CHAPTER 3 RIVER CHANNEL PLAN

Based on the discharge capacity and the characteristics on floods, etc. for each object river, the optimal river channel plan is formulated.

The probability for channel plan for each river is set at 1/50 years, and the river channel plans not only from the point of long-term aspect but also from strategic and urgent aspect are formulated.

3.1 Design for Alignment of Dike

The alignment of dike was designed based on the present status of dike. The river width was designed fundamentally as wide as possible.

3.2 Design for Cross Section of River

The longitudinal profiles and typical cross sections (river channel cross section) for each river were planned based on the securing of the discharge capacity and the alignment of plan.

3.3 Design for High Water Level

The examinations of design for high water level (H.W.L) and alignment of dike for the design high water discharge (1/50 year scale) for each river are carried out, and the dimensions of facilities are determined.

Design of high water level is set as the height which can flow down safely in the case of the discharge of design probable scale (1/50 year), and the dike height is set by applying design criteria on rivers in Japan as mentioned below.

■ Design Scale of River Plan

According to the previous maximum discharge record for each river which is arranged based on the observation data, the flood with scale 1/50 years probability occurred about once to twice in the past. These floods with scale of 50 years probability make serious damages in the past floods.

Taking into account the river improvement condition in Peru, it is progressing level for the improvement of rivers, the necessity of river plan exceeding the scale of previous floods is low. However, floods occurred in the past caused serious damages, the river plan for flood control should be ensured at the same scale as past floods.

Therefore, scale of 1/50 year probable flood which is the maximum scale of flood in the past record is appropriate for the river plan in this study.

Table 3.1 **Comparison of Probable Scale Discharge and Previous Maximum Discharge in Each River**

	1/5 (m^3/s)	1/10 (m^3/s)	1/25 (m^3/s)	1/50 (m^3/s)	Previous Maximum Discharge (m^3/s)
Chira River	1,752	2,276	2,995	3,540	3,595
Canete River	407	822	1,496	2,175	900
Chincha River（Before Diversion）	474	580	808	918	1,269
Chico River	237	290	404	459	635
Matagente River	237	290	404	459	635
Pisco River	287	451	688	855	956
Yauka River	37	90	167	263	211
Majes – Camana River	728	1,166	1,921	2,658	2,021

※In the Canete River, it is judged that the previous maximum discharge could not be measured.
(Since the maximum possible measurement value is 900m3/s from the cross section of the observation station, the discharge beyond it cannot be measured.)

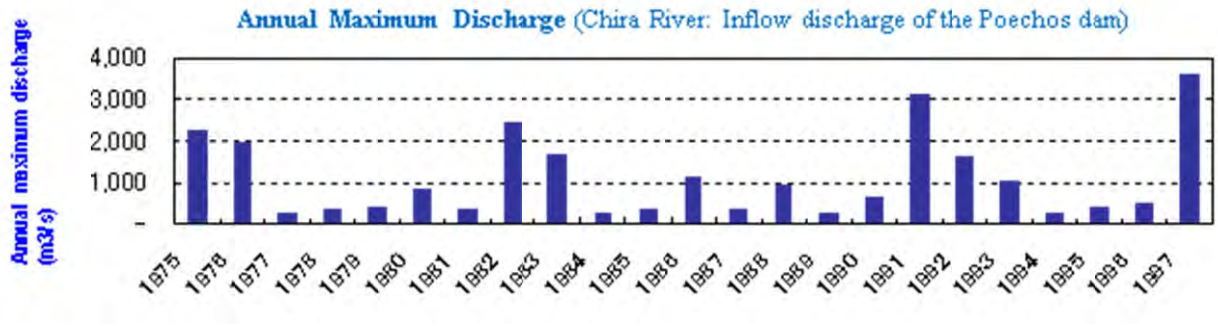


Figure 3.1 **Annual Maximum Discharge (Inflow of Poechos Dam in the Chira River)**

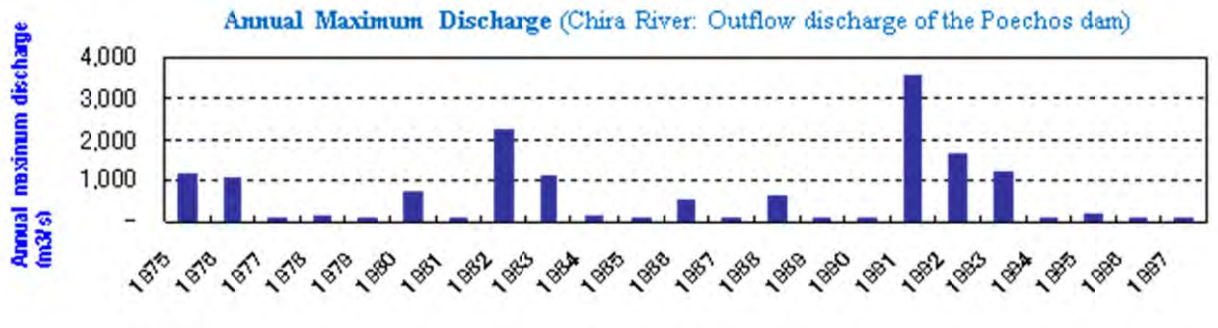


Figure 3.2 **Annual Maximum Discharge (Outflow of Poechos Dam in the Chira River)**

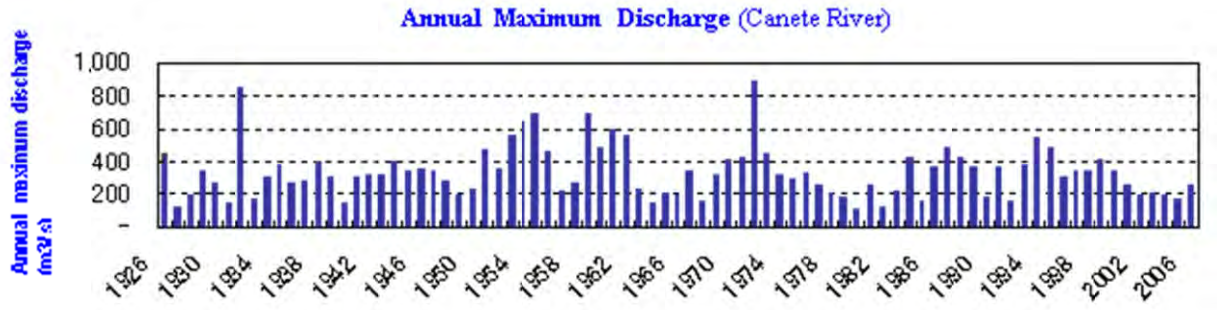


Figure 3.3 **Annual Maximum Discharge (Canete River)**

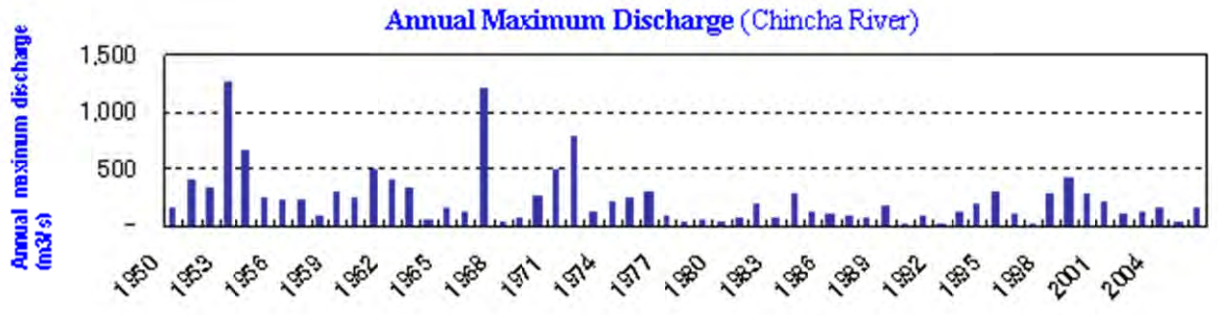


Figure 3.4 **Annual Maximum Discharge (Chincha River)**

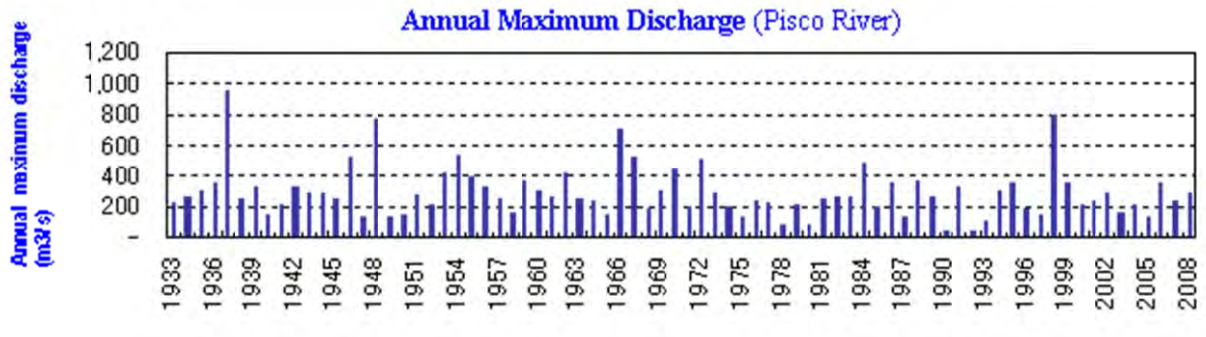


Figure 3.5 **Annual Maximum Discharge (Pisco River)**

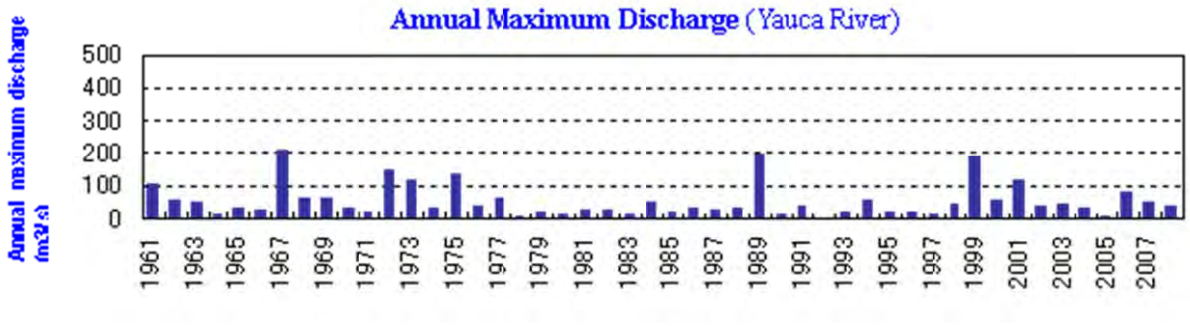


Figure 3.6 **Annual Maximum Discharge (Yauca River)**

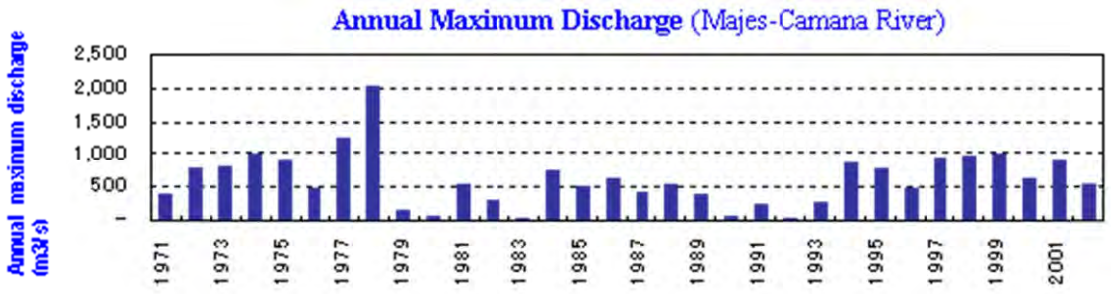


Figure 3.7 **Annual Maximum Discharge (Majes-Camana River)**

■ Freeboard

Since the bank is made of earth and sand, it is generally very weak structure for overflow. Therefore, the bank height should be set up not to allow the overflow against the design high water level, and it is necessary to take appropriate margins caused by temporary water-level rising, wind wave, swell, hydraulic jump, etc., at the time of flood. Moreover, in order to cover various factors, such as securing of safety by inspection and flood fighting activities at the time of flood, and countermeasures for flowing materials such as driftwood, the height of appropriate margin (freeboard) is required for dike.

In accordance with the Structural Standard for River in Japan, freeboard for each design flood discharge is as follows.

Table 3.2 **Freeboard for Each Design Flood Discharge**

Design Flood Discharge	Freeboard in meter
Less than 200 m^3/s	0.6 m
200 m^3/s and more – less than 500 m^3/s	0.8 m
500 m^3/s and more – less than 2,000 m^3/s	1.0 m
2,000 m^3/s and more – less than 5,000 m^3/s	1.2 m
5,000 m^3/s and more – less than 10,000 m^3/s	1.5 m
10,000 m^3/s and more	2.0 m

There were no criteria on freeboard of dike in Peru, freeboard based on the Structural Standard for River in Japan is applied for design. Freeboard adopted in the design for each river is as follows.

Table 3.3 **Freeboard for each River**

River Name		Design Flood Discharge (1/50Year)	Freeboard
Chira River		3,540 m^3/s	1.2 m
Canete River		2,175 m^3/s	1.2 m
Chincha River	Chico River	459 m^3/s	0.8 m
	Matagente River	459 m^3/s	0.8 m
Pisco River		855 m^3/s	1.0 m
Yauka River		263 m^3/s	0.8 m
Majes – Camana River		2,658 m^3/s	1.2 m

3.4 River Channel Plan (Design Scale: 1/50 Year Probable Flood)

< Outline of Plan >

(1) The dike which can flow down safely against the 1/50 year probable discharge is designed.

(2) The dike construction section is set in the areas where the flood flow spreads into inland area of the bank based on the flood simulation results.

(3) The dike is arranged in the sections where design water level exceeds the existing dike height or protected inland height among the flood spreading sections.

(4) The design dike height is set as the water level of 1/50 year probable flood + freeboard

The dike construction plan in each river is shown in ***Table 3.4***.

Table 3.4 **Dike Plan for Each River**

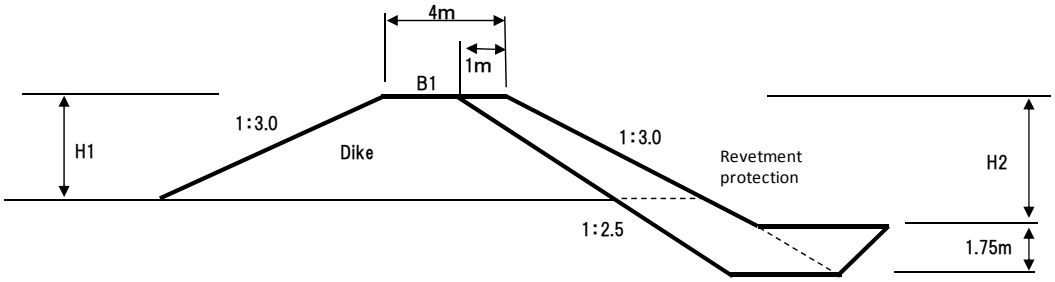
River Name		Improvement Section		Shortage for Design Height (m)	Dike Plan	Dike Length (km)
Chira River		Left bank side	0.0k-99.0k	3.00	Dike h=4.0m Revetment h=4.0m	77.5
		Right bank side	0.0k-99.0k	4.17		89.5
		Total		4.00		167
Canete River		Left bank side	0.0k-21.5k	1.20	Dike h=1.5m Revetment h=3.0m	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
Yauca River		Left bank side	-	-	Dike h=1.5m Revetment h=3.0m	-
		Right bank side	0.5k- 8.0k	0.46		3.0
		Total		0.46		3.0
Majes-Camana River		Left bank side	0.0k-108.0k	1.77	Dike h=2.0m Revetment h=3.0m	79.5
		Right bank side	0.0k-111.0k	1.81		56.5
		Total		1.79		136.0
Grand Total						395.5

< Initial Cost Estimated for the Project >

The direct cost by private sector's price and project cost are shown in ***Table 3.5*** and ***Table 3.6***, respectively. Moreover, the project cost by social price is shown in ***Table 3.7***.

Table 3.5 Direct Construction Cost for the Whole Flood Control Plan

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



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

Table 3.6 **Project Cost of the Whole Flood Control Plan (Market Price)**

River basin	Costo Directo **Direct construction cost** (1)	Costo de Obras Temporales **Common temporary work cost** (2) = 0.1 x (1)	Costo de Obras **Construction cost** (3) = (1) + (2)	Gastos Operativos **Overhead cost** (4) = 0.15 x (3)	Utilidad **Profit** (5) = 0.1 x (3)	Costo Total Infraestructura **Structures construction cost** (6) = (3)+(4)+(5)	IGV **Tax** (7) = 0.18 x (6)	Costo Total Obra **Construction cost** (8) = (6)+(7)	Impacto Ambiental **Environmental Impact** (9)=0.01 x (8)	Expediente Tecnico **Detailed Design** (10) = 0.05 x (8)	Supervisión **Construction management cost** (11) = 0.1 x (8)	**Structure/ Project Cost** (12) = (8)+(9)+(10)+(11)
CHIRA	429,868,400	42,986,840	472,855,240	70,928,286	47,285,524	591,069,050	106,392,429	697,461,479	6,974,615	34,873,074	69,746,148	809,055,316
CAÑETE	55,510,000	5,551,000	61,061,000	9,159,150	6,106,100	76,326,250	13,738,725	90,064,975	900,650	4,503,249	9,006,498	104,475,371
CHINCHA	44,803,500	4,480,350	49,283,850	7,392,578	4,928,385	61,604,813	11,088,866	72,693,679	726,937	3,634,684	7,269,368	84,324,667
PISCO	58,859,500	5,885,950	64,745,450	9,711,818	6,474,545	80,931,813	14,567,726	95,499,539	954,995	4,774,977	9,549,954	110,779,465
YAUCA	5,271,000	527,100	5,798,100	869,715	579,810	7,247,625	1,304,573	8,552,198	85,522	427,610	855,220	9,920,549
Majes/Camana	247,520,000	24,752,000	272,272,000	40,840,800	27,227,200	340,340,000	61,261,200	401,601,200	4,016,012	20,080,060	40,160,120	465,857,392
TOTAL	**841,832,400**	**84,183,240**	**926,015,640**	**138,902,346**	**92,601,564**	**1,157,519,550**	**208,353,519**	**1,365,873,069**	**13,658,731**	**68,293,653**	**136,587,307**	**1,584,412,760**

Table 3.7 **Project Cost of the Whole Flood Control Plan (Social Price)**

River basin	Costo Directo **Direct construction cost** (1)	Costo de Obras Temporales **Common temporary work cost** (2) = 0.1 x (1)	Costo de Obras **Construction cost** (3) = (1) + (2)	Gastos Operativos **Overhead cost** (4) = 0.15 x (3)	Utilidad **Profit** (5) = 0.1 x (3)	Costo Total Infraestructura **Structures construction cost** (6) = (3)+(4)+(5)	IGV **Tax** (7) = 0.18 x (6)	Costo Total Obra **Construction cost** (8) = (6)+(7)	Impacto Ambiental **Environmental Impact** (9)=0.01 x (8)	Expediente Tecnico **Detailed Design** (10) = 0.05 x (8)	Supervisión **Construction management cost** (11) = 0.1 x (8)	**Project Cost** (12) = (8)+(9)+(10)+(11)
CHIRA	345,614,194	34,561,419	380,175,613	57,026,342	38,017,561	475,219,516	85,539,513	560,759,029	5,607,590	28,037,951	56,075,903	650,480,474
CAÑETE	44,630,040	4,463,004	49,093,044	7,363,957	4,909,304	61,366,305	11,045,935	72,412,240	724,122	3,620,612	7,241,224	83,998,198
CHINCHA	36,022,014	3,602,201	39,624,215	5,943,632	3,962,422	49,530,269	8,915,448	58,445,718	584,457	2,922,286	5,844,572	67,797,033
PISCO	47,323,038	4,732,304	52,055,342	7,808,301	5,205,534	65,069,177	11,712,452	76,781,629	767,816	3,839,081	7,678,163	89,066,690
YAUCA	4,237,884	423,788	4,661,672	699,251	466,167	5,827,091	1,048,876	6,875,967	68,760	343,798	687,597	7,976,121
Majes/Camana	199,006,080	19,900,608	218,906,688	32,836,003	21,890,669	273,633,360	49,254,005	322,887,365	3,228,874	16,144,368	32,288,736	374,549,343
TOTAL	**676,833,250**	**67,683,325**	**744,516,575**	**111,677,486**	**74,451,657**	**930,645,718**	**167,516,229**	**1,098,161,947**	**10,981,619**	**54,908,097**	**109,816,195**	**1,273,867,859**

CHAPTER 4 MAINTENANCE PLAN

Formulation of the channel plan in consideration of the sediment dynamic state is a basic theme in this study. Based on one-dimensional-riverbed-fluctuation analysis, sections caused by sedimentation/erosion are grasped and the countermeasures against them are planned.

As for the current situation in rivers, sections which located road bridges, farm facilities (diversion weirs), etc. are narrow areas, and upstream of narrow areas have tendency of sedimentation.

In the maintenance plan, discharge capacity in narrow areas is enhanced, and sediments are kept not to accumulate in the channel of narrow areas and its upstream section. Moreover, it is planned so that the sediment is stored as much as possible in the upstream section (wide river channel) located upstream of the narrow areas at the occurrence of the scale of exceeding 1/50 scale flood.

Based on the riverbed-fluctuation simulation results for 6 (six) rivers at the 50 years after, the sections or places where the maintenance works should be done are selected and arranged as shown below.

Table 4.1 **Sections/Places to be Carried Out Maintenance Works**

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

	Place2	Target Section: 100.0km-101.0km Target Volume:460,000m3	It is a wide channel section. It has high possibility that a lot of sediment accumulates easily. By carrying out excavation maintenance in the section, it is expectable that the effectiveness of the riverbed aggradation in the middle stream can be also controlled. The place is considered to be carried out the planned excavation maintenance from the viewpoint on flood control.

