Probability is higher in the area without vegetation.

(i) Geology:
Probability is higher in the area with faults, fracture zones and weathered surfaces.

(j) Others:
Development of gully, construction, structures, etc. are to be considered.

(B) Slope failure area

(a) Slope length and height:
The longer the slope is, the higher the danger is. Slope with higher than 5 m is generally considered to be danger.

(b) Slope gradient:
Dangerous in case of over 30°, especially most dangerous in the range of 40-50°.

(c) Shape of slope:
Dangerous level is higher in case of the slope with overhanging, cracks, floating rocks, and spring.

(d) Rainfall condition:
Dangerous level is higher in the area with high possibility of heavy rainfall.

(e) Geological condition:
Dangerous level is higher in case of the slope material with remarkable weathering, change of quality and weakness against water.

(f) Others:
Artificial action, structure etc. are to be considered.

2.3 Structural Measures

2.3.1 Selection of Alternative Structural Measures

There are two kinds of disaster as follows:

(a) Debris/mud flow
(b) Slope failure

The conceivable structural measures are examined for each of the above disasters hereunder.

(A) Debris/mud flow disaster

There are three (3) ideas for preventing or mitigating the debris/mud flow disaster as follows:

- Provision of a series of low dams for preventing the occurrence of debris flow
- Provision of check dams for preventing the occurrence of debris flow
- Protection of properties

The necessary structures and expected function in each of the above three (3) ideas are as follows:

(1) A series of low dams

This measure provides a function to dissipate the energy of debris/mud flow as well as to prevent the erosion which increases the magnitude of debris flow. This function can be given with the provision of a series of low dams, ground sills in the gully bed and channel work.

A series of low dams to be constructed at an interval of about 50 m create a series of steps, each step having a height of 2 to 3 m. A series of steps are expected to dissipate the energy of debris flow.

The erosion of gully will be prevented by the ground sills which will be provided in the gully at an interval of about 50 m.

The channel work will safely handle the mud flow.

(2) Check dams

This measure consists of the construction of several check dams including one or two main check dams, channel work and ground sills.

The main check dam has the following functions:

- To store the debris,
- To reduce the slope in the upstream reaches, resulting in the decrease of flow velocity and erosion,
- To decrease the collapse or sliding of slope, resulting from the rise of gully bed,
- To control the outflow to the downstream reaches by temporarily keeping the debris flow in the storage.

The dam will not be founded on a firm base rock in view of the actual geological condition in field. Then, the dam height will be limited to around 15 m. The non-overflow section in both wings of dam will be extended up to the firm ground at both sides of the valley.

Other several check dams make the slope of gully bed gentle as well as create several high steps. The energy of debris flow is expected to be dissipated with the said gentle slope and several high steps. It is considered that the debris flow will safely be stopped by about 500 m length with a gentle slope of around 1/20. Therefore, the several dams, each having a height of about 10 m, will be arranged so as to create a slope of about 1/20 with a length more than 500 m.

It is noted that there is a case that several check dams are not possible to be provided due to the topographic condition. In this case, only the main check dam is required to be provided.

The channel work with 30 to 40 m width is required in the downstream reaches to safely handle the mud flow. The channel work should be provided with the ground sills at an interval of 30 to 40 m to prevent the erosion.

In addition to the above, a dual care is usually provided in the countermeasure for the debris flow; that is, the slit dams or large trees, etc. are additionally provided against some unexpected events.

(3) Protection of properties

This measure does not consider to prevent the occurrence of debris flow, but considers to safely handle the debris flow with the training wall or channel work, etc. for protecting the properties from the disaster.

The measure is useful in the case that the necessity of preventing the occurrence of debris flow is small due to less properties for protection. The measure is effective also in the case that the measure for preventing the occurrence of debris flow will extremely be costly due to a huge scale of quebrada.

As mentioned above, there are three (3) ideas for the debris flow disaster. However, the technical reliability of the first idea (a series of low dams) is not completely confirmed yet, especially in the case that the debris flow is confined in a relatively narrow gully without spreading widely. In consideration that most of the debris flows in the basin occur in the confined narrow gully, the idea is not recommendable in view of its less technical reliability as stated.

On the other hand, the technical reliability of the second idea (the provision of check dams) is satisfactorily confirmed through a sufficient experience.

As for the third idea (the protection of properties), the basin has a lot of quebradas for which the application of third idea is most suitable.

Thus, the latter two ideas are the conceivable structural measure for the debris flow disaster prevention in the basin.

(B) Slope failure

Major disaster due to the slope failure in the basin is the interruption of the traffic road and railway.

The following are the conceivable measures in consideration of the actual situation of basin:

(i) To cover the road and railway with a rock shed tunnel,

(ii) To safely cross over the gully portion with a bridge,

(iii) To provide a retaining wall,

(iv) To remove the dangerous materials,

(v) To provide the hillside works, and

(vi) To provide a vegetation on the slope.

The complete and effective measures to prevent the mentioned disaster are considered to be (i) to cover the road and railway with a rock shed tunnel and (ii) to cross over the gully portion with a bridge. The provision of a retaining wall will also be effective as a measure to mitigate the disaster in consideration that the slope failure is induced mainly due to a collapse at the bottom portion of slope, although the measure is not a perfect one.

On the other hand, the remaining three measures will require a huge scale of the necessary work. Thus, the areas where these measures are effectively applicable are considered to be limited to a small extent.

Such being the case, three measures of (i) to (iii) above will be selected as the typical structural measures for preventing the disaster due to the slope failure.

2.3.2 Application of Structural Measures

As discussed in the previous section 2.3.1, the two measures of the provision of check dams and protection of properties are selected as the conceivable structural measure for the debris flow disaster prevention in the basin.

In applying these structural measures for each quebrada, the measures can be further classified into five (5) types in accordance with the circumstances of respective quebrada as outlined below:

(1) Type A :

This type considers the provision of check dams as well as the channel work in view that the occurrence of debris flow has to be prevented due to the extensive development of residential houses in the quebrada.

Type A is divided into the following Type A1 and Type A2.

Type A1:

In Type A1, one or several main check dams as well as the several erosion control dams are constructed in the upper reaches of quebrada. The channel work is duly provided in the lower reaches for safely handling the mud flow.

Type A2:

Type A2 does not have a suitable area for constructing the check dams due to the topographic condition.

Therefore, the debris flow is forced to be handled with the channel work without the check dams as mentioned in Type A1 above. In this type, a low dam to safely lead the debris flow into the channel work will be provided at the top of channel work.

(2) Type B :

This type has less necessity of preventing the occurrence of debris flow due to less or no number of residential houses, and then, considers to effectively protect the properties.

Type B is divided into the following Type B1 and Type B2:

Type B1:

In this type, there is no residential houses to be protected. However there exist the important road or railway crossing the quebrada. Then, the measure considers to duly protect the road or railway as well as fix the way of debris flow with the training wall.

Type B2:
In this case, there are some residential houses requiring the protection although its number is limited.
Then, the measure considers to safely protect the residential houses from the debris flow as well as control the outflow of debris flow to some extent with a low sand arresting dam.

(3) Type C :

This type is applied in the case that the debris flow dams up the main stream, causing the inundation disaster for the developed area in the downstream.

The countermeasure considers to construct a check dam which mitigates the debris flow as well as reduces the collapse of slope.

Besides the above, the measure considers to make arrangements so that the debris flow smoothly flows into the main stream.

Detailed explanations on the above five (5) types are given in Chapter IV.

As discussed, a structural plan for debris flow/slope failure disaster is determined in accordance with the situation of each objective area, implying that there is no other alternative plan for the comparative study.

2.4 Estimate of Disaster

2.4.1 Disaster Area and Condition

The estimate of the probable damage is made for the economic evaluation. After the classification of group, more specific delineation of disaster area and condition is required for the probable damage estimate. The delineation of disaster area and conditions will be made on the basis of the following criteria.

The following items are required to be obtained for delineating the disaster area and condition:

(a) Total volume of the debris and sand,

(b) Division of the outbreak area, flowing-down (transportation) area and depositing area,

(c) Division and conditions of the depositing area, and

(d) Probable inundation area in case of overflow from the main stream.

The total volume of debris and sand in the above item (a) will be determined as follows:

- The determination of volume will be based on the debris flow disaster happened in Chosica district in March, 1987.

- The disaster happened in a large scale in Qda Pedregal is assumed and selected as the long-term disaster: that is, the volume of debris flow happened in Qda Pedregal in March, 1987 will be applied for the long-term debris flow volume in other quebradas.

- Thus, the debris flow volume per a unit basin area in Qda Pedregal will be applied to the catchment basin area of other quebradas for assessing the long-term debris flow volume in the respective quebradas.

- With consideration that the existence of vegetation in the respective quebrada will considerably effect on the volume of debris flow, some reduction factor of debris flow volume will be taken into account in accordance with the degree of vegetation in the respective quebrada.

- The mid-term and short-term volumes of debris flow should also be assessed for estimating the annual average damage. The mid-term and short-term volumes of debris flow will be assumed to be 0.5 and 0.1 of the long-term debris flow volume respectively.

The determination of items (b) to (d) above will be made based on a comprehensive engineering judgement, taking into consideration the features in each area.

2.4.2 Damage

The damage in each disaster area will be estimated on the basis of the criteria described below:

(1) Group A Area

The damage will be estimated individually in each disaster area.

The damage estimate will be carried out by summing up the damage of the following items.

(a) House
(b) Public building
(c) Road
(d) Railway
(e) Bridge
(f) Farm land
(g) Forest/wood
(h) Other direct damage
(i) Indirect damage including traffic blockade

The calculation will be made by counting the quantity of each item suffered by debris flow and applying the damage rate estimated for each item.

The majority of indirect damage is that due to the traffic blockade, which will be assessed as follows: The indirect damage due to traffic blockade is considered to be proportional to the number of days of the blockade: that is, the damage can be assessed multiplying the number of days of blockade by the estimated unit damage rate per day. The number of days of blockade is assumed to be proportional to the magnitude of debris flow and be estimated in accordance with the volume of debris flow referring to the past experience.

The indirect damage may include some damage other than the above damage due to traffic blockade, which will be assumed to be 10% of the damage due to traffic blockade.

(2) Group B Area

The damage for the quebrada of Group B will be estimated on the basis of the following major damage items in view of its relatively less priority compared with Group A:

(a) Damage on houses,
(b) Removal of piled debris, and
(c) Indirect damage due to the traffic blockade.

The estimate of the damage on houses and indirect damage due to traffic blockade will follow the similar procedures to those for Group A as mentioned. The cost for removal of piled debris will be based on the volume of debris flow and the estimated unit cost for removal per m^3.

The total damage may include some other damages in addition to the above, and then, some increase factor of damage will be taken into consideration at 10% to 20%.

The damage for Spe. area consists mainly of the damage on houses and the indirect damage due to traffic blockade.

Then, the damage will be estimated based on the above two damage items as follows: The damage on houses will be based on the number of houses, unit rate per a house and coefficients to be determined in accordance with the situation of vegetation and slope in the respective Spe. area.

The indirect damage due to traffic blockade will be estimated based on a consideration that the respective Spe. areas share the total indirect damage due to the traffic blockade in accordance with the degree of danger. The total indirect damage due to traffic blockade in the whole basin, will be calculated based on the annual average number of days of blockade to be estimated and the unit indirect damage rate per a day. The degree of danger will be considered proportional to the number of dangerous gullies on the respective Spe. area and the length of Spe. area along the road.

The damage for Spe. area includes some other damages than the above two items. Then, some damage increase factor will duly be taken into consideration.

2.5 Evaluation

2.5.1 Technical Evaluation

The technical evaluation will be made on the following aspects;

(a) Safety and durability,

(b) Technical disaster reduction effect,

(c) Operation and maintenance, and

(d) Implementation of construction work.

2.5.2 Economic Evaluation

The economic evaluation will be carried out to the structural measures selected in each disaster area.

The evaluation will be made through the following studies:

(a) The basic design of structural measures including not only dam and channel works but also the other additional structures is made.

(b) The quantity and construction cost of structures are calculated.

(c) The project benefit is estimated as a mitigated damage by structural measures for disaster prevention.

(d) The economic evaluation is carried out by using the economic internal rate of return (EIRR) caluclated by the economic project cost and the above project benefit.

Note: EIRR is defined as discount rate which makes net present worth of cash flow equivalent to zero.

3. CRITERIA FOR PLANNING AGAINST INUNDATION DISASTER

3.1 Division of Study Area

The objective flood inundation disaster areas for the study are the inundation areas overflowed from the Rimac, Santa Eulalia and Jicamarca rivers.

The study at a same study level for the whole basin area is considered unnecessary, since the degree of danger and protective properties varies with the respective river reaches.

The degree of danger and protective properties for the flood inundation can generally be classified with the upper, middle and lower reaches of respective river. Then, the following division of study area is considered appropriate.

(A) Rimac River

(a) Upper reaches
(b) Middle reaches
(c) Lower reaches

(B) Santa Eulalia River

(a) Upper reaches
(b) Lower reaches

(C) Jicamarca River

(a) Upper reaches
(b) Lower reaches

3.2 Classification of Divided Areas

The classification of study level for inundation type disaster is made by the same or similar consideration taken for the Debris flow type disaster. That is, the classification of Group A, B or C is made for effectively formulating the master plan based on the levels of protective objects and probability of occurrence.

As for the classification of study area for the flood inundation, it is considered sufficient to determine based on a general judgement since the levels of protective objects and probability of occurrence can clearly be recognized in each reaches.

3.3 Structural Measures and Evaluation

3.3.1 Selection of Alternative Measures

The various measures for preventing or mitigating the flood inundation can be listed up as follows;

(a) Improvement of the width of river channel for increasing the flow capacity,

(b) Improvement of the alignment of river channel for a smooth flow by the method of cut-off (short-cut), etc.,

(c) Channel excavation (dredging) for an increase of flow capacity or smooth river flow,

(d) Construction or heightening of the dike or parapet for preventing the overtopping,

(e) Protection works such as the revetment, groyne and ground sill, etc.,

(f) Provision of a flood way,

(g) Provision of a retarding basin, and

(h) Provision of a flood control dam, etc.

The alternative plans for the examination will be selected out of the conceivable combinations of the measures as mentioned above. However, the alternative plans to be dealt with in this master plan study will be limited to the combinations of the fundamental items in the flood prevention planning such as;

- Examinations on the width and alignment of river,
- Possibility or effectiveness of the retarding basin, flood way and flood control dam, etc., and

- Necessity of protection works such as the revetment, groyne and ground sill, etc.

The reason is as follows: that is, the master plan study aims to indicate a basic guideline for what the planning should be. On the other hand, the next detailed design work should handle such a detailed comparative study on the kinds, types, shapes or materials to be used, etc. for the respective structure.

3.3.2 Estimate of Disaster and Damage

(1) Disaster Area and Condition

The evaluation of plan requires the estimate of damage. The estimate of damage necessitates a delineation of the flood inundation area and condition.

The flood inundation area and condition will be delineated based on the studies on the following items:

(a) Probable flood discharge (calculated)
(b) Water level in the river channel at the time of each probable flood
(c) Result of flood inundation analysis

The damage will be estimated by dividing the whole area into mesh blocks. The estimate on the following items, which is required for the damage estimate, will be made in each mesh block.

(A) For houses, buildings and structures

(a) Inundation depth

(B) For road and railway

(a) Inundation length
(b) Inundation duration
(c) Inundation depth

(C) For farm land, forest

(a) Inundation area
(b) Inundation duration
(c) Inundation depth

(D) For indirect Damage

(a) Duration of traffic blockade

(2) Damage

The damage due to inundation disaster will be estimated based on the above-mentioned disaster conditions as follows.

(A) Houses, building and structure

The damage will be estimated in each mesh block, multiplying the whole assets by the damage rate.

The standard rate in accordance with the inundation depth, which was developed by Ministry of Construction in Japan, will be taken as the approximate damage rate conceivable in the basin.

(B) Road, railway

The relation curves of damage amount and inundation duration & depth will be prepared for unit length of road and railway. The curve will give the damage amount based on the inundation duration, depth and length estimated in each mesh block.

(C) Farm land,

The relation curves of damage amount and inundation duration & depth per unit area will be prepared for each representative condition of farm land and forest. The curve will give the damage amount in accordance with the inundation area, duration and depth estimated in each mesh block.

(D) Indirect damage

The following two kinds of damage are estimated.

(a) Traffic blockade of road and/or railway
The relation curves between the damage and the blockade duration will be prepared.

(b) Other indirect damage
The ratio to the direct damage amount will be decided from the comprehensive study including the examples of the similar projects.

(3) Technical and Economic Evaluation

The structural plan for preventing the flood inundation disaster will be selected through the technical and economic evaluations on the conceivable alternative plans.

The procedures of both evaluations will be similar to those as mentioned in Section 2.5.1 and 2.5.2 for the debris flow disaster prevention plan.

4. SELECTION OF NON-STRUCTURAL MEASURES

4.1 Definition of Non-Structural Measures

The "Non-structural Measure" is herewith defined as an indirect measure to reduce the damage due to disaster against the structural measure which directly protects the properties from the damage with some structures or facilities.

The structural measure, for instance, includes such means as the ground sill to prevent the erosion, channel works to protect the properties from the inundation of mud flow, low dams to dissipate the energy of debris flow, and dike or revetment in the river for flood protection.

On the contrary, the non-structural measure deals with the means such as the establishment or improvement of administrative organization for disaster prevention, regulation in land use, management of river, warning and evacuation system, preparation and organization for restoring the disaster, and education to the inhabitants, etc.

It is noted that the non-structural measure may also require more or less some structures or facilities in a small scale. For example, the establishment of warning and evacuation system will require an installation of some equipment to detect the disaster and give an alarm.

4.2 Selection of Non-structural Measures

In view that the disaster in the basin is increased due to the insufficient administrative regulation and preparation for the disaster, the following requirements will be stressed in the non-structural measure.

(a) Improvement of land use regulation and its strict execution,

(b) Establishment of river law and strict river management under the law,

(c) Preparation for the disaster such as,

- Establishment of information system of disaster,
- Establishment of warning and evacuation system,
- Preparation of essential materials and equipment in emergency,
- Establishment of a satisfactory disaster relief system, etc.

