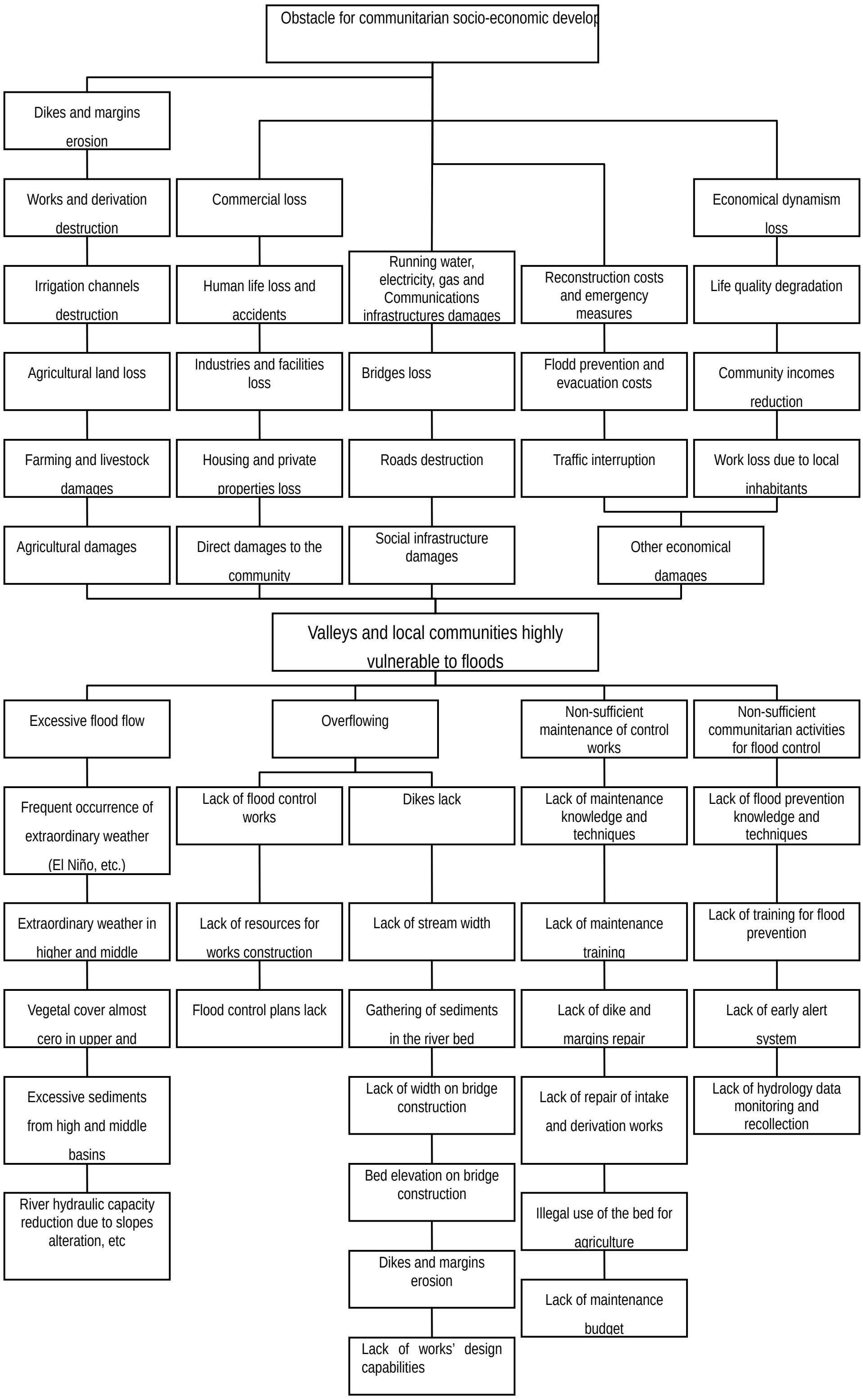


Figure 3.2.4-1 Causes and effects diagram

3.3 Objective of the Project

The final impact that the Project wants to achieve is to alleviate the vulnerability of valleys and local community to flooding and promote local economic development.

3.3.1 Solving measures for the main problem

(1) Main objective

Soothe the valleys and local community to flooding vulnerability.

(2) Direct and indirect measures

In Table 3.3.1-1, direct and indirect solutions measures for the problem are shown.

Table 3.3.1-1 Direct and indirect solution measures to the problem

Direct measures	1. Analyze and relieve excessive flood flow	2. Prevent overflow	3. Full compliance with maintenance of flood control works	4. Encourage community flood prevention
Indirect measures	1.1 Analyze extraordinary weather (El Niño, etc..)	2.1 Construct flood control works	3.1 Strengthen maintenance knowledge and skills	4.1 Strengthen knowledge and skills to prevent flooding
	1.2 Analyze extraordinary rainfall in the upper and middle basins	2.2 Provide resources for the works construction	3.2 Reinforce training maintenance	4.2 Running flood prevention training
	1.3 Planting vegetation on the upper and middle basins	2.3 Develop plans for flood control basins	3.3 Maintain and repair dikes and margins	4.3 Creating early warning system
	1.4 Relieve Excessive sediment entrainment from the upper and middle river dikes	2.4 Build dikes	3.4 Repair intake and derivation works	4.4 Strengthen monitoring and water data collection
	1.5 Take steps to alleviate the reduction in hydraulic capacity of rivers by altering slopes, etc.	2.5 Extends the width of the channel	3.5 Control the illegal use of bed for agricultural purposes	
		2.6 Excavation of bed	3.6 Increase the maintenance budget	
		2.7 Extending the river at the bridge's construction		
		2.8 Dredging at the point of the bridge construction		
		2.9 Control dikes and margins erosion		
		2.10 Strengthen the capacity for works design		

3.3.2 Expected impacts for the main's objective fulfillment

(1) Final Impact

The final impact that the Project wants to achieve is to alleviate the vulnerability of the valleys and the local community to floods and promoting local socio-economic development.

(2) Direct and indirect impacts

In Table 3.3.2-1 direct and indirect impacts expected to fulfill the main objective to achieve the final impact are shown.

Table 3.3.2-1Direct and indirect impacts

Direct Impacts	1. Agricultural damage relief	2. Relief of direct harm to the community	3. Relief of social infrastructure damage	4. Relief of other economic damage
Indirect Impacts	1.1 Relief to crops and livestock damage	2.1 Housing and private properties loss prevention	3.1 Road destruction prevention	4.1 Traffic interruption prevention
	1.2 Relief for farmland loss	2.2 Prevention of Industries and facilities establishments	3.2 Prevention of bridges loss	4.2 Reducing costs of flood prevention and evacuation
	1.3 Prevention of the destruction of irrigation channels	2.3 Prevention of accidents and human life loss	3.3 Running water, electricity, gas and communication infrastructures' relief	4.3 Cost reduction of the reconstruction and emergency measures
	1.4 Prevention of destruction works of intake and derivation	2.4 Commercial loss relief		4.4 Increase of local community hiring
	1.5 Dikes and margins erosion relief			4.5 Community income increase
				4.6 Life quality improvement
				4.7 Economic activities development

3.3.3 Measures - objectives – impacts Diagram

In Figure 3.3.3-1 the measures - objectives – impacts diagram is shown.

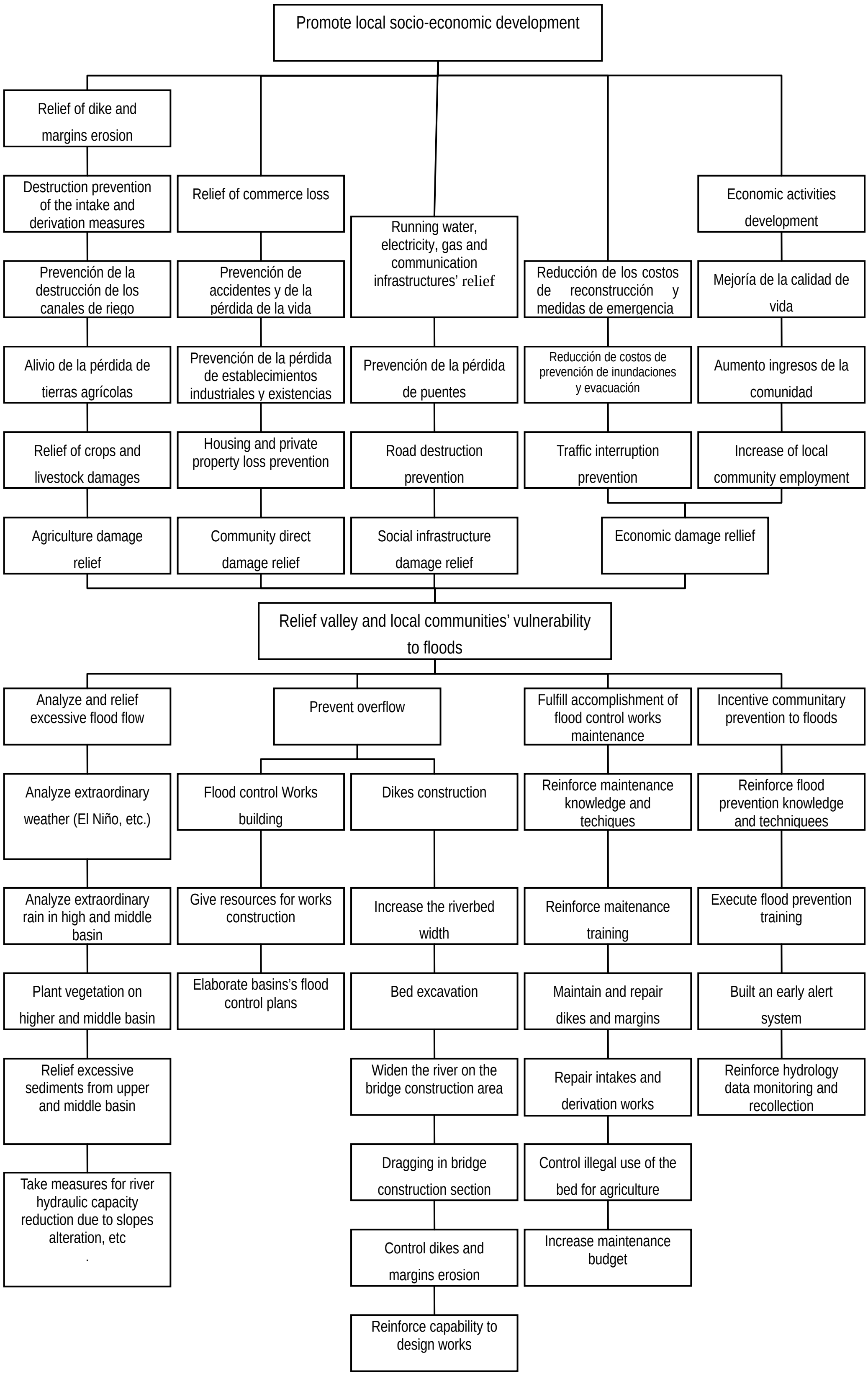


Figure 3.3.3-1 Measures - objectives – impacts diagram

4. FORMULATION AND EVALUATION

4.1 Definition of the Assessment Horizon of the Project

The Project's assessment horizon will be of 15 years, same as the one applied on the Program Profile Report. The Annex-10 of SNIP regulation stipulates that the assessment horizon should be basically 10 years; however the period can be changed in case that the project formulator (DGIH in this Project) admits the necessity of change. DGIH adopted 15 years in the Program Profile Report and OPI and DGPM approved it in March 19, 2010. In JICA's development study it should be generally 50 years, so the JICA Study Team inquired on the appropriate period to DGIH and OPI, they directed JICA Study Team to adopt 15 years. And the social evaluation in case of 50 years assessment horizon is described in Annex-14 Implementation Program of Japanese Yen Loan Project.

4.2 Supply and Demand Analysis

The theoretical water level was calculated considering flowing design flood discharge based on river cross sectional survey executed with a 500m interval, in each Watershed, considering a flood discharge with a return period of 50 years. Afterwards, the dike height was determined as the sum of the design water level plus the freeboard of dike.

This is the dike height required to prevent damages caused by design floods and represents the local community demand indicator.

The height of the existing dike or the height of the present ground is that required to prevent present flood damages, and represents the present supply indicator.

The difference between the design dike (demand) and the height of the present dike or ground represents the difference or gap between demand and supply.

Table 4.2-1 shows the averages of flood water level calculated with a return period of 50 years in "3.1.9 Run-off Analysis"; of the required dike height (demand) to control the discharge adding the design water level plus the freeboard dike; the dike height or that of the present ground (supply), and the difference between these last two (difference between demand-supply) of the river. Then, Table 4.2-2 shows as an example values of each point taking the Cañete river case. The dike height or that of the present ground is greater than the required dike height, at certain points. In these, the difference between supply and demand was considered null.

Table 4.2-1 Watershed Demand and Supply

Basin	Present Height of Embankment or Ground(supply)		Flood Water Level of 1/50 Year Probability	Freeboard of Embankment	Required Height of Embankment (demand)	Supply and Demand Gap	
	Left Bank	Right Bank				Left Bank	Right Bank
	①	②	③	④	⑤=③+④	⑥=⑤-①	⑦=⑤-②
Chira River	31.85	29.27	31.38	1.20	32.58	2.71	3.53
Cañete River	188.40	184.10	184.77	1.20	185.97	1.18	2.03
Chincha river							
Chico River	144.81	145.29	144.00	0.80	144.80	0.40	0.45
Matagente River	133.72	133.12	132.21	0.80	133.01	0.29	0.36
Pisco River	219.72	217.26	214.82	1.00	215.82	0.63	0.76
Yauca River	187.54	183.01	179.03	0.80	179.83	0.21	0.40
Majes-Camana River	401.90	405.19	399.43	1.20	400.63	1.21	0.88

According to this Table, the larger gap between demand and supply is in Chira River, followed by Cañete, Majes-Camana Rivers. On the other hand, this gap is reduced in the Chincha and Yauca rivers.

Table 4.2-2 Demand and Supply according to the calculation (Cañete river example)

Distance (km)	Dike Height / current land (supply)		Theoretical water level with a return period of 50 years	Dike Freeboard	Required dike's heigth (demand)	Diff. demand/supply	
	Left bank	Right bank				Left bank	Right bank
	①	②	③	④	⑤=③+④	⑥=⑤-①	⑦=⑤-②
0.0	3.04	2.42	3.88	1.20	5.08	2.04	2.66
0.5	10.85	6.43	6.69	1.20	7.89	0.00	1.46
1.0	19.26	15.46	11.66	1.20	12.86	0.00	0.00
1.5	23.14	22.02	18.55	1.20	19.75	0.00	0.00
2.0	28.54	24.14	24.47	1.20	25.67	0.00	1.53
2.5	29.77	30.43	30.42	1.20	31.62	1.85	1.19
3.0	39.57	36.32	36.54	1.20	37.74	0.00	1.42
3.5	44.29	41.17	41.52	1.20	42.72	0.00	1.55
4.0	50.87	44.51	45.90	1.20	47.10	0.00	2.59
4.5	50.77	50.90	51.48	1.20	52.68	1.91	1.78
5.0	56.72	55.97	56.70	1.20	57.90	1.18	1.93
5.5	61.60	62.63	61.30	1.20	62.50	0.90	0.00
6.0	67.94	67.29	66.75	1.20	67.95	0.01	0.66
6.5	71.98	72.26	72.21	1.20	73.41	1.43	1.15
7.0	75.91	77.89	77.87	1.20	79.07	3.16	1.18
7.5	84.54	83.93	83.14	1.20	84.34	0.00	0.41
8.0	87.14	86.94	89.24	1.20	90.44	3.30	3.50
8.5	92.88	94.92	95.12	1.20	96.32	3.44	1.40
9.0	97.59	99.58	99.95	1.20	101.15	3.55	1.57
9.5	103.52	106.09	104.87	1.20	106.07	2.55	0.00
10.0	113.17	112.15	110.18	1.20	111.38	0.00	0.00
10.5	115.92	115.66	116.69	1.20	117.89	1.97	2.23
11.0	120.02	120.74	121.86	1.20	123.06	3.04	2.32
11.5	126.04	125.46	126.55	1.20	127.75	1.71	2.29
12.0	133.58	131.61	132.64	1.20	133.84	0.26	2.23
12.5	138.25	137.29	138.65	1.20	139.85	1.60	2.56
13.0	144.87	144.19	145.04	1.20	146.24	1.37	2.05
13.5	151.37	149.50	151.14	1.20	152.34	0.97	2.84

14.0	157.25	155.68	157.32	1.20	158.52	1.27	2.84
14.5	163.04	162.65	162.70	1.20	163.90	0.85	1.24
15.0	169.07	168.02	168.53	1.20	169.73	0.66	1.71
15.5	174.33	173.29	173.80	1.20	175.00	0.67	1.71
16.0	178.76	179.67	179.56	1.20	180.76	2.00	1.09
16.5	189.69	184.90	185.00	1.20	186.20	0.00	1.30
17.0	198.92	190.23	192.31	1.20	193.51	0.00	3.28
17.5	204.00	196.35	198.05	1.20	199.25	0.00	2.90
18.0	208.64	202.64	203.68	1.20	204.88	0.00	2.24
18.5	216.02	208.07	208.90	1.20	210.10	0.00	2.03
19.0	231.58	214.00	215.17	1.20	216.37	0.00	2.37
19.5	234.50	219.81	221.58	1.20	222.78	0.00	2.97
20.0	227.59	225.71	227.83	1.20	229.03	1.44	3.32
20.5	232.17	231.84	233.16	1.20	234.36	2.19	2.51
21.0	239.69	238.14	239.70	1.20	240.90	1.21	2.76
21.5	243.75	244.32	245.70	1.20	246.90	3.15	2.58
22.0	258.48	248.71	251.12	1.20	252.32	0.00	3.61
22.5	261.54	255.90	256.70	1.20	257.90	0.00	2.00
23.0	277.79	260.72	263.17	1.20	264.37	0.00	3.65
23.5	286.32	266.55	268.34	1.20	269.54	0.00	2.99
24.0	293.96	274.25	274.19	1.20	275.39	0.00	1.14
24.5	279.29	280.51	279.73	1.20	280.93	1.64	0.42
25.0	305.10	286.83	285.94	1.20	287.14	0.00	0.31
25.5	310.22	289.46	291.96	1.20	293.16	0.00	3.70
26.0	317.26	295.71	297.32	1.20	298.52	0.00	2.81
26.5	307.24	302.64	303.34	1.20	304.54	0.00	1.90
27.0	307.18	306.25	308.61	1.20	309.81	2.64	3.56
27.5	335.69	311.92	313.47	1.20	314.67	0.00	2.75
28.0	342.51	321.75	317.21	1.20	318.41	0.00	0.00
28.5	323.24	329.22	326.63	1.20	327.83	4.59	0.00
29.0	331.04	327.61	331.31	1.20	332.51	1.47	4.90
29.5	335.86	332.81	336.85	1.20	338.05	2.19	5.25
30.0	340.36	343.00	341.99	1.20	343.19	2.83	0.19
30.5	346.28	347.78	349.42	1.20	350.62	4.33	2.84
31.0	352.37	355.00	355.54	1.20	356.74	4.38	1.74
31.5	363.03	362.32	363.14	1.20	364.34	1.31	2.02
32.0	372.35	365.18	368.39	1.20	369.59	0.00	4.41
32.5	375.30	373.38	376.70	1.20	377.90	2.60	4.52
Average	188.40	184.10	184.77	1.20	185.97	1.18	2.03

4.3 Technical Planning

4.3.1 Structural Measures

As structural measures it is necessary to prepare a flood control plan for the whole Watershed. The later section 4.13 “Medium and Long Term Plan” and 4.13.1 “General Flood Control Plan” details results on the analysis. This plan proposes the construction of dikes for flood control in the entire Watershed. However, in the case of each watershed, a big project needs to be set up investing very high costs, far beyond those considered in the budget of the present Project, which makes it difficult to take this proposal. Therefore, supposing the flood control dikes in the whole watershed are to be built progressively within a medium and long term plan, hereinafter they would be focused on the study of more urgent and priority works for flood prevention.

(1) Design flood discharge

1) Guideline for flood control in Peru

The Methodological Guide for Projects on Protection and/or Flood Control in Agricultural or Urban Areas prepared by the Public Sector Multiannual Programming General Direction (DGPM) of the Economy and Finance Ministry (MEF) recommends to carry out the comparative analysis of different return periods: 25 years, 50 years and 100 years for the urban area, and 10 years, 25 years and 50 years for rural area and agricultural lands.

Considering that the present Project is focused on the protection of rural and agricultural areas, the design flood discharge should be the discharge with return period of 10year to 50-year.

2) Maximum discharge in the past and design flood discharge

The yearly maximum discharge in each watershed is as shown in Figure-4.3.1(1) ~ Figure-4.3.1-1(7). Based on the figures, the maximum discharge in the past can be extracted as shown in the Table- 4.3.1-1 together with the flood discharges with different return periods.

The maximum discharge in the past in each watersheds occurred one to two times of which scale is same as the flood discharge with return period of 50-year. And it is true that the flood discharges of same scale as the flood discharge with return period of 50-year caused large damages in the past. The maximum flood in the past is same as or less than the flood discharge with return period of 50-year except for the Chincha watershed. The maximum discharge in the past in Chincha watershed occurred before 1960s, and the maximum discharges in recent 40 years are less than the discharge with return period of 50-year.

Since the flood control facilities in Peru not well developed, it is not necessary to construct the facilities for more than the maximum discharge in the past, however it is true that the past floods caused much disaster so that the facilities should be safe for the same scale of flood, therefore the design flood discharge in this Project is to be the discharge with return period of 50-year.

Table - 4.3.1-1 Flood discharge with different return period(m^3/sec)

Watershed	10-year	25-year	50-year	100-year	Max.in Past
Chira	2,276	2,995	3,540	4,058	3,595
Cañete	822	1,496	2,175	2,751	900
Chincha	580	807	917	1,171	1,269
Pisco	451	688	855	963	956
Yauca	90	167	263	400	211
Majes-Camana	1,166	1,921	2,659	3,586	2,021

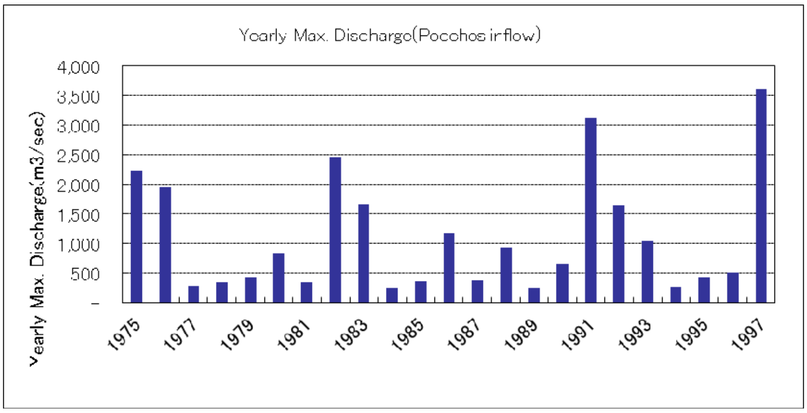


Figure- 4.3.1-1(1) Yearly Max. Discharge (Chira, Poechos Dam Inflow)

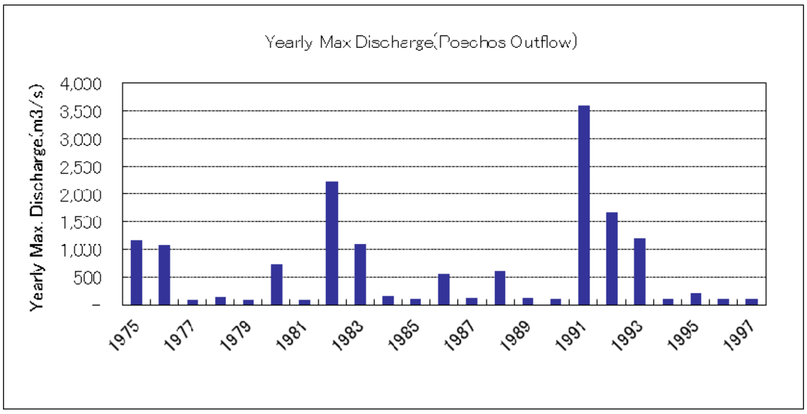


Figure- 4.3.1-1(2) Yearly Max. Discharge (Chira, Poechos Dam Outflow)

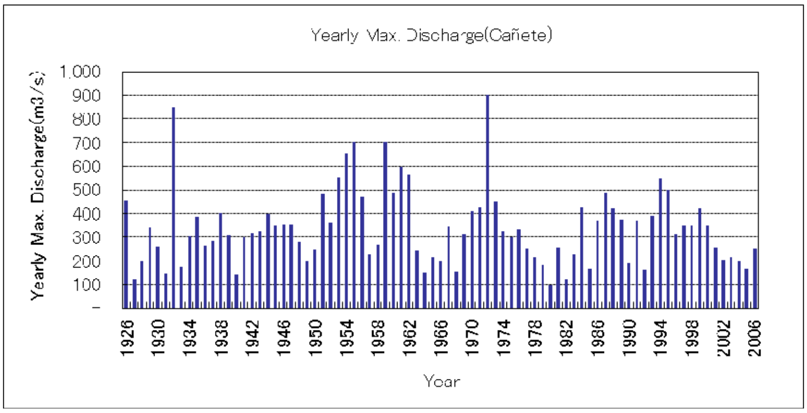


Figure- 4.3.1-1(3) Yearly Max. Discharge (Cañete)

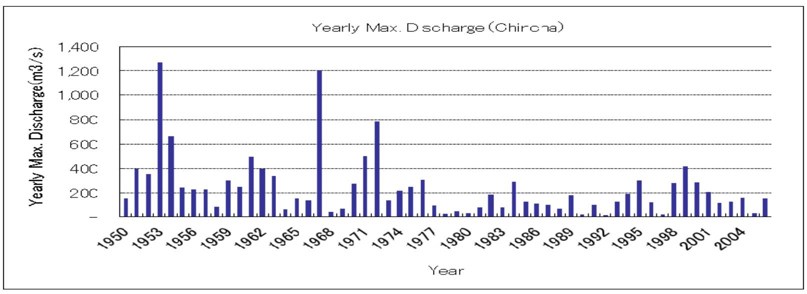


Figure- 4.3.1-1(4) Yearly Max. Discharge (Chincha)

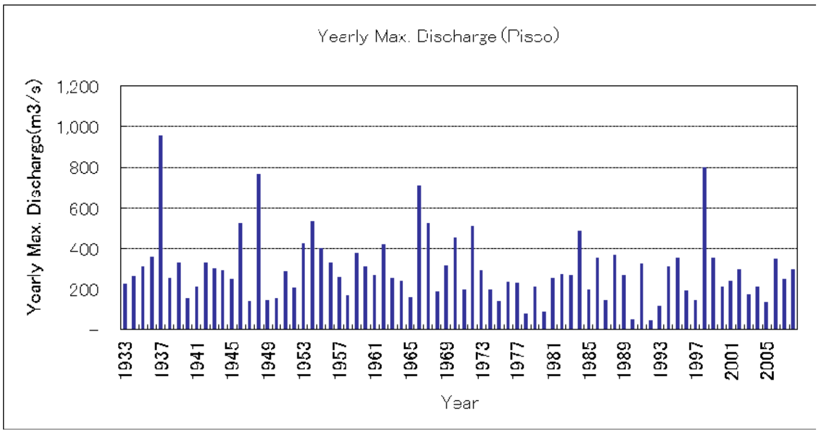


Figure- 4.3.1-1(5) Yearly Max. Discharge (Pisco)

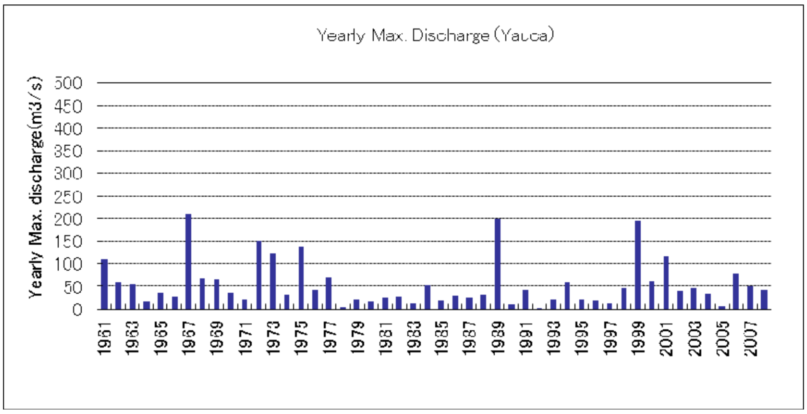


Figure- 4.3.1-1(6) Yearly Max. Discharge (Yauca)

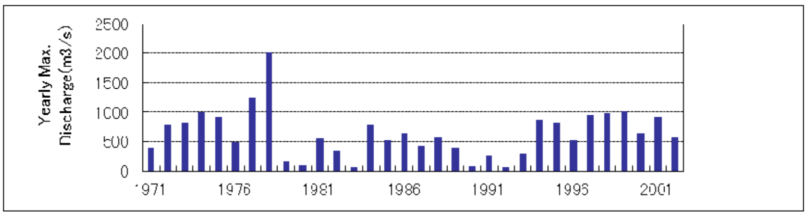


Figure- 4.3.1-1(7) Yearly Max. Discharge (Majes-Camana)

3) Relation among probable flood, Damage and inundation area

The relation among probable flood, Damage and inundation area in each watershed are shown in the Figure-4.3.1-2(1) ~ Figure-4.3.1-2(6).

Based on the figures the following facts can be expressed except for Chira watershed.

① The more increase probable flood discharge, the more increase inundation area (green line in the figure).

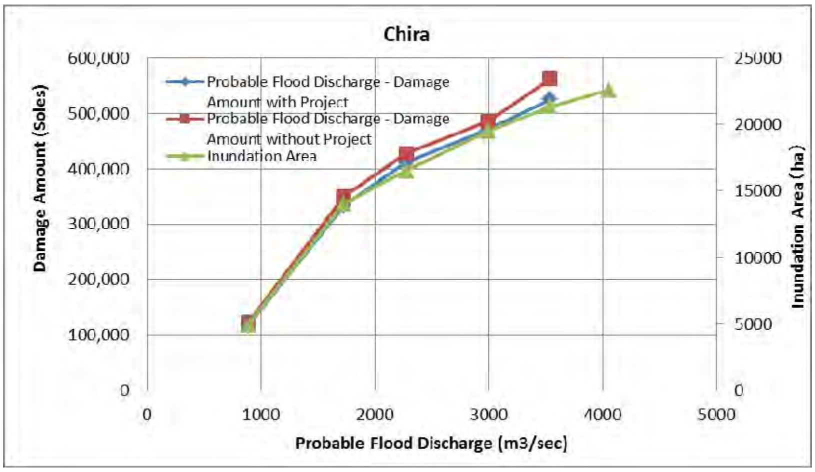
② The more increase probable flood discharge, the more increase damage (red line in the figure).

③ According to increase of probable flood discharge, the damage with project increase gently (blue line in the figure).

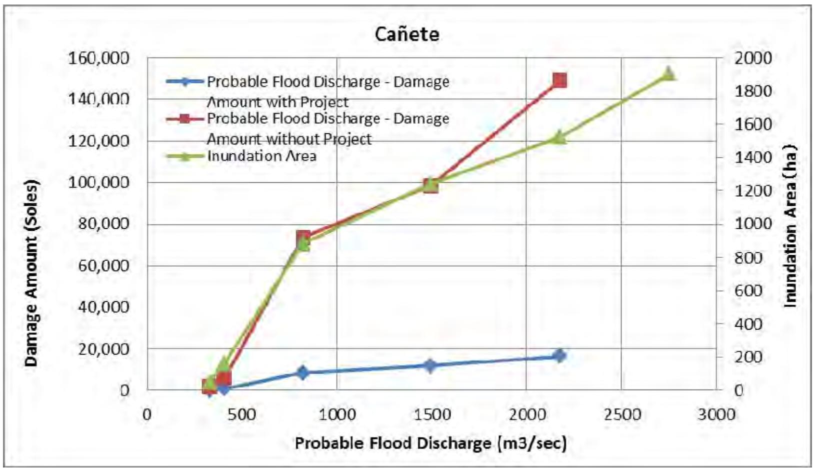
④ According to increase of probable flood discharge, damage reduction (difference between red line and blue line) increase steadily, and it reaches maximum at the probable flood of 50- year within the scope of study.

In the Chira watershed the three lines go up on the same line, namely the effect of damage reduction is almost nil. The projects in Chira and Yauca watersheds are excluded from this Project due to low economical effect as described in 4.5 Social Evaluation and 4.8 Selection of Candidates Watersheds for Project.

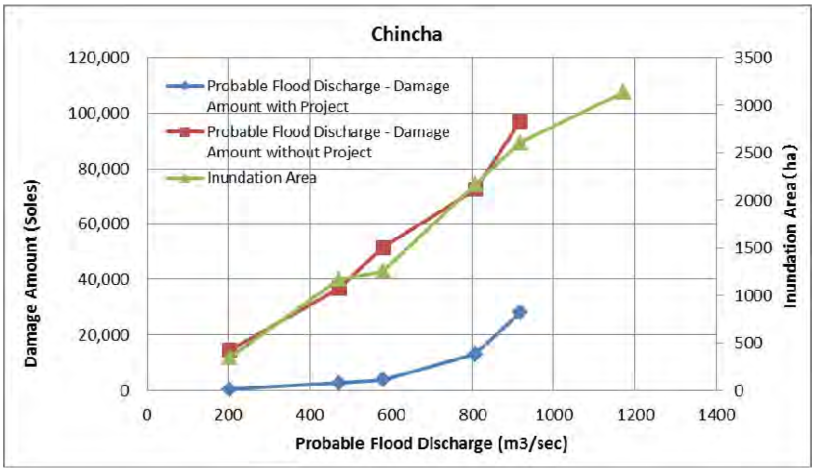
As shown in the above section, the design flood discharge with return period of 50-year is almost equal to the maximum flood in the past, and absolute damage reduction amount in the design discharge is largest among the probable flood discharge less than with return period of 50-year, and economic viability of the design flood is confirmed.



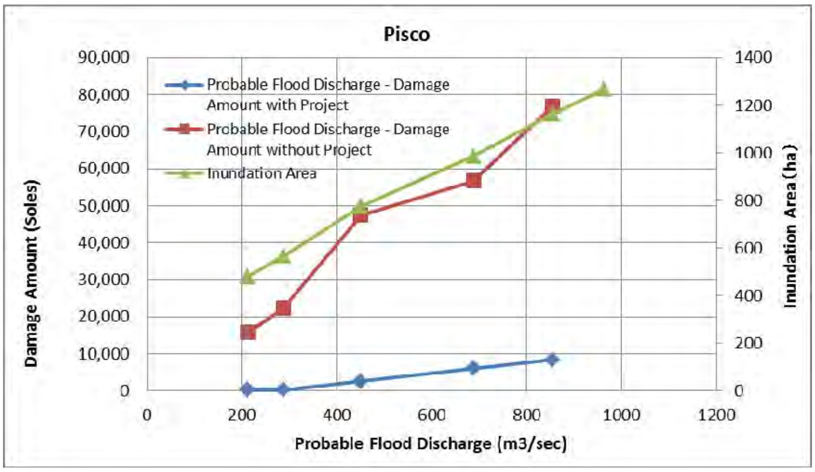
Figure－4.3.1-2 (1) Probable Flood Discharge, Damage Amount and Inundation Area (Chira river)



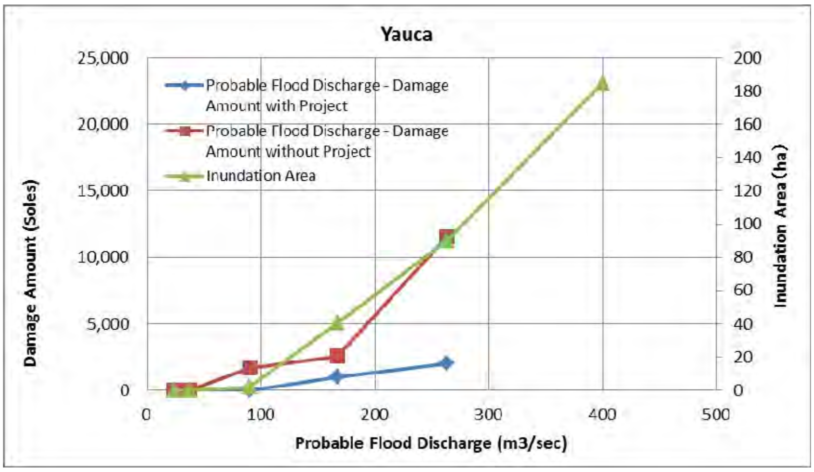
Figure－4.3.1-2 (2) Probable Flood Discharge, Damage Amount and Inundation Area (Cañete river)



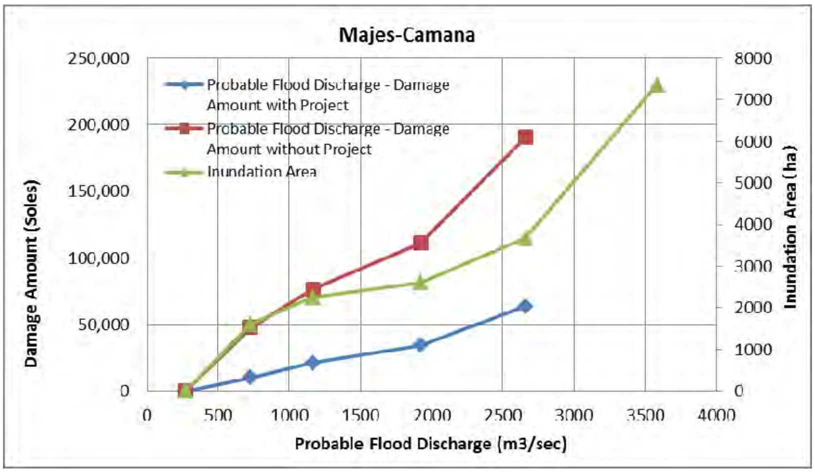
Figure－4.3.1-2 (3) Probable Flood Discharge, Damage Amount and Inundation Area (Chincha river)



Figure－4.3.1-2 (4) Probable Flood Discharge, Damage Amount and Inundation Area (Pisco river)



Figure－4.3.1-2 (5) Probable Flood Discharge, Damage Amount and Inundation Area (Yauca river)



Figure－4.3.1-2 (6) Probable Flood Discharge, Damage Amount and Inundation Area (Majes-Camana river)

(2) Topographical survey

The topographical survey was carried out in selected places for the execution of structural measurements (Table 4.3.1-2). The preliminary design of control works was based on these topographical survey results.

Table 4.3.1-2 Quantities of Topographical Survey

Watershed	Topographiclal survey (S=1/1000～1/2000) (ha)	Cross sectional Survey (S=1/200, interval100m) (km)
Chira	234.5	23.8
Cañete	94.8	10.6
Chincha	80.0	9.0
Pisco	182.5	19.4
Yauca	42.0	4.8
Majes-Camana	193.0	21.3
Total	826.8	88.9

(3) Selection of flood protection works with high priority

1) Basic Guidelines

For the selection of priority flood protection works, the following elements were considered:

- Demand from the local community (based on historical flood damage)
- Lack of discharge capacity of river channel (including the sections affected by the scouring)
- Conditions of the adjacent area (conditions in urban areas, farmland, etc.).
- Conditions and area of inundation (type and extent of inundation according to inundation analysis)
- Social and environmental conditions (important local infrastructures)

Based on the river survey, field investigation, discharge capacity analysis of river channel, inundation analysis, and interviews to the local community (irrigation committee needs, local governments, historical flood damage, etc...) a comprehensive evaluation was made applying the five evaluation criteria listed above. After that we selected a total of thirty two (32) critical points (with the highest score in the assessment) that require flood protection measures.

Concretely, since the river cross sectional survey was carried out every 500m interval and discharge capacity analysis and inundation analysis were performed based on the survey results, the integral assessment was also done for sections of 500 meters. This sections have been assessed in scales of 1 to 3 (0 point, 1 point and 2 points) and the sections of which score is more than 6 were selected as prioritized areas. The lowest limit (6 points) has been determined also taking into account the budget available for the Project in general

Table 4.3.1-3 details evaluated aspects and assessment criteria.

Table 4.3.1-3 Assessment Aspects and Criteria

Assessment Aspects	Description	Assessment Criteria
Demand of local population	● Flood damages in the past ● Demand of local population and producers	・Flooding area with big floods in the past and with great demand from local community (2 points) ・Demand of local population (1 point)
Lack of discharge capacity (bank scouring)	● Possibility of river overflow given the lack of discharge capacity ● Possibility of dike and bank collapse due to scouring	・Extremely low discharge capacity (discharge capacity with return period of 10 years or less) (2 points) ・Low discharge capacity (with return period of less than 25 years) (1 point)
Conditions of surrounding areas	● Large arable lands, etc. ● Urban area, etc. ● Assessment of lands and infrastructure close to the river.	・Area with large arable lands (2 points) ・Area with arable lands mixed with towns, or big urban area (2 points) ・Same configuration as the previous one, with shorter scale (1 point)
Inundation conditions	● Inundation magnitude	・Where overflow extends on vast surfaces (2 points) ・Where overflow is limited to a determined area (1 point)
Socio-environmental conditions (important structures)	● Intake of the irrigation system, drinking water, etc. ● Bridges and main roads (Carretera Panamericana, etc.)	・Where there are important infrastructures for the area (2 points) Where there are important infrastructures (but less than the first ones) for the area (regional roads, little intakes, etc.) (1 point)

2) Selection results

Figure 4.3.1-3 ~ Figure 4.3.1-9 detail assessment results of each the river, as well as the selection results of flood protection priority works.

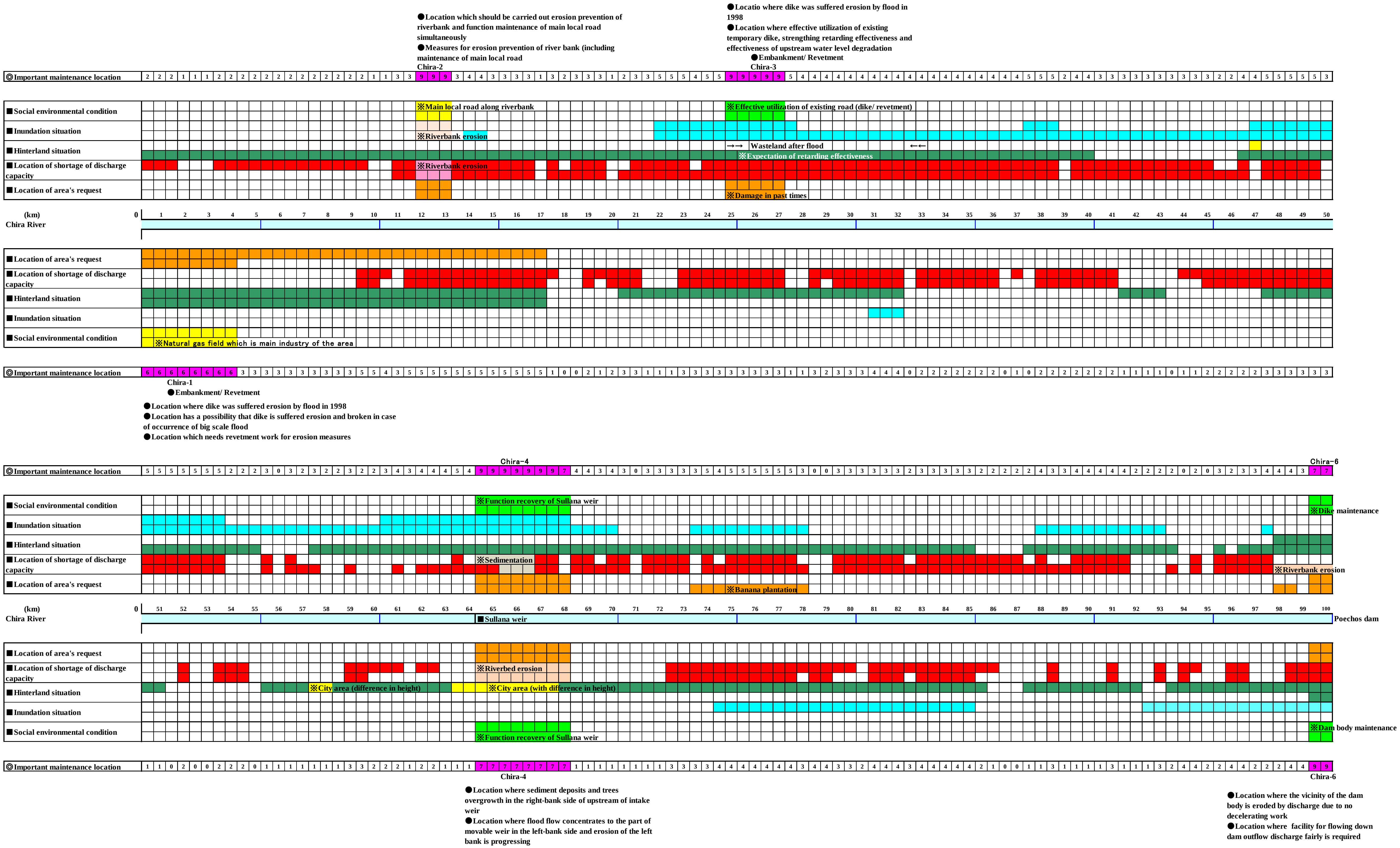
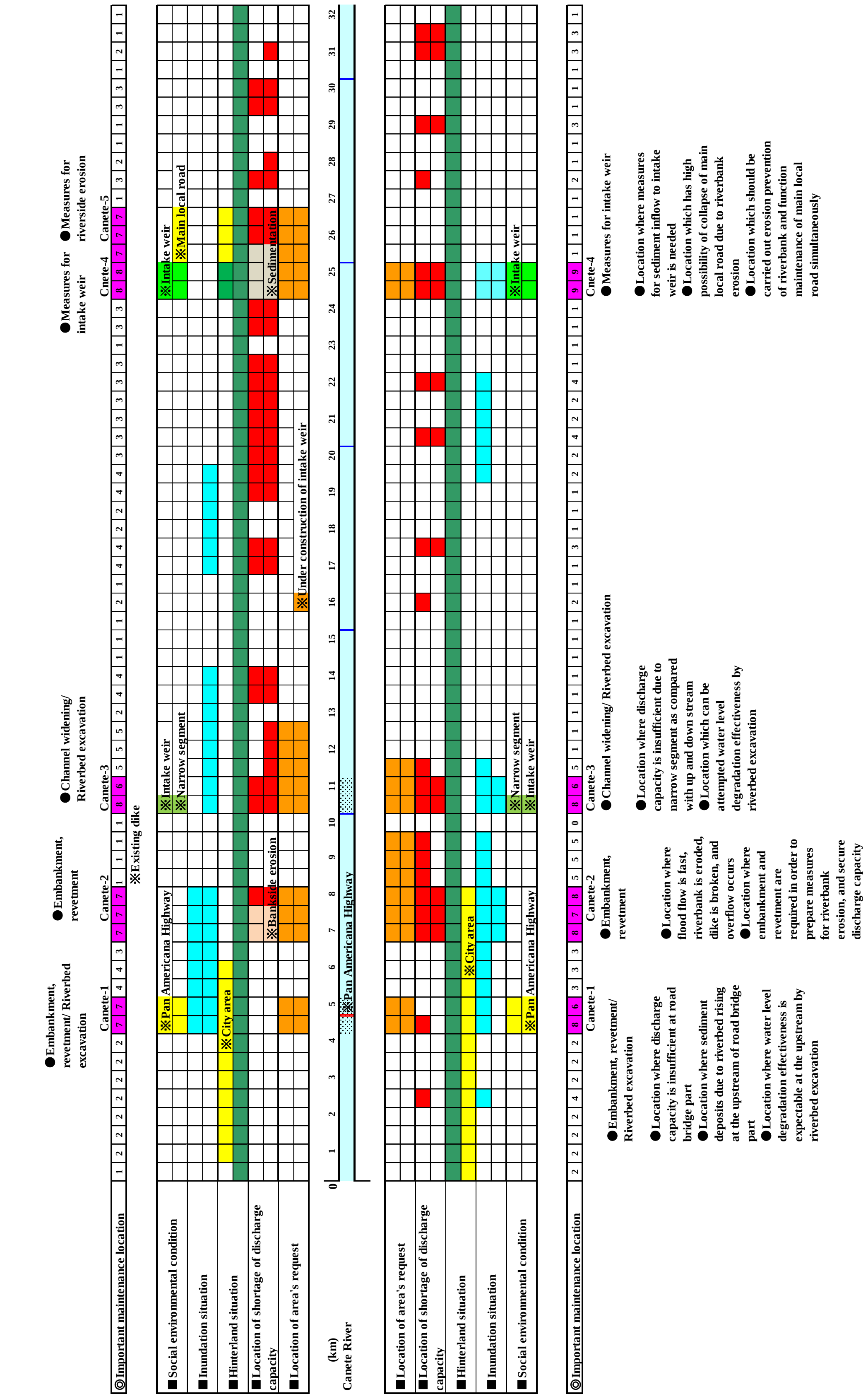
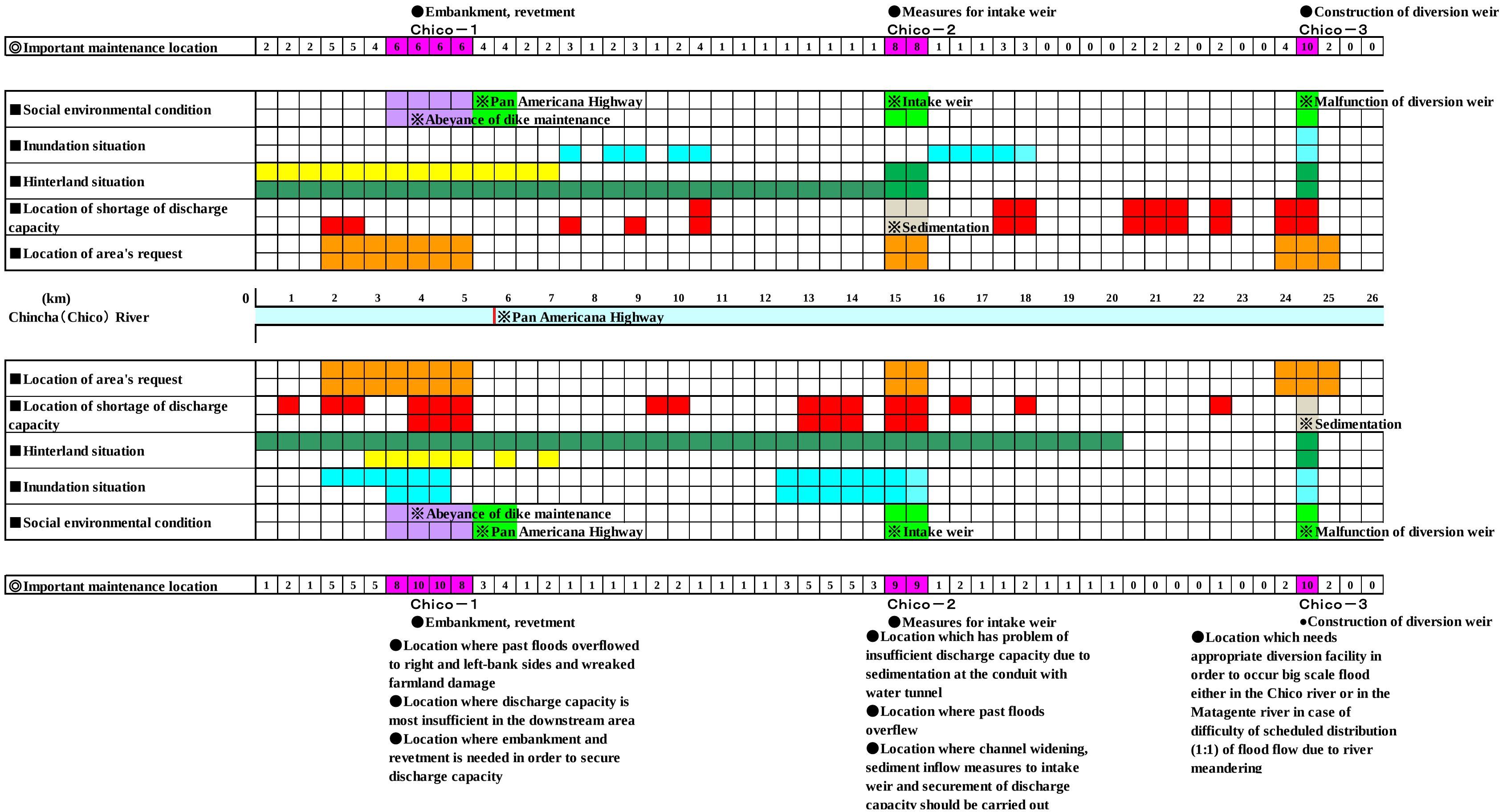
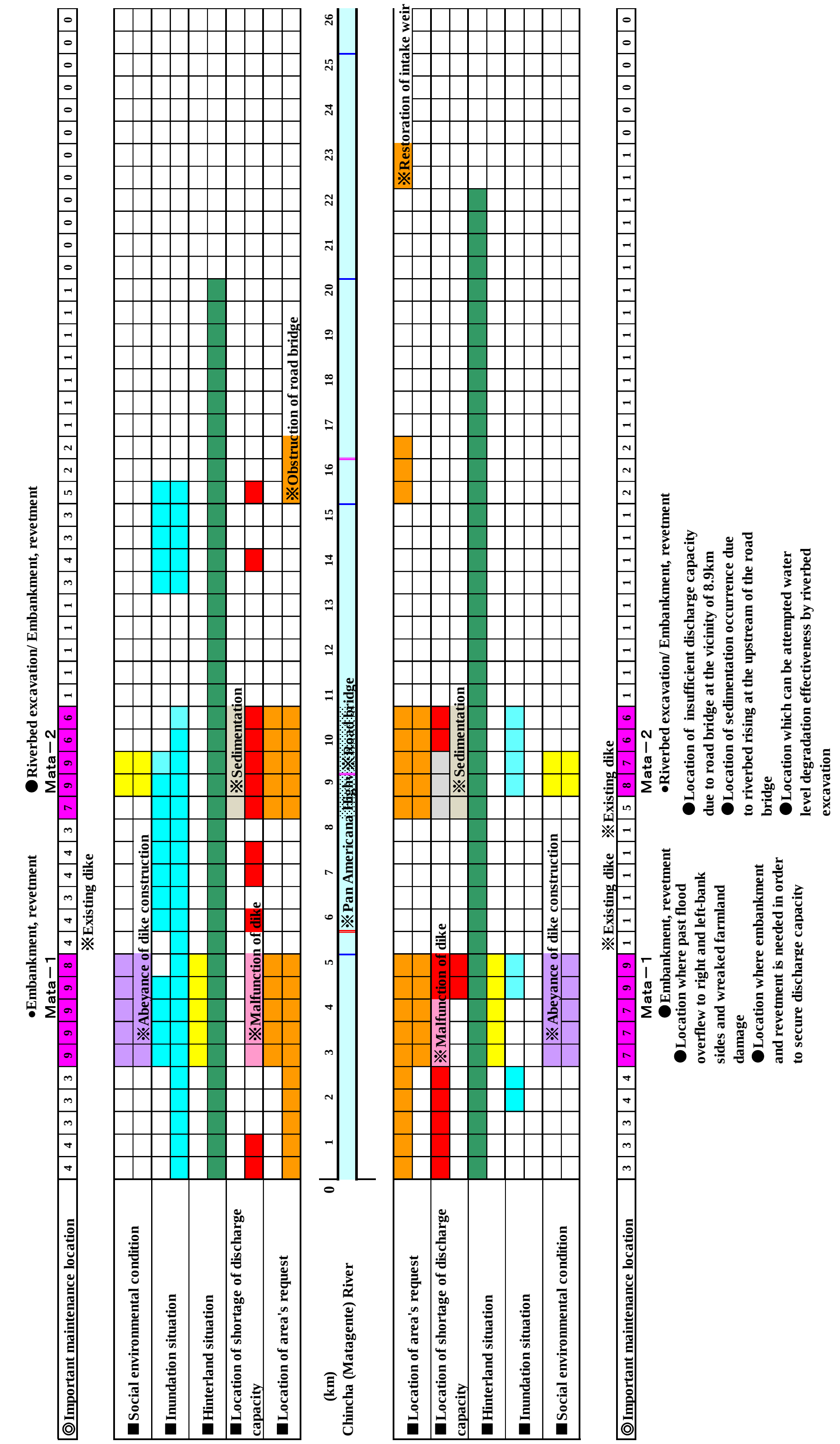
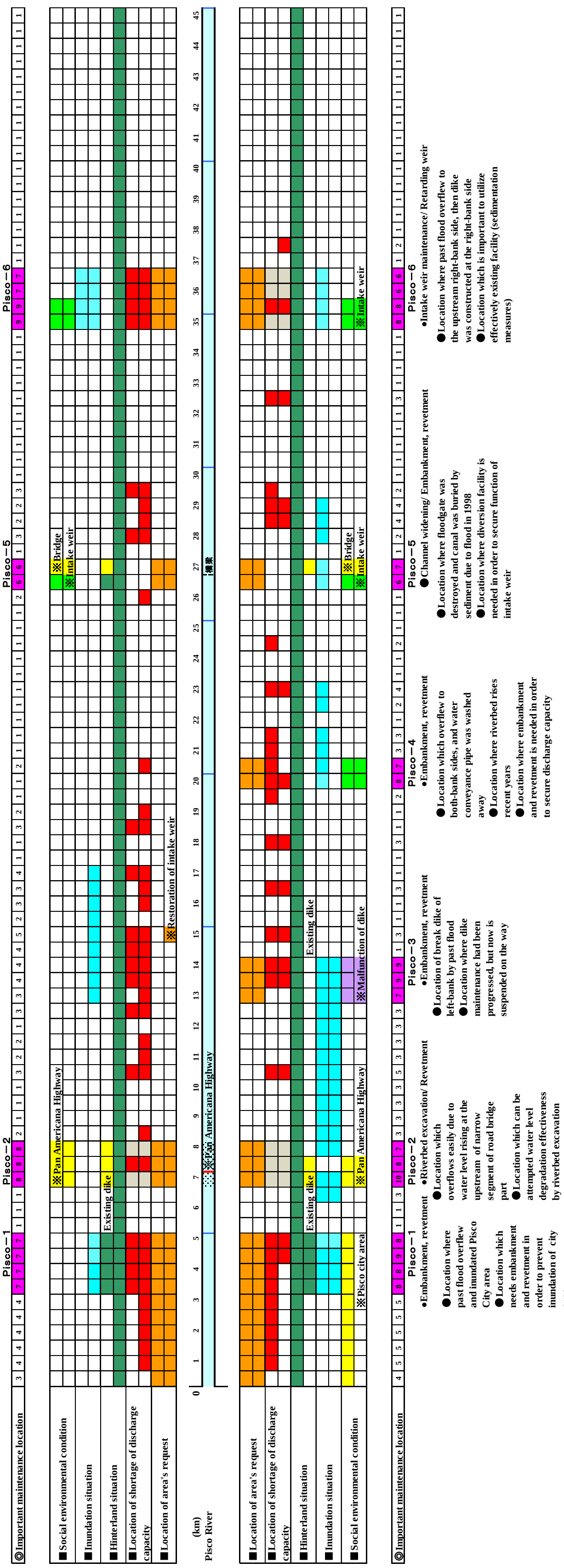


