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***.

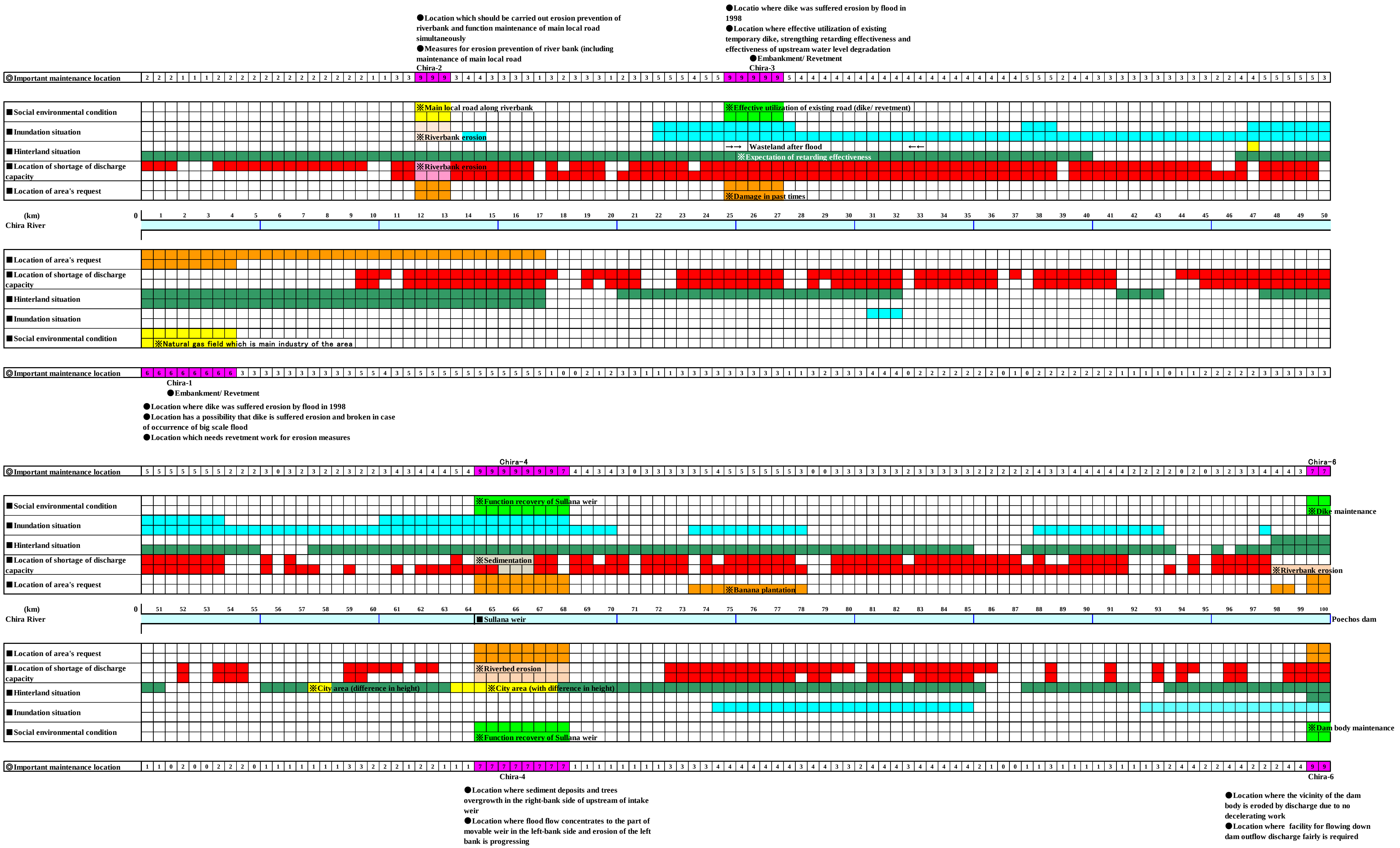


Figure 5.1 **Selection of High Priority Improvement Facilities in the Chira River**

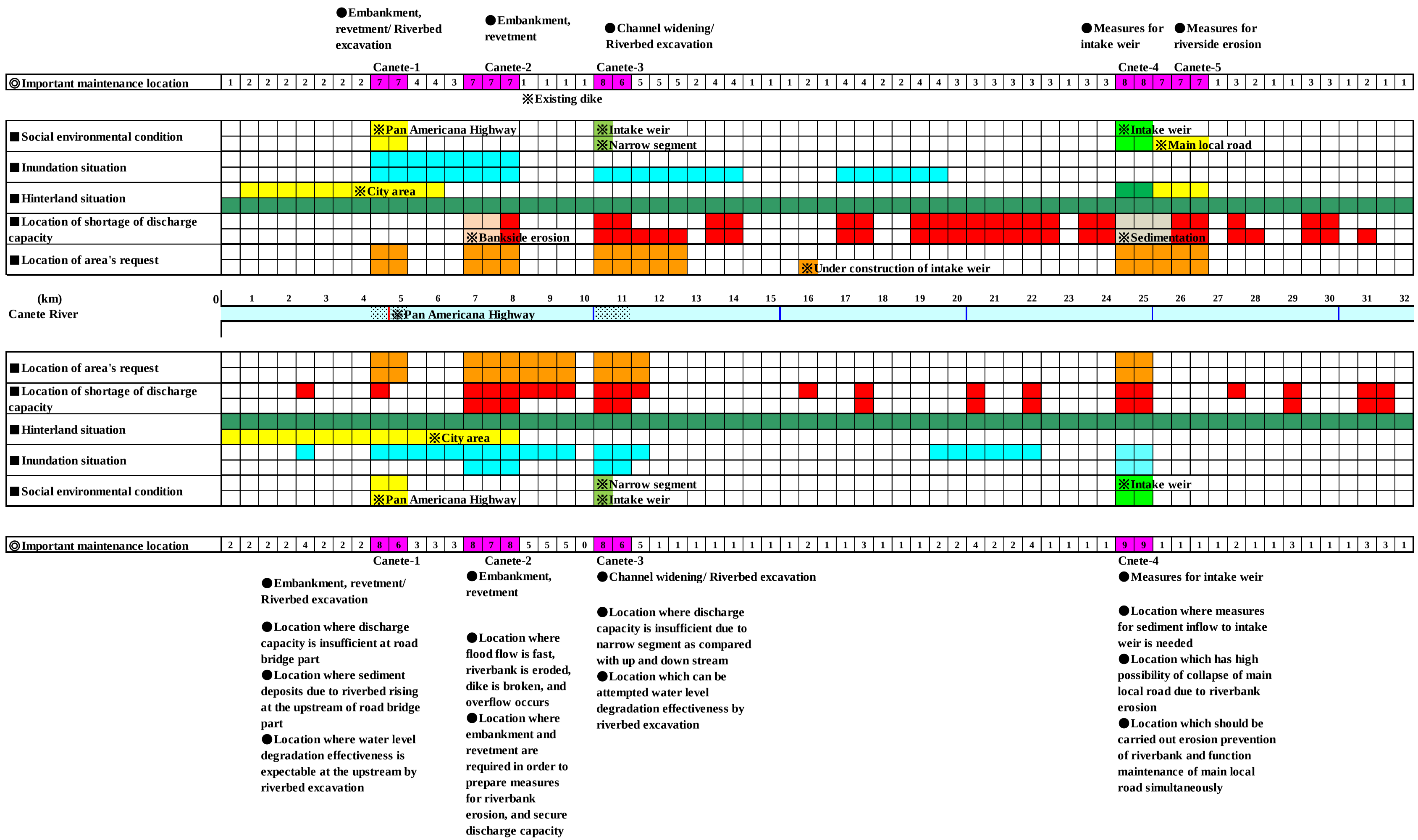


Figure 5.2 **Selection of High Priority Improvement Facilities in the Canete River**

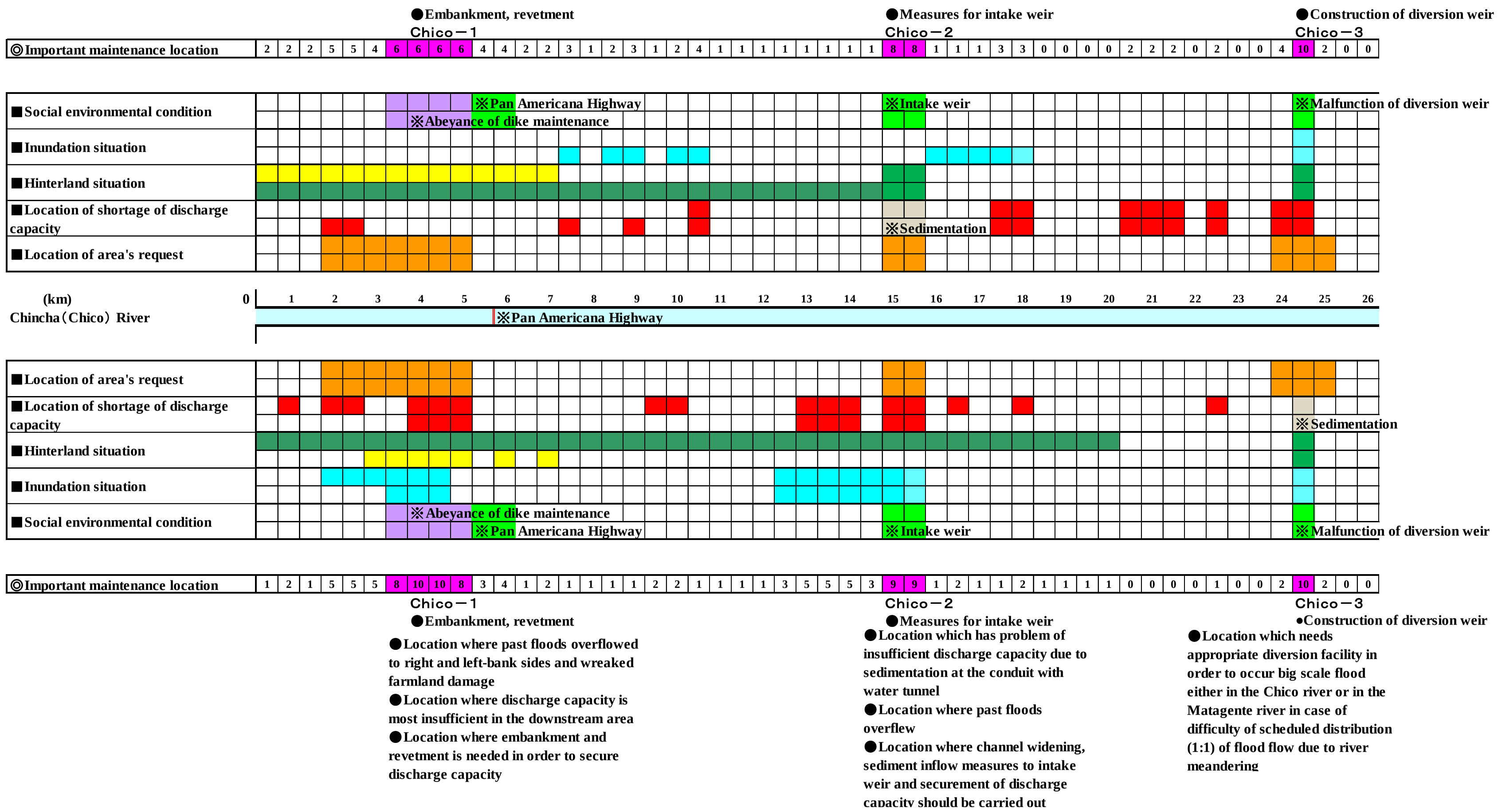


Figure 5.3 **Selection of High Priority Improvement Facilities in the Chincha (Chico) River**

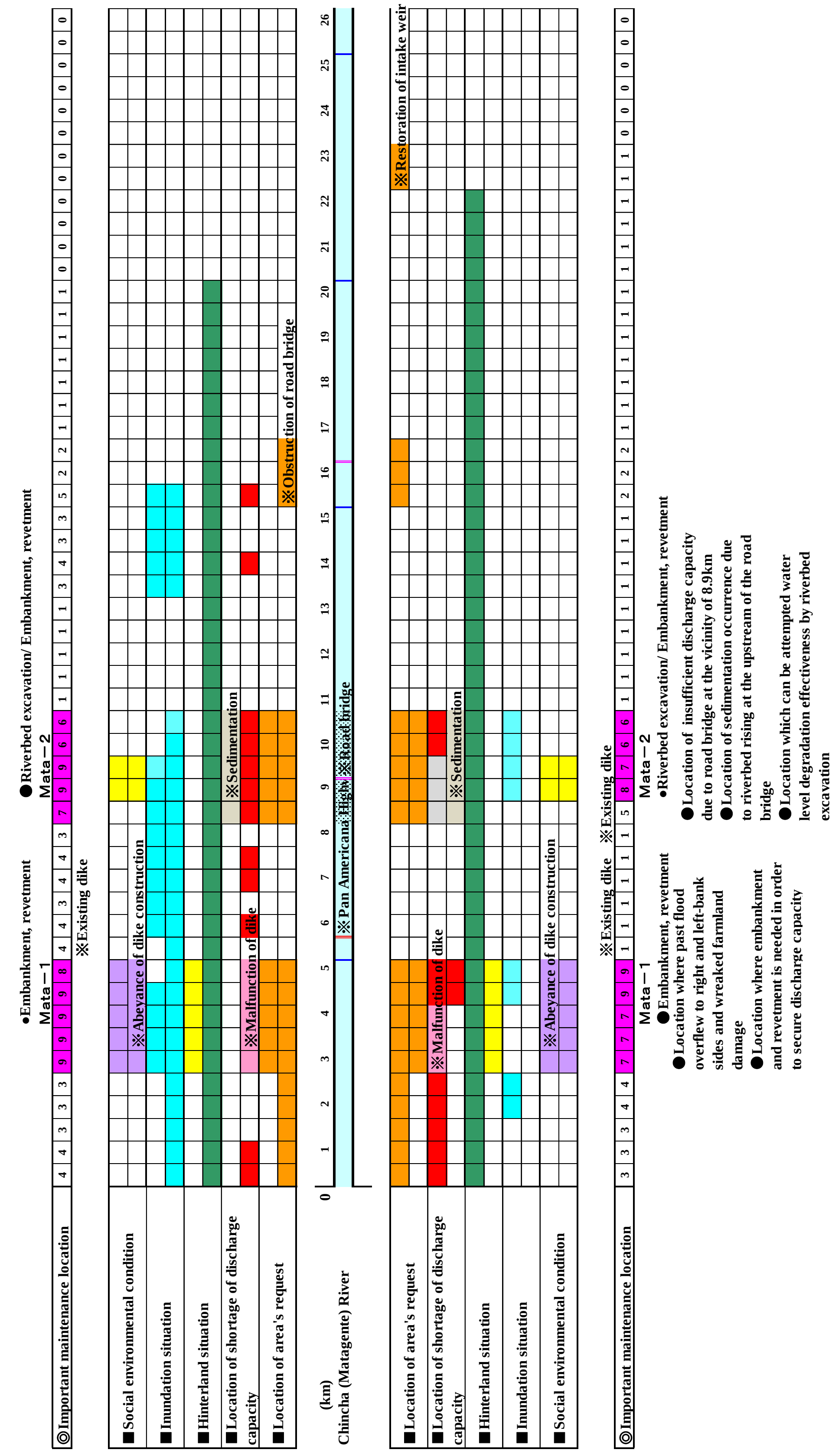


Figure 5.4 **Selection of High Priority Improvement Facilities in the Chincha (Matagente) River**

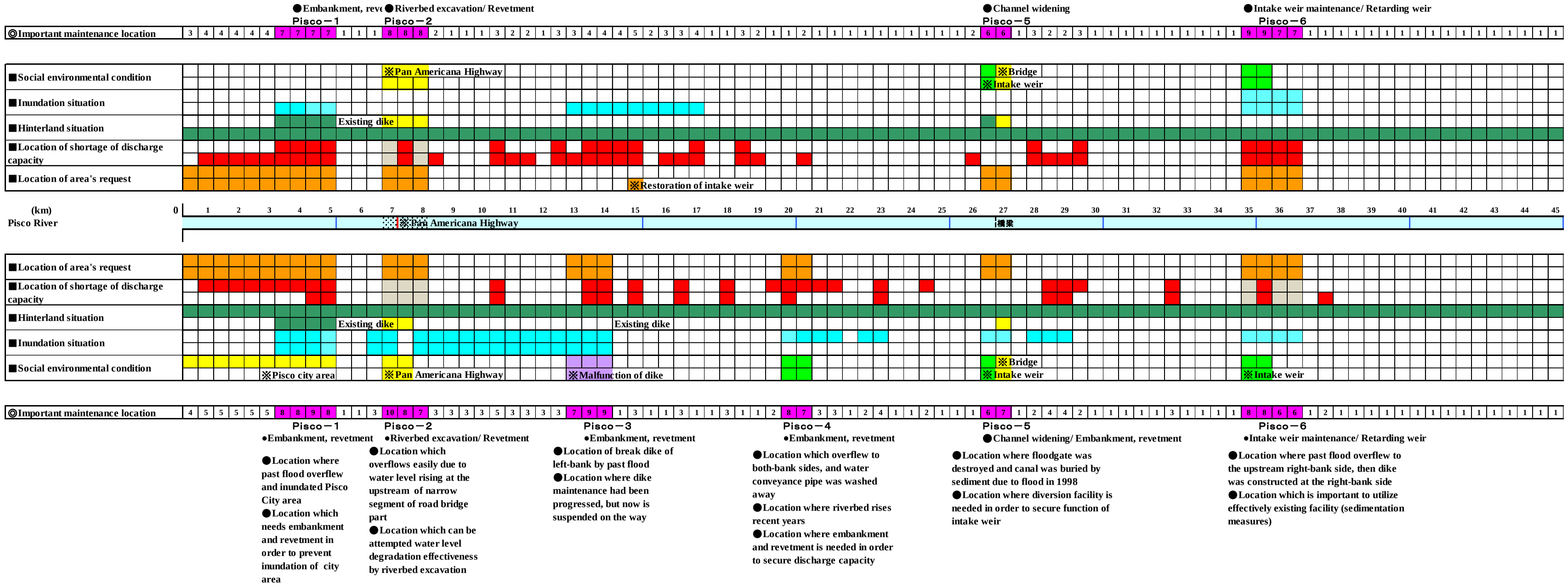


Figure 5.5 **Selection of High Priority Improvement Facilities in the Pisco River**

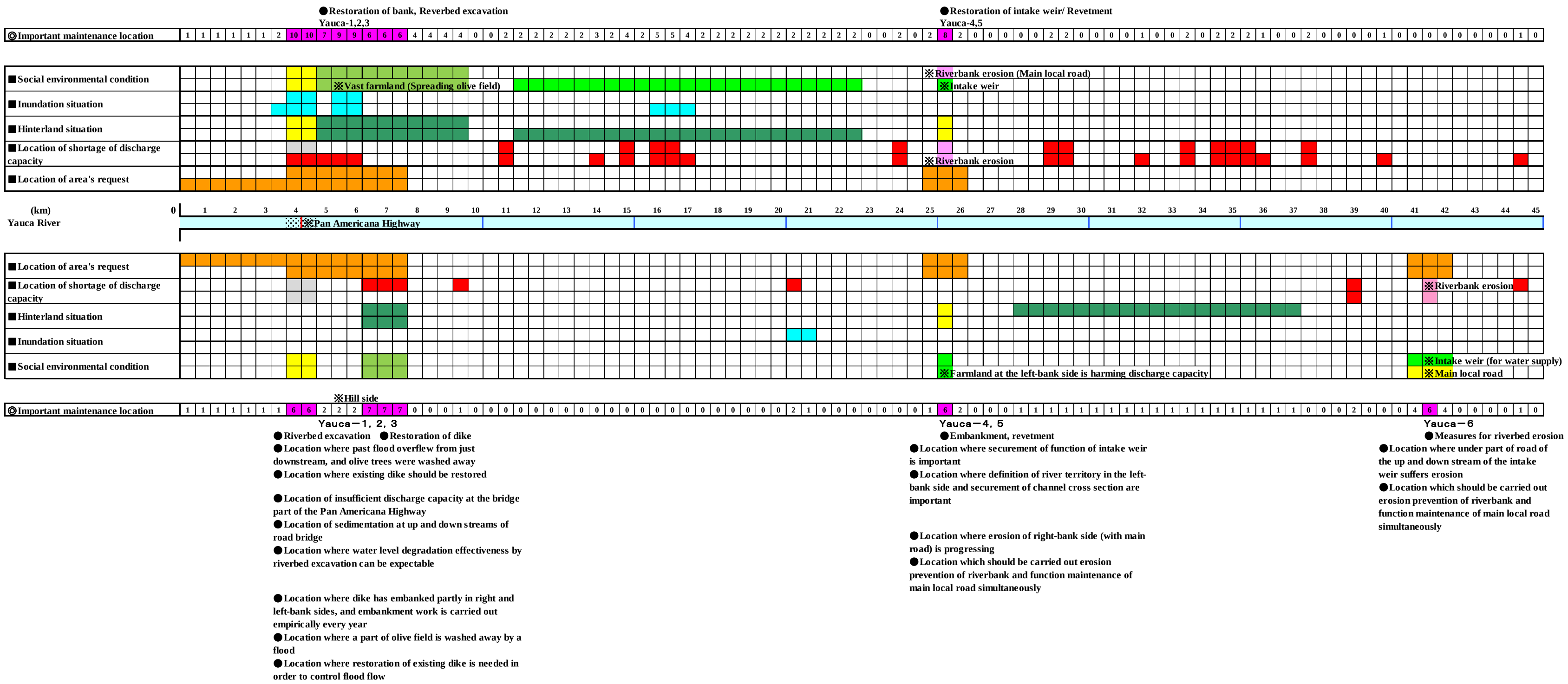


Figure 5.6 **Selection of High Priority Improvement Facilities in the Yauca River**

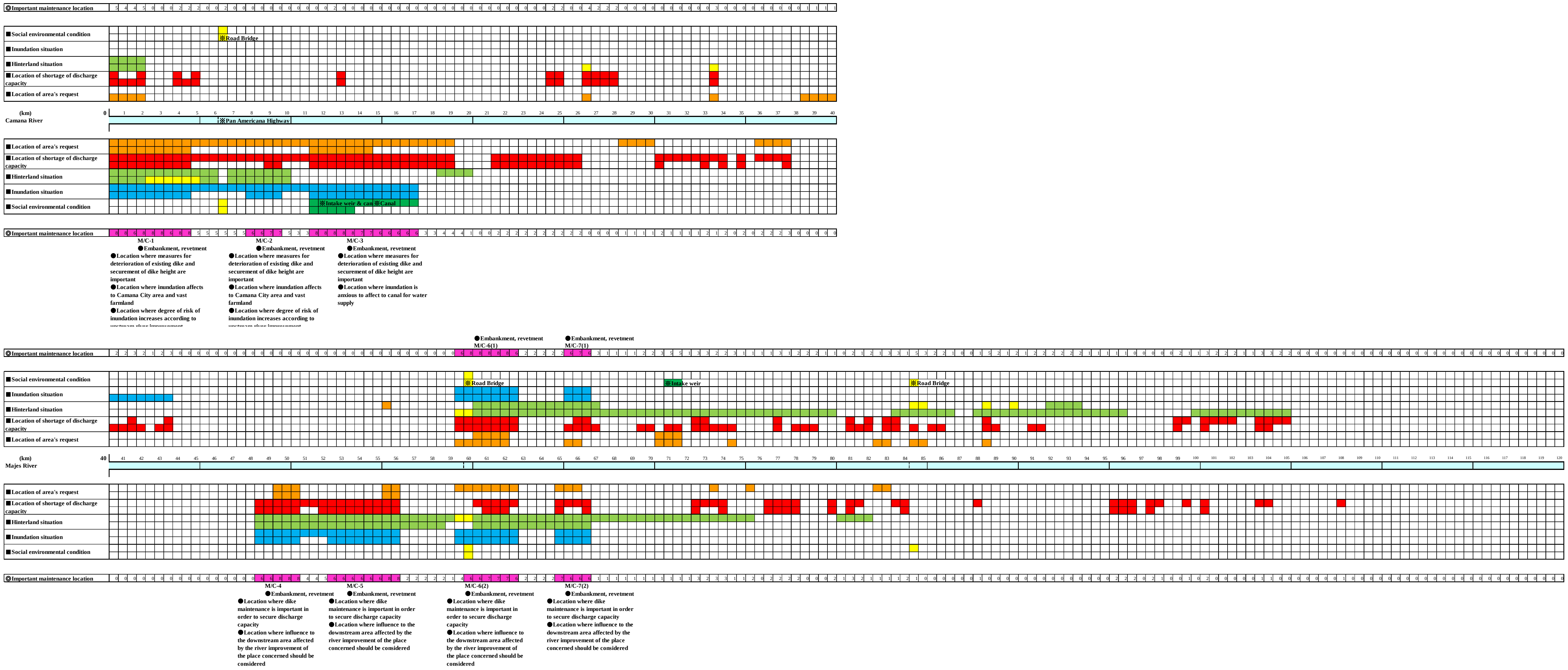


Figure 5.7 **Selection of High Priority Improvement Facilities in the Majes-Camana River**

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.

