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

Watersheds	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
Cañete	188.40	184.10	184.77	1.20	185.97	1.18	2.03
Chincha							
Chico	144.81	145.29	144.00	0.80	144.80	0.40	0.45
Matagente	133.72	133.12	132.21	0.80	133.01	0.29	0.36
Pisco	219.72	217.26	214.82	1.00	215.82	0.63	0.76
Majes-Camana	401.90	405.19	398.84	1.20	400.04	0.85	0.65

According to this Table, the larger gap between demand and supply is in Cañete and Majes-Camana Rivers followed by Pisco, and low in the Chincha river.

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

Watershed	Dike Height / current land (supply)		Water level with return period of 50 years	Dike Freeboard	Required dike's heigth (demand)	Diff. demand/supply	
	Left margin	Right margin				Left margin	Right margin
	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 4.15 "Medium and Long Term Plan" and 4.15.1 "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) (present DGPI) 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(4). 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	2-year	10-year	25-year	50-year	100-year	Max. in the Past
Cañete	331	822	1,496	2,175	2,751	900
Chincha	203	580	807	917	1,171	1,269
Pisco	213	451	688	855	963	956
Majes-Camana	306	1,007	1,416	2,084	2,703	2,400

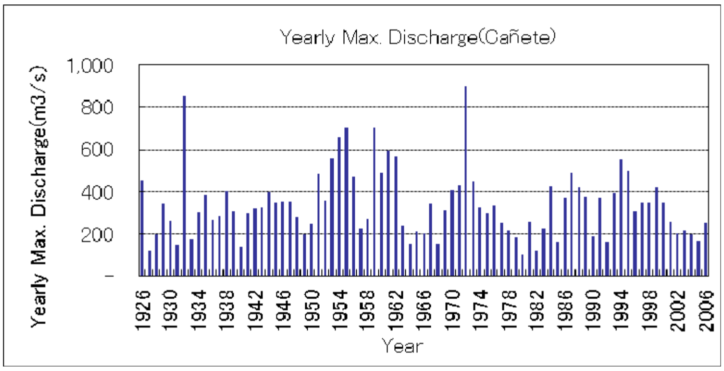


Figure- 4.3.1-1(1) Yearly max. discharge (Cañete)

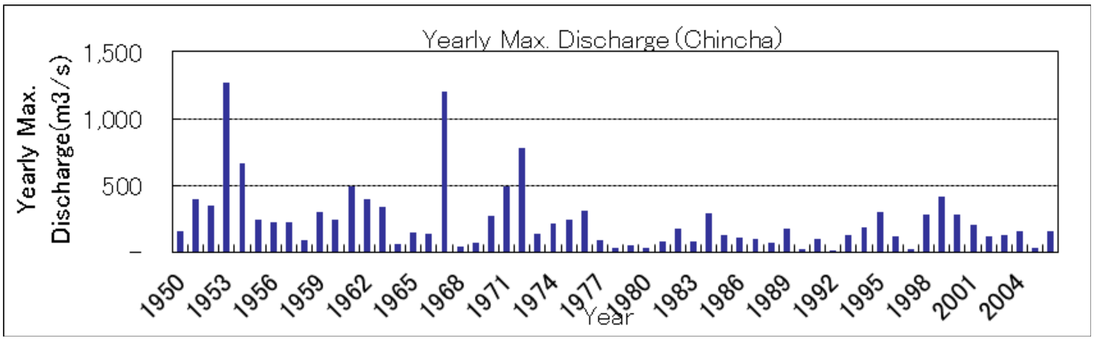


Figure- 4.3.1-1(2) Yearly max. discharge (Chincha)

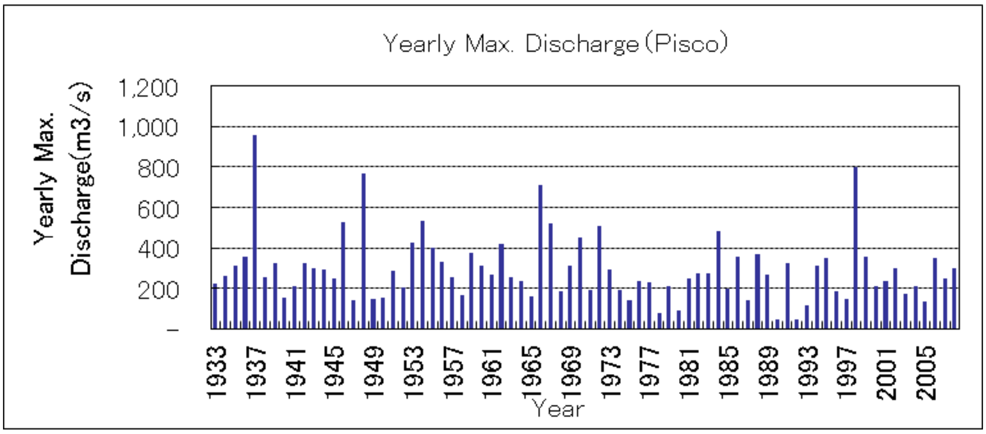


Figure- 4.3.1-1(3) Yearly max. discharge (Pisco)

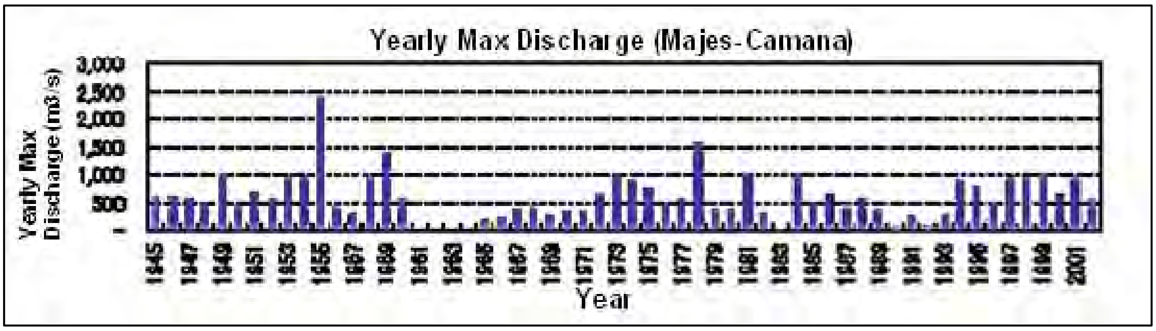


Figure- 4.3.1-1(4) Yearly max. discharge (Majes-Camana)

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(4).

Based on the figures the following facts can be expressed.

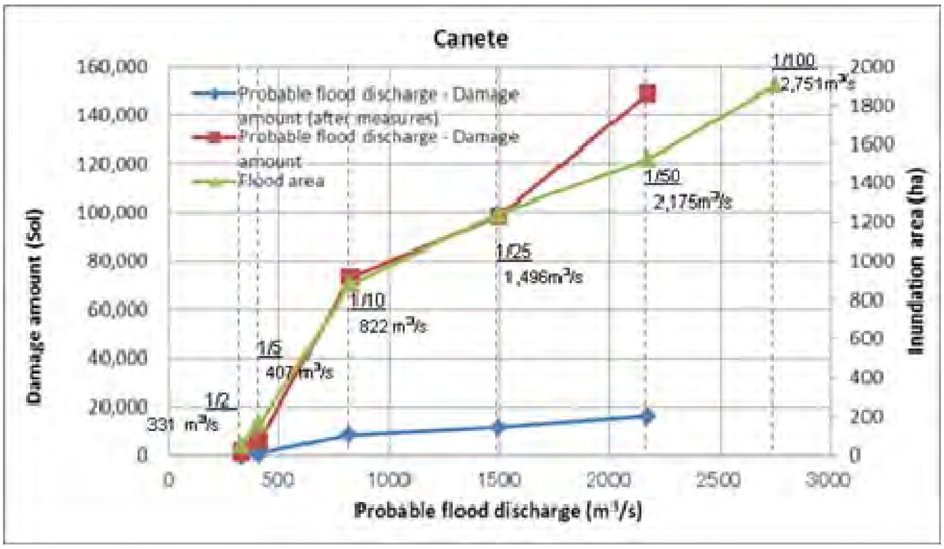
i) The more increase probable flood discharge, the more increase inundation area (green line in the figure).

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

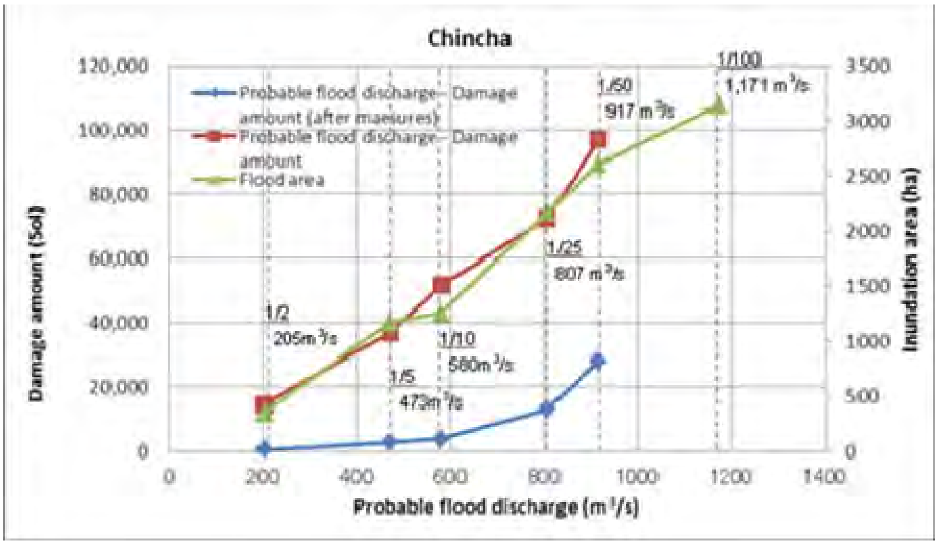
iii) According to increase of probable flood discharge, the damage with project increase gently (blue line in the figure).

iv) 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.

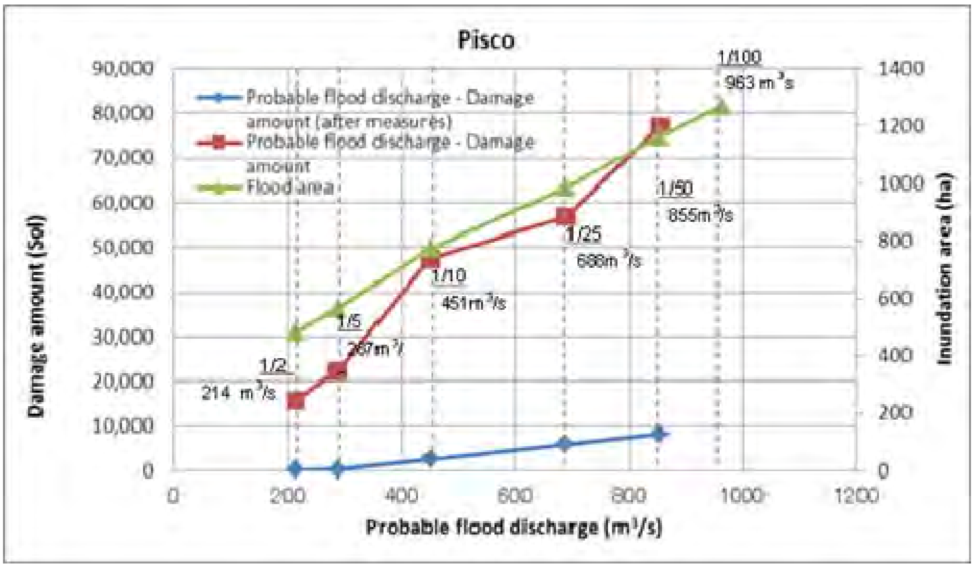
As shown in the above section, the design flood discharge with return period of 50-year is almost equal to the maximum flood in the past, and absolute damage reduction amount in the design discharge is largest among the probable flood discharge less than with return period of 50-year, and economic viability of the design flood is confirmed. Although the design discharge is the flood with return period of 50-year, the inundation area of the flood with return period of 100-year is described in the figures.



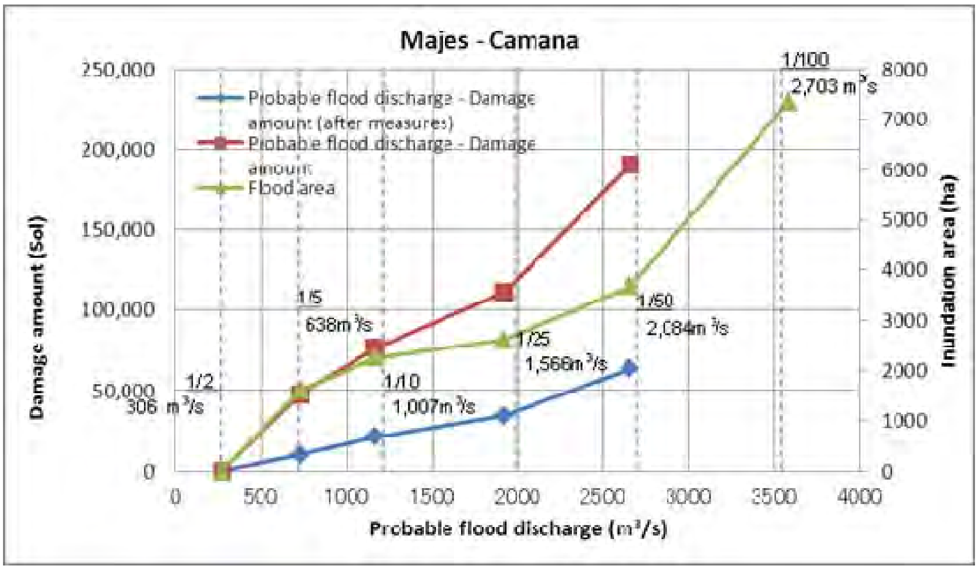
Figure－4.3.1-2 (1) Probable flood discharge, damage amount and inundation area (Cañete river)



Figure－4.3.1-2 (2) Probable flood discharge, damage amount and inundation area (Chincha river)



Figure－4.3.1-2 (3) Probable flood discharge, damage amount and inundation area (Pisco river)



Figure－4.3.1-2 (4) 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 4.3.1-7 detail assessment results of each the river, as well as the selection results of flood protection priority works.

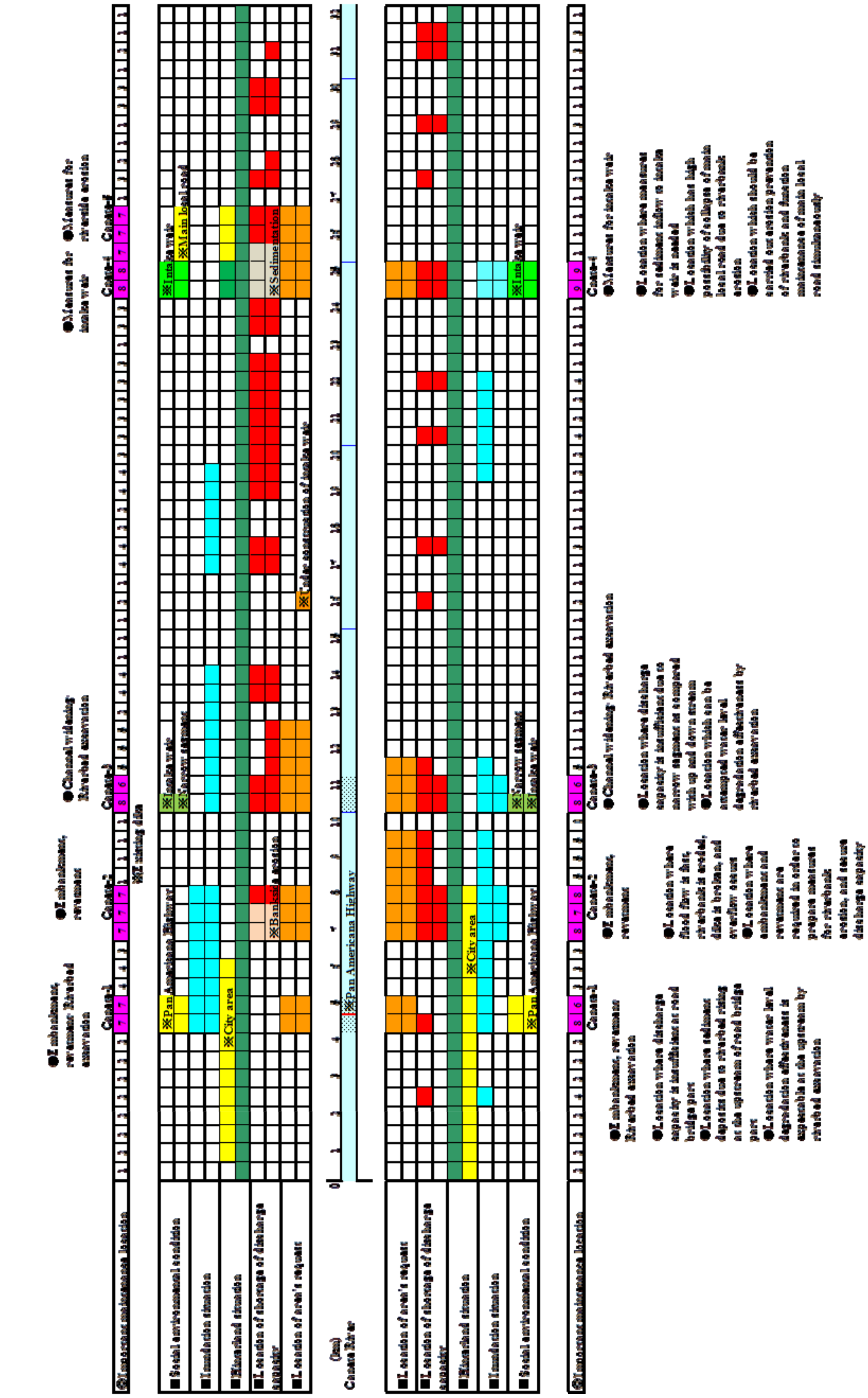


Figure 4.3.1-3 Selection results of prioritized flood protection works in Cañete river

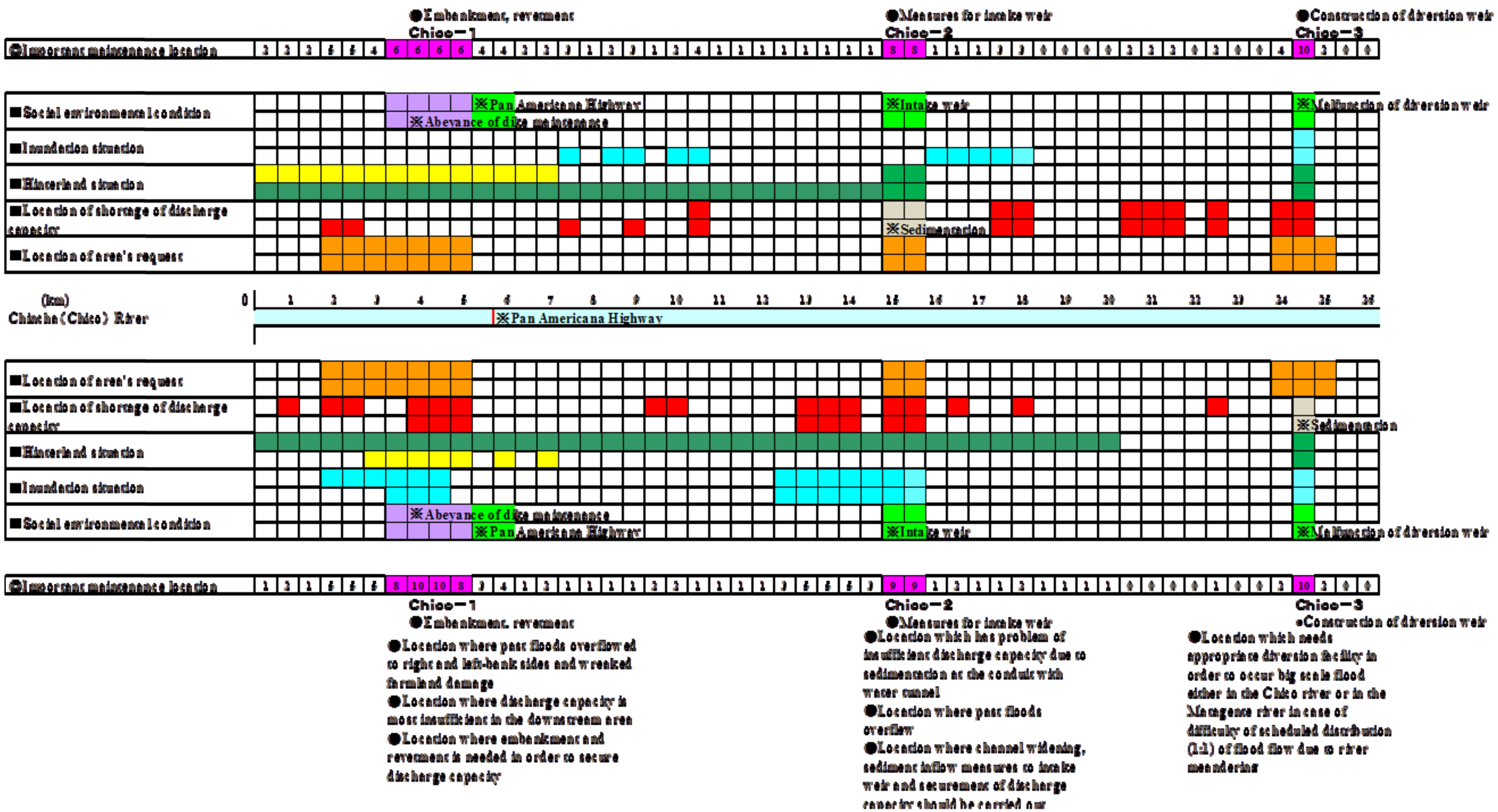


Figure 4.3.1-4 Selection results of prioritized flood protection works in Chincha-Chico river

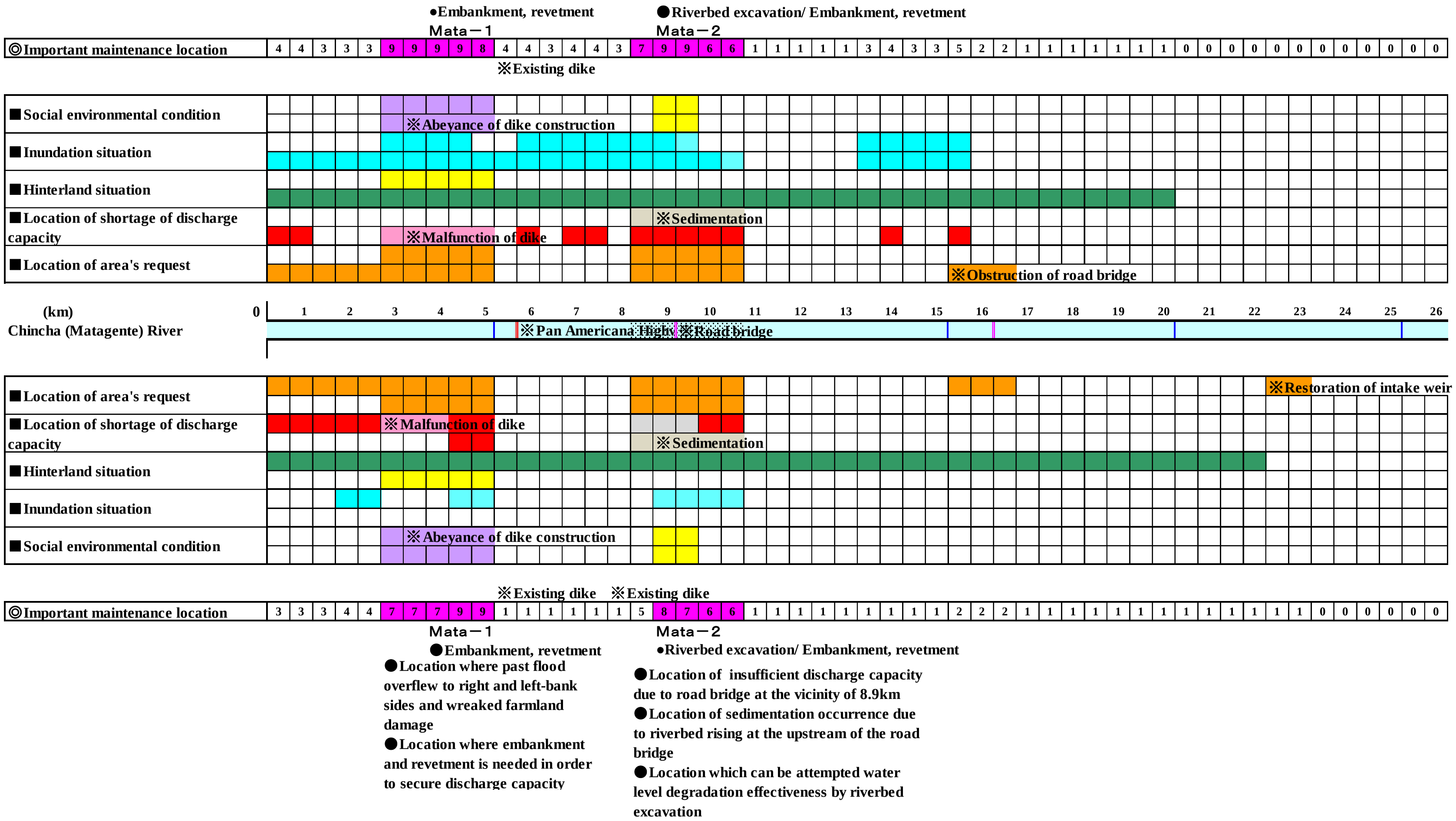


Figure 4.3.1-5 Selection results of prioritized flood protection works in Chincha-Matagente river

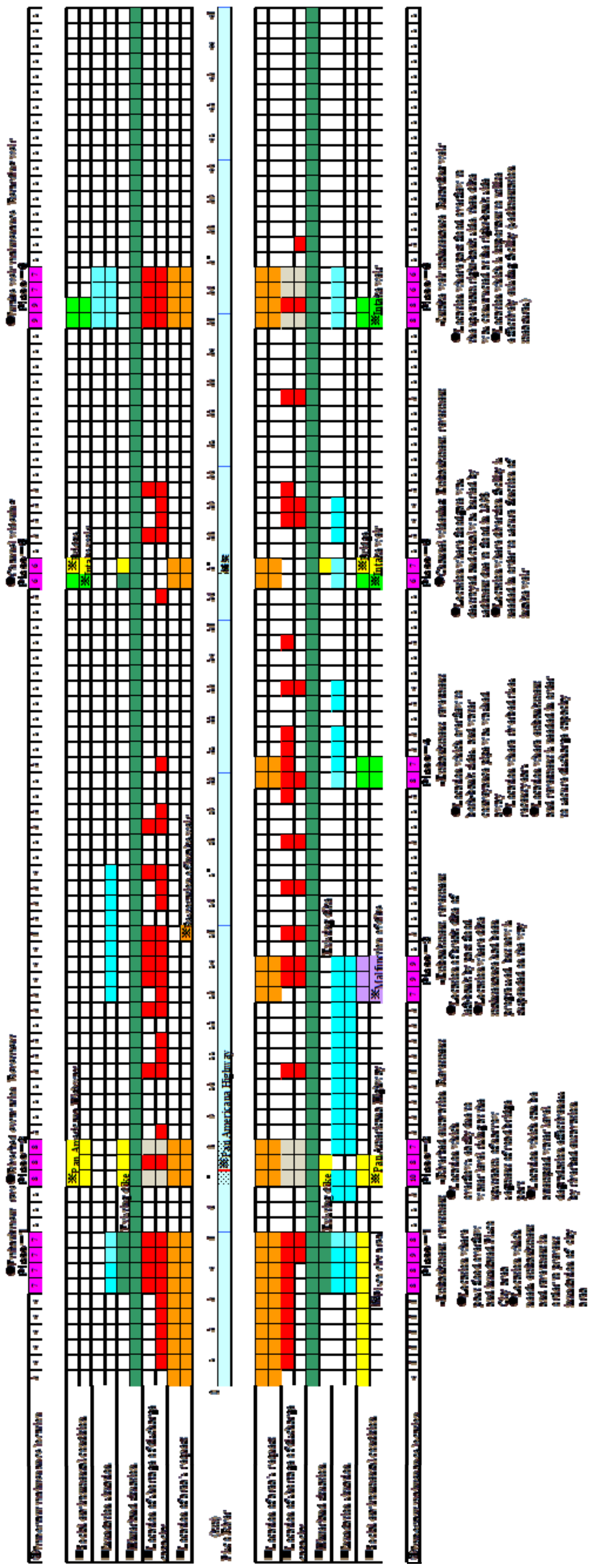


Figure 4.3.1-6 Selection results of prioritized flood protection works in Pisco river

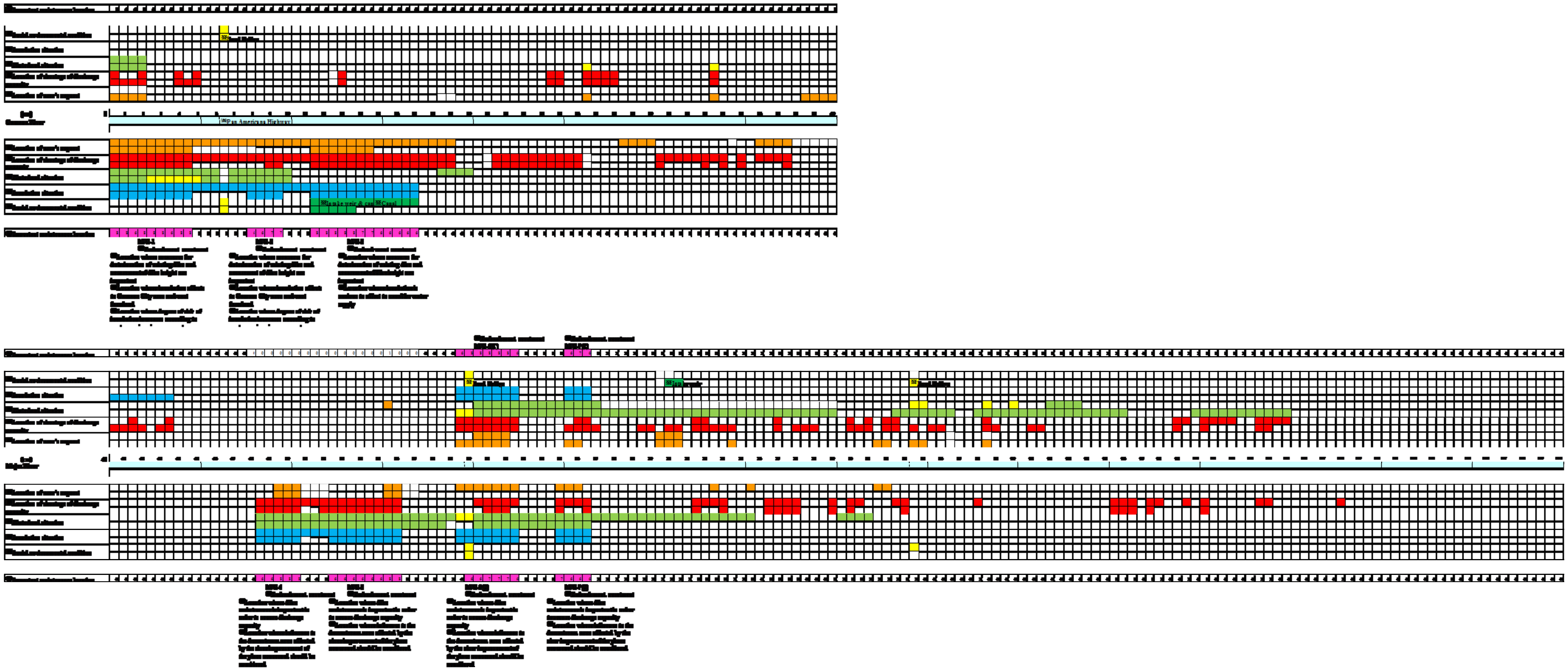


Figure 4.3.1-7 Selection results of prioritized flood protection works in Majes-Camana River

3) Basis of selection

Table 4.3.1-4 ~ 4.3.1-7 presents basis of selection of each work.

a) 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-4.3.1-4 Basis of Selection for flood protection work (Cañete river)

No	Location	Basis of Selection
i)	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.
ii)	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).
ｉｉｉ)	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.
ｉv)	km24.25-km24.75 (widening river width on left bank)	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 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.
v)	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.

b) 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 discharge is distributed equally to the both rivers as the each river channel has same scale (in case of execution of No.iii)). There is no discharge distribution plan at present.

Table 4.3.1-5 Selected sections bases to execute works (Chincha River)

No	Location	Basis of Selection
i)	**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
ii)	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
iii)	**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.
ⅰv)	**Matagente** 川 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.
v)	**Matagente** 川 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.

c) 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 4.3.1-6 Selected sections bases to execute works (Pisco River)

No	Location	Basis of Selection
i)	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.
ii)	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.
iii)	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.
iv)	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.
v)	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.
iv)	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.

d) 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 4.3.1-7 Selected sections bases to execute works (Majes-Camana river)

No	Location	Basis of Selection
i)	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.
ii)	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.
Iii)	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.
iv)	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.
v)	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.
vi)	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 ~ Figure 4.3.1-12 the location of prioritized flood control works in indicated in each watershed and in the Table- 4.3.1-8 the summary of flood control works is indicated..

