3.3.3 River Work Section

(1) Quinali (A) River

i) General

The Quinali (A) River gathering many streams originating on the southern to western slope of Mayon Volcano flows generally in a westerly or northwesterly direction and finally pours into Lake Bato. It is the biggest river among the above rivers to be studied in the project area. The total length of the river is about 150 km and its drainage area is about 330 km^2 (excluding Talisay River). The catchment area is mostly cultivated lands. Most of them are rice fields. But along the main course of Quinali, there are such densely populated municipalities as Camalig, Guinobatan, Ligao, Oas, Polangui and Libon and many other properties that can hardly be removed. Along the middle and the lower reaches of the main course, major tributaries are the Nasisi River from Mayon Volcano, the Polangui River and the Talisay River. And no good sites for flood control dams and retarding basins are found.

ii) Upstream reaches of the main course

Along the Quirangay and Tumpa Rivers, flood inundation occurs in the limited area downstream the Maharlika National Highway mostly due to poor drainage.

The junction with the Maninila River is treated well with revetment near the relocated PNR bridge piers under construction.

Along the upstream reaches of the main course, Guinobatan suffered most from flood damage and inundation due to the limited discharge capacity of the present river channel in the town. Repairing, heightening and extending of the present dike will be effective if the structure of revetment is modified with proper foot protection. The bridge of Maharlika

National Highway, which used to be located at the upstream end of the town and was destroyed due to typhoon "Daling", should be so re-constructed as to have an adequate flow area to discharge floods. Further upstream, cut-off channel made of boulder dikes is underway, but it does not seem to have an adequate flow area. Therefore, careful consideration seems necessary in such a way that this channel will not scour the foundation of the bridge mentioned above.

iii) Cabilogan River

After the Banao Bridge, the Cabilogan River flows in a deep valley receiving two (2) left tributaries. After passing this valley it is meandering, especially at Tagpo-Cavaci. The left dike of grouted riprap was mostly destroyed by typhoon "Daling" there. A plan of shortcut should properly be implemented there.

iv) Ogsong River

The Ogsong River seems rather stable in its middle reaches. But, downstream the Paulog Bridge, it changed its river course due to vast amount of sedimentation during typhoon "Daling". The dredging of the old river course is underway to facilitate the old course as before.

v) Nasisi River

Along the Nasisi River after the Ligao-Tabaco National Highway bridge destroyed by typhoon "Daling", there are such important structures as newly constructed Gamut Bridge, PNR bridge and National Highway bridge. The latter two structures are heightening the river bed with sedimentation. It seems that National Highway bridge especially should be re-constructed as well as PNR bridge under planning of re-construction with adequate flow area to avoid sedimentation.

vi) Polangui River

Along the Polangui River, there exists Quinali Left and Right Irrigation Dam, which is an overflow type fixed weir with a small sand flush. As the dam height is about 3 m, and as it is heightening the river bed, it is one of a main causes of flood inundation of Polangui. It is also causing scouring of piers of Quinali Bridge just downstream.

vii) Talisay River

The Talisay River receives big right tributary which gathers water mainly from Emergency Economic Administration (EEA) Spillway just upstream the South Quinali Dam at low water and from Bongoran Spillway at flood. It used to be an irrigation drainage channel. It has formed a deep valley after repeated floods.

The river course up to the upstream reaches of the Bacolod Bridge has a wide and deep channel for passage of a large flood, but suddenly becomes shallow after the bridge. River control by cut-off channel is underway there. And it causes flood inundation in the area near the Talisay River. It receives the Libon River before the Bailey Bridge, and joins the main course about 2 km before Lake Bato.

viii) Quinali (A) River

The middle and lower reaches of the main course, which is called the Quinali (A) River, are considerably mingled with the Talisay river, the Polangui River and other tributaries, all of which flow down from the surrounding mountains and hills other than Mayon Volcano. These tributaries have flushy nature of discharge and contain much more suspended materials due to surface soil erosion than the rivers coming from Mayon Volcano. About two-thirds (2/3) of the Quinali (A) River course in length is provided by levees. However, the levees are often destroyed in many places. This is mainly because of lack of discharge capacity of the river course. It is found that the left bank levees at Oas intentionally constructed lower than the right bank. Among such four (4) irrigation intake dams as South Quinali, Busac-Alomon, San Agustin and Agos-Sta. Cruz dams are existing in the main course, San Agustin dam was destroyed by typhoon "Daling", and all others are overflow type fixed weirs with a small sand flush. These dams offer adverse effects from the viewpoints of flood control of the river, since they not only reduce discharge capacity during floods, but also heighten the river bed with sedimentation. The Busac-Alomon dam is causing scouring of piers of Quinali Bridge as well as Quinali Left and Right dam along the Polangui River. There are at present three (3) connecting canals between the Quinali (A) River and the Talisay River; at Bongoran Spillway upstream Oas, at EEA Spillway downstream Oas and the Libon River upstream the newly constructed Busac-Alomon dam. First two (2) canals join each other before entering into the Talisay River. Presently a part of the ordinary discharge of the Quinali (A) River is diverted through these canals into the Talisay River. And it seems that they also function as flood ways, but the inundation in the area between the two (2) rivers does not seem to be avoided by these canals.

ix) Lake Bato

Presently, Lake Bato is utilized as a flood retarding basin. The flood inundation in the downstream reaches near Lake Bato, some 2,000 ha is mainly due to Lake Bato so far as it functions as a natural retarding basin. It is a different phenomenon from the flooding pattern of the middle reaches of the Quinali (A) River. This implies that the area near Lake Bato of about 2,000 ha could not be improved by the flood control works of the Quinali (A) River unless artificial regulation of Lake Bato is considered. The possibility of Lake Bato-Pantao Bay Diversion Scheme, the Levee Around Lake Bato, and other plans should be carefully studied.

(2) Quinali (B) River

The Quinali (B) River originates on the western to northwestern slope of Mayon Volcano and gathers several tributaries both from Mayon Volcano, Mt. Masaraga and Mt. Malinao. The affected area covers the Malinao plain, Tabaco, Malinao and a large tract of rice field. It passes across the National Highway bridge near the river mouth.

Along the middle and the lower reaches of the main course, the Taki River from Mt. Malinao from the left and the San Francisco River from Mayon Volcano from the right, join the main course. The tributaries from Mayon Volcano have less discharge while the tributaries from Mt. Malinao have flushy nature and their discharge is great.

Among the tributaries from Mt. Malinao, the Plansa River and the Taki River particularly, which join the main course in the lower reaches, cause flood damages to rice fields of Malinao. The San Francisco River is the major tributary coming from Mayon Volcano, and it meanders in the lower reaches and the river course is not stable. Along the main course, due to contraction of fords near Ogob, the river bed is heightened with sedimentation. Bank erosion is notable in meandering river reaches at Tuliew.

Flood protection dikes were constructed several years ago on the right bank of the main course and the San Francisco River respectively to protect the Malinao Plain from flooding. However, these dikes are often destroyed due to flood caused by typhoons. Either the reinforcement and extension of these protection or new construction of dikes will be required. the main course meanders in the middle reaches, but it forms a natural retarding basin in rather a wider channel. The sand spits due to coastal sedimentation develop at the river mouth. But it has been observed that they are flushed out during floods.

(3) Yawa River

The Yawa River gathers three (3) streams on the southern to southeastern slope of Mayon Volcano and other small tributaries from the southern hills (which are outside of the project area and among which the biggest one is the Busay River). And it flows mostly in easterly direction along the Legazpi Airport passing across the National Highway bridge and pouring finally into Poliqui Bay of Albay Gulf, at the north of Legazpi City. The three (3) streams are the Anuling River, the Budiao River and the Pawa-Burabod River from the west to the east. The main course of the Yawa River has gravels and boulders in its middle reaches. However, the river channel seems stable.

The overflow culvert type bridge near Cagsawa Ruin was partially destroyed by typhoon "Daling", but it was repaired afterwards. The Culiat dam for irrigation is newly constructed between this bridge and the overflow culvert at Kilicao. The bank erosion is seen in the middle reaches for which some bank protection work is required. The overflow culvert, which is bridge cum intake dam for industrial water for a paper mill, hinders the passage of flood flow. This should be replaced by an intake structure with a movable weir. From Kilicao to the point near the Legazpi Airport, the dikes are provided on both banks. However, about 2.5 km of the lower-most reaches of the Yawa River causes sometimes inundation with 0.5 m deep during floods. This section will require the construction of dikes to protect the densely populated Legazpi City and its suburbs. It is noted that such rivers as the San Roque River should be improved in drainage. Sand spits due to coastal sedimentation are formed at the river mouth. But it has been observed that they are flushed out during floods.

(4) East and North-East Streams

i) There are many independent streams originating in Mayon Volcano and flowing into Albay Gulf and Tabaco Bay between the Yawa River and the Quinali (B) River. Among these, eleven (11) streams were selected to be the ones within the scope of study in this project. They are numbered one (1) to eleven (11) from south to north as shown in the General Map. One of the important features of this area is that careful consideration should be made for Sabo works and flood control works mainly for Malilipot, Tabaco, Balading and Malinao. Another is that among these, number four (4), six (6), eight (8) and ten (10) are relatively important than the others. Eleven (11) streams are basically divided into two (2) groups. Those in the first group (No. 1 to 6) are located between the Yawa River and Pre Mayon Volcano. And the river bed slope of them is kept steep until they form alluvial fans just before pouring into the sea except No.5 which has relatively longer river course than the others. Among these, number three (3), four (4) and six (6) are devastated. Those in the 2nd group (No.7 to 11) are located between Pre Mayon Volcano and the Quinali (B) River. They flow north-east to north and change their courses to east at around EL. 100 m. Sediment deposition is notable around there, and some form big alluvial fans. After changing their courses, river bed slope of them becomes gentler, and they flow into Tabaco Bay. Among these only number ten (10) is devastated.

ii) No.1 Stream (Buyuan (A) River)

The upstream course forms a small gorge, and it approaches very near to the Pawa-Burabod River, a tributary of the Yawa River. After the gorge, it forms a big alluvial fan together with the Pawa-Burabod River. At the junction with the National Highway, sediment load is not notable and river bed seems to be stable.

iii) No.2 Stream (Buyuan (B) river)

This stream is composed of two (2) tributaries flowing in parallel along the southern side of Mayon golf course. The upstream gorge is relatively deep. The northern tributary is flowing along the southern edge of the golf course, and the mud/debris flow during typhoon "Daling" entered the golf course. Excavation of boulders and gravel is being made along this river. Along the southern tributary, there grow coconut trees and bushes. No damage downstream due to mud/debris flow is expected.

iv) No. 3 Stream (Matanag River)

There exists a relatively new lava flow at EL. 500 m. Invading of vegetation covers reddish-brown surface of lava partially. Erosion at the upstream portion below lava is not notably recognized. Due to the influence of lava, poor vegetation is revealed around there. But it is still probable that the river course becomes devastated due to further erosion. Sediment deposition exists down to El. 80 m followed by rice fields downstream.

v) No. 4 Stream (Basud River)

This stream is one of the most devastated similarily to the Pawa-Burabod River. And right tributary comes from the left side of the same lava flow as No. 3 stream. And left tributary is relatively stable provided with better geological condition. Right tributary formed an alluvial fan between EL. 230 m and EL. 120 m, and during the flood in 1968, a mass movement of sediment occurred, and sediment was deposited at the junction with the left tributary at the National Highway bridge. The bridge was partially destroyed during typhoon "Daling", but repairing with improvement of abutments is underway. Sedimentation at that time is notably recognized.

vi) No. 5 Stream (Bacacay River)

Invading of vegetation is revealed at a higher elevation than the other streams. And gully erosion is recognized on a small scale. Consequently, the river course is in a stable state. Five (5) tributaries are passing across the National Highway, but the discharge capacity does not seem to be adequate. The 4th tributary from south seems to be the largest in ordinary discharge, and a notable amount of sediment transport is expected during floods. Judging from a mountainous mass and the form of the basin seen downstream the National Highway, it seems that the river course could be devastated in old days. But the basin at present is used as rice fields and is in a stable state.

vii) No. 6 Stream (Bulawan River)

It flows through a narrow course in its middle reaches, and forms a flat plain. And sediment is deposited there. The river course changes toward east, and then toward north-east after the National Highway and flows into Tabaco Bay at a steep river bed slope. The top of an alluvial fan exists at the highway, and a vast amount of boulders and a notable ordinary flow exist there. But the water infiltrates afterwards. As no vegetation is revealed at the flat plain upstream, a notable amount of sediment load is assumed. The very wide river course spread over near the river mouth.