(d) Establishment of an organization to execute the land use regulation and river management,

(e) Establishment of an organization to implement the structural measures for disaster prevention,

(f) Training of engineers to implement the structural measures for disaster prevention.

Chapter IV

IV. STRUCTURAL PLAN FOR DEBRIS FLOW AND SLOPE FAILURE DISASTER PREVENTION

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CHAPTER IV STRUCTURAL PLAN FOR DEBRIS FLOW AND SLOPE FAILURE DISASTER PREVENTION

1. GENERAL

In accordance with the basic concept and criteria established in Chapter III, the structural plans for debris flow and slope failure disasters are examined in this Chapter IV.

As there are so many quebradas (tributaries) and mountain slopes in the Rimac river basin, the study is made in the following order for covering all the basin and effectively making a plan with an appropriate level to each area.

(a) Division of study area

(b) Arrangement of features in each study area

(c) Evaluation of protective objects and danger in each study area

(d) Classification of each area into a Group (A, B or C)

(e) Study of structural plans for Groups "A" and "B".

(f) Estimation of disaster and damage

(g) Evaluation on structural plan for each Area of Groups "A" and "B"

2. DIVISION OF STUDY AREA

The Rimac river basin with the catchment area of approximately 3,230 km^2 is divided into the following areas.

(A) Sub-basin area (Qda Area)

Qda Area is an area with an tributary which enters into the main river, Rimac river or Sta Eulalia river. As there are so many tributaries, Qda Area is selected as a tributary area with the catchment area of over 5-10 km^2.

However, some Qda Areas with less than 5 km^2 in catchment area such as Qda Carosio (0.4 km^2) and Qda Corrales (1.4 km^2) are also especially selected as one of Qda Areas in the case that those areas have particular by important protective objects and high danger.

On the contrary, the areas located in the lower reaches of the Rimac river are not divided into individual area of a tributary, since the possibility of heavy rainfall is very low and no serious disaster has happened in the past in tributaries of the lower reach.

(B) Mountain slope area (Spe Area)

Spe area is the area surrounded by the areas of Qda and the main river. The division of Spe Area is automatically decided as Qda areas are selected first. Some Spe Areas are to have not only mountain slope but also some small tributaries or gullies.

The result of division is shown in Fig.IV-2-1.

As seen in the figure, number of divided areas is as follows:

(A)	Qda Area	: 75 areas
	Rimac river	: 48 areas
	Santa Eulalia river	: 27 areas
(B)	Spe Area	: 71 areas
	Rimac river	: 45 areas
	Santa Eulalia river	: 26 areas

3. MAIN FEATURES OF DIVIDED AREAS

3.1 Features of Each Quebrada Area

The features of all the Qda Areas are investigated by using the topographical map of 1/100,000 in scale.

The features of all Qda Areas are summarized in Table IV-3-1.

More detailed explanation on the features of each quebrada is made in Appendix X, Supporting Report II.

Though the features are different by Qda Area, the features are characterized as follows:

(a) The highest portion of each Qda Area is remarkably high. Most Qda Areas have a peak portion higher than El.2,000 m.

(b) Height difference of each Qda Area is also remarkable. Most Qda Areas have a height more than 1,000 m.

(c) Slope of tributary in Qda Area is generally very steep. Most tributaries have an average slope of steeper than 10°. Tributaries with 30° or more in slope are also not exceptional.

3.2 Features of Each Slope Area

The features of all the Spe Areas are also investigated with the topographical maps of 1/100,000 in scale. The features are summarized in Table IV-3-2.

More specific explanation on the feature is made in Appendix X, Supporting Report II.

The characteristics of Spe Area are as follows:

(a) The length of Spe Area generally ranges from 1 km to 10 km.

(b) The horizontal length of slope generally ranges from 1 km to 4 km.

(c) Slope height is higher than 500 m. Most of them are lower than 2,000 m.

(d) Average slope gradient of Spe Area is steeper than 15° and about a quarter of them is steeper than 30°.

4. CLASSIFICATION OF DIVIDED AREAS

There is a large difference in the priority level among the divided areas, i.e. in the degree of danger and protective properties.

Then, it is proposed, for an effective formulation of the master plan, to make a classification of the study level in accordance with the degree of danger and protective properties.

The classification is made by dividing the areas into three (3) groups in accordance with the degree of danger and protective properties as follows:

<u>Group A</u> :

Group A has the highest degree of danger and protective properties, also having the actual experience of disaster. It is ranked in the highest priority level. Then, the countermeasure for debris flow disaster prevention is individually established in each area through a detailed study.

<u>Group B</u> :

Group B has a relatively less degree of danger and protective properties compared with the above Group A. Then, the countermeasure is preliminarily examined by duly applying the several typical types of countermeasures to be established through the examination for Group A.

Group C :

Group C has little danger or protective properties. Then the counter-measure is not examined in this study.

The result of classification into the above three (3) groups, which is made in accordance with the criteria mentioned in Chapter III, is summarized below. The classification is also shown visually in Fig. IV-4-1.

(A) Group A

(a) Qda Area : 7 areas

R-6	Q. Quirio
R-7	Q. Pedregal
R-8	Q. Carosio
R-9	Q. Corrales
R-19	Q. Rio Seco
R-32	Q. Paihua
S-1	Q. Cashahuacra

(b) Spe Area : None

(B) Group B

(a) Qda Area : 23 areas

R-1	Q. Chacracayo
R-2	Q. Chacrasana
R-3	Q. California
R-4	Q. Santa Maria
R-5	Q. La Cantuta
R-10	Q. La Ronda
R-11	Q. Santa Ana
R-13	Q. Cupiche
R-15	Q. Canchacalla
R-16	Q. Guayabo
R-17	Q. Agua Salada
R-18	Q. Esperanza
R-23	Q. Huacre
R-24	Q. Matata
R-25	Q. Cuchimachay
R-31	Q. Chucumayo
R-33	Q. Chacahuaro
R-34	Q. Pancha
R-35	Q. Viso
R-37	Q. Parac
S-2	Q. Redonda
S-3	Q. Infiernilla
S-5	Q. Lucuma

(b) Spe Area : 25 areas

R--/0	River mouth - Jicamarca
R--/1	River mouth - Chacracayo

R-0/2	Jicamarca - Chacrasana
R-1/3	Chacracayo - California
R-4/6	Santa Maria -Ronda
R-7/8	Pedregal - Carosio
R-8/9	Carosio - Corrales
R-9/-	Corrales - Confluence
R-10/-	La Ronda - Confluence
R--/11	Confluence - Santa Ana
R--/12	Confluence - San Juan
R-11/13	Santa Ana - Cupiche
R-13/16	Cupiche - Guayabo
R-16/17	Guayabo - Agua Salada
R-19/20	Rio Seco - Esperanza
R-20/21	Esperanza - Verrugas
R-21/23	Verrugas - Huacre
R-22/27	Linday - Yamajune
R-26/29	Chacamaza - Barranco
R-31/33	Chucumayo - Chacahuaro
R-37/40	Parac - R. Blanco
S--/1	Confluence - Cashahuacra
S--/4	Confluence - Alcula
S-1/2	Cashahuacra - Redonda
S-2/3	Redonda - Infiernilla

(c) Group C

(a) Qda Area : 45 areas
(b) Spe Area : 46 areas

5. STRUCTURAL PLAN FOR GROUP "A" AREA

5.1 Scale of Debris Flow for Structural Plan

The deposit volume of a long-term scale debris flow with about 100-year return period is considered for the structural plan for debris flow disaster prevention in accordance with the usual practice.

The estimate of the above long-term deposit volume is made in Section 7.

The long-term deposit volume estimated for the quebradas in Group A is as follows:

Quebrada in Group A	Long-term Deposit Volume (m^3)
(a) Qda. Quirio	184,700
(b) Qda. Pedregal	188,200
(c) Qda. Carosio	7,100
(d) Qda. Corrales	24,900
(e) Qda. Rio Seco	292,700
(f) Qda. Paihua	198,900
(g) Qda. Cashahuacra	268,200

5.2 Classification of Type for Structural Plan

The field reconnaissance reveals that the countermeasure for debris/mud flow disaster is basically divided into three/five types in accordance with the topographic, geological and land use conditions as follows;

(A) Type A

It is required to check the debris/mud flow as much as possible and control the excessive flow confining in the channel since the residential houses are already settled densely along the quebrada channel on the fan.

This Type A is further divided into the following two types.

Type A1: There is a suitable site(s) for check dam.

Type A2: There is no suitable site for check dam.

(B) Type B

It is considered not to be reasonable from economic viewpoint to check the debris/mud flow by check dam in the case that the residential houses are not located or thinly located along the channel of quebrada. However, it is required to control the course of flow for avoiding the disaster to farm lands and public structures such as road and railway.

This Type B is further divided into the following two types.

Type B1: There is no or a very few houses on the fan area.

Type B2: There are some houses on the fan. It is required to control the direction of flow as much as possible at the top of fan.

(C) Type C

It is required to check the debris/mud flow as much as possible and control the excessive flow smoothly to the main river, the Rimac river or the Sta. Eulalia river, for avoiding the overflow from the main river since the densely populated residential areas and/or important public structures are located on the opposite side of the confluence or in the downstream stretch.

The structural plan for each of the above types is made as follows;

(A) Type A

(a) Channel works for erosion control of fan and fixing of channel route (Type A1 and A2)

(b) A series of dam at the upstream stretch of channel works for debris/mud checking and erosion control (Type A1)

(c) Sand arresting works at the upstream side of channel works as there is no appropriate dam site for checking sufficient volume of debris/mud (Type A2)

(B) Type B

(a) Training dikes and excavation of channel for regulating the course of flow (Type B1 and B2)

(b) Protection of public structures such as road and railway and/or improvement of existing protection structures (Type B1 and B2)

(c) Low dam for sand arresting and erosion control at the top of fan (Type B2)

(d) Plantation for sand arresting at the top of fan or energy dissipation on banks (Type B2)

(C) Type C

(a) Dam for checking the debris/mud erosion control and stabilizing hillside base

(b) Low dam(s) for energy dissipation, flow direction control and erosion control at the downstream stretch of check dam

(c) Excavation at the outlet of quebrada channel for smooth inflow to the main river

(d) Dike on the bank of main river located on the opposite side of quebrada outlet for preventing overflow from the main river and attack of debris flow to opposite side properties

The typical design of the dam, channel works and dike is shown in Fig. IV-5-1 and IV-5-3.

The schematic features of each type are shown in Fig. IV-5-4.

One of the above five types is applied for each quebrada in accordance with the situation of respective quebrada. As such, there is no other alternative plan, requiring no comparative study for selection.

5.3 Structural Plan in Each Quebrada

The structural plan made for each Qda Area, duly applying the mentioned type of structural plan, is as follows:

(A) Qda Quirio

Type A1 is applied for Qda. Quirio.

The general plan and profile of structure, layout of dam, and design of main dam are made as shown in Figures IV-5-5 to IV-5-8. The particular features are explained below.

(a) At upstream side of present residential area, at around EL. 980 m, the main dam with the height of about 15 m is constructed for sediment storage, flow velocity regulation and mitigation of channel bed gradient.

(b) At upstream stretch of the main dam, an erosion control dam with the height of about 14 m is constructed for lessening the river bed gradient (from the present 1/12 to 1/18) and also for preventing the channel bed scouring. The flowing energy of debris flow will be much reduced.

(c) In the stretch from the main dam to the Rimac river, the channel works will be provided for confining the flow in the channel.

(d) The channel width will be about 20 - 30 m and arranged to be as straight as possible.

(e) The channel runs along the right side hill along the existing channel. However, the new excavation will be required for making the channel without any remarkable bending in the downstream stretch.

(f) The ground sill will be constructed in the channel at the interval of 30 - 50 m for preventing the erosion of channel bed as well as a sufficient energy dissipation of debris flow by mitigating the present channel bed gradient to about 1/20.

(g) The channel has to enter the main river (Rimac river) smoothly for preventing the disturbance as well as blockade of main river flow.

(h) Bridges will be provided at the crossing points of channel and national road/town roads.

(B) Qda Pedregal

Type A1 is applied for Qda. Pedregal.

The general plan and profile of structure, layout of dam, and design of main dam are made as shown in Figures IV-5-9 to IV-5-12. The particular features are explained below.

(a) At upstream stretch of dam section (approximately EL. 1,080 m), the upstream main dam with the height of about 15 m is constructed for sediments storage, flow velocity regulation and mitigation of channel bed gradient.

(b) At downstream stretch of dam section (approximately EL. 1,010 m) in the upstream side of channel works section, the downstream main dam with the height of 10-15 m is constructed for the same functions as the primary main dam.

(c) In the stretch between the both main dams, supplementary check dam with the height of about 10 m is constructed mainly for mitigating the channel bed gradient (from the present 1/8 to 1/13) and also for preventing the channel bed scouring. The flowing energy of debris flow will be much reduced in these dams.

(d) In the channel works stretch located downstream of the downstream main dam, the present channel gradient of about 1/10 will be lessened to 1/20-1/30. The channel width will be about 30-40 m in consideration of the allowance for the possible excessive debris overflowed from the dam.

(e) The channel alignment is arranged as straight as possible. Three routes of channel alignment are considered by the difference how much the channel runs along the existing/old channel. The most smooth alignment is selected for safety though the excavation is increased.

(f) The ground sill will be constructed in the channel works with the interval of 30-50 m for the sufficient energy dissipation of debris flow and prevention of channel bed erosion.

(g) The channel has to enter the main river smoothly for preventing the disturbance as well as blockade of main river flow.

(C) Qda Carosio

Type A2 is applied for Qda. Carosio.

The general plan and profile of structures, layout of dam, and design of dam are made as shown in Figures IV-5-13 to IV-5-16. The particular features are explained below.

(a) As there is no appropriate location of check dam mainly due to steep profile, the dam with training section is constructed for the sand arresting and also for training the flow to the downstream channel.

(b) The training dam with the height of about 10 m is constructed at the top of fan, at about EL. 930 m.

(c) The present road running almost straightly from the top of fan down to the national road is used as the channel.

(d) The channel width will be limited to 6-8 m as the houses are densely located along the road. The footpath is required on both sides of the channel.

(e) The channel is extended to the main river. A careful consideration has to be made at the crossing point with the national road.

(D) Qda Corrales

Type A2 is applied for Qda. Corrales.

The general plan and profile of structures, layout of dams, and design of dams are made as shown in Figures IV-5-17 to IV-5-20. The particular features are explained below.

(a) As there is no appropriate location of check dam mainly due to steep profile, two sets of dam with training section are constructed for sand arresting and also for training the flow to the downstream stretch.

(b) The training dams are constructed at the top of fan where the garbage dumps are located at present. The garbages have to be removed before the dam construction.

(c) The dam height will be more or less 10 m. The upper dam will be founded at about EL. 940 m and the lower dam will be at about EL. 925 m.

(d) The channel works will be provided at the downstream steep (i=1/6~1/7) stretch from the dam to the main river. The channel width will be about 10 m and has a series of ground sills for lessening the channel gradient.

(e) A careful consideration has to be made at the crossing point with the national road where a debris-flow-shed tunnel will be provided.

(E) Qda Rio Seco

Type B1 is applied for Qda. Rio Seco.

The structural plan and profile are made as shown in Figures IV-5-21 and IV-5-22. The particular features are explained below.

(a) In consideration of land use condition, mainly used as farm land on the fan, it is decided not to construct the check dam.

(b) At the top of fan, the training dikes are constructed to train the flow in the channel.

(c) Though the existing channel has considerably wide cross section, the improvement of alignment and cross section will be required at some portions.

(d) The dikes for training the debris flow overtopping from the channel section are provided at some places in consideration of the topography and the course of channel.

(e) There are three crossing points with the railway and one crossing point with the national road. Though such points are already protected by bridge or tunnel at present, the improvement works of structure especially by extending its length will be required.

(F) Qda Paihua

Type C is applied for Qda. Paihua.

The general plan and profile of structures, layout of dams, and design of main dam are made as shown in Figures IV-5-23 to IV-5-26. The particular features are explained below.

(a) The main dam with the height of about 30 m is constructed at about EL. 2,480 m as the large scale land sliding zone is located at the upstream side on the left bank slope of which bottom is at around EL. 2,520 m.

(b) The supplementary dam with the height of about 5-10 m is constructed just at upstream stretch of the confluence, at about EL. 2,410 m for regulating the flow direction, erosion control of channel and energy dissipation of flow.

(c) The right bank at the outlet of the Quebrada is cut slantly for leading the debris flow smoothly to the main river.

(d) The existing dike located on the left bank of main river and in front of the outlet of Qda Paihua is improved for preventing the overflow to Matucana town area.

(G) Qda Cashahuacra

Type B2 is applied for Qda. Cashahuacra.

The general plan and profile of structures, layout of dam, and design of dam are made as shown in Figures IV-5-27 to IV-5-30. The particular features are explained below.

(a) In consideration of the land use condition on the fan and the topography, it is decided not to provide the check dam.

(b) At the top of fan, the training dikes are constructed for preventing the flow into the old channel.

(c) At the top of fan, connecting with the downstream end of the first training dike, the dam with the height of about 5 m and length of about 220 m is constructed for making sand arresting area and erosion control of channel.

(d) At the downstream stretch of the first training dike, the next training dike is constructed for preventing the flow into the farm land area located on the left bank of existing channel.

(e) As the protective objects, mainly houses, are located on the right bank of existing channel at the downstream stretch, the existing channel section is excavated widely and deeply at the downstream stretch.

(f) The third training dike is constructed along the said excavation channel for preventing the flow to the right bank area.

(g) The local polder dikes are constructed for the areas with high damage potential on the fan.

(h) The plantation of trees is considered at the top portion of fan and also on the both banks in the downstream stretch for restraining the debris flow.

6. STRUCTURAL PLAN FOR GROUP 'B' AREAS

6.1 Structural Plan of Qda Areas in Group "B"

The structural plan for Qda areas in Group "B" is preliminarily made referring to the results of structural study for Group "A".

All the Qda areas are classified into the following five types by the various conditions such as land form, stream profile, land use, drainage area, location of protective properties and etc.