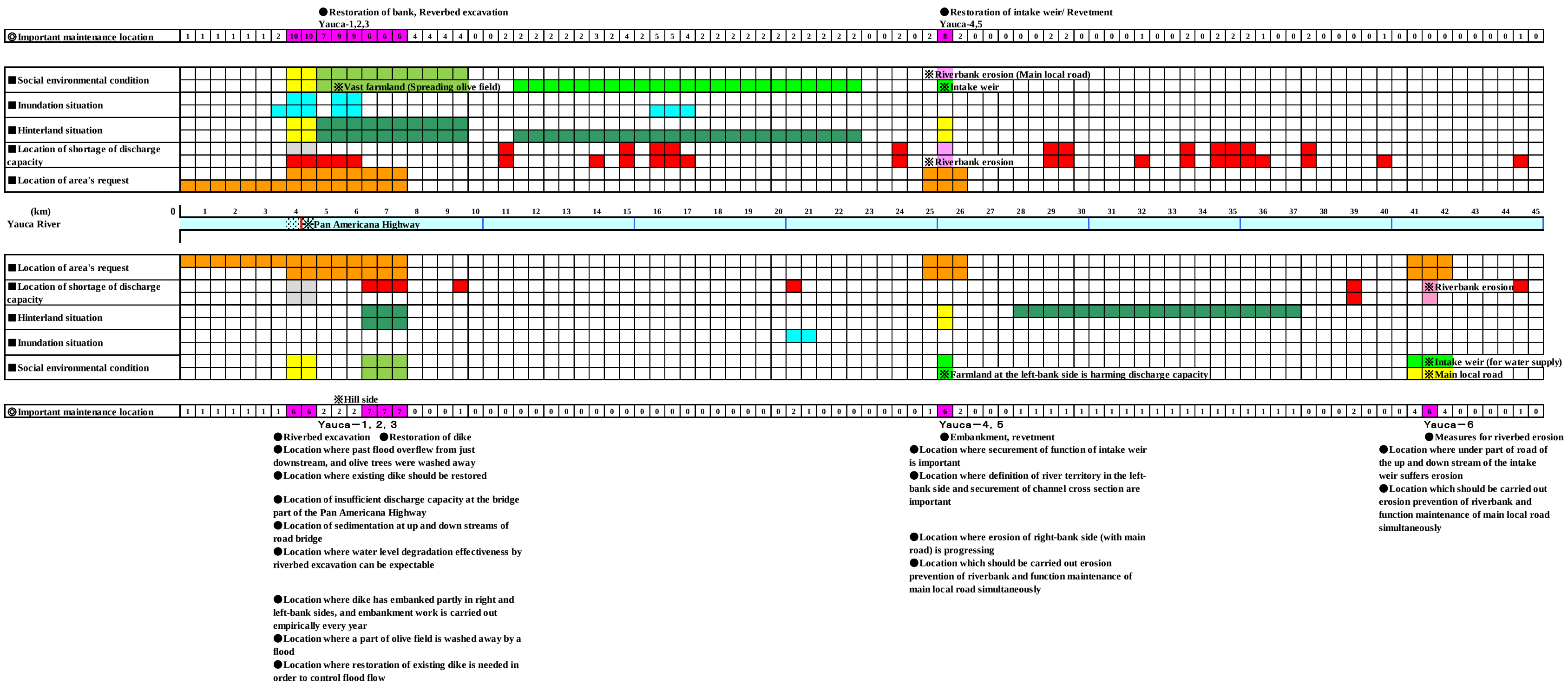
Figure 4.3.1-3 Selection of High Priority Improvement Facilities in the Chira River


◎Important maintenance location
■Social environmental condition
■Inundation situation
■Hinterland situation
■Location of shortage of discharge capacity
■Location of area's request
(km)
Canete River
■Location of area's request
■Location of shortage of discharge capacity
■Hinterland situation
■Inundation situation
■Social environmental condition
◎Important maintenance location
●Embankment, revetment/ Riverbed excavation
●Embankment, revetment
●Channel widening/ Riverbed excavation
●Measures for intake weir
●Measures for riverside erosion
Canete-1
Canete-2
Canete-3
Cnete-4
Canete-5
※Existing dike
※Pan Americana Highway
※City area
※Intake weir
※Narrow segment
※Main local road
※Bankside erosion
※Sedimentation
※Under construction of intake weir
●Location where discharge capacity is insufficient at road bridge part
●Location where sediment deposits due to riverbed rising at the upstream of road bridge part
●Location where water level degradation effectiveness is expectable at the upstream by riverbed excavation
●Location where flood flow is fast, riverbank is eroded, dike is broken, and overflow occurs
●Location where embankment and revetment are required in order to prepare measures for riverbank erosion, and secure discharge capacity
●Location where discharge capacity is insufficient due to narrow segment as compared with up and down stream
●Location which can be attempted water level degradation effectiveness by riverbed excavation
●Location where measures for sediment inflow to intake weir is needed
●Location which has high possibility of collapse of main local road due to riverbank erosion
●Location which should be carried out erosion prevention of riverbank and function maintenance of main local road simultaneously


●Embankment, revetment
Chico－1
●Measures for intake weir
Chico－2
●Construction of diversion weir
Chico－3
◎Important maintenance location
2 2 2 5 5 4 6 6 6 6 4 4 2 2 3 1 2 3 1 2 4 1 1 1 1 1 1 1 1 8 8 1 1 1 3 3 0 0 0 0 2 2 2 0 2 0 0 4 10 2 0 0
■Social environmental condition
※Pan Americana Highway
※Abeyance of dike maintenance
※Intake weir
※Malfunction of diversion weir
■Inundation situation
■Hinterland situation
■Location of shortage of discharge capacity
※Sedimentation
■Location of area's request
(km)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Chincha（Chico）River
※Pan Americana Highway
■Location of area's request
■Location of shortage of discharge capacity
※Sedimentation
■Hinterland situation
■Inundation situation
■Social environmental condition
※Abeyance of dike maintenance
※Pan Americana Highway
※Intake weir
※Malfunction of diversion weir
◎Important maintenance location
1 2 1 5 5 5 8 10 10 8 3 4 1 2 1 1 1 1 2 2 1 1 1 1 3 5 5 5 3 9 9 1 2 1 1 2 1 1 1 1 0 0 0 0 1 0 0 2 10 2 0 0
Chico－1
●Embankment, revetment
●Location where past floods overflowed to right and left-bank sides and wreaked farmland damage
●Location where discharge capacity is most insufficient in the downstream area
●Location where embankment and revetment is needed in order to secure discharge capacity
Chico－2
●Measures for intake weir
●Location which has problem of insufficient discharge capacity due to sedimentation at the conduit with water tunnel
●Location where past floods overflew
●Location where channel widening, sediment inflow measures to intake weir and securement of discharge capacity should be carried out
Chico－3
•Construction of diversion weir
●Location which needs appropriate diversion facility in order to occur big scale flood either in the Chico river or in the Matagente river in case of difficulty of scheduled distribution (1:1) of flood flow due to river meandering


●Embankment, revetment
Mata－1
●Riverbed excavation/ Embankment, revetment
Mata－2
◎Important maintenance location
4 4 3 3 3 9 9 9 9 8 4 4 3 4 4 3 7 9 9 6 6 1 1 1 1 1 3 4 3 3 5 2 2 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0
※Existing dike
■Social environmental condition
※Abeyance of dike construction
■Inundation situation
■Hinterland situation
■Location of shortage of discharge capacity
※Malfunction of dike
※Sedimentation
■Location of area's request
※Obstruction of road bridge
(km)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Chincha (Matagente) River
※Pan Americana Highway
※Road bridge
■Location of area's request
※Restoration of intake weir
■Location of shortage of discharge capacity
※Malfunction of dike
※Sedimentation
■Hinterland situation
■Inundation situation
■Social environmental condition
※Abeyance of dike construction
◎Important maintenance location
3 3 3 4 7 7 7 9 9 1 1 1 1 1 1 5 8 7 6 6 1 1 1 1 1 1 1 1 1 2 2 2 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0
※Existing dike
※Existing dike
Mata－1
●Embankment, revetment
●Location where past flood overflew to right and left-bank sides and wreaked farmland damage
●Location where embankment and revetment is needed in order to secure discharge capacity
Mata－2
•Riverbed excavation/ Embankment, revetment
●Location of insufficient discharge capacity due to road bridge at the vicinity of 8.9km
●Location of sedimentation occurrence due to riverbed rising at the upstream of the road bridge
●Location which can be attempted water level degradation effectiveness by riverbed excavation


●Embankment, revetment
●Riverbed excavation/ Revetment
●Channel widening
●Intake weir maintenance/ Retarding weir
Pisco−1
Pisco−2
Pisco−5
Pisco−6
◎Important maintenance location
■Social environmental condition
■Inundation situation
■Hinterland situation
■Location of shortage of discharge capacity
■Location of area's request
※Pan Americana Highway
※Bridge
※Intake weir
Existing dike
※Restoration of intake weir
(km)
Pisco River
※Pan Americana Highway
■Location of area's request
■Location of shortage of discharge capacity
■Hinterland situation
■Inundation situation
■Social environmental condition
Existing dike
※Pisco city area
※Pan Americana Highway
※Malfunction of dike
※Bridge
※Intake weir
◎Important maintenance location
Pisco−1
●Embankment, revetment
●Location where past flood overflew and inundated Pisco City area
●Location which needs embankment and revetment in order to prevent inundation of city area
Pisco−2
●Riverbed excavation/ Revetment
●Location which overflows easily due to water level rising at the upstream of narrow segment of road bridge part
●Location which can be attempted water level degradation effectiveness by riverbed excavation
Pisco−3
●Embankment, revetment
●Location of break dike of left-bank by past flood
●Location where dike maintenance had been progressed, but now is suspended on the way
Pisco−4
●Embankment, revetment
●Location which overflew to both-bank sides, and water conveyance pipe was washed away
●Location where riverbed rises recent years
●Location where embankment and revetment is needed in order to secure discharge capacity
Pisco−5
●Channel widening/ Embankment, revetment
●Location where floodgate was destroyed and canal was buried by sediment due to flood in 1998
●Location where diversion facility is needed in order to secure function of intake weir
Pisco−6
●Intake weir maintenance/ Retarding weir
●Location where past flood overflew to the upstream right-bank side, then dike was constructed at the right-bank side
●Location which is important to utilize effectively existing facility (sedimentation measures)


●Restoration of bank, Reverbed excavation
Yauca-1,2,3
●Restoration of intake weir/ Revetment
Yauca-4,5
◎Important maintenance location
1 1 1 1 1 1 2 10 10 7 9 9 6 6 6 4 4 4 4 0 0 2 2 2 2 2 2 3 2 4 2 5 5 4 2 2 2 2 2 2 2 2 2 2 2 0 0 2 0 2 8 2 0 0 0 0 0 2 2 0 0 0 0 1 0 0 2 0 2 2 2 1 0 0 2 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0
■Social environmental condition
※Vast farmland (Spreading olive field)
※Riverbank erosion (Main local road)
※Intake weir
■Inundation situation
■Hinterland situation
■Location of shortage of discharge capacity
※Riverbank erosion
■Location of area's request
(km)
Yauca River
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45
※Pan Americana Highway
■Location of area's request
■Location of shortage of discharge capacity
※Riverbank erosion
■Hinterland situation
■Inundation situation
■Social environmental condition
※Intake weir (for water supply)
※Main local road
※Farmland at the left-bank side is harming discharge capacity
※Hill side
◎Important maintenance location
1 1 1 1 1 1 1 6 6 2 2 2 7 7 7 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2 1 0 0 0 0 0 0 0 1 6 2 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 2 0 0 0 4 6 4 0 0 0 0 1 0
Yauca－1, 2, 3
●Riverbed excavation ●Restoration of dike
●Location where past flood overflew from just downstream, and olive trees were washed away
●Location where existing dike should be restored
●Location of insufficient discharge capacity at the bridge part of the Pan Americana Highway
●Location of sedimentation at up and down streams of road bridge
●Location where water level degradation effectiveness by riverbed excavation can be expectable
●Location where dike has embanked partly in right and left-bank sides, and embankment work is carried out empirically every year
●Location where a part of olive field is washed away by a flood
●Location where restoration of existing dike is needed in order to control flood flow
Yauca－4, 5
●Embankment, revetment
●Location where securement of function of intake weir is important
●Location where definition of river territory in the left-bank side and securement of channel cross section are important
●Location where erosion of right-bank side (with main road) is progressing
●Location which should be carried out erosion prevention of riverbank and function maintenance of main local road simultaneously
Yauca－6
●Measures for riverbed erosion
●Location where under part of road of the up and down stream of the intake weir suffers erosion
●Location which should be carried out erosion prevention of riverbank and function maintenance of main local road simultaneously

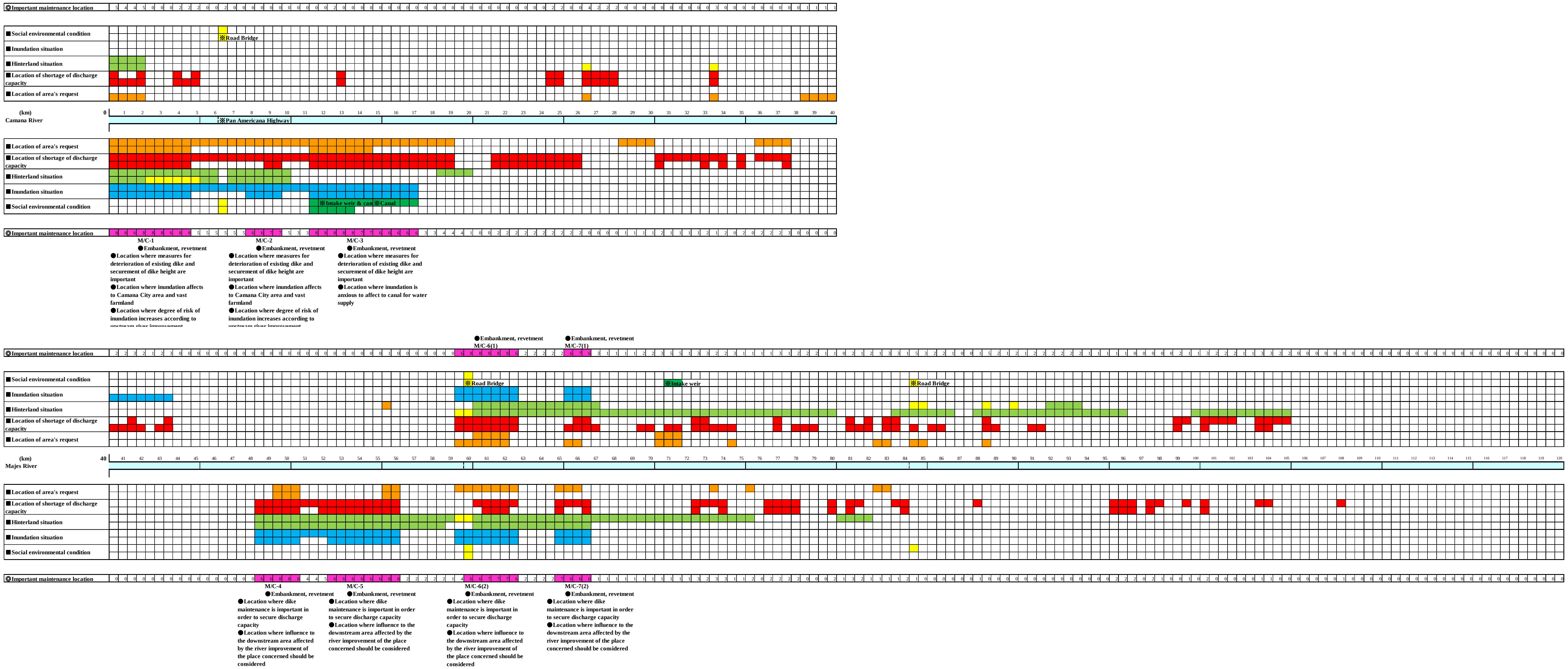


Figure-4.3.1-9 Selection of High Priority Improvement Facilities in the Majes-Camana River

3) Basis of Selection

Table 4.3.1-4 ~ 4.3.1-9 presents basis of selection of each work.

① Chira river

Chira River is characterized due to the lack of discharge capacity, causing overflowing in all sections. Water flow reaches low lands and plain lands along the river. However, in Chira River case, the presence of Poechos dam may contribute to solve problems in case middle and small floods take place. Therefore, in case a flood with magnitudes that are bigger than the dam's capacity it is probable that serious damage is caused.

In order to control floods in this river, it is important to build dikes, beginning from the lower watershed to upper watershed, however this time the flood protection works with high priority are to be selected considering importance of facilities for adjacent area and heavily damaged areas in the past.

Table-4.3.1-4 Basis of Selection for Flood Protection Work (Chira river)

No	Location	Basis of Selection
①	0.0km～4.0km (Left Bank)	In this section there are dikes built but the banks are not protected. Floods of 1998 caused dike erosion. So, in case floods last for a long period causing erosion and dikes destruction, great damage to near infrastructures will happen (gas production field, crop lands, etc). This section has groins instead of bank protection works. It is true that groin may stop waves, but it is necessary to execute bank protection works considering the existence of important infrastructure (natural gas field, crop land, etc.) that must be protected [Characteristics of the Section] ●Section where dike was scoured and eroded by 1998 floods. ●Section in which the dike will be eroded and may collapse in case a big flood occurs ●Section in which bank must be protected against erosion [Elements to Protect] ○Big crop fields, natural gas field, etc of the left bank [Method of Protection] ▼Implementation of embankment and bank protection utilizing the existing dike to increase discharge capacity and durability for bank erosion. ▼To protect the wide farmland and gas production field, the objective flood discharge should be 3,600m3/sec, which is equal to the flood in El niño disaster and to the flood discharge with return period of 50-year.
②	11.75km ～ 12.75km (Right Bank)	This section forms a big curve, causing strong erosion of the right bank, giving the current river's course section. If no adequate measure is taken, it is probable that the rural road located on the right bank is destroyed. It is considered important to execute bank protection works keeping as possible the current river course section to maintain the storage effect of the current river channel and at the same time, protect the road (since its destruction will have a strong impact for regional economy) [Characteristics of the Section] ●Section in which bank erosion during floods may cause destruction of the regional road ●Section in which bank erosion protection works and regional road functioning conservation works must be carried out simultaneously [Elements to Protect] ○Regional road of the right bank

		[Method of Protection] ▼To keep the safety of the regional road of which destruction will have a strong impact for regional economy for the flood discharge which is equal to the flood in El niño disaster and to the flood discharge with return period of 50-year. ▼Bank protection work is implemented in the section basically damaged in the past disaster.
③	24.5km ~ 27.0km （Right Bank）	It is a section in which the right bank was strongly affected by the past floods damages. Currently, has a provisional dike which is also used as a road. It is considered important to effectively use this existing work. The provisional existing dike has been built with enough wide space of river and because of that it has a retardant effect when a flood occur. To have a better control of floods in the Chira River, it is important to create several sections as this that will be used as natural reservoirs, in order to reduce the water level along the whole river. The existing dike in this section is provisional and it does not have the sufficient height as to maximize the flood retarding effect. So, we are proposing to increase the height of the current dike in order to maximize the retarding effect [Characteristics of the Section] ●Section in which the dike was eroded by 1998 floods ●Section in which the water level must be reduced increasing the retardation effect by using the existing provisional dike [Elements to Protect] ○Agriculture lands of the right bank [Method of Protection] ▼In order to protect the wide area of farmland in the right bank side as well as to make maximum effect of flood retarding, the existing provisional dike will be utilized, and the protection work should be safe in the past El niño class disaster. ▼The dike with road constructed after the disaster will be raised for securing the discharge capacity of river and expecting the retarding effect.
④	64.0km ~ 68.0km	Sullana intake has sediments gathered on the right bank fixed weir section, which is being covered by vegetation. As consequence, left bank's erosion is produced. If no action is taken, the right bank's vegetation will grow its density increasing more its impact on the left bank Bearing in mind the importance of the intake and to maintain safety of the left bank, it is considered necessary to eliminate all vegetation and gathered sediments of the right bank fixed weir section to stabilize flowing condition during floods. This measure is also important for the maintenance of existing structures [Characteristics of the Section] ●Section in which sediments have gathered on the right bank side of the intake and is covered of dense vegetation ●Section in which overflows are focused on the movable weir of the left bank, causing bank erosion [Elements to Protect] ○Intake (Sullana) [Method of Protection] ▼Sullana intake is the most important facility in this river. If the function

		of this intake occur, the influence on the region is very heavy, therefore it should be safe in the case of El niño. ▼To keep the discharge capacity of the upstream of Sullana intake,the dense vegetation at right bank side of upstream of the weir and sediment deposit should be removed.

② Cañete river

Cañete river has narrow sections at the main bridges and intake at the downstream of 10 km from the river mouth, and upstream of which the inundation is apt to occur. The inundation spreads widely to the right bank side causing big damage, although the inundation upstream of 10 km is limited to nearby crop areas. Therefore the embankment and bank protection in the lower section of 10 km, which has large damage potential, is to be implemented with priority securing the discharge capacity at narrow sections.

And upstream of Cañete river there is tourist area due to rich water flow and short access from Lima. In order to keep short access to the area, the conservation of principal regional road are important from view point of regional economic activities, so that the bank protection work for scouring is also selected as flood prevention work.

At the Pan-American road the river width is narrowed, so that the widening the river width with building new bridge is considered, however taking account of the large traffic volume, necessity of access road to the bridge causing large cost, and that DGIH judged that the construction of new bridge is difficult for demarcation of administrative responsibility among Ministries, the construction of new bridge is not adopted in this Project.

Table-4.3.1-5 Basis of Selection for Flood Protection Work (Cañete river)

No	Location	Basis of Selection
①	km4,0-km5,0 (right bank) + (riverbed partial excavation)	This section is one of the sections with less discharge capacity of the Cañete River lower watershed, where the Pan American Road's Bridge is built. In the flood caused by El niño phenomena, daming up of flow occurred and inundated in this section. Since it is impossible to rebuilt the bridge, the dike's height is required to be elevated on the right bank and dredge part of the riverbed crossing the bridge to increase discharge capacity [Characteristics of the section] ●Narrow section (where the bridge is) in which the discharge capacity is reduced ●Section in which damming up of flow occurs and sediments deposited due to the narrowness ●Section in which the water level can be reduced by the riverbed excavation [Elements to be protected] ○ Great agricultural lands that are downstream [Method of Protection] ▼Inundation occurs at the flood with return period of 10-year and the damage become heavily at the flood with return period of 50-year, so that the flood protection work is implemented for the latter flood flowing down safely. ▼In order to secure discharge capacity, the embankment and bank protection work in the section in which the embankment height is insufficient are built utilizing existing embankment as well as riverbed excavation.
②	km6,5-km8,1 (both banks)	Erosion of the right bank caused by former flooding has provoked dike's destruction, leaving great damage. Likewise, due to the reduced discharge capacity, it is considered as a section in which a dike and bank protection must be built to protect banks erosion and

		maintain the necessary discharge capacity On the lower reach (between the mouth and km 10) the inundation extends to the right bank side causing more damage, inundation extends to the left bank side also, flooding agricultural land, but in less magnitude that on the right bank. The flooded area is bigger than the upper section. [Characteristics of the section] ●Section where the discharge capacity is lowest in the lower reach of Cañete river ●Section where flood flow is fast, causing banks erosion, dike's destruction and inundation ●Section where a dike has to be built to prevent bank erosion and keep the necessary discharge capacity [Elements to be protected] ○Agricultural lands of both banks [Method of Protection] ▼Inundation occurs at the flood with return period of 10-year and the damage become heavily at the flood with return period of 50-year, so that the flood protection work is implemented for the latter flood flowing down safely. ▼In order to secure discharge capacity, the embankment and bank protection work in the section in which the embankment height is insufficient are built utilizing existing embankment as well as riverbed excavation (effective use of existing dike at right bank side).
③	km10.0-km11.0 (widening river width on left bank)	The intake weir formulates the narrow section at this section, which causes the rise of water level and inundation at the upstream of this section. The most damage occurs to the crop land in this section among the sections from 10km towards upstream, therefore widening river and excavation of riverbed is required. And the upstream discharge capacity can be increased by lowering water level. [Characteristics of the section] ●Section where the intake has to be protected ●Narrow section with insufficient discharge capacity compared to the upstream and downstream sections ●Section where scouring performance will reduce the water level of the superior section [Elements to be protected] ○Intake ○Left bank agricultural lands [Method of Protection] ▼This intake is the most important in the river. If the intake function is damaged, the influence to the region is very heavy, therefore the intake is to be safe in case of El niño flood (equal to flood with return period of 50-year) ▼Widening river width so that the flood dose not concentrate to the intake.
④	km24.25-km24.75 (widening river width on left	In this section, the intake is constructed. In the past flood in El niño phenomena the water could not take for more than one month. At present the sediment deposits in every flooding so that the maintenance works such as excavation etc. are required to maintain the function of intake. In future if the

	bank)	big flood occurs, the function of the intake will be lost and the large influence will be given to the crop land. The diversion work is required to distribute water adequately. [Characteristics of the section] ●Section where sediment inflow control to the entrance of the intake is required. [Elements to be protected] ○Intake [Method of Protection] ▼This intake is the most important in the river. If the intake function is damaged, the influence to the region is very heavy, therefore the intake is to be safe in case of El niño flood (equal to flood with return period of 50-year) ▼Protection work utilizing present river characteristics.
⑤	km24.75-km26.5 (right bank)	The banks have been eroded due to former flooding and their impact has reached the regional roads. It is urgent to take adequate measures, if not, the road will be destroyed and this will affect local economy [Characteristics of the section] ●Section where the bank's erosion may cause regional road destruction ●Section in which banks erosion control works and regional roads functioning conservation works have to be done simultaneously [Elements to be protected] ○Right bank regional road [Method of Protection] ▼Since the destruction of regional road affects regional economy, very much,the road is to be safe in case of El niño flood (equal to flood with return period of 50-year) ▼The protection of road only is one solution, however together with that, the protection work for smooth flowing down of flood is required because the agricultural land at right bank is low and feared to be eroded and affect the road.

③ Chincha river

The characteristics of Chincha river is that in case of unequal diversion of flood water to Chico river and Matagente river , the flooding water inflow unevenly to one river causing heavy damage in all section of that river due to insufficient discharge capacity. Even when the water is adequately distributed among rivers Chico and Matagente in a 1:1 relation, Chico River may overflow at Km 15 and Km 4 causing great damages on the left bank, and Matagente River may overflow at Km 9 and Km 3, flooding great areas from right bank. Therefore, the basic policy of flood prevention is to build the diversion weir and embankment with bank protection in the section where inundation areas in the past due to insufficient discharge capacity. The flood prevention works are planned on the condition that the water diversion is properly implemented (in case of execution of No.③).

Table 4.3.1-6 Selected sections bases to execute works (Chincha River)

No	Location	Basis of Selection
	Chico river 3.0km～5.1km (both banks)	The embankment with bank protection is required in this section where the discharge capacity is lowest in the lower reach of Chico river, especially for the left bank to prevent the damage increasing. And in case that the flood protection work is constructed in the upstream section, inundation occurs and enlarges in the right bank. Therefore the embankment at both banks is required. [Characteristics of the section] ●Section in which the past inundations on both banks have caused damages on crops, etc ●Section only the left bank dike is partially built. If dikes are constructed in upstream sections, this may lead to inundation in this section ●The section with the lowest discharge capacity in the lower reach [Elements to protect] ○Vast agricultural lands that go beyond both banks of this section (especially on the left bank) [Method of Protection] ▼Inundation occurs at the flood with return period of 5-year and the damage become heavily at the flood with return period of 50-year, so that the flood protection work is implemented for the latter flood flowing down safely. ▼Embankment with bank protection is built for securing the discharge capacity utilizing the existing dike partially
	Chico river 14.8km～15.5km (widening the river with to left bank)	This section has the problem of accumulating great amounts of sediments in the intakes and has an absolute lack of discharge capacity already mentioned. So, it is a very important section where the control of sediments to the intake (construction of a derivation work that distributes the flow correctly) and ensuring the required discharge capacity are the main tasks. [Characteristics of the section] ●Section that inundated due to former floods ●Section that requires widening river, control of sediments in the intake and keeping the necessary discharge capacity ●Section where a water channel tunnel exists, in which sediments have deposited, and stops the function of tunnel. [Elements to protect] ○Intake ○Left bank crop lands [Method of Protection] ▼Inundation occurs at the flood with return period of 5-year and the damage become heavily at the flood with return period of 50-year, so that the flood protection work is implemented for the latter flood flowing down safely. ▼Widenning river width and preventing the concentration of flow to the intake
	Chico river Km24.2-km24.5 (total)	This section is a diversion point of Chincha river to Chico river and Matagente river, and the most important section in the flood prevention plan for Chincha river (Base of flood prevention plan). The diversion weir exists at the section; however it was built in 1954, and heavily devastated. And in flooding the flow meanders in the upstream of the weir and water flows in the one of two rivers, which means diversion is not

		well functioned. Therefore the construction of diversion weir to distribute the flood evenly is indispensable in the flood control in Chincha river [Characteristics of the section] ● Section that requires a proper derivation work because in case that it is not possible to distribute stream in a relation 1:1 due to the river meandering. This will cause great flooding in one of both rivers: Chico or Matagente [Elements to protect] ○ Every district of Chico and Matagente (because if the overflow stream is not adequately distributed, great damage will happen in one of both rivers) [Method of Protection] ▼The diversion weir which can divert the flow steadily is constructed.
	Matagente 2.5km～5.0km （both banks）	This section is past inundation area with tendency of spreading widely to the right bank. And the irregular embankment was implemented for preventing the past damage. If the flood prevention work in the upstream is exwcuted, inundation occurs in left bank also so that the embankment is required at both banks. [Characteristics of the section] ●Section with lowest discharge capacity in downstream ●Section in which the past floods have caused inundation on both banks causing great damages to croplands, etc. ●Section where dikes were irregularly constructed. [Elements to protect] ○ Vast agricultural lands that spreads beyond both banks of this section (specially on the right bank) [Method of Protection] ▼Construction of dike to improve insufficient discharge capacity and bank protection to covering slope and end of slope ▼Inundation occurs at the flood with return period of 5-year and the damage become heavily at the flood with return period of 50-year, so that the flood protection work is implemented for the latter flood flowing down safely.
	Matagente 8.0km～10.5km （both banks）	This section is the past inundation area. In this narrow section (where the bridge is built), the discharge capacity is insufficient and the river bed has raised 4 – 5 m during past 50 years. The river bed needs to be excavated to increase the discharge capability (taking the proper precautions in order not to damage the bridge's base) and a dike must be built on both banks. [Characteristics of the section] ●Section where sediments deposited upstream of the bridge due to its damming up effect ●Section in which the discharge capacity is very reduced due to the river's narrowness at km 8.9 (where the bridge is) [Elements to protect] ○ Vast agricultural lands that go beyond both banks of this section (especially on the right bank) [Method of Protection] ▼This section has tendency of riverbed raising so that riverbed excavation is to be executed for keeping discharge capacity and lowering upstream water level.

		▼Inundation occurs at the flood with return period of 5-year and the damage become heavily at the flood with return period of 50-year, so that the flood protection work is implemented for the latter flood flowing down safely.

④ Pisco river

At the section from the river mouth to7km upstream, the water inundates farmland nearby due to lack of discharge capacity, but not extending beyond. However, when the inundation occurs in the lower reach (from the mouth to 7 km), the water inundates large areas of the left bank causing serious damage in urban areas of Pisco. Therefore at the downstream section from 7km, the embankment is executed in the section with highest risk of inundation and at the upstream area countermeasures in the sections with low discharge capacity such as brides and intake.

At the Pan-American road the river width is narrowed, so that the widening the river width with building new bridge is considered, however taking account of the large traffic volume, necessity of access road to the bridge causing large cost, and that DGIH judged that the construction of new bridge is difficult for demarcation of administrative responsibility among Ministries, the construction of new bridge is not adopted in this Project.

Table 4.3.1-7 Selected sections bases to execute works (Pisco River)

No	Location	Basis of Selection
①	3.0km～5.0km （both banks）)	In this section once the inundation reaches urban area, the influence to the regional economy will be serious. And in case that the flood protection work is constructed in the upstream section, inundation occurs and enlarges in the right bank. And this section the river meanders so that slope and end of sloe are to be protected. Therefore the embankment at both banks is required. And also it should be taken note that the existing dikes were constructed from 5.0km ~5.5km at both banks. [Characteristics of the section] ● Section that inundation occurred in the past flood to the city of Pisco. ● Section where it is needed to build embankment with bank protection to prevent inundation of the city. ● Section in which the inundation will be extended on the right bank in the case that the flood prevention work is performed in the upstream. [Elements to protect] ○ Large agricultural land extending to both sides of the section in question ○ The city of Pisco to the left of the section in question [Method of Protection] ▼Inundation occurs at the flood with return period of 5-year and the damage become heavily at the flood with return period of 50-year(nearly equal to 950m3/sec causing maximum damages) , so that the flood protection work is implemented for the latter flood flowing down safely. ▼Embankment with bank protection is to be constructed with consideration of upstream and downstream reach and land acquisition.
②	6.5km～8.0km （riverbed excavation）	The section in question is the narrow section of the river where it crosses the bridge, and sediment deposits and discharge capacity is insufficient. Damming up of water causes the elevation of the water level in the upper section. Since it is impossible to reconstruct the bridge it is required to dredge the bed around the bridge site to increase discharge capacity and lower the water level in the upper section.

		[Characteristics of the section] ● Section narrow (where the road bridge) in which the discharge capacity is insufficient. ● Section in which sediments have accumulated in the upper due to the damming up effect. ● Section which may reduce the water level in the upper bed by river bed excavation. [Elements to protect] ○ Farmland extending to the left bank of the section in question and on the upper section. [Method of Protection] ▼Insufficient discharge capacity promote the inundation of the upstream so that the facility which can discharge the flood with return period of 50-year(nearly equal to 950m3/sec causing maximum damages) is to be performed. ▼The discharge capacity is to be secured by riverbed excavation, and without rebuilding the Pan-American bridge.
③	12.5km～14.0km (left bank)	In this section the discharge capacity is lowest at the left bank, and is likely to inundate frequently even with a small scale of flooding. In the event of major floods, the damage can be severe, so it is urgent to build dikes with bank protection. On the other hand, given that a new dike between km14. 5-km 14. 0, taking the necessary precautions for the connection of the dikes. [Characteristics of the section] ● Section in which the embankment was destroyed on the left bank by flooding. ● Section in which the construction of the embankment was suspended on the way. [Elements to protect] ○ Cropland to both sides of the section in question. [Method of Protection] ▼Inundation occurs at the flood with return period of 5-year and the damage become heavily at the flood with return period of 50-year, so that the flood protection work is implemented for the latter flood flowing down safely. ▼The embankment with bank protection is executed in the section in which the height of dike is not enough utilizing the existing dikes and condition of natural grand.
④	19.5km～20.5km (left bank)	In this section the discharge capacity is lowest at the left bank, and is likely to inundate frequently even with a small scale of flooding. In the event of major floods, the damage can be severe, so it is urgent to build dikes with bank protection. [Characteristics of the section] ● No embankment section where inundate occurs on both banks and the water conveyance pipe leading to Pisco was lost. ● Section in which the river bed is raising in recent years. ● Section where embankment with bank protection is required to recover adequate discharge capacity. [Elements to protect] ○ Cropland on the left bank of the section in question. ○Water conveyance pipe to Pisco (important facility).

		[Method of Protection] ▼Inundation occurs at the flood with return period of 5-year and the damage become heavily at the flood with return period of 50-year, so that the flood protection work is implemented for the latter flood flowing down safely. And the conservation of water conveyance pipe to Pisco. ▼The embankment with bank protection is executed in the section in which the height of dike is not enough utilizing the existing dikes and condition of natural grand.
⑤	26.0km～27.0km（widening river width to the left bank）	In this section it is important to keep the operational function of the existing intake. The gate was destroyed in the floods of the past, and the accumulation of sediment has left irrigation channels inoperative. Therefore, it is necessary to build a bypass work at km26. 75point (upstream of the intake) to allow water to flow towards the right bank at the time of low water and let more water flow to the left in the flood season. [Characteristics of the section] ● Section where the gate was destroyed by the 1998 floods also being buried the irrigation channel. ● Section which requires to build the bypass to protect the operation of the intake. [Elements to protect] ○ Intake on the right bank of the section in question [Method of Protection] ▼This intake is the most important in the river. The influence to the region is very big in case of lost function so that the protection work should be safe in the flood of 950m3/sec which caused serious damage in the past and nearly equal to the flood with return period of 50-years. ▼There are no existing dikes in this section so that the river width can be widened considering the condition of upstream and downstream and land acquisition.
⑥	34.5km～36.5km（total）	The site of the weir built at the km34.5 is a narrow section, and has accumulated large amounts of sediment upstream. It is considered necessary to effectively use this weir, and take the upper reservoir of the weir as retarding basin when floods occur which exceed the magnitude of design. Intends to use the existing weir to retard the flood exceeding the design scale and at the same time, reduce sediment transport. Ideally, to achieve progressively a degree of safety on the order of 1/50 years from downstream. However, for the moment it is important to make effective use of existing structures where possible to control water flow exceeding the design scale (return period of 50 years). [Characteristics of the section] ● Section where inundation occurred in the upstream right bank of the weir in the past floods. ● Section where it is important to effectively use existing works (sediment control, etc.). [Elements to protect] ○ The entire area downstream of the section in question. [Method of Protection] ▼This section is located in the most upstream of the river and appropriate to control flood and sediment flow. The characteristics of Pisco river such that the inundation area increases gradually in accordance with the increase of flood discharge. However when the discharges over the discharge with return

		period of 50-years the damage increases greatly. Once the discharge more than the discharge with return period of 50-years, the more the damage increases. Therefore it is important to prepare for flood over the return period of 50 years. In that case the excess of design flood and sediment flow are to be reserved in this section.

⑤ Yauca river

Yauca river is characterized due to its overflowing tendency at km 7 downwards the intake, flooding right bank crops. Therefore the flood prevention works are to be inundation prevention work for farmland in the section downstream of 7km and conservation works for intake and regional road eroded by scouring with high priority.

Table 4.3.1-8 Selected sections bases to execute works (Yauca River)

No	Location	Basis of Selection
①	3.5km ～ 7.5km (right bank)	The existing dikes in this section may be destroyed due to the erosion caused during floods; so, repair and bank protection works must be executed [Characteristics of the section] ●The overflow water from the lower section swept away the olives ●Section in which the existing dike has to be repaired [Elements to Protect] ○Agricultural lands of the right bank [Method of Protection] In this section the conservation of olive field which is special product in this region is main target. The bank protection is to be executed utilizing the existing dike eroded by the past flood with same scale of the flood with return period of 50-years.
②		Inundation occurred at km 7 downstream from river mouth, spreading farm land of the right bank. Excavation of the riverbed has to be carried out to maintain the necessary discharge capacity at the road bridge [Characteristics of the section] ●Narrow section (where the road bridge is) in which the discharge capacity is reduced ●Section on which sediments have deposited due to damming up caused by the narrowness ●Section in which the water level can be reduced due to the riverbed excavation [Elements to Protect] ○ Agricultural lands of the right bank in the section (olive field of regional special product) [Method of Protection] The riverbed excavation is to be executed considering the balance of upstream and downstream flood protection works as well as aiming at lowering the water level in the upstream section.
③		Inundation occurred at km 7 downstream from river mouth, spreading farm land of the right bank. The existing dike in this section may be destroyed due to the erosion caused during floods; so, repair and bank protection works must be executed [Characteristics of the section]

<table>
<tr><td></td><td></td><td>●Both sides of dikes are partially constructed. Sand and gravel material is embanked there empirically and annually
●Floods swept away part of the olives
●The existing dikes have to be repaired to prevent inundation on right bank

[Elements to Protect]
○ Agricultural lands of the right bank

[Method of Protection]
In this section the conservation of olive field which is special product in this region is main target. The bank protection is to be executed utilizing the existing dike eroded by the past flood with same scale of the flood with return period of 50-years.</td></tr>
<tr><td>④</td><td rowspan="2">25.0km～25.7km (total)</td><td>In this section the intake is constructed, however it is not working properly due to the enlarged private property of the left bank to the river, and floods flow into the intake directly, sediment deposit and destruction of intake, therefore the appropriate river section is to be secured considering comprehensive flow condition in this section .

[Characteristics of the section]
●Section in which it is important to protect the intakes functioning
●Section in which it is important to maintain the river's section delimitating it from the left bank

[Elements to Protect]
○Intake

[Method of Protection]
▼The most important intake in this river. In case that the function of it is damaged, the influence to the region will be serious, therefore the protection work is to be implemented not to cause the damage in the past flood of 210m3/sec which is almost equal the flood with return period of 50-year.
▼It is difficult to take water due to sediment deposit, and the private property enlarges at the left bank to the river causing direct inflow to the intake in flooding, therefore the appropriate layout of river is to be planned considering comprehensive flow condition in this section .</td></tr>
<tr><td></td><td>This section formulates bending and quick flow at the right bank, which is causing bank erosion. If no adequate measure is taken, the eroded bank may disturb the regional road located on the upper section of the right bank resulting in stop of trafic. So, it is necessary to take erosion control actions, such as bank protection works for conservation of the road.

[Characteristics of the section]
●Right bank's progressive erosion (the main road is located on the upper section)
●Section in which bank erosion control together with regional road conservation should be performed

[Elements to Protect]
○Regional road of the right bank

[Method of Protection]
▼In case that the regional main road is destroyed , the influence to the region will be serious, therefore the protection work is to be implemented not to cause the damage in the past flood of 210m3/sec which is almost equal the</td></tr>
</table>

		flood with return period of 50-year. ▼If it is left as it is, the bank will be eroded resulting in destruction of road, therefore the erosion protection work such as groin is to be implemented.
⑥	40.9km～41.3km (left bank)	The intake located on the upper watershed of the Yauca River is an important facility to ensure drinking water for local population. However, erosion still affects the upstream left bank of the intake, also affecting regional road located on the upper part of the left bank. So, it is urgent to take action on the erosion control of this section. [Characteristics of the section] ●Section in which the base of the road that runs upstream and downstream the intake is eroded. ● Section in which bank erosion control works as well as regional road conservation should be performed. [Elements to Protect] ○ Intake ○ Regional road of the left bank [Method of Protection] ▼The intake is the most important facility in this river. In case that the function of the facility is lost, the influence to the region will be serious, therefore the protection work is to be implemented not to cause the damage in the past flood of 210m3/sec which is almost equal the flood with return period of 50-year. ▼If the erosion to the important intake for securing drinking water and regional main road will progress, there is possibility to hinder intake of drinking water and destruction of regional main road,thefore the erosion protection work is to be executed.

⑦ Majes-Camana river

The existing dike in Camana river presents an advanced degree of obsolescence, and numerous eroded sections can be observed.
Currently, overflow occurs mainly in the upstream reach (Majes river), reducing the impact in this area. However, once this problem is solved in the upstream reach, impact would increase in this area, extending inundation area.
Likewise, at 13km there are a water supply intake to the urban area of Camana and a water channel along the river. Given that currently the left bank in the 12 km of the river is eroded and feared that the effect might strike the adjacent channel.
On the other hand, there are many sections without dike in Majes river so that damage by inundation and lost of farmland occur in every year.
Therefore in Camana river the rehabilitation and raising of existing dike is the most important in the left bank area which has large potential of damage, and in Majes river the embankment in the area without dike and with frequent flood damage is to be executed with priority.
The flood protection works in Majes river will affect the Camana river, therefore the order of the works should be carefully considered.

Table 4.3.1-9 Selected sections bases to execute works (Majes-Camana River)

No	Location	Basis of Selection
①	0.0km-4.5km (left bank)	In this section the existing dike is deteriorated and eroded sections are observed scattering here and there. At present inundation in this area is reduced due to inundation in upstream area (Majes river), however when the flood protection work in the upstream will progress, which will affect this area increasing inundation area. [Characteristics of the section] ● Section where it is important to solve the obsolescence issue in the existing dike and increase its height. ● Section where inundation in the left bank can affect the urban area of Camana as well as its adjoining vast arable lands. ● Section where inundation risk increases associated with the development of flood protection work in the upstream reach. [Elements to be protected] ○ Large arable lands extending in the left bank ○ Urban area of Camana city [Method of Protection] ▼It is characteristics of Camana river that once the flood discharge over the discharge with scale of 50-years, damage increases become serious so that the protection works are to be safe for the discharge with return period of 50-years. ▼Embankment with bank protection is to be executed in the section of insufficient dike height, utilizing the existing dikes.
②	7.5km-9.5km (left bank)	In this section the existing dike is deteriorated and eroded sections are observed scattering here and there. At present inundation in this area is reduced due to inundation in upstream area (Majes river), however when the flood protection work in the upstream will progress, which will affect this area increasing inundation area. [Characteristics of the section] ● Section where it is important to solve the obsolescence issue in the existing dike and increase its height. ● Section where inundation in the left bank can affect the urban area of Camana as well as its adjoining vast arable lands. ● Section where inundation risk increases associated with the development of flood protection work in the upstream reach. [Elements to be protected] ○ Large arable lands extending in the left bank ○ Urban area of Camana city [Method of Protection] ▼It is characteristics of Camana river that once the flood discharge over the discharge with scale of 50-years, damage increases become serious so that the protection works are to be safe for the discharge with return period of 50-years. ▼Embankment with bank protection is to be executed in the section of insufficient dike height, utilizing the existing dikes.
③	11.0km-17.0km (left bank)	In this section the existing dike is deteriorated and eroded sections are observed scattering here and there. The intake for drinking water of Camana urban area is constructed at 13km and conveyance channel along river. The left bank at 12km is eroded and feared that the effect might

		strike the adjacent channel. [Characteristics of the section] ● Section where it is important to solve the obsolescence issue in the existing dike and increase its height. ●Section where inundation causes serious damage to the conveyance channel of drinking water. [Elements to be protected] ○ Channel (of drinking water service) in the left bank [Method of Protection] ▼At present inundation in this area is reduced due to inundation in upstream area (Majes river), however when the flood protection work in the upstream will progress, which will affect this area increasing damage in this area. The conveyance channel along the river will be also affected. In case that the channel is destroyed, the damage will be serious, therefore it will be safe in the flood with return period of 50-year. ▼Embankment with bank protection is to be executed to secure the discharge capacity in the section of insufficient dike height, utilizing the existing dikes.
④	48.0km-50.5km (left bank)	This is a section with most insufficient discharge capacity in the river that inundates easily with small flooding and causes big damages in accordance with increase of the flood discharge. [Characteristics of the section] ●Section where it is important to build a dike to keep necessary discharge capacity and to protect the secondary wide farmland in Majes area . [Elements to be protected] ○ Arable lands extending in the left bank (maximum area of inundation n) [Method of Protection] ▼Inundation occurs at the flood with return period of 5-year and the damage become heavily at the flood with return period of 50-year, so that the flood protection work is implemented for the latter flood flowing down safely. ▼The combination of protection work of ④and ⑤ can increase the effect of facilities.
⑤	52.0km-56.0km (left bank)	This is a section with most insufficient discharge capacity in the river that inundates easily with small flooding and causes big damages in accordance with increase of the flood discharge. The whole area was inundated in flooding in 1998 and damaged heavily. [Characteristics of the section] ●Section where it is important to build a dike to keep necessary discharge capacity and to protect the secondary wide farmland in Majes area . [Elements to be protected] ○ Arable lands extending in the left bank (secondary wide farmland in Majes area with the maximum area of inundation) [Method of Protection] ▼Inundation occurs at the flood with return period of 5-year and the damage become heavily at the flood with return period of 50-year, so that the flood protection work is implemented for the latter flood flowing down safely.

		▼The combination of protection work of ④and ⑤ can increase the effect of facilities.
⑥	59.0km-62.5km (right bank) 59.5km-62.5km (left bank)	It is a narrow section where discharge capacity is insufficient, causing frequent flood damages in arable lands in the upstream section. There is a road bridge in the narrowness, and no dike in the adjacent area. [Characteristics of the section] ● Section where it is important to build a dike to keep necessary discharge capacity and to protect the maximum farmland in Majes area. [Elements to be protected] ○ Arable lands in both banks of the selected stretch (largest arable lands in Majes) [Method of Protection] ▼Inundation occurs at the flood with return period of 5-year and the damage become heavily at the flood with return period of 50-year, so that the flood protection work is implemented for the latter flood flowing down safely. ▼The combination of protection work of ⑥ and ⑦ can increase the effect of facilities.
⑦	65.0km-66.5km (right bank) 64.5km-66.5km (left bank)	This is a section with most insufficient discharge capacity in the river that inundates easily with small flooding and causes big damages in accordance with increase of the flood discharge. [Characteristics of the section] ● Section where it is important to build a dike to keep necessary discharge capacity and to protect the maximum farmland in Majes area. [Elements to be protected] ○ Arable lands in both banks of the selected stretch (largest arable lands in Majes) [Method of Protection] ▼Inundation occurs at the flood with return period of 5-year and the damage become heavily at the flood with return period of 50-year, so that the flood protection work is implemented for the latter flood flowing down safely. ▼The combination of protection work of ⑥ and ⑦ can increase the effect of facilities.

(4) Location of prioritized flood control works

In Figure 4.3.1-8 and Figure 4.3.1-14 the location of prioritized flood control works in indicated in each watershed.