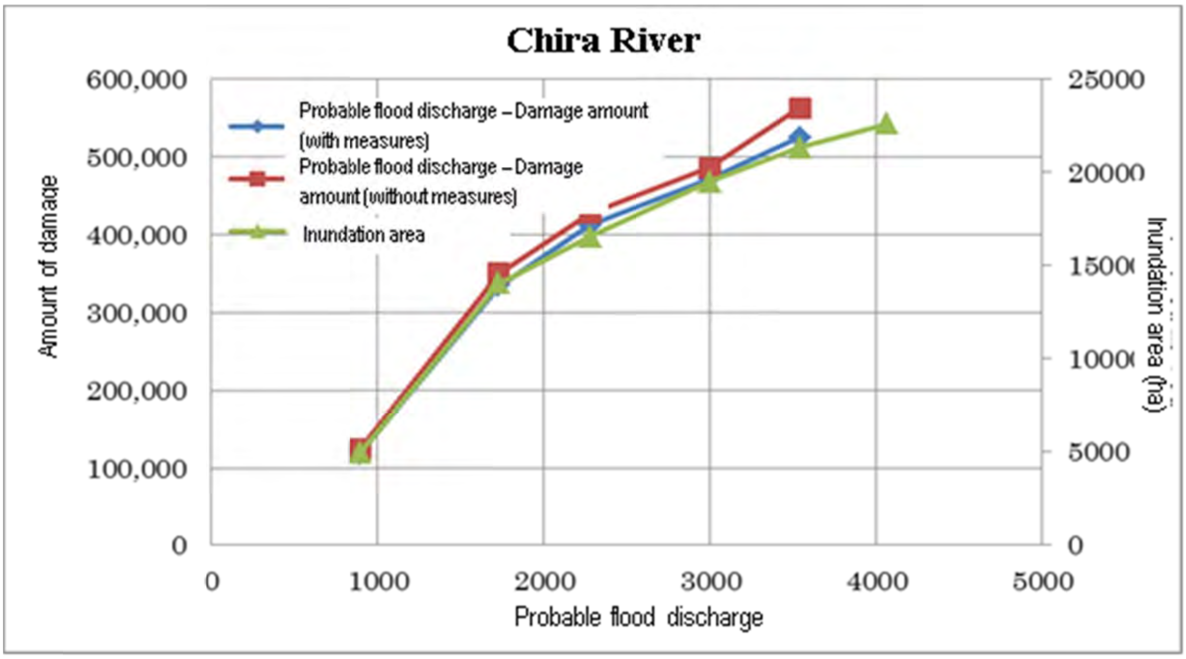
Fundamentally, it is important for the river improvement plan for floods in the Chira River to commence from the downstream section. For planning, these sections for improvement plan are selected by taking into account the situations of hinterland, the important infrastructures in the areas as well as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

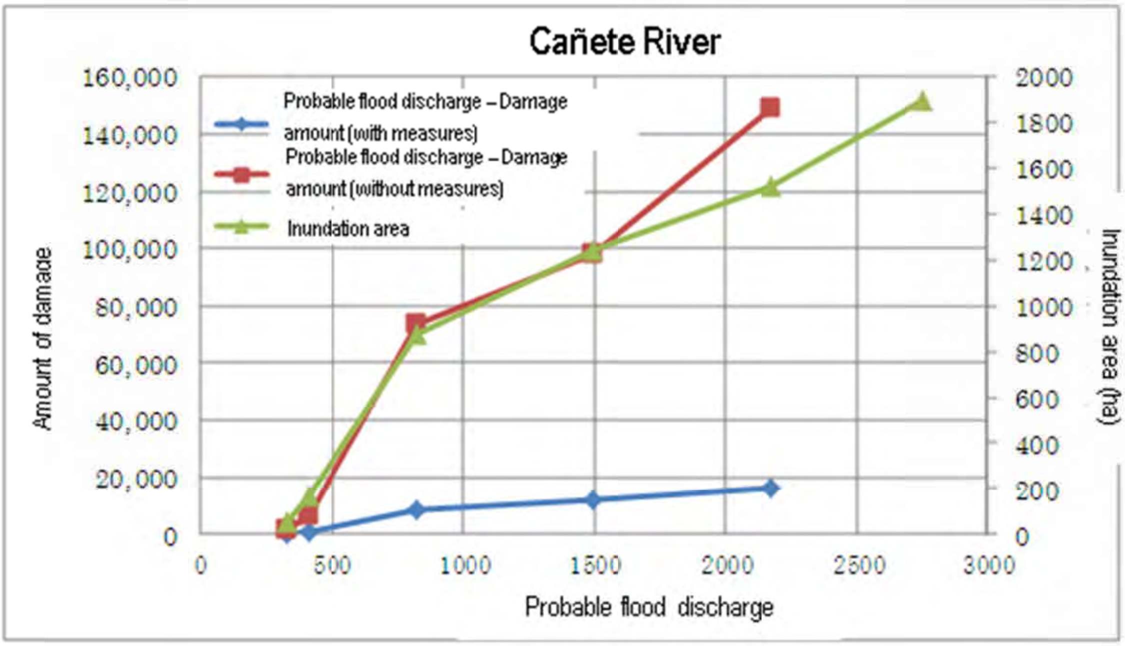
As for road bridge located in the narrow area of Pan American Road, the renewal was also considered, however, the traffic volume is very large and a substitute bridge and approach roads are needed, so that the project cost become huge. Through the meetings on renewal of bridge, DGIH replied that it was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

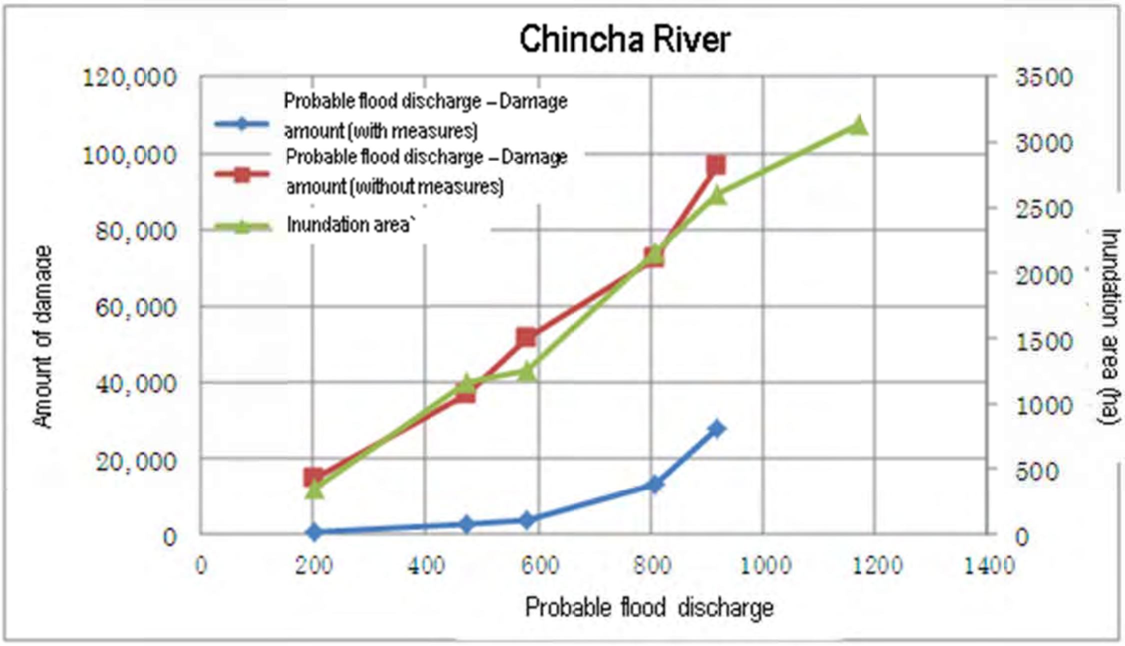
The proposed improvement plan for every section is arranged on the basis of the case that flood flow is distributed properly to both the Chico River and the Matagente River.

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.

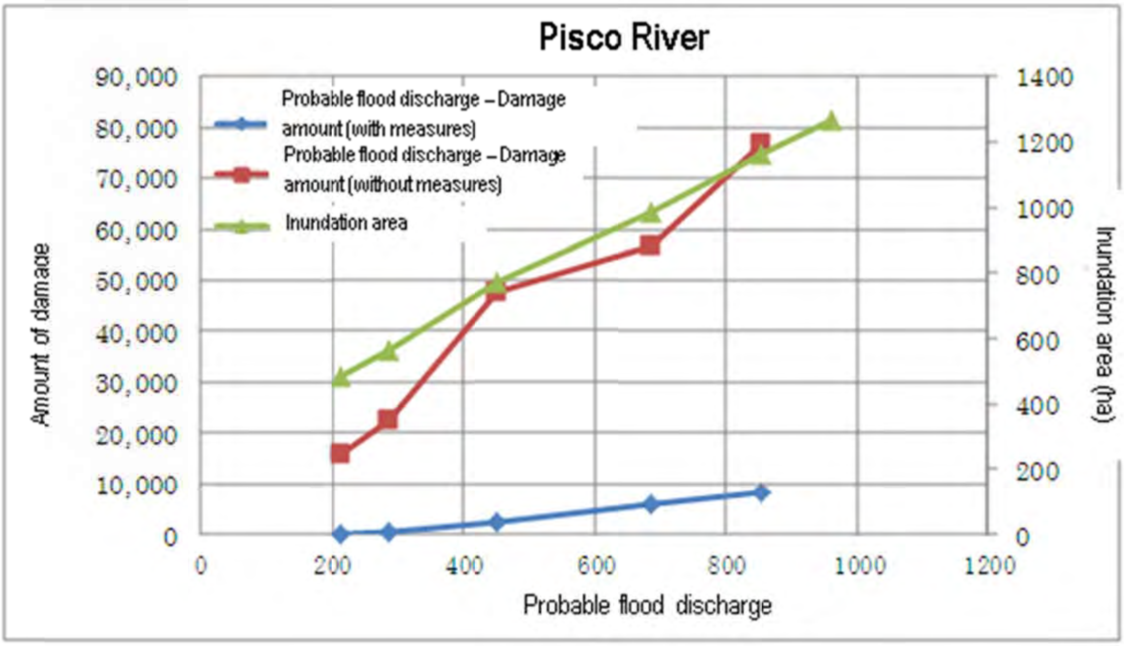
Table 5.5 **River Improvement Plan (Pisco River)**

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.

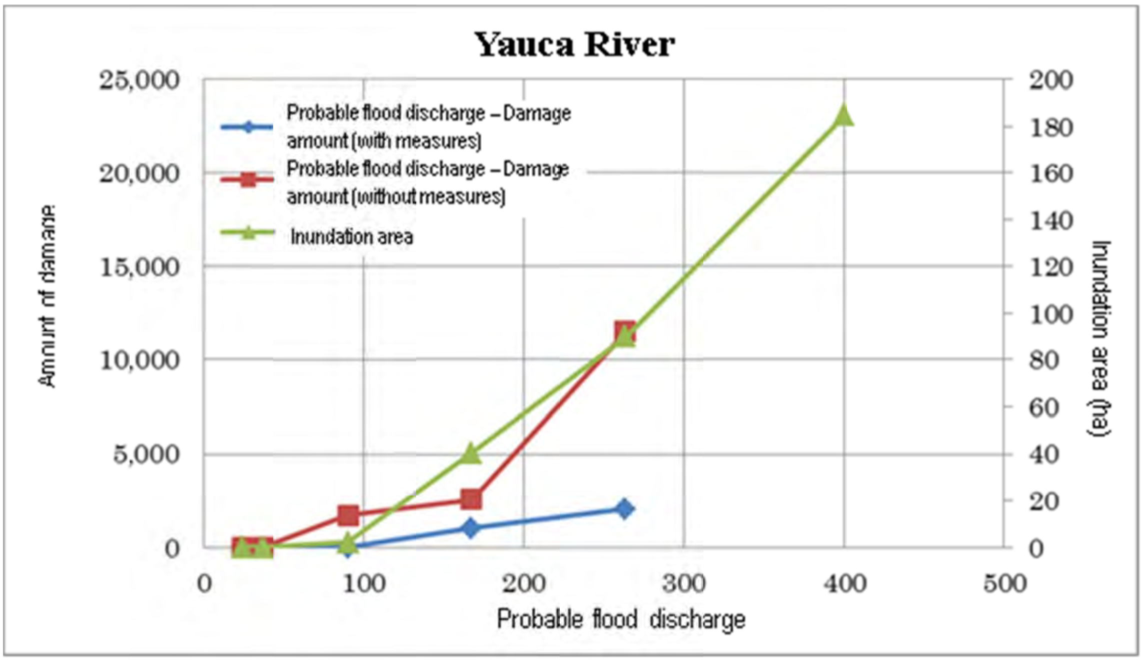
Table 5.6 **River Improvement Plan (Yauca River)**

<table>
<tr><th>No</th><th>Sections for Improvement</th><th>Explanation for Selection</th></tr>
<tr><td>(1)</td><td rowspan="3">3.5km～7.5km
(Left-bank side)</td><td>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.</td></tr>
<tr><td>(2)</td><td>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.</td></tr>
<tr><td>(3)</td><td>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.</td></tr>
<tr><td>(4)</td><td>25.0km～25.7km
(Whole area)</td><td>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</td></tr>
</table>

		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.

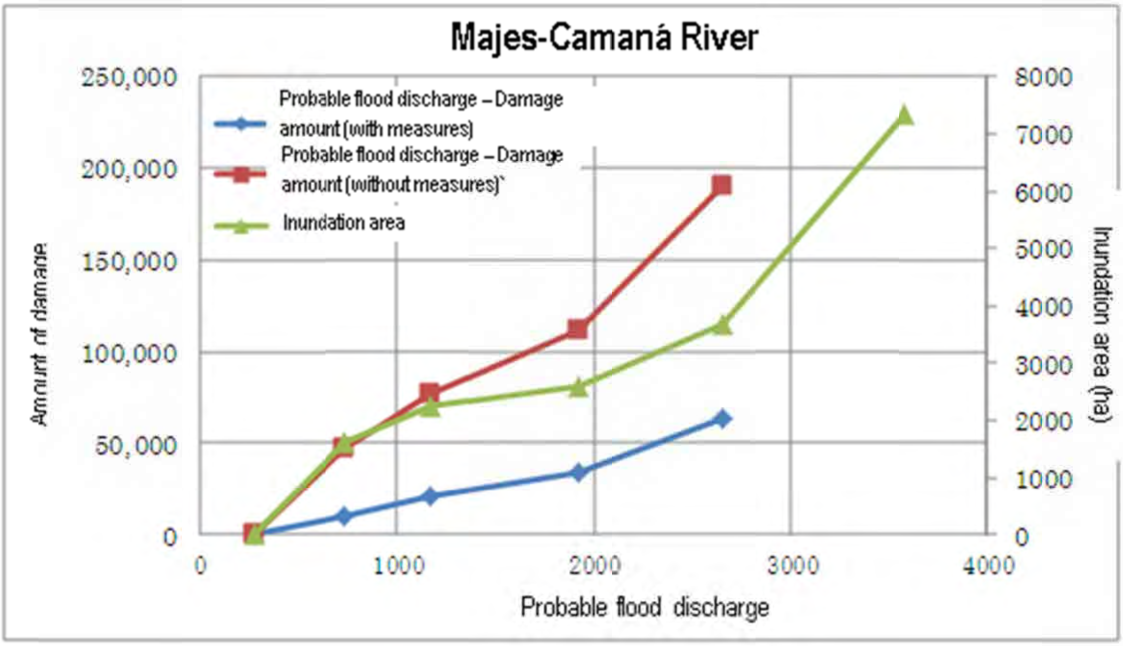
Table 5.7 **River Improvement Plan (Majes-Camana River)**

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.