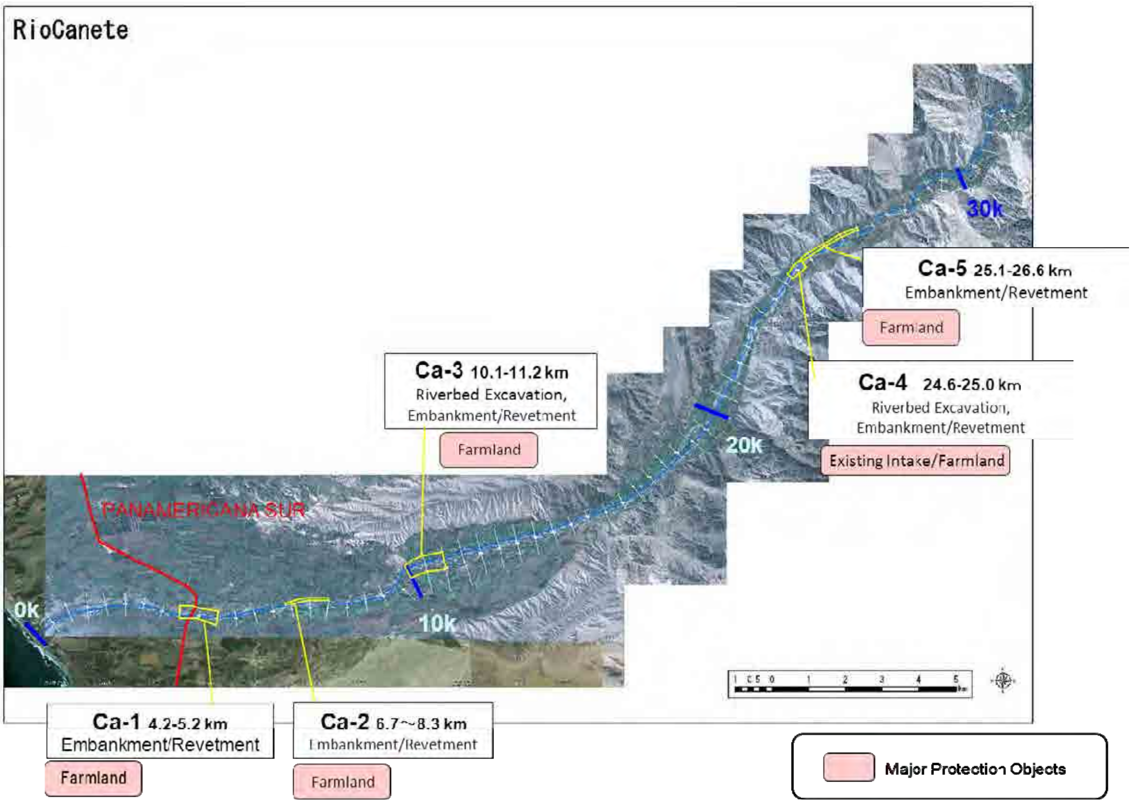


Figure 4.3.1-8 Prioritezed flood control works in Cañete river

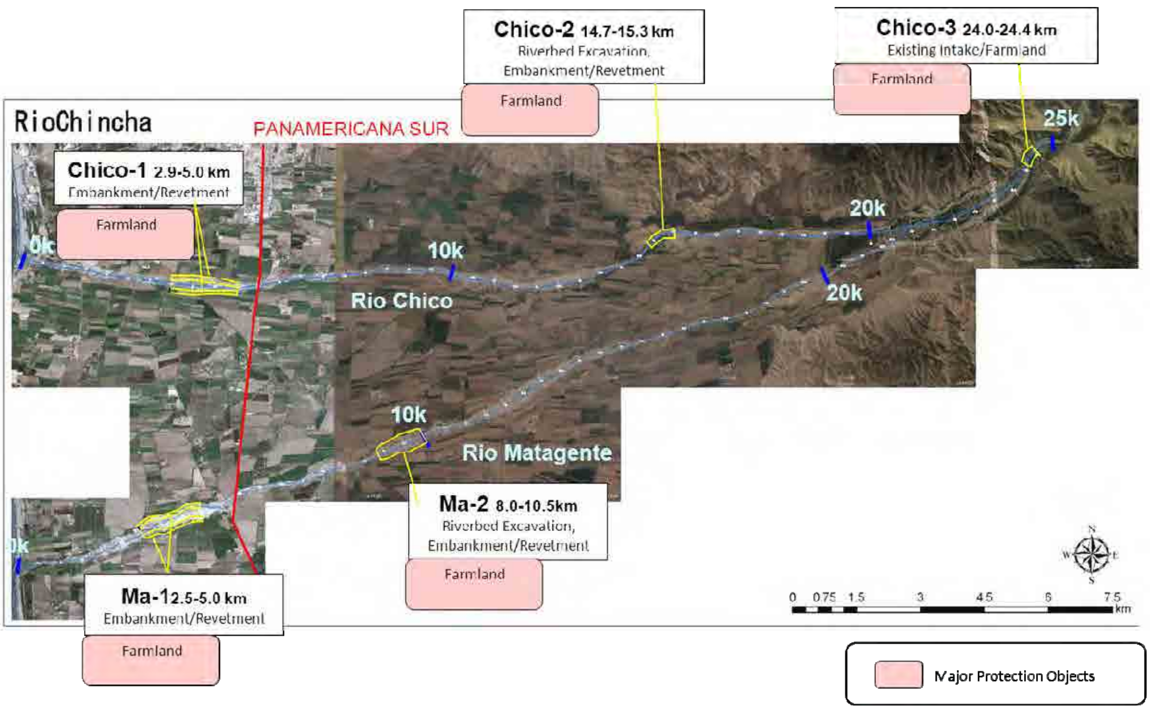


Figure 4.3.1-9 Prioritezed flood control works in Chincha river

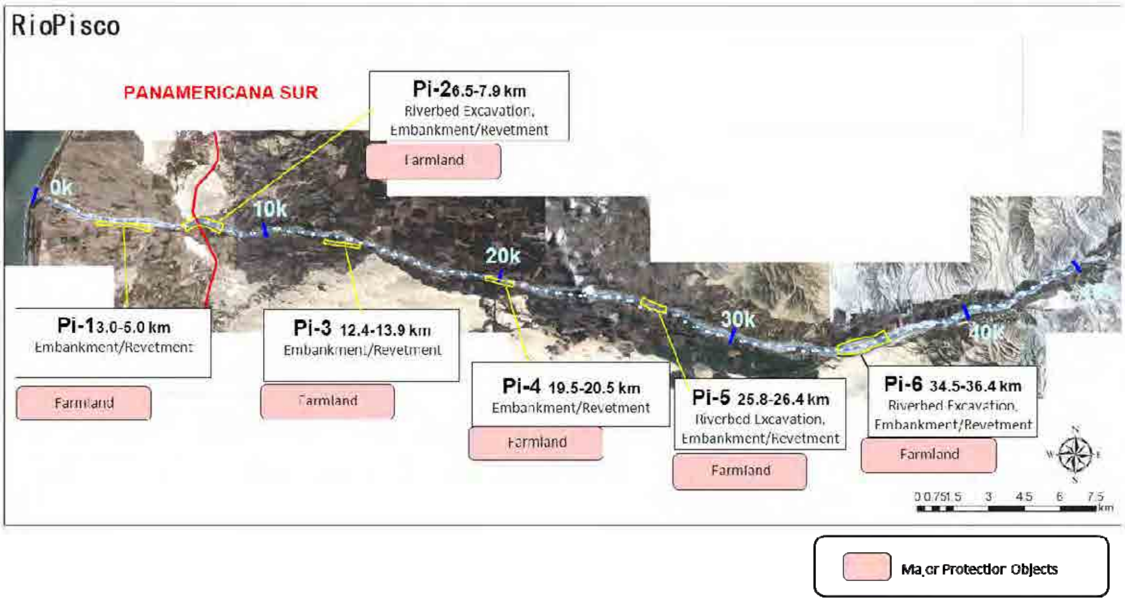


Figure 4.3.1-10 Prioritezed flood control works in Pisco river

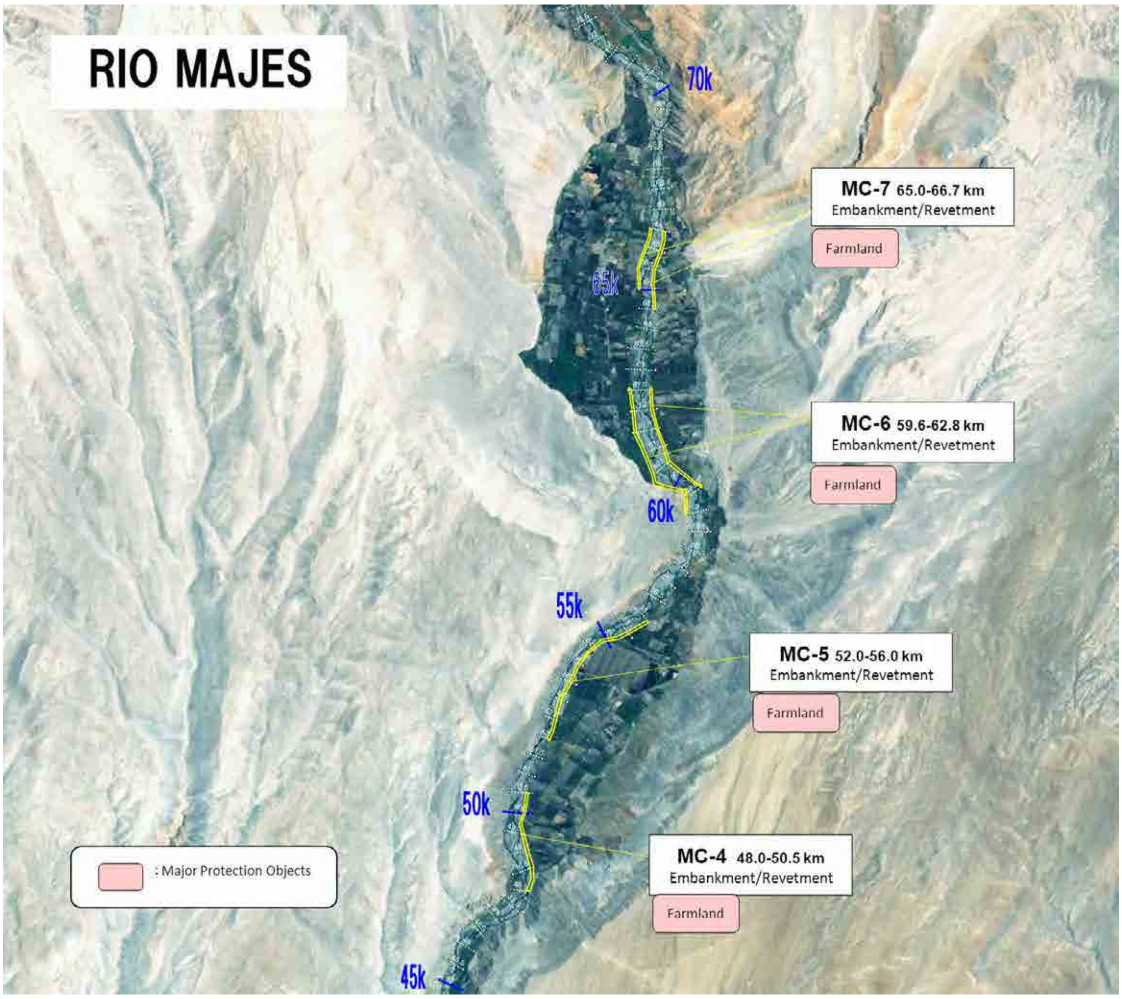


Figure 4.3.1-11 Prioritezed flood control works in Majes river

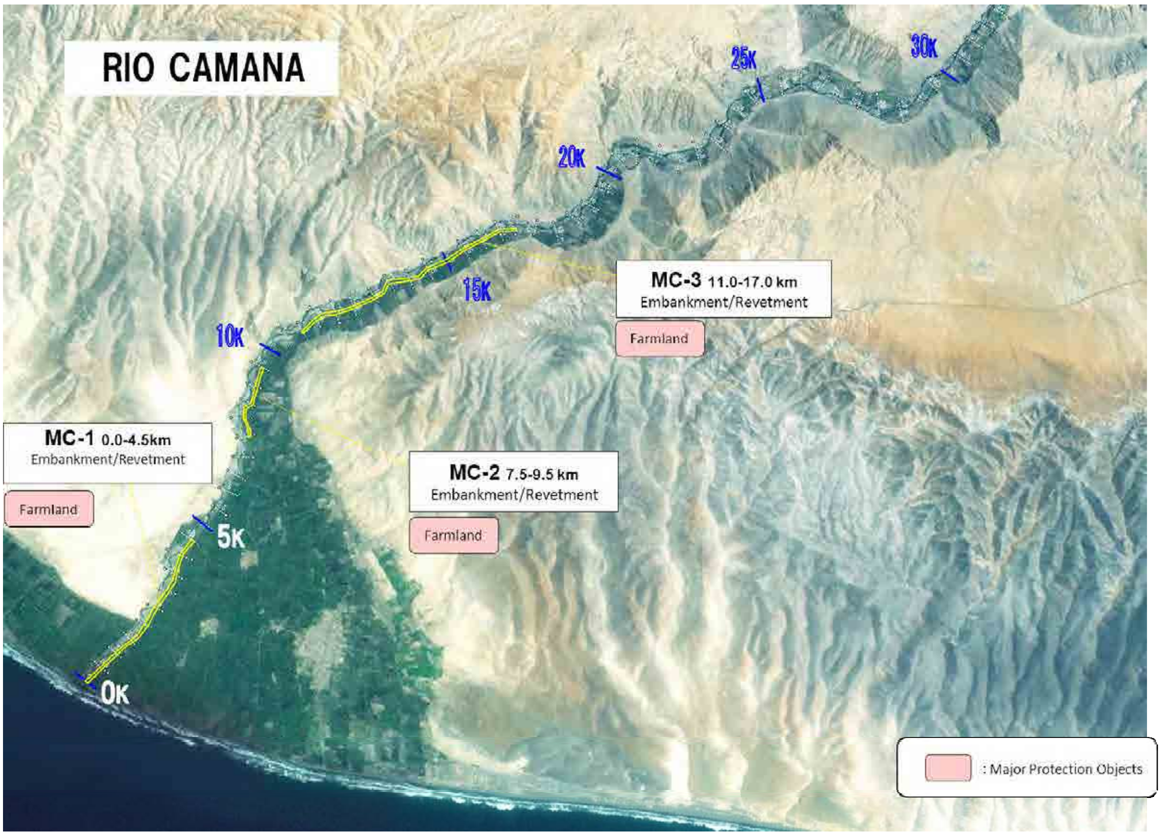


Figure 4.3.1-12 Prioritezed flood control works in Camana river

Table 4.3.1-8 Summary of facilities

River	Location		Critical Point	Main Protection Objects	Measure	Feature of Work	
Rio Canete	Ca-1	4..2-5.2 km	Narrow Section	Agricultural Lands (Apple, Grape, Cotton, etc.)	Dike with Bank Protection	Length Bank Protection Large Boulder Riplap	1,100 m 5,430 m3 9,230 m3
	Ca-2	6.7～8.3 km	Innnuded Point		Dike with Bank Protection	Length Dike with Bank Protection Large Boulder Riplap	3,200 m 113,700 m3 28,200 m3
	Ca-3	10.1-11.2 km	Narrow Section		Riverbed Excavation、Dike with Bank Protection	Riverbed Excavation Dike with Bank Protection Large Boulder Riplap	L=700 m, V=80,270m3 1,630 m 16,730 m3
	Ca-4	24.6-25.0 km	Existing Intake Weir (w:150m, i: 1:2, crest w:2.0m)	Intake Weir, Agricultural Lands	Riverbed excavation、Dike with Bank Protection	Riverbed Excavation Dike with Bank Protection Large Boulder Riplap	L=370 m, V=34,400 m3 L=710m, V=20,150 m3 7,300 m3
	Ca-5	25.1-26.6 km	Narrow Section	Agricultural Lands (Apple, Grape, Cotton, etc.)	Dike with Bank Protection	Length Dike with Bank Protection Large Boulder Riplap	1,520 m 95,125 m3 14,000 m3
Rio Chincha	Chico-1	2.9-5.0 km	Innnuded Point	Agricultural Lands (Apple, Grape, Cotton, etc.), Intake Weir	Dike with Bank Protection	Length Dike with Bank Protection Large Boulder Riplap	3,150 m 60,160 m3 23,700 m3
	Chico-2	14.7-15.3 km	Existion Intake Weir (w:100m, H:3.0m, crest w:2.0m)		Riverbed excavation、Dike with Bank Protection	Riverbed Excavation Dike with Bank Protection Large Boulder Riplap	L=540 m, V=20,000 m3 L=850 m, V=5,500 m3 23,700 m3
	Chico-3	24.0-24.4 km	Existing Intake Weir (w:70m, H: 3.0m, crest w:2.0m)		Intake Weir/ Dike with Bank Protection	Construction of Intake Weir Dike with Bank Protection Large Boulder Riplap	Ground Sill 1 V=5,200 m3, Diversion Weir 1 V=4,300 m3 L=730 m, V=20,350 m3 7,400 m3
	Ma-1	2.5-5.0 km	Innnuded Point		Dike with Bank Protection	Length Dike with Bank Protection Large Boulder Riplap	4,630 m 49,900 m3 37,000 m3
	Ma-2	8.0-10.5km	Narrow Section		Riverbed excavation、Dike with Bank Protection	Riverbed Excavation Dike with Bank Protection Large Boulder Riplap	L=2,500 m, V=123,500 m3 L=4,080 m, V=37,700 m3 32,200 m3
Rio Pisco	Pi-1	3.0-5.0 km	Innnuded Point	Agrictural Lands	Dike with Bank Protection	Length Dike with Bank Protection Large Boulder Riplap	4,120 m 92,900 m3 32,200 m3
	Pi-2	6.5-7.9 km	Narrow Section		Riverbed Excavation、Dike with Bank Protection	Riverbed excavation Dike with Bank Protection Large Boulder Riplap	L=1,200 m, V=74,900 m3 L=2,950 m, V=42,520 m3 25,000 m3
	Pi-3	12.4-13.9 km	Innnuded Point		Dike with Bank Protection	Length Dike with Bank Protection Large Boulder Riplap	1,500 m 33,900 m3 12,600 m3
	Pi-4	19.5-20.5 km	Innnuded Point	Agrictural Lands	Dike with Bank Protection	Length Dike with Bank Protection Large Boulder Riplap	1,010 m 17,400 m3 8,060 m3
	Pi-5	25.8-26.4 km	Narrow Section		Riverbed Excavation、Dike with Bank Protection	Riverbed excavation Dike with Bank Protection Large Boulder Riplap	L=600 m, V=67,600 m3 L=1,250 m, V=29,900 m3 10,600 m3
	Pi-6	34.5-36.4 km	Existing Intake Weir (Sediment Retuding Basin 1,800 x 700m)		Riverbed Excavation・Dike with Bank Protection	Riverbed excavation Outer Dike/ Bank protection Large Boulder Riplap Inner Dike/ Bank protection Large Boulder Riplap	L=1,900 m, V=496,000 m3 L=2,050 m, V=103,600 m3 19,900 m3 L=3,750 m, V=114,000 m3 63,100 m3
Rio Camana	MC-1	0.0-4.5km	Innnuded Point	Agrictural Lands	Dike with Bank Protection	Length Dike with Bank Protection Large Boulder Riplap	4,500 m 155,700 m3 44,300 m3
	MC-2	7.5-9.5 km	Innnuded Point	Agrictural Lands	Dike with Bank Protection	Length Dike with Bank Protection Large Boulder Riplap	2,000 m 43,100 m3 18,300 m3
	MC-3	11.0-17.0 km	Innnuded Point	Agrictural Lands	Dike with bank Protection	Length Dike with Bank Protection Large Boulder Riplap	6,000 m 169,000 m3 59,000 m3
Rio Majes	MC-4	48.0-50.5 km	Innnuded Point	Agrictural Lands	Dike with Bank Protection	Length Dike with Bank Protection Large Boulder Riplap	2,500 m 75,200 m3 17,700 m3
	MC-5	52.0-56.0 km	Innnuded Point	Agrictural Lands	Dike with bank Protection	Length Dike with Bank Protection Large Boulder Riplap	4,300 m 179,000 m3 39,400 m3
	MC-6	59.6-62.8 km	Innnuded Point, Local Erosion	Agrictural lands	Dike with Bank Protection	Length Dike with Bank Protection Large Boulder Riplap	6,200 m 235,000 m3 51,400 m3
	MC-7	65.0-66.7 km	Innnuded Point	Agrictural Lands	Dike with Bank Protection	Length Dike with Bank Protection Large Boulder Riplap	2,900 m 32,300 m3 27,500 m3

(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 area to area, this can be summarized as follows, based on the information given by the administrators interviewed:

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

ii) 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.

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

iv) 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.

v) 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.

vi) 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.

vii) 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.

i) 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. The stability problems forecasted in this case are as follows.

- Infiltrate destruction caused by piping due to washing away fine material
- Sliding destruction of slope due to infiltrate pressure

In order to secure the stability of dike the appropriate standard section should be determined by infiltration analysis and stability analysis for sliding based on unit weight, strength and permeability of embankment material.

ii) 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.

The infiltration analysis and stability analysis of dike based on the soil investigation and martial tests are not performed in this Study so that the slope is determined by simple stability analysis assuming the strength factors of dike material estimated by field survey of material and by adding some safety allowance.

And the slope of dike in Japan is generally 1:2.0 in minimum, however the average slope will be more than 1:3.0 because the dike has several steps in every interval of 2m~3m of height.

iii) 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.

iv) The penetration depth to bank protection is to be i) difference height between the deepest riverbed in the past and present riverbed or ii) empirical depth (0.5m~1.5m in Japan), the former is u certain without chronological riverbed fluctuation data, therefore according to the latter the depth is to be 1.75m referring to the river channel improvement section in Ica river

v) Heightening method of dike

The heightening length of existing dike is 1.0 km among the total length of dike construction of 7.7 km in Cañete, 0.6 km of 13.2 km in Chincha, 0.8 km of 15.2 km in Pisco, 15.0 km of

24.8 km and 17.4 km of 60.9 km in total.

The heightening method of dike is basically an overall enlargement type due to the following reasons and the alignment of dike accords with the one of exiting dike.

- The heightening method of widening dike in riverside decreases river width so that the discharge capacity is reduced resulting in raising height of dike more than the other methods.
- The heightening method of widening dike in land side requires more land acquisition. It is desirable that the land acquisition is to be reduced as much as possible because the land is mainly important agricultural land of expensive.
- Although the workmanship of dike construction such as the compaction condition and material characteristics are unknown, the existing dike is to be utilized because the dike has been functioned in the past flooding, and the heightening method of overall enlargement type is to be applied, in which the existing dike is covered by the new dike with high strength, and can secure the safety and be economical with less land acquisition.

  On the other hand, in the section with the narrow river width and river channel near to the dike, the heightening method of widening dike in land side is applied, in this case the riverside slope is protected with revetment.

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 4.3.1-9 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-4.3.1-9 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

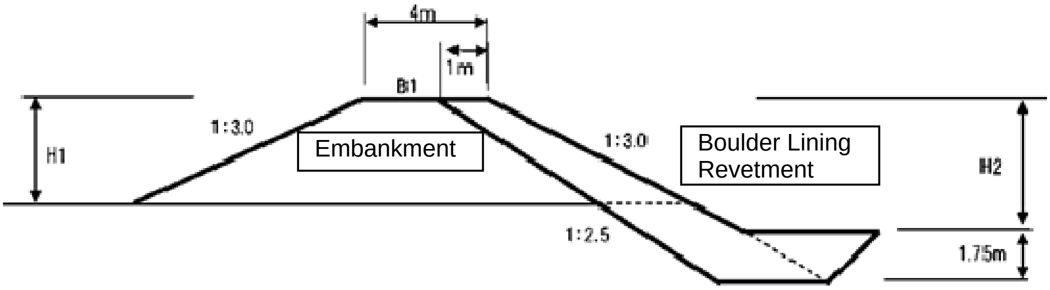


Figure 4.3.1-13 Standard dike section

4) Importance in construction work

The importance in dike construction is sufficient compaction of dike material. The cost estimate standard in Peru the compaction is to be made by tractor; however for the sufficient compaction it is desirable to use compaction equipment such as vibration roller etc.

And in order to supervise the compaction of material, the density test and grain size analysis are important, of which are specified in the technical specification of the tender document.

(6) Effect of flood prevention facilities

The discharge capacity of each river is enlarged up to the flood discharge with return period of 50-year by construction of the flood prevention facilities as shown in the Figure-4.3.1-14~Figure-4.3.1-19, and the inundation area is reduced remarkably.