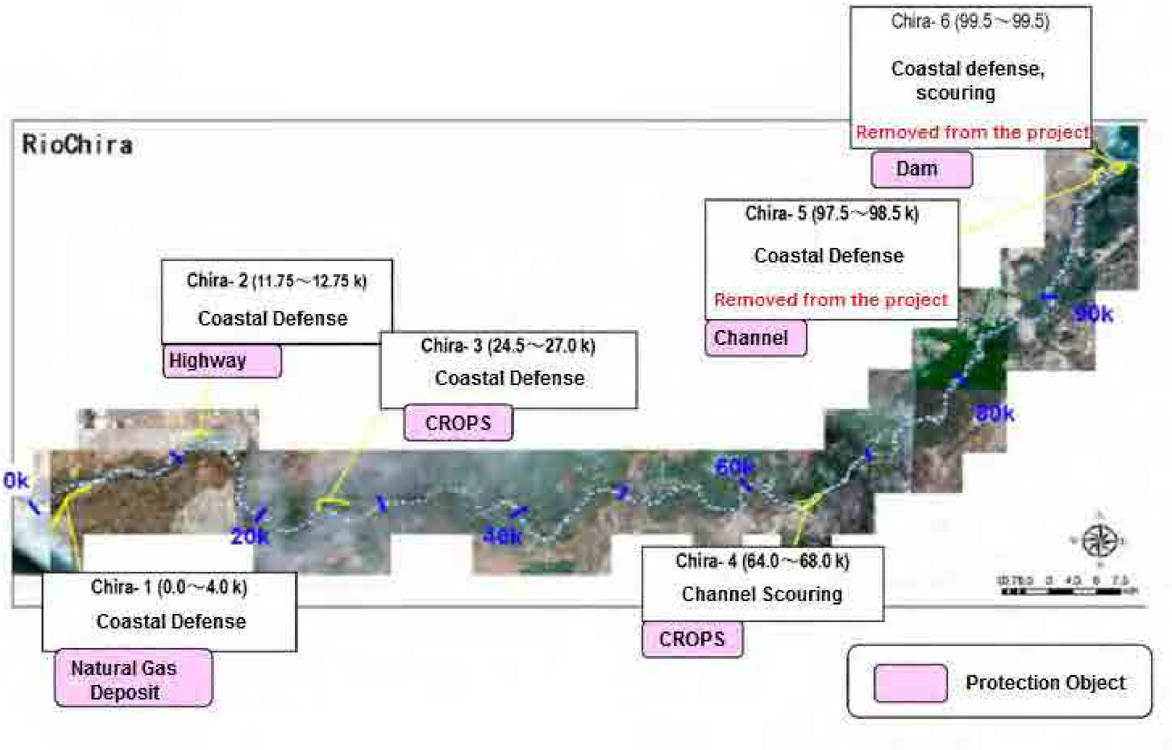


Figure 4.3.1-8 Prioritezed flood control works in Chira river

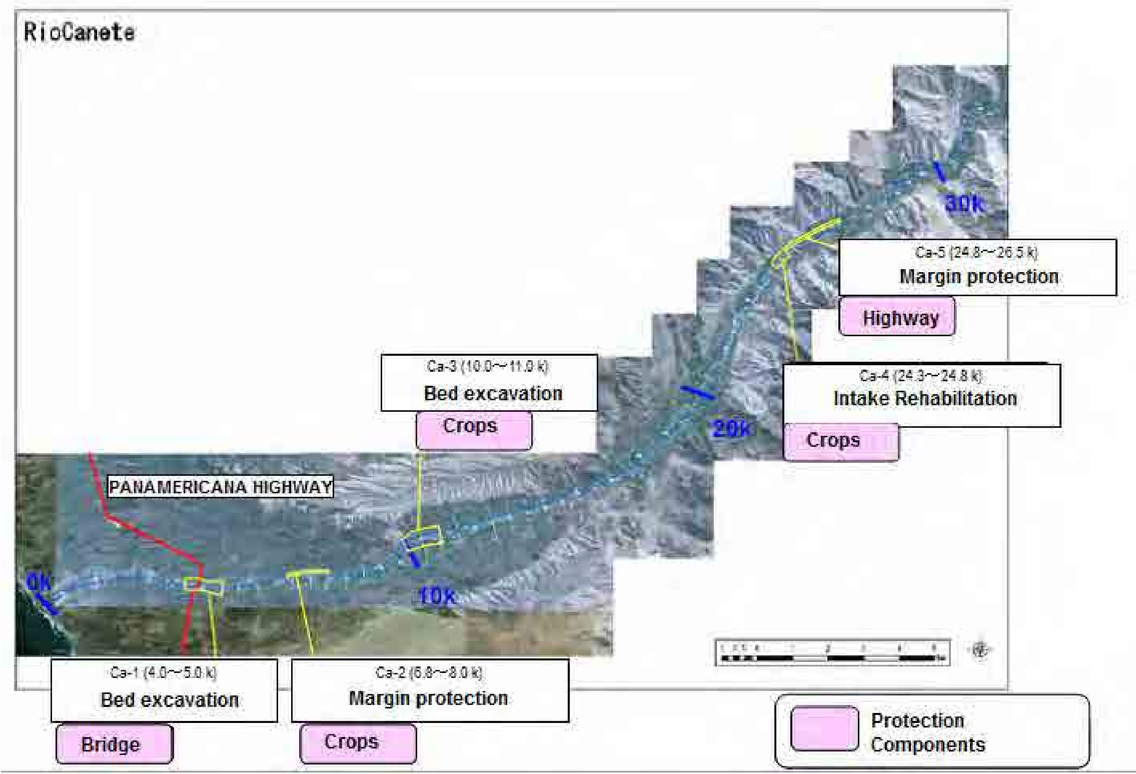


Figure 4.3.1-9 Prioritezed flood control works in Cañete river

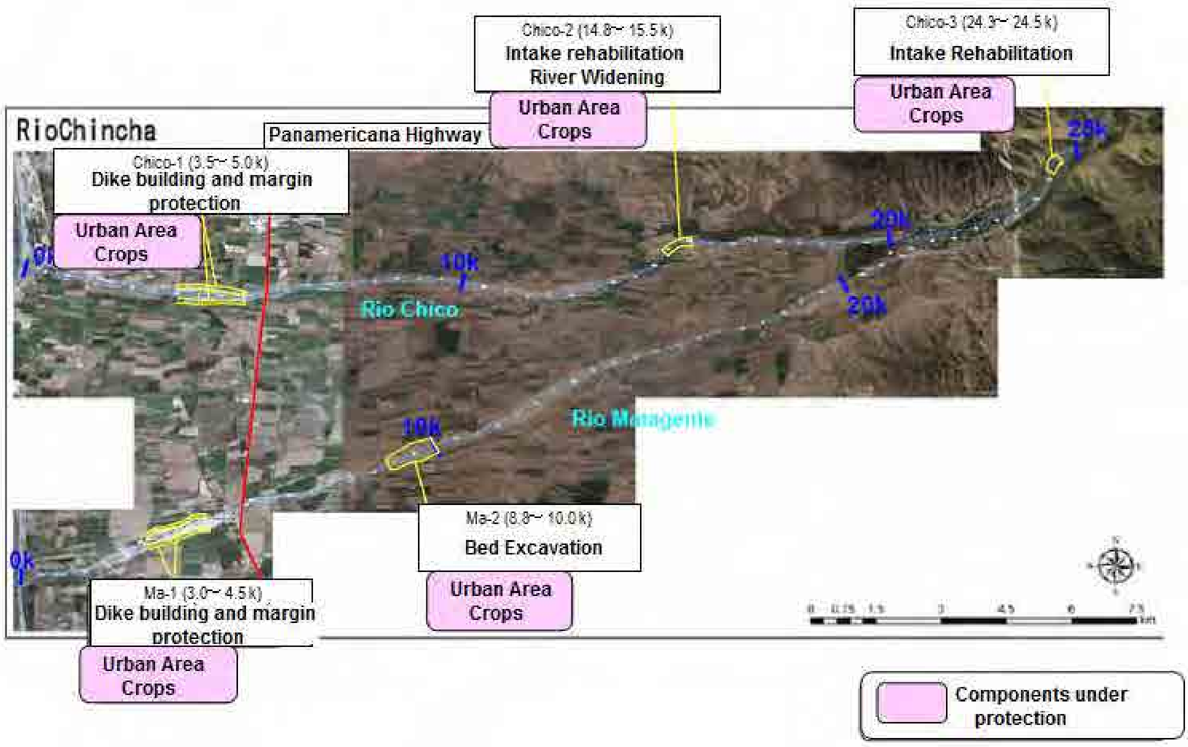


Figure 4.3.1-10 Prioritezed flood control works in Chincha river

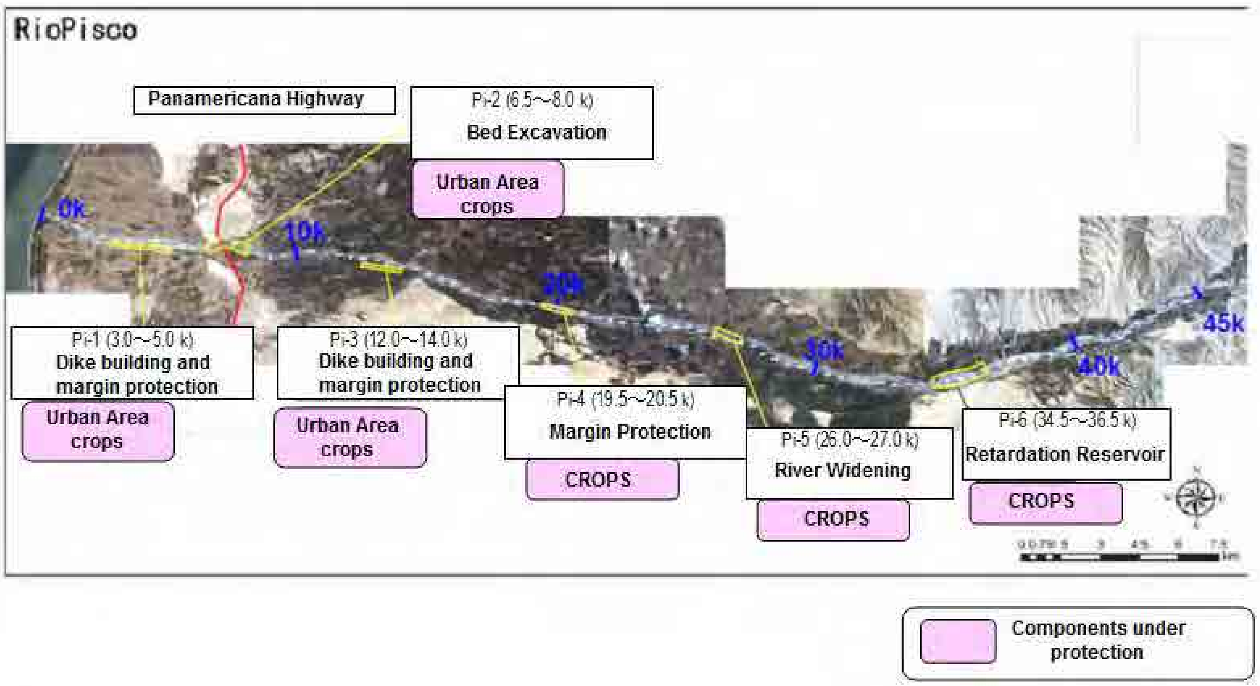


Figure 4.3.1-11 Prioritezed flood control works in Pisco river

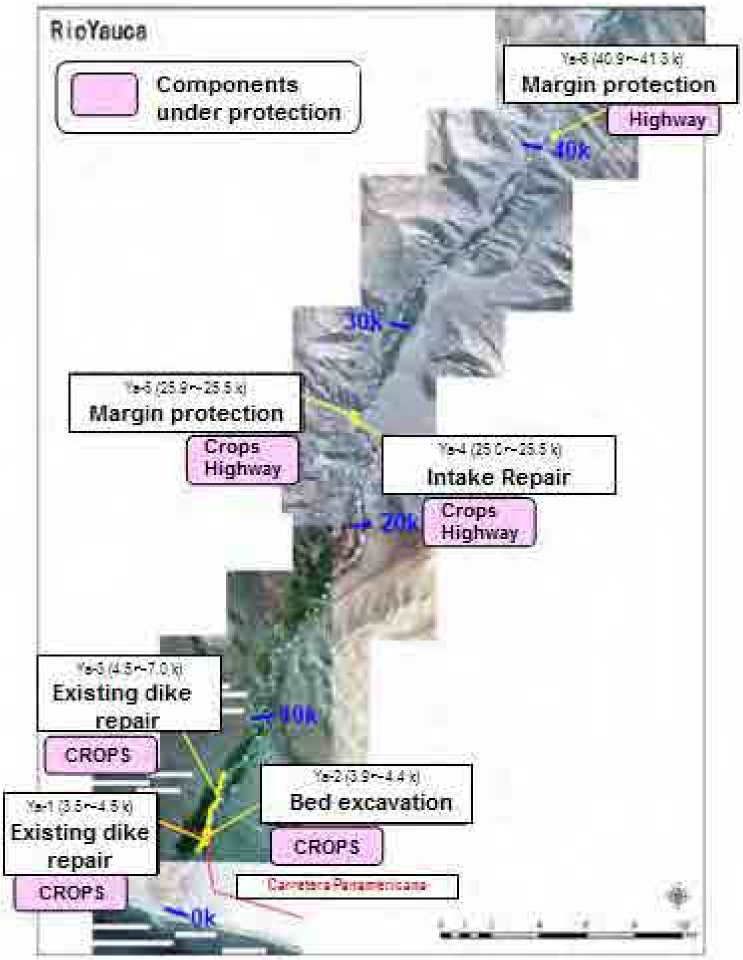


Figure 4.3.1-12 Prioritezed flood control works in Yauca river

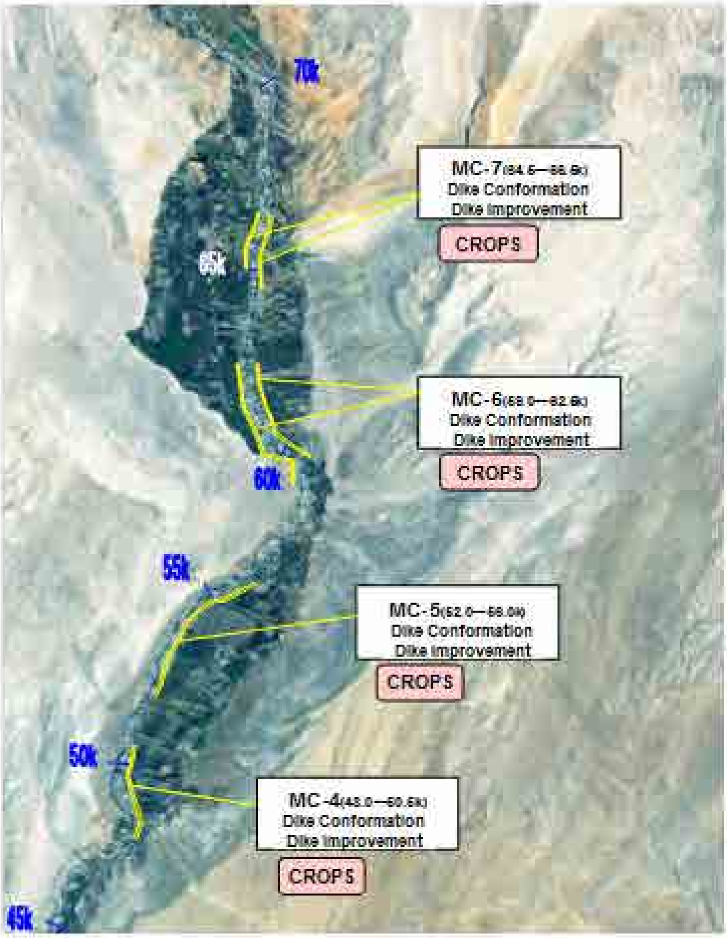


Figure 4.3.1-13 Prioritezed flood control works in Majes river

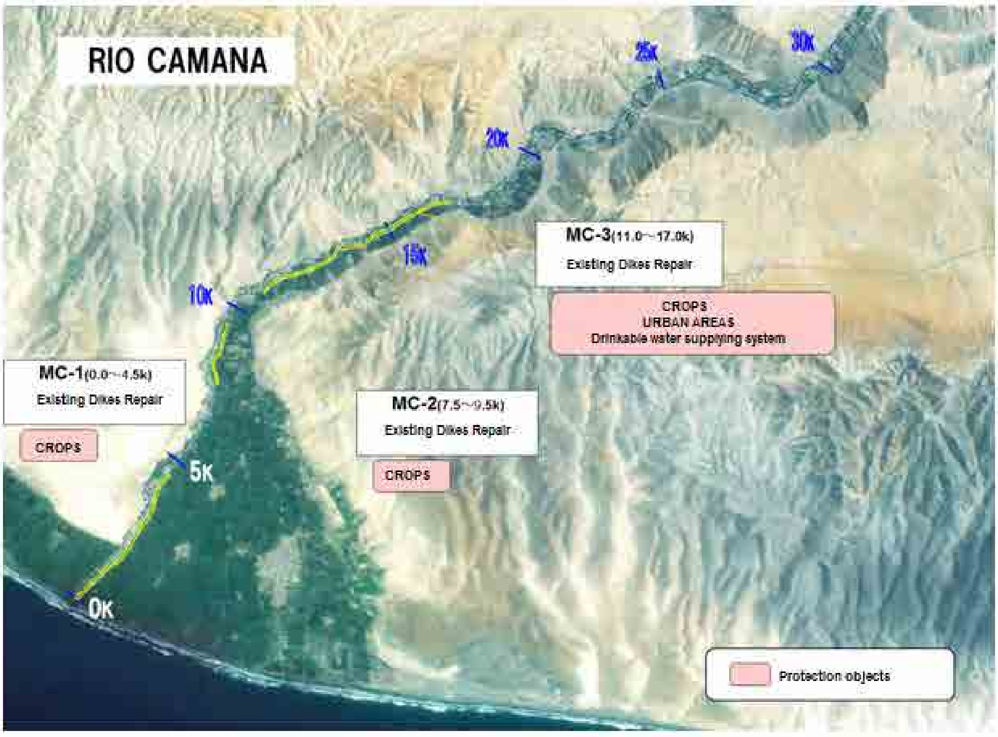


Figure 4.3.1-14 Prioritezed flood control works in Camana river

Table‐4.3.1-10 Summary of Flood Prevention Facilities

Basin	Location			Preservation Object	Counter Measure	Summary of Facility	Objective Section
Chira	1	0.0k-4.0k	Revetment	Crop land/ natural gas	Revetment	H；2.0m Slope；1:3 L；4000m	0.0km～4.0km（left bank）
	2	11.75k-12.75k	Erosion	Road		H；2.0m Slope；1:3 L；1,000m	11.75km～12.75km（right bank）
	3	24.5k-27.0k	Revetment	Crop land		H；2.0m Slope；1:3 L；2,500m	24.5km～27.0km（right bank）
	4	64.0k-68.0k	Riverbed Excavation	Crop land	Riverbed excavation	Ex.width；100m Ex. depth；1.0m L；1,000m	64.0km～68.0km（total）
Cañete	1	4.3km	Narrow Section	Road bridge	Riverbed excavation	Ex.width；100m Ex. depth；1.0m L；1,000m	4.0km～5.0km（total）
	2	6.8k～8.0k	Inundation	Crop land	Revetment	H；2.0m slope；1:3 L；1,200m	6.5km～8.1km（right bank）
	3	10.25k	Narrow Section		Riverbed excavation	Ex.width；100m Ex. depth；1.0m L；1,000m	10.0km～11.0km（total）
	4	24.5k	Intake		Diversion weir	Weir width；150m H；3.0m T；2.0m	24.25km～24.75km（total）
	5	25.0k, 26.25k	Erosion	Road	Revetment	H；2.0m Slope；1:3 L；750m	24.75km～26.5km（right bank）
Chincha	1	C-3.5～5.0k	Inundation	Crop land（Cotton Grape） Urban area	Dike（no dike section） Revetment	Top W；4.0m H；2.0m Slope；1:3 L；3,000m（1,500+1,500）	3.0km～5.1km(total)
	2	C-15k	Intake		Intake Widening river width	Weir W；100m H；3.0m T；2.0m	14.8km～15.5km（total）
	3	C-24k	Diversion weir		Rehabilitation of diversion weir（rehbilitation of existing weir, channel and training dike）	Weir w；70m H；3.0m T；2.0m	24.2km～24.5km（total）
	4	M-3.0k～4.5k	Inundation		Dike（no dike section） Revetment	Top W；4.0m H；2.0m Slope；1:3 L；3,000m（1,500+1,500）	2.5km～5.0km（total）
	5	M-8.9k	Narrow Section		Riverbed excavation	Ex. width；100m Ex. depth；1.0m L；1,200m	8.0km～10.5km（total）
Pisco	1	5.5k	Inundation	Crop land	Dike（no dike section） Revetment	Top W；4.0m H；2.0m Slope；1:3 L；2,000m	3.0km～5.0km（left bank）
	2	7.0k	Narrow Section		Riverbed excavation	Ex. width；100m Ex. depth；1.0m L；1,500m	6.5km～8.0km（total）
	3	13.5k	Inundation		Dike（no dike section） Revetment	Top W；4.0m H；2.0m Slope；1:3 L；1,500m	12.5km～14.0km（left bank）
	4	20.5k	Inundation	Crop land	Dike（no dike section） Revetment	Top W；4.0m H；2.0m Slope；1:3 L；2,000m	19.5km～20.5km（left bank）
	5	26.5k	Narrow Section		Widening river width	Ex. width；100m Ex. depth；1.0m L；1,000m	26.0km～27.0km（total）
	6	34.5k	Intake		Retarding basin	Retarding basin；1,800m×700m	34.5km～36.5km（total）
Yauca	1	4.5k下流	Inundation	Crop land（olive）	Rehabilitation of dike	Top W；4.0m H；2.0m Slope；1:3 L；1,000m	3.5km～7.5km（total）
	2	4.1km	Narrow Section		Riverbed excavation	Ex. width；100m Ex. depth；1.0m L；500m	
	3	4.5-7.0k	Inundation		Rehabilitation of dike	Top W；4.0m H；2.0m Slope；1:3 L；2,500m	
	4	25.0k	Intake	Crop land（olive）	Rehabilitation of intake	Weir W；100m H；3.0m T；2.0m	25.0km～25.7km（total）
	5	25.0k	Intake		Revetment	H；2.0m Slope；1:2 L；500m	
	6	41km	Intake	Road	Revetment	H；2.0m Slope；1:2 L；400m	40.9～41.3km(left bank)
Majes-Camana	MC 1	0.0k-4.5k	Inundation	Crop land（rice、others）	Dike（no dike section） Revetment	Top W；4.0m h；2.0m-3.0m Slope；1:3 L；4,500m	0.0km-4.5km (left bank)
	MC 2	7.5k-9.5k	Inundation			Top W；4.0m h；2.0m-3.0m Slope；1:3 L；2,000m	7.5km-9.5km (left bank)
	MC 3	11.0k-17.0k	Inundation			Top W；4.0m h；2.0m-3.0m Slope；1:3 L；6,000m	11.0k-17.0k(left bank)
	MC 4	48.0k-50.5k	Inundation			Top W；4.0m h；2.0m-3.0m Slope；1:3 L；2,500m	48.0km-50.5km (left bank)
	MC 5	52.0k-56.0k	Inundation			Top W；4.0m h；2.0m-3.0m Slope；1:3 L；4,o00m	52.0k-56.0k(left bank)
	MC 6	59.0k-62.5k 59.5k-62.5k	Inundation /erosion			Top W；4.0m h；2.0m-3.0m Slope；1:3 L；6,500m	59.0km-62.5km (left bank) 59.5km-62.5km. (right bank)
	MC 7	65.0k-66.5k 64.5k-66.5k	Inundation			Top W；4.0m h；2.0m-3.0m Slope；1:3 L；3,500m	65.0km.-66.5 km.(right bank) 64.5km.-66.5 km. (left bank)

(5) Standard section of the dike

1) Width of the crown

The width of the dike crown was defined in 4 meters, considering the dike stability when facing design overflows, width of the existing dike, and width of the access road or that of local communication.

2) Dike structure

The dike structure has been designed empirically, taking into account historic disasters, soil condition, condition of surrounding areas, etc.

Dikes are made of soil in all the Watersheds. Although there is a difference in its structure varying from zone to zone, this can be summarized as follows, based on the information given by the administrators interviewed:

① The gradient of the slope is mainly 1:2 (vertical: horizontal relationship); the form may vary depending on rivers and areas.

② Dike materials are obtained from the river bed in the area. Generally these are made of sand/gravel ～sandy soil with gravel, of reduced plasticity. As to the resistance of the materials, we cannot expect cohesiveness.

③ The Watershed of the Cañete River is made of loamy soil with varied pebble, relatively compacted.

④ The lower stretch of the Sullana weir of the Chira River is made of sandy soil mixed with silt. Dikes have been designed with a “zonal-type” structure where material with low permeability is placed on the riverside of the dike and the river; material with high permeability is placed on landside of the dike. However, given the difficulty to obtain material with low permeability, it has been noticed that there is lack of rigorous control of grain size distribution in supervision of construction.

⑤ When studying the damaged sections, significant differences were not found in dike material or in the soil between broken and unbroken dike. Therefore, the main cause of destruction has been water overflow.

⑥ There are groins in the Chira and Cañete rivers, and many of them are destroyed. These are made of big rocks, with filler material of sand and soil in some cases, what may suggest that destruction must been caused by loss of filler material.

⑦ There are protection works of banks made of big rocks in the mouth of the Pisco River. This structure is extremely resistant according to the administrator. Material has been obtained from quarries, 10 km. away from the site.

Therefore, the dike should have the following structure.

① Dikes will be made of material available in the zone (river bed or banks). In this case, the material would be sand and gravel or sandy soil with gravel, of high permeability.

② The gradient of the slope of the dike will be between 30º ～35º (angle of internal friction) if the material to be used is sandy soil with low cohesiveness. The stable gradient of the slope of an embankment executed with material with low cohesiveness is determined as: $\tan\theta=\tan\varphi/n$ (where “θ” is gradient of the slope; “φ” is angle of internal friction and “n” is 1.5 safety factor).

The stable slope required for an angle of internal friction of 30° is determined as: V:H=1:2.6 ($\tan\theta=0.385$).

Taking into consideration this theoretical value, a gradient of the slope of 1:3.0 was considered, with more gentle inclination than the existing dikes, considering the results of the discharge analysis, the prolonged time of the design flood discharge (more than 24 hours), the fact that most of the dikes with slope of 1:2 have been destroyed, and the relative resistance in case of overflow due to unusual flooding.

③ The dike slope by the riverside must be protected for it must support a fast water flow given the quite steep slope of the riverbed. This protection will be executed using big stones or big rocks easily to get in the area, given that it is difficult to get connected concrete blocks .

The size of the material was determined between 30cm and 1m of diameter, with a minimum protection thickness of 1m, although these values will be determined based on flow speed of each river.

3) Freeboard of the dike

The dike is made of soil material, and as such, it generally turns to be an weak structure when facing overflow. Therefore, it is necessary to prevent water overflow, to a lower water rise than the design discharge. So it is necessary to keep a determined freeboard when facing a possible increase in water level caused by the waves by the wind during water rise, tidal, hydraulic jump, etc. Likewise, it is necessary that the dikes have sufficient height to guarantee safety in surveillance activities and flood protection work , removal of logs and other carryback material, etc.

Table 4.3.1-16 shows guidelines applied in Japan regarding freeboard. Although in Peru there is a norm on freeboard, it has been decided to apply the norms applied in Japan, considering that rivers in both countries are alike.

Table-4.3.1-16 Design discharge and freeboard

Design discharge	Freeboard
Less than 200 m^3/s	0.6m
More than 200 m^3/s, less than500 m^3/s	0.8m
More than 500 m^3/s, less than 2,000 m^3/s	1.0 m
More than 2,000 m^3/s, less than 5,000 m^3/s	1.2 m
More than 5,000 m^3/s, less than10,000 m^3/s	1.5 m
More than 10,000 m^3/s	2.0 m

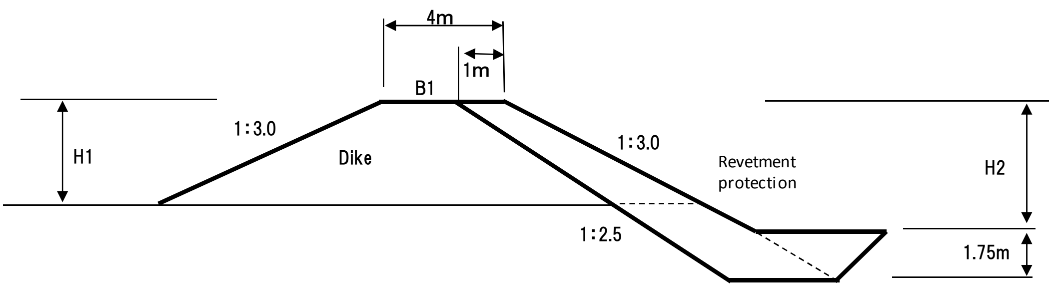


Figure 4.3.1-4 Standard dike section

4.3.2Nonstructural measures

4.3.2.1Reforestation and vegetation recovery

(1)Basic policies

The Reforestation and Vegetation Recovery Plan satisfying the goal of the present Project can be classified in: i) reforestation along river structures; and ii) reforestation in the high Watershed. The first one contributes directly to flood control and expresses its effect in short time. The second one demands a huge investment and an extended time, as detailed in the later section 4.14 “Medium and long term Plan”, 4.14.2 “Reforestation Plan and Vegetation Recovery”, what makes not feasible to implement it in the present Project. Therefore, the analysis is here focused only in option i).

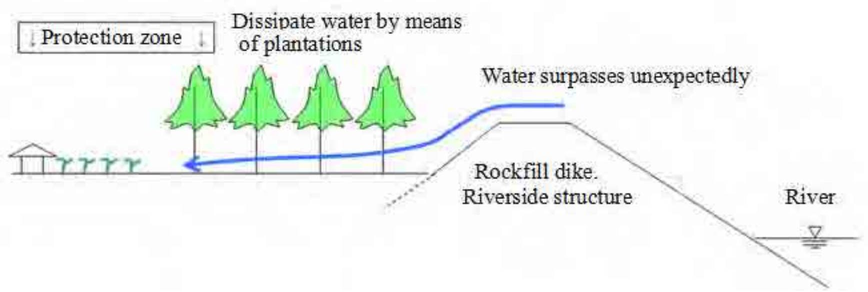
Policies for the afforestation plan along river structure is as shown below. The conceptual diagram of the afforestation scheme are shown in Figures 4.3.2.1-1 and 4.3.2.1-2. There are two types of forestry, since afforestation type A can not be applied Majes- Camaná River watershed, the afforestation type B will be applied. In the every watershed except for the one mentioned above, type A afforestation will be applied.

a) Objective: Reduce impact of river overflow when water rise occurs or when river narrowing is produced by the presence of obstacles, by means of vegetation borders between the river and the elements to be protected.

b) Methodology: Create vegetation borders of a certain width along river structuresr.

c) Work execution: Plant vegetation at a side of the river structures (dikes, etc.)

d) Maintenance post reforestation: The maintenance will be assumed by irrigation commissions by own initiative.



Source: JICA Study Team)

Figure 4.3.2.1-1 Conceptual Diagram Afforestation in the Riverside structures (A Type)

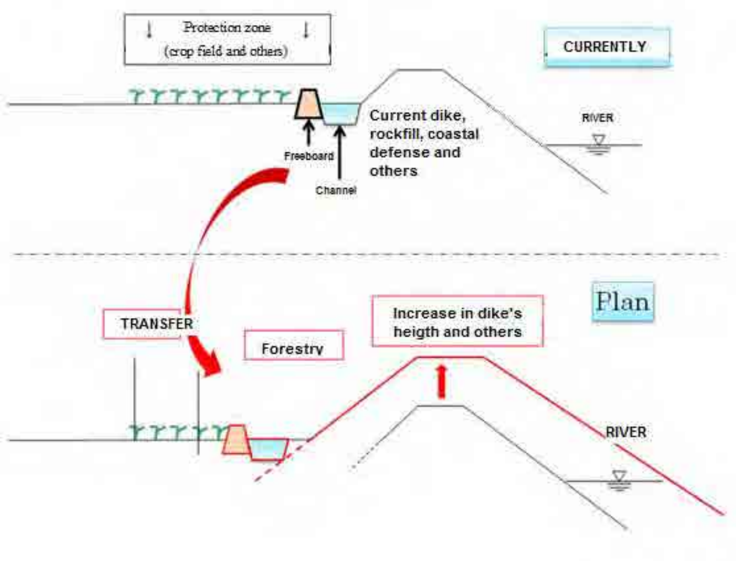


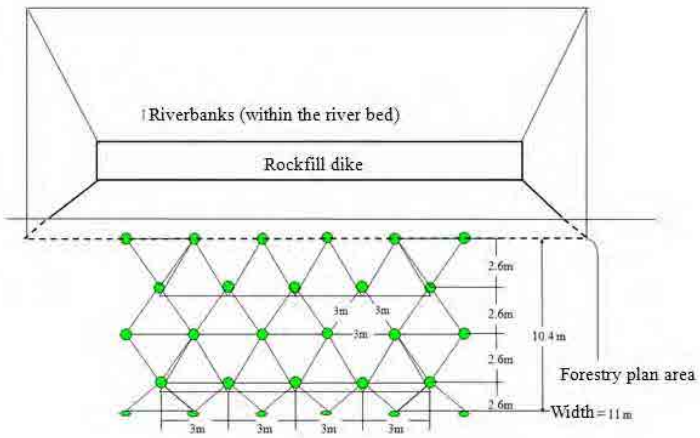
Figure 4.3.2.1-2 Conceptual Diagram Afforestation or river bank structures (Type B)
(Source: JICA Study Team)

In the Camana river watershed, channels have been built along existing dikes, and most rice fields reach to edge of dike. According to the interview with the Board of users, landowners would not agree to type A afforestation (afforestation 11metros width) since it would reduce their cultivation area. Therefore it is assumed that afforestation is difficult. So, if the land can not be acquire, there is Type B afforestation and afforestation in channels for their conservation.

(2) Planning reforestation quantities

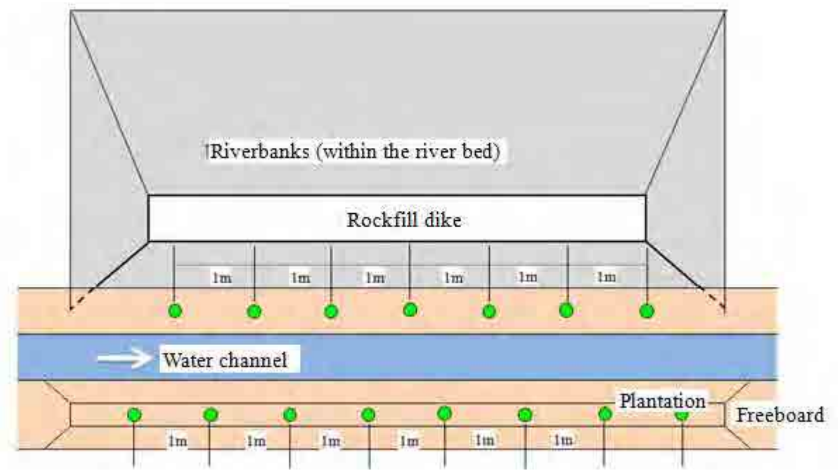
a) Structure (afforestation location)

Type A: In Peru the most common pattern for afforestation is with equilateral triangles. This project also uses this model by planting trees with 3-meter intervals (Figure 4.3.2.1-3). If this method is used, it is expected that trees will act to stop and cushion even 1-meter diameter rocks, for what rows will be quadrupled, thus increasing their effectiveness. However, the main goal is to dissipate flow water energy ; in case floods strike directly with plants sowed, good results might not be expected.



(Source: JICA Study Team)
Figure 4.3.2.1-2 Location of the afforestation design plan in the riverside structure (Type A)

Type B: In the current situation, forestation takes place with 1 meter interval parallel to the channel; in this plan this afforestation will be applied. The design location of the afforestation plan in shown in Figure 4.3.2.1-4



(Source: JICA Study Team)

Figure 4.3.2.1-4 Location of afforestation design plan in bank structure (Type B)

b) Species to be afforested

The following list of forestry species has been developed for selecting the species to be planted.

- Forestry species for production (information obtained by forest nursery companies): see Table 4.3.2.1-1
- Forestry species verified in situ: see Table 4.3.2.1-2.

The mentioned species are selected for afforestation in bank structures. For selecting them, an evaluation was conducted considering certain criteria. In Table 4.3.2.1-4 shows the details of the selection, in Table 4.3.2.1-3 you can find the Table with the selection criteria.

Evaluation criteria used for selection:

1. Species with adequate properties to grow and develop in the riverside (preferably native)
2. Possibility of growing in plant nurseries
3. Possibility of wood and fruit use
4. Demand of local population
5. Native species (preferably)

After making a field survey, a list of planted or indigenous species of each zone was firstly made. Then, a list of species whose plants would grow in seedbeds, according to interviews made to plant growers, was prepared.

Priority was given to the aptitude of local conditions and to plant production precedents, leaving as second priority its usefulness and demand or if they were native species or not. Table 4.3.2.1-1 shows the assessment criterion.

Table 4.3.2.1-1 List of seedlings that may be produced

Watershed	Producers	Seedlings production sites	Commonly produced species	Sporadic produced species
Chira	AGRORURAL	Lambayeque	Algarrobo, Molle, Eucalipto, Huarango (*Acacia macracantha*)	Aliso, Queñual
	Fomeco	Lima	Algarrobo, Tara, Eucalipto	Molle, Huarango (*Acacia Macracantha*)
	Montaña azul	Piura	Algarrobo, Molle, Eucalipto, Huarango, (*Acacia macracantha*)	Sauce, Casuarina, pájaro bobo
Cañete	AGRORURAL	Santa Eulalia	Pino, Molle, Eucalipto, Huarango (*Prosopis limensis*)	Ciprés, Tara
	Fomeco	Lima	Tara, Molle, Huarango (*Prosopis limensis*)	
	Agrimex	Lima	Aliso, Algarrobo, Caña, Támarix, Bambú, Pino, Casuarina, Eucalipto	
Chincha Pisco	AGRORURAL	Lima	Pino, Molle, Eucalipto, Huarango (*Prosopis limensis*)	Ciprés, Tara
	Fomeco	Lima	Tara, Molle, Huarango (*Prosopis limensis*)	
	AGRORURAL	Ica	Aliso, Algarrobo, Caña, Támarix, Bambú, Pino, Casuarina, Eucalipto	
Yauca	Fomeco	Huancayo	Aliso, Queñual, Colle, Pino, Eucalipto	
Camaná-Majes	APAIC	Arequipa	Sólo Tara	
	Los Girasoles de Florentino	Arequipa	Sauce, Álamo, Molle, Casuarina, Tara	
	AGRORURAL	Arequipa		Tara, Sauce, Huarango, Acacia, Casuarina

(Source: Information gathered by the forestry seedlings producers)

Table 4.3.2.1-2 List of Verified Tree Species in the Field (for Riparian Forestation)

Location	Tree Species	Characteristics
Chira	Algarrobo	Growing on the place 4m over the usual river water level
	Casuarina	Growing on the place 1 to 2m higher than usual river water level. It is not popular because of less usage.
	Eucalyptus	It is planted in the urban areas, but can not be seen along the rivers. Its characteristics shows high adequateness. Most of people believe it should be planed in the high elevation areas.
	Tamalix	As same as Algarrobo. Fruit is edible. It is viewed with suspicion as invader species in some quarters.
	Paharobobo	Growing on the place 1 to 2m higher than usual river water level.
Canete	Eucalyptus	Common along the river, and its characteristics shows high adequateness.
	Casuarina	Common along the river, and its characteristics shows high adequateness.
	Sauce	Common along the river, and its characteristics shows high adequateness.
	Molle	Shrub species, its characteristics shows high adequateness.
Chincha	Eucalyptus	It has good track record in plantation/forestation, its characteristics shows high adequateness.
	Casuarina	Common along the river, and its characteristics shows high adequateness.
Pisco	Huarango (*Prosopis limensis*)	It has good track record in plantation/forestation, was taken as forestation species in the forestation plan of Cansus, Ica Region.
	Aromo	-
Yauca	Eucalyptus	Common along the river, and its characteristics shows high adequateness.
	Casuarina	, its characteristics shows high adequateness. Common surrounding farm lands to protect it against wind and sands.
	Sause	It grows along rivers naturally. Very common in usage for planting along the canals besides paddy. The branches are used for fuel wood. Germination from the stamp. The most common species in Camana-Majes River Basin.
	Callacas	It grows along rivers naturally. Growth with Sause is common. Trees along canal are not planted, remained from natural one.
	Eucalyptus	Most of the trees in the area is planted. It planted on a part of the river basin beside to the mountain. Most of the plantation of Eucalyptus in 2007 were almost died in accordance with hearing from water users group in Vamana-Majes River Basin.
	Casuarina	It grows in some areas along rivers, but not many. Sometimes it can be seen around houses.

(Source: JICA Study Team)

Table 4.3.2.1-3 Results of Planting Species Selection (Details)

River Basin	Tree Species	Adequateness to evaluation items*						Remarks
		1	2	3	4	5	Total**	
Chira	Aliso	C	B	A	C	A	--	Adequate for high elevation areas rather as
	Algarrobo	A	A	C	B	A	++	Adequate much for the area, common to there
	Tamalix	A	C	B	B	B	+	As invader plant in some quarters
	Casuarina	A	B	C	B	B	+	Survive near the seashore areas
	Eucalyptus	B	A	B	B	B	-	Fast growing up, useful for log/firewood
	Quinual	C	C	B	C	A	--	Adequate for high elevation areas rather as
	Sauce	A	B	C	B	A	+	Its characteristics shows high adequateness to riparian areas
	Tara	D	A	A	B	A	-	Recently, fruit was found as effectiveness, becomes popular for plantation
	Paharobobo	A	B	D	B	A	-	Its characteristics shows high adequateness to lower riparian places
	Pine	B	D	B	B	B	-	Adequate for high elevation areas rather as
	Molle	B	A	B	B	A	+	It is said as its root grows in deep
	Huarango (*Acacia Macracantha*)	A	A	B	B	A	+	Similar to Algarrobo
Canete Chincha Pisco Yauca	Aliso	C	B	A	C	A	--	Adequate for high elevation areas rather as
	Algarrobo	B	A	C	B	A	--	Similar to Huarango (*Prosopis limensis*), Prosopis is selected in the southern areas
	Canya (Cariso)	A	C	B	B	A	--	Grass
	Quinual	C	C	B	C	A	--	Adequate for high elevation areas rather as
	Colle	C	D	D	B	A	--	Adequate for high elevation areas rather as
	Tamalix	B	A	B	B	B	--	Its characteristics shows high adequateness in the Northern areas, but unknown in the southern areas
	Tara	D	A	A	B	A	-	Recently, fruit was found as effectiveness, becomes popular for plantation
	Bamboo	A	A	B	B	A	+	Unknown for forestation record
	Pine	B	D	B	B	B	-	Adequate for high elevation areas rather as
	Molle	B	A	B	B	A	+	It is said as its root grows in deep
	Casuarina	A	B	C	B	B	+	Adequate for high elevation areas rather as
	Eucalyptus	A	B	B	A	B	++	Adequate for high elevation areas rather as
	Huarango (*Prosopis limensis*)	A	A	D	A	A	++	Its characteristics shows high adequateness in the area near to the sea or dry area
Camana-Majes	Sause	A	A	B	A	A	++	Adequate much for the area, good practice, requirements from water uses group
	Callacas	A	D	D	B	A	--	Not producing seedlings
	Eucalyptus	B	A	B	B	B	-	Not adequate for silt soil and wet condition along the canals
	Casuarina	B	A	B	B	B	+	Not many achievement, but its character is adequate for the sea side areas
	Huarango (*Prosopis limensis*)	B	A	D	B	A	--	Not adequate for silt soil and wet condition along the canals

* Evaluation criteria are shown above, ** ++: Selected, +: second, -: nominated but not so good,--: not be selected

(Source: JICA Study Team based on hearing from the seedling providers)

2 criteria for the selection of tree species have been taken: 1: Adaptation to the area and 2: Seedling production experience. The following criteria were taken as reference: 3: Use and 4: the need for the population, and 5 Local species. The criteria are shown in Table 4.3.2.1-4.

Table 4.3.2.1-4 Selection Criteria for Planting species

		Evaluation item				
		1：Adequateness	2：Possibility of seedling production	3：Usage	4：Requests of local communities	5: native species
Evaluation point	A	Confirmed its growth in the field	Usual production	Wood and fruit are used	Requested from water users association	Native
	B	Not confirmed the growth, but generally its characteristics shows adequateness	Production sometimes	Single usage of fruit or wood	No requests from water users association	Not native
	C	Not applicable to the 2 points above	Possible, but rare	Not be used	-	-
	D	unknown	No production	Unknown	-	-

(Source: JICA Study Team)

Table-4.3.2.1-5 shows a list of selected species applying these assessment criterions. ◎ marks main species, ○ are those species that would be planted with a proportion of 30% to 50%. This proportion is considered to avoid irreversible damages such as plagues that can kill all the trees.

Table 4.3.2.1-5 Selected Tree Species

Chira River Basin : Algarrobo (++), Tamalix (+), casuarina (+)
Canete and ither three river basins: Eucalyptus (++), Huarango (+), Casuarina (+)
Camana-Majes River basin: Sause (++), Casuarina (+)

(Source: JICA Study Team)

In the Chira Watershed the main forestry specie is Algarrobo and also have more experience in forestry. This specie is a native specie form the northern coast of Peru. Because this plant exists in the area, farmers are used to it and know it very well. Tamarix has the same qualities as Algarrobo admits fruit can be eaten. Casuarinas specie requires little water and supports saline water, which is why is used in areas near the ocean.

In the Cañete Watershed the main forestry specie is Eucalyptus. This specie adapts very well in this area, it adapts to the zone and has high demand by the Water User's Committees. Huarango (*Prosopis limensis*: is how this plant is known in the northern region of Peru, comes from another seed) is a native specie form the southern region of Peru. It is planted along the Panamericana Highway. Casuarina specie has been planted in this area to protect from wind and sand, moreover for the lands near farms

In the Watershed of the Camana-Majes River the main afforestation specie is the Willow. This specie adapts very well in highly humid environments and there is experience in afforestation activities in the zone. This specie is generally afforested by the Users Board. However, the Willow and the Callacas are found between the seashore up to 1.5km, and still its growth is not optimal. This is due to the tide impact, for what it is proposed to replace the Willow with the Casuarina, given that the later one adapts better in salty zones. In the area there is abundance of Callacas, but they do not grow in plant nurseries. In the Watershed of the Camana-Majes River most of the fields are rice crop fields, therefore water level is high and the soil is clay soil. For this reason, the Eucalyptus is not apt for afforestation in this zone, since it may wither.

(c) Afforestation plan area

The afforestation plan has been selected as it is mentioned in the location and type of species plan, in the dikes and rock fill, sedimentation wells along the riverside. The Type A afforestation will have 11 meters width and within the sediment tank trees will be planted where the river water doesn't pass. In Type B afforestation it has been calculated to afforest two lines along the dike with 1 meter interval.

Following Table 4.3.2.1-6 shows the estimating area for the Afforestation and Recovery of Vegetation Cover Plan by Watersheds.

Table 4.3.2.1-6 Amount of Afforestation/Vegetation Recovery Plan (Riparian Afforestation)

(Chira River Basin, Type A)

No.	Side	Length (m)	Width (m)	Forestation Area (ha)	No. of Planting Stocks (No.)	Number of planting stocks for each Species (No.)			
						Algarrobo	Tamalix	Casuarina	Total
Cira-1	L	4,000	11	4.4	13,024	2,605	1,302	9,117	13,024
Cira-2	R	1,000	11	1.1	3,256	1,628	977	651	3,256
Cira-3	R	2,500	1	0.3	888	444	266	178	888
Cira-4				0.0	0	－	－	－	－
Cira-5	R	1,000	11	1.1	3,256	1,954	1,302	0	3,256
Cira-6	L	500	11	0.6	1,776	1,066	710	0	1,776
Total Chira		9,000		7.5	22,200	7,697	4,557	9,946	22,200

(Canete, Chincha, Pisco and Yauca River Basin, Type A)

No.	Side	Length (m)	Width (m)	Forestation Area (ha)	No. of Planting Stocks (No.)	Number of planting stocks for each Species (No.)			
						Eucalyptus	Hurango	Casuarina	Total
Ca-1				0.0	0	－	－	－	－
Ca-2	R	1,600	11	1.8	5,328	2,664	1,598	1,066	5,328
Ca-3				0.0	0	－	－	－	－
Ca-4				0.0	0	－	－	－	－
Ca-5	R	1,750	11	1.9	5,624	2,812	1,687	1,125	5,624
Total Canete		3,350		3.7	10,952	5,476	3,285	2,191	10,952
Chico-1	Both	2,100	22	4.6	13,616	6,808	4,085	2,723	13,616
Chico-2				0.0	0	－	－	－	－
Chico-3				0.0	0	－	－	－	－
Ma-4	Both	2,500	22	5.5	16,280	8,140	4,884	3,256	16,280
Ma-5				0.0	0	－	－	－	－
Total Chincha		4,600		10.1	29,896	14,948	8,969	5,979	29,896
Pi-1	L	2,000	11	2.2	6,512	3,256	1,954	1,302	6,512
Pi-2				0.0	0	－	－	－	－
Pi-3	L	1,500	11	1.7	5,032	2,516	1,510	1,006	5,032
Pi-4	L	1,000	11	1.1	3,256	1,628	977	651	3,256
Pi-5				0.0	0	－	－	－	－
Pi-6	Whole	2,000	600	120.0	355,200	177,600	106,560	71,040	355,200
Total Pisco		6,500	633	125.0	370,000	185,000	111,001	73,999	370,000
Ya-1	Whole	1,000	11	1.1	3,256	1,628	977	651	3,256
Ya-2				0.0	0	－	－	－	－
Ya-3		2,500	11	2.8	8,288	4,144	2,486	1,658	8,288
Ya-4		0	11	0.0	0	－	－	－	－
Ya-5	R	500	11	0.6	1,776	888	533	355	1,776

No.	Side	Length (m)	Width (m)	Forestation Area (ha)	No. of Planting Stocks (No.)	Number of planting stocks for each Species (No.)			
						Eucalyptus	Hurango	Casuarina	Total
Ya-6	R	400	11	0.4	1,184	592	355	237	1,184
Total Yauca		4,400		4.9	14,504	7,252	4,351	2,901	14,504
Ground Total		18,850		151.2	447,552	212,676	127,606	85,070	425,352

(Majes- Camana River Basin)

No.	Side	Length (m)	Width (m)	Forestation Area (ha)	No. of Planting Stocks (No.)	Number of planting stocks for each species(No.)		
						Sause	Casuarina	Total
Type B								
Camana-1	L	1,500	－	－	3,000	1,500	1,500	3,000
Camana-1	L	3,000	－	－	6,000	6,000	－	6,000
Camana-2	L	2,000	－	－	4,000	4,000	－	4,000
Camana-3	L	6,000	－	－	12,000	12,000	－	12,000
Type A								
Majes-4	L	2,500	11	2.8	8,288	8,288	－	8,288
Majes-5	L	4,000	11	4.4	13,024	13,024	－	13,024
Majes-6	R	3,500	11	3.9	11,544	11,544	－	11,544
Majes-6	L	3,000	11	3.3	9,768	9,768	－	9,768
Majes-7	R	1,500	11	1.7	5,032	5,032	－	5,032
Majes-7	L	2,000	11	2.2	6,512	6,512	－	6,512
Total		29,000		18.3	79,168	77,668	1,500	79,168

(Source: JICA Study Team)

In Table 4.3.2.1-7 shows the percentage according to forest species and the explanation in each bank structure.

Table 4.3.2.1-7 Ratios of Number of Planting Stocks by Species for each Construction

(Chira Riber Basin)

Serial No.	No.	Ratio of No. by Species			Remarks
		Algarrobo	Casuarina	Tamalix	
1	Cira-1	2	7	1	Casuarina is used a lot, because the site is near the sea sied
2	Cira-2	5	2	3	Algarrobo is main species, Tamalix and Casuarina are sub species
3	Cira-3	5	2	3	
5	Cira-5	6	0	4	Casuarina is not used, because the site is far from the sea side

(Canete and three river basins)

Serial No.	No.	Ratio of No. by Species			Remarks
		Eucalyptus	Casuarina	Huarango	
8	Ca-2	5	2	3	Eucalyptus is main species, and Hurango is sub. Huarango is the native species, it is expected that its characteristics has much adequateness than Casuarina. Then, Huarango is planted with prior than Casuarina
11	Ca-5	5	2	3	
12	Chico-1	5	2	3	
15	Ma-4	5	2	3	
17	Pi-1	5	2	3	
19	Pi-3	5	2	3	
20	Pi-4	5	2	3	
22	Pi-6	5	2	3	
23	Ya-1	5	2	3	
25	Ya-3	5	2	3	
27	Ya-5	5	2	3	
28	Ya-6	5	2	3	

(Majes-Camana River Basin)

No.	Ratio of No. by Species		Remarks
	Sause	Casuarina	
Camana-1	5	5	Due to near to seashore line, Casuarina is used. Ratio of No. of Sause and Casuarina is same as 50%.
Camana-2	5	5	
Camana-2 Majes-3 to Majes-8	10	-	These areas are far from seashore line, not necessary to consider Casuarina usage.

(Source: JICA Study Team)

(d) Plan location and execution

The location of the vegetation recovery area and afforestation plan for every bank structure is the same. It is worth mentioning that the vegetation recovery area and afforestation plan will take place once finished the construction of bank structures.

(3) Reforestation and Vegetation Recovery Plan cost (short term)

(a) Unitary cost for the forestation plan and vegetation recovery

Direct costs for the forestation plan and vegetation recovery are formed by the following elements:

- Planting unitary cost (planting unitary cost + transportation)
- Labor cost
- Direct costs (tool costs: 5% labor)

(b)Planting unitary cost

The supply of seedlings can be divided between private and agro-rural companies. The seedlings for afforestation upstream of the Chincha river watershed is acquired by AFRORURAL, in the case of plants for the river banks private companies will be the providers. The cost of plants for afforestation is detailed in Table **4.3.2.1-8**. The price of different plants has been consulted in different private companies, just as with the means of transportation. (For more information see Appendix 7-Table 2)

Table 4.3.2.1-8 Unit Price of Seedling (for Riparian Forestation)

River Basin	Species	Unit Price (Sol./seedling)
Chira	Algarrobo	1.3
	Tamalix	5.4
	Casuarina	1.9
Canete	Eucalyptus	1.4
	Huarango	1.6
	Casuarina	1.9
Chincha, Pisco	Eucalyptus	1.4
	Huarango	1.8
	Casuarina	2.2
Yauca	Eucalyptus	1.5
	Huarango	1.8
	Casuarina	2.3
Camana-Majes	Sause	2.5
	Casuarina	2.8

Note: Unit price of seedling = (Seedling price + transportation fee)
(Source: Hearing from suppliers)

(c) Labor cost

Criteria to assign labor costs come from the information obtained from AGRORURAL and the Water users board, cost assigned by forestation of 40 seedling a day. So, 33,6 Soles/man-day is assigned for the workers foresting in river banks.

(d) Direct costs

In direct costs the costs of the required tools are considered for the forestation project, instruments to dig holes for plants, plant transportation from its reception to the project area. Planting costs increase in 5%

(e) Work cost calculation for forestation and vegetation recovery in bank structures

The work costs for the forestry plan and vegetation recovery in bank structures are indicated in Table 4.3.2.1-9. The total work cost is 2.651.388 soles (approximately 80.000.000 yens)

To carry out the afforestation the contractor is needed to execute bank works. Just like the cost of construction works, 88% of direct costs is destined to indirect costs.

Table 4.3.2.1-9 Cost Estimation of Afforestation along River Protection Constructions (Riparian Afforestation)

No.	No. of Construction	Cost of Afforestation (Sol)					
		Direct Cost				Indirect Cost	Total
		Seedlings	Planting works	Direct Expense	Sub Total		
1	Cira-1	27,740	10,940	547	39,227	34,598	73,824
2	Cira-2	8,629	2,735	137	11,501	10,144	21,645
3	Cira-3	2,352	746	37	3,135	2,765	5,900
4	Cira-4				0	0	0
Chira River Basin		53,512	18,648	44,950	53,863	47,507	101,370
7	Ca-1				0	0	0
8	Ca-2	8,312	4,476	224	13,012	11,477	24,489
9	Ca-3				0	0	0
10	Ca-4				0	0	0
11	Ca-5	6,074	4,724	236	11,034	9,732	20,766
Canete River Basin		14,386	9,200	460	24,046	21,209	45,255
12	Chico-1	22,875	11,437	572	34,884	30,768	65,652
13	Chico-2				0	0	0
14	Chico-3				0	0	0
15	Ma-4	27,350	13,675	684	41,709	36,787	78,496
16	Ma-5				0	0	0
Chincha River Basin		50,225	25,113	1,256	76,594	67,555	144,148
17	Pi-1	10,940	5,470	274	16,684	14,715	31,399
18	Pi-2				0	0	0
19	Pi-3	8,454	4,227	211	12,892	11,371	24,263
20	Pi-4	5,470	2,735	137	8,342	7,358	15,700
21	Pi-5				0	0	0
22	Pi-6	596,736	298,368	14,918	910,022	802,639	1,712,661
Pisco River Basin		621,600	310,800	15,540	947,940	836,083	1,784,023
23	Ya-1	5,698	2,735	137	8,570	7,559	16,129
24	Ya-2				0	0	0
25	Ya-3	14,504	6,962	348	21,814	19,240	41,054
26	Ya-4				0	0	0
27	Ya-5	3,108	1,492	75	4,675	4,123	8,798
28	Ya-6	2,072	995	50	3,117	2,749	5,866
Yauca River Basin		25,382	12,183	610	38,175	33,671	71,847
29	MC-1	7,950	2,520	126	10,596	9,346	19,942

30	MC-1	15,000	5,040	252	20,292	17,898	38,190
31	MC-2	10,000	3,360	168	13,528	11,932	25,460
32	MC-3	30,000	10,080	504	40,584	35,795	76,379
33	MC-4	20,720	6,962	348	28,030	24,722	52,752
34	MC-5	32,560	10,940	547	44,047	38,849	82,896
35	MC-6	28,860	9,697	485	39,042	34,435	73,477
36	MC-6	24,420	8,205	410	33,035	29,137	62,172
37	MC-7	12,580	4,227	211	17,018	15,010	32,028
38	MC-7	16,280	5,470	274	22,024	19,425	41,449
Majes-Camana River Basin		198,370	66,501	3,325	268,196	236,549	504,745
Total		966,175	442,445	22,124	1,408,814	1,242,574	2,651,388

(Source: JICA Study Team)

(4) Implementation process planning

The Process Plan of afforestation works in riverbanks is part of the coastal structure, thus the same will be considered for the Construction Plan of the Coastal Structure. Afforestation works should generally start at the beginning of the rainy season or just before, and must end approximately one month before the season finishes. However, there is scarce rain in the coastal area; therefore there is no effect of dry and rainy seasons. For the sake of afforestation, it is most convenient is to take advantage of water rise, but according to the Construction Process Plan of the coastal structure there are no major afforestation issues in seasons where water level is low. The gravity irrigation system can be used to irrigate just planted plants during approximately the first 3 months until water level rises. This irrigation is performed using perforated horse which is a field technique actually carried out in Poechos dam area

4.3.2.2 Sediment Control Plan

(1) Importance of the Sediment Control Plan

Below flood control issues in selected Watersheds are listed. Some of them relate to sediment control. In the present Project an overall flood control plan covering both the high and the low Watershed is prepared. The study for the preparation of the Sediment Control Plan comprised the whole Watershed.

- Flood water overflows bank and inundates.
- Rivers have a steep slope of 1/30 to 1/300. The flow speed is high, as well as the sediment transport capacity.
- The accumulation of large quantities of sediment and the consequent elevation of the river bed aggravate flood damages.
- There is a great quantity of sediment accumulated on the river bed forming plural sandbar. The flow route and the flow collision point are unstable, causing route change and consequently, change of flow collision point.
- Riverside is highly erodible, causing a decrease of adjacent farming lands, destruction of regional roads, etc., for what they should be duly protected.
- Big stones and rocks cause damages and destruction of water intakes.

(2) Sediment Control Plan (structural measures)

The sediment control plan suitable for the present sediment movement pattern was analyzed. Table 4.3.2.2-1 details basic guidelines.

Table 4.3.2.2-1 Basic guidelines of the Sediment Control Plan

Conditions	Typical year	Precipitations with 50-year return period
Sediment transport impact	Bank erosion and river bed change	Bank erosion and river bed change Sediment flow from ravines
Measures	Erosion control → Bank protection Control of riverbed variation → compaction of ground, bands (compaction of ground in the alluvial cone, bands)	Erosion control → bank protection Riverbed variation control →compaction of ground, bands (compaction of ground in the alluvial cone, bands) Sediment flow → protection of slopes, sediment control dams

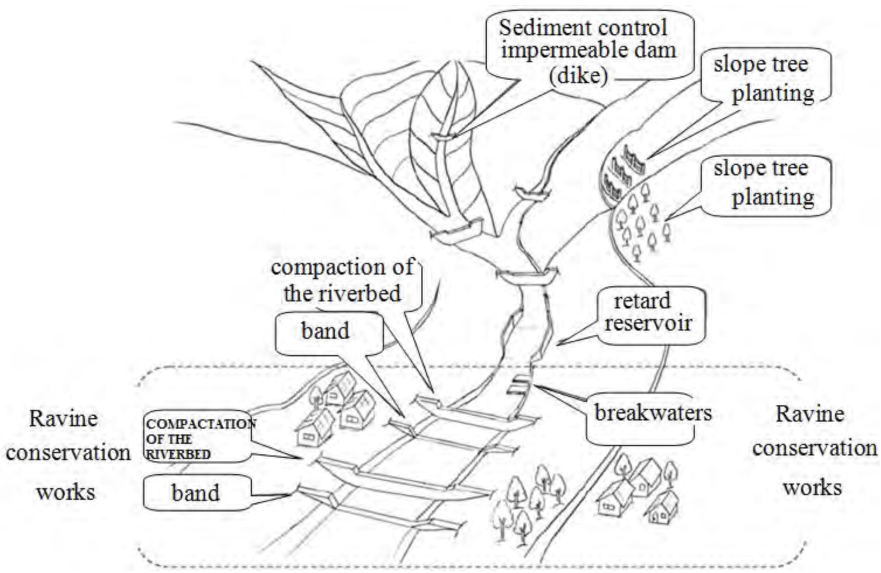


Figure 4.3.2.2-1 Sediment control works

1) Sediment control plan in the high Watershed

The later section 4.13 "Medium and long term Plan" 4.13.3 "Sediment Control Plan" details the sediment control plan covering the whole high Watershed. This plan will require an extremely long time with huge costs, what makes it quite not feasible. Therefore, it must be executed progressively within the medium and long term.