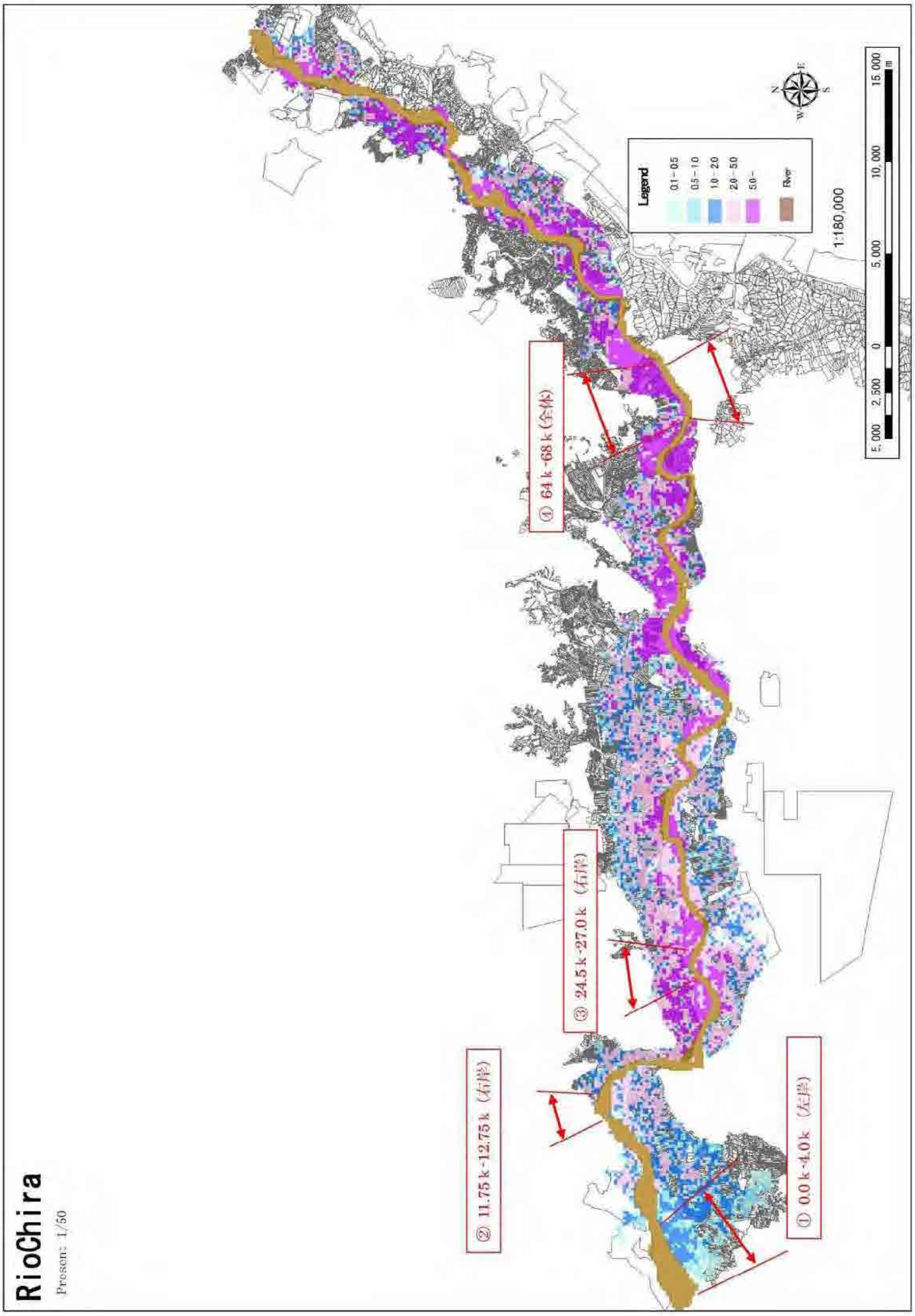


Figure 5.8 **Locations for River Improvement Facilities (Chira River)**

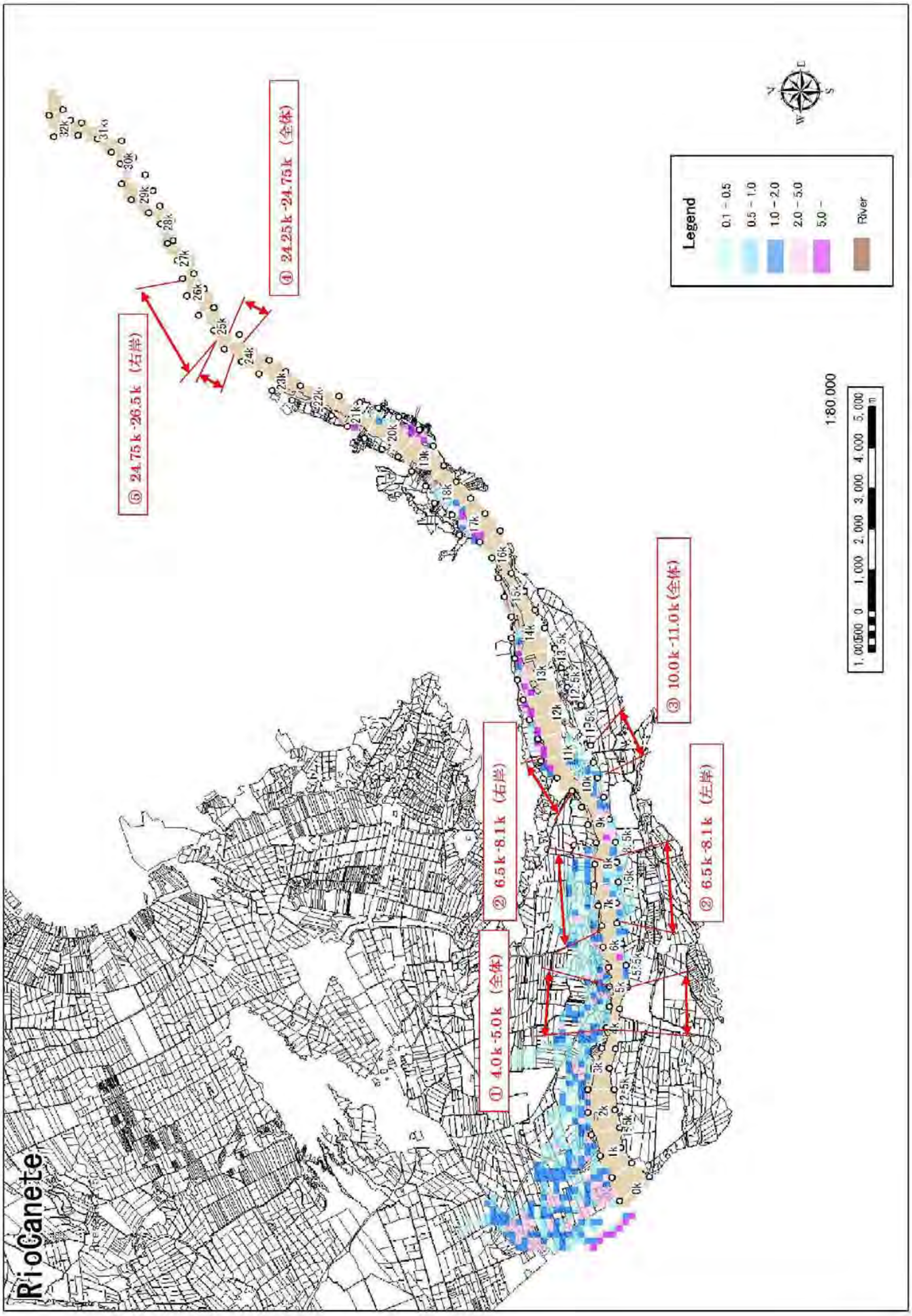


Figure 5.9 **Locations for River Improvement Facilities (Canete River)**

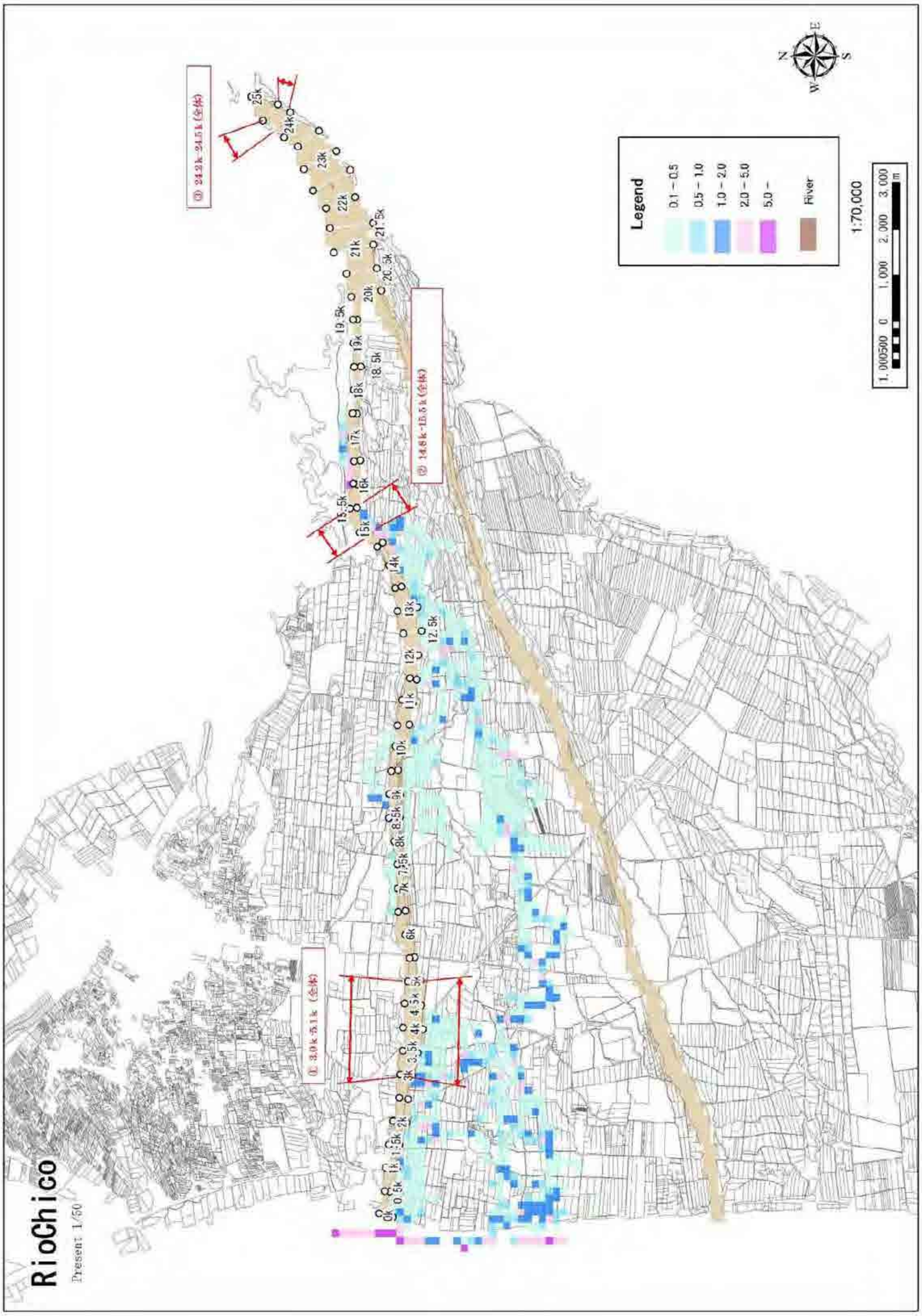


Figure 5.10 **Locations for River Improvement Facilities (Chico River)**

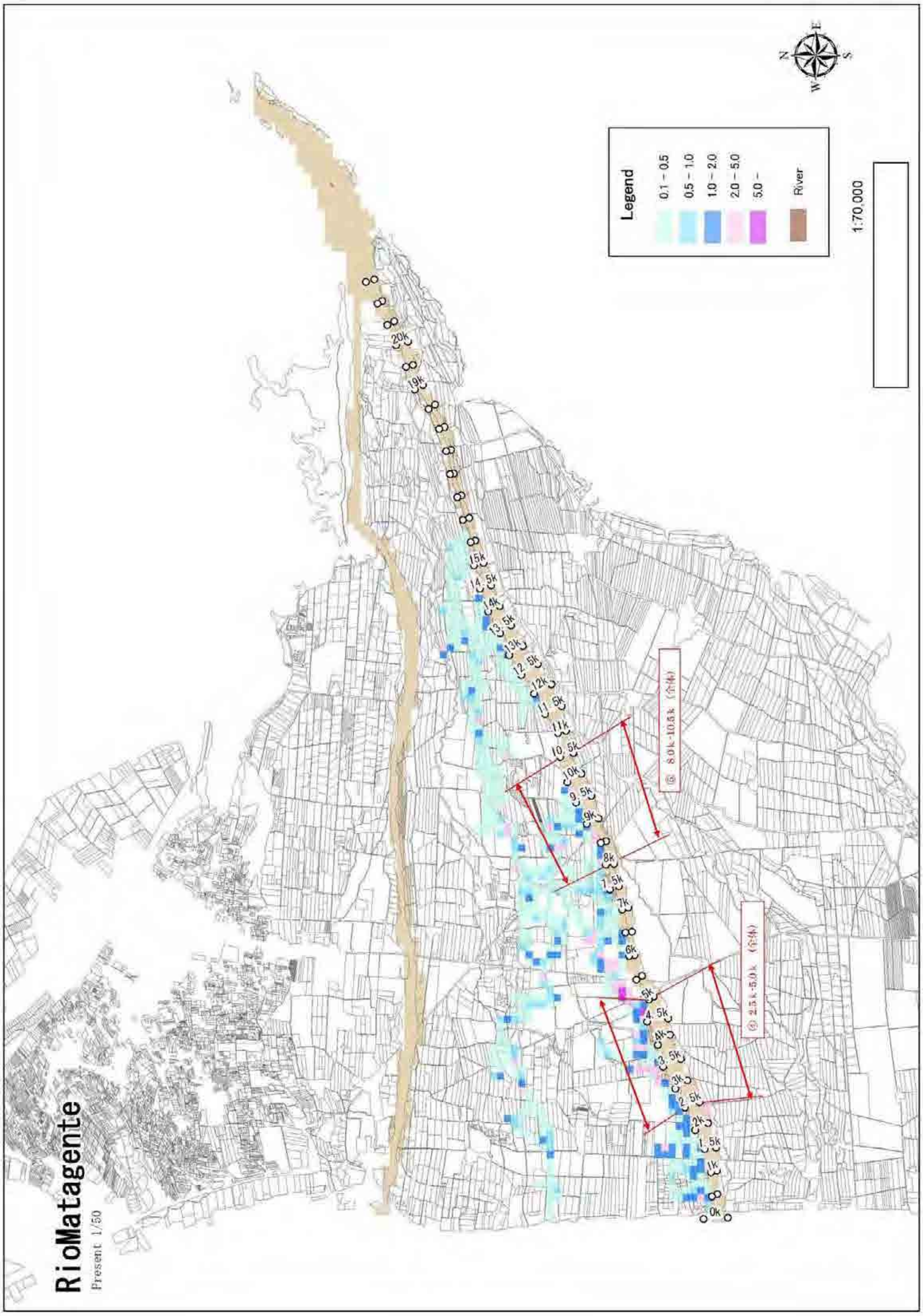


Figure 5.11 **Locations for River Improvement Facilities (Matagente River)**

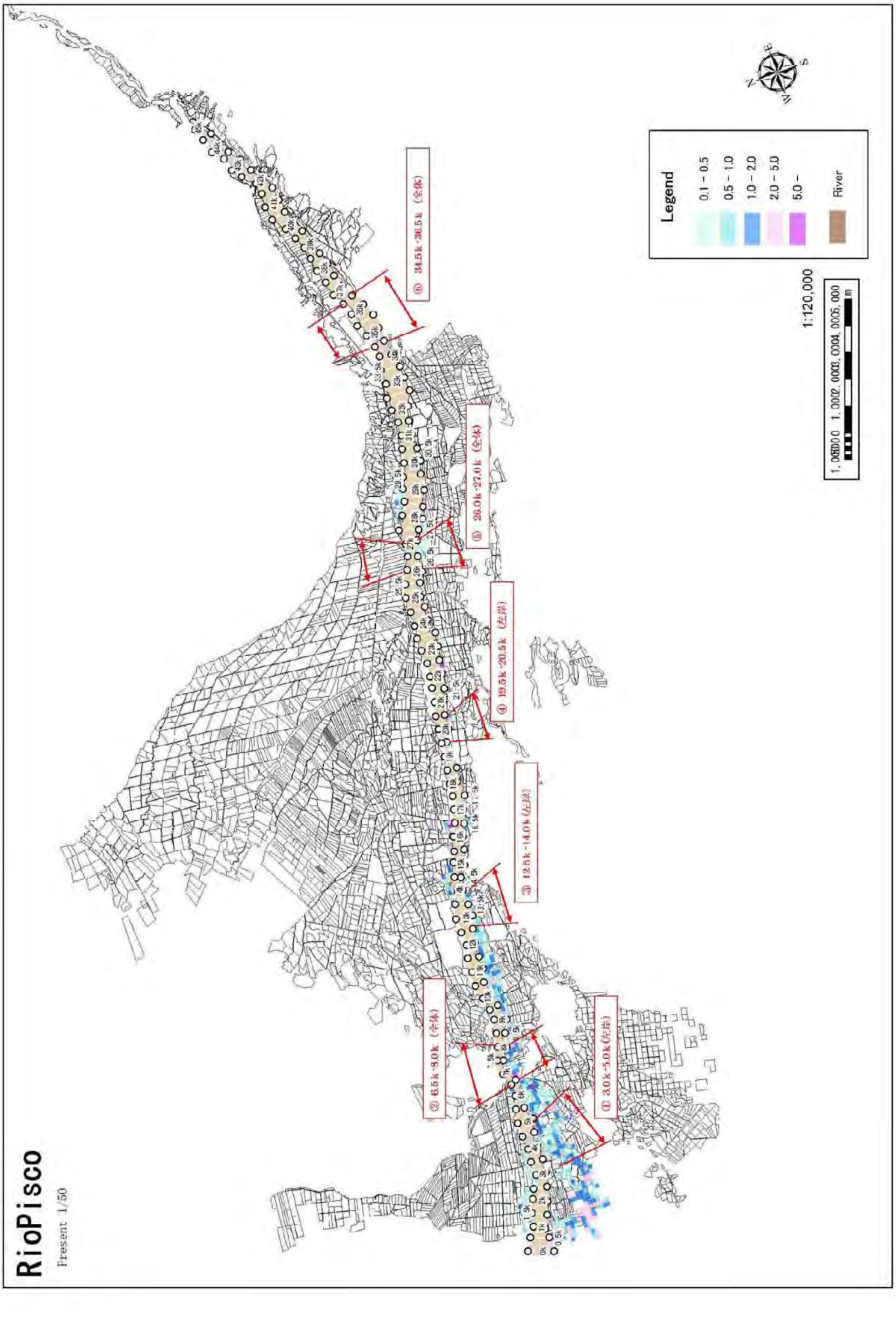


Figure 5.12 **Locations for River Improvement Facilities (Pisco River)**

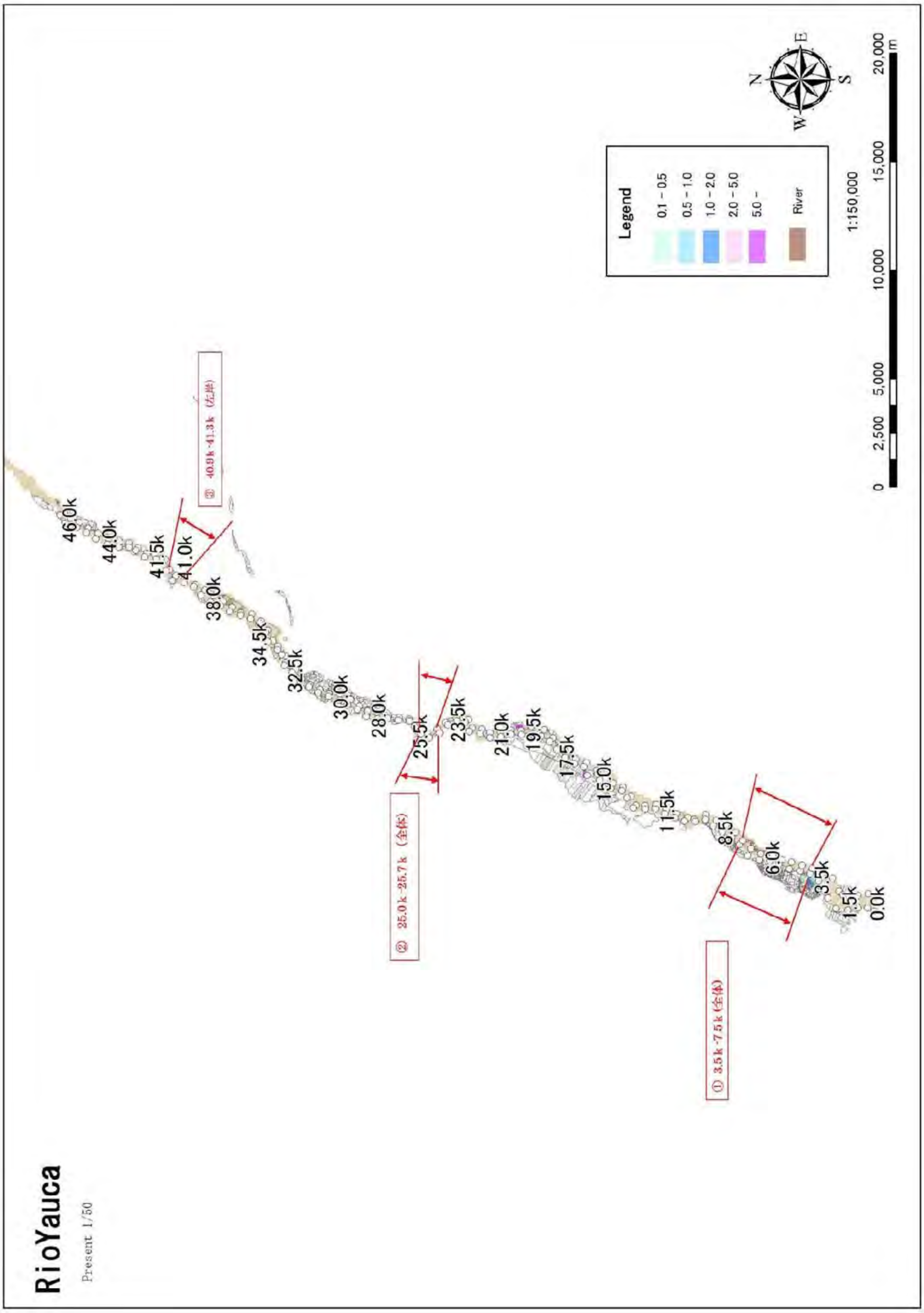


Figure 5.13 **Locations for River Improvement Facilities (Yauca River)**

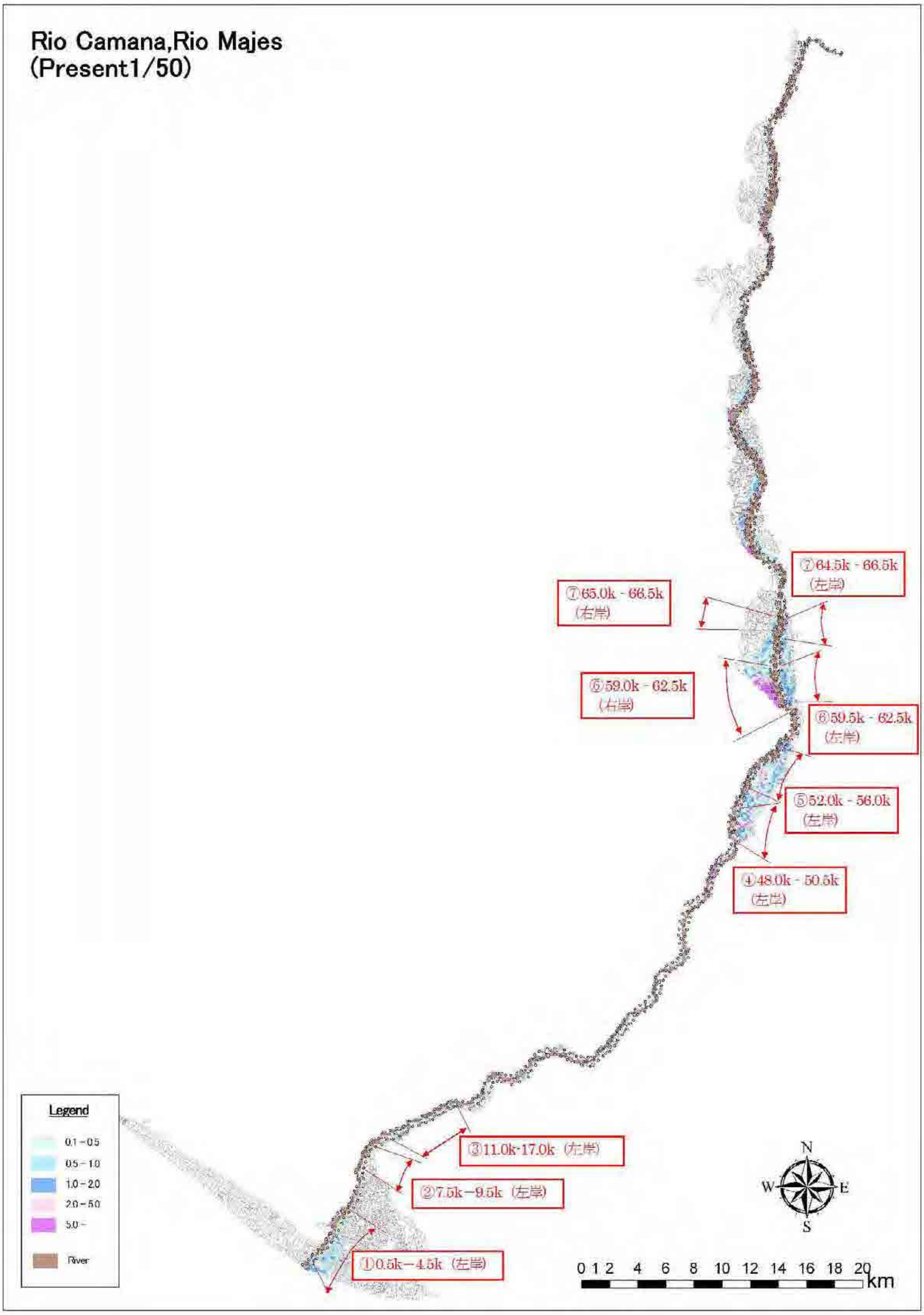


Figure 5.14 **Locations for River Improvement Facilities (Majes-Camana River)**

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***.