viii) No. 7 Stream (Tiagao River)

From Mayon Volcano, it flows north-east and changes its course to east at EL. 100 m and it flows along the northern side of Malilipot being joined by several small tributaries from Pre Mayon Volcano. The river bed is now in a stable state. As far as the ordinary discharge is concerned, one eastern-most tributary from Pre Mayon Volcano that flow along the southern side of Malilipot is largest.

ix) No. 8 Stream (Tagas River)

The origin of this stream is very near to that of No. 7 stream, but it flows north and flows along the southern side of Tabaco. As rice fields exists at a higher elevation than the others, it seems that the river course became stable in old days. Profile of the river course seems to be quite smooth. River bank erosion occurred during typhoon "Dinang" in 1981 along the meandering reaches upstream and downstream the National Highway bridge.

x) No. 9 Stream (Bonbon River)

The origin of this stream is an underground aquifer at EL. 100 m. Around the origin, a gully erosion on a small scale can be observed. But sediment yield seems to be small, and its influence downstream is negligibly small. Even though the water comes from the underground aquifer, ordinary discharge is comparatively large. And as the river bed slope is gentle, the river course is meandering and causing right bank erosion just upstream the National Highway bridge.

xi) No. 10 Stream (San Vicente River)

The upstream river course is most devastated among the eleven (11) streams. The upstream-most portion forms the deepest gorge. And there is a trace that the river course ran to No. 8 Stream previously. A vast alluvial cone starts at around EL. 180 to 160 m, and a mud/debris flow on a large scale, flowed along the left side of the cone and overflowed Ligao-Tabaco National Highway between San Vicente and San Antonio, after deposition of mud and debris. The river course becomes narrower and it flows into the San Francisco River. And at the same time, most of the runoff flows down with erosion along the right side of the cone. And it mainly flows into No. 11 stream and partly into No. 10 stream. The downstream reaches are the old river course from San Vicente. Therefore, it is quite probable that a flood flows from San Vicente to the downstream reaches of this stream. The present river course is used for irrigation. And the discharge capacity for flood does not seem to be adequate.

xii) No. 11 Stream (Sawang River)

This is the present river course from San Vicente. And it is actually used as an irrigation canal at present.

3.4 Present Condition of Agriculture

3.4.1 Natural Condition of Agriculture

The terrain of the objective area for irrigation development is gently sloping from the foothills of Mayon Volcano to a generally flat area along the Quinali (A) and (B) Rivers.

The interior alluvial plain is predominated by rice field. Most of the soils in the alluvial plain except those developed under the influence of the Talisay River are formed in a recent alluvium derived mainly from pyroclastic materials. The soils developed under the influence of the Talisay River is derived from the clastic deposit and limestone and is often calicaneons.

The soils in the alluvial plain are mostly well suited for irrigated rice cultivation. They are deep and have moderate to high natural fertility. Surface soils are silty clay to loam and are easily puddled. The soils in the south of the Talisay River are very clayey and are marginally or not suited for upland crops because of soil tillage problems and relatively high groundwater level. The soils in the piedmont area are sandy loam in the surface soil and have moderate to locally low fertility. The soils in or near valleys of Mayon Volcano are very acid with pH values of 4.5 to 6.2 in the surface soil and 3.3 to 4.1 below about 60 cm deep.

3.4.2 Population and Household

Administratively, the project area is situated in Albay Province and consists of twelve municipalities and Legazpi City. According to the population census in 1980, population in the project area is estimated at 416,700 consisting of 73,370 households. Based on the results of farm economic survey by the survey team of the Master Plan, the number of farm household in 1980 is estimated at 39,190.

3.4.3 Present Land Use

With regarding the present land use in the project area, the agricultural land is 44,712 ha consisting of 21,714 ha of rice field, 1,879 ha of upland field, 20,866 ha of coconut field, 131 ha of abaca field and 122 ha of citrus field. The national and communal irrigation systems cover about 2,400 and 10,000 ha of rice field, respectively. The remaining rice fields are mostly cultivated under rainfed condition.

The non-agricultural land totals 25,190 ha including 10,182 ha of forest and 7,720 ha of grass land. Due to the limitations such as slope and soils, these areas are mostly not suitable for further reclamation to arable land.

The average farm size is about 1.2 ha including rice field, upland field, coconut field, abaca field and citrus field, while about 60% of the total farm household has an area of less than 0.9 ha. In respect to land tenure, only 18% of the farm household are ownercultivator. The remaining 17% is amortizing farmer, 45% is leaseholder, 16% is sharetenants and 4% is mixed tenure.

3.4.4 Present Cropping Pattern and Farming Practices

The present cropping pattern prevailing into the irrigation development area is illustrated in FIG.-3.4.1.

The main crop grown in the project area is rice. The cropping pattern of rice is restricted by the rainfall pattern. Normally, the start of the land preparation such as puddling coincides with the start of the wet season. Typhoon and flood seasons also influence the cropping patterns of rice. The rice cultivation areas are grouped into three areas according to the cropping patterns, i.e., Quinali (A) River basin, Quinali (B) River basin and Lake Bato flood areas. In the Quinali (A) River basin area, double cropping of rice is practiced. The sowing of wet season rice starts in April and ends in June. The harvest starts in August and ends in October. The sowing for dry season rice cultivation starts in November and ends in January. The harvest season is from March to early May.

The Quinali (B) River basin area, the rice cultivation starts one month earlier than in the Quinali (A) River basin because of more rainfall in the dry season. The double cropping of rice is commonly practiced in this area. The sowing of wet season rice starts in late March and ends in May. The harvesting starts in August and ends in September. The dry season rice is sown from October to November and is harvested from late February to early April.

About 1,000 ha adjacent to Lake Bato is severely flooded every year, where only single rice cultivation is practiced. The sowing of rice is done in april and harvesting is from late July to August.

Farming practices of rice cultivation are partially mechanized. Plowing is done for most cases by carabao and puddling is done by carabao or hand-tractor attached with puddling wheels. Weeding is done mostly by hands and herbicides and rotary hand weeders are used subsidiary. Improved high-yielding varieties such as IR-36, IR-42 are the major varieties of rice in the project area. Planting density is 20 cm x 20 cm in most cases.

Fertilizer application is the common agricultural practices for rice in the irrigation development area. The average used of fertilizers in the Quinali (A) River basin are 76 kg N/ha, 16 kg P_2O_5/ha and 8 kg K_2O/ha, and those in the Quinali (B) River basin are 67 kg N/ha, 19 kg P_2O_5/ha and 6 kg K_2O/ha.

Damages by diseases are very little. Major rice diseases are tungro, leaf spot and bacterial leaf blight diseases. Farmers apply insecticides normally 3 to 4 times against stem borer and whorl maggot for a preventive measure.

3.4.5 Agricultural Production

Based on the data obtained from the Regional Office of BAEx, existing yield and production of palay in the project area in 1979 are estimated as shown in TABLE-3.4.1 and summarized as below:

Basin	Area (1,000 ha)	Yield (ton/ha)	Production (1,000 tons)
Wet Season			
- Irrigated	9.4	3.0	28.2
- Rainfed	7.1	1.7	12.1
Dry Season			
- Irrigated	9.4	3.2	30.5
Total	25.9	2.7	70.8

On the other hand, the sample servey on paddy yield through interviews was carried out by the survey team of the Master Plan in 1980. According to the results of this sample survey, the average yield of palay in all sample areas is estimated at 3.5 tons/ha in the dry season and 3.2 tons/ha in the wet season. It is considered that the high yield of palay is attributable to the well extension services and flood-free condition.

Coconuts are planted on 21,200 ha, from which about 20,000 tons of copra are produced annually. Average yield is about 40 nuts per tree per year. The planting density is around 120 trees per hectare. About 88% of trees are fruit bearing. Around 350 to 400 nuts produce 100 kg of dried copra. Major pest and disease of coconut in the project area are Asiatic palm weevils and Cadang-cadang disease.

Major upland crops in the project area are corn, cassave, sweet potato, vegetables, banana and citrus. Corn is not so important for staple food in the project area. Information on the planted area and production of corn in the project area is not available. Average yield of corn in Albay Province in the phase 6 (January to June, 1980) of Masagana Maisan was 1.9 tons/ha according to the information from BPI (Bureau of Plant Industry). Leafy vegetables and rootcrops are grown for the home consumption, for most cases.

Livestock raising is not a mainline of the agricultural activities in the project area. Most of livestock are grazed on a small scale in the home yard and around the farm land.

3.5 Present Condition of Irrigation and Drainage Systems

Out of 44,700 ha of agricultural land in the project area, rice field occupies approximately 21,700 ha and extend over three major river basins, namely, the Quinali (A), the Quinali (B) and the Yawa River basins, and the East and North-East areas of Mayon Volcano. At present, total 13,000 ha of rice field is irrigated under existing irrigation systems.

There are 4 National Irrigation Systems covering approximately 2,400 ha, and 65 Communal Irrigation Systems covering about 10,600 ha in the project area. TABLE-3.5.1 shows the net irrigable area of existing irrigation systems. FIG.-3.5.1 shows location of each irrigation system.

The National Irrigation System is implemented from planning stage to construction stage by the National Irrigation Administration (NIA). Operation and maintenance works after accomplishment of the project are continuously carried out by NIA.

The Communal Irrigation System is also implemented from planning stage to construction stage by NIA, but operation and maintenance works are handed over to associated farmers' organization after accomplishment of the project. Some Communal Irrigation Systems have systematical irrigation canal networks with major permanent facilities such as headworks and related structures. However, the other communal Irrigation Systems have only temporary brush dams and simple irrigation canal networks which are operated individually by farmers themselves.

Canals of the existing irrigation systems are almost unlined and trapezoidal. The irrigation facilities and canal networks are kept in good condition.

Drainage canal networks in the existing irrigation systems are not completely established yet. A number of natural rivers and streams in the project area are utilized as the drainage canal networks. Therefore, a local inundation often occurs just after heavy rain.

Five-year Communal Irrigation Development Program (1981-1985) in Albay Province has been established by NIA. The program includes rehabilitation of existing Communal Irrigation Systems and new development of irrigation system in the project area. The implementation of plan is scheduled from 1981. The rehabilitation program aims at integration of 3 existing irrigation systems with a total area of 1,664 ha in the Quinali (A) River basin and 2 systems totalling 585 ha in the Quinali (B) River basin.

As for the new development program, 4 schemes are contemplated in the project area. Among them, 3 schemes are located in the Quinali (A) River basin and cover 1,030 ha. The remaining new scheme is located in the East and North-East area of Mayon Volcano, and its total area amounts to 312 ha.

3.6 Present Condition of Infrastructure

3.6.1 Population and Labor Structure

Present condition of infrastructure in the project area is described on the basis of socio-economic and physical profile of Albay Province and of twelve municipalities and Legazpi City. Total population of the project area was 419 thousand in 1980, 377 thousand in 1975 and about 52% of the total population of Albay Province. According to the population census, it increased by 2.2% and 2.7% per annum during 1970 to 1975 and 1975 to 1980 respectively. The population is concentrated in the project area, and the population density is 599 persons per km^2 at present compared with the average density of 286 persons per km^2 in Albay Province. The project area is predominantly rural and only about 20% of the total population lives in the urban area. The number of barangays are 307 and about 50% of the total barangays is located in the project area.

Total households were 73,400 in 1980 in the project area and an average family size was 5.7 persons. The households increased at 17% during 1975 to 1980.

With respect to age composition, about 47% of total population belongs to younger age group, 0-14 years, while about 50% to working age group from 15 to 64 years and the remaining 3% to older age group.

Out of the persons of Albay Province, aged ten years and over in 1975, 43.1% are engaged in gainful occupation and 53.8% in non-gainful occupations such as students, housekeepers. Agriculture, forestry and fishing were engaged in by 53.8% of the gainful workers. On the other hand, the proportions of gainful workers such as manufacturing, construction and commerce were 18.5%, 3.1% and 6.0%, respectively.

3.6.2 Infrastructure

(1) Roads

The barangays, the municipalities and the growth centers in the project area are interconneted to each other by national, provincial, municipal, city and barangay roads. The national road has 21 road links of 171.63 km in 1979, and especially the Daan Maharlika Highway (Manila South Road) serves as the main arterial road traversing Albay Province and leading to the external zones of Camarines Sur and Sorsogon.