2) Sediment control plan in the low Watershed

We observed that building sediment control dams covering the whole Watershed will demand huge costs. Therefore, the same calculation was done but reducing its scope to just the lower Watershed of the river. In this process, analysis results on riverbed variation were taken into consideration, also included in the present study.

i) Bed variation analysis results

- Table 4.3.2.2-3 presents the analysis results of river bed variation. The average bed height has been increasing in all five rivers, except Chira, so basically it is concluded that this is the general trend. The total variation volume of the bed and sediment transport is augmenting in all three rivers (Majes-Camana, Chincha and Pisco) compared to Cañete and Yauca. As for the Rio Chira specifically, Poechos dam built upstream of the section is not currently filled, and most of the sediments produced upstream of the dike is retained here, so basically in the lower section of the dam, there was a trend of reduction in riverbed level.

- The most susceptible to the accumulation of sediment are Majes-Camana, Chincha and Pisco. This tendency coincides to the field hearing results and actual riverbed conditions.

- According to the results of the analysis of variation of the river bed, Chincha and Pisco rivers are more susceptible to the accumulation of sediments carried, so sediment control works must be done in their respective alluvial fan. It is worth mentioning that in Cañete River watershed the Platanal dam was built last year to retain sediment, so it is expected that the volume of sediment for the lower basin will be reduced drastically in the future.

- One of the reasons why the Majes-Camana river discharges a relatively large amount of sediment is in the vast watershed area compared with other rivers, and the great magnitude of floods, what makes this river to transport large amounts of sediment downstream. While the variation of the bed (volume of sediment) is great too, looking at the average height of the bed, only 0.2 meters has changed in 50 years, and is therefore considered that the entry of sediments won't affect much the river downstream. Therefore, it is considered that it is not necessary to take a special sediment control measure.

Table 4.3.2.2-3 River bed variation analysis result

Basin	Total income sediment volume (mil m^3)	Annual income sediment volume (mil m^3)	Total variation volume (mil m^3)	Average height variation of riverbed (m)	Remarks
Cañete	3000	60	673	0.2	
Chincha	5759	115	2610	0.5	Total Chico and Matagente
Pisco	8658	173	2571	0.2	
Yauca	1192	23.84	685	0,1	
Chira	5000	100	-1648	-0.01	On the assumption of zero sediment income to the river due to Poechos dam
Majes-Camaná	20956	419	5316	0.2	

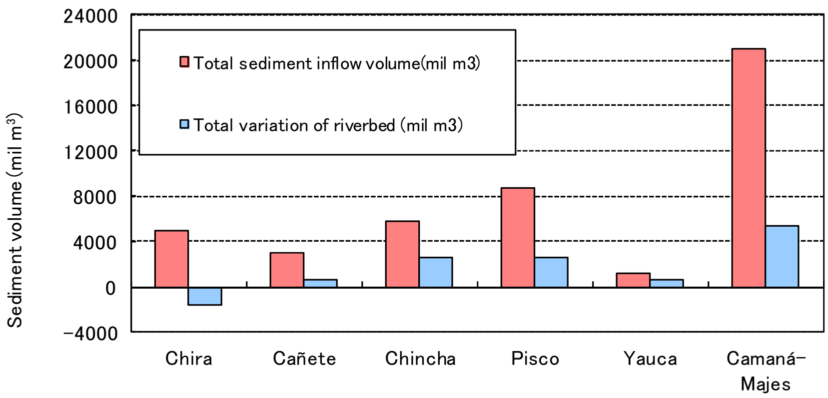


Figure 4.3.2.2-2 River bed variation analysis result (sediment volume)

ii) Sediment control plan in the alluvial fan

To control sediments within this fan there are ravine conservation works, combined with sand reservoirs, riverbed consolidation, groin or a combination of these. These do not only work for sediment control, but as river structures.

Currently there are plans to build a retardation reservoir at the point of 34.5 km from river mouth in the Pisco River watershed, which also serves as a sediment retarding basin.

It is also planned to build a diversion weir in Chincha River. This includes stabilizing of the flow and training longitudinal dyke which serve to control the sediments.

These structures are more economical and yield better cost benefit compared with structures designed to cover the entire watershed. It is much more profitable even when the cost of maintenance includes removal of stones and rocks.

Whereas the main objective of this project is in mitigating flood damage, the most effective option would be to control sediment in the alluvial fan.

It is already being planned to build river structures which also serve to control sediment in rivers Chincha and Pisco, and its implementation would be the most effective also for this project.

4.3.2.3 Early Alarm System

(1)Objectives

The objectives of this study on the early alarm system are the following:

- Precipitation stations, flow stations, data transfer system, early alert center, community Communications system
- Forecast of floods, flow, flood pattern, arrival time, etc on real timing based on monitoring and registering precipitations and flow
- Know hydrologic phenomenon in terms of location and time
- Emit forecasts and early alerts for flood risks to local communities
- Gather teams to evacuate the community and also for flood damage prevention
- Give entertainment and capability development for the early alarm center staff, on measures and responses to floods
- Training and education of the community in disaster prevention topics

(2) Rain and Flow Monitoring Stations

Currently in Chira-Piura watershed there are several observation stations of the Chira-Piura Special Project and SENAHMI, which have their proper operation conditions and that may be used in the early alarm system. Every Station of the Chira River is operating since 1972 or even before. The 7 flow monitoring stations and 8 meteorological stations that are part of this early alarm system are shown in Table 4.3.2.3-1 and 4.3.2.3-2 respectively. Also, on Figure 4.3.2.3-1 their location is shown.

These stations have been built after 1963 and also after 1972. The monitoring work is performed by experimented staff well trained in this field, due to which the data quality is good, precise and trustable. All information, including data of more than 30 years has been digitalized.

Table 4.3.2.3-1 Flow Monitoring Stations for Early Alert System

N°	STATION	PROV	DIST	SUB BASINS	Coordinates UTM		ALTITUDE	CATEGORY	INSTITUTION WHO WORKS
					N	E			
1	El Ciruelo	Ayabaca	Suyo	Chira	9524654	594327	202	Hg	PECHP
2	Ardilla	Sullana	Sullana	Chira	9503270	567048	106	Hg	PECHP
3	Pte.Internac.	Ayabaca	Suyo	Macará	9515414	616512	408	Hg	PECHP
4	Paraje Grande	Ayabaca	Paimas	Quiroz	9488151	620548	555	Hg	PECHP
5	Sapillica	Ayabaca	Sapillica	Chipillico	9471196	612750	1446	Hg	SENAMHI
6	Alamor	Sullana	Lancones	Chira	9505457	566997	125	Hg	PECHP
7	El Arenal	Paita	El Arenal	Chira	9459524	529062	62	Hg	PECHP

Table 4.3.2.3-2 Meteorological Observation Stations for Early Alert System

N°	ESTACION	PROV	DIST	SUB CUENCAS	Coordenadas UTM		ALTITUD	CATEGORIA	INSTITUCION QUE OPERA
					N	E			
1	Ayabaca	Ayabaca	Ayabaca	Quiroz	9487823	642699	2700	MAO	SENAMHI
2	Chilaco	Sullana	Sullana	Chira	9480963	554900	90	MAO	PECHP
3	El Ciruelo	Ayabaca	Suyo	Chira	9524654	594327	202	PV-PG	PECHP
4	Pte.Internac.	Ayabaca	Suyo	Macará	9515414	616512	408	PV-PG	PECHP
5	Paraje Grande	Ayabaca	Paimas	Quiroz	9488151	620548	555	PV	PECHP
6	Sapillica	Ayabaca	Sapillica	Chipillico	9471196	612750	1446	PV	SENAMHI
7	El Partidor	Piura	Las Lomas	Chipillico	9477296	580134	255	CO	SENAMHI
8	Alamor	Sullana	Lancones	Chira	9505457	566997	125	PV	SENAMHI

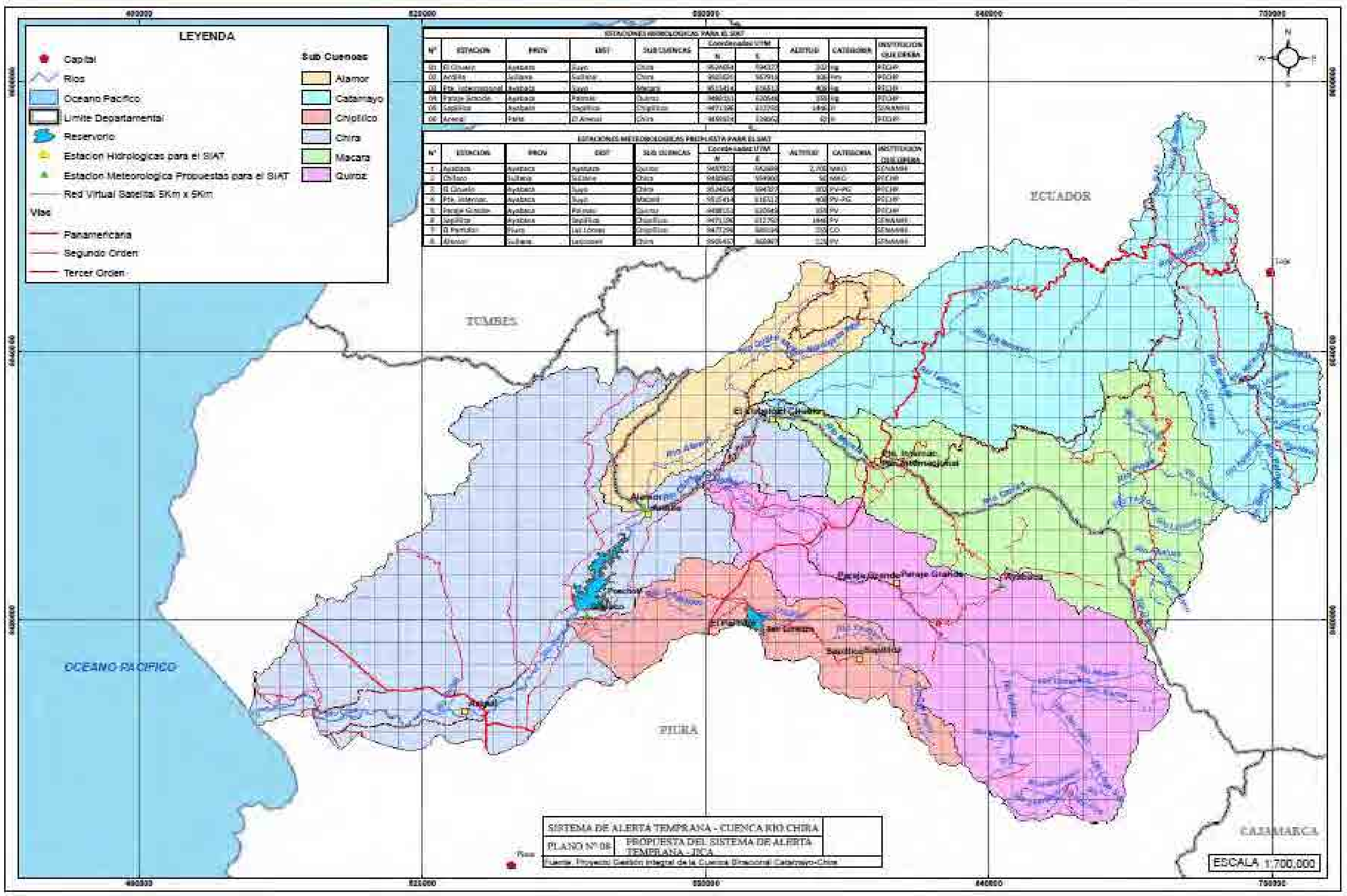


Figure 4.3.2.3-1 Location of the Early Alarm System

(3)Renewal of the monitoring equipment

1) Current conditions and renewal justification

The 7 discharge observation stations and 8 meteorological stations equipment that are part of the Chira River early alert system are operative. However, these are obsolete, and may present capacity o functioning (maintenance) trouble any moment. We are recommending the renewal of these equipments taking advantage of the new early alert system installation, in order to standardize the equipment and reinforce their capacity.

2) Type of equipment to be renewed

i) Flow monitoring stations

We are proposing the equipment renewal of the 7 flow monitoring stations, that include the following:

- Meteorological data sensors
- Water level sensors
- Digital storage system for the digital information transmission
- Satellite communication system
- Photovoltaic panels for energy storage
- Lightning rod
- Installation works and protective fences

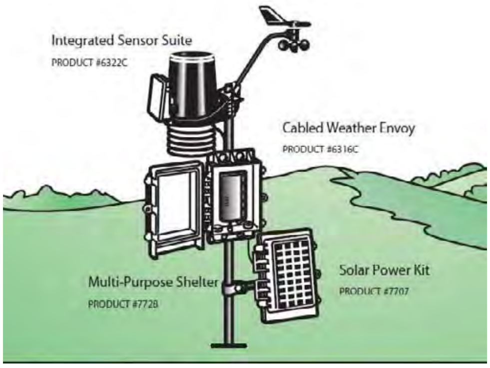
ii) Meteorological Stations

The following equipment for 8 meteorological stations is proposed to be renewal:

- Meteorological monitoring automatic equipment
- Data register

In Figure 4.3.2.3-2 some equipment are shown:

		
Water level sensor	Rain level sensor	Data register



Meteorological monitoring equipment

Figure 4.3.2.3-2 Some examples of monitoring equipment

(4) Data Transmission System

The early alert system must be operated in real time. So, for data transmission in real time the next procedures must be followed:

1) Register gathered data from automatic stations
2) Transmit registered and compiled data to the base station through satellite or telephone transmission
3) Transmit processed data of the base station to ministries and institutions throughout the early alert communication system

(5) Early Alert Center Creation

An early alert center is proposed to be created as base station, where all data gathered in the field will be received and precipitation and flow will be monitored to forecast floods flow, emitting alerts to the relevant institutions when necessary. The early alert center shall be located on a strategic point according to the other monitoring stations, for example, within the Chira-Piura Special Project Area, or in Poechos Dam site, or even in the Sullana dam Administration Office.

The early alert system of Piura River is being operated and maintained without any problem. Chira and Piura Rivers are near and are located in the same Piura region. So, from the organization and capacity point of view, it is positive to integrate the early alert system of Chira River with the Piura River so the Chira-Piura Special Project of the Regional Government takes control and operates both systems.

The base station will be equipped with data receptors, decoders, PC, information panel and other necessary equipment.

In Figure 4.3.2.3-3 the early alert system is shown

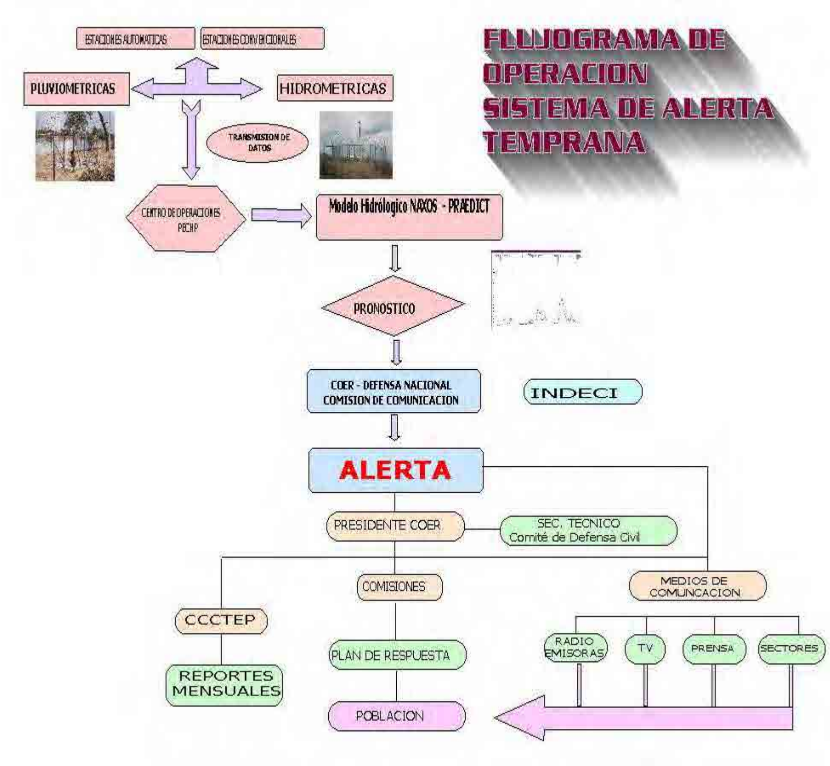


Figure 4.3.2.3-3 Early Alert System

(6) Software Provision for flood forecast

We are proposing to acquire the software to forecast maximum flow and floods pattern from precipitation and flow data (for example: NAXOS) and up-dating this on time.

(7) Transmission System Construction to Alert the Community

We are proposing to acquire the system and transmission equipment to alert local governments, private disaster prevention system and local community, parallel to the implementation of this Project.

(8)Training and capacity development of the early alert center staff

(9)Disaster prevention education and practical training for local community and local government staff

(10)Costs

In Table 4.3.2.3-3 the necessary cost to build the early alert system is shown. This is estimated in US$ 550.000.

Table 4.3.2.3-3 Alarm System Cost

Ite	Descriptio	Uni	Quantit	U	Partial	Subtot US
1	**Hydrometeorological**					
1.	Equipment					
	Hydrometric	Uni	7.0	10,000.0	70,000.0	
	Meteorological E. (New and	Uni	15.0	8,000.0	120,000.0	
1.	Installation					
	Hydrometric	Uni	7.0	13,000.0	91,000.0	
	Meteorological E	Uni	8.0	3,000.0	24,000.0	
2	**Data Transmission**					
	Transmission Equipment	Uni	7.0	7,000.0	49,000.0	
3	**Base**					
3.	Equipme	Glob	1.0	50,000.0	50,000.0	
3.	Local (Pry.					
4	**Hydrologic**					
4.	System Adaptation		1.0	20,000.0	20,000.0	
4.	Softwar		1.0	30,000.0	30,000.0	
4.	Adviser and	monthl	3.0	15,000.0	45,000.0	**499,000.0**
5	**Institutional**					
5.	Civil	Glob			2,500.0	
5.	Poechos operation	Glob			2,500.0	**5,000.0**
5.	**Maintenance (annual**					
5.	Hydrometeorological	monthl	2.0	1,000.0	2,000.0	
5.	Base	monthl	2.0	1,000.0	2,000.0	
5.	Satellite Connection (08	monthl	72.0	500.0	36,000.0	
5.	Technical Assistance (contingency	Glob			4,000.0	
5.	Prevention equipment and	Glob			2,000.0	**46,000.0**
	TOTAL					**550,000.0**

(11) Problems on installation of flood alert system

There are following problems on the installation of flood alert system:

1) Questionable points in the installation of flood alert system

a) The area expected to be inundated is almost farmland and scarcely urban area for which urgent evacuation is required.

b) Since the Poechos dam is located at the upstream end of the study area, and inflow to the reservoir is observed, the forecasting of flood occurrence and increase of flood discharge can be estimated with accuracy to same extent.

c) The flood alert system in Chira river has slightly meanings as model case since the sysytem in Piura river adjacent to Chira river is already mobilized.

d) The flood prevention project for Chira river is to be excluded due to its low economic viability. The flood alert system with small scale cost is not always implemented by Japanese Yen Loan but also can be done by the budget from the provincial government based on thestudy results by JICA Study Team.

e) The observation stations included in the system are under mobilization at present and data has been collected, however the conditions of observation equipment could not be collected, therefore the necessity of their renewal is unknown. If the renewal of equipment is not required, 64% of cost(2,640,000soles) is not necessary.

（12）Conclusion

In the meeting held on December 5,2011 among JICA Peru office, DGIH, OPI, DGPM and JICA Study Team, it was concluded that the flood alert system is exclude from Project, and if necessary, Piura provincial government will implement it（Minutes of Meetings on Main Points of Interim Report, Lima, December 5, 2011）.

4.3.3 Technical Assistance

Based on the proposals on flood control measures, a component on technical assistance is proposed in order to strengthen risk management capabilities in the Program.

(1) Component objective

The component objective in the Program is the "Adequate capability of local population and professionals in risk management application to reduce flood damages in Watersheds".

(2) Target area

The target area for the implementation of the present component are the six watersheds: Chira, Cañete, Chincha, Pisco, Yauca and Majes-Camana.

In the execution stage, the implementation has to be coordinated with local authorities in the five Watersheds. However, each authority has to execute those activities related with the characteristics of each Watershed to carry out an adequate implementation.

(3) Target population

Target populations will represent irrigator associations and other community groups, provincial, district and local community governments in the Chira River Watershed, considering the limited capacity to receive beneficiaries of this component.

Participants are those with skills to widespread technical assistance contents of local populations in the five Watersheds.

Besides, the participation of women has to be considered because currently only few ones participate in technical assistance opportunities.

(4) Activities

Component 1: Knowledge on River Bank Protection Actions in consideration of Agriculture and Natural Enviornment

Course	a) River Bank Operation and Maintenance b) River Bank Plant Management c) Erosion Prevention and Mitigation Natural Resource Management
Objectives	a) In this project, local populations learn suitable technology to operate and give maintenance to constructions and works from prior projects. b) Local populations learn suitable technology on river bank plants and vegetation for flooding control purposes. c) Local populations learn suitable technology on erosion and natural resources for flooding control purposes.
Participants	a) Engineers and / or technicians from local Governments b-c) Engineers and / or technicians from local Governments and Water Users Associations, Community representatives
Times	a) 12 times in all (every six (6) hours)

	b) 12 times in all (every five (5) hours) c) 26 times in all (every three (3) hours)
Lecturers	a) Contractors of constructions and works, Engineers from MINAG and / or the Regional Government b-c) Engineers from MINAG and / or the Regional Government, College professors (From universities, institutes, NGOs, etc.)
Contents	a-1) Suitable operation and maintenance technology for constructions and works from prior projects a-2) Suitable operation and maintenance technology for constructions and works in this project b-1) River bank protection with the use of plants b-2) The importance of river bank vegetation in flooding control b-3) Types of river bank plants and their characteristics c-1) Evaluation of the erosion conditions c-2) Evaluation of natural resource conditions c-3) Erosion approach for flooding control c-4) Natural resource approach for flooding control c-5) Environmental consideration approach c-6) Use of water resourceS c-7) Alternatives for suitable farming crops

Component 2: Preparation of Commnity Disaster Management Plan for Flood Control

Course	a) Risk management Plan Formulation b) Detailed Risk management Plan Formulation
Objectives	a) Local populations gain knowledge and learn technology to prepare a flooding control plan b) Ditto
Participants	a-c) Engineers and / or technicians from local Governments and Water Users Associations, Community representatives
Times	a) 19 times in all (every four (4) hours) b) 34 times in all (every five (5) hours) c) 24 times in all (every five (5) hours)
Lecturers	a-c) Engineers from MINAG and / or the Regional Government, Community Development Expert, Facilitator (local participation)
Contents	a-1) Flooding control plan preparation manuals a-2) Current condition analyses for flooding control a-3) Community development alternatives by means of local participation a-4) Workshop for flooding control plan preparation b-1) Communy activity planning in consideartion of ecological zoning b-2) Risk management b-3) Resource management c-1) Preparation of community disaster management plan c-2) Joint activity with local governments, users' association, etc.

Component 3: Basin Management for Anti – River Sedimentation Measures

Courses	a) Hillside Conservation Techniques b) Forest Seedling Production c) Forest Seedling Planting d) Forest Resource Management and Conservation
Objectives	a) Local populations learn suitable technology on hillside conservation for flooding control purposes b) Local populations learn suitable technology on forest seedling production c) Local populations learn suitable technology on forest seedling planting d) Local populations learn suitable technology on forest resource management and conservation
Participants	a-d) Engineers and / or technicians from local Governments and Water Users Associations,

	Community representatives and Local People
Times	a) 12 times in all (every five (5) hours) b-d) 40 times in all for three (3) "Courses on Basin Management for Anti - River Sedimentation Measures" (every five (5) hours)
Lecturers	a-d) Engineers from MINAG and / or the Regional Government, College professors (From universities, institutes, NGOs, etc.)
Contents	a-1) Soil characteristics and conservation on hillsides a-2) Hillside agroforestry system a-3) Animal herding system on hillsides a-4) Reforestation with traditional vegetation and plants a-5) Hillside conservation and alleviation alternatives b-1) A selection of plants that are suitable to the local characteristics b-2) Forest seedling production technology b-3) Control carried out by the local population's involvement c-1) Candidate areas for forestation c-2) Forest plantation control technology c-3) Forest plantation soil technology c-4) Control carried out by the local population's involvement d-1) Forestation for flooding control purposes d-2) Forest plantation control technology d-3) Forest plantation output technology d-4) Control carried out by the local population's involvement

Component 4: Information Networks on Flooding Risk management

Courses	a) Risk management and Forecasting and Warning Usefulness b) Workshop – Meeting with Local Authorities
Objectives	a) Local populations learn suitable technology on risk management and forecasting and warning usefulness. b) Cooperation preparedness between local Governments, Water Users Associations, communities, and local populations for flooding control purposes.
Participants	a-b) Engineers and / or technicians from local Governments and Water Users Associations, Community representatives
Times	a) 12 times in all (every five (5) hours b) 12 times in all (every five (5) hours
Lectures	a-b) Engineers from MINAG and / or the Regional Government, Forecasting and warning usefulness contractors and College professors (From universities, institutes, NGOs, etc.)
Contents	a-1) Disaster risk conditions and forecasting and warning usefulness a-2) Comprehensive risk management technology for flooding control a-3) Forecasting and warning usefulness technology a-4) Forecasting and warning usefulness control carried out by the local population's involvement b-1) Setting up an information network for Disaster risk conditions and forecasting and warning usefulness b-2) Local cooperation set up for forecasting and warning usefulness b-3) Preparation of a disaster risk plan that includes Forecasting and warning usefulness

(5) Costs and period of time

Costs of activities are detailed in the following Table. The total amount is S./ 831.125 Nuevo Soles.

The period is of approximately two years although the processes on structural and non-structural measures for flood prevention have to be considered in the program.

Table 4.3.3-1 Activity plan to improve flood prevention capacities

Item	Activities Alternative 1	Measure ment Unit	No. of Valleys	TOTAL	Year 1st.	Year 2nd.
1.00	**Knowledge on River Bank Protection Actions in consideration of Agriculture and Natural Enviornment**					
1.1.	Workshop on Works Operation and Maintenance	Event	6	55,800	27900	27900
1.2.	Workshop on River Bank Plant Management	Event	6	55,800	27900	27900
	Prevention and Mitigation for Erosion	Event	6	55,800	27900	27900
	Natural Resources Management	Event	6	55,800	27900	27900
2.00	**Preparation of Commnity Disaster Management Plan for Flood Control**					
2.1	Workshop on Risk Management Plan	Event	6	50,220	25110	25110
2.2	(in detail)					
	Communy activity planning in consideartion of ecological zoning	Event	6	73,200	36600	36600
	Risk management	Event	6	73,200	36600	36600
	Resource management	Event	6	73,200	36600	36600
	Preparation of community disaster management plan	Event	6	73,200	36600	36600
2.3	Risk management and Early warning system	Event	6	55,800	27900	27900
	Joint activity with local governments, users ' association, etc.	Event	6	33,480	16740	16740
3.00	**Hillside Management for River silting up Prevention**					
3.1	Field works for hillside conservation technique	Event	6	45,000	22500	22500
	Forest seedling productions	Event	6	47,400	23700	23700
	Fores plantation setting up	Event	6	47,400	23700	23700
	Forest reource management and conservation	Event	6	47,400	23700	23700
3.2	Difusion of posters and leaflets		6	21,600	10800	10800
4.00	**Risk Management Information and Instruments**					
4.1	Workshop on risk management and forecasting & warning system	Event	1	9,300	4650	4650
4.2	Workshop with local authorities	Event	1	5,580	2790	2790
	TOTAL			**879,180**	**439,590**	**439,590**

(6) Implementation Plan

The Hydraulic Infrastructure General Direction (DGIH-MINAG) executes this component as the executing unity in cooperation with the Agriculture Regional Direction (DRA), the Board of Users and related Institutions. In order to execute the activities efficiently the following has to be considered:

- For the implementation of the present component, the DGIH-MINAG will coordinate actions with the Central Management Unit responsible for each Watershed, as well as with Regional Managements of Agriculture (DRA).
- For the Project administration and management, the DGIH-MINAG will coordinate actions with PSI-MINAG (Sub-sector Irrigation Program with extensive experience in similar projects).
- Considering there are some local governments that have initiated the preparation of a similar crisis management plan through the corresponding civil defense committee, under the advice of the National Institute of Civil Defense (INDECI) and local governments, the DGIH-MINAG must coordinate so that these plans be consistent with those existing in each Watershed.

- Training courses will be managed and administered by irrigator associations (particularly the unit of skills development and communications) with the support of local governments in each Watershed, to support timely development in each town.
- Experts in disaster management departments in each provincial government, ANA, AGRORURAL, INDECI, etc., as well as (international and local) consultants will be in charge of course instruction and facilitation.

4.4 Costs

4.4.1 Cost Estimate (at private prices)

(1) Project Costs Components

Project costs include the following:

① Work direct costs = total quantity of works by type × unit price
② Common provisional works = ① x 10%
③ Construction cost -1 = ① + ②
④ Miscellaneous = ③ x 15%
⑤ Benefits = ③ x 10%
⑥ Construction cost -2 = ③+④+⑤
⑦ Tax = ⑥ x 18% (IGV)
⑧ Construction cost = ⑥+⑦
⑨ Environmental measures cost = ⑧ x 1%
⑩ Detailed design cost = ⑧ x 5%
⑪ Construction supervision cost = ⑧ x 10%

Project Cost = ⑧+⑨+⑩+⑪

(2) Work direct costs

On Table 4.4.1-1 a summary Table of direct costs for structural measures is presented for all Watersheds. Structural measure Chira -5 consists in bank protection to protect irrigation channels. In the most recent field study it was seen that Chira-6 work execution implies change of the river course along the Chira-5 work, converging the current course downstream the bank protection proposed for Chira-5. So, this last was decided to be discharged because it was unnecessary. Chira-6 has been excluded in the present Project because a similar project has been initiated by the Regional Government of Piura.

(3) Project Costs

The project cost is estimated in 323.4 million of soles as shown in Table 4.4.1-2. It includes reforestation and vegetation recovery costs, construction of early warning system and technical assistance. The annual operation and maintenance cost of completed works is approximately 0.5% of the project’s cost.

Table 4.4.1-1 Summary Table of the work's direct cost (at private prices)

WATERSHED 流域名	CRITICAL POINTS クリティカル・ポイント		MEASURES 対策		DIRECT COST 直接工事費計 (1)
Rio Chira	1	0.0K～4.0K	Coastal defense	築堤・護岸工	8,442,000
	2	11.75K～12.75K	Coastal defense	築堤・護岸工	15,480,000
	3	24.5K～27.0k	Coastal defense	築堤・護岸工	6,075,000
	4	64K～68K	Flow desilting	河床掘削	2,400,000
	5	97.5K～98.5K	Coastal defense	築堤・護岸工	0
	6	99K	Coastal defense + Desilting	築堤・護岸工・河床掘削	0
				SUB TOTAL	32,397,000

Watershed 流域名	Critical Points クリティカル・ポイント		Measures	対策	Direct Cost 直接工事費計 (1)
Rio Cañete	1	4.0K～5.0K	Flow desilting	河床掘削	2,250,000
	2	6.5K～8.1K	Dike building + coastal defense	築堤・護岸工	2,786,000
	3	10.0K～11.0K	Flow desilting	築堤・護岸工・河床掘削	2,656,000
	4	24.25K～24.75K	intake channel wall + desilting	導流壁・河床掘削・築堤・護岸工	2,822,000
	5	24.75K～26.5K	Coastal defense	築堤・護岸工	2,985,000
				SUB TOTAL	13,499,000

Watershed 流域名	Critical Points クリティカル・ポイント		Measures	対策	Direct Cost 直接工事費計 (1)
Chincha	1	C-3.5～5.0k	Dike building + coastal defense	築堤・護岸工	5,134,000
	2	C-15K	Flow desilting	築堤・護岸工	3,366,000
	3	C-24K	Distributor+Floor Consolidation	分流堰・床止工	8,510,800
	4	M-3.0K～4.5K	Dike building + coastal defense	築堤・護岸工	5,134,000
	5	M-8.9K	Flow desilting	河床掘削・護岸工	1,030,000
				SUB TOTAL	23,174,800

Watershed 流域名	Critical Points クリティカル・ポイント		Measures	対策	Direct Cost 直接工事費計 (1)
Rio Pisco ピスコ川	1	5.5K	Dike building + coastal defense	築堤・護岸工	5,240,000
	2	7.0K	Flow desilting	河床掘削	2,700,000
	3	13.5K	Dike building + coastal defense	築堤・護岸工	5,486,000
	4	20.5K	Dike building + coastal defense	築堤・護岸工	1,965,000
	5	26.5K	Fluvial flow widening	河道拡幅	9,530,800
	6	34.5K	Retention Reservoir	遊水地	12,163,000
				SUB TOTAL	37,084,800

Watershed 流域名	Critical Points クリティカル・ポイント		Measures	対策	Direct Cost 直接工事費計 (1)
Rio Yauca	1	4.5K	Dike building + coastal defense	築堤・護岸工	321,000
	2	4.1K	Flow desilting	河床掘削	350,000
	3	4.5K～7.0K	Dike building + coastal defense	築堤・護岸工	6,995,000
	4	25.0K	Intake Rehabilitation	取水堰の修復（分流堰）	900,000
	5	25.0K	Coastal defense	護岸工	1,393,000
	6	41.1K	Coastal defense	護岸工	995,000
				SUB TOTAL	10,954,000

WATERSHED 流域名	CRITICAL POINTS クリティカル・ポイント		MEASURES 対策		DIRECT COST 直接工事費計 (1)
Rio Majes-Camaná	1	0.0K～4.5K	Dike building + coastal defense (LM)	築堤・護岸工(左岸)	10,504,491
	2	7.5K～9.5K	Dike building + coastal defense (LM)	築堤・護岸工(左岸)	3,435,369
	3	11.0K～17.0K	Dike building + coastal defense (LM)	築堤・護岸工(左岸)	12,992,759
	4	48.5K～50.5K	Dike building + coastal defense (LM)	築堤・護岸工(左岸)	3,347,558
	5	52.0K～56.0K	Dike building + coastal defense (LM)	築堤・護岸工(左岸)	8,964,815
	6	59.0K～62.5K	Dike building + coastal defense (LM+RM)	築堤・護岸工(右岸・左岸)	8,008,891
	7	65.0K～66.5K	Dike building + coastal defense (LM+RM)	築堤・護岸工(右岸・左岸)	4,042,225
				TOTAL	51,296,107

Table 4.4.1-2 Construction cost at private prices

(soles)

Watershed	STRUCTURAL MEASURES												NON STRUCTURAL MEASURES 非構造物対策		TECHNICAL ASSISTANCE 能力開発	TOTAL COST OF THE PROGRAM 全体事業費
	DirectCost (直接工事費)			INDIRECT COST (間接工事費)												
流域名	Direct Cost 直接工事費計 (1)	Temporary works cost 共通仮設費 (2) = 0.1 x (1)	Works Cost 工事費 (3) = (1) + (2)	Operative Expenses 諸経費 (4) = 0.15 x (3)	Utility 利益 (5) = 0.1 x (3)	Total Cost of Infrastructure 構造物工事費 (6) = (3)+(4)+(5)	TAX 税金 (7) = 0.18 x (6)	Total work cost 建設費 (8) = (6)+(7)	Environmental Impact 環境影響 (9)=0.01 x (8)	Technical File 詳細設計 (10) = 0.05 x (8)	Supervision 施工管理費 (11) = 0.1 x (8)	HYDRAULIC INFRASTRUCTURE Total Cost 構造物・事業費 (12) = (8)+(9)+(10)+(11)	REFORESTATION Total Cost 植林・植生回復 事業費 (13)	EARLY ALERT SYSTEM Total Cost 洪水予警報 事業費 (14)	TRAINING Total Cost 防災教育 事業費 (15)	
CHIRA	32,397,000	3,239,700	35,636,700	5,345,505	3,563,670	44,545,875	8,018,258	52,564,133	525,641	2,628,207	5,256,413	60,974,394	101,892	2,640,213	314,273	64,030,772
CAÑETE	13,499,000	1,349,900	14,848,900	2,227,335	1,484,890	18,561,125	3,341,003	21,902,128	219,021	1,095,106	2,190,213	25,406,468	40,397	0	219,105	25,665,970
CHINCHA	23,174,800	2,317,480	25,492,280	3,823,842	2,549,228	31,865,350	5,735,763	37,601,113	376,011	1,880,056	3,760,111	43,617,291	128,678	0	219,105	43,965,072
PISCO	37,064,800	3,706,480	40,753,280	6,116,992	4,075,328	50,995,600	9,178,488	60,170,088	601,701	3,008,504	6,017,009	69,797,302	1,592,339	0	219,105	71,608,946
YAUCA	10,954,000	1,095,400	12,049,400	1,807,410	1,204,940	15,061,750	2,711,115	17,772,865	177,729	888,643	1,777,287	20,616,523	84,134	0	219,105	20,919,762
MAJES-CAMANA	51,296,107	5,129,611	56,425,718	8,463,858	5,642,572	70,532,147	12,695,786	83,227,934	832,279	4,161,397	8,322,793	96,544,403	450,569	0	219,105	97,214,077
TOTAL	168,403,707	16,840,371	185,248,278	27,786,942	18,524,828	231,557,847	41,680,412	273,238,260	2,732,383	13,661,913	27,323,826	316,956,381	2,378,208	2,640,213	1,409,716	323,384,598

Table 4.4.2-2 Construction cost at social prices

(soles)

Watershed	STRUCTURAL MEASURES												NON STRUCTURAL MEASURES 非構造物対策		TECHNICAL ASSISTANCE 能力開発	TOTAL COST OF THE PROGRAM 全体事業費
	DirectCost (直接工事費)			INDIRECT COST (間接工事費)												
流域名	Direct Cost 直接工事費計 (1)	Temporary works cost 共通仮設費 (2) = 0.1 x (1)	Works Cost 工事費 (3) = (1) + (2)	Operative Expenses 諸経費 (4) = 0.15 x (3)	Utility 利益 (5) = 0.1 x (3)	Total Cost of Infrastructure 構造物工事費 (6) = (3)+(4)+(5)	TAX 税金 (7) = 0.18 x (6)	Total work cost 建設費 (8) = (6)+(7)	Environmental Impact 環境影響 (9)=0.01 x (8)	Technical File 詳細設計 (10) = 0.05 x (8)	Supervision 施工管理費 (11) = 0.1 x (8)	HYDRAULIC INFRASTRUCTURE Total Cost 構造物・事業費 (12) = (8)+(9)+(10)+(11)	REFORESTATION Total Cost 植林・植生回復 事業費 (13)	EARLY ALERT SYSTEM Total Cost 洪水予警報 事業費 (14)	TRAINING Total Cost 防災教育 事業費 (15)	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2,343,438	[illegible]	[illegible]
CAÑETE	10,853,198	1,085,320	11,938,518	1,790,777	1,193,852	14,923,145	2,686,166	17,609,311	176,093	880,466	1,760,931	20,426,800	31,517	0	189,759	20,648,077
CHINCHA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible]	[illegible]
PISCO	29,816,179	2,981,618	32,797,797	4,919,670	3,279,780	40,997,246	7,379,504	48,376,751	483,768	2,418,838	4,837,675	56,117,031	1,257,601	0	189,759	57,564,391
YAUCA	8,807,016	880,702	9,687,718	1,453,158	968,772	12,109,647	2,179,736	14,289,383	142,894	714,469	1,428,938	16,575,685	50,751	0	189,759	16,816,195
MAJES-CAMANA	42,641,292	4,264,129	46,905,421	7,035,813	4,690,542	58,631,776	10,553,720	69,185,496	691,855	3,459,275	6,918,550	80,255,175	374,619	0	189,759	80,819,553
TOTAL	136,797,410	13,679,741	150,477,151	22,571,573	15,047,715	188,096,439	33,857,359	221,953,798	2,219,538	11,097,690	22,195,380	257,466,405	1,857,965	2,343,438	1,221,302	262,929,110

4.4.2 Cost Estimate (at social prices)

(1) Work direct costs

In Table 4.4.2-1 a summary Table of direct costs for structural measures is presented for the all watersheds. The works' direct cost at private prices was turned into social prices applying the conversion factor.

(2) Project Costs

The project cost is estimated in 262.9 million of soles as shown in the previous Table 4.4.2-2. It includes reforestation and vegetation recovery costs, construction of early warning system and technical assistance, before converting from private prices.

Table 4.4.2-1 Summary Table of the work's direct cost (at social prices)

Watershed 流域名	Critical Points クリティカル・ポイント		Measures 対策		Private Prices 民間価格 (PP)	Correction Factor 係数 (%)	Social Price 社会価格 (PS)=(%)×(PP)
Rio Chira	1	3.0K~4.0K	Coastal Defense	河床掘削	8,442,000	0.804	6,787,368
	2	11.75~12.75K	Coastal Defense	築堤・護岸工	15,480,000	0.804	12,445,920
	3	24.5K~27.0K	Coastal Defense	築堤・護岸工・河床掘削	6,075,000	0.804	4,884,300
	4	64K~65K	Flow desilting	導流堤・河床掘削・築堤・護岸工	2,400,000	0.804	1,929,600
	5	97.5K~98.5K	Coastal Defense	築堤・護岸工	0	0.804	0
	6	99K	1st Defense+Desilting		0	0.804	0
				SUB TOTAL	32,397,000		26,047,188
Watershed 流域名	Critical Points クリティカル・ポイント		Measures 対策		Private Prices 民間価格 (PP)	Correction Factor 係数 (%)	Social Price 社会価格 (PS)=(%)×(PP)
Rio Cañete	1	4.5K~5.0K	Flow desilting	河床掘削	2,250,000	0.804	1,809,000
	2	5.5K~6.1K	Dike building+coastal defense	築堤・護岸工	2,788,000	0.804	2,238,944
	3	10.0K~11.0K	Flow desilting	築堤・護岸工・河床掘削	2,656,000	0.804	2,135,424
	4	24.25K~24.75K	Intake channel wall + desilting	導流堤・河床掘削・築堤・護岸工	2,892,000	0.804	3,286,888
	5	24.75K~26.5K	Coastal Defense	築堤・護岸工	2,855,000	0.804	2,298,940
				SUB TOTAL	13,499,000		10,853,196
Watershed 流域名	Critical Points クリティカル・ポイント		Measures 対策		Private Prices 民間価格 (PP)	Correction Factor 係数 (%)	Social Price 社会価格 (PS)=(%)×(PP)
Chincha	1	0-3.5~5.0k	Dike building+coastal defense	築堤・護岸工	5,134,000	0.804	4,127,736
	2	0~1.6K	Flow desilting	築堤・護岸工	3,366,000	0.804	2,706,264
	3	C~2.4K	Distribution + Floor consolidation	分流堤・床止工	8,510,800	0.804	6,842,683
	4	M-3.0K~4.5K	Dike building+coastal defense	築堤・護岸工	5,134,000	0.804	4,127,736
	5	M-6.5K	Flow desilting	河床掘削・護岸工	1,030,000	0.804	828,120
				合計	23,174,800		18,632,539
Watershed 流域名	Critical Points クリティカル・ポイント		Measures 対策		Private Prices 民間価格 (PP)	Correction Factor 係数 (%)	Social Price 社会価格 (PS)=(%)×(PP)
Rio Pisco ピスコ川	1	3.5K	Dike building+coastal defense	築堤・護岸工	5,240,000	0.804	4,212,960
	2	7.0K	Flow desilting	河床掘削	2,700,000	0.804	2,170,800
	3	13.5K	Dike building+coastal defense	築堤・護岸工	5,486,000	0.804	4,410,744
	4	20.5K	Dike building+coastal defense	築堤・護岸工	1,965,000	0.804	1,579,860
	5	28.5K	Fluvial flow widening	河道拡幅	9,530,800	0.804	7,662,763
	6	34.5K	Retention reservoir	遊水池	12,163,000	0.804	9,779,052
				SUB TOTAL	37,084,800		29,816,179
Watershed 流域名	Critical Points クリティカル・ポイント		Measures 対策		Private Prices 民間価格 (PP)	Correction Factor 係数 (%)	Social Price 社会価格 (PS)=(%)×(PP)
Rio Yauca	1	4.5K	Dike building+coastal defense	築堤・護岸工	321,000	0.804	258,084
	2	4.1K	Flow desilting	河床掘削	350,000	0.804	281,400
	3	4.5K~7.0K	Dike building+coastal defense	築堤・護岸工	6,995,000	0.804	5,623,980
	4	26.0K	Intake Rehabilitation	取水堰の移設（分流堤）	900,000	0.804	723,600
	5	28.0K	Coastal defense	護岸工	1,393,000	0.804	1,119,972
	6	41.1K	Coastal defense	護岸工	995,000	0.804	799,980
				SUB TOTAL	10,954,000		8,807,016

VALLEY	CRITICAL POINTS		MEASURES	Direct Cost (Private Prices) S/.	CORRECTION FACTOR	DIRECT COST (Social Price)
Camana - Majes	1	0+000 - 4+500	Coastal defense Left Margin	10,504,490.59	0.831	8,729,998.45
	2	7+500 - 9+500	Coastal defense Left Margin	3,435,368.74	0.832	2,858,247.91
	3	11+000 - 17+000	Coastal defense Left Margin	12,992,758.90	0.831	10,799,732.18
	4	48+500 - 50+500	Coastal defense Left Margin	3,347,557.80	0.832	2,785,417.33
	5	52+000 - 56+000	Coastal defense Left Margin	8,964,815.10	0.831	7,451,803.13
	6	59+000 - 62+500	Coastal defense left and right margin	8,008,890.57	0.831	6,654,949.17
	7	65+000 - 66+500	Coastal defense left and right margin	4,042,225.31	0.832	3,361,143.33
			TOTAL	**51,296,107.01**		**42,641,291.50**
			TOTAL	**168,405,707**		**138,797,410**

4.5 Social Assessment

4.5.1 Private prices costs

(1) Benefits

Flood control benefits are flood loss reduction that would be achieved by the implementation of the Project and is determined by the difference between the amount of loss with and without Project. Specifically, in order to determine the benefits that will be achieved by the works' construction. First, the flood amount per flood loss of the different return periods (between 2 to 50 years) is calculated; assuming that the flood control works have a useful life of 50 years. To finish, determine the annual average amount of the loss reduction from the loss amount of different return periods. [The Methodological Guideline for Protection and/or Flood Control Projects in agricultural or urban areas, 4.1.2p-105)] establishes similar procedures.

Above find the description of the procedures to determine concrete benefits

①Determine the flood loss amount in the flood area by analyzing the magnitude of overflow that occurs without the Project for each return period (between 2 and 50 years)

②After, determine the amount of flood loss in the flood area by analyzing the magnitude of overflow that occurs when flood control priority works are built.

③Determine the difference between ① and ②. Add the benefits of other works different than dikes (intakes, roads and dams protection, etc.) in order to determine the total profits

"Benefits of the Project" are considered as the sum of direct loss amount caused by overflow and indirect loss caused by the destruction of structures in vulnerable sections (farmland loss, interruption of traffic, etc.)

1) Method of loss amount calculation

In this study, the amount of loss from direct and indirect damages to the variables listed in Table 4.5.1-1 was determined.

Table 4.5.1-1 Flood loss amount calculation variables

Loss	Variables	Description
(1) Direct	① Crops	・ Crops in flooding season The amount of crop loss by flooding is determined by multiplying the damage % regarding water depth and the number of days flooded ・ Agricultural land and infrastructure (channels, etc.) ・ Crop loss amount is determined by multiplying the damage % regarding water depth and the number of days flooded
	② Hydraulic Works	・ Loss amount due to hydraulic structures destruction (intakes, channels, etc.).
	③ Road Infrastructures	・ Flood damage related to road infrastructure is determined by the damage in transport sector
	④ Housing	・Residential and industrial buildings It is calculated applying the loss coefficient depending on the flood depth Housing: residential and industrial buildings; household goods: furniture, household appliances, clothing, vehicles, etc. Flood damages in housing, commercial buildings, assets and inventories (buildings and assets) is determined applying the loss coefficient according to the flood depth
	⑤ Public Infrastructures	・ Determine the loss amount in roads, bridges, sewers, urban infrastructures, schools, churches and other public facilities ・ Determine the loss amount in public works by applying the correspondent coefficient to the general assets loss amount
	⑥ Public Services	・ Electricity, gas, water, rail, telephone, etc.
(2) Indirect	① Agriculture	・ Estimate the loss caused by irrigation water interruption due to the damage of hydraulic structures ・ Determine the construction and repair costs of hydraulic structures such as direct year costs
	② Traffic Interruption	・ Estimate the loss lead by traffic interruption due to damages on flooded roads ・ Determine road’s repair and construction costs as damage direct cost

A. Direct loss

Direct loss is determined by multiplying the damage coefficient according to the inundation depth as the asset value.

B. Indirect Loss

Indirect loss is determined taking into account the impact of intakes and damaged roads. Below, calculation procedures are described.

a. Intake damage

The loss amount due to intake damage is calculated by adding the direct loss (intake’s rehabilitation and construction) and the indirect loss amount (harvest loss due to the interruption of irrigation water supply)

① Calculating the infrastructure cost

Works Cost = construction cost per water unit taken × size (flow, work length)

Unit cost of the work: for intakes and channels, it is required to gather information on the water intake volume of the existing work and the works' execution cost (construction or repair). The unit cost is calculated by analyzing the correlation among them both.

It was estimated that the work will be completely destroyed by the flow with a return period of 10 years.

② Crop loss

Annual earnings are determined according to the crops grown in the correspondent irrigation district.

Annual Profit = (crops selling - cost) × frequency of annual harvest

Crop Sale = planted area (ha) x yield (kg/ha) × transaction unit price

Cost = unit cost (s/ha) × planted area (ha)

b. Road infrastructure damage

Determine the loss due to traffic interruption.

Amount of loss = direct loss + indirect loss

Direct loss: road construction cost (construction, rehabilitation)

Indirect Loss: opportunity loss cost due to road damage (vehicle depreciation + staff expenses loss)

Then, a 5 days period takes place of non-trafficability (usually in Peru it takes five days to complete the rehabilitation of a temporary road)

2) Loss estimated amount according to different return periods

In Table 4.5.1-2 the amounts of loss estimated for disasters of different return periods with or without Project, for the 6 Watersheds is shown.

Table 4.5.1-2 Loss Estimated Value (at private prices)

CASE ケース	t	PRIVATE PRICES / 民間価格					
		Chira	Cañete	Chincha	Pisco	Yauca	Majes-Camana
WITHOUT PROJECT 事業を実施しない場合	2	0	1,660	14,576	15,788	0	0
	5	349,698	6,068	36,902	22,310	0	47,669
	10	427,001	73,407	51,612	47,479	1,695	76,278
	25	485,714	98,357	72,416	56,749	2,569	111,113
	50	562,385	149,018	96,886	76,992	11,497	190,662
	Total	1,824,797	328,510	272,392	219,318	15,761	425,722
WITH PROJECT 事業を実施した場合	2	0	153	423	197	0	0
	5	333,585	832	2,731	270	0	10,021
	10	411,472	8,413	3,904	2,556	7	21,316
	25	471,293	11,776	13,140	6,019	1,005	34,254
	50	525,002	16,428	28,112	8,318	2,028	63,532
	Total	1,741,353	37,602	48,311	17,360	3,040	129,123

3) Loss amount (annual average) expected to be reduced by the Project

The annual average loss amount that is expected to be reduced by the Project by the total annual average loss amount occurred as flow multiplying the amount of loss reduction occurred as flow for the corresponding flood probabilities.

Considering that floods happen probabilistically, the annual benefit is determined as the annual average amount of loss reduction. Next, find the procedures of calculation.

Table 4.5.1-3 Loss reduction annual average amount

Probabilities	Loss Amount			Average path's loss	Paths' Probabilities	Loss reduction annual average amount
	Without Project	With Project	Loss Reduction			
1/1			$D_0 = 0$			
				$(D_0+D_1)/2$	1-(1/2) = 0,500	$d_1 = (D_0+D_1)/2$ x 0,67
1/2	L_1	L_2	$D_1 = L_1\text{-}L_2$			
				$(D_1+D_2)/2$	(1/2)-(1/5) = 0,300	$d_2 = (D_1+D_2)/2$ x 0,300
1/5	L_3	L_4	$D_2 = L_3\text{-}L_4$			
				$(D_2+D_3)/2$	(1/5)-(1/10) = 0,100	$d_3 = (D_2+D_3)/2$ x 0,100
1/10	L_5	L_6	$D_3 = L_5\text{-}L_6$			
				$(D_3+D_4)/2$	(1/10)-(1/20) = 0,050	$d_4 = (D_3+D_4)/2$ x 0,050
1/20	L_7	L_8	$D_4 = L_7\text{-}L_8$			
				$(D_4+D_5)/2$	(1/20)-(1/30) = 0,017	$d_5 = (D_4+D_5)/2$ x 0,017
1/30	L_9	L_{10}	$D_5 = L_9\text{-}L_{10}$			
				$(D_5+D_6)/2$	(1/30)-(1/50) = 0,013	$d_6 = (D_5+D_6)/2$ x 0,013
1/50	L_{11}	L_{12}	$D_6 = L_{11}\text{-}L_{12}$			
				$(D_6+D_7)/2$	(1/50)-(1/100) = 0,010	$d_7 = (D_6+D_7)/2$ x 0,010
1/100	L_{13}	L_{14}	$D_7 = L_{13}\text{-}L_{14}$			
Foreseen average annual amount of loss reduction			$d_1+d_2+d_3+d_4+d_5+d_6+d_7$			

4) Results of the loss amount calculation (annual average)

In Table 4.5.1-4 the results of the loss amount calculation are shown (annual average), which are hoped to be reduced by implementing each river's Project.

Table 4.5.1-4 Annual average of damage reduction (private prices)

流域 Watershed	流量規模 Return Period	超過確率 Probability	被害額 (Total damage - thousands of S/.) 事業を実施しない場合① Without Project ①	事業を実施した場合② With Project	軽減額 ③=①−② Mitigated damages ③=①−②	区間平均被害額 ④ Damage Avergare	区間確率 ⑤ Probability incremental value	年平均被害額 ④×⑤ Average value of the damages flow	年平均被害額の累計=年平均被害軽減期待額 Annual Medial Damage
CHIRA	1	1.000	0	0	0			0	0
	2	0.500	0	0	0	0	0.500	0	0
	5	0.200	349,698	333,585	16,113	8,056	0.300	2,417	2,417
	10	0.100	427,001	411,472	15,529	15,821	0.100	1,582	3,999
	25	0.040	485,714	471,293	14,421	14,975	0.060	898	4,897
	50	0.020	562,385	525,002	37,382	25,901	0.020	518	5,415
CAÑETE	1	1.000	0	0	0			0	0
	2	0.500	1,660	153	1,507	754	0.500	377	377
	5	0.200	6,068	832	5,236	3,372	0.300	1,012	1,388
	10	0.100	73,407	8,413	64,994	35,115	0.100	3,512	4,900
	25	0.040	98,357	11,776	86,581	75,787	0.060	4,547	9,447
	50	0.020	149,018	16,428	132,589	109,585	0.020	2,192	11,639
CHINCHA	1	1.000	0	0	0			0	0
	2	0.500	14,576	423	14,153	7,076	0.500	3,538	3,538
	5	0.200	36,902	2,731	34,171	24,162	0.300	7,249	10,787
	10	0.100	51,612	3,904	47,708	40,939	0.100	4,094	14,881
	25	0.040	72,416	13,140	59,276	53,492	0.060	3,210	18,090
	50	0.020	96,886	28,112	68,774	64,025	0.020	1,281	19,371
PISCO	1	1.000	0	0	0			0	0
	2	0.500	15,788	197	15,591	7,795	0.500	3,898	3,898
	5	0.200	22,310	270	22,040	18,815	0.300	5,645	9,542
	10	0.100	47,479	2,556	44,923	33,481	0.100	3,348	12,890
	25	0.040	56,749	6,019	50,730	47,826	0.060	2,870	15,760
	50	0.020	76,992	8,318	68,674	59,702	0.020	1,194	16,954
YAUCA	1	1.000	0	0	0			0	0
	2	0.500	0	0	0	0	0.500	0	0
	5	0.200	0	0	0	0	0.300	0	0
	10	0.100	1,695	7	1,688	844	0.100	84	84
	25	0.040	2,569	1,005	1,564	1,626	0.060	98	182
	50	0.020	11,497	2,028	9,469	5,517	0.020	110	292
MAJES-CAMANA	1	1.000	0	0	0			0	0
	2	0.500	0	0	0	0	0.500	0	0
	5	0.200	47,669	10,021	37,648	18,824	0.300	5,647	5,647
	10	0.100	76,278	21,316	54,962	46,305	0.100	4,631	10,278
	25	0.040	111,113	34,254	76,859	65,911	0.060	3,955	14,232
	50	0.020	190,662	63,532	127,130	101,994	0.020	2,040	16,272

(2) Social Assessment

1) Assessment's objective and indicators

The social assessment's objective in this Study is to evaluate investment's efficiency in structural measures using the analysis method of cost-benefit (C/B) from the national economy point of view. For this, economic assessment indicators were determined (relation C/B, Net Present Value - NPV and IRR). The internal return rate (IRR) is an indicator that denotes the efficiency of the project's investment. It is the discount rate to match the current value of the project's generated cost regarding the benefit's current value. It is the discount rate necessary so the Net Present Value (NPV) equals zero and the relation C/B equals one. It also indicates the percentage of benefits generated by such investment. The internal return rate used in the economic assessment is called "economical internal return rate (EIRR)". The market price is turned into the economical price (costs at social prices) eliminating the impact of market distortion.