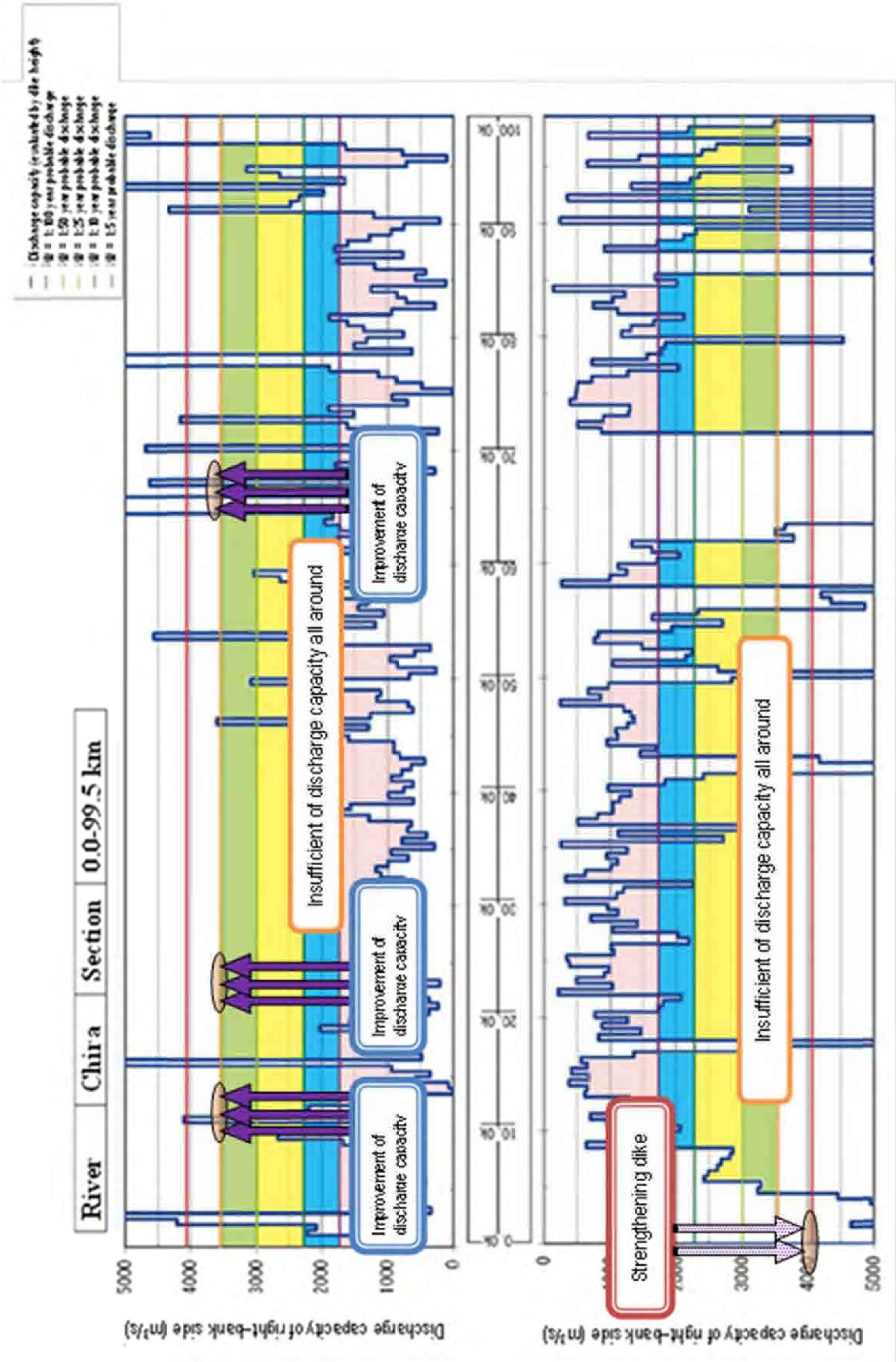


Figure 6.1 **Mitigation Effects for Inundation by Improvement (Chira River)**

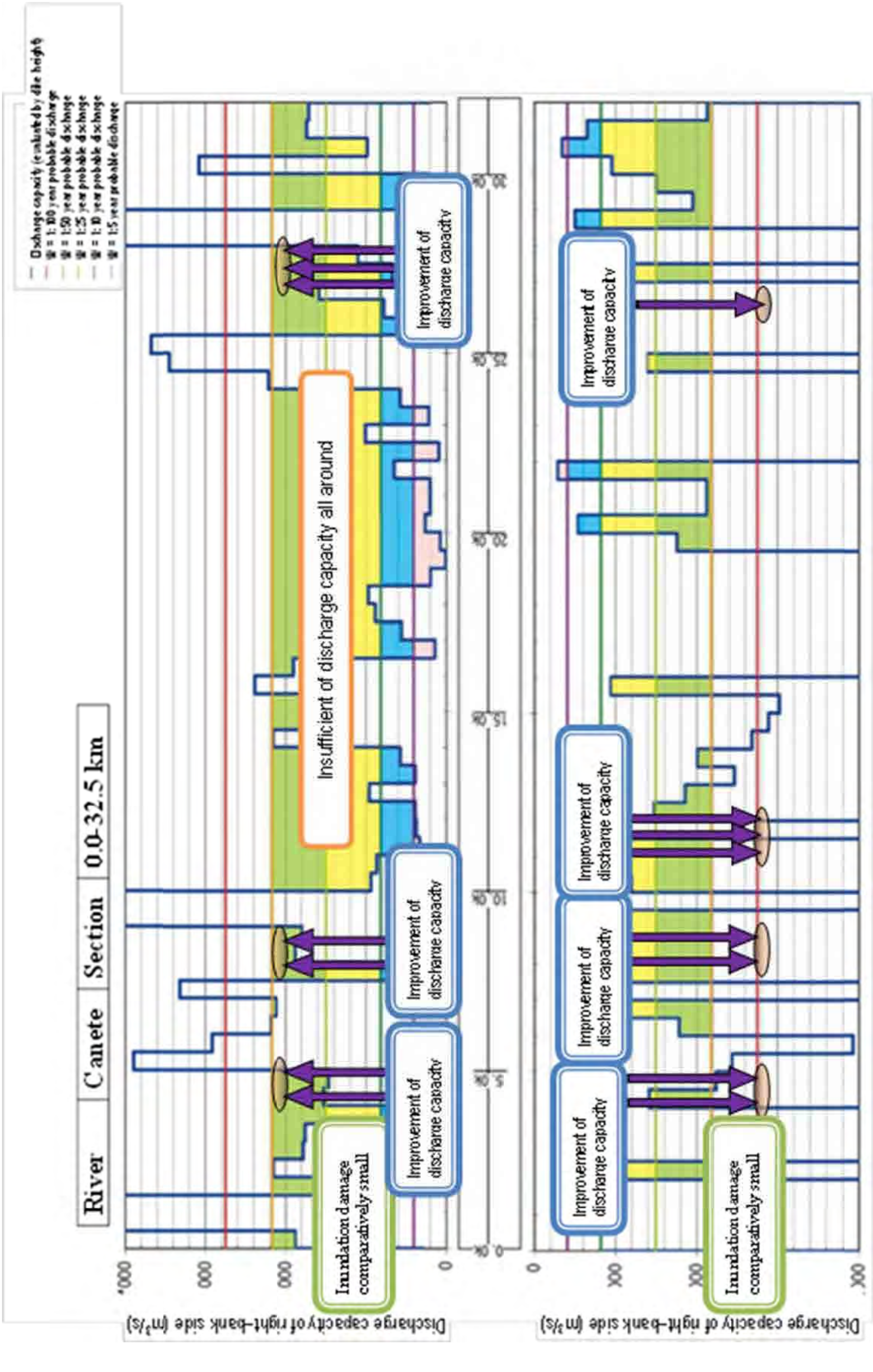


Figure 6.2 **Mitigation Effects for Inundation by Improvement (Canete River)**

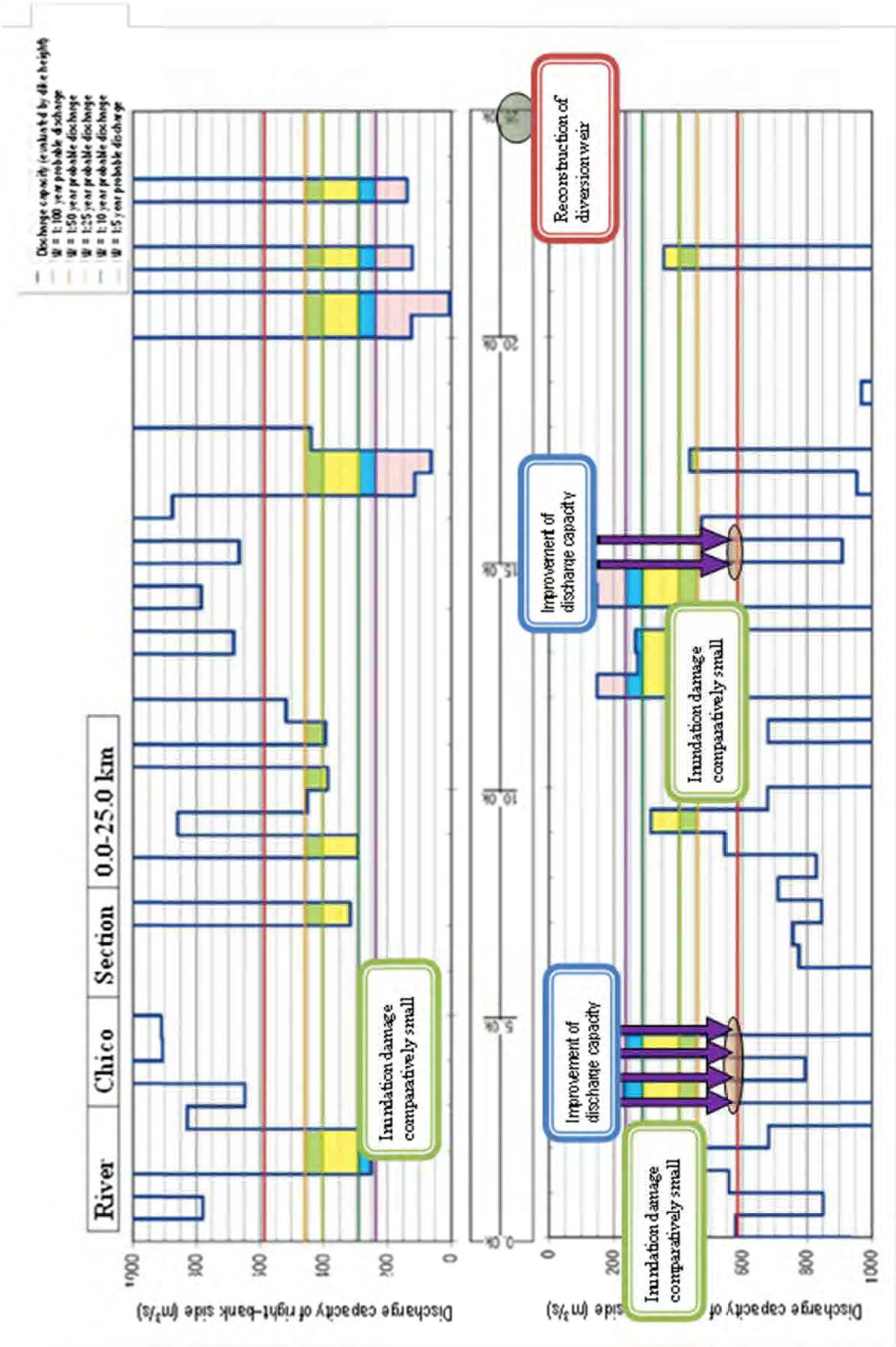


Figure 6.3 **Mitigation Effects for Inundation by Improvement (Chincha (Chico) River)**

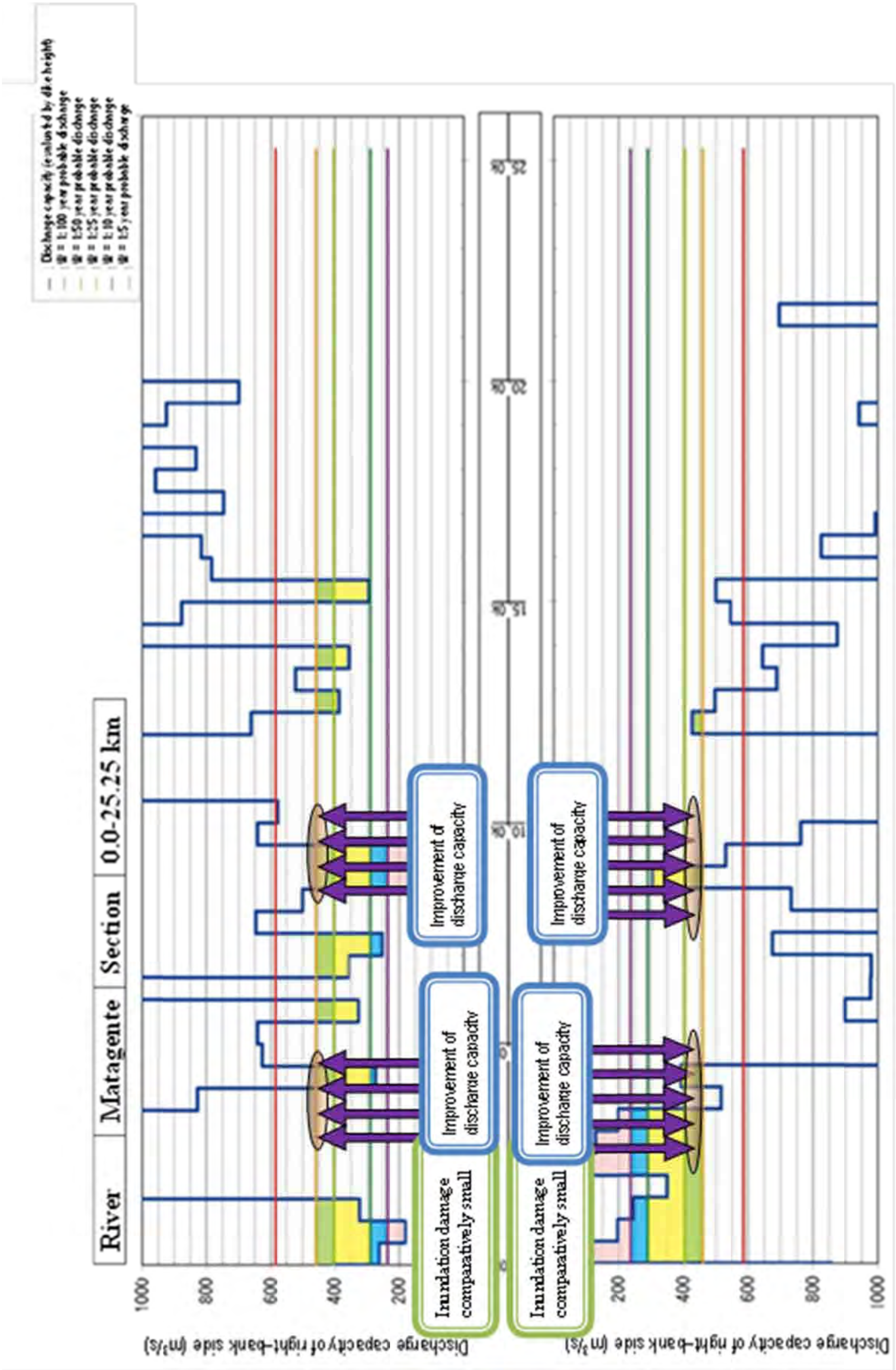


Figure 6.4 **Mitigation Effects for Inundation by Improvement (Chincha (Matagente) River)**

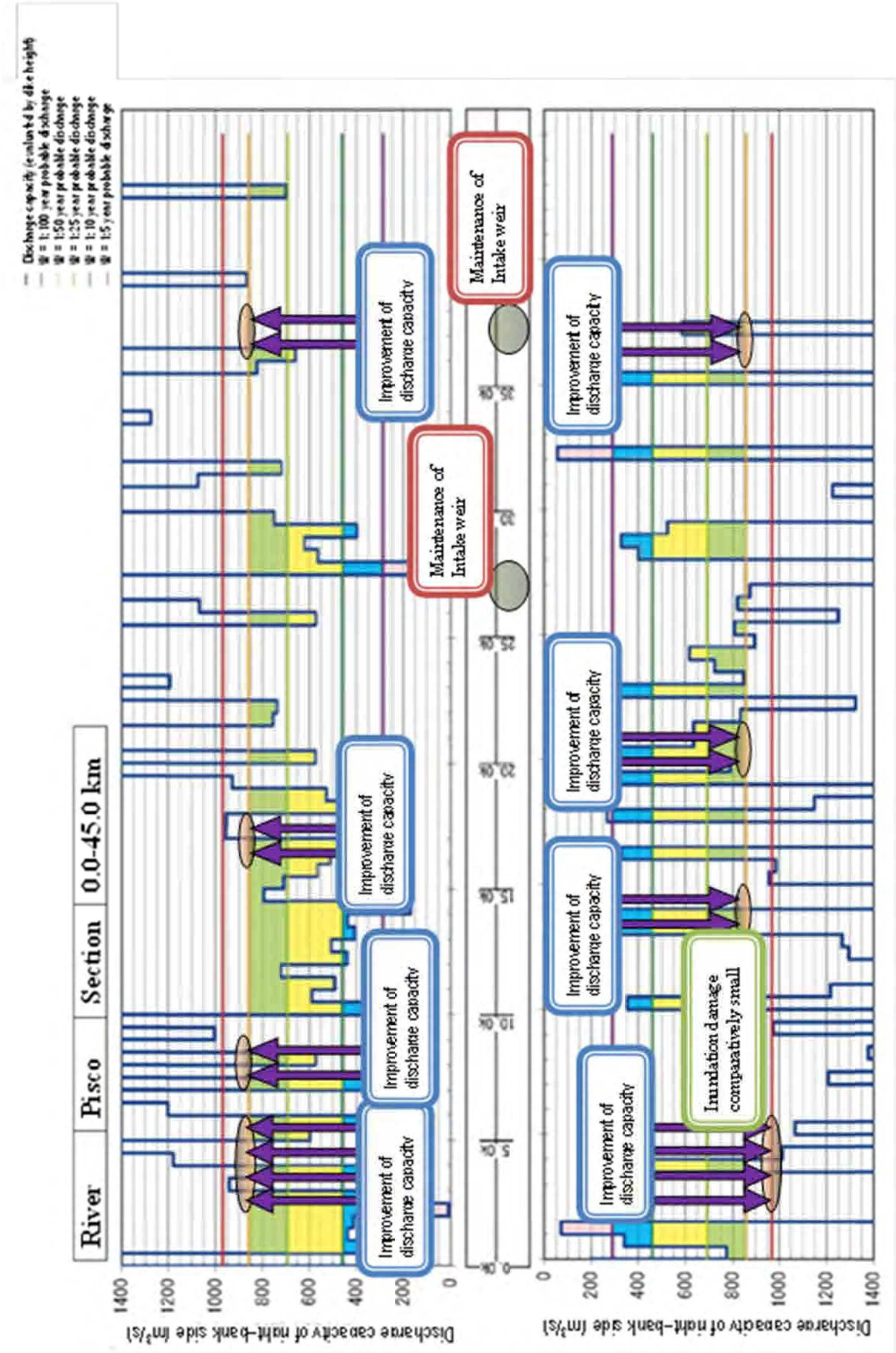


Figure 6.5 **Mitigation Effects for Inundation by Improvement (Pisco River)**

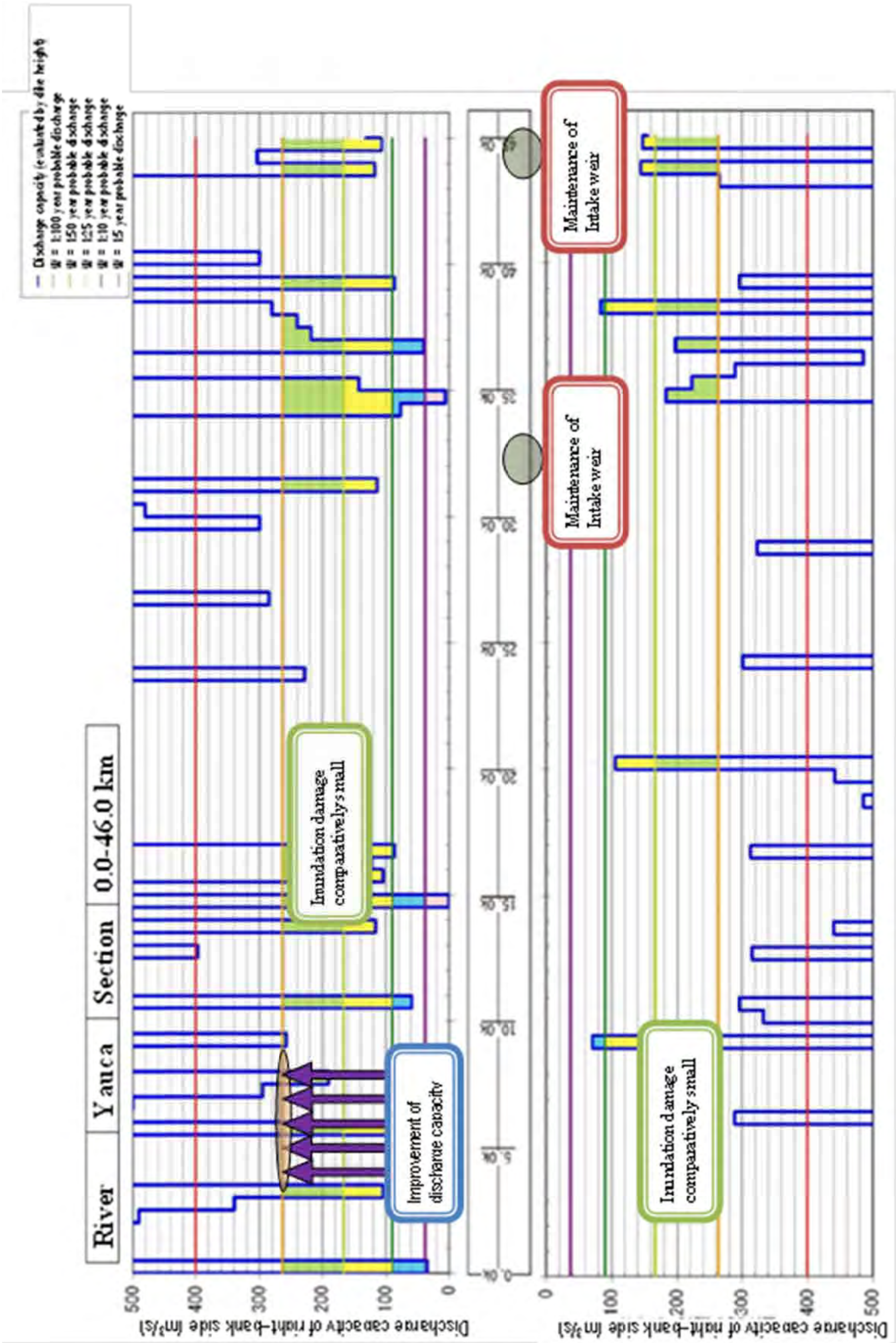


Figure 6.6 **Mitigation Effects for Inundation by Improvement (Yauca River)**

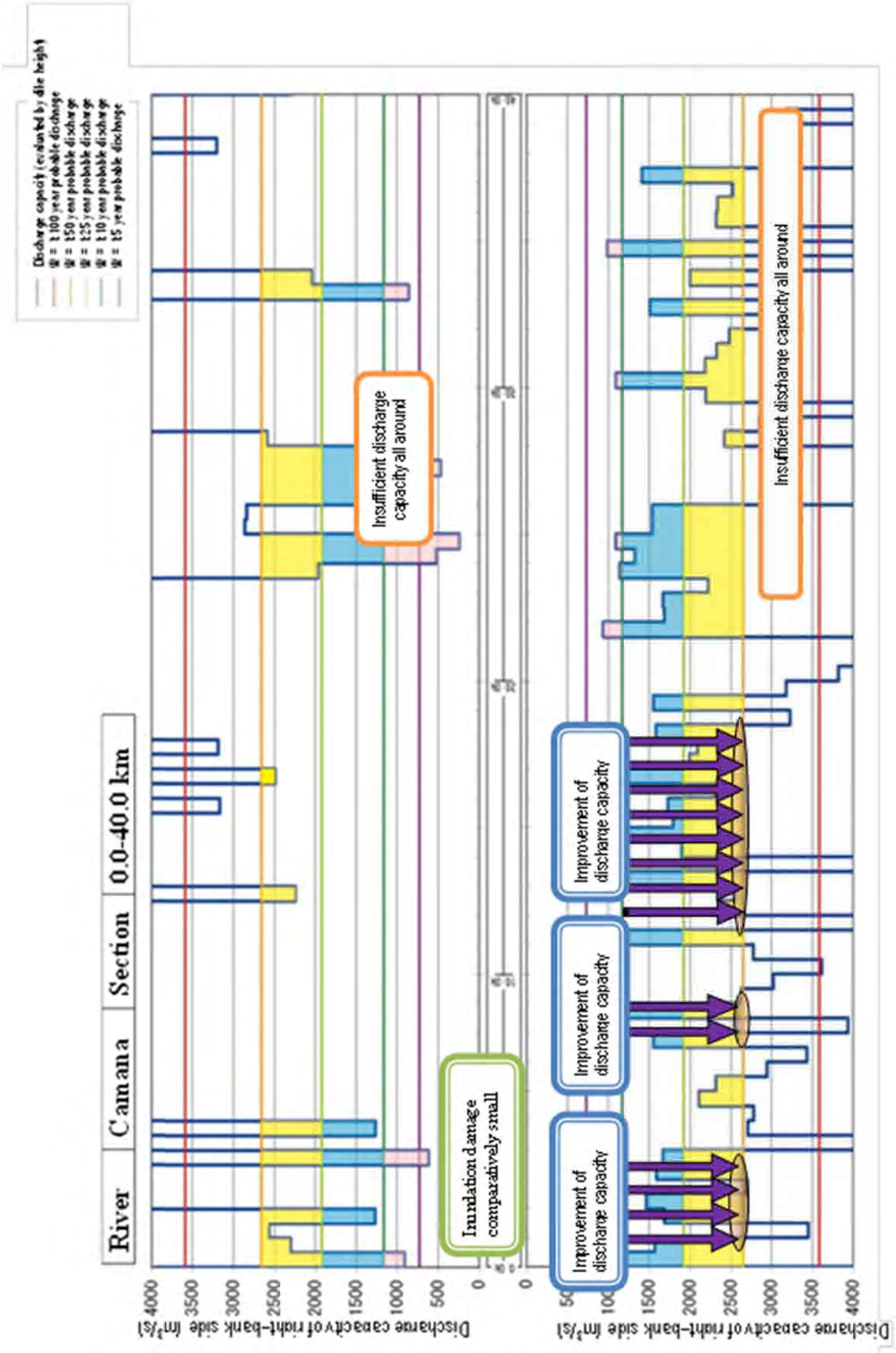


Figure 6.7 **Mitigation Effects for Inundation by Improvement (Camana River)**

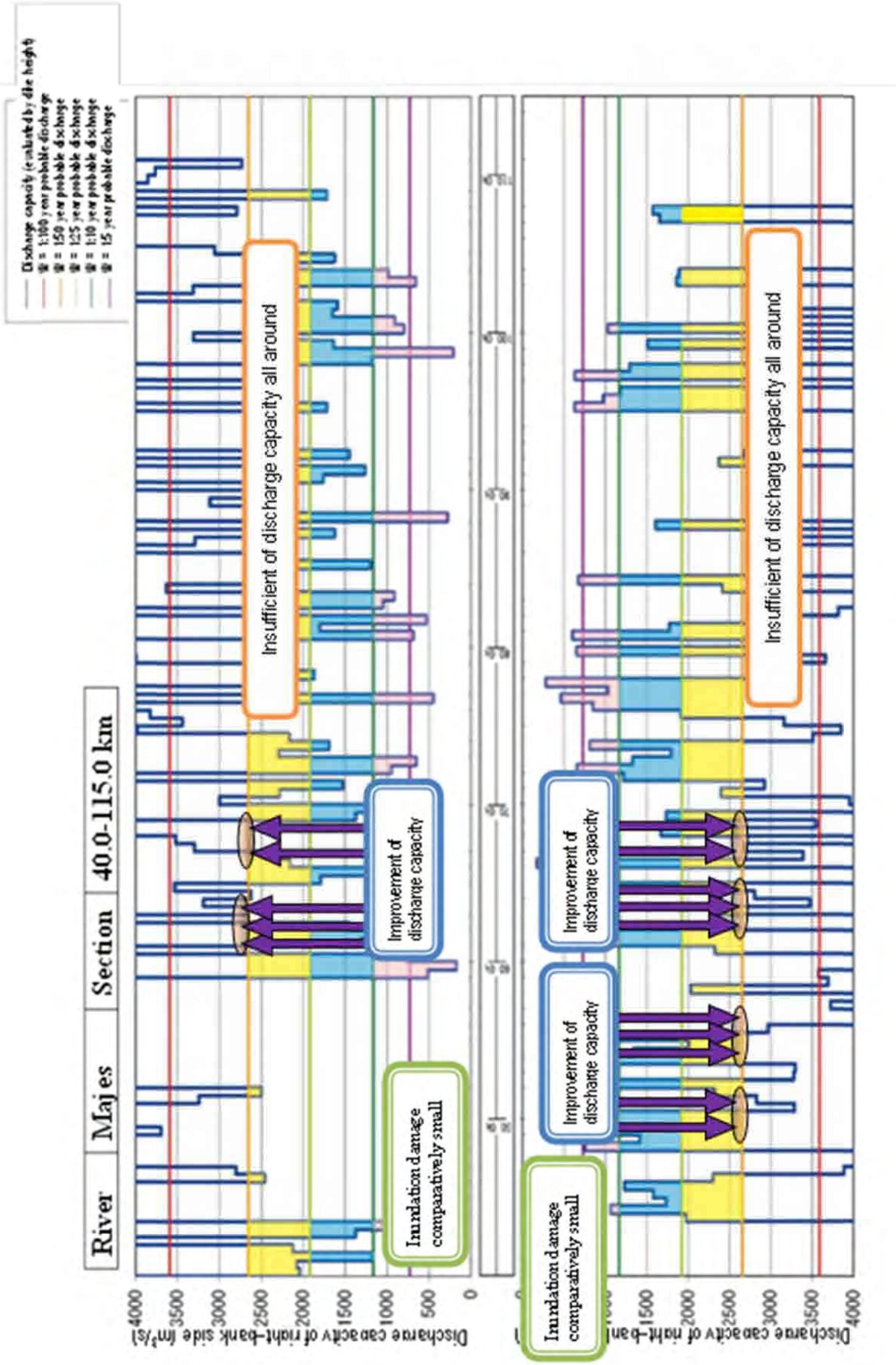


Figure 6.8 **Mitigation Effects for Inundation by Improvement (Majes River)**

Ministry of Agriculture
Republic of Peru

THE PREPARATORY STUDY
ON
PROJECT OF THE PROTECTION OF FLOOD PLAIN AND VULNERABLE RURAL POPULATION AGAINST FLOOD IN THE REPUBLIC OF PERU

FINAL REPORT
I-6 SUPPORTING REPORT
ANNEX-5 FLOOD FORECASTING AND WARNING SYSTEM IN THE CHIRA BASIN

March 2013

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

YACHIYO ENGINEERING CO., LTD.
NIPPON KOEI CO., LTD.
NIPPON KOEI LATIN AMERICA –
CARIBBEAN Co., LTD.