The project area has 138.96 km of provincial road, 139.77 km of municipality/city road and 238.37 km of barangay road in 1979. All barangays within the project area are with road connection.

The project area has 688.73 km of road in 1979 accounting for 44.7% of the total length in Albay Province. Gravel and earth surfacing road is estimated at 60.5% of total length in the project area (at 76.3% of the total length except national road).

Twelve (12) percent of bridges of the road network is of concrete type and the rest are timber, bailey, foot, suspension bridges and spillways. Out of them, some bridges were constructed during the Spanish era.

(2) Railway

The Railway Southline of 474.05 km links Manila and Albay. This line passes through 4 municipalities of Albay Province, namely, Polangui, Oas, Ligao, Guinobatan, and ended down to the terminal point at Camalig. The original terminal at Legazpi City was cut off when the 1975 flood washed away the steel bridges at Daraga.

The railway length between Bato station and Camalig station is 40.06 km, and 13.63 km between Camalig and Legazpi started to be dismantled from 1975. New railway Line (Deviation Line Project, Guinobatan-Camalig- Daraga) started to be constructed from 1977. This Line is 18.8 km in length and is located at southern area of Maharlika Highway to avoid the influence of mud/debris flow and flood from Mayon Volcano.

Train services are available in Albay Province; three a day service of north bound and south bound each between Albay Province and Manila.

The railway in the project area has 41 railway bridges and these bridges are mainly made of I-beams and wooden piles. The bridges located over the tributaries of the Quinali (A) River between Ligao and Camalig were constructed as temporary bridges, since these bridges are affected by the flood and mud/debris flow.

(3) Flood Control

Some part of project area is annually inundated at present during rainy season by the flood of the Quinali (A) River and the Quinali (B) River, and the area around Mayon Volcano is affected by the inundation and sand sedimentation. Also the government infrastructure such as road structures, railway structures and river facilities are damaged by the flood water. Therefore, the Ministry of Public Works had 17 river control projects and City Engineering Office has 4 river control projects in the project area in 1979.

In 1977, the Ministry of Public Works undertook a flood control construction of 10,951 m and 10,762 m repairs of dike, and continued the construction. However, some levee and dikes are damaged every year by the flood and the damaged portions are reconstructed after flood. Total amount of P 4.74 million was spent for the Quinali (A) River and Quinali (B) River, and total amount of P 1.49 million was spent for the Yawa river during 1975 to 1979.

In addition to the above amount released for the river control project, total amount of P 1.89 million was spent for the project area in 1980 and total amount of P 1.98 million was spent in 1981. Especially, total amount of P 3.75 million was spent in 1982 after the recent damage due to typhoon "Daling".

(4) Communication

The Mayon Telephone Cooperation (MATELCO) operates the telephone system in Legazpi City, Daraga and Tabaco. Albay Province accounts for 29.8 percent of the total number of telephone connection in the Bicol Region and the number of 1,320 subscribers indicates a low density of 0.17/100 population in 1977.

All municipalities and one city in Albay Province are equipped with telegraph service operated by the Bureau of Telecommunications. Also six private telegraph companies complement the telegraph service.

Postal service in Albay Province is provided mainly by the government post offices to the municipalities and city and 1.6 percent of all barangay are served by postal agencies. This yields an average ratio of 0.04 post officer per 100,000 population.

(5) Waterwork System

The water supply comes mainly from springs, artesian wells, shallow pump wells and open wells. All the poblacions and city are served with a piped waterworks system, however, this system is far from adequate.

(6) Power

The electrification of Albay Province covers Legazpi City and the poblacions of 13 municipalities of the project area. The electrification supplied by the Albay Electric Cooperative affected 18,300 household which was about 16 percent of the total household, 2,500 commercial consumers and 69 industrial consumers in 1979.

3.7 Present Condition of Disaster Prediction and Warning System

3.7.1 Disaster

Disasters concerned to this Sabo and flood control project have been flood inundation, mud/debris flow and storm surge. These are brought to the project area by typhoon and monsoon accompanying torrent heavy rainfall and strong wind.

Rainfall with high intensity in the mountain slope turns to be a flood with high peak and flushed into river channels. The channel slopes are as steep as more than 5 percent in the mountain slope and 1 percent even at mountain skirt. Whereas ones in flat area adjacent to mountain skirt are less than one per mil and the river channels suddenly decrease their flow capacities. In this accord, the flush flood from mountain slope tends to overflow from natural channel and the vast lands are to be submerged by inundation along rivers. Calamities have been recorded as well as damages to houses, road and other structures due to inundation.

Volcanic materials hang on the slopes and gullies of Mayon Volcano. Most of ones in gullies are silting of volcanic product once slided and concentrated thereto. A certain depth of rainfall is liable to cause land slide of the materials on the slope into gullies. It triggers secondary sliding of materials in gullies once silted therein. Mud/debris flow formed in this manner goes down scouring out the river channel bed and channel banks. It spills out from the river channel and spreads wide along the river when it comes down to the areas of one to two hundreds meters above mean sea level in altitude. The mud/debris flow widely spread out has caused serious casualties and damages since the areas of these elevation are populated rather densely. Remarkable damages due to mud/debris flow have been experienced repeatedly within a few years after each eruption of the Volcano since volcanic materials were newly produced and deposited in loose condition.

Strong wind accompanied with tropical storm has caused storm surge. A well developed storm surge has beaten over the sea shore area of the eastern coast of the project area. Storm surge has claimed calamities and damages to fisherman's houses, roads and other structures located in these areas.

According to the results of damage analysis, the magnitude of damage due to typhoon "Daling" for each cause is as follows;

(1) Flood Inundation

Inundation has taken place from some sides of most rivers in the project area. The largest area of 12,800 hectare was inundated along the Quinali (A) River. The rivers which caused major inundation damages are as follows;

Quinali (A) River	12,800 ha
Quinali (B) River	3,100 ha
Yawa River	700 ha

As shown on the inundation map, submerged area is concentrated in the downstream reaches of the Quinali (A) River. Legazpi City and Municipalities of Daraga, Camalig, Ligao, Oas, Polangui and Libon were submerged by the inundation nevertheless these towns are the local center of political, economic, educational and other activities. The casualty record shows that some 100 deads are to be claimed by a flood runoff of similar magnitude with one brought by typhoon "Daling" in these river basins.

(2) Mud/Debris Flow

Volcanic materials produced by the recent eruption are piled on the South-East slope of the Mayon. Gullies in this slope are filled with volcanic sand, gravel and boulder. These deposits flowed downward and brought considerable damages to habitants and infrastructures at the passage of typhoon "Daling". Summary of the reported damages are as follows;

i) Quirangay River

Earth embanked dike on the left bank was hit by mud/debris flow and partly broken upstream the PNR bridge.

ii) Masarawag River

The old earth dike on the left bank was attacked and breached. Mud/debris flow damaged provincial road and the barangay of Maninila.

iii) Anuling 1 River

Mud/debris flow damaged the barangay of Salvacion claiming casualties. The provincial road was also damaged.

iv) Budiao River

The provincial road was destroyed.

v) Pawa-Burabod River

The spilled out mud/debris flow hitted the barangays located along the river and casualties (dead) of 18 was reported. The damaged barangays are Mabinit, Bonga, Burabod and Buyuan.

Casualties (dead and missing) of some 60 persons are reported in barangays in the mountain slope area of Mayon Volcano attributable to typhoon "Daling". It should be specially noted that the evacuation activities were behind time since the disasters occurred in the mid night and people did not acknowledge the warning disseminated through public radio broadcast.

(3) Storm Surge

Storm surge has brought casualties and damages to houses, roads and other infrastructures in coastal area. People in seashore in the following towns have been subject to storm surge; Legazpi City, Sto. Domingo, Bacacay and Tabaco.

3.7.2 Disaster Preparedness

The activities to prevent and mitigate disasters are to be conducted by various authorities which organize the Disaster Coordinating Counsel (DCC) in respective level. National and Regional DCC act covering 9 fields whereas DCC of barangay level covers 11 fields of activities as shown in FIG.-3.7.1. Each authority is assigned to respective field. Respective DCC is chaired by General, Governor, Mayor and barangay captain. OCD acts as the secretariat of DCC.

Members of DCC are assigned to prepare equipments, material and manpower against impending disaster to mitigate damages. It is understood that the well advanced information and accurate forecasts are extremely useful to make the activities of DCC effective.

Information on an approaching typhoon is to be sent to the OCD Central Office in Manila from the PAGASA Central Office in Manila. The same information is to be sent to the OCD Regional Office in Legazpi either from the PAGASA Legazpi Office or the OCD Central Office.

The record of route and the forecasted route of the typhoon and the wind velocity are included in the information, but rainfall is not included.

Communication between the OCD Central Office and Regional Office is carried out through specific SSB system and telephone of PLDTS.

The SSB communication lines tend to be disturbed after 8:00 p.m. by wave of public radio broadcasting, since the frequencies are close each other and power level used by the SSB is low. Further, the PLDTS stops its service at 9:00 p.m. Accordingly the communication between the OCD Central and Regional Offices encounters difficulties in the night time frequently in spite of their 24 hours services.

Warning to various offices and public is disseminated from the OCD basing on the information provided by the PAGASA or the COMVOL through existing all available media including public radio broadcasting. The Regional Office of the PAGASA and the COMBOL are also entitled to announce warning to public with the approval of their respective Central Offices.

The PAGASA established the Bicol River Basin Flood Forecasting System in December 1980 as shown in FIG.-3.7.2. Data obtained at telemeterized observation stations located mainly in the downstream area from Lake Bato have been sent to the National Flood Forecasting Center in Manila. The observed are hourly rainfall and water level at respective station. Warning has been disseminated to the people from the regional PAGASA and OCD based on the acquisited data.

Dikes have been constructed along tributaries mainly by MPWH as a structural measure of disaster mitigation. The left bank dike in the Pawa-Burabod River functioned well at typhoon "Daling" and protected a part of barangays Bonga and Pawa from mud/debris flow. The barangay Mabinit was, however, suffered disaster due to shifting the course of the mud/debris flow upstream the existing confining dike on the right bank at the provincial road.

MPWH has plans to construct the Sabo works in the Pawa-Burabod, the Nasisi and other rivers. The works are planned in the emergent Sabo works level and there remain some possibilities that mud/debris flow of these rivers may cause disasters even after the completion of works.

Earth embanked road dike and concrete lined boulder dikes have been constructed along various rivers to protect towns and buildings by MPWH and other authorities concerned. The works are effective and considerable area has been protected from inundation. The works have been designed based on the recorded flood water level and are considered in emergency works level. Accordingly there still remain the possibilities of inundation in some part of the project area.

Several evacuation centers have been established in each municipalities. The Ministry of Education and Culture is a member of DCC and school buildings are to be provided as evacuation centers. Buildings selected as the evacuation centers are situated in rather high land in the area. And they are conceived to be safe against mud/debris flow, flood and storm surge. The evacuation centers in the respective municipalities are as follows:

Legazpi City	:	Bonga, Mabinit and Gogon
Daraga	:	Malabog, Busay and Daraga
Camalig	:	Camalig, Ilawod and Bariw
Guinobatan	:	Guinobatan
Ligao	:	Tuburan and Ligao
Oas	:	Oas
Libon	:	Libon
Polangui	:	Polangui
Tabaco	:	Bantayan, Quinastillohan, San Antonio, Panal and Tabaco
Bacacay	:	Hindi and Bacacay
Sto. Domingo	:	San Fernando and Sto. Domingo

PAGASA, Legazpi has installed SSB system and has exchanged information with its Central Office in Manila. Nation wide typhoon information has been available in Legazpi City.

COMVOL has observed the activity of the Volcano at the Rest House and Sta. Misericordia. Both observatories are facilitated with SSB, and the communication network is established among both observatories and the Head Office in Manila.

CHAPTER Ⅳ

IV. FLOOD AND SEDIMENT (MUD/DEBRIS FLOW) DAMAGE

4.1 General

The flood and mud/debris flow damages are classified into tangible damages and intangible damages in general. The tangible damages consist of direct physical damages and indirect damages including economic losses such as loss of wages, interruption of services and transportation, impairment of commercial distribution facilities, etc., and emergency costs such as flood fighting, disaster relief, incresed costs of nursing and medical assistence to victims, etc. The intangible damages consist, for example, of loss of life, personal injury and sickness.

The first field inventory survey on the flood and sediment damages in the project area was carried out in 1979, and the second field inventry survey for the Master Plan study which is a follow-up of the first survey was made in 1980 by using topographic maps on the scale of 1/25,000. Data of the flood and sediment damages in the project area were mainly collected for the following three aspects: infrastructure, agro-economy, and irrigation facilities to be studied.