※Design sediment volume: Sediment volume deposited in 50 years

Table 4.2 **Direct Construction Cost for Chanel Excavation**

River Basin		Quantity (M m3)	Unit	Unit price (Sol)	Direct Construction Cost (M Soles)
Chira River		2,500	m3	10.0	25,000.0
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
Yauca River		60	m3	10.0	600.0
Majes-Camaná River		70	m3	10.0	700.0
		460	m3	10.0	4,600.0

Table 4.3 Project Cost for Channel Excavation (Market Price)

Nombre de la Cuenca River basin	Costo Directo (soles) Direct construction cost (1)	Costo de Obras Temporales Common temporary work cost (2) = 0.1*(1)	Costo de Obras Construction cost (3) = (1) + (2)	Gastos Operativos Overhead cost (4) = 0.15*(3)	Utilidad Profit (5) = 0.1*(3)	Costo Total Infraestructura Structures construction cost (6) = (3)+(4)+(5)	IGV Tax (7) = 0.18*(6)	Costo Total Obra Construction cost (8) = (6)+(7)	Impacto Ambiental Environmental Impact (9)=0.01*(8)	Expediente Tecnico Detailed Design (10) = 0.05*(8)	Supervisión Construction management cost (11) = 0.1*(8)	Costo Total Project Cost (12) = (8)+(9)+(10)+(11)
CHIRA	25,000	2,500	27,500	4,125	2,750	34,375	6,188	40,563	406	2,028	4,056	47,053
CAÑETE	4,220	422	4,642	696	464	5,803	1,044	6,847	68	342	685	7,942
CHINCHA	4,790	479	5,269	790	527	6,586	1,186	7,772	78	389	777	9,015
PISCO	5,690	569	6,259	939	626	7,824	1,408	9,232	92	462	923	10,709
YAUCA	600	60	660	99	66	825	149	974	10	49	97	1,129
MAJES-CAMANA	5,300	530	5,830	875	583	7,288	1,312	8,599	86	430	860	9,975
TOTAL	45,600	4,560	50,160	7,524	5,016	62,700	11,286	73,986	740	3,699	7,399	85,824

Table 4.4 Project Cost for Chanel Excavation (Social Price)

Nombre de la Cuenca River basin	Costo Directo (soles) Direct construction cost (1)	Costo de Obras Temporales Common temporary work cost (2) = 0.1*(1)	Costo de Obras Construction cost (3) = (1) + (2)	Gastos Operativos Overhead cost (4) = 0.15*(3)	Utilidad Profit (5) = 0.1*(3)	Costo Total Infraestructura Structures construction cost (6) = (3)+(4)+(5)	IGV Tax (7) = 0.18*(6)	Costo Total Obra Construction cost (8) = (6)+(7)	Factor de Corrección Correction Factor Cf	Costo Total Obra Construction cost (9) = Cf*(8)	Impacto Ambiental Environmental Impact (10)=0.01*(9)	Expediente Tecnico Detailed Design (11) = 0.05*(9)	Supervisión Construction management cost (12) = 0.1*(9)	Costo Total Project Cost (13) = (9)+(10)+(11)+(12)
CHIRA	25,000	2,500	27,500	4,125	2,750	34,375	6,188	40,563	0.804	32,612	326	1,631	3,261	37,830
CAÑETE	4,220	422	4,642	696	464	5,803	1,044	6,847	0.804	5,505	55	275	551	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
YAUCA	600	60	660	99	66	825	149	974	0.804	783	8	39	78	908
MAJES-CAMANA	5,300	530	5,830	875	583	7,288	1,312	8,599	0.804	6,914	69	346	691	8,020
TOTAL	45,600	4,560	50,160	7,524	5,016	62,700	11,286	73,986		59,486	594	2,974	5,948	69,002

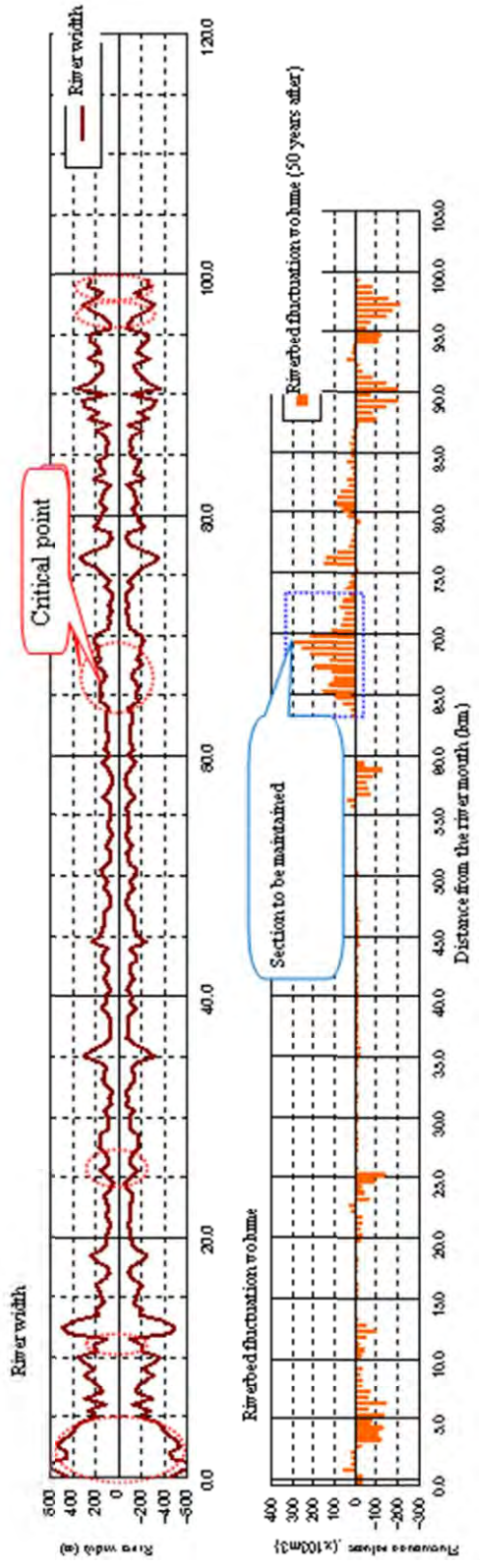


Figure 4.1 **Sedimentation Section to be carried out Maintenance Works (Chira River)**

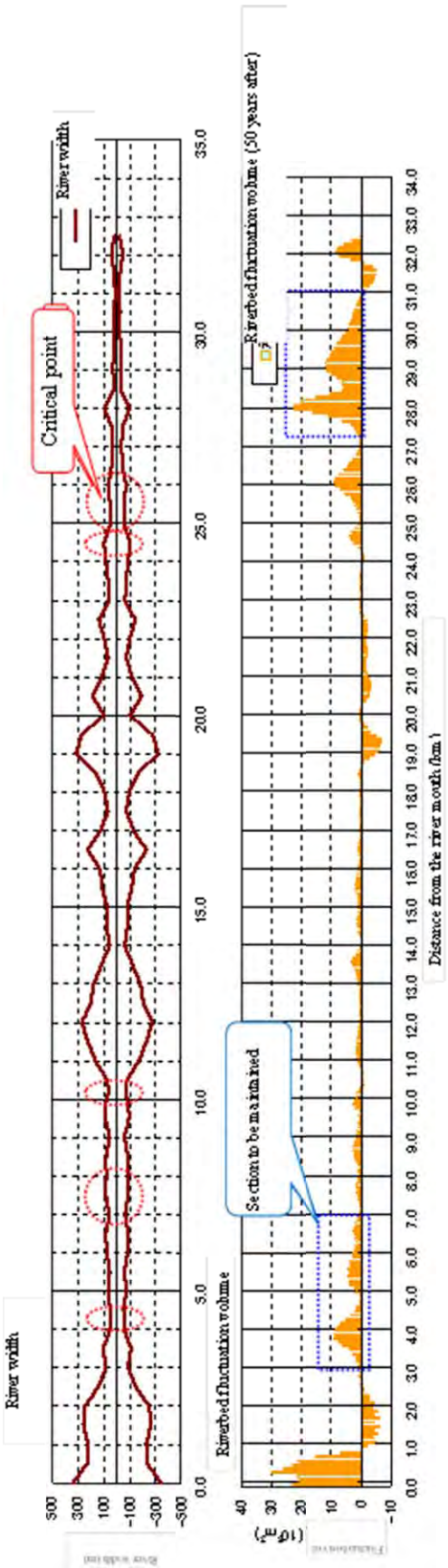


Figure 4.2 **Sedimentation Section to be carried out Maintenance Works (Canete River)**

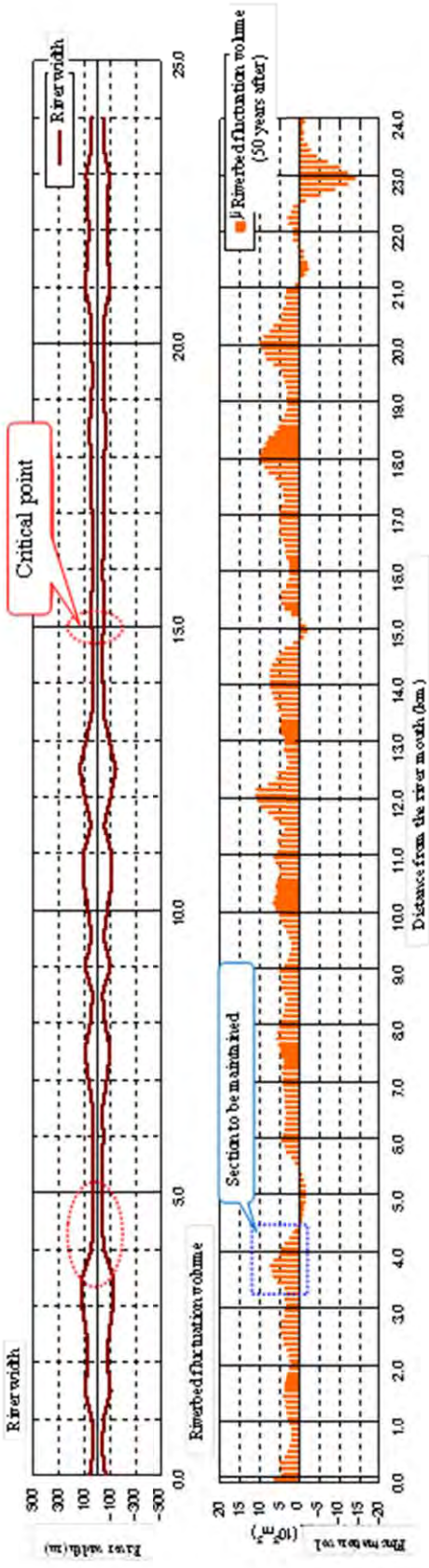


Figure 4.3 **Sedimentation Section to be carried out Maintenance Works (Chincha (Chico) River)**

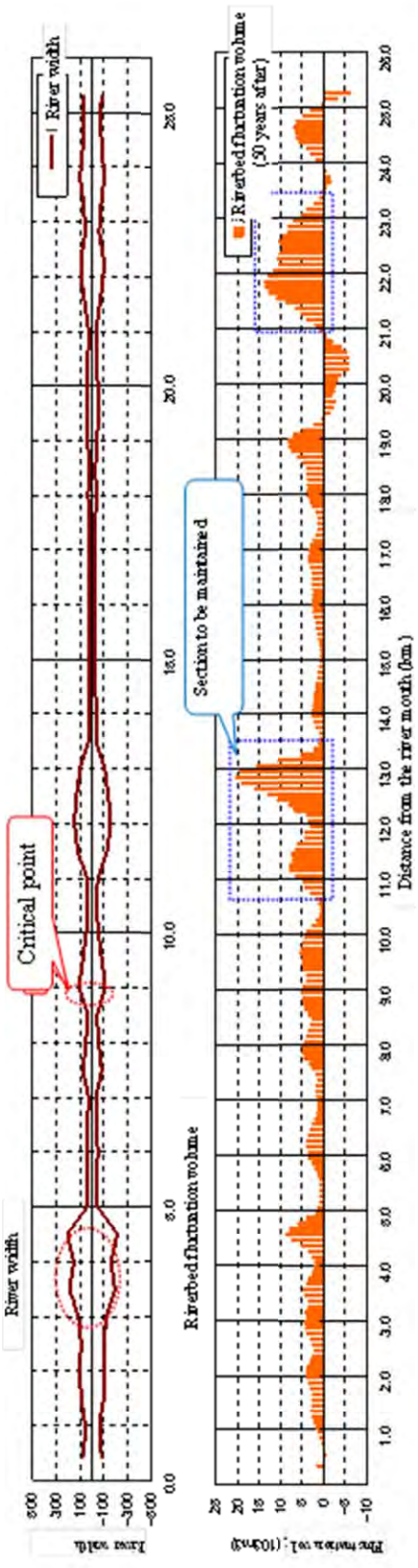


Figure 4.4 **Sedimentation Section to be carried out Maintenance Works (Chincha (Matagente) River)**

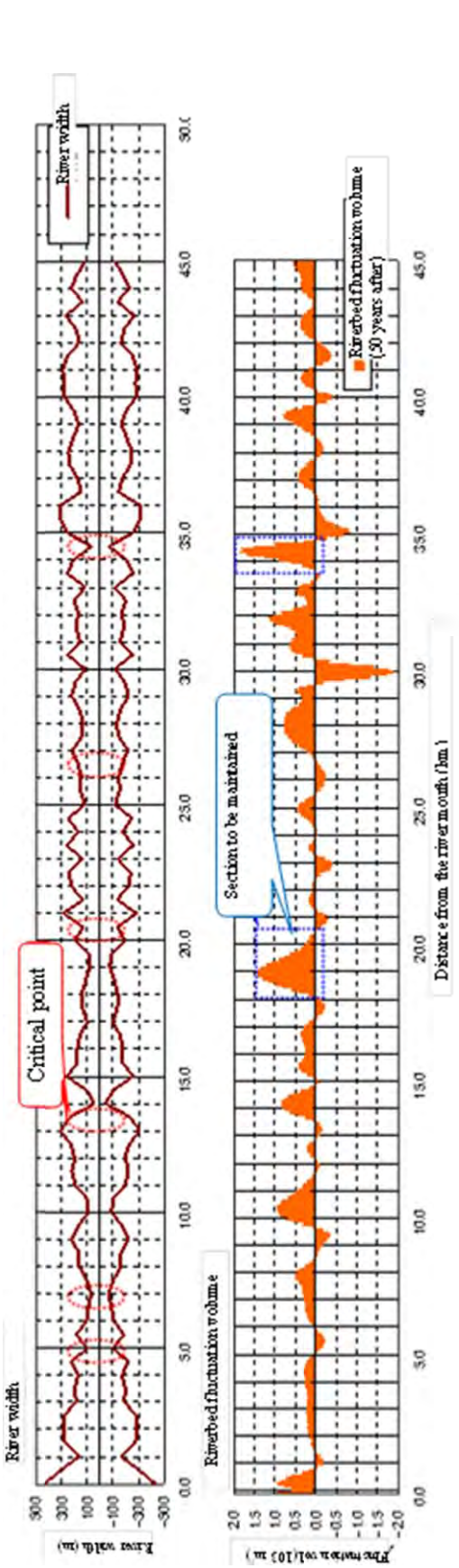


Figure 4-5 **Sedimentation Section to be carried out Maintenance Works (Pisco River)**

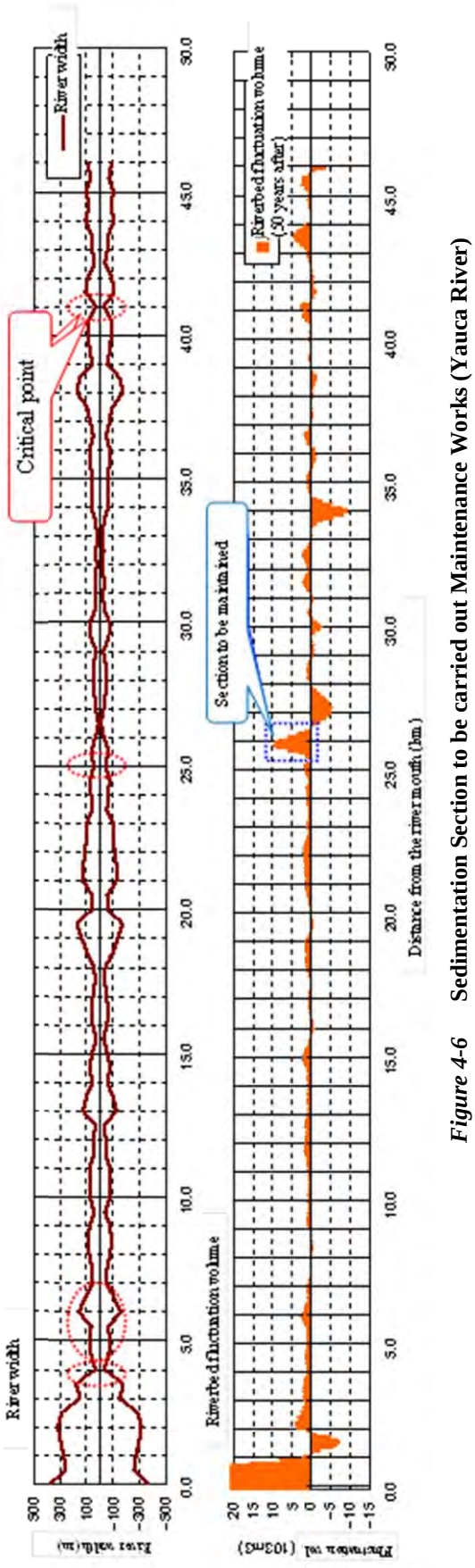


Figure 4-6 **Sedimentation Section to be carried out Maintenance Works (Yauca River)**

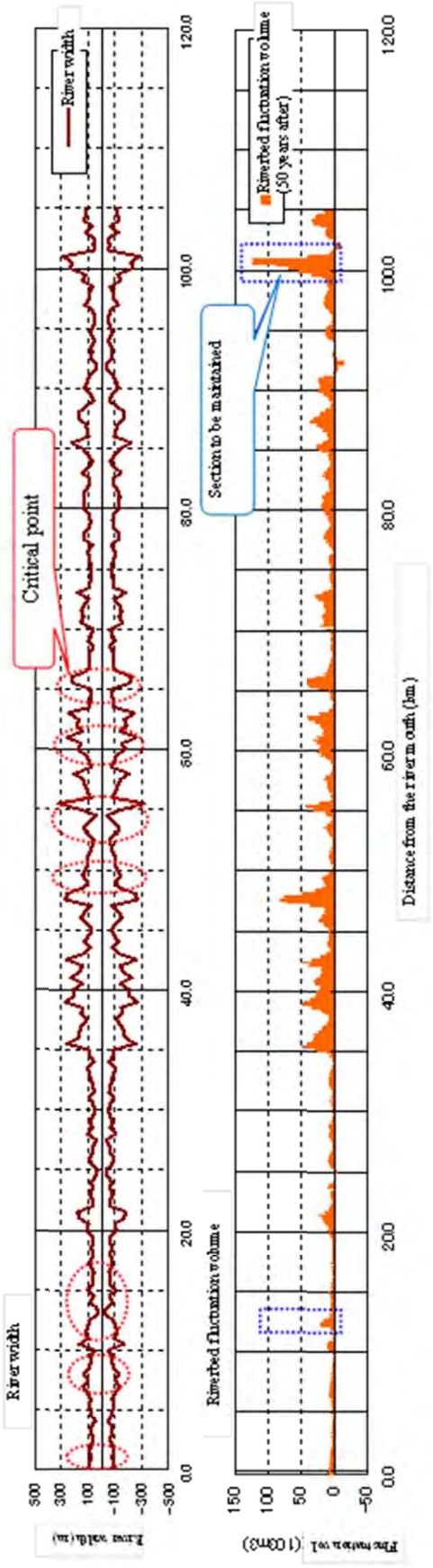


Figure 4-7 **Sedimentation Section to be carried out Maintenance Works (Majes - Camana River)**

For advancing on river improvement, the sections with high priority (section where the serious damage is expected by floods, section which has great effects on local economic activities, etc.) are improved immediately in consideration of the characteristics of rivers. After that, works is carried out from the downstream section by taking into consideration the scale of improvement plan. (For over all construction plan, it is based on securement of the safety scale for flood control from the downstream section)

The selection procedure for river improvement sections with high priority is shown next chapter.

CHAPTER 5 SELECTION FOR HIGH PRIORITY RIVER IMPROVEMENT SECTION

The locations for high priority facilities for flood control in six rivers are evaluated synthetically and prioritized from the view point of followings i) past flood damage, ii) present situation of the river and bank, iii) situation on possible inundation area when large-scale flood is occurred, and iv) properties of the hinterland, etc.

The following five items were extracted as evaluation criteria for selection.

- Sections/parts of shortage on discharge capacity (scouring parts is also included)
- Situation of hinterland (important hinterlands; situation of urban areas and farmlands)
- Flood characteristics (inundation areas based on inundation analysis)
- Social environment condition (important facilities in local communities, etc.)
- Opinions/requests from the Stakeholders (based on the past flood damage and priorities)

Base data utilized for examination are as follows.

- Overall plan (land use and the characteristics of rivers, etc.)
- Topographic survey results (characteristics of cross section, etc.)
- Field reconnaissance results (characteristics of topographic feature, current condition of facilities river improvement)
- Discharge capacity (evaluation of discharge capacity)
- Flood analysis for inundation (grasp of characteristic of inundation)
- Interview results with local organization and stakeholders (irrigation associations and local governments, past flood damages)

< Evaluation items and selection criteria by scoring >

When selecting the priority sections/sites, the above-mentioned synthetic evaluation on five items was carried out based on the survey results of rivers, field reconnaissance results, discharge capacity evaluations, flood analysis, local interview results (request of irrigation association and the local government, the past flood damage), etc. The 32 sections/sites (section with high score of synthetic evaluation) in total are selected as high priority improvement section/site.

Concretely, since the river topographic survey is carried out with 500m interval for cross section, and the evaluation on discharge capacity as well as inundation analysis are carried out based on every cross section with 500m interval. For evaluation, scoring method with three grades (o (zero) , 1(one) , 2(two)) was performed for above-mentioned items at every cross section. Finally, the section getting 6 (six) or more points in total was selected.

In addition, the getting lowest limit (6(six) points) for the selection was set up in consideration of the budget of the overall project, etc.

Evaluation items and grading standard with score are shown in ***Table 5.1***.

Table 5.1 **Evaluation Items and Grading Standard with Score**

Evaluation item	Explanation	Grading standard with Score
Request by local government and stakeholders	●Records of past flood damage ●Request from local residents and farmers	・Experience of large-scale flood damage and strong request from the stakeholders (2 points) ・Request of the area (1 point)
Discharge capacity (scouring parts is included)	●Possibility of inundation ●Possibility of the dike collapse by scouring	・Section where the discharge capacity is especially low (the 1/10 year or less probable flood discharge) (2 points) ・Section of low discharge capacity (1 / 25 year or less) (1 point)
Situation of hinterland	●Large-scale farmland areas, etc. ●Urban areas, etc. ●Facilities in hinterland or circumferences	・Large-scale farmland spreading area (2 points) ・City and farmland, large-scale city area (2 points) ・Small scaled area above-mentioned (1 point)
Inundation conditions	●The scale of floods	・Flood spreads superficially and greatly (2 points) ・Flood stops at the restrictive area (1 point)
Social environment conditions (important infrastructures)	●Irrigation and water supply intake facility, etc. ●Bridges and roads (Pan Americana Road etc.)	・Important facility located in the area (2 points) ・Rather small scale facility comparing with important facility (local roads, small-scale water intake facilities, etc.)

In addition, the evaluation result for each section and the selection results of high priority improvement sections are shown in ***Figure 5.1*** to ***Figure 5.7***.