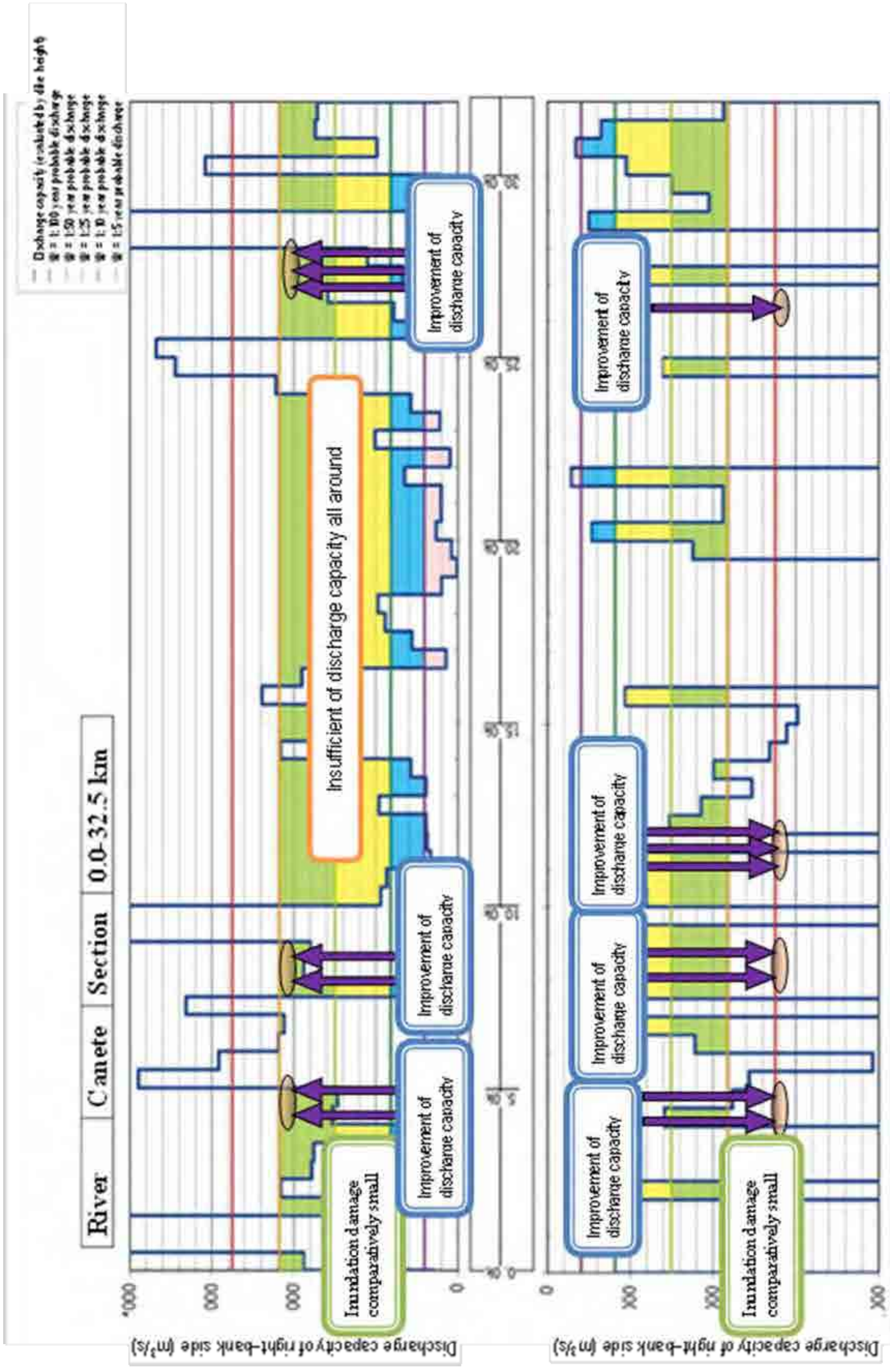


Figure-4.3.1-14 Effect of flood prevention facilities（Rio Cañete）

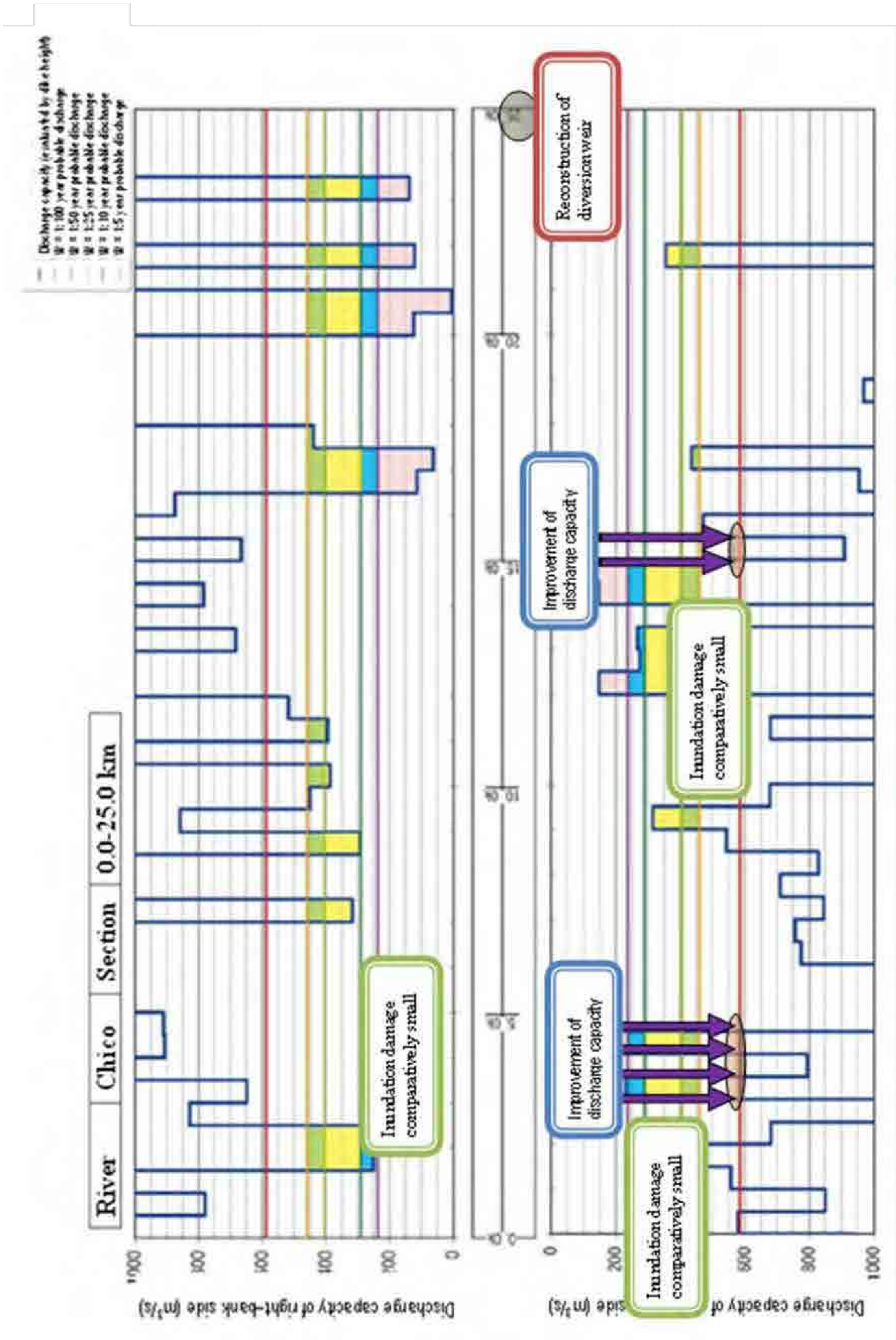


Figure-4.3.1-15 Effect of flood prevention facilities（Rio Chincha－Rio Chico）

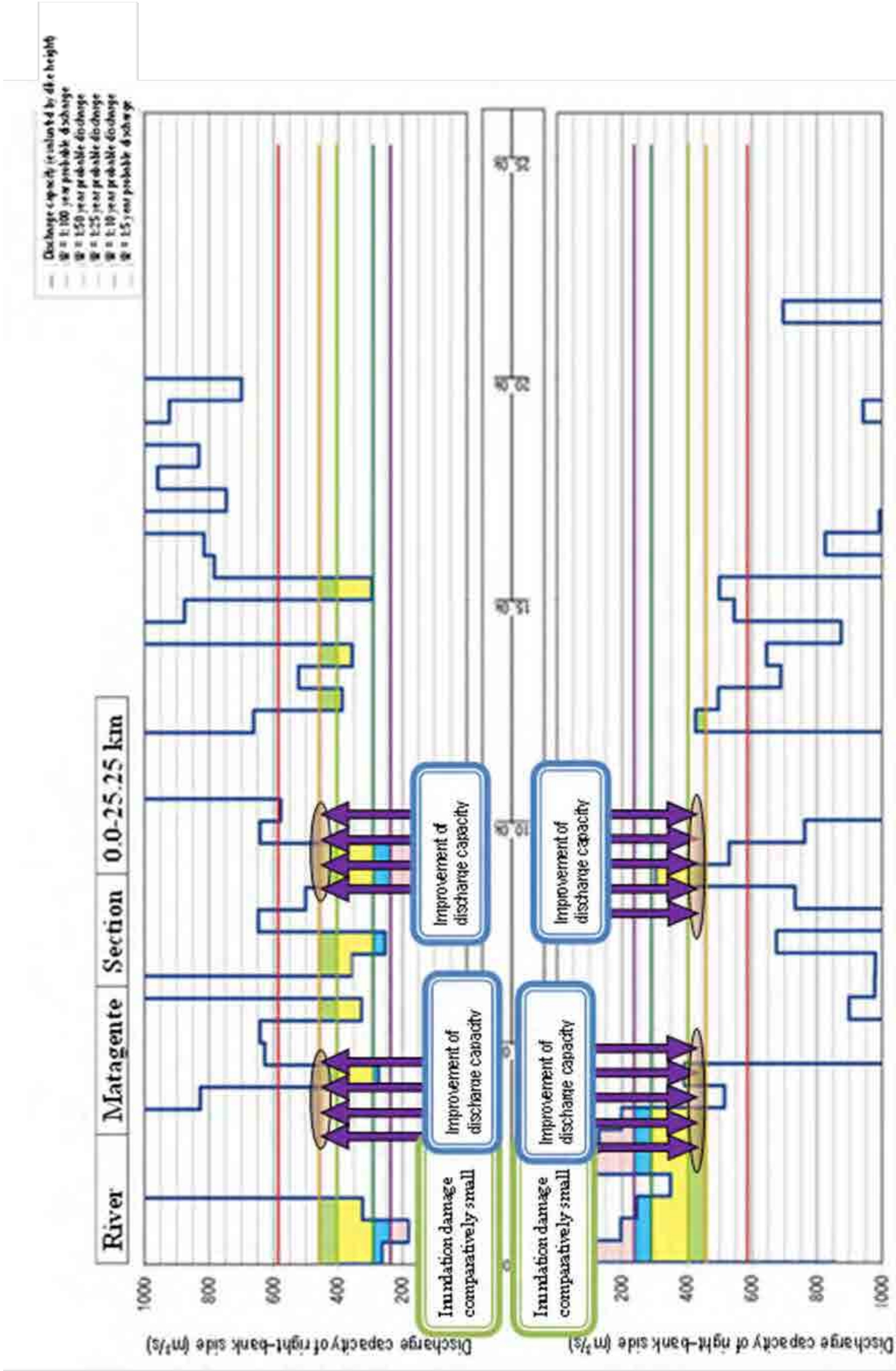


Figure-4.3.1-16 Effect of flood prevention facilities（Rio Chincha－Rio Matagente）

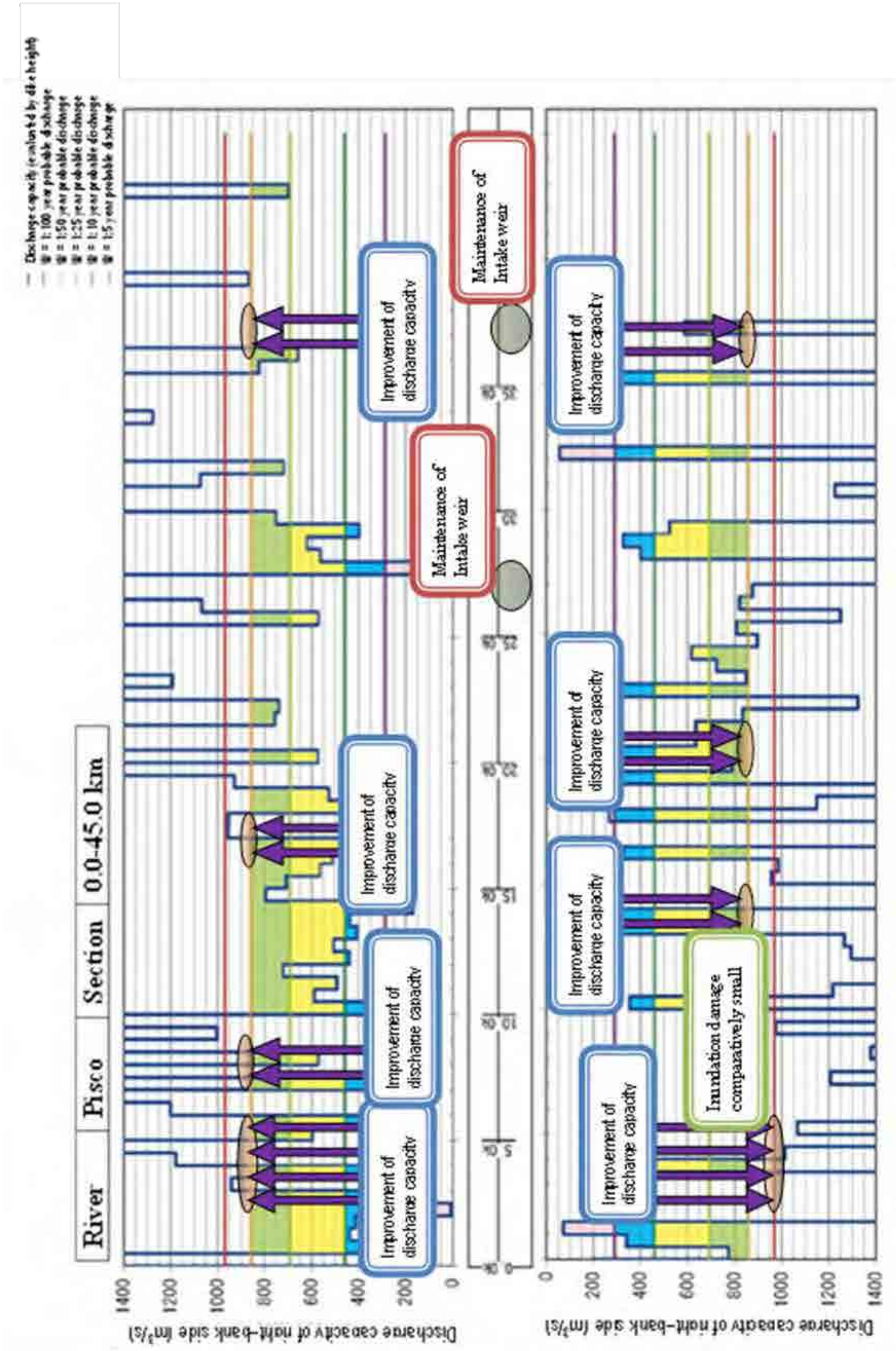


Figure-4.3.1-17 Effect of flood prevention facilities（Rio Pisco）

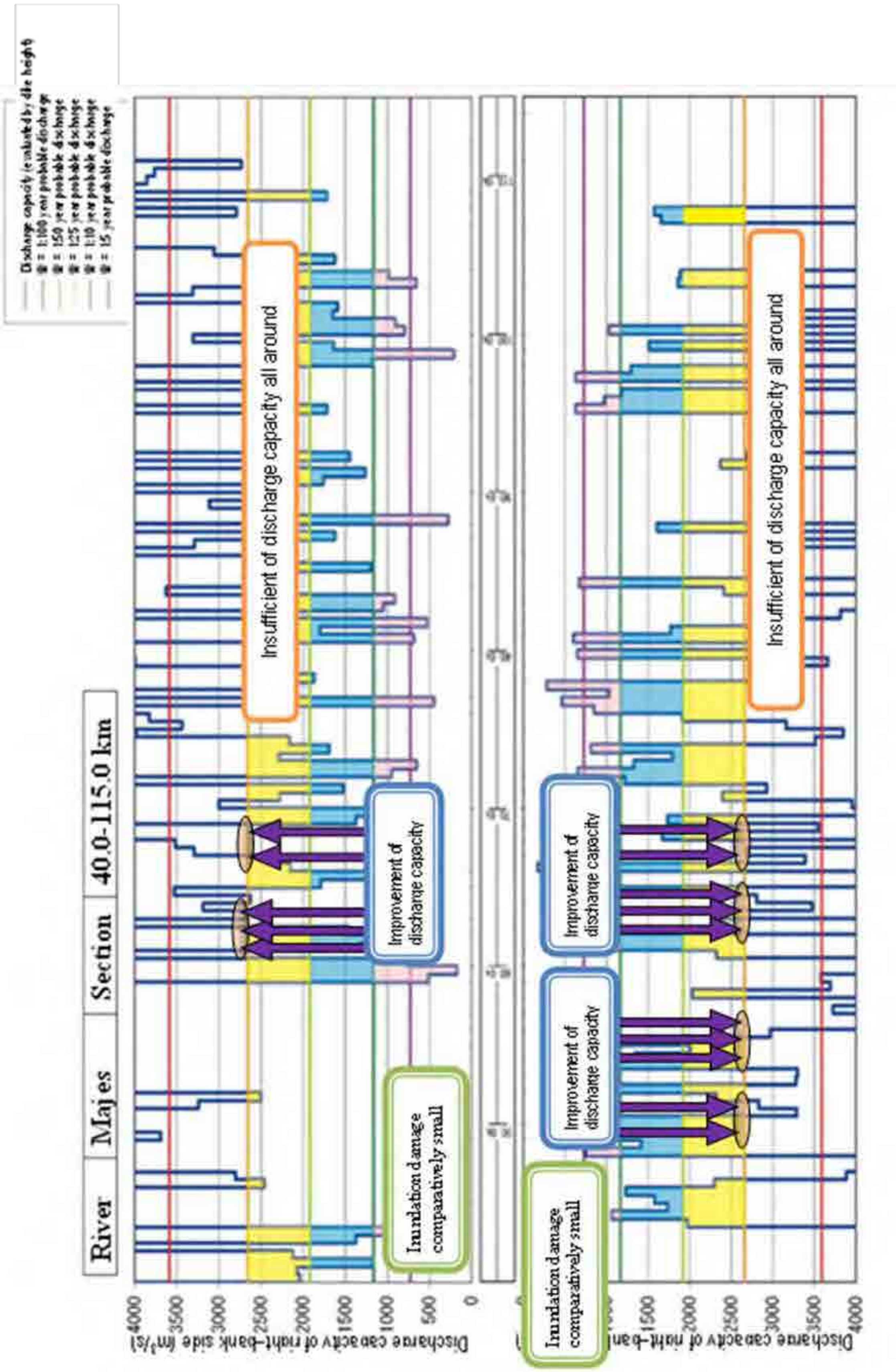


Figure-4.3.1-19 Effect of flood prevention facilities（Rio Majes）

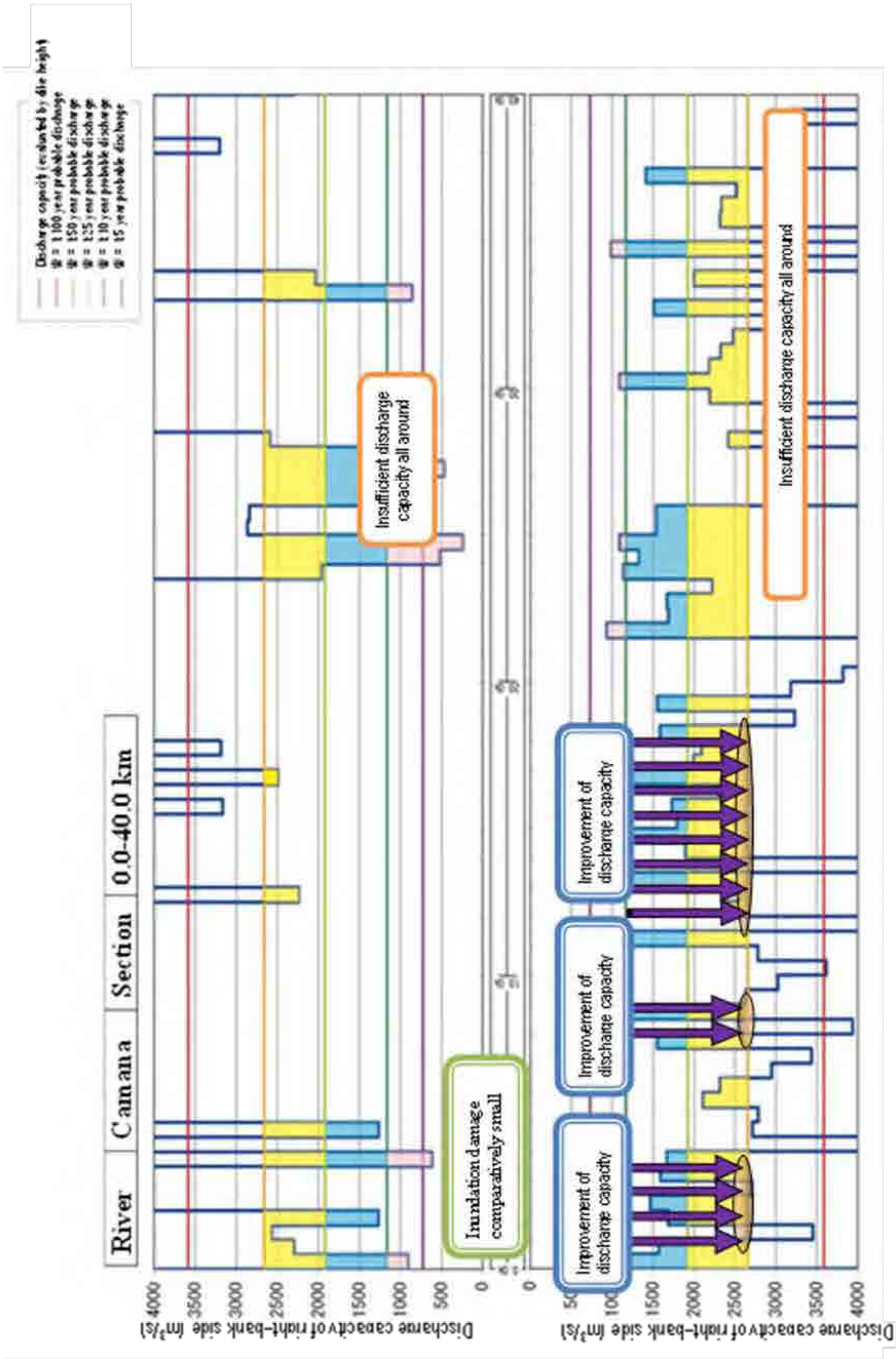


Figure-4.3.1-18 Effect of flood prevention facilities（Rio Camana）

4.3.2Nonstructural Measures

4.3.2.1 Reforestation 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 4.15 “Medium and long term Plan”, 4.15.2 “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-Camana 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.

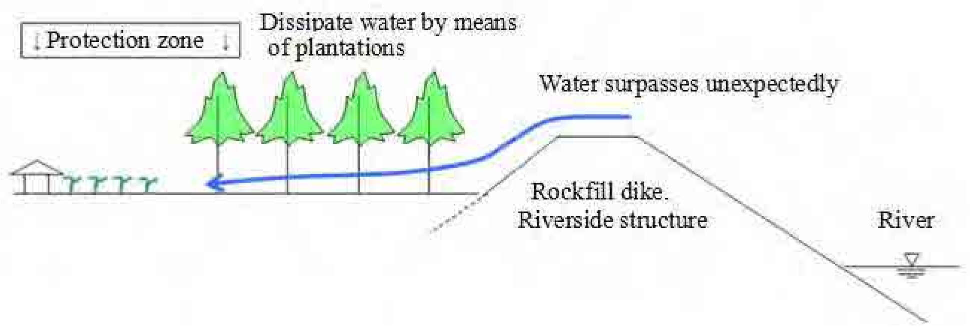
b) Methodology: Create vegetation borders of a certain width between river structures and the river.

c) Work execution: Plant vegetation at a side of the river structures (dikes, etc.) is to be a part of construction work of river structures, and which is carried out by the same contractor as for the river structures. The reasons are i) plant vegetation is to be certain for the withered damage just after plantation and ii) The same contractor for the river structures is appropriate due to the parallel work of plantation and structure construction.

d) Maintenance post reforestation: The maintenance will be assumed by irrigation commissions by own initiative. In the past project, it is usually performed that the agreement is made between the irrigation committee and DGIH on the following two items.
   i) The ownership of plantation belongs to the irrigation committee.
   ii) Operation and maintenance cost of the plantation is born by the committee

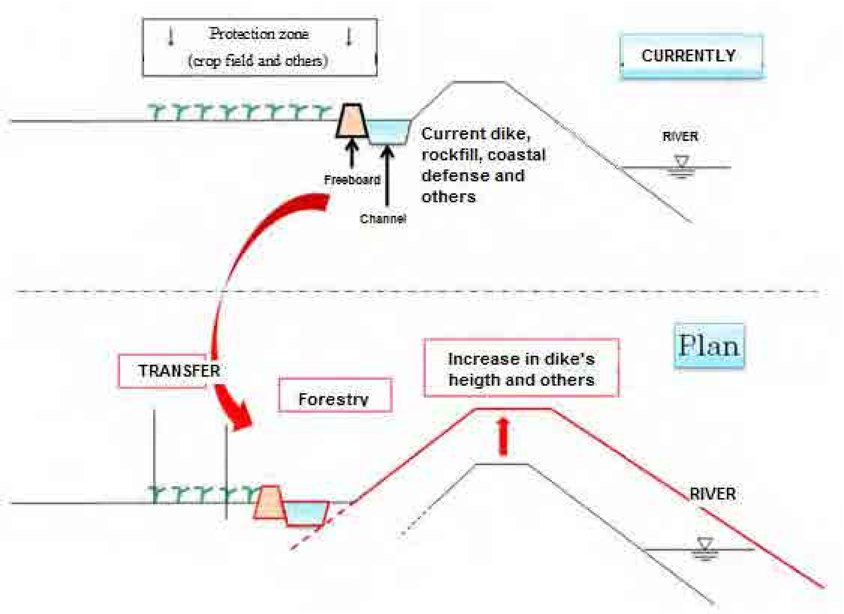
   Therefore the plantation is not private property but public one in the committee.

e) Plantation section : Since the purpose of plantation is mitigation of damage in overflowing of flood, the plantation is to be made in the preventive side of dike. In case that the plantation is made in the section without dike, the trees are knocked down directly by flood water, and they flow down along river causing the choke in the bridges etc. resulting in secondary damage, and as the length without dike is long , the cost of construction and land acquisition increases.



(Source: JICA Study Team)

Figure 4.3.2.1-1 Conceptual diagram afforestation in the riverside structures (Type A)



(Source: JICA Study Team)

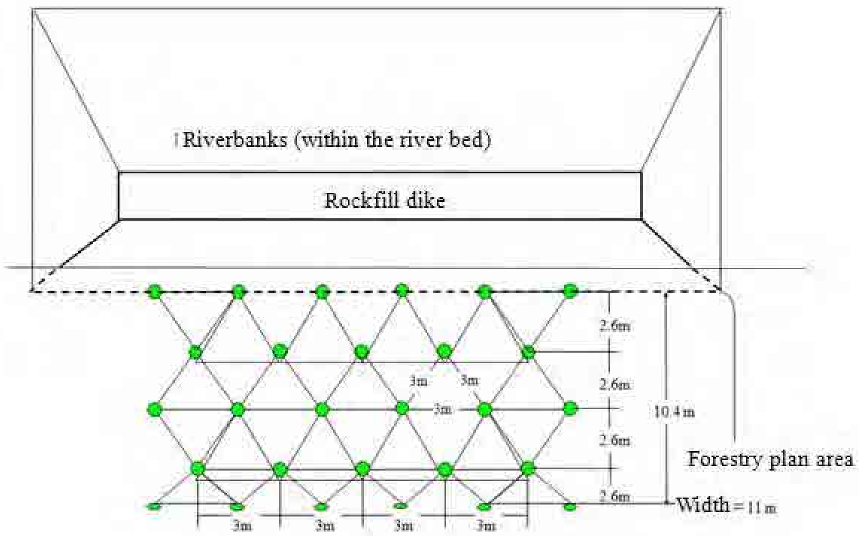
Figure 4.3.2.1-2 Conceptual diagram afforestation or river bank structures (Type B)

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)

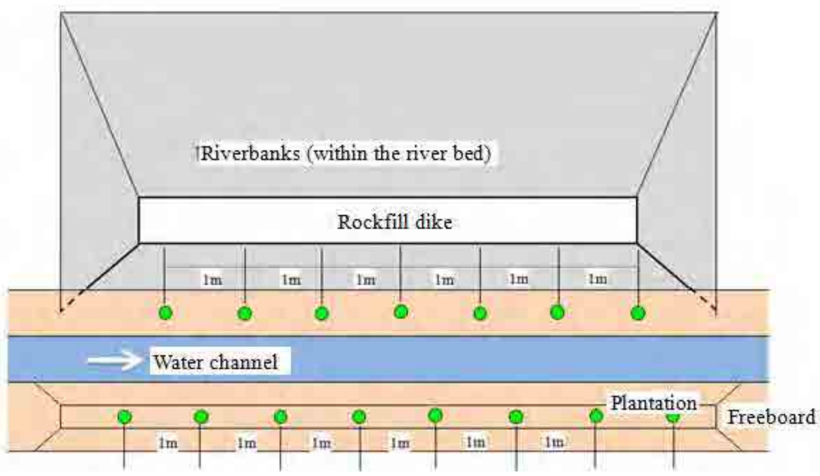
Type A: In Peru the most common pattern for afforestation is with equilateral triangles. This project also uses this model by planting trees with 3-meter intervals (Figure 4.3.2.1-3). If this method is used, the interval of trees vertical to the dike will be 2.6m and in the case of zigzag arrangement, the width will be 1.3m of which interval can stop the bolder with diameter of 1m or dissipate the energy of the boulder. And 4 lines of trees can increase the effect. Thus the width of plantation zone will be 11 m adding the allowance to 10.4 m.



(Source: JICA Study Team)

Figure 4.3.2.1-2 Arrangement plan of the afforestation along the riverside structure (Type A)

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



(Source: JICA Study Team)

Figure 4.3.2.1-4 Arrangement plan of afforestation 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 available production species

Area	Provider	Production Place	Species produced usually	Species produced sometimes
Canete	AGRORURAL	Santa Eulalia	Pine, Molle, Eucalyptus, Huarango (*Prosopis limensis*)	Cypress, Tara
	FOMECO SAC	Lima	Tara, Molle, Huarango (*Prosopis limensis*)	-
	AGRIMEX EIRL	Lima	Aliso, Algarrobo, Canya,Tamarix, Bamboo, Pine, Casuarina, Eucalyptus	-
Chincha Pisco	AGRORURAL	Lima	Pine, Molle, Eucalyptus, Hurango (*Prosopis limensis*)	Cypress, Tara
	FOMECO SAC	Lima	Tara, Molle, Huarango (*Prosopis limensis*)	-
	AGRIMEX EIRL	Ica	Aliso, Algorrobo, Canya,Tamalix, Bamboo, Pine, Casuarina, Eucalyptus	-
Majes-Camana	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
Cañete	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	-
Majes-Camana	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 Camana-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**	
Cañete	Aliso	C	B	A	C	A	--	Adequate for high elevation areas rather as
Chincha	Algarrobo	B	A	C	B	A	--	Similar to Huarango (*Prosopis limensis*), Prosopis is selected in the southern areas
Pisco	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
Majes-Camana	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 Selection of forest species

Cañete and 2 other basins:	Eucalipto (◎), Huarango (○), Casuarina (○)
Majes- Camaná:	Sauce (◎), Casuarina (○)

(Source: JICA Study Team)

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. 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)

(Cañete, Chincha and Pisco watersheds: 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	1,450	11	1.6	4,736	2,368	1,421	947	4,736
Total Pisco		5,950		6.6	19,536	9,768	5,862	3,906	19,536
Ground Total		13,900		20.4	60.384	30,192	18,116	12,076	60,384

(Majes-Camana watershed)

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

(Cañete and other 2 watersheds)

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	

(Majes-Camana Watershed)

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)

c) Labor cost

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 2,483,253 soles (approximately 70,000,000 yenes)

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)

(4) Implementation process planning

The Process Plan of afforestation works in riverbanks is part of the river structure, thus the same will be considered for the Construction Plan of the River 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 Schedule of the river structure there are no major afforestation issues in seasons where water level is low. The simple 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

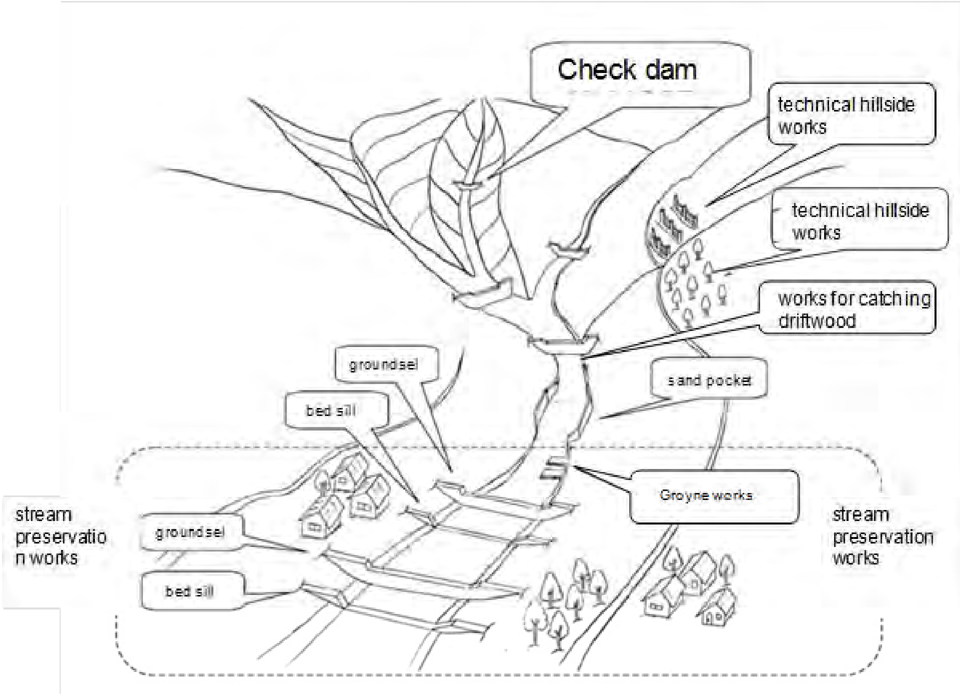


Figure 4.3.2.2-1 Sediment control works

1) Sediment control plan in the high watershed

The later section 4.15 "Medium and long term Plan" 4.15.3 "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) Riverbed fluctuation analysis results

- Table 4.3.2.2-3 presents the analysis results of river bed fluctuation. The average riverbed raising shows the average of raising in the objective section in future 50 years. The average bed height has been increasing in all rivers, 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.

- 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, Pisco and Majes-Camana rivers are more susceptible to the accumulation of sediments carried, so sediment control works must be done in their respective alluvial fan. However the sediment disaster will happen suddenly and locally so that the required river channel maintenance work will be examined for all rivers with monitoring of river bed sedimentation.

  It is worth mentioning that in Cañete River watershed the Platanal dam was built last year, which is for hydropower generation and has small storage capacity so that it will be filled soon with sedimentation, however it can retain the function of sediment regulation, 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

River	Total Inflow Sediment Volume (10^3m^3)	Annual Inflow Sediment Volume (10^3m^3)	Total Bed Fluctuation (10^3m^3)	Average Bed Fluctuation (m)	Remarks
Cañete	3,000	60	673	0.2	
Chincha	5,759	115	2610	0.5	Total inflow to Chico and Matagente Rivers
Pisco	8,658	173	2571	0.2	
Majes-Camana	20,956	419	5,316	0.2	

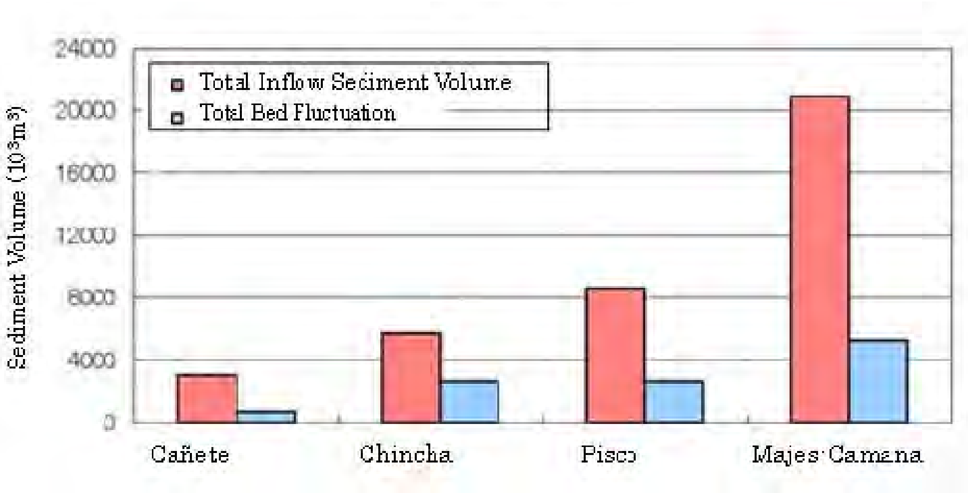


Figure 4.3.2.2-2 River bed variation analysis result (sediment volume)

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.

4.3.3 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 four watersheds: Cañete, Chincha, Pisco and Majes-Camana.

In the execution stage, the implementation has to be coordinated with local authorities in the four 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 and local people in each 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 each watershed.

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

(4) Activities

In order to achieve the above purpose, the following 3 component of study and training is to be carried out.

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

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 d) Forest Seedling Planting e) 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 f) Local populations learn suitable technology on forest seedling planting g) 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

(5) Direct cost and period

The direct cost for the above activities is as shown in the Table 4.3.3-1. The total cost for the objective 4 basins is estimated as 576,200 soles, and the brakdaown of the unit cost is as shown in the Annex-12, Appendix No.5. And the period required for study and training is assumed to be as same as the construction period of 2 years.

Table 4.3.3-1 Contents of technical assistance and direct cost

(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 cost is composed of the following components:

1) Infrastructure cost
i) Construction work cost
① Work direct costs (including plantation cost, environmental work cost, disaster prevention education/capacity development cost, infrastructure rehabilitation cost)
② Overhead cost＝① x 15％
③ Profit = ① x 10%
④ Work cost= ① + ② + ③
⑤ Tax =④ x 18% (IGV)
⑥ Construction cost = ④＋⑤
ii) Consultant cost (for structure, plantation, environmental work and disasterprevention education/capacity development)
⑦ Detailed design cost
⑧ Construction supervision cost
⑨ Consultant cost=⑦＋⑧
2) Infrastructure cost=⑥＋⑨
3) Land acquisition cost
4) Management cost of implementation agency
Total project cost ＝1）＋2）＋3）

(2) Direct cost

The direct costs were calculated by multiplying the unit prices with the work quantities. And the unit price is estimated for each work item based on the labor cost, material cost and equipment cost,

1) Labor cost
The labor costs in Cañete river are as shown in the Table-4.4.1-1 as an example.

2) Material cost
The major material costs in Cañete river are as shown in the Table-4.4.1-2 as an example.

3) Equipment cost
The rental costs of equipment in Cañete river are as shown in the Table-4.4.1-3 as an example.

4) Work quantities

The work quantity of each work item in each flood prevention facility is as shown in the Table-4.4.1-4. For further detail of work quantities refer to Annex-8 Plan and Design of Facility.

5) Unit price of work

Based on the above costs the unit price of each work is estimated, of which results in in Cañete river are as shown in the Table--4.4.1-5. For further detail refer to Annex-9 Construction Planning and Cost Estimate.

Based on the work quantities and the unit price of work, the direct cost of construction work is calculated as shown in the Table-4.4.1-6

(3) Infrastructure cost

The infrastructure cost is as shown in the Table4.4.1-12, in which the breakdown of the detail design cost and construction supervision cost are as shown in the Table-4.4.1-7 and Table-4.4.1-8 respectively. The consultant cost was estimated based on the Terms of Reference attached to Annex-14 Implementation Program of Japanese Yen Loan Project as Appendix-1

(4) Land acquisition and infrastructure rehabilitation

The land acquisition coat and infrastructure rehabilitation cost are as shown in the Table-4.4.1-9 and the Table-4.4.1-10 respectively. For further detail refer to Annex-9 Construction Planning and Cost Estimate, 4. Compensation.

(5) Management cost of implementation agency

The management cost of implementation agency is as shown in the Table-4.4.1-11.

(6) Total project cost

The total project cost is calculated as shown in the Table-4.4.1-12.

(7) Operation and maintenance cost

The operation and maintenance cost after completion of the Project is estimated as shown in the Table-4.4.1-14 (refer to Annex-9 Constructoion Planning and Cost Estimation).

Table-4.4.1-1 Unit labor cost (1) (example of Cañete river) (SOLES)

Table-4.4.1-1 Unit labor cost (2) (example of Cañete river)

Table-4.4.1-2 Unit price of main material (example of Cañete river)

Table-4.4.1-3 Unit cost of main heavy equipment(example of Cañete river)

Table-4.4.1-4 Work quantities

Work		Unit	Quantities				TOTAL
			CAÑETE	CHINCHA	PISCO	MAJES - CAMANA	
1.0	**Temporary work**						
1.1	Field office	M2	460	530	530	1,150	2,670
1.2	Construction notice board	L.S.	5	5	6	7	23
1.3	Temporary road	KM	7	9	13	30	58
1.4	Equipment transportation	L.S.			1		1
2.0	**Preparatory work**						
2.1	Coordinates and leveling survey	M	8,000	23,774	16,020	26,600	74,394
2.2	Supervision of survey	M	8,000	13,201	16,020	26,600	63,821
2.3	Equipment transportation	L.S.	5	5	5	7	22
2.4	Removal of existing concrete	M3	0	1,035	0	0	1,035
2.5	Riverbed excavation	M3		139,745			139,745
2.6	Soil disposal	M3	0	107,913	0	0	107,913
3.0	**Earth work**						
3.1	Riverbed excavation	M3	143,074	174,085	641,708	104,821	1,063,688
3.2	-ditto-	M3	156,717	14,088	203,197	695,325	1,069,327
3.3	Banking and compaction	M3	330,559	218,234	344,392	1,103,196	1,996,381
3.4	Ripper excavation	M3	89,651	135,808	200,055	303,050	728,564
3.5	Finishing slope of dike	M3	38,228	47,848	77,898	136,936	300,910
3.6	Soil disposal	M2	58,884	147,710	555,648		
3.7	Riverbed excavation(for structure)	M3		10,130			10,130
4.0	**Bank protection**						
4.1	Quarry of rock with blasting	M3	110,289	146,821	231,922	400,293	889,325
4.2	Accumulation of boulders	M3	110,289	146,821	231,922	400,293	889,325
4.3	Transportation of boulders	M3	110,289	146,821	231,922	400,293	889,325
4.4	Rivetment	M3	34,086	31,384	61,875	142,701	270,046
4.5	Installation of boulders	M3	76,203	116,087	170,047	257,592	619,929
4.6	Supply and installation of GEOTEXTILE sheet	M2	79,153	109,283	167,830	275,443	631,709
5.0	**Concrete work**						
5.1	Form work	M2	0	6,318	0	0	6,318

5.2	Concrete placing (FC=210 KG/CM2)	M3	0	9,418	0	0	9,418
6.0	**Gabion work**						
6.1	Accumulation ofcrushed stone（6～8 inches）	M3	0	3,900	0	0	3,900
6.2	Transportation of crushed stone	M3	0	3,900	0	0	3,900
6.3	Installation of mattress basket(5.0x1.0x1.0)m	No.	0	780	0	0	780
6.4	Putting crushed stone into basket(5.0x1.0x1.0)m	M3	0	3,900	0	0	3,900
6.5	Covering basket(5.0x1.0x1.0)m	No.	0	780	0	0	780

Table-4.4.1-5 Estimate of work unit cost(example of Cañete river: Ca-1)

Table-4.4.1-6 Direct cost (private price and social price）

le 4.4.1-7 Consultant cost for detail design stage (for 4 basins)

Table 4.4.1-8 Consultant cost for construction supervision stage (for 4 basins)

Table 4.4.1-9 Land acquisition cost (soles)

Table 4.4.1-10 Rehabilitation cost of existing facility (direct cost)

Table-4.4.1-11 Administration cost of implementation agency (for 4 basins)

Table-4.4.1-12 Total project cost (private price)

Table-4.4.1-13 Total project cost (social price)

Table-4.4.1-14 Annual operation and maintenance cost

4.4.2 Cost Estimate (at Social Price)

The direct cost at social price is as shown in the previous Table-4.4.1-6. The consultant cost, land acquisition cost and administration cost of the implementation agency are converted from the private price to the social price. The total project cost at social price is calculated as shown in the Table - 4.4.1-13.

The social price is calculated by multiplying the private price (labor cost, material cost and equipment cost) with the standard conversion factor(SCF). SCF is the ratio of the private price in domestic and the social price calculated at the border with respect to all goods of the country's economy,

In this study, economic evaluation is calculated based on the Guidelines which are available in Peru (Guideline of the National Public Investment System (Directorial Resolution No. 003-2011-EF/68.01, Annex SNIP 10-V3.1)) . Ministry of Economy and Finance is indicated SCF as shown in Table -4.4.2-1.

Table-4.4.2-1 Standard conversion factor (SCF)

Correction Factors for Social Rates (Methodology MEF)	
DESCRIPCION	VALOR
·**National Property Expenditures**	0.85
·**Imported Goods Expenditures**	0.92
·**Indirect Imported Goods Expenditures***	
Tasa Ad. Valorem	0.12
General Sales Tax Rate	0.18
·**Currency correction factor**	1.08
·**Fuel costs**	0.66
·**Indirect costs (administrative and financial)**	0.85
Legal entity	0.85
Natural Person	0.91
·**Expenditures on skilled labor**	0.91
·**Expenditures on non skilled labor**	0.68
Lima Metropolitana urbano	0,86
Urban Coast Region	0,68
Rural Coast Region	0,57
Urban Sierra Region	0,60
Urban Sierra Region	0,41
Urban Forest Region	0,63
Rural Forest Region	0,49
·**Indirect taxes Manpower ****	
Fourth Category Rate for Non-Personal Services (10%)	0.91

As an example, the process of conversion from private price to social price for the direct cost of river structures is as shown in the Table-4.4.2-2. For other costs the process is shown in the Annex-10 Socio-economy and Economic Evaluation, Attachment-3...

Table-4.4.2-2 Conversion process from private price to social price for direct cost of river structure (soles)

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 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.

i) 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)

ii) 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

The loss amount according to the different return periods is calculated as shown in the Table 4.5.1-2 as an example. For further detail refer to I-7 Data Book.

Table 4.5.1-2 Esimated loss by flooding at private price (example of Cañete river)

(1,000 soles)

Description	T=50 years	
	Without Project	With Project
Agricultural Product	102,502	14,573
Hydraulic Structure	16,221	2,538
Road	24,502	92
Housing	11,685	683
Public Facility	3,103	0
Public Service	161	0
Total	158,173	17,886

In the Table 4.5.1-3, the estimated amounts of loss by flooding of different return periods with or without Project, for the 4 Watersheds is shown.

Table 4.5.1-3 Loss estimated value (at private prices)

(!0^3 Soles)

Case	t	Private Price			
		Cañete	Chincha	Pisco	Majes-Camana
Without Project	2	1,735	15,262	16,668	311
	5	6,420	39,210	23,343	48,616
	10	77,850	55,372	50,239	78,391
	25	104,090	77,797	59,936	111,072
	50	158,173	103,947	81,510	191,990
	Total	348,269	291,588	231,698	430,380
With Project	2	167	449	221	0
	5	878	3,005	302	8,349
	10	9,260	4,309	2,756	18,278
	25	12,897	14,282	6,595	31,256
	50	17,886	29,945	9,108	50,734
	Total	41,088	51,991	18,982	108,617

The estimated loss by flood without project in return period of 50- year will be 158.2 million soles in Cañete river, 103.9 million soles in Chincha, 81.5 million soles in Pisco and 192.0 million soles in Majes-Camana respectively, and the loss in the last is highest.

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

The average annual damage reduction amount is calculated by multiplying the annual damage reduction corresponding to probable flood with occurrence probability and by accumulating the annual damage reduction of each probable flood. The calculation method is as shown in the Table 4.5.1-4.

Table 4.5.1-4 Calculation method of annual average of loss reduction 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	$D_1 = L_1 - L_2$			
				$(D_1+D_2)/2$	(1/2)-(1/5) = 0,300	$d_2 = (D_1+D_2)/2$ x 0,300
1/5	L_3	L_4	$D_2 = L_3 - L_4$			
				$(D_2+D_3)/2$	(1/5)-(1/10) = 0,100	$d_3 = (D_2+D_3)/2$ x 0,100
1/10	L_5	L_6	$D_3 = L_5 - L_6$			
				$(D_3+D_4)/2$	(1/10)-(1/20) = 0,050	$d_4 = (D_3+D_4)/2$ x 0,050
1/20	L_7	L_8	$D_4 = L_7 - L_8$			
				$(D_4+D_5)/2$	(1/20)-(1/30) = 0,017	$d_5 = (D_4+D_5)/2$ x 0,017
1/30	L_9	L_{10}	$D_5 = L_9 - L_{10}$			
				$(D_5+D_6)/2$	(1/30)-(1/50) = 0,013	$d_6 = (D_5+D_6)/2$ x 0,013
1/50	L_{11}	L_{12}	$D_6 = L_{11} - L_{12}$			
				$(D_6+D_7)/2$	(1/50)-(1/100) = 0,010	$d_7 = (D_6+D_7)/2$ x 0,010
1/100	L_{13}	L_{14}	$D_7 = L_{13} - L_{14}$			
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 4.5.1-5 the results of the loss amount calculation are shown (annual average), which are expected to be reduced by implementing each river's Project.