In addition to the above previous survey, data of the flood and sediment damage, especially mud/debris flow damage due to the recent typhoon "Daling" are collected to re-assess and review the Master Plan. Typhoon "Daling" which hit Albay Province and crossed over the Southern edge of Luzon Island brought a heavy rainfall in Mayon Volcano and its surrounding area, especially in Legazpi City. Flush floods and mud/debris flow caused by the heavy rain due to typhoon "Daling" rushed down the gullies on Mt. Mayon's southern slope and caused heavy calamities to the barangays located on the foot of Mayon Volcano. The low-lying area was also inundated and the flood control facilities and bridges were damaged seriously.

Data of the flood and sediment damages are available for 7 years since 1975 to 1981, of which the data of typhoon "Pepang" in 1979 and mud/debris flow damages due to typhoon "Daling" in 1981 are mainly used for this re-study.

As a result of these field inventory surveys and studies, primary causes of flood and sediment (mud/debris flow) are considered to be as follows.

i) There are local sediment of sand and debris at individual river structures such as bridges, culverts, headworks, etc., in the Quinali (A), the Quinali (B) and the Yawa Rivers. The local sediment decreases the stream flow capacities of individual river section against flood.

ii) Drainage structures such as culverts and small bridges constructed on the tributaries of the major rivers have not enough flow capacities compared with drainage water flowing out from rice fields. Therefore, the flood flows over rice fields and in many barangays and some municipalities scattered along the Quinali (A), the Quinali (B) and the Yawa Rivers and their tributaries. And inundation due to the flood lasts for 1 day to one week in the individual area.

iii) Mud/debris flow due to typhoon "Daling" in 1981 on the southern slope of Mayon Volcano was attributed to the 1968 and 1978 eruptions wherein most of the volcanic materials had been repeatedly disgorged towards this area by the heavy rain.

4.2 Damaged area

4.2.1 Area due to flood and sediment

According to the results of field inventory surveys and studies in 1979, it can be said that the damages are mainly caused by the inundation due to flood. The inundation area is delineated by counterchecking the data of the field inventory surveys and the results of hydrological and hydraulic analysis, especially, in view of inundation depth and inundation period. As the result, the inundation area due to typhoon "Pepang" is approximately 113 km^2 in the project area as shown in FIG.-3.3.2. The inundation area due to typhoon "Daling" is approximately 166 km^2 as shown in FIG.-3.3.3. This area is estimated based on the all inundation area including the area due to other rivers which are out of the project area, i.e. the Taki River, the Plansa River, the San Roque River, the Macabal River, the Gapo River, the Panal River and the Maowod River. The flood due to typhoon "Daling" is assumed to be 5-year probable.

(1) Quinali (A) River Basin

The lower part of the Quinali (A) River basin; the vicinity of Lake Bato, is inundated annually for more than one week by backwater from the lake during the rainy season. According to water level record of Lake Bato which has been observed since 1974, the high water level rises annually up to more than 8.30 m above mean sea level. One of the main causes of the backwater is surely shortage of drainage capacity of the Bicol River which originates from Lake Bato and functions as the outlet of the lake. The middle part of the basin is also inundated by the floods from the streams crossing the area due to their low flow capacities and breach of river dikes by flood. The inundation depth varies from 0.3 m to 0.5 m and the inundation period lasts for 1 day to one week. Since a lot of municipalities, barangays, road network and infrastructure concentrates in this area, the damages to these facilities are serious.

Flood in the area along the upper reaches of the Quinali (A) River and its tributaries is of torrential nature involving sand and debris. The causes of flood are mainly their limited flow capacities and obstructions such as bridges and road culverts constructed on the rivers. There are only local damages in this area such as erosion of river bank and sedimentation of sand and debris in rice field and river structures and on the roads.

(2) Quinali (B) River Basin

Flood occurs mostly in lower parts of the Quinali (B) River mainly due to limited flow capacity of the river, especially at river structures. The flood often flows in the municipalities, barangays and rice fields along the provincial road, but the inundation period is not so long; one day at most.

(3) Yawa River Basin

Flood occurs mostly in lower parts of the Yawa River mainly due to limited flow capacity of the river, especially at river structures. The flood often flows in rice fields but the inundation period is not so long; less than one day.

(4) East and North-East Area of Mayon Volcano

The flood is mainly of torrential nature involving sand and debris, which causes only local damages such as erosion of river bank and deposition of sand and debris in rice field and river structures and on the roads.

4.2.2 Area due to Mud/Debris Flow on the Slope of Mayon Volcano

Based on the result of risk analysis, the area covered by mud/debris during the past 2 years from 1980 to 1982 is estimated at about 438 ha including 202 ha of palay field and 83 ha of coconut field, as shown below.

(Unit: ha)

	Devastation Area			Land Use of Devastation Area		
	1980	1982	Expanded Area	Palay Field	Coconut Field	Others
Quinali (A)	788	974	186	105	45	36
Quinali (B)	40	42	2	-	-	2
Yawa	271	430	159	91	23	45
East and North-east	230	321	91	6	15	70
Total	1,329	1,767	438	202	83	153

The serious damage to agricultural land has been occurred particularly in the Quinali (A) River and the Yawa River basin.

4.3 Damage to Infrastructure

In this study, the damage to infrastructure consists of the damages such as those to houses and buildings, national roads, provincial roads, municipal roads, barangay roads, railways and river facilities. These damage data are collected by the field survey between July and August in 1980 and between June and July 1982.

The field data for the damages to houses and buildings were collected after identifying those barangays suffering from the greatest damage in the past and inundated every year. This information was obtained from the Ministry of Public Works and Highways, the District Engineering Office, the City Engineering Office, the Provincial Development Staff, the Municipality, etc.

The damages to government infrastructure were collected as the estimated damage costs due to flood caused by typhoon and heavy rain in Albay Province. These damage costs were obtained from the Ministry of Public Works and Highways, the Provincial Engineering Office, the Municipality, the City Engineering Office, the District Engineering Office, the Philippine National Railways, etc.

4.3.1 Damage to Houses and Buildings

(1) Flood Damage and Mud/Debris Flow Damage Survey

The 1981 Flood Damage and Mud/Debris Flow Damage Survey

In an effect to determine the damages caused by typhoon "Daling" in June 1981 in the project area, the Study Team conducted a field survey. As a result of the survey, the magnitude of typhoon "Daling" is assumed to be almost the same as typhoon "Pepang", and the same inundation as the one studied in the Master Plan is assumed. However, the mud/debris flow due to typhoon "Daling" caused serious damage, especially, casualities, to the barangays at the foot of Mayon Volcano.

The 1979 Flood Damage Survey

In an effect to determine the flood damages caused by typhoon "Pepang" in September 1979 in the project area, the Study Team conducted a survey of 13 municipalities and Legazpi City. By the survey, data were collected on damages to houses and buildings.

During the survey, the flood damage data were obtained especially from interview with barangay captains and staff of each municipality on random sample basis. The establishments and buildings damage data were obtained from the Provincial Development Staff. These data, however, were damage cost of only four municipalities such as Libon, Oas, Polangui and Ligao and consisted of a few data of barangays.

The data of buildings damages for elementary schools and governmental buildings were obtained from only Legazpi City and these damages, however, were not caused by flood but caused by the wind and rain of typhoon.

The Past Flood Damage Survey

In the past records of the flood damages before 1979, it was confirmed that the greatest flood damage was caused in 1969-1970 and the next serious flood damage was caused in 1975 (Typhoon Sisang), by the field survey in the project area. However, the data and information for the past flood damage except the government infrastructure were not collected completely in this survey.

Damage to Houses and Buildings

During the field survey in the project area, the flood situation, inundation depth, inundation area and damage caused by flood were studied by interview with about 50 barangay captains in the Master Plan study. The inundated barangays caused by typhoon "Pepang" in 1979 amounts to more than 50 in the project area. Especially, the barangays near the Quinali (A) River of Polangui, Libon, Oas, Ligao, Guinobatan and Camalig, are inundated every year due to overflow on levee and flushing water from the destroyed dike. The damage to houses and buildings are estimated on the basis of flood analysis and data of field interview.

Damage to Houses caused by Mud/debris Flow in 1981

Based on the results of field interview survey in the project area, damage to houses caused by mud/debris flow due to typhoon "Daling" in 1981 is estimated below. Details are as shown in TABLE-4.3.1.

Typhoons	Houses (No.)	Value ($P10^3$)
Quinali (A)	374	180
Yawa	801	689
Quinali (B)	-	-
East and North-east	253	227
Total	1,428	1,096

Out of 1,428 houses, about 27% is totally destroyed and remaining 73% is partially damaged. These damages to houses occurred in the southern and western part of the foot of Mayon Volcano.

4.3.2 Damage to Government Infrastructure

(1) Damage to Road Structures

The damage data of road structures were collected during the period of 1975 - 1981. The damage is classified into the ones to the national, provincial, municipal, city and barangay roads.

The road structures are damaged by flood and heavy rain every year. Filling and surfacing materials are eroded, scoured and washed out. The grouted riprap is scoured and washed out. The concrete and asphalt pavement are cracked. The related structures such as box culvert, concrete pipe, timber bridge and concrete bridge are washed out.

The damage to bridges and roads can be approximately measured by the estimated damage costs, since these damage costs due to each typhoon and heavy rain are submitted as the calamity fund to the Government by the Ministry of Public Works and Highways, the Provincial Engineering Office, the City Engineering Office and the Municipalities.

During typhoon "Daling", the road structures in the Quinali (A) River basin were damaged seriously compared with other typhoons. The estimated damage costs in the past records are revalued at 1982 price level by using an average infration rate of 13 percent per annum considering the consumer price indices in Bicol Region. These damages are estimated at P 4.70 million, P 1.56 million, P 5.73 million, P 2.29 million, P 3.03 million and P 4.00 million for the floods in 1975, 1976, 1977, 1978, 1979 and 1981 respectively in the whole project area. Also, the revalued damages for each river basin are listed in TABLE-4.3.2.

(2) Damage to Railway Structures

Railway from Legazpi City to Tabaco was destroyed by the eruption in 1938 and dismantled afterwards. The railway from Daraga to Camalig was damaged by mud/debris flow in 1969 after the eruption of 1968 and many bridges were damaged heavily in 1975 by flood water and mud/debris flow from Mayon Volcano. The railway system in Albay Province has been dismantled between Camalig and Legazpi City. The following damage due to flood was caused by typhoon "Pepang" in 1979 and this damage was caused at ST.8881-8882 (Oas-Ligao, the Nasisi River). The latest damage due to typhoon "Daling" in 1981 was caused by the flood and flush water from Mayon Volcano.

The damage to railway trucks and bridges were obtained from the Philippine National Railway. These estimated damage costs are revalued at 1982 price level as listed in TABLE-4.3.3, which are P 10.20 million, P 0.46 million, P 0.26 million and P 1.70 million for the floods in 1975, 1979, 1980 and 1981.

(3) Damage to River Facilities

In the project area, flooding of such main rivers including various tributaries as the Quinali (A) River, the Yawa River and the Quinali (B) River, has caused damages to river structures by washing out and eroding of dikes and scouring of boulder riprap. In the East and North-East Area, flooding of 11 small streams has not caused serious damage after the eruption of Mayon Volcano in 1968.

The damage costs were measured by the estimated damage costs submitted as the calamity fund to the Government by the Ministry of Public Works and Highways and the City Engineering Office. These estimated damage costs are revalued at 1982 price level, which are P 1.32 million, P 0.10 million, P 0.21 million, P 0.91 million, P 1.40 million, P 3.80 million and P 8.97 million for the flood of 1975, 1976, 1977, 1978, 1979, 1980 and 1981 respectively in the whole project area. Also, the revalued damage costs for each river basin are listed in TABLE-4.3.4 and TABLE-4.3.5.

(4) Damage to waterworks

The damage cost of waterworks was estimated at P 1.66 million in 1981 (1982 price level) by the Ministry of Public Works and Highways as shown in TABLE-4.3.6.

(5) Damage to Government Infrastructure

Flood damage to government infrastructure from 1975 to 1981 is listed in TABLE-4.3.7. The estimated damage costs are divided into four river basins and are estimated including the indirect damages. Those at 1982 price level are P16.22 million, P1.66 million, P5.94 million, P3.20 mllion, P4.89 million, P4.06 million and P16.32 million for the flood of 1975, 1976, 1977, 1978, 1979, 1980 and 1981 respectively as shown in TABLE-4.3.7.