Type A1 : Quirio/Pedregal type
Type A2 : Carosio/Corrales type
Type B1 : Rio Seco type

Type B2 : Cashahuacra type
Type C : Paihua type

The classification of Qda areas in Group "B" is made as shown in Table IV-6-1.

The approximate plans for Qda areas of Group "B" are made on the basis of the available data at this stage such as the topographical maps, aerial photographs, rough profiles of quebradas, photographs taken at the site and field inspection at the site.

The structural plans for all the quebrada areas in Group "B" are shown in the figures attached in Appendix X.

6.2 Structural Plan of Spe Areas in Group "B"

There are the following types of disaster in the Spe area of the Rimac river basin.

(a) Debris flow in quebrada
(b) Rockfall/Slope failure in gully or on Slope

It is considered that the scale of debris flow in Spe Areas is generally small since the scale of quebrada is small.

For the debris flow/rockfall/slope failure, the following structures are considered.

(a) Bridge (in gully/quebrada)
(b) Rockshed tunnel (in gully/quebrada)
(c) Retaining wall (on slope)

The typical type design of above structures is shown in Figures IV-6-1 to IV-6-3.

The structural plan for Spe Areas is made by duly arranging these measures at the necessary places.

7. DISASTER AND DAMAGE AT GROUP "A" AREAS

7.1 General

The examination on the probable disasters is required for planning and evaluating the disaster prevention measure.

The examination on the probable disasters includes;

(a) Estimate of the probable deposit volumes at the long, mid and short terms,
(b) Estimate of the deposit area for the above probable deposit volumes,

(c) Estimate of the probable damage quantities, and

(d) Estimate of the probable damage amounts.

The examination on each of the above is detailed hereunder.

7.2 Probable Deposit Volumes

7.2.1 Long-term Deposit Volume

The estimate of the long-term deposit volume at each quebrada is based on the deposit volume experienced in a large scale in Qda Pedregal in March, 1987, considering that the past records show that the similar scale of deposit volume occurs at a long term of 60 to 100 years.

Furthermore, the deposit volume is considered to be proportional to the drainage area of each quebrada. Besides that, it is considered that the situation of vegetation will predominantly effect on the probable deposit volume.

Consequently, the long-term deposit volume at each quebrada is based on the following equation;

$$V = \frac{Vp}{Cp} \times C \times 1.2^{(*)} \times F$$

where,

V : The long-term deposit volume at each quebrada (m^3),

Vp: The deposit volume occurred in Qda Pedregal in March, 1987 (157,200 m^3),

Cp: The catchment area of Qda Pedregal (10.6 km^2),

C : The catchment area of each quebrada (km^2),

* The safety factor which is usually applied in consideration of the accuracy in the measurement, and

F : The reduction factor to be determined in accordance with the situation of vegetation in each quebrada.

The reduction factor (F) in accordance with the situation of vegetation is determined through a comprehensive engineering judgement as follows;

F = 1 : Almost no vegetation

F = 0.8 : Vegetation covers more than 10% but less than 30% of the basin

F = 0.6 : Vegetation covers more than 30% but less than 60%

F = 0.4 : Vegetation covers more than 60% but less than 90%

F = 0.2 : Vegetation covers more than 90%

In case of Qda areas of Group "A", the reduction factor is decided as follows:

(a)	Qda Quirio	F = 1
(b)	Qda Pedregal	F = 1
(c)	Qda Carosio	F = 1
(d)	Qda Corrales	F = 1
(e)	Qda Rio Seco	F = 0.4
(f)	Qda Paihua	F = 0.4
(g)	Qda Cashahuacra	F = 1

The long-term deposit volume calculated for each quebrada is shown in Table IV-7-1. The following summarizes the result for Group A.

	Quebrada in Group A	Long-term Deposit Volume
(a)	Qda. Quirio	184,700 m^3
(b)	Qda. Pedregal	188,200 m^3
(c)	Qda. Carosio	7,100 m^3
(d)	Qda. Corrales	24,900 m^3
(e)	Qda. Rio Seco	292,700 m^3
(f)	Qda. Paihua	198,900 m^3
(g)	Qda. Cashahuacra	268,200 m^3

7.2.2 Deposit Volume in Mid Term and Short Term Scales

The mid and short term deposit volumes are assessed based on the long-term deposit volume calculated. It is assumed that the mid and short term deposit volumes are 0.5 and 0.1 of the long-term deposit volume, respectively. Table IV-7-1 also summarizes the mid and short term deposit volume calculated for the quebradas in Group A.

7.3 Deposit Area

The deposit area necessary for assessing the damage is estimated for each of the calculated probable deposit volumes, duly distributing the deposit volume in consideration of the topography and conditions of channel. In the estimate of deposit area, reference is also made to the actual disaster conditions experienced in March 1987 or in the past.

The estimated deposit areas in the quebradas of Group A for the long-term deposit volume are shown in Fig. IV-7-1 to IV-7-6. Those for the mid and short term deposit volumes are provided in Appendix X, Supporting Report II. As shown in the figures, the deposit area is classified into the following three (3) levels of damage;

(a) Serious destruction area (70-100% destroyed, say 90%)

(b) Semi-destruction area (30-70% destroyed, say 50%)

(c) Other affected area (0-30% destroyed, say 20%)

The above classification is taken into consideration in estimating the damage amount.

7.4 Damage Quantity and Amount

The damage amount is estimated based on the estimated deposit area. The procedure for damage estimate is as follows:

(A) Checking the quantity of items to be damaged.

(a) House (No.)

- Upper class
- Middle class
- Lower class

(b) Public building (No. and m^2)

- Market
- School
- Others

(c) Farm land (ha.)

- Good harvest land
- Poor harvest land

(d) Public structures/facilities

- Road
- Bridge
- Well
- Park
- Other

(e) Traffic block

(f) Rehabilitation works

- Removal of debris* (m^3)
- Removal of mud (m^3)

* including destroyed structures/houses

(g) Other damage

(B) Decision of unit cost for each item of damage to be taken from the Inventory of Damageable Value investigated in Appendix X, Supporting Report II.

(C) Estimate of damage amount based on the quantities and unit cost of damage.

The quantity of damage in each Qda. Area is estimated as summarized in Tables attached in Appendix X, Supporting Report II. The counting of quantity in each property item is carried out by using maps, aerial-photographs and site inspection.

The quantities of indirect damage are estimated on the basis of the past disaster records and the examples of the other places.

The damage amount in each Qda Area is estimated on the basis of the quantities and the unit cost as shown in Tables attached in Appendix X, Supporting Report II. The summary of total damage is shown below.

(A) Qda. Quirio Area

(a)	Long-term scale	I./229.25 x 10^6
(b)	Mid-term scale	I./137.11 x 10^6
(c)	Short-term scale	I./29.09 x 10^6

(B) Qda. Pedregal Area

(a)	Long-term scale	I./466.61 x 10^6
(b)	Mid-term scale	I./267.36 x 10^6
(c)	Short-term scale	I./27.66 x 10^6

(C) Qda. Carosio Area

(a)	Long-term scale	I./101.78 x 10^6
(b)	Mid-term scale	I./57.45 x 10^6
(c)	Short-term scale	I./7.17 x 10^6

(D) Qda. Corrales Area

(a)	Long-term scale	I./127.84 x 10^6
(b)	Mid-term scale	I./77.30 x 10^6
(c)	Short-term scale	I./7.71 x 10^6

(E) Qda. Rio Seco Area

(a)	Long-term scale	I./215.97 x 10^6
(b)	Mid-term scale	I./96.22 x 10^6
(c)	Short-term scale	I./21.32 x 10^6

(F) Qda. Paihua Area

(a) Long-term scale I./222.28 x 10^6
(b) Mid-term scale I./113.62 x 10^6
(c) Short-term scale I./16.37 x 10^6

(G) Qda. Cashahuacra

(a) Long-term scale I./96.89 x 10^6
(b) Mid-term scale I./38.90 x 10^6
(c) Short-term scale I./6.88 x 10^6

8. DISASTER AND DAMAGE AT GROUP "B" AREA

8.1 Qda Areas

8.1.1 General Features of each Area

There are 23 Qda Areas in Group "B". The particular features in regard to damage conditions in each Qda area of Group "B" are described in Appendix X, Supporting Report II.

8.1.2 Deposit Volume

The deposit volume of Group "B" areas is estimated by the same method as taken for Group "A" areas. The results of estimation are summarized in Table IV-8-1.

8.1.3 Method of Damage Estimate

The disaster and damage amount in Qda area of Group "B" are estimated by the following manner.

(A) The quantity of damage is estimated for some representative items which will share the most part of damage amount.

(B) The representative damages are decided to be the following three items.

(a) Houses
(b) Deposit removal works
(c) Traffic blockade

(C) The damage of houses (C1) is estimated by the following expression.

C1 = Nh x F x UCh

where,

Nh : Number of houses located in the probable disaster area.

F : Reduction Factor *

UCh : Unit Cost of a typical house, including indoor movables in each area.

* : The reduction factor is con- sidered to incorporate the difference in the degree of danger in accordance with the situation of vegetation.

(D) The reduction factors for Qda areas of Group "B" are decided by the similar manner taken for Group "A" areas. That is, the ratio of vegetation area in each Qda area is used as the principal item to decide the factor. The ratio is decided as shown in Table IV-8-1 which is prepared for estimation of deposit volume.

(E) The cost of deposit removal (C2) works is estimated by the following expression.

C2 = DV x UCd x KR

where,

DV : Estimated deposit volume

UCd : Unit Cost for removing the deposits

KR : Necessary ratio of removal

(F) The damage caused by traffic block (C3) is estimated by the following expression.

C3 = Day x UCt

where,

Day : Estimated days of traffic blockade (to be described in (G) below)

UCh : Damage amount caused by traffic blockade per day.

(G) The day(s) of traffic blockade is estimated on the basis of estimation for Group "A" areas by assuming that the day is in proportion to the estimated deposit volume. It is estimated as follows:

Deposit Volume (x 10^3 m^3)	Day (S)
0-90	0-3
90-180	3-4
180-270	4-5
270-540	5-7
540-900	7-10
900 up	10-15

(H) The total damage amount (ct) is estimated by the following expression.

$Ct = (C_1 + C_2) \times 1.2 + C_3 \times 1.1$

There are some other items which would suffer the disaster. It is assumed that 20% of direct cost (house and deposit removal) and 10% of indirect damage (traffic blockade) are added for these other items.

(I) The amount in case of mid-term scale and short-term scale is obtained by deciding the ratios to that in case of long-term scale. The ratios are decided referring to the results of Group "A" as follows:

Mid-term scale : 0.52
Short-term scale : 0.08

Note: The ratios are obtained as an average of the ratios in quebrada areas of Group "A" as shown in Table IV-8-2.

8.1.4 Damage Estimate

In accordance with the method described in the previous subsection 8.1.3, the damage amount of each Qda. area in case of long-term, mid-term and short-term scales is estimated.

The results of estimation are summarized in Table IV-8-3. The breakdown of estimate is shown in Tables attached in Appendix X, Supporting Report II.

8.2 Spe Areas

8.2.1 Method of Damage Estimate

The disaster and damage amount in Spe area of Group "B" are estimated by the following manner.

(A) The quantity of damage is estimated for some representative items which will share the most part of damage amount.

(B) The representative damage items are decided to be the following two items.

(a) Houses
(b) Traffic blockade

(C) The damage of houses (C1) is estimated by the following expression.

$C_1 = Nh \times F \times UCh$

where,

Nh : Number of houses located in the probable disaster area

F : Reduction factor *

UCh : Unit cost of a typical house, including indoor movables in each area.

* : To be explained in the following paragraph (D)

(D) The reduction factor for Spe areas is required to incorporate the difference in the degree of danger in accordance with the circumstances of each Spe area.

For Qda areas, the reduction factors are decided on the basis of vegetation conditions. For Spe areas, it is considered that the slope gradient also has much effect on the probability of disaster occurrence.

Therefore, the reduction factors (F) for Spe area are decided as follows:

$F = F_1 \times F_2$

where,

F_1 : Reduction factor based on the vegetation condition

F_2 : Reduction factor based on the slope gradient

F_1 is decided by the similar consideration taken for Qda areas and F_2 is decided in accordance with the average slope gradient at representative slope in each Spe area by the following criteria.

$35° \leq S < 40°$ $F_2 = 0.5$
$30° \leq S < 35°$ $F_2 = 0.4$
$25° \leq S < 30°$ $F_2 = 0.3$
$20° \leq S < 25°$ $F_2 = 0.2$
$15° \leq S < 20°$ $F_2 = 0.1$
$10° \leq S < 15°$ $F_2 = 0.05$

The reduction factors for Spe areas are determined as summarized in Table attached in Appendix X, Supporting Report II.

(J) The damage caused by traffic blockade (C2) on the national road is estimated by the following expression.

$C_2 = Day \times UCt + Day' \times UCt'$

where,

Day : Estimated days of traffic blockade on the national road

UCt : Damage amount caused by traffic blockade per day on the national road

Day': Estimated days of traffic blockade on the railway or Sta. Eulalia main road

UCt': Damage amount caused by traffic blockade per day on the railway or Sta. Eulalia main road

(K) The day(s) of traffic blockade in each Spe area is assumed as follows:

$$Day = \frac{Dl}{2L} + \frac{Dn}{2N}$$

(National road)

$$Day' = \frac{D'l'}{2L'} + \frac{D'n'}{2N'}$$

(Railway road or Sta.Euralia main road)

where,

L : Total length of national road (No.20) facing to dangerous slope in Group "B"

l : Length of national road facing the dangerous slope in each Spe area

N : Total number of dangerous gully (or quebrada) crossing the national road in Group "B"

n : Number of dangerous gully (including quebrada) crossing the national road in each Spe area.

L' : Total length of railway or Sta. Eulalia main road facing to dangerous slope in Group "B"

N' : Total number of dangerous gully (including Quebrada) crossing the railway or Sta. Eulalia main road

l' : Length of railway or Sta. Eulalia main road facing to dangerous slope in each Spe area

n' : Number of dangerous gully (including quebrada) crossing the railway or Sta. Eulalia main road

D : Total days of traffic block on the national road (No. 20) in Group "B" slopes in a year in the Rimac river basin

D' : Total days of traffic blockade on the railway or Sta. Eulalia main road in Group "B" slopes in a year in the whole basin

(L) The total damage amount is estimated by the following expression

$CT = C1 \times 1.5 + C2 \times 1.1$

Besides the damage on houses and traffic, some other items have to be considered for estimating the total amount of damage. It is assumed that 50% of direct damage (house) and 10% of indirect damage (traffic blockade) are added for the other items.

(M) The amount in case of mid-term scale and short-term scales is obtained by using the same ratios as used for Qda areas.

8.2.2 Damage Estimate

In accordance with the method described in the previous subsection 8.2.1, the damage amount of each Spe area in case of long-term, mid-term and short-term scales is estimated.

The results of estimation are summarized in Table IV-8-4. The breakdown of estimate is shown in tables attached in Appendix X, Supporting Report II.

9. EVALUATION

9.1 Project Cost

The project cost consists of the five items of (i) Preparatory work, (ii) Main construction work, (iii) Compensation, (iv) Engineering service of government administration, and (v) Physical contingency.

The cost for the preparatory work, engineering service of government administration and physical contingency are assessed based on the cost estimated for the main construction work and compensation. The cost for the main construction work is estimated based on the work quantity measures on the preliminary design prepared and the unit price established for each work item. The compensation cost is also estimated based on the measured necessary quantity and the unit price.

Further details of the project cost as well as the unit prices established for each work item are given in Appendix VIII, Supporting Report I.

The work quantities measured on the preliminary design for Group A are shown in Table IV-9-1. Those for Group B are given in Table IV-9-2 and Table IV-9-3.

The project costs are assessed by applying the unit price on work quantities in Table IV-9-4 to IV-9-5 for Group A and Table IV-9-6 to IV-9-7 for Group B.

The project cost estimated for Group A is summarized below:

Quebrada	Project Cost (10^3 US$)
(a) Qda. Quirio	8,623.4
(b) Qda. Pedregal	11,649.4
(c) Qda. Carosio	1,432.7
(d) Qda. Corrales	3,054.5
(e) Qda. Rio Seco	3,145.9
(f) Qda. Paihua	6,442.1
(g) Qda. Cashahuacra	3,057.4

9.2 Benefit

The benefit is considered to be the damage reduction due to the provision of structural measure; that is, the benefit is assessed by the damage amount estimated under the present condition without structural measure less the damage estimated under the condition with structural measure.

The damage amount under the present condition without structural measure is assessed by the annual average damage amount based on the damage amounts estimated at the long-term (100-year return period), mid-term (50-year return period) and short-term (10-year return period).

The damage amount under the condition with the structural measure is considered as follows; that is, no damage will occur by the scale of debris flow less than the long-term scale of 100-year return period since the structural plan is made to withstand the above long-term scale of debris flow. On the other hand, it is assumed, for the debris flow scale larger than the long-term scale with 100-year return period, that the same damage as the present condition without the structural measure will arise.

The calculation of benefit is made in Appendix X, Supporting Report II.

The annual average benefit amount assessed for Group A is as shown below:

Quebrada	Annual Average Benefit (10^3 US$)
(a) Qda. Quirio	2,676.2
(b) Qda. Pedregal	3,891.7
(c) Qda. Carosio	939.0
(d) Qda. Corrales	1,135.0
(e) Qda. Rio Seco	2,131.3
(f) Qda. Paihua	1,941.0
(g) Qda. Cashahuacra	800.2

9.3 Economic Analysis and Evaluation

The economic analysis is carried out based on the project cost and benefit assessed above under the following conditions:

(a) The evaluation horizon is 50 years.

(b) The necessary construction period will be four (4) years for Type A1 and C of structural plan, and three (3) years for Type A2, B1 and B2.

(c) The operation and maintenance cost (O & M cost) is required in addition to the investment cost.

The O & M cost is assumed to be 0.5% of the cost for the main construction work, referring to the past experience in the other similar projects.

(d) The annual average benefit (damage reduction) is assessed under the present conditions of properties and economic activities. This annual average benefit is assumed to increase by 3% per annum due to the increase of population and enhancement of economic activities, referring to the past records.

(Section 8, Chapter II provides a supplemental explanation on the above annual increase of 3%.)

(e) The economic analysis is made in the price level as of June, 1987.