Table 4.5.1-5 Annual average of loss reduction amount (private prices)

(10^6 Soles)

Basin	Return Period	Probability	Total Damage (10^6 Soles)			Average Damage ④	Section Probability ⑤	Annual Average Damage ⑥=④×⑤	Accumulation of Annual Average Damage
			Wiyhout Project ①	With Project ②	Damage Reduction ③=①−②				
CAÑETE	1	1.000	0	0	0			0	0
	2	0.500	1,735	167	1,568	784	0.500	392	392
	5	0.200	6,420	878	5,542	3,555	0.300	1,067	1,459
	10	0.100	77,850	9,260	68,590	37,066	0.100	3,707	5,165
	25	0.040	104,090	12,897	91,193	79,891	0.060	4,793	9,959
	50	0.020	158,173	17,886	140,287	115,740	0.020	2,315	12,273
CHINCHA	1	1.000	0	0	0			0	0
	2	0.500	15,262	449	14,813	7,406	0.500	3,703	3,703
	5	0.200	39,210	3,005	36,205	25,509	0.300	7,653	11,356
	10	0.100	55,372	4,309	51,063	43,634	0.100	4,363	15,719
	25	0.040	77,797	14,282	63,515	57,289	0.060	3,437	19,156
	50	0.020	103,947	29,945	74,002	68,758	0.020	1,375	20,532
PISCO	1	1.000	0	0	0			0	0
	2	0.500	16,668	221	16,447	8,224	0.500	4,112	4,112
	5	0.200	23,343	302	23,041	19,745	0.300	5,924	10,036
	10	0.100	50,239	2,756	47,483	35,263	0.100	3,526	13,562
	25	0.040	59,936	6,595	53,341	50,412	0.060	3,025	16,587
	50	0.020	81,510	9,108	72,402	62,872	0.020	1,257	17,844
MAJES-CAMANA	1	1.000	0	0	0			0	0
	2	0.500	311	0	311	155	0.500	78	78
	5	0.200	48,618	8,349	40,269	20,289	0.300	6,087	6,164
	10	0.100	78,391	18,278	60,113	50,191	0.100	5,019	11,183
	25	0.040	111,072	31,256	79,816	69,965	0.060	4,198	15,381
	50	0.020	191,990	50,734	141,256	110,536	0.020	2,211	17,592

(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 I, 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 4.5.1-6 Evaluation indicator of economic benefit and its characteristics

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

The assessment period is 15 years which is same period as the adopted period in the Perfil program report of this Project. The SNIP regulation stipulates that the assessment period is to be 10 years basically, however the period can be changed if the project formulation agency (DGIH in this Project) admits that it is necessary. DGIH adopted 15 years in the Perfil program report and which was approved by OPI and DGPI (March 19, 2010). In JICA's development project the evaluation period of 50 years is generally adopted, so that JICA Study Team inquired DGIH and OPI on this matter, they directed to adopt 15 years. In case of 50 years, the evaluation will be made in the Annex-14, Implementation Program of Japan Yen Loans Project.

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. SCF is stipulated by MEF as shown in the previous Table 4.4.2-1.

iii) Other preliminary conditions

Price level: 2011

Social discount rate: 10% (according to SNIP regulation)

Annual maintenance cost: estimated in the Table 4.4.1-14

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 4.5.1-7 results of calculations C/B, NPV and IRR to private prices is shown.

Table 4.5.1-7 Social assessment (C/B, NPV, IRR) (at private prices)

The social evaluation at private price level is calculated as shown in the Table 4.5.1-8 for Cañete river as an example.

Table-4.5.1-8 Social evaluation at private prices (Cañete river)

Table-4.5.1-9 Social evaluation at social prices (Cañete river)

4.5.2 Social Prices Costs

(1) Benefits

1) Estimated loss amount according to different return periods

The loss amount according to the different return periods is calculated as shown in the Table 4.5.2-1 as an example. For further detail refer to I-7 Data Book.

Table 4.5.2-1 Estimated loss by flooding at social price (example of Cañete river)

(1,000 soles)

Description	T=50 years	
	Without Project	With Project
Agricultural Product	180,161	19,037
Hydraulic Structure	13,415	2,099
Road	19,357	73
Housing	9,897	579
Public Facility	2,628	0
Public Service	128	0
Total	**225,586**	**21,787**

In the Table 4.5.2-2, the estimated amounts of loss by flooding of different return periods with or without Project, for the 4 Watersheds is shown.

Table 4.5.2-2 Loss estimated value (at social prices)

(!0^{3} Soles)

Case	t	Social Price			
		Cañete	Chincha	Pisco	Majes-Camana
Without Project	2	2,711	16,758	17,099	317
	5	11,180	44,275	22,817	48,503
	10	110,910	74,539	54,702	78,738
	25	153,056	101,437	64,250	113,789
	50	225,586	133,108	87,899	201,622
	Total	503,443	370,117	246,768	442,970
With Project	2	293	456	310	0
	5	1,077	4,859	433	8,540
	10	10,834	6,955	3,243	17,867
	25	15,524	18,932	8,543	31,916
	50	21,787	34,979	11,643	54,564
	Total	49,515	66,181	24,172	112,888

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

In Table 4.5.2-3 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 loss reduction amount (social prices)

(10^6 Soles)

Basin	Return Period	Probability	Total Damage (10^6 Soles) Wiyhout Project ①	With Project ②	Damage Reduction ③=①−②	Average Damage ④	Section Probability ⑤	Annual Average Damage ⑥=④×⑤	Accumulation of Annual Average Damage
CAÑETE	1	1.000	0	0	0			0	0
	2	0.500	2,711	293	2,418	1,209	0.500	605	605
	5	0.200	11,180	1,077	10,103	6,216	0.300	1,865	2,469
	10	0.100	110,910	10,834	100,076	55,090	0.100	5,509	7,978
	25	0.040	153,056	15,524	137,532	118,804	0.060	7,128	15,107
	50	0.020	225,586	21,787	203,799	170,665	0.020	3,413	18,520
CHINCHA	1	1.000	0	0	0			0	0
	2	0.500	16,758	456	16,302	8,151	0.500	4,076	4,076
	5	0.200	44,275	4,859	39,416	27,859	0.300	8,358	12,433
	10	0.100	74,539	6,955	67,584	53,500	0.100	5,350	17,783
	25	0.040	101,437	18,932	82,505	75,044	0.060	4,503	22,286
	50	0.020	133,108	34,979	98,129	90,317	0.020	1,806	24,092
PISCO	1	1.000	0	0	0			0	0
	2	0.500	17,099	310	16,789	8,394	0.500	4,197	4,197
	5	0.200	22,817	433	22,384	19,586	0.300	5,876	10,073
	10	0.100	54,702	3,243	51,459	36,922	0.100	3,692	13,765
	25	0.040	64,250	8,543	55,707	53,583	0.060	3,215	16,980
	50	0.020	87,899	11,643	76,256	65,982	0.020	1,320	18,300
MAJES-CAMANA	1	1.000	0	0	0			0	0
	2	0.500	317	0	317	159	0.500	80	80
	5	0.200	48,503	8,540	39,963	20,140	0.300	6,042	6,122
	10	0.100	78,738	17,867	60,871	50,417	0.100	5,042	11,163
	25	0.040	113,789	31,916	81,873	71,372	0.060	4,282	15,446
	50	0.020	201,622	54,564	147,058	114,465	0.020	2,289	17,735

(2) Social Assessment

In Table 4.5.2-4 results of the calculation C/B, NPV and IRR at social prices are shown.

Table 4.5.2-4 Social assessment (C/B, NPV, IRR) (at social prices)

流域 Basin	年平均被害軽減額 Average Annual Damage Reduction Amount	評価期間被害軽減額(15年) Damage Reduction Amount in Evaluation Period(15years)	事業費 Project Cost	維持管理費 Operation & Maintenance Cost	B/C Benefit and Cost Ratio	Net Present Value (NPV) Valor Actual Neto (VAN)	Internal Rate of Return (IRR) Tasa Interna de Retorno (TIR)
Cañete	240,931,523	108,799,900	24,863,886	2,871,563	4.73	85,780,474	55%
Chincha	313,198,474	141,434,223	39,164,079	4,822,421	3.89	105,033,115	47%
Pisco	237,897,809	107,429,935	55,430,191	4,230,554	2.13	57,079,434	27%
Majes-Camana	230,549,756	104,111,700	73,841,176	7,844,174	1.53	36,063,846	19%
All Basin	1,022,577,561	461,775,757	200,811,371	19,768,712	2.60	283,956,869	32%

The social evaluation at social price level is calculated as shown in the Table 4.5.1-9 for Cañete river as an example.

4.5.3 Social Assessment Conclusions

(1) Damage reduction amount

The damage reduction amount with Project is as shown in the Table-4.5.3-1.

Table - 4.5.3-1 Damage reduction amount with project

Basin	Damage amount without Project		Damage reduction amount with Project		Expected yearly average amount of damage reduction	Total benefit in evaluation period (15 years)
	Average Annual Damage Amount	Damage Amount in Evaluation Period (15 years)	Average Annual Damage Amount	Damage Amount in Evaluation Period (15 years)		
	i)	ii)	iii)	iv)	i)-iii)	ii)-iv)
All basin	77,530	1,162,934	9,288	139,314	68,242	1,023,620
Canete	13,952	209,273	1,687	25,169	12,274	184,104
Chincha	22,528	337,919	1,996	29,942	20,532	307,977
Pisco	18,568	278,516	724	10,860	17,844	267,656
Majes-Camana	22,482	337,226	4,890	73,343	17,592	263,883

1) The damage amount in all 4 basins without Project is 77,530,000 soles. In case of with Project the amount will be reduced to 9,288,000 soles. The difference between above two amount which is expected yearly average amount of damage reduction will be 68,242,000 soles and reach 88% of annual average damage amount. As a result, the benefit will be 1,023,620,000 soles in the evaluation period of 15 years.

2) The total benefit in the evaluation period of 15 years will be generated higher in order of Chincha, Pisco, Majes-Camana and Cañete basin. The maximum benefit will be 1.6 times of the minimum benefit and the same level of benefit will be generated in each basins.

(2) Concrete effect

The following concrete effects will be expected with the Project.

① The total area of 5,500 ha land will be prevented against inundation in 4 basins.
② The agricultural land of 1,215 ha will be protected from erosion and wash away by river improvement.
③ The stable agriculture will be realized by the conservation of 13 intake weirs.
④ The road distruction of 7 places will relieved, which contributes to the traffic convenience and stability of daily life in the district.
⑤ The annual average benefit of 68,241,000 soles and the total benefit of 1,023,620,000in the evaluation period of 15 years will be expected.

(3) Conclusion

The conclusion of social evaluation of this Project is shown as follows:

1) The economic viability of all projects for 4 basins is confirmed.
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

2) The economic viability of total 4 basins is also confirmed at private price and social 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 are shown.

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

	Basin		Item	Basic Case	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
					Cost increase 5%	Cost increase 10%	Benefit decrease 5%	Benefit decrease 10%	Disc.rate increase 5%	Disc. rate decrease 5%
PRIVATE PRICE	ALL BASINS		IRR (%)	23%	22%	21%	22%	20%	23%	23%
			B/C	1.89	1.80	1.72	1.79	1.70	1.46	2.52
			NPV(s)	188,411,915	178,326,517	168,241,120	168,381,242	148,350,570	90,983,920	350,795,189
	EACH BASIN SEPARATELY	CAÑETE	IRR (%)	33%	32%	30%	32%	30%	33%	33%
			B/C	2.63	2.51	2.41	2.50	2.37	2.04	3.51
			NPV(s)	44,681,147	43,388,857	42,096,567	41,078,521	37,475,894	26,429,301	74,757,445
		CHINCHA	IRR (%)	35%	33%	32%	33%	32%	35%	35%
			B/C	2.76	2.64	2.53	2.62	2.49	2.14	3.68
			NPV(s)	76,905,695	74,851,989	72,798,284	70,879,052	64,852,409	46,239,359	127,369,505
		PISCO	IRR (%)	21%	20%	19%	20%	19%	21%	21%
			B/C	1.74	1.66	1.58	1.65	1.56	1.34	2.33
			NPV(s)	44,377,936	41,471,590	38,565,243	39,140,315	33,902,693	19,082,579	86,701,555
		MAJES - CAMANA	IRR (%)	15%	14%	13%	14%	13%	15%	15%
			B/C	1.28	1.22	1.17	1.21	1.15	0.99	1.70
			NPV(s)	22,447,137	18,614,081	14,781,025	17,283,356	12,119,574	-767,319	61,966,685
SOCIAL PRICE	ALL BASINS		IRR (%)	32%	30%	29%	30%	28%	32%	32%
			B/C	2.60	2.48	2.37	2.47	2.34	2.01	3.47
			NPV(s)	283,956,869	275,512,283	267,067,696	260,868,082	237,779,294	166,899,787	476,920,446
	EACH BASIN SEPARATELY	CAÑETE	IRR (%)	55%	53%	51%	53%	51%	55%	55%
			B/C	4.73	4.51	4.32	4.49	4.25	3.66	6.30
			NPV(s)	85,780,474	84,694,340	83,608,206	80,340,479	74,900,484	56,890,166	132,831,360
		CHINCHA	IRR (%)	47%	45%	43%	45%	43%	47%	47%
			B/C	3.89	3.71	3.55	3.69	3.50	3.01	5.17
			NPV(s)	105,033,115	103,321,945	101,610,775	97,961,404	90,889,692	67,971,426	165,573,203
		PISCO	IRR (%)	27%	25%	24%	25%	24%	27%	27%
			B/C	2.13	2.04	1.95	2.03	1.92	1.65	2.86
			NPV(s)	57,079,434	54,657,431	52,235,427	51,707,937	46,336,440	30,344,695	101,432,164
		MAJES - CAMANA	IRR (%)	19%	18%	17%	18%	16%	19%	19%
			B/C	1.53	1.46	1.40	1.45	1.38	1.19	2.04
			NPV(s)	36,063,846	32,838,567	29,613,288	30,858,261	25,652,676	11,693,501	77,083,721

(3) Assessment of the sensitivity analysis

The impact on the economic evaluation due to the socio-economic change in the Project is as follows:

1) For whole 4 basins

If the cost or benefit is change from 5% to 10%, there is no significant change in the IRR, B/C and NPV so that the total project of 4 basins shows the economic effectiveness for the socio-economic change.

2) Each basin

As to Cañete, Chincha and Pisco rivers, the projects have high economic viability even in the base case so that IRR, B/C and NPV have no significant variation for the change of cost or benefit of the projects, and they are still effective projects. As to Majes-Camana river, the effectiveness becomes less than the boundary of the viability when the discount rate increases by 5%, however the effectiveness at social price is still high in any case.

4.7 Risk Analysis

The risk analysis is performed for flood prevention facilities of 4 basins.

(1) Definition of risk

The increase % of cost and decrease % of benefit which make NPV value equal to zero, are calculated, then the magnitude of risk is defined as shown below.

High risk : When the cost increases from 0% to less than 15% or the benefit decrease from 0% to less than15%, NPV becomes zero.

Middle risk: When the cost increases more than 15% to less than 30% or the benefit decrease more than 15% to less than 30%, NPV becomes zero.

Low risk: When the cost increases more than 30% or the benefit decrease more than 30%, NPV becomes zero.

(2) Magnitude risk in each basin

The increase % of cost and decrease % of benefit which make NPV equal to zero, are calculated as shown in the Table 4.7-1. According to the Table, the risk is very low in each basin

Table 4.7-1 Increase % of cost and decrease % of benefit for NPV=0%

4.8 Sustainability Analysis

This project will be implemented 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. Although the sharing percentage will be determined through discussions among stake holders, the percentage is assumed provisionally 80% for the central government (in this case MINAG), 15% for regional government and 5% for irrigation committee. 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.

(1) Profitability

The profitability of projects in 4 basins is high enough as shown in 4.5 social evaluation so that there is no questionable point in the sustainability of the Project.

(2) Irrigation committee

The irrigation committee is non-profitable organization established by local people based on the law （Resolución Ministerial Nº 0837-87-AG） issued on October 14, 1987.

Peru irrigation committee is composed of 114 committees which are divided into 1582 sectors. It is registered to the National Committee (Junta Nacional, composed of 7 members

elected by all irrigation committees) and acts as an representative of agricultural sector in all Peru, and recognized in the various sectors such as public and private agricultural departments.

Each irrigation committee is composed of plural irrigation sectors. The irrigation sector means the unit irrigation area which has same characteristics of irrigation area with same topography, and same intake, secondary and thirdly irrigation canals etc.

The decisions of committee is made by the Assignment Board（Cesión de Consejo Directivo） held twice per month, which is composed of 7 members such as president, vice president, secretary, 2-directors, accountant and assistant accountant etc.

The main task of the committee is as follows:

- To promote the agreement of will among members and to integrate members' will as the opinion of the committee
- Effective and fair distribution of water resources
- Administration and operation and maintenance of hydraulic facilities
- Education and capacity building for water resources
- Promotion of agricultural development and increase of life quality by increase of income

(3) Capacity of operation and maintenance

The recent annual budget of the irrigation committee of each basin is as shown in the Table 4.8-1.

Table 4.8-1 Irrigation Committee's budget

Rivers	Annual Budget			(Unit/ S)
	2007	2008	2009	2010
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
Majes-Camana	-	1,867,880.10	1,959,302.60	1,864,113.30
Total	5,566,488.09	7,690,420.39	7,499,040.48	5,898,261.87

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)

The annual revenue of irrigation committee is composed of ① irrigation water cost (/m3), ② rental cost of heavy equipment to private company etc. and there is no governmental subsidy. And the annual expenditure is composed of ① operation cost of intake facilities (operator cost of intake weir etc.) ② operation and maintenance cost for such as irrigation canal and intake etc., ③ investigation cost for upgrading of irrigation facilities, ④ operation cost for irrigation committee office.

On the other hand the required operation and maintenance cost is as shown in the Table 4.8-2 according to the clause 4.4.1. The ratio of O/M cost to the annual budget in 2009 and to the annual average of the damage reduction amount are also as shown in the same table.

The ratio of O/M cost to the annual budget in 2009 is highest in Majes-Camana river as 36.2%, followed in Chincha river as 29.3 %, Pisco river as 22.2 % and lowest in Cañete river as 11.1 %.

On the other hand the ratio of O/M cost to the annual average of the damage reduction amount varies from 2 to 4 %, which seems to be very low.

The ratio of O/M cost to the annual budget seems to be rather high, however the ratio of O/M cost to the annual average flood damage amount is very low so that after the flood damage is reduced and profit of farmer increase, it is quite possible that the irrigation committee bears the O/M cost.

And each committee has heavy equipment such as bull-dozer, excavator, trailer, dump truck etc. and performed maintenance works for dike, revetment, intake, irrigation channel etc. therefore the committee could carry out the O/M of the facilities constructed in the Project under the technical assistance of MINAG and the regional government.

Table 4.8-2 Ratio of O/M cost to annual budget and damage reduction amount

Irrigation Committee	Annual Budget(1,000soles)	O/M Cost(1,000soles)	Percentage of O/M cost(%)	Average Yearly Damage Reduction(1,000soles)	Percentage of O/M cost(%)
	①	②	③=②/①	④	⑤=②/④
Cañete	2,331	260	11.1	12,274	2.1
Chincha	1,483	435	29.3	20,532	2.1
Pisco	1,725	383	22.2	17,844	2.1
Majes-Camana	1,959	710	36.2	17,592	4.0
Total	7,499	1,788	23.8	68,242	2.6

(4) Agreement with irrigation committee

The following items are to be discussed and made agreement between the central government (MINAG) and the irrigation committee as soon as possible.

- Sharing ratio of Project cost
- Delivery of flood prevention facilities
- O/M of facilities
- Delivery of plantation aong river structure and O/M

4.9 Environmental Impact

4.9.1 Procedure of Environmental Impact Assessment

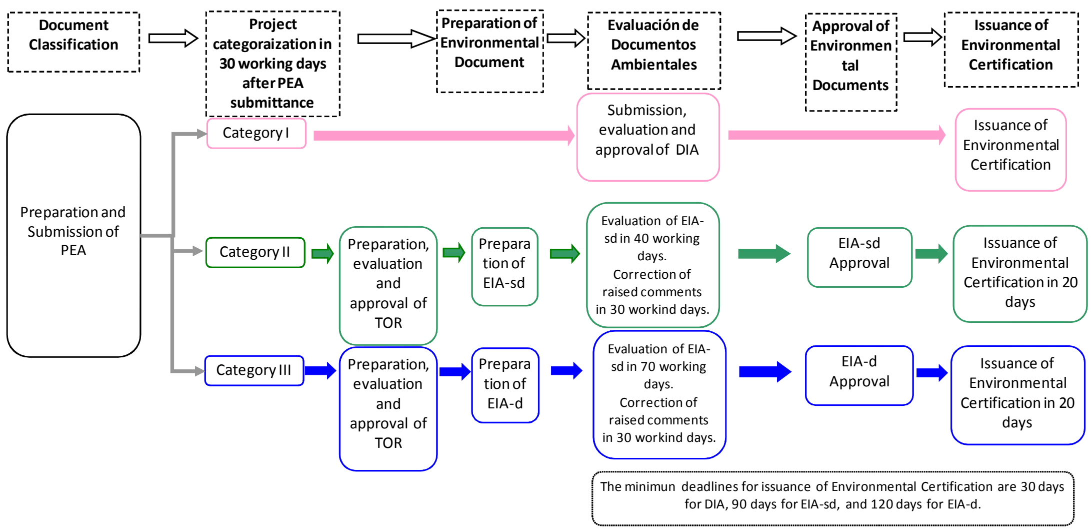
Projects are categorized in three scales, based on the significance level of the negative and positive impacts, and each sector has an independent competence on this categorization. The following table shows the environmental management instruments that are required for each category. The Project holder 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 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 and 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. Chira river was excluded from the Project due to its low viability so that the additional environmental impact analysis is not required for the 3 objective rivers, Cañete, Chincha, Pisco, for Feasibility Study. As to Majes-Camana river DGAA issued the approval of EAP and categorized the project as Category I in August 16, 2012. Therefore the additional environmental impact analysis for 4 rivers is not required.

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 describes “working sites” to be considered in the Environmental Impact section for the 4 watersheds.

Table 4.9.1-2 Works description

River	Location		Critical Point	Main Protection Objects	Measure	Feature of Work	
Rio Canete	Ca-1	4..2-5.2 km	Narrow Section	Agricultural Lands (Apple, Grape, Cotton, etc.)	Dike with Bank Protection	Length	1,100 m
						Bank Protection	5,430 m3
						Large Boulder Riplap	9,230 m3
	Ca-2	6.7～8.3 km	Innnuded Point		Dike with Bank Protection	Length	3,200 m
						Dike with Bank Protection	113,700 m3
						Large Boulder Riplap	28,200 m3
	Ca-3	10.1-11.2 km	Narrow Section		Riverbed Excavation、Dike with Bank Protection	Riverbed Excavation	L=700 m, V=80,270m3
						Dike with Bank Protection	1,630 m
						Large Boulder Riplap	16,730 m3
	Ca-4	24.6-25.0 km	Existing Intake Weir (w:150m, i: 1:2, crest w:2.0m)	Intake Weir, Agricultural Lands	Riverbed excavation、Dike with Bank Protection	Riverbed Excavation	L=370 m, V=34,400 m3
						Dike with Bank Protection	L=710m, V=20,150 m3
						Large Boulder Riplap	7,300 m3
	Ca-5	25.1-26.6 km	Narrow Section	Agricultural Lands (Apple, Grape, Cotton, etc.)	Dike with Bank Protection	Length	1,520 m
						Dike with Bank Protection	95,125 m3
						Large Boulder Riplap	14,000 m3
Rio Chincha	Chico-1	2.9-5.0 km	Innnuded Point	Agricultural Lands (Apple, Grape, Cotton, etc.), Intake Weir	Dike with Bank Protection	Length	3,150 m
						Dike with Bank Protection	60,160 m3
						Large Boulder Riplap	23,700 m3
	Chico-2	14.7-15.3 km	Existion Intake Weir (w:100m, H:3.0m, crest w:2.0m)		Riverbed excavation、Dike with Bank Protection	Riverbed Excavation	L=540 m, V=20,000 m3
						Dike with Bank Protection	L=850 m, V=5,500 m3
						Large Boulder Riplap	23,700 m3
	Chico-3	24.0-24.4 km	Existing Intake Weir (w:70m, H: 3.0m, crest w:2.0m)		Intake Weir/ Dike with Bank Protection	Construction of Intake Weir	Ground Sill 1 V=5,200 m3, Diversion Weir 1 V=4,300 m3
						Dike with Bank Protection	L=730 m, V=20,350 m3
						Large Boulder Riplap	7,400 m3
	Ma-1	2.5-5.0 km	Innnuded Point		Dike with Bank Protection	Length	4,630 m
						Dike with Bank Protection	49,900 m3
						Large Boulder Riplap	37,000 m3
	Ma-2	8.0-10.5km	Narrow Section		Riverbed excavation、Dike with Bank Protection	Riverbed Excavation	L=2,500 m, V=123,500 m3
						Dike with Bank Protection	L=4,080 m, V=37,700 m3
						Large Boulder Riplap	32,200 m3
Rio Pisco	Pi-1	3.0-5.0 km	Innnuded Point	Agrictural Lands	Dike with Bank Protection	Length	4,120 m
						Dike with Bank Protection	92,900 m3
						Large Boulder Riplap	32,200 m3
	Pi-2	6.5-7.9 km	Narrow Section		Riverbed Excavation、Dike with Bank Protection	Riverbed excavation	L=1,200 m, V=74,900 m3
						Dike with Bank Protection	L=2,950 m, V=42,520 m3
						Large Boulder Riplap	25,000 m3
	Pi-3	12.4-13.9 km	Innnuded Point		Dike with Bank Protection	Length	1,500 m
						Dike with Bank Protection	33,900 m3
						Large Boulder Riplap	12,600 m3
	Pi-4	19.5-20.5 km	Innnuded Point	Agrictural Lands	Dike with Bank Protection	Length	1,010 m
						Dike with Bank Protection	17,400 m3
						Large Boulder Riplap	8,060 m3
	Pi-5	25.8-26.4 km	Narrow Section		Riverbed Excavation、Dike with Bank Protection	Riverbed excavation	L=600 m, V=67,600 m3
						Dike with Bank Protection	L=1,250 m, V=29,900 m3
						Large Boulder Riplap	10,600 m3
	Pi-6	34.5-36.4 km	Existing Intake Weir (Sediment Retuding Basin 1,800 x 700m)		Riverbed Excavation・Dike with Bank Protection	Riverbed excavation	L=1,900 m, V=496,000 m3
						Outer Dike/ Bank protection	L=2,050 m, V=103,600 m3
						Large Boulder Riplap	19,900 m3
						Inner Dike/ Bank protection	L=3,750 m, V=114,000 m3
						Large Boulder Riplap	63,100 m3
Rio Camana	MC-1	0.0-4.5km	Innnuded Point	Agrictural Lands	Dike with Bank Protection	Length	4,500 m
						Dike with Bank Protection	155,700 m3
						Large Boulder Riplap	44,300 m3
	MC-2	7.5-9.5 km	Innnuded Point	Agrictural Lands	Dike with Bank Protection	Length	2,000 m
						Dike with Bank Protection	43,100 m3
						Large Boulder Riplap	18,300 m3
	MC-3	11.0-17.0 km	Innnuded Point	Agrictural Lands	Dike with bank Protection	Length	6,000 m
						Dike with Bank Protection	169,000 m3
						Large Boulder Riplap	59,000 m3
Rio Majes	MC-4	48.0-50.5 km	Innnuded Point	Agrictural Lands	Dike with Bank Protection	Length	2,500 m
						Dike with Bank Protection	75,200 m3
						Large Boulder Riplap	17,700 m3
	MC-5	52.0-56.0 km	Innnuded Point	Agrictural Lands	Dike with bank Protection	Length	4,300 m
						Dike with Bank Protection	179,000 m3
						Large Boulder Riplap	39,400 m3
	MC-6	59.6-62.8 km	Innnuded Point, Local Erosion	Agrictural lands	Dike with Bank Protection	Length	6,200 m
						Dike with Bank Protection	235,000 m3
						Large Boulder Riplap	51,400 m3
	MC-7	65.0-66.7 km	Innnuded Point	Agrictural Lands	Dike with Bank Protection	Length	2,900 m
						Dike with Bank Protection	32,300 m3
						Large Boulder Riplap	27,500 m3

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) – Cañete river

Construction Stage			Work	1-5	1-5	1-5	4,5	1,2,3	2,4,5	1-5	1-5	1-5	1-5	1-5		
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		N			5	0
		Cantidad de agua superficial							N						1	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 %

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

Operation Stage										
Environment	Component	Environmental Factors	Works	Riverbed without Silting Point 1	Dike-Right Side Point 2	Riverbed without Silting Point 3	Intake Point 4	Protection - Right Side Point 5	Total Negative	Total Positive
Physique	Air	PM-10 (Particulate matter)							0	0
		Gas emissions							0	0
	Noise	Noise							0	0
	Soil	Soil fertility						P	0	1
		Land Use							0	0
	Water	Calidad del agua superficial					P	P	0	2
		Cantidad de agua superficial		P	P	P	P		0	3
	Physiography	Morfología fluvial		N	N	N			3	0
		Morfología terrestre							0	0
Biotic	Flora	Terrestrial flora							0	0
		Aquatic flora							0	0
	Fauna	Terrestrial fauna							0	0
		Aquatic fauna		N	N	N			3	2
Socio-economic	Esthetic	Visual landscape		P	P	P		P	0	4
	Social	Quality of life		P	P	P	P	P	0	5
		Vulnerability - Security		P	P	P	P	P	0	5
	Economic	PEA							0	0
		Current land use		P	P	P	P	P	0	4
Total				7	7	7	5	6	6	26
Percentage of positive and negative									19 %	81 %

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

On the Cañete River basin, based on the impact identification results for the construction stage, a total number of 64 interactions have been found. 62 of these interactions (97 %) correspond to impacts that will be perceived as negative, and 2 (3 %) correspond to impacts that will be perceived as positive. In addition, 32 interactions have been found for the operation stage; 6 of these interactions (19 %) correspond to impacts that will be perceived as negative, and 26 (81 %) correspond to impacts that will be perceived as positive.

Hereinafter, the same tables above on the other basins are omitted, for which refer to Anex-11 Environmental and Social consideration/Gender

On the Chincha River basin, based on the impact identification results for the construction stage, a total number of 64 interactions have been found. 62 of these interactions (97 %) correspond to impacts that will be perceived as negative, and 2 (3 %) correspond to impacts that will be perceived as positive. In addition, 33 interactions have been found for the operation stage; 7 of these interactions (21 %) correspond to impacts that will be perceived as negative, and 26 (79 %) correspond to impacts that will be perceived as positive.

On the Pisco River basin, based on the impact identification results for the construction stage, a total number of 69 interactions have been found. 67 of these interactions (97 %) correspond to impacts that will be perceived as negative, and 2 (3 %) correspond to impacts that will be perceived as positive. In addition, 34 interactions have been found for the operation stage; 8 of these interactions (24 %) correspond to impacts that will be perceived as negative, and 26 (76 %) correspond to impacts that will be perceived as positive.

On the Majes-Camana River basin, based on the impact identification results for the construction stage, a total number of 47 interactions have been found. 45 of these interactions (97 %) correspond to impacts that will be perceived as negative, and 2 (3 %) correspond to impacts that will be perceived as positive. In addition, 56 interactions have been found for the operation stage; 21 of these interactions (37.5%) correspond to impacts that will be perceived as negative, and 35 (62.5 %) correspond to impacts that will be perceived as positive.

(2) Environmental and social impact assessments

Environmental and social impacts are assessed with the methodology that was explained in 4.9.2 Methodology. The following tables show the environmental and social assessment results for each basin, during the construction and operation stages.

Table 4.9.3-2 Environmental impact assessment matrix – Cañete river

Medio	Componente	Acciones del proyecto / Factores Ambientales	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
		The Cañete River Basin	Construction Stage											Operation Stage				
		Puntos de Obras:	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	28.0	31.0	28.0	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

It must be pointed out that in the Cañete River basin only 15 out of a total of 62 negative impacts have been quantified as significant, and 2 have been quantified as very significant, during the construction stage. Meanwhile, out of a total of 6 negative impacts, only 2 have been quantified as significant, and 4 have been quantified as very significant, during the operation stage.

During the construction stage, the works site preparation component and the DME installation and operation will significantly affect the land morphology. During the operation stage, river morphology and aquatic fauna will be significantly affected at “Ca1” and “Ca3” points, where the river basin will be unclogged.

Table 4.9.3-3 Environmental impact assessment matrix – Chincha river

			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

It must be pointed out that in the Chincha River basin only 15 out of a total of 62 negative impacts have been quantified as significant, and 2 have been quantified as very significant, during the construction stage. Meanwhile, out of a total of 7 negative impacts, only 5 have been quantified as significant, and 2 have been quantified as very significant, during the operation stage.

During the construction stage, the works site preparation component will significantly affect the land morphology. At the same time, the Riverbed Excavation and Filling component will affect the "Chico1", "Ma1", and "Ma2" points. During the operation stage, river morphology and aquatic fauna will be significantly affected at the "Ma3" points, where the river basin will be unclogged.

Table 4.9.3-4 Environmental impact assessment matrix – Pisco river

Medio	Componente	Acciones del proyecto / Factores Ambientales (Puntos de Obras)	Construction Stage: Civil Work (Concreting) (Pi 1.3.4 y 6)	Construction Stage: I&O of stone pits and material production plants (Pi 1.3.4 y 6)	Construction Stage: DME I&O (Pi 1-6)	Construction Stage: Camps work I&O (Pi 1-5)	Construction Stage: Carriage Staff (Pi 1-6)	Construction Stage: Transportation of machinery, equipment, materials and supplies (Pi 1-6)	Operation Stage: Pi1	Operation Stage: Pi2	Operation Stage: Pi3	Operation Stage: Pi4	Operation Stage: Pi5	Operation Stage: Pi6
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

It must be pointed out that in the Pisco River basin only 12 out of a total of 67 negative impacts have been quantified as significant, and 2 have been quantified as very significant, during the construction stage. Meanwhile, out of a total of 8 negative impacts, only 6 have been quantified as significant, and 2 have been quantified as very significant, during the operation stage.

During the construction stage, the works site preparation component will significantly affect the land morphology. At the same time, the Riverbed Excavation and Filling component will affect the “Pi1”, “Pi2”, “Pi3”, and “Pi4” points. During the operation stage, river morphology and aquatic fauna will be significantly affected at the “Pi2” points, where the river basin will be unclogged.

Table 4.9.4-5 Environmental impact assessment matrix – Majes-Camaná river

			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

It must be pointed out that in the Majes-Camaná River basin 11 out of a total of 14 negative impacts have been quantified as significant, and 1 haa been quantified as very significant, during the construction stage. Meanwhile, 3 significant negative impacts have been quantified as during the operation stage.

During the construction stage, the works site preparation component will significantly affect the land morphology. During the operation stage, river morphology and aquatic fauna will be significantly affected all the point, where the dikes will be built.

During the construction stage, actions that will generate most significant negative impacts along all 4 basins include: "Site Works Preparation and Clearance", "Riverbed Excavation and Embankment", and "Surplus Material Deposits Operation (DME, in Spanish)." "Site works Preparation and Clearance" will bring about a significant modification to the land morphology, whereas "Riverbed Excavation and Filling" will bring about a significant modification to river morphology.

During the operation stage, hydraulic infrastructure works that will bring about most significant negative environmental impacts include “Riverbed excavation and embankment” that will cause a modification to the river morphology and subsequently, decreased river habitability conditions that will directly impact the aquatic fauna.

Most significant positive impacts are related to all works to be constructed along the river basins, and are directly related to improve the quality of the lives of the population around the area of influence, improve the “Current Use of land / soil”, improve the security conditions, and reduce vulnerability at social and environmental levels.

4.9.4 Socio-Environmental Management Plans

The objective of the Socio-Environmental Plans is to internalize both positive and negative significant and very significant environmental impacts that are related to the Project’s construction and operation stages, so that prevention and/or mitigation of significant and very significant negative impacts, preservation of environmental heritage, and Project sustainability are ensured.

During the construction stage, Projects of all 4 basins have set out the following measures: “Local Hiring Program”, “Works Sites Management and Control Program”, “Riverbed Diversion Program”, “Riverbank Excavation and Filling Management”, “Riverbed Excavations and Filling Management”, “Quarry Management”, “DME Management”, “Camp and Site Residence Standards”, and “Transportation Activity Management.” During the operation stages, Projects for all 4 basins have considered the development of activities with regard to “Riverbed and Aquatic Fauna Management”. These activities should develop riverbed conditioning downstream the intervention points, for erosion probabilities to be reduced, and habitability conditions to be provided for aquatic fauna species. The following are measures related to those negative impacts to be mitigated or those positive impacts to be potentiated. Overall measures have been established for all 4 basins, based on the impacts, as identified in all basins.

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

(1) Follow up and monitoring plan

The follow-up plan has to implement firmly the management of environmental plan. The monitoring plan is to be carried out to confirm that the construction activity fulfill the environmental standard such as Environmental Quality Standards (EQS) either or Maximum Permissible Limits (MPL). 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.

1)·Construction stage

During the construction period of the projects to be done in the 4 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:

a) Water quality and biological parameters:

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

b) Air quality:

During impact analysis, in the projects to be developed in the 4 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

c) 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 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

2) 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	°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 atthe 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 Cost for the Environmental Impact Management

The cost for the environmental management in this Project is as shown in the Table 4.9.6-1. In the table, (1) shows the cost for the environmental management of each facility, based on which the cost required in each basin (2) is calculated. And the cost for the counter measures 1) – 7) is calculated based on the accumulated construction period of each facility which is described in the Annex-9 Construction Plan/Cost Estimate, Table 2.1-1.