4.4 Damage to Irrigation Facilities

Available data of damages to irrigation facilities caused by flood of each typhoon and monsoon for 8 years from 1975 to 1981 were collected in the project area. These data were prepared by the National Irrigation Administration (NIA) based on the investigation carried out immediately after the flood of each typhoon and monsoon. The damages investigated include not only those on National Irrigation System but also those on Communal Irrigation systems. TABLE-4.4.1 presents the flood damage costs to the irrigation facilities during the period from 1975 to 1981.

The damages investigated in the Quinali (A) River basin include; (1) erosion of fore apron of the existing permanent headworks and scouring of protection wall; (2) sedimentation of sand and gravel in front of every intake gate; (3) complete breach of temporary brush dams; (4) local erosion at foundation of the river structures; (5) erosion and scouring of canal embankment; (6) local sedimentation of sand and gravel in canal networks; (7) sedimentation of sand and debris in rice field along the Quinali (A) River; and (8) local erosion of rice field along the upper reaches of the Quinali (A) River.

The damages observed in the Quinali (B) River basin consist of; (1) erosion of fore apron of existing permanent headworks; (2) complete breach of temporary brush dams; (3) local erosion and sedimentation of sand and gravel around the river structures; (4) erosion and scouring of canal embankment; (5) local sedimentation of sand and debris in canal networks; and (6) local erosion of rice field along the steep streams.

The damages occurred in the East and North-East area of Mayon Volcano include; (1) breach of temporary brush dams; (2) local sedimentation of sand in canal network and in rice field; and (3) local erosion of rice field along the steep streams.

4.5 Damage to Agricultural Product

Flood damages to crops were caused for most cases by typhoons, whose damages to crop were surveyed by the extension workers of BAEx municipal offices and the regional office of Ministry of Agriculture whenever typhoon attacked the project area. According to the information of extension workers, typhoon damages to upland crops such as coconut and abaca mainly consist of damages by strong wind and those damages caused by flood are negligibly small. The typhoon damages to palay in the project area are mostly flood damages and in some cases including strong wind damages resulting in shattering of rice grain and sterility of grain.

Based on the data obtained from the municipal office of BAEx and the Regional Office of Ministry of Agriculture, flood damages to palay by typhoon "Papang" in 1979 and typhoon "Daling" in 1981 are estimated as shown in TABLE-4.5.1 and TABLE-4.5.2, and summarized below.

	Production Loss /1 (ton)	Unit Price /1 (P/ton)	Damage Value (P10^3)
Pepang (1979)	9,610	1,200	11,530
Quinali (A)	9,130	1,200	10,950
Quinali (B)	480	1,200	580
Yawa	* /3	-	*
East and Northeast	*	-	*
Daling (1981)	6,610	1,200	7,932
Quinali (A)	6,010	1,200	7,212
Quinali (B)	*	-	*
Yawa	600	1,200	720
East and North-east	*	-	*

/1: Paddy grain

/2: Farmgate price at 1982

/3: No data

As for the flood damage of the Yawa river basin and East and North-east area in 1979 and the Quinali (B) river basin and East and North-east area in 1981, no data is available. According to the information from the Regional Office of the Ministry of Agriculture, it seems that flood damage to palay in those areas is negligible.

With regard to the mud/debris flow damage, no systematic investigation and evaluation of damages on agricultural product are conducted in the project area. Therefore, the agricultural damages are estimated on the basis of the field interview survey and the result of risk analysis. The mud/debris flow damages during the 2 years from 1980 to 1981 are as shown in TABLE-4.5.3 and summarized below.

Basin	Palay		Coconut		Total
	Area (ha)	Damage Value ($P10^3$)	Area (ha)	Damage Value ($P10^3$)	Damage Value ($P10^3$)
Quinali (A)	105	214	45	68	282
Quinali (B)	-	-	-	-	-
Yawa	91	142	23	35	177
East and North-east Area	6	12	15	23	135
Total	202	368	83	126	494

Among these damages caused by typhoons "Daling", "Anding" and "Dinang", especially, damages due to typhoon "Daling" were biggest. According to the information from the interview survey with farmers, it is estimated that more than 80% of total damage value consists of the damage due to typhoon "Daling" in 1981.

4.6 Indirect Damage

As mentioned in Section 4.1, indirect damages consist of economic losses and emergency costs.

In addition to direct physical damage, there are associated business and financial losses. These economic losses accrue principally to commercial and industrial development and reflect losses inherent in lost productivity, loss of wages, and impairment of commercial distribution facilities. Economic losses to transportation companies resulting from traffic delays and detour mileage are also included.

Emergency costs include those additional expenses resulting from a flood that would not otherwise be incurred, such as evacuation and reoccupation, flood fighting, disaster relief, increased cost of normal operations during flood and mud/debris flow, increased costs of police and military patrol, and cost for nursing and medical assistance rendered to victims.

Although such indirect damages as these would be estimated at considerable value, these evaluation are difficult because no data is available, except data for disaster relief, nursing and medical assistance to victims. Therefore, the indirect damages are assumed to be 15 percent of the damage to government infrastructure, as conservative assumptions concerning the damages created by floodwater and mud/debris flow in the project area. This percentage has been used by the Bureau of Public Works and Highways in their damage estimates of the past flood damage costs. The indirect damages caused by typhoons "Pepang" and "Daling" are estimated at P733 thousand and P2,447 thousand, respectively.

As for disaster relief, nursing and medical assistance rendered to victims after the disaster caused by typhoon "Daling" in the project area, the costs are estimated at about P701 thousand on the basis of the data obtained from the Regional Office of National Red Cross and the Provincial Health Office, as shown in TABLE-4.6.1 and TABLE-4.6.2. This estimated cost is included in the total indirect damage as mentioned above.

4.7 Casualties and Families Affected

According to the data and information obtained from the OCD, MSSD and field interview survey in 1982, casualties and families affected due to typhoons in Albay Province and Legazpi City related to the project area are estimated as below:

		Casualties	Families Affected
Pepang	(Sept.17-18/'79)	1	110
Aring	(Nov.4/'80)	-	1,190
Daling	(Jun.28-Jul.2/'81)	277	2,180
Yeyeng	(Nov.17-21/'81)	-	70
Anding	(Nov.22-27/'81)	1	7,640
Dinang	(Dec.23-27/'81)	1	2,070

As shown in the above table, typhoon "Daling" caused serious damage to life of people in Albay Province and Legazpi City. In the project area, casualties caused by typhoon "Daling" are estimated at 261 persons including 154 persons for dead and missing as shown in TABLE-4.7.1. Out of this total casualties, about 60% or 159 persons had been caused by mud/debris flow.

4.8 Total Damage

The damages due to the flood and mud/debris flow of typhoon "Pepang" in 1979 and typhoon "Daling" in 1981 are evaluated in monetary terms at the 1982 financial price level using the inflation rate of consumer price of Bicol Region. The evaluated results are summarized as below, and details are as shown in TABLE-4.8.1 and TABLE-4.8.2.

Damage Category	Damage Value	
	Pepang ($P10^3$)	Daling ($P10^3$)
1) Infrastructure	4,889	16,319
2) Houses and buildings	18,674	19,770
3) Irrigation facilities	710	2,384
4) Agricultural product	11,530	8,426
5) Indirect damage	733	2,447
Total	36,536	49,346

CHAPTER V

V. RE-ASSESSMENT AND REVIEW OF THE MASTER PLAN

5.1 General

This chapter presents the re-assessment and review of the Master Plan for the Mayon Volcano Sabo and Flood Control Project submitted by JICA in March 1981, taking account of the recent disaster occurred in the Mayon Volcano area in June and July, 1981 among others. The study covers the area of Mayon Volcano and its surrounding area the same as the Master Plan.

Before starting the re-assessment and review of the Master Plan, available data collected during the study in 1980 were re-checked and reviewed on the additional data collected in 1982. The study was made at the Master Plan level according to the evaluation of all data. Especially, the Sabo plan was reviewed carefully on the basis of the devastation area by aerophoto interpretation.

5.2 Hydrological Analysis

5.2.1 General

After the completion of the Master Plan in 1981, typhoon "Daling" attacked the project area and caused serious damage.

The hydrological analysis in the Master Plan was made on the basis of the meteoro-hydrological data before 1980, so that it should be reviewed adding data after 1980 which include the storm rainfall of the above typhoon. If the results of the previous analysis are much different from the ones revised by adding new data, the Master Plan of Sabo works and river improvement works have to be modified since they were prepared based on the results of the previous analysis. To put it concretely, the Sabo and river improvement plans were established based on the probable flood peak runoff estimated from the probable rainfall through a flood analysis.

Accordingly, the review of the study focuses on the flood analysis to check the influence to Sabo and river improvement plans by the storm phenomena including the said typhoon after the previous study.

Regarding the other analysis items such as low flow, sediment, etc., they are almost unaffected by adding data of such short period as 2 years. Therefore the results of the previous analysis for these items are unchanged.

5.2.2 Review of Flood Analysis

(1) Basic Principle

Basic Principle of flood analysis for the review of the Master Plan is described as follows:

Analysis is made for the estimation of only probable flood peak runoff from probable rainfall.

The flood hydrograph analysis is not made, since no hourly record of both rainfall and streamflow and no flood peak runoff record is available within the project area. The flood hydrograph analysis is not always needed for the present Sabo and flood control plans, either. Accordingly, the estimation of only probable flood peak runoff based on the probable rainfall is satisfactorily acceptable.

In order to estimate the probable flood peak runoff, Rational formula is employed, which is commonly used for that purpose. It is expressed in the following formula:

$$Q = \frac{1}{3.6} A \cdot I \cdot f$$

In the above, Q is flood peak runoff in m^3/sec, A is drainage area in km^2, I is average rainfall intensity over the basin for a given duration equal to flood concentration time in mm/hr and f is runoff coefficient.

The review study is made to finally check the probable 50-yr peak runoff, which is taken as design discharge, at several base points for planning through the rainfall analysis. The base points to be checked are selected as follows:

i) A-59 : the river mouth of the Quinali (A) River to Lake Bato

ii) A-34 : the Nasisi River at the confluence with the Cabilogan River

iii) Y-14 : the river mouth of the Yawa River

iv) Y-12 : the Pawa-Burabod River at the confluence with the Yawa River

v) Y-1 : the Anuling River at the confluence with the Yawa River

vi) B-21 : the river mouth of Quinali (B) River

The location of the above selected base points are referred to FIG.-5.2.1.

(2) Probable Rainfall

i) Probable Point Rainfall

There are few rainfall stations in the project area, so that each basin average rainfall is estimated by using point rainfall of one representative rainfall station.

In the flood analysis of the Master Plan, five representative stations are selected, namely: Guinobatan, Legazpi, Allang, Sto. Domingo and Malinao.

The probable 50-yr rainfalls for a duration of 1-day at the representative stations are calculated adding the rainfall data after the 1980 to the data used in the Master Plan. Gumbel's, Hazen's and Iwai's formula are employed for a frequency analysis. The result is listed below.

Probable 50-yr Rainfall at Representative Stations

Station	Subject Basin	Master Plan (Period)	Review (Period)
Guinobatan	Quinali (A) River basin	386 mm (1956-79)	394 mm (1956-81)
Legazpi	Yawa River basin	519 (1956-79)	510 (1956-81)
Allang	Talisay River basin	389 (1975-79)	344 (1975-81)
Sto. Domingo	Northeast-Southeast torrents' basins	350 (1956-79)	342 (1956-81)
Malinao	Part of northeast-southeast torrents' basins Quinali (B) River basin	381 (1972-79)	382 (1972-80)

As shown in the above table, the probable 1-day rainfall with a return period of 50-year re-calculated at four stations except Guinobatan are smaller than those in the Master Plan.

The difference between the Master Plan and review of the study ranges from 11% for Allang which is the representative station for the Talisay River to 0.2% for Malinao.