The results of the economic analysis are shown in Table IV-9-8 for Group A and Table IV-9-9 to IV-9-10 for Group B.

The result for Group A is summarized below:

Quebrada	EIRR (%)
(a) Qda. Quirio	5.25
(b) Qda. Pedregal	5.65
(c) Qda. Carosio	9.85
(d) Qda. Corrales	6.02
(e) Qda. Rio Seco	10.12
(f) Qda. Paihua	5.09
(g) Qda. Cashahuacra	4.15

It is considered that eight percent of EIRR is the threshold EIRR level for economic feasibility. As Table IV-9-8 to IV-9-10 shows, more than 25 percent of the whole study area show EIRR higher than 8%. Areas with EIRR higher than 3% amount for about 70% of the total area. These figures confirm fairly good economic feasibility of the project.

The feasibility of the structural plan is enhanced by incorporating various intangible benefits in analysis such as reduction of death numbers and stabilization of social welfare, coming to a conclusion that the structural plan is justifiable from the comprehensive aspects.

Tables

Table IV-3-1 PRINCIPAL FEATURE OF MAJOR TRIBUTARY AREAS (1/2)

*1 No.	*2 Name of tributaries	*3 Distance (km)	*4 River Length A(m)	*5 River Length B(m)	*6 Area (km2)	*7 Elevation Highest	*8 Elevation Lowest	*9 Height Difference of River(m)	*10 Average Slope A	*11 Average Slope B
Qda. (R-0)	Q.Jicamarca	20.8	49,000	50,000	489.3	4,230	260	3,970	12.3	4.6
(R-1)	Q.Chacracayo	44.9	3,900	5,100	9.8	1,875	690	1,185	3.3	16.9
(R-2)	Q.Chacrasana	46.1	3,900	4,200	4.7	1,800	705	1,090	3.6	15.6
(R-3)	Q.California	47.9	4,000	5,000	8.4	1,700	750	950	4.2	13.4
(R-4)	Q.Santa Maria	47.9	4,000	5,000	4.6	1,650	755	895	4.5	12.6
(R-5)	Q.La Cantuta	50.4	6,000	6,700	15.0	2,210	800	1,410	4.3	13.2
(R-6)	Q.Quirio	50.5	5,200	5,600	10.4	2,010	805	1,215	4.3	13.2
(R-7)	Q.Pedregal (San Antonio)	51.5	5,800	6,100	10.6	2,330	820	1,480	3.9	14.3
(R-8)	Q.Carosio (Moyopampe)	53.4	1,100	1,300	0.4	1,675	840	835	1.3	37.2
(R-9)	Q.Corrales (Rayus de Sol)	54.0	1,600	2,400	1.4	2,000	850	1,150	1.4	35.7
(R-10)	Q.La Ronda	54.0	5,000	5,600	9.0	2,210	890	1,320	3.8	14.8
(R-11)	Q.Santa Ana	59.1	5,200	5,800	13.5	2,300	1,030	1,270	4.1	13.7
(R-12)	Q.San Juan	60.3	6,000	6,300	8.8	2,950	1,150	1,800	3.3	16.7
(R-13)	Q.Cupiche	62.7	4,500	5,400	9.3	2,600	1,150	1,450	3.1	17.9
(R-14)	Q.Lloquepampa	62.7	2,500	3,700	2.7	2,650	1,150	1,500	1.7	31.0
(R-15)	Rio Canchacalla	64.8	21,200	22,000	118.0	4,850	1,230	3,620	5.9	9.7
(R-16)	Q.Guayabo	67.4	3,900	4,600	6.8	2,650	1,280	1,370	2.8	19.4
(R-17)	Q.Agua Salada	69.2	5,000	7,000	15.3	3,200	1,320	1,880	2.7	20.6
(R-18)	Q.Del Pate	69.5	5,200	7,200	10.3	3,605	1,350	2,255	2.3	23.4
(R-19)	Q.Rio Seco	72.9	12,200	13,000	49.3	4,630	1,520	3,110	3.9	14.3
(R-20)	Q.Esperanza	75.1	2,800	3,700	4.4	3,750	1,550	2,200	1.3	38.2
(R-21)	Q.Verrugas	77.8	4,800	5,800	9.4	4,470	1,650	2,820	1.7	30.4
(R-22)	Q.Linday	80.0	5,800	8,200	19.4	4,800	1,780	3,020	1.9	27.5
(R-23)	Q.Huacre	83.0	4,400	5,600	7.5	4,470	1,950	2,520	1.7	29.8
(R-24)	Q.Matata	83.3	6,900	7,200	14.8	4,630	1,970	2,660	2.6	21.1
(R-25)	Q.Cuchimachay	83.9	5,000	5,800	6.6	4,580	2,010	2,570	1.9	27.2
(R-26)	Q.Chacamaza	84.5	4,200	5,000	7.5	4,500	2,030	2,470	1.7	30.5
(R-27)	Q.Yamajune	86.3	8,000	9,000	18.6	4,880	2,100	2,780	2.9	19.2
(R-28)	Q.Palcacancha	87.9	9,800	11,900	29.3	4,900	2,200	2,700	3.6	15.4
(R-29)	Q.Barranco	88.0	6,900	8,000	14.8	4,680	2,200	2,480	2.8	19.8
(R-30)	Q.Lucumo	90.0	2,600	3,500	2.3	4,260	2,320	1,940	1.3	36.7
(R-31)	Q.Chucumayo	90.5	8,000	9,200	34.8	5,020	2,360	2,660	3.0	18.4
(R-32)	Q.Paihua (Llanahualla)	92.0	6,100	6,100	14.9	4,760	2,400	2,360	2.6	21.2
(R-33)	Q.Chacahuaro	95.6	4,100	4,100	5.3	4,720	2,490	2,230	1.8	28.5
(R-34)	Q.Pancha	96.1	11,200	13,300	69.3	5,300	2,510	2,790	4.0	14.0
(R-35)	Q.Viso	98.1	7,400	8,100	20.9	5,315	2,750	2,565	2.9	19.1
(R-36)	Q.Ocatara	101.0	2,600	3,200	3.7	4,750	2,850	1,900	1.4	36.2
(R-37)	Q.Parac	104.3	20,600	21,200	130.6	5,310	2,950	2,360	8.7	6.5
(R-38)	Q.Challumay	104.7	3,300	5,900	6.1	5,000	2,950	2,050	1.6	31.8
(R-39)	Q.Turumanya	108.8	8,500	9,000	26.2	5,250	3,200	2,050	4.1	13.6
(R-40)	Rio Blanco	111.8	33,500	35,000	235.7	5,650	3,450	2,200	15.2	3.8
(R-41)	Q.Tranquilla	114.5	4,200	5,600	4.9	5,250	3,700	1,500	2.8	19.7
(R-42)	Q.Santa Rosa	118.5	7,900	8,300	23.4	5,300	3,900	1,400	5.6	10.0
(R-43)	Q.Tacpin	120.0	9,500	10,000	32.9	5,280	3,980	1,300	7.3	7.8
(R-44)	Q.Veintiuno	121.1	2,200	3,000	2.3	5,020	4,050	970	2.3	23.8
(R-45)	Q.Carmen	122.1	5,100	6,600	11.9	5,300	4,150	1,150	4.4	12.7
(R-46)	Q.Chinchan	124.5	8,100	9,000	42.0	5,200	4,280	920	8.8	6.5
(R-47)	Q.Corina	125.6	2,600	4,200	8.3	5,200	4,380	820	3.2	17.5
(R-48)	Q.Antaranra	125.6	3,400	4,600	12.6	5,000	4,380	620	5.5	10.3

Rimarks : *3 : From river mouth *4 : To the end of river-like section *10 : *4/*9
*5 : To the border line of catchment area *11 : Degree (o)

Table IV-3-1 PRINCIPAL FEATURE OF MAJOR TRIBUTARY AREAS (2/2)

*1 No.		*2 Name of tributaries	*3 Distance (km)	*4 River Length A(m)	*5 River Length B(m)	*6 Area (km2)	*7 Elevation Highest	*8 Elevation Lowest	*9 Height Difference of River(m)	*10 Average Slope A	*11 Average Slope B
Qda.	(S-1)	Q.Cachahuacra	57.1	5,200	6,600	15.1	2,600	980	1,620	3.2	17.3
	(S-2)	Q.Redonda	62.1	6,000	7,100	12.1	3,220	1,190	2,030	3.0	18.7
	(S-3)	Q.Infiernillo	65.0	3,200	5,100	6.7	3,220	1,320	1,900	1.7	30.7
	(S-4)	Q.Alcula	65.1	7,900	9,000	16.4	3,820	1,320	2,500	3.2	17.6
	(S-5)	Q.Lucuma	69.4	3,900	5,000	40.3	3,520	1,570	1,950	2.0	26.6
	(S-6)	Q.Santo Domingo	69.6	11,700	14,800	9.5	4,765	1,570	3,195	3.7	15.3
	(S-7)	Q.Huanchunya	72.4	4,000	6,900	12.9	4,230	1,680	2,550	1.6	32.5
	(S-8)	Q.San Antonio	73.3	4,000	5,900	8.0	4,000	1,790	2,210	1.8	28.9
	(S-9)	Q.Negro	73.5	2,900	3,300	5.9	3,920	1,800	2,120	1.4	36.2
	(S-10)	Q.Vado	73.6	4,800	6,200	2.1	4,030	1,800	2,230	2.2	24.9
	(S-11)	Q.Mito Mito	77.2	6,500	8,000	18.4	4,230	1,970	2,260	2.9	19.2
	(S-12)	Rio Carhuayuma	77.8	15,800	16,500	59.7	4,830	2,020	2,810	5.6	10.1
	(S-13)	Q.Del Zorrillo	79.9	5,200	7,000	14.4	4,470	2,200	2,270	2.3	23.6
	(S-14)	Q.Marropuquio	81.4	6,000	6,600	9.1	4,470	2,300	2,170	2.8	19.9
	(S-15)	Q.Carhuachayo	82.1	5,100	5,900	6.8	4,820	2,330	2,490	2.0	26.0
	(S-16)	Q.Maquerhua	83.1	7,600	8,100	25.3	4,750	2,420	2,330	3.3	17.0
	(S-17)	Q.Challamayllo	87.0	7,300	8,900	17.9	4,750	2,660	2,090	3.5	16.0
	(S-18)	Q.Pozo	87.5	9,700	10,900	22.8	4,910	2,700	2,210	4.4	12.8
	(S-19)	Q.Huancacocha	90.5	4,800	6,000	6.5	4,750	2,950	1,800	2.7	20.6
	(S-20)	Q.Chilcacocha	90.8	3,300	4,400	5.1	4,710	2,970	1,740	1.9	27.8
	(S-21)	Q.Pillihua	91.8	18,600	19,900	99.3	5,035	3,030	2,005	9.3	6.2
	(S-22)	Q.Acobamba	93.1	19,000	259,000	178.5	5,360	3,120	2,240	8.5	6.7
	(S-23)	Q.Collque	96.3	19,000	19,600	78.5	5,100	3,330	1,770	10.7	5.3
	(S-24)	Rio Shuncha	97.5	18,800	21,900	137.8	5,300	3,460	1,840	10.2	5.6
	(S-25)	Q.Yanac	102.7	4,000	5,200	6.1	5,500	3,840	1,660	2.4	22.5
	(S-26)	Q.Huasca	108.1	11,200	12,900	41.7	5,120	4,100	1,020	11.0	5.2
	(S-27)	Rio Pallca	108.1	6,060	11,900	54.8	5,280	4,100	1,180	5.1	11.0

Rimarks : *3 : From river mouth *4 : To the end of river-like section *10 : *4/*9
*5 : To the border line of catchment area *11 : Degree (o)

Table IV-3-2 PRINCIPAL FEATURE OF SLOPE AREAS (1/2)

	*1 No.	*2 Name of Slope	*3 Distance (km)	*4 Section Length (m)	*5 Slope Length (m)	*6 Area (km2)	*7 Slope Elevation (m) Highest	*8 Lowest	*9 Height (m)	*10 Average Slope A	*11 B
Spe.	(R--/0)	(river-mouth) - Jicamarca	10.4	20,800	-	149.5	2,200	-	-	-	-
	(R--/1)	(river-mouth) - Chacracayo	24.0	47,900	-	198.6	1,760	-	-	-	-
	(R-0/2)	Jicamarca - Chacrasana	33.5	25,300	-	63.0	1,850	-	-	-	-
	(R-1/3)	Chacracayo - California	46.7	2,900	2,600	4.1	1,550	830	720	3.6	15.5
	(R-2/4)	Chacrasana - Santa Maria	47.0	1,800	2,500	2.1	1,450	730	720	3.5	16.1
	(R-3/5)	California - La Cantuta	49.2	2,500	1,000	0.9	1,150	770	380	2.6	20.8
	(R-4/6)	Santa Maria - Quirio	49.2	2,600	2,600	3.0	1,600	770	830	3.1	17.7
	(R-5/10)	La Cantuta - La Ronda	52.2	3,600	3,900	7.1	1,950	850	1,100	3.5	15.8
	(R-6/7)	Quirio - Pedregal	52.7	1,100	700	0.2	1,000	810	190	3.7	15.2
	(R-7/8)	Pedregal - Carosio	53.5	3,500	2,250	4.6	1,950	870	1,080	2.1	25.6
	(R-8/9)	Carosio - Corrales	53.8	600	1,000	0.3	1,550	830	720	1.4	35.8
	(R-9/-)	Corrales - (confluence)	54.4	800	1,000	0.4	1,400	840	560	1.8	29.2
	(R-10/-)	La Ronda - (confluence)	54.8	1,500	1,300	0.9	1,450	910	540	2.4	22.6
	(R--/11)	(confluence) - Santa Ana	57.3	3,600	2,650	7.3	2,070	1,000	1,070	2.5	22.0
	(R--/12)	(confluence) - San Juan	57.9	4,800	2,000	5.2	2,165	1,000	1,165	1.7	30.2
	(R-11/13)	Santa Ana - Cupiche	60.9	3,600	1,500	2.6	1,820	1,080	740	2.0	26.3
	(R-12/14)	San Juan - Lloquepampa	61.5	2,400	1,500	0.7	1,760	1,100	660	2.3	23.7
	(R-13/16)	Cupiche - Guayabo	65.1	4,700	1,950	5.7	2,110	1,210	900	2.2	24.8
	(R-14/15)	Lloquepampa - R.Canchacalla	63.8	2,100	2,400	2.7	2,450	1,700	750	3.2	17.4
	(R-15/22)	R.Canchacalla - Linday	72.4	15,200	3,800	24.3	3,650	1,570	2,080	1.8	28.7
	(R-16/17)	Guayabo - Agua Salada	68.3	1,800	1,250	1.8	2,070	1,360	710	1.8	29.6
	(R-18/19)	Del Pate - Rio Seco	71.2	3,400	2,250	3.7	2,150	1,390	760	3.0	18.7
	(R-19/20)	Rio Seco - Ezperanza	74.0	2,200	1,800	3.7	2,600	1,510	1,090	1.7	31.2
	(R-20/21)	Esperanza - Verrugas	76.5	2,700	1,950	2.6	2,800	1,600	1,200	1.6	31.6
	(R-21/23)	Verrugas - Huacre	80.4	5,200	3,700	7.4	4,000	1,810	2,190	1.7	30.6
	(R-22/27)	Linday - Yamajune	83.2	6,300	2,500	8.3	3,620	2,000	1,620	1.5	32.9
	(R-26/29)	Chacamaza - Barranco	86.3	3,500	3,100	4.8	3,800	2,150	1,650	1.9	28.0
	(R-27/28)	Yamajune - Palcacancha	87.1	1,600	1,750	1.3	3,100	2,250	850	2.1	25.9
	(R-28/32)	Palcacancha - Llanahualla	90.0	4,100	2,750	5.2	3,800	2,320	1,480	1.9	28.3
	(R-29/30)	Barranco - Lucumo	89.0	2,000	1,900	1.9	3,550	2,280	1,270	1.5	33.8
	(R-31/33)	Chucumayo - Chacahuaro	93.1	5,100	4,000	10.0	4,570	2,450	2,120	1.9	27.9
	(R-32/34)	Llamahualla - Pancha	94.1	4,100	3,100	4.3	3,950	2,480	1,470	2.1	25.4
	(R-33/35)	Chacahuaro - Viso	96.9	2,500	2,050	3.0	4,250	2,600	1,650	1.2	38.8
	(R-34/36)	Pancha - Ocatara	98.6	4,900	2,200	5.5	4,270	2,820	1,450	1.5	33.4
	(R-35/37)	Viso - Parac	101.2	6,200	2,200	5.3	4,400	2,950	1,450	1.5	33.4
	(R-36/38)	Ocatara - Challumay	102.9	3,700	1,400	1.7	3,850	2,900	950	1.5	34.2
	(R-37/40)	Parac - Rio Blanco	108.1	7,500	2,950	11.2	4,950	3,200	1,750	1.7	30.7
	(R-38/39)	Challumay - Turumanya	106.3	4,100	3,000	7.9	4,800	3,150	1,650	1.8	28.8
	(R-39/41)	Turumanya - Tranquilla	111.7	5,700	2,100	7.7	4,640	3,500	1,140	1.8	28.5
	(R-40/44)	Rio Blanco - Veintiuno	116.5	9,300	3,000	14.3	4,950	3,900	1,050	2.9	19.3
	(R-41/42)	Tranquilla - Santa Rosa	116.5	4,000	1,550	3.6	4,800	3,810	990	1.6	32.6
	(R-42/43)	Santa Rosa - Tacpin	119.3	1,500	950	0.9	4,580	3,950	630	1.5	33.6
	(R-43/46)	Tacpin - Chinchan	122.3	4,500	1,550	3.6	5,050	4,210	840	1.8	28.5
	(R-44/45)	Veintiuno - Carmen	121.6	1,000	900	0.5	4,520	4,100	520	1.7	30.0
	(R-45/47)	Carmen - Corina	123.9	3,500	2,550	3.7	5,170	4,230	940	2.7	20.2

Rimarks : *3 : From river mouth to the middle reach of the section
*5,*6 : Horizontal length
*7,*8 : Elevation at logenst slope
*9 : *7-*8
*10 : *5/*9
*11 : Degree (o)