Table 4.9.6-1 Cost of environmental management plan

4.9.7 Conclusions and Recommendations

(1) Conclusions

According to the Preliminary Environmental Appraisals to all 4 basins, most impacts identified during the construction and operation stages were found out to be of little significance. Significant and very significant negative impacts can be controlled or mitigated, as long as suitable Environmental Management Plans are carried out. In addition, the Project will be implemented in the short term, as environmental conditions will be quickly restored. However, the execution of a follow – up and monitoring plan is important, and in the event that unexpected impacts are generated, immediate mitigation measures must be taken.

In addition, significant positive impacts are also present, especially during the operation stage. These positive impacts include: An enhanced security / safety and a decreased vulnerability at social and environmental levels; an improved quality of life among the population in the area of influence, and an improved “Current use of land / soil”.

(2) Recommendations

1) We mainly recommend that the beginning of the construction activities coincides with the beginning of the dry seasons in the region (May to November) when the level of water is very low or the river dries up. Each river characteristics / features should be taken into account, that is, that the Cañete and Majes-Camana Rivers are year - round rivers, and that the Chico, Matagente and Pisco Rivers are seasonal rivers. At the same time, the crop season cycle in the areas of direct influence should be taken into account, so that traffic jams caused by the large trucks and farming machinery is prevented.

2) It is recommended that the Project holder (DGIH) should define the limit of river area during detailed design stage, and identify the people who live within the river area illegally. Continually the DGIH should carry on the process of land acquisition based on the Land Acquisition Low, which are; Emission of Resolution for land acquisition by the State, Proposition of land cost and compensation for land owner, Agreement of the State and land owner, Payment, archaeological assessment certification.

3) DGIH has to promote the process to obtain the CIRA in the detail design stage. The process to be taken is i) Application form, ii) Copies of the location drawings and outline drawings, iii) voucher, iv) Archaeological Assessment Certificate.

4) The participation of the women in the workshops can be promoted through the existing women

group such as Vaso de Leche.

Finally, the DGAA submitted the resolutions (Environmental Permissions) for three basins (Cañete, Chincha and Pisco). The three projects have been categorized as “Category I”, which means that these three projects are not required to carry out neither EIA-sd nor EIA-d. As to Majes-Camana river DGAA issued the approval of EAP and categorized the project as Category I in August 16, 2012. Therefore the additional environmental impact analysis for 4 rivers is not required.

4.10 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. The following description was prepared by the local consultant and governmental offices and is used in the office of DGIH.

1) 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 PSI(Programa Subsectorial de Irrigaciones, Ministerio de Agricultura) is dedicated to calculate project costs, detail design and supervision of the works execution.

＊ The Planning and Investment Office (OPI) 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 DGPI(previous DGPM) of the Economy and Finance Ministry (MEF)

＊ The General Administration Office of the Agriculture Ministry (OGA-MINAG) along with the Public Debt National Direction (DGETP, previous 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

2) Economy and Finance Ministry (MEF)

＊ The DGPI approves feasibility studies. It also confirms and approves the conditions ofloan contracts in yen. In the investment stage, it gives technical comments prior to the project execution.

＊ Financial management is in charge of DGETP (previous DNEP)from the Economy and Finance Ministry and OGA-MINAG

＊The Public Debt National Direction (DGETP , previous DNEP) of the Economy and Finance Ministry administers expenses in the investment stage and post-investment operation

3) 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 4.10-1 and 4.10-2.

In this Project, PSI from MINAG is scheduled to be the execution agency in the investment stage (Project execution). The PSI is currently performing JICA projects, etc. and in case of beginning a new project, it forms the correspondent Project Management Unit (PMU), and PSI is responsible of employment of international consultant with deep experience on Japanese Yen Loan project and carried out the detail design, procurement of contractor, and supervision of construction work etc. The following figure describes the structure of the different entities involved in the Project's execution stage. PMU is organized directly under PSI and the organization is as shown in the Figure-4.10-4.

The Agreement of Fund Transfer and Fund Management in the Figure-4.10-1 means MEF transferrs the fund to PSI and controls the expenditure

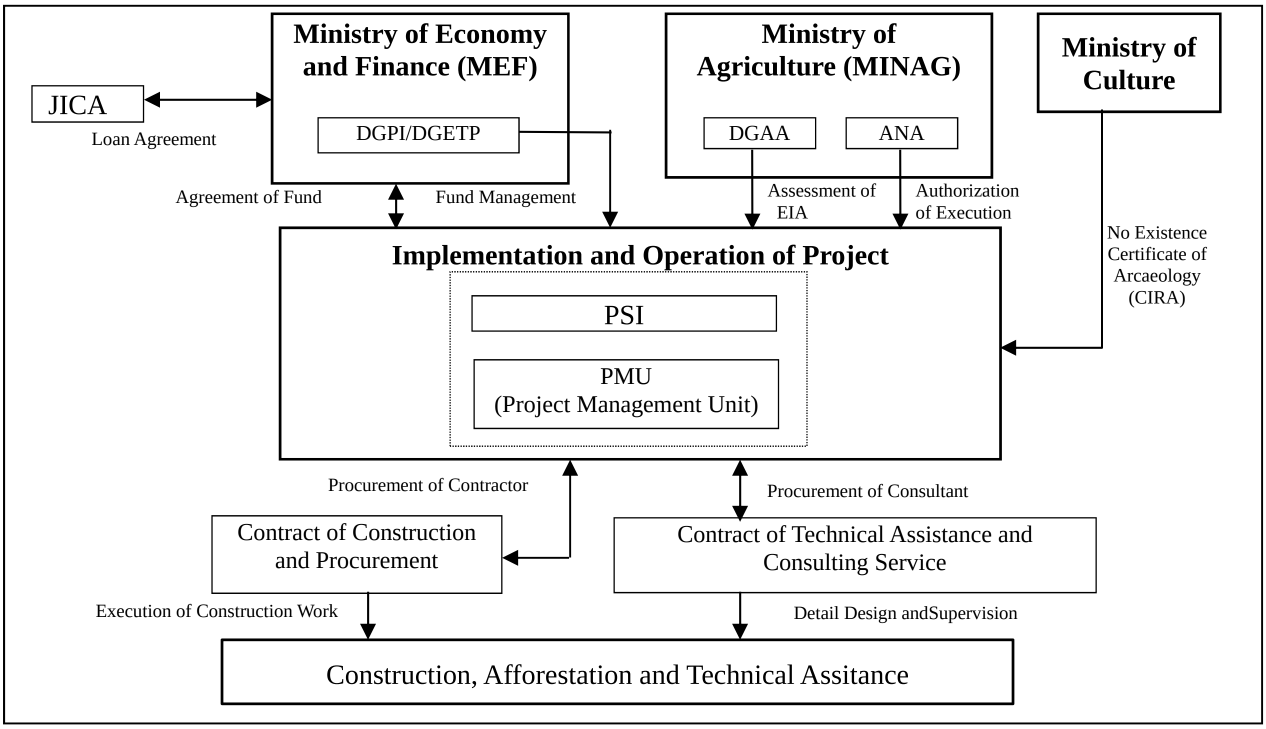


Figure 4.10-1 Related agencies in implementation stage of project

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.

Next, the relationship of different organizations involved in post-project implementation stage is detailed.

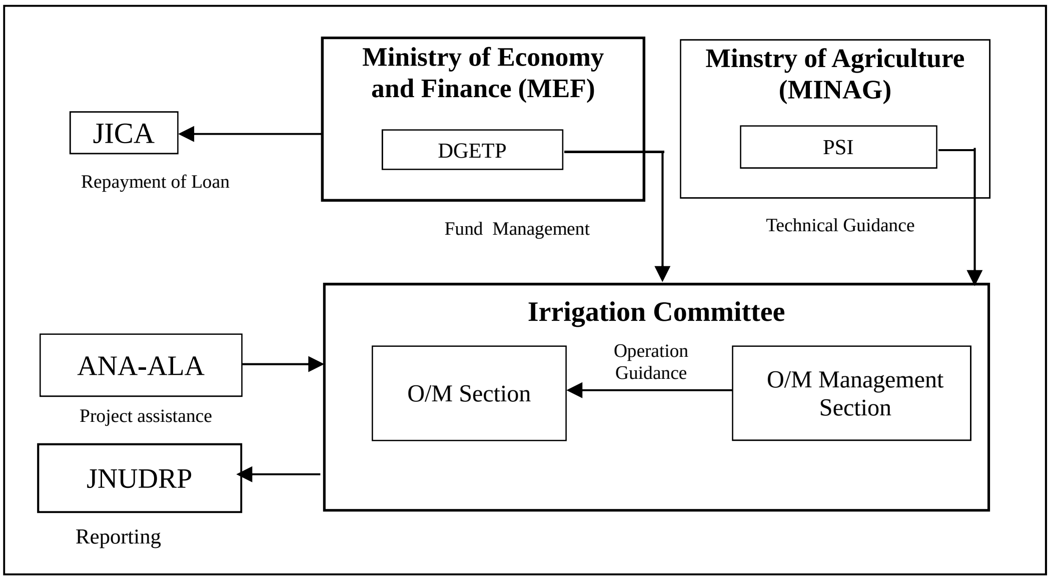


Figure 4.10-2 Related agencies in operation stage of project

(1) 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 4.10-1 the PSI budget for 2011 is shown.

Table 4.10-1 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 confirmed by 235employees, from which 14 are assigned for JBIC Projects and 29 technicians and assistants are working under them.

Table 4.10-2 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 4.10-3, PSI organization is detailed:

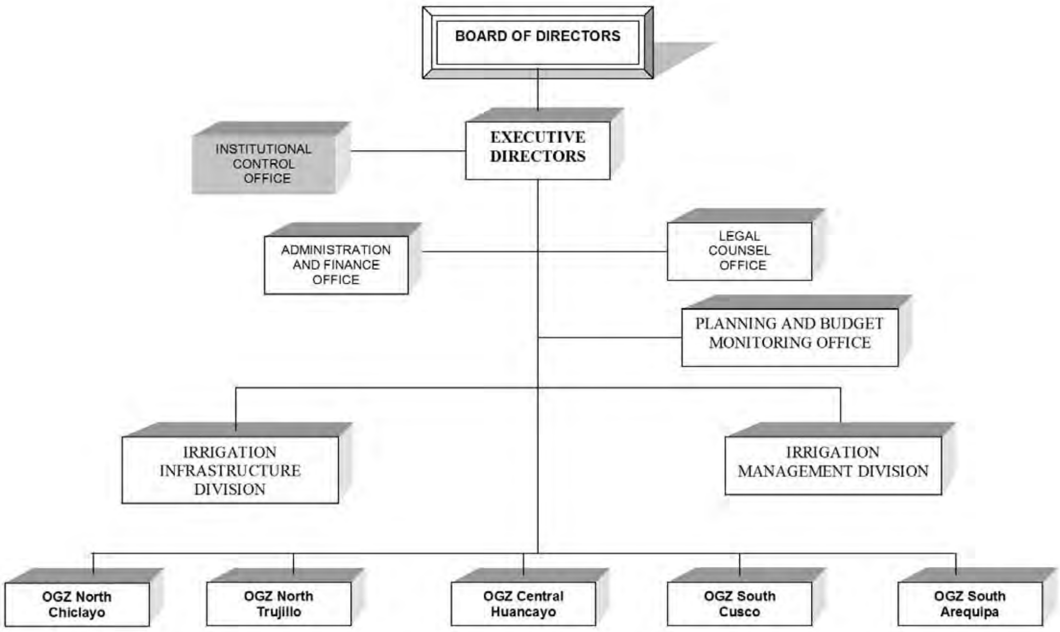
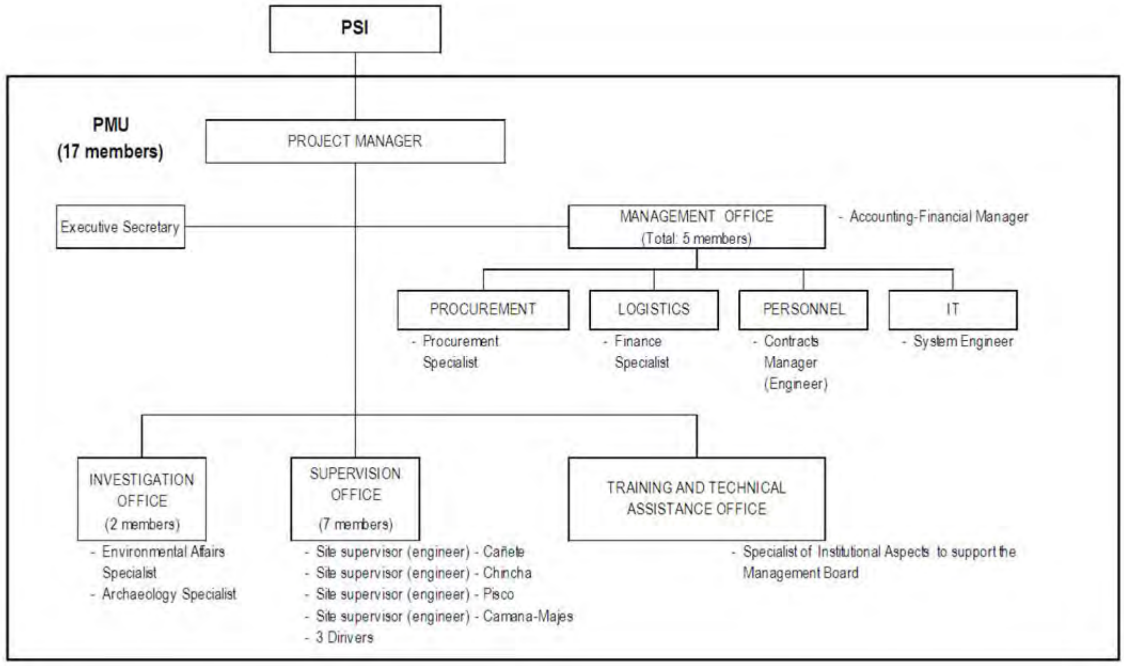


Figure 4.10-3 Organization of PSI

(3) Organization of PMU（Project Management Unit）

1）Organization

PMU is installed directly connected the Irrigation Infrastructure Division of PSI. The organization of PMU is as shown in the Figure 4.10-4.



Note: ( )shows number of personnel

Figure 4.10-4 Organization of PMU

2) Main staff

PMU is composed of the following main staff.

－Project manager
－Contract specialist
－Construction supervisor
－IT specialist
－Procurement specialist
－Financial specialist
－Organization specialist (Adviser to the irrigation commitee)
－Environmental assessment specialist
－Archeological specialist
－Accountant

3) Cost

The cost for operation of PMU is budgeted at 8.5 million soles as described in the clause 4.4.1, Table 4.4.1-11.

The Project will be promoted safely, by installing PMU in the implementation agency PSI) and receiving the assistance of the consultant procured separately.

4.11 Execution Plan

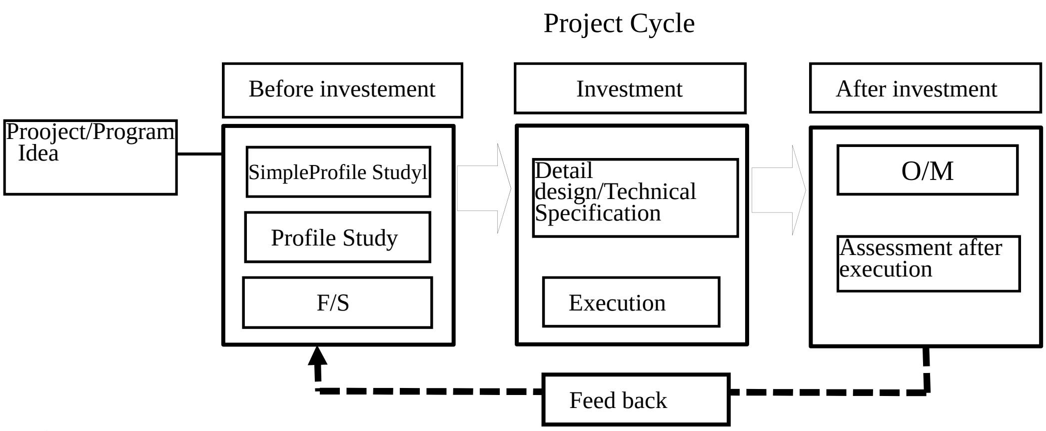
The Project's Execution Plan will be examined in the preliminary schedule, which includes the following components. For pre-investment stage: ① full execution of profile and feasibility studies to obtain SNIP's approval in the pre-investment stage; for the investment stage: ② signing of loans (L/A), 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.

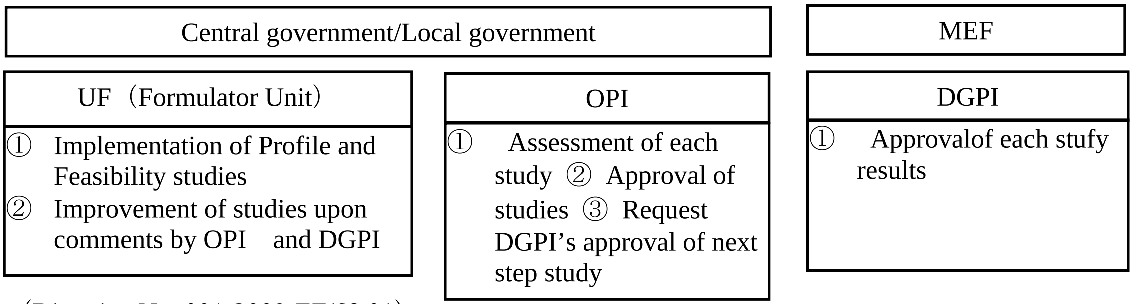


(Source : DGPI)

Figure 4.11-1 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 a little bit 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 Direction General of Investment Policy (hereinafter referred to DGPI) to approve feasibility studies and initiation of following studies. Finally DGPI evaluates, determines and approves the public investment's justification.



（Directiva No. 001-2009-EF/68.01）

Figure 4.11-2 Related institutions to SNIP

Due to the comments of examining authorities (OPI and DGPI) 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 on September 22, 2011. And OPI examined project report of Majes-Camana river and issued its comment on August 4, 2012.

DGIH revised the reports of 3 rivers, Cañete , Chincha, Pisco, and submitted to OPI in May 2012、and revised the report of Majes-Camana and submitted to OPI December 12, 2012.

OPI transferred the revised 3 reports to DGPI with its comments in July 2012 and DGPI approved the proceed to F/S with its comments in October 2012.

Chira river was excluded due to low economic viability depending on reducing the number of flood prevention facilities.

(2) Yen loan contract

Once the feasibility report of this Project is submitted, then the OPI and DGPI examine the contents of report, and finally the declaration of viability of the Project is to be issued by DGPI. When the declaration of viability is almost confirmed, 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 6 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 4.11-1 presents the Project's overall schedule (As to the details of construction time schedule, refer to Annex-9 Construction Planning and Cost Estimate).

1) Consultant selection: 10 months
2) Detailed design and technical specifications of the work: 6 months
3) Contractor selection: 15 months
4) onstruction supervision by Consultant on river structures and plantation along river structures: 24 months
5) The afforestation along river structures is carried out in parallel with the construction.
6) Disaster prevention education/Capacity development is carried out from time to time in parallel with construction work.

Table 4.11-1 Implementation plan

	Item	2010–2018 (3, 6, 9, 12)	Months
1	Profile Study/SNIP Appraisal	Study / Appraisal	28
2	Feasibility Study/SNIP Appraisal	Study / Appraisal	27
3	Loan Appraisal		6
4	Selection of Consultant		10
5	Project Management Unit		45
6	Consulting Services		45
1)	Detailed Design		6
2)	Tender Preparation, Assistance		15
3)	Supervision		24
7	Selection of Contractor, Contract		15
8	Implementation		
1)	Structural Measures		24
2)	Vegetation		24
3)	Disaster Education/Capacity Building		24
4)	Land Acquisition		27
9	Completion/Inauguration		-

(4) Procurement

1) Employment of Consultants

The employment of consultant is to be made according the following itmes:

① The consultants should be active in international market and have enough qualification and experience.

② The consultants are to have efficiency, transparency and non-discrimination among eligible consultants

③ The selection procedure should be taken in accordance with the stipulation in the Loan Agreement and the guideline for the Employment of Consultants under Japanese ODA Loans prepared by JICA

2) Procurement of contractor

The procurement of contractors is to be made according to the following items:

①The procurement of contractors is to be made using due attention to consideration s of economy, efficiency, transparency and non-discrimination among eligible bidders.

②The procurement procedure should be taken in accordance with the stipulation in the Loan Agreement and the guideline for the Employment of Consultants under Japanese ODA Loans prepared by JICA

③The International Competitive Bidding: ICB is to be applied.

④ The pre-qualification (PQ) of bidders is to be applied in order to confirm the technical and financial capability of bidders. The following items are to be considered in PQ: a) experience of and past performance on similar contracts, b) capabilities with respect to personnel, equipment and plant, c) financial position.

4.12 Financial Plan

(1) Sharing ratio of project cost

This project will be implemented 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.

As to the sharing ratio among the central government, regional government and irrigation committee, DGIH reported that in some dam project the ratio among the central government, regional government , local government and irrigation committee is 50%, 30%, 10% and10% respectively and JICA Peru office reported that in some irrigation project, the irrigation committee bore 20 %. However there are no such examples as the flood protection project of this Project

Considering the direct benefit received by the irrigation committee is not so much as in the irrigation project, the sharing percentage will be determined through discussions among stake holders, the ratio is assumed provisionally 80% for the central government (in this case MINAG), 15% for regional government and 5% for irrigation committee. And the final ratio will be determined through negotiation among 3 parties.

(2) Financial plan

The total project cost is

The counter fund is divided into stakeholders as shown in the Table 4.12-1. The contribution of regional government and irrigation committee is distributed in proportion of project cost of each basin.

Table 4.12-1 Financial plan at implementation of project

(3) Repayment of loan

The yen loan shall be repaid according to the conditions stipulated in the Loan Agreement which is estimated as shown in the Table 4.12-2. The repayment will be made by the stakeholders according to the sharing ratio including the interest of loan.

Table 4.12-2 Estimated conditions of Japan Yen Loan

Interest	1.70%
Commitment Charge	0.10%
Maturity Period	25 years
Grace Period	7 years

4.13 Logical Framework

In Table 4.13-1 the logical framework of the definite selected option is shown.

Table 4.13-1 Logical framework of the project

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	Socio-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 number and flooded areas, functional improvement of intakes, irrigation channels protection, bank erosion control	Number of areas and flooded areas, water intake flow variation, bank erosion progress	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 construction of 23 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 (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
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

4.14 Baseline for Impact Assessment

The indicators of impact assessment are as shown below.

- Scale of flood discharge
- Inundation area
- Damage caused by flood
- Environment impact
- Operation and maintenance cost

1) Scale of flood discharge

As to the flood which causes the damage, the flood discharge is to be estimated using the rainfall and discharge observation data. Since the probable flood discharges were estimated in each basin in this Study, the occurrence probability of actual flood could be estimated and the impact given by the flood could be assessed.

2) Inundation area

The inundation caused by the actual flood is to be plotted on the topographical map or satellite image so that the inundation area around flood prevention facilities can be identified. Since the inundation area corresponding to the probable flood was estimated in the this Study, this area can be compared with the actual inundation area and the impact given by the actual inundation can be assessed.

3) Flood damage

The actual flood damage is to be estimated foe crops, loss of farm land, irrigation facilities, intake, traffic interruption, and other indirect damage. The actual damage can be compared with the damage caused by the probable flood. The impact caused by the actual damage can be assessed.

4) Environment impact

In the operation and maintenance stage, the environment impact is to be assesses regularly using the same method in this Study. The results are to be compared with the original results, then the environmental impact of the project can be assessed.

5) Operation and maintenance cost

The operation and maintenance cost of the Project was estimated in this Study. The actual O/M cost incurred to the irrigation committee is monitored in every year. The actual cost is to be compared with the estimated and the impact on O/M cost can be assessed.

4.15 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.

4.15.1 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 and 46.5 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 channel

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 the section 3.1.10, Figure 3.1.10-3~ Figure 3.1.10-8.

2) Inundation characteristics

Inundation analysis of each River was performed, which results are shown in the section 3.1.10, Figures 3.1.10-9~3.1.10-13 for inundation for floods with probabilities of 50 years. The inundation characteristics are shown in Table 4.15.1-1.

Table 4.15.1-1 Inundation characteristics of each river

River name	Inundation characteristics
Canete River	In the upstream area from 10km (distance mark) from the river mouth, although it overflows due to the shortage of discharge capacity, it remains in the influence of the farmland on the circumference of the channel. However, in downstream area from 10km from the river mouth, the flood flow spreads

		greatly just in the right-bank side, and the damage becomes large.
Chincha River	Chico	At the vicinities of 15km and 4km from the river mouth, overflows occur, and flood flows spread greatly in the left-bank side.
	Matagente	At the vicinities of 10km and 4km from the river mouth, overflows occur, and flood flows spread greatly in the right-bank side.
Pisco River		In the upstream area from 7km from the river mouth, although it overflows around the channel by the shortage of discharge capacity, the flood flow does not spread widely. However, if it overflows in the downstream area from 7km, the flood flow will spread greatly in the left-bank side, and serious damage will be occurred in the Pisco City.
Majes- Camana River		It overflows at the vicinity of 5km from the river mouth, and the flood flow spreads greatly in the left-bank side. In middle stream and upstream areas, It overflows in lowland plain, and flood flow stagnates by the surrounded hills and mountains.

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 applying the standard section of dike already mentioned in section 4.3.1, 5), 3) to the present river channel. In Table 4.15.1-2, 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 4.15.1-1 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 4.15.1-2 Flood water level and height of dike (example: Cañete river)

Canete

Distance	Actual dike height		Calculated water level					Actual dike height -HWL(1/50)		Dike height	Shortage of dike height	
	Left-bank side	Right-bank side	1/5	1/10	1/25	1/50	1/100	Left-bank side	Right-bank side		Left-bank side	Right-bank side
0.0	3.04	2.42	2.6	3.0	3.5	3.9	4.17	-0.84	-1.46	5.08	2.04	2.66
0.5	10.55	8.43	4.7	5.4	6.1	6.7	7.11	4.19	-0.26	7.39	-2.96	1.46
1.0	19.26	15.46	10.2	10.7	11.2	11.7	12.06	7.61	3.51	12.88	-6.41	-2.61
1.5	23.14	22.02	17.5	17.9	18.3	18.5	18.77	4.53	3.47	19.75	-3.39	-2.27
2.0	28.54	24.14	23.4	23.8	24.2	24.5	24.67	4.07	-0.33	25.67	-2.87	1.53
2.5	29.77	30.43	29.3	29.8	30.1	30.4	30.69	-0.88	0.01	31.62	1.88	1.19
3.0	39.57	38.32	34.9	35.4	36.0	36.5	36.95	3.03	-0.22	37.74	-1.83	1.42
3.5	44.29	41.17	39.6	40.3	41.0	41.5	41.90	2.77	-0.38	42.72	-1.57	1.58
4.0	50.57	44.51	44.1	44.4	45.2	45.9	46.45	4.07	-1.32	47.10	-3.77	2.59
4.5	50.77	50.90	49.3	50.0	50.8	51.5	52.00	-0.71	-0.58	52.68	1.91	1.78
5.0	56.72	55.97	54.5	55.1	56.1	56.7	57.14	0.02	-0.73	57.90	1.18	1.93
5.5	61.60	62.63	59.3	60.1	60.8	61.3	61.81	0.30	1.33	62.50	0.90	-0.13
6.0	67.94	67.29	64.8	65.4	66.0	66.8	67.18	1.19	0.54	67.95	0.01	0.66
6.5	71.66	72.26	70.6	71.1	71.7	72.2	72.60	-0.23	0.05	73.41	1.43	1.15
7.0	78.51	77.88	75.9	76.5	77.2	77.9	78.57	-1.56	0.02	79.07	2.16	1.18
7.5	84.54	83.93	81.3	81.8	82.6	83.1	83.56	1.40	0.79	84.34	-0.20	0.41
8.0	87.14	88.34	87.2	87.8	88.6	89.2	89.74	-2.10	-2.50	90.44	3.30	3.50
8.5	92.88	94.92	93.0	93.6	94.4	95.1	95.68	-2.24	-0.20	96.32	3.44	1.40
9.0	97.53	99.88	97.5	98.4	99.2	99.9	100.46	-2.26	-0.36	101.15	3.58	1.51
9.5	103.82	106.09	103.3	103.9	104.4	104.9	105.21	-1.35	1.22	106.07	2.55	-0.02
10.0	113.17	112.15	108.0	108.7	109.6	110.2	110.66	2.98	1.97	111.38	-1.78	-0.77
10.5	115.92	115.66	115.0	115.5	116.2	116.7	117.08	-0.77	-1.02	117.89	1.97	2.22
11.0	120.02	120.74	120.1	120.6	121.3	121.9	122.26	-1.84	-1.12	123.06	3.04	2.32
11.5	126.04	125.46	125.6	125.9	126.3	126.6	126.97	-0.51	-1.06	127.75	1.71	2.26
12.0	133.58	131.61	131.7	132.0	132.3	132.6	132.87	0.54	-1.03	133.84	0.29	2.23
12.5	138.25	137.29	137.3	137.7	138.2	138.8	138.96	-0.40	-1.36	139.85	1.60	2.56
13.0	144.87	144.18	143.6	144.0	144.6	145.0	145.38	-0.17	-0.85	146.24	1.37	2.06
13.5	151.37	149.90	149.5	150.0	150.6	151.1	151.52	0.23	-1.64	152.34	0.97	2.84
14.0	157.25	155.65	155.4	156.0	156.7	157.3	157.90	-0.07	-1.64	158.32	1.27	2.84
14.5	163.04	162.68	160.8	161.3	162.0	162.7	163.10	0.34	-0.04	163.90	0.85	1.24
15.0	169.07	168.02	166.9	167.4	168.0	168.5	168.98	0.54	-0.51	169.73	0.66	1.71
15.5	174.33	173.29	172.1	172.6	173.3	173.8	174.18	0.53	-0.51	175.00	0.67	1.71
16.0	178.76	179.67	178.3	178.7	179.2	179.6	179.94	-0.80	0.11	180.78	2.00	1.09
16.5	189.69	184.90	182.9	184.3	184.7	185.0	185.23	4.69	-0.10	185.20	-3.49	1.30
17.0	198.92	190.23	190.7	191.2	191.8	192.3	192.86	6.61	-2.08	193.51	-5.41	3.28
17.5	204.00	196.38	196.1	196.7	197.4	198.0	198.52	5.95	-1.70	199.25	-4.75	2.90
18.0	208.64	202.64	202.2	202.7	203.2	203.7	204.03	4.96	-1.04	204.88	-3.76	2.24
18.5	216.02	208.07	207.5	207.9	208.3	208.9	209.24	7.12	-0.83	210.10	-5.92	2.03
19.0	231.58	214.90	214.2	214.6	214.9	215.2	215.38	16.41	-1.17	216.37	-15.21	2.37
19.5	234.50	219.81	220.6	220.9	221.3	221.6	221.80	12.62	-1.77	222.78	-11.72	2.97
20.0	227.88	225.71	226.4	226.8	227.4	227.8	228.12	-0.24	-2.12	229.03	1.44	3.32
20.5	232.17	231.84	232.1	232.4	232.8	233.2	233.57	-0.99	-1.32	234.36	2.19	2.51
21.0	239.69	238.14	238.4	238.8	239.3	239.7	240.00	-0.01	-1.56	240.50	1.21	2.76
21.5	243.75	244.32	244.0	244.5	245.2	245.7	246.12	-1.95	-1.38	246.90	3.15	2.58
22.0	258.48	248.71	249.5	250.1	250.6	251.1	251.56	7.56	-2.41	252.32	-6.16	3.61
22.5	261.54	255.90	255.3	255.9	256.3	256.7	256.99	4.94	-0.90	257.90	-3.64	2.00
23.0	277.79	260.72	261.1	261.7	262.5	263.2	263.70	14.62	-2.45	264.37	-13.42	3.65
23.5	288.32	266.55	266.2	266.8	267.7	268.3	268.79	17.98	-1.79	269.54	-16.78	2.99
24.0	293.98	274.25	272.5	273.1	273.7	274.2	274.87	19.77	0.06	275.39	-18.57	1.14
24.5	279.25	280.51	278.4	278.8	279.3	279.7	280.17	-0.44	0.78	280.93	1.64	0.42
25.0	306.10	286.83	284.3	284.8	285.4	285.9	286.30	19.16	0.85	287.14	-17.96	0.31
25.5	310.22	289.46	289.7	290.4	291.2	292.0	292.55	18.26	-2.50	293.16	-17.06	3.70
26.0	317.26	295.71	295.1	295.9	296.6	297.3	297.79	18.94	-1.61	298.52	-17.74	2.81
26.5	307.24	302.64	300.5	301.4	302.4	303.3	304.00	3.90	-0.70	304.54	-2.70	1.90
27.0	307.18	306.28	305.5	306.6	307.6	308.6	309.45	-1.44	-2.26	309.31	2.64	3.46
27.5	338.69	311.92	310.5	311.2	312.6	313.5	314.17	22.22	-1.55	314.67	-21.02	2.75
28.0	342.51	321.78	315.2	315.9	316.5	317.2	317.70	25.30	4.55	318.41	-24.10	-3.35
28.5	323.24	329.22	322.5	324.1	325.5	326.6	327.53	-3.39	2.16	327.83	4.59	-1.28
29.0	331.04	327.61	329.0	330.0	330.3	331.3	332.08	-0.27	-3.70	332.51	1.47	4.90
29.5	335.86	332.81	333.4	334.5	335.9	336.9	337.83	-0.99	-4.05	338.05	2.19	5.25
30.0	340.36	343.00	339.3	340.2	341.2	342.0	342.64	-1.63	1.01	343.19	2.83	0.19
30.5	346.25	347.78	346.5	347.4	348.4	349.4	350.19	-3.13	-1.64	350.62	4.33	2.84
31.0	352.31	355.00	351.6	352.8	354.3	355.5	356.64	-3.18	-0.54	356.74	4.38	1.74
31.5	363.03	362.32	359.2	360.4	361.9	363.1	363.96	-0.11	-0.82	364.34	1.31	2.02
32.0	372.35	365.18	365.8	366.5	367.5	368.4	369.08	3.96	-3.21	369.59	-2.76	4.41
32.5	376.30	373.38	372.4	373.6	375.3	376.7	377.69	-1.40	-3.32	377.90	2.60	4.52

■: Shortage of Present Dike Height: 1m or more to H.W.L (1/50).
■: Shortage of Present Dike Height: less than1m to H.W.L (1/50).
■: Shortage of Present Dike Height: 1m or more to Design Dike Height (H.W.L+1.2m)
■: Shortage of Present Dike Height: less than 1m to Design Dike Height (H.W.L+1.2m)

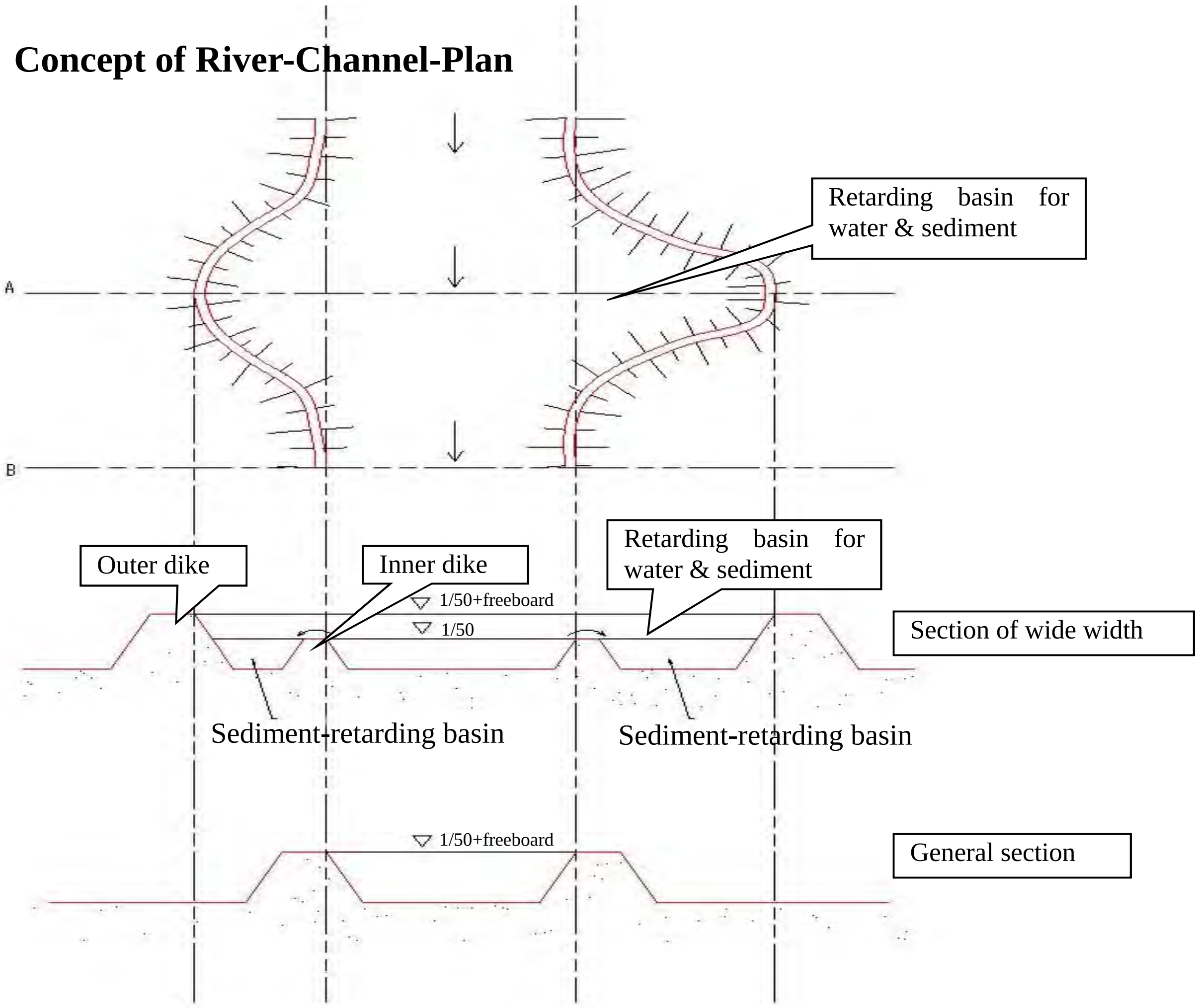


Figure 4.15.1-1 Definition of dike alignment

5) Plan and section of river

The plan of rivers are as shown in the Figure 4.15.1-2 ~ -4.15.1-6 and the longitudinal section river are as shown in the Figure 4.15.1-7~ Figure 4.15.1-12.