With respect to the depth-duration relation, the probable 50-yr rainfall intensity-duration curve defined by Talbot's formula for Legazpi station is used in the flood analysis of the Master Plan. Talbot's formula is expressed below.

$$I = \frac{b}{t + a}$$

where, I: rainfall intensity (mm/hr)

t: duration (hours)

a,b: constants

The constants, a and b, are determined by the least square method for the probable 50-yr rainfall intensities with the duration of 6-, 12-, 18- and 24-hours. The result is as follows:

Probable 50-yr Rainfall Intensity at Legazpi

Duration	Master Plan	Review
6 hr	49.3 mm	50.3 mm
12	25.8	26.4
18	18.6	18.4
24	18.6	17.2
Equation	$I_{50} = \frac{427}{t + 2.88}$	$I_{50} = \frac{417}{t + 2.74}$

Above two probable 50-yr rainfall intensity-duration curves of the Master Plan and review of the study are shown in FIG.-5.2.2. As seen in that figure, comparing with the curve of the Master Plan, the re-calculated probable 50-yr rainfall intensity becomes slightly larger in short duration of less than 4 hours.

ii) Probable Basin Average Rainfall

In the Master Plan, Horton's formula was employed to estimate the basin average rainfall. Horton's formula shows the relation between the average depth of rainfall and the area, and it is expressed by

$$P = Po \exp (-KA^n)$$

where,

- P : average depth of rainfall for a given duration over a certain area (in.)
- Po: largest rainfall amount in the area (in.)
- A : area ($mile^2$)
- K, n: constants

The constant n is determined by letting K be 0.1 constantly based on the probable basin average 1-day rainfall of the Quinali (A) River basin including the Talisay River basin, which is estimated by Thiessen's method using the concerned stations, namely, Guinobatan, Malama, Allang, Polangui and Lake Bato. Po is estimated at an increase rate of 50 percent of the point rainfall at a station selected as a representative one, mentioned before, taking into account influence due to altitude.

Re-calculated probable basin average 1-day rainfall with a return period of 50-year and the constants of n and K are as follows:

	Master Plan	Review
Probable Basin Average 1-day Rainfall	358 mm	336 mm
Period	1972-79	1972-81
n	0.30	0.33
K	0.1	0.1

Probable 50-yr rainfall depth-area curves of the Master Plan and review of the study are shown in FIG.-5.2.3. As seen in that figure, the re-calculated probable 50-yr basin average rainfall is smaller than that of the Master Plan in the area of more than 50 km^2.

(3) Probable Flood Peak Runoff at Base Point

In the calculation of the probable flood peak runoff through Rational formula, drainage area, runoff coefficient and flood concentration time in the Master Plan are used, because base points within the project area for Sabo planning and river improvement planning are unchanged.

The calculation procedure is itemized as follows:

i) The drainage area, river length, slope and runoff coefficient are given at first.

ii) The flood concentration time is calculated by Kraven's formula.

iii) The probable basin average 1-day rainfall is given by converting the probable 1-day point rainfall of the representative station into the areal rainfall through Horton's formula against the drainage area of the subject basin.

iv) The probable rainfall intensity - duration curves of Legazpi are revised with the ratio of the probable basin average 1-day rainfall obtained above to the probable 24-hour rainfall given by the original curves in order to apply to the basin concerned.

v) The probable average rainfall intensity during the flood concentration time to be substituted to Rational formula is given by the above revised rainfall intensity - duration curve against the flood concentration time.

vi) The probable flood peak runoff is calculated by substituting the drainage area, runoff coefficient and the rainfall intensity given above to Rational formula.

The re-calculated probable 50-yr flood peak runoff at six base points selected and the difference between the Master Plan and review of the study are listed below.

Probable 50-yr Flood Peak Runoff

Name of River	Drainage Area	Master Plan	Review	Difference
Quinali (A) (A-59)	524.2 km^2	4,070 m^3/sec	4,170 m^3/sec	2.4%
Nasisi (A-34)	84.2	1,697	1,656	2.5
Yawa (Y-14)	74.4	2,083	2,142	2.7
Pawa-Burabod (Y-12)	7.6	299	296	1.0
Anuling (Y-1)	9.4	377	373	1.1
Quinali (B) (B-21)	157.8	2,369	2,383	0.6

As shown in the above table, the differences are negligibly small, more detailed data are referred to TABLE-5.2.1.

Accordingly, the probable 50-yr flood peak runoff in the Master Plan summarized in TABLE-5.2.2 remains unchanged.

5.2.3 Consideration on Typhoon "Daling"

On June 30, 1981, typhoon "Daling" hit the project area and crossed over the Southern edge of Luzon island, causing heavy rainfall in Mayon Volcano area. It caused serious damage due to mud/debris flow in the skirts of Mayon Volcano and due to flooding in the plain area. The track of typhoon "Daling" is shown in FIG.-5.2.4.

The hourly rainfall distribution at typhoon "Daling", which is shown in FIG.-5.2.5, was recorded at two rainfall gaging stations of Ligao and Legazpi. As shown in FIG.-5.2.5, 1-day rainfall and maximum 1-hour rainfall observed are 398 mm and 157 mm at Ligao, 220 mm and 62 mm at Legazpi respectively.

Rainfall intensities of typhoon "Daling" with a duration of 6-, 12-, 18- and 24-hour at Ligao and Legazpi are as follows, compared with the probable rainfall intensities at Legazpi in the Master Plan:

Comparison of Probable Rainfall Intensity

Return Period	6-hour	12-hour	18-hour	24-hour
2 year	21.2 mm/hr	13.9 mm/hr	10.4 mm/hr	8.6 mm/hr
5	30.2	17.8	13.1	11.8
10	36.2	20.3	14.8	13.9
20	42.0	22.8	16.4	16.0
50	49.3	25.8	18.6	18.6
100	55.0	28.3	20.2	20.5
			in the Master Plan (Legazpi)	
Rainfall intensity at Legazpi (Typhoon "Daling")	29.0	16.1	11.4	8.6
Rainfall Intensity at Ligao (Typhoon "Daling")	61.3	32.6	22.1	16.6

As shown in the above table, the rainfall at Legazpi due to typhoon "Daling" is estimated at about 5-year return period. On the other hand, the rainfall at Ligao corresponds to more than 100-year probable rainfall at Legazpi, although the probable rainfall intensity at Ligao can not be estimated because of inadequate record length.

It might be considered that there was an extraordinary intensive storm rainfall in a short duration at Ligao.

5.3 Sabo Plan

5.3.1 General

During typhoon "Daling" in 1981, the mud/debris flows occurred and caused great disasters on the southeastern to southwestern slope of Mayon Volcano. Aerophotos covering the project area were taken two (2) times before and after the typhoon in 1980 and 1982 respectively. The rough amount of sediment runoff and the conditions of devastation in respective rivers are studied by the aerophoto interpretation. These data and informations obtained are very important because there was no datum for sediment runoff and yield in the area to date. Therefore, the Master Plan is re-assessed and reviewed depending on these data, ground survey and findings. The outline of the Sabo plan for the selected rivers is mentioned as follows and the details are described for the re-study of the Sabo project in chapter VII.

5.3.2 Subject Rivers

The subject rivers in this study are the streams of the Quinali (A) River and the Yawa River, which were selected in the Master Plan. Namely, they are the Quirangay, the Tumpa, the Maninila, the Masarawag, the Ogsong and the Nasisi Rivers in the Quinali (A) River basin, and the Anuling 1, the Anuling 2, the Budiao and the Pawa-Burabod Rivers in the Yawa River basin.

5.3.3 The Principle of Sabo Plan

(1) Quinali (A) River Basin

The Principle of Sabo plan of respective rivers in the Quinali (A) River basin is mentioned below.

i) Quirangay River

The principle of Sabo plan for the Quirangay River is not changed from the Master Plan, but the arrangement of Sabo facilities is modified. Sand and earth dike on the left bank upstream PNR was partially destroyed by the river bed scouring due to the typhoon. The devastation of the drainage area is proceeding. Along the downstream reaches, there is densely populated town of Camalig, which is the most important object to be protected from sediment disaster for Sabo plan. Therefore, the direction of mud/debris flow is controlled not to hit Camalig by arranging Sabo facilities. In the middle reaches, sand retarding basin with spur dikes and training levee is constructed to control the direction of mud/debris flows, and to arrest the sediment.

ii) Tumpa River

No change is found out in the river conditions before and after the typhoon and the conditions of whole drainage area are also gentle. Therefore, the Master Plan is not changed.

iii) Maninila River

As the river conditions in the Maninila river did not change either, it is not necessary to change the Master Plan.

iv) Masarawag River

Sand and earth dike on left bank of eastern course upstream the Provincial Road was completely washed away due to the typhoon. Devastation of the river is remarkable. In the upstream reaches large amount of unstable sediment exists, and it has possibility to turn to mud/debris flows. A Sabo dam is planned to be constructed to reduce sediment yield from the bed and banks. For the bifurcated two river courses at the middle reaches, a few spur dikes are arranged for the eastern tributary which is the main course.

v) Ogsong River (Nabonton Creek)

This river has a large retarding basin upstream the Provincial Road. The front of sediment flow reached the Provincial Road during the typhoon, but the conditions of downstream river did not change much; therefore, Sabo plan of this river follows the Master Plan.

vi) Nasisi River

The overflow culvert type bridge of Ligao-Tabaco National Highway and Nasisi Bridge were destroyed by the flood during the typhoon. However, as the amount of sediment runoff does not seem to have been much, the severe scouring downstream these bridges seems to have broken them. On the other hand, large amount of unstable sediment has been deposited in upstream river bed; therefore, a few consolidation dams and so on are planned to be constructed supplementing the Master Plan.

(2) Yawa River Basin

The devastation of respective rivers of the Yawa River basin was very notable and the mud/debris flows due to the typhoon "Daling" caused great disaster especially loss of lives.

i) Anuling 1 River

The mud/debris flow hit the Salvacion and caused loss of lives of thirteen (13). The front of mud/debris flow reached to the main course of the Yawa River. As there is plenty of unstable sediment to be stabilized in the upstream river bed, one Sabo dam and several consolidation dams are arranged. In the downstream reaches near Salvacion, sand retarding basin is planned with spur dikes and ground sills around the confluence with the Anuling 2 River. The sand retarding basin aims at checking the sediment runoff and to control the direction of mud/debris flows.

ii) Anuling 2 River

One Sabo dam and a few ground sills are added to the Master Plan.

iii) Budiao River

There was no damage during the typhoon except paddy fields along the river, but amount of sediment runoff was as much as that of the other rivers in the Yawa River basin. The source of sediment seems to be in the upstream reaches; therefore a few consolidation dams are arranged. In the middle and downstream reaches, no change from the Master Plan is made.

iv) Pawa-Burabod River

The mud/debris flows due to the typhoon caused loss of lives of eighteen (18) mostly in Mabinit. This river is the most devastated one among the rivers originating in Mayon Volcano. The principle of Sabo plan for this river is the same as the Master Plan, but considering the change in the river conditions, additional arrangement of Sabo facilities is made.

As a new river course was formed in the middle and downstream reaches due to the mud/debris flow during the typhoon, it is necessary to include the study on the new course in the Sabo plan.

5.4 River Improvement Plan

5.4.1 Quinali (A) River

(1) General

No basic changes from the Master Plan are made for the river improvement plan throughout this study.

As stated in Subsection 3.3.1, divides of Sabo work section and flood control work section are plotted off as follows.

For the Nasisi River

i) The bridge site of Ligao-Tabaco National Highway

For the eastern tributaries upto the Ogsong River

ii) Bridges of Maharlika National Highway

(2) River Width and Discharge Capacity of The Present River Channel

Using the profiles and cross sections of the present river channel, river width and discharge capacity are calculated as shown in FIG.-5.4.1 to FIG.-5.4.3. For the calculation of discharge capacity, Manning's Formula is used assuming uniform flow and the roughness coefficient being 0.035 throughout this study.

(3) Design Discharge

The design discharge is selected to be 50-year probable flood, considering importance of the region, design discharge of other rivers in the Philippines and the Japanese Standard of river planning (hereinafter called the Standard). From the results of hydrological analyses, design discharge distribution diagram is established as shown in FIG.-5.4.4.

(4) River Reaches for Improvement

Comparing FIG.-5.4.1 to FIG.-5.4.3 with FIG.-5.4.4, it can be said that the present river course has not sufficient discharge capacity and it results in flood inundation. Thus, damage is caused to human lives, crops, houses, railways, highways, river structures and irrigation facilities, especially in the affected area including six (6) important municipalities of Camalig, Guinobatan, Ligao, Oas, Polangui and Libon. Consequently, it is necessary to establish a flood control plan to avoid this damage by improving the river channel. The river reaches for improvement are selected as follows considering the discharge capacity of the present river and importance of the affected area.

i) Main course - Lake Bato to Sta. 27+500 (reaches of 27.5 km)

ii) Talisay River - Junction with the main course to Sta. 13+700 (reaches of 13.7 km)

iii) Nasisi River - Junction with the main course to the bridge site of Ligao-Tabaco National Highway (reaches of 7.6 km)

But, as the downstream area from the junction of the main course and the Talisay River has been affected by backwater from Lake Bato as far as the Lake functions as a retarding basin, the downstream-most reaches of 2 km near the Lake should be improved after completion of Lake Bato regulation works such as Lake Bato - Pantao Bay Diversion, the Levee Around Lake Bato etc.