COLOMBIA
ECUADOR
BRAZIL
BOLIVIA
CHILE
PERU
SOUTH PASIFIC OCEAN
LORETO
PIURA
ピウラ州
Chira River
LAMBAYEQUE
CAJAMARCA
AMAZONAS
SAN MARTIN
LA LIBERTAD
ANCASH
HUANUCO
PASCO
UCAYALI
LIMA
リマ州
JUNIN
MADRE DE DIOS
Canete River
Chincha River
Pisco River
HUANCAVELICA
CUSCO
AYACUCHO
APURIMAC
ICA
イカ州
PUNO
Yauca River
AREQUIPA
アレキパ州
Majes-Camana River
MOQUEGUA
TACNA
Amazon
Legend
International boundary
Province boundary
Project Area (関連州)
Taget Rivers (対象河川)
National capital
Department capital
Railroad
Road
200 Km
200 Miles

Study Area

THE PREPARATORY STUDY ON PROJECT OF THE PROTECTION OF FLOOD PLAIN AND VULNERABLE RURAL POPULATION AGAINST FLOOD IN THE REPUBLIC OF PERU
FEASIBILITY STUDY REPORT
SUPPORTING REPORT

Annex-5

Flood Forecasting and Warning System in the Chira Basin

TABLE OF CONTENTS

STUDY AREA

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 INTRODUCTION

1.1 Project Background

Perú is a country exposed to be at high risk of natural disasters, especially floodings. Particularly, the El Niño Phenomenon in the northern area of the country occurs at recurrent intervals every certain number of years, and has caused river overflows. The most serious and recent disasters include the occurrences during the rainy seasons of 1982- 1983 and 1997 – 1998 that brought about losses over US Dollar 3,500 million throughout the country.

Recent floodings occurred in January 2010 close to the Machu Picchu World Heritage Site, in Cusco. As a result of the heavy rainfall that disrupted traffic on the railway and roads, around 2,000 people were left isolated, 60 Japanese tourists included.

In this context, the Ministry of Agriculture started the River Channeling and Catchment Structure Protection Program (PERPEC, in Spanish) in 1999, aiming at protecting populated areas, farmlands, agricultural infrastructures, etc. that are located within the areas at risk of floodings. This program involved input from the Central Government's financial resources and a balancing entry from the local Governments for the protection works on the river banks to be executed. However, works executed so far have been of a very small size, and risks have not been totally removed.

In 2009, through its Hydraulic Infrastructure General Directorate (DGIH, in Spanish), the Ministry of Agriculture prepared the "Valley and Rural and Vulnerable Population Protection against Risks" Project for nine (9) hydrographic basins. However, given its little availability in terms of experiences, techniques, and financial resources to set up a pre – investment study for such a major flood control project, support has been requested to JICA to carry out this project.

In response to such request, JICA and the Ministry of Agriculture (MINAG) have held discussion meetings under the assumption of setting up this project within the preparatory study scheme towards the formulation of a JICA ODA loan project. The study's content and approach, the implementation schedule, the obligations and commitments for both parties, etc, was stated in writing in the Discussion Minutes that were subscribed on January 21st and April 16th, 2010. This Study is developed upon the basis of these agreements, as established and commissioned by JICA.

1.2 Previous Study Backgrounds

A forecasting and warning system for the Chira River is part of the "Valley and Rural and Vulnerable Population Protection against Risks" Project. Available references from previous studies include:

(1) "Definite Study for Reconstruction and Rehabilitation of Protection Systems against Floodings in the Lower Piura"

A Flood Forecasting and Warning System Project for the Piura River basin, as developed within the study that was prepared by the Class – Salzgitter Consortium for the Chira Piura Special Project, 2001. It is specifically found in Volume VIII, Hydrological Model and Hydrometeorological Network Extension, and Volume I, Report. It is currently implemented.

(2) "Hydrometeorological Information Remote Monitoring System on the Chira Piura River Basin, Profile Level Study"

The Ministry of Agriculture formulated this project at profile level in June 2010. Its objective is to gather suitable hydrometeorological information for prevention actions along the Chira River basin. This project is within the National Public Investment System (SNIP, in Spanish), and was approved by Ministry of Agriculture's Investment Project Office (OPI, in Spanish)

This Project sets up the agreements between the Government of Perú and JICA for the execution of the "Valley and Rural and Vulnerable Population Protection against Risks" Project for nine (9) hydrographic basins, under the assumption of setting up this project within the preparatory study scheme [1] towards the formulation of a JICA ODA loan project. The study's content and approach, the implementation schedule, the obligations and commitments for both parties, etc, was stated in writing in the Discussion Minutes that were subscribed on January 21st and April 16th, 2010. This Study is developed upon the basis of these agreements.

(3) Information and Forecasting and Warning Systems to face Climate Changes: A Proposal for Technological Adaptation and Response to Climate Changes in Piura, Apurímac, and Cajamarca, ITDG

Other experiences developed by the Intermediate Technology Development Group, ITDG[2] include Programs on Information and Forecasting and Warning Systems to face Climate Changes: A Proposal for Technological Adaptation and Response to Climate Changes in Piura, Apurímac, and Cajamarca, Lima 2008. This approach involves developing a SIAT to monitor climate change along the Yapatera River in the Higher Piura for local capacity building purposes and response to adverse climate occurrences.

(4) Hydric Characterization and Adequacy between Supply and Demand along the Bi – National Catamayo Chira Basin.

The Chira River is a border river that involves areas both in the Republic of Perú and the Republic of Ecuador. Within this context, and as a result of the agreements between both countries in 1998, a Bi –

[1] Preparatory Study on the Valley and Rural and Vulnerable Population Protection Against Floodings in the Republic of Perú, Initial Report, September 2010, Yachiyo Engineering Co Ltd.; NIPPON KOEI Co Ltd; NIPPON KOEI LAC.

[2] *Information and Forecasting and Warning Systems to face Climate Changes: A Proposal for Technological Adaptation and Response to Climate Changes in Piura, Apurímac, and Cajamarca, ITDG*. Lima 2008.

National Commission was established in year 2000 for border development and integration purposes, with the participation of the Spanish Technical Cooperation Agency (AECI) and the Management Unit that was made up of representatives from Perú and Ecuador. Within the Project scope, this Commission entrusted the development of Hydric Characterization and Adequacy Studies between Supply and Demand [3] and the Territorial Characterization Studies along the Catamayo Chira Basin, as these studies include a chapter on Forecasting and Warning System.

1.3 Hystorical Flooding Backgrounds

The Hazard Map study for the Chira and Piura River basins that was developed by the National Institute of Civil Defense's (INDECI, in Spanish) National Defense Office [4] accounts for the historical flooding backgrounds in the Chira River and the Piura River, as the precipitations occurrences are correlated with the floodings:

Floodings represent a major external geodynamics phenomenon affecting the basins; references of their occurrences are traced back to Colonial times, and show higher incidence on the lower basins, especially on the coastal plain areas.

The El Niño Phenomenon, which is the major natural cause for floodings, is an oceanographic phenomenon that is controlled and / or motivated by the atmosphere. It appears at 5 to 16 year – intervals. It is characterized by the presence of very warm waters along the coastline, violent rains, and the collapse of the marine ecosystem.

Historians and scientists have studied the El Niño Phenomenon, as it relates to the Piura floodings, and the following information has been recollected: Dr. Maria Rostorowski de Diez Canseco mentions the occurrence of another El Niño in 1578; Friklinck records the occurrences of 1728, 1770, 1791, 1828, 1864, 1871, 1877, 1884, and 1981; Lucas records the occurrences of 1835, 1869, 1879, and 1891; V. Eguiguren (1894) establishes semi – quantitative table that records rainfall in Piura between 1791 and 1891. As he takes journalistic reports of 1925 as a basis, Woodman R., (1984), establishes 60 mm as an average precipitation index for heavy rainfall, and a 20 mm average precipitation index for normal rainfall; based on that criterion, he gets 1,200 mm as a total estimated accumulated rainfall for 1925, and relates it to the 1983 precipitation estimations of 2,381mm.

It is estimated that the precipitations in the areas of Piura and Sullana are around 50 mm. The 1983 rains were around 50 times more intense than their average value; this meant that Piura, considered to be one of the driest desert areas, started to experience violent rains that only fall in the most torrid regions.

---

[3] HYDRIC CHARACTERIZATION AND ADEQUACY BETWEEN SUPPLY AND DEMAND ALONG THE BI – NATIONAL CATAMAYO CHIRA BASIN, EXECUTIVE SUMMARY, Bi – National Perú Ecuador Commission, AECI, ATA, UNL UNP Consortium, Loja, Piura 2003.

[4] Natural Hazard Map Study for the Chira Piura River Basins, National Defense Office, INDECI, Lima, 2000

In 1965, as there were 3,500 m3 / sec. discharges, around 8,000 hectares were flooded. In addition, as a result of the Poechos Dam's operation, in 1978 around 1,500 hectares were flooded with 700 m3 / sec. discharges that were also caused by El Niño.

Figures 1.1 and ***Figure 1.2*** compare rainfall in a normal year with rainfall in those "El Niño" years, namely 1982 -1983 and 1997 -1998. ***Figure 1.3*** shows annual mean discharges from the Chira River at the Ardilla Station and so, the river's hydrological regime to detect years with discharges over 2,500 m3/sec., as these are flooding discharges; these values are also considered to be annual averages.

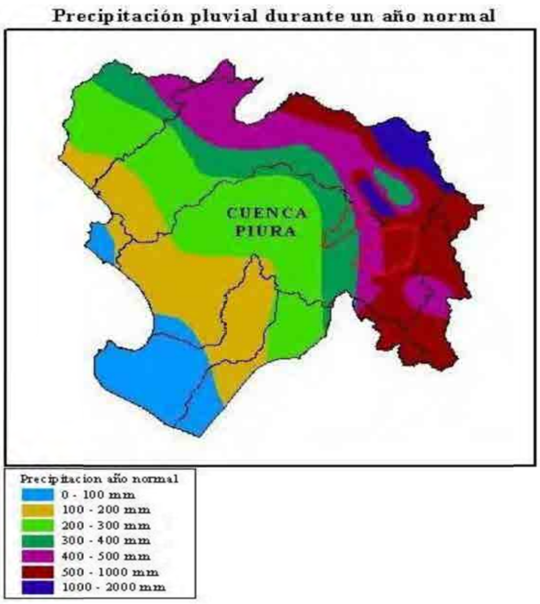


Figure 1.1 **Rainfall during a Normal Year**

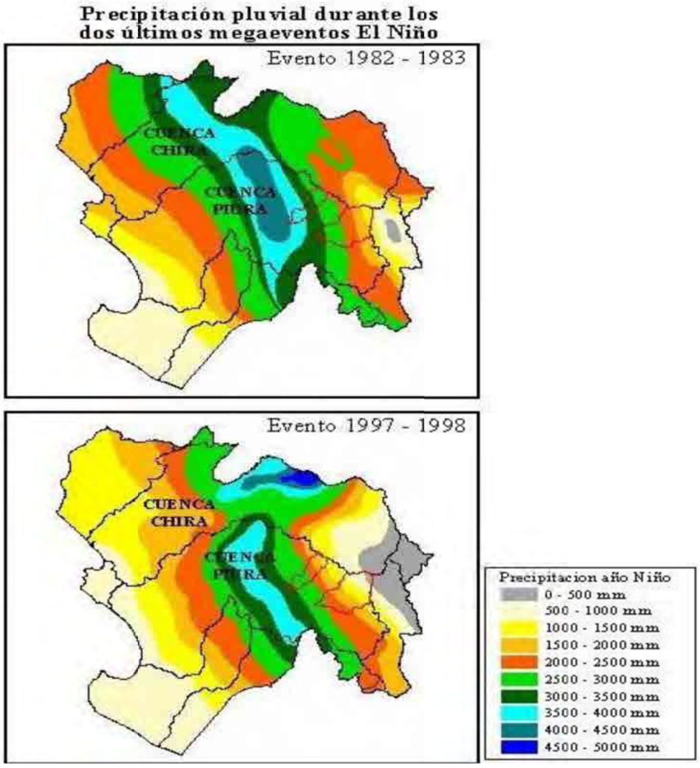


Figure 1.2 **Rainfall during the Last Two El Niño Mega Occurrences**

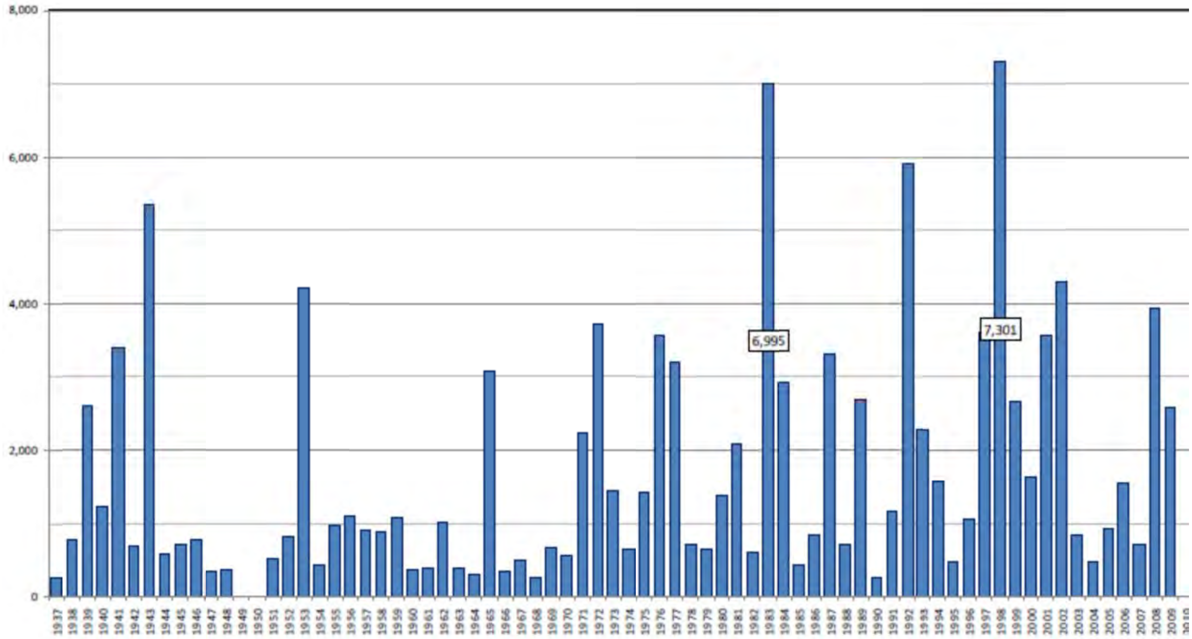


Figure 1.3 **Chira River, Ardilla Station m3/sec. Discharges (1937 -2010)**

CHAPTER 2 DIAGNOSTIC OF THE CURRENT SITUATION

2.1 Project Scope

As the Chira River involves areas both in the Republic of Perú and the Republic of Ecuador, the Bi – National Development Plan for the Borderline Region was in charge of developing the studies within the Project scope. The Study on Territorial Characterization was developed by AECI – Bi – National Plan for the Organization, Management, and Development of the Catamayo – Chira Basin[5], and it describes the basin's scope and major characteristics.

The Bi – National Catamayo – Chira hydrographic basin's area is 17,199.1 km2: 7,212.3 km2 area in Ecuadorian territory, namely in the Celica, Pindal, Macará, Sozoranga, Calvas, Espíndola, Gonzanamá, Quilanga cantons, and partly in areas belonging to the Loja, Catamayo, Paltas, Olmedo, Puyango, and Zapotillo cantons. In Peruvian territory, the basin has an area of 9,986.81 km2, covering the Sullana province, and partly, the Ayabaca, Huancabamba, Morropón, Paita, Talara, and Piura provinces, in the Department of Piura. Drawing N° 1 shows the basin's hydrography.

The basin is located between 03° 30´ to 05° 08´ Southern Latitude and 79° 10´ to 81° 11´ Western Longitude coordinates. Its elevation ranges between sea level (0 m.a.s.l.) at the Catamayo – Chira River mouth discharging to the Pacific Ocean and 3,700 m.a.s.l. Its boundaries are: to the north, the Puyango – Tumbes basin (Department of Tumbes in Perú and the El Oro and Loja provinces in Ecuador); to the east, the Zamora – Chinchipe province in Ecuador; to the south, the Piura and Huancabamba provinces in Perú (the Piura and Huancabamba basins); and to the west, the Pacific Ocean.

2.2 Phsycal Characteristics of the Basin

2.2.1 Hidrography

The hydrographic network has dendritic characteristics that show a good drainage. Its main course is the Catamayo – Chira River, with a total length from its headwaters to its mouth discharging to the Pacific Ocean, of 315 km. From these, 196 km are in Ecuadorian territory, and 119 km are in Peruvian territory.

The Catamayo Chira basin is made up of six (6) sub – basins that are shown in Drawing N° 2 and ***Table 2.1***, its partial area and the percentage with regard to the total area.

In Ecuadorian territory, the Catamayo – Chira River is born from the confluence of two rivers: One of them flows in a southeast – northeast direction, and its various stretches bear several names, such as Palmira River, Piscobamba River, Solanda River, Chinguilamaca River, and El Arenal River; the

---

[5] AECI- Bi – National Plan for the Catamayo – Chira Basin Arrangement, Management, and Development, "Territorial Characterization and Basic Documentaton within the Catamayo – Chira Bi – National Basin", Volume I, Main Report, ATA – UNP – UNL Consortium, Loja, Piura 2003.

other one flows in a north – south direction, and it is known as the Guayabal River. The Guayabal River flows 45 km before joining the El Arenal River. In this way, the Catamayo – Chira is established, and as it flows downstream, it receives discharges from small rivers until it joins the Macará River that bears the name of Calvas River upstream. The Macará River is born from the confluence of the Espíndola River and Chiriyacu River. The

Table 2.1 **The Catamayo Chira River Sub - Basins**

Sub cuenca	Area Ha	% area
Quiroz	3.108,7	18,08
Parte Baja del Chira	4.711,8	27,40
Chipillico	1.170,9	6,81
Alamor	1.190,2	6,92
Macará	2.833,2	16,46
Catamayo	4.184,0	24,33
Total	**17.198,8**	**100,00**

Espíndola River flows ina south – north direction, and the Chiriyacu River flows in a northeast – southeast direction.

In Peruvian territory, starting from the confluence of the Catamayo River and Macará River, the main course bears the name of Chira River, and it receives discharges downstream from the Quiroz River, the Alamor River, the Chipillico River, and other small gullies that activate during the rainy seasons.

2.2.2 Geology

The study developed by AECI- Bi – National Plan for the Catamayo – Chira Basin Arrangement, Management, and Development, Territorial Characterization, Geology[6], briefly describes the following:

There are units in the Catamayo – Chira basin's geological conformation that range from the oldest, belonging o the Pre – Cambrian – Paleozoic, to the most recent units belonging to the Quaternary with sharp hiatuses, mainly in the Triassic and Jurassic. Intrusive rocks from the upper – tertiary lower Paleozoic and Cretaceous, by means of small stocks and an intrusive body called Andean Batholith. This Andean Batholith is of a granite, granodiorite, and tonalite nature. The oldest rocks of a metamorphic nature outcrop in the Amotape Hills massif, in the western sector and the eastern side of the Western Cordillera (Andes Mountains Range) in Perú and the Central Cordillera in Ecuador; it is made up of sand – pelitic type rocks with different degrees of metamorphism.

Very sharp hiatuses from the Triassic – Jurassic and from the Mesozoic, as represented by the Cretaceous, are shown both on Peruvian and Ecuadorian territory. The Tertiary starts with the

[6] AECI- Bi – National Plan for the Catamayo – Chira Basin Arrangement, Management, and Development, "Territorial Characterization and Basic Documentaton within the Catamayo – Chira Bi – National Basin", Volume III, Basic Studies, Volume 3.2 Geology, ATA – UNP – UNL Consortium, Loja, Piura 2003.

development of the Talara Group in the Peruvian sector, followed by the Verdun, Chira – Verdun, Chira, and Mirador formations and their counterparts from the Saraguro and Quillollaco groups in Ecuadorian territory. Sedimentary sand – politic rocks were developed in the basins located in the western sector, and an intense development of a pyroclastic volcanism was formed in the Cordillera sector with andesitic, dacitic, and riodacitic lava interbeddings from the Llama, Porculla, and Shimbe volcanics in Peruvian territory and the Sacapalca volcanic in Ecuadorian territory.

In the Pleistocene Quaternary, lifting processes on the Coast have caused transgressions and regressions that created sandy, coquina rocks that appear as lifted terraces at different levels, as a result of the complex interaction between the Regional Tectonism and the oscillations of the sea level. In the Andean sector, volcanic type deposits are produced. In the Ecuadorian territory, these deposits are represented by the Tarqui formation that is made up of pyroclasts, tobas, volcanic ashes and ignimbrites.

