REPUBLICA DEL PERU

MINISTERIO DE AGRICULTURA

INSTITUTO NACIONAL

DE

AMPLIACION DE LA FRONTERA AGRICOLA

(INAF — PE-REHATIC)

FEASIBILITY STUDY
ON
CHANCAY-HUARAL VALLEY
REHABILITATION PROJECT
MAIN REPORT

MARCH 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Republic of Peru, the Japanese Government decided to conduct a survey on the Chancay - Huaral Valley Rehabilitation Project and entrusted the survey to the Japan International Cooperation Agency (JICA).
The JICA sent to Peru a survey team headed by Mr. Narao Takemura from February 15 to August 29, 1984.

The team exchanged views on the Project with the officials concerned of the Government of Peru and conducted a field survey in the Project area. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Republic of Peru for their close cooperation extended to the team.

March, 1985

Keisuke Arita

Keisuke Arita
President
Japan International Cooperation Agency

March , 1985

Mr. Keisuke Arita
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Sir:

Letter of Transmittal

We are great pleasure to submit herewith the report of the feasibility study on the Chancay-Huaral Valley Rehabilitation Project in the Republic of Peru.

The field work carried out apart into two times,i.e.,45 days in first stage beginning on February 15, 1984 and 74 days in second stage beginning on June 15, 1984, here follows the home work by the end of November in the same year.

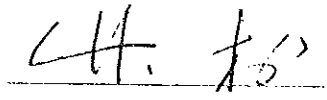
The report includes all aspects concerning the Project, particularly, rehabilitation of the existing irrigation and drainage facilities as designated by JICA.

Results of the study show that the total project cost is estimated at US$41.5 million of which foreign currency portion and local currency portion are US$22.6 million and US$18.9 million, respectively. The economical internal rate of return is calculated at 17.8%.

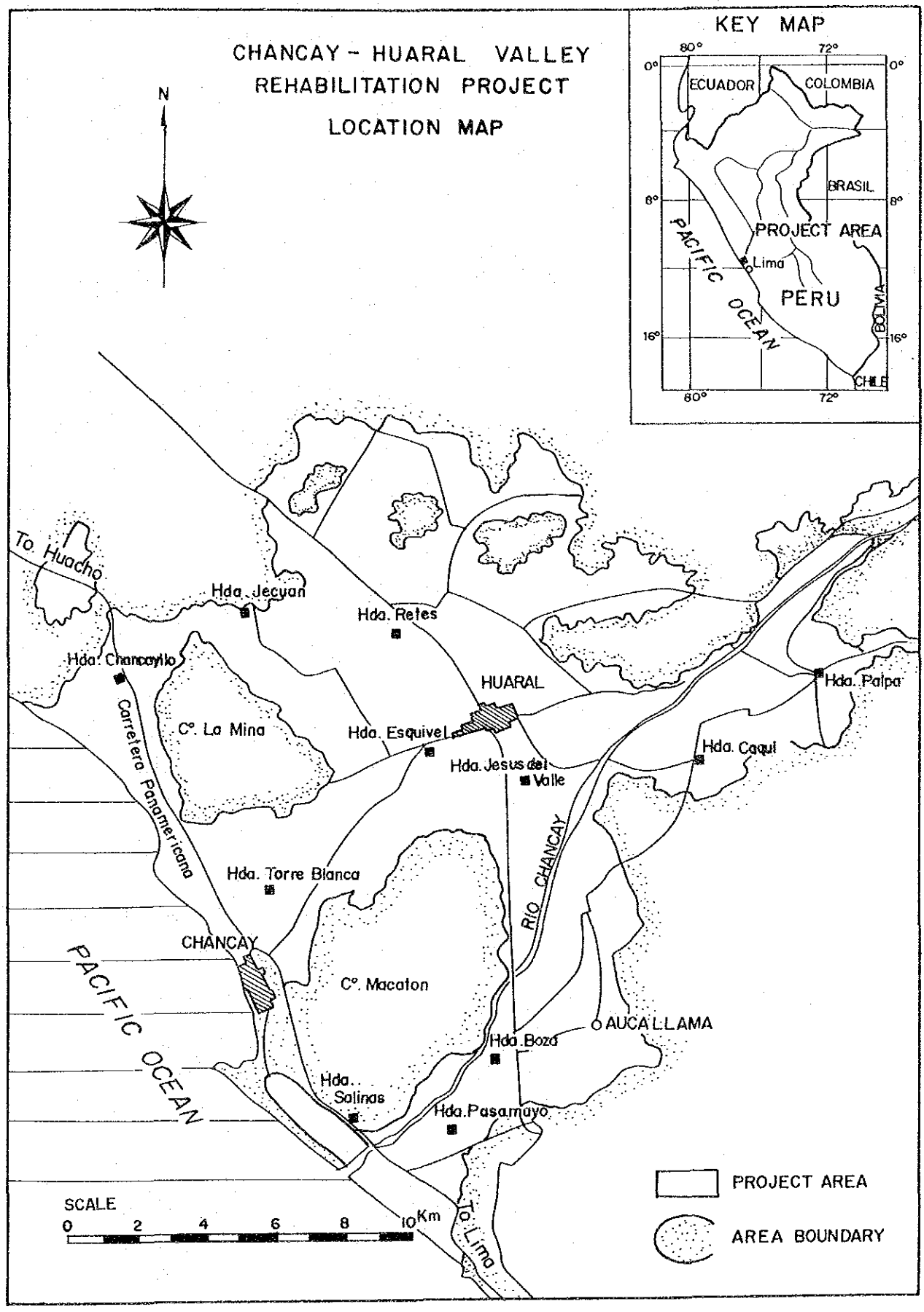
Therefore, the project is considered to be worthy to implement with high priority as early as possible in order to supply sufficient food to the peoples living in Lima and in its neighboring area and to increase the farmers' income who are cultivating in the project area. We wish the project be taken up to early implementation.

We would like to take this opportunity to express a sincere gratitude to the concerned officers and engineer personnel of the agency, the Advisory Committee, the Embassy of Japan in Peru, the Ministry of Foreign Affairs and the Ministry of Agriculture, Forestry and Fishery. We would like also to express our heartfelt thanks to the counterpart experts, officers and engineers of the Ministry of Agriculture and other authorities of the Government of Peru for their close cooperation and supporting shown to us during our field work.

Sincerely yours,

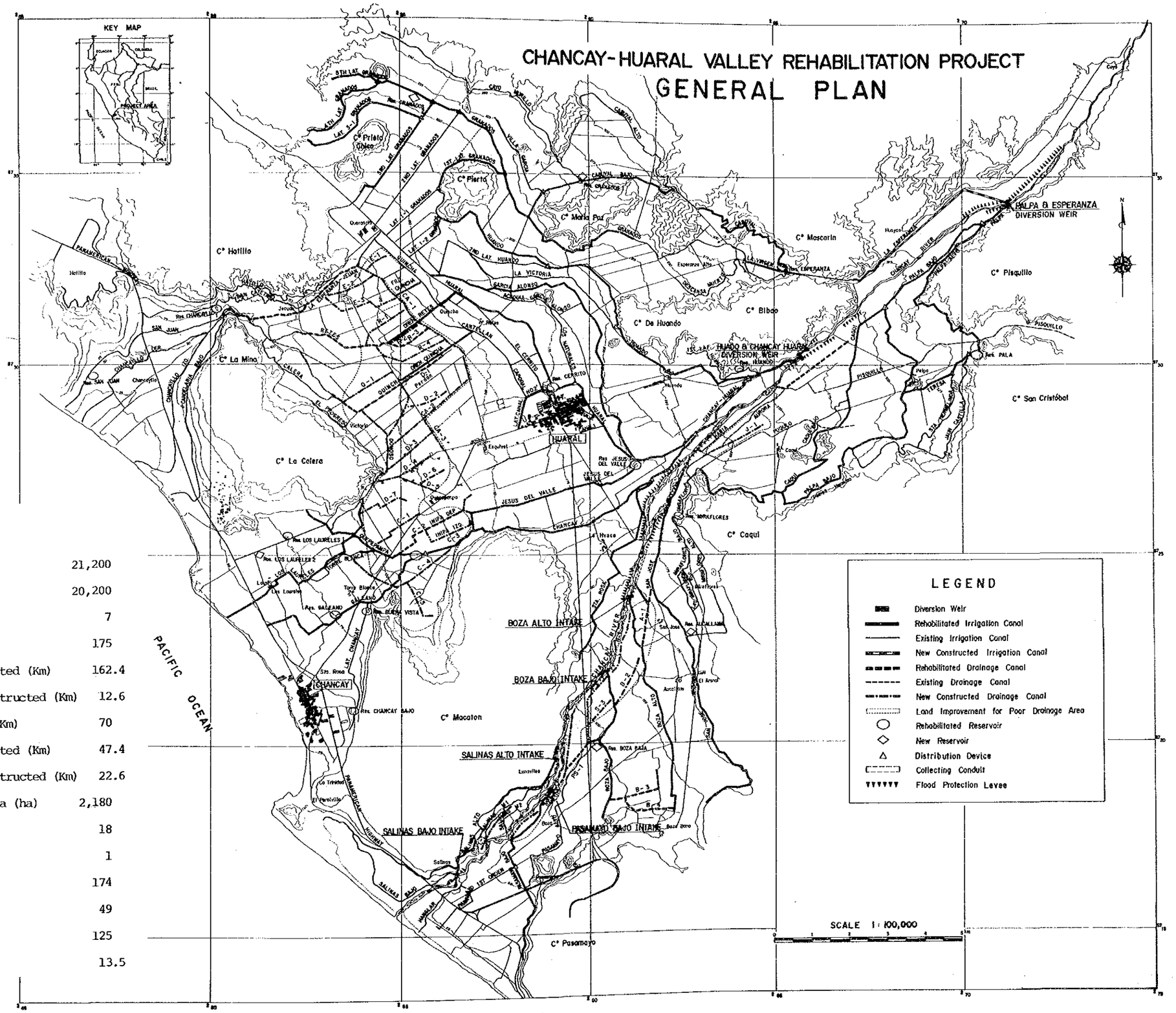


Narao Takemura
Team Leader
Study Team of The Chancay-Huaral
Valley Rehabilitation Project


CHANCAY - HUARAL VALLEY
REHABILITATION PROJECT
LOCATION MAP
N
KEY MAP
80°
72°
0°
ECUADOR
COLOMBIA
BRASIL
8°
PROJECT AREA
Lima
PACIFIC OCEAN
PERU
BOLIVIA
16°
CHILE
To. Huacho
Hda. Jecuan
Hda. Retes
Hda. Chancaylla
HUARAL
Hda. Palpa
Carretera Panamericana
C°. La Mina
Hda. Esquivel
Hda. Jesus del Valle
Hda. Caqui
Hda. Torre Blanca
RIO CHANCAY
CHANCAY
C°. Macaton
AUCALLAMA
Hda. Boza
Hda. Salinas
Hda. Pasamayo
SCALE
0 2 4 6 8 10 Km
To. Lima
PROJECT AREA
AREA BOUNDARY

CHANCAY-HUARAL VALLEY REHABILITATION PROJECT

GENERAL PLAN

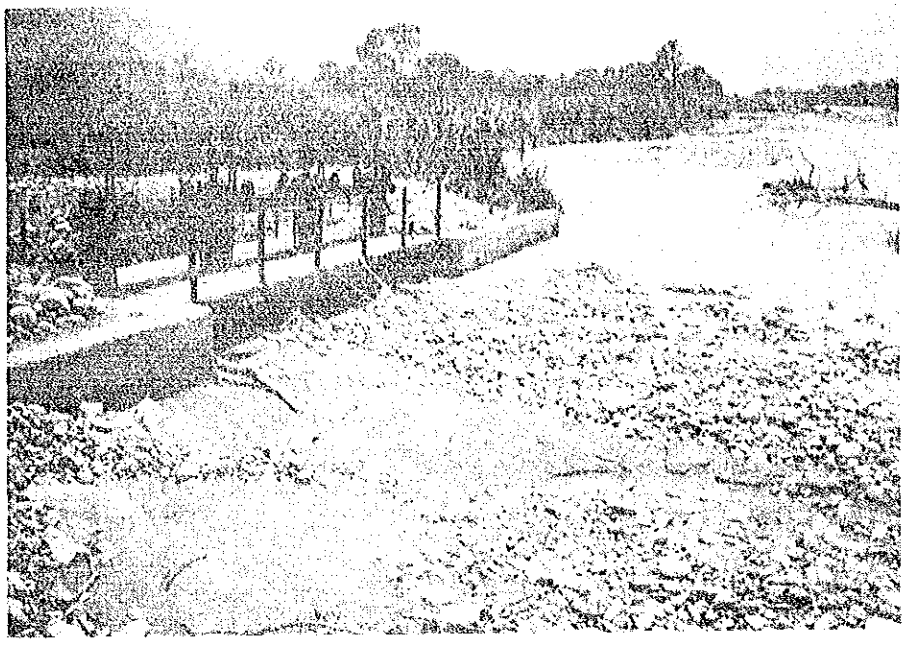


PROJECT SUMMARY

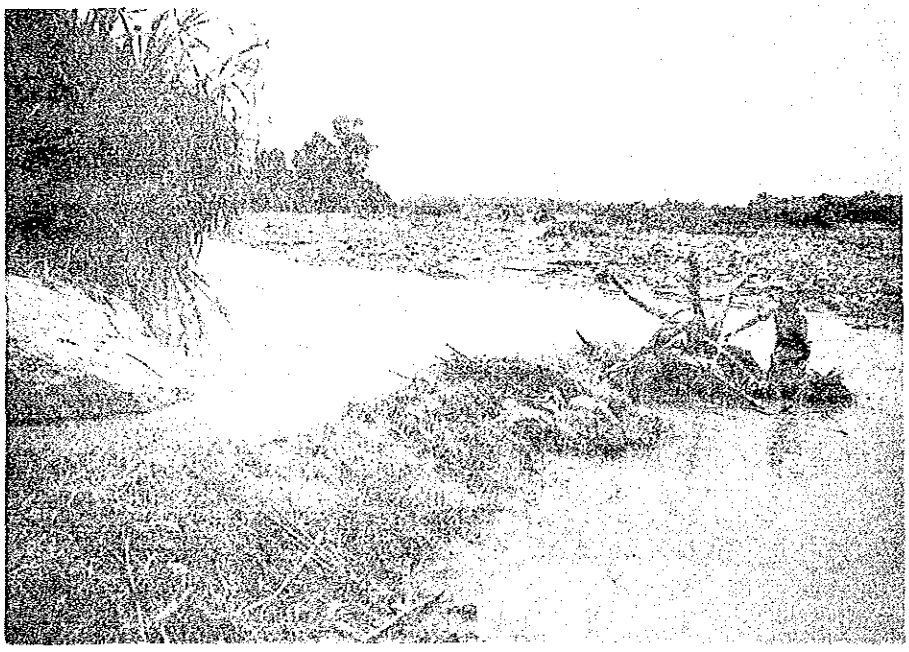
A.	Project Area : Gross (ha)	21,200
	Net (ha)	20,200
B.	No. of Diversion Weir	7
C.	Length of Irrigation Canal (Km)	175
	Length of Canal to be Rehabilitated (Km)	162.4
	Length of Canal to be Newly Constructed (Km)	12.6
D.	Length of Canal Drainage Canal (Km)	70
	Length of Canal to be Rehabilitated (Km)	47.4
	Length of Canal to be Newly Constructed (Km)	22.6
E.	Improvement of Poor Drainage Area (ha)	2,180
F.	No. of Reservoir	18
G.	No. of Collecting Conduit	1
H.	Improvement of Road (Km)	174
	Main Road (Km)	49
	Secondary Road (Km)	125
I.	Protection Levee (Km)	13.5

Boza Area, Salinity Problem Area

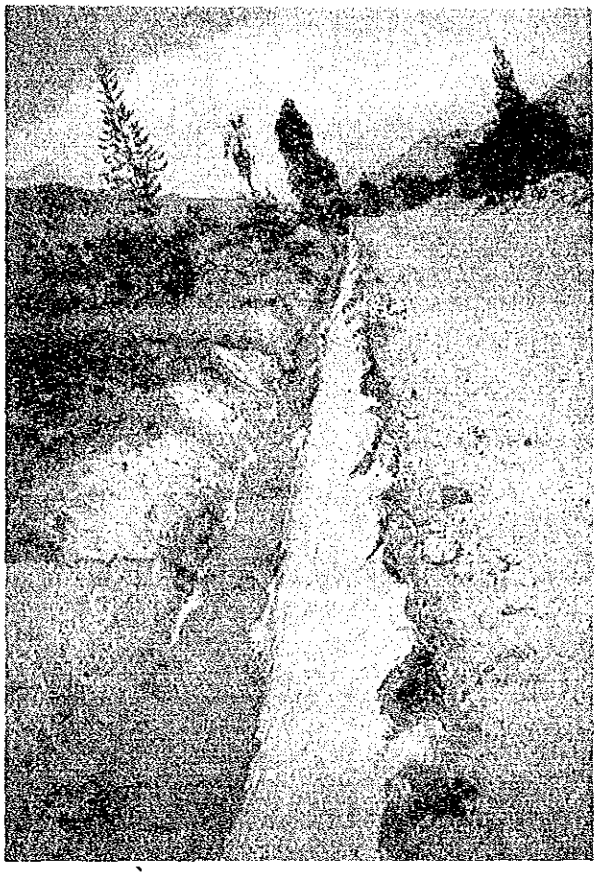
Flood of The River



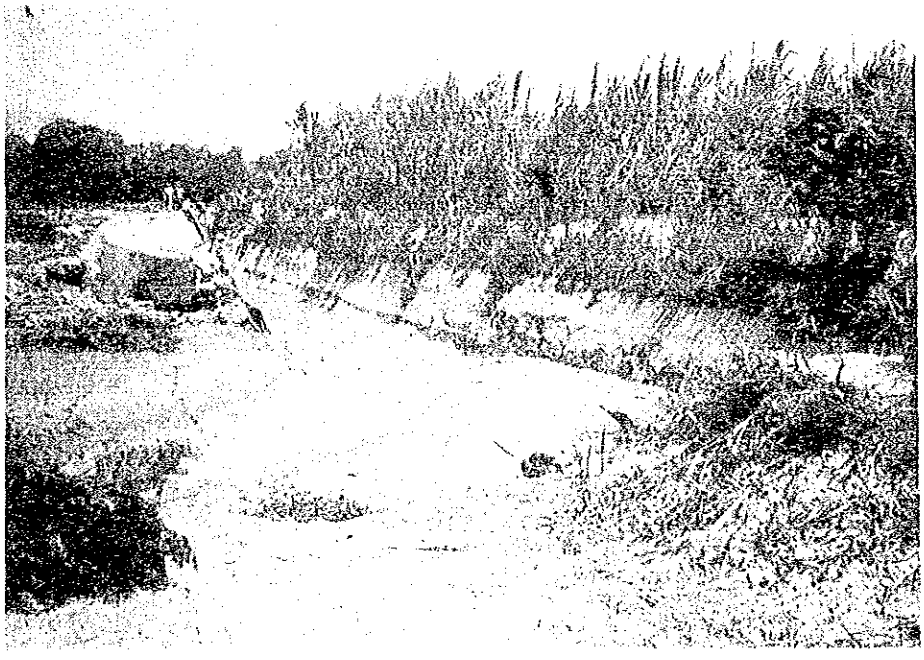
Esperanza Diversion Weir Buried by Sedimentation of Flood



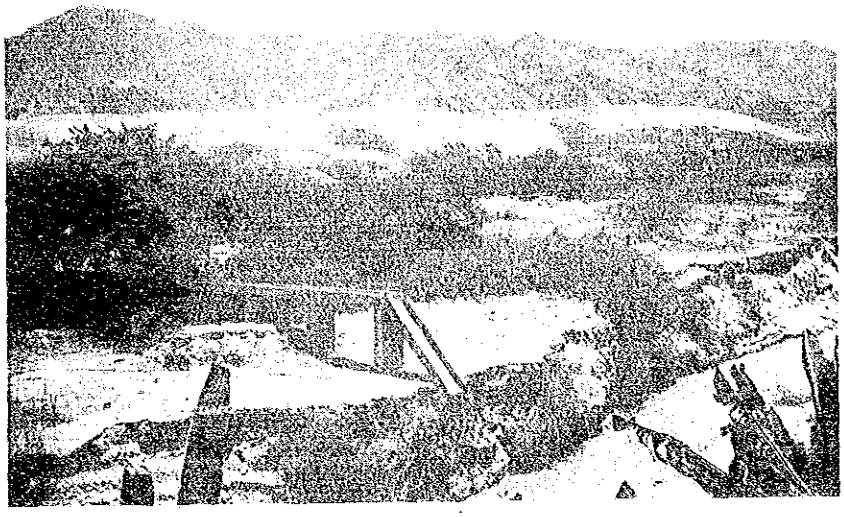
Salinas Intake Structure



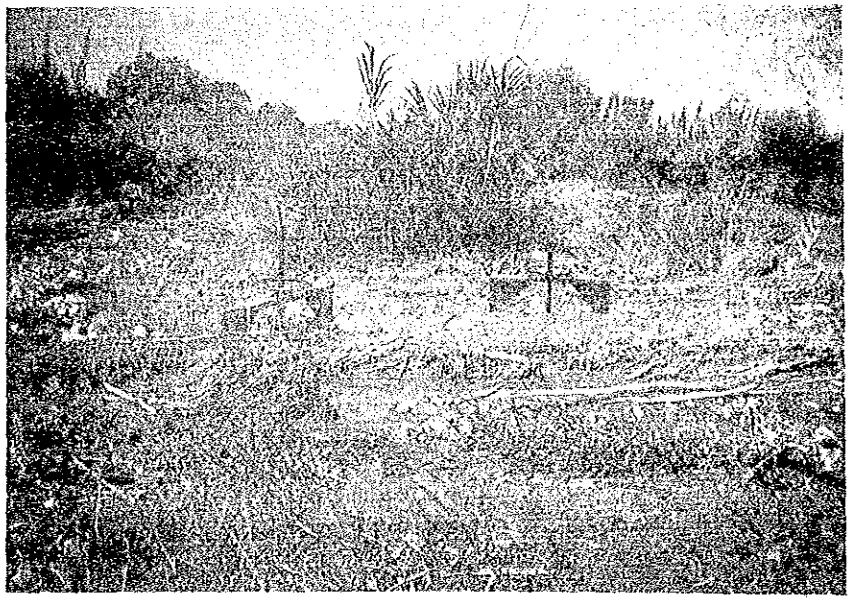
Deteriorated Lining of Irrigation Canal



Esperanza Irrigation Canal Flushed Away by Flood



Aqueduct Destoryed by Flood



Caqui Bifurcation Sedimented by Flood

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VOLUME II

ABBREVIATIONS AND GROSSARY

1) Abbreviations

ATDA	Administracion Tecnica del Distrito Agropecuario
ATDR	Administracion Tecnica del Distrito de Riego
BAP	Banco Agrario del Peru
BCR	Banco Central de Reserva del Peru
BID	Banco Interamericano de Desarrollo
BIRF	Banco Internacional de Reconstruccion y Fomento
CAT	Cooperativa Agraroa de Trabajadores
CAU	Cooperativa Agraria de Usuarios
CIPA	Centro de Investigacion y Promocion Agropecuaria
DEPE-REHATIC	Direccion General del Proyecto Especial de Rehabilitacion de Tierras Costeras
DGAIC	Direccion General de Aguas, Suelos y Irrigaciones
DGASI	Direccion General de Agroindustria y Comercializacion
ENCI	Empresa Nacional de Comercializacion de Insumos
IICA	Instituto Interamericano de Ciencia Agricola
INAF	Instituto Nacional de Ampliacion de la Frontera Agricola

INE	Instituto Nacional de Estadestica
INP	Instituto Nacional de Planificacion
INIPA	Instituto Nacional de Investigacion y Promocion Agropecuaria
JICA	Japan International Cooperation Agency
ONERN	Oficina Nacional de Evaluacion de Recursos Nacionales
OSE	Oficina Sectorial de Estadistica,MAG
OSPA	Oficina Sectorial de Planificacion Agraria
PE-REHATIC	Proyecto Especial de Rehabilitacion de Tierras Costeras
PLANREHATIC	Plan Nacional de Rehabilitacion de Tierras Costeras
R.A.	Region Agraria
SENAMA	Servicio Nacional de Maquinaria Agricola
SENAMHI	Servicio National de Meteorologia y Hidrologia
SENAPA	Servicio Nacional de Agua Potable y Alcantarillado
GDP	Gross Domestic Production
EIRR (IRR)	Economic Internal Rate of Return
F/C	Foreign Currency
L/C	Local Currency

2) Grossary

Km	Kilometer
m	Meter
cm	Centimeter
ton, M.T.	Metric Ton
Kg	Kilogram
g	Gram
l	Litre
m^2 (sq.m)	Square Meter
m^3 (cu.m)	Cubic Meter
ha	Hectare
m^3/sec	Cubic Meter per Second
mmhos/cm, mS/cm	Millimhos per Centimeter
Ec	Electrical Conductivity
ppm	Part per Million
Kwh	Kilowatt Hour
$	U.S. Dollar
s/.	Sol de.Oro

ϕ	Diameter
°C	Centi Grade
hr	Hour
min	Minute
sec	Second
%	Percent
HP	Horse Power (75kg,m/sec)
qq	Quintal (46kg)

3) EXCHANGE RATE

Exchange rate	Date
US$ = s/. 1,060	End of January, 1983
US$ = s/. 1,730	End of July, 1983
US$ = s/. 2,360	End of January, 1984
US$ = s/. 3,450	End of July, 1984

SUMMARY OF THE PROJECT, CONCLUSION AND RECOMMENDATION

SUMMARY OF THE PROJECT, CONCLUSION AND RECOMMENDATION

1. SUMMARY OF THE PROJECT

1-1 Objectives

The objectives of the project are rehabilitation of superannuated irrigation and drainage facilities and improvement of salt accumulated farm land spreading out to the lower reaches of the Chancay River for increasing agricultural productivity, and stabilization and grade-up of farm household so as to contribute to the regional economic development.

1-2 The Problems and Actual Situation in the Project Area

(1) Actual situation

- The project area is located in north northwest approximately 80 km from Lima, and is easily accessable and of favorable locality transportation.

- The climate is warm and mild regardless of low latitude due to the influence of the Humboldt Sea Current (Peruvian current),however, rainfall is experienced in a little amount.

- The project area is the alluvial plains which has been formed by the sediments of the Chancay River running in the south of the project area from east and west.

- An area of Chancay River basin is estimated 3,454 km^2 and the annual discharge is 533.6 million m^3 in average. But most of discharge flashes away in short time after every rainfall because of rapid stream.

- Farm land of 20,200 ha is extended in the project area and of which irrigation water is taken from the Chancay River.

- Area is classified by manners of taking irrigation water as follows;

  . diverted directly from the river through the year round
  . diverted from the river in only wet season
    and collected infiltrated water from the upstream area in dry season
  . used return flow from the upstream area through the year round
  . used sewage water from Huaral town.

- Farm land is mostly private proprietary except 1,578 ha of common land by cooperatives. Average land is about 4.0 ha per farm household and 85% of farmers hold farm land less than 6.0 ha.

- The farming patterns are characteristic in the project area as follows;

  . The upper reaches of right bank: Citrus and Apple
  . The middle reaches of right bank: Cotton, Maize
  . The down reaches of right bank: Vegetables, Maize
  . The upper reaches of left bank: Cotton, Maize
  . The down reaches of left bank: Maize, Vegetables

(2) The problems and necessity of the rehabilitation

Constraints for agricultural development in the project area are as follows;

- Prevailing shortage of irrigation water caused by deterioration of existing facilities.

- Poor drainage condition in the lower area by poor and super-annuated drainage facilities.

- Salinity accumulate in the arable land.

- Inundation in the lower area of Palpa.

- Less developed farming technology and water management.

Decreasing of the productivity is not only economical loss but also the cause of declining incentive of production. Accordingly, the above mentioned points should be improved promptly.

Furthermore, these measures should be carried out together with the comprehensive improvement plan covering land use, agriculture and livestock production, farm management, water usage and maintenance for the facilities.

1-3 Major Items of the Project

- Irrigable area	:	20,200 ha
Right bank	:	14,480 ha
Left bank	:	5,720 ha
- Water requirements		
Annually	:	211,844,000 m^3
For irrigation water	:	201,274,000 m^3
For water supply and industrial water	:	10,570,000 m^3
- Available amount of water sources		
River discharge	:	131,643,000 m^3 (Return period 1/10 year)
Return flow	:	46,058,000 m^3
Lagoon water	:	24,000,000 m^3 (At the site of Palpa)
Ground water	:	10,146,000 m^3
- Poor drainage area to be improved	:	2,180 ha
- Area to be desalinized	:	1,430 ha

- Improvement of the facilities

. Diversion facilities		
Construction of new diversion weir	:	2 in upstream
Rehabilitation of intake structures	:	5 in downstream
Construction of new collecting conduit	:	1
. Irrigation canals	:	175.0 km
Rehabilitation	:	162.4 km
Newly installation	:	12.6 km
. Reservoirs in the project area		
Rehabilitation	:	13 storage capacity 250,000 m^3
Newly installation	:	5 storage capacity 76,000 m^3
. Drainage canals	:	70km
. Pipe drains	:	407km
. Roads Improvement	:	174km
Improvement of main bridges	:	2
. Levee	:	13.5 Km

- Construction cost	:	US$41,474,000
Foreign currency portion	:	US$22,584,000
Local currency portion	:	US$18,890,000
- Operation and maintenance costs	:	US$964,000/year (US$48/ha/year)
- Project implementation period	:	6.5 years including D/D

- Major crops

Citrus	:	2,120 ha
Apple	:	1,680 ha
Maracuya	:	550 ha
Grape and others	:	2,180 ha
Cotton	:	5,660 ha
Maize	:	5,660 ha
Beans	:	2,830 ha
Green manure	:	2,830 ha
Vegetables and others	:	5,425 ha
Total	:	28,935 ha
Planting rate	:	143%
Planting increase	:	5,455 ha

- Benefit

. Net benefit increase of agricultural products	:	US$18,600,000/year
. Cost saving by improved operation and maintenance	:	US$101,000/year
. Benefit of road	:	US$284,000/year

- Evaluation

. Economic internal rate of return	:	17.8%
. Sensitivity analysis	:	12 -- 20%

2. CONCLUSION

The results of feasibility study of the Chancay-Huaral valley rehabilitation project, of which area is 20,200ha vested water right have drawn the following conclusions.

(1) In order to eliminate the impeded primary factors such as superannuated irrigation facilities, water shortage, salinity problem and poor drainage conditions, the project should be urgently implemented.

(2) To achieve the target, major civil works of the project are proposed as follows;

- Unification and/or improvement of intake facilities;
  - . Unification and newly installation : 2 diversion weirs
  - . Rehabilitation : 5 intake structures
  - . Collecting conduit : 1 place

- Rehabilitation and new construction of canals;
  - . Rehabilitation : 162.4 km
  - . New construction : 12.6 km

- Rehabilitation and installation of reservoirs;
  - . Rehabilitation : 13 reservoirs
  - . Newly installation : 5 reservoirs

- Rehabilitation and installation of pipe drain and drainage canals;
  - . Pipe drains : 407 km
  - . Drainage canals : 70 km

- Improvement of roads;
  - . Rehabilitation : 174.0 km
  - . Levee (Levetment) : 13.5 Km

(3) Estimated total construction cost is US$41,474,000.

. Foreign currency portion	:	US$22,584,000
. Local currency portion	:	US$18,890,000

(4) Construction period is expected to be 6.5 years including detailed design period.

(5) If the project is executed as originally scheduled, the benefit equivalent to US$18,985,000 in the target year is anticipated.

(6) The economic internal rate of return is calculated for 50 years after completion of the civil works and its numerical value is 17.8%, and 12% -- 20% with sensitivity analysis in consideration with condition of alteration in future. This EIRR shows that the project is in high priority in comparison with another similar project in Peru.

(7) The results of farm managements' analysis study shows that economical status of farmers household will be quickly improved after completion of the Project.

3. RECOMMENDATIONS

(1) Due to an urgency and profitability of the project, the Perurian government should be prepared to undertake the project implementation as soon as possible. Then, it is also recommended to take action in preparation on the following items;

- Formation of the project coordinating committee of the government and private sector.

- Preparation for formation of the organization of project execution in accordance with the project implementation.

- Explanation of the project to the concerned farmers and people in the project area.

- Land acquisition and the alteration of water right based on the project plan.

(2) In order to establish the project successfully, the following items are necessary to be taken.

a. Operation and maintenance manners of the completed facilities should be clarified and specification for water management should be stipulated.

b. Establishment and transfer of new farming technology such as cultivating in the consolidated farm land water management, mitigation of salinity problems and preventing measures of alkali soil to the concerned farmers are inevitable in the project area.

To conduct the abovementioned measures smoothly, the following proposals are suggested.

a An experimental station should be furnished. Fortunately, in the project area, the CIPA experimental station are organized in Huaral. Therefore, it is one of the best idea to strengthen the existing experimental station.

b *Designation and demonstration of model farm:*

New farming technology can be transfered in the model farm to the farmers through qualified farmers.

Establishment of the abovementioned experimental station farm and model farm should be commenced as early as possible so that these better farming technology will be achieved before completion of the project.

The followings are items to be completed before end of the project implementation.

a. Strengthening of water management organization, training of staff in charge of water management and provision of operation and maintenace manuals of newly constructed facilities.

b. Cooperation of existing supporting organization and organizing for mobilization.

c. Establishment of farm mechanization center.

d. In order to strengthen the existing agricultural cooperatives to meet completion of the Project, and to improve the present marketing system, cooperation and supporting of the concerned organization will be needed.

(3) In order to obtain additional data and information for detailed design and to study operation and maintenance of the Project, the following study and investigations are recommended to continue.

a. Additional automatic rainfall gauging stations should be installed in drainage area of major tributaries.

b. Observation of river water level at the site of existing intake structures.

c. Re-arrangement of present irrigation blocks and rotation blocks.

This re-arrangement should be conducted based on the results of the study carried out in the experimental station mentioned in (2) of the recommendation.

Regarding this issue, understanding and agreement of the concerned farmers are indispensable. Therefore, possibility and problems of this issue should be clarified before on-set of the detailed design.

(4) In order to design the major structures during the detailed design, surveying and geological exploration of the site should be taken place. Furthermore, hydraulic model test of the Palpa diversion weir which is one of the major structures in the project is proposed by the study team.

(5) In order to utilize more effectively the water resources in the Chancay Huaral River basin, the following items should be studied.

a. Groundwater resources should be pumped up deliberately because of difficulty in catching the exact potential capacity of the groundwater. To this end, pumping up of the wells should be controlled to prevent from over suction and fluctuation of water surface in the wells should be always checked.

b. Water from wells are normally used by individuals or s small group of farmers. Therefore, understanding of the users will be necessary when such water resources is incorporated into common water resources of the Project. In such case, it is needed to examine allocation of operation and maintenance cost of the wells.

c. In case of unification of the existing intake structures, possibility of mini hydro-power generation with maximum capacity of around 570kw utilizing hydraulic balance of 13 m on the way of connecting canal between Huand and Chancay - Huaral.

This possibility of generating hydro-power seems to be worthy examined.

d. Regarding lagoons located in upstream area, it is desirable to exploit these lagoons in correspondence with increasing of water demand in future. Particularly, seven lagoons operated by the Ministry of Agriculture should be rehabilitated and maintained to be fully utilized. (Refer to annex L)

e. Sewage water is re-used for irrigation purpose in the area downstream from Huaral Town. However, cultivation of vegetables in this area is not allowed from view of sanitary standpoint. Small area (19 ha) is currently irrigated by plant should be provided because sewage water amount will increase in near future.

f. Orchard in the upstream area and vegetable cultivating area in the downstream area of the Project are definitely and technically suitable to introduce drip or splinkler irrigation. Therefore, dissemination of drip and splinkler irrigation will be urgent in order to utilize valuable water resources effectively. (Refer to annex G)

CHAPTER 1. PREFACE

CHAPTER 1. PREFACE

1 Background of the Project

The Government of Peru has put emphasis with highest priority on the promotion of the the agricultural sector in the 5-year national economic plan 1983-1987 and in its policy is described as follows:

- To strive for improvement of living conditions and standards of its rural inhabitants;

- To promote an increase of agriculture and live-stock productivity for food security;

- To create the employment opportunities through agricultural development in the Andean high land and the tropical forest, also to accelerate the promotion of agriculture and live-stock production using the initiative of the private sector in the coastal region;

- To promote the introduction of new techniques to farmers according to the comprehensive plan including investigation, extension, etc;

- To push forward the organization of rural communities and the settlement of farmers by performance of the over-all development;

- To strive for the national utilization of natural resources and its conservation.

As one of the developmental plans following the above mentioned policy, the Caostal Region Rehabilitation Plan (Plan Nacional de Rehabilitacion de Tierras Costeras) has been established, and some of its projects are already taking definite form.

The Chancay-Huaral Valley Rehabilitation Project (Proyecto de Rehabilitatio del valle Chancay-Huaral) is one of the above projects known as PLANREHATIC III.

The project site is situated in north northwest approximately 80 km from Lima and includes an area of arable land of 20,000 ha., which spread out over the lower reaches of the Chancay River.

This arable land is utilizing water from the Chancay River as irrigation water, but the problem for farming have appeared, e.g., water shortages, poor drainage, salt accumulation in the soil, increase of maintenance cost for irrigation facilities, etc. These problems are due to existing superannuated irrigation and drainage facilities.

In consideration of the importance of this project, the Peruvian government requested technical cooperation to carry out a feasibility study on the project to the Japanese government on June 10, 1983.

In response to the request, the Japanese government concluded an agreement with the Peruvian government on the subject of the scope of work on December 16, 1983.

1-2 Object of the Project

The project area contiguous to Lima is playing an important role to the metropolitan area as a food (fresh vegetables) and agroindustrial crop production area. The object of the project is to increase agricultural and live-stock production by means of rehabilitation of irrigation and drainage facilities and salt accumulated farm land, the improvement of agricultural infrastructure such as rural roads, etc., and elevating the technical level of farmers on farm management including water management.

The project will contribute to the stabilization of the national economy by reducing the importation of food and increasing the export of agricultural products and by improving of the nutritional level of people.

The project intends to stabilize the farm household economy, the expansion of employment opportunities, and economical impact to related industry.

1-3 Study

1-3-1 Object

The study was commenced on February 15, 1984 on the basis of the agreement concluded between the Peruvian and the Japanese governments.

The study will evaluate the project's feasibility to attain the above mentioned improvements and rehabilitations.

1-3-2 Limits of the project area and its study

The project area is an arable land of approximately 20,000 ha. which spreads out over the lower reaches of the Chancay River.

Collected data and information, and field studies on the following items include:

- Natural environment;
- Existing farm management and cropping patterns;
- Marketing system and price of agricultural products;
- Agricultural economy and institutions;
- Existing irrigation and drainage systems and their facilities;
- Flood and sediment;
- Actual situation of groundwater use;
- Social infrastructure;
- Construction materials and their prices.

These survey and studies have been carried out apart into two times of Japanese fiscal years, 1983 and 1984.

After the examination and analysis at the home office, a report has been prepared relative to the following items:

- Establishment of an over-all rehabilitation plan;
- Recommendation on the water resource development in the whole Chancay River basin;
- The schedule of the project;
- Establishment of operation and maintenance program for the project;
- Estimation of the cost/benefit ratio of the project;
- Economic and financial analysis.

1-3-3 Progress and a person in charge

The field study and the project formulation work were carried out according to the following schedule.

First stage of the field study: 45 days, started on February 15, (Humid period) 1984
Second stage of the field study: 75 days, started on June 15, 1984 (Droughty period)
Home works: Until the end of November, 1984 after completion of the second stage of the field study.

The feasibility study was carried out by the study team (first stage: 8 members, second stage: 11 members), dispatched by the Japanese government (Japan International Cooperation Agency-JICA), in cooperationof Peruvian counterparts and four persons are also nominated to supervise the feasibility study from the Japanese government. Their name list is attached at the end of this report.

During a period of the field study, the study team has exchanged views with the Peruvian agency concerned on the subject of the project formulation (Refer to the paper at the end of this report).

The reports submitted to the Peruvian government from the study team during a period of the field study are as follow, and described minutes on the planning, schedule and result of the study.

- Plan of operation February, 1984
- Progress report March, 1984
- Inception report June, 1984
- Field report August, 1984

1-4 Formation of the Report

The report is compiled by four volumes as follows:

Main report	(Japanese, English)
Annex	(English)
Drawings	(English)
Summary	(Spanish)

The annex is contains the following sections.

Annex A Meteorology and Hydrology
B Geology and Groundwater
C Soil and Land Classification
D Salinity Control
E Agriculture
F Agricultural Economy
G Irrigation and Drainage
H Infrastructure
I Project Implementation and Cost Estimation
J Operation and Maintenance
K Economic Evaluation and Financial Analysis
L Others

CHAPTER 2. PRESENT STATUS OF THE PROJECT AREA AND ITS CONSTRAINTS

CHAPTER 2. PRESENT STATUS OF THE PROJECT AREA AND ITS CONSTRAINTS

2-1 Physical Condition

2-1-1 Configuration and geology

The region including the Project area is situated in north-north west of Lima and is gently sloped toward the Pacific Ocean. Climate of the Project area is relatively mild regardless of low latitude due to influence of the Humboldt Sea Current. However, flat area is mostly occupied by the desert and small area of farm land because of almost no precipitation year round. Southern part of the Project area is penetrated by the Chancay River, which is principal water resource for this area and supplied irrigation water to the farm land extending in the Chancay Huaral Valley and distributes domestic water to the peoples living in the area along the River. The Chancay River is originated from western part of the Andes Mountains range and flows down in steep river coarse of about 105 km in length meandering among the deep mountainous area. The drainage area of the Chancy River is estimated at approximately 3,454 square km , of which 90% is extended in the mountainous area. The area of more than 4,000 m in altitude is covered by mosses and Alpine trees due to high land area with heavy rainfall. While little vegetation such as cactus variety can be seen among outcrop of the rocks and sedimented sand and gravels in middle reach of the River.

The valley opens out into a fluvial plain at Palpa. The formation of the fluvial plain which was governed by hills, Macaton, La Mina and La Calera, also influenced formation of another plain on the right bank slope of diminishing gradient in the Huaral valley while on the left bank hills, Tinchera, Atalaya and Huand the Palpa and Boza planation surfaces were formed.

On the Chancay River bank, a fluvial terrace and a terrace scarp have developed from the vicissitudes of the river stream and on the coast, a marine terrace was formed by from sea level and cruatal movement. The coastal plain is located along the long narrow coastal

strip with a length of about 8 km southward from Chancay town and a width of 0.5--1.0 km.

Geology in the Project area consists of batholith, coastal bedrock and deposits, as shown in Fig.2-1-1. The batholith of the Chancay River basin is a plutonic rock denominated as Coastal Batholith which consists of diorite, tonalite and granodiorite. The batholith is an intrusive rock from the Cretaceous to Tertiary Period. Diorite and granodiorite are observed in the Project area, and distributed on the northeastern hills of the Huaral district and the Aucallama district.

The coastal bedrocks distributed in the Chancay district are volcanic sedimentary rocks, denominated as the Puente Piedro formation, compounded by bolcanic fluids, andestitic flows, mudstones and tuffaceous sandstones formed from the Jurassic to the Cretaceous.

Deposits in the Project area are classified into fluvial, eolian, compound and marine deposits. The fluvial deposits are observed on existing plains, alluvial area and terraces, and consists of clays, sands, gravels and boulders and broken stones. Eolian deposits are observed on the slopes, foothills and mountains, and also formed the dunes along the coast. The said deposits mainly consist of medium to fine sands. Compound deposits are formed in the currents of intermittent floods and consist of alternate deposits of fluvial layer and eolian layer. The deposits may be observed in dried river beds of the area and consist of sands, gravels, eolian sands with gravels, angular fragments and residual fine sands. Marine deposits are observed on the coast near the Chancay river's estuary, consisting of sand layers with a shell.

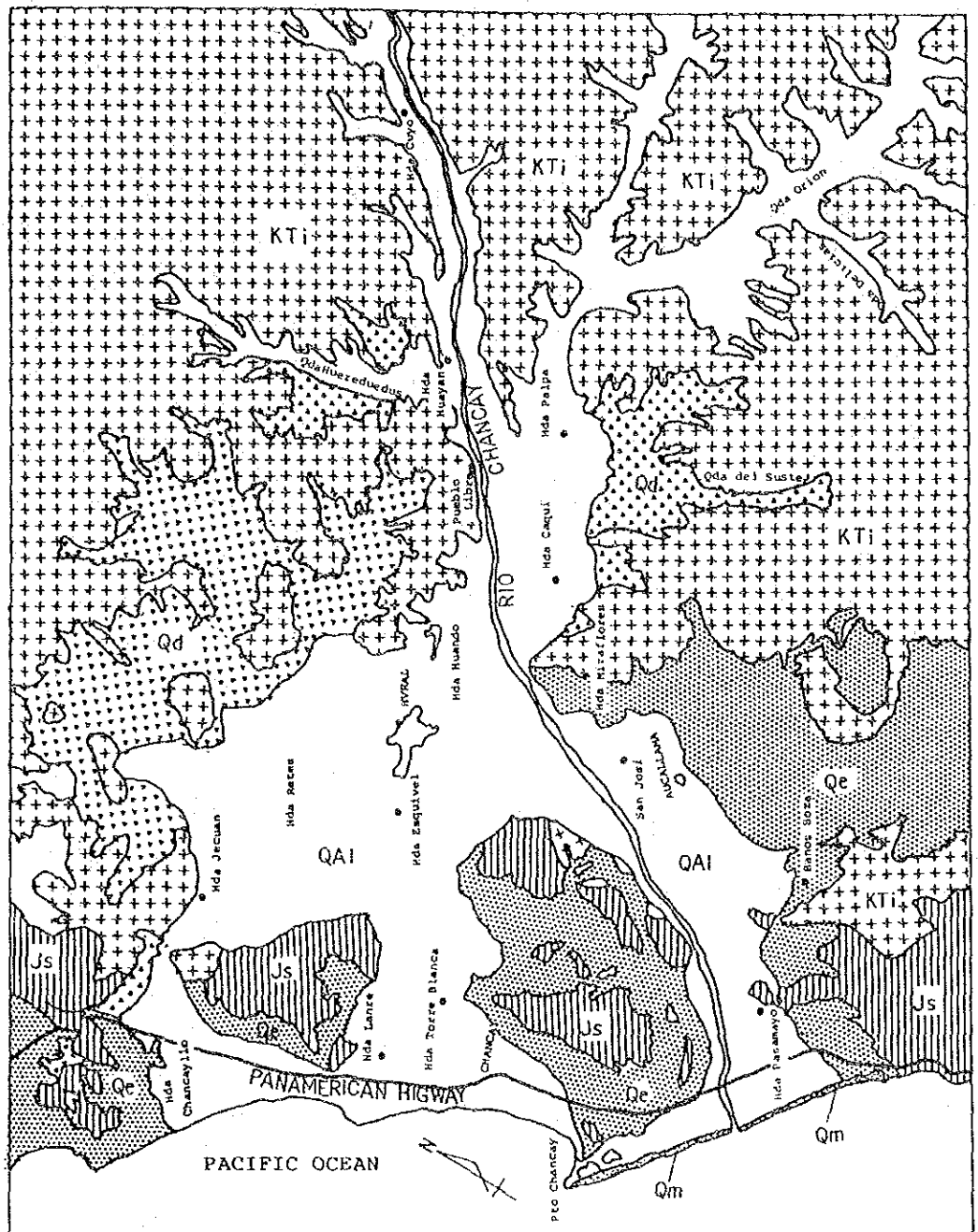


Fig.2-1-1 Geologic Map of The Project Area
(Source ONRN Scale 1/150,000)

2-1-2 Meteorology and hydrology

(1) Climatology of the project area

Temperature

Temperature prevailing in the project area is relatively moderate caused by the Humboldt sea current in spite of the low latitude ($11^{o}30'$ South). The mean annual temperature is about $19^{o}C$, with fluctuation of about $\pm 3.2^{o}C$ throughout the year.

Humidity

The annual mean relative humidity is about 94% throughout the year. The monthly mean relative humidity is about 91% in the dry season from January to March and 95% in the wet and cold season from June to August.

Sunshine

The sunshine data is applied to the average record at the Huanta and Jesus Maria observatories.

The sunshine ratio fluctuates in accordance with the season, sunshine hours per day is about seven hours in the dry season and is about two hours in the wet season.

Wind

The mean wind velocity is about 3.5 m/sec. varying slightly throughout the year, however it becomes low velocity in the cold season. The general direction tendency of the frequent wind can be found out easterly.

Evaporation

The mean annual evaporation is about 567 mm. The mean evaporation in August is 28 mm in minimum, for it is cold weather and higher moisture.

In the hot season, the mean evaporation rises above 60 mm.

Rainfall

In the coastal plain, rainfall hardly ever happened and the mean annual rainfall is recorded at only about 10 mm.

According to the available data, the maximum monthly rainfall shows 19 mm for the last fifteen years and there is five years with no rainfall throughout the year.

Thus, the regional rainfall is not enough for water demand of the project.

Remark

Above mentioned climatological conditions are mainly based on the records at Huaral-Retes (Donoso at present) observatory.

(2) Water resources available in the river basin

Rainfall in the mountainous area with altitude of higher than 2,000 m above M.S.L. can be available for water resources . 48% of the river basin (equivalent to 1,654 km^2) is located in mountainous area.

The Chancay River basin is roughly divided into six sub-areas. Each of them have particular shape with steep slope.

The Chancay River is running through middle part of the river basin to the Project area with slope of 1/60 in average.

In upper reaches of the Chancay River basin located are 25 caldera lagoons of various scale at altitude of higher than 4,200 m above M.S.L.

However, owing to small drainage area, stored water of these lagoons can hardly supply necessary water for the Project.

Almost no trees can be seen in the drainage area. Therfore, the water holding capacity of the area is so small.

Five lagoons out of 25 have been utilized as means of supplement water by dams up during dry season (Refer to Annex A).

(3) Hydrology in the river basin

A) Characteristic of rainfall

There are six rainfall gauging stations of which four are located in and two outside of the river basin. According to the rainfall data, annual rainfall recorded by the gauging stations is diversified at the range of one to four times depending upon the location.

Contour lines can be drawn approximately by the annual rainfall. The contour lines shows that increasing tendency at the rate of 250 mm/1,000 m in the area less than 4,000 m above M.S.L. and at the rate of 500 mm/1,000 m in the area higher than 4,000 m. 80% of the mean annual rainfall is concentrated during the rainy season from December to April. The maximum monthly rainfall is usually recorded in the month from January to March.

Maximum daily rainfall of every year are recorded in the range between 30 - 50 mm regardless altitude and the maximum daily rainfall during observed years was recorded at 94 mm. Rainfall of short period in the area of every tributaries are fluctuated in great extent. Therefore, there is no general rules or method to analyze runoff of the whole river basin as one package.

As mentioned above, the present tendency of the short term rainfall may be concentrated in some sub-area. Therefore, uniform analysis of them cannot be clarified because of almost no correlation among them.

Regarding to the analogy of relation between the long term rainfall such as the monthly or the annual rainfall and the runoff in the river basin. The data at Santa Cruz located in height of 3,500 m above M.S.L. are taken for the representative record of over all area.

According to the data at Sta. Cruz, the mean annual rainfall is 551 mm and the maximum or minimum monthly rainfall of the year are recorded at 125 mm in March or 2.4 mm in June, respectively.

B) Characteristics of runoff

For the runoff of the Chancay River, only one gauging station at Santo Domingo (located at a distance of 37 km from the estuary, on an altitude of 614 m) has been measuring on a fixed time of the day during 64 years since 1920.

Based on the latest data of 21 years, both the maximum or the minimum monthly runoff of the year are 157 M.C.M. in March or 13 M.C.M. in September and the mean annual runoff is 534 M.C.M.

Flow Regime

The flow regime of 21 years calculated by arrangement the daily discharge since 1963 is shown in Table 2-1-1.

Moreover, each of the droughty water discharge, the low water discharge and the flood discharge estimated by applying probability of non-exceedance or exceedance are compiled in Table 2-1-2 and 2-1-3.

2-1-3 Groundwater

In the Project area, groundwater is used to supply water when surface water is not sufficient for irrigation and live-stock farming. According to existing data, there are 33 irrigation wells providing an annual supply water amount of 5,600,000--20,200,000m^3/year (0.18--0.64m^3/s). Permisive mining yield of the same however, may be only 11,600,000m^3/year (0.37m^3/s).

As the cost of using groundwater is normally higher than that at surface water, use of groundwater for irrigation will be limited to supplementary supply in the dry season.

Features and problems concerning the use of groundwater in the project area are as follows:

(1) Distribution of aquifer

Groundwater in the Project area is saturated with fluvial deposits transported mainly by the Chancay River, its tributaries and dried up rivers in the hills surrounding the Project area. A compound deposit at a piedmont will form an effective aquifer, if the same is located over a groundwater artery. An eolian deposit may form a small aquifer at the depth of the clayey layer.

According to previous studies of the hydrogeology and groundwater in the Project area, the aquifer is about 1--2min depth from ground surface, with a thickness of about 10--40m and of very good permeability. The depth, thickness and stratified condition of the aquifer, however, are different in various places.

Geological profiles are based on existing well logs and topographical charts shown in Fig.2-1-2. It is evident from the same that the layers on the left bank of the Chancay River are rich in cohesive soils and on the right bank layers are rich in sandgravels. However, two traces of buried erosion caused by the river stream at La Huaca and north of Huaral can be seen. While water from Boza's spring has been infiltrating through volcanic sedimentary rocks.

(2) Groundwater System

Expected groundwater systems are shown in Fig.2-1-4 from existing well logs, geological profiles, river net and topographical chart. From the figure, the main source of groundwater in the Project area appears to be the Chancay River stream and influent flow in the riverbed. Grounwater is classified into infiltration water from irrigation water and groundwater current from the upstream right bank, and into groundwater from Orcon River, infiltration water from irrigation water, groundwater current from the upstream and infiltration water from the east hill area on the left bank of the river.

Main flows are as follows:

(a) Miraflores via San Jose and Boza to Pasamayo (in Aucallama Dist.)
(b) Jesus via the west foot of the Macaton hill to Chancay (in Huaral and Chancay Dist.)
(c) Esperanza Alta via Retes to the Calera hill (in Huaral Dist.)
(d) Esperanza Baja via Jecuan to Chancayllo (in Huaral and Chancay Dist.)

Irrigation water in poor drainage area such as Quincha and Donoso cannot infiltrate into the deep zone. Where zones have no aquiclude which block infiltration, irrigated water flows directly into the aquifer.

(3) Direction of groundwater flow and displacement of groundwater level

Dynamic groundwater trend in the Project area is controlled by hydrogeologic structure, the Chancay River flow and its utilization rate.

The groundwater level in the Project area rose during the ten years from 1966 to 1975, and lowered during the six years from 1975 to 1981. The groundwater level is considered to correspond directly with increases and decreases by precipitation of the upper area.

When annual rainfall is scarce, use of groundwater increases as groundwater is used to compensate for irrigation water shortages. During such periods, groundwater level drops.

(4) Use of Groundwater

Based on contours of groundwater level in 1981, groundwater reserve is calculated on the profile from San Jose in Aucallama Dist. to Esperanza Baja. The quantity of groundwater reserve on the profile is $5.96m^3/s$ and total annual reserve is $189,900,000m^3$.

In this case the water-table depression must have been calculated at about 2.5--3.7m. If available range of the depression is made hydrodynamically 1.0--2.0m, utilizable quantity is 11,600,000m^3/year. Thus, total utilized quantity in 1982, 9,400,000m^3, is 81% of the utilizable quantity and quantity utilized for irrigation, 20,200,000m^3 in 1979--1980, is 174% equal to the lift rate taken by water-table depression of about 3m in all aquifers of the Project area. Maximum utilizable quantity appears to be the maximum permissive mining yield, as the Chancay River is the only groundwater resource in the Project area.

In the Project area irrigation water shortages occur in the northwest part of La Esperanza, Quepe pampa and Casa Blanca. Possibility of use of groundwater for those areas generally do not meet the expected project requirements in the Project area, due to insufficiency of the permissive mining yield.

2-1-4 Water quality

Fifty-nine groundwater and surface water samples were collected in the Project area once in March and twice in July, 1984 for chemical analysis.

According to the results of water analysis, both groundwater and surface water are classified from medium to high salinity hazard and low to medium sodium hazard (C2S1--C3S2) and are suitable for irrigation use, except for Granada spring in Boza. The latter is classified as having high salinity and high sodium hazard (C4S4) and is rich in boron (3.0--6.2p.p.m), rendering the same unsuitable for irrigation use.

Fig.2-1-3 show key diagrams of the percentage of anion and cation content for each sampling period. The figures indicate that grouondwater and surface water mainly contain Calcium-Magnesium Bicarbonate while the spring contains Alkali-Chloride, Alkali-Sulfate. Groundwater and surface water have the properties of shallow groundwater, infiltration water and river water, while the spring water is similar to a spa. Chloride and sulfate content of groundwater, surface water and the spring, however, increased during a 4 month period.

Table 2-1-1 Chancay River Flow Regime
(at Santo Domingo Observatory)

Unit:cu.m/sec

Water Year	Droughty Wat.Dis.	Low Wat. Dis.	Ordinary Wat.Dis.	95 days Dis.	Annual Min.	Annual Max.	Annual Average	Remark
1963	4.94	5.65	9.90	25.89	4.52	97.86	19.56	
1964	5.16	5.86	7.17	10.48	5.01	180.21	18.38	
1965	3.81	4.94	5.91	9.61	3.64	61.00	9.11	
1966	3.03	5.95	10.98	20.59	2.96	400.60	30.29	
1967	3.97	4.57	5.58	9.00	3.75	37.50	8.66	
1968	3.72	3.94	5.86	8.68	3.51	88.79	11.74	
1969	2.81	4.23	9.32	18.85	2.60	158.83	19.31	
1970	4.54	5.59	8.10	18.42	4.24	83.20	16.36	
1971	4.73	5.64	9.60	20.24	4.22	484.19	32.82	
1972	5.25	6.60	9.93	31.36	4.67	172.08	23.68	
1973	6.09	8.07	10.63	30.05	6.09	143.20	22.50	
1974	4.85	5.49	7.14	13.39	4.21	86.33	13.51	
1975	5.21	5.80	7.25	18.79	5.11	125.43	15.52	
1976	4.49	5.56	6.30	11.37	4.14	115.51	14.45	
1977	3.96	4.78	5.98	12.72	3.61	64.85	10.47	
1978	4.00	4.82	5.86	8.54	3.63	90.05	11.84	
1979	3.42	4.08	5.49	7.24	2.91	76.25	8.41	
1980	3.27	5.11	7.31	19.28	2.82	142.53	19.09	
1981	4.84	5.70	7.91	15.07	4.26	76.69	13.21	
1982	4.80	5.40	8.00	25.00	4.59	120.00	19.36	
1983	4.20	4.85	8.12	17.10	4.06	116.62	16.95	
Mean	4.33	5.36	7.73	16.75	4.03	139.13	16.92	

Note: Droughty Wat. Dis.; The 355th largest discharge of the year
Low Wat. Dis. ; The 275th " " "
Ordinary Wat. Dis.; The 185th " " "
95 days Dis. ; The 95th " " "

Table 2-1-2 Probable Discharge at Sto. Domingo

(Unit: $m^3/sec.$)

Return Period (Year)	Drougty Water Discharge	Low Water Discharge	Flood Discharge
200	--	--	770
100	--	--	580
50	2.54	4.07	450
20	2.75	4.18	310
10	2.98	4.32	240
5	3.29	4.55	180
2	3.98	5.18	140

Note: Catchment area at Sto. Domingo; A = 1,860 km^2

Table 2-1-3 Probable Discharge

Return Period Year	Flood Discharge m^3/sec	Specific Discharge $m^3/sec/km^2$	Remarks
200	770	0.414	Catchment area
100	580	0.312	1,860 km^2
80	540	0.290	
50	450	0.242	
30	360	0.194	
20	310	0.167	
10	240	0.129	
5	180	0.097	
2	140	0.075	

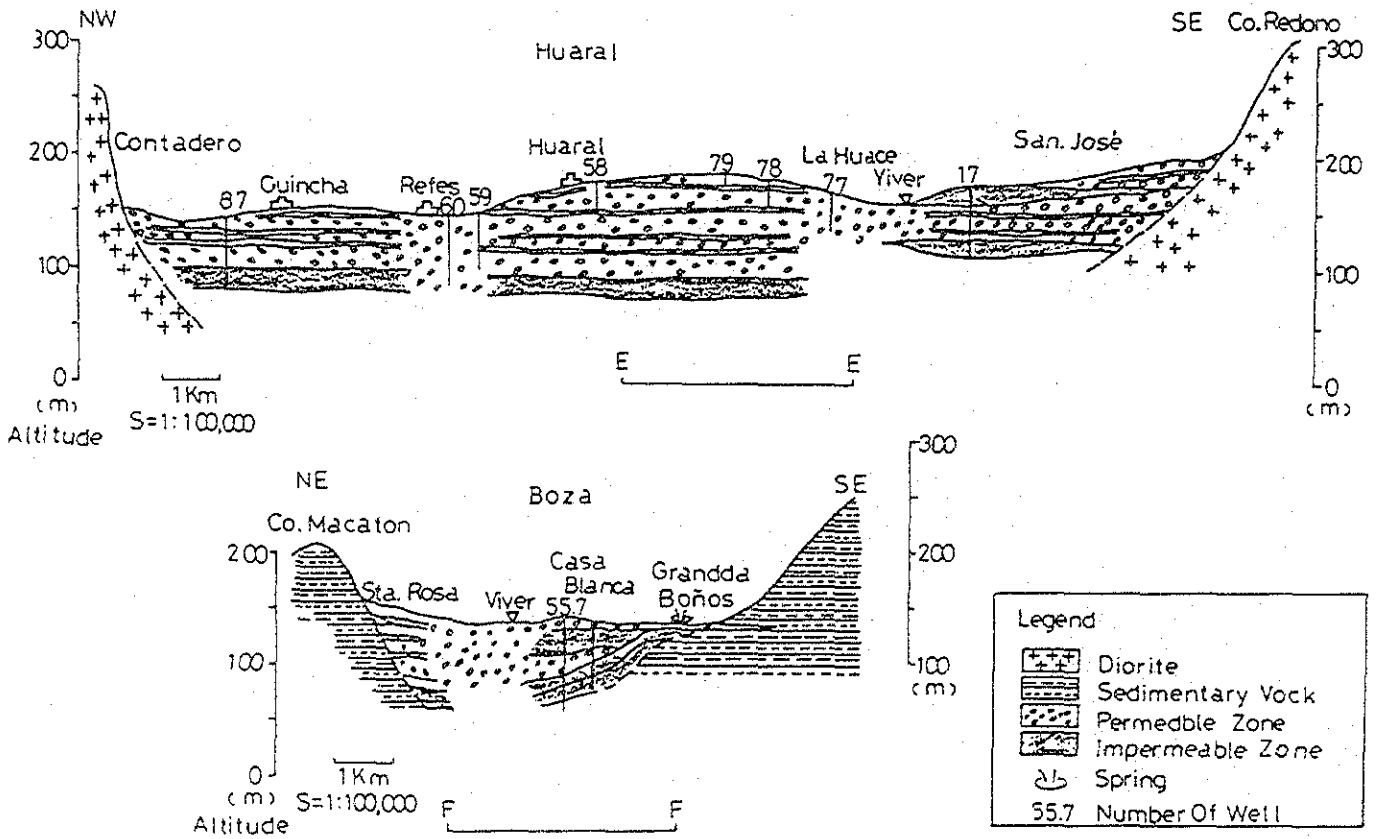


Fig. 2-1-2 Geologic Profiles

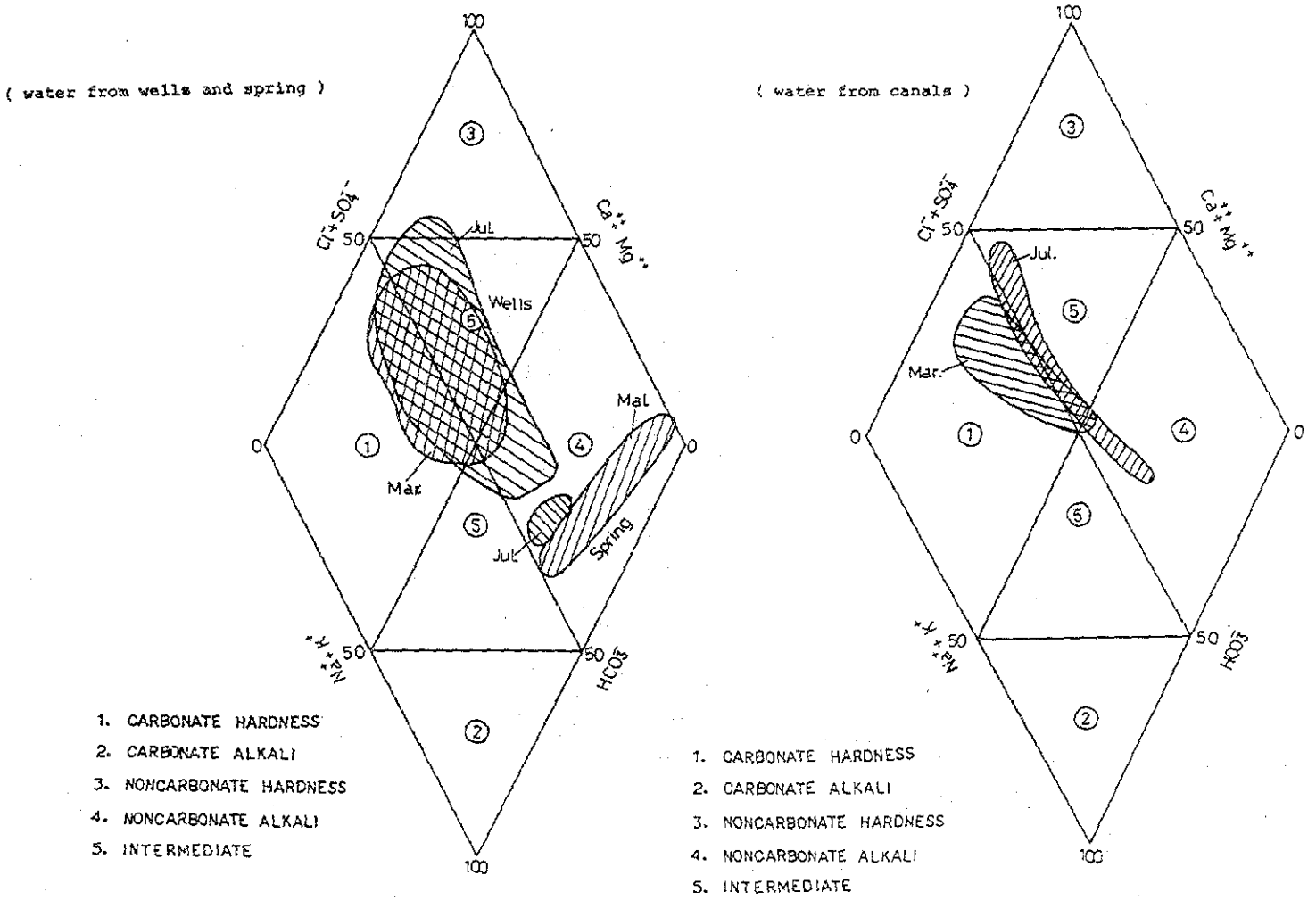