Table IV-3-2 PRINCIPAL FEATURE OF SLOPE AREAS (2/2)

	*1 No.	*2 Name of Slope		*3 Distance (km)	*4 Section Length (m)	*5 Slope Length (m)	*6 Area (km2)	*7 Slope Elevation (m) Highest	*8 Slope Elevation (m) Lowest	*9 Height (m)	*10 Average Slope A	*11 Average Slope B
Spe.	(S--/1)	(confluence)	- Cashahuacra	56.3	1,600	2,100	1.5	1,550	950	600	3.5	15.9
	(S--/4)	(confluence)	- Alcula	60.3	9,600	2,100	18.0	2,200	1,160	1,040	2.0	26.3
	(S-1/2)	Cashahuacra	- Redonda	59.6	5,000	4,150	10.4	2,400	1,090	1,310	3.2	17.5
	(S-2/3)	Redonda	- Infiernillo	63.6	2,900	2,050	2.4	1,970	1,250	720	2.8	19.4
	(S-3/5)	Infiernillo	- Lucuma	67.2	4,600	2,600	5.4	2,760	1,450	1,310	2.0	26.7
	(S-4/6)	Alcula	- Santo Domingo	67.4	4,300	4,300	11.1	3,450	1,450	2,000	2.2	24.9
	(S-5/7)	Lucuma	- Huanchuya	76.9	3,900	3,050	3.0	3,200	1,630	1,570	1.9	27.2
	(S-6/8)	Santo Domingo	- San Antonio	71.5	2,800	3,750	5.4	3,400	1,640	1,760	2.1	25.1
	(S-7/10)	Huanchunya	- Vado	73.0	1,100	2,100	1.4	3,200	1,740	1,460	1.4	34.8
	(S-9/12)	Negro	- Carhuayuma	75.7	3,700	2,800	7.2	3,600	2,040	1,560	1.3	29.1
	(S-10/11)	Vado	- Mito Mito	75.4	4,200	4,200	6.4	3,770	2,080	1,690	2.5	21.9
	(S-11/13)	Mito Mito	- Del Zorrillo	78.6	2,700	3,850	7.6	3,970	2,200	1,770	2.2	24.7
	(S-12/15)	R.Carhuayuma	- Carhuachayo	80.0	4,300	3,750	8.4	4,250	2,200	2,050	1.8	28.7
	(S-13/14)	Del Zorrillo	- Marcopuquio	80.7	1,500	1,850	1.3	3,300	2,270	1,030	1.8	29.1
	(S-14/16)	Marcopuquio	- Maquerhua	82.3	1,700	1,850	1.1	3,450	2,350	1,100	1.7	30.7
	(S-15/17)	Carhuachayo	- Challamayllo	84.6	4,900	4,900	11.2	4,820	2,570	2,250	2.2	24.7
	(S-16/18)	Maquerhua	- Pozo	85.3	4,400	2,800	5.7	4,250	2,600	1,650	1.7	30.5
	(S-17/20)	Challamayllo	- Chilcacocha	88.9	3,800	2,600	5.6	4,240	2,800	1,440	1.8	29.0
	(S-18/19)	Pozo	- Huancacocha	89.0	3,000	3,450	6.2	4,380	2,800	1,580	2.2	24.6
	(S-19/22)	Huancacocha	- Acobamba	91.8	2,600	3,400	5.0	4,400	3,080	1,320	2.6	21.2
	(S-20/21)	Chilcacocha	- Pillihua	91.3	1,000	900	0.4	3,700	3,000	700	1.3	37.9
	(S-21/24)	Pillihua	- Rio Shuncha	94.7	5,700	2,800	7.9	4,730	3,400	1,330	2.1	25.4
	(S-22/23)	Acobamba	- Collque	94.7	3,200	2,800	4.7	4,480	3,350	1,130	2.5	22.0
	(S-23/26)	Collque	- Huasca	102.2	11,800	2,850	20.7	5,230	3,970	1,260	2.3	23.9
	(S-24/25)	Rio Shuncha	- Yanac	100.1	5,200	1,650	4.4	4,650	3,780	870	1.9	27.8
	(S-25/27)	Yanac	- Rio Pallca	105.4	5,400	2,500	10.7	5,060	3,980	1,080	2.3	23.4

Rimarks : *3 : From river mouth to the middle reach of the section
*5,*6 : Horizontal length
*7,*8 : Elevation at logenst slope
*9 : *7-*8
*10 : *5/*9
*11 : Degree (o)

Table IV-6-1 TYPE OF QDA AREAS OF GROUP "B"

Name and No. of Qda		Type
Q. Chaclacayo	(R1)	A1
Q. Chacrasana	(R2)	A1
Q. California	(R3)	A1
Q. Santa Maria	(R4)	A1
Q. La Cantuta	(R5)	A1
Q. La Ronda	(R10)	A1
Q. Santa Ana	(R11)	B1
Q. Cupiche	(R13)	B1
Q. Rio Canchacalla	(R15)	C
Q. Guayabo	(R16)	B2
Q. Agua Salada	(R17)	B1
Q. Del Pate	(R18)	B1
Q. Huacre	(R23)	B1
Q. Matata	(R24)	B1
Q. Cuchimachay	(R25)	A1
Q. Chucumayo	(R31)	B2
Q. Chacahuacra	(R33)	B2
Q. Pancha	(R34)	C
Q. Viso	(R35)	C
Q. Parac	(R37)	C
Q. Redonda	(S2)	B2
Q. Infiernillo	(S3)	B1
Q. Lucuma	(S5)	B1

Note : A1 : Quirio/Pedregal Type
A2 : Carosio/Corrales Type
B1 : Rio Seco Type
B2 : Cashahuacra Type
C : Paihua Type

Table IV-7-1 ASSUMED DEPOSIT VOLUME IN EACH QDA AREA

Name of Qda	(1) Catchment Area (Km2)	(2) Total Deposit Volume in (m3) March 1987 Disaster	Reduction Factory (F)	Deposit Volume (3) Long-term scale (m3)	(4) Mid-term scale (m3)	(5) Short-term scale(m3)
Qda Quirio	10.4	14,100	1	184,700	92,400	18,500
Qda Pedregal	10.6	157,200	1	188,200	94,100	18,800
Qda Carcsio	0.4	4,400	1	7,100	3,600	700
Qda Corrales	1.4	21,700	1	24,900	12,400	250
Qda Cashahuacra	15.1	102,000	1	268,200	134,100	26,800
Qda Rio Seco	41.2	-	0.4	292,700	146,400	29,300
Qda Paihua *	28.0	-	0.4	198,900	99,400	19,900

Note: (3) = (1) 14,800* x 1.2 x F *: Deposit Volume per 1 Km2 in Qda Pedregal
(4) = (3) x 0.5
(5) = (3) x 0.2

Table IV-8-1 DISASTER DEPOSIT VOLUME IN QDA AREAS OF GROUP "B"

Qda Area		(3) Catchment Area (km2)	Reduction Factor (F)	umed Deposit Volume		
(1)No.	(2) Name			(4) Long-term	(5) Mid-term	(6) Short-term
R 1	Q. Chacracayo	9.8	1	174,000	87,000	17,400
R 2	Q. Chacrasana	4.7	1	83,500	41,700	8,400
R 3	Q. California	8.4	1	149,200	74,600	14,900
R 4	Q. Santa Maria	4.6	1	81,700	40,800	8,200
R 5	Q. La Cantuta	15.0	1	266,400	133,200	26,600
R10	Q. La Ronda	9.0	1	159,800	79,900	16,000
R11	Q. Santa Ana	13.5	0.8	191,800	96,000	19,200
R13	Q. Cupiche	9.3	0.8	132,200	66,100	13,200
R15	Q. Rio Canchacalla	118.0	0.4	838,300	419,100	83,800
R16	Q. Guayabo	6.8	0.8	96,600	48,300	9,700
R17	Q. Agua Salada	15.3	0.6	163,000	81,500	16,300
R18	Q. Del Pate	10.3	0.6	109,700	54,900	11,000
R23	Q. Huacra	7.5	0.4	53,300	26,600	5,300
R24	Q. Matata	14.8	0.4	105,100	52,600	10,500
R25	Q. Cuchimachay	6.6	0.4	46,900	23,400	4,700
R31	Q. Chucumayo	34.8	0.4	247,200	123,600	24,700
R33	Q. Chacahuaro	5.3	0.4	37,600	18,800	3,800
R34	Q. Pancha	69.3	0.2	246,200	123,100	24,600
R35	Q. Viso	20.9	0.2	74,200	37,100	7,400
R37	Q. Parac	130.6	0.2	464,000	231,900	46,400
S 2	Q. Redonda	12.1	0.8	171,900	86,000	17,200
S 3	Q. Infiernillo	6.7	0.8	95,200	47,600	9,500
S 5	Q. Lucuma	9.5	0.6	101,200	50,600	10,100

Note: (4) = (3) x 14,800 x 1.2 x F
(5) = (4) x 0.5
(6) = (4) x 0.1

Table IV-8-2 RATIO OF DAMAGE AMOUNT IN EACH SCALE OF GROUP "A"

Name of Qda	Long-term scale		Mid-term scale		Short-term scale	
	Amount	Ratio	Amount	Ratio	Amount	Ratio
Quirio	229	1	137	0.60	29	0.13
Pedregal	467	1	267	0.57	28	0.06
Carosio	102	1	57	0.56	7	0.07
Corrales	128	1	7	0.60	8	0.06
Rio Seco	216	1	96	0.44	21	0.10
Paihua	222	1	114	0.51	16	0.07
Cashahuacra	97	1	39	0.40	7	0.07
Mean	-	1	-	0.52	-	0.08

Note : Unit of amount is x 10^6 Intis

Table IV-8-3 SUMMARY OF ESTIMATED DAMAGE OF QDA AREA

Name and No. of Qda	Damage Amout (I./ x 10^6)		
	Long-term scall	Mid-term scale	Short-term scale
Q. Chaclacayo (R1)	583.8	303.6	46.7
Q. Chacrasana (R2)	102.4	53.2	8.2
Q. California (R3)	253.5	131.8	20.3
Q. Santa Maria (R4)	104.4	54.3	8.4
Q. La Cantuta (R5)	144.8	75.3	11.6
Q. La Ronda (R10)	161.1	83.8	12.9
Q. Santa Ana (R11)	175.6	91.3	14.0
Q. Cupiche (R13)	137.5	71.5	11.0
Q. Rio Canchacalla (R15)	169.7	88.2	13.6
Q. Guayabo (R16)	128.8	67.0	10.3
Q. Agua Salada (R17)	138.7	72.1	11.1
Q. Del Pate (R18)	131.1	68.2	10.5
Q. Huacre (R23)	14.4	7.5	1.2
Q. Matata (R24)	28.8	15.0	2.3
Q. Cuchimachay (R25)	54.3	28.2	4.3
Q. Chucumayo (R31)	162.5	84.5	13.0
Q. Chacahuacra (R33)	63.0	32.8	5.0
Q. Pancha (R34)	64.5	33.5	5.2
Q. Viso (R35)	63.8	33.2	5.1
Q. Parac (R37)	127.8	66.4	10.2
Q. Redonda (S2)	54.1	28.1	4.3
Q. Infiernillo (S3)	34.3	17.8	2.7
Q. Lucuma (S5)	34.2	17.8	2.7

Note : Damage of Mid-term scale
= 0.52 x Damage of long-term scale
Damage of Short-term scale
= 0.08 x Damage of lont-term scale

Table IV-8-4 SUMMARY OF ESTIMATED DAMAGE OF SPE AREA

Name and No. of spe Area	Estimated Damage (I/. x 10^6)			
	Direct Damage			Indirect Damage
	Long-term scale	Mid-term scale	Short-term scale	(Annual)
River mouth-Jicamarca (R-¯/10)	196.8	102.3	15.7	0
River mouth-Chaclacayo (R-¯/1)	183.8	95.6	14.7	0.495
Jicamarca Chacrasana (R-0/2)	3.0	1.6	0.2	0
Chaclacayo-California (R-1/3)	5.5	2.9	0.4	0
Snata Maria-Quirio (R-4/6)	0.5	0.2	0.1	0
La Cantuta-La Ronda (R5/10)	5.9	3.1	0.5	0
Pedregal-Carosio (R-7-8)	8.0	4.2	0.6	0
Carosio-Corrales (R-8/9)	3.9	2.0	0.3	0
Corrales-Cashahuacra (R-9/- and S-¯/1)	2.4	1.2	0.2	0
La Ronda-Confluence (R-10/-)	0.3	0.2	0.1	0.033
Confluence-Santa Ana (R-¯/11)	13.7	7.1	1.1	0
Confluence-San Juan (R-¯/12)	6.4	3.3	0.5	0
Santa Ana-Cupiche (R-¯11/13)	0	0	0	3.188
Cupiche-Guayabo (R-13/16)	27.8	14.5	2.2	2.068
Guayabo-Agua Salada (R-16/17)	0	0	0	1.458
R.Seco-Esperanza (R-19/20)	4.4	2.3	0.4	4.552
Eseranza-Verrugas (R-20-21)	0.5	0.3	0.1	5.313
Verrugas-Huacre (R-21/23)	5.2	2.8	0.4	4.136
Linday-Yamajune (R-22/27)	2.4	1.2	0.2	4.158
Chacamaza-Barranco (R-26/29)	0.4	0.2	0.1	0.167
Chucumayo-Chacahuaro (R-31/33)	22.7	11.8	1.8	0.132
Parac-R. Blanco (R-37/40)	37.8	19.6	3.0	2.998
Confluence-Alcula (S-¯4)	7.2	3.8	0.6	0
Cashahuacra-Redonda (S-1/2)	4.8	2.5	0.4	0.126
Redonda-Infiernillo (S-2/3)	4.5	2.3	0.3	0.088

Note:
(1) Direct damage = Damage on House x 1.5
(2) Indirect damage = Traffic damage x 1.1
(3) Mid-term scale damage = Large scale damae x 0.52
(4) Short-term scall damage = Large scale damage x 0.08
(5) Indirect damage is shown as an annual amount as the recurrence period will be estimated later for the evaluation of the project.

Table IV-9-1 WORK QUANTITY OF MAIN CONSTRUCTION WORKS IN QDA AREAS OF GROUP "A" (1/2)

Description	Unit	Qda Quirio	Qda Pedregal	Qda Carosio	Qda Corrales	Qda Rio Seco	Qda Paihua	Qda Cashahuacra
IV. Channel Works								
- Excavation, common	cu.m	120,000	128,500	9,400	10,100	-	5,000	21,500
- Backfill with random materials	cu.m	11,700	12,800	800	800	-	0	0
- Concrete	cu.m	0	0	0	0	-	0	0
- Rubble concrete	cu.m	18,500	20,600	4,000	1,700	-	0	1,700
- Backfill concrete	cu.m	0	0	0	1,200	-	0	0
- Reinforcing bar	tons	0	0	0	0	-	0	0
- Protection works with wet masonry	aq.m	21,500	8,200	3,300	1,600	-	0	2,300
- Gabion mattress	nos	860	860	75	60	-	0	15
- New Bridge/Rockshed tunnel	NA	LS	LS	LS	LS		0	0
V. Dike								
- Excavation, common	cu.m	-	-	-	-	44,700	3,300	23,500
- Backfill with random materials	cu.m	-	-	-	-	6,200	-	3,300
- Backfill with gravel	cu.m	-	-	-	-	3,400	470	1,800
- Backfill with cobble & rubble	cu.m	-	-	-	-	50,900	0	18,600
- Concrete	cu.m	-	-	-	-	0	0	0
- Rubble concrete	cu.m	-	-	-	-	0	0	0
- Backfill concrete	cu.m	-	-	-	-	0	0	0
- Reinforcing bar	tons	-	-	-	-	0	0	0
- Protection works with wet masonry	sq.m	-	-	-	-	25,700	1,900	2,300
- Gabion mattress	nos	-	-	-	-	2,360	500	15
VI. Improvement of Structures								
- Extention of road tunnel	m	-	-	-	-	60	-	-
- Extention of railway tunnel No.1	m	-	-	-	-	60	-	-
- Extention of railway tunnel No.2	m	-	-	-	-	80	-	-
- New road bridge (L=20 m)	sq.m	-	-	-	-	120	-	-
- New railway bridge (L=20 m)	sq.m	-	-	-	-	80	-	-

Table IV-9-1 WORK QUANTITY OF MAIN CONSTRUCTION WORKS IN QDA AREAS OF GROUP "A" (2/2)

Description	Unit	Qda Quirio	Qda Pedregal	Qda Carosio	Qda Corrales	Qda Rio Seco	Qda Paihua	Qda Cashahuacra
I. Main Dam								
- Excavation, common	cu.m	25,700	27,900	-	-	-	76,300	-
- Backfill with random materials	cu.m	71,200	22,300	-	-	-	5,000	-
- Concrete	cu.m	4,000	2,800	-	-	-	42,000	-
- Rubble concrete	cu.m	23,900	13,500	-	-	-	0	-
- Backfill concrete	cu.m	13,500	11,000	-	-	-	9,000	-
- Reinforcing bar	tons	71	86	-	-	-	126	-
- Protection works with wet masonry	sq.m	1,900	3,000	-	-	-	4,100	-
- Gabion mattress	nos	40	40	-	-	-	50	-
II. Lower Erosion Control Dam								
- Excavation, common	cu.m	33,500	30,200	6,800	7,600	-	7,700	-
- Backfill with random materials	cu.m	1,000	600	1,700	1,300	-	450	-
- Concrete	cu.m	9,000	8,700	6,200	10,800	-	4,300	-
- Rubble concrete	cu.m	0	0	0	0	-	0	-
- Backfill concrete	cu.m	0	0	0	0	-	0	-
- Reinforcing bar	tons	44	50	15	37	-	15	-
- Protection works with wet masonry	sq.m	1,000	1,000	1,800	1,600	-	450	-
- Gabion mattress	tnos	40	40	0	15	-	25	-
III. Upper Erosion Control Dam								
- Excavation, common	cu.m	-	43,400	-	6,300	-	-	10,700
- Backfill with random materials	cu.m	-	600	-	1,200	-	-	13,000
- Concrete	cu.m	-	8,700	-	9,900	-	-	9,500
- Rubble concrete	cu.m	-	0	-	0	-	-	0
- Backfill concrete	cu.m	-	0	-	0	-	-	7,500
- Reinforcing bar	tons	-	50	-	32	-	-	41
- Protection works with wet masonry	sq.m	-	1,300	-	1,200	-	-	170
- Gabion mattress	nos	-	40	-	15	-	-	260