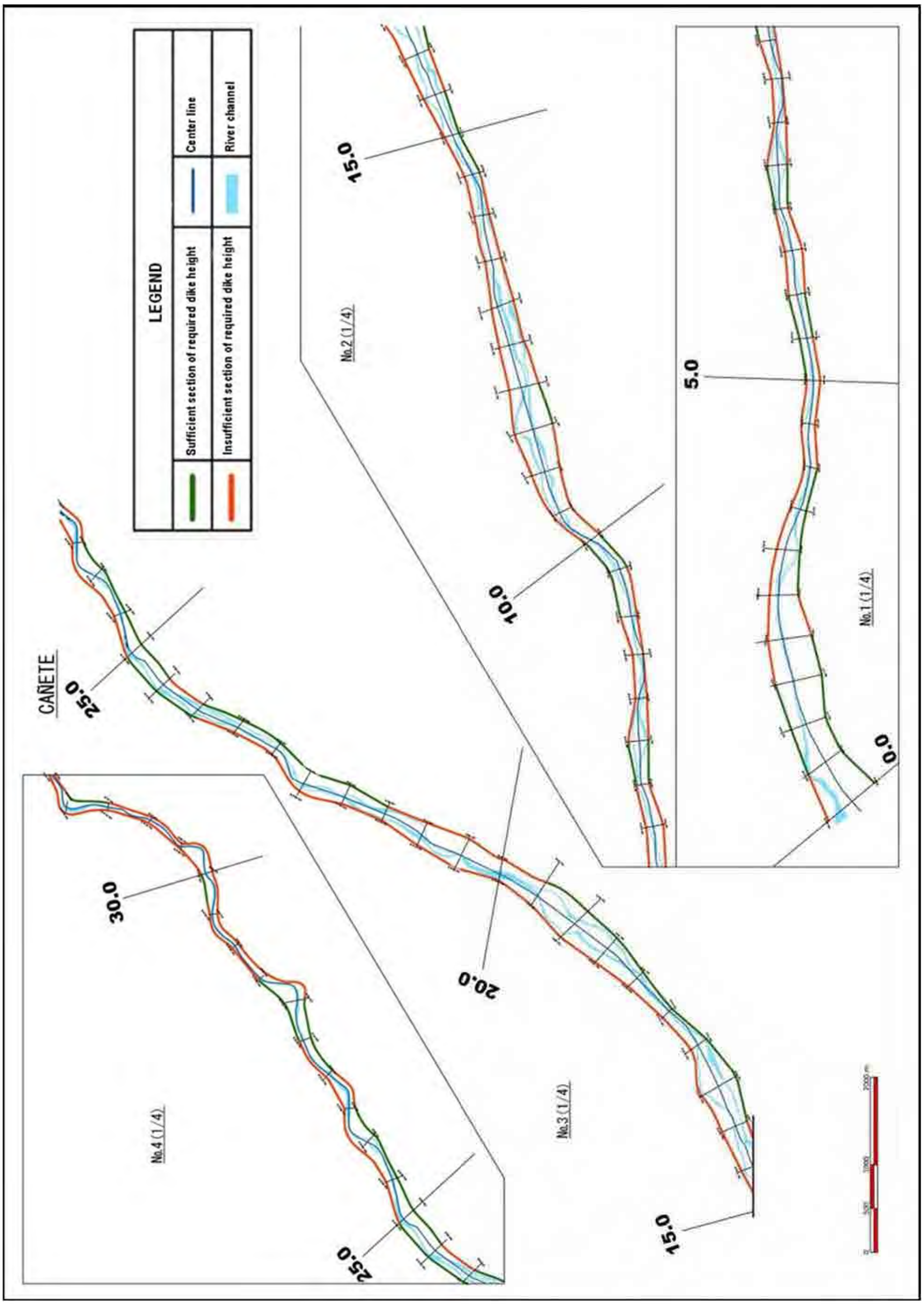


Figure 4.15.1-2 Plan of Cañete river

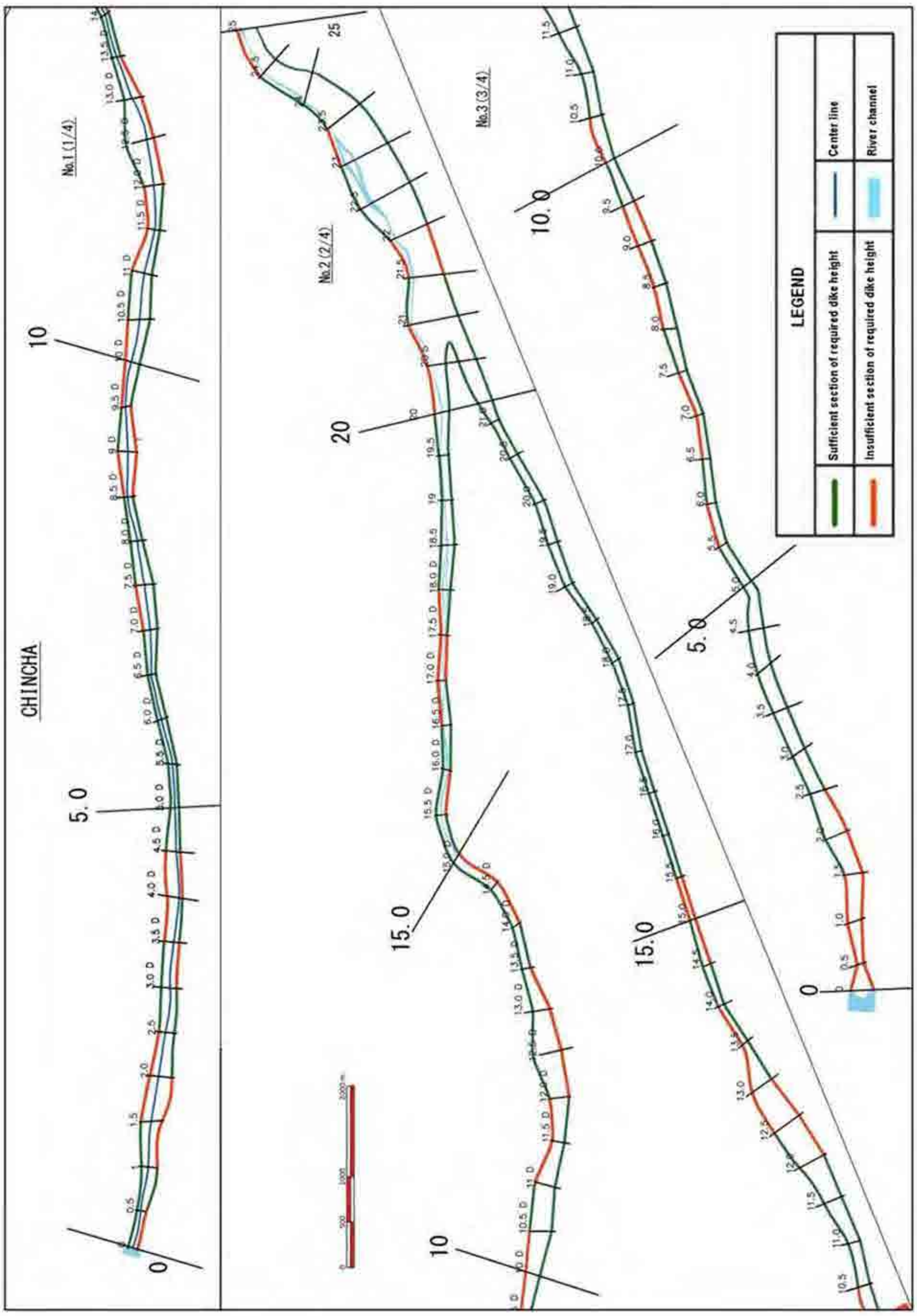


Figure 4.15.1-3 Plan of Chincha river

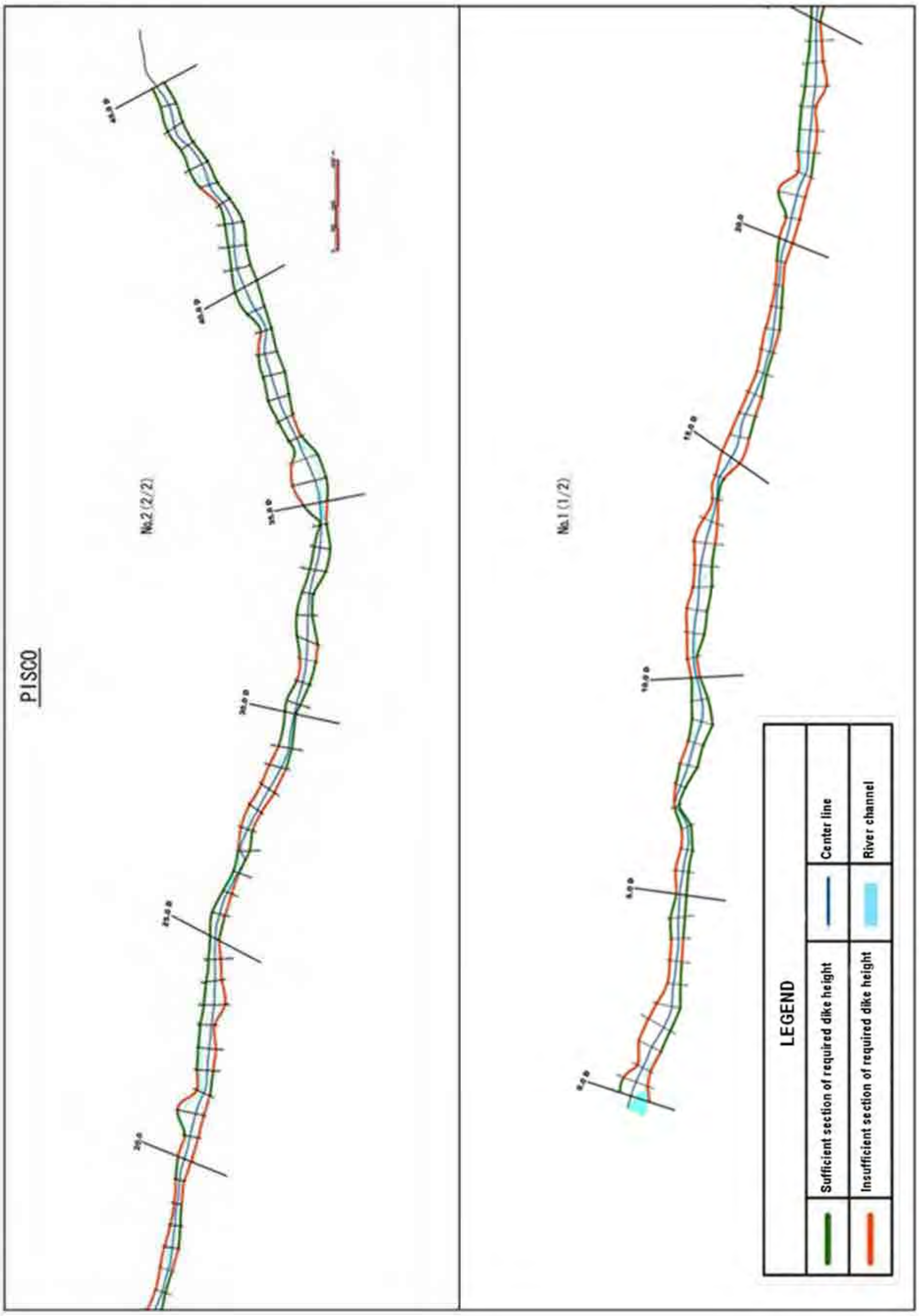


Figure 4.15.1-4 Plan of Pisco river

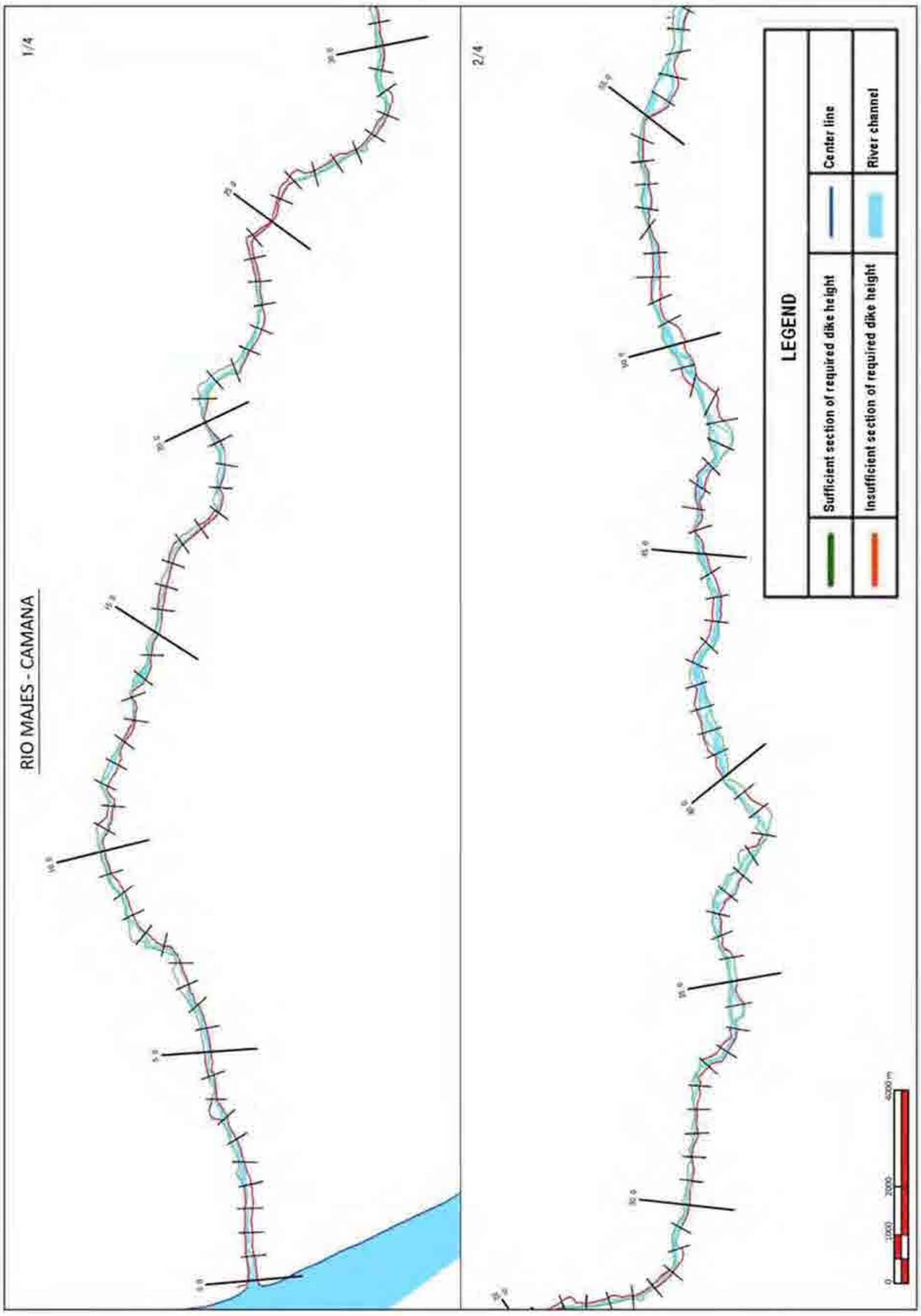


Figure 4.15.1-5 Plan of Majes-Camana river（0-55K）

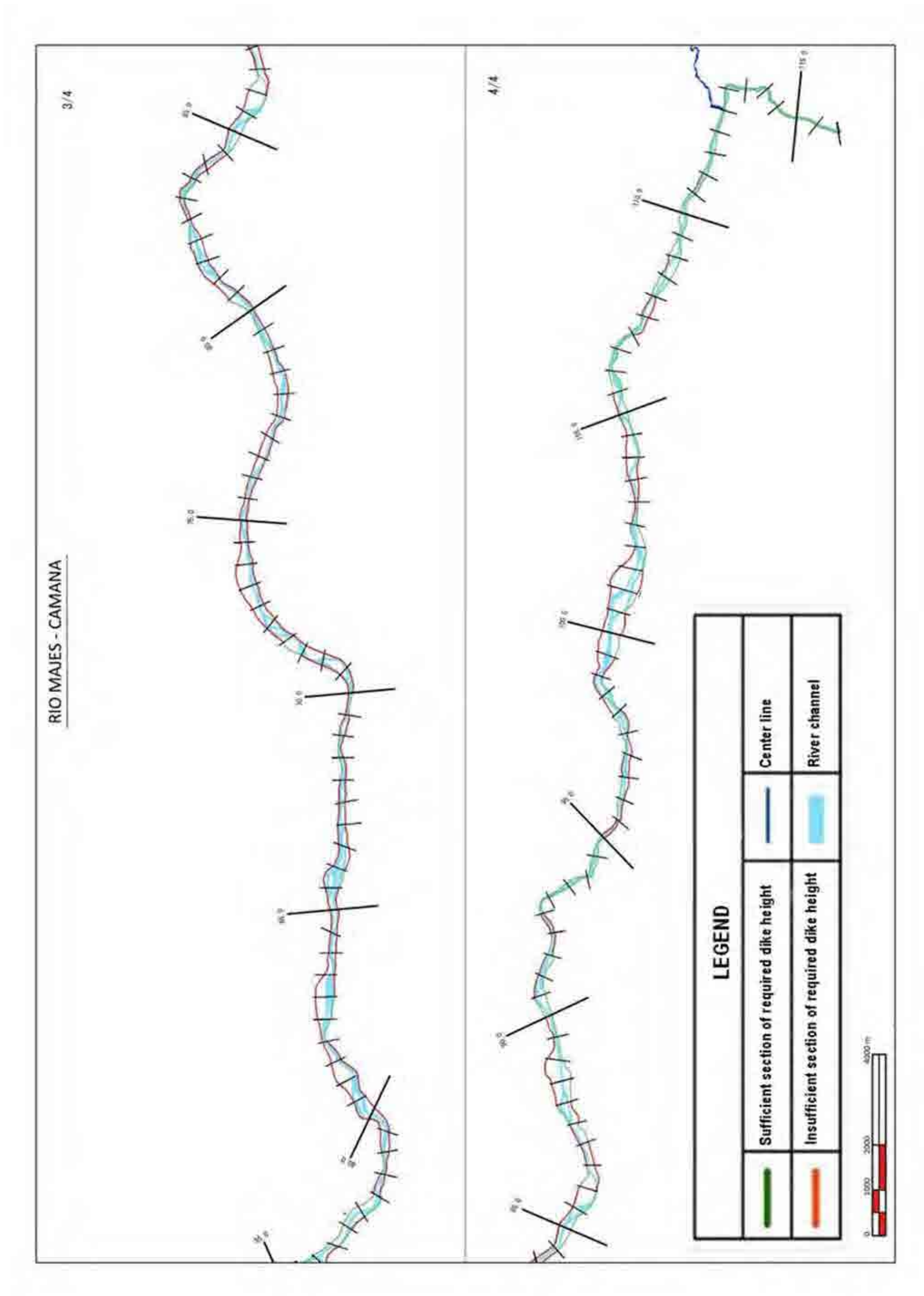


Figure 4.15.1-6 Plan of Majes-Camana river（55-115K）

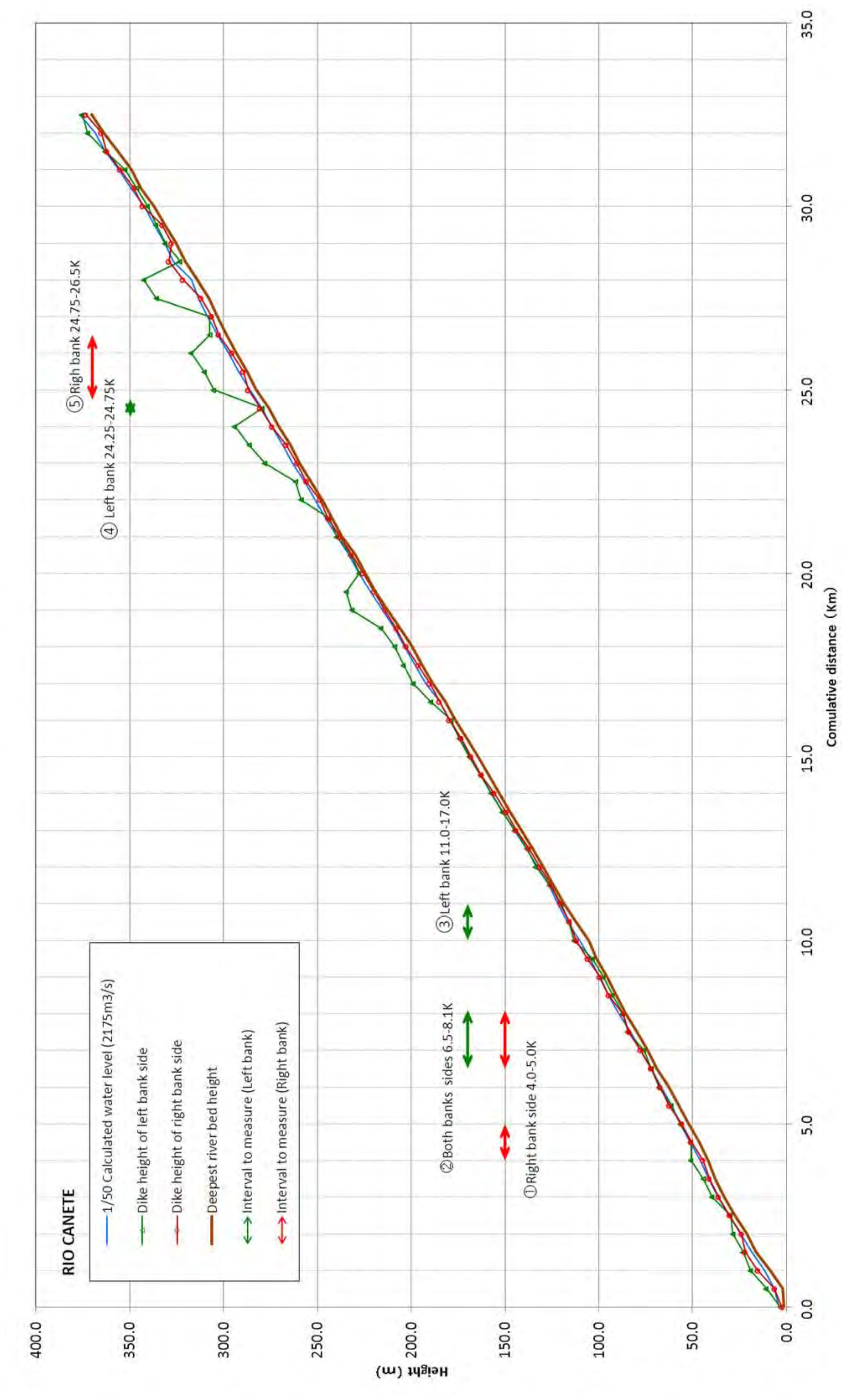


Figure 4.15.1-7 Cañete river longitudinal profile

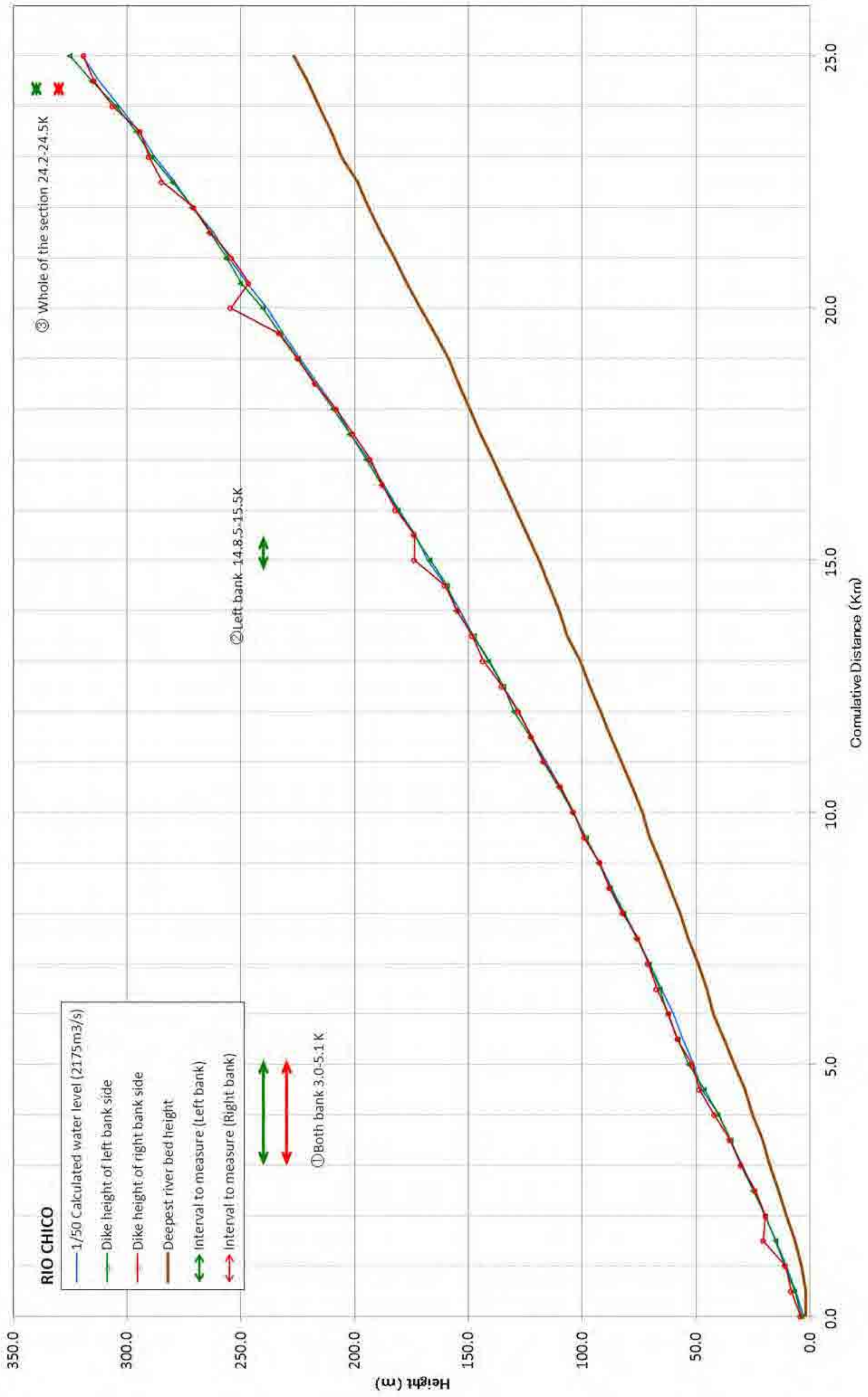


Figure 4.15.1-8 Chincha river longitudinal profile (Chico river)

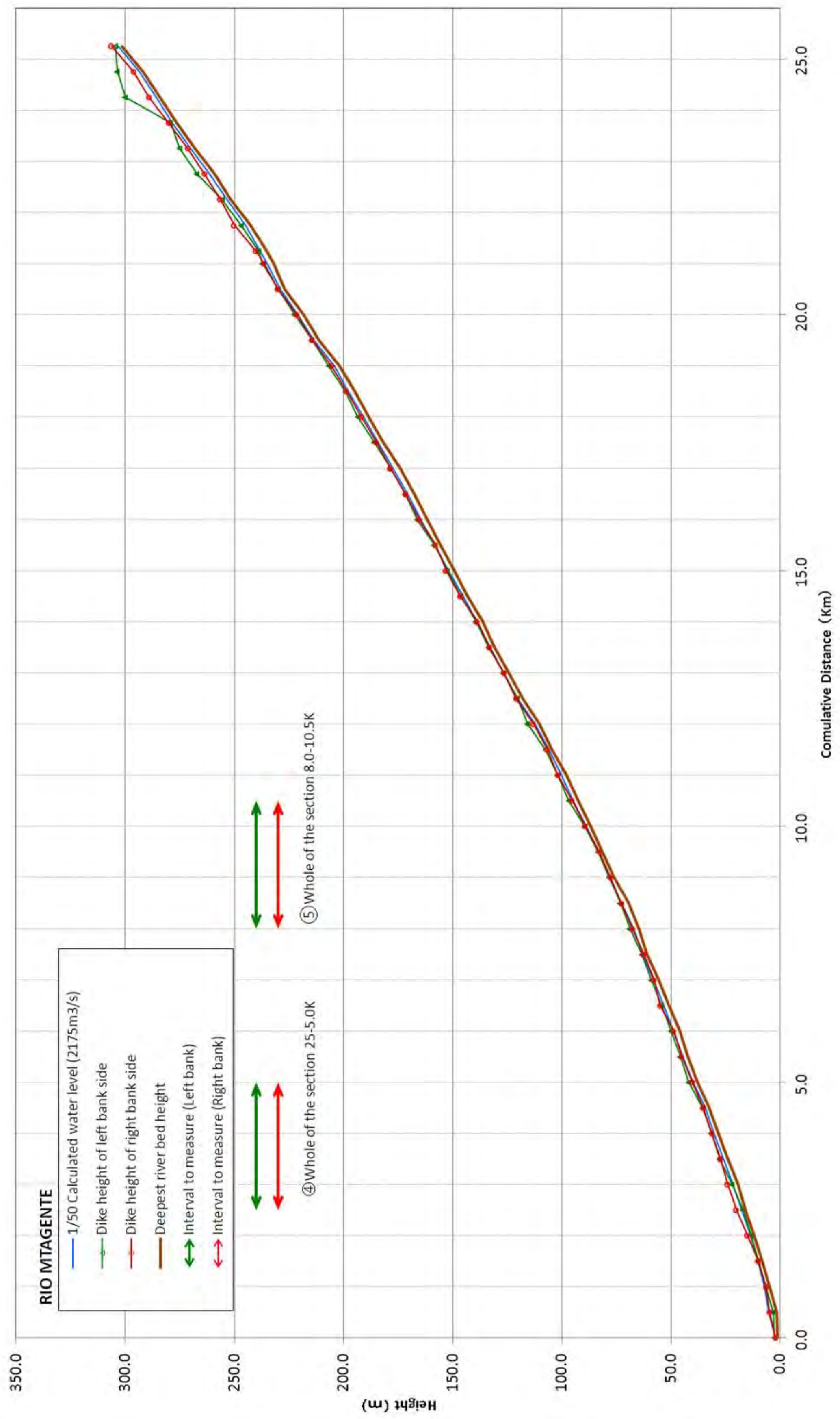


Figure 4.15.1-9 Chincha river longitudinal profile (Matagente river)

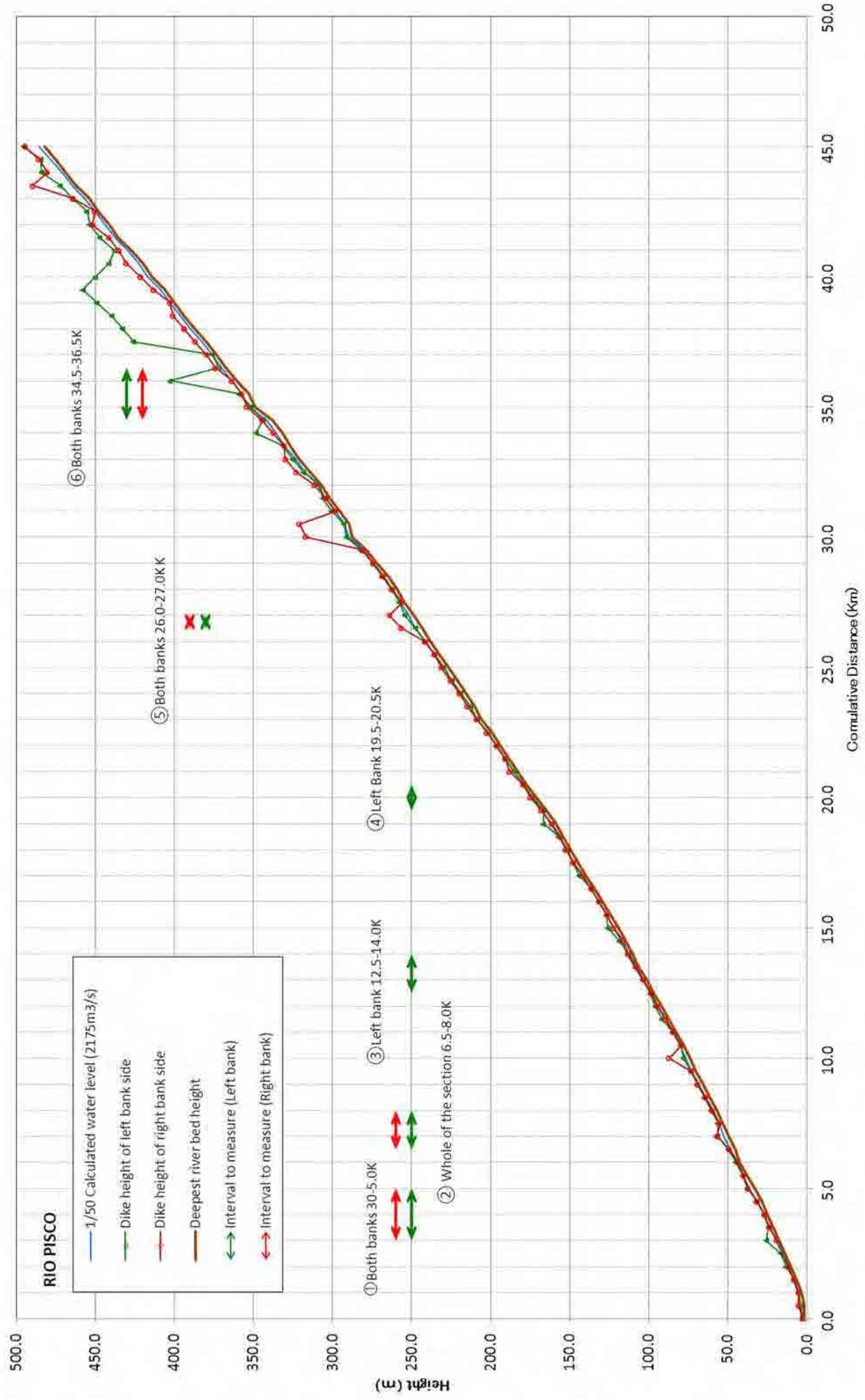


Figure 4.15.1-10 Pisco river longitudinal profile

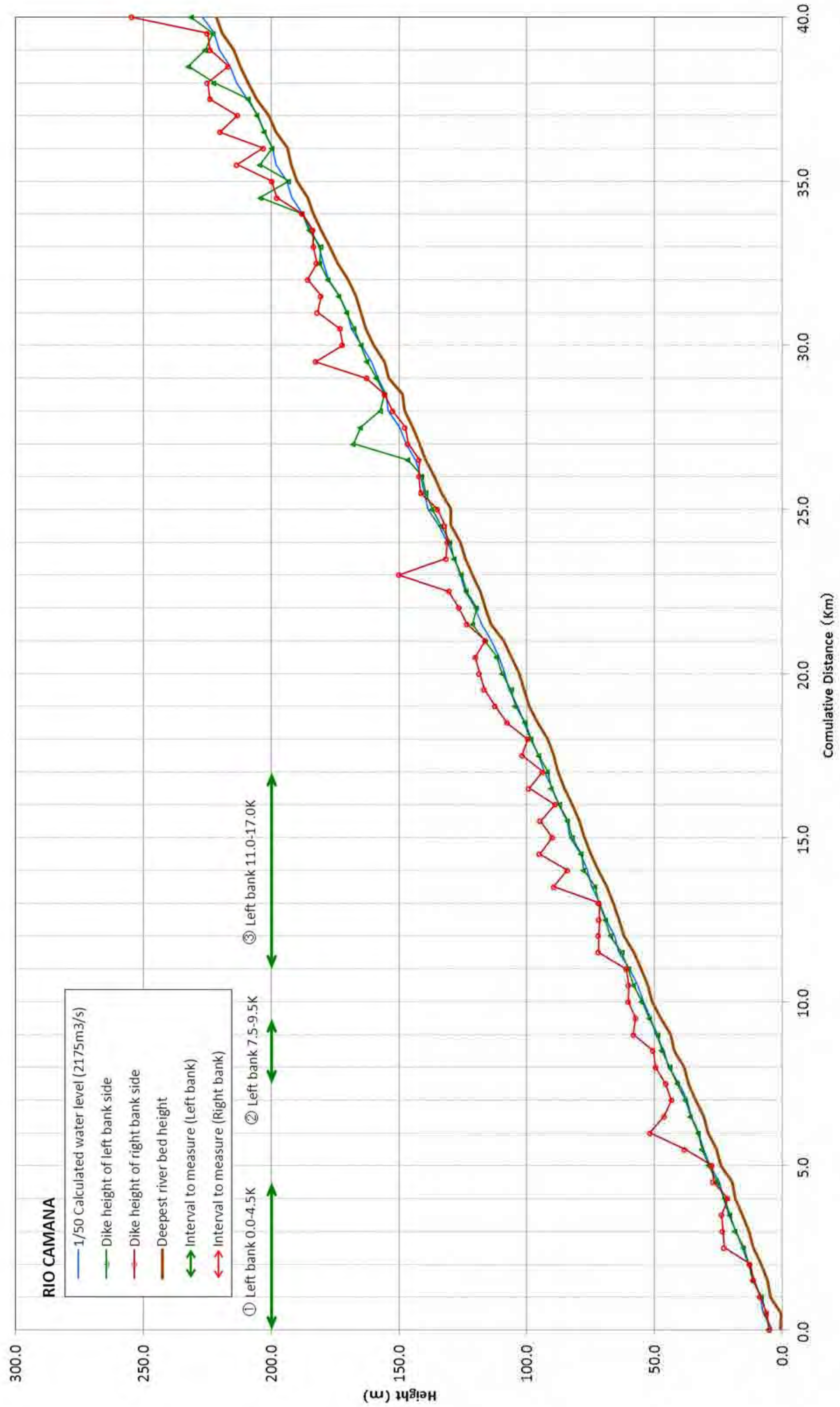


Figure 4.15.1-11 Majes-Camana river longitudinal profile (Camana)