(The said reaches are indicated by dotted lines in FIG.-5.4.7.)

(5) River Improvement Plan

i) Route Selection

In fact, along the main course, there are densely populated municipalities especially Oas and many other properties that can hardly be removed due to necessary river improvement. Basically the route should be selected along the present river course, considering topography, land use and difficulties of land acquisition, but for such an important municipality of Oas, a diversion of Oas and a diversion to the Talisay River (a flood way) are considered. Two (2) alternatives as shown in FIG.-5.4.5 and explained below, are established and compared. Alternative I is the Oas Diversion Scheme, the route of which is selected along the present river course except Oas. And alternative II is the Bongoran Diversion Scheme constructing a newly excavated flood way from Bongoran to the Talisay River. And Alternative I is selected as a recommendable scheme, comparing the construction cost (Alternative II is about 30% more costly than Alternative I), environmental problems and maintenance after improvement.

(a) Alternative I (Oas Diversion Scheme, Selected Scheme)
As shown in FIG. -5.4.5, it is basically a plan to improve the main course along the present river course except the river course near the city of Oas. Existing levees are entirely replaced by newly constructed ones. The Oas diversion scheme is considered due to difficulties of land acquisition. The four (4) present fixed weir type dams (South Quinali, Busac-Alomon, San Agustin to be repaired and Agoz-Sta. Cruz) for irrigation are integrated to proposed Agus Sta Cruz-South Quinali Dam, which is of a movable weir type. Generally speaking, any weir type structures across the main course of rivers shall be of a movable type. And Cabilogan Dam is also a movable weir type and proposed for integration of irrigation systems together with proposed Agos Sta. Cruz-South Quinali Dam. The cross section is designed as a compound section except the Nasisi River, which is designed as a simple trapezoidal section. Total construction cost for Alternative I Scheme is estimated at about P780 million excluding price escalation.

(b) Alternative II (Bongoran Diversion Scheme)
As shown in FIG.-5.4.5, it is a plan to divert all of the flood water from Bongoran directly to the Talisay River with a concrete made fixed weir of 220 m in width 2.5 m in height and 3 m in top length with horizontal apron type stilling basin of 20 m in length and 220 m in width and a diversion channel newly excavated of 170 m in width and 4.4 km in length. The bed slope is selected to be 1/800 in conformity with the one of the Talisay River. (It becomes about 1/320 if the channel connects the main course and the Talisay River straight regardless of proper transition.)

The river reaches of 10.5 km in length between Bongoran to the junction with the Polangui River through Oas is left as it is including existing levees, South Quinali Dam and EEA Spillway just upstream. And it functions as a low water channel. To avoid flood inundation from the existing channel during flood, a gate at the upstream end of the existing channel is installed. (Heightening of the levees of 10.5 km reaches without a gate to avoid inundation results in being more costly than the installation of a gate.) The cross section is designed as a compound section except the Nasisi River, which is designed as a simple trapezoidal section. To obtain design discharge, specific discharge of the Quinali (A) River basin is used. And the design discharge distribution diagram is shown in FIG.-5.4.6. Total construction cost for Alternative II Scheme is estimated at about P 1,013 million excluding price escalation.

ii) Alignment of River Channel

The alignment of river channel is designed with the following considerations:

(a) The alignment should follow the course of the present river channel to the extent possible.
(b) The radius of curves of river channel should be as large as possible.
(c) Existing levees are entirely replaced by the newly constructed ones.
(d) The alignment should not be selected to involve such existing important infrastructures as railways, highways etc. in the river channel.
(e) The alignment should not be selected to involve the land occupied by houses, etc. as much as possible.

Final alignment of levees of proposed scheme is shown in FIG.-5.4.7 and FIG.-5.4.8.

iii) River profile

River profile should principally be designed to meet the present river bed slope as much as possible to keep the equilibrium river bed slope and minimize the construction cost. Thus, the river bed slope is designed ranging from 1/1,550 to 1/550 for the main course, from 1/1,000 to 1/800 for the Talisay River and from 1/400 to 1/130 for the Nasisi River as shown in FIG.-5.4.9 to FIG.-5.4.11.

iv) River Cross Section

As the design discharge is over 300 m^3/sec, the river cross section is designed as a compound section except the Nasisi River, which is designed as a simple trapezoidal section due to the limitation by the formation height of the PNR (For a design criterion, 1.0 m of clearance is taken in accordance with a plan underway of a permanent bridge by PNR.), and which is also a transition from Sabo work section. Considering the river bed depth measured from the ground level of inland, formation height of side sections is designed to be 2.5 m higher than the main section except the Talisay River upstream Sta. 8+000. The width of the main section is so designed that the side sections are used for passage of flood water 1 to 3 times a year. As there is not much densely populated area except Oas, land aquisition is not very difficult, therefore, river width is selected to be wider than other rivers within the range specified in the Standard.

The dimensions of cross section are determined by Manning's Formula assuming uniform flow. The levees are basically designed in conformity with the Standard. The freeboard is set at 1.2 to 1.0 m and the top width is 5 m to 4 m depending on the design discharge. The slope of levee is selected to be 1:2. The berm of inland side of 3 m in width is constructed at every 3 m height in case total height of the levee is over 4 m. And the one of riverside of the same width is constructed at every 4 m height in case total height of the levee is over 6 m. The maximum height of levee will be about 6.5 m near Lake Bato and about 5.3 m at the junction with the Talisay River. The river width will be about 450 m at Lake Bato, and 360 m at the junction with the Talisay River. The formation height of levee at Lake Bato is EL. 12 m, which leaves 1.2 m of freeboard on design water level of the Lake of EL. 10.80 m. The design water level corresponds to the water level of Lake Bato during 50-year probable flood. It is necessary to construct sluiceways for drainage. The typical cross sections are shown in FIG.-5.4.12.

v) Major River Structures

Relating to the above mentioned river improvement, the necessary river structures are listed as follows:

(a) Levees with sod facing
(b) Foot protection and wet masonry for levees
(c) Sluiceways for river drainage

Only gravity drainage is considered. And box culvert type sluiceways will be constructed as follows, calculated by an empirical formula depending on topographic conditions and drainage areas.

The main course	
Junction with the Sugtad Creek at Matacon	2 m x 2 m x 4 nos.
Junction to Oas diversion	2 m x 2 m x 5 nos.
Junction with Oas diversion	2 m x 2 m x 5 nos.
The Talisay River	
Junction with the right tributary from EEA Spillway	2 m x 2 m x 3 nos.
Junction with the Libon River	2 m x 2 m x 2 nos.
Junction with the right creek just upstream the junction with the main course	2 m x 2 m x 2 nos.
The Ogsong River	
Junction with the Nasisi River	2 m x 2 m x 5 nos.

5.4.2 Quinali (B) River

(1) General

As stated in subsection 3.3.1, the divide of Sabo work section and flood control work section is plotted off at the contraction at Bantayan.

(2) River Width and Discharge Capacity of The Present River Channel

Using the profiles and cross sections of the present river channel, river width and discharge capacity are calculated as shown in FIG.-5.4.13.

(3) Design Discharge

The design discharge is selected to be 50-year probable flood, considering importance of the region, design discharge of other rivers in the Philippines and the Standard. From the results of hydrological analyses, design discharge distribution diagram is established as shown in FIG.-5.4.14. The design discharge for the San Vicente River is estimated at 270 m^3/sec.

(4) River Reaches for Improvement

From FIG.-5.4.13 and FIG.-5.4.14, it can be said that the present river course has not sufficient discharge capacity, and it results in flood inundation. Thus, damage is caused on a smaller scale than the Quinali (A) River to human lives, crops, houses, highways, river structures and irrigation facilities, especially in the affected area including two (2) important municipalities of Tabaco and Malinao. Consequently, it is necessary to establish a flood control plan to avoid this damage by improving the river channel. The river reaches for improvement are selected as follows considering the discharge capacity of the present river and importance of the affected area.

i) The main course - River mouth to Ogob, 2 km downstream the contraction at Bantayan
(reaches of 11.3 km)

ii) The San Francisco River - Junction with the main course to Ligao-Tabaco National Highway bridge at San Antonio (reaches of 6.5 km)

iii) The San vicente River* - The river mouth to Ligao-Tabaco National Highway bridge at San Vicente (reaches of 4.0 km)

* This river is out of the scope of the Master Plan.

(5) River Improvement Plan

i) Alignment of river channel

The alignment of river channel is designed with the following considerations:

(a) The alignment should follow the present course of the river channel to the extent possible.

(b) The radius of curves of river channel should be as large as possible.

(c) Existing levees are entirely replaced by the newly constructed ones.

(d) The alignment should not be selected to involve the land occupied by houses, etc. as much as possible.

Final alignment of levees of proposed scheme is shown in FIG.-5.4.15. The ones for the San Francisco River and the San Vicente River are also shown by dotted lines (because of no river survey data) in the same figure.

ii) River profile

River profile should principally be designed to maintain the present river bed slope as much as possible to keep the equilibrium river bed slope and to minimize the construction cost. Thus, the river bed slope is designed ranging from 1/1,200 to 1/80 as shown in FIG.-5.4.16. The average river bed slope of 1/190 and 1/100 for the San Francisco River and the San Vicente River is used respectively for calculation.

iii) River cross section

As the design discharge is over 300 m^3/sec, the river cross section along the main course is designed as a compound section. And the ones for the San Francisco River and the San Vincente River are designed as simple trapezoidal sections. Considering the river bed depth measured from the ground level of inland, formation heights of side sections are designed to be 2.5 m higher than the main section. The width of the main section is so designed that the side sections are used for passage of flood water 1 to 3 times a year. As there is not much densely populated area, land acquisition is not very difficult; therefore, river width is selected within the range specified in the Standrd.

The dimensions of cross section are determined by Manning's Formula assuming uniform flow. The levees are basically designed in conformity with the Standard. The freeboard is set at 1.2 m to 1.0 m and the top width is 5 m to 4 m depending on the design discharge. The slope of levee is selected to be 1:2. The berm of inland side of 3 m in width is constructed at every 3 m height in case total height of the levee is over 4 m. The maximum height of levee becomes about 4.0 m near the river mouth. The river width becomes about 270 m there. As the high water level of EL. 5.1 m at the river mouth is higher than the highest tide of 1.3 m recorded during the period between Jan. '79 and Apr. 80, no special consideration is given to tidal effect. The typical cross sections are shown in FIG.-5.4.17.

(6) Major river structures

Relating to the above mentioned river improvement, the necessary river structures are listed as follows:

(i) Levees with sod facing

(ii) Foot protection and wet masonry for levees

5.4.3 Yawa River

(1) General

As stated in subsection 3.3.1, the divide of Sabo work section and flood control work section is plotted off at Banag Railway Bridge.

(2) River Width and Discharge Capacity of the Present River Channel

Using the profiles and cross sections of the present river channel, river width and discharge capacity are calculated as shown in FIG.-5.4.18.

(3) Design Discharge

The design discharge is selected to be 50-year probable flood, considering importance of the region, design discharge of other rivers in the Philippines and the Standard. From the results of hydrological analyses, design discharge distribution diagram is established as shown in FIG.-5.4.19.

(4) River Reaches for Improvement

From FIG.-5.4.18 and FIG.-5.4.19, it can be said that the discharge capacity of the present river course is relatively large and amounts to about half of the design discharge. And also the flood inundation area is relatively smaller than other rivers. Due to flood inundation, damage on a smaller scale than the other rivers is caused to crops, houses, highways, and river structures especially in the affected area including a very important city of Legazpi. Consequently, it is necessary to establish a flood control plan to avoid this damage by improving the river channel. The river reaches for improvement are selected as follows considering the discharge capacity of the present river and importance of the affected area.

River mouth-downstream the junction with the Pawa-Burabod River.

(5) River Improvement Plan

i) Alignment of river channel

The alignment of river channel is designed with the following considerations:

(a) The alignment should follow the present course of the river channel to the extent possible.

(b) The radius of curves of river channel should be as large as possible.

(c) Existing levees are entirely replaced by the newly constructed ones.