The IRR, C/B relation and NPV are determined applying mathematical expressions shown in the Table below. When IRR is greater than the social discount rate, the relation C/B is greater than one and NPV is greater than zero, it is considered that the project is efficient from the national economic growth point of view.

Table 4.5.1-5 Analysis assessment indicators of cost-benefit relation

Indicators	Definition	Characteristics
Net Present Value (NPV)	$NPV = \sum_{i=1}^{n} \frac{B_i}{(1+r)^i} - \sum_{i=1}^{n} \frac{C_i}{(1+r)^i}$	- Allows comparing net benefit magnitude performed by the project - It varies depending on the social discount rate
Cost-Benefit Relation (C/B)	$B/C = \sum_{i=1}^{n} \frac{B_i}{(1+r)^i} \Big/ \sum_{i=1}^{n} \frac{C_i}{(1+r)^i}$	- Allows comparing the investment efficiency by the magnitude of benefit per investment unit - Varies depending on the social discount rate
Economical Internal Return Rate (EIRR)	$\sum_{i=1}^{n} \frac{B_i}{(1+r)^i} = \sum_{i=1}^{n} \frac{C_i}{(1+r)^i}$	- Allows knowing the investment efficiency comparing it to the social discount rate - Does not vary depending on the social discount rate
Where Bi: benefit per "i" year / Ci: cost per "i" year / r: social discount rate (11 %) / n: years of assessment		

2) Assumptions

Next, find the assumptions of every indicator used from the economical assessment

i) Assessment Period

The assessment period is set between 2013 and 2027 (15 years after construction works started). This Project implementing schedule is the following:

2012: Detailed Design

2013-2014: Construction

2013-2027: Assessment Period

ii) Standard Conversion Factor (SCF)

The standard conversion factor (SCF) is the relationship between socioeconomic prices established along the border and national private prices of all goods in a country's economy. It is used to convert goods and services prices purchased in the local market at affordable prices. In this Study the following SCF values were used:

Dams 0.804

Gabions 0.863

Intakes 0.863

TAX (Peruvians use IGV) is not taken into account in the conversion of market prices to socioeconomic prices.

iii) Other preliminary conditions

Price level: 2011

Social discount rate: 10%

Annual maintenance cost: 0.5% of construction cost

3) Cost-benefit relation analysis

A comparison of the total cost and total benefit of flood control works converted to present values applying the social discount rate was performed. In this case, the total cost is the addition of construction, operation and maintenance costs. The total benefit is the loss amount that was reduced due to the works. For this, a base year was established for the conversion into the current value at the moment of the assessment, and the assessment period was set for the next 15 years from the beginning of the Project. The total cost was determined adding-up the construction, operation and maintenance costs of the works converted into present values; and the total benefit adding-up the annual average loss amount turned into current values.

In Table 4.5.1-6 results of calculations C/B, NPV and IRR to private prices is shown.

Table 4.5.1-6 Social Assessment (C/B, NPV, IRR) (at private prices)

流域名	年平均被害軽減額 Accumulated Average Annual Benefit	評価期間被害軽減額(15年) Accumulated Average Annual Benefit (in 15 years)	事業費 Project's Cost	維持管理費 O&M Cost	C/B Cost/Benefit Relation	Net Present Value (NPV) NPV	Internal Rate of Return (IRR) IRR
Chira	70,400,707	31,791,564	64,030,772	3,416,669	0.55	-25,662,760	0.6%
Cañete	151,304,096	68,325,931	25,665,970	1,423,638	2.96	45,266,114	36%
Chincha	251,818,212	113,716,113	43,965,072	2,444,072	2.88	74,212,307	35%
Pisco	220,402,316	99,529,317	71,608,946	3,911,056	1.55	35,225,349	19%
Yauca	3,799,425	1,715,745	20,899,762	1,155,236	0.09	-17,059,601	-
Majes-Camana	211,538,859	95,526,756	97,214,077	5,409,816	1.09	8,174,200	12%

4.5.2 Social prices costs

(1) Benefits

1) Estimated loss amount according to different return periods

In Table 4.5.2-1 the amounts of loss with and without Project are shown. These are estimated for disaster of different return periods in the all Watersheds.

Table 4.5.2-1 Estimated loss amount (at social prices)

CASE ケース	t	SOCIAL PRICES / 社会価格					
		Chira	Cañete	Chincha	Pisco	Yauca	Majes-Camana
WITHOUT PROJECT 事業を実施しない場合	2	0	2,582	16,283	16,681	0	0
	5	407,180	10,558	42,375	22,436	0	48,468
	10	494,866	105,137	70,525	52,469	2,150	78,194
	25	563,929	144,972	95,769	61,739	3,313	116,730
	50	649,089	213,134	125,742	84,256	12,092	206,459
	Total	2,115,064	476,384	350,693	237,581	17,555	449,851
WITH PROJECT 事業を実施した場合	2	0	272	430	289	0	0
	5	384,769	1,024	4,507	402	0	10,435
	10	473,618	9,908	6,449	3,055	9	21,738
	25	544,283	14,260	17,698	7,985	1,341	36,455
	50	605,046	20,117	33,329	10,889	2,653	70,838
	Total	2,007,716	45,580	62,414	22,620	4,003	139,466

2) Loss amount (annual average) is expected to be reduced with the Project

In Table 4.5.2-2 results of loss amount calculation (annual average) that are expected to reduce to implement the Project in each River are shown.

Table 4.5.2-2 Annual average of damage reduction (social prices)

流域 Watershed	流量規模 Return Period	超過確率 Probability	被害額 (Total damage - thousands of S/.) 事業を実施しない場合① Without Project ①	事業を実施した場合② With Project	軽減額 ③=①−② Mitigated damages ③=①−②	区間平均被害額 ④ Damage Average	区間確率 ⑤ Probability incremental value	年平均被害額 ④×⑤ Average value of the damages flow	年平均被害額の累計＝年平均被害軽減期待額 Annual Medial Damage
CHIRA	1	1.000	0	0	0			0	0
	2	0.500	0	0	0	0	0.500	0	0
	5	0.200	407,180	384,769	22,410	11,205	0.300	3,362	3,362
	10	0.100	494,866	473,618	21,248	21,829	0.100	2,183	5,544
	25	0.040	563,929	544,283	19,646	20,447	0.060	1,227	6,771
	50	0.020	649,089	605,046	44,043	31,844	0.020	637	7,408
CAÑETE	1	1.000	0	0	0			0	0
	2	0.500	2,582	272	2,311	1,155	0.500	578	578
	5	0.200	10,558	1,024	9,534	5,922	0.300	1,777	2,354
	10	0.100	105,137	9,909	95,229	52,382	0.100	5,238	7,592
	25	0.040	144,972	14,260	130,712	112,971	0.060	6,778	14,371
	50	0.020	213,135	20,117	193,018	161,865	0.020	3,237	17,608
CHINCHA	1	1.000	0	0	0			0	0
	2	0.500	16,283	430	15,852	7,926	0.500	3,963	3,963
	5	0.200	42,275	4,507	37,868	26,860	0.300	8,058	12,021
	10	0.100	70,525	6,449	64,076	50,972	0.100	5,097	17,118
	25	0.040	95,769	17,699	78,070	71,073	0.060	4,264	21,383
	50	0.020	125,742	33,329	92,413	85,242	0.020	1,705	23,088
PISCO	1	1.000	0	0	0			0	0
	2	0.500	16,681	289	16,392	8,196	0.500	4,098	4,098
	5	0.200	22,436	402	22,034	19,213	0.300	5,764	9,862
	10	0.100	52,469	3,055	49,414	35,724	0.100	3,572	13,434
	25	0.040	61,739	7,985	53,754	51,584	0.060	3,095	16,529
	50	0.020	84,258	10,889	73,369	63,561	0.020	1,271	17,801
YAUCA	1	1.000	0	0	0			0	0
	2	0.500	0	0	0	0	0.500	0	0
	5	0.200	0	0	0	0	0.300	0	0
	10	0.100	2,150	9	2,141	1,071	0.100	107	107
	25	0.040	3,313	1,341	1,972	2,057	0.060	123	230
	50	0.020	12,092	2,653	9,439	5,706	0.020	114	345
MAJES-CAMANA	1	1.000	0	0	0			0	0
	2	0.500	0	0	0	0	0.500	0	0
	5	0.200	48,458	10,425	38,033	19,016	0.300	5,705	5,705
	10	0.100	78,194	21,739	56,455	47,244	0.100	4,724	10,429
	25	0.040	118,730	38,455	80,275	68,365	0.060	4,102	14,531
	50	0.020	208,459	72,838	135,621	107,948	0.020	2,159	16,690

(2) Social Assessment

In Table 4.5.2-3 results of the calculation C/B, NPV and IRR at social prices are shown.

Table 4.5.2-3 Social Assessment (C/B, NPV, IRR) (at social prices)

流域名	年平均被害軽減額	評価期間被害軽減額(15年)	事業費	維持管理費	C/B	Net Present Value (NPV)	Internal Rate of Return (IRR)
	Accumulated Average Annual Benefit	Accumulated Average Annual Benefit (in 15 years)	Project's Cost	O&M Cost	Cost/Benefit Relation	NPV	IRR
Chira	96,306,401	43,490,062	51,721,005	2,747,002	0.94	-2,911,709	9%
Cañete	228,904,527	103,368,747	20,648,077	1,144,605	5.57	84,817,688	62%
Chincha	300,137,698	135,536,235	35,359,690	1,965,034	4.27	103,764,959	50%
Pisco	231,407,622	104,499,095	57,564,591	3,144,489	2.02	52,806,516	25%
Yauca	4,479,470	2,022,840	16,816,195	928,810	0.13	-13,083,633	-
Majes-Camana	216,973,372	97,980,874	80,819,553	4,497,057	1.35	25,359,998	16%

4.5.3 Social assessment conclusions

Next, the social assessment results of this Project are shown, based on C/B relation analysis.

Regarding social prices costs, the project can shown a positive impact in Cañete, Chincha, Pisco and Majes-Camana, with a C/B relation over 1.0. However, the contrary happens in Chira and Yauca Rivers. In Chira River specific case, the economic impact was reduced because this was discharged in order to perform conservation works in Poechos Dam of Chira-6.

In case of Yauca River, the result is due to the reduced flood loss amount because of the small floodable area due to topographic reasons.

Also, the following hardly quantifiable positive economical Projects effects are shown:

- Contribution to local economic development when soothing the fear due to economic activities suspension and damage
- Contribution by increasing local employment opportunities for the construction of the project
- Strengthening the local population's awareness for floods damage and other disasters
- Income increase contributions due to an stable agricultural production because flood damages are soothed
- Increase of agricultural land price

For the economic assessment results previously presented, it is considered that this Project will contribute substantially to the local economic development.

4.6 Sensitivity Analysis

(1) Objective

A sensitivity analysis was made in order to clarify the uncertainty due to possible changes in the future of the socioeconomic conditions. For the cost-benefit analysis it is required to foresee the cost and benefit variation of the project, subject to assessment, to the future. However, it is not easy to perform an adequate projection of a public project, since this is characterized for the long period required from planning to the beginning of operations. Also because of the long useful life of works already in operation and the intervention of a number of uncertainties that affect the future cost and benefit of the project. So, analysis results are obtained frequently and these are discordant to reality when the preconditions or assumptions used do not agree with reality. Therefore, for the uncertainty compensation of the cost-benefit analysis it should be better to reserve a wide tolerance-margin, avoiding an absolute and unique result. The sensitivity analysis is a response to this situation.

The objective of the sensitivity analysis is to provide the cost-benefit analysis results a determined margin that will allow a proper managing of the project's implementation, give numbers to the population and achieve greater accuracy and reliability of the project's assessment results.

(2) Sensitivity Analysis

1) General description of the sensitivity analysis

There are three methods of the sensitivity analysis, as indicated in Table 4.6-1.

Table 4.6-1 Sensitivity Analysis Methods

Methods	Description	Products
Variables sensitivity analysis	It consists in changing only one predetermined variable (precondition or hypothesis), to assess how the analysis result is affected	Margin values from the analysis when a precondition or hypothesis varies
Better and worst alternatives	It consists in defining the cases in which the analysis results are improved or worsen when changing the main pre-established preconditions or hypothesis to assess the analysis result margin	Margin values from the analysis when the main precondition or hypothesis vary
Monte Carlo	It consists in knowing the probability distribution of the analysis results by simulating random numbers of Monte Carlo simulation of pre-established preconditions and hypothesis	Probable results distribution when all main precondition or hypothesis vary

2) Description of the sensitivity analysis

In this project the sensitivity analysis method of the variables usually used in public works investments was adopted. Next, the scenarios and economic indicators used in the sensitivity analysis are shown.

Table 4.6-2 Cases subjected to the sensitivity analysis and economic indicators

Indicators	Variation margin according to factors	Economic indicators to be evaluated
Construction cost	In case the construction cost increases in 5 % and 10 %	IRR, NPV, C/B
Benefit	In case of reducing the benefit in 5 % and 10 %	IRR, NPV, C/B
Social discount rate	In case of increase and reduction of the discount social rate in 5 % respectively	NPV, C/B

3) Results of the sensitivity analysis

In Table 4.6-3 the results of the sensitivity analysis of each assessed case to private and social prices is shown.

Table 4.6-3 Results of the sensitivity analysis of IRR, C/B and NPV

	流域	Item	Basic Case	Case 1 Cost increase 5%	Case 2 Cost increase 10%	Case 3 Benefit decrease 5%	Case 4 Benefit decrease 10%	Case 5 Discount rate increase 5%	Case 6 Discount rate decrease 5%
民間価格	CHIRA	IRR (%)	0.6%	–	−1%	–	–	0.6%	0.6%
		B/C	0.55	0.53	0.50	0.53	0.50	0.43	0.74
		NPV(s)	−25,662,760	−28,535,476	−31,408,193	−27,252,338	−28,841,917	−30,786,945	−15,812,908
	CAÑETE	IRR (%)	36%	35%	33%	35%	33%	36%	36%
		B/C	2.96	2.82	2.69	2.81	2.67	2.28	3.99
		NPV(s)	45,266,114	44,113,123	42,960,132	41,849,817	38,433,521	27,605,013	74,293,435
	CHINCHA	IRR (%)	35%	34%	32%	34%	32%	35%	35%
		B/C	2.88	2.74	2.62	2.73	2.59	2.22	3.87
		NPV(s)	74,212,307	72,237,117	70,261,927	68,526,502	62,840,696	44,893,501	122,434,010
	PISCO	IRR (%)	19%	18%	17%	18%	16%	19%	19%
		B/C	1.55	1.47	1.41	1.47	1.39	1.19	2.08
		NPV(s)	35,225,349	32,010,150	28,794,952	30,248,883	25,272,417	11,533,380	75,102,472
	YAUCA	IRR (%)	–	–	–	–	–	–	–
		B/C	0.09	0.09	0.08	0.09	0.08	0.07	0.12
		NPV(s)	−17,059,601	−17,998,368	−18,937,135	−17,145,388	−17,231,175	−16,296,088	−17,760,074
	MAJES – CAMANA	IRR (%)	12%	11%	10%	11%	10%	12%	12%
		B/C	1.09	1.04	0.99	1.04	0.98	0.84	1.47
		NPV(s)	8,174,200	3,806,572	−561,055	3,397,862	−1,378,475	−12,860,682	44,424,771
社会価格	CHIRA	IRR (%)	9%	8%	7%	8%	7%	9%	9%
		B/C	0.94	0.89	0.85	0.89	0.84	0.72	1.26
		NPV(s)	−2,911,709	−5,231,797	−7,551,886	−5,086,212	−7,260,715	−12,054,326	13,085,346
	CAÑETE	IRR (%)	62%	60%	57%	60%	57%	62%	62%
		B/C	5.57	5.31	5.07	5.29	5.01	4.29	7.50
		NPV(s)	84,817,688	83,890,135	82,962,582	79,649,251	74,480,814	57,014,823	130,016,170
	CHINCHA	IRR (%)	50%	48%	46%	48%	46%	50%	50%
		B/C	4.27	4.06	3.88	4.05	3.84	3.29	5.74
		NPV(s)	103,764,959	102,176,396	100,587,832	96,988,148	90,211,336	67,804,372	162,443,112
	PISCO	IRR (%)	25%	24%	23%	24%	23%	25%	25%
		B/C	2.02	1.93	1.84	1.92	1.82	1.56	2.72
		NPV(s)	52,806,516	50,221,887	47,637,258	47,581,561	42,356,606	26,882,586	95,916,361
	YAUCA	IRR (%)	–	–	–	–	–	–	–
		B/C	0.13	0.13	0.12	0.13	0.12	0.10	0.18
		NPV(s)	−13,083,633	−13,838,957	−14,594,281	−13,184,775	−13,285,917	−12,649,776	−13,357,212
	MAJES – CAMANA	IRR (%)	16%	15%	14%	15%	14%	16%	16%
		B/C	1.35	1.28	1.23	1.28	1.21	1.04	1.82
		NPV(s)	25,359,998	21,728,954	18,097,910	20,460,954	15,561,910	2,658,312	63,876,226

(3) Assessment of the sensitivity analysis

A sensitivity analysis of the Project's impact regarding socio-economic change, to private and social prices, was performed. According to this analysis, even when costs, benefits and discount rate suffer a determined variation, its impact on the IRR, C/B and NPV will be reduced and it will still be a Project with high economic impact.

① Basic Projects of Cañete, Chincha, Pisco and Majes-Camana Rivers are economically efficient and their values IRR, C/B and NPV do not vary if costs and benefits moderate a bit

② Regarding Chira River, the economic impact of the basic project is not yet acquire, so it's not possible to ensure the hoped economic value if the discount rate is not reduced up to 5%

③ For Yauca River, the relation C/B of the base scenario is already low (0.1) and there is no variation.

4.7 Sustainability Analysis

This project will be co-managed by the central government (through the DGIH), irrigation committees and regional governments. Also, the project cost will be covered with the respective contributions of the three parties. Usually the central government (in this case, the MINAG) takes the 80%, irrigation commissions 10% and regional governments 10%. However, the percentages of the contributions of these last two are decided through discussions between both parties. On the other hand, the operation and maintenance (O & M) of the completed works is assumed by the irrigation committee. So, the sustainability of the project depends on the profitability of the Project and the ability of the irrigation committees for O & M.

Table 4.7-1 presents the data of the budget for irrigation committees in recent years.

Table 4.7-1 Project Budget of the irrigation commissions

Rivers	Annual Budget				(In soles)
	2006	2007	2008	2009	2010
Chira	30.369,84	78.201,40	1.705.302,40	8.037.887,44	
Cañete		2.355.539,91	2.389.561,65	2.331339,69	2.608.187,18
Chincha		1.562.928,56	1.763.741,29	1.483.108,19	
Pisco		1.648.019,62	1.669.237,35	1.725.290,00	1.425.961,39
Yauca	114.482,12	111.102,69	130.575,40		
Majes-Camana			1.867.880,10	1.959.302,60	1.864.113,30
Total		5.755.792,18	9.526.298,10	15.536.928,01	5.898.261,84

Note: Since the Irrigation Commission of Majes-Camana has no budget data for Majes River in 2008, we have supposed it in Rio Camana 2008 (1.122.078,40) + Majes River budget of 2009 (745.810,70)

(1) Profitability

The project in profitable in the four watersheds, but not in Chira and Yauca Rivers. This shows the high project's sustainability. In the two mentioned rivers, the low profitability does not justify the project's implementation.

(2) Cost of operation and maintenance

In Table 4.7-2 a relation between 2008 irrigation commission's budgets according to watershed, and the respective annual operation and maintenance cost are shown, supposing that the project requires an annual investment of 0.5% of the building cost for the maintenance of already built works.

The annual cost of O&M in the Majes-Camana River is a high percentage of the irrigation commission's annual budget. However, in Yauca River's case it is excessively high so the Project's sustainability is a problem.

Table 4.7-2 Irrigation Commissions Budget and Operation and Maintenance Annual Costs

Rivers	Irrigation Commissions Budget (2008) S/	Building Cost S/	O&M annual cost	O&M annual percentage cost (%)
Chira	1.705.302,40	52.564.133	262.821	15,4
Cañete	2.389.561,65	21.902.128	109.511	4,6
Chincha	1.763.741,29	37.601.113	188.006	10,7
Pisco	1.669.237,35	60.170.088	300.850	18,0
Yauca	130.575,40	17.772.865	88.864	68,1
Majes-Camana	1.867.880,10	83.227.934	416.140	22,2
Total	9.526.298,10	273.238.260	1.366.191	14,3

Judging the irrigation commission's capability to pay the profitable O&M cost, the project may be sustainable in the Cañete, Chincha, Pisco and Majes-Camana Watersheds.

4.8 Project Selection

In Table 4.8-1 shows the socioeconomic impact (social prices costs) and the project's costs in the 6 watersheds. In this Table the priority order according to the calculated socioeconomic impact magnitude is also shown. Chira and Yauca watersheds were discharged from the Table due to their reduced economic impact and only 4 watersheds were included that will show positive impact. These are: Cañete, Chincha, Pisco and Majes-Camana, which altogether cost would be: 238,377,000 soles. This equals 114% of the initial estimated cost of 209,899,000 soles which results in an increase of 28,478,000 soles.

Table 4.8-1 Project Selection

RIVERS	Socioeconomic Impact (social prices cost)				Project Cost (Private prices)	OBSERVATIONS
	C/B	NPV	IRR(%)	PRIORITY	(Thousand Soles)	
Cañete	5.57	84,818	62	1	25,666	
Chincha	4.27	103,765	50	2	43,965	
Pisco	2.02	52,807	25	3	71,608	
Majes-Camaná	1.35	25,422	16	4	97,137	
Chira (Chira-1～4)	0.94	2,912	9	5	64,031	
Yauca	0.13	13,084	-	6	20,900	
Total (1 - 6)					323,308	
①Total except Yauca (1 - 5)					302,408	①/③＝144%
②Total except Yauca Chira (1-4)					238,377	②/③＝114%
③ INITIAL BUDGET					209,899	②－③＝28,478

4.9 Environmental Impact

4.9.1 Procedure of Environmental Impact Assessment

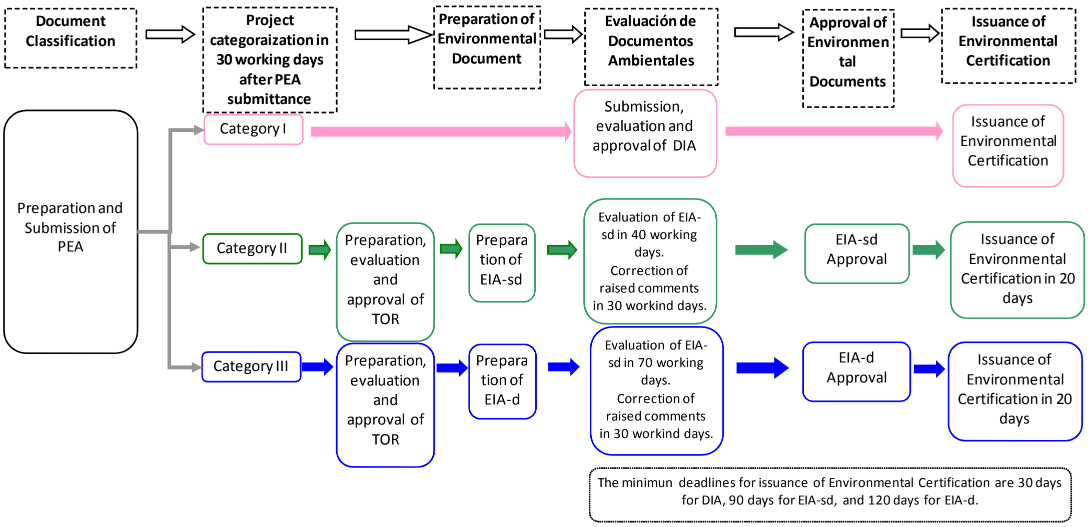
Projects are categorized in three scales, based on the significance level of the negative and positive impacts, and each sector has an independent competence on this categorization. The following table shows the environmental management instruments that are required for each category. The Project holder should submit the Environmental Impact Statement (DIA, in Spanish) for all Projects under Category I. The project holder should prepare an EIA-sd or an EIA-d if the Project is categorized under Category II or III, respectively, to be granted the Environmental Certification from the relevant Ministry Directorate.

Table 4.9.1-1 Project Categorization and Environmental Management Instruments

	Description	Required Environmental Management Instrument
Category I	It includes those Projects that when carried out, they cause no significant negative environmental impacts whatsoever.	PEA that is considered a DIA after the assessment for this category
Category II	It includes those Projects that when carried out, they can cause moderate environmental impacts, and their negative effects can be removed or minimized through the adoption of easily applicable measures.	Semi-Detailed Environmental Impact Assessment (EIA-sd)
Category III	It includes those Projects than can cause significant quantitative or qualitative negative environmental impacts because of their characteristics, magnitude and/or location. Therefore, a deep analysis is required to revise those impacts and set out a relevant environmental management strategy.	Detailed Environmental Impact Assessment (EIA-d)

Source: Prepared by the JICA Study Team based on the SEIA Law (2001)

The next graph shows the Environmental Document's Classification, the Environmental Document's Assessment, and the Environmental Certification.



Source: Prepared by the JICA Study Team based on the SEIA Regulations (2009)

Figure 4.9.1-1 The Process to Obtain the Environmental Certification

First, the Project holder applies for the Project classification, by submitting the Preliminary Environmental Assessment (PEA). The relevant sector assesses and categorizes the Project within the next 30 working days after the document's submission. The Project's PEA that is categorized under Category I becomes an EID, and those Projects categorized under Category II or III should prepare an EIA-sd or EIA-d, as applicable. There are cases in which the relevant sector prepares the Terms of Reference for these two studies, and submits them to the holder. There are other cases in which the holder prepares the Terms of Reference and these are approved by the relevant sector, based on the interview with DGAA. Number of working days required for EIA-sd revision and approval is 90, and number of working days required for EIS-d is 120; however, these maximum deadlines may be extended.

The progress of the environmental impact study is as shown below.

The JICA Study Team subcontracted a local Consultant (CIDE Ingenieros S.A.), and a Preliminary Environmental Assessment (PEA) was carried out, from December 2010 to January 2011 for 5 rivers of Chira, Cañete, Chincha, Pisco, Yauca from September to October 2011for Majes-Camana river.

EAP for the antecedent 5 rivers was submitted to DGIH from JICA on January 25, 2011 and EAP for Majes- Camana on December 20, 2012. DGIH submitted the former to DGAA on July 19, 2011and the latter on January 4, 2012. EAP for Yauca river was not submitted to DGAA from DGIH because DGIH excluded Yauca project from the Project.

EAP for 4 rivers except Yauca river was examined by DGAA, and DGAA issued their comments on EAP to DGIH. JICA Study Team revised EAP upon the comments and submitted them to DGAA on September 21, 2011. DGAA completed examination on the revised EAP and issued approval letter on 4 rivers in which DGAA classified 4 rivers into Category I. Therefore the additional environmental impact analysis for 4 rivers is not required. Although EAP of the Majes-Camana river is still under examination of DGAA, the river will be also classified into Category I because the flood prevention facilities in the river are similar to that of antecedent 4 rivers.

The positive and negative environmental impact associated with the implementation of this project was confirmed and evaluated, and the plan for prevention and mitigation measures are prepared by EAP results, field investigation and hearing by JICA Study Team.

The proposed works in this project include: the reparation of existing dikes, construction of new dikes, riverbed excavation, margins protection works, repair and improvement of the derivation and intakes works, and also river expansion. Table 4.9.1-2 described “working sites” to be considered in the Environmental Impact section for the 6 watersheds.

Table 4.9.1-2 Works Description

Basin	Location			Preservation Object	Counter Measure	Summary of Facility	Objective Section
Chira	1	0.0k-4.0k	Revetment	Crop land/ natural gas	Revetment	H; 2.0m Slope; 1:3 L; 4000m	0.0km～4.0km (left bank)
	2	11.75k-12.75k	Erosion	Road		H; 2.0m Slope; 1:3 L; 1,000m	11.75km～12.75km (right bank)
	3	24.5k-27.0k	Revetment	Crop land		H; 2.0m Slope; 1:3 L; 2,500m	24.5km～27.0km (right bank)
	4	64.0k-68.0k	Riverbed Excavation	Crop land	Riverbed excavation	Ex.width; 100m Ex. depth; 1.0m L; 1,000m	64.0km～68.0km (total)
Cañete	1	4.3km	Narrow Section	Road bridge	Riverbed excavation	Ex.width; 100m Ex. depth; 1.0m L; 1,000m	4.0km～5.0km (total)
	2	6.8k～8.0k	Inundation	Crop land	Revetment	H; 2.0m slope; 1:3 L; 1,200m	6.5km～8.1km (right bank)
	3	10.25k	Narrow Section		Riverbed excavation	Ex.width; 100m Ex. depth; 1.0m L; 1,000m	10.0km～11.0km (total)
	4	24.5k	Intake		Diversion weir	Weir width; 150m H; 3.0m T; 2.0m	24.25km～24.75km (total)
	5	25.0k, 26.25k	Erosion	Road	Revetment	H; 2.0m Slope; 1:3 L; 750m	24.75km～26.5km (right bank)
Chincha	1	C-3.5～5.0k	Inundation	Crop land (Cotton Grape) Urban area	Dike (no dike section) Revetment	Top W; 4.0m H; 2.0m Slope; 1:3 L; 3,000m (1,500+1,500)	3.0km～5.1km(total)
	2	C-15k	Intake		Intake Widening river width	Weir W; 100m H; 3.0m T; 2.0m	14.8km～15.5km (total)
	3	C-24k	Diversion weir		Rehabilitation of diversion weir (rehbilitation of existing weir, channel and training dike)	Weir w; 70m H; 3.0m T; 2.0m	24.2km～24.5km (total)
	4	M-3.0k～4.5k	Inundation		Dike (no dike section) Revetment	Top W; 4.0m H; 2.0m Slope; 1:3 L; 3,000m (1,500+1,500)	2.5km～5.0km (total)
	5	M-8.9k	Narrow Section		Riverbed excavation	Ex. width; 100m Ex. depth; 1.0m L; 1,200m	8.0km～10.5km (total)
Pisco	1	5.5k	Inundation	Crop land	Dike (no dike section) Revetment	Top W; 4.0m H; 2.0m Slope; 1:3 L; 2,000m	3.0km～5.0km (left bank)
	2	7.0k	Narrow Section		Riverbed excavation	Ex. width; 100m Ex. depth; 1.0m L; 1,500m	6.5km～8.0km (total)
	3	13.5k	Inundation		Dike (no dike section) Revetment	Top W; 4.0m H; 2.0m Slope; 1:3 L; 1,500m	12.5km～14.0km (left bank)
	4	20.5k	Inundation	Crop land	Dike (no dike section) Revetment	Top W; 4.0m H; 2.0m Slope; 1:3 L; 2,000m	19.5km～20.5km (left bank)
	5	26.5k	Narrow Section		Widening river width	Ex. width; 100m Ex. depth; 1.0m L; 1,000m	26.0km～27.0km (total)
	6	34.5k	Intake		Retarding basin	Retarding basin; 1,800m×700m	34.5km～36.5km (total)
Yauca	1	4.5k下流	Inundation	Crop land (olive)	Rehabilitation of dike	Top W; 4.0m H; 2.0m Slope; 1:3 L; 1,000m	3.5km～7.5km (total)
	2	4.1km	Narrow Section		Riverbed excavation	Ex. width; 100m Ex. depth; 1.0m L; 500m	
	3	4.5-7.0k	Inundation		Rehabilitation of dike	Top W; 4.0m H; 2.0m Slope; 1:3 L; 2,500m	
	4	25.0k	Intake	Crop land (olive)	Rehabilitation of intake	Weir W; 100m H; 3.0m T; 2.0m	25.0km～25.7km (total)
	5	25.0k	Intake		Revetment	H; 2.0m Slope; 1:2 L; 500m	
	6	41km	Intake	Road	Revetment	H; 2.0m Slope; 1:2 L; 400m	40.9～41.3km(left bank)
Majes-Camana	MC 1	0.0k-4.5k	Inundation	Crop land (rice、others)	Dike (no dike section) Revetment	Top W; 4.0m h; 2.0m-3.0m Slope; 1:3 L; 4,500m	0.0km-4.5km (left bank)
	MC 2	7.5k-9.5k	Inundation			Top W; 4.0m h; 2.0m-3.0m Slope; 1:3 L; 2,000m	7.5km-9.5km (left bank)
	MC 3	11.0k-17.0k	Inundation			Top W; 4.0m h; 2.0m-3.0m Slope; 1:3 L; 6,000m	11.0k-17.0k(left bank)
	MC 4	48.0k-50.5k	Inundation			Top W; 4.0m h; 2.0m-3.0m Slope; 1:3 L; 2,500m	48.0km-50.5km (left bank)
	MC 5	52.0k-56.0k	Inundation			Top W; 4.0m h; 2.0m-3.0m Slope; 1:3 L; 4,o00m	52.0k-56.0k(left bank)
	MC 6	59.0k-62.5k 59.5k-62.5k	Inundation /erosion			Top W; 4.0m h; 2.0m-3.0m Slope; 1:3 L; 6,500m	59.0km-62.5km (left bank) 59.5km-62.5km. (right bank)
	MC 7	65.0k-66.5k 64.5k-66.5k	Inundation			Top W; 4.0m h; 2.0m-3.0m Slope; 1:3 L; 3,500m	65.0km.-66.5 km.(right bank) 64.5km.-66.5 km. (left bank)

Source: JICA Study Team

4.9.2 Methodology

In order to identify environmental impacts of the works to be executed in the different watersheds, we developed identification impact matrixes for watershed.

First, the operation and activities for each project based on typical activities of "hydraulic works" construction were determined. Afterwards, the concrete activities type was determined which will be executed for each work that will be developed in the watersheds. Then, to evaluate Socio-environmental impacts the Leopold matrix was used.

Table 4.9.2-1 Evaluation Criterion - Leopold Matrix

Index		Description	Valuation
"Na" nature		It defines whether change in each action on the means is positive or negative	Positive (+) : beneficial
			Negative (-): harmful
Probability of Occurrence "P.O."		It includes the probability of occurrence of the impact on the component	High (>50 %) = 1.0
			Medium (10 – 50 %) = 0.5
			Low (1 – 10 %) = 0.2
Magnitude	Intensity (In)	It indicates the magnitude of change in the environmental factor. It reflects the degree of disturbance	Negligible (2)
			Moderate intensity (5)
			Extreme Disturbance (10)
	Extension "Ex"	It indicates the affected surface by the project actions or the global scope on the environmental factor.	Area of indirect influence: 10
			Area of direct influence: 5
			Area used up by the works: 2
	Duration "Du"	It refers to the period of time when environmental changes prevail	➢ 10 years: 10
			5 – 10 years : 5
			1 – 5 years: 2
	Reversibility "Rev"	It refers to the system's capacity to return to a similar, or an equivalent to the initial balance.	Irreversible: 10
			Partial return: 5
			Reversible: 2

Source: Prepared based on PEAs of 6 Basins

Table 4.9.2-2 Impact Significance Degrees

SIA	Extent of Significance
≤ 15	Of little significance
15.1 - 28	Significant
≥ 28	Very significant

Source: Prepared based on PEAs of 6 Basins

4.9.3 Identification, Description and Social Environmental Assessment

(1) Identification of social environmental impacts

In the following matrix (construction/operation stages) in all Watersheds, elaborated based on the report analysis of the Preliminary Environmental Assessment.

Table 4.9.3-1 Impact Identification Matrix (Construction and Operation Stage) –Chira River Basin

Construction Stage			Work	1-4	1-4	1-4	4	1,4	1, 4	1-4	1-4	1-4	1-4	1-4		
Environment	Component	Environmental Factors	Activity	Labor Recruitment	Site preparation work (Clearing, land grading, Levelled)	Diversion of riverbed (Cofferdams)	Digging and refilling in riverside	Digging and refilling in riverbed	Civil Work (Concreting)	I&O of stone pits and material production plants	DME I&O	Camps work I&O	Carriage Staff	Transportation of machinery, equipment, materials and supplies	Total Negative	Total Positive
Physique	Air	PM-10 (Particulate matter)			N	N	N	N		N	N		N	N	8	0
		Gas emissions			N	N	N	N	N	N	N		N	N	9	0
	Noise	Noise			N	N	N	N	N	N	N	N	N	N	10	0
	Soil	Soil fertility			N					N	N				3	0
		Land Use			N					N	N				3	0
	Water	Calidad del agua superficial				N	N	N		N					4	0
		Cantidad de agua superficial							N			N			2	0
	Physiography	Morfología fluvial				N	N	N		N					4	0
		Morfología terrestre			N						N				2	0
Biotic	Flora	Terrestrial flora			N						N				2	0
		Aquatic flora				N	N	N		N					4	0
	Fauna	Terrestrial fauna			N						N				2	0
		Aquatic fauna				N	N	N		N					4	0
Socio-economic	Esthetic	Visual landscape								N	N				2	0
	Social	Quality of life		P								N	N	N	3	1
		Vulnerability - Security													0	0
	Economic	PEA		P											0	1
		Current land use													0	0
Total				2	8	7	7	7	3	10	9	3	4	4	62	2
Percentage of positive and negative															97 %	3 %

Operation Stage							
Environment	Component	Environmental Factors	Works	Dike Point 1,2,3	Riverbed without Silting Point 4	Total Negatives	Total Positives
Physique	Air	PM-10 (Particulate matter)				0	0
		Gas emissions				0	0
	Noise	Noise				0	0
	Soil	Soil fertility				0	0
		Land Use				0	0
	Water	Calidad del agua superficial				0	0
		Cantidad de agua superficial		P	P	0	2
	Physiography	Morfología fluvial		N	N	2	0
		Morfología terrestre				0	0
Biotic	Flora	Terrestrial flora				0	0
		Aquatic flora				0	0
	Fauna	Terrestrial fauna				0	0
		Aquatic fauna		N	N	2	0
Socio-economic	Esthetic	Visual landscape		P	P	0	2
	Social	Quality of life		P	P	0	2
		Vulnerability - Security		P	P	0	2
	Economic	PEA				0	0
		Current land use		P	P	0	2
Total				7	7	4	10
Percentage of positive and negative						29 %	71 %

N: Negative, P: Positive
Source: Prepared by the JICA Study Team

In the Chira River watershed, according to the impact identification results for the building stage, a total of 64 interactions have been found, from which 62 (97%) correspond to impacts which effect will be perceived as negative and 2 (3%), which effects will be positive. We have to mention that from the 62 negative impacts, only 15 have been quantifiable as significant and 2 as very significant. To identify and obtain presented results of the impacts assessment in the construction stage of each one of the developed works of the Chira River the impact identification matrix was developed, where “P” means: Positive Impacts and N: Negative Impacts. Remember that for Cañete River and the other rivers the number of impacts was determined using the same Table, so the transcription of the matrix here is omitted.

According to the results of impacts identification, in the operation stage a total of 14 interactions have been found, from which 4 (29%) correspond to impacts which effect is negative and 10 (79%), which effect is positive. It is worth mentioning that from the 4 negative impacts, only 2 have been significant and 2 as very significant. The calculation method is the same one as the applied for the construction phase, before mentioned. For Cañete River and the rest of rivers, the number of impacts was determined using the same Table, so the matrix is not written here.

In the Cañete River watershed, according to the impact identification results for the building stage, a total of 64 interactions have been found, from which 62 (97%) correspond to impacts which effect will be perceived as negative and 2 (3%), which effects will be positive. We have to mention that from the 62 negative impacts, only 15 have been quantifiable as significant and 2 as very significant.

According to the results of impacts identification, in the operation stage a total of 32 interactions have been found, from which 6 (19%) correspond to impacts which effect is negative and 26 (81%), which effect is positive. It is worth mentioning that from the 6 negative impacts, only 2 have been significant and 4 as very significant.

In the Chincha River watershed, according to the impact identification results for the building stage, a total of 64 interactions have been found, from which 62 (97%) correspond to impacts which effect will be perceived as negative and 2 (3%), which effects will be positive. We have to mention that from the 62 negative impacts, only 15 have been quantifiable as significant and 2 as very significant.

According to the results of impacts identification, in the operation stage a total of 33 interactions have been found, from which 7 (21%) correspond to impacts which effect is negative and 26 (79%), which effect is positive. It is worth mentioning that from the 7 negative impacts, only 5 have been significant and 2 as very significant.

In the Pisco River watershed, according to the impact identification results for the building stage, a total of 69 interactions have been found, from which 67 (97%) correspond to impacts which effect will be perceived as negative and 2 (3%), which effects will be positive. We have to mention that from the 67 negative impacts, only 12 have been quantifiable as significant and 2 as very significant.

According to the results of impacts identification, in the operation stage a total of 34 interactions have been found, from which 8 (24%) correspond to impacts which effect is negative and 26 (76%), which effect is positive. It is worth mentioning that from the 8 negative impacts, only 6 have been significant and 2 as very significant.

In the Yauca River watershed, according to the impact identification results for the building stage, a total of 67 interactions have been found, from which 65 (97%) correspond to impacts which effect will be perceived as negative and 2 (3%), which effects will be positive. We have to mention that from the 65 negative impacts, only 13 have been quantifiable as significant and 3 as very significant.

According to the results of impacts identification, in the operation stage a total of 38 interactions have been found, from which 6 (20%) correspond to impacts which effect is negative and 32 (80%), which effect is positive. It is worth mentioning that from the 6 negative impacts, only 4 have been significant and 2 as very significant.

In the Majes-Camana River watershed, according to the impact identification results for the building stage, a total of 47 interactions have been found, from which 45 (96%) correspond to impacts which effect will be perceived as negative and 2 (4%), which effects will be positive. We have to mention that from the 45 negative impacts, only 12 have been quantifiable as "strong" and 3 as "very strong"
During the operation and maintenance period 56 interaction are estimated, from which 21 (37.5%) are negative impacts and 35 (62.5%) positive impacts. From the 21 interaction with negative impacts, all of them are "strong" and none has been classified under "very strong"

During constructive stage the actions generated by the most significant negative impacts in the 6 watersheds would be: "preparation and clearance of working site" and "Excavation and filling of streams." The "preparation and clearance of working site" would cause a modification in land morphology, meanwhile "Excavation and filling of streams" causes significant modification of fluvial morphology. Apart from these two activities, the “Excess Material Deposit Operation (EMD)” will give significant negative impact in Yauca River works.

The two positive impacts identified during building stage, for all the watersheds, are related to local labor hiring, which will cause a better life quality for beneficiaries and it will also improve the active economic population indicator.

During operation stage of hydraulic infrastructure that will cause that negative environment impacts that are more significant we can mention “stream unclogging or desilting”. This will cause a modification of fluvial morphology and a reduction of the conditions of the river’s habitability, which will directly impact the aquatic fauna.

More significant positive impacts are related to every building work in a river watershed and are directly related to improve the influence area population’s life quality, improve the “current use of land” and improve the safety conditions and reduce vulnerability at social and environmental level.

(2) Environmental and Social Impact Assessments

In the next Table the environmental impact assessment results are presented, expressed in grades. The impact may be in building stage grouped according to type of works, and the impact after the operation entrance has been grouped according to areas.

In the Chira River Watershed 62 interaction were identified that may show negative impacts during construction stage, from which 15 are “strong” and 2 are “very strong.” From the 6 interaction that may be negative impacts after being used, 2 are “strong” and 2 are “very strong.”

During the construction stage, plot division, land leveling and other site preparation jobs may be negative to the local topography in all the project sites. After entering into service, it is foreseen that desilting that wants to be done in Chira-4 during construction will have a strong impact on fluvial topography and aquatic fauna.

It is worth mentioning that in 4.9.5 “Monitoring and Control Management Plan” the prevention and mitigation measures will be analyzed as these interactions are “strong and very strong.”

Table4.9.3-2 Environmental Impact Assessment Matrix – The Chira River Basin

			The Chira River Basin												
			Construction Stage											Operation Stage	
Medio	Componente	Acciones del proyecto	Labor Recruitment	Site preparation work (Clearing, land grading, Levelled)	Diversion of riverbed (Cofferdams)	Digging and refilling in riverside	Digging and refilling in riverbed	Civil Work (Concreting)	I&O of stone pits and material production plants	DME I&O	Camps work I&O	Carriage Staff	Transportation of machinery, equipment, materials and supplies	Chi 1, 2 and 3	Chi 4
		Factores Ambientales / Puntos de Obras:	Chi 1 - 4	Chi 1 - 4	Chi 1 - 4	Chi 1 - 4	Chi 1, 2, 3, 4	Chi 1, 2, 3	Chi 1 - 4	Chi 1 - 4	Chi 1 - 4	Chi 1 - 4	Chi 1 - 4		
Physique	Air	PM-10 (Particulate matter)	0.0	-12.0	-12.0	-12.0	-12.0	0.0	-18.0	-18.0	0.0	-12.0	-12.0	0.0	0.0
		Gas emissions	0.0	-11.5	-11.5	-11.5	-11.5	-11.5	-11.5	-11.5	0.0	-11.5	-11.5	0.0	0.0
	Noise	Noise	0.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	0.0	0.0
	Soil	Soil fertility	0.0	-11.5	0.0	0.0	0.0	0.0	-14.2	-14.2	0.0	0.0	0.0	0.0	0.0
		Land Use	0.0	-14.2	0.0	0.0	0.0	0.0	-15.0	-15.0	0.0	0.0	0.0	0.0	0.0
	Water	Calidad del agua superficial	0.0	0.0	-17.5	-12.0	-23.0	0.0	-15.0	0.0	0.0	0.0	0.0	0.0	0.0
		Cantidad de agua superficial	0.0	0.0	0.0	0.0	0.0	-9.0	0.0	0.0	-15.0	0.0	0.0	26.0	31.0
	Physiography	Morfología fluvial	0.0	0.0	-12.0	-20.0	-31.0	0.0	-23.0	0.0	0.0	0.0	0.0	-25.5	-30.5
		Morfología terrestre	0.0	-33.0	0.0	0.0	0.0	0.0	0.0	-28.0	0.0	0.0	0.0	0.0	0.0
Biotic	Flora	Terrestrial flora	0.0	-28.0	0.0	0.0	0.0	0.0	0.0	-22.5	0.0	0.0	0.0	0.0	0.0
		Aquatic flora	0.0	0.0	-12.0	-14.5	-14.5	0.0	-14.5	0.0	0.0	0.0	0.0	0.0	0.0
	Fauna	Terrestrial fauna	0.0	-24.2	0.0	0.0	0.0	0.0	0.0	-22.5	0.0	0.0	0.0	0.0	0.0
		Aquatic fauna	0.0	0.0	-12.0	-14.5	-22.5	0.0	-15.0	0.0	0.0	0.0	0.0	-25.5	-30.5
Socio-economic	Esthetic	Visual landscape	0.0	0.0	0.0	0.0	0.0	0.0	-12.0	-12.0	0.0	0.0	0.0	36.0	36.0
	Social	Quality of life	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-17.5	-17.5	-17.5	36.0	36.0
		Vulnerability - Security	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.0	36.0
	Economic	PEA	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Current land use	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.0	36.0

Grade of Positive Impacts		Grade of Negative Impacts	
0–15.0	Little significant	0–15.0	Little significant
15.1–28.0	Significant	15.1–28.0	Significant
28.1–	Very significant	28.1–	Very significant

Source: Prepared based on PEAs from 6 Basins

In the Cañete River Watershed 62 interaction were identified that may show negative impacts during construction stage, from which 15 are "strong" and 2 are "very strong." From the 6 interaction that may be negative impacts after entering into service, 2 are "strong" and 4 are "very strong."

During the construction stage, plot division, land leveling and other site preparation jobs may be negative to the local topography in all the project sites. After entering into service, it is foreseen that desilting that wants to be done in Ca-1 and Ca-3 during construction will have a strong impact on fluvial topography and aquatic fauna.

It is worth mentioning that in 4.9.5 "Monitoring and Control Management Plan" the prevention and mitigation measures will be analyzed as these interactions are "strong and very strong."

Table 4.9.3-3 Environmental Impact Assessment Matrix – The Cañete River Basin

			The Cañete River Basin															
			Construction Stage											Operation Stage				
Medio	**Componente**	**Acciones del proyecto**	Labor Recruitment	Site preparation work (Clearing, land grading, Levelled)	Diversion of riverbed (Cofferdams)	Digging and refilling in riverside	Digging and refilling in riverbed	Civil Work (Concreting)	I&O of stone pits and material production plants	DME I&O	Camps work I&O	Carriage Staff	Transportation of machinery, equipment, materials and supplies	**Ca1**	**Ca2**	**Ca3**	**Ca4**	**Ca5**
		Puntos de Obras: / **Factores Ambientales**	**Ca 1-5**	**Ca 1-5**	**Ca 1-5**	**Ca 4 y 5**	**Ca 1, 2 y 3**	**Ca 4 y 5**	**Ca 1-5**	**Ca 1-5**	**Ca 1-5**	**Ca 1-5**	**Ca 1-5**					
Physique	**Air**	PM-10 (Particulate matter)	0.0	-12.0	-12.0	-12.0	-12.0	0.0	-18.0	-18.0	0.0	-12.0	-12.0	0.0	0.0	0.0	0.0	0.0
		Gas emissions	0.0	-11.5	-11.5	-11.5	-11.5	-11.5	-11.5	-11.5	0.0	-11.5	-11.5	0.0	0.0	0.0	0.0	0.0
	Noise	Noise	0.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	0.0	0.0	0.0	0.0	0.0
	Soil	Soil fertility	0.0	-11.5	0.0	0.0	0.0	0.0	-14.2	-14.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.0
		Land Use	0.0	-14.2	0.0	0.0	0.0	0.0	-15.0	-15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Water	Calidad del agua superficial	0.0	0.0	-17.5	-12.0	-23.0	0.0	-15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.0	31.0
		Cantidad de agua superficial	0.0	0.0	0.0	0.0	0.0	-9.0	0.0	0.0	-15.0	0.0	0.0	31.0	26.0	31.0	26.0	0.0
	Physiography	Morfología fluvial	0.0	0.0	-12.0	-20.0	-31.0	0.0	-23.0	0.0	0.0	0.0	0.0	-30.5	-25.5	-30.5	0.0	0.0
		Morfología terrestre	0.0	-33.0	0.0	0.0	0.0	0.0	0.0	-28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Biotic	**Flora**	Terrestrial flora	0.0	-28.0	0.0	0.0	0.0	0.0	0.0	-22.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Aquatic flora	0.0	0.0	-12.0	-14.5	-14.5	0.0	-14.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Fauna	Terrestrial fauna	0.0	-24.2	0.0	0.0	0.0	0.0	0.0	-22.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Aquatic fauna	0.0	0.0	-12.0	-14.5	-22.5	0.0	-15.0	0.0	0.0	0.0	0.0	-30.5	-25.5	-30.5	0.0	0.0
Socio-economic	**Esthetic**	Visual landscape	0.0	0.0	0.0	0.0	0.0	0.0	-12.0	-12.0	0.0	0.0	0.0	36.0	36.0	36.0	0.0	36.0
	Social	Quality of life	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-17.5	-17.5	-17.5	36.0	36.0	36.0	31.0	36.0
		Vulnerability - Security	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.0	36.0	36.0	31.0	36.0
	Economic	PEA	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Current land use	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.0	36.0	36.0	36.0	36.0

Grade of Positive Impacts		Grade of Negative Impacts	
0–15.0	Little significant	0–15.0	Little significant
15.1–28.0	Significant	15.1–28.0	Significant
28.1–	Very significant	28.1–	Very significant

Source: Prepared based on PEAs from 6 Basins

In the Chincha River Watershed 62 interaction were identified that may show negative impacts during construction stage, from which 15 are "strong" and 2 are "very strong." From the 7 interaction that may be negative impacts after entering into service, 5 are "strong" and 2 are "very strong."

During the construction stage, plot division, land leveling and other site preparation jobs may be negative to the local topography in all the project sites. It is foreseen that the "bed excavation" in Chico-1, Ma-1 and Ma-2 will have strong impact on topography. After entering into service, it is foreseen that desilting that wants to be done in Ma-3 during construction will have a strong impact on fluvial topography and aquatic fauna.

It is worth mentioning that in 4.9.5 "Monitoring and Control Management Plan" the prevention and mitigation measures will be analyzed as these interactions are "strong and very strong."

Table 4.9.3-4 Environmental Impact Assessment Matrix – The Chincha River Basin

			The Chincha River Basin															
			Construction Stage											Operation Stage				
Medio	Componente	Acciones del proyecto	Labor Recruitment	Site preparation work (Clearing, land grading, Levelled)	Diversion of riverbed (Cofferdams)	Digging and refilling in riverside	Digging and refilling in riverbed	Civil Work (Concreting)	I&O of stone pits and material production plants	DME I&O	Camps work I&O	Carriage Staff	Transportation of machinery, equipment, materials and supplies	Chico1	Chico2	Chico3	Ma1	Ma2
		Puntos de Obras: / Factores Ambientales	Todos	Todos	Todos	Chico 2 y 3	Chico 1, Ma 1 y 2	Chico 1, 2, 3, Ma1	Todos	Todos	Todos	Todos	Todos					
Physique	Air	PM-10 (Particulate matter)	0.0	-12.0	-12.0	-12.0	-12.0	0.0	-18.0	-18.0	0.0	-12.0	-12.0	0.0	0.0	0.0	0.0	0.0
		Gas emissions	0.0	-11.5	-11.5	-11.5	-11.5	-11.5	-11.5	-11.5	0.0	-11.5	-11.5	0.0	0.0	0.0	0.0	0.0
	Noise	Noise	0.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	0.0	0.0	0.0	0.0	0.0
	Soil	Soil fertility	0.0	-11.5	0.0	0.0	0.0	0.0	-14.2	-14.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Land Use	0.0	-14.2	0.0	0.0	0.0	0.0	-15.0	-15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Water	Calidad del agua superficial	0.0	0.0	-17.5	-12.0	-23.0	0.0	-15.0	0.0	0.0	0.0	0.0	0.0	28.0	0.0	0.0	0.0
		Cantidad de agua superficial	0.0	0.0	0.0	0.0	0.0	-9.0	0.0	0.0	-15.0	0.0	0.0	26.0	31.0	26.0	26.0	31.0
	Physiography	Morfología fluvial	0.0	0.0	-12.0	-20.0	-31.0	0.0	-23.0	0.0	0.0	0.0	0.0	-25.5	0.0	26.0	-25.5	-30.5
		Morfología terrestre	0.0	-33.0	0.0	0.0	0.0	0.0	0.0	-28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Biotic	Flora	Terrestrial flora	0.0	-28.0	0.0	0.0	0.0	0.0	0.0	-22.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Aquatic flora	0.0	0.0	-12.0	-14.5	-14.5	0.0	-14.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Fauna	Terrestrial fauna	0.0	-24.2	0.0	0.0	0.0	0.0	0.0	-22.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Aquatic fauna	0.0	0.0	-12.0	-14.5	-22.5	0.0	-15.0	0.0	0.0	0.0	0.0	-25.5	0.0	-25.5	-25.5	-30.5
Socio-economic	Esthetic	Visual landscape	0.0	0.0	0.0	0.0	0.0	0.0	-12.0	-12.0	0.0	0.0	0.0	36.0	0.0	36.0	36.0	36.0
	Social	Quality of life	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-17.5	-17.5	-17.5	36.0	31.0	36.0	36.0	36.0
		Vulnerability - Security	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.0	31.0	36.0	36.0	36.0
	Economic	PEA	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Current land use	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.0	36.0	36.0	36.0	36.0

Grade of Positive Impacts		Grade of Negative Impacts	
0–15.0	Little significant	0–15.0	Little significant
15.1–28.0	Significant	15.1–28.0	Significant
28.1–	Very significant	28.1–	Very significant

Source: Prepared based on PEAs of 6 Basins

In the Pisco River Watershed 67 interaction were identified that may show negative impacts during construction stage, from which 17 are "strong" and 2 are "very strong." From the 8 interaction that may be negative impacts after entering into service, 6 are "strong" and 2 are "very strong."

During the construction stage, plot division, land leveling and other site preparation jobs may be negative to the local topography in all the project sites. It is foreseen that the "bed excavation" in Pi-1, Pi-2, Pi-3 and Pi-4 will have strong impact on topography After entering into service, it is foreseen that desilting that wants to be done in Pi-2 during construction will have a strong impact on fluvial topography and aquatic fauna.