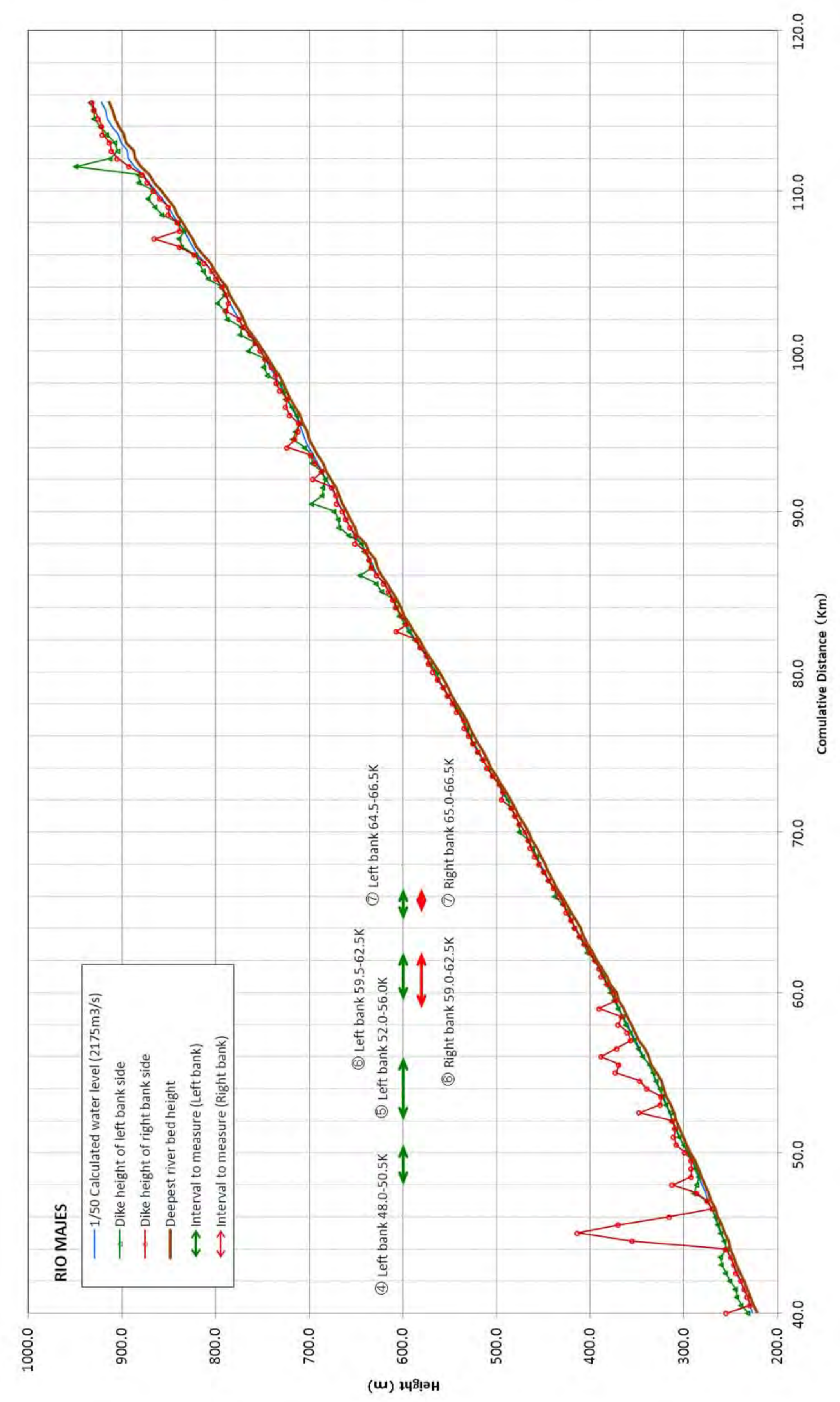


Figure 4.15.1-12 Majes-Camana river longitudinal profile (Majes)

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 constructed 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 4.15.1-3 and Figure 4.13.1-11~Figure 4.15.1-15 show the dike’s construction plan on every watershed.

Table 4.15.1-3 Dike plan for each river

River Name		Improvement Section		Shortage for Design Height (m)	Dike Plan	Dike Length (km)
Canete River		Left bank side	0.0k-21.5k	1.20	Dike h=1.5m Revetment h=3.0m	12.0
		Right bank side	0.0k-21.5k	1.48		18.5
		Total		1.38		30.5
Chincha River	Chico River	Left bank side	0.5k-17.5k	0.56	Dike h=1.5m Revetment h=3.0m	7.0
		Right bank side	2.0k-18.0k	0.53		5.5
		Sub-Total				12.5
	Matagente River	Left bank side	0.5k-15.5k	0.58		5.5
		Right bank side	0.0k-15.5k	0.55		7.5
		Sub-Total		0.56		13.0
	Total					25.5
Pisco River		Left bank side	0.0k-29.0k	0.55	Dike h=1.5m Revetment h=3.0m	14.0
		Right bank side	0.0k-29.5k	0.53		19.5
		Total		0.53		33.5
Majes-Camana River		Left bank side	0.0k-108.0k	1.36	Dike h=2.0m Revetment h=3.0m	72.5
		Right bank side	0.0k-111.0k	1.46		52.0
		Total		1.40		124.5
Grand Total						214.0

7) Project Cost

The direct cost and the project cost at private price are as shown in the Tables 4.15.1-4 and 4.15.1-5. Also, the cost of the project in social prices is presented in the Table 4.15.1-6.

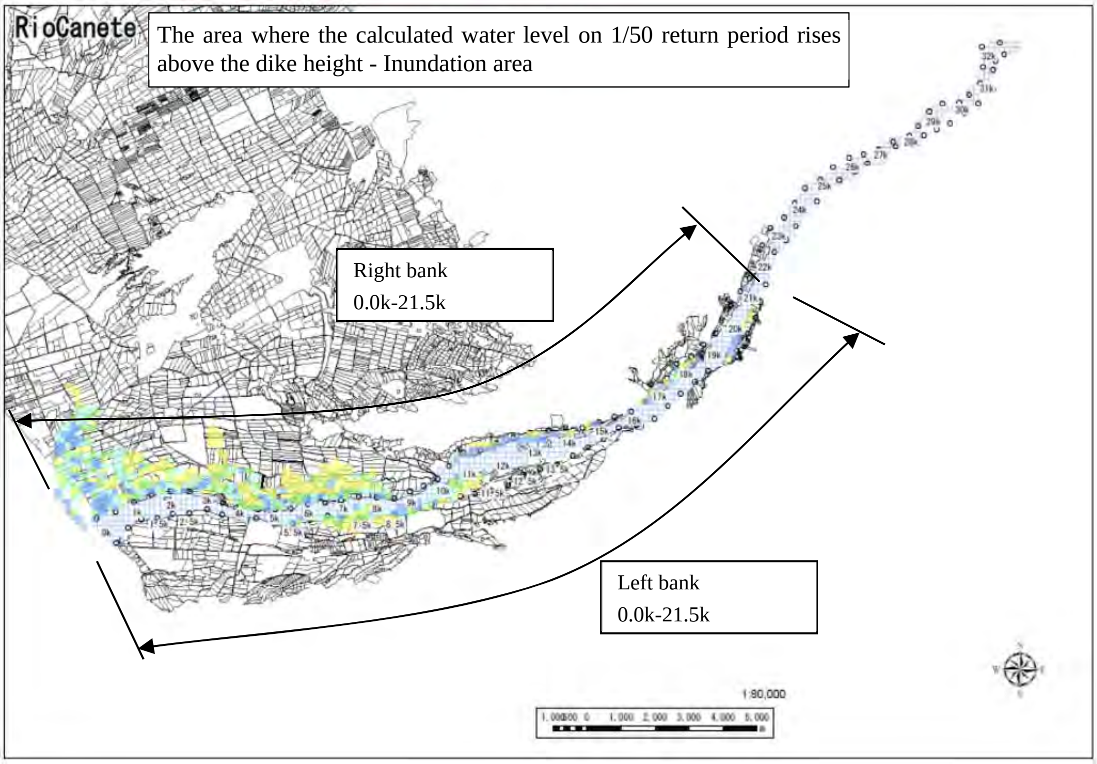


Figure 4.15.1-13 Layout of dike in Cañete river

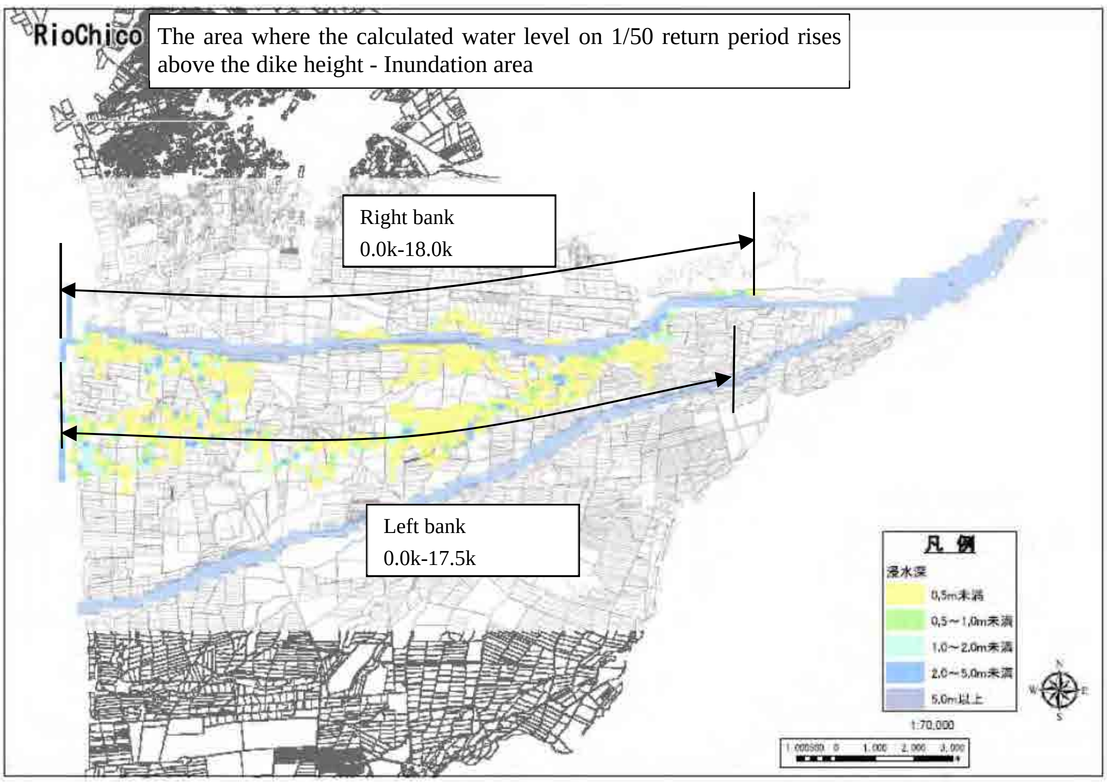


Figure 4.15.1-14 Layout of dike in Chincha river (Chico river)

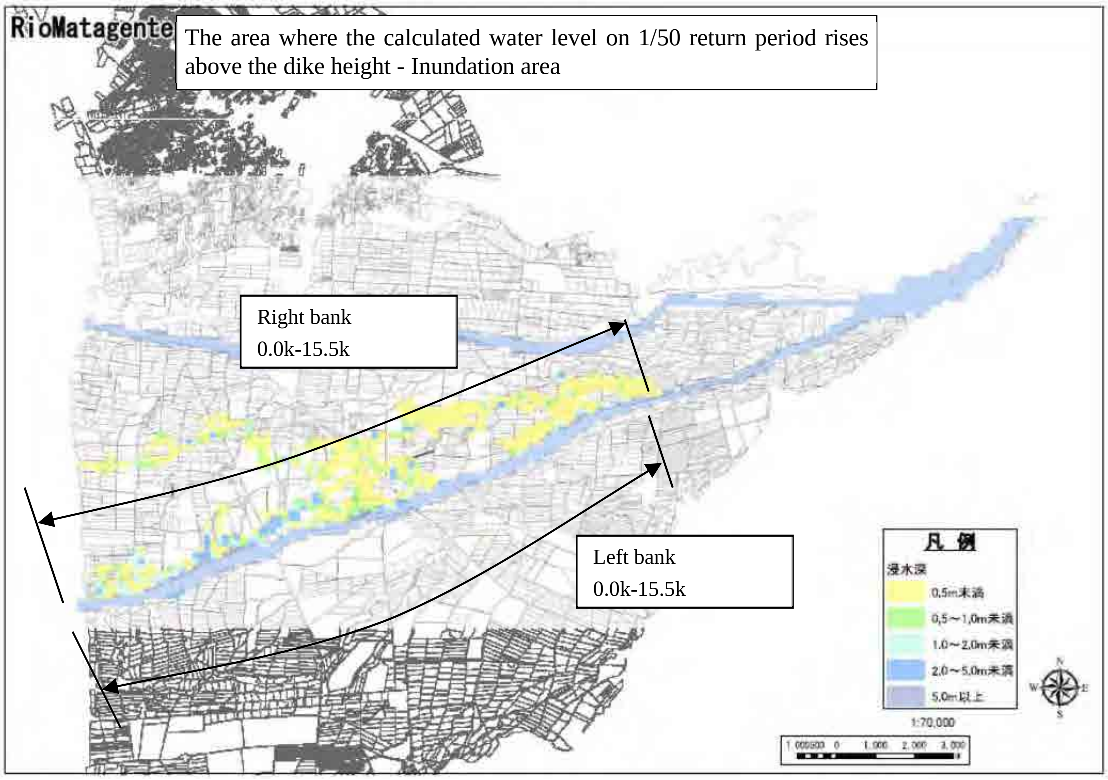


Figure 4.15.1-15 Layout of dike in Chincha river (Matagente river)

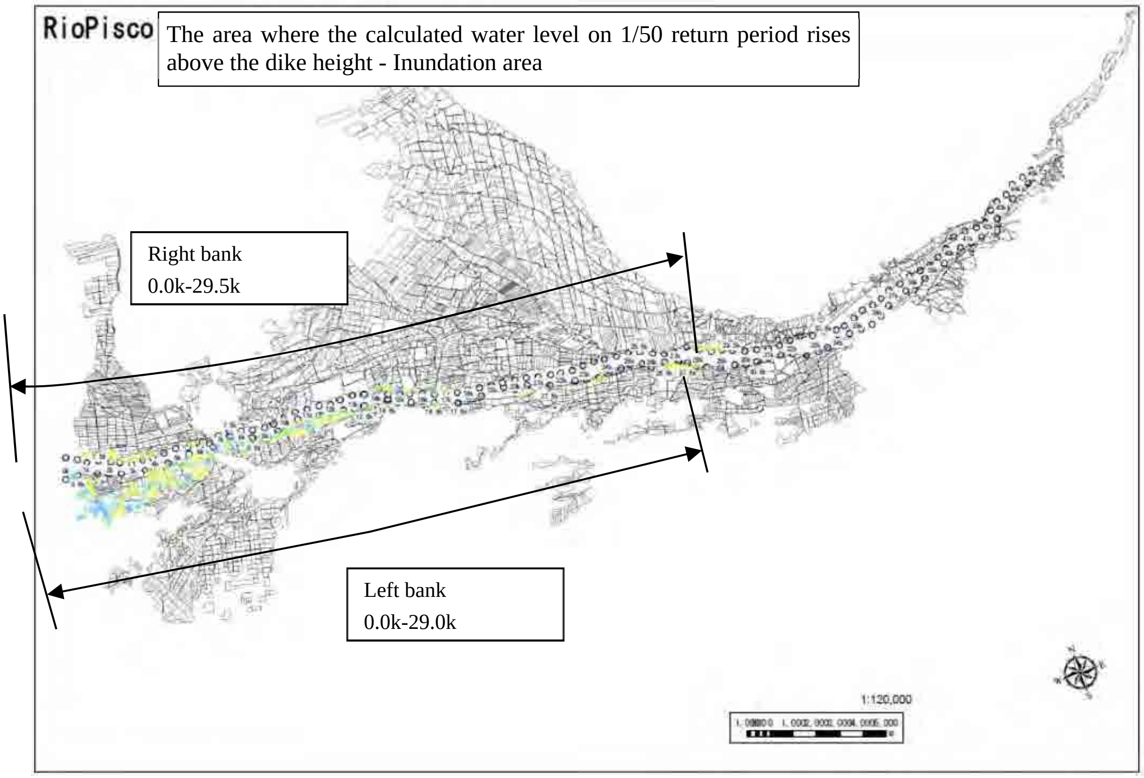


Figure 4.15.1-16 Layout of dike in Pisco river

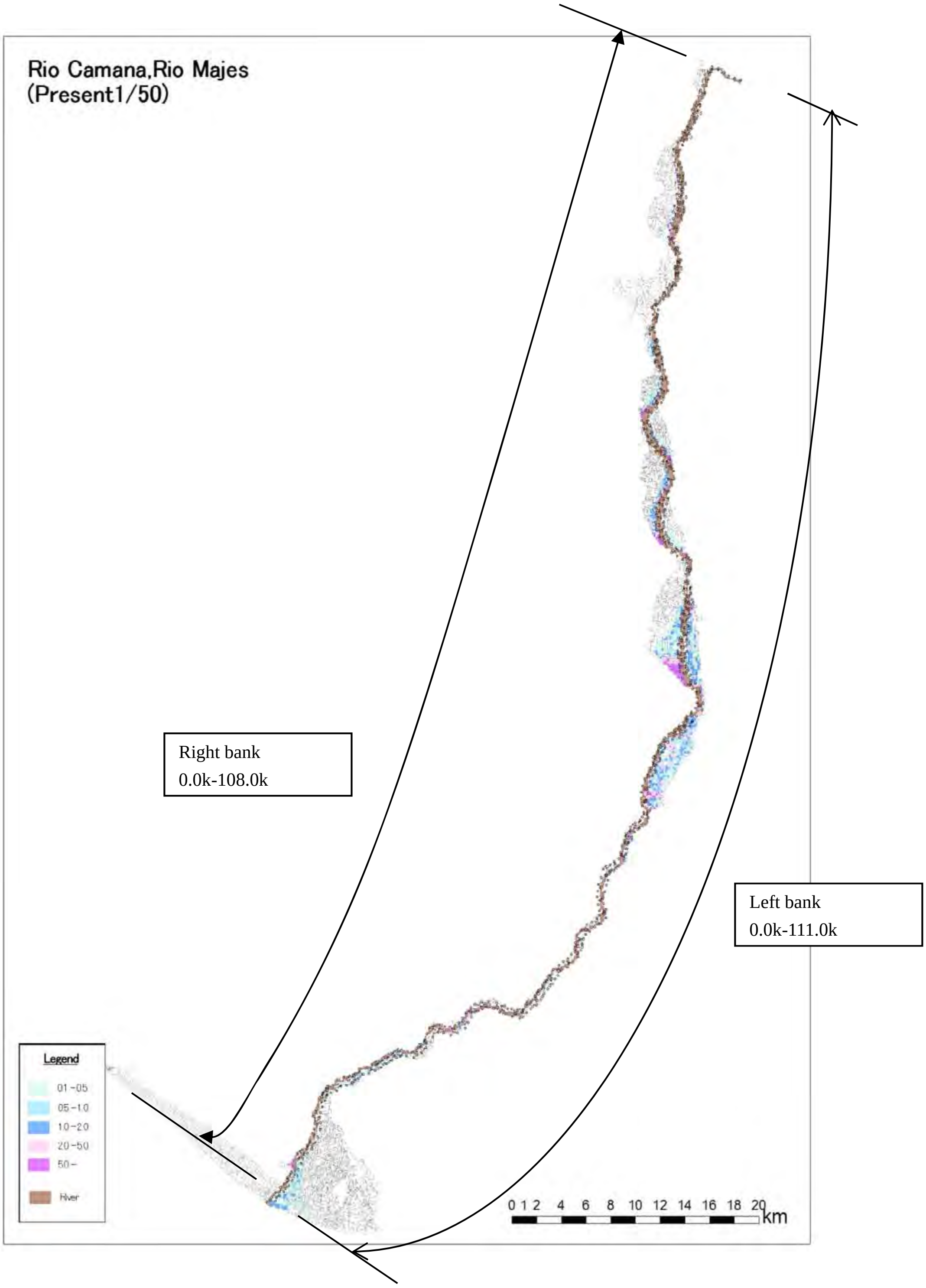
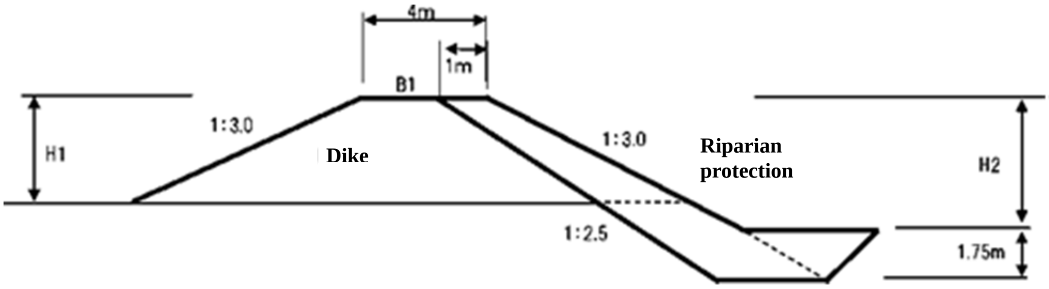


Figure 4.15.1-15 Layout of dike in Majes-Camana river

Table 4.15.1-4 Directs cost of the complete flood control

Construction of dike				Riparian 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	1.5	11.3	10.7	1.0	1.5	2.6	12.0
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



Basin		Quantity	Unit	Unit Price (Sol)	Direct Construction Cost /m (Sol)	Direct Construction Cost /km (10^3 Soles)	Total Dike Length (km)	Direct Construction Cost (10^3 Soles)
Cañete	Embankment/ Revetment	17.0	m3	10.0	170.0	170.0	30.5	5,185.0
		16.5	m3	100.0	1,650.0	1,650.0		50,325.0
Chincha	Embankment/ Revetment	10.7	m3	10.0	107.0	107.0	25.5	2,728.5
		16.5	m3	100.0	1,650.0	1,650.0		42,075.0
Pisco	Embankment/ Revetment	10.7	m3	10.0	107.0	107.0	33.5	3,584.5
		16.5	m3	100.0	1,650.0	1,650.0		55,275.0
Majes - Camana	Embankment/ Revetmen	17.0	m3	10.0	170.0	170.0	124.5	21,165.0
		16.5	m3	100.0	1,650.0	1,650.0		205,425.0

Table 4.15.1-5 Projects' cost (at private prices)

(Sol)

Basin	Direct Cost 直接工事費			Indirect Cost 間接工事費								Infrastructure Cost, Total Cost
	Direct Cost (1)	Temporary Construction Cost (2)	Total Direct Cost (3)=(1)+(2)	Overhead (4)=0.15x(3)	Profit (5)=0.1x(3)	Work Cost (6)=(3)+(4)+(5)	Tax (IGV) (7)=0.18x(6)	Total Construction Cost (8)=(6)+(9)	Environmental Cost (9)=0.01x(8)	Detatil Design Cost (10)=0.05x(8)	Construction Supervision Cost (11)=0.1x(8)	(12)=(8)+(9)+(10)+(11)
CAÑETE	585,576	144,050	17,129,336	2,569,400	1,712,934	21,411,671	3,854,101	25,265,771	585,576	1,236,604	1,829,962	28,332,338
CHINCHA	798,096	144,050	28,053,654	4,208,048	2,805,365	35,067,068	6,312,072	41,379,140	798,096	2,025,254	2,997,030	46,401,424
PISCO	772,915	144,050	40,018,500	6,002,775	4,001,850	50,023,125	9,004,162	59,027,287	772,915	2,889,022	4,275,259	66,191,569
MAJES-CAMANA	1,043,414	144,050	50,087,119	7,513,068	5,008,712	62,608,899	11,269,602	73,878,501	1,043,414	3,615,898	5,350,910	82,845,309
TOTAL	**3,200,002**	**576,200**	**135,288,610**	**20,293,291**	**13,528,861**	**169,110,762**	**30,439,937**	**199,550,699**	**3,200,002**	**9,766,778**	**14,453,162**	**223,770,639**

Table 4.15.1-6 Projects' cost (at social prices)

(Sol)

Basin	Direct Cost 直接工事費			Indirect Cost 間接工事費								Infrastructure Cost, Total Cost
	Direct Cost (1)	Temporary Construction Cost (2)	Total Direct Cost (3)=(1)+(2)	Overhead (4)=0.15x(3)	Profit (5)=0.1x(3)	Work Cost (6)=(3)+(4)+(5)	Tax (IGV) (7)=0.18x(6)	Total Construction Cost (8)=(6)+(9)	Environmental Cost (9)=0.01x(8)	Detatil Design Cost (10)=0.05x(8)	Construction Supervision Cost (11)=0.1x(8)	(12)=(8)+(9)+(10)+(11)
CAÑETE	496,251	124,788	14,254,476	2,138,171	1,425,448	17,818,095	3,207,257	21,025,353	496,251	1,108,551	1,652,295	23,786,198
CHINCHA	676,353	124,788	23,147,893	3,472,184	2,314,789	28,934,866	5,208,276	34,143,142	676,353	1,800,180	2,683,167	38,626,489
PISCO	655,013	124,788	33,012,987	4,951,948	3,301,299	41,266,234	7,427,922	48,694,156	655,013	2,567,375	3,826,671	55,088,201
MAJES-CAMANA	884,249	124,788	41,671,399	6,250,710	4,167,140	52,089,249	9,376,065	61,465,314	884,249	3,240,727	4,830,303	69,536,344
TOTAL	**2,711,866**	**499,153**	**112,086,755**	**16,813,013**	**11,208,676**	**140,108,444**	**25,219,520**	**165,327,964**	**2,711,866**	**8,716,833**	**12,992,435**	**187,037,232**

(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) Riverbed fluctuation analysis

The summary of the riverbed fluctuation analysis model is as shown in the Table 4.15.1-7 and the analysis conditions are as shown in the Table 4.1.15-8.

The Figures 4.15.1-17~ 4.15.l -21 show the results of the riverbed fluctuation analysis of the each river for the next fifty years. The rivers with easy sedimentation are Chincha, Pico and Majes-Camana rivers which coincides to the field hearing and actual riverbed conditions.

From this figure a projection of the riverbed's sedimentation and scouring trend and its respective volume can be made.

Table 4.15.1-7 Summary of riverbed fluctuation analysis model

Items	Content
Water Flow	One-dimensional Non-uniform Flow Model
Sediment Transportation	One-dimensional Mixed Grain Size Riverbed Fluctuation Model
Bed Load	Ashida & Michiue’s Bed load formula
Suspended Load	Ashida & Michiue’s Suspended Load formula considering non-equilibrium of suspended sediment
Calculation Method	MacCormack Method

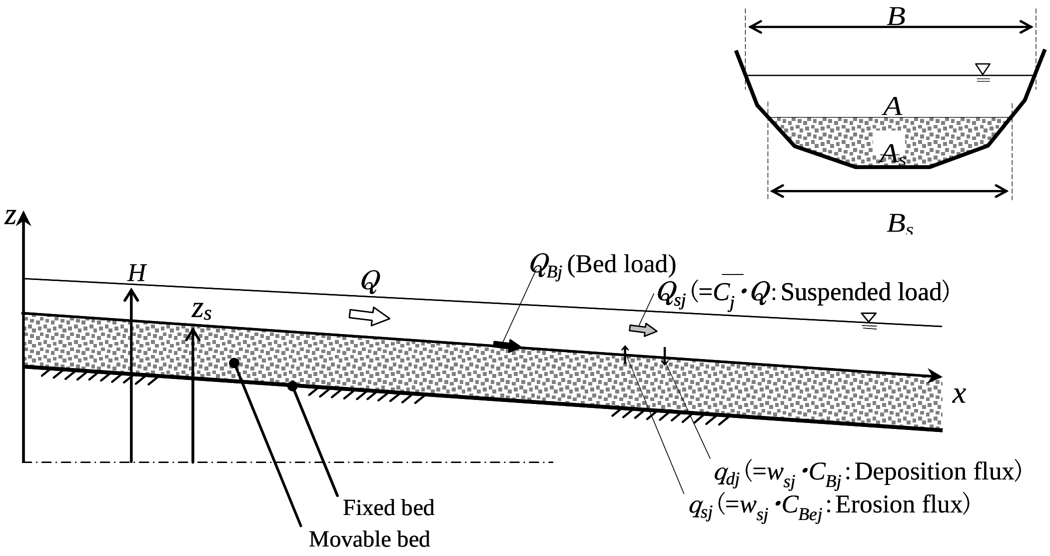


Figure 4.15.1-18 Pattern diagram of riverbed fluctuation analysis model

Table 4.15.1-8 Analysis condition of each river

	Cañete	Chincha	Pisco	Majes-Camana
Calculation river length	32.5km	46.0km	45.0km	115km
Period	For future 50 years			
Space interval (Δx)	100m	100m	100m	250m
Time interval (Δt)	2.0sec			
Input discharge	50 years discharge prepared based on observation data (max. annual discharge), in case of insufficient year number prepared by repeating the limited year data.			
Sediment Supply	60,000m3/year	115,000m3/year	173,000m3/year	419,000m3/year
Tributary inflow	Disregarded since there are only small tributaries			
Grain size	Based on the grain size distribution in the riverbed material, 8～9 grain size are assumed (d=0.075mm～500mm).			
Water level at downstream end	Assumed normal water depth at the downstream end			
Roughness coefficient	n=0.05 (all section)			
Void ration	0.4 (representative value of sand and gravel)			
Others		Analysis for 2 rivers Chico and Matagente		

2) Sections that need maintenance

In the Table 4.15.1-9 possible sections that require a process of long-term maintenance in the each river is shown.