(to be continued)

Table IV-9-2 QUANTITY OF STRUCTURAL PLAN FOR QDA AREAS OF GROUP "B"

Name and No. of Qda.	Q'ty of Structure			Others
	No. of Dam	Length of Channel Works	Length of Dike Section	
Q. Chaclacayo (R1)	3 Nos	3.3 km	-	
Q. Chacrasana (R2)	1	1.1	-	
Q. California (R3)	1	1.3	-	
Q. Santa Maria (R4)	1	1.0	-	
Q. La Cantuta (R5)	3	1.2	-	
Q. La Ronda (R10)	4	1.3	-	
Q. Santa Ana (R11)	-	(0.4)	0.6 km	Road & Railway Protection
Q. Cupiche (R13)	-	(0.4)	0.5	- ditto -
Q. Rio Canchacalla (R15)	5	(0.5)	0.5	
Q. Guayabo (R16)	2	0.4	-	Road & Railway Protection
Q. Agua Salada (R17)	-	(0.5)	0.5	- ditto -
Q. Del Pate (R18)	-	-	0.4	- ditto -
Q. Huacre (R23)	-	(0.5)	0.5	- ditto -
Q. Matata (R24)	-	(0.5)	0.5	- ditto -
Q. Cuchimachay (R25)	2	1.1	-	
Q. Chucumayo (R31)	1	0.7	1.6	Road & Raileay Protection
Q. Chacahuacra (R33)	1	0.3	-	- ditto -
Q. Pancha (R34)	3	(0.5)	-	
Q. Viso (R35)	2	(0.5)	-	
Q. Parac (R37)	3	(0.3)	-	
Q. Redonda (S2)	1	1.3	1.3	
Q. Infiernillo (S3)	-	(0.4)	0.4	
Q. Lucuma (S5)	-	(0.9)	0.9	

Note: Channel works with parenthesis : Excavation for improvement of existing channel

Table IV-9-3 STRUCTURES AND ITS QUANTITIES IN SPE AREA OF GROUP "B"

Name and No. of Spe Area	Kind of Structure and Number or Length (km)						
	Bridge		Bock S.Tunnel		Retain. Wall		Other
	Road	Rail	Road	Rail	High	Low	
River mouth-Jicamarca (R-⁻/0)	-	-	-	-	-	15	
River mough-Chaclacayo (R-⁻/1)	-	-	-	-	0.5	17.5	
Jicamarca-Chacrasana (R-0/2)	-	-	-	-	0.5	1.5	
Chaclacayo-California (R-1/3)	-	-	-	-	-	0.05	
Santa Maria-Quirio (R-4/6)	-	-	-	-	-	0.11	
La Cantuta-La Ronda (R-5/10)	-	-	-	-	-	1.5	
Pedregal-Carosio (R-7/8)	-	-	-	-	-	0.68	
Carosio-Corrales (R-8/9)	-	-	-	-	-	0.2	
Corrales-Cashauacra (R-9/1) and (S-⁻/1)	-	-	-	-	-	0.2	
La Ronda-Confluence (R-10/-)	-	-	-	-	-	0.04	
Confluence-Santa Ana (R-⁻/11)	-	-	-	-	-	0.32	
Confluence-San Juan (R-⁻/12)	-	-	-	-	-	0.08	
Santa Ana-Cupiche (R-11/13)	1	-	2	1	1.5	0	
Cupiche-Guayabo (R-13/16)	-	-	2	5	1.5	0.66	
Guayabo-Agua Salada (R-16/17)	-	-	2	0	1.0	0	
R. Seco-Esperanza (R-19/20)	1	1	3	5	2.5	0.05	
Esperanza-Verrugas (R-20/21)	1	1	6	7	2.5	0.01	
Verrugas-Huacre (R-21/23)	1	1	3	5	2.0	0.08	
Linday-Yamajune (R-22/27)	1	-	2	-	2.5	0.04	
Chacamaza-Barranco (R-26/29)	-	-	-	7	-	0.04	
Chucumayo-Chacahuaro (R-31/33)	-	-	-	3	-	0.9	
Parac-Rio Blanco (R-37/40)	2	2	2	2	-	1.12	
Confluence-Alcula (S-⁻/4)	-	-	-	-	-	0.11	
Cashahuacra-Redonda (S-1/2)	-	1	-	5	-	0.11	
Redonda-Infiernillo (S-2/3)	-	-	-	4	-	0.09	

Table IV-9-4 ECONOMIC COST OF MAIN CONSTRUCTION WORKS IN QDA AREAS OF GROUP "A" (1/2)

Description	Unit of Q'ty	Unit Price (US$)	Qda Quirio	Qda Pedregal	Qda Carosio	Qda Corrales	Qda Rio Seco	Qda Paihua	Qda Cashahuacra
I. Main Dam									
- Excavation, common	cu.m	4.00	102.8	111.6	-	-	-	305.2	-
- Backfill with randam materials	cu.m	4.00	284.8	89.2	-	-	-	20.0	-
- Concrete	cu.m	80.00	320	224.0	-	-	-	3,360.0	-
- Rubble concrete	cu.m	45.00	1,075.5	607.5	-	-	-	0	-
- Backfill concrete	cu.m	45.00	607.5	495.0	-	-	-	405.0	-
- Reinforcing bar	tons	267.00	19.0	23.0	-	-	-	33.6	-
- Protection works with wet masonry	sq.m	22.00	41.8	66.0	-	-	-	90.2	-
- Gabion mattress	nos	45.00	1.8	1.8	-	-	-	2.3	-
Sub-total			2,453.2	1,618.1				4,216.3	
II. Lower Erosion Control Dam									
- Excavation, common	cu.m	4.00	130.4	120.8	27.2	30.4	-	30.8	42.8
- Backfill with randam materials	cu.m	4.00	4.0	2.4	6.8	5.2	-	1.8	52.0
- Concrete	cu.m	80.00	720.0	696.0	496.0	864.0	-	344.0	760.0
- Rubble concrete	cu.m	45.00	0.0	0.0	0.0	0.0	-	0	0
- Backfill concrete	cu.m	45.00	0.0	0.0	0.0	0.0	-	0	337.5
- Reinforcing bar	tons	267.00	11.7	13.4	4.0	9.9	-	4.0	10.9
- Protection works with wet masonry	sq.m	22.00	22.0	22.0	39.6	35.2	-	9.9	3.7
- Gabion mattress	tnos	45.00	1.8	1.3	0.0	0.7	-	1.1	11.7
Sub-total			893.5	856.4	578.4	945.4		391.6	1,218.7
III. Upper Erosion Control Dam									
- Excavation, common	cu.m	4.00	0.0	173.6	-	25.2	-	-	-
- Backfill with randam materials	cu.m	4.00	0.0	2.4	-	4.8	-	-	-
- Concrete	cu.m	80.00	0.0	696.0	-	792.0	-	-	-
- Rubble concrete	cu.m	45.00	0.0	0.0	-	0.0	-	-	-
- Backfill concrete	cu.m	45.00	0.0	0.0	-	0.0	-	-	-
- Reinforcing bar	tons	267.00	0.0	13.4	-	8.5	-	-	-
- Protection works with wet masonry	sq.m	22.00	0.0	28.6	-	26.4	-	-	-
- Gabion mattress	nos	45.00	0.0	1.8	-	0.7	-	-	-
Sub-total				915.8		857.6			

(to be continued)

Table IV-9-4 ECONOMIC COST OF MAIN CONSTRUCTION WORKS IN QDA AREAS OF GROUP "A" (2/2)

Description	Unit of Q'ty	Unit Price (US$)	Qda Cuirio	Qda Pedregal	Qda Carosio	Qda Corrales	Qda Rio Seco	Qda Paihua	Qda Cashahuacra
IV. Channel Works									
- Excavation, common	cu.m	4.00	480.0	514.0	37.6	40.4	-	20.0	86.0
- Backfill with randam materials	cu.m	4.00	46.8	51.2	3.2	3.2	-	0	0
- Concrete	cu.m	80.00	0.0	0.0	0.0	0.0	-	0	0
- Rubble concrete	cu.m	45.00	832.5	927.0	180.0	76.5	-	0	76.5
- Backfill concrete	cu.m	45.00	0.0	0.0	0.0	54.0	-	0	0
- Reinforcing bar	tons	267.00	0.0	0.0	0.0	0.0	-	0	0
- Protection works with wet masonry	aq.m	22.00	473.0	180.4	72.6	35.2	-	0	50.6
- Gabion mattress	nos	45.00	38.7	38.7	3.4	2.7	-	0	0.7
- Rockshed tunnel/Bridge	NA	LS	815.6	1,856.0	55.7	84.8	-	0	0
Sub-total			2,056.6	3,567.3	352.5	296.8		20.0	
V. Dike									
- Excavation, common	cu.m	4.00	-	-	-	-	178.8	13.2	94.0
- Backfill with randam materials	cu.m	4.00	-	-	-	-	24.3	0	13
- Backfill with gravel	cu.m	7.00	-	-	-	-	23.3	3.3	12.6
- Backfill with cobble & rubble	cu.m	10.00	-	-	-	-	509.0	0	186.0
- Concrete	cu.m	80.00	-	-	-	-	0	0	0
- Rubble concrete	cu.m	45.00	-	-	-	-	0	0	0
- Backfill concrete	cu.m	45.00	-	-	-	-	0	0	0
- Reinforcing bar	tons	267.00	-	-	-	-	0	0	0
- Protection works with wet masonry	sq.m	22.00	-	-	-	-	565.4	41.8	572.0
- Gabion mattress	nos	45.00	-	-	-	-	106.2	22.5	55.4
Sub-total							1,408.0	80.8	933.2
VI. Improvement of Structures									
- Extention of road tunnel	m	4,240	-	-	-	-	254.4	-	-
- Extention of railway tunnel No.1	m	2,120	-	-	-	-	172.2	-	-
- Extention of railway tunnel No.2	m	2,120	-	-	-	-	169.6	-	-
- New road bridge (L=20 m)	sq.m	870	-	-	-	-	104.4	-	-
- New railway bridge (L=20 m)	sq.m	1,100	-	-	-	-	83.0	-	-
Sub-total							743.6		
TOTAL*			5,403.3	6,957.5	930.9	2,099.8	2,151.6	4,708.7	2,365.6

* Total amount does not include the cost for miscellaneous works.

Table IV-9-5 ECONOMIC PROJECT COST IN QDA AREAS OF GROUP"A"

(Unit : x 10^3 US$)

Description	Quirio	Pedregal	Carosio	Corrales	Rio Seco	Paihua	Cashahuacra
1. Preparatory Works	284.4	366.2	49.0	110.5	113.2	247.8	124.5
2. Construction Works							
(1) Check dam	2,453.2	1,618.1	-	-	-	4,216.3	-
(2) Erosion control/ sand arrosting dam	893.5	1,772.2	578.4	1,803.0	-	391.6	1,218.7
(3) Channel works	2,056.6	3,567.3	352.5	296.8	-	20.0	213.8
(4) Training/Polder dike	-	-	-	-	1,408.0	-	933.2
(5) Protection of road and railway	-	-	-	-	743.6	80.8	-
(6) Miscellaneous	284.4	366.2	49.0	110.5	113.2	247.8	124.5
Sub-Total	5,687.7	7,323.7	979.9	2,210.3	2,264.8	4,956.5	2,490.1
3. Compensation	1,003.3	1,733.3	130.0	150.0	166.7	6.7	18.3
4. Engineering Service and Government administration	523.2	706.7	86.9	185.3	190.8	390.8	197.5
5. Physical Contingency	1,124.8	1,519.5	186.8	398.4	410.3	840.3	424.6
Total	8,623.4	11,649.4	1,432.7	3,054.5	3,145.9	6,442.1	3,057.4

Note : 1.; 5% of 2.
4.;7.5% of (1.+2.+3.)
5.; 15% of (1.+2.+3.+4.)

Table IV-9-6 ECONOMIC PROJECT COST ESTIMATED FOR STRUCTURAL PLAN FOR QDA AREAS OF GROUP "B"

(Unit: x 10^3 US$)

Name of No. of Qda	Construction Cost					Project Cost
	Dam	Channel Works	Dike	Others	Total	
Q. Chaclacayo (R1)	3,149.4	2,604.3	-	302.8	6,056.5	9,448.2
Q. Chacrasana (R2)	1,511.3	1,249.8	-	145.3	2,906.4	4,534.0
Q. California (R3)	2,700.5	2,233.1	-	259.7	5,193.3	8,101.6
Q. Santa Maria (R4)	1,478.8	1,222.8	-	142.2	2,843.8	4,436.3
Q. La Cantuta (R5)	4,821.8	3,987.3	-	463.6	9,272.8	14,465.5
Q. La Ronda (R10)	2,892.3	2,391.7	-	278.1	5,562.2	8,677.1
Q. Santa Ana (R11)	-	-	923.9	566.3	1,490.2	2,071.4
Q. Cupiche (R13)	-	-	636.9	390.3	1,027.2	1,427.8
Q. Rio Canchacalla (R15)	19,221.6	-	426.3	1,245.1	20,893.0	27,160.9
Q. Guayabo (R16)	438.7	250.7	-	197.0	895.3	1,101.2
Q. Agua Salada (R17)	-	-	785.2	481.3	1,266.5	1,760.4
Q. Del Pate (R18)	-	-	528.5	323.9	852.4	1,184.8
Q. Huacre (R23)	-	-	256.7	157.4	414.1	575.6
Q. Matata (R24)	-	-	506.3	310.3	816.6	1,135.1
Q. Cuchimachay (R25)	848.9	701.0	-	81.6	1,632.5	2,946.7
Q. Chucumayo (R31)	1,122.6	183.3	847.7	114.6	2,291.1	2,818.1
Q. Chacahuacra (R33)	170.7	127.9	-	46.3	348.4	428.6
Q. Pancha (R34)	5,645.2	-	-	490.9	6,136.1	7,976.9
Q. Viso (R35)	2,875.3	-	-	250.0	3,125.3	2,404.1
Q. Parac (R37)	10,639.2	-	-	925.1	11,564.3	15,033.6
Q. Redonda (S2)	780.7	127.4	589.5	79.7	1,593.2	1,959.7
Q. Infiernillo (S3)	-	-	458.6	281.1	739.7	1,028.2
Q. Lucuma (S5)	-	-	487.5	298.8	786.3	1,093.0

Note : (1) Unit : US$ x 10^6
(2) Project Cost : 1.56 x Construction cost for A1 type
1.54 x " for A2 type
1.39 x " for B1 type
1.23 x " for B2 type
1.30 x " for C type

Table IV-9-7 ECONOMIC PROJECT COST FOR SPE AREAS OF GROUP "B"

(Unit: x 10^6 US$)

Name and No. of Spe Area	Construction cost					Project cost
	Bridge	R. Tunnel	R. Wall	Others	Total	
River mouth-Jicamarca (R-⁻/0)	-	-	10.5	0.553	11.053	15.585
River mough-Chaclacayo (R-⁻/1)	-	-	12.85	0.676	13.53	19.077
Jicamarca-Chacrasana (R-0/2)	-	-	1.65	0.087	1.74	2.453
Chaclacayo-California (R-1/3)	-	-	0.035	0.002	0.037	0.052
Santa Maria-Quirio (R-4/6)	-	-	0.077	0.004	0.081	0.114
La Cantuta-La Ronda (R-5/10)	-	-	1.05	0.055	1.105	1.558
Pedregal-Carosio (R-7/8)	-	-	0.476	0.025	0.501	0.706
Carosio-Corrales (R-8/9)	-	-	0.14	0.007	0.147	0.207
Corrales-Cashauacra (R-9/1) and (S-⁻/1)	-	-	0.14	0.007	0.147	0.207
La Ronda-Confluence (R-10/-)	-	-	0.028	0.001	0.029	0.041
Confluence-Santa Ana (R-⁻/11)	-	-	0.224	0.012	0.236	0.333
Confluence-San Juan (R-⁻/12)	-	-	0.056	0.003	0.059	0.083
Santa Ana-Cupiche (R-11/13)	0.139	0.297	1.8	0.118	2.354	3.319
Cupiche-Guayabo (R-13/16)	-	0.466	2.262	0.144	2.872	4.049
Guayabo-Agua Salada (R-16/17)	-	0.254	1.2	0.076	1.530	2.157
R. Seco-Esperanza (R-19/20)	0.227	0.594	3.035	0.203	4.059	5.723
Esperanza-Verrugas (R-20/21)	0.227	1.060	3.007	0.226	4.520	6.373
Verrugas-Huacre (R-21/23)	0.227	0.594	2.456	0.172	3.449	4.863
Linday-Yamajune (R-22/27)	0.139	0.254	3.028	0.180	3.601	5.077
Chacamaza-Barranco (R-26/29)	-	0.297	0.028	0.017	0.342	0.482
Chucumayo-Chacahuaro (R-31/33)	-	0.127	0.63	0.040	0.797	1.124
Parac-Rio Blanco (R-37-40)	0.454	0.339	0.784	0.083	1.660	2.34
Confluence-Alcula (S--/4)	-	-	0.077	0.004	0.081	0.114
Cashahuacra-Redonda (S-1/2)	-	0.121	0.077	0.015	0.304	0.429
Redonda-Infiernillo (S-2/3)	-	0.170	0.063	0.012	0.245	0.345

Note; (1) Project Cost = 1.41 x Construction Cost.
(2) 1.41 is the mean in case of Qda areas of Group "A"

Table IV-9-8 RESULTS OF ECONOMIC EVALUATION FOR QDA AREAS OF GROUP "A"

Name of Quebrada	Project Cost (103 US$)	Annual Average Benefit (103 US$)	EIRR (%)
Quirio	8,623.4	2,676.2	5.25
Pedregal	11,649.4	3,891.7	5.65
Carosio	1,432.7	939.0	9.85
Corrales	3,054.5	1,135.0	6.02
Rio Seco	3,145.9	3,131.3	10.12
Paihua	6,442.1	1,941.0	5.09
Cashahuacra	3,057.4	800.2	4.15