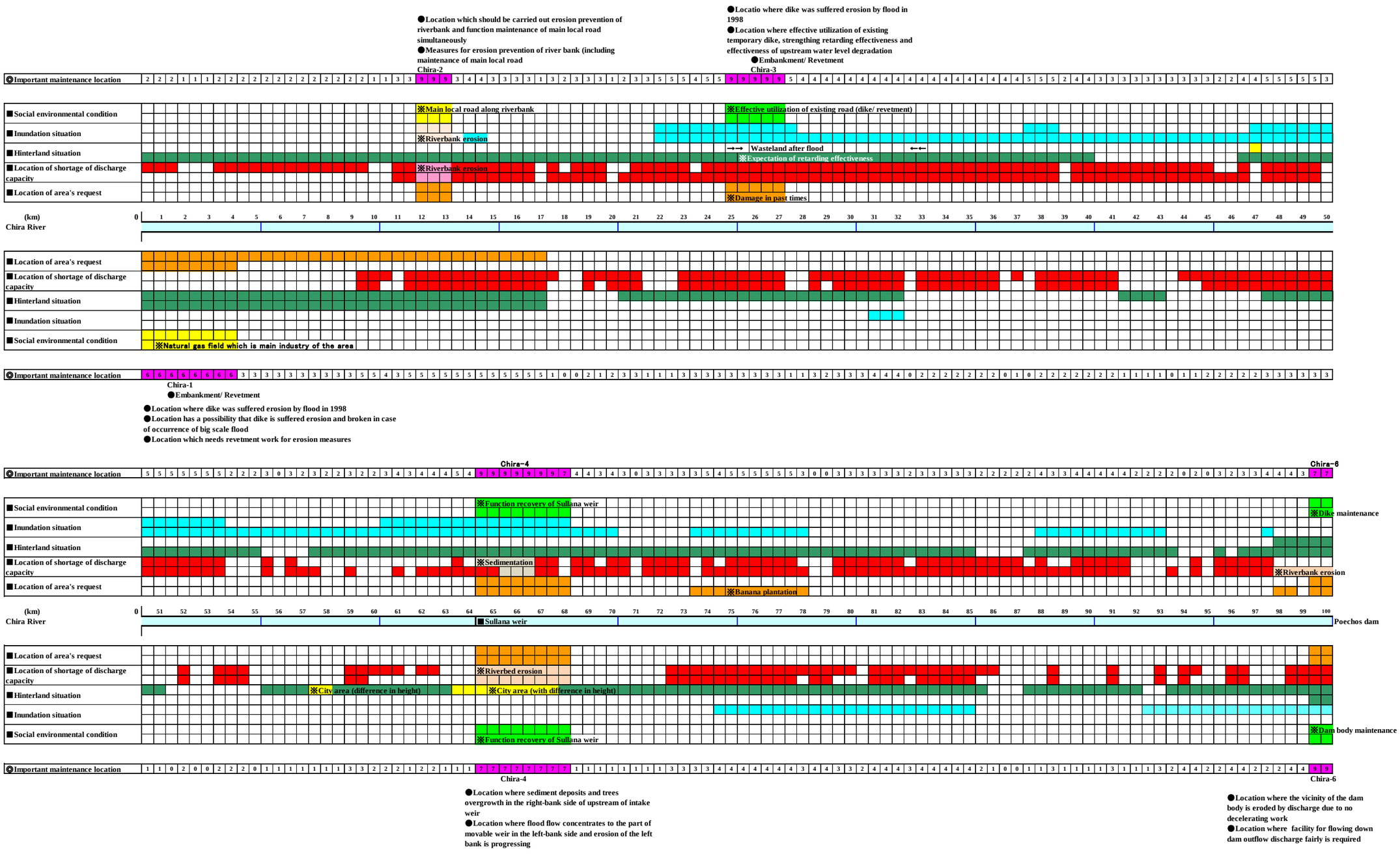


Figure 5.1 **Selection of High Priority Improvement Facilities in the Chira River**

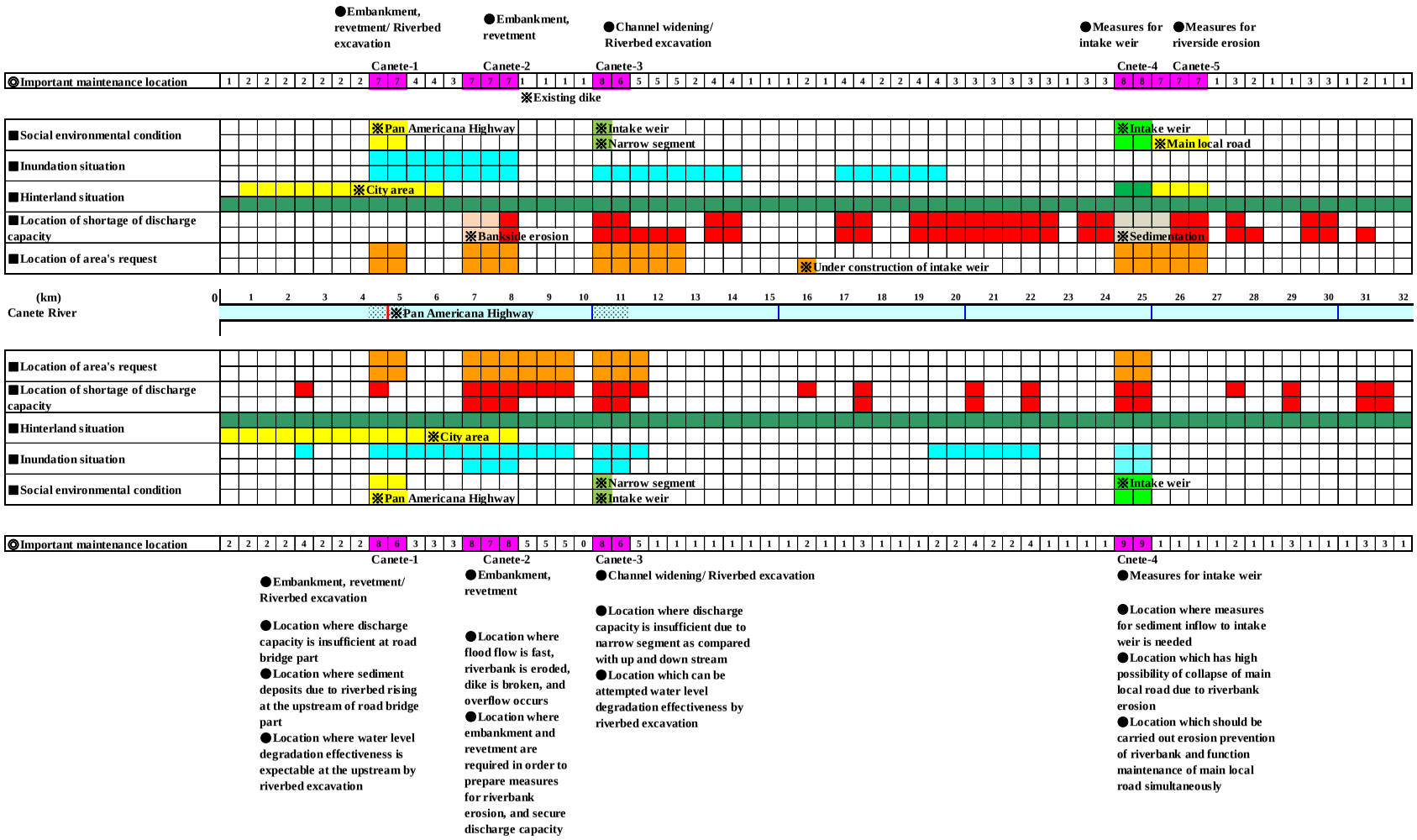


Figure 5.2 **Selection of High Priority Improvement Facilities in the Canete River**

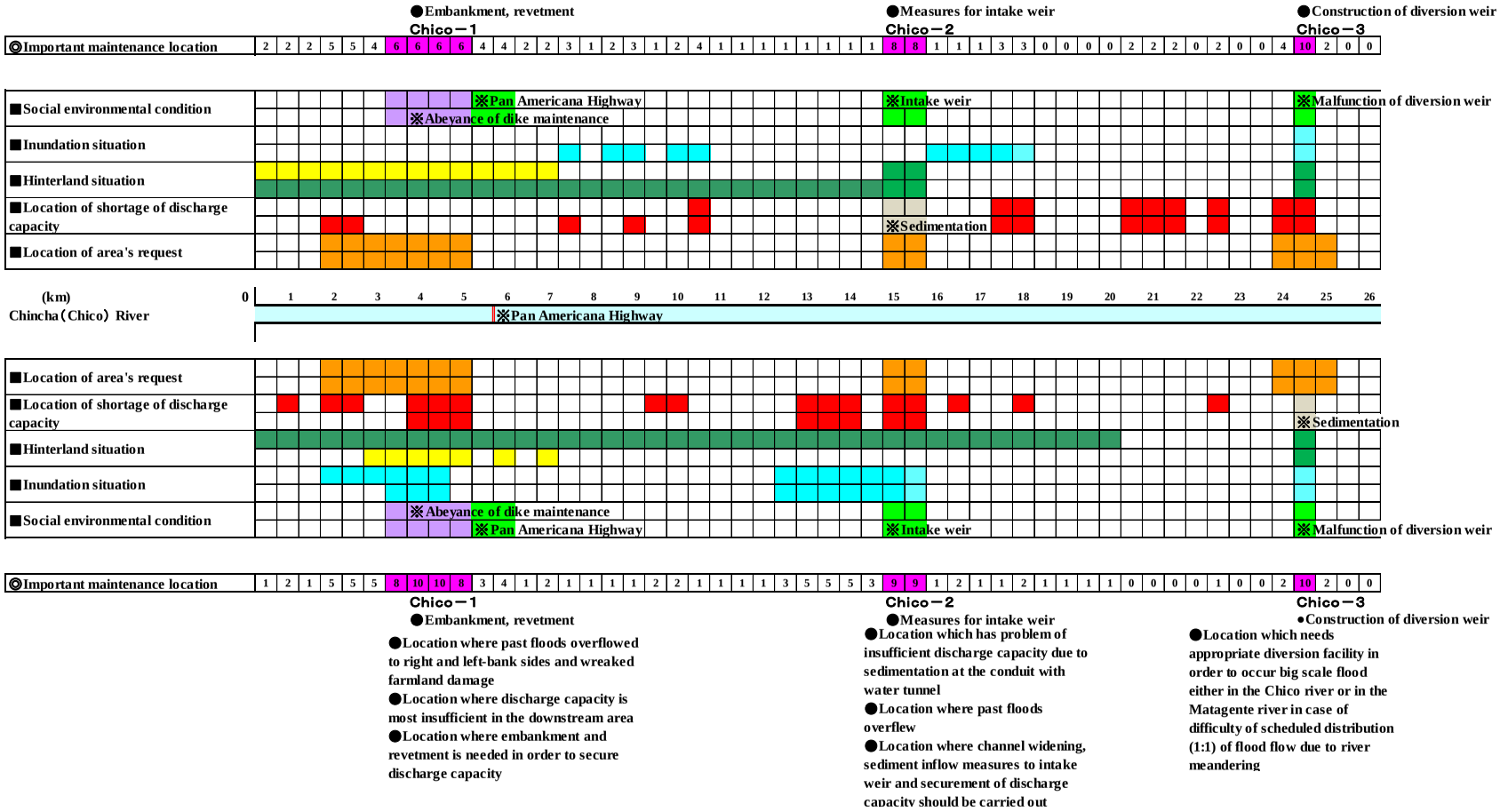


Figure 5.3 **Selection of High Priority Improvement Facilities in the Chincha (Chico) River**

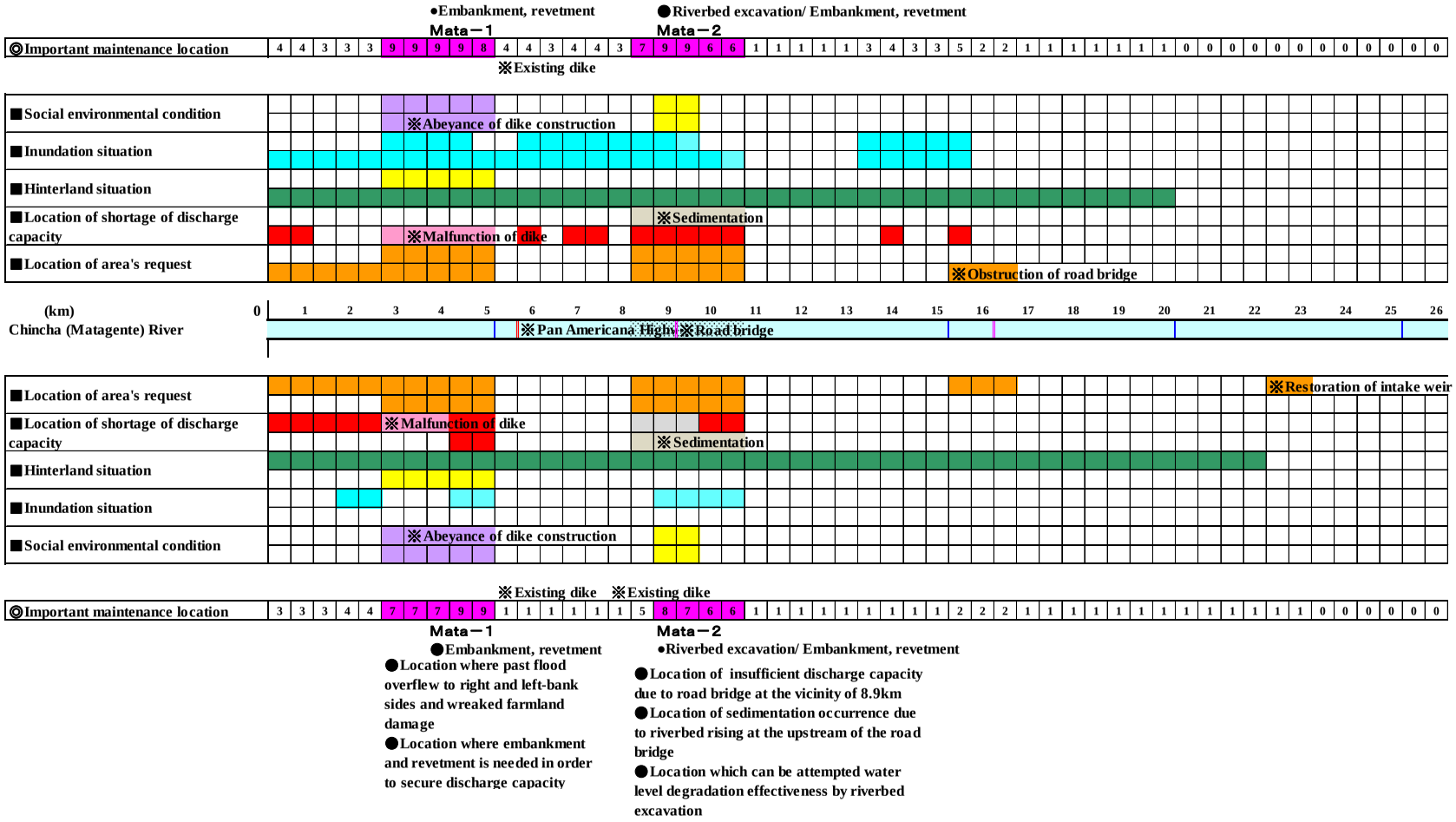


Figure 5.4 **Selection of High Priority Improvement Facilities in the Chincha (Matagente) River**

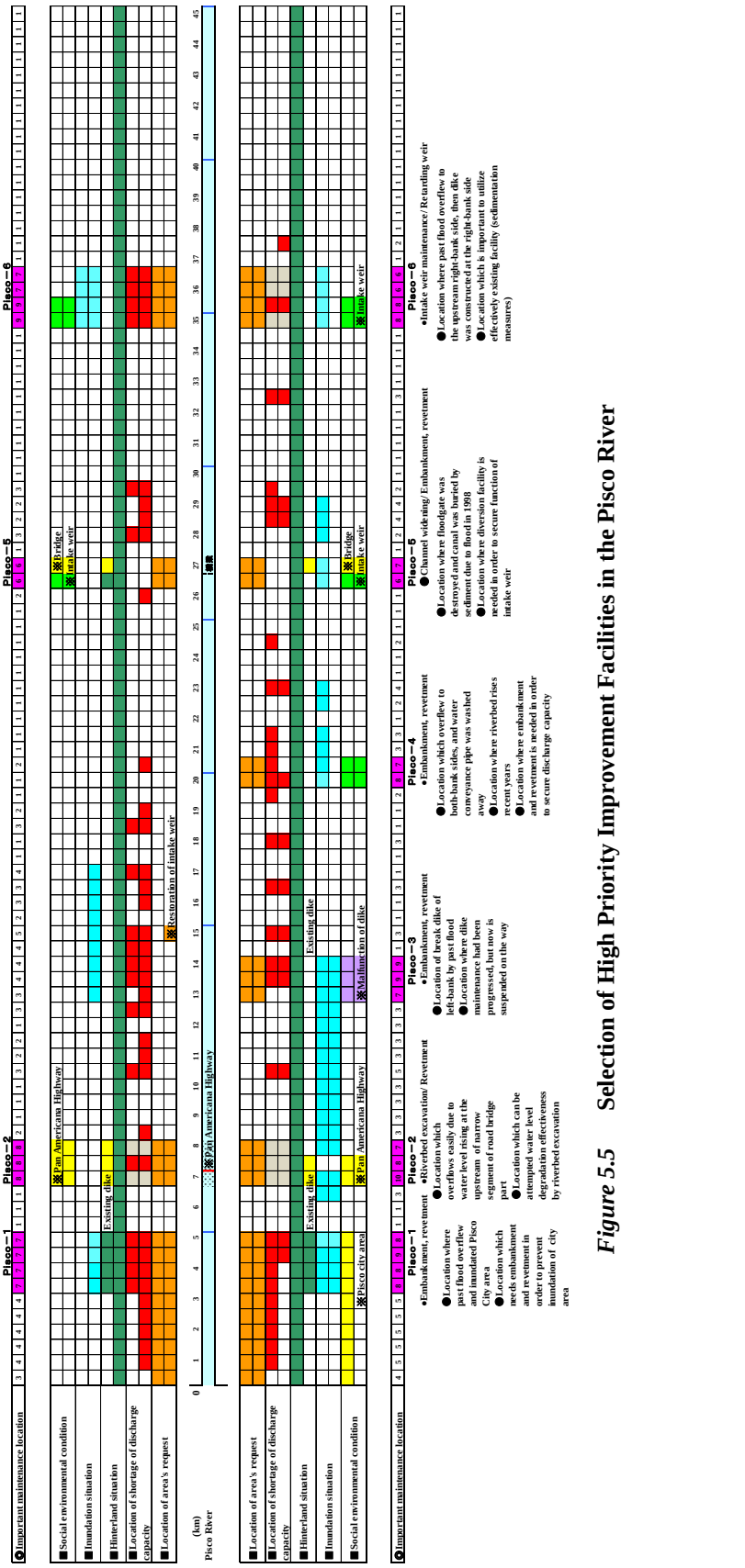


Figure 5.5 **Selection of High Priority Improvement Facilities in the Pisco River**

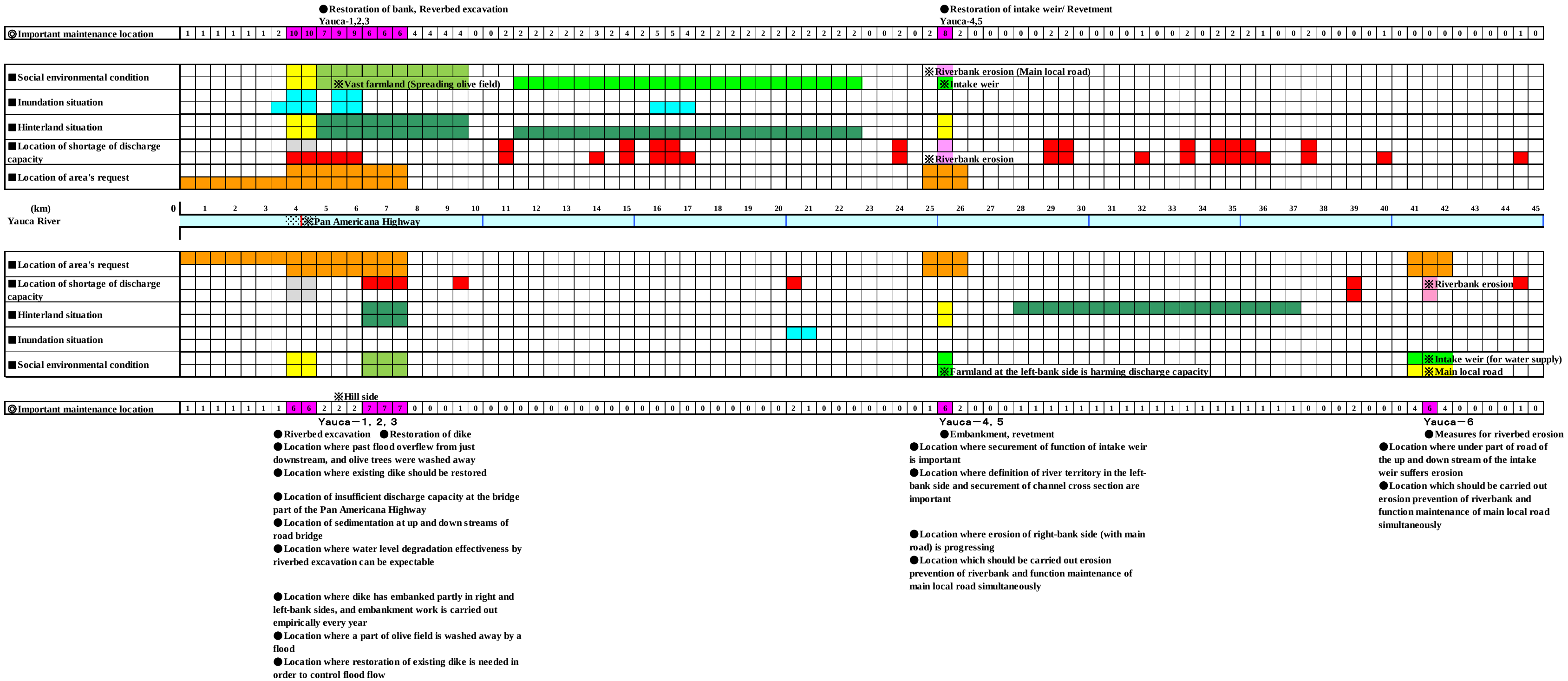


Figure 5.6 **Selection of High Priority Improvement Facilities in the Yauca River**

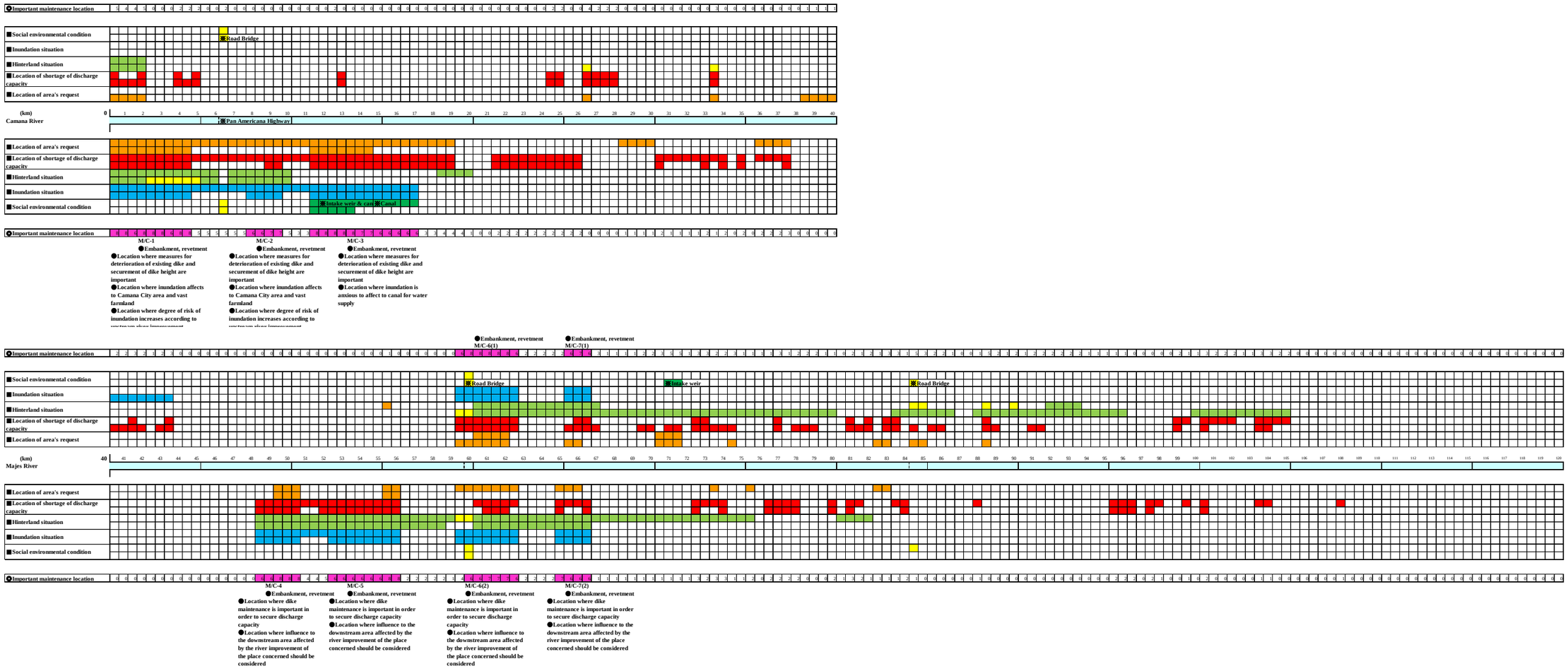


Figure 5.7 **Selection of High Priority Improvement Facilities in the Majes-Camana River**

5.1 River Improvement Plan in Chira River

<Overall plan>

Since the discharge capacity is insufficient on the whole in the Chira River, flood water tend to overflows at all the points and flood flow spreads widely in the lowland along the river channel. In the Chira River , Poechos Dam has a role of flood control for small scaled floods, however, it cannot control for the scale exceeding the design probability of the dam operation, and make severe damages in downstream section.