In a lower proportion and in specific locations, Pleistocene glacial type deposits are noticed, particularly in the Cordillera areas. There are also alluvial deposits in the gullies, depressions, and eolian deposits along the coastal plains that can be recognized.

2.2.3 Soils

The already mentioned basin territorial characterization study also describes the characteristics of the soils that correspond to the Catamayo – Chira basin.

The composition of the basin soils include soils of recent formation, such as the entisols (that cover over half the basin’s total area) and the inceptisols, through more mature soils that show a greater pedogenetic evidence, such as aridisols, alfisols, mollisols, and vertisols.

Entisols are primarily represented by the large Ustorthents and Torriorthents groups that are located in Centro Loja, the Andean part of Perú, the lower part of the Catamayo sub – basin, and under the Poechos Dam elevation. Aridisols are located in the lower parts of the basin with a dry climate, and among these, the large Camborthids and Haplargids groups prevail.

Inceptisols are preferably located in the high parts, above 2,000 m.a.s.l., and correspond to the large Dystropepts group. Alfisols are mainly located in the higher parts of the Ecuadorian part of the basin, and from these, the Rhodustalfs prevail.

With regard to the molisols, the great Haplustoll group prevails. Vegetation coverage of the soils mainly consists of forests, pastures, and shrubs. Forests are most representative, and are made up of the natural dry forest on the hills of the basin’s lower part. Pastures are located in the high parts of the basin, along with shrubby vegetation.

Croplands are scattered throughout the high, medium, and low parts especially on the banks of the

Chira River and Alamor River.

According to their classification based on their potential use, basin soils are suitable for farming and cattle – raising activities on over half the basin's surface, that is, the lower parts of the Alamor, Catamayo, Macará, Quiro, Chipillico sub – basins, and almost all of the Chira sub – basin. The remaining area (the high parts) should be preferably used to combine agricultural – forestry – herding, forestry, and basin protection activities, so that the natural vegetation and the river flows are maintained.

2.3 Climate Characteristics

Six (6) types of climate have been identified along he Catamayo – Chira basin:

- Warm, in 44.57 % of the total basin surface, at elevations below 1,000 m.a.s.l.
- Semi - warm, in 23.55 % of the total basin surface, between 1,000 and 1,700 m.a.s.l.
- Mild warm, in 20.40 % of the total basin surface, between 1,700 and 2,300 m.a.s.l.
- Mild cold, in 7.28 % of the total basin surface, between 2,300 and 3,000 m.a.s.l.
- Semi – cold, in 3.54 % of the total basin surface, between 3,000 and 3,500 m.a.s.l.
- Moderate cold in 0.66 % of the total basin surface, at elevations over 3,500 m.a.s.l.

Temperatures vary from relatively high in the lower basin - around 24° C - to temperatures around 7° C in the high parts of the basin, on elevations over 3,200 m.a.s.l. Temperature in the middle basin is 20° C.

Precipitations in the basin show sharp variations in space and time; there are two specific seasons: A rainy season, between December and April, and a dry season, between May an November.

The lower basin has short and scanty rainy seasons, except during the El Niño years; it rains from January to April at an annual mean of 10 to 80 mm.

At the middle basin, rainy season is from December to May, with annual mean precipitations between 500 and 1,000 mm.

In the high basin, rainfall is from October to May, with annual means over 1,000 mm. There are exceptions in this area, though, such as the high parts of the Quilanga and Gonzamaná cantons, where it rains all year round on a regularly spread basis, with annual means between 1,000 and 2,000 mm.

Temporary evaporation variations are small, but they have a large spatial variation, ranging between 6.0 in the lower basin and up to 3.0 mm / day in the high basin.

2.4 Population Characteristics, Production and Urban Insfrastructures

The population involved in the Project is settled in the Paita and Sullana provinces. As shown in ***Table 2.2***, official information is supplied by the National Institute of Statistics and Information Technology (INEI, in Spanish), from the definitive 2007 census (population and housing census) results, as broken down by districts and gender.

Table 2.2 **Population in the Paita and Sullana Provinces**

Region	Province	District	Population		Total
			Men	Women	
Piura	Sullana	Sullana	75 934	80 667	156 601
		Ignacio Escudero	9 156	8 706	17 862
		Marcavelica	13 291	12 740	26 031
		Querecotillo	12 361	12 091	24 452
		Salitral	3 072	3 025	6 097
	Paita	Amotape	1 210	1 095	2 305
		Colán	6 304	6 028	12 332
		La Huaca	5 664	5 203	10 867
		Tamarindo	2 263	2 139	4 402
Total					260 949

Agricultural infrastructure is as shown in ***Table 2.3***; with farming areas and users for the Sullana and Paita provinces that will be benefited with the Project, especially the farming land located along the Chira River, from Poechos to the River mouth.

Table 2.3 **Irrigation User Organizations, Croplands, and Number of Users**

Irrigation Sectors	Irrigation Associations	Irrigated Areas ha	Nº of Users
Miguel Checa	Miguel Checa	9 998.0	5 579.0
El Arenal	El Arenal	3 549.0	1 625.0
Poechos Pelados	Poechos Pelados	4 450.0	1 848.0
Cieneguillo	Cieneguillo	4 903.0	1 192.0
Margen Derecha	Margen Derecha	7 205.0	2 365.0
Margen Izquierda	Margen Izquierda	3 805.0	1 117.0
		33 910.0	13 726.0

Table 2.4 shows the largest irrigation infrastructure, namely, the Poechos Dam, the channel, drainage, and intake systems that are shown with their replacement value for such works, and that will be protected under this Project, as established by the Chira Piura Project.

Table 2.4 **Appraisal of the Chira Piura Project Irrigation Infrastructure Replacement Value for the Chira Piura Special Project Works**

VALOR DE REPOSICIÓN DE LAS OBRAS DEL PROYECTO ESPECIAL CHIRA PIURA

ITEM	DESCRIPCIÓN	VALOR DECLARADO CON IGV EN US$	VALOR DECLARADO SIN IGV EN US$
	Obras de la I Etapa		
1	Presa Poechos	275,664,000	231,650,420
2	Canal de Derivación Chira Piura (Km. 0+000 al Km. 53+000)	110,282,000	92,673,950
	Obras de la II Etapa		
3	Presa Los Ejidos	27,958,000	23,494,118
4	Canal Principal Bajo Piura (Km. 0+000 al Km. 56+780)	86,574,000	72,751,261
5	Diques de Defensa Valle Bajo Piura	75,481,000	63,429,412
	Obras de la III Etapa		
6	Presa Derivadora Sullana	25,245,000	21,214,286
7	Canal Norte (Km. 0+00 al Km. 39+200) incluido el sifon Chira	53,312,507	44,800,426
8	Canal Sur (Km. 0+000 al Km. 25+800) incluido el sifon Sojo	24,949,000	20,965,546
9	Diques de Defensa Valle Del Chira	22,564,000	18,961,345
	TOTAL en US$	**702,029,507**	**589,940,762**

2.5 Hydrometeorological Station Networks

2.5.1 Existing Stations

The Catamayo – Chira basin meteorological network is made up of 41 stations. 14 of these stations work in Peruvian territory, and 27 work in Ecuadorian territory. These stations include pluviometric (PLU) stations, ordinary climatological (CO) stations, ordinary agricultural meteorological (MAO) stations, aeronautic (AR) stations, and some special (E) stations, as shown in ***Table 2.5***. Stations currently operating in the Catamayo Chira Bi – National basin, as studied by the Perú Ecuador Bi – National Commission[7], are being run by various institutions, such as the National Meteorology and Hydrology Authority of Perú (SENAMHI, in Spanish), The Chira Piura Special Project of Perú, the National Institute of Meteorology and Hydrology of Ecuador (INAMHI, in Spanish), and the National Development Program for the South of Ecuador (PREDESUR, in Spanish).

[7] "Hydric Characterization and Adequacy between Supply and Demand within the Catamayo Chira Bi – National Basin Scope", Volume II, Basic Studies, Volume 3.1 Forecasting and Warning Network Diagnostics.

Table 2.5 **Stations Currently Operating in the Catamayo Chira Bi – National Basin**

N°	ESTACION	PROV	DIST	SUB CUENCAS	UBICACIÓN			CATEGORIA	INSTITUCION OPERADORA	PAIS
					N	E	ALTITUD			
1	Ayabaca	Ayabaca	Ayabaca	Quiroz	9487823	642699	2700	MAO	SENAMHI	PERU
2	Chilaco	Sullana	Sullana	Chira	9480963	554900	90	MAO	PECHP	PERU
3	El Ciruelo	Ayabaca	Suyo	Chira	9524654	594327	202	PV-PG	PECHP	PERU
4	La Esperanza	Paita	Pblo.Nuevo	Chira	9456418	493286	12	CO	SENAMHI	PERU
5	Mallares	Sullana	Marcavelica	Chira	9463137	529784	45	AP	SENAMHI	PERU
6	Paita	Paita	Paita	Chira	9438150	487550	6	AR	LA NAVAL	PERU
7	Sausal Culucán	Ayabaca	Ayabaca	Quiroz	9474842	636789	980	CO	SENAMHI	PERU
8	Pte.Internac.	Ayabaca	Suyo	Macará	9515414	616512	408	PV-PG	PECHP	PERU
9	Pacaypampa	Ayabaca	Pacaypampa	Quiroz	9449023	647832	1960	PV-PG	SENAMHI	PERU
10	Paraje Grande	Ayabaca	Paimas	Quiroz	9488151	620548	555	PV	PECHP	PERU
11	Sapillica	Ayabaca	Sapillica	Chipillico	9471196	612750	1446	PV	SENAMHI	PERU
12	Lancones *	Sullana	Lancones	Chira	9487166	550491	120	CO	SENAMHI	PERU
13	El Partidor	Piura	Las Lomas	Chipillico	9477296	580134	255	CO	SENAMHI	PERU
14	Alamor	Sullana	Lancones	Chira	9505457	566997	125	PV	SENAMHI	PERU
15	Alamor	Puyango	Alamor	Alamor	9555383	607434	1250	PV	INAMHI	ECUADOR
16	Alamor en Saucillo	Zapotillo	Garza Real	Macará	9528672	588697	315	PV	INAMHI	ECUADOR
17	Amaluza	Espindola	Amaluza	Macará	9493392	674770	1690	CO	INAMHI	ECUADOR
18	Cajanuma	Loja	Loja	Santiago	9548762	699492	2267	PV	PREDESUR	ECUADOR
19	Cariamanga	Calvas	Cariamanga	Macará	9521176	660606	1960	MAO	INAMHI	ECUADOR
20	Catacocha	Paltas	Catacocha	Catamayo	9551949	650752	1763	PV	INAMHI	ECUADOR
21	Celica	Celica	Celica	Catamayo	9546579	616616	2017	CO	INAMHI	ECUADOR
22	Changaimina	Gonzanam	CHANGAIMI	Catamayo	9533920	664116	1970	E	PREDESUR	ECUADOR
23	Colaisaca	Calvas	Colaisaca	Catamayo	9522957	645158	2285	PV	INAMHI	ECUADOR
24	El Cisne	Loja	El Cisne	Catamayo	9574167	675000	2300	PV	PREDESUR	ECUADOR
25	El Ingenio	Espindola	El Ingenio	Macará	9512380	674403	1220	E	PREDESUR	ECUADOR
26	El Lucero	Calvas	El Lucero	Macará	9513854	670376	1190	PV	INAMHI	ECUADOR
27	El Tambo	Catamayo	El Tambo	Catamayo	9549939	687880	1575	PV	PREDESUR	ECUADOR
28	Jimbura	Espindola	Jimbura	Macará	9488283	670616	2150	PV	INAMHI	ECUADOR
29	La Argelia	Loja	Loja	FC	9553464	699403	2160	CO	INAMHI	ECUADOR
30	Catamayo-At	Catamayo	Catamayo	Catamayo	9558425	681296	1250	AR	DAC	ECUADOR
31	Lauro Guerrero	Paltas	Lauro	Catamayo	9561629	638095	1923	PV	PREDESUR	ECUADOR
32	Mercadillo	Puyango	Mercadillo	Alamor	9555570	613632	1175	PV	PREDESUR	ECUADOR
33	Nambacola	Gonzanam	Nambacola	Catamayo	9542456	674175	1795	E	PREDESUR	ECUADOR
34	Quilanga	Quilanga	Quilanga	Macará	9524562	677858	1805	CO	PREDESUR	ECUADOR
35	Quinara	Loja	Vilcabamba	Catamayo	9523236	695345	1595	CO	PREDESUR	ECUADOR
36	Sabanilla	Celica	Sabanilla	Alamor	9536068	597312	740	PV	PREDESUR	ECUADOR
37	Sabiango	Macara	Sabiango	Macará	9517751	632012	750	PV	INAMHI	ECUADOR
38	Sozoranga	Sozoranga	Sozoranga	Macará	9522032	634505	1480	PV	PREDESUR	ECUADOR
39	Vilcabamba	Loja	Vilcabamba	Catamayo	9530595	699000	1920	CE	S. FRANCISCO	ECUADOR
40	Yangana	Loja	Yangana	Catamayo	9516982	702487	1860	CO	INAMHI	ECUADOR
41	Zapotillo	Zapotillo	Zapotillo	Catamayo	9515321	584254	230	CO	INAMHI	ECUADOR

2.5.2 Locations of Stations

Stations are distributed throughout the basin, as shown in Drawing N°3, with the Ecuador area showing a greater density. Those stations set up in Perú are basically devoted to the Poechos Dam operation.

In order to overcome the limitation caused by a greater number of stations in locations with very little population and means of communication, a solution that involves the use of infrared - type satellite images has been set up in the last few years.

2.6 Hydrometeorological Information

2.6.1 Quality of the Information

Quality of the meteorological and hydrometric information largely depends on the person who registers the data. In this case, staff in charge of this job in the Project area are the meteorological and hydrometric observers, who know their job, as they were trained for this activity, and keep the stations in good conditions since their installation in 1963 and 1972. Data recording is accurate and of a high quality, information that has been gathered is highly reliable, as confirmed by the studies on the information's statistical consistency.

In spite of their age, stations are in good maintenance and conservation conditions.

2.6.2 Status of the information

Hydrometeorological information records have been studied and evaluated, and found these are still stored and registered, and are extremely valuable. All the information is computerized, including the original meteorological and hydrometric information reels that are over 30 years old. The study carried out by the Catamayo Chira Bi – National Commission on the hydric characterization fully describes and listsinformation both from the Peruvian and the Ecuadorian side, as to stations, quality, consistency.

2.7 Institutional Organization

There are laws in Perú that deal with Hazard and Disaster Prevention and Mitigation, namely:

- The 1993 State Constitution
- Decree Law N° 19338, Establishment of the National Civil Defense System
- Supreme Decree N° 005-88-SGMD, Rules of the National Civil Defense System

In the specific case of Piura, there is a Regional Committee run by the Regional Government of Piura and Local Committees that are run by the provincial municipalities. All of these are established and are operating, they have experience, and have been trained on prevention systems.

In addition, there are scientific organizations that participate carrying out follow – ups to the El Niño Phenomenon, as well as NGOs promoting prevention actions; they have all established a technical committee that reports to the Civil Defense Committee.

CHAPTER 3 DEFINITION OF THE PROBLEM AND ITS CAUSES

The heavy rainfall caused by the El Niño Phenomenon bring about unusual floods in the Chira River that affect populated settlements, croplands, deteriorate infrastructures in the Bajo Chira Valley, and demand a special operation of the Poechos Dam.

3.1 Definition of the Problem

Loss of farmlands, loss of growing crops; damages to the irrigation, road, and urban infrastructures; reduced income for farmers; and loss of crop yields.

3.2 Identification of the Causes

Extreme occurrences, with great floods and precipitations, as a result of a frequent presence of the El Niño Phenomenon; floodings.

3.3 Identification of the Effects

Disminución de los ingreso de los agricultores, disminución de la producción agrícola y pérdida de tierras de cultivo, infraestructura productiva, urbana y vial.

CHAPTER 4 DEFINITION OF THE PROBLEM AND ITS CAUSES

4.1 The General Objective

To develop a Flood Forecasting and Warning System Project for extraordinary large flood occurrence prevention purposes downstream the Lower Chira Valley and the Poechos Dam.

4.1 The Specific Study Objectives for the Flood Forecasting and Warning System

- A real time definition of the occurrence of extreme hydrological events, namely, large floods, by specifying their runoff, magnitude, severity, and reaching time to sensitive areas.
- A monitoring of the hydrological system's space – time process during the extreme event at the Chira River basin.
- The establishment of the civil society's organization in associations or groups for extreme destructive hydrological phenomena occurrence prevention purposes.
- Training Poechos Dam operators on the occurrence of extraordinary floods and timely maneuvering for large flood retention or lamination, and dam and lower Chira Valley area protection purposes.

CHAPTER 5 BACKGROUND, FORECASTING AND WARNING SYSTEMS, SOLUTION PROPOSALS

5.1 Existing Forecasting and Warning System in the Area

5.1.1 The Piura River Basin

There is an existing Flood Forecasting and Warning System (SIAT, in Spanish), for the Piura River basin that was developed at the Flood Protection System Reconstruction and Rehabilitation in the Lower Piura Feasibility Study[8]. This system was set up in 2001 with funds from the German Government, via GTZ, and the Piura Regional Administration Temporary Council, CTAR – Piura, in Spanish.

The occurrence of the El Niño Phenomenon (ENP) in the northern area, and especially in the Department of Piura, brings about floodings that cause damages to the urban and farming / agricultural areas, erode and destroy bridges and irrigation infrastructure works. The ENP is characterized by very heavy rainfall from January to April, and it mostly affects the Piura River's central reach area that is located in the region between Tambogrande and Morropón.

Setting up a Flood Forecasting and Warning System along the Piura River basin to prevent and alert those areas that are at greater flooding risk, namely, those areas that are especially located on the Higher Piura valley, the city of Piura, and the reach downstream the Piura River heading to the Ramón Lake, establish a high priority justification.

This Project objectives include:

- Planning and organizing work for those institutions that are engaged in the Forecasting and Warning System
- Setting up a Telemetry Network on strategic points along the Piura River
- Setting up and operating a NAXOS Hydrological Model as a basis for flooding forecasting
- Researching the rainfall behavior of the El Niño Phenomenon along the Piura River basin
- Giving technical assistance and support in the preparation of the Contingency and Vulnerability Reduction Plans at district level in the health and agriculture sectors

Operation [9] of the Flood Forecasting and Warning System – SIAT.

SIAT's operation is based on the following: A total of 30 pluviometric and hydrometric stations that operate in coordination with SENAMHI, PECH, and DIRESA, and send real time data to the

---

8 The Flood Protection System Reconstruction and Rehabilitation in the
Lower Piura Feasibility Study; Volume VIII, Hydrological Model and Hydrometeorological Network
Extension, Volume I, Report, Class-Salzgietter Consortium, Piura 2001.

9 The Flood Forecasting and Warning System - SIAT Management Manual for the Piura River Basin, Regional Emergency Operations Center, COER, 2003.

Operations Center that have been installed at the Chira Piura Project.

Precipitation data are received, analyzed, and processed by the NAXOS Hydrological Model.

The Model results allow for flood forecasting along the Piura River basin. Alert Warning is timely transmitted to the Regional Information Center (CIR, in Spanish) at the CTAR – Piura, for relevant organizations and the Civil Defense System to make decisions and support decisions that will aim at mitigating any negative impacts on the most vulnerable areas.

SIAT is executed via an Inter Institutional Agreement that has been subscribed between: the Regional Government of Piura (RGP), the German Development Cooperation (GTZ, in German), the National Meteorology and Hydrology Authority (SENAMHI, in Spanish), the Piura Regional Health Directorate (DIRESA, in Spanish), the University of Piura (UDEP, in Spanish), the Regional Government of Piura's Scientific and Technological Consulting Council (CCCTEP, in Spanish),and the Chira – Piura Special Project (PECHP, in Spanish.)

The SIAT network works via a communications system that was initially telemetric and it is currently via satellite. Drawing N° 4 shows the Information Warning System, as installed in the Piura River basin, and its connection for its operation.

Table 5.1 **Hydrometric Stations Currently Operating along the Chira Piura River Basin**

Nº	Estacion	Coordenadas UTM		RIO	Condicion
		N	E		
1	Paraje Grande	9488151	620548	Quiroz	Existente
2	Pte. Internacional	9515414	616512	Macara	Existente
3	Alamor	9529244	589330	Alamor	Existente
4	El Ciruelo	9524654	594327	Chira	Existente
5	Ardilla	9503620	567918	Chira	Existente
6	Poechos	9482714	552473	Chira	Existente
7	Pte. Sullana	9459530	534271	Chira	Existente

Table 5.2 **Meteorological Stations Currently Operating along the Chira River Basin**

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

5.1.2 The Chira River Basin

The Chira Piura Project has an information recollection system to operate the Chira Piura system, and especially, to operate the Poechos Dam. This system is based on a network that was built as of 1971. This network includes 8 meteorological stations and 7 hydrometric stations. Communications are all via a multichannel radio and by telephone. ***Tables 5.1*** and ***Figure 5.2*** show the stations, and Drawing N° 5 shows the relevant stations. This information recollection and data transmission procedure has been in place since stage 1 of the Project works construction.

This Early Alert Information System's preliminary process is being currently used, as data are transmitted via a multichannel radio system on a daily basis, from 7:00 to 19:00, to the Piura base station. Here, all information on the Chira Piura system is consolidated, and re – transmitted to the Poechos Dam and the Sullana Bridge. The transmission sequence is as follows:

- Transceiver radio at the hydrometeorological station
- Transceiver radio at the base station
- Information entry at the database CP
- No runoff precipitation model for the basin is available, but isochrone information is being used to transmit discharge values from the high basin and lower areas. Satellite information is sporadically used.

5.2 Proposal Approach for Existing Forecasting and Warning Systems

5.2.1 The - Bi National Catamayo Chira Commision Proposal (2003)

Ecuador and Perú subscribed agreements in September 1971 for a joint and harmonious use of the Catamayo – Chira River Resources. In addition, in October 1998, they subscribed, among other bilateral documents, the Ecuadorian – Peruvian Broad Agreement on Borderline Integration, Development, and Neighbor Relations; Title V, Chapter I of this Agreement contemplates the Bi – National Development Plan for the Borderline Region.

Within this framework, the Governments of Perú and Ecuador invited the Spanish International Cooperation Agency (AECI, in Spanish) to execute the Bi – National Development Plan for the Borderline Region, including the Territorial and Hydric Characterization and Adequacy between Supply and Demand Studies.

Characterization and Adequacy between Supply and Demand Studies.

In May 2002, the Bi – National Project for the Catamayo – Chira Basin Arrangement, Management and Development started hydric characterization studies, by hiring the ATA – UNP – UNL Consortium[10]. These studies include the basic studies, such as the Network Diagnostics and the

[10] "Hydric Characterization and Adequacy between Supply and Demand within the Bi – National Catamayo – Chira

Forecasting and Warning Prevention Studies

This study involves a general diagnostics on the bi – national basin, as well as the recollection and analysis of the hydrometeorological information from both countries. A Flood Forecasting and Warning System proposal is one of the approaches herein.

The Flood Forecasting and Warning System proposed approach, as proposed by the Peruvian – Ecuadorian Bi – National Commission, involves a hydrometeorological data recollection system for the Catamayo – Chira basin and a transceiver system.

Field data recollection includes: i) 42 meteorological remote stations (14 Peruvian stations and 28 Ecuadorian stations) that register precipitations. 33 of these stations belong to the existing network, and 9 are projected stations (3 Peruvian stations and 6 Ecuadorian stations); ii) 8 hydrometric stations, 6 of them are already existing (4 Peruvian stations and 2 Ecuadorian stations) and 2 are projected stations (Ecuadorian stations.)

Table 5.3, ***Table 5.4***, and ***Table 5.5*** show the projected hydrometric and meteorological network and the repeater station networks, as located in Drawing N° 6.

Given the basin characteristics and the difficult communication, the suggested data transmission system for the Flood Forecasting and Warning System would be as follows:

- Pluviometric data transmission via radio frequency with repeater antennae or via satellite.
- Data will be transmitted from the hydrometric stations via the multichannel radio or via satellite.