It is worth mentioning that in 4.9.5 "Monitoring and Control Management Plan" the prevention and mitigation measures will be analyzed as these interactions are "strong and very strong."

Table 4.9.3-5 Environmental Impact Assessment Matrix – The Pisco River Basin

			The Pisco River Basin											
			Construction Stage						Operation Stage					
Medio	Componente	Acciones del proyecto	Civil Work (Concreting)	I&O of stone pits and material production plants	DME I&O	Camps work I&O	Carriage Staff	Transportation of machinery, equipment, materials and supplies	Pi1	Pi2	Pi3	Pi4	Pi5	Pi6
		Factores Ambientales / Puntos de Obras:	Pi 1,3,4 y 6	Pi 1,3,4 y 6	Pi 1-6	Pi 1-5	Pi 1-6	Pi 1-6						
Physique	Air	PM-10 (Particulate matter)	0.0	-11.5	-18.0	0.0	-11.5	-11.5	0.0	0.0	0.0	0.0	0.0	0.0
		Gas emissions	-11.5	-11.5	-11.5	0.0	-11.5	-11.5	0.0	0.0	0.0	0.0	0.0	0.0
	Noise	Noise	-15.0	-12.0	-15.0	-15.0	-12.0	-12.0	0.0	0.0	0.0	0.0	0.0	0.0
	Soil	Soil fertility	0.0	0.0	-14.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Land Use	0.0	-15.0	-15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Water	Calidad del agua superficial	0.0	-15.0	0.0	-15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Cantidad de agua superficial	-9.0	0.0	0.0	0.0	0.0	0.0	26.0	31.0	26.0	26.0	0.0	0.0
	Physiography	Morfología fluvial	0.0	-23.0	0.0	0.0	0.0	0.0	-25.5	-30.5	-25.5	-25.5	0.0	0.0
		Morfología terrestre	0.0	0.0	-28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Biotic	Flora	Terrestrial flora	0.0	0.0	-22.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Aquatic flora	0.0	-14.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Fauna	Terrestrial fauna	0.0	0.0	-22.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Aquatic fauna	0.0	-15.0	0.0	0.0	0.0	0.0	-25.5	-30.5	-25.5	-25.5	0.0	0.0
Socio-economic	Esthetic	Visual landscape	0.0	-12.0	-12.0	0.0	0.0	0.0	36.0	36.0	36.0	36.0	0.0	0.0
	Social	Quality of life	0.0	0.0	0.0	-18.0	-18.0	-17.5	36.0	36.0	36.0	31.0	41.0	36.0
		Vulnerability - Security	0.0	0.0	0.0	0.0	0.0	0.0	36.0	36.0	36.0	31.0	41.0	36.0
	Economic	PEA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Current land use	0.0	0.0	0.0	0.0	0.0	0.0	36.0	36.0	36.0	36.0	41.0	36.0

Grade of Positive Impacts		Grade of Negative Impacts	
0–15.0	Little significant	0–15.0	Little significant
15.1–28.0	Significant	15.1–28.0	Significant
28.1–	Very significant	28.1–	Very significant

Source: Prepared based on PEAs of 6 Basins

In the Yauca River Watershed 65 interaction were identified that may show negative impacts during construction stage, from which 13 are "strong" and 3 are "very strong." From the 6 interaction that may be negative impacts after entering into service, 4 are "strong" and 2 are "very strong."

During the construction stage, plot division, land leveling and other site preparation jobs may be negative to the local topography in all the project sites. It is foreseen that the "bed excavation" in Ya-1, Ya-2 and Ya-4 will have strong impact on topography. After entering into service, it is foreseen that riverbed excavation that wants to be done in Ya-2 during construction will have a strong impact on fluvial topography and aquatic fauna.

It is worth mentioning that in 4.9.5 "Monitoring and Control Management Plan" the prevention and mitigation measures will be analyzed as these interactions are "strong and very strong."

Table 4.9.3-6 Environmental Impact Assessment Matrix – The Yauca River Basin

			The Yauca River Basin																
			Construction Stage											Operation Stage					
Medio	Componente	Acciones del proyecto	Labor Recruitment	Site preparation work (Clearing, land grading, Levelled)	Diversion of riverbed (Cofferdams)	Digging and refilling in riverside	Digging and refilling in riverbed	Civil Work (Concreting)	I&O of stone pits and material production plants	DME I&O	Camps work I&O	Carriage Staff	Transportation of machinery, equipment, materials and supplies	Ya1	Ya2	Ya3	Ya4	Ya5	Ya6
		Puntos de Obras: / Factores Ambientales	Ya 1-6	Ya 1-6	Ya 1-6	Ya 4-6	Ya 1, 2 y 3	Ya 1, 3, 4, 5 y 6	Ya 1-6	Ya 1-6	Ya 1-6	Ya 1-6	Ya 1-6						
Physique	Air	PM-10 (Particulate matter)	0.0	-15.0	-11.5	-12.0	-12.0	0.0	-18.0	-18.0	0.0	-12.0	-12.0	0.0	0.0	0.0	0.0	0.0	0.0
		Gas emissions	0.0	-11.5	-11.5	-11.5	-11.5	-11.5	-15.0	-11.5	0.0	-11.5	-11.5	0.0	0.0	0.0	0.0	0.0	0.0
	Noise	Noise	0.0	-12.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	0.0	0.0	0.0	0.0	0.0	0.0
	Soil	Soil fertility	0.0	-14.5	0.0	0.0	0.0	0.0	-14.2	-14.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.0	31.0
		Land Use	0.0	-14.2	0.0	0.0	0.0	0.0	-15.0	-15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Water	Calidad del agua superficial	0.0	0.0	-17.5	-15.0	-23.0	-14.5	-15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.0	31.0	31.0
		Cantidad de agua superficial	0.0	0.0	0.0	0.0	0.0	-9.0	0.0	0.0	-15.0	0.0	0.0	26.0	31.0	26.0	26.0	0.0	0.0
	Physiography	Morfología fluvial	0.0	0.0	-12.0	-26.0	-31.0	0.0	-23.0	0.0	0.0	0.0	0.0	-25.5	-30.5	-25.5	0.0	0.0	0.0
		Morfología terrestre	0.0	-33.0	0.0	0.0	0.0	0.0	0.0	-28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Biotic	Flora	Terrestrial flora	0.0	-24.5	0.0	0.0	0.0	0.0	0.0	-22.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Aquatic flora	0.0	0.0	0.0	0.0	-14.5	0.0	-14.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Fauna	Terrestrial fauna	0.0	-24.2	0.0	0.0	0.0	0.0	0.0	-22.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Aquatic fauna	0.0	0.0	-12.0	-11.5	-17.5	0.0	-14.5	0.0	0.0	0.0	0.0	-25.5	-30.5	-25.5	0.0	0.0	0.0
Socio-economic	Esthetic	Visual landscape	0.0	0.0	0.0	0.0	0.0	0.0	-12.0	-12.0	0.0	0.0	0.0	36.0	36.0	36.0	0.0	36.0	36.0
	Social	Quality of life	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-14.5	-17.5	-17.5	36.0	36.0	36.0	31.0	36.0	36.0
		Vulnerability - Security	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.0	36.0	36.0	31.0	36.0	36.0
	Economic	PEA	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Current land use	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.0	36.0	36.0	36.0	36.0	36.0

Grade of Positive Impacts		Grade of Negative Impacts	
0-15.0	Little significant	0-15.0	Little significant
15.1-28.0	Significant	15.1-28.0	Significant
28.1-	Very significant	28.1-	Very significant

Source: Prepared based on PEAs of 6 Basins

In the Majes-Camana River Watershed 45 interaction were identified that may show negative impacts during construction stage, from which 12 are "strong" and 3 are "very strong." From the 24 interaction that may be negative impacts after entering into service, all are "a little strong" and none has been classified as "strong" or "very strong."

During the construction stage, plot division, land leveling and other site preparation jobs may be negative to the local topography in all the project sites. After entering into service it will have a strong impact on fluvial topography and aquatic fauna.

Like this, according to the environmental and social impact assessments of each watershed, the works that may cause very strong negative impacts during building stage in the 6 watersheds' are "preparation and abandon of working sites" that will strongly affect local topography and "excavation and filling of the river's course" that will strongly affect fluvial topography.

After entering into service, the fluvial topography will change, especially in sites where unclogging wants to be performed during building stage, affecting the aquatic fauna ecosystem very much.

On the other hand, as positive impact in all the 6 watersheds, we are hoping to improve the local inhabitants' life and the use of lands, achieving more safety and reducing vulnerability.

Table 4.9.3-7 Environmental Impact Assessment Matrix – The Majes-Camaná River Basin

			The Majes-Camaná River Basin									
			Construction Stage									Operation Stage
Medio	**Componente**	**Acciones del proyecto**	Labor Recruitment	Site preparation work (Clearing, land grading, Levelled)	Digging and refilling in riverside	Civil Work (Concreting)	I&O of stone pits and material production plants	DME I&O	Camps work I&O	Carriage Staff	Transportation of machinery, equipment, materials and supplies	**MC1-MC7**
		Puntos de Obras: **Factores Ambientales**	**MC1-MC7**	**MC1-MC7**	**MC1-MC7**	**MC1-MC7**	**MC1-MC7**	**MC1-MC7**	**MC1-MC7**	**MC1-MC7**	**MC1-MC7**	
Physique	**Air**	PM-10 (Particulate matter)	0.0	-12.0	-12.0	0.0	-18.0	-18.0	0.0	-12.0	-12.0	0.0
		Gas emissions	0.0	-11.5	-11.5	-11.5	-11.5	-11.5	0.0	-11.5	-11.5	0.0
	Noise	Noise	0.0	-15.0	-12.0	-12.0	-15.0	-15.0	-15.0	-15.0	-15.0	0.0
	Soil	Soil fertility	0.0	-11.5	0.0	0.0	-14.2	-14.2	0.0	0.0	0.0	0.0
		Land Use	0.0	-14.2	0.0	0.0	-15.0	-15.0	0.0	0.0	0.0	0.0
	Water	Calidad del agua superficial	0.0	0.0	-12.0	0.0	-15.0	0.0	0.0	0.0	0.0	0.0
		Cantidad de agua superficial	0.0	0.0	0.0	-9.0	0.0	0.0	-15.0	0.0	0.0	26.0
	Physiography	Morfología fluvial	0.0	0.0	0.0	0.0	-23.0	0.0	0.0	0.0	0.0	-25.5
		Morfología terrestre	0.0	-33.0	-15.0	0.0	0.0	-28.0	0.0	0.0	0.0	-25.5
Biotic	**Flora**	Terrestrial flora	0.0	-28.0	0.0	0.0	0.0	-22.5	0.0	0.0	0.0	0.0
		Aquatic flora	0.0		-14.5	0.0	-14.5	0.0	0.0	0.0	0.0	0.0
	Fauna	Terrestrial fauna	0.0	-24.2	0.0	0.0	0.0	-22.5	0.0	0.0	0.0	0.0
		Aquatic fauna	0.0	0.0	-14.5	0.0	-15.0	0.0	0.0	0.0	0.0	-25.5
Socio-economic	**Esthetic**	Visual landscape	0.0	0.0	0.0	0.0	-12.0	-12.0	0.0	0.0	0.0	36.0
	Social	Quality of life	17.0	0.0	0.0	0.0	0.0	0.0	-17.5	-17.5	-17.5	36.0
		Vulnerability - Security	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.0
	Economic	PEA	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Current land use	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.0

Grade of Positive Impacts		Grade of Negative Impacts	
0–15.0	Little significant	0–15.0	Little significant
15.1–28.0	Significant	15.1–28.0	Significant
28.1–	Very significant	28.1–	Very significant

Source: Prepared based on PEAs of 6 Basins

4.9.4 Socio-Environmental Management Plans

The objective of these plans is to internalize positive environmental impacts as significant and very significant negative impacts, linked to the project's building and operation stages. This in order to guarantee prevention and/or mitigation of significant and very significant negative impacts, environmental patrimony conservation and project's sustainability.

In the construction stage in all the Watersheds, the following measures have been set: "Local hiring Program", "Management and control of construction sites Program," "Channel deviation Program," "Management of excavation and fill banks", "Management of excavation and streams filling," "Quarry Management", "DME handling," "Camp rules and stay in work" and "Transportation activities' management." During the operation stages, the development of activities regarding "Management of streams and aquatic fauna" where conditioning to downstream of the intervention points actions to reduce erosion probability and provide habitability conditions for aquatic fauna species had been considered.

Next, the mitigation measures associated to the negative impacts that mitigate or the improving positive impacts. These environmental management plans for works points where significant or very significant negative impacts should be taken into account.

Table 4.9.4-1 Environmental Impact and Prevention/Mitigation Measures

Item	Impact	Counter Measures	Period
Natural environment	Water quality of surface water	Management of river diversion and coffering	Construction period
		Management of bank excavation and banking	
		Management of riverbed excavation and back filling	
	River topography	Management of bank excavation and banking	
		Management of riverbed excavation and back filling	
		Management of quarry site	
	Other topography	Management of construction site	
		Management of large amount of excavated or dredged material	
	Dust	Management of construction site	
		Management of large amount of excavated and dredged material	
Biological environment	Aquatic fauna	Management of riverbed excavation and back filling	O/M period
	Terrestrial fauna	Management of construction site	Construction period
		Management of large amount of excavated and dredged material	
	Terrestrial flora	Management of construction site	
		Management of large amount of excavated and dredged material	
Social environment	Quality of life	Management of labor and construction office	
		Management of traffic of construction vehicle	
		Employment plan of local people	
	Population of economic activity	Employment plan of local people	

Source: JICA Study Team

4.9.5 Monitoring and Control Plan

This plan has two types of activities:

1. Monitoring: are the verification activities of the set management measures
2. Control: Includes the monitoring and measurement activities for compliance of the environmental regulations like Environmental Quality Standards (ECA's) or Maximum Permissible Limits (LMA's). And the monitoring and control must be carried out under the responsibility of the project's owner or a third party under the supervision of the owner.

· Construction stage

During the construction period of the projects to be done in the 5 watersheds, the Monitoring and Control Plan will be directed to the verification of the fulfillment measures designed as part of the environmental monitoring plan and the verification of the fulfillment of laws and regulation of the Peruvian Legislation. The following aspects will also be monitored:

<u>Water Quality and Biological Parameters:</u>

Water quality and biodiversity parameters control shall be performed at downstream of these works must be monitored. In the following table the profile of this plan is shown.

Table 4.9.5-1 Monitoring to Water Quality and Biological Parameters

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards
pH	pH			"National Standard for Water Quality" D.S. No. 002-2009 MINAM
TSS	mg/l			
BOD/COD	mg/l			
DO	mg/l			
Total Nitrogen	mg/l			
Heavy Metals	mg/l			
Temperature	^{o}C			
Biological Diversity indices: Shannon; Pielou; richness and abundance				

[Measurement Points]
-50 meters upstream the intervention points
-50 meters downstream the intervention points
-100 meters downstream the intervention points
[Frequency]
Quarterly
[Person in charge of Implementation]
DGIH-MINAG, or a third party under the project holder's supervision
Source: JICA Study Team

<u>Air Quality:</u>

During impact analysis, in the projects to be developed in the 5 watersheds no significant impacts will be seen in the activities related to hydraulic infrastructure works. However, the generation of dust and atmospheric contaminant emissions always affects the working area and the workers and inhabitants health. So, it is recommended to monitor air quality.

Table 4.9.5-2 Monitoring to Air Quality

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Peruvian Standards (D.S. No 074-2001-PCM)	Referred International Standards
SO^2				"National Standard for Air Quality" D.S. No.074-2001-PCM	National Ambient Air Quality Standards (NAAQS) (Updated in 2008)
NO^2					
CO					
O^3					
PM-10					
PM-2.5					

[Measurement Points]
*02 stations per monitoring point: Windward and downwind (upwind and against the wind direction)
-1 point at the working zones
-1 point at a quarry, away from the river (the largest and / or the closest point to a populated area)
-1 point at a D.M.E. (the largest and / or the closest point to a populated area)
[Frequency]
Quarterly
[Person in charge of the Implementation]
DGIH-MINAG, or a third party under the project holder's supervision

Source: JICA Study Team

Noise Quality

Likewise, it is proposed to perform a noise monitoring at the potential receptors located near the noise emission spots towards the working sites, in the next table 4.9.4-3, the terms are described.

Table 4.9.5-3 Monitoring to Noise Quality

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards
Noise level	LAeqT (dB(A))			National Environmental Quality Standards for noise (EQS) - S.N. N° 085-2003-PCM	-IEC 651/804 – International -IEC 61672- New Law: Replaces IECs 651/804 -ANSI S 1.4 – America

[Measurement Point]
Monitoring to acoustic contamination levels will be carried out at the potential receivers that are located around the noise emission points per work front.
01 point per potential receiver will be monitored.
[Frequency]
Every two months during construction phase
[Person in charge of the Implementation]
DGIH-MINAG, or a third party under the project holder's supervision

Source: JICA Study Team

· Operation Stages

Regarding works impact of all projects, it is mainly recommended to monitor biologic parameters and water quality as river topography and the habitat of aquatic life.

Table 4.9.5-4 Monitoring to Water Quality (Operation Stage)

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards
pH	pH			"National Standard for Water Quality" D.S. No. 002-2009 MINAM
TSS	mg/l			
BOD/COD	mg/l			
DO	mg/l			
Total Nitrogen	mg/l			
Heavy Metals	mg/l			
Temperature	^{o}C			
Biological Diversity indices: Shannon; Pielou; richness and abundance				

[Measurement Points]
-50 meters upstream the intervention points
-50 meters downstream the intervention points
-100 meters downstream the intervention points
[Frequency]
Quarterly in first two years of operation phase
[Person in charge of Implementation]
DGIH-MINAG, or a third party under the project holder's supervision

Source: JICA Study Team

(2) Closure or Abandon Plan

Closure or abandon plans have been made for each watershed. These will be executed at the end of construction activities and involves the removal of all temporary works and restoration of intervened and/or affected areas as a result of the works execution. The restoration includes the removal of contaminated soil, disposal of waste material, restoration of soil morphology and restoration with vegetation of intervened sites.

(3) Citizen Participation

Citizen participation plans have been made for each watershed, which must be executed before and during construction and when the works are completed. The recommended activities are:

• Before works: Organize workshops in the surrounding community's area near the project and let them know what benefits they will have. Informative materials in communities, which will explain the profile, lapse, objectives, benefits, etc. of the Project

• During works execution: Give out information on the construction progress. Responding complaints generated from the local community during works execution. For this, a consensus wants to be previously achieved with the community in order to determine how claims will be met

• When works are completed: Organize workshops to inform about works completion. Works delivery to the local community inviting local authorities for the transfer of goods, which means the work finished.

4.9.6 Budget for the environmental impact management

Next, direct costs for the environmental impact management measures previously mentioned according to watershed is detailed in the table.

Table 4.9.6-1 Direct costs of measures to manage environmental impact

Actions	Unit	Qty	Unitary price (S/.)	Subtotal (S/.)	Total (s/.)
Sign for vehicles entrance	Month	6	S/. 1.400,0	S/. 8.400,0	S/. 8.400,0
Industrial weaste transportation	Month	6	S/. 4.200,0	S/. 25.200,0	S/. 25.200,0
Project sites landscape protection measures	Month	6	S/. 2.800,0	S/. 16.800,0	S/. 16.800,0
Operation and maintenance of construction equipment	Month	6	S/. 1.960,0	S/. 11.760,0	S/. 11.760,0
Measures for staff noise protection	Month	6	S/. 1.120,0	S/. 6.720,0	S/. 6.720,0
Functioning expenses to implement environmental impact mitigation measures	Month	6	S/. 4.480,0	S/. 26.880,0	S/. 26.880,0
Soil and air contaminant prevention capacity development	Month	6	S/. 2.520,0	S/. 15.120,0	S/. 15.120,0
Bed and aquatic fauna monitoring					S/. 11.239,2
Diversity indicators monitoring	times	3	S/. 672,0	S/. 2.016,0	
Water flow monitoring	times	3	S/. 588,0	S/. 1.764,0	
Tº, pH, OD monitoring	times	3	S/. 571,2	S/. 1.713,6	
DBO monitoring	times	3	S/. 638,4	S/. 1.915,2	
Total solids dissolve monitoring (SDT)	times	3	S/. 638,4	S/. 1.915,2	
Total suspended solids monitoring (SST)	times	3	S/. 638,4	S/. 1.915,2	
Air and noise quality monitoring					S/. 37.500,0
Gas emissions monitoring	times	3	S/. 4.500,0	S/. 13.500,0	
Dust monitoring	times	3	S/. 5.000,0	S/. 15.000,0	
Noise monitoring	times	3	S/. 3.000,0	S/. 9.000,0	
Total					S/. 159.619,2

4.9.7 Conclusions and Recommendations

(1) Conclusions

According to the Preliminary Environmental Assessment regarding impacts on construction and operation stage, most of the identified impacts are characterized by mild significance. The ones with significant and very significant negative impacts are controllable or mitigated; always that the Environmental Management Plans are performed properly.

Also, significant positive impacts exist, especially in the operation stage. These are: safety improvement and vulnerability reduction of social and environmental levels, improvement of the life quality of the influence area population and enhancing the “current land use.”

(2) Recommendations

1) Starting construction works in the dry season is recommended

Meanwhile, Chira, Cañete and Majes-Camana Rivers keep their flows along the year (with season variations), Chincha (Chico and Matagente), Pisco and Yauca are rivers that have marked periods of flood and drought. It is important to develop the work’s implementation schedule taking into account the area’s agricultural cycle, since many of the sites are located near agricultural lands. In this way, the impact of local residents that have to transport agricultural machinery and crops can be minimized.

2) About ecosystem impact, it is important to take into account that to Chira River, during flood season between November until March, flamingos arrive, although in little amount. The impact on these birds may be mitigated by avoid performing works during this season.

3) About land topic, the following measures must be taken into consideration in case it is not clear in which parts the works will be executed. The DGIH of MINAG, as executor of the Project, shall: ① clearly define the stages of the project, immediately after E/F, and ② identify land and users included in these lands that will be used in the Project. Afterwards, the necessary lands will have to be obtained fulfilling the set procedures in the Expropriation General Regulation. In case the land is owned by the community, it must be negotiated with the correspondent local community and achieve consensus.

4) For procedures related to cultural heritage conservation, DGIH must obtain CIRA before starting the Project, fulfilling the procedures provided for such purpose, immediately after E/F is completed.

5) Regarding to gender, so far it has been noted that there has been a certain percentage of women participating in the activities of the irrigation commissions, but not in the capacity building workshops. Therefore, it is necessary to take some steps to promote women’s participation within the components of this Project. For example, bearing in mind that there are several groups of women in the Project’s Watersheds, women can be summoned in the workshops that are organized by these groups. It is also necessary to consider women’s working hours and choose dates and times that they are easy for them to participate.

6) Finally, the actions to be taken in order to let DGIH obtain the necessary environmental license for the Project are indicated. On April 2011, DGAA-MINAG evaluates EAP report to determine the status of the Project. In case, it is classified as Category I, the environmental license shall be issued. If it is classified as Category II or III, it requires EIA-sd or EIA -d as indicated by DGAA, and must obtain an environmental license before finishing stage E/F.

4.10 Execution Plan

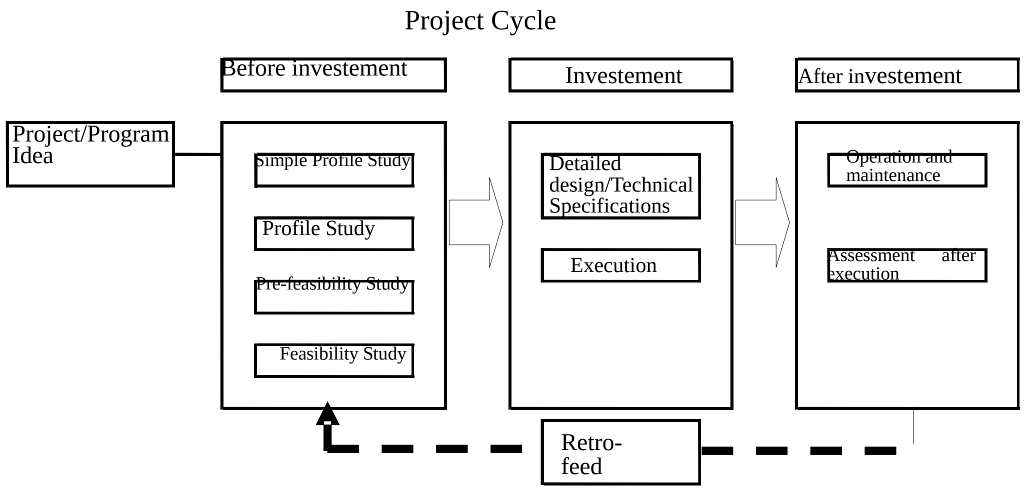
The Project's Execution Plan will be examined in the preliminary schedule, which includes the following components. For pre-investment stage: ① full execution of pre-feasibility and feasibility studies to obtain SNIP's approval in the pre-investment stage; for the investment stage: ② signing of loans (L/A), ③ consultant selection, ④ consulting services (detailed design and elaboration of technical specifications), ⑤ constructor selection and ⑥ work execution. For the post-investment stage: ⑦ Works' completion and delivery to water users associations and beginning of the operation and maintenance stage.

(1) Review by the Public Investment National System (SNIP)

In Peru, the Public Investment National System (SNIP hereinafter) is under operation. This reviews the rationality and feasibility of public investment projects, and will be applied to this Project.

In SNIP, among previous studies to an investigation, it will be conducted in 3 stages: profile study (study on the project's summary), pre-feasibility and feasibility. SNIP was created under Regulation N° 27293 (published on June 28, 2000) in order to achieve efficient use of public resources for public investment. It establishes principles, procedures, methods and technical regulations to be fulfilled by central/regional governments in public investment scheme plans and executed by them.

SNIP, as described below, is all public works projects which are forced to perform a 3-stage pre-investment study: profile study, pre-feasibility and feasibility, and have them approved. However, following the Regulation amendment in April 2011, the execution of pre-feasibility study of the intermediate stage was considered unnecessary; but in return, a study based on primary data during the profile study is requested. The required precision degree throughout all stages of the study has hardly changed before and after this modification.

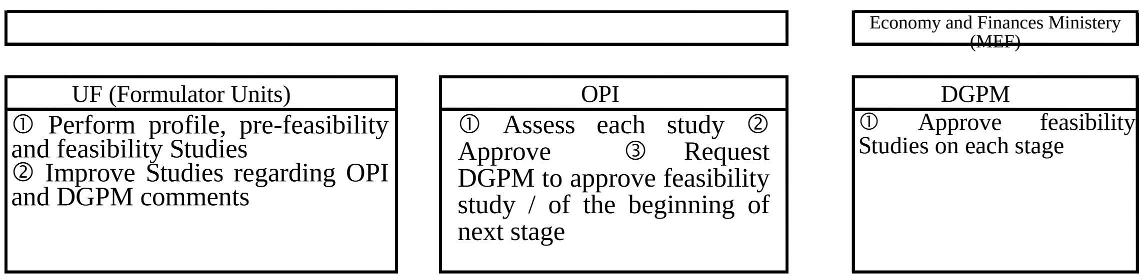


(Source: DGPM HP)

Figure 4.10-1 SNIP Project Cycle

In order to carry out this Project, which is a project composed by several programs, pre-investment studies at investments' programs level are required to be performed and also have them approved.

Although the procedure is quite different in each stage, in SNIP procedures, the project's formulation unit (UF) conducts studies of each stage, the Planning and Investment Office (OPI) assesses and approves the UF's presented studies and requests Public Sector Multi-Annual Programming General Direction (hereinafter referred DGPM) to approve feasibility studies and initiation of following studies. Finally DPGM evaluates, determines and approves the public investment's justification.



(See Regulation No.001-2009-EF/68.01.)

Figure 4.10-2 Related Institutions to SNIP

Due to the comments of examining authorities (OPI and DGPM) to UF, it will be necessary to prepare correspondent responses and improve the studies. Since these authorities officially admit applications after obtaining definitive answers, there are many cases in which they take several months from the completion of the study report until the completion of the study.

It is important to obtain well recognition of the contents and effectiveness of the project, for which UF is required to present the effect of project from the view point of study, design, construction plan as well as public investment and operation in continuity of the project. The study of natural conditions, planning of facilities, cost estimate, financial analysis etc. and also the table of contents of the study report should follow the regulation of SNIP.

DGIH registered 4 rivers except for Yauca river to SNIP on July 21, 2011 based on the Project Report of 5rivers (Chira, Cañete, Chincha, Pisco and Yauca rivers). DGIH did not register Yauca river due to its low economic viability. And DGIH registered Majes-Camana river to SNIP on January 9, 2012.

OPI had examined project reports with pre-F/S level of 4 rivers (Chira, Cañete, Chincha and Pisco) from the end of July and issued their comments September 22, 2011. The correction of the reports and negotiation with OPI is still under progress. Chira river was excluded due to low economic viability depending on reducing the number of flood prevention facilities.
The comments on Majes-Camana river were not issued by OPI

(2) Yen loan contract

Once the feasibility report of this Project is submitted, then the OPI and DGPM examine the contents of report, and finally the declaration of viability of the Project is to be issued by DGPM. After that the appraisal mission of JICA is dispatched and the negotiation of loan agreement is commenced and Loan Agreement (LA) is concluded. The period of negotiation period is assumed about 9 months.

(3) Procedure of the project's execution

After the documents are assessed by SNIP and a loan agreement between Japan (JICA) and the Peruvian counterpart is signed, a consultant will be selected. The consulting service includes the detailed design and technical specifications, the contractors' selection and the work's supervision. Next find the required time for each process. Table 4.10-1 presents the Project's overall schedule.

1) Consultant selection: 3 months

2) Detailed design and technical specifications of the work: 6 months

3) Contractor selection: 12 months

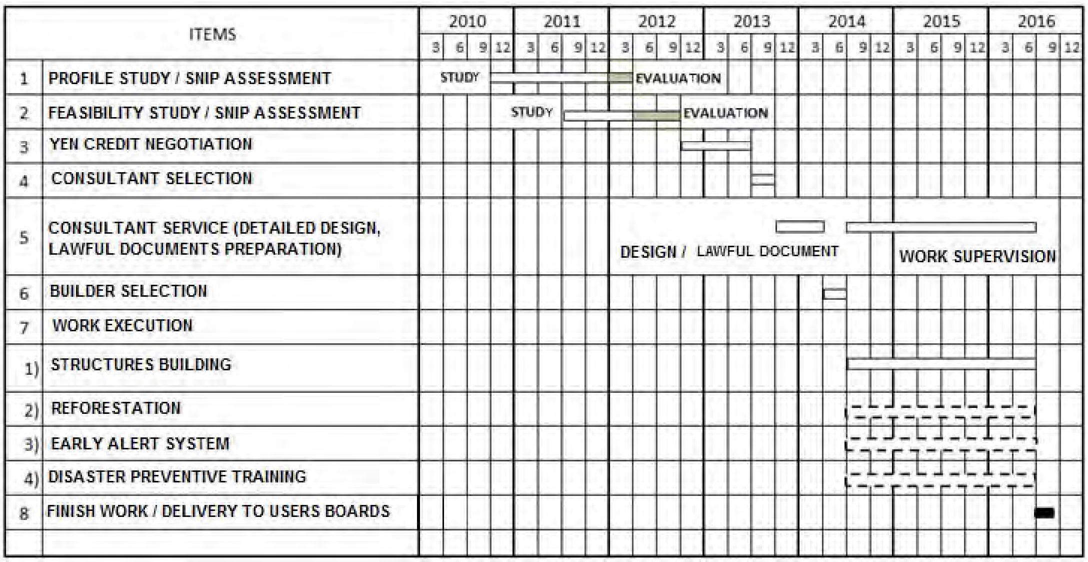
4) Construction supervision by Consultant on river structures and plantation along river

structures: 24 months

5）Construction of river structures and plantation along river structure :24months

6）Disaster prevention/Capacity development in parrael with construction work:24 months

Table 4.10-1 Implementation Plan



4.11 Institutions and Administration

Peruvian institutions regarding the Project's execution and administration are the Agriculture Ministry, Economy and Finance Ministry and Irrigation Commission, with the following roles for each institution:

Ministry of Agriculture (MINAG)

＊The Ministry of Agriculture (MINAG) is responsible for implementing programs and the Hydraulic Infrastructure General Direction (DGIH) is responsible for the technical administration of the programs. The Hydraulic Infrastructure General Direction (DGIH) is dedicated to the coordination, administration and supervision of investment programs

＊ In investment stage, the DGIH project management is dedicated to calculate project costs, detail design and supervision of the works execution. The study direction conducts studies for projects and planning formation

＊ The Planning and Investment Office (IPO) from the Agriculture Ministry is the one responsible for pre-feasibility and feasibility studies in the pre-investment stage of DGIH projects and requests approval of DGPM from the Economy and Finance Ministry (MEF)

＊ The General Administration Office of the Agriculture Ministry (OGA-MINAG) along with the Public Debt National Direction (DNEP) of the Economy and Finance Ministry is dedicated to financial management. It also manages the budget for procurement, commissioning works, contracting, etc. from the Agriculture Ministry
＊ The Environmental Affairs General Direction (DGAA) is responsible for reviewing and approving the environmental impact assessment in the investment stage

Economy and Finance Ministry (MEF)
＊ The DGPM approves feasibility studies. It also confirms and approves the conditions of loan contracts in yen. In the investment stage, it gives technical comments prior to the project execution.
＊ Financial management is in charge of DNEP from the Economy and Finance Ministry and **OGA-MINAG**
＊The Public Debt National Direction (DNEP) of the Economy and Finance Ministry administers expenses in the investment stage and post-investment operation

Irrigation Commission
＊ Responsible for the operation and maintenance of facilities at the post-investment operation stage

The relationship between the involved institutions in the Project's execution is shown in Figures 4.11-1 and 4.11-2.
In this Project, the investment stage (Project execution) corresponds to PSI from MINAG. The PSI is currently performing JBIC projects, etc. and in case of beginning a new project, it forms the correspondent Project Management Unit (UGP), who is responsible of choosing the consulting firm, hire construction services, works supervision, etc. The following figure describes the structure of the different entities involved in the Project's execution stage.

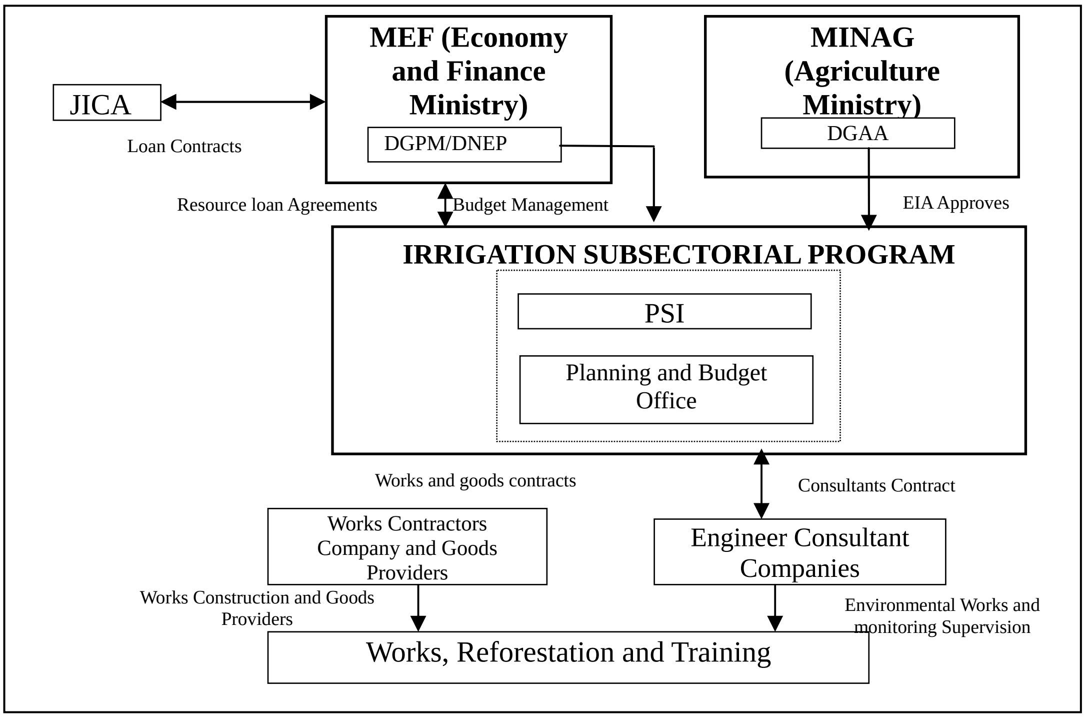


Figure 4.11-1 Related institutions to the Project's execution (investment stage)

The main operations in the post-investment stage consist of operation and maintenance of the built works and the loan reimbursement. The O & M of the works will be assumed by the respective irrigation commission. Likewise, they should pay the construction costs in credits mode. Next, the relationship of different organizations involved in post-project implementation stage is detailed.

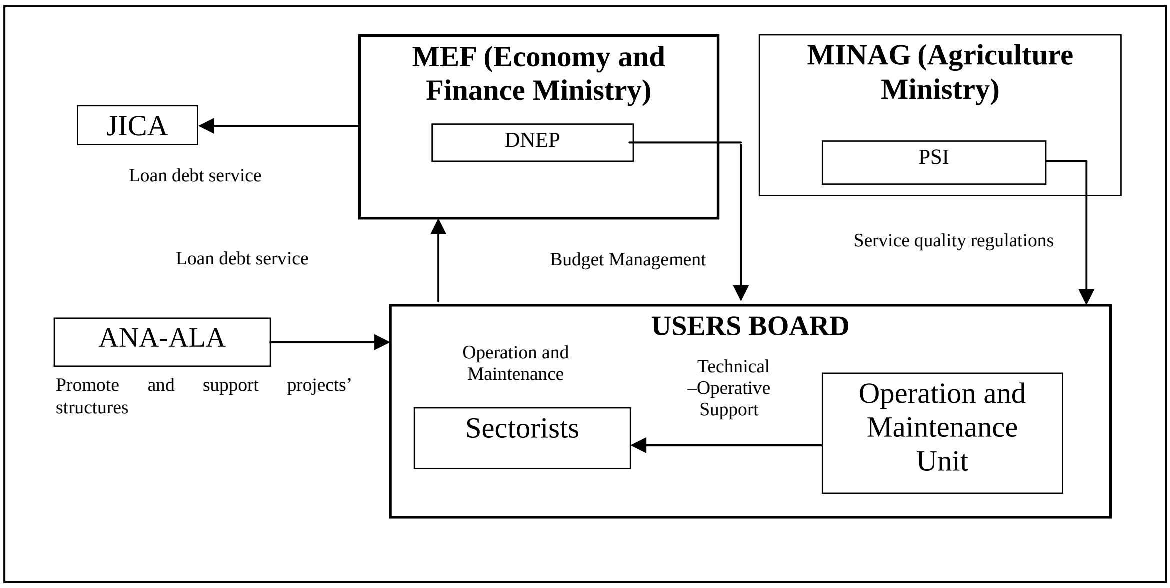


Figure 4.11-2 Institutions related to the Project (operation and maintenance stage)

(2) DGIH

1) Role and Functions

The Hydraulic Infrastructure General Direction is in charge of proposing public policies, strategies and plans aimed to promoting water infrastructure development, according with the Water Resources National Policy and the Environmental National Policy.

Water Infrastructure development includes studies, works, operation, maintenance and construction risk management, fit-out, improve and expand dams, intakes, river beds, irrigation channels, drains, meters, outlets, groundwater wells and modernize plot irrigation.

2) Main functions

a. Coordinate with the planning and budget office to develop water infrastructure and propose sectorial and management policies on infrastructure development. Monitor and assess the implementation of sectorial policies related to hydraulic infrastructure development

b. Propose government, region and provinces intervention regulations, as part of sectorial policies

c. Verify and prioritize hydraulic infrastructure needs

d. Promote and develop public investment projects at the hydraulic infrastructure profile level

e. Elaborate technical regulations to implement hydraulic infrastructure projects

f. Promote technological development of hydraulic infrastructure

g. Elaborate operation and maintenance technical standards for hydraulic infrastructure

(2) PSI

1) Function

The Irrigation Sub-sectorial Program (PSI) is responsible of executing investment projects. A respective management unit is formed for each project.

2) Main functions

a. Irrigation Sub-sectorial Program - PSI, under the Agriculture Ministry, is a body with administrative and financial autonomy. It assumes the responsibility of coordinating, managing and administering involved institutions in projects in order to meet goals and objectives proposed in investment projects

b. Also, it coordinates the disbursements of foreign cooperation agencies financing, such as JICA.

c. The Planning, Budget and Monitoring Office of PSI is responsible for hiring services, elaborating investment programs, as well as project execution plans. These Project preparation works are executed by hiring “in-house” consultants.

d. Likewise, it gathers contractors, makes a lease, executes works and implements supply projects, etc.

e. Contract management is leaded by the Planning, Budget and Monitoring Office

3) Budget

In Table 4.11-1 the PSI budget for 2011 is shown.

Table 4.11-1 PSI Budget (2011)

Programs / Projects / Activities	PIM (S/.)
JBIC Program (Loan Agreement EP-P31)	69.417.953
Program - PSI Sierra (Loan Agreement 7878-PE)	7.756.000
Direct management works	1.730.793
Southern Reconstruction Fund (FORSUR)	228.077
Crop Conversion Project (ARTRA)	132.866
Technified Irrigation Program (PRT)	1.851.330
Activity- 1.113819 small farmers...	783.000
PSI Management Program (Other expenses)	7.280.005
TOTAL	**89.180.024**

4) Organization

PSI is conformed by 235employees, from which 14 are assigned for JBIC Projects and 29 technicians and assistants are working under them.

Table 4.11-2 PSI Payroll

Central Level	Data from May 31, 2011		
	CAS	Servic. and Consult.	TOTAL
Main Office	61	43	104
Zonal Office LIMA	12	24	36
Zonal Office AREQUIPA	14	12	26
Zonal Office CHICLAYO	17	13	30
Zonal Office TRUJILLO	13	26	39
TOTAL	**117**	**118**	**235**

In Figure 4.11-3, PSI organization is detailed:

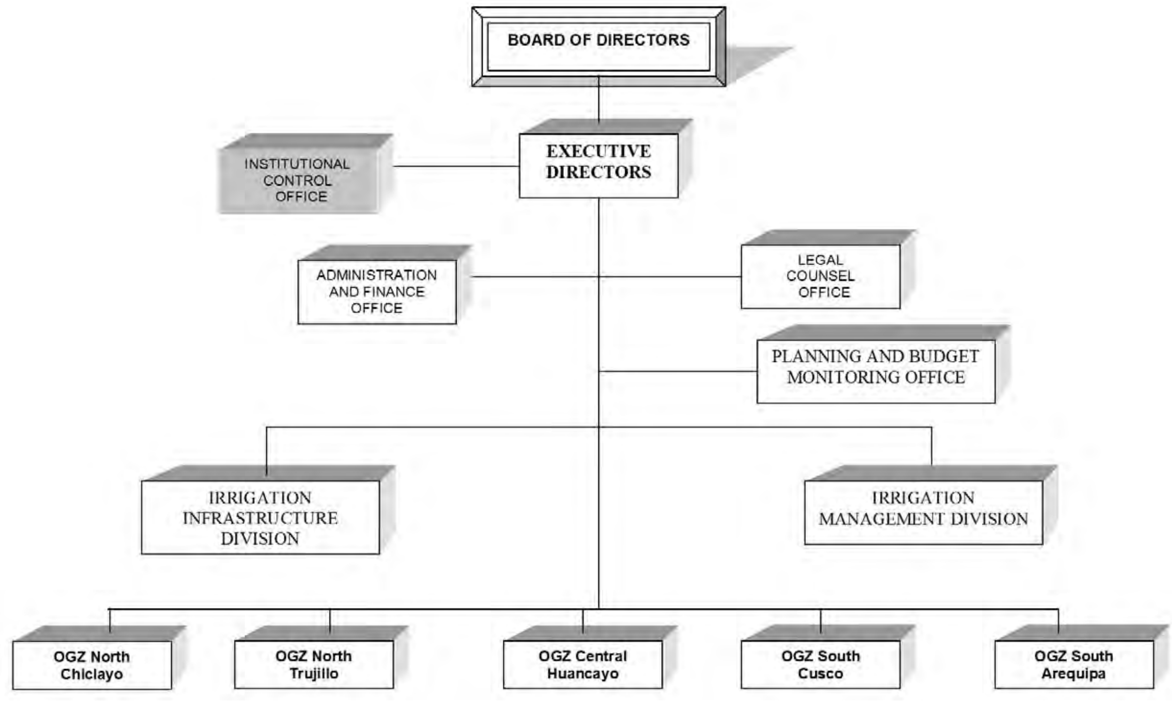


Figure 4.11-3 Organization of PSI

4.12 Logical framework of the eventually selected option

In Table 4.12-1 the logical framework of the definite selected option is shown.

Table 4.12-1 Logical framework of the definite selected option

Narrative Summary	Verifying Indicators	Verifying Indicators Media	Preliminary Conditions
Superior Goal			
Promote socioeconomic local development and contribute in communities' social welfare.	Improve local productivity, generate more jobs, increase population's income and reduce poverty index	Published statistic data	Scio-economic and policy stability
Objectives			
Relief the high vulnerability of valleys and local continuity to floods	Types, quantity and distribution of flood control works, population and beneficiaries areas	Monitoring annual calendar works and financial plan, budget execution control	Ensure the necessary budget, active intervention from central and regional governments, municipalities, irrigation communities, local population, etc.
Expected results			
Reduction of areas and flooded areas, functional improvement of intakes, road destruction prevention, irrigation channels protection, margin erosion control and Poechos dike safety	Number of areas and flooded areas, water intake flow variation, road destruction frequency, margin erosion progress and watershed's downstream erosion.	Site visits, review of the flood control plan and flood control works reports and periodic monitoring of local inhabitants	Maintenance monitoring by regional governments, municipalities and local community, provide timely information to the superior organisms
Activities			
Component A: Structural Measures	Dikes rehabilitation, intake and margin protection works, road damages prevention, construction of 28 works, including dike's safety	Detailed design review, works reports, executed expenses	Ensure the works budget, detailed design/works execution/good quality works supervision
Component B: Non-Structural Measures			
B-1 Reforestation and vegetation recovery	Reforested area, coastal forest area	Works advance reports, periodic monitor by local community	Consultants support, NGO's, local community, gathering and cooperation of lower watershed community
B-2 Early alert system	Installed equipments, operational state, emitted alerts state, emitted alerts frequency and information transmission state	Work advance reports, public entity and local community monitoring	Equipment adequate functioning, appropriate staff training, communication and promotion, equipment and programs O & M
Component C: Disaster prevention and capabilities development education	Number of seminars, trainings, workshops, etc	Progress reports, local governments and community monitoring	Predisposition of the parties to participate, consultants and NGO's assessments
Project's execution management			
Project's management	Detailed design, work start order, work operation and maintenance supervision	Design plans, work's execution plans, costs estimation, works specifications, works management reports and maintenance manuals	High level consultants and contractors selection, beneficiaries population participation in operation and maintenance

4.13 Middle and long term Plan

Up to this point, only flood control measures have been proposed and these must be executed most urgently, due to the limitations on the available budget for this Project. However, there are other measures that must be performed in the long term framework. In this section we will be talking about the middle and long term flood control plan.

4.13.1 Flood Control General Plan

There are several ways to control floods in the entire watershed, for example building dams, retarding basins, dikes or a combination of these.

In case of building a dam, assuming that this will reduce the flood peak (maximum flow) with a 50 year return period to an equivalent flow of 10 return years. It will be necessary to build a dam with 14.6 million m3 capacity for Cañete River, 4.4 million m3 capacity for Chincha River, 5.8 million m3 capacity for Pisco River, 3.7 million m3 capacity for Yauca River and 48.6 million m3 capacity for Majes-Camana River. Usually upstream of an alluvial area, there is canyon like steep topography, and in order to build a dam with enough capacity, a very high dam need to be built, which implies investing a large amount (more than thousand million soles).
Also, it would take between three to five years to identify the dam site, perform geological survey, material assessment and conceptual design. The impact on the local environment is huge. So, it is considered inappropriate to include the dam analysis option in this Study.

Likewise, the option of building a retarding basin would be lightly viable for the same reasons already given for the dam, because it would be necessary to build a great capacity retarding basin and it is difficult to find a suitable location because most of the flat lands along the river’s downstream are being used for agricultural purposes. So, its analysis has been removed from this Study.

Therefore, we will focus our study in the construction of dyke because it is the most viable option.

(1) Plan of the river’s course

1) Discharge capacity

An estimation was done on the discharge capacity of the current flow based on longitudinal and cross sectional river survey, which results are shown in Table 3.1.10 and Figure 3.1.10-3.

2) Inundation characteristics

Inundation analysis of each River was performed. In Table 3.1.10 and Figures 3.1.10-9, 3.1.10-14 the inundation condition for floods with probabilities of 50 years is shown. The inundation characteristics are shown in Table 4.13.1-1.

Table 4.13.1-1 Inundation characteristics of each river

Rivers		Inundation characteristics
Chira		The lack of discharge capacity produces overflows in every section and reaches lower and flat lands along the river
Cañete		Water overflows 10km from the mouth upwards due to the lack of discharge capacity of the river, but it floods only crop areas near the river. However, 10 km from the mouth downwards, when water overflows, causes floods in large areas, specially on the right margin
Chincha	Río Chico	It overflows on km 15 and km 4 from the mouth, flooding great areas of left margin
	Río Matagente	It overflows on sections of km10 and km4 from the mouth, flooding great areas of right margin
Pisco		Water overflows at km 7 from the mouth upwards, due to the lack of discharge capacity of the river, but it only floods nearby the river. However, from km7 downwards, when water overflows, it causes floods in great areas doing several damages in the urban area of Pisco
Yauca		It overflows from km 7 downwards, flooding crop areas of the right margin
Majes-Camana		There are sections in which the discharge capacity is very reduced. Specially, the overflow water is flooding crop areas of left margin of km 4 and km55 from the mouth and on the right margin on km62

3) Design flood level and dike’s standard section

The design flood level was determined in the flood water level with a return period of 50 years, and the dike’s standard section is determined as already mentioned in section 4.3.1, 5), 1). In Table 4.13.1-2, as an example, the theoretical design flood level and the required height of the Cañete River crown is shown. (For the other Rivers see Annex 4)

4) Dikes’ Alignment

Considering the current conditions of existing dikes the alignment of the new dikes was defined. Basically, the broader possible river width was adopted to increase the discharge capacity and the retard effect. In Figure 4.13.1-1 the current channel and the setting alignment method of a section where the current channel has more width is explained schematically. In a normal section, the dike’s crown has the same height to the flood water level with a return period of 50 years plus free board, while in the sections where the river has greater width, double dikes be constructed with inner consistent dike alignment and continuous with normal sections upstream and downstream. The crown height is equal to the flood water level with a return period of 50 years. The external dike’s crown height is equal to flood water level with a return period of 50 years, so in case the river overflows the internal dike, the open gap between the two dikes will serve to store sediments and retarding water.

Table 4.13.1-2 Relation between flood water level in different return periods (example: Cañete River)

Km Mark 標	Dike Height / current land		Theoretical water level			
	Left margin	Right margin	1/5	1/10	1/25	1/50
0.0	3.04	2.42	2.6	3.0	3.5	3.9
0.5	10.85	6.43	4.7	5.4	6.1	6.7
1.0	19.26	15.46	10.2	10.7	11.2	11.7
1.5	23.14	22.02	17.5	17.9	18.3	18.5
2.0	28.54	24.14	23.4	23.8	24.2	24.5
2.5	29.77	30.43	29.3	29.6	30.1	30.4
3.0	39.57	36.32	34.9	35.4	36.0	36.5
3.5	44.29	41.17	39.6	40.3	41.0	41.5
4.0	50.87	44.51	44.1	44.4	45.2	45.9
4.5	50.77	50.90	49.3	50.0	50.8	51.5
5.0	56.72	55.97	54.5	55.1	56.1	56.7
5.5	61.60	62.63	59.3	60.1	60.6	61.3
6.0	67.94	67.29	64.8	65.4	66.0	66.8
6.5	71.98	72.26	70.6	71.1	71.7	72.2
7.0	75.91	77.89	75.9	76.5	77.2	77.9
7.5	84.54	83.93	81.3	81.8	82.6	83.1
8.0	87.14	86.94	87.2	87.8	88.6	89.2
8.5	92.88	94.92	93.0	93.6	94.4	95.1
9.0	97.59	99.58	97.5	98.4	99.2	99.9
9.5	103.52	106.09	103.3	103.9	104.4	104.9
10.0	113.17	112.15	108.0	108.7	109.6	110.2
10.5	115.92	115.66	115.0	115.5	116.2	116.7
11.0	120.02	120.74	120.1	120.6	121.3	121.9
11.5	126.04	125.46	125.6	125.9	126.3	126.6
12.0	133.58	131.61	131.7	132.0	132.3	132.6
12.5	138.25	137.29	137.3	137.7	138.2	138.6
13.0	144.87	144.19	143.6	144.0	144.6	145.0
13.5	151.37	149.50	149.5	150.0	150.6	151.1
14.0	157.25	155.68	155.4	156.0	156.7	157.3
14.5	163.04	162.65	160.8	161.3	162.0	162.7
15.0	169.07	168.02	166.9	167.4	168.0	168.5
15.5	174.33	173.29	172.1	172.6	173.3	173.8
16.0	178.76	179.67	178.3	178.7	179.2	179.6
16.5	189.69	184.90	183.9	184.3	184.7	185.0
17.0	198.92	190.23	190.7	191.2	191.8	192.3
17.5	204.00	196.35	196.1	196.7	197.4	198.0
18.0	208.64	202.64	202.2	202.7	203.2	203.7
18.5	216.02	208.07	207.5	207.9	208.3	208.9
19.0	231.58	214.00	214.2	214.6	214.9	215.2
19.5	234.50	219.81	220.6	220.9	221.3	221.6
20.0	227.59	225.71	226.4	226.8	227.4	227.8
20.5	232.17	231.84	232.1	232.4	232.8	233.2
21.0	239.69	238.14	238.4	238.8	239.3	239.7
21.5	243.75	244.32	244.0	244.5	245.2	245.7
22.0	258.48	248.71	249.5	250.1	250.6	251.1
22.5	261.54	255.90	255.3	255.9	256.3	256.7
23.0	277.79	260.72	261.1	261.7	262.5	263.2
23.5	286.32	266.55	266.2	266.8	267.7	268.3
24.0	293.96	274.25	272.5	273.1	273.7	274.2
24.5	279.29	280.51	278.4	278.8	279.3	279.7
25.0	305.10	286.83	284.3	284.8	285.4	285.9
25.5	310.22	289.46	289.7	290.4	291.2	292.0
26.0	317.26	295.71	295.1	295.9	296.6	297.3
26.5	307.24	302.64	300.5	301.4	302.4	303.3
27.0	307.18	306.25	305.5	306.6	307.6	308.6
27.5	335.69	311.92	310.5	311.2	312.6	313.5
28.0	342.51	321.75	315.2	315.9	316.5	317.2
28.5	323.24	329.22	322.9	324.1	325.5	326.6
29.0	331.04	327.61	328.0	329.0	330.3	331.3
29.5	335.86	332.81	333.4	334.5	335.9	336.9
30.0	340.36	343.00	339.3	340.2	341.2	342.0
30.5	346.28	347.78	346.5	347.4	348.4	349.4
31.0	352.37	355.00	351.6	352.8	354.3	355.5
31.5	363.03	362.32	359.2	360.4	361.9	363.1
32.0	372.35	365.18	365.8	366.5	367.5	368.4
32.5	375.30	373.38	372.4	373.6	375.3	376.7

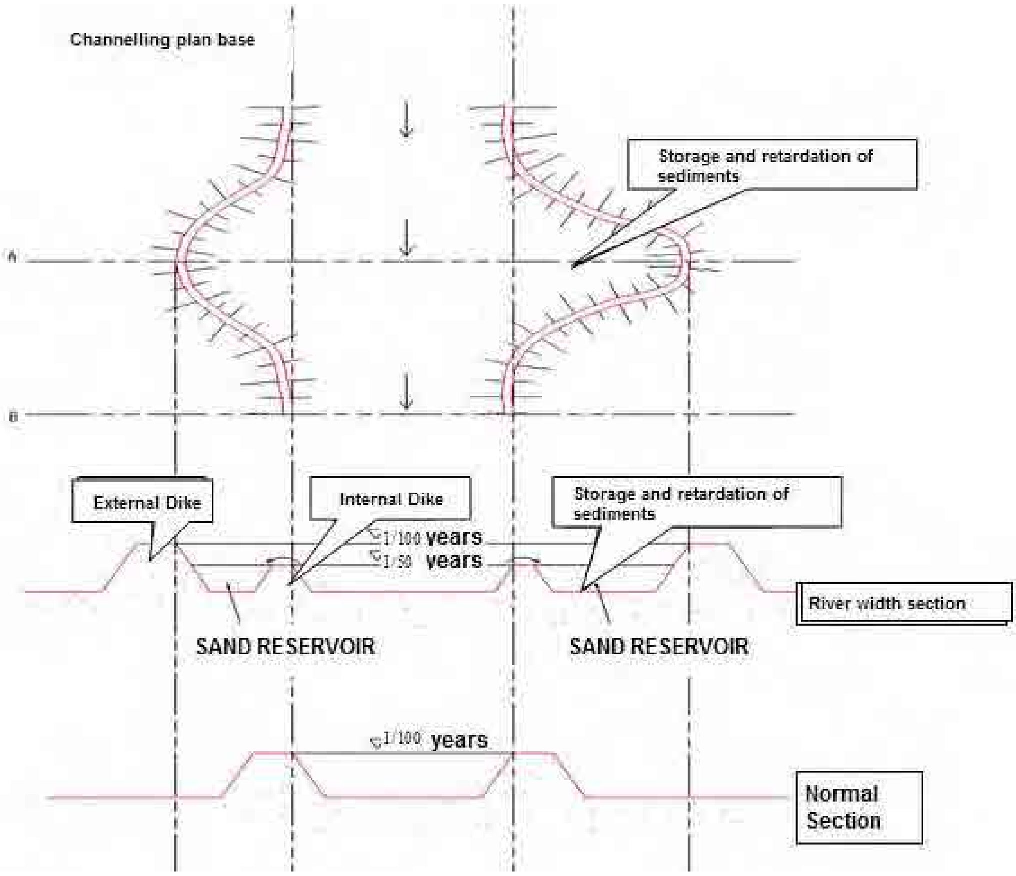


Figure 4.13.1-1 Definition of dike alignment

5) Plan and section of river

In Figures 4.13.1-2 ~ -4.13.1-7 the plan and longitudinal section of each river is shown.