Table 4.15.1-9 Sections/places to be carried out maintenance works

River Name		Excavation Area		Method of Maintenance Works
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.
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

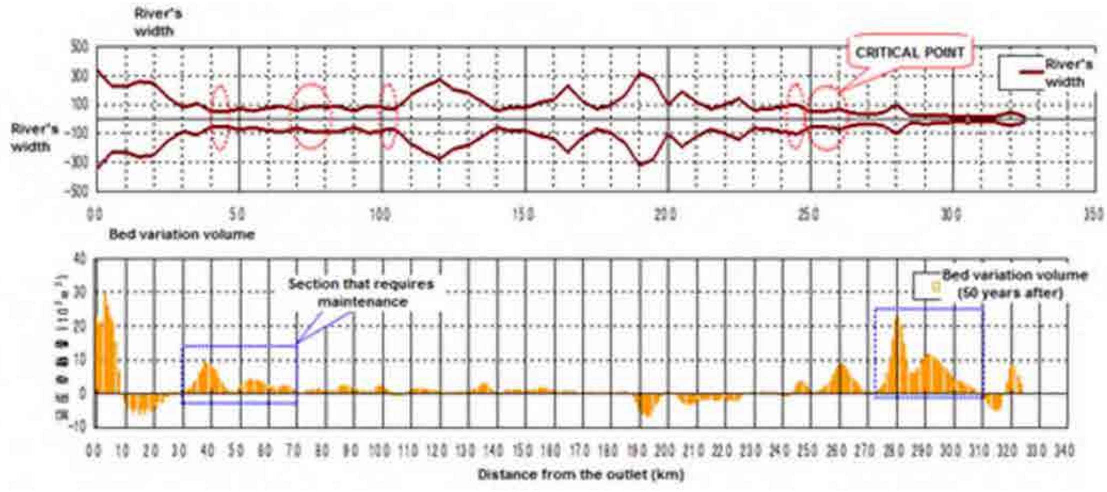


Figure 4.15.1-19 Section that requires maintenance (Cañete)

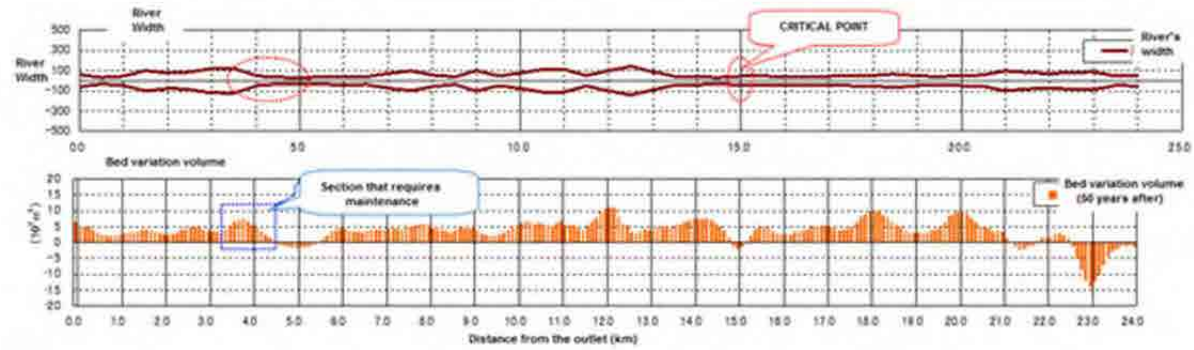


Figure 4.15.1-20 Section that requires maintenance (Chincha-Chico river)

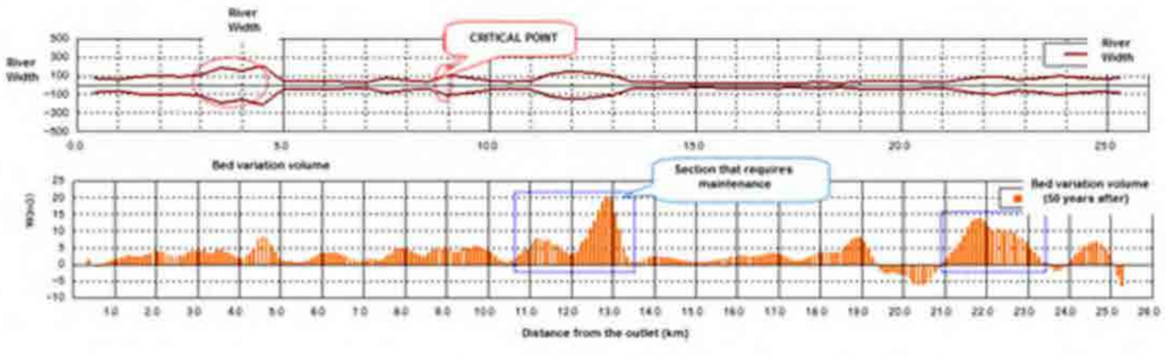


Figure 4.15.1-21 Section that requires maintenance (Chincha-Matagente river)

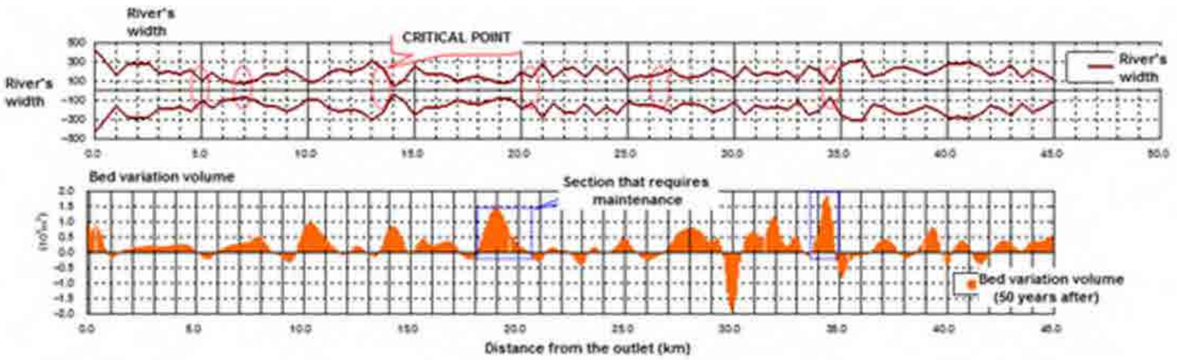


Figure 4.15.1-22 Section that requires maintenance (Pisco river)

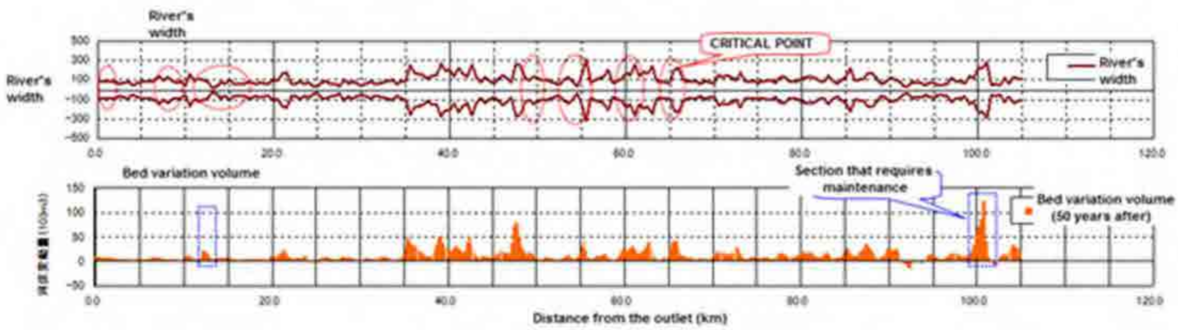


Figure 4.15.1-23 Section that requires maintenance (Majes-Camana river)

3) Operation and maintenance cost

The direct cost at private prices for maintenance (bed excavation) required for each watershed in the next 50 years is as shown in the Table 4.15.1-10.

The Project's cost for 50 years on private and social prices is as shown in the Table 4.15.1-11 and 4.15.1-12.

Table 4.15.1-10 Direct cost of riverbed excavation

River Basin		Quantity (M m3)	Unit	Unit price (Sol)	Direct Construction Cost (M Soles)
Cañete River		135	m3	10.0	1,350.0
		287	m3	10.0	2,870.0
Chincha River	Chico River	53	m3	10.0	530.0
	Matagente River	229	m3	10.0	2,290.0
		197	m3	10.0	1,970.0
Pisco River		314	m3	10.0	3,140.0
		255	m3	10.0	2,550.0
Majes-Camaná River		70	m3	10.0	700.0
		460	m3	10.0	4,600.0

Table 4.15.1-11 Bed excavation works cost (private prices)

Basin 流域名	Direct cost 直接工事費計 (1)	Common Temporary Work Cost 共通仮設費 (2) = 0.1*(1)	Construction cost 工事費 (3) = (1) + (2)	Overhead Cost 諸経費 (4) = 0.15*(3)	Profit 利益 (5) = 0.1*(3)	Structure Construction Cost 構造物工事費 (6) = (3)+(4)+(5)	Tax (IGV) 税金 (7) = 0.18*(6)	Construction Cost 建設費 (8) = (6)+(7)	Environment Cost 環境影響 (9)=0.01*(8)	Detail Design Cpst 詳細設計 (10) = 0.05*(8)	Construction Supervision Cost 施工管理費 (11) = 0.1*(8)	Total Project Cost 事業費 (12) = (8)+(9)+(10)+(11)
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
MAJES-CAMANA	5,300	530	5,830	875	583	7,288	1,312	8,599	86	430	860	9,975
TOTAL	20,000	2,000	22,000	3,300	2,200	27,500	4,950	32,450	325	1,623	3,245	37,642

Table 4.15.1-12 Bed excavation works cost (social prices)

Basin 流域名	Direct Cost 直接工事費計 (1)	Common Temporary Work Cost 共通仮設費 (2) = 0.1*(1)	Construction Cost 工事費 (3) = (1) + (2)	Overhead Cost 諸経費 (4) = 0.15*(3)	Profit 利益 (5) = 0.1*(3)	Structure Construction Cost 構造物工事費 (6) = (3)+(4)+(5)	Tax(IGV) 税金 (7) = 0.18*(6)	Construction Cost 建設費 (8) = (6)+(7)	Conversion Factor 修正係数 fc	Construction Cost 建設費 (9) = fc*(8)	Environment Cost 環境影響 (10) = 0.01*(9)	Detail Design Cost 詳細設計 (11) = 0.05*(9)	Construction Supervision Cost 施工管理費 (12) = 0.1*(9)	Total Project Cost 事業費 (13) = (9)+(10)+(11)+(12)
CAÑETE	4,220	422	4,642	696	464	5,803	1,044	6,847	0.804	5,505	55	275	550	6,386
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
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	14,700	1,470	16,170	2,426	1,617	20,213	3,638	23,851	-	19,176	192	959	1,918	22,244

(3) Social assessment

1) Private prices cost

a) Damage amount

Table 4.15.1-13 shows the damage amount calculated analyzing the overflow caused by floods in each watershed with return periods between 2 and 50 years.

Table 4.15.1-13 Amount of damage for floods of different return periods (private prices)

(10^3 Soles)

Year	Damage Amount			
	Cañete	Chincha	Pisco	Majes-Camana
2	1,735	15,262	16,668	311
5	6,420	39,210	23,343	48,616
10	77,850	55,372	50,239	78,391
25	104,090	77,797	59,936	111,072
50	158,173	103,947	81,510	191,990
Total	348,269	291,588	231,698	430,380

b) Damage reduction annual average

Table 4.15.1-14 shows the damage reduction annual average of each watershed calculated with the data of Table 4.15.1-13.

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

Table 4.15.1-5 shows the projects' cost. The annual operation and maintenance (O & M) cost for dikes and bank protection works is calculated from the 0.5% of the construction cost plus the bed excavation annual average cost indicated in Table 4.15.1-11.

d) Economic assessment

In Table 4.15.1-15 the results of economic assessment are shown.

Table 4.15.1-14 Damage reduction annual average (private prices)

(10^6 Soles)

Basin	Return Period	Probability	Total Damage			Average Damage ④	Section Probability ⑤	Annual Average Damage ⑥=④×⑤	Accumulation of Annual Average Damage
			Wiyhout Project ①	With Project ②	Damage Reduction ③=①−②				
CAÑETE	1	1.000	0	0	0			0	0
	2	0.500	1,735	0	1,735	868	0.500	434	434
	5	0.200	6,420	0	6,420	4,078	0.300	1,223	1,657
	10	0.100	77,850	0	77,850	42,135	0.100	4,214	5,871
	25	0.040	104,090	0	104,090	90,970	0.060	5,458	11,329
	50	0.020	158,173	0	158,173	131,132	0.020	2,623	13,952
CHINCHA	1	1.000	0	0	0			0	0
	2	0.500	15,262	0	15,262	7,631	0.500	3,816	3,816
	5	0.200	39,210	0	39,210	27,236	0.300	8,171	11,986
	10	0.100	55,372	0	55,372	47,291	0.100	4,729	16,715
	25	0.040	77,797	0	77,797	66,584	0.060	3,995	20,710
	50	0.020	103,947	0	103,947	90,872	0.020	1,817	22,528
PISCO	1	1.000	0	0	0			0	0
	2	0.500	16,668	0	16,668	8,334	0.500	4,167	4,167
	5	0.200	23,343	0	23,343	20,006	0.300	6,002	10,169
	10	0.100	50,239	0	50,239	36,791	0.100	3,679	13,848
	25	0.040	59,936	0	59,936	55,088	0.060	3,305	17,153
	50	0.020	81,510	0	81,510	70,723	0.020	1,414	18,568
MAJES-CAMANA	1	1.000	0	0	0			0	0
	2	0.500	311	0	311	155	0.500	78	78
	5	0.200	48,618	0	48,618	24,464	0.300	7,339	7,417
	10	0.100	78,391	0	78,391	63,504	0.100	6,350	13,767
	25	0.040	111,072	0	111,072	94,732	0.060	5,684	19,451
	50	0.020	191,990	0	191,990	151,531	0.020	3,031	22,482

Table 4.15.1-15 Economic assessment results (private prices)

流域名 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
Cañete	181,369,899	81,903,051	104,475,371	8,236,962	0.86	-13,204,737	7%
Chincha	292,863,416	132,251,314	84,324,667	7,429,667	1.71	55,091,224	21%
Pisco	241,380,602	109,002,695	110,779,465	9,420,215	1.08	7,808,090	11%
Majes-Camana	292,262,168	131,979,802	426,465,039	26,889,287	0.34	-252,832,589	-

2) Social prices cost

a) Damage amount

Table 4.15.1-16 shows the damage amount calculated analyzing the overflow caused by floods with return periods between 2 and 50 years in each watershed.

Table 4.15.1-16 Amount of damage for floods of different return periods (at social prices)

(10^3 Soles)

Year	Damage Amount			
	Cañete	Chincha	Pisco	Majes-Camana
2	2,711	16,758	17,099	317
5	11,180	44,275	22,817	48,503
10	110,910	74,539	54,702	78,738
25	153,056	101,437	64,250	113,789
50	225,586	133,108	87,899	201,622
Total	503,443	370,117	246,768	442,970

b) Damage reduction annual average

Table 4.13.1-17 shows the damage reduction annual average of each watershed calculated with the data of Table 4.13.1-16.

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

Table 4.15.1-6 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, as well as the bed excavation annual average cost indicated in Table 4.15.1-12.

d) Economic assessment

In Table 4.13.1-18 the results of economic assessment are shown.

(4) Conclusions

The economic assessment result shows that the Project has positive economic impact in terms of social evaluation on both private (Chincha and Pisco) and social prices (Cañete, Chincha and Pisco), but the required cost is extremely high (726.0 million soles) so that this Project could not be adopted at this stage.

Table 4.15.1-17 Damage reduction annual average (social prices)

(10^6 Soles)

Basin	Return Period	Probability	Total Damage: Wiyhout Project ①	Total Damage: With Project ②	Total Damage: Damage Reduction ③=①−②	Average Damage ④	Section Probability ⑤	Annual Average Damage ⑥=④×⑤	Accumulation of Annual Average Damage
CAÑETE	1	1.000	0	0	0			0	0
	2	0.500	2,711	0	2,711	1,356	0.500	678	678
	5	0.200	11,180	0	11,180	6,946	0.300	2,084	2,762
	10	0.100	110,910	0	110,910	61,045	0.100	6,105	8,866
	25	0.040	153,056	0	153,056	131,983	0.060	7,919	16,785
	50	0.020	225,586	0	225,586	189,321	0.020	3,786	20,572
CHINCHA	1	1.000	0	0	0			0	0
	2	0.500	16,758	0	16,758	8,379	0.500	4,190	4,190
	5	0.200	44,275	0	44,275	30,517	0.300	9,155	13,345
	10	0.100	74,539	0	74,539	59,407	0.100	5,941	19,285
	25	0.040	101,437	0	101,437	87,988	0.060	5,279	24,565
	50	0.020	133,108	0	133,108	117,273	0.020	2,345	26,910
PISCO	1	1.000	0	0	0			0	0
	2	0.500	17,099	0	17,099	8,549	0.500	4,275	4,275
	5	0.200	22,817	0	22,817	19,958	0.300	5,987	10,262
	10	0.100	54,702	0	54,702	38,760	0.100	3,876	14,138
	25	0.040	64,250	0	64,250	59,476	0.060	3,569	17,706
	50	0.020	87,899	0	87,899	76,075	0.020	1,522	19,228
MAJES−CAMANA	1	1.000	0	0	0			0	0
	2	0.500	317	0	317	159	0.500	80	80
	5	0.200	48,503	0	48,503	24,410	0.300	7,323	7,403
	10	0.100	78,738	0	78,738	63,621	0.100	6,362	13,765
	25	0.040	113,789	0	113,789	96,264	0.060	5,776	19,540
	50	0.020	201,622	0	201,622	157,706	0.020	3,154	22,695

Table 4.15.1-18 Economic assessment results (social prices costs)

流域名 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
Cañete	267,429,377	120,765,806	83,998,198	6,622,517	1.58	44,299,144	19%
Chincha	349,827,412	157,975,125	67,797,033	5,973,452	2.55	95,938,413	32%
Pisco	249,965,955	112,879,671	89,066,690	7,573,853	1.39	31,519,208	16%
Majes-Camana	295,026,234	133,227,999	342,877,891	21,618,987	0.43	-176,161,163	-

4.15.2 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, flood peak is reduced in high flood season, this increases water resources in mountain areas, and reduces and prevents flooding.

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 required 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 4.15.2-1)

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 4.15.2-2)

Step 3: With steps' 1 and 2 results, the forestry area of each watershed can be estimated by a simple relation (see Table 4.15.2-3): multiply A/B of each vegetation category of Table 4.15.2-2 by the area of Table 4.15.2-1, 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 2, the total of forestry plan area was 210,000ha and for Majes-Camana was 300,000ha. So, this together is 510,000ha for the forestry plan area calculation.

Table 4.15.2-1 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
Camana-Majes	10.454	310.812	157.008	133.476	15.520	6.616	64.144	1.006.921

Table 4.15.2-2 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 4.15.2-3 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
Camana-Majes	-	5.315	60.605	29.338	-	398	-	211.554	307.210
Total		11,104	120,112	71,375		10,840		301,906	515,337

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 14 to 98 years to reforest and the total project's cost is 1,390 million soles, a very high amount (see Table 4.15.2-4)

Table 4.15.2-4 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
Majes- Camaná	307,210	98	829,200,856
TOTAL	515,337	—	1,390,963,000
Cost of Chincha project per ha: ＝ 2,699.13 (soles /ha) (Example of calculation: (Cañete basin) 110,114 / 44,075 x 14 = 35 (year) 110,114 x 2,699.13 = 297,212,406 (ha)			

(Source: JICA Study Team)

4) Conclusions

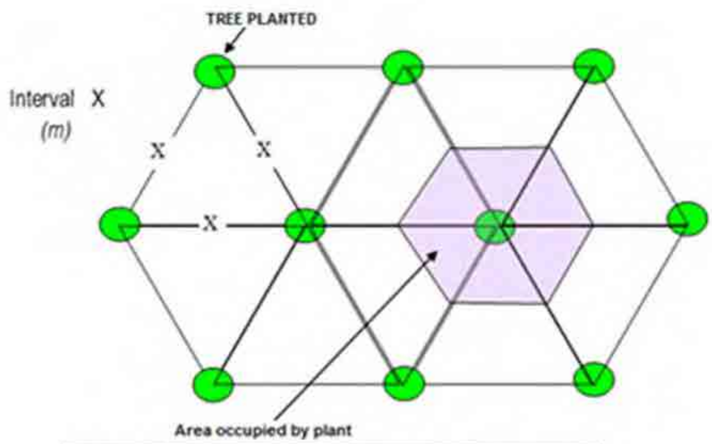
The objective of this project is to execute the most urgent works and give such a long period for reforestation which has an indirect effect with an impact that takes a long time to appear would not be consistent with the proposed objective for the Project. Considering that 14 to 100 years and investment of 1,390 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 m^2	6.670 plants / ha
3 m	3,38 m^2	2.960 plants / ha
5 m	9,38 m^2	1.070 plants / ha
6 m	13,50 m^2	740 plants / ha

Figure 4.15.2-1 Standard reforestation map

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 4,000m.a.s.l 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 4.15.2-2 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 4.15.2-5 the volume of the reforesting plan and selected vegetation recovery is shown.

Table 4.15.2-5 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

Area No.	Surface to reforest (ha)			Execute at:
	Pine	Queñua	Total	
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)

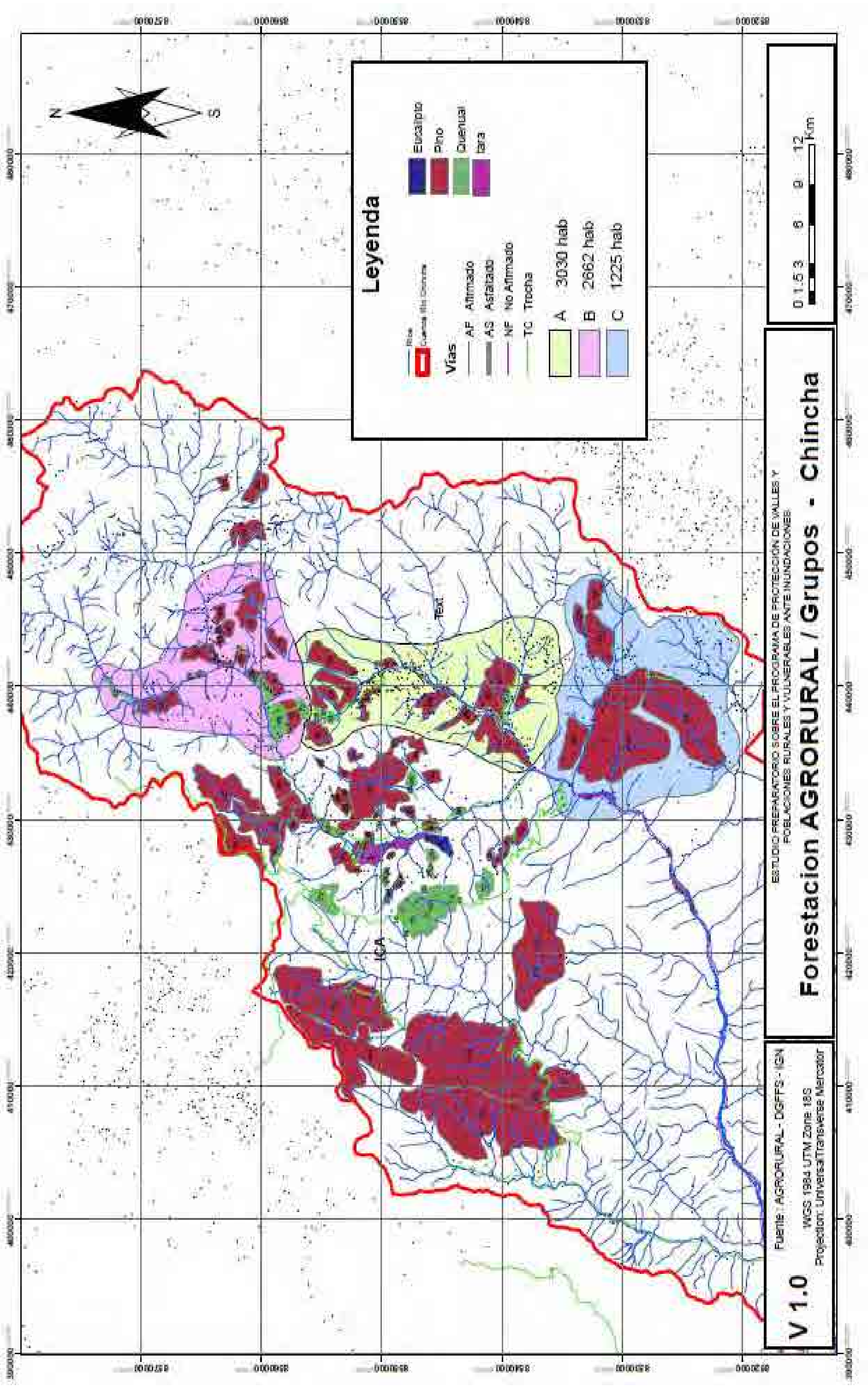


Figure 4.15.2-2 Reforesting plan and selected vegetation recovery in the Chincha river

4) Execution costs

This execution costs were estimated following:

Seedlings unitary costs (unitary price + transportation)

Labor cost

Seedlings suppliers can be i) Agro rural or ii) Private Suppliers. For reforestation of 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 information by AGRORURAL and irrigation commissions. In bank plantation, unit cost of labor would be 33.6 soles /man-day, in the upper basin was determined as 16.8 soles/man-day, which is half the first one.

In Table 4.15.2-6 unit costs applied to estimate direct work costs by ha are shown.

Table 4.15.2-6 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 4.15.2-7 direct cost of the works for the reforestation works on the upper watershed is shown

Table 4.15.2-7 Direct cost of reforestation work

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 4.15.2-8)

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

(Source: JICA Study Team)

Figure 4.15.2-3 Reforestation and vegetal recovery calendar

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 4.15.2-8, 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 by reforesting 4,000 ha. The projects' cost is high, estimated in 22.1 million soles, that represent 46% of the total project's cost of this river, of 48.4 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 4.15.2-8 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

4.15.3 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 bank protection works. The cost of works in each river was estimated focusing on: a) covers the entire watershed, and b) covers only the priority areas, analyzing the disposition of works for each case (refer to Annex-6 Sediment Control Plan, 2.3). The results are shown in Table 4.15.3-1.

Due to the wide extension of each watershed, the construction cost for every alternative would be too high in case of carrying-out the bank 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 4.15.3-1 Upper watershed sediment control works execution estimated costs

Watershed	Area	Bank Protection		Riverbed Girdle		Sediment control dam		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/.)		
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
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	1,239	S/.1,323	123	S/.4	613	S/.771	S/.2,098	S/.3,948
	Prioritized Section	1,239	S/.1,323	123	S/.4	412	S/.525	S/.1,852	S/.3,485

5. Conclusion and Recommendation

5.1 Conclusion

The flood prevention facilities selected finally in this Project are safe in structural, and have high viability and give scarcely impact to the environment. It is concluded that the Project should be implemented as soon as possible so that the high vulnerability against flood in valleys (Valles) and rural communities could be reduced and the social economic development will be promote d in the Project area.

5.2 Recommendation

Based on the knowledge and experience obtained from this Study, the following recommendations are presented on the implementation of this Project and the future flood control measures in Peru.

5.2.1 Recommendation on Implementation of This Project

(1)Problems to be solved at present

1) The project cost will be covered by the central government (through the DGIH), regional governments and irrigation committees.
The sharing ratio among stakeholders is assumed provisionally 80% for the central government (in this case MINAG), 15% for regional government and 5% for irrigation committee. Since the total cost of this Project was determined in the Feasibility Study, the final ratio will be determined through negotiation among 3 parties as soon as possible.

2) The area to be occupied by the flood prevention facilities and the plantation along river was determined in this study. It is recommended that the Project holder (DGIH) should define the limit of river area with private land and continually should carry on the process of land acquisition based on the Land Acquisition Low, which are; Emission of Resolution for land acquisition by the State, Proposition of land cost and compensation for land owner, Agreement of the State and land owner, Payment etc.

3) Confirmation of implementation agency of the Project
The implementation agency is assumed to be PSI, MINAG, however DGPI, MEF and OPI,MINAG do not always agree that, so that the final implementation agency will be determined as soon as possible.

4) As to the environment impact assessment of this Project, DGAA,MINAG evaluated the Initial Environment Assessment (EAP) of the Project and classified this Project in to Category I so that the additional environment assessment is not required, however it is necessary to proceed the process of preservation of archeological heritage.

5) Acquisition of CIRA（Certificación de Inexistente de Restos Arqueológicos） DGIH has to promote the process to obtain the CIRA in the detail design stage. The process to be taken is i)

Application form, ii) Copies of the location drawings and outline drawings, iii) voucher, iv) Archaeological Assessment Certificate.

6) The operation and maintenance after implementation of the Project will be carried out by the irrigation committee. They are not familiar the flood prevention facilities which are different type of structure from the agricultural facilities such as irrigation channel, intake and so on, so that that the technical and economic assistance by MINAG and local government

(2) Structural measures

1) Basic policy of flood control

In the basic policy of flood control, the flood prevention measures should be prepared gradually from the downstream to the upstream of river. However the facilities with high priority such as wide inundation area and giving serious impact on the socio-economy of the region were selected and planned to be implemented in this Project.

Once the preparation in the upstream area is completed, of which influence occurs in the opposite bank or downstream area. And the asset will be accumulated by preparation of flood prevention measures which means the increase of damage potential, if the flood over design flood will occur the damage might be enlarged more than before due to increase of damage potential. Therefore it could not be said that the damage will be not always decreased, which should be noticed to people and the land use regulation should be prepared.

2) Problems for flood control planning in each river

i) 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.

The sections with high priority are selected as described above, even when the facility in each section is complete it cannot be said that the preparation of whole Cañete river is completed. In future the sections where discharge capacity is not enough and need the strengthening dike will be prepared for flood control. In addition to that the bridges at narrow sections should be rebuilt with cooperation of road department.

ii) 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 15Km and 4Km causing great damages on the left bank, and Matagente River may overflow at 9Km and 3Km, 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.

The most important facility is the diversion weir at the diversion point of Chico river and Matagente river. After completion of the weir the operation and maintenance for adequate diversion of discharge will be required by monitoring of sedimentation at and the upstream of the weir.

The sections with high priority are selected in Chincha river , even when the facility in each section is complete it cannot be said that the preparation of whole Chincha river is completed. In future the sections where discharge capacity is not enough and need the strengthening dike will be continuously prepared for flood control.

iii) 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.

The sections with high priority are selected as described above, even when the facility in each section is complete it cannot be said that the preparation of whole Pisco river is completed. In future the sections where discharge capacity is not enough and need the strengthening dike will be continuously prepared for flood control. In addition to that the bridges at narrow sections should be rebuilt with cooperation of road department. And the inundation area of Pisco river includes the urban area of Pisco city. There is possibility that the floods over the design flood will occur so that the minimization measures of flood damage such as the non- structural measures for flood forecasting and warning and secure of evacuation road should be promoted.

iv) 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 loss 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.

The sections with high priority are selected as described above, even when the facility in each section is complete it cannot be said that the preparation of whole Majes-Camana river is completed. In future the sections where discharge capacity is not enough and need the strengthening dike will be continuously prepared for flood control.

And implementation of flood prevention facilities affects on the downstream Camana river so that the preparation order of facilities in Majes river should be well considered not to affect on the downstream Camana river

3) Problems in design and construction work

i) Construction work period

The dry season in the study area is from May to November when the level of water is very low or the river dries up, however the possible construction period is desirable to be from April to December considering the transition period from season to season.

Each river characteristics / features should be taken into account, that is, that the Cañete and Majes-Camana Rivers are year - round rivers, and that the Chico, Matagente and Pisco Rivers are seasonal rivers. At the same time, the crop season cycle in the areas of direct influence should be taken into account, so that traffic jams caused by the large trucks and farming machinery is prevented.

ii) Safety of dike

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. The stability problems forecasted in this case are as follows.

- Infiltrate destruction caused by piping due to washing away fine material
- Sliding destruction of slope due to infiltrate pressure

In order to secure the stability of dike the appropriate standard section should be determined by infiltration analysis and stability analysis for sliding based on unit weight, strength and permeability of embankment material.

The importance in dike construction is sufficient compaction of dike material. The cost estimate standard in Peru the compaction is to be made by tractor; however for the sufficient compaction it is desirable to use compaction equipment such as vibration roller etc.

And in order to supervise the compaction of material, the density test and grain size analysis are important, of which are specified in the technical specification of the tender document (refer to Annex-9 Construction Planning/Cost Estimate, 3.3 Cost Estimate of Direct Cost, Item 2.2 Survey and Quality Control of Integrated List).

iii) Reduction of bank protection cost

The cost of construction work for the revetment occupies over 80% of the direct cost of the project in the embankment section. Moreover, the conveyance cost for the rocks from quarry site occupies 45% of the revetment works. In the places where existing revetment works and groin works still remain, such as in the Majes-Camana River and the Canete River, it should be considered that reusing of materials leads to reduction of construction costs.

iv) Balance of banking and excavation volume

As for balance of earth volume for embankment and excavation, there are shortages earth materials for embankment with 240,000m3 in the Canete River, 122,000m3 in the Chincha River, 203,000m3 in the Pisco River, and 695,000 in the Majes-Camana River. Since the land along the river is used for farmland, the earth materials for embankment shall be taken from riverbed material. In case of excavation in riverbed for making flow capacity increase, there is a possibility that dike height will be lower a little. On the other hand, there is a possibility for promoting riverbed scouring due to steep slope of river. In the detail design phase, the selection of adequate places for borrow pits shall be important.

v) As for the diversion weir planning in the place which distributes to the Chincha River and the Matagente River, since the existing weir is not in operation, the mechanism of destruction by floods shall be clarified and detail design shall be done by taking into account the safety for floods. The consolidation dam work in direct upstream of the diversion weir is also destroyed by floods. Destruction in this section is caused by concrete structures, scouring of foundation and impacts by sediment flow. Hydraulic model test might be conducted for the clarification of hydraulic phenomena, if necessary, judging from the detail design results.

Moreover, the upstream consolidation work is close to filling up by sediments. The riverbed fluctuation for the design should be also considered.

(3) Non-structural measures

1) Afforestation

The afforestation and vegetation recovery plan is divided into i) short term plan, ii) middle term plan (in upstream of Chincha river) and iii) long term plan (upstream area in each river), among which the short term plan is adopted in this Project. In future flood control plan it is necessary that the middle term plan and the long term plan will be executed, however the long term plan requires enormous project period and project cost. The project period and cost of the middle term plan are 4years and 29.0 million soles respectively. The middle term plan could be realized although the project size seems to be rather small. In this middle term plan the negotiation between the irrigation committee in Chincha river and framer in the upstream area has been continued for long year. If the budget will be prepared, the project will be realized easily. Therefore it is recommended that at first the middle term plan is realized as an model project, next the long term plan will be realized by the effort of securing budget step by step.

2) Sediment control and riverbed fluctuation

i) Sediment control plan

Cost for sediment control plan in the mountainous area is expensive (3,948 million soles), in addition project need long term periods. There are no objects to be conserved in the mountainous area, so cost-benefit performance is low. Main purpose in this project is mitigation of the flood disaster. With the view to this purpose, it is judged that sediment control works in the alluvial fans is most effective. It is judged that implementation of the river structures that have the functions of sediment control in Chincha and Pisco basins that have a profound effect of the sedimentation would be most effective.

Despite being distinct from the project purpose, in Peru sediment disasters have occurred frequently. So Non-structural measures to mitigate the sediment disasters would be suggested as shown below. These Non-structural measures are more economical than structural measures and have function to prevent the human life and minimum property from the sediment disaster.

- Regulation of agricultural areas and residential areas
- Setting the alert rainfall for each region and establishment early warning Systems.
- Collect sample of sediment disaster and raise awareness of disaster prevention through education and patrimony of disaster prevention

ii) Riverbed fluctuation

The results of field investigation and reverbed fluctuation analysis show no urgent necessity of sediment control measures in all rivers. However from the long term point of view the decrease of riverbed elevation is forecasted in the Cañete river upstream of which the dam is located and increase of riverbed elevation by the unstable sediment run-off in Majes-Camana river upstream of which no sediment control facilities exist so that the flood control function is reduced. And it is important that the effect of the facilities is confirmed in Chincha and Pisco rivers upstream of which the sediment control facilities planned,.

From now on the monitoring system for topography of river channel and local scouring should be established in all rivers depending on the riverbed fluctuation characteristics, and the accumulation of such basic data is required.

(4) Disaster prevention education/capacity development

1) Soft counter measures for reduction of flood damage

The design flood discharge in this Study is a flood with return period of 50 years which is calculated based on the past rainfall observation data. However the flood over design flood may occur due to El Niño or extraordinary meteorological phenomena. Since the forecasting of such floods is difficult it is impossible to prepare for such floods by hard counter measures. Since there is still risk for such floods, the establishment of soft countermeasures such as flood defense work, evacuation, preparation of hazard map and the notification and education to people is required.

2) Promotion of community disaster prevention

It is important to promote the community disaster prevention, which reinforces the effect of this Project and induces the local people participation to the Project. The long time approach and activities are required until that the self and mutual assistance is motivated and the people start voluntarily concrete activities as a first step of activation of voluntary disaster prevention organization.

It is necessary that the irrigation committee builds the community disaster prevention system as a core based on the disaster prevention education in this Project in order to increase the effect of the Project

5.2.2 Recommendation for Future Flood Control Plan in Peru

(1) Preparation of comprehensive master plan of flood control

There are almost no flood prevention facilities in the Study area although the dikes are built in some places. The flood prevention facilities constructed in this Project are also partly, however they cover the important points and give the high economic effect as seen in the social evaluation results so that it can be said very significant project.

However, as to the future flood control in Peru, the integral master plan for major basins should be established and implemented step by step for objectives of not only agricultural facilities but also urban areas, roads, bridges etc.

(2) Establishment of implementation agency for integral flood control project

The counterpart ministry of this Project is MINAG which is responsible for the agricultural sector so that they cannot easily implement the disaster prevention project belong to the other sector.

In order to realize the above (1) it is necessary that the role of the existing agency will be change to be able to implement the flood control plan with integral purpose or establishment of new agency. By such agency the integral flood prevention measures and operation and maintenance of river such as dike, bank protection, groin, erosion of river bank, sedimentation in riverbed, intake weir etc. should be carried out completely.

(3) Execution of strict river management

The boundary of river area and private land is not clear, the river area is used sometimes as agricultural land, and the garbage is dumped in the river area illegally, which means the administration of river area is not well performed. Therefore the preparation of river law system and strict application of it is quite required.

(4) Establishment of nationwide network of rainfall and discharge observation stations

The estimation of flood discharge and flood pattern is indispensable as basic data for establishment of flood control plan. In order to estimate the above data with appropriate accuracy, the rainfall observation stations with enough density in the basin and the discharge observation stations at important points along the river are necessary as well as hourly observation data. And in order to estimate the flood discharge and flood pattern, the hourly data is indispensable.

However the data to be used in the Study area is very limited, for example, in the Yauca basin with area of 4,312km2 there are 7 rainfall stations, of which only one station (Cora Cora2) is under operation. The observation data in the study area is all daily base for rainfall and discharge and not in hourly base.

To promote the flood control in Peru, the establishment of network of rainfall and observation stations is indispensable. To do so, it is necessary that the master plan of observation network covering all Peru is to be established and the base stations are selected and the observation is carried out. The followings are to be examined to make the master plan and to select the basic stations.

＊Review of observation data of existing stations
＊Select observation stations to be used and digitalize of available data
＊Plan of observation network and classification of planned and existing stations depending on importance
＊Renewal of observation equipment in the existing stations depending on importance
＊Installation new basic stations
＊Plan of transmission system of data
＊Plan of recording and keeping system of observation data
＊Plan of operation and maintenance system
＊Trial observation at the stations above

In implementation of above project, the all Peru is divided into several areas depending on the importance, then the project will be implemented step by step, and the implementation might be done by the assistance of foreign country. The administration of observation data is performed by SENAMHI at present, the observation data will be opened regularly to the public and can be used widely by the utilizer.