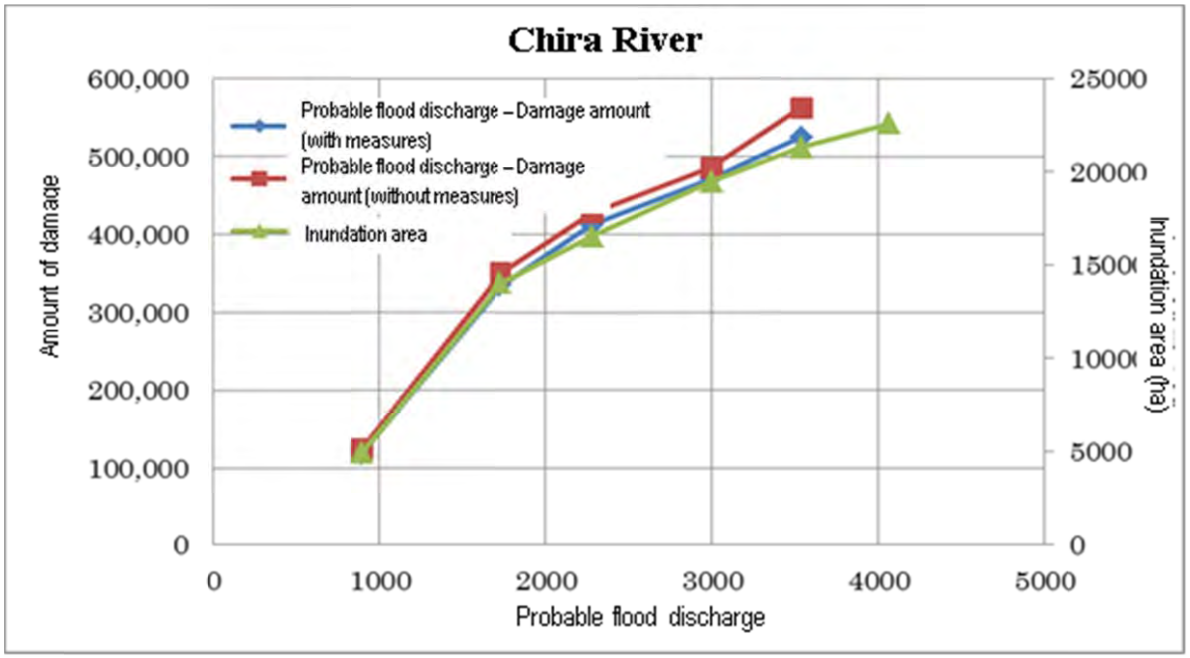
Fundamentally, it is important for the river improvement plan for floods in the Chira River to commence from the downstream section. For planning, these sections for improvement plan are selected by taking into account the situations of hinterland, the important infrastructures in the areas as well as protecting damaged areas in the past.

Table 5.2 **River Improvement Plan (Chira River)**

No.	Sections for Improvement	Explanation for Selection
(1)	0.0km～4.0km (Left-bank side)	This section is in the situation that the revetment works is not done, although the present dike is constructed, and the dike had scoring by the flood in 1998. Therefore, when flood continues over long period, erosion progresses and dike break occurs the important facilities (gas fields, farmlands, etc.) located in the hinterland will be damaged. Moreover, the sections which groin installed instead of revetment are also damaged. Although the groin has a function for turning of water course, taking into consideration on importance of infrastructures in the hinterland, revetment work shall be done in these sections. **<Characteristic of Sections for Improvement>** ● Sections where the dike received erosion by the flood in 1998 ● Sections which has the possibility that the dike receives erosion and collapses in case of large-scale flood due to no revetment. ● Sections which needs the revetment works for measures against erosion **<Protected Areas>** ○ Vast farmland and natural-gas field, etc. which spread in the left-bank side in the section for improvement **<Improvement Plan (How? / How much?)>** ▼ Existing bank shall be used effectively, the embankment works and the revetment works shall be carried out, and discharge capacity shall be secured, and the measures against bank erosion shall be also implemented. ▼ In order to protect the vast farmlands and gas fields, the facilities shall be designed in consideration of enduring against the discharge of about 3600m3/s (about 1/50 year probable flood scale) suffering damages at the time of El Nino in the past.
(2)	11.75km～ 12.75km (Right-bank side)	This section curves greatly, the right-bank is eroded remarkably, and the present channel is formed. When leave present situation as it is, there is very high possibility of collapse in local main roads located in the right-bank. Therefore, revetment works shall be done, and present channel shall be maintained as much as possible. Maintaining the storage effects by river channel, the planning for road shall be done. (In consideration of the impacts to the regional economy caused by road collapse). **<Characteristic of Sections for Improvement>** ● Sections where there is high danger of local main road collapsing by the

		dike erosion at the time of flood ● Sections which should carry out the erosion control of riverbank and the functional preservation for local main roads, simultaneously. **<Protected Areas>** ○ Local main roads located in the right-bank **<Improvement Plan (How? and How much?)>** ▼ Since the impact by collapsing of local main road is great, the safety level shall be ensured for the scale of occurrence of El Nino, etc. (about 1/50 year probable flood scale). ▼ Revetment works shall be done in sections eroded by disasters.
(3)	24.5km～27.0km (Right-bank side)	Sections where the right-bank side suffered serious damage by the past flood. The tentative dike with road combination has been constructed, and the maintenance which utilized this facility is important. By constructing the tentative dike with large width than usual, the retarding effects are enhanced, and the water level in the upstream is raise. In order to raising the safety factor in flood control plan in the Chira River , it is important to design many retention areas like these sections, and to lower the water level in the whole river. Since height of current tentative dike is not planned by designated design height, raise of bank shall be needed for the secure of retention function as much as possible against the floods. **<Characteristic of Sections for Improvement>** ● Sections where the dike had eroded by the flood in 1998 ● Sections which should use the present tentative dike effectively, should heighten the retention effect, and should plan the upstream water-level going down **<Protected Areas>** ○ Farmland in the right-bank in the planned sections **<Improvement Plan (How? and How much?)>** ▼ In order to protect the vast farmlands of the right-bank side, and to raise retention effect as much as possible, while utilizing the function of present tentative bank effectively, based on experiences which suffered damage from past El Nino, river improvement which does not suffer a great deal of damages even if El Nino occurs shall be done. ▼ By heightening the bank road improved after disaster, the discharge capacity and the retarding effect shall be secured.
(4)	64.0km～68.0km (Whole area)	Sections where the large-scale intake weir (Sullana Weir) is constructed. In the present condition of Sullana Weir, sediment deposits and growth of trees are in progress in the upstream part of the right-bank of the fixed weir (spillway). Caused by influences, the left-bank side which is the opposite side is eroded. If it is neglected as it is, there is possibility that the growth of trees and the function of the sluicegate weir in the left-side bank will be spoiled. Therefore, from the viewpoint of importance of the weir and safety securement of the movable weir, removing the trees and sedimentation in the right-bank of the upstream part of the fixed weir is important in order to stabilize the flow regime at the time of flood, and also to maintain the facility. **<Characteristic of Sections for Improvement>** ● Sections where sediment accumulates and trees grow in the right-bank side in the upstream part of the intake weir ● Sections where the flood flow concentrates to the movable weir, and the erosion advances in left-bank side. **<Protected Areas>** ○ Intake weir (Sullana Weir) **<Improvement Plan (How? and How much?)>** ▼ Since the Sullana Weir has the most important roles as river facilities, and has the big influences when damaged by floods, this weir shall be

		designed to avoid severe damages. ▼ In order to secure the discharge capacity of the upstream of the Sulyana Weir, the trees thickly covered in the upper right-bank of the weir should be cut down, and sediment deposit shall be also dredged.



Damage amount of 1/2、1/5、1/10、1/25、1/50 year probable discharge
Inundation Area of 1/2、1/5、1/10、1/25、1/50、1/100 year probable discharge
Previous maximum discharge: 3600m3/s

According to increasing flood discharge, the amount of damage and the inundation areas are increasing. In these proposed improvement, the damage mitigation effects are low.

In the case of the improvement in the Chira River , the discharge capacity is insufficient at almost all sections. In order to reduce damage by floods, it is necessary to carry out river improvement (dike improvement, etc.) one by one from the downstream section.

As for the improvement plan, improvement with emphasis on the situation of hinterland and the protection of important infrastructures shall be carried out.

5.2 River Improvement Plan in Canete River

<Overall Plan>

In the Canete River , main bridges and intake weirs are located in narrow areas, and it tends to occur inundation just upstream of each narrow area. Additionally, as characteristic of inundation, although inundation remains within the farmland along the river channel in the upstream section from the 10km distance mark, whereas the flood flow spreads greatly especially in the right-bank side in the downstream section from the 10km distance mark, and damages by flow is to be large.

Therefore, the river plans to be carried out in Canet River are the securement of discharge capacity in narrow areas and embankment/revetment works in the downstream from 10km mark where the damage potential is to be large.

In addition, discharge of the Canete River is rich and this river is close to the capital Lima, the tourist resorts are formed in the upstream areas. The protected plans (measures for bank erosion) for the important main roads as access to the upstream area are also selected from a viewpoint of effects in regional economy.

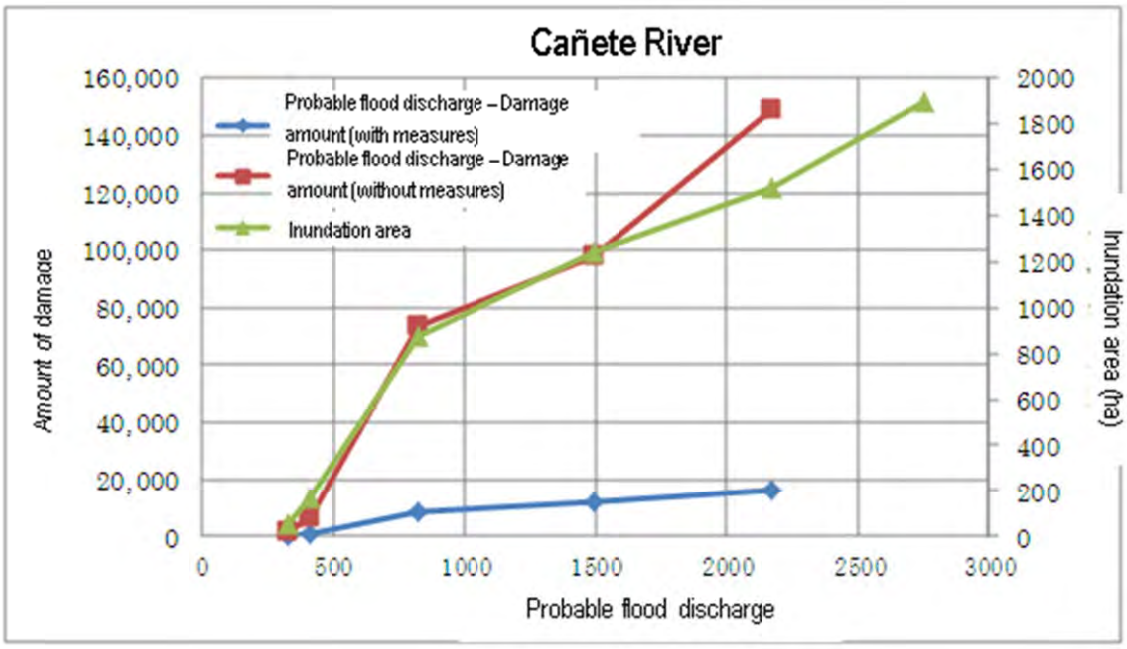
As for road bridge located in the narrow area of Pan American Road, the renewal was also considered, however, the traffic volume is very large and a substitute bridge and approach roads are needed, so that the project cost become huge. Through the meetings on renewal of bridge, DGIH replied that it was difficult to construct new bridge. Renewal plan of bridge is excluded from river improvement plan.

Table 5.3 **River Improvement Plan (Canete River)**

No	Sections for Improvement	Explanation for Selection
(1)	4.0km～5.0km (Right-bank side) ＋ (Riverbed excavation in a part)	The road bridge of the Pan Americana which travels through the South American Continent exists in the sections. The narrow areas is existed and it is one of the section with the most low discharge capacity in the downstream of the Canete River . (Sections with remarkably insufficient discharge capacity in the downstream from 10km mark are this section and 6.5-8.5km section (right-and-left side bank) described in (2)) In the El Nino Flood in 1998, the riverbed aggradation occurred in the upper part and flood damage was occurred. Since the renewal of the bridge, etc. is judged to be impossible as the present stage, it is important to heighten the dike of the right-bank side to secure the discharge capacity by riverbed excavation near the bridge. **<Characteristic of Sections for Improvement>** ●Narrow area (bridge section) and one of sections with the most insufficient discharge capacity in the Canete River ●Sections which accumulates sediment in upstream according to the riverbed aggradation by narrow segment, and is promoting the flood of the upstream ●Sections which can be planned in the water-level reduction effect of the upstream part by securing the discharge capacity by riverbed excavation **＜Protected Areas＞** ○The vast farmland and dwelling areas which spread in downstream from the sections for improvement **<Improvement Plan >** ▼A flood will begin at 1/10 year probable discharge scale, and damage will become serious at the 1/50 year probable discharge scale. For this reasons, the facilities which can flow down the discharge of 1/50 year probable flood scale are improved. ▼While the existing dikes are used, the maintenance of the embankment of dike and the revetment in the right bank with insufficient height, and the riverbed excavation are adopted in order to secure the discharge capacity.

(2)	6.5km～8.1km (Right-bank side) + (Left-bank side)	The right bank of this section is damaged by bank erosion at the flood in the past, the bank collapsed, and great damage generated. Moreover, since this section is insufficient for discharge capacity, embankment/ revetment works as measures for bank erosion is required. In downstream from 10km, the flood flow spreads greatly especially in the right-bank side, and the damage becomes large. In left-bank side, the flood does not spread more greatly than the right-bank side, and the flood water expands limitedly to surrounding farmland. (The inundation area is wider than the upstream section) **< Characteristic of Sections for Improvement >** ● Sections where the discharge capacity is most insufficient in the downstream of the Canete River ● Sections where the flow velocity of flood flow is high, the riverbank is eroded, the dikes collapse, and the river overflows ● Sections where the measures for bank erosion, embankment/ revetment works for securement of discharge capacity are required **< Protected Areas >** ○ Farmland which spreads in the right-and-left bank side **< Improvement Plan >** ▼ Flood will start at 1/10 year probable discharge scale, and damage will become serious to the 1/50 year probable discharge scale. For this reason, the river plan which can flow down the discharge of 1/50 year probable flood scale is adopted. ▼ In order to secure the discharge capacity, using the existing dike, the embankment and the revetment works are carried out (effective use of the existing bank in the right-bank side).
(3)	10.0km～11.0km (Channel widening in the left-bank side)	The intake weir currently existing in this section forms the narrow area, and makes water level in the upstream area goes up at the time of flood, and causes damage. In addition, the damage to farmland is most expanded in the upstream area from this section (10km mark). Therefore, in order to secure the discharge capacity, the channel widening and the riverbed excavation, etc. are required. Moreover, the effectiveness of increasing discharge capacity in the upstream can also be expected by excavation of the channel and lowering the water level in the channel. **<Characteristic of Sections for Improvement>** ●Sections to be protected for intake weir ●Sections which is narrow area compared with the up-and-down streams and has insufficient discharge capacity ●Sections which can be planned in the effect of water-level reduction in upstream when channel excavation is carried out **<Protected Areas>** ○Intake weir ○Farmland which spreads in the left-bank side of the sections for Iimprovement **<Improvement Plan >** ▼Intake weir is the most important facility in the river, and the influence affected to the area is serious in case of damaged by floods. For this reason, the safety is ensured at the scale of El Nino, etc. (1/50 year probable flood scale) occurs. ▼River channel is widened, and it is devised so that flood flow may not concentrate near the intake weir.

(4)	24.25km ～24.75km (Channel widening in the left-bank side)	The intake weir is installed in the sections. A lot of sediment deposited by the past El Nino flood, and the intake did not functioned during one month or more. Since sediment by floods has accumulated still now, and it is in the situation that the intake weir functions barely by maintenances such as excavation. When a large-scale flood is generated in the future, the function of the intake weir is lost, it is anxious about the great adverse effect to related farmland etc. Therefore, improvement of the diversion facility for proper discharge distribution is very important. **<Characteristic of Sections for Improvement>** ●The sections which needs the measures for sediment inflow in intake weir **<Protected Areas>** ○Intake weir **<Improvement Plan (How? / How much?)>** ▼Since the intake weir is the most important facility in the river, and the influence affected to the area in case of no operation of the facility function is serious. safety is ensured for the scale when El Nino, etc. (1/ 50 year probable scale) occurs. ▼River improvement by taking into the current characteristics of river is carried out.
(5)	24.75km ～26.5km (Right-bank side)	In the sections concerned, bank erosion is processing caused by flood flow and the influence of erosion has reached even near the local main road. If it is neglected as it is, road will be collapsed and impacts in regional economy will be large (especially for tourist industry), the measures for erosion should be implemented immediately. **<Characteristic of Sections for Improvement>** ●Sections with high possibility that the local main road will collapse by bank erosion ●Sections which should carry out erosion control for riverbank and functional preservation for the local main road, simultaneously. **<Protected Areas>** ○The local main road located in the right-bank **<Improvement Plan >** ▼Since the impacts to the regional economies is large, caused by collapsing in the local main road, the safety measures is ensured even if El Nino, etc. (1/50-year probable scale) is occurred. ▼Although improving only the road part is to be considered for improvement plan, it is anxious that the farmland in the right-bank side during flood is eroded because of locating in the low land area. Improvement with easy flowing for discharge is the key measures.



Damage amount of 1/2、1/5、1/10、1/25、1/50 year probable discharge
Inundation Area of 1/2、1/5、1/10、1/25、1/50、1/100 year probable discharge
Previous maximum discharge: 1000m3/s

When the discharge exceeds about 2000m^3/s, the amount of damage will go up remarkably, but the amount of damage will be greatly reduced by advancing the above-mentioned maintenance.

5.3 River Improvement Plan Cincha River

<Overall Plan>

Issue in the Chincha River is insufficient function to divert flood water the Chico River and the Matagente River in the upstream part. When flood water flow either river, the discharge capacity is insufficient in all sections both the Chico River and the Matagente River, and then the possibility of severe damage is high. Furthermore, even if the flow diverts toward the Chico River and the Matagente River with properly ratio such as 1:1, their river banks are still insufficient for design discharge. In Chico River, there are sections of overflow in the vicinity of 15km mark and 4km mark from the river mouth, and the flood flow tend to spread greatly in the left-bank side. In Matagente River, there are also sections of overflow in the vicinity of 9km mark and 3km mark from the river mouth, the flood flow tend to spread greatly in the right-bank. Therefore, the fundamental river improvement plan is the construction of the diversion weir and improvement for securement of discharge capacity by embankment and reverbed excavation in existing insufficient sections.

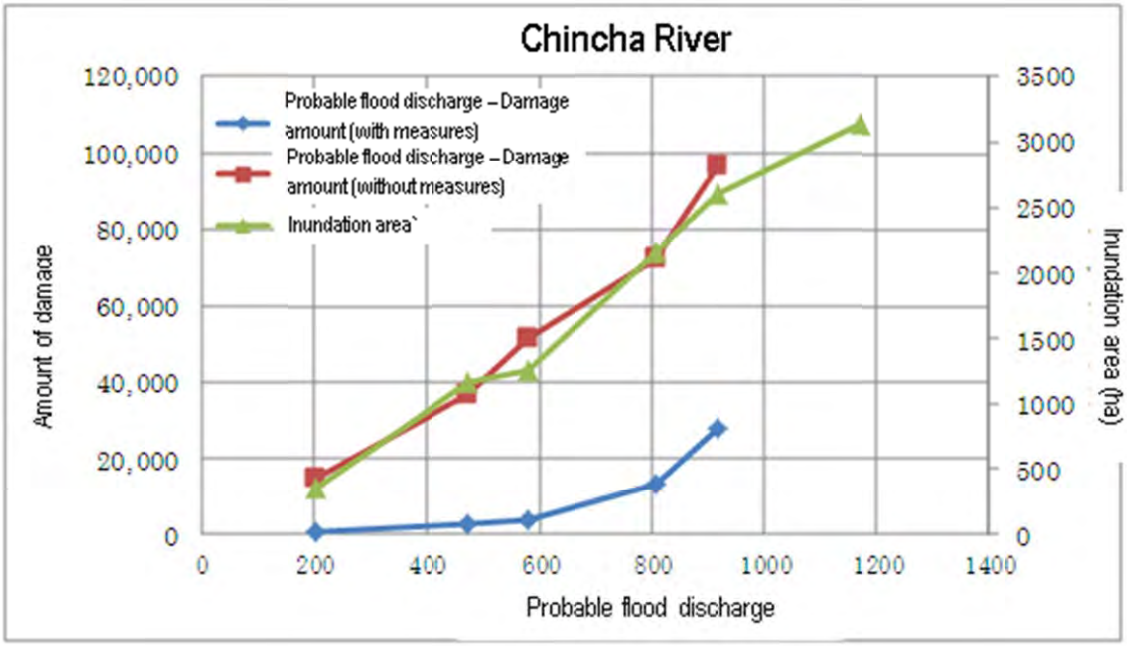
The proposed improvement plan for every section is arranged on the basis of the case that flood flow is distributed properly to both the Chico River and the Matagente River.