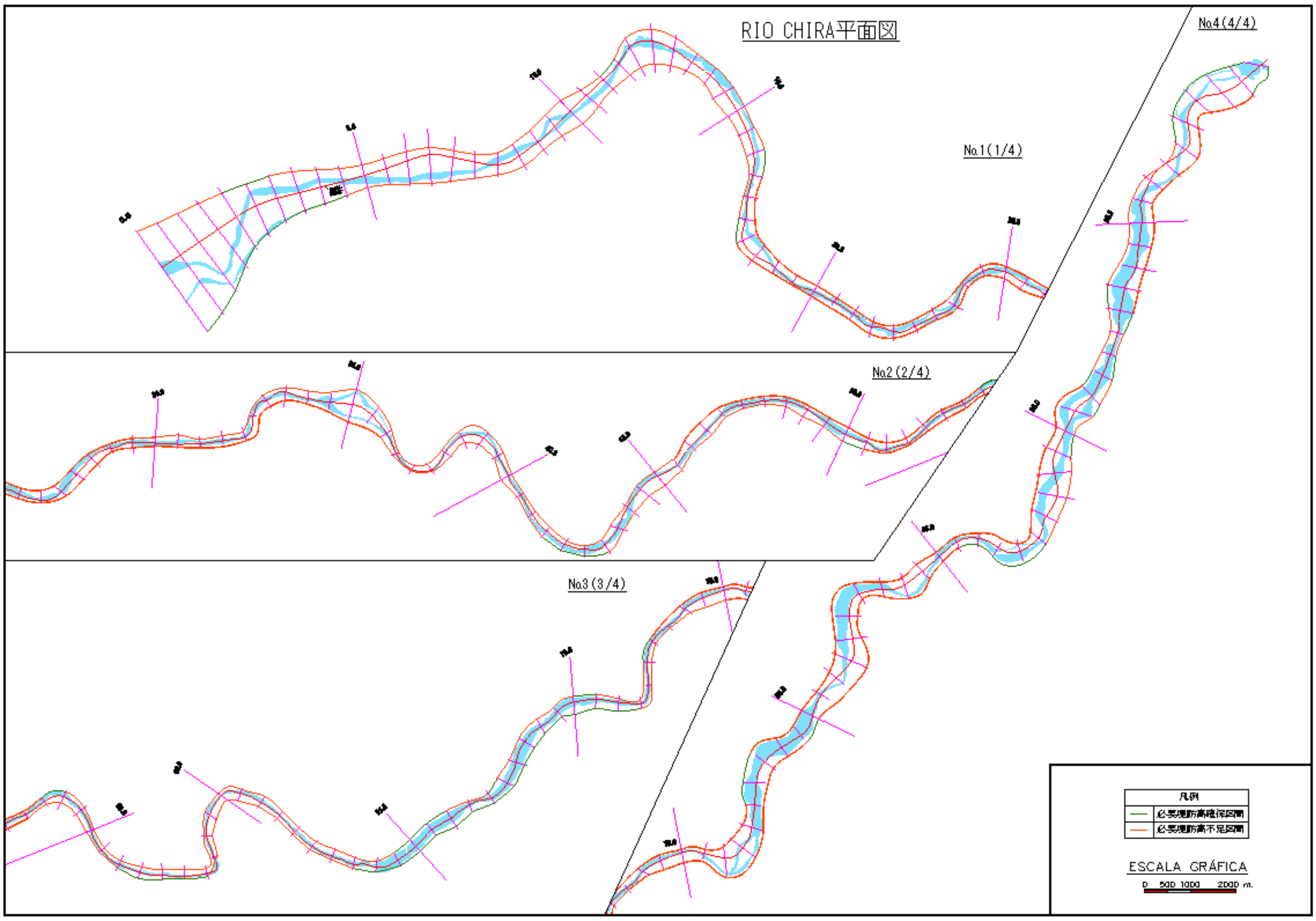


Figure 4.13.1-2 Plan of Chira River

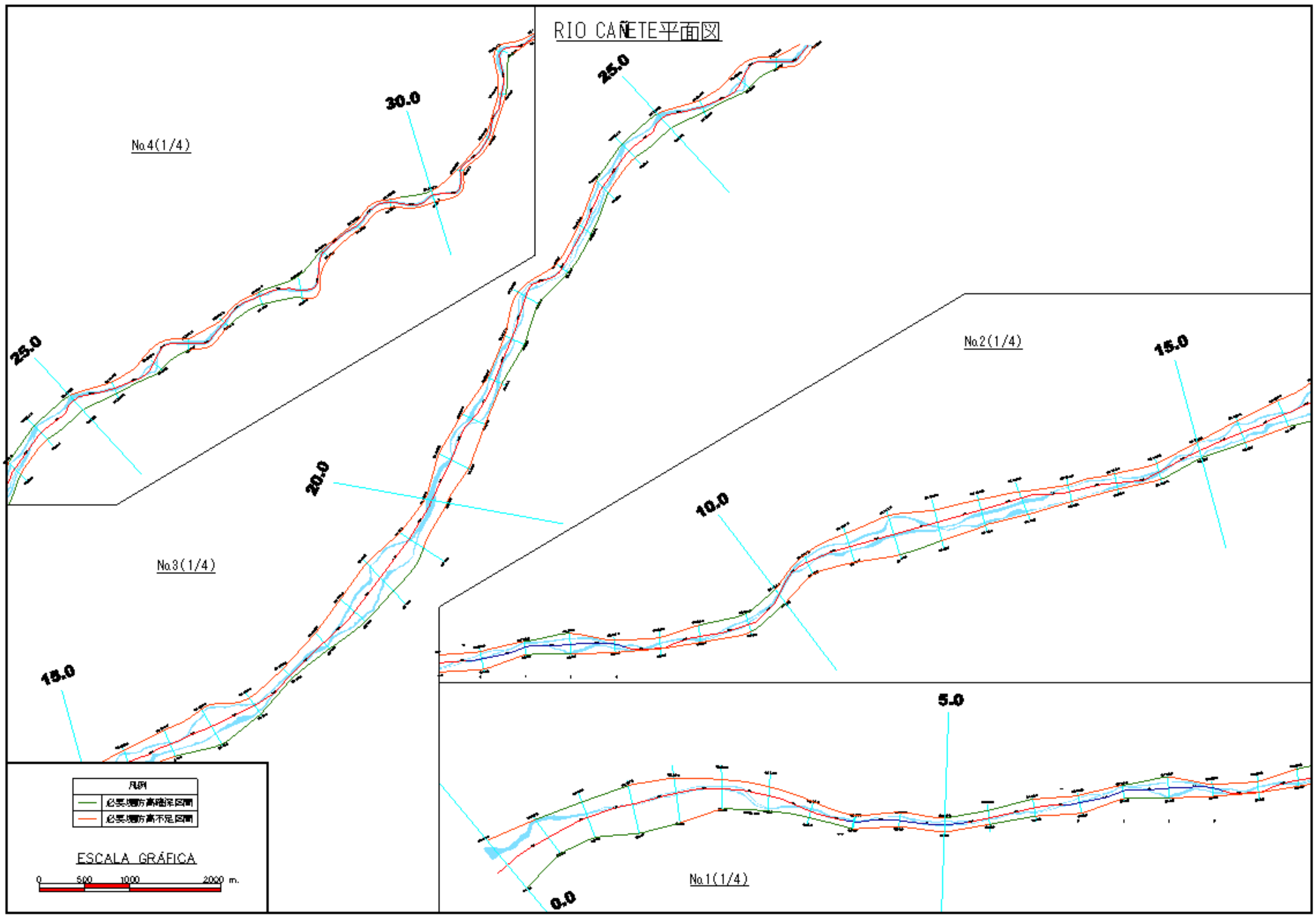


Figure 4.13.1-3 Plan of Cañete River

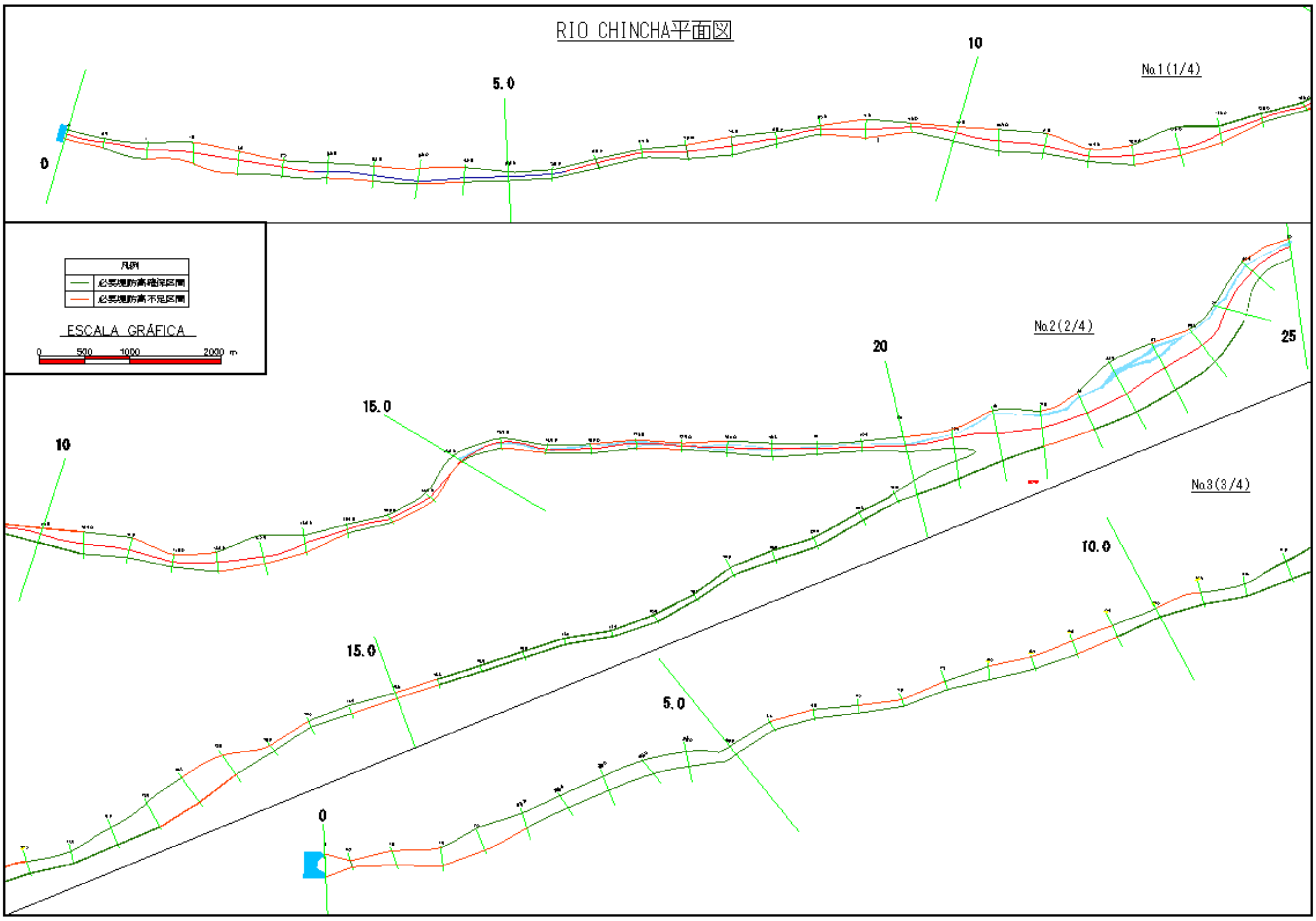


Figure 4.13.1-4 Plan of Chincha River

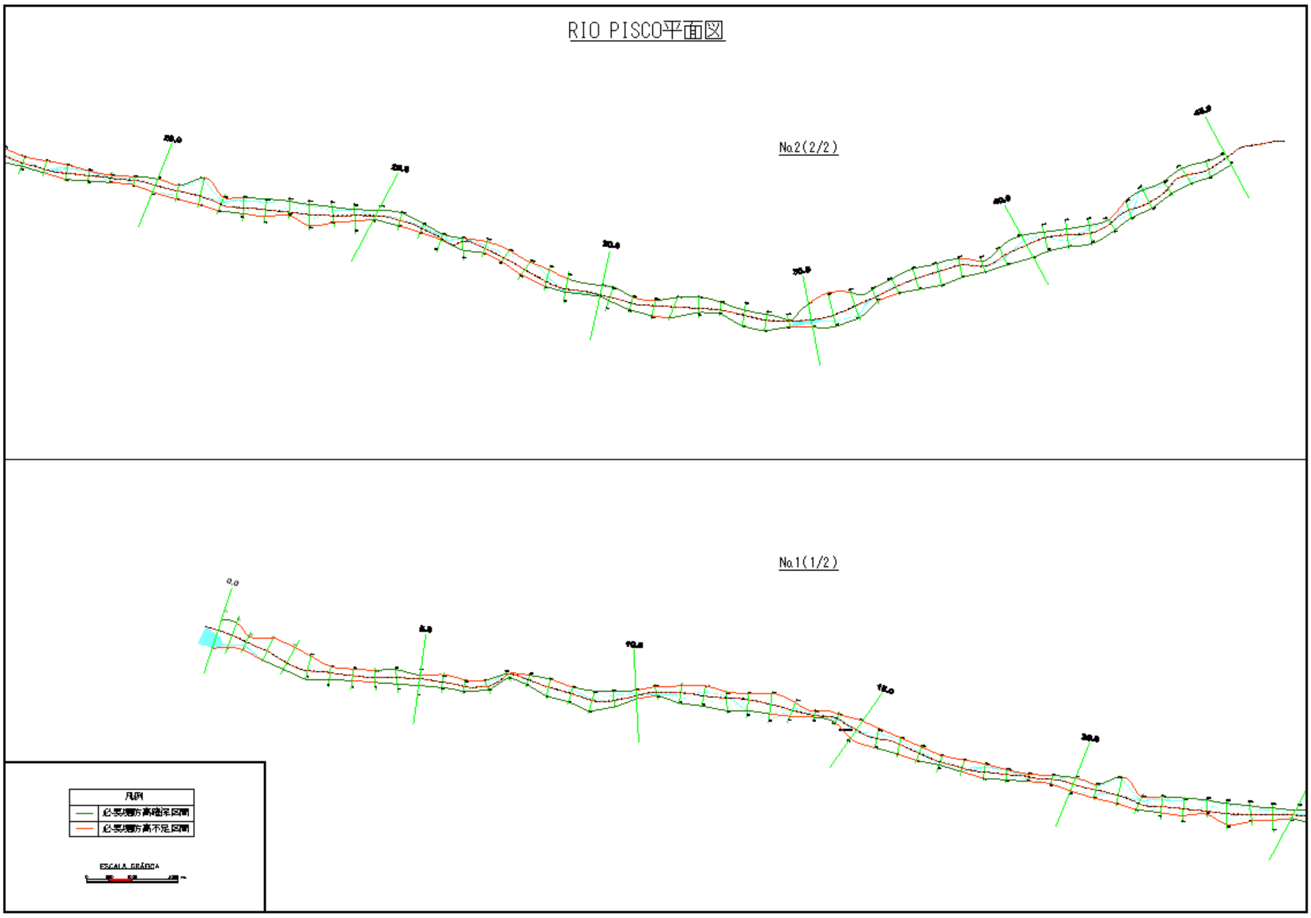


Figure 4.13.1-5 Plan of Pisco River

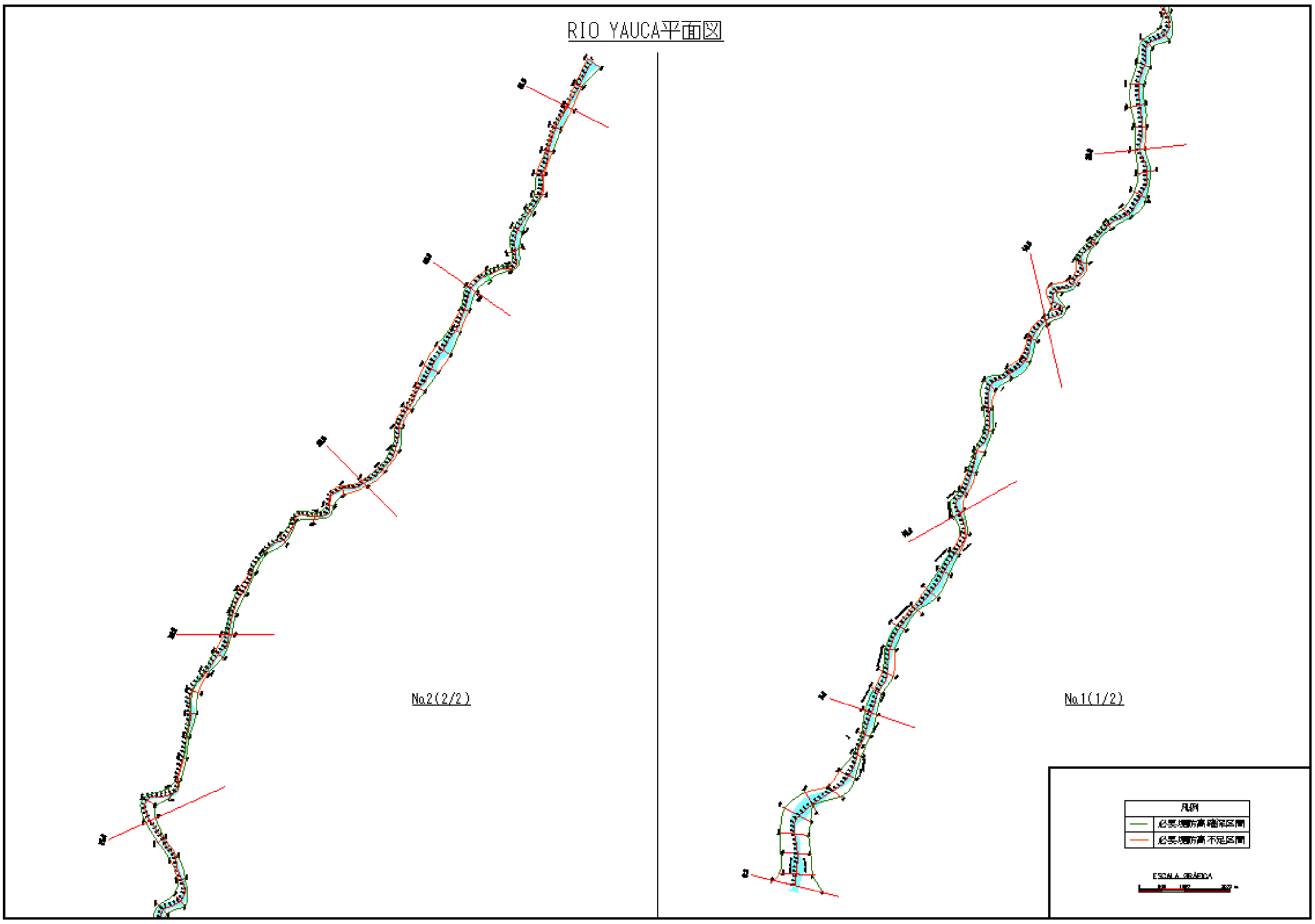


Figure 4.13.1-6 Plan of Yauca River

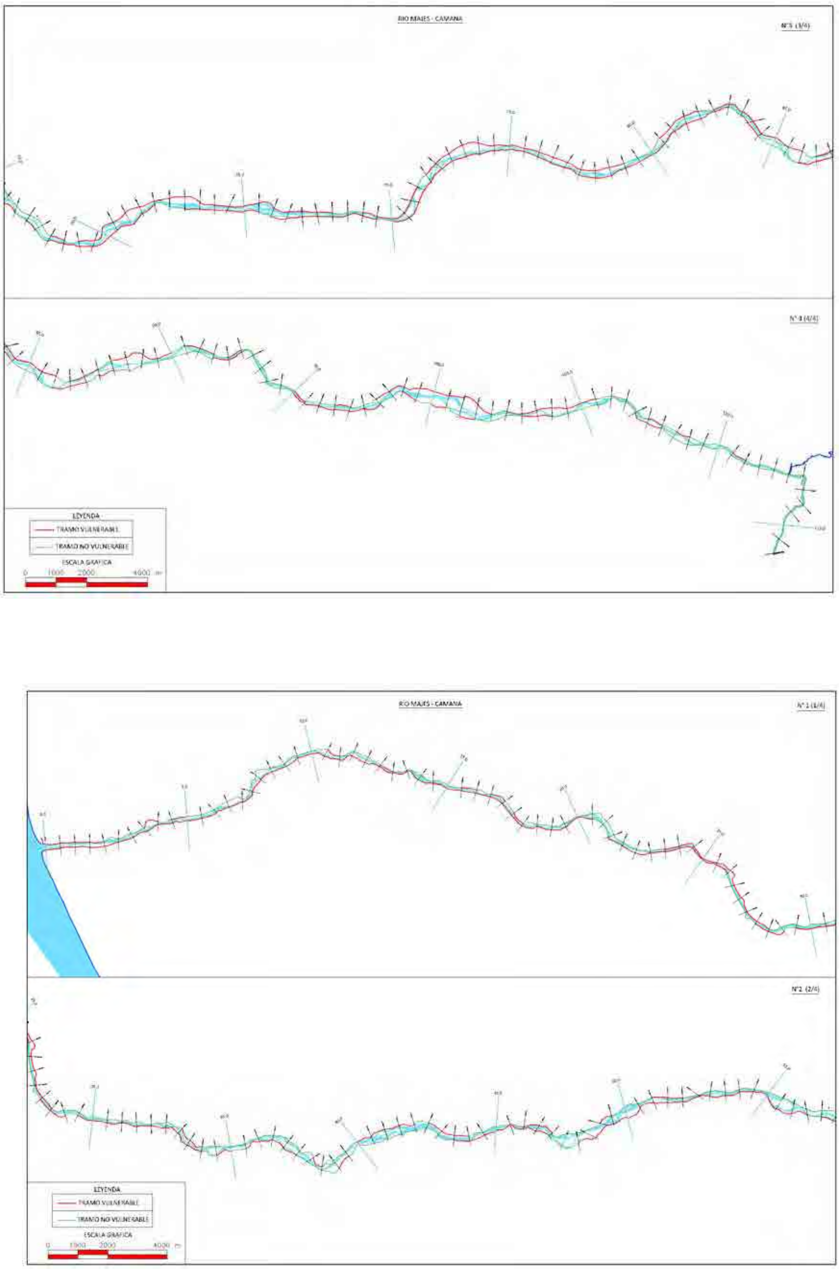


Figure 4.13.1-7 Plan of Majes-Camana River

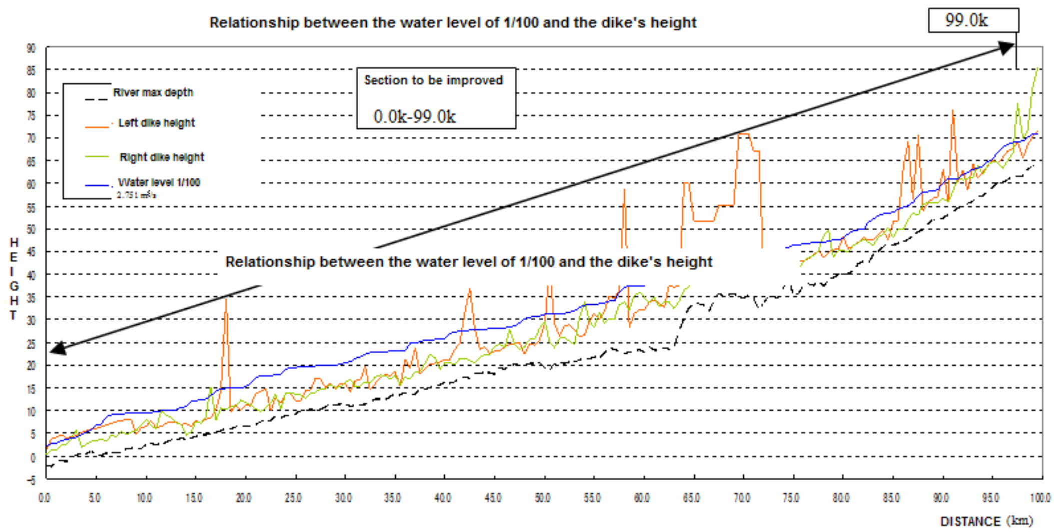


Figure 4.13.1-8 Chira River Longitudinal Profile

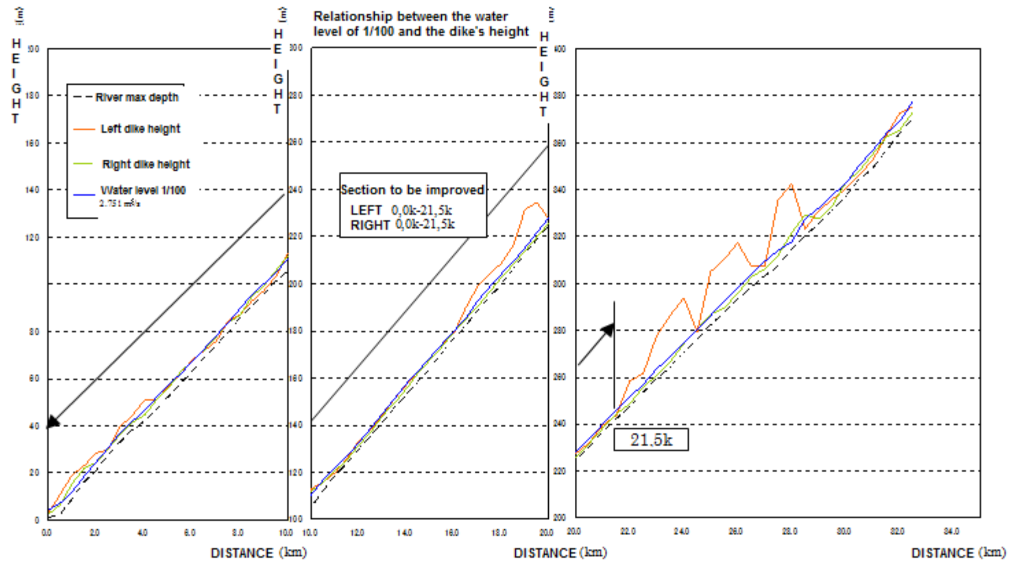


Figure 4.13.1-9 Cañete River Longitudinal Profile

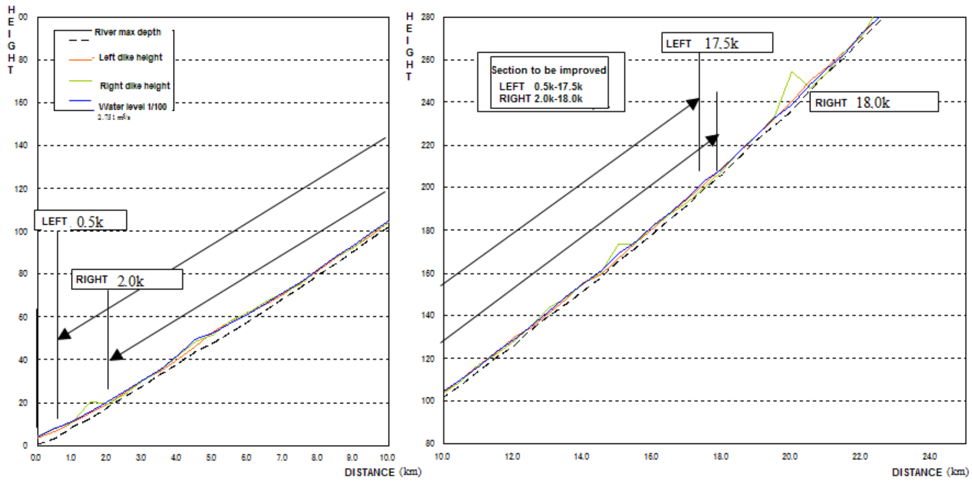


Figure 4.13.1-10 Chincha River Longitudinal Profile (Chico River)

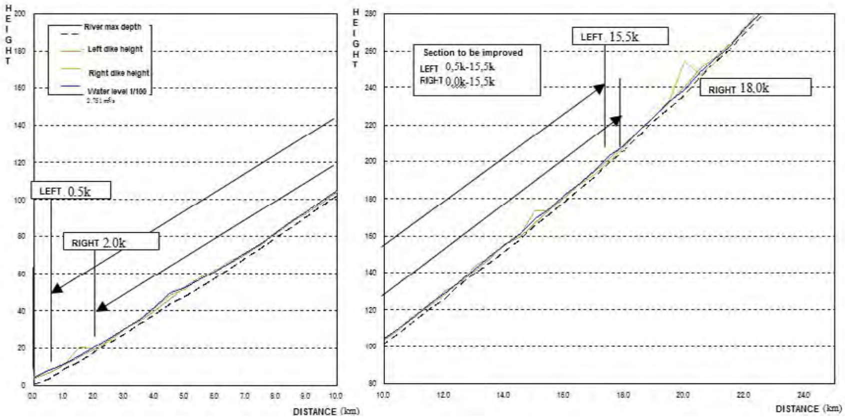


Figure 4.13.1-11 Chincha River Longitudinal Profile (Matagente River)

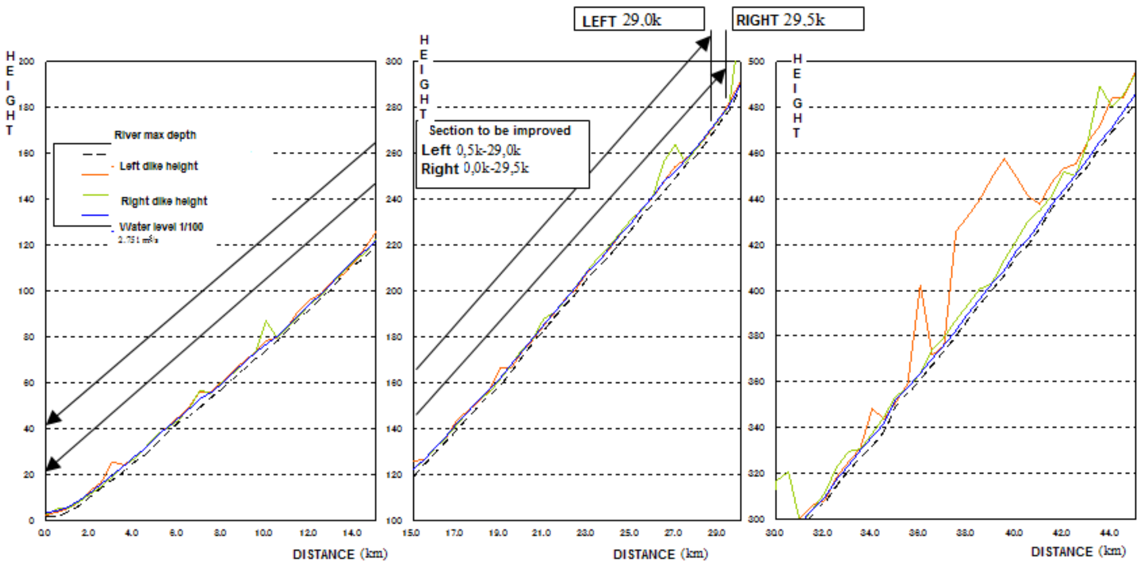


Figure 4.13.1-12 Pisco River Longitudinal Profile

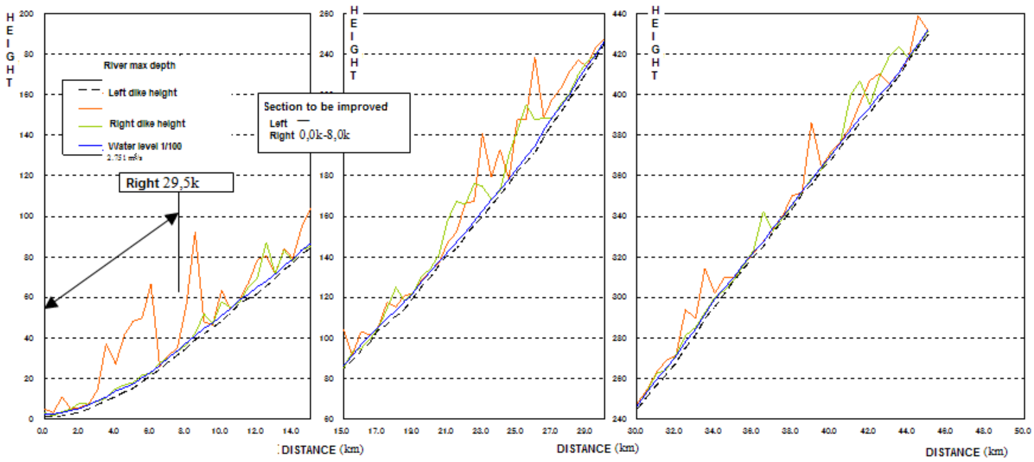


Figure 4.13.1-13 Yauca River Longitudinal Profile

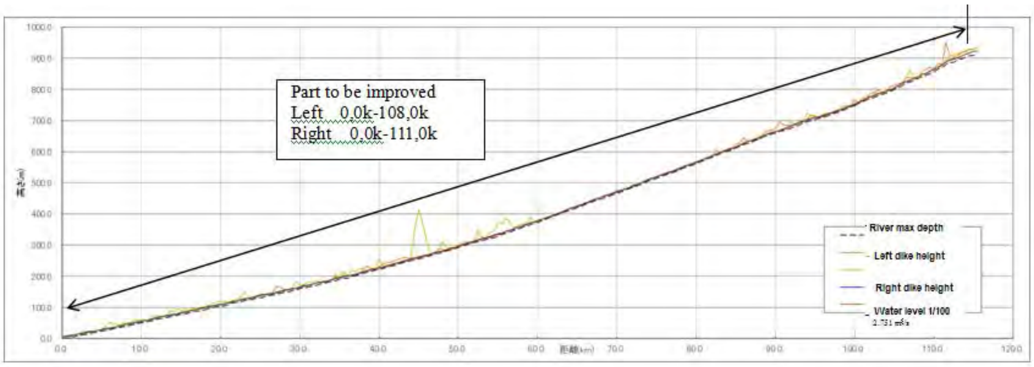


Figure 4.13.1-14 Majes-Camana River Longitudinal Profile

6) Dike's construction plan

Next, basic policies for the dike's construction plan on every watershed are shown:

- Build dikes that allow flood flow safe passage with a return period of 50 years
- The dikes will be constructed in areas where inundation will occur, according to the flood simulation
- The dikes will be placed in the sections above mentioned, where the design water level exceeds the existing dike's height or the ground level
- The dike's height is defined in the flood water level with a return period of 50 years plus the free board

Table 4.13.1-2 and Figure 4.13.1-5 show the dike's construction plan on every watershed

Table 4.13.1-1 Dike's Construction Plan

River	Sections to be improved		Dike missing heigth average (m)	Dike proposed size	Dike length (km)
Chira	Left margin	0,0k-99,0k	3,80	Dikes' height = 4,0m Margin protection works height = 4,0m	77,5
	Right margin	0,0k-99,0k	4,17		89,5
	Total		4,00		167
Cañete	Left margin	0,0k-21,5k	1,20	Dikes' height = 1,5m Margin protection works height = 3,0m	12,0
	Right margin	0,0k-21,5k	1,48		18,5
	Total		1,38		30,5
Chincha	Left margin	0,5k-17,5k	0,56	Dikes' height = 1,5m Margin protection works height = 3,0m	7,0
	Right margin	2,0k-18,0k	0,53		5,5
	Total		-		12,5
	Left margin	0,5k-15,5k	0,58		7,5
	Right margin	0,0k-15,5k	0,55		13,0
	Total		0,56		25,5
Pisco	Left margin	0,0k-29,0k	0,55	Dikes' height = 1,5m Margin protection works height = 3,0m	14,0
	Right margin	0,0k-29,5k	0,53		19,5
	Total		0,53		33,5
Yauca	Left margin	-	-	Dikes' height = 1,5m Margin protection works height = 3,0m	-
	Right margin	0,5k-8,0k	0,46		3,0
	Total		0,46		3,0
Majes-Camaná	Left margin	0,0k-108,0k	1,77	Dikes' height = 2,0m Margin protection works height = 3,0m	79,5
	Right margin	0,0,k-111,0k	1,81		56,5
	Total		1,79		136,0
Total					395,5

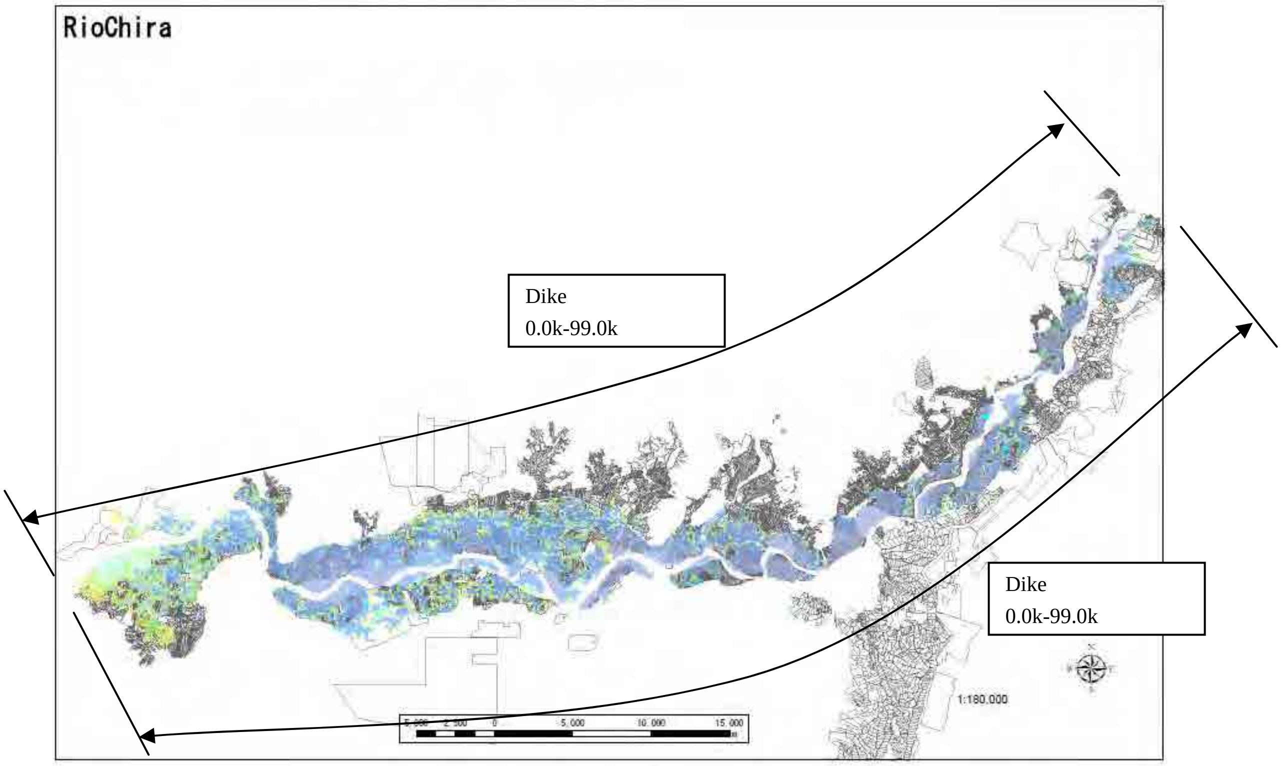


Figure 4.13.1-15 Chira River Dike's construction works approach

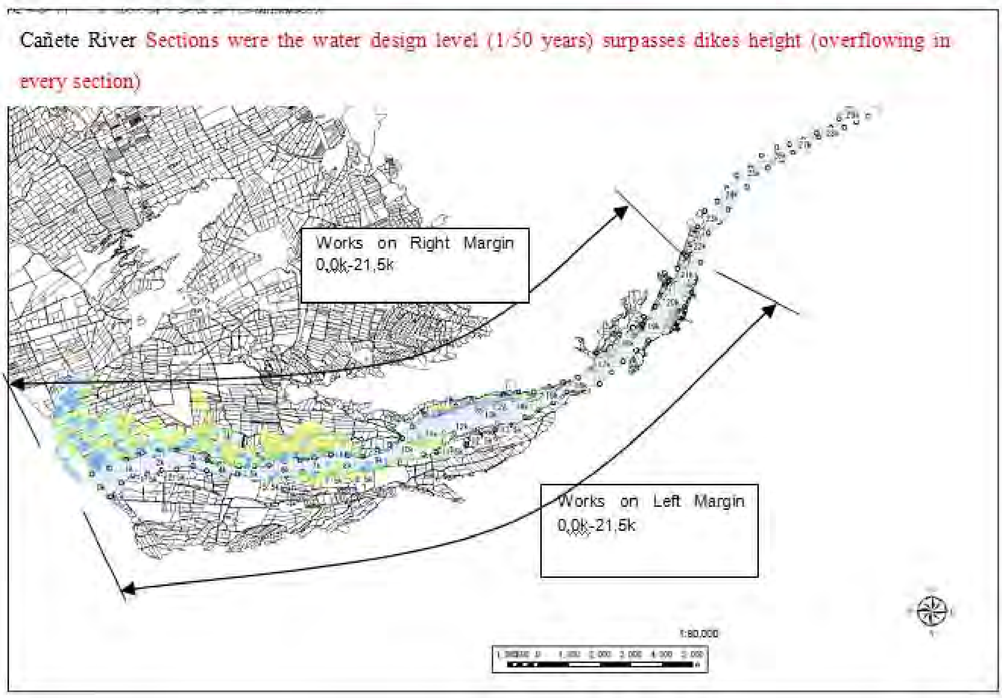


Figure 4.13.1-16 Cañete River Dike's construction works approach

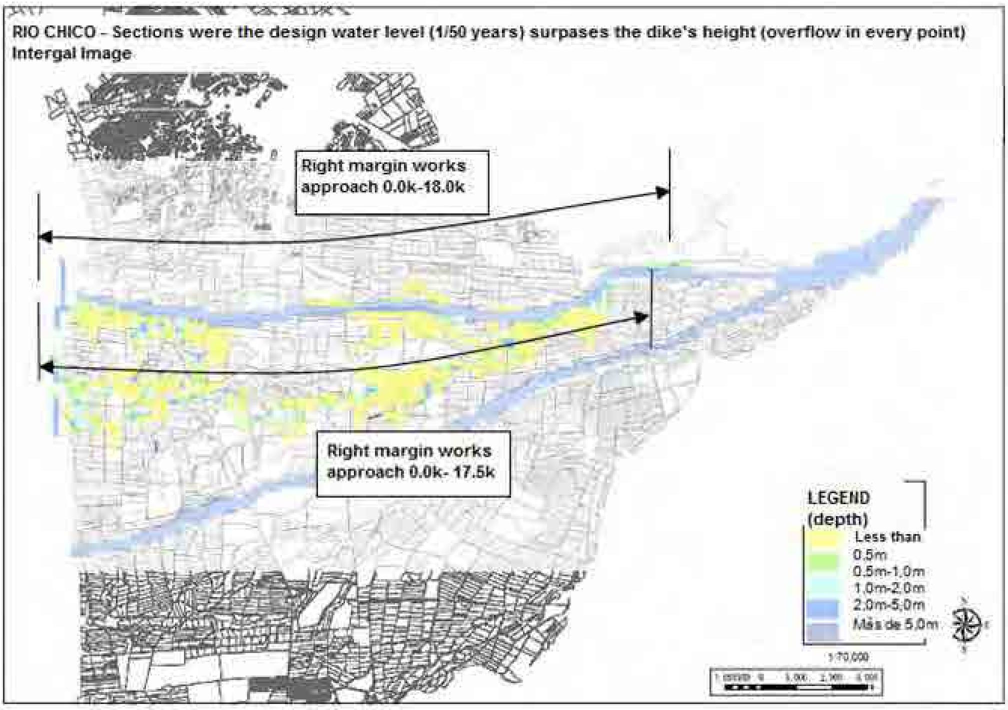


Figure 4.13.1-17 Chincha River Dike's construction works approach (Chico River)

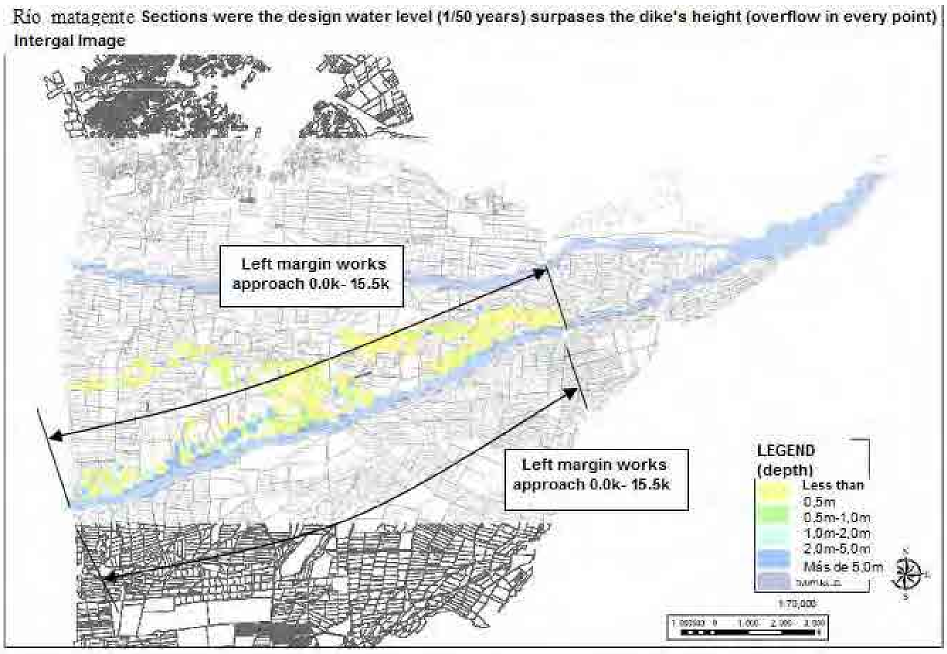


Figure 4.13.1-18 Chincha River Dike's construction works approach (Matagente River)

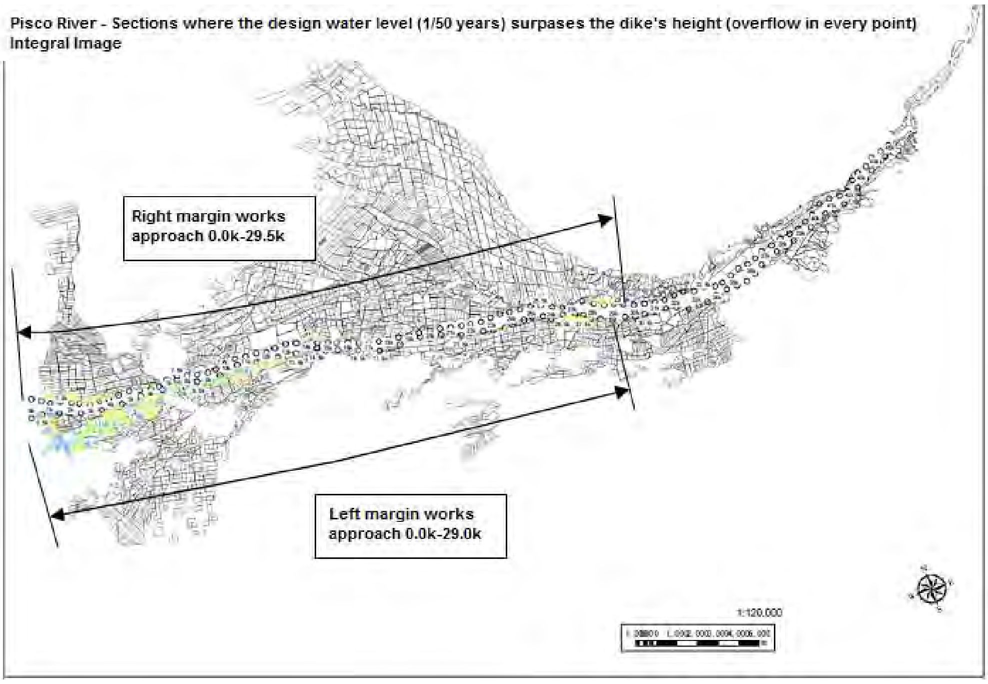


Figure 4.13.1-19 Pisco River Dike's construction works approach

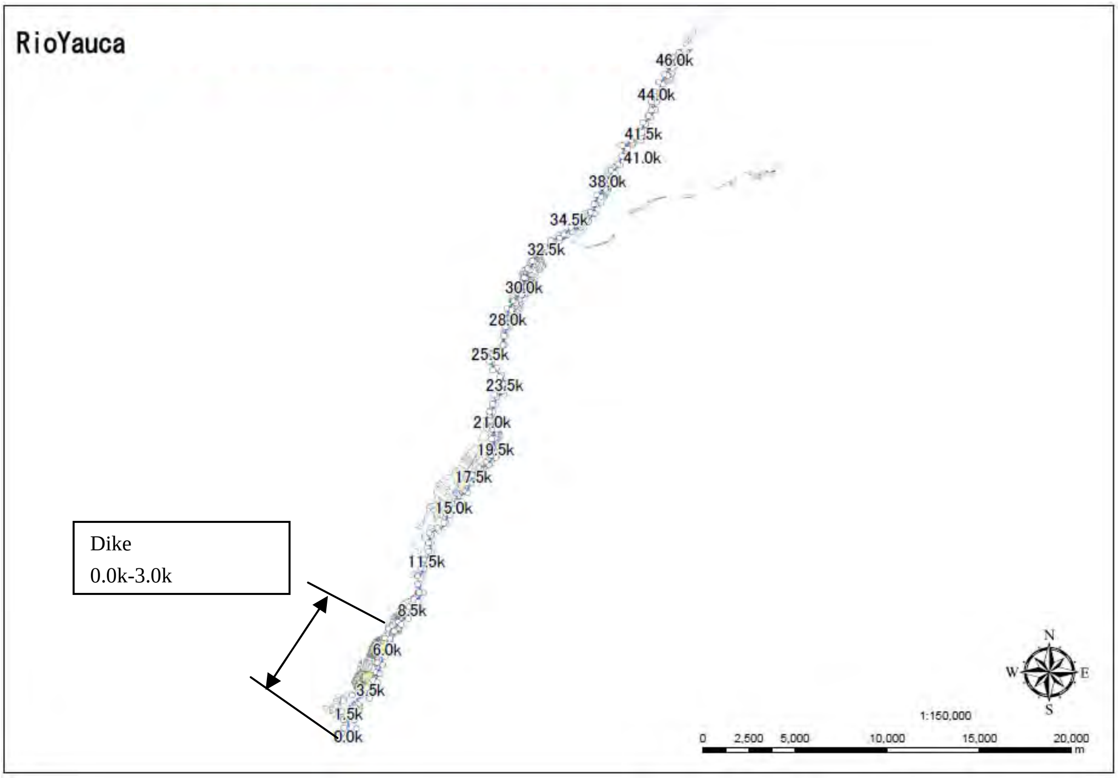


Figure 4.13.1-20 Yauca River Dike's construction works approach

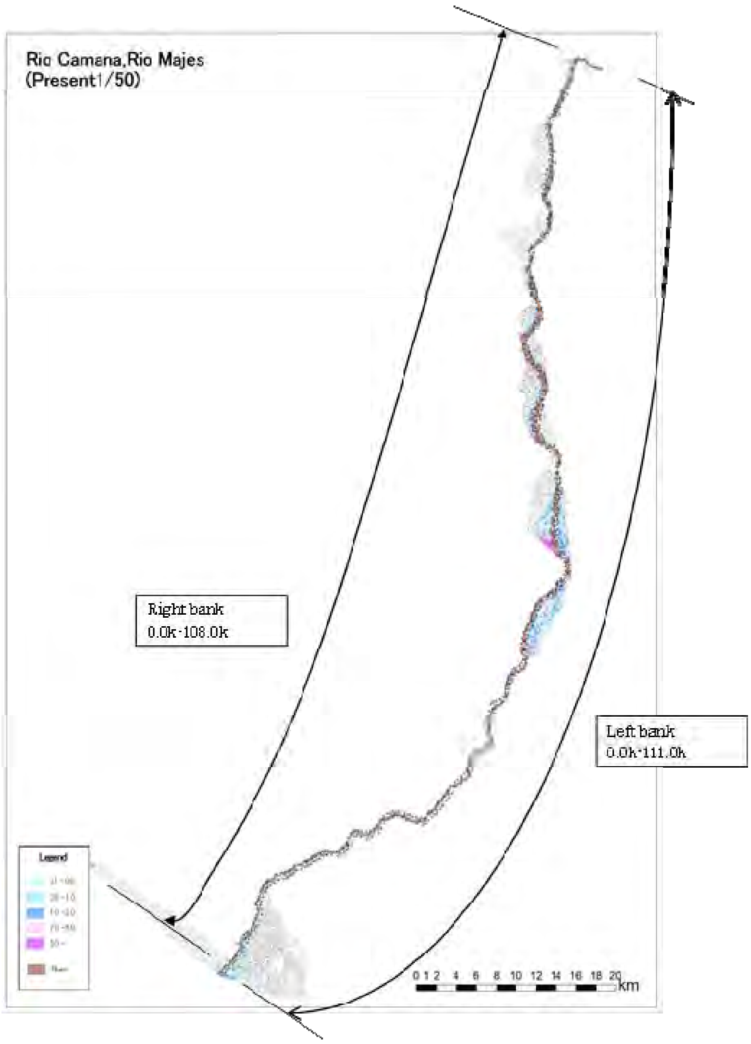


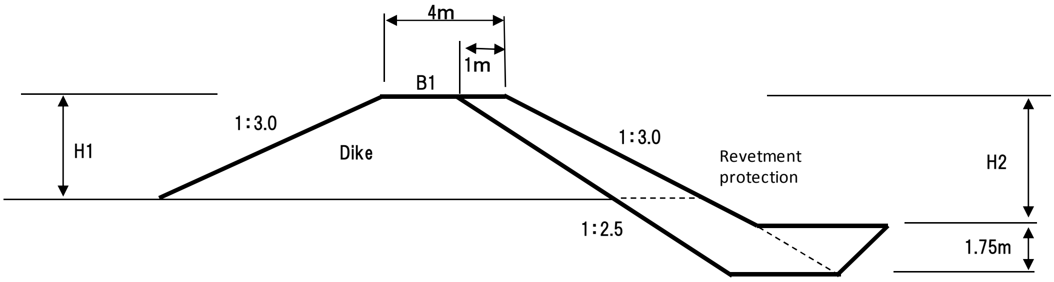
Figure 4.13.1-21 Majes-Camana River Dike's construction works approach

7) Project Cost

In Tables 4.13.1-4 and 4.13.1-5 works' direct costs in private prices and the Project's cost are shown. Also, the cost of the project in social prices is presented in Table 4.13.1-6.