(d) The alignment should not be selected to involve such existing important infrastructures as highways, etc. as much as possible.

(e) The alignment should not be selected to involve the land occupied by houses, etc. as much as possible.

Final alignment of levees of proposed scheme is shown in FIG.-5.4.20.

ii) River profile

The river bed is left as it is as shown in FIG.-5.4.21, maintaining the present river bed slope to keep the equilibrium river bed slope and to minimize the construction cost.

iii) River cross section

As the design discharge is over 300 m^3/sec, the river cross section is designed as a compound section. And the present river channel is used as main section and side sections are formed by constructing new levees. As the surrounding area is the densely populated area of Legazpi, land acquisition is more difficult than the other rivers; therefore, river width is selected as narrow as possible within the range specified in the Standard.

The height of levees is determined by Manning's Formula assuming uniform flow. They are basically designed in conformity with the Standard. The freeboard is set at 1.2 m and the top width is 5 m. The slope of levee is selected to be 1:2. The berm of inland side of 3 m in width is constructed at every 3 m height in case total height of the levee is over 4 m. And the one of river side of the same width is constructed at every 4 m height in case total height of the levee is over 6 m. The maximum height of levee will be about 6.6 m near the river mouth. And the river width is about 190 m. As the high water level of EL. 7.1 m is higher than the highest tide of 1.3 m recorded during the period between Jan. '79 and Apr. '80, no special consideration is given to tidal effect. The typical cross section is shown in FIG.-5.4.22.

iv) Major river structures

Relating to the above mentioned river improvement, the necessary river structures are listed as follows:

(a) Levees with sod facing
(b) Foot protection and wet masonry for levees

5.5 Agricultural Development Scheme

5.5.1 Agricultural Development Plan

(1) Basic Strategy

In due consideration of the national policy, the basic strategies for agricultural development are formulated below:

- expansion of irrigated cropping area,
- integration of the existing irrigation systems, and
- increase of agricultural inputs such as fertilizer.

In connection with the Sabo and river improvement works, the land use intensification of the flooded agricultural land in the project area is promoted through the implementation of the agricultural development plan.

(2) Delineation of Development Area and Future Land Use

Out of the present rice field of 10,500 ha in the Quinali (A) River basin, the lower part of rice field near Lake Bato suffers from inundation annually for more than one week and its water level rises higher than EL. 8.3 m in the rainy season. Considering that the height of rice in the ripening stage is 0.8 m on an average, 1,000 ha with an elevation below EL. 7.5 m is excluded from the development area under the project. Furthermore, 3,150 ha in the Nasisi-Hibiga schemes is also excluded because of these schemes have already been taken up under the NISIP Program of NIA with financial assistance from the World Bank. Thus, the irrigation development area in the Quinali (A) River basin totals 6,350 ha in net, comprising Agos Sta. Cruz-South Quinali scheme (4,350 ha), Cabilogan scheme (1,400 ha) and Quinali scheme (600 ha).

As for the Quinali (B) River basin, the irrigation development area is delineated to be 2,400 ha in net, taking into account the availability of water source for irrigation.

After the implementation of the irrigation project, land use pattern in the irrigation development area will change as follows.

	Quinali (A)		Quinali (B)	
	Present Condition (ha)	With Project (ha)	Present Condition (ha)	With Project (ha)
Irrigated Rice Field	3,120	6,350	1,370	2,400
Rainfed Rice Field	3,050	-	800	-
Coconut Field	180	-	230	-
Total	6,350	6,350	2,400	2,400

(3) Proposed Cropping Pattern and Farming Practices

The proposed cropping pattern is the irrigated double cropping of rice as illustrated in FIG.-5.5.1, which is established by modifying the present cropping pattern predominant in the Project area. The proposed cropping pattern is technically sound from the view point of the farm labour requirement.

The farm input and farming practices of rice cultivation in the present condition have no weak points except for the amount of the nitrogen applied. The present application of about 70 kg N/ha is not sufficient considering the yield obtained through the fertilizer field trials which are conducted by FAO/UNDP. It can be increased to 100 kg N/ha for the dry season and 80 kg N/ha for the wet season under flood-free condition.

(4) Anticipated Yield and Production

Based on the existing palay yield and the results of varietal and fertilizer response tests in the Bicol Rice and Corn Experiment Station as shown in TABLE-5.5.1, palay yields under future without and with irrigation project are estimated as below.

(Unit: ton/ha)

	Irrigated Field		Reinfed Field
	Wet	Dry	Wet
- Existing Condition			
Flooded Area	3.0	3.2	1.7
Flood-free area	3.2	3.5	-
- Results of Experiment1/	-	6.6 - 7.9	-
- Future Without Project	3.5	3.8	2.5
- Future With Project	4.5	5.0	-

The palay production will increase by 23,700 tons from the present production level of 34,300 tons in the Quinali (A) River basin and by 10,200 tons from the present level of 12,600 tons in the Quinali (B) River basin. This increment is attributable to the proposed irrigation development scheme when commenced after implementation of the proposed flood control plan.

5.5.2 Irrigation Development Plan

(1) General

The facilities required for the irrigation and drainage development in the project area include headworks, irrigation canals and their relevant structures, drainage facilities and farm roads. The principle for determining the facility requirements for each function is that the project facilities are provided in the most effective and economical manner so that each function can be combined with and fully compatible with the other farming operations at the respective storages of development.

The major rivers and their tributaries crisscross in the project area. A large number of temporary brush dams and permanent headworks have been built on these rivers for the purpose of irrigation water intake. Most of these structures have inadequate flow capacities and cause flood problem in the paddy fields along the rivers. In the flood

1/: See TABLE-5.5.1

control plan for the major rivers, the temporary brush dams and some of the headworks are to be removed and integration of existing canal systems is proposed for their practical and efficient operation through construction of new headworks at the suitable locations.

(2) Irrigation Water Requirements

In planning of irrigation project, sufficient information on water consumption by crops from seeding time until harvest is needed. Since field measurement of consumptive use of water by crop was not carried out in the survey period, this study is mainly depending on the study results in the report on Soil and Land Resources Appraisal and Training Project on Bicol River Basin/1 and Feasibility Studies of Quinali Integrated Development Area/2. The empirical and theoretical formulas developed in the past by various experts are also used in this study.

The calculation procedure adopted in this study is shown in the following equation:

$$IDR = (KC \times PET + P + N + LP - RE)/IE$$

where,

IDR = Irrigation diversion requirement,
KC = Crop growth stage coefficient,
PET = Potential evapotranspiration,
P = Percolation rate,
N = Nursery requirement,
LP = Land preparation requirement,
RE = Effective rainfall, and
IE = Overall irrigation efficiency.

/1: Bureau of Soil, Department of Agriculture, UNDP/FAO, 1976.
/2: Bicol River Basin Development Program, 1980.

The unit irrigation diversion requirement for the design of irrigation facilities, or the design intake discharge, for each area is determined to be equivalent to 20% probability of occurrence for the annual maximum monthly mean requirements taken from TABLE-5.5.2 to TABLE-5.5.4. Following figures thus estimated are adopted to the design of irrigation facilities.

Area	Design Discharge (l/sec/ha)
Quinali (A) River basin	
Lower area	1.28
Upper area	1.67
Quinali (B) River basin	1.14

(3) Water Sources

Reliable water sources in the Quinali (A) River basin are the Cabilogan, Ogsong, Nasisi, Salog and Polangui Rivers. Except for the Quinali (A) river, stream flow records are available at 3 gauging stations as shown below.

Gauging Station	River	Drainage Area (km^2)	Period of Records
Bobongsuran	Cabilogan	131	1956 - 1978
Benanuan	Ogsong	11	1956 - 1978
Nasisi	Nasisi	39	1951 - 1978

The stream runoff for the Salog and Polangui Rivers can be estimated by extrapolation from flow records observed at Nasisi gauging station. The extrapolation is carried out based on relationship between drainage area and annual mean runoff.

A certain portion of runoff from the Ogsong, Nasisi, Salog and Polangui Rivers has been diverted by existing intake facilities of the 4 National Irrigation Systems. Available discharge for the new development should, therefore, be calculated by deducting irrigation diversion requirements of the National Irrigation Systems from river runoff. Water sources for the proposed irrigation schemes can be evaluated as follows:

i) Water source for the Cabilogan Scheme:
Cabilogan River (Drainage area = 122 km^2)

ii) Water sources for the Agos Sta. Cruz - South Quinali Scheme:
  a) Remaining discharge on the Cabilogan River after diversion by the Cabilogan National Irrigation System,
  b) Remaining discharge on the Ogsong River after diversion by the Ogsong National Irrigation System, and
  c) Remaining discharge on the Nasisi River after diversion by the Nasisi National Irrigation System.

iii) Water sources for the Quinali Scheme:
  a) Remaining discharge on the Salog River after diversion by the Mahaba National Irrigation System,
  b) Remaining discharge at the Hibiga Headworks after diversion by the Hibiga National Irrigation System, and
  c) Stream runoff from the drainage area of the Polangui River (excluding the drainage area at the Hibiga Headworks).

Irrigation diversion requirements for the National Irrigation System are calculated taking the future irrigable area into account as shown in TABLE-5.5.5. Based on the unit irrigation diversion requirement for the upper area in the Quinali (A) area calculated as shown in TABLE-5.5.6.

The monthly mean discharge at the proposed Cabilogan Headworks, the existing headworks for the National Irrigation Systems and for the Polangui River are calculated by using available records and conversion ratio as shown in TABLE-5.5.7. Results of calculation are shown in TABLE-5.5.8.

Available discharge at the proposed Agos Sta. Cruz - South Quinali Headworks and at the Quinali Headworks are calculated as shown in TABLE-5.5.9.

The Quinali (B) River is the most reliable water source for irrigation. Since stream flow records for this river are not available, the stream runoff at the proposed Bantayan Headworks is extrapolated from flow records observed at Bobongsuran gauging station using conversion ratio of 0.715. The result of calculation is summarized in TABLE-5.5.10.

(4) Scale of Irrigation Area

The following criteria[1/] concerning limitations for water shortages are utilized in determining the adequacy of project water supplies.

i) Maximum annual shortage should not be greater than 50% of the annual irrigation diversion requirement.

ii) Maximum combined shortages in any two consecutive years should not be greater than 37.5% of the irrigation diversion requirements, and

iii) The average annual shortage over the 1956-1978 period should not be greater than 7%.

First, physically maximum irrigable areas by gravity irrigation are delineated on the available topographic map with a scale of 1 to 25,000 as shown in TABLE-5.5.12.

Irrigation diversion requirements for the delineated schemes are calculated as shown in TABLE-5.5.11. In order to confirm the availability of water source for irrigation, water balance calculations are carried out based on the criteria mentioned above.

1/: Irrigation Development Plan for Central Luzon, NIA/ECI, 1977

The amount of irrigation water shortage is calculated for each scheme as shown in TABLE-5.5.13. Irrigation water for envisaged irrigation areas can be supplied by stream flow within the limitation of shortage mentioned above. Hence, the scale of irrigation area for each scheme is proposed as follows.

Name of Scheme		Net Irrigation Area (ha)
Quinali (A) River basin		
i)	Cabilogan	1,400
ii)	Agos Sta. Cruz-South Quinali	4,350
iii)	Quinali	600
	Sub-total	6,350
Quinali (B) River basin		
iv)	Bantayan	2,400
	Total	8,750

(5) Drainage Requirement

The drainage facilities are to be provided to remove the excess water in the fields taking place due to the heavy rainfall during storm and to create adequate conditions of drawdown in a harvesting period. The unit drainage requirement is estimated referring the NIA design criteria1/. Surface drains are designed so as to handle flows generated from 10-year storm frequencies.

The 10-year, 1-day storm rainfall in the project area is calculated as follows.

Area	10-year, 1-day storm rainfall (mm/day)
Quinali (A) River basin	250
Quinali (B) River basin	300

1/: Design Criteria for Irrigation Canals, Drainage Channels and Appurtenant Structures, G.N. Iglesia.

These storm rainfall are used as a design rainfall for estimation of unit drainage requirement.

The unit drainage requirement is calculated by the following equation.

$$R = \frac{I - 100}{T} \times 10^4$$

where,

R : Unit drainage requirement (l/sec/ha)

I : Design rainfall (mm/day) and

T : Drainage period (86,400 sec)

Using design rainfalls for both basins, unit drainage requirements for the Quinali (A) and Quinali (B) River basins are estimated at 17.4 l/sec/ha and 23.1 l/sec/ha, respectively.