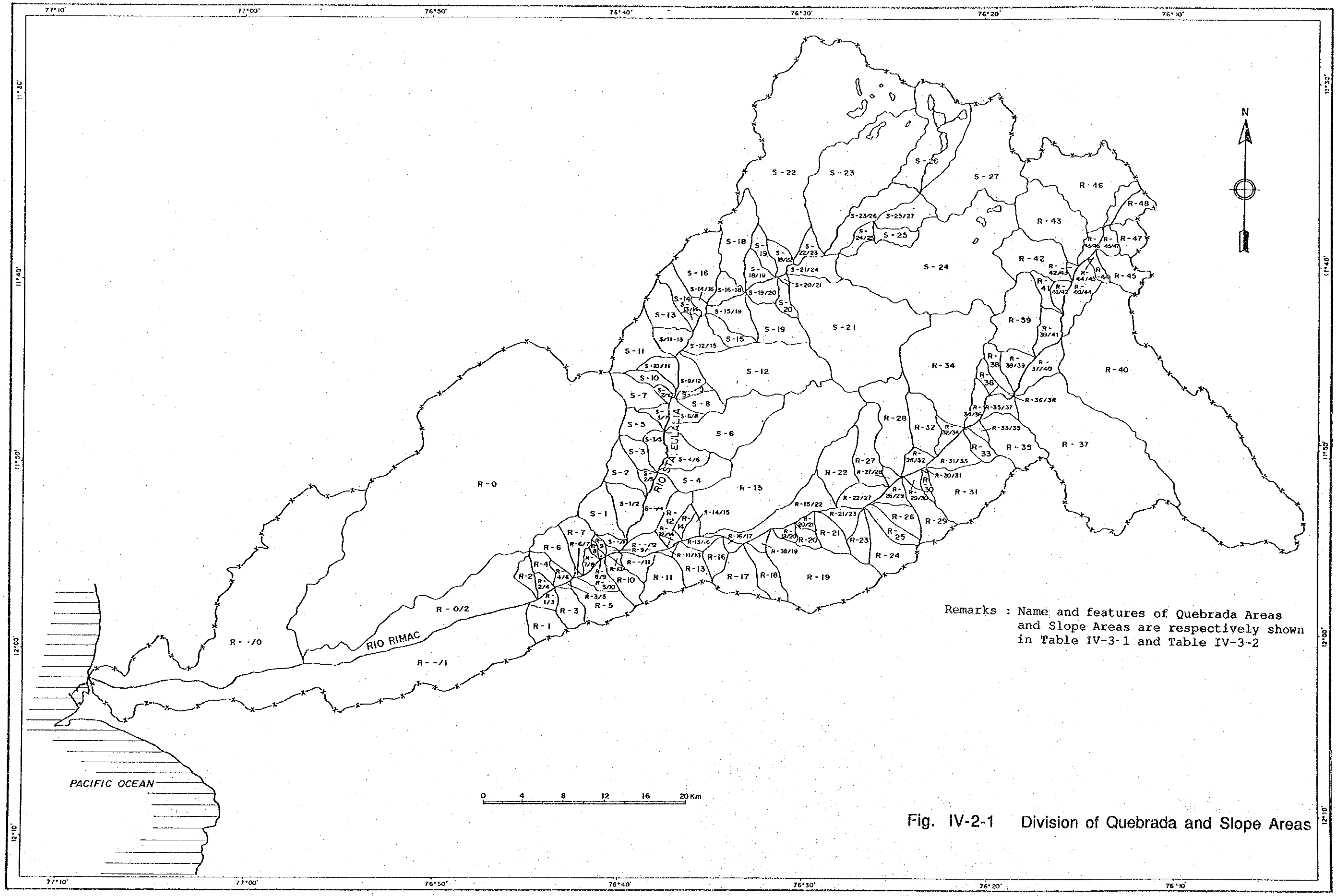
Table IV-9-9 RESULTS OF ECONOMIC EVALUATION FOR QDA AREAS OF GROUP "B"

Name of Quebrada	Project Cost (10^3 US$)	Annual Average Benefit (10^3 US$)	EIRR (%)
Q. Chaclacayo (R1)	9,448.2	547.9	8.99
Q. Chacrasana (R2)	4,534.0	96.1	3.19
Q. California (R3)	8,101.6	238.0	4.79
Q. Santa Maria (R4)	4,436.3	98.2	3.39
Q. La Cantuta (R5)	14,465.5	136.0	-0.24
Q. La Ronda (R10)	8,677.1	151.3	2.31
Q. Santa Ana (R11)	2,071.4	164.5	11.54
Q. Cupiche (R13)	1,427.8	129.0	12.79
Q. Rio Canchacalla (R15)	27,160.9	159.4	-2.09
Q. Guayabo (R16)	1,101.2	120.9	14.94
Q. Agua Salada (R17)	1,760.4	130.2	10.90
Q. Del Pate (R18)	1,848.8	123.1	14.30
Q. Huacre (R23)	575.6	13.8	3.75
Q. Matata (R24)	1,135.1	27.0	3.71
Q. Cuchimachay (R25)	2,546.7	50.7	2.90
Q. Chucumayo (R31)	2,818.1	152.5	8.45
Q. Chacahuacra (R33)	428.6	58.9	17.90
Q. Pancha (R34)	7,976.9	60.87	-1.07
Q. Viso (R35)	2,404.1	119.8	3.96
Q. Parac (R37)	15,033.6	59.9	-0.89
Q. Redonda (S2)	1,959.7	50.6	4.12
Q. Infiernillo (S3)	1,028.2	32.0	5.07
Q. Lucuma (S4)	1,093.0	31.9	4.73

Table IV-9-10 RESULTS OF ECONOMIC EVALUATION FOR SPE AREAS OF GROUP "B"

Name of Quebrada		Project Cost (10^3 US$)	Annual Average Benefit (10^3 US$)	EIRR (%)
River mouth - Jicamarca	(R - ¯/0)	15,585	84.4	0.68
River mouth - Chaclacayo	(R - ¯/1)	19,077	172.5	-0.04
Jicamarca - Chacrasana	(R - 0/2)	2,453	2.6	-
Chaclacayo - California	(R - 1/3)	52	5.0	13.67
Santa Maria - Quirio	(R - 4/6)	1,140	0.6	-2.42
La Cantuta - La Ronda	(R - 5/10)	1,585	5.7	-4.06
Pedregal - Carosio	(R - 7/8)	706	7.3	0.15
Carosio - Corrales	(R - 8/9)	207	3.6	3.39
Corrales - Cashahuacra	(R - 9/1) and (S - ¯/1)	207	2.3	0.45
La Ronda - Confluence	(R - 10/¯)	41	0.6	6.68
Confluence - Santa Ana	(R - ¯/11)	333	12.9	6.23
Confluence - San Juan	(R - ¯/12)	83	5.9	10.64
Santa Ana - Cupiche	(R - 11/12)	3,319	8.0	5.22
Cupiche - Guayabo	(R - 13/16)	4,049	26.0	3.64
Guayabo - Agua Salada	(R - 16/17)	2,157	9.0	3.46
R. Seco-Esperanza	(R - 19/20)	5,723	4.4	4.39
Esperanza - Verrugas	(R - 20/21)	6,373	0.8	4.50
Verrugas - Huacre	(R - 21/23)	4,863	4.76	4.9
Linday - Yamajune	(R - 22/27)	5,077	2.3	4.47
Chacamaza - Barranco	(R - 26/29)	482	0.6	1.02
Chucumayo - Chacahuaro	(R - 31/33)	1,124	21.2	3.50
Parac - Rio Blanco	(R - 37/40)	2,340	35.3	8.92
Confluence - Alcula	(S - ¯/4)	114	6.9	9.30
Cashahuacra - Redonda	(S - 1/2)	429	4.6	3.02
Redonda - Infiernillo	(S - 2/3)	345	3.9	2.86

Figures



Remarks : Name and features of Quebrada Areas and Slope Areas are respectively shown in Table IV-3-1 and Table IV-3-2

Fig. IV-2-1 Division of Quebrada and Slope Areas

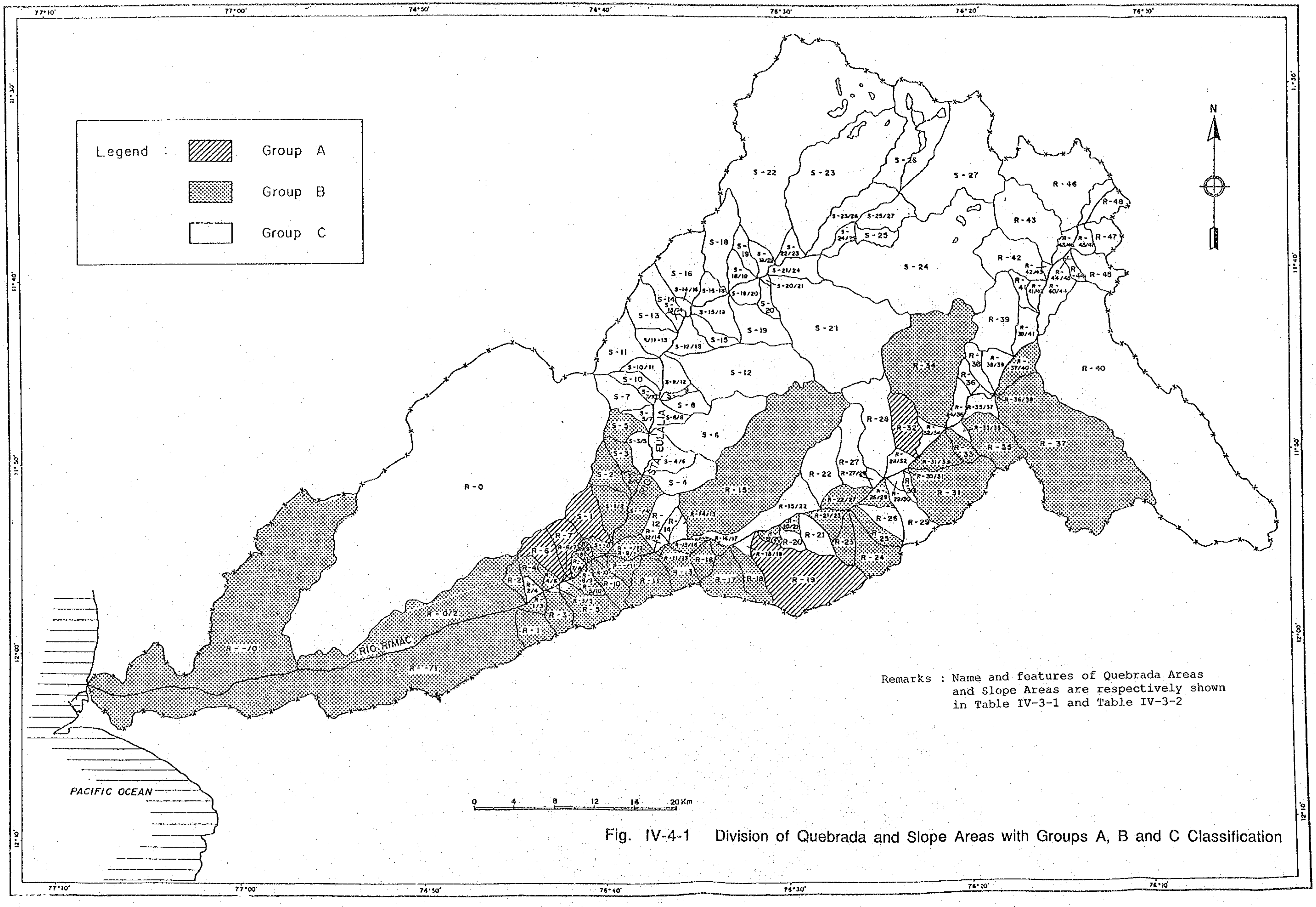
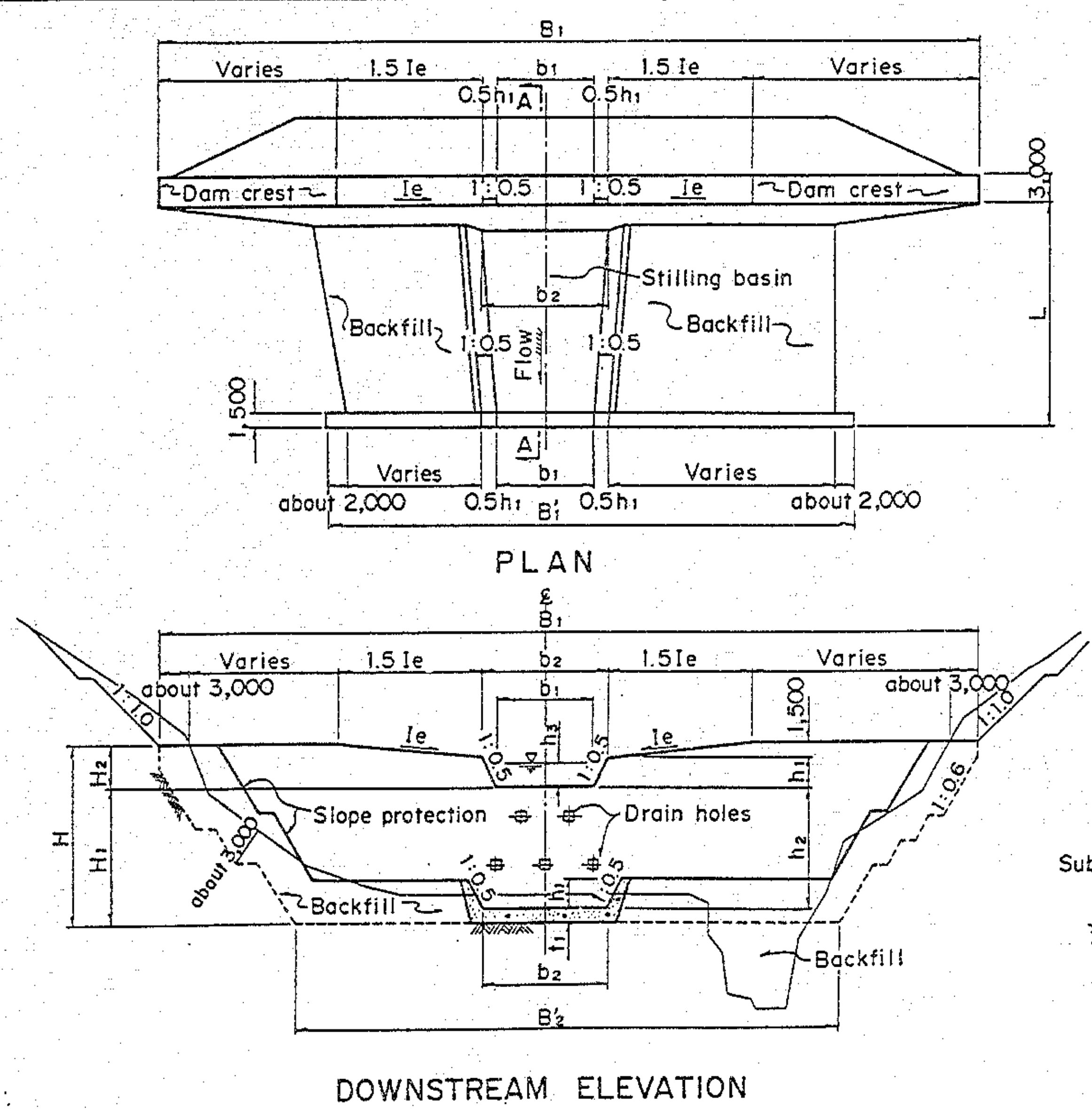


Fig. IV-4-1 Division of Quebrada and Slope Areas with Groups A, B and C Classification



Remarks ; m : To be decided by stability analysis
b_2, h_3 : To be decided by hydraulic calculation
b_1 : Existing river width
h_1 : h_3 + Freeboard
L : $1.5 (h_2 + h_3)$
t_1 : $0.1 (0.6 h_2 + 3 h_3 - 1.0)$

Note : Drain holes have the following functions :
(i) To reduce the water pressure acting to dam.
(ii) To discharge small grain size of sediments.
(iii) To use as the diversion facility during dam construction work.

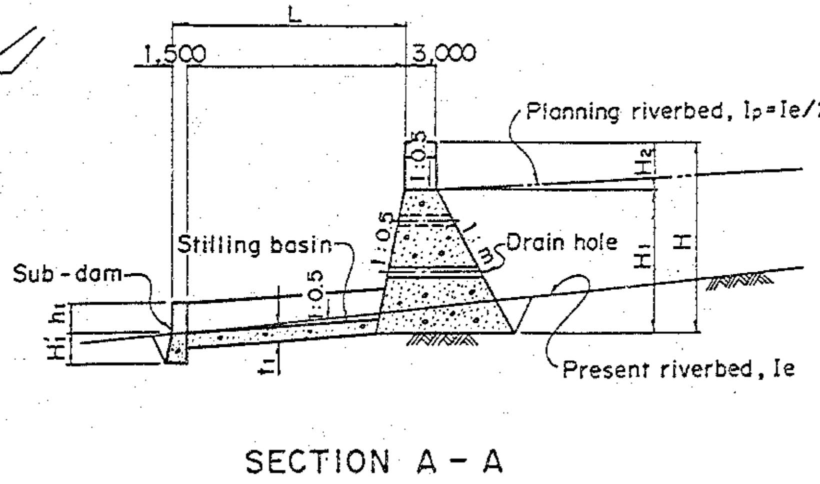


Fig. IV-5-1 Standard Design of Dam

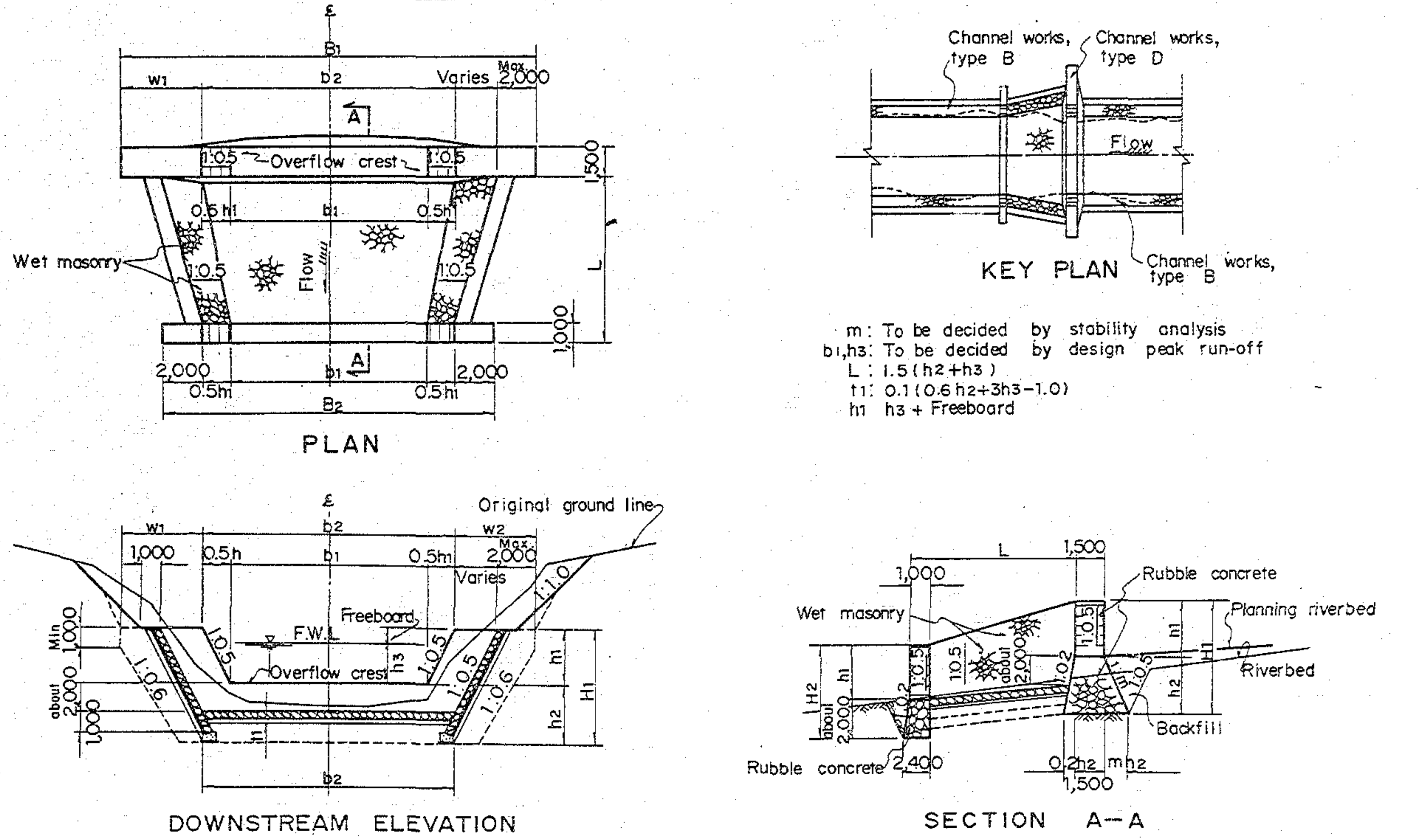


Fig. IV-5-2 Standard Design of Channel Works

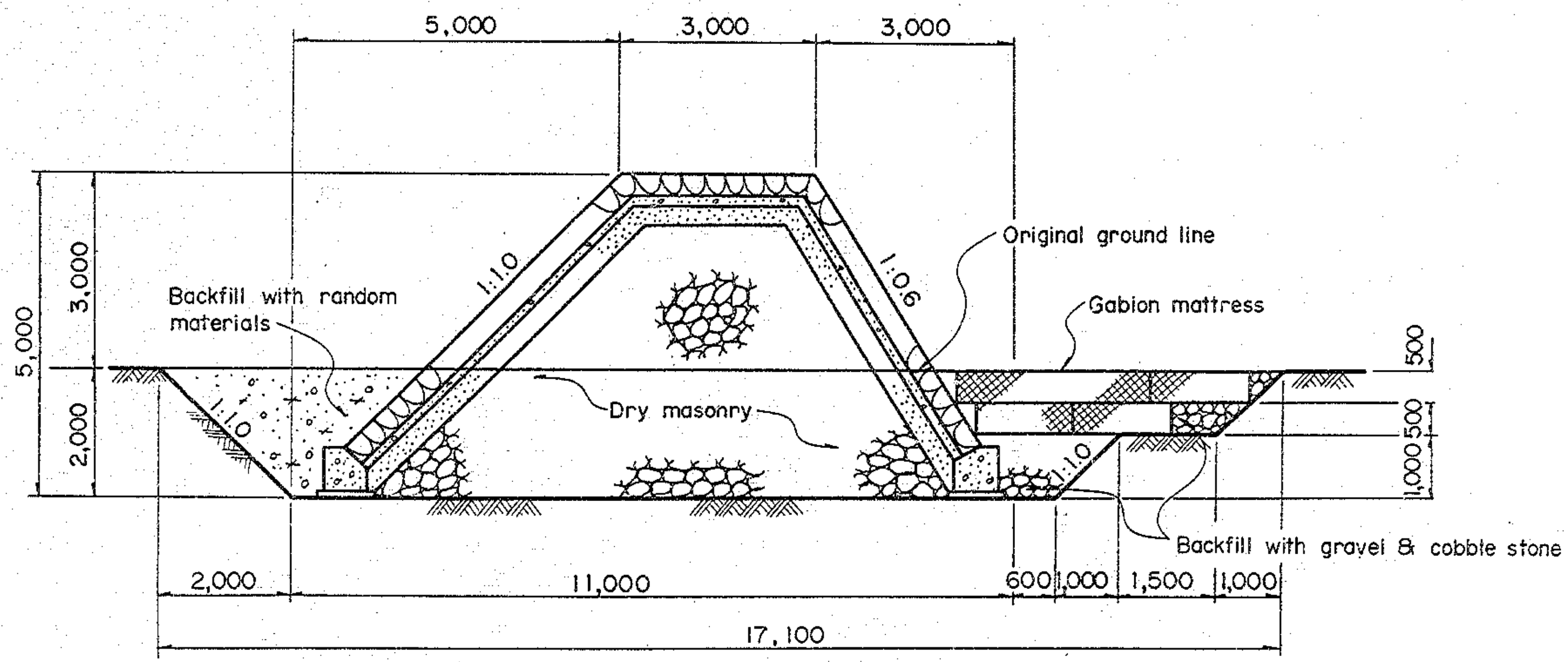


Fig. IV-5-3 Standard Design of Dike

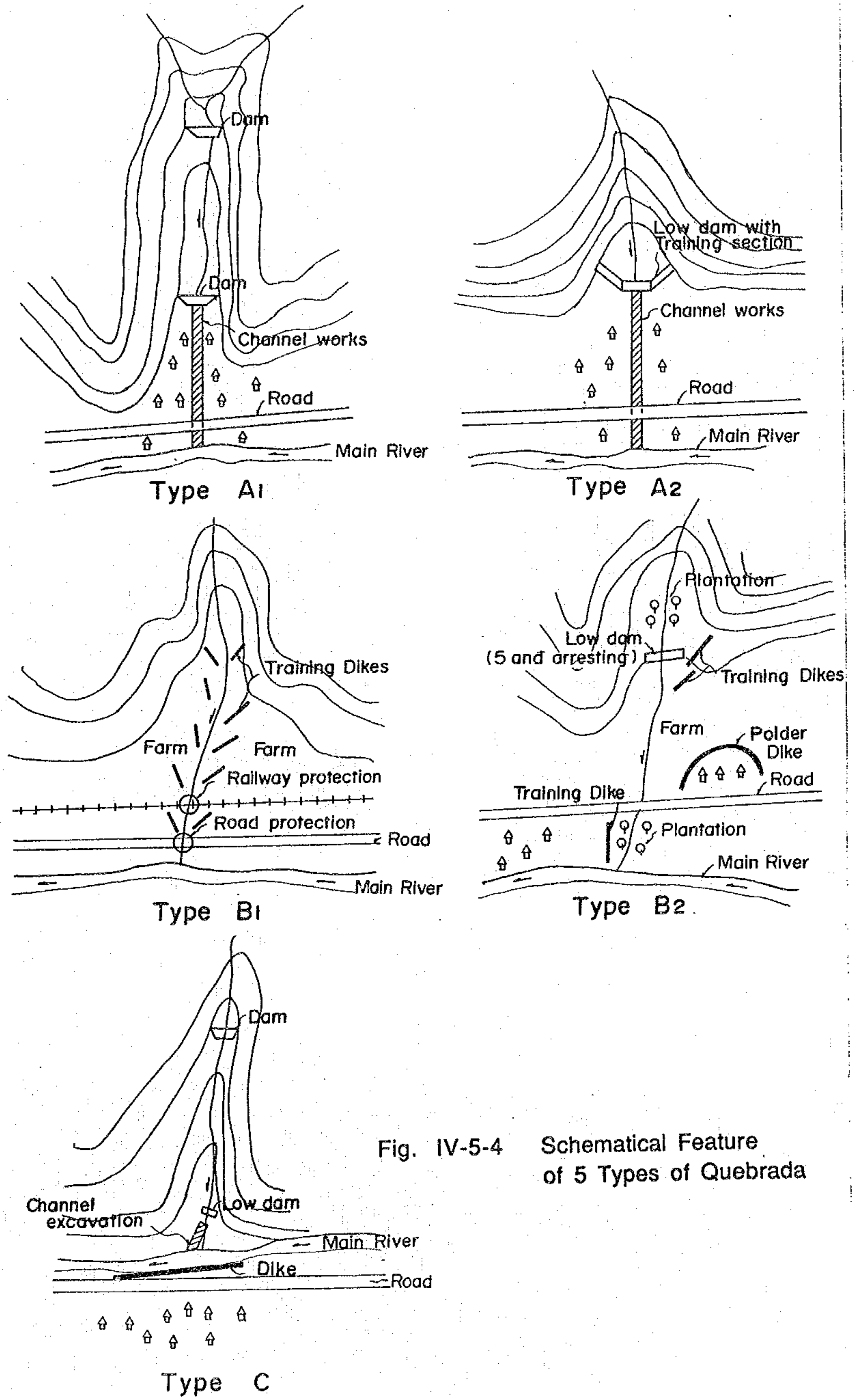


Fig. IV-5-4 Schematical Feature of 5 Types of Quebrada

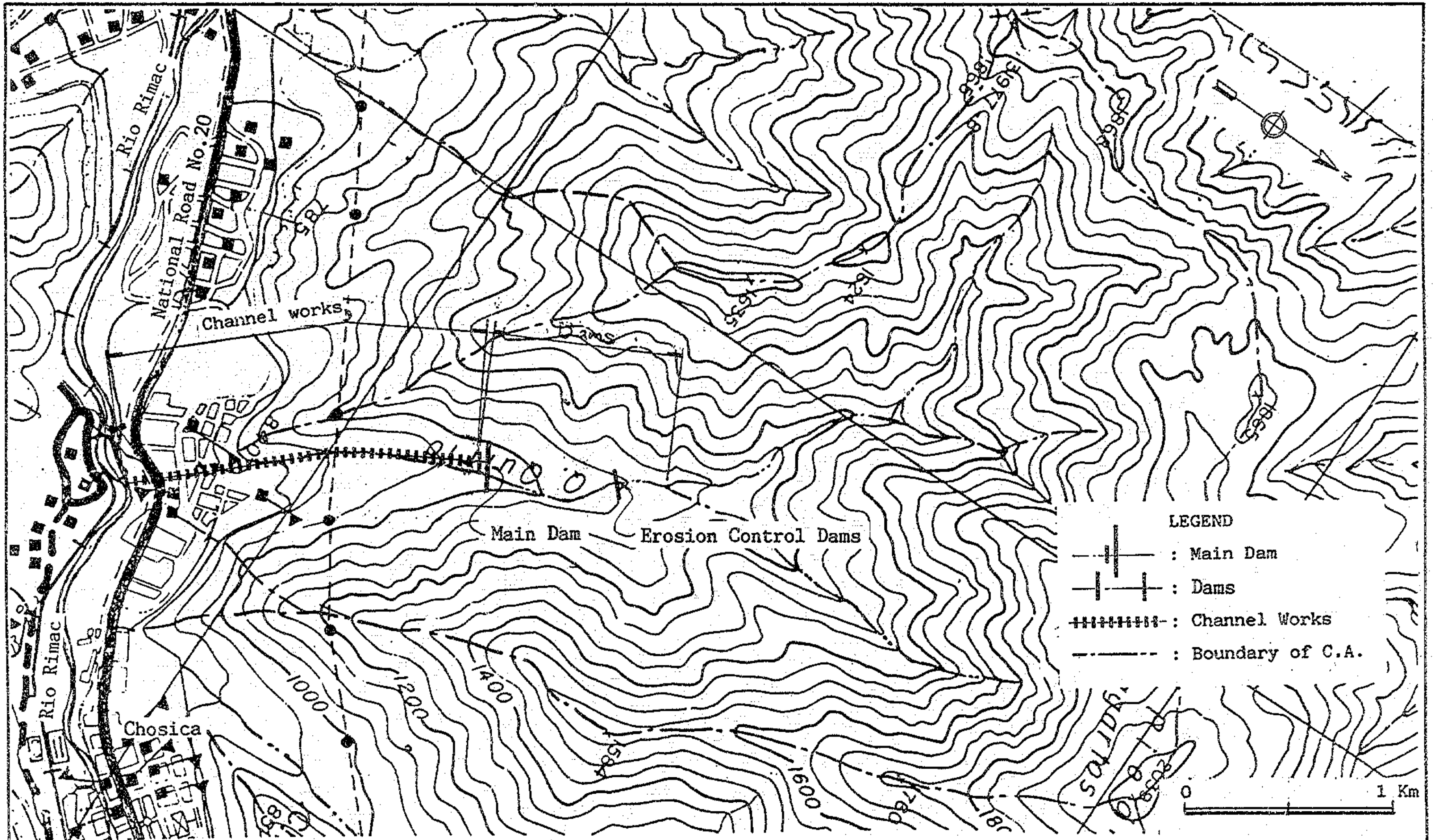


Fig. IV-5-5 Alignment of Channel and General Layout of Structures in Qda Quirio

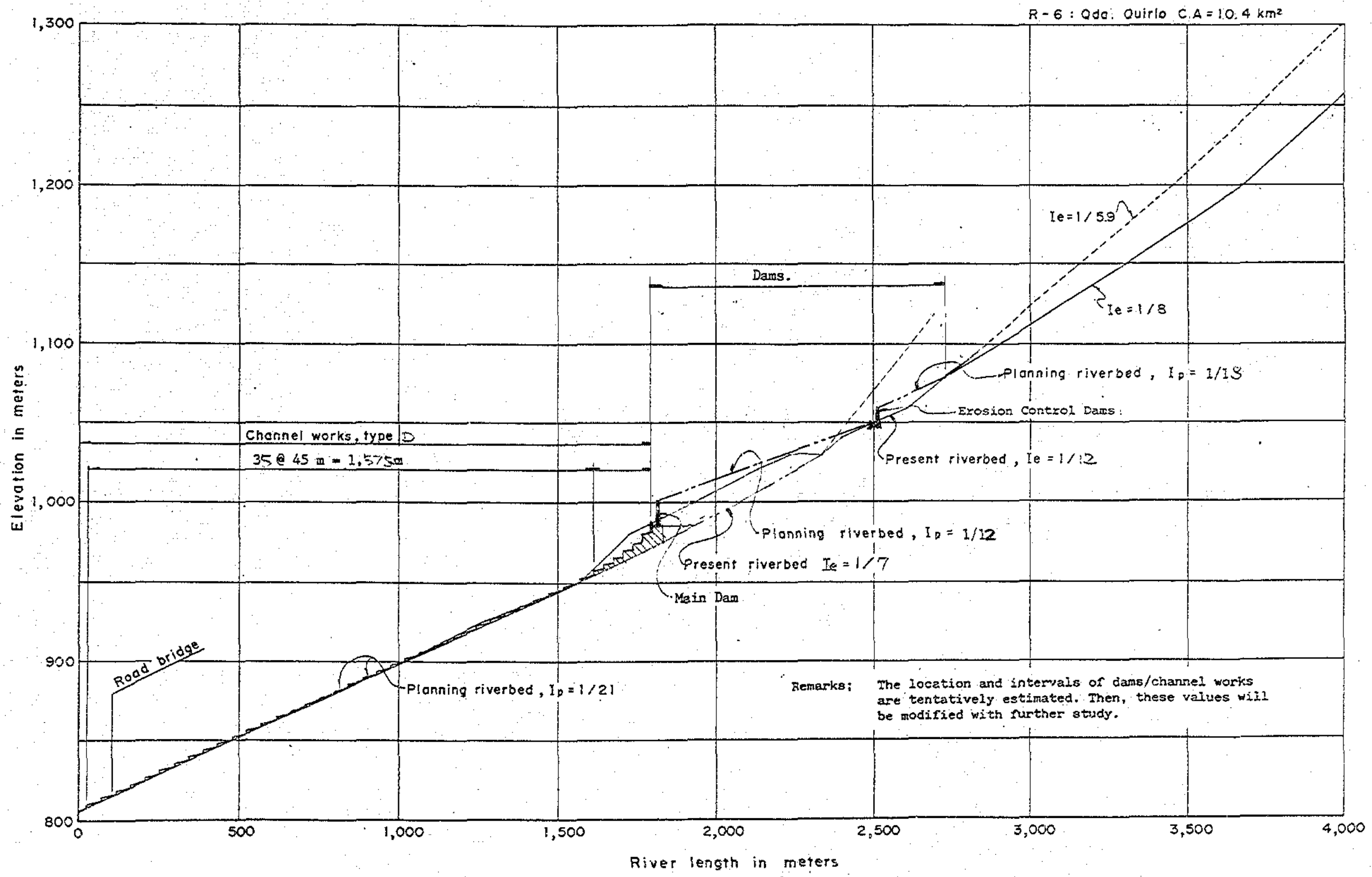


Fig. IV-5-6 Channel Profile and Location of Structures in Qda Quirio