Table 4.13.1-4 Works directs cost of the complete flood control

Construction of dike					Revetment protection			
B1	H1	B2	A		B1	H2	B2	A
3.0	1.0	8.5	5.8		1.0	1.0	2.4	10.8
3.0	2.0	14.0	17.0		1.0	2.0	2.9	13.4
3.0	3.0	19.5	33.8		1.0	3.0	3.4	16.5
3.0	4.0	25.0	56.0		1.0	4.0	3.9	20.1
3.0	5.0	30.5	83.8		1.0	5.0	4.4	24.3
3.0	1.5	11.3	10.7		1.0	6.0	4.9	28.9
					1.0	1.5	2.6	12.0
					1.0	10.0	6.9	52.4



River Basin		Quantity	Unit	Unit Price (Sol)	Direct Construction Cost/ 1m (Sol)	Direct Construction Cost/ 1km (10^3 Soles)	Dike length (km)	Direct Construction cost (10^3 Soles)
Chira	Embankment	56.0	m3	10.0	560.0	560.0	167.0	93,520.0
	Revetment	20.1	m3	100.0	2,010.0	2,010.0		335,670.0
Canete	Embankment	17.0	m3	10.0	170.0	170.0	30.5	5,185.0
	Revetment	16.5	m3	100.0	1,650.0	1,650.0		50,325.0
Chincha	Embankment	10.7	m3	10.0	107.0	107.0	25.5	2,728.5
	Revetment	16.5	m3	100.0	1,650.0	1,650.0		42,075.0
Pisco	Embankment	10.7	m3	10.0	107.0	107.0	33.5	3,584.5
	Revetment	16.5	m3	100.0	1,650.0	1,650.0		55,275.0
Yauca	Embankment	10.7	m3	10.0	107.0	107.0	3.0	321.0
	Revetment	16.5	m3	100.0	1,650.0	1,650.0		4,950.0
Majes	Embankment	17.0	m3	10.0	170.0	170.0	136.0	23,120.0
Camana	Revetment	16.5	m3	100.0	1,650.0	1,650.0		224,400.0

Table 4.13.1-5 Projects' Cost (at private prices)

Watershed 流域名	Costo Directo	Costo de Obras Temporales	WORKS COST	OPERATIVE EXPENSES	UTILITY	INFRASTRUCTURE TOTAL COST	TAX	WORKS TOTAL COST	ENVIRONMENTAL IMPACT	TECHNICAL FILE	SUPERVISION	構造物・事業費 (12) = (8)+(9)+(10)+(11)
CHIRA	429,868,400	42,986,840	472,855,240	70,928,286	47,285,524	591,069,050	106,392,429	697,461,479	6,974,615	34,873,074	69,746,148	809,055,316
CAÑETE	55,510,000	5,551,000	61,061,000	9,159,150	6,106,100	76,326,250	13,738,725	90,064,975	900,650	4,503,249	9,006,498	104,475,371
CHINCHA	44,803,500	4,480,350	49,283,850	7,392,578	4,928,385	61,604,813	11,088,866	72,693,679	726,937	3,634,684	7,269,368	84,324,667
PISCO	58,859,500	5,885,950	64,745,450	9,711,818	6,474,545	80,931,813	14,567,726	95,499,539	954,995	4,774,977	9,549,954	110,779,465
YAUCA	5,271,000	527,100	5,798,100	869,715	579,810	7,247,625	1,304,573	8,552,198	85,522	427,610	855,220	9,920,549
Majes/Camana	247,520,000	24,752,000	272,272,000	40,840,800	27,227,200	340,340,000	61,261,200	401,601,200	4,016,012	20,080,060	40,160,120	465,857,392
TOTAL	841,832,400	84,183,240	926,015,640	138,902,346	92,601,564	1,157,519,550	208,353,519	1,365,873,069	13,658,731	68,293,653	136,587,307	1,584,412,760

Table 4.13.1-6 Projects' Cost (at social prices)

Watershed 流域名	Costo Directo	Costo de Obras Temporales	WORKS COST	OPERATIVE EXPENSES	UTILITY	INFRASTRUCTURE TOTAL COST	TAX	WORKS TOTAL COST	ENVIRONMENTAL IMPACT	TECHNICAL FILE	SUPERVISION	構造物・事業費 (12) = (8)+(9)+(10)+(11)
CHIRA	345,614,194	34,561,419	380,175,613	57,026,342	38,017,561	475,219,516	85,539,513	560,759,029	5,607,590	28,037,951	56,075,903	650,480,474
CAÑETE	44,630,040	4,463,004	49,093,044	7,363,957	4,909,304	61,366,305	11,045,935	72,412,240	724,122	3,620,612	7,241,224	83,998,198
CHINCHA	36,022,014	3,602,201	39,624,215	5,943,632	3,962,422	49,530,269	8,915,448	58,445,718	584,457	2,922,286	5,844,572	67,797,037
PISCO	47,323,038	4,732,304	52,055,342	7,808,301	5,205,534	65,069,177	11,712,452	76,781,629	767,816	3,839,081	7,678,163	89,066,690
YAUCA	4,237,884	423,788	4,661,672	699,251	466,167	5,827,091	1,048,876	6,875,967	68,760	343,798	687,597	7,976,121
Majes/Camana	199,006,080	19,900,608	218,906,688	32,836,003	21,890,669	273,633,360	49,254,005	322,887,365	3,228,874	16,144,368	32,288,736	374,549,342
TOTAL	676,833,250	67,683,325	744,516,575	111,677,486	74,451,657	930,645,718	167,516,229	1,098,161,947	10,981,619	54,908,097	109,816,195	1,273,867,859

(2) Operation and Maintenance Plan

The operation and maintenance cost was calculated identifying the trend of the sedimentation and scouring of riverbed based on the one-dimensional analysis results of the bed variation, and a long-term operation and maintenance plan was created.

The current river course has some narrow sections where there are bridges, farming works (intakes, etc.) and there is a tendency of sediment deposit upstream of these sections. Therefore, in this project there is a suggestion to increase the discharge capacity of these narrow sections in order to avoid as possible upstream and in the bed (main part) sedimentation, together with gathering sediments as much as possible when floods over a return period of 50 years occur.

1) Bed variation analysis

Figures 4.13.1-22 until -28 shows the results of the bed variation analysis of the each river for the next fifty years. From this figure a projection of the bed's sedimentation and scouring trend and its respective volume can be made.

2) Sections that need maintenance

In table 4.13.1-7 possible sections that require a process of long-term maintenance in the each river is shown.

3) Operation and maintenance cost

In Table 4.13.1-8 the direct cost at private prices for maintenance (bed excavation) required for each watershed in the next 50 years is shown.

In Table 4.13.1-9 and 4.13.1-10 the Project's cost for 50 years on private and social prices is shown.

Table 4.13.1-7 Sections/Places to be Carried Out Maintenance Works

River Name		Excavation Area		Method of Maintenance Works
Chira River		Place 1	Target Section：64.0km-68.0km Target Volume：2,500,000m^3	Since sediments will accumulate in the upstream of Sullana Weir, it is considered that sediments should be removed periodically from now on. Since the amount of sediment is extensive and it is actually difficult to remove all, it is considered to be especially important that the excavation for maintenance should be carried out preponderantly in the right upstream of the weir.
Canete River		Place 1	Target Section：3.0km-7.0km Target Volume：135,000m^3	It is a past flood occurrence part. Since the riverbed aggradation advances gradually, it is considered that periodical excavation should be carried out from now on.
		Place 2	Target Section：27.0km-31.0km Target Volume：287,000m^3	In the object section, the channel is narrow, and since sediments are not fully passed, the possibility of riverbed aggradation is high. Since the riverbed aggradation advances gradually from now on and flood may be occurred, the periodical excavation maintenance should be carried out.
Chincha River	Chico River	Place 1	Target Section：3.5km-4.5km Target Volume：53,000m^3	It is a existing flood part. Since the riverbed aggradation advances gradually, it is considered that periodical excavation should be carried out from now on.
	Matagente River	Place 1	Target Section：10.5km-13.5km Target Volume：229,000m^3	The channel is wide and the section where sediment tend to deposit. Since the riverbed aggradation advances gradually from now on and flood may be caused, the periodical excavation maintenance should be carried out.
		Place 2	Target Section：21.0km-23.5km Target Volume：197,000m^3	
Pisco River		Place 1	Target Section：18.0km-20.5km Target Volume：314,000m^3	Since the riverbed aggradation advances gradually from now on and flood may be caused, the periodical excavation maintenance should be carried out.
		Place 2	Target Section：34.0km-35.0km Target Volume：255,000m^3	In the section, sediment tends to deposit in the upstream of the existing intake weir. By the periodical excavation in the section, it is thought to be possible to reduce the riverbed aggradation risk in the whole downstream channel.
Yauca River		Place 1	Target Section：25.5km-26.5km Target Volume：60,000m^3	The section locates in the direct upstream of an existing intake weir. In order to keep the function of the weir, the periodical excavation maintenance should be carried out.
Majes-Camana River		Place1	Target Section：12.0km-13.0km Target Volume：70,000m3	It is comparatively narrow section. The possibility that a remarkable riverbed aggradation will occur also in small amount of sediment is surmised to be high. Periodical excavation maintenance every year is desirable in consideration of the influence on intake facilities.
		Place2	Target Section：100.0km-101.0km Target Volume：460,000m3	It is a wide channel section. It has high possibility that a lot of sediment accumulates easily. By carrying out excavation maintenance in the section, it is expectable that the effectiveness of the riverbed aggradation in the middle stream can be also controlled. The place is considered to be carried out the planned excavation maintenance from the viewpoint on flood control.

※Design sediment volume: Sediment volume deposited in 50 years

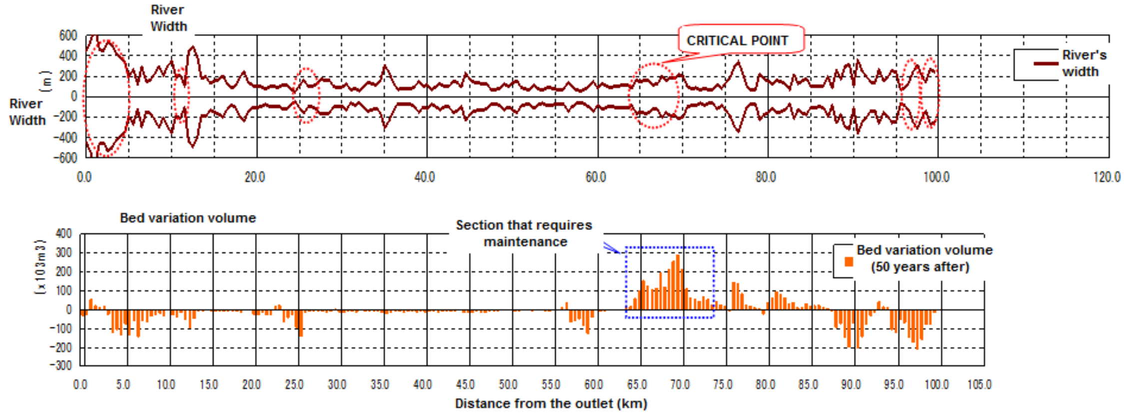


Figure 4.13.1-22 Section that requires maintenance (Chira)

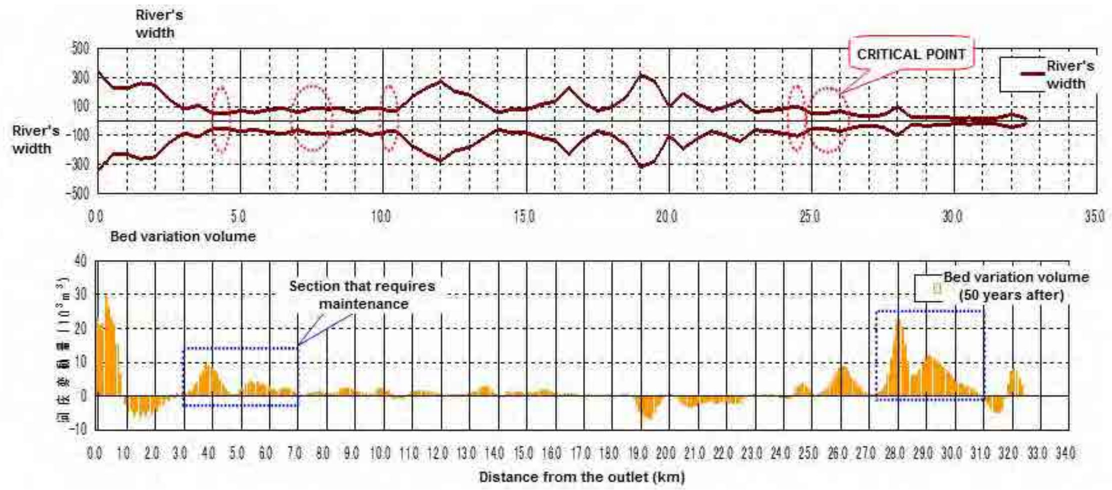


Figure 4.13.1-23 Section that requires maintenance (Cañete)

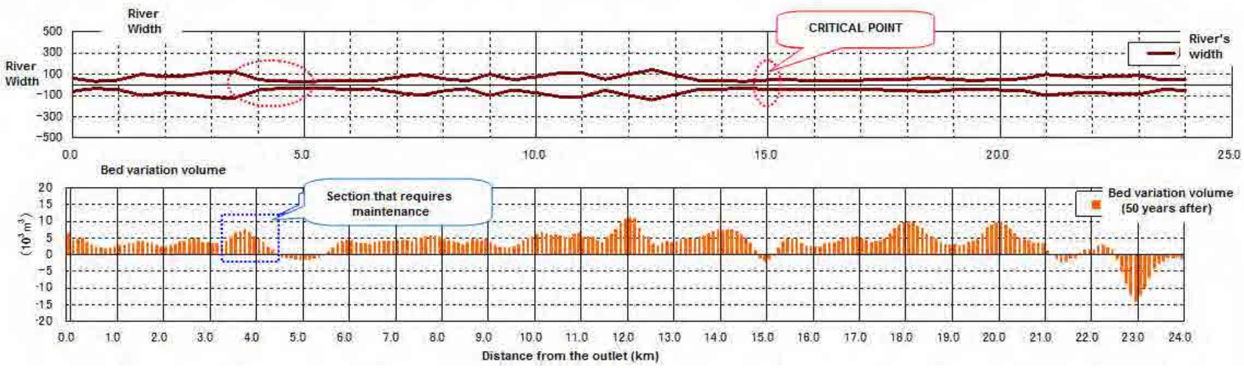


Figure 4.13.1-24 Section that requires maintenance (Chincha-Chioco River)

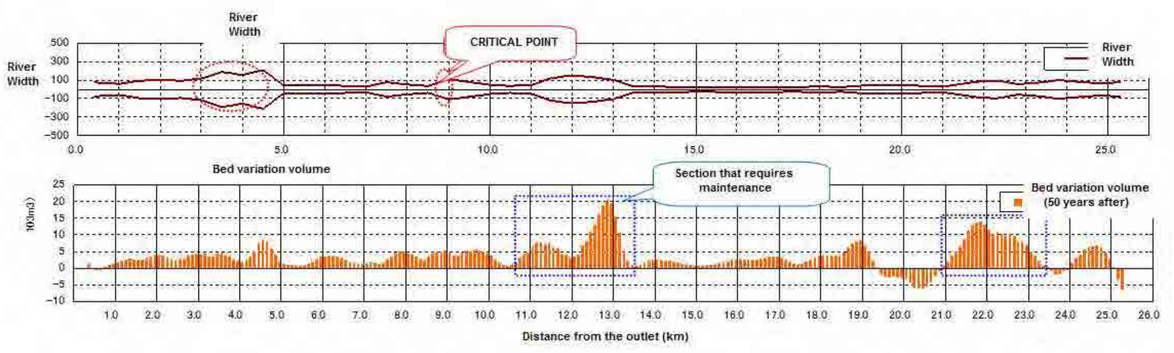


Figure 4.13.1-25 Section that requires maintenance (Chincha-Matagente River)

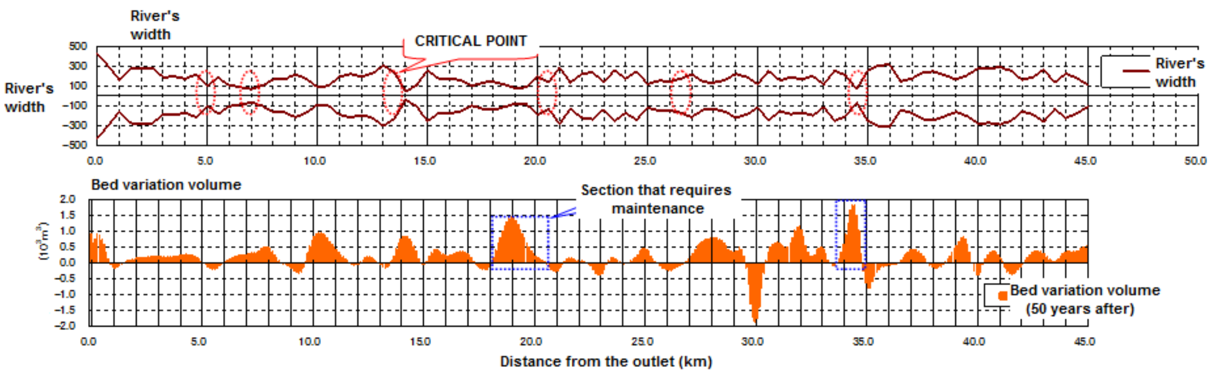


Figure 4.13.1-26 Section that requires maintenance (Pisco River)

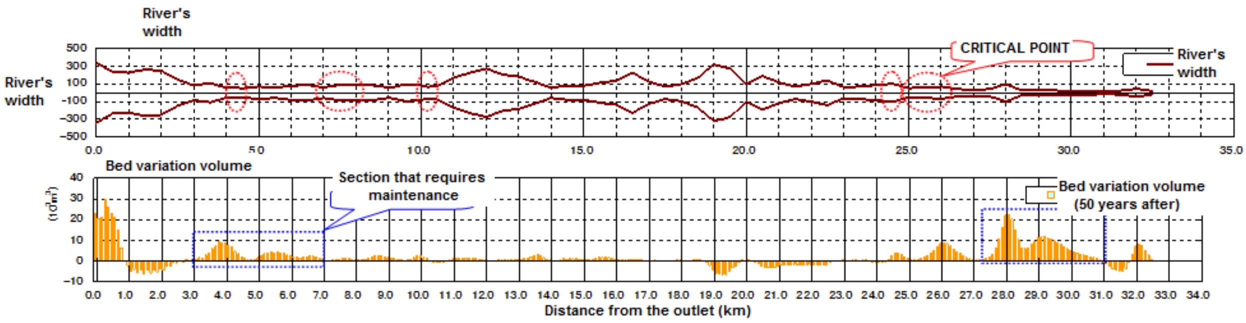


Figure 4.13.1-27 Section that requires maintenance (Yauca River)

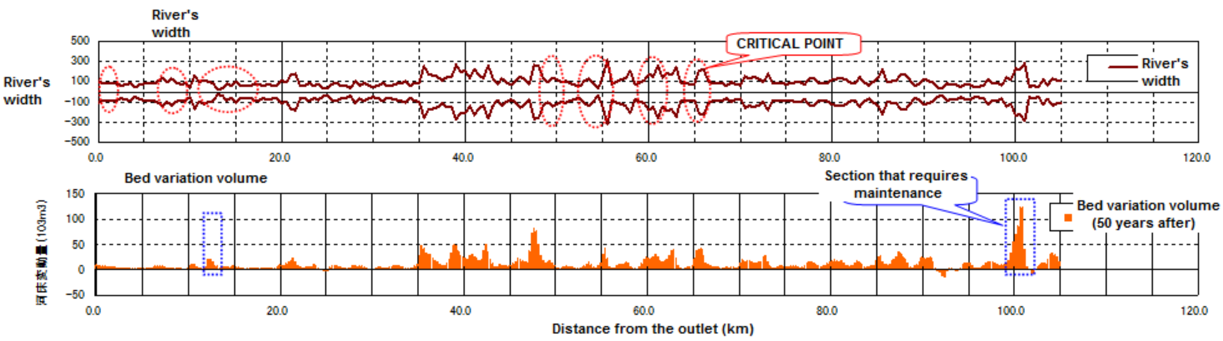


Figure 4.13.1-28 Section that requires maintenance (Majes-Camana River)

Table 4.13.1-8 Direct cost of riverbed excavation works

RIVERS		Quantity (thousand m3)	UNIT	Unitary Price (soles)	Direct Cost of Works (Thousand soles)
Chira		2,500	m 3	10.0	25,000.0
Cañete		135	m 3	10.0	1,350.0
		287	m 3	10.0	2,870.0
Chincha	Chico	53	m 3	10.0	530.0
	Matagente	229	m 3	10.0	2,290.0
		197	m 3	10.0	1,970.0
Pisco		314	m 3	10.0	3,140.0
		255	m 3	10.0	2,550.0
Yauca		60	m 3	10.0	600.0
Majes-Camaná		530	m 3	10.0	5,300.0

Table 4.13.1-9 Riverbed excavation works cost (private prices)

Watershed 流域名	Costo Directo	Costo de Obras Temporales	WORKS COST	OPERATIVE EXPENSES	UTILITY	INFRASTRUCTURE TOTAL COST	TAX	WORKS TOTAL COST	ENVIRONMENTAL IMPACT	TECHNICAL FILE	SUPERVISION	構造物・事業費 (12) = (8)+(9)+(10)+(11)
CHIRA	25,000	2,500	27,500	4,125	2,750	34,375	6,188	40,563	406	2,028	4,056	47,053
CAÑETE	4,220	422	4,642	696	464	5,803	1,044	6,847	68	342	685	7,942
CHINCHA	4,790	479	5,269	790	527	6,586	1,186	7,772	78	389	777	9,015
PISCO	5,690	569	6,259	939	626	7,824	1,408	9,232	92	462	923	10,709
YAUCA	600	60	660	99	66	825	149	974	10	49	97	1,129
MAJES-CAMANA	5,300	530	5,830	875	583	7,288	1,312	8,599	86	430	860	9,975
TOTAL	45,600	4,560	50,160	7,524	5,016	62,700	11,286	73,986	740	3,699	7,399	85,824

Table 4.13.1-10 Rivebed excavation works cost (social prices)

Name of Watershed 流域名	Direct Cost 直接工事費計 (1)	Temporal works cost 共通仮設費 (2) = 0.1 x (1)	Works Cost 工事費 (3) = (1) + (2)	Operative Expenses 諸経費 (4) = 0.15 x (3)	Utility 利益 (5) = 0.1 x (3)	Infrastructure total cost 構造物工事費 (6) = (3)+(4)+(5)	TAX 税金 (7) = 0.18 x (6)	Work's Total Cost 建設費 (8) = (6)+(7)	Environmental Impact 環境影響 (9)=0.01 x (8)	Technical File 詳細設計 (10) = 0.05 x (8)	Supervision 施工管理費 (11) = 0.1 x (8)	Total Cost 事業費 (12) = (8)+(9)+(10)+(11)	Supervision 施工管理費 [illegible]	Costo Total 事業費 (13) = (9)+(10)+(11)+(12)
CHIRA	25,000	2,500	27,500	4,125	2,750	34,375	6,188	40,563	0.804	32,612	326	1,631	3,261	37,880
CAÑETE	4,220	422	4,642	696	464	5,803	1,044	6,847	0.804	5,505	55	275	550	6,385
CHINCHA	4,790	479	5,269	790	527	6,586	1,186	7,772	0.804	6,249	62	312	625	7,248
PISCO	5,690	569	6,259	939	626	7,824	1,408	9,232	0.804	7,423	74	371	742	8,610
YAUCA	600	60	660	99	66	825	149	974	0.804	783	8	39	78	908
MAJES-CAMANA	5,300	530	5,830	875	583	7,288	1,312	8,599	0.804	6,914	69	346	691	8,020
TOTAL	40,400	4,080	44,880	6,650	4,488	55,412	9,974	65,387	-	52,571	526	2,629	5,257	60,982

(3) Social Assessment

1) Private prices cost

a) Damage amount

Table 4.13.1-11 shows the damage amount calculated analyzing the overflow caused by floods in each watershed with return periods between 2 and 50 years.

Table 4.13.1-11 Amount of damage for floods of different return periods (private prices)

DAMAGES IN THOUSAND SOLES 被害額（千ソーレス）						
t	Chira	Cañete	Chincha	Pisco	Yauca	Majes-Camana
2	0	1,660	14,576	15,788	0	0
5	349,698	6,068	36,902	22,310	0	47,669
10	427,001	73,407	51,612	47,479	1,695	76,278
25	485,714	98,357	72,416	56,749	2,569	111,113
50	562,385	149,018	96,886	76,992	11,497	190,662
Total	1,824,797	328,510	272,392	219,318	15,761	425,722

b) Damage reduction annual average

Table 4.13.1-12 shows the damage reduction annual average of each watershed calculated with the data of Table 4.13.1-11.

c) Project's Cost and the operation and maintenance cost

Table 4.13.1-5 shows the projects' cost. Also, the annual operation and maintenance (O & M) cost for dikes and bank protection works can be observed in the table. This is calculated from the 0.5% of the construction cost plus the bed excavation annual average cost indicated in Table 4.13.1-9.

d) Economic assessment

In Table 4.13.1-13 the results of economic assessment are shown.

Table 4.13.1-12 Damage Reduction Annual Average (private prices)

s/1000

民間価格：流域全体 (Pivate Prices for ALL watersheds)									
流域 Watershed	流量規模 Retunr Period	超過確率 Probability	被害額 (Total damages - thousand S/.)			区間平均被害額 ④ Damages Average	区間確率 ⑤ Probability incremental value	年平均被害額 ④×⑤ Average value of damages flow	年平均被害額の累計＝年平均被害軽減期待額 Annual medial damages
			事業を実施しない場合① Without Project ①	事業を実施した場合② With Project ②	軽減額 ③=①－② Mitigated damages ③=①－②				
CHIRA	1	1.000	0	0	0			0	0
	2	0.500	0	0	0	0	0.500	0	0
	5	0.200	349,698	0	349,698	174,849	0.300	52,455	52,455
	10	0.100	427,001	0	427,001	388,350	0.100	38,835	91,290
	25	0.040	485,714	0	485,714	456,358	0.060	27,381	118,671
	50	0.020	562,385	0	562,385	524,050	0.020	10,481	129,152
CAÑETE	1	1.000	0	0	0			0	0
	2	0.500	1,660	0	1,660	830	0.500	415	415
	5	0.200	6,068	0	6,068	3,864	0.300	1,159	1,574
	10	0.100	73,407	0	73,407	39,737	0.100	3,974	5,548
	25	0.040	98,357	0	98,357	85,882	0.060	5,153	10,701
	50	0.020	149,018	0	149,018	123,687	0.020	2,474	13,175
CHINCHA	1	1.000	0	0	0			0	0
	2	0.500	14,576	0	14,576	7,288	0.500	3,644	3,644
	5	0.200	36,902	0	36,902	25,739	0.300	7,722	11,366
	10	0.100	51,612	0	51,612	44,257	0.100	4,426	15,791
	25	0.040	72,416	0	72,416	62,014	0.060	3,721	19,512
	50	0.020	96,886	0	96,886	84,651	0.020	1,693	21,205
PISCO	1	1.000	0	0	0			0	0
	2	0.500	15,788	0	15,788	7,894	0.500	3,947	3,947
	5	0.200	22,310	0	22,310	19,049	0.300	5,715	9,662
	10	0.100	47,479	0	47,479	34,894	0.100	3,489	13,151
	25	0.040	56,749	0	56,749	52,114	0.060	3,127	16,278
	50	0.020	76,992	0	76,992	66,870	0.020	1,337	17,615
YAUCA	1	1.000	0	0	0			0	0
	2	0.500	0	0	0	0	0.500	0	0
	5	0.200	0	0	0	0	0.300	0	0
	10	0.100	1,695	0	1,695	847	0.100	85	85
	25	0.040	2,569	0	2,569	2,132	0.060	128	213
	50	0.020	11,497	0	11,497	7,033	0.020	141	353
Majes-Camana	1	1.000	0	0	0			0	0
	2	0.500	0	0	0	0	0.500	0	0
	5	0.200	47,669	0	47,669	23,835	0.300	7,150	7,150
	10	0.100	76,278	0	76,278	61,974	0.100	6,197	13,348
	25	0.040	111,113	0	111,113	93,696	0.060	5,622	18,969
	50	0.020	190,662	0	190,662	150,888	0.020	3,018	21,987

Table 4.12.1-10 Economic assessment results (private prices costs)

Basin	年平均被害軽減額 Annual Average Damage Reduction	評価期間被害軽減額(15年) Damage Reduction in Evaluation Period(15years)	事業費 Project Cost	維持管理費 O&M Cost	B/C Cost Benefit Ration	NPV Net Present Value	IRR(%) Internal Return of Rate
Chira	1,678,976,217	758,192,379	809,055,316	59,450,746	1.03	23,878,182	11%
Cañete	171,269,615	77,341,963	104,475,371	8,236,962	0.81	-17,765,825	6%
Chincha	275,669,025	124,486,667	84,324,667	7,429,667	1.61	47,326,578	20%
Pisco	229,000,371	103,412,028	110,779,465	9,420,215	1.02	2,217,423	10%
Yauca	4,592,758	2,073,999	9,920,549	894,671	0.23	-7,014,101	-
Majes-Camana	285,833,001	129,076,518	465,857,392	29,096,617	0.31	-291,140,628	-
6Basin	2,645,340,988	1,194,583,554	1,584,412,760	114,528,877	0.83	-242,498,371	7%

2) Social prices cost

a) Damage amount

Table 4.13.1-14 shows the damage amount calculated analyzing the overflow caused by floods with return periods between 2 and 50 years in each watershed.

Table 4.13.1-14 Amount of damage for floods of different return periods (at social prices)

DAMAGES IN THOUSAND SOLES 被害額(千ソーレス)						
t	Chira	Cañete	Chincha	Pisco	Yauca	Majes-Camana
2	0	2,582	16,283	16,681	0	0
5	407,180	10,558	42,375	22,436	0	48,468
10	494,866	105,137	70,525	52,469	2,150	78,194
25	563,929	144,972	95,769	61,739	3,313	116,730
50	649,089	213,134	125,742	84,256	12,092	206,459
Total	2,115,064	476,384	350,693	237,581	17,555	449,851

b) Damage reduction annual average

Table 4.13.1-15 shows the damage reduction annual average of each watershed calculated with the data of Table 4.13.1-14.

c) Project's Cost and the operation and maintenance cost

Table 4.13.1-6 shows the projects' cost. Also, the annual operation and maintenance (O & M) cost for dikes and margin protection works can be observed in the table. This is calculated from the 0.5% of the construction cost, as well as the bed excavation annual average cost indicated in Table 4.13.1-10.

d) Economic assessment

In Table 4.13.1-16 the results of economic assessment are shown.

(4) Conclusions

The economic assessment result shows that the Project has positive economic impact in terms of cost on both private (Chira, Chincha and Pisco) and social prices (Chira, Cañete, Chincha and Pisco), but the required cost is extremely high (1,584.4 million soles, equivalent to 47,530 million of yens), so, this Project is less viable to be adopted.

Table 4.13.1-15 Damage Reduction Annual Average

s/1000

民間価格：流域全体 (Pivate Prices for ALL watersheds)

流域 Watershed	流量規模 Retunr Period	超過確率 Probability	被害額 (Total damages - thousand S/.) 事業を実施しない場合① Without Project ①	事業を実施した場合② With Project ②	軽減額 ③=①−② Mitigated damages ③=①−②	区間平均被害額 ④ Damages Average	区間確率 ⑤ Probability incremental value	年平均被害額 ④×⑤ Average value of damages flow	年平均被害額の累計＝年平均被害軽減期待額 Annual medial damages
CHIRA	1	1.000	0	0	0			0	0
	2	0.500	0	0	0	0	0.500	0	0
	5	0.200	407,180	0	407,180	203,590	0.300	61,077	61,077
	10	0.100	494,866	0	494,866	451,023	0.100	45,102	106,179
	25	0.040	563,929	0	563,929	529,398	0.060	31,764	137,943
	50	0.020	649,089	0	649,089	606,509	0.020	12,130	150,073
CAÑETE	1	1.000	0	0	0			0	0
	2	0.500	2,582	0	2,582	1,291	0.500	646	646
	5	0.200	10,558	0	10,558	6,570	0.300	1,971	2,617
	10	0.100	105,137	0	105,137	57,848	0.100	5,785	8,401
	25	0.040	144,972	0	144,972	125,055	0.060	7,503	15,905
	50	0.020	213,134	0	213,134	179,053	0.020	3,581	19,486
CHINCHA	1	1.000	0	0	0			0	0
	2	0.500	16,283	0	16,283	8,142	0.500	4,071	4,071
	5	0.200	42,375	0	42,375	29,329	0.300	8,799	12,869
	10	0.100	70,525	0	70,525	56,450	0.100	5,645	18,514
	25	0.040	95,769	0	95,769	83,147	0.060	4,989	23,503
	50	0.020	125,742	0	125,742	110,756	0.020	2,215	25,718
PISCO	1	1.000	0	0	0			0	0
	2	0.500	16,681	0	16,681	8,341	0.500	4,170	4,170
	5	0.200	22,436	0	22,436	19,559	0.300	5,868	10,038
	10	0.100	52,469	0	52,469	37,453	0.100	3,745	13,783
	25	0.040	61,739	0	61,739	57,104	0.060	3,426	17,209
	50	0.020	84,256	0	84,256	72,998	0.020	1,460	18,669
YAUCA	1	1.000	0	0	0			0	0
	2	0.500	0	0	0	0	0.500	0	0
	5	0.200	0	0	0	0	0.300	0	0
	10	0.100	2,150	0	2,150	1,075	0.100	108	108
	25	0.040	3,313	0	3,313	2,732	0.060	164	271
	50	0.020	12,092	0	12,092	7,703	0.020	154	425
Majes-Camana	1	1.000	0	0	0			0	0
	2	0.500	0	0	0	0	0.500	0	0
	5	0.200	48,468	0	48,468	24,234	0.300	7,270	7,270
	10	0.100	78,194	0	78,194	63,331	0.100	6,333	13,603
	25	0.040	116,730	0	116,730	97,462	0.060	5,848	19,451
	50	0.020	206,459	0	206,459	161,595	0.020	3,232	22,683

Table 4.13.1-16 Economic assessment results (social prices costs)

Basin	年平均被害軽減額 Annual Average Damage Reduction	評価期間被害軽減額(15年) Damage Reduction in Evaluation Period(15years)	事業費 Project Cost	維持管理費 O&M Cost	B/C Cost Benefit Ration	NPV Net Present Value	IRR(%) Internal Return of Rate
Chira	1,950,952,864	881,011,642	650,480,474	47,798,400	1.49	290,623,028	18%
Cañete	253,314,406	114,391,764	83,998,198	6,622,517	1.50	37,925,103	18%
Chincha	334,336,127	150,979,568	67,797,033	5,973,452	2.43	88,942,856	31%
Pisco	242,702,673	109,599,716	89,066,690	7,573,853	1.35	28,239,253	16%
Yauca	5,531,228	2,497,793	7,976,121	719,315	0.34	-4,809,039	-
Majes-Camana	294,878,168	133,161,136	374,549,343	23,393,680	0.39	-204,693,450	-
6Basin	3,081,715,466	1,391,641,619	1,273,867,859	92,081,217	1.20	236,227,751	14%

4.13.2 Reforestation and Recovery of Vegetation Plan

(1) Reforestation of the upper watershed

1) Basic Policies

Objectives: Improve the water source area's infiltration capacity, reduce surface water flow and at the same time, increase water flow in intermediate soils and ground-water level. Because of the above mentioned, water flow is interrupted in high flood season, this increases water resources in mountain areas, reduces and prevents floods increasing with it the amount and greater flow of ground-water level, reducing and preventing floods.

Forestry area: means forestry in areas with planting possibilities around watersheds with water sources or in areas where forest area has decreased. Based on Chincha River forestry plan made by AGRORURAL, the other watershed's forestry area is calculated

2) Selection of forestry area

The calculation of the forestry plan area for the 5 watersheds (Chira, Cañete, Pisco, Yauca and Camana-Majes) has been obtained comparing measuring calculations and the vegetation classification of areas in the Chincha River Watershed done by AGRORURAL. Next, the calculation method will be explained:

Step 1: Each watershed's vegetation classification area is grouped (see Table 4.13.2-1)

Step 2: The forestry plan's area is measures including the vegetation classification area for each classification of the Chincha River watershed done by AGRORURAL. Calculate the comparison between forestry plan and the vegetation classification area (see Table 4.13.2-2)

Step 3: With steps' 1 and 2 results, the forestry area of each watershed can be estimated by a simple relation (see Table 4.13.2-3): multiply A/B of each vegetation category of Table 4.13.2-2 by the area of Table 4.13.2-1, and that will result in the forestry plan per area of each vegetation category according to the watershed

As result, for some Watersheds, such as Cañete and the other 4, the total of forestry plan area was 300,000ha and for Majes-Camana was 300,000ha. So, this together is 610,000ha for the forestry plan area calculation.

Table 4.13.2-1 Grouping of the vegetation classification areas of each watershed

Watershed	Vegetation Classification							
	Cu	Dc	Ms	Msh	Mh	Cp	N	Pj
Cañete	4.789	104.384	57.601	103.201	9.409	22.228	9.515	295.447
Chincha	16.489	99.092	54.662	45.203	355	84.920	0	29.668
Pisco	21.429	135.095	41.900	42.843	14.702	66.307	0	104.933
Yauca	4.926	146.689	98.012	76.480	25.564	38.602	0	41.984
Chira	644	0	0	115.567	97.696	0	0	11.600
Camana-Majes	10.454	310.812	157.008	133.476	15.520	6.616	64.144	1.006.921

Table 4.13.2-2 Forestry Plan for each vegetation classification of Chincha Watershed

Classification	Vegetation Classification								
	Cu	Dc	Ms	Msh	Mh	Cp	N	Pj	Total
A: AGRORURAL Forestry Plan Area (ha)	0,00	1.693,61	21.098,77	9.934,05	0.00	5.108,46	0.00	6.233,64	44.068,53
B: Vegetation distribution area(ha)	16.489	99.092	54.662	45.203	355	84.920	0	29.668	330.389
A/B	-	0,0171	0,3860	0,2198	-	0,0602	-	0,2101	0,1334

Table 4.13.2-3 Vegetation general plan of each Watershed

Watershed	Vegetation Classification								
	Cu	Dc	Ms	Msh	Mh	Cp	N	Pj	Total
Cañete	-	1.785	22.234	22.684	-	1.338	-	62.073	110.114
Chincha	-	1.694	21.100	9.936	-	5.112	-	6.233	44.075
Pisco	-	2.310	16.173	9.417	-	3.992	-	22.046	53.938
Yauca	-	2.508	37.833	16.810	-	2.324	-	8.821	68.296
Chira	-	0	0	25.402	-	0	-	2.437	27.839
Camana-Majes	-	5.315	60.605	29.338	-	398	-	211.554	307.210
Total	-	13.612	157.945	113.587	-	13.164	-	313.164	611.472

3) Project's Cost Calculation (long term plan)

Based on Chincha River forestry plan (above mentioned) the time required and the project's cost has been obtained. According to this estimate, it will take 11 to 35 years to reforest and the total project's cost is 1,670,000,000 soles, a very high amount (see Table 4.13.2-4)

Table 4.13.2-4 Upstream Watershed Forest General Plan

Watershed	Forestry Area (ha) A	Required period for the project (years) B	Required budget (soles) C
Cañete	110,114	35	297,212,406
Chincha	44,075	14	118,964,317
Pisco	53,938	17	145,585,872
Yauca	68,296	22	184,340,033
Chira	27,839	9	75,141,182
Camaná-Majes	307,210	98	829,200,856
TOTAL	611,472	–	1,650,444,666
Costo del Proyecto de Chincha por cada hectárea: ＝ 2,699.13 (soles /ha) (Ejemplo del cálculo: Cuenca del río Cañete) 110,114 / 44,075 x 14 = 35 (años) 110,114 x 2,699.13 = 297,212,406 (ha)			

(Source: JICA Study Team)

4) Conclusions

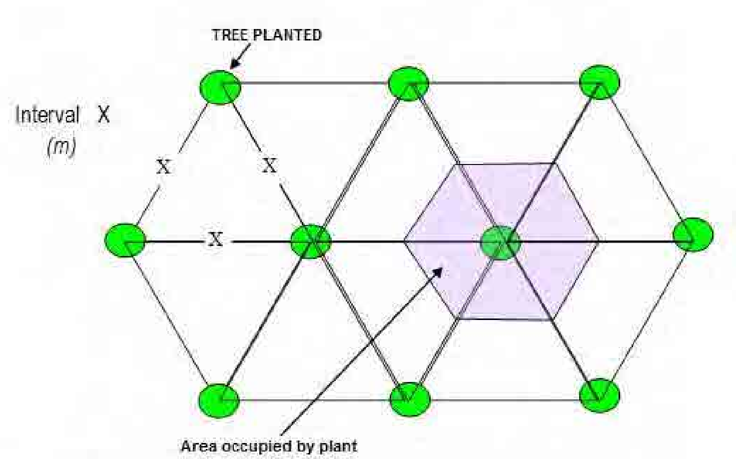
The objective of this project is to execute the most urgent works and give such a long period for reforestation which has an indirect effect with an impact that takes a long time to appear would not be consistent with the proposed objective for the Project. Considering that 11 to 100 years and investment of 1600 million soles are required, we can say that it is impractical to implement this alternative in this project and that it shall be timely executed within the framework of a long-term plan after finishing this project.

(2) Middle term plan (Forestation and vegetation recovery plan in model areas)

This plan is based on reforesting the chosen model area of Chincha River Watershed.

1) Configuration (tree disposition)

Tree disposition is usually adopted in Peru as triangle disposition. So, in this Project we are proposing to adopt this disposition keeping between trees an interval of 3 meters.



Interval	Area occupied by plant	Plants per hectare
2 m	1,50 m²	6.670 plants / ha
3 m	3,38 m²	2.960 plants / ha
5 m	9,38 m²	1.070 plants / ha
6 m	13,50 m²	740 plants / ha

Figure 4.13.2-1 Standard Reforestation Arrangement

2) Species to be used

The mostly used specie in the Mountain region of Peru is the eucalyptus and then Pine. Especially on altitudes over 4.00mosl pine is very common. Also, native species such as Quañua, Molle, Aliso, etc. can be found. However, due to the producers economic reasons predominant species are eucalyptus and pine. Tara is also used in the agro forestry sector, in case of prioritized case of effective income.

In general, reforestry is planned and implemented with local community consensus. In such case, apart from explaining about forest public interest, property of species, etc, also species to be planted are discussed and agreed. In AGRORURAL project, species to be used are selected by listening local community's opinions, which mostly all of them chose pine and queñua in relatively low altitudes. So in this project we will select the same species.

3) Reforesting plan volume and vegetation recovery

Currently, there are 44,068.53 ha to be reforested in the upper watershed of Chincha river. With aims of identifying the reforested area throughout the present project by reforesting volume within the established period, the following criteria shall be applied:

- That it is a aquifer recharge area
- That the soil is erodible
- That the altitude is less than 4,000a.m.s.l
- That several communities are near and capable to supply labor necessary for reforesting

In Figure 4.13.2-2 the location of the selected areas is shown applying these criteria. A and B groups were chosen as area subjected to this project. Groups C was not included due to the population's low density, which will translate as few labor supply for executing the necessary work

In Table 4.13.2-5 the volume of the reforesting plan and selected vegetation recovery is shown

Table 4.13.2-5 Reforesting Plan and Selected Vegetation Recovery of the upper basin

Group A

Area No.	Surface to reforest (ha)			Execute at:
	Pine	Queñua	Total	
47	650.4		650.04	Second year
48	311.1		311.91	Second year
49	211.90		211.90	Third year
50	276.40		276.40	Third year
51	79.94		79.94	Third year
52	166.27		166.27	Third year
53	55.96		55.96	Third year
56		0.05	0.05	Third year
61	67.58		67.58	Fourth year
102	548.38		548.38	Fourth year
103	161.45		16145	Fourth year
Total	2,529.83	0.05	2,529.88	

Group B

Area No.	Surface to reforest (ha)			Execute at:
	Pine	Queñua	Total	
42		63.03	63.03	Second year
43		2.,30	24.30	Second year
44		12.22	12.22	Second year
45	249.00		249.00	Third year
65		397.23	397.23	Second year
66	14.69		14.69	Third year
67	1.06		1.06	Third year
68	26.90		26.90	Third year
69	30.28		30.28	Third year
70	0.00		0.00	Third year
71	236.58		236.58	Third year
72		76.53	76.53	Fourth year
73		128.96	128.96	Fourth year
74	173.82		173.82	Fourth year
75	55.19		55.19	Fourth year
76	66.34		66.4	Fourth year
77	14.82		14.82	Fourth year
78	165.11		165.11	Fourth year
79	89.24		89.24	Fourth year
Total	1,.123.03	717.09	1,825.30	

(Source: JICA Study Team)

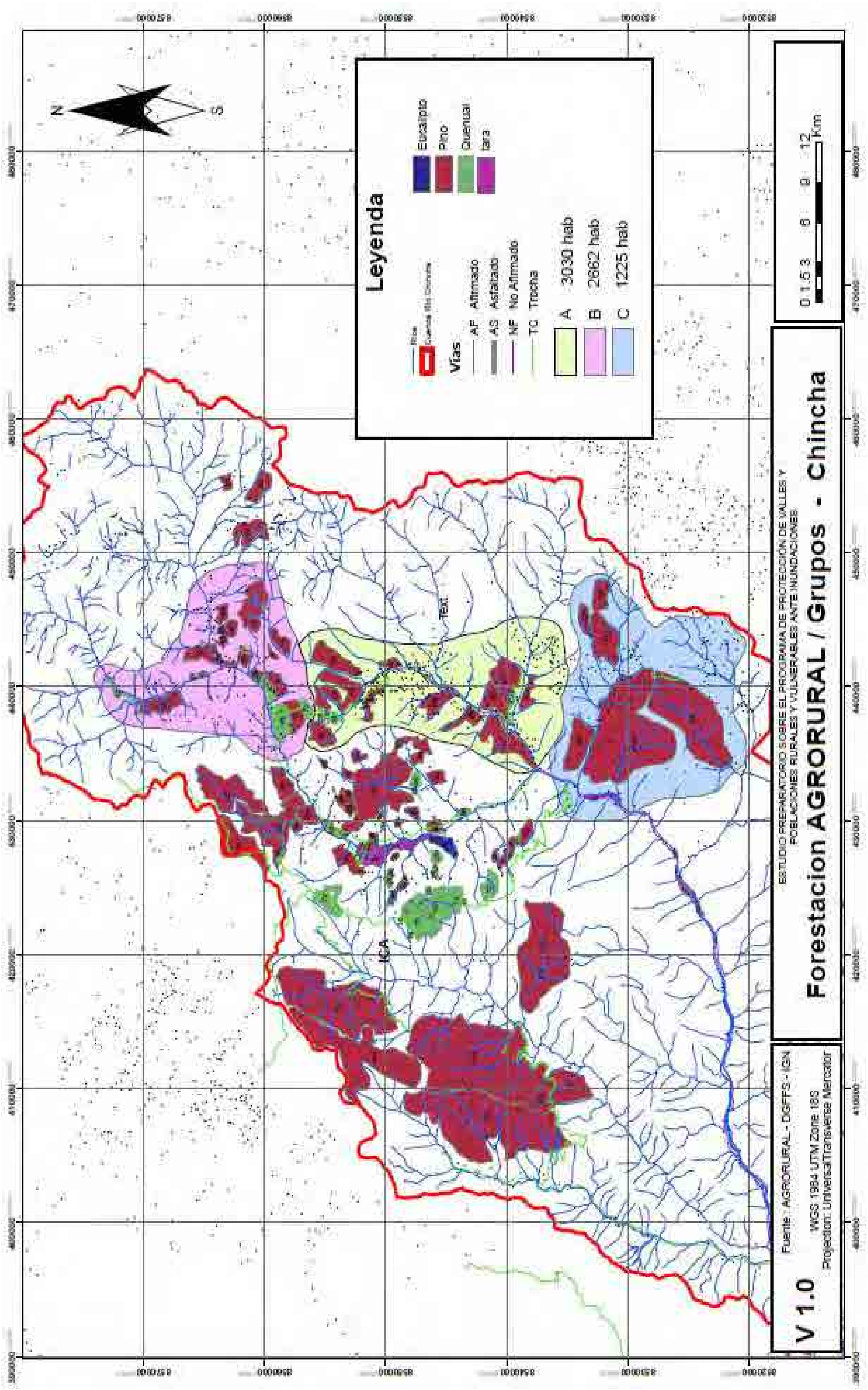


Figure 4.13.2-2 Reforesting Plan and Selected Vegetation Recovery of the Chincha River

4) Execution costs

This execution costs were estimated following:

- Seedlings unitary costs (unitary price + transportation)

- Labor cost

Seedlings suppliers can be i) Agrorural or ii) Private Suppliers. For reforestry the upper watershed of Chincha River the seedlings will be obtained from AGRORURAL.

To estimate unitary cost of labor, we are proposing to apply unitary cost of common labor for forestry of margins, meanwhile for the upper watershed of Chincha River we are thinking of hiring local inhabitants disposing half of labor cost in order to beneficiate (additional income) to the local community.

(i) Seedlings unit cost
This cost was defined based on the information obtained through AGRORURAL interviews. Because seedlings costs and transportation cost varies depending on suppliers, the average was applied.

(ii) Labor cost
This was determined by 40 trees/person per day, according to the gathered info by AGRORURAL and irrigation commissions. In margins reforestry, unit cost of labor would be 33,6 soles /men-day, in the upper basin was determined as 16,8soles/men-day, which is half the first one.
In table 4.13.2-6 unit costs applied to estimate direct work costs by ha are shown.

Table 4.13.2-6 Unit costs applied to estimate direct cost

	Units	Eucalyptus	Pine	Queñua	Tara
Plants per hectare	Plant/ha	2,960	2,960	2,960	2,960
Cost of seedlings	Soles/ha	1,332	1,480	1,332	1,332
Labor Cost	Soles/ha	1,243	1,243	1,243	1,243
Total Cost of reforestation	Soles/ha	2,575	2,723	2,575	2,575

(iii) Reforestation execution cost
In Table 4.13.2-7 direct cost of the works for the reforestry works on the upper watershed is shown

Table 4.13.2-7 Direct cost of the works for the reforest

Area No.	Species to be planted		
	Pine	Queñua	Total
Group A			
2nd year	2,619.390	0	2,619.390
3rd year	2,152.450	129	2,152.579
4th year	2,116.887	0	2,116.887
Subtotal	6,888.727	129	6,888.856
Group B			
2nd year	0	1,279.209	1,279.209
3rd year	1,520.823	0	1,520.823
4th year	1,537.188	529.137	2,066.325
Subtotal	3,058.011	1,808.345	4,866.356
Total	9,946.738	1,808.474	11,755.212

Within the cost of the project, the following will be estimated:
11.76 million soles (direct work cost) x 1.882 (indirect work cost, etc.) = 22.1 million soles

5) Project's cost-benefit

For the estimation of benefits for the upper watershed, an example of the cash flow was taken for each hectare of Pine typical productive forest in the Mountain region of Peru, modifying density and plantation cost and adding up carbon benefit. So, a relation C/B by hectare unit of 5.20 was determined as well as the ENPV of US$ 14,593 (see table 4.13.2-8)

6) Working calendar

This includes for the 1st year: choosing an NGO (by the consultant) to offer support to the community, forestry detailed elaboration (by NGO), organize the community to perform reforestation works (by NGO), seedlings production, etc. Preparation stage

For the next three years (from the 2nd to the 4th) reforestation labors will be carried out. Seedling production require between 3 to 6 months. Aiming to ensure a high survival it is best to use big seedlings, dedicating its production to the dry season (7 months, between April and October) and completing the transplant in the rainy season (four months between November and March).

Years	Dry season						Rainy Season				
	May	June	July	August	Sept.	Oct.	Nov.	Dec.	January	February	March
First	Preparatives										
Second	Seedling production (7 months)							Transplant			Reserve
Third	Ídem							Ídem			Reserve
Fourth	Ídem							Ídem			Reserve

Figure 4.13.2-3 Reforestation and vegetal recovery calendar

(Source: JICA Study Team)

For the upper watershed reforestation plan, an adequate sensitizing of the local community towards reforestation needs is required. A communitarian organization shall be arranged for this purpose. Additionally, to ensure flood preventive function, forests of the upper watershed have to be conserved in a sustainable way. In this regard, it is necessary to establish a short and repopulation forestry cycle. To have this system, it is necessary to have specialized engineers and NGO's support to train the community.

7) Conclusions

According to Table 4.13.2-8, this alternative will have a positive economic impact if benefits of carbons absorption are taken into consideration. But it will have negative impact if its impact is only to control floods and no damage is reduced nor reforesting 4,000 ha is done. The projects' cost is high, estimated in 22.1 million soles, that represent 50% of the total project's cost of this river, of 44.0 million soles. So, this alternative is concluded not to be included in this Project considering that the model area (Alternative 3) reforestation must be implemented as a project aside from the present Project.

Table 4.13.2-8 Results from cost-benefit relation of the Pine reforesting project (In US$/ha)

Year	Investment Cost	Forestry Labors	Administrative expenses	Incomes	Cash flow (without taxes)	Taxes	Cash flow (with taxes)	Total costs	Benefits as carbon sink	Total benefits
	(A)	(B)	(C)	(D)	(D) -(A)-(B)-(C)	(E)	(D)-(E)	(A)+(B)+(C)	(F)	(D)-(E)+(F)
0	481,56	449,39	321,16	0,00	-1.252,11	0,00	-1.252,11	1.252,11	0,00	0,00
1	226,17	704,13	111,65	0,00	-1.041,95	0,00	-1.041,95	1.041,95	222,79	222,79
2	0,00	704,13	84,49	0,00	-788,62	0,00	-788,62	788,62	445,58	445,58
3	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	668,37	668,37
4	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	891,16	891,16
5	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1.113,95	1.113,95
6	0,00	1.000,96	120,12	1.614,55	493,47	148,00	345,47	1.121,08	1.336,74	2.803,29
7	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1.559,53	1.559,53
8	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1.151,08	1.151,08
9	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1.522,39	1.522,39
10	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1.893,71	1.893,71
11	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2.265,03	2.265,03
12	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2.636,34	2.636,34
13	0,00	1.491,46	178,97	4.372,73	2.702,30	809,96	1.892,34	1.670,43	3.007,66	6.570,43
14	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	3.378,97	3.378,97
15	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	4.178,43	4.178,43
16	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	6.513,78	6.513,78
17	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	8.849,13	8.849,13
18	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	11.184,48	11.184,48
19	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	13.519,84	13.519,84
20	0,00	0,00	0,00	7.625,00	7.625,00	-2.288,00	5.337,00	0,00	15.855,19	21.192,19

Net cost current value = 3.477,84
Benefit net current value = 18.071,01
Relation C/B = 5,20

ENPV = $14.593

4.13.3 Sediment control plan

For the long-term sediment control plan, it is recommended to execute the necessary works in the upper watershed.

The Sediment Control Plan in the upper watershed will mainly consist in construction of sediment control dikes and margin protection works. In Figure 4.12.3-1 the sediment control works disposition proposed to be executed throughout the watershed is shown. The cost of Chincha River works was estimated focusing on: a) covers the entire watershed, and b) covers only the priority areas, analyzing the disposition of works for each case. The results are shown in Table 4.13.3-1.

Due to the Chincha River extension, the construction cost for every alternative would be too high in case of carrying-out the margin protection works, erosion control dikes, etc. Apart from requiring a considerably long time. This implies that the project will take a long time to show positive results. So, it is decided that it is impractical to execute this alternative within this project and should be timely executed within the framework of a long-term plan, after finishing this project.

Table 4.13.3-1 Upper watershed sediment control works execution estimated costs

Watershed	Approach	Margin Protection		Strip		Sediment control dike		Total works direct cost	Project Cost (Millions S/.)
		Vol. (km)	Direct Cost (Million S/.)	Vol. (units)	Direct Cost (Million S/.)	Vol. (units)	Direct Cost (Million S/.)		
Chira	All Watershed	0	S/.0	0	S/.0	272	S/.423	S/.423	S/.796
	Prioritized Section	0	S/.0	0	S/.0	123	S/.192	S/.192	S/.361
Cañete	All Watershed	325	S/.347	32	S/.1	201	S/.281	S/.629	S/..1.184
	Prioritized Section	325	S/.347	32	S/.1	159	S/.228	S/.576	S/..1.084
Chincha	All Watershed	381	S/.407	38	S/.1	111	S/.116	S/.524	S/..986
	Prioritized Section	381	S/.407	38	S/.1	66	S/.66	S/.474	S/.892
Pisco	All Watershed	269	S/.287	27	S/.1	178	S/.209	S/.497	S/.935
	Prioritized Section	269	S/.287	27	S/.1	106	S/.126	S/.414	S/.779
Yauca	All Watershed	565	S/.604	57	S/.2	97	S/.144	S/.750	S/.1.412
	Prioritized Section	565	S/.604	57	S/.2	37	S/.54	S/.660	S/.1.242
Majes-Camana	All Watershed	264	S/.282	26	S/.1	123	S/.165	S/.448	S/.843
	Prioritized Section	264	S/.282	26	S/.1	81	S/.105	S/.388	S/.730
Total	All Watershed	1.803	S/.1.927	180	S/.5	982	S/.1.338	S/.3.271	S/.6.155
	Prioritized Section	1.803	S/.1.927	180	S/.5	572	S/.772	S/.2.705	S/.5.090

5. CONCLUSIONS

The selected alternative for flood control in this Study is structurally safe. Also, the social assessment showed a sufficiently high economic value, except for Chira and Yauca Rivers. Its environmental impact is reduced. The implementation of this Project will contribute to relief the high vulnerability of valleys and local community to floods, and will also contribute with the local economic development. Therefore, we conclude to implement it as quickly as possible.