Table 5.4 **River Improvement Plan (Chincha River)**

No	Sections for Improvement	Explanation for Selection
(1)	**Chico River** 3.0km～5.1km (Right-bank side) + (Left-bank side)	Since Discharge capacity in the sections mentioned above is most small in the downstream of the Chico Rive, the embankment/ revetment works which prevents expansion of damages in the left bank is required. Moreover, in the case of improvement in the upstream section, it is thought that overflow also occurs and water expands in the right-bank side, the sections concerned needs the embankment in both banks. **<Characteristic of Sections for Improvement>** ●Sections where flood overflowed into the right-and-left both banks areas, and damaged to farmlands in the past. ●Although sections where partial embankments are done in the left bank currently, flood expand accompanied by improvement in the upstream. ●Sections where the discharge capacity is the most insufficient in the downstream **<Protected Areas>** ○Vast farmland which spreads in the right-and-left both sides (especially left side) **<Improvement Plan >** ▼Inundation starts at the scale of 1/10 year probable discharge, and damage occurs at the scale of the 1/50 year probable discharge seriously. For this reason, the river improvement which can flow down the discharge of 1/50 year probable flood is curried out. ▼Since the existing dike is improved partially, they are utilized effectively and the embankment and the revetment works which secures the discharge capacity are also carried out.
(2)	**Chico River** 14.8km～15.5km (Channel widening in left-bank side)	Sections where sedimentation of the vicinity of intake weir is remarkable and the discharge capacity is considerably insufficient. Therefore, the measures for sediment inflow around intake weir (construction of diversion weir with proper discharge distribution) and the securement of discharge capacity are adopted **<Characteristic of Sections for Improvement>** ●Sections overflowed by the past floods ●Sections in which the channel should be widen, and the measures against sediment inflow around intake weir and the increase of discharge capacity should be carried out. ●Sections which the sedimentation is in progress in the tunnel of irrigation channel **<Protected Areas>** ○Intake weir ○Farmland which spreads in the left-bank side **<Improvement Plan >** ▼Inundation starts at the scale of 1/10 year probable discharge, and damage occurs at the 1/50 year probable discharge. For this reason, the improvement which can flow down the discharge of 1/50 year probable flood is improved. ▼Channel width is widened, and it is devised so that flood flow may not concentrate around the intake weir.
(3)	**Chico River**	Sections which the Chico River divert to both the Matagente River and the Chincha River, and is the most important section from the view point of

	24.2km～24.5km (Whole section)	improvement. (Bases for the flood control plan) Although the old diversion weir built in 1954 exists, and facility is aged remarkable. When floods coming and it continues, flood flow moves to the upstream of the weir, and flows into either the Chico River or the Matagente River. Finally, distribution function becomes insufficient situation. Therefore, the construction of the new diversion weir which distributes flood flow to both the Chico River and the Matagente River properly is the integral measures from the view point of the flood control plan in the Chincha River . **<Characteristic of Sections for Improvement>** ●Due to meandering stream, in the case of which cannot distributed the discharge as designed ratio at 1:1, sections where there is possibility of large scale inundation occurrence in either the Chico River or the Matagente River so that suitable diversion facility is required. **<Protected Areas>** ○All the areas in the Chico River and the Matagente River (It brings serious damage in one river of the two when discharge distribution is not carried out properly) **<Improvement Plan >** ▼The facility which can distribute flood flow is improved.
(4)	**Matagente River** 2.5km～5.0km (Whole section)	Sections concerned is the past overflow point, and flood flow tend to spread greatly in the right-bank side. Moreover, since the embankment was made disorderly for rehabilitation by flood, it is thought that inundation will also occur and expand in the left-bank in case of upstream improvement. For this reason, the section concerned needs the embankment in both sides of bank. **<Characteristic of Sections for Improvement>** ●Sections where the discharge capacity is insufficient in the downstream ●Sections where it overflowed in both sides and serious damage caused to farmland etc. by past floods. ●Section where disorderly embankment was carried out **<Protected Areas>** ○Vast farmland which spreads in the right-and-left both sides in the sections for improvement (especially the right-bank side) **<Improvement Plan >** ▼Bank improvement and revetment woks and slope protection shall be done. ▼Inundation starts at the scale of 1/10 year probable discharge, and damage will become serious at the 1/50 year probable discharge. For this reason, the facility plan which can flow down the discharge of 1/50 year probable flood scale shall be adopted.
(5)	**Matagente River** 8.0km～10.5km (Whole section)	The sections concerned are damaged by the past floods. While the discharge capacity have been insufficient in the narrow area (at road bridge), the riverbed has risen by about 4-5m in the last 50 years. While the riverbed is excavated, and discharge capacity is enhance (taking into account the foundation at the road bridge), the embankment is needed in the both banks. **<Characteristic of Sections for Improvement>** ●Sections where discharge capacity is insufficient for the narrow area near 8.9km mark (road bridge) ●Sections where sediment have deposited in an upper part caused by riverbed aggradation by road bridge **<Protected Areas>** ○Vast farmland which spreads in both sides of the sections for improvement (especially the right-bank side) **<Improvement Plan >**

		▼Since the riverbed tend to rising, the channel excavation, which can expect the securement of discharge capacity of the area concerned and the water-level lowering effect in the upstream, shall be carried out. ▼Inundation will start at the scale of 1/10 year probable discharge, and damage will become serious at the scale of 1/50 year probable discharge. For this reason, the improvement plan which can flow down the discharge of 1/50 year probable flood shall be done.



Damage amount of 1/2、1/5、1/10、1/25、1/50 year probable discharge
Inundation Area of 1/2、1/5、1/10、1/25、1/50、1/100 year probable discharge
Previous maximum discharge: 1270m3/s

When the discharge exceeds about 900m3/s, the amount of damage will goes up sharply. Although the amount of damage is greatly reduced by advancing the above-mentioned improvement, the mitigation effectiveness for floods becomes weak.

5.4 River Improvement Plan in the Pisco River

<Overall Plan>

In the upstream section from 7km mark, the inundation flow spreads farmland along the channel due to low discharge capacity; however, inundation flow does not spread widely. On the other hand, in the downstream section from 7 km mark, flood flow spreads greatly in the left-bank side, and serious damage to be occurred occurs in the Pisco City. Therefore, for the improvement measures, the embankment in the downstream section of 7 km mark where the highest risks for overflowing is carried out, and the improvement works in low discharge capacity sections and bridge and diversion weir in the upstream section from 7km mark is also conducted.

As for road bridge located in the narrow area of Pan American Road, the renewal was also considered, however, the traffic volume is very large and a substitute bridge and approach roads are needed, so that the project cost become huge. Through the meetings on renewal of bridge, DGIH replied that it was difficult to construct new bridge. Renewal plan of bridge is excluded from river improvement plan.

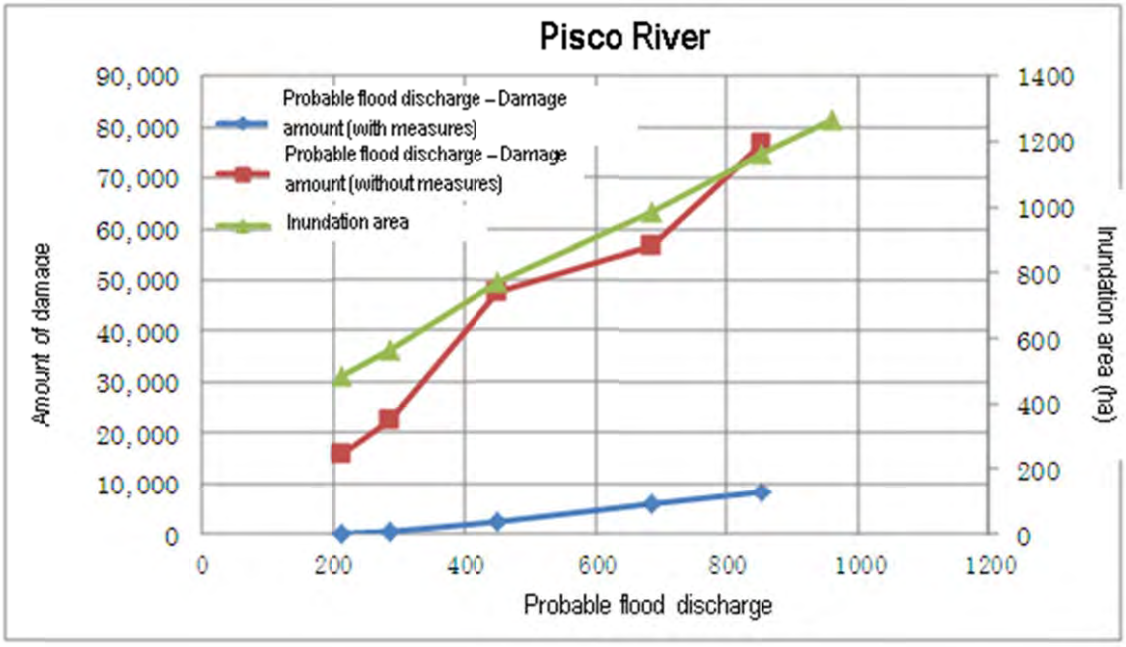
Table 5.5 **River Improvement Plan (Pisco River)**

No	Sections for Improvement	Explanation for Selection
(1)	3.0km～5.0km (Right-bank side) + (Left-bank side)	Sections concerned where the impacts to the regional economy should be considered in case of inundation flow reaches urban areas. Moreover, when the upstream section is improved, it is thought that flood also starts and expands in the right-bank side. Since it is meandering section, protection works for slope and foot of bank embankment shall be needed. For this reason, the embankment and the revetment in both sides are required. Moreover, it is also necessary to take notice that the existing dike near 5.0km-5.5km (right-and-left both sides). **<Characteristic of Sections for Improvement>** ●Sections where it overflows by flood in the past and the Pisco City area was inundated ●Sections which needs the embankment and the revetment in order to prevent the flood of the city area ●Sections where the flood also expands to the right-bank side by improvement of the upstream **<Protected Areas>** ○Vast farmland which spreads to the both sides of the sections for improvement ○Pisco city area of the left-bank side **<Improvement Plan >** ▼Inundation will begin at the scale of 1/10 year probable discharge, and damage will become serious at the scale of 1/50 year probable discharge. For this reason, the improvement plan which can flow down the discharge of 1/50 year probable flood scale shall be adopted. The improvement shall be done so that the damage does not occurs at 950m3/s (equivalent of 1/50 year probable discharge scale) which brought serious damage in the past. ▼The embankment and the revetment works shall be carried out in consideration of rover condition in upstream section as well as in downstream section.
(2)	6.5km～8.0km (Channel Excavation)	Section concerned is narrow areas locating road bridge and processing of sedimentation, and the discharge capacity is insufficient. The water level in the upstream section goes up by back water of bridge at the time of flood, and inundation is accelerated. Although improvement of the road bridge is proposed as one of the measures, it is difficult as the present stage (as mentioned above). Therefore, while carrying out channel excavation near the bridge, etc., and the discharge capacity is secured. Lowering water level is also expected. **<Characteristic of Sections for Improvement>** ●Sections where there is a narrow area (at the site of road bridge) and where the discharge capacity is low. ●Sections where riverbed aggradation is remarkable due to sediment deposition ●Sections which can be planned in the water-level lowering in the upstream by carrying out the channel excavation **<Protected Areas>**

		○The farmland in the left-bank side in the upstream section. **<Improvement Plan >** ▼Since inundation of the upstream tend to promote due to the shortage of the discharge capacity in the sections, the river facilities which can flow down the discharge of 1/50 year probable discharge scale shall be improved. The facilities is also improved so that the damage does not occurs in 950m3/s (equivalent of 1/50 year probable discharge scale) which brought serious damage in the past. ▼The sections concerned which secures the discharge capacity by the excavation of the channel without widening the road bridge (Pan Americana).
(3)	12.5km～14.0km (Left-bank side)	The section concerned has the lowest discharge capacity in the left-bank side, and the possibility of overflowing also in small-scale floods is remarkably high. Since there is high possibility of bringing damages to the farmland of the left-bank side, and causing serious damages by large-scale floods, it is necessary to construct the embankments and the revetments immediately. In addition, since the new embankment works near 14.5km -14.0km has already carried out, it is necessary to take enough attention for the works in transition section. **<Characteristic of Sections for Improvement>** ●Sections where the left bank broken by the past flood flow ●Sections where the bank improvement progressed in the past, but stops now on the way **<Protected Areas>** ○The left-bank side of the protected sections and the farmlands in the downstream **<Improvement Plan >** ▼Flood will begin at the scale of 1/10 year probable discharge, and damage will become serious at the 1/50 year probable discharge. For this reason, the improvement plan which can flow down the discharge of 1/50 year probable flood scale shall be done. ▼In order to enhance the discharge capacity, the embankment and the revetment works in the insufficient section shall be carried out efficiently by taking advantage of the existing dikes and land features.
(4)	19.5km～20.5km (Right-bank side)	In the sections concerned, the discharge capacity of the left-bank is the lowest in the circumference, and the possibility of overflowing by small-scale floods is very high. Since there is high possibility of bringing damage repeatedly to the farmland in the side of the left bank, and occurring serious damage by large-scale floods, it is necessary to improve the dikes and the revetments immediately. **<Characteristic of Sections for Improvement>** ●Sections where both banks were flooded due to no dikes, and the water conduit to the Pisco Sity was washed away. ●Sections where the riverbed has been rising in recent years ●Sections which needs the embankments and the revetments in order to improve the shortage of discharge capacity. **<Protected Areas>** ○Farmland in the left-bank in the protected area. ○Water conduit for Pisco City　(Important facility) **<Improvement Plan >** ▼Flood will begin at the scale of 1/10 year probable discharge, and damage will become serious at the scale of the 1/50 year probable discharge. For this reason, the facilities which can flow down the discharge of 1/50 year probable flood scale shall be introduced. Moreover, the protection of the water conduit to Pisco city area should be taken account.

		▼In order to enhance the discharge capacity, the embankment of the insufficient section in the dike sections shall be done with taking advantage of the existing dike, land features.
(5)	26.0km～27.0km (Channel widening in left-bank side)	Section concerned is important to protect the function of the intake facility. It is the sections where the sluice gate was destroyed by the past flood, sediment accumulated, and the irrigation canal also damaged with no operation. For this reason, at the 26.75km mark (at the upstream of the weir), it is necessary to construct the diversion weir which the flow water flows into the right-bank side at the time of low water level, and much flow water flows into the left-bank side at the time of floods. **<Characteristic of Sections for Improvement>** ●Sections where the sluice gate was destroyed by the flood in 1998, and the irrigation canal was also buried with sediment ●Sections which needs a diversion facility because of functional securement for intake weir. **<Protected Areas>** ○Intake weir in the right-bank side **<Improvement Plan >** ▼Weir is the most important facility for taking water, it is very serious in case that the facility function is damaged. For this reason, it is necessary to improve the facility so that the damage does not occurs at the scale of 950m3/s (equivalent of 1/50 year probable discharge) which brought serious damage in the past. ▼Since there are no existing dikes, in consideration of the current situations and the characteristics, the widening of the channel shall be carried out. (In the road bridge section in the channel shall be excavated)
(6)	34.5km～36.5km （Whole area）	Section at weir of the 34.5 km mark is narrow area, and great quantity of sediment has accumulated in the upstream. Therefore, it is important to devise so that the section concerned may be utilized effectively, and the upstream section at the weir may be used as retarding reservoir and sand pocket in order to demonstrate retarding effect at the time of the floods. While utilizing effectively the facility concerned against flood which exceeds the planned scale, the deposit function of sediment discharge shall be secured. Ideally, it is desirable to secure the safety factors at the scale of 1/50 year probable flood from the downstream section to upstream section by gradation. It is important, at present stage, to consider the effective use river facilities concerned so that the inundation water exceeding the designed scale (1/50 year probable flood scale) does not flow to downstream. section **<Characteristic of Sections for Improvement>** ●Overflow in the right-bank in the upstream of the weir ●Sections where effective use of the existing facility (sediment measures, etc.) is important **<Protected Areas>** ○The whole downstream areas **<Improvement Plan >** ▼Sections concerned locates in the upstream of the Pisco River , and is most suitable part for controlling the sediment and the flow water. Pisco River has the characteristics that the inundated area increases gradually whenever the discharge increases. When the discharge increases to the scale for 1/10 year probability flood, the amount of damage trends to increase greatly. When the discharge exceeded at the scale of 1/50 year, the amount of damage is thought to increase further. Therefore, considering the characteristics of the Pisco River , it is important to take measures against the excess flood more than the 1/50 year probable flood.

		Accordingly, when the flood more than the 1/50 year probable flood is generated, improvement which stores the excess volume of the flood flow water, and further improvement with the sediment storage function which does not discharge sediment to downstream immediately shall be done.



Damage amount of 1/2、1/5、1/10、1/25、1/50 year probable flood discharge
Inundation Area of 1/2、1/5、1/10、1/25、1/50、1/100 year probable flood discharge
Previous maximum discharge: 950m3/s

When the discharge exceeds about 800m3/s, the amount of damage will go up remarkably, but the amount of damage is greatly reduced by advancing the above-mentioned improvement. However, it is thought that serious damage occurs to the discharge of 900m3/s or more.

5.5 River Improvement Plan in the Yauca River

<Overall Plan>

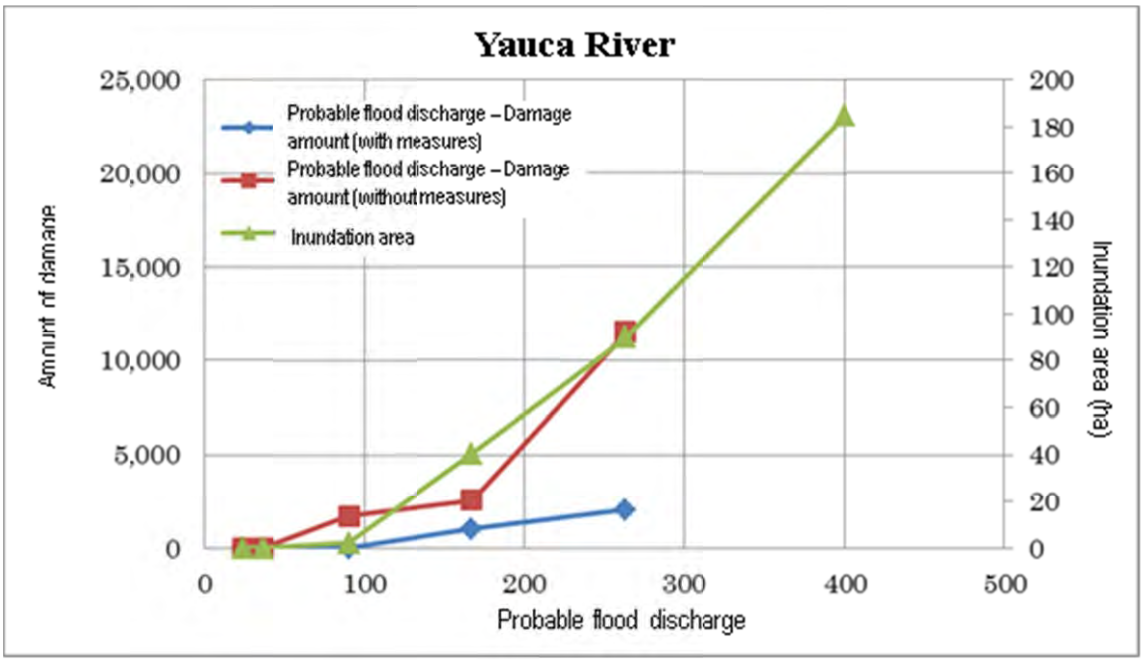
As the characteristics of the Yauca River , it overflows in the downstream section from near 7km mark of the river mouth, and flood flow tend to spread in the farmland of the right-bank side. Therefore, the measures for preventing the inundation to farmland in the downstream section from the 7km mark, and the countermeasures for the part affected to intake weir or local main road by bank erosion in the upstream section from 7km mark are implemented preferentially.

Table 5.6 **River Improvement Plan (Yauca River)**

No	Sections for Improvement	Explanation for Selection
(1)	3.5km～7.5km (Left-bank side)	On the existing dike located in the sections concerned, since erosion occurs at the time of floods and there is possibility of bank collapse, it is necessary to carry out restoration reinforcement and revetment works. **<Characteristic of Sections for Improvement>** ●Sections where the flood occurred in the downstream and the olive trees of the local specialty products washed away ●Sections where the existing dike has damaged and should be repaired **<Protected Areas>** ○Farmland of the right-bank side (Olive fields for the local specialty products) **<Improvement Plan >** Protected Areas in the river is olive fields which product of the local specialty of the area. Therefore, the revetment works with existing dikes for preventing the erosion affected by the past flood (1/50 year probable flood scale) shall be done.
(2)		It overflows in the downstream from near the 7km mark, and the inundation flow spreads in the farmland in the right-bank side. The securement of the discharge capacity near the road bridge is required. **<Characteristic of Sections for Improvement>** ●Sections which is the narrow area (near the road bridge) and is the insufficient part for the discharge capacity ●Sections which are riverbed aggradation caused by sediment deposition due to the narrow area. ●Sections where the water-level lowering effect in the upstream by carrying out channel excavation can be planned **<Protected Areas>** ○Farmland in the right-bank of the Improvement (Olive fields) **<Improvement Plan >** Considering on hydraulic balance in upstream and downstream section, channel excavation and securing the discharge capacity as well as the water-level lowering shall be planned.
(3)		It overflows in the downstream from near 7km mark, and the inundation flow spreads in the farmlands of the right-bank side. In the sections concerned, since the existing dike has the possibility of erosion at the time of flood, the improvement and the reinforcement of the existing dike, and the revetment work shall be required. **<Characteristic of Sections for Improvement>** ●The dike is located partially in the both sides. The sections where the embankment is carried out experientially every year ●Sections where olive fields are washed away with floods ●Sections where the existing dike has damaged and the repair is required **<Protected Areas>** ○Farmlands in the right-bank (Olive fields) **<Improvement Plan >** Protected Areas in the river is olive fields which product of the local specialty of the area. Therefore, the revetment works with existing dikes for preventing the erosion affected by the past flood (1/50 year probable flood scale) shall be done.
(4)	25.0km～25.7km (Whole area)	Intake weir is located in the right-bank side of the sections concerned. Since the private land in the left-bank side has stretched out into the river side largely, and the inundation flows directly come into intake weir. Intake weir becomes a difficult situation by sedimentation or damage of

		facility. Therefore, it is necessary to set the channel cross section in consideration of the flow regime of the river. **<Characteristic of Sections for Improvement>** ●Sections where functional in operation of the intake weir is prioritized. ●Sections where the clarification of river zone in the left-bank and the securement of flow capacity in channel cross section is important **<Protected Areas>** ○Intake weir **<Improvement Plan >** ▼It is the most important intake facility in the river, and the influence affected to the area is serious when the facility is destroyed. Therefore, the facility improvement shall be required so that damage does not occur at scale of 210m3/s (equivalent for 1/50 year probable flood) which brought damage in the past. ▼Sediment deposits in the intake weir of the sections concerned, and the intake is in difficult situation. Moreover, since the private land in the left-bank is stretched out into the river side largely and inundation water flows directly into the intake weir in the right-bank at the time of floods, the alignment of the river is set in consideration of the flow regime in the whole sections.
(5)		Section concerned is the meandering section, the flow velocity of the right-bank is high, and bank erosion is in progress. Local main road running in the right-bank of the upstream of the sections, and if it is neglected as it is, the riverbank will be eroded and finally the transportation of road. will become difficult situation. Therefore, in order to protect the road, the measures for erosion such as the revetment works, etc. are shall be required. **<Characteristic of Sections for Improvement>** ●Sections in which the erosion of right-bank side (local main road on the bank) in progress ●Sections which the erosion control of the riverbank and the functional preservation of the local main road should be carried out, simultaneously **<Protected Areas>** ○Main road located in the right-bank side in the sections **<Improvement Plan >** ▼Since the impact to the regional economy caused by the local main road collapsing is large, the facility shall be improved so that the damage does not generate in 210m3/s (equivalent for 1/50 year probable flood) which brought damage in the past. ▼If it is neglected as it is, it is anxious that the riverbank will be eroded and the road will collapse. The measure against erosion is implemented by the revetment works in order to protect the roads.
(6)	40.9km～41.3km (Left-bank side)	Intake located in the upstream of the Yauvca River is an important facility from the viewpoint of supply of city water. However, while the erosion in the left-bank side of the weir has progressed, transportation for the local main road located on the left-bank of the upstream has also interfered. Therefore, the measures against bank erosion of the sections concerned shall be immediately required. **<Characteristic of Sections for Improvement>** ●Sections where the lower part of the road located in upstream and downstream of the intake weir has received erosion ●Sections which the erosion control of the riverbank, and the functional preservation of the local main road should be carried out, simultaneously **<Protected Areas>** ○Intake weir ○Local main road located in the left-bank

		<Improvement Plan > ▼It is the most important intake in the river, and the influence affected to the area is serious when the facility function is damaged. Therefore, the facility improvement is required so that damage does not generate in 210m3/s (equivalent for 1/50 year probable flood) which brought damage in the past. ▼Since the intake weir is important to secure water supply, and there is high possibility that the local main road will collapse when the erosion in the left-bank side of the upstream of the weir progresses, the measures against bank erosion shall be implemented.



Damage amount of 1/2、1/5、1/10、1/25、1/50 year probable discharge
Inundation Area of 1/2、1/5、1/10、1/25、1/50、1/100 year probable discharge
Previous maximum discharge: 210m3/s

When the discharge exceeds about 250m3/s, the amount of damage will go up remarkably. But the amount of damage is greatly reduced by advancing the above-mentioned improvement. However, it is thought that the damage increase further for the discharge of 300m3/s or more.

5.6 River Improvement Plan in the Majes-Camana River

<Overall Plan>

Existing bank in the Camana River in the downstream is degraded, and many erosion parts appear there.

Since inundation occurs in the upstream (Majes River) at present, inundation in the targeted section (Camana River) is mitigated. If improvement of the upstream will progress from now on, the influence affected to the Camana River will become large, and the flood areas become large.

Moreover, the intake weir for water supply to the Camana City is installed near the 13km mark, and the irrigation canal run along the riverside. The part of the left bank of 12km is eroded now, and the influence on the adjoining irrigation canal is anxious. On the other hand, no dike sections are located in the Majes River in the upstream, the overflow by flood water and the farmland damage by flood have generated every year.

Therefore, improvement for aged dikes and the securement of the dike height is the key measures for the prevention in the left-bank side in the downstream of the Camana River where damage potential by flood is high. Bank improvement in the sections where damage occurs frequently due to no dikes in the upstream of the Majes River shall be carried out preferentially. In addition, since improvement in the Majes River also affects the Camana River in the downstream, it is necessary to consider the order of implementation measures, etc.

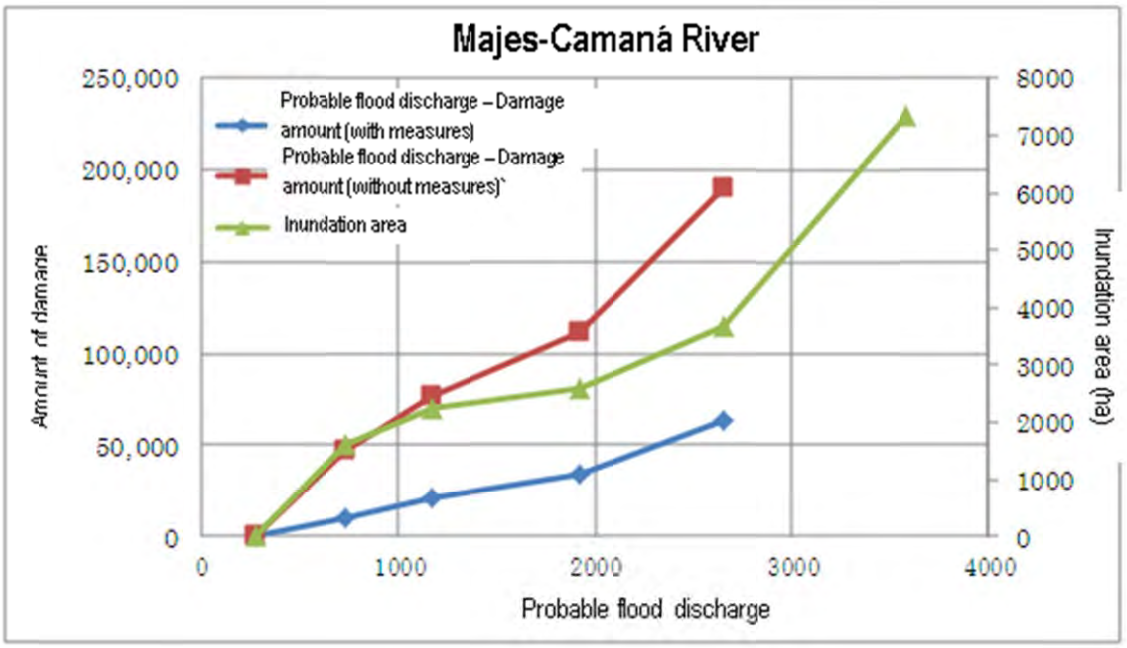
Table 5.7 **River Improvement Plan (Majes-Camana River)**

No	Sections for Improvement	Explanation for Selection
(1)	0.0km-4.5km (Left-bank side)	The existing dike in the sections concerned is superannuated and many erosion parts appear here and there. Since floods occurs in the upstream (in Majes River) at present, the flood of the area (in Camana River) is mitigated. When the improvement in the upstream will progress from now on, the influence by improvement in the area will become large and the inundated area will become large. **<Characteristic of Sections for Improvement>** ●Sections where the measures against aged existing dike and securement of dike height are important ●Sections which affects the influence to Camana City and vast farmlands by the flood in the left-side bank ●Sections where the danger of the flood increases accompanying with the improvement of the upstream **<Protected Areas>** ○Vast farmland which spreads in the left-bank ○Camana City area **<Improvement Plan >** ▼As the characteristics of the most downstream section in the Camana River , when the Majes River overflows, the flood damage is mitigated, but when improvement of the Majes River progresses, the damage in the left-side in the downstream is expanded greatly, and the influence will also reach the Camana City. Moreover, as the characteristics of the Camana River , when the flood exceeding the scale 1/50 year probable flood will be generated, the damage will become serious. Therefore, the facility should be designed to be safe for the flood of 1/50 year probable flood scale. ▼Embankment and the revetment works for the existing dikes in the sections where discharge capacity is insufficient shall be carried out.
(2)	7.5km-9.5km (Left-bank side)	The existing dike in the sections concerned is superannuated and many erosion parts appear here and there. Since floods occurs in the upstream (in Majes River) at present, the flood of the area (in Camana River) is mitigated. When the improvement in the upstream will progress from now on, the influence by improvement in the area will become large and the inundated area will become large. **<Characteristic of Sections for Improvement>** ●Sections where the measures against aged existing dike and securement

		of the dike height are important ●Sections which affects the influence on the Camana City area and vast farmland in the left-bank side by floods ●Sections where the danger of the flood increases accompanying with improvement in the upstream **<Protected Areas>** ○Vast farmland which spreads in the left-bank side of the Sections for Improvement ○Camana City area **<Improvement Plan >** ▼As the characteristics of the most downstream section in the Camana River , when the Majes River overflows, the flood damage is mitigated, but when improvement of the Majes River progresses, the damage in the left-side in the downstream is expanded greatly, and the influence will also reach the Camana City. Moreover, as the characteristics of the Camana River , when the flood exceeding the scale 1/50 year probable flood will be generated, the damage will become serious. Therefore, the facility should be designed to be safe for the flood of 1/50 year probable flood scale. ▼Embankment and the revetment works for the existing dikes in the sections where discharge capacity is insufficient shall be carried out
(3)	11.0km-17.0km (Left-bank side)	The existing dike of the sections concerned is superannuated and many erosion parts appear here and there. Moreover, the intake weir for water supply to the Camana city area is located near 13km, and the irrigation canal is built along the riverside. The riverbank of the left-bank side of 12km mark is eroded now, and the influence on the adjoining irrigation canal is anxious. **<Characteristic of Sections for Improvement>** ●Sections where the measures against superannuation of the existing dike and securement of the dike height are important ●Sections which brings serious damage to the water supply canal when it overflows **<Protected Areas>** ○The canal (for water supply) along the left bank of the Sections for Improvement **<Improvement Plan >** ▼As the characteristics of the most downstream section in the Camana River , when the Majes River overflows, the flood damage is mitigated, but when improvement of the Majes River progresses, the damage in the downstream is expanded greatly, and the influence will also reach to the channel for water supply. When the flood exceeding the scale 1/50 year probable flood will be generated, the damage for channel will become serious. Therefore, the facility should be designed to be safe for the flood of 1/50 year probable flood scale. ▼For enhancing the discharge capacity, embankment and the revetment works for the existing dikes in the sections where discharge capacity is insufficient shall be carried out
(4)	48.0km-50.5km (Left-bank side)	In the river concerned, it is one of the most insufficient sections for the discharge capacity. The overflow starts also at the time of small discharge, and as the flood scale becomes large, the damage is expanded. **<Characteristic of Sections for Improvement>** ●Sections where the securement of the discharge capacity and the dike improvement is important in order to protect the 2nd order farmland in the Majes area **<Protected Areas>** ○Farmland in the left-bank side (2nd order farmland in the Majes area: the

		maximum inundated area) **<Improvement Plan >** ▼Flood will begin at the scale of the discharge of the 1/5 year, and since the damage will become serious remarkably at the 1/50 year probable flood, the facility which can flow down the discharge with the 1/50 year probable flood scale shall be improved. ▼Embankment and the revetment works maintenance combining (4) and (5) shall be carried out, and the effectiveness of improvement shall be heightened.
(5)	52.0km-56.0km (Left-bank side)	It is one of the most insufficient section for the discharge capacity. The overflow starts also at the time of small flood discharge, and as the flood scale becomes large, the damage is expanded. In the flood in 1998, the area inundated, and the serious damage arose. **<Characteristic of Sections for Improvement>** ●Sections where the securement of the discharge capacity and the dike improvement is important in order to protect the 2nd order farmland in the Majes area **<Protected Areas>** ○Farmland in the left-bank side of the Sections for Improvement (the maximum inundated area) **<Improvement Plan >** ▼Flood will begin at the discharge of the 1/5 year probable flood, and since the damage will become serious remarkably at the 1/50 year probable flood, improvement which can flow down the discharge with the 1/50 year probable flood scale shall be done. ▼Embankment and the revetment works combining with (4) and (5) shall be carried out, and the effectiveness of improvement shall be heightened.
(6)	59.0km-62.5km (Right-bank side) 59.5km-62.5km (Left-bank side)	For a narrow segment, the discharge capacity is insufficient and flood damage has occurred frequently in the farmland of the upstream section. **<Characteristic of Sections for Improvement>** ●Sections where the securement of the discharge capacity and the dike improvement is important in order to protect the 1st order wide farmland in the Majes area **<Protected Areas>** ○Farmland in the left-bank side of the Sections for Improvement (the widest farmland in the Majes area) **<Improvement Plan >** ▼Flood will begin at the discharge of the 1/5 year probable flood, and since the damage will become serious remarkably at the 1/50 year probable flood, improvement which can flow down the discharge with the 1/50 year probable flood scale shall be done. ▼Embankment and the revetment works combining with (6) and (7) shall be carried out, and the effectiveness of improvement shall be heightened
(7)	65.0km-66.5km (Right-bank side) 64.5km-66.5km (Left-bank side)	In the river concerned, it is one of the most insufficient section for the discharge capacity. Overflow starts also at the time of small flood discharge, and as the flood scale becomes large, the damage is expanded. **<Characteristic of Sections for Improvement>** ●Farmland in the left-bank side of the Sections for Improvement (the widest farmland in the Majes area) **<Protected Areas>** ○Farmland in the left-bank side of the Sections for Improvement (the widest farmland in the Majes area) **<Improvement Plan >** ▼Flood will begin at the discharge of the 1/5 year probable flood, and since the damage will become serious remarkably at the 1/50 year

		probable flood, improvement which can flow down the discharge with the 1/50 year probable flood scale shall be done. ▼Embankment and the revetment works combining with (6) and (7) shall be carried out, and the effectiveness of improvement shall be heightened



Damage amount of 1/2、1/5、1/10、1/25、1/50 year probable flood discharge
Inundation Area of 1/2、1/5、1/10、1/25、1/50、1/100 year probable flood discharge
Previous maximum discharge: 2020m3/s

Although, when the discharge exceeds about 2000m^3/s, the amount of damage will go up remarkably, the amount of damage is greatly mitigated by advancing the above-mentioned maintenance. However, it is thought that the serious damage occurs in case of the discharge of 3000m3/s or more.

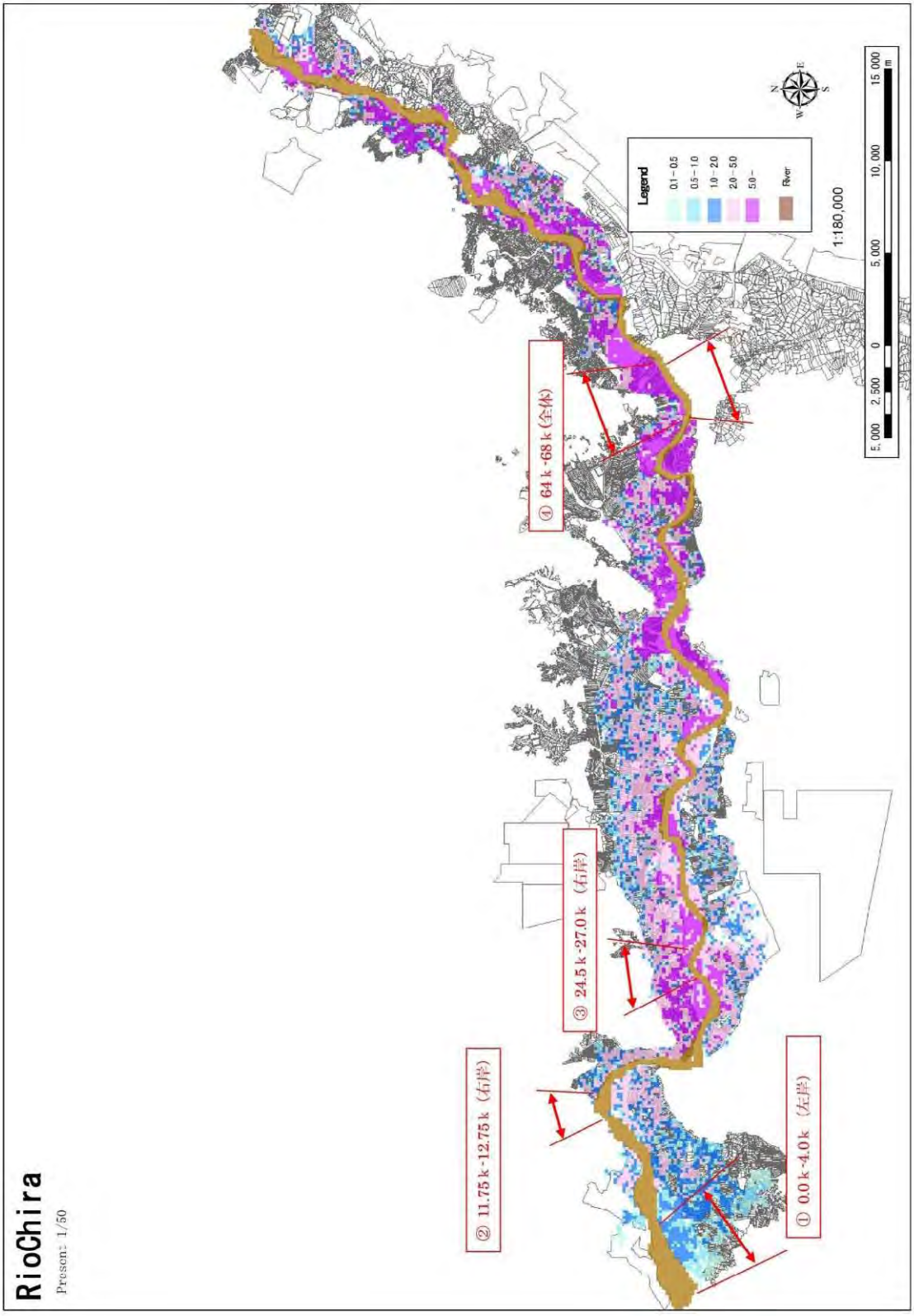


Figure 5.8 **Locations for River Improvement Facilities (Chira River)**

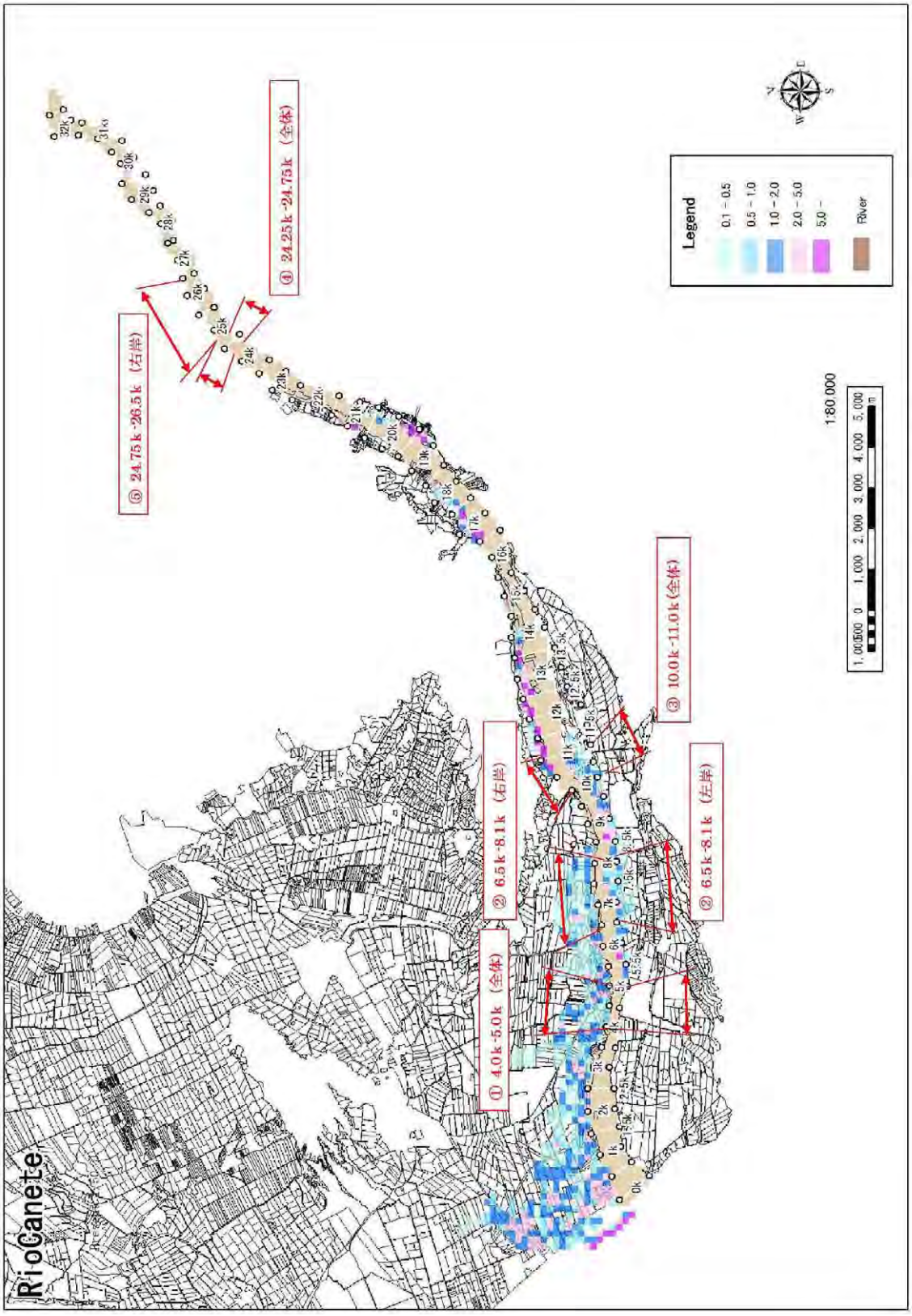


Figure 5.9 **Locations for River Improvement Facilities (Canete River)**

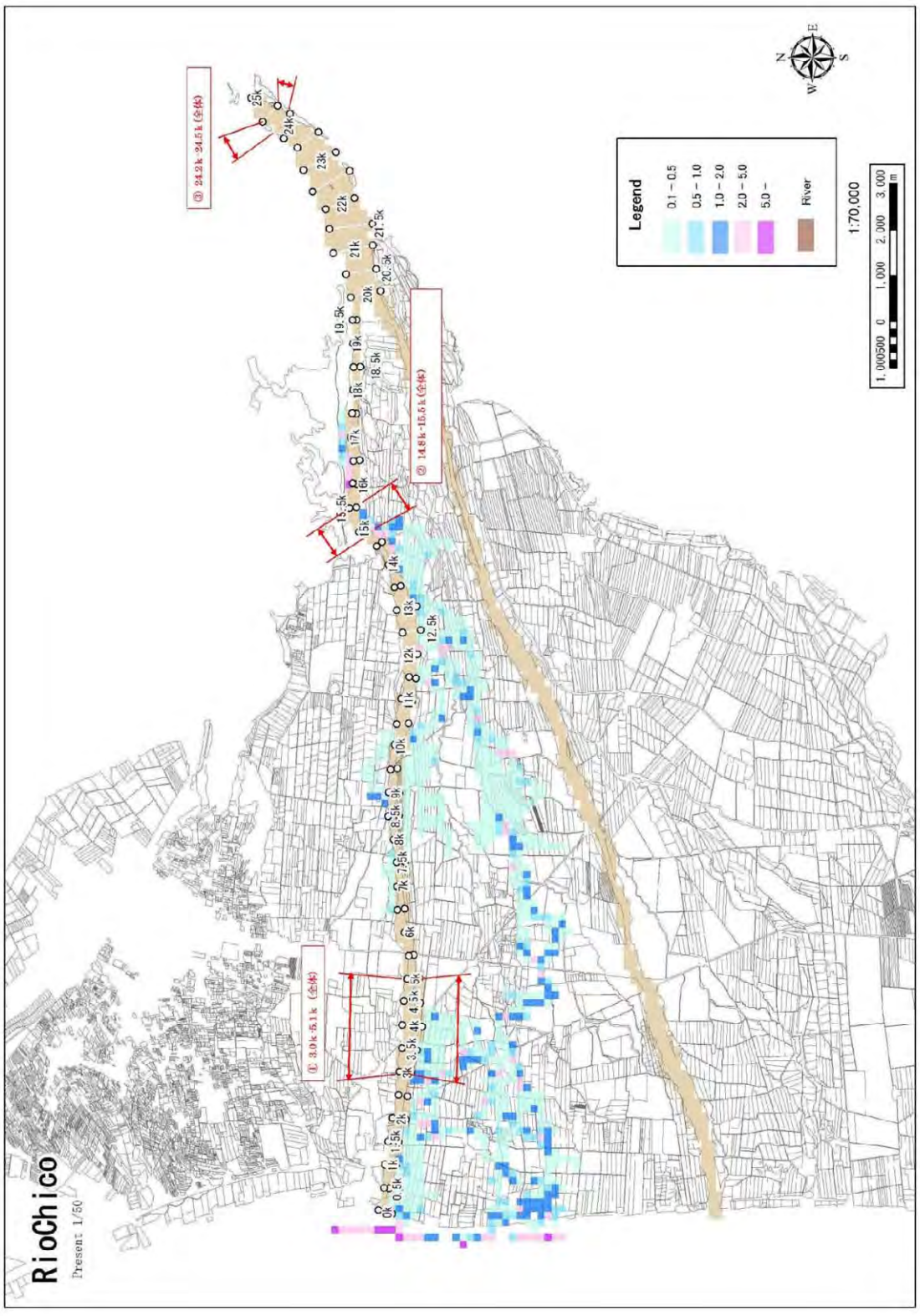


Figure 5.10 **Locations for River Improvement Facilities (Chico River)**

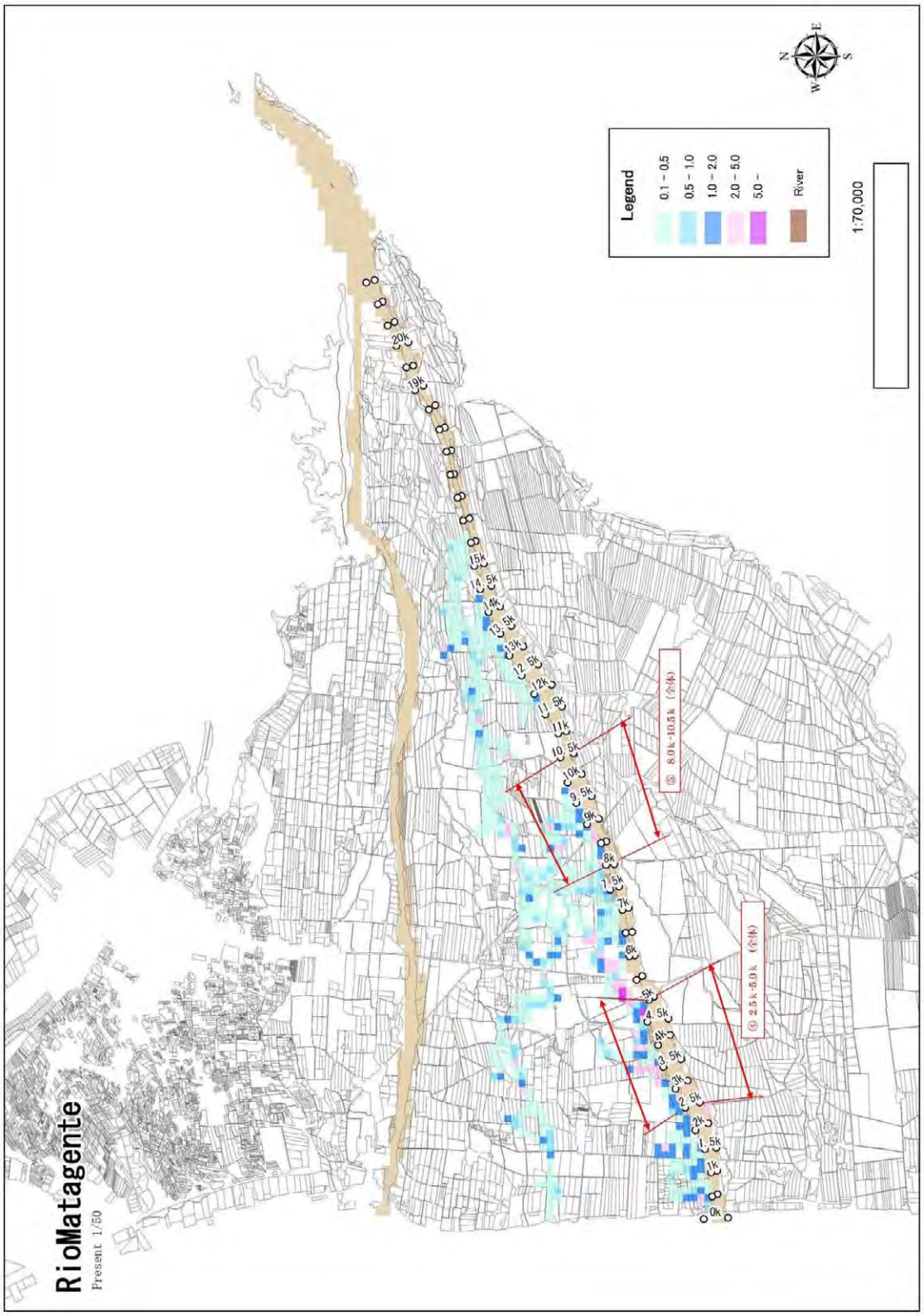


Figure 5.11 **Locations for River Improvement Facilities (Matagente River)**

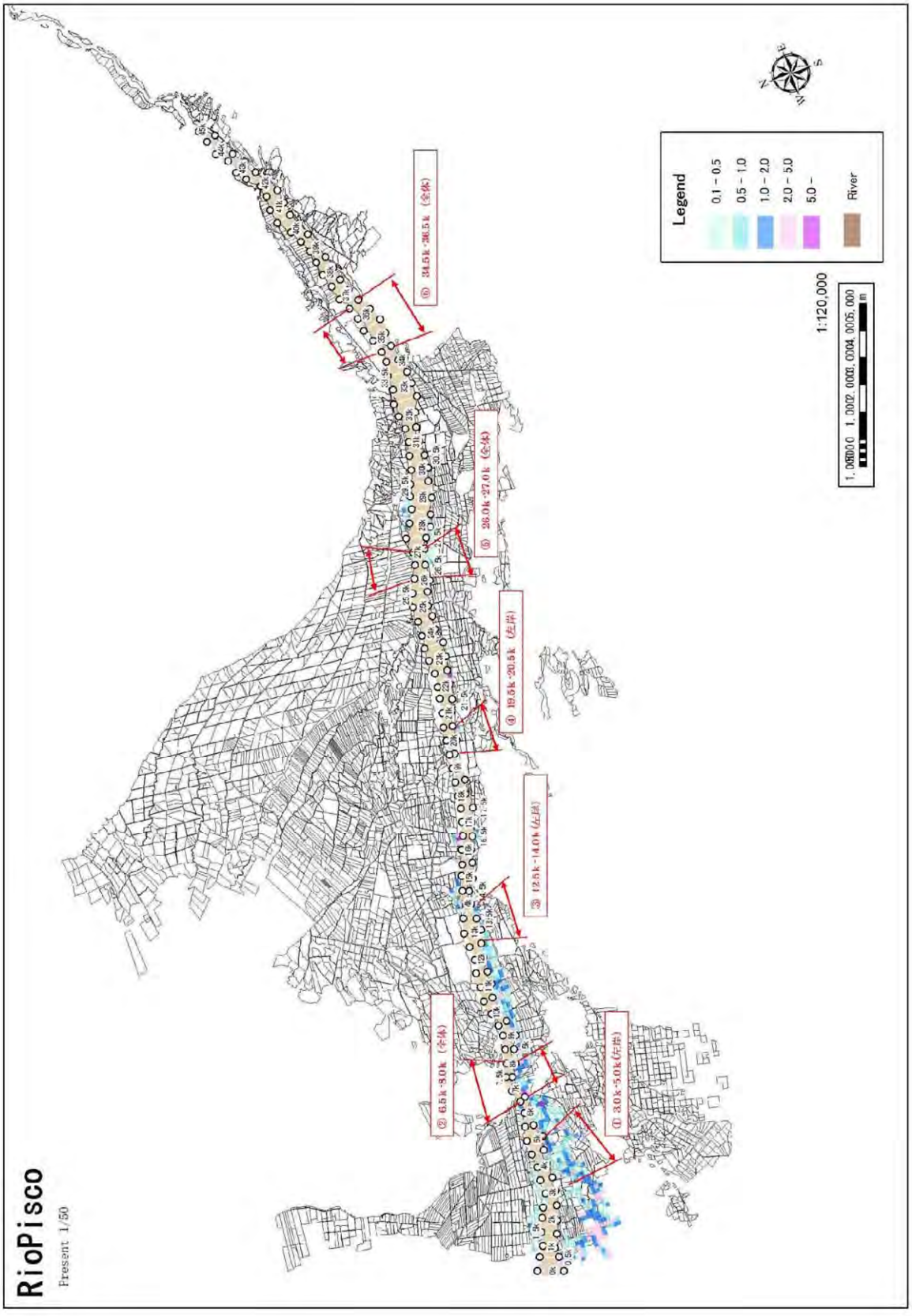


Figure 5.12 **Locations for River Improvement Facilities (Pisco River)**

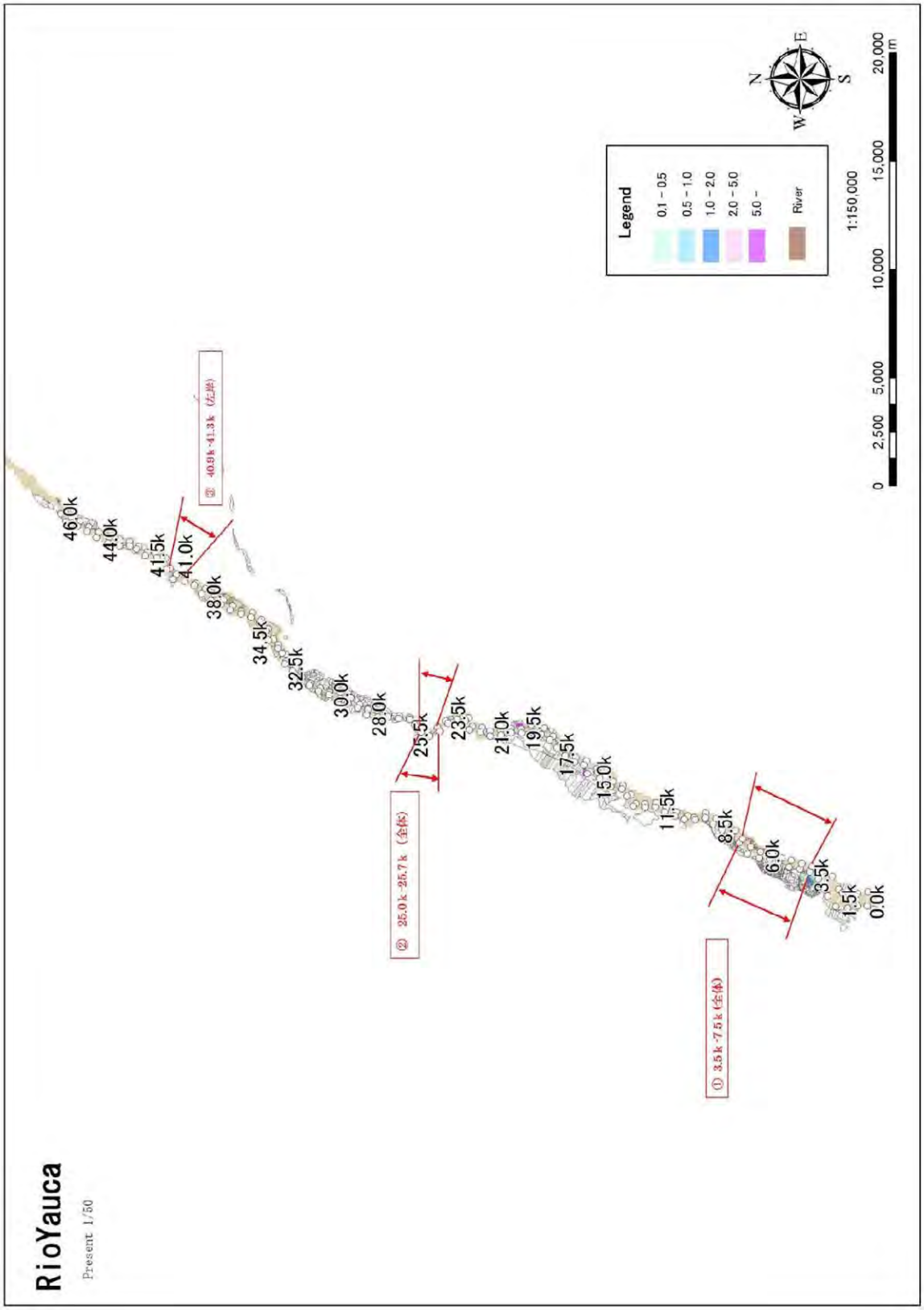


Figure 5.13 **Locations for River Improvement Facilities (Yauca River)**

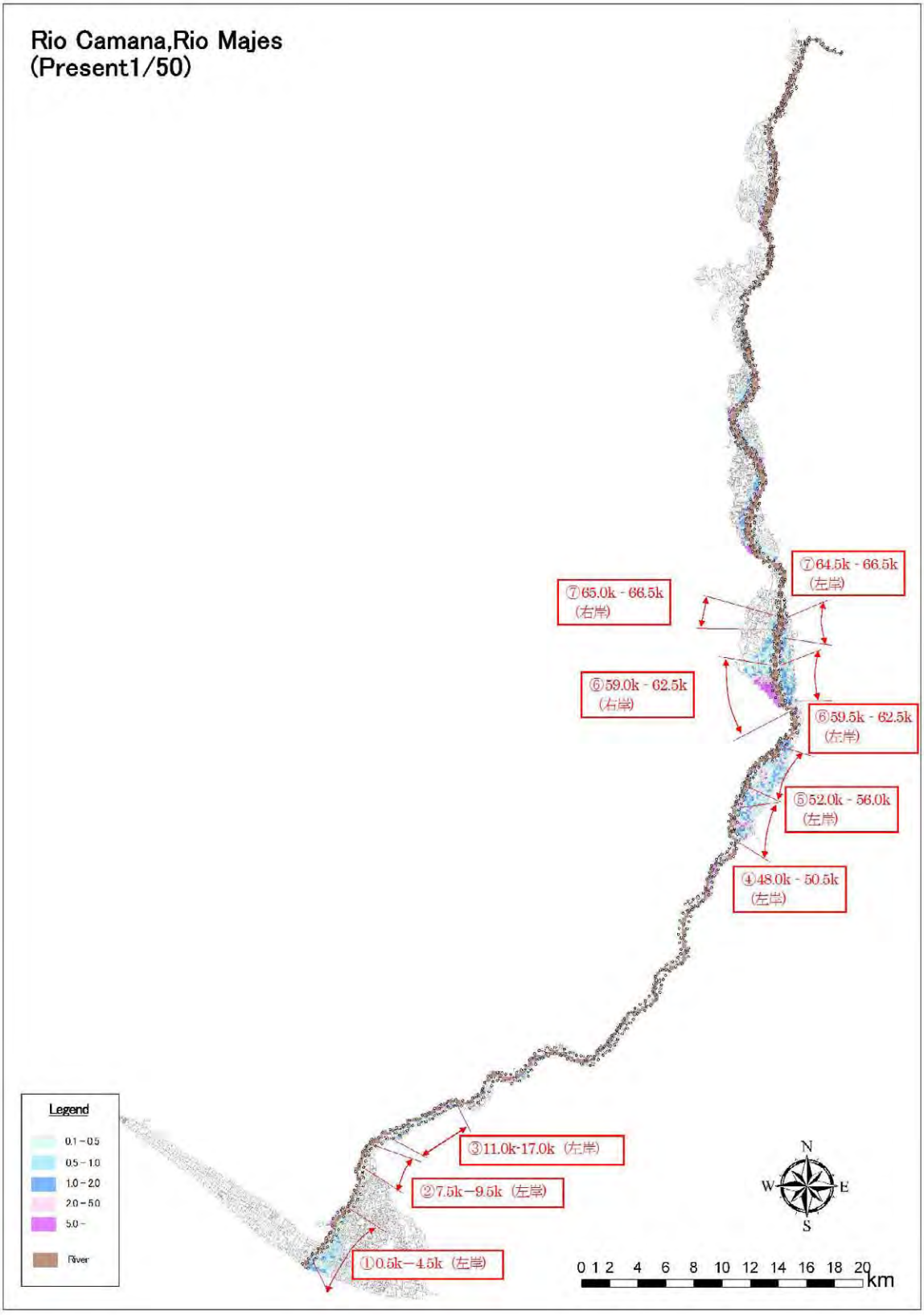


Figure 5.14 **Locations for River Improvement Facilities (Majes-Camana River)**

CHAPTER 6 MITIGATION EFFECTS BY RIVER IMPROVEMENT

By construction of river facilities for flood mitigation, the discharge capacity in each river is enhanced up to 1/50 year probable discharge. Mitigation effects for inundation by river improvement such as embankment, revetment works increase remarkably as shown in following Figures as shown in ***Figure 6.1*** to ***Figure 6.8***.

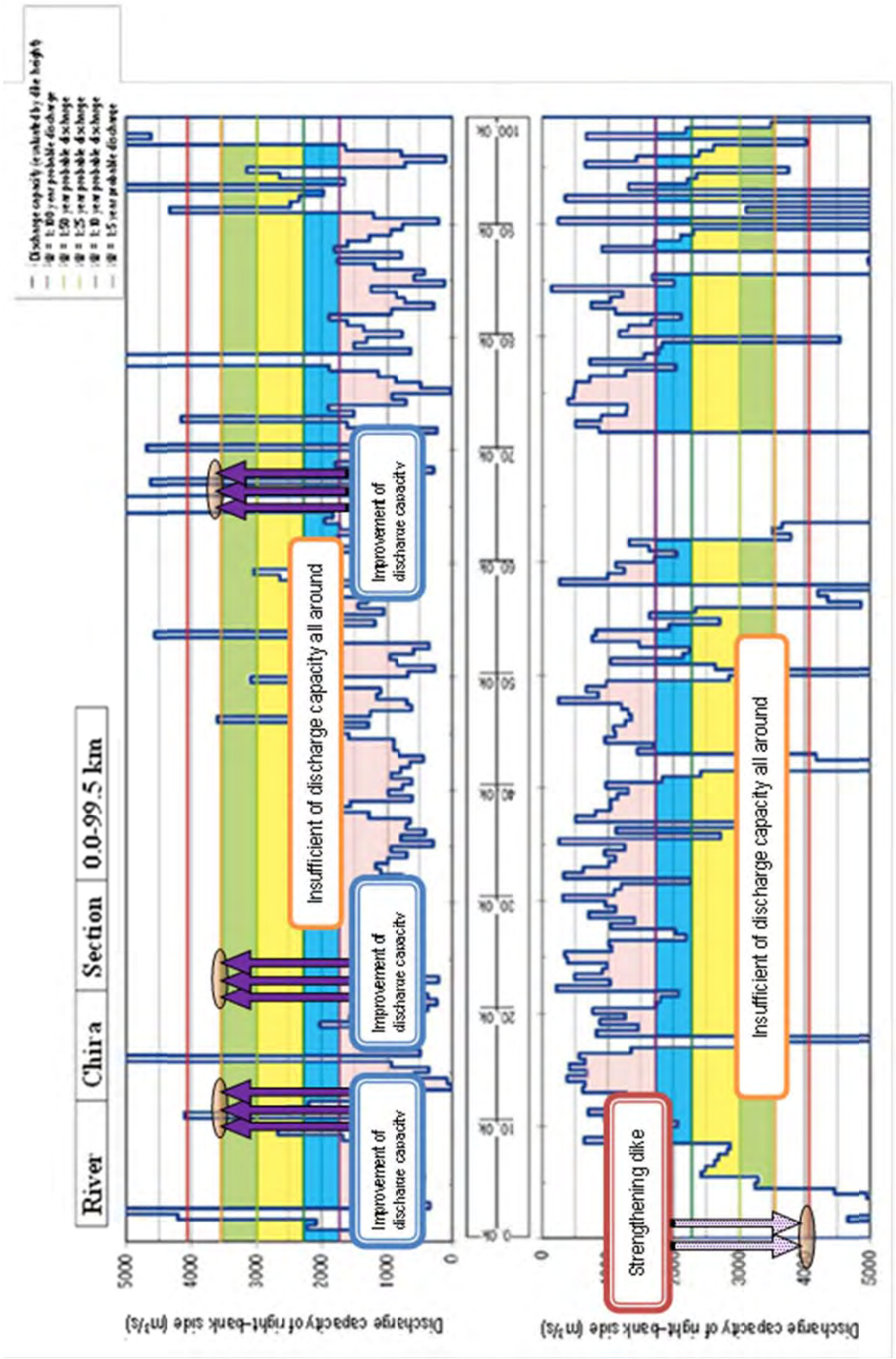


Figure 6.1 **Mitigation Effects for Inundation by Improvement (Chira River)**

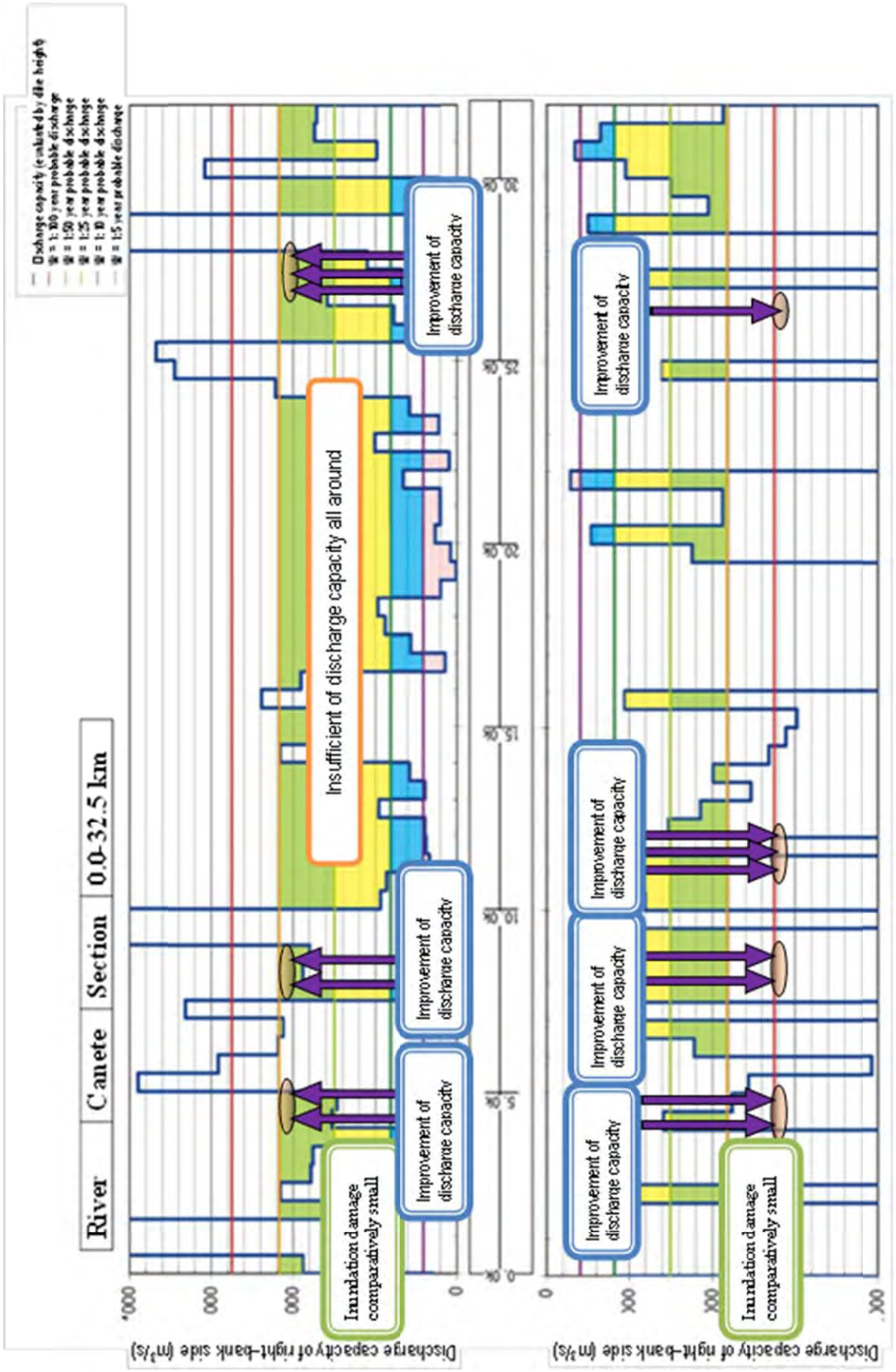


Figure 6.2 **Mitigation Effects for Inundation by Improvement (Canete River)**

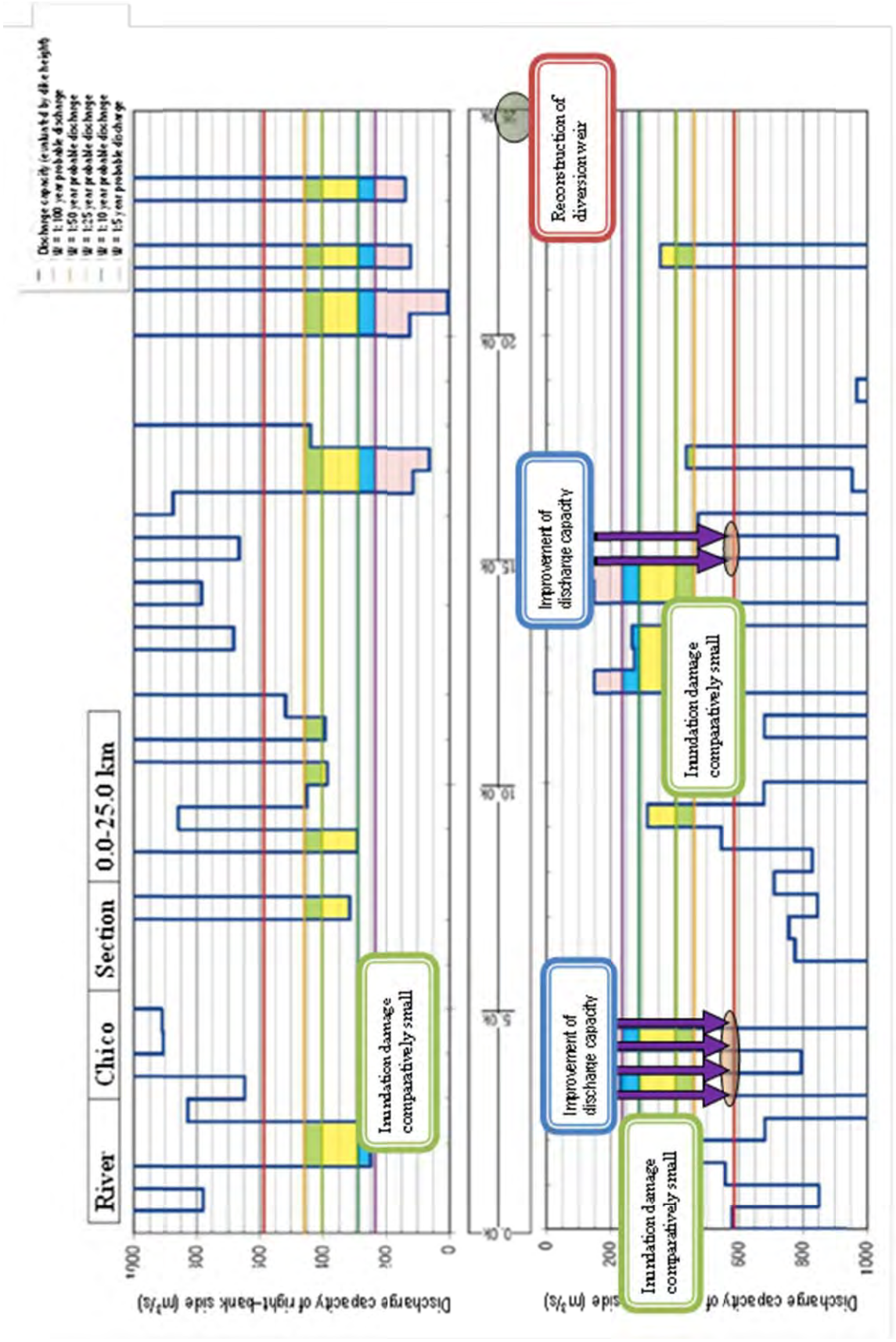


Figure 6.3 **Mitigation Effects for Inundation by Improvement (Chincha (Chico) River)**

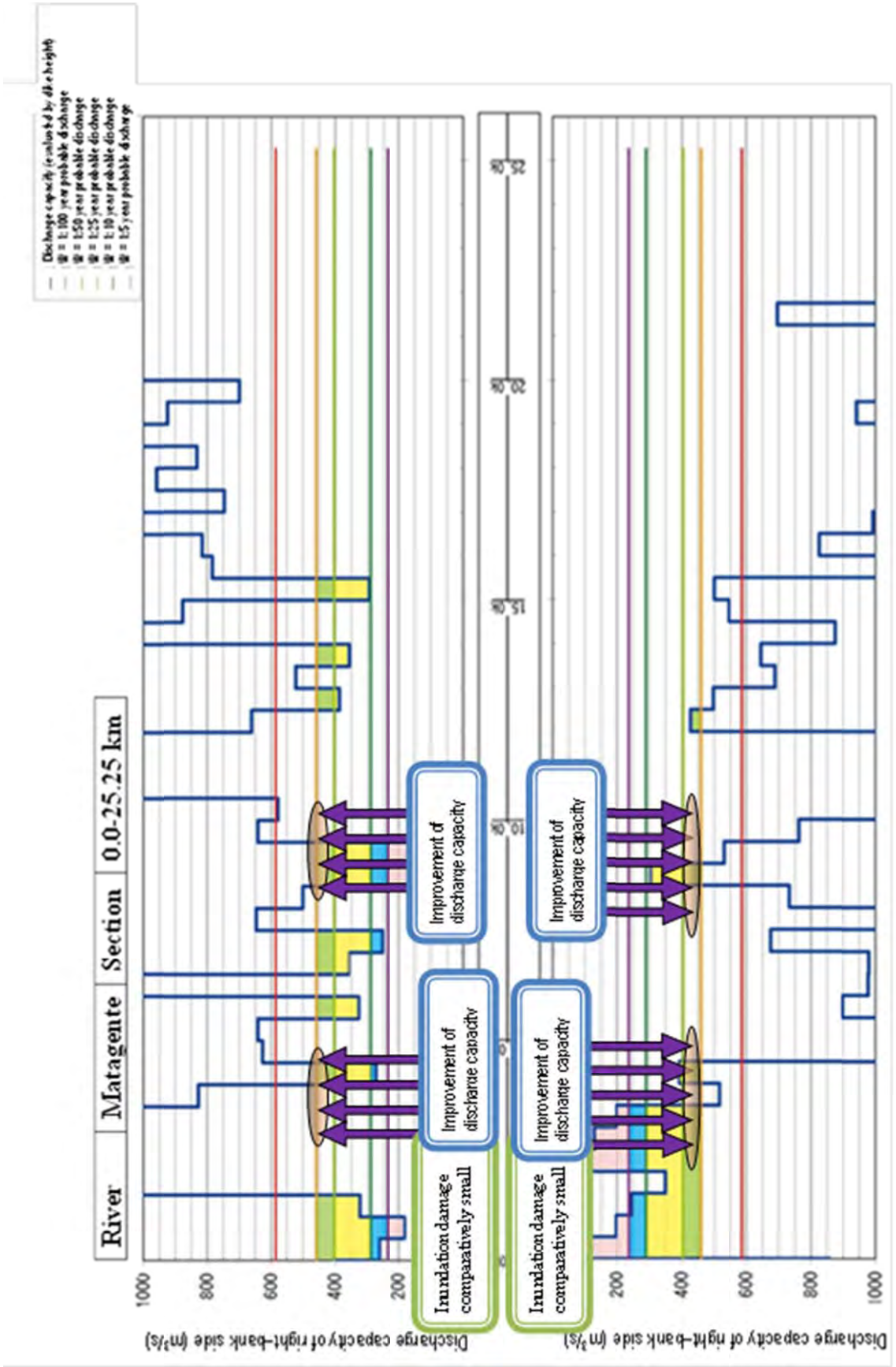


Figure 6.4 **Mitigation Effects for Inundation by Improvement (Chincha (Matagente) River)**

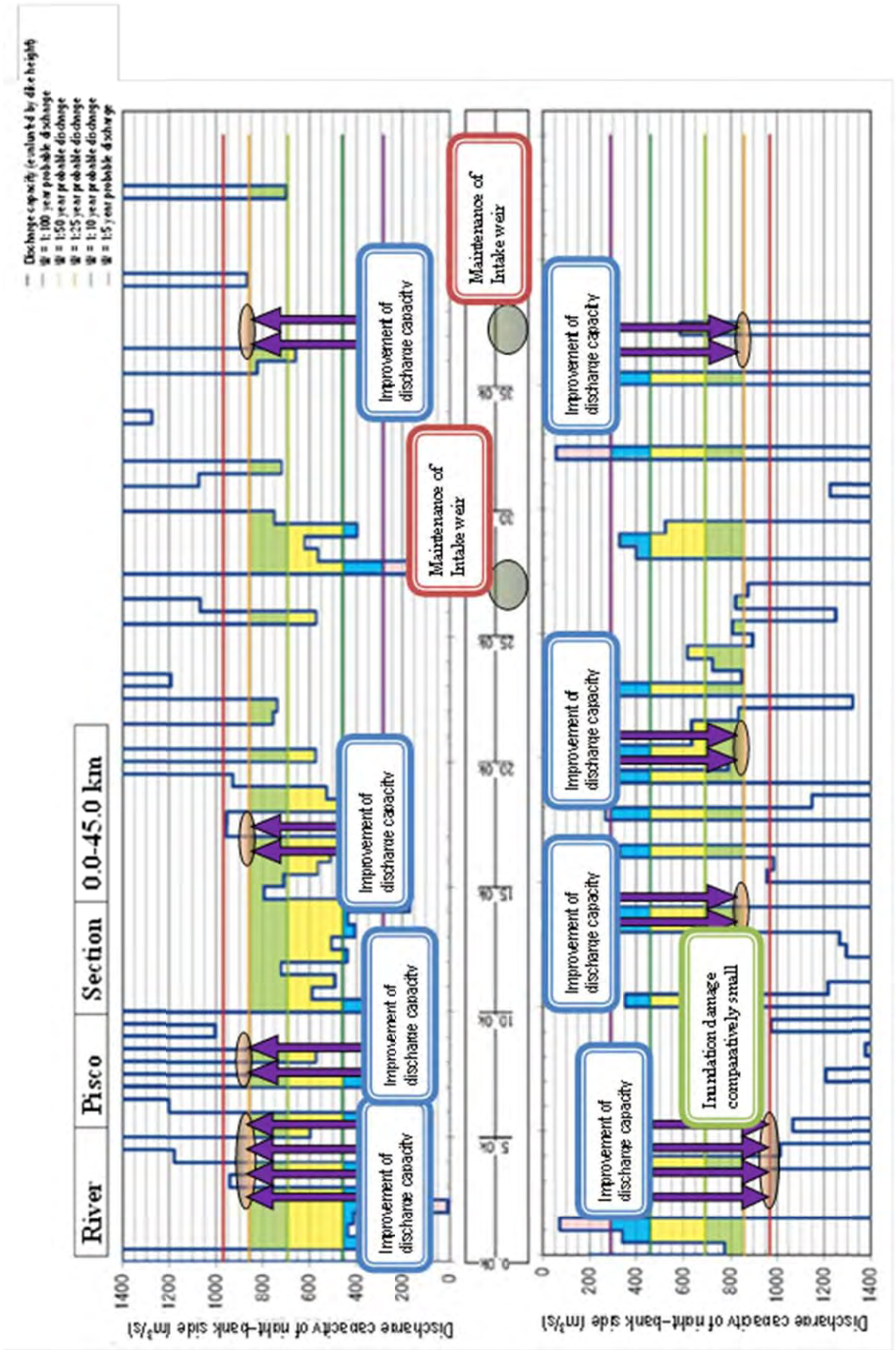


Figure 6.5 **Mitigation Effects for Inundation by Improvement (Pisco River)**

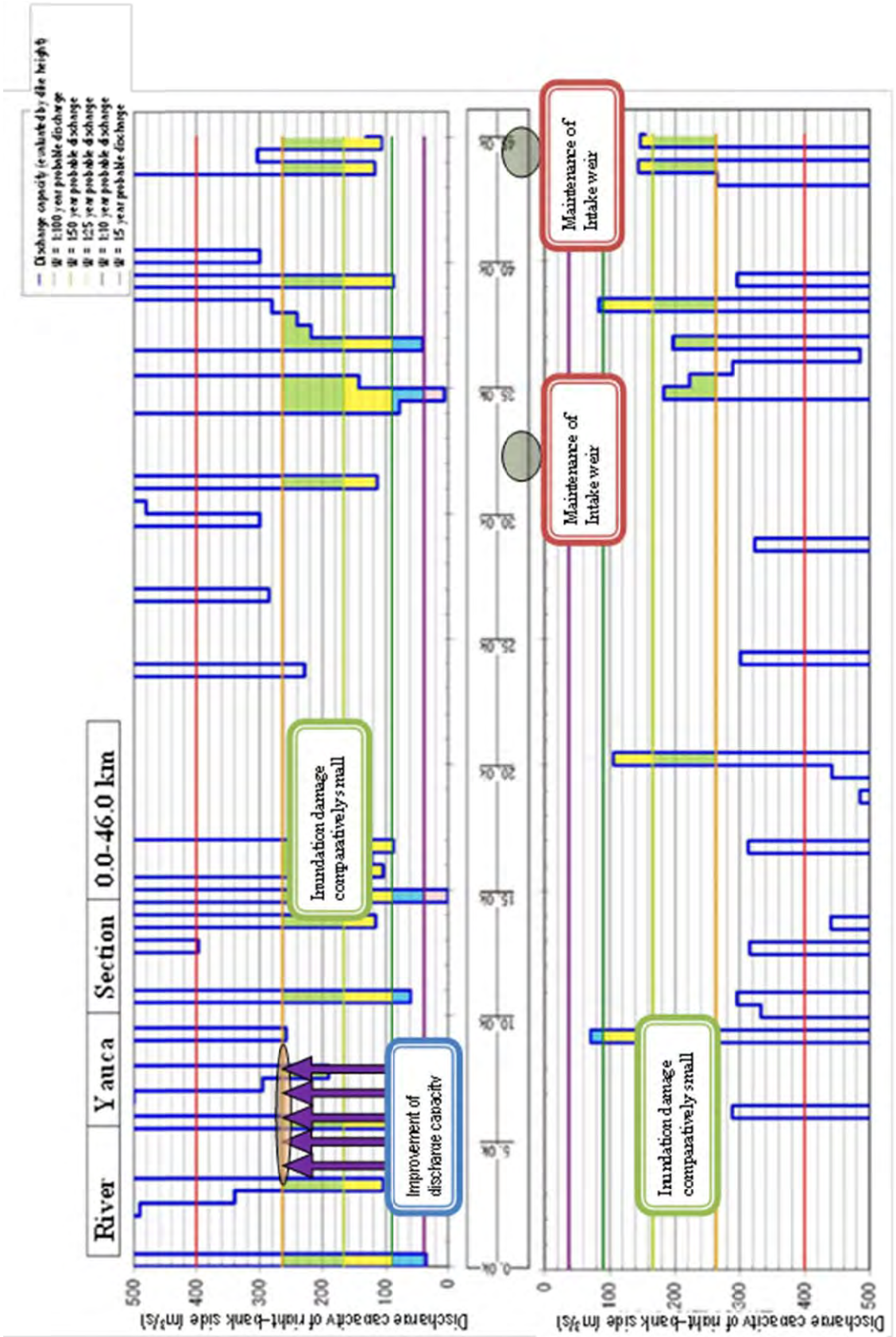


Figure 6.6 **Mitigation Effects for Inundation by Improvement (Yauca River)**

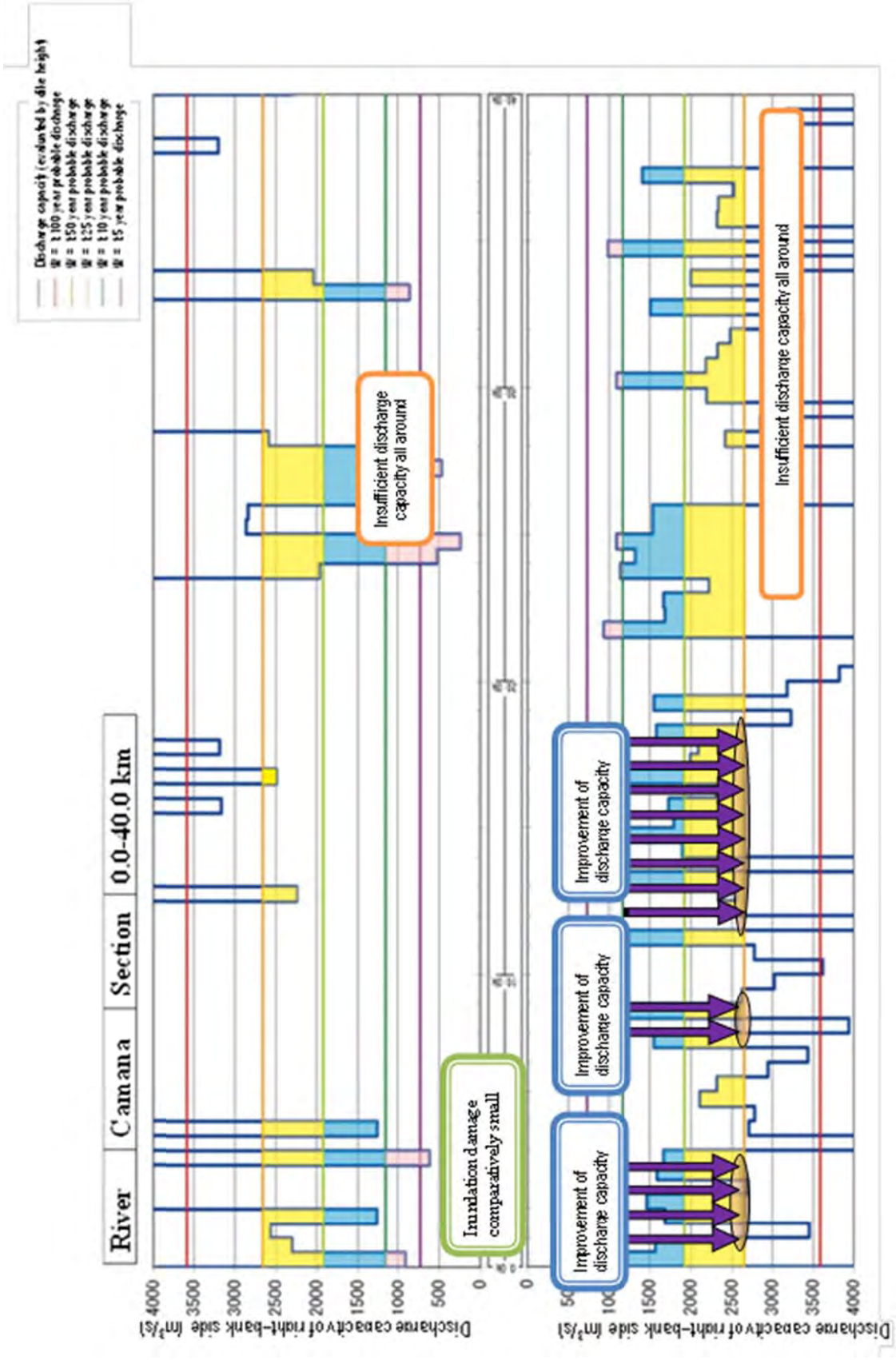


Figure 6.7 **Mitigation Effects for Inundation by Improvement (Camana River)**

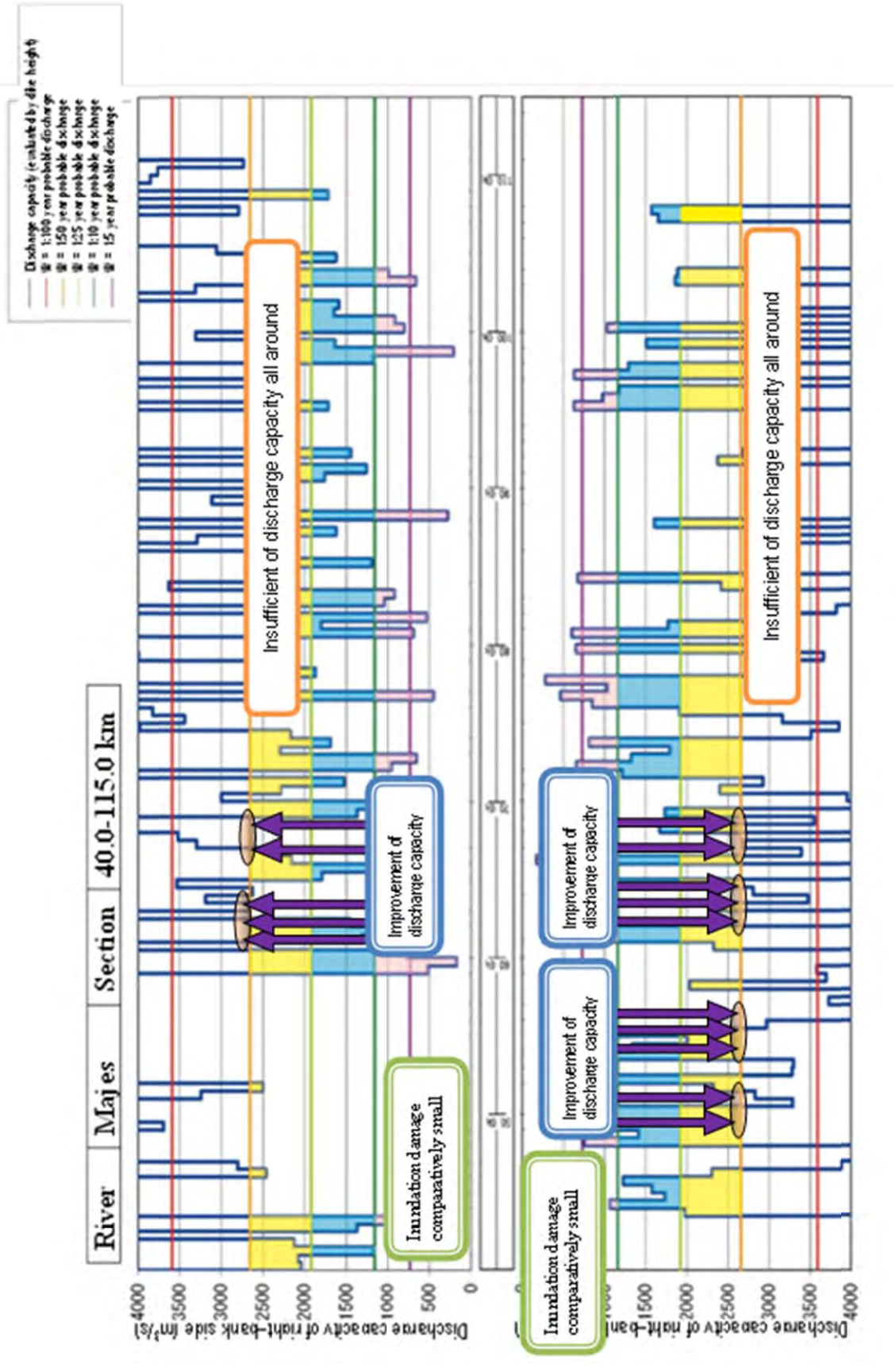


Figure 6.8 **Mitigation Effects for Inundation by Improvement (Majes River)**