This proposal includes implementing three types of transmission stations: **A remote – repeater station; a remote – via satellite station; a multichannel radio station.** Once it is received at the **Sullana Base Station**, the information will be included to a database in the central computer.

The base station was considered to be located at the Sullana Municipality, as it is the local center for civil defense actions.

The selected Hydrological model that would process information from the hydrometeorological network would be either NAXOS or HFAM.

Cost of the set out proposal in the study, as mentioned in page 83, for 10 remote stations and the base station, amounts Two hundred nineteen thousand seven hundred twenty – five American Dollars (US$ 219,725.00.)

Transmission would be via a radio frequency system with three repeater stations that report in turn to the base station that would be located in Sullana. This station receives the information and a hydrological model would be used. This model would be either NAXOS or HFAM.

Basin"; Volume III Basic Studies, Volume 3.1 Network Diagnostics and Early Alert Prevention; The Bi – National Catamayo – Chira Project Management Unit, ATA-UNL-UNP Consortium; Loja, Piura 2003

Table 5.3 **Stations for the Flood Forecasting and Warning System Meteorological Network**

N°	CODIGO	ESTACION	Coordenadas UTM		ALTITUD	CONDICION	ESTACION REMOTA
			N	E			
1	ERtm 01	Nambacola	9542456	674175	1,975	EXISTENTE	ER 01
2	Ertm 02	Vilcabamba	9530595	699000	1920	EXISTENTE	ER 01
3	Ertm 03	Quinara	9523236	695345	1595	EXISTENTE	ER 01
4	Ertm 04	Yangana	9516982	702487	1860	EXISTENTE	ER 01
5	Ertm 05	Changaimina	9533920	664116	1970	EXISTENTE	ER 01
6	Ertm 06	La Argelia	9553464	699403	2160	EXISTENTE	ER 01
7	Ertm 07	El Tambo	9549939	687880	1575	EXISTENTE	ER 01
8	Ertm 08	El Cisne	9574167	675000	2300	EXISTENTE	ER 01
9	Ertm 09	Amaluza	9493392	674770	1690	EXISTENTE	ER 01
10	Ertm 10	Catamayo-Aerop.	9558425	681296	1250	EXISTENTE	ER 01
11	Ertm 11	Quilanga	9524562	677858	1805	EXISTENTE	ER 02
12	Ertm 12	El Ingenio	9512380	674403	1220	EXISTENTE	ER 02
13	Ertm 13	Cariamanga	9521176	660606	1955	EXISTENTE	ER 02
14	Ertm 14	Ayabaca	9487823	642699	2700	EXISTENTE	ER 02
15	Ertm 15	Pacaypampa	9449023	647832	1960	EXISTENTE	ER 02
16	Ertm 16	Colaisaca	9522957	645158	2285	EXISTENTE	ER 02
17	Ertm 17	Sabiango	9517751	632012	750	EXISTENTE	ER 02
18	Ertm 18	Sausal Culuca	9474842	636789	980	EXISTENTE	ER 02
19	Ertm 19	Paraje Grande	9488151	620548	555	EXISTENTE	ER 02
20	Ertm 20	Levín San Pablo	9455850	660800	2150	PROYECTADA	ER 02
21	Ertm 21	Tapal	9478745	661125	1890	PROYECTADA	ER 02
22	Ertm 22	Vado Grande	9507000	655375	900	PROYECTADA	ER 02
23	Ertm 23	Pte Internacional	9515414	616512	408	EXISTENTE	ER 03
24	Ertm 24	Celica	9546579	616616	2067	EXISTENTE	ER 03
25	Ertm 26	Alamor	9555383	607434	1250	EXISTENTE	ER 03
26	ERtm 25	Sabanilla	9536068	597312	740	EXISTENTE	ER 03
27	ERtm 26	El Ciruelo	9424654	594327	202	EXISTENTE	ER 03
28	ERtm 28	Zapotillo	9515321	584254	215	EXISTENTE	ER 03
29	ERtm 29	Catacocha	9551949	650752	1763	EXISTENTE	ER 03
30	ERtm 30	Lauro Guerrero	9561629	638095	1923	EXISTENTE	ER 03
31	ERtm 31	Chinchanga	9536250	639200		PROYECTADA	ER 03
32	ERtm 32	Alamor (Lancones)	9505457	566997	125	EXISTENTE	EB
33	ERtm 33	Sapillica	9471196	612750	1446	EXISTENTE	EB
34	ERtm 34	El Partidor	9477296	580134	255	EXISTENTE	EB
35	ERtm 35	Chilaco	9480963	554900	90	EXISTENTE	EB
36	ERtm 36	Lancones	9787166	550491	120	EXISTENTE	EB
37	ERtm 37	Mallares	9463137	569784	45	EXISTENTE	EB
38	ERtm 38	El Cortezo	9496079	583700	200	PROYECTADA	EB
39	ERtm 39	Hacienda Joaquín	9495945	603575	180	PROYECTADA	EB
40	ERtm 40	La Ramadita	9507105	538400	140	PROYECTADA	EB
41	ERtm 41	Pajaro Bobo	9488275	522812	135	PROYECTADA	EB
42	ERtm 42	Los Encuentros	9521080	554900	142	PROYECTADA	EB

Taken from the "Hydric Characterization and Adequacy between Supply and Demand within the Catamayo Chira Bi – National Basin"; Volume III Basic Studies, Volume 3.1 Network Diagnostics and Forecasting an Warning System.

Table 5.4 **Projected Hydrological Stations for SIAT, as proposed by the Bi – National Commission**

N°	CODIGO	ESTACION	Coordenadas UTM		ALTITUD	CONDICION	ESTACION REMOTA
			N	E			
01	Erth01	Moyococha	9524807	700070	1490	Existente	ER1
02	Erth02	El Remolino	9503200	656800	0	Proyectada	ER2
03	Erth03	Paraje Grande	9488151	620548	555	Existente	ER2
04	Erth04	Pte. Internacional	9515414	616512	408	Existente	ER3
05	Erth05	Alamor Saucillo	9529244	589330	290	Existente	ER3
06	Erth06	El Ciruelo	9524654	594327	202	Existente	ER3
07	Erth07	El Emplame	9539025	654125	0	Proyectada	ER3
08	Erth08	Pte. Sullana	9459530	534271	32	Existente	ER

Taken from the "Hydric Characterization and Adequacy between Supply and Demand within the Catamayo Chira Bi – National Basin"; Volume III Basic Studies, Volume 3.1 Network Diagnostics and Forecasting an Warning System

Table 5.5 **Transmission Repeater Stations for SIAT, as proposed by the Bi – National Commission**

Nro.	Código	Estación	Ubicación Geográfica			Fuente de energía	Distancia recta, km
			Latitud S	Longitud W	Altitud msnm		
1	ER 01	Cerro Paco	9535920	709230	3650	Panel Solar	94 a 2 ER03
2	ER 02	Sicchez	9499270	640630	2600	Panel Solar	55.3 a ER03
3	ER 03	Cerro Celica	9548580	615780	2600	Panel Solar	120 a EB
4	EB	Sullana	9459530	534271	32	Serv Publico	

Taken from the "Hydric Characterization and Adequacy between Supply and Demand within the Catamayo Chira Bi – National Basin"; Volume III Basic Studies, Volume 3.1 Network Diagnostics and Forecasting an Warning System

5.2.2 The Catamayo Chira Comprehensive Management Proposal for SIAT Implementation (2010)

Via its Operative Unit - namely the Bi – National Catamayo – Chira Basin Comprehensive Management Project-, The Regional Government of Piura has been studying the probabilities to set up a Flood Forecasting and Warning System from the above mentioned study that was carried out in 2003.

Within this framework, the Bi – National Catamayo – Chira Project has been executed from 2001 to 2010, and has impacted the trans – borderline basin management; however, no hydrometeorological networks have been set up for SIAT so far. During 2009, actions were taken to set up such networks, including the SIAT Implementation Proposal[11], as well as a proposal for an implementation study of a 07 hydrometeorological station network along the Chira River basin for SIAT [12]. ***Table 5.6*** shows the station network, as suggested by the Management Unit.

---

11 Hydrometeorological Network Diagnostics, Catamayo – Chira Basin – Peruvian Counterpart for the SIAT Implementation. 2009.

12 Meteorological Station Installation Field Study, December 2009, IP TELECTRONICA

The proposal made by the IP TELECTRONICA DIGITAL Company involves the installation of seven (07) automatic pluviometric – hydrometric stations for precipitation and water level data recording by sensors and digital storage by satellite or telephone transmission in a central station or base station with Internet or fixed telephony access.

A Flood Forecasting and Warning System is intended to be started with the proposed network. This network would be supplemented with the network that is currently operated by the Chira Piura Project and SENAMHI. A Flood Forecasting and Warning System is intended to be started with via satellite and telephone data transmission.

The Transmission system proposal involves two blocks. The first one is made up of hydrometeorological stations that register information in a receiver that in turn transmits all stored information via satellite or telephone. The second block is the base station that receives the information and processes it.

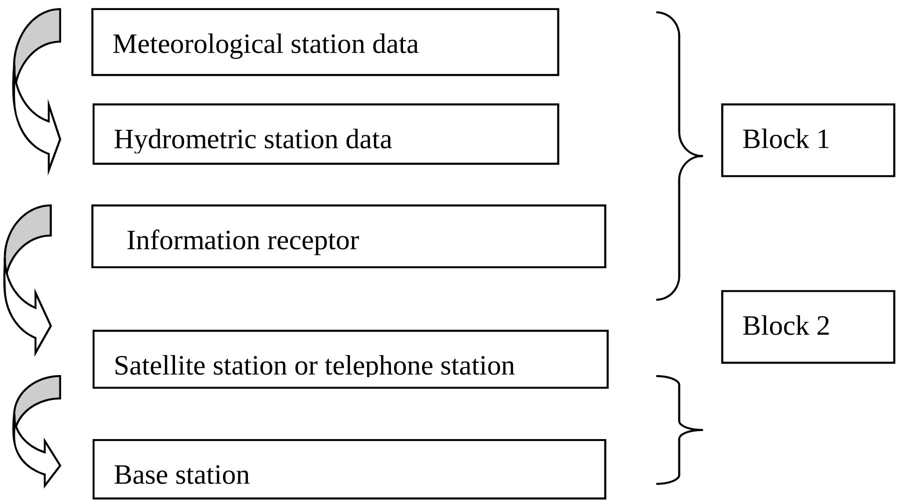


Table 5.6 **Station Network, as suggested by the Catamayo Chira Unit in 2010**

ESTACIONES Hidrometricas –pluviometricas Propuesta 2010					
Nº	Estacion	Coordenadas UTM		RIO	Condicion
		N	E		
1	Paraje Grande	9488151	620548	Quiroz	Existente
2	Pte. Internacional	9515414	616512	Macara	Existente
3	Alamor	9529244	589330	Alamor	Existente
4	El Ciruelo	9524654	594327	Chira	Existente
5	Ardilla	9503620	567918	Chira	Existente
6	Sapillica	9471196	612750	Chipillico	Existente
7	Arenal	9459524	529062	Chira	Proyectada

DIGITAL, CATAMAYO – CHIRA COMPREHENSIVE MANAGEMENT PROJECT, Piura, January 2010.

Budget to develop this seven (07) station system amounts two hundred eighty - nine thousand three hundred one 80 / 100 American Dollars (US$ 289,301.80), as set out in the January 2010 proposal made by the above mentioned Bi – National Catamayo – Chira Basin Comprehensive Management Project.

Drawing Nº 7 shows the proposed station network.

5.2.3 Hydrometeorological Information Remote Monitoring System in the Chira Piura River Basin, Profile Level Study, June 2010

The Ministry of Agriculture developed the Project Study[13] at profile level, in compliance with the SNIP regulations. Its objective is:

“A suitable hydrometeorological information for prevention actions in the Chira River basin.”

The Project’s ultimate goal is:

“To contribute to a sustainable and competitive growth in the intervention scope”, in this case, the Chira River basin.

[13] HYDROMETEOROLOGICAL INFORMATION REMOTE MONITORING SYSTEM ON THE CHIRA PIURA RIVER BASIN, Project at profile level, Ministry of Agriculture, June 2010.

CHAPTER 6 PROPOSAL AND FORMULATATION FOR THE CHIRA RIVER BASIN FLOOD FORECASTING AND WARNING PROJECT

The Flood Forecasting and Warning System (SIAT, in Spanish) is an important means of prevention, as it relates to a civil society's full organization towards protection against extraordinary occurrences.

In this context, the Information and Flood Forecasting and Warning System is focused on risk management, climate change adaptation, and climate variability, and it establishes key tools for a population's comprehensive vulnerability reduction strategy and a productive infrastructure for the Chira River basin area.

Indeed, this information system is the set of organized resources (personal resources, data, materials) that allow for piling up, storing, analyzing, and disseminating information in various formats and based on specific objectives.

An information system proposal is a supporting tool for decision making, as it allows for describing, explaining, forecasting, and performing, based on the occurrences. In this sense, this system will allow for coordinating the activities to be carried out by the actors towards meeting the set out objectives, namely in our case, risk management, climate change adaptation, and climate variability (El Niño Phenomenon.)

On the other hand, there is SIAT Piura for the Department of Piura, and it is successfully operated; therefore, it could be used as a model for the Chira case.

Within this framework, all agricultural or infrastructure investment projects for the Chira Valley need to come along with a prevention system, especially around the Poechos Dam area. The Poechos Dam is one of the major storage structures in Peru. At present, it stores around 600 hm3 of water, and this volume assures direct irrigation to over 100, 000 hectares, that is, the Lower and Middle Piura Valleys and the Chira Valley. SIAT is a core element for its hydraulic system operation.

6.1 SIAT Proposal for the Chira River Basin

The proposed Flood Forecasting and Warning System for the Chira River basin includes:

- **A Monitoring System**.

  Stations that are being operated by the Chira Piura Project and SENAMHI, and the satellite images released by the **Geostationary Operational Enviromental Satellite (GOES)** and the **Tropical Rainfall Measuring Mission (TRRM),** are being used to complete the monitoring system.

- **Equipment**

Implementation of seven (7) hydrometeorological stations with sensors or rainfall and basin water level maintenance meters, and a satellite registration and transmission system. The remaining stations will be subject to upgrading.

- **Base Station**

  The base station will be set up with state – of – the – art hardware and software and data transceiver equipments.

- **Hydrological Model**

  Purchase of a forecast hydrological model (NAXOS), training and coaching to operators .

- **Forecasting and Warning System Committee**

  The establishment of a Flood Forecasting and Warning System for the basin and the description of the institutional functions and responsibilities.

6.2 Hydrometeorological Monitoring System for SIAT, Chira

At present, the Chira Piura River basin has a network that involves the Chira Piura Project stations and SENAMHI stations. This network operates satisfactorily. Data recollection is on a frequent basis, and meets the objectives for the Chira Piura hydraulic system, with regard to current operation and future flooding preventions.

Proposed meteorological – pluviometric stations are all existing, and have been operating since 1972, or even earlier. Hydrological stations are used in the Chira Piura system operation.
Table 6.1 and ***Table 6.2*** show the suggested stations to be used in SIAT. These stations have been plotted in Drawing N° 8.

Table 6.1 **Meteorological Stations to be Upgraded, as suggested for SIAT Chira**

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

Table 6.2 **Hydrological Stations for SIAT Chira**

N°	ESTACION	PROV	DIST	SUB CUENCAS	Coordenadas UTM		ALTITUD	CATEGORIA	INSTITUCION QUE OPERA
					N	E			
1	El Ciruelo	Ayabaca	Suyo	Chira	9524654	594327	202	Hg	PECHP
2	Ardilla	Sullana	Sullana	Chira	9503270	567048	106	Hg	PECHP
3	Pte.Internac.	Ayabaca	Suyo	Macará	9515414	616512	408	Hg	PECHP
4	Paraje Grande	Ayabaca	Paimas	Quiroz	9488151	620548	555	Hg	PECHP
5	Sapillica	Ayabaca	Sapillica	Chipillico	9471196	612750	1446	Hg	SENAMHI
6	Alamor	Sullana	Lancones	Chira	9505457	566997	125	Hg	PECHP
7	El Arenal	Paita	El Arenal	Chira	9459524	529062	62	Hg	PECHP

In this case, hydrometeorological monitoring is also set out via the Geostationary Operational Environmental Satellite GOES and the Tropical Rainfall Measuring Mission TRRM Satellite signals to supplement the information on the non – covered areas and the Ecuador area.

Satellite images represent state- of – the - art information data, and they have been registered as of year 2000. They can be used as basic information for algorithms to be used when precipitations are quantified, in connection with the temperature and cloud humidity conditions.

This technology allows for probable virtual pluviometer generations in a dense network that with data that cannot be gathered from field surveys. The proposal estimates a virtual pluviometer network every 25 km2. The cost for this procedure is minimal; authorization from the satellite managers is required for satellite use, at a very low annual cost, as these are free images; however, a good hardware and training are required for optimum use.

As an application example, SENAMHI Piura generated a precipitation map at macro level for the Northern Region with GOES information and service on February 8th, 2011. A quite acceptable correlation is shown when this map is contrasted with the information on that date for the Chira Piura Project.

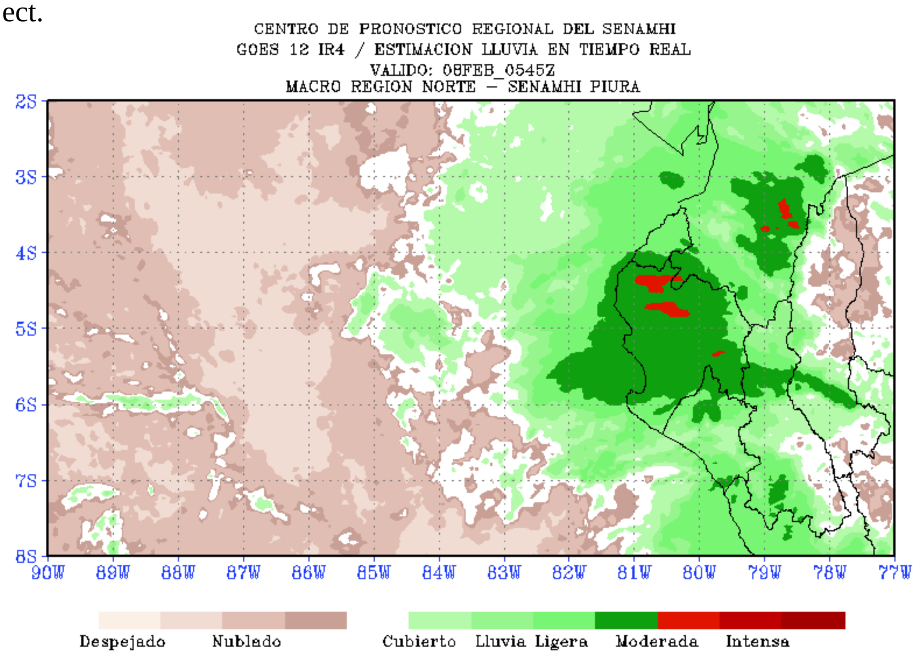


Figure 6.1 **Rainfall Estimation in Real Time, February 8th, 2011**

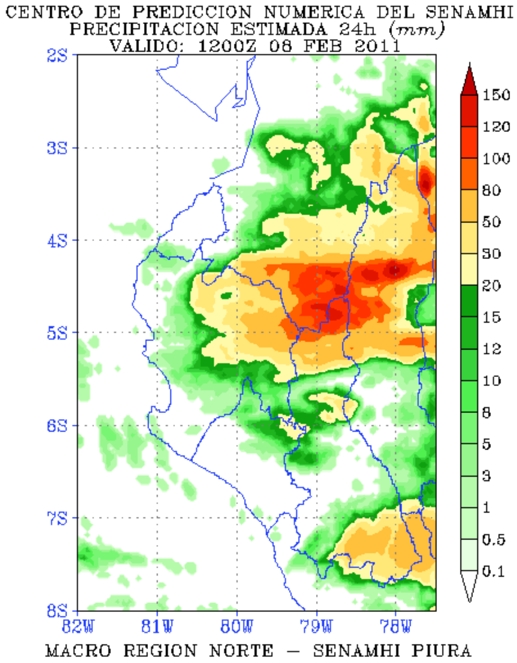


Figure 6.2 **Estimated Precipitation in mm for 24 h February 8th, 2011**

PROYECTO ESPECIAL CHIRA - PIURA
DIVISIÓN DE HIDROMETEOROLOGIA
INFORME SEMANAL DEL ESTADO HIDROMETEOROLÓGICO

FECHA: 08 de Febrero del 2011 HORA: 07:00

CUENCA	ESTACIÓN	Caudal 07:00Hrs m3/s	Q.Prom. 24 Hrs m3/s	Q.Máx. 24 Hrs m3/s	Precipitación. 24 Hrs mm.
RIO MACARA	PUENTE INTERNACIONAL (m3/s)	90.0	65.08		98.3
RIO CHIRA	EL CIRUELO (m3/s)	175.0	153.58		44.0
	ARDILLA (m3/s)		173.2		18.0
RIO QUIROZ	PARAJE GRANDE (m3/s)	52.6	20.16		42.1
RESERVORIO POECHOS	ENTRADA (m3/s)		173.21		0.0
	COTA REPRESA (msnm)	94.06		94.06	
	VOLUMEN: MMC.	136.0		136.0	
	INCREMENTO VOL.: MMC.	0.9	10.7	0.9	
SALIDA DE RESERVORIO	ALIVIADERO (m3/s)	0.00	0.0	0.00	
	TUNEL (m3/s)				
	CANAL M. CHECA; (m3/s)	10.00	10.00	10.00	
	RÍO CHIRA (POECHOS)(m3/s)	0.0	5.0	35.00	
	C. DERIVACIÓN (Bocatoma) (m3/s)	29.0	31.54	37.0	
	CANAL HUAYPIRA (m3/s)	0.26	0.26	0.26	
	EVAPORACION (m3/s)		2.57		
	TOTAL DE SALIDA (m3/s)		49.37		
PUNTOS DE CONTROL CD	CHECK (KM 29+900) (m3/s)	21.80	23.29	28.50	5.0
	CURUMUY (m3/s)	16.70	17.01	21.39	
PRESA SULLANA	COTA EMBALSE (msnm)	36.999		36.999	0.3
	RIO CHIRA (Sullana)(m3/s)	24.5	7.50	24.5	
	CANAL NORTE (m3/s)	8.5	8.44		
RÍO PIURA	PTE. ÑACARA (m3/s)				
	TAMBOGRANDE				
	BIGOTE				0.0
	MALACASI				0.0
	MORROPON				0.0
	"EL PAPAYO"				
PRESA EJIDOS	COTA EMBALSE (msnm)	30.59		30.709	2.5
	PTE. SANCHEZ CERRO (m3/s)	5.0	2.08	5.0	
	CANAL PRINCIPAL (m3/s)	14.5	14.50		

Figure 6.3 **Hydrometeorological Conditions Weekly report**

(THE CHIRA PIURA SPECIAL PROJECT HYDROMETEOROLOGICAL DIVISION)

6.3 Hydrometeorological Equipment Suply for the SIAT Network

The use of automatic equipment is suggested. The Regional Government requirements and the equipment requested to equipment suppliers are combined into the following lists:

6.3.1 SEBA Equipment

Suggested hydrometeorological equipment is based on quotation submitted to the Regional Government by the above mentioned IP ELECTRONICA DIGITAL Company, for all seven (7) hydrometric stations:

Includes the following:

- 07 meteorological sensors
- 07 SEBA sensors for water level measurements
- 07 digital storage systems for digital transmission information storage (WiFi).
- 07 satellite communications systems
- 07 energy storage systems (solar panels)
- 07 protection systems (lightning rods)
- Software
- 07 infrastructure requirement proposals for equipment and protection installation

6.3.2 Existing Station Upgrading

- 08 automatic meteorological equipment sets
- 08 information recording equipment sets

6.3.3 Equipment Models to be Purchased

		
Figure 6.3.1 **Level Measurement Sensor**	***Figure 6.3.2*** **Pluviometer with Information Sensor**	***Figure 6.3.3*** **Observed Data Recording Equipment**

DAVIS Equipment

This meteorological equipment registers, stores, and transmits via satellite major meteorological parameter data (precipitation, temperature, humidity, radiation, evaporation, wind speed).

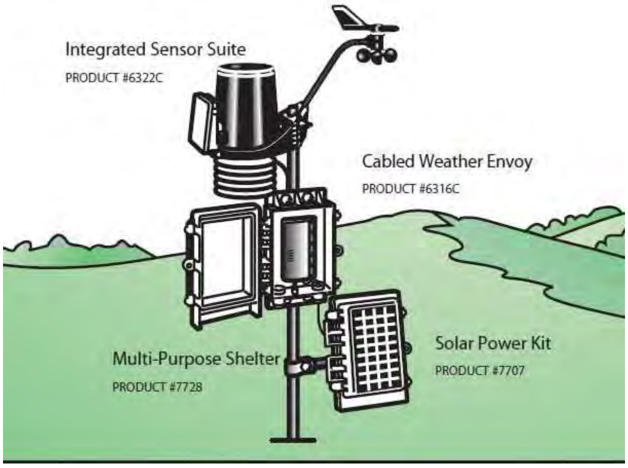


Figure 6.4 **DAVIS Automatic Meteorological Station**

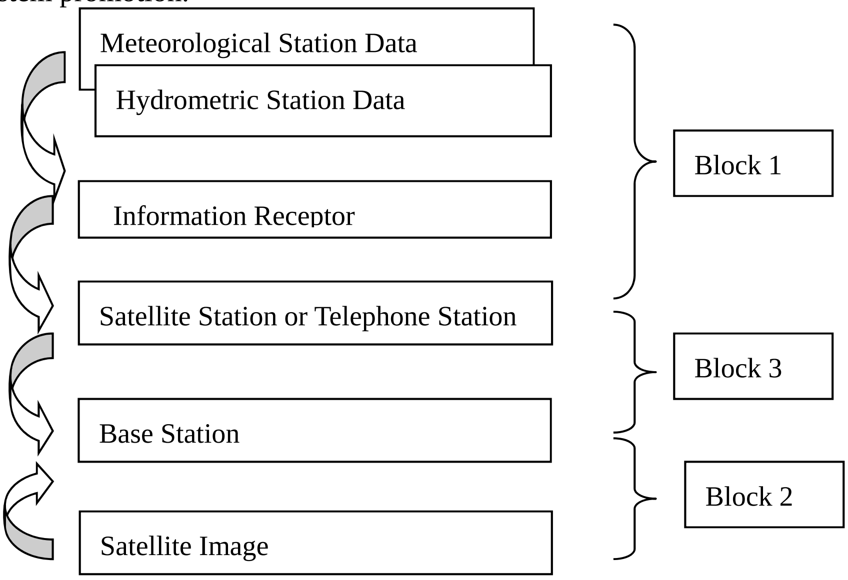
6.4 Information Transmission Systems

An essential aspect for the system's operation is the real time transmission of the information that is recollected in the field, for storage, registering, and processing purposes. In this sense, the following is set out:

Information will be transmitted via three defined blocks. The first one will involve recollecting registered data at the automatic stations in a storage unit, and sending them via satellite or by telephone. State – of - the - art meteorological and hydrometric equipment suppliers provide automatic equipment, and have transmission software for generated data. Suppliers include SEBA Hydrometrie GmbH, a German supplier, and DAVIS, a U.S. supplier.

A second block will involve capturing or getting satellite GOES or TRMM images through the Internet and the base station.

The third and last block involves forecast generation process and information to the authorities for a warning system promotion.



6.5 Base Station

The Base Station is the station that receives field – gathered information, and stores it in a central unit for subsequent processing and forecast releasing. It is in charge of monitoring precipitations and discharges, defining flood wave formations and flood transmission delay times to vulnerable areas, and informing the Civil Defense System about the alert and prevention actions when faced with extreme phenomena.

During meetings and interviews on February 7th and 8th [14] with the Regional Government of Piura, the Management Unit, the Bi – National Catamayo – Chira Basin, the Chira Piura Special Project, the National Meteorology and Hydrology Authority (SENAMHI, in Spanish), and the Civil Defense Organization, attendants expressed that the Forecasting and Warning Project must have a centralized unit for decision making purposes; information recollection and processing must be centralized, as well.

In that sense, officials expressed that the Flood Forecasting and Warning System's Information Registration and Processing Base Unit should be the Chira Piura Project, as it centralizes information on the Piura River basin Flood Forecasting and Warning System, and currently establishes the Piura River basin forecasts.

Needs for a base station implementation were set out in the above mentioned hydrological characterization study. These needs included hardware and software for information processing, in compliance with the hydrological model requirements.

Equipment to be considered at the base station must include:

- Receptor equipment
- Decoder
- Computer equipment for information receiving and storage, hydrological model processing.

6.6 Hydrological Model for Runoff Precipitation

Information processing requires having a program that allows for flood forecast generation, hydrological monitoring, and runoff precipitation model application, in correlation with the basin characteristics and the parameters that allow for providing real time information.

The hydrological model must meet minimum requirements for its use, such as: i) a multifunctional capacity to transmit, process, submit, and inform; ii) an automatic information import execution; iii) file protection; iv) data files and recovery; v) result or outcome submitting by station groups or

[14] Interviews with Regional Government of Piura Officials, Mr. Álvaro López, Eng., General Manager; Ms. Nimia Elera, Eng., Executive Director, Mr. Andrés Vera, MBA, Co – Director, Catamayo Chira Comprehensive Management; Mr. Miguel Vallebuona, Eng., General Manager, the Chira Piura Project; Mr. Jorge Yerrén, Eng., Head, SENAMHI Regional Office; and Mr. Víctor Labán, Eng., Head, Civil Defense at the Regional Government.

data periods.

The NAXOS Model that is used along the Piura River basin is a good alternative for information management and flood forecast standardizations. It is recommended that such program is updated, and that this model is executed along with work on the Piura River basin. In this sense, an Expert on modeling and software installation on the equipment at the base station is required.

Based on real time precipitation and satellite image information, flood forecast generation establishes the parallel and independent scenarios for the Forecasting and Warning System. The first one is for the Poechos Dam, and the second one is downstream Poechos.

6.7 Forecasts Before Reaching the Poechos Dam

Based on real time precipitation and satellite image information, flood forecast generation establishes the parallel and independent scenarios for the Forecasting and Warning System. The first one is for the Poechos Dam, and the second one is downstream Poechos.

6.8 Forecasts Before Reaching the Poechos Dam

Once the forecast for the hydrograph showing flood inlets to the Poechos Reservoir is defined, discharge evacuation models will be created to the Valley lower area. These models should be added to the discharges that have been directly generated from the Chipillico sub basin and the San Francisco, Samán, Cieneguillo, La Manuela gullies that will bear a direct impact on the populated areas, their productive infrastructure, their urban areas, and bank protections along the lower valley area.

6.9 Reference Costs

As information from the Piura Region’s Catamayo Chira Management Unit, as well as the proposals made by suppliers and the information from the Forecasting and Warning System that was prepared by the Bi – National Commission, are taken as a reference, estimated budget amounts USD 550,000, based on the following breakdown:

Item	**Cost USD**
Equipment	499 000
Training	5 000
Operation	46 000
Total	550 000

Table 6.3 **The Chira Flood Forecasting and Warning System's Implementation Budget**

Item	Descripcion	Unidad	Cantidad	PU	Costo Parcial	Subtotal USD
1	**Equipamiento Equipo hidrometeorológico**					
1.1	Equipamiento					
	E. Hidrometrico	Unidad	7.00	10,000.00	70,000.00	
	E. Meteorologico (Nuevo y repotenciacion)	Unidad	15.00	8,000.00	120,000.00	
1.2	Instalación					
	E Hidrometrico	Unidad	7.00	13,000.00	91,000.00	
	E Meteorologico (repotenciacion)	Unidad	8.00	3,000.00	24,000.00	
2	**Sistema de Transmisión de datos**					
	Equipo de transmisión H/M	Unidad	7.00	7,000.00	49,000.00	
3	**Estación base**					
3.1	Equipamiento	Global	1.00	50,000.00	50,000.00	
3.2	Local (Pry. Chira-Piura)					
4	**Modelo Hidrológico**					
4.1	Adaptación del sistema (Implementación)		1.00	20,000.00	20,000.00	
4.2	Software		1.00	30,000.00	30,000.00	
4.3	Asesor e Investigación	mes	3.00	15,000.00	45,000.00	**499,000.00**
5	**Gestión Institucional**					
5.1	Capacitación civil	Global			2,500.00	
5.2	Capacitación operación Poechos	Global			2,500.00	**5,000.00**
5.3	**Mantenimiento (costo anual)**					
5.4	Estación hidrometeorológica	mes	2.00	1,000.00	2,000.00	
5.5	Estación Base	mes	2.00	1,000.00	2,000.00	
5.6	Conexión satelital (08 estaciones)	mes	72.00	500.00	36,000.00	
5.7	Asistencia técnica (planes de contingencia)	Global			4,000.00	
5.8	Equipos y herramientas de prevención	Global			2,000.00	**46,000.00**
TOTAL usd						**550,000.00**

CHAPTER 7 INSTITUTIONAL MANAGEMENT

The SIAT monitoring is carried out in two (2) stages: The first one, by a follow – up to the meteorological observations and the forecasts from the Chira Piura Project and the hydrological forecast, and the second one, via the Regional Government of Piura that will make the Regional Civil Defense System start operating.

There is a commitment made by the Regional Government to set up the institutional part for monitoring and prevention system activities.

7.1 Procedure

The Forecasting and Warning System organization begins by gathering information from the hydrometeorological stations that report to the Base Station in our case, the Chira Piura Project.

The Base Station: Receives the information and captures satellite information, prepares the Hydrograph along with the Hydrological Model, releases the Flood Forecast, and reports to the Regional Emergency Committee.

The Regional Emergency Committee (COER, in Spanish): It activates the Civil Defense System that releases the WARNING SYSTEM, via the Civil Defense System.

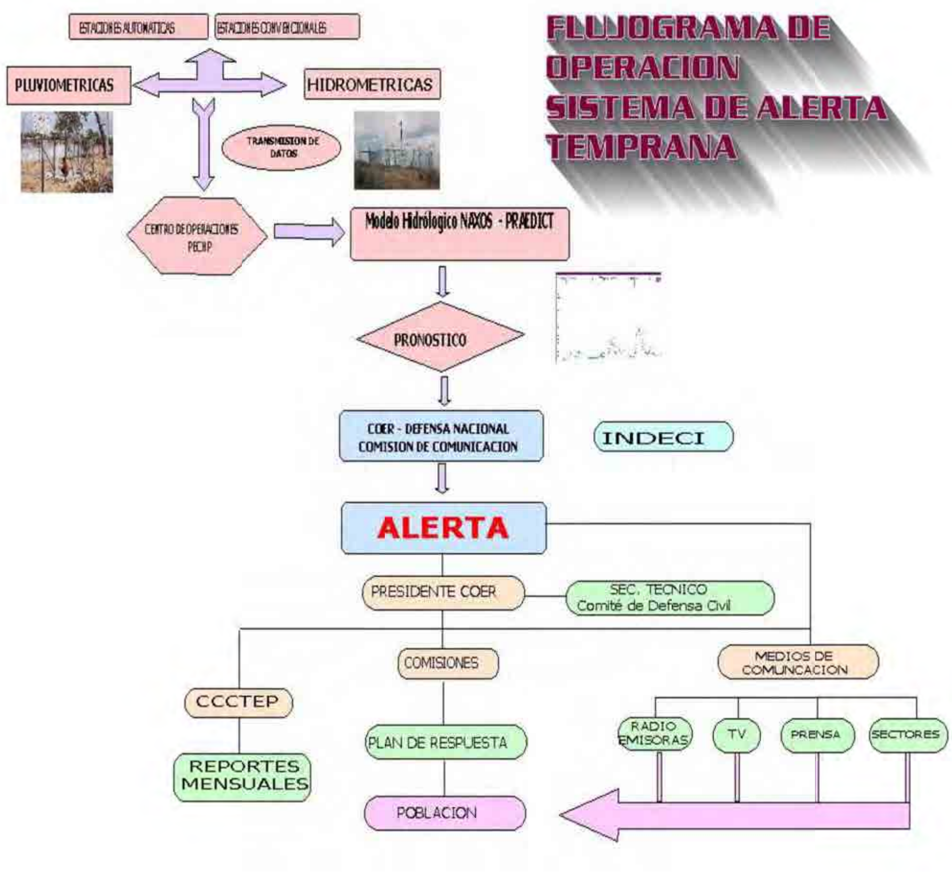


Figure 7.1 **Operation Distribution Diagram of Early Warning System**

The Regional Civil Defense Committee: It is led by the Regional President. It organizes the execution via five (5) operational units:

- The Communications Commission
- The Operations Commission
- The Logistics Commission
- The Health Commission
- The Law and Order Commission

THE CIVIL DEFENSE COMMITTEE'S ORGANIZATION

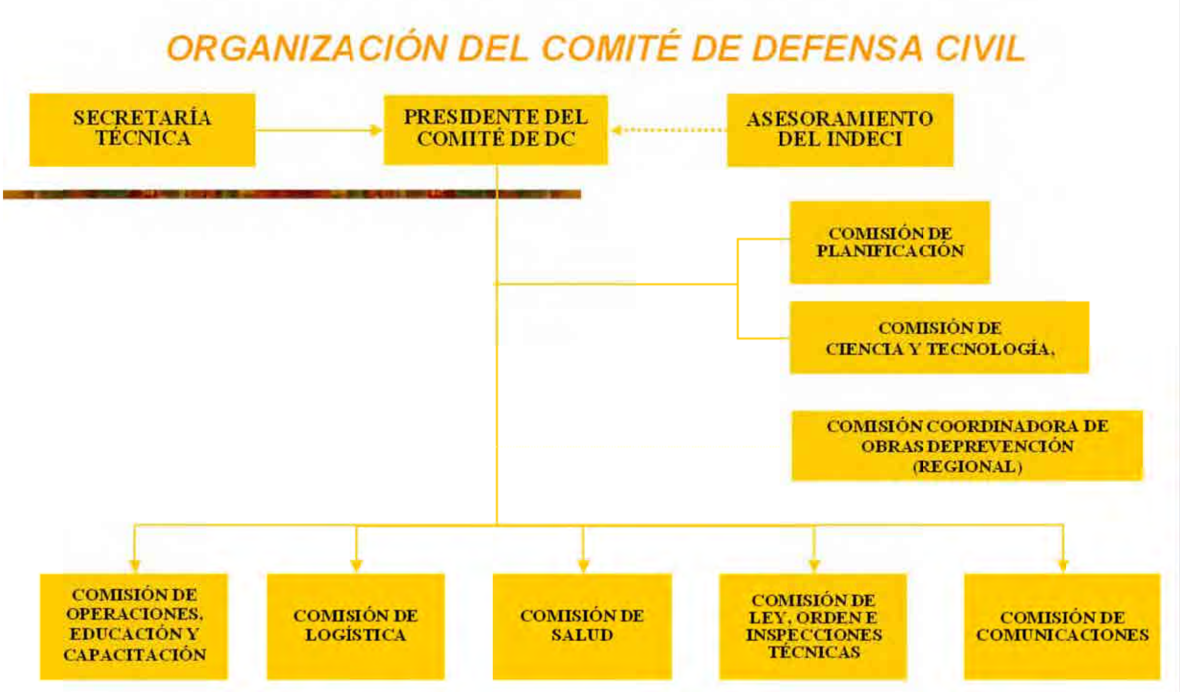


Figure 7.2 **Organization Chart of Disaster Measures Committee**

7.2 Partipacing Organization

The Emergency Operations Center: It is the system's starting point, and it will be run by the Chira – Piura Project, as the information is received and processed, and the forecast is released there.

Emergency Operations Committee: In the case of the Chira Flood Forecasting and Warning System, it is made up of:

The Regional Government of Piura: A public autonomous decentralized organism that aims at promoting and encouraging the Piura Region population's socioeconomic development.

The National Meteorology and Hydrology Authority (SENAMHI, in Spanish): It is the decentralized organism within the national scope that looks for the organization, operation, control, and maintenance of the National Network of Meteorological, Hydrological, and Agro Meteorological Stations.

Provincial Municipality of Sullana: It is an autonomous local Government that is in charge of the provincial development, and coordinates with the districts within its geographic scope.

Provincial Municipality of Paita: It is an autonomous local Government that is in charge of the provincial development, and coordinates with the districts within its geographic scope.

Chira Piura Special Project, PCHP: It is a public decentralized Government institution that promotes agricultural development along the Chira and Piura Valleys, by means of the construction, operation, and maintenance of irrigation, drainage, and bank protection works that will protect against floodings.

University of Piura (UDEP, in Spanish): It is a private higher education institution that intends to favor its students' comprehensive training, and encourage and disseminate scientific research in all fields of human knowledge.

The Piura's Scientific and Technological Consulting Council (CCCTEP, in Spanish): It is an advisory and consulting body within the Regional Civil Defense Committee and the Regional Government of Piura that is in charge of analyzing and evaluating behavior and climate impact at regional level.

Irrigation Water Users' Organizations: They are in charge of the irrigation minor infrastructure's operation and maintenance within the jurisdictional scope, as granted by the Hydric Resource Law.

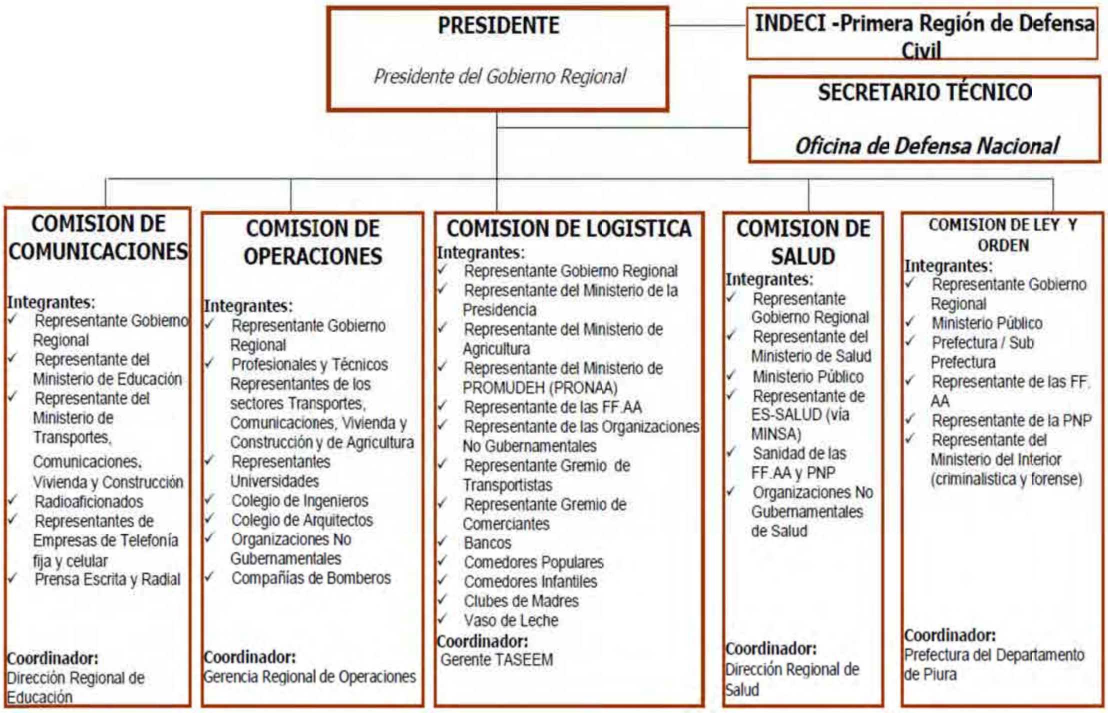
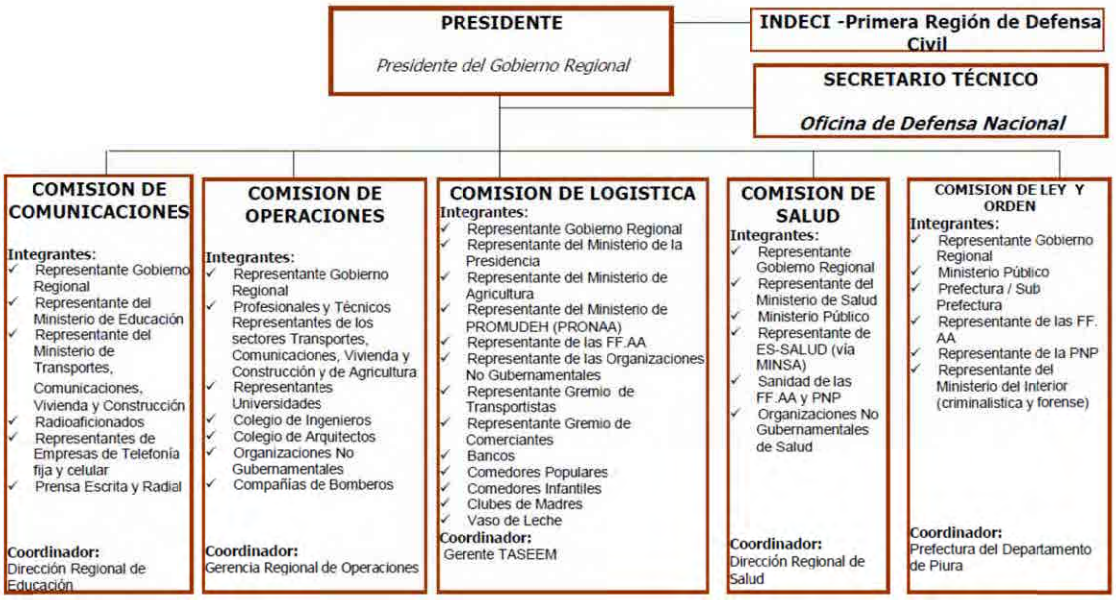


Figure 7.3 **Participating Organizations**



Taken from the Flood Forecasting and Warning System in Piura

Figure 7.4 **General Functions**

CHAPTER 8 PROJECT BENEFIT

Major benefits from the Flood Forecasting and Warning System include:

- Hydrometric and meteorological data from the Chira River basin in real time.
- A timely flooding prevention.
- Timely information to the population and in advance of extraordinary flood occurrences.
- Timely information on extraordinary inflows to the Poechos Dam that will lead to its protection
- The Dam operation for large flood control and lamination.
- Anticipated organization to mitigate any hydrometeorological disasters.

CHAPTER 9 CONCLUSION

(1) Problem on Installation of Food Early Warning System

Problem points about flood forecasting and warning early system (FFWS) are as follows:

1) Problem concerning installation of flood early warning system

a) Land use for possible inundation areas are mainly farmland. There are almost no areas which need early refuge such as city areas and so on.

b) In Poechos Dam located at the upper end area in the study area, the inflow of the reservoir is monitored. About occurrence of flood and increase of river water level, the forecast is possible in remarkable accuracy.

c) As a model case, FFWS has already been performed in the Piura River basin contiguous to the Chira River basin. To carry out as a model case is not important.

d) Construction of the important facilities for flood countermeasures in the Chira River basin will be excluded from the target of this project. In case that the FFWS is not adopted as a Japan loan project because of the small project cost, the project is thought to be carried out sufficiently by the budget of the regional government.

2) Situation of available instruments for the system

The monitoring stations to be installed for the FFWS are still working. Although collection of data is possible, the current information on operation of monitoring instruments cannot be obtained. The necessity for updating the instruments is unknown. When renewal of monitoring instruments is unnecessary, 64% of the project expenses (S/.2,640,000) become unnecessary.

(2) Conclusion

In the joint meeting held by JICA Peru Office, DGIH, OPI, DGPI, and JICA Study Team on December 5, 2011, the FFWS in Chira River is decided to be excluded from this project based on the above-mentioned situation. It can be carried out by the Piura Regional Government, if needed (refer to Minutes of Meetings on Main Points of Interim Report, Lima, December 5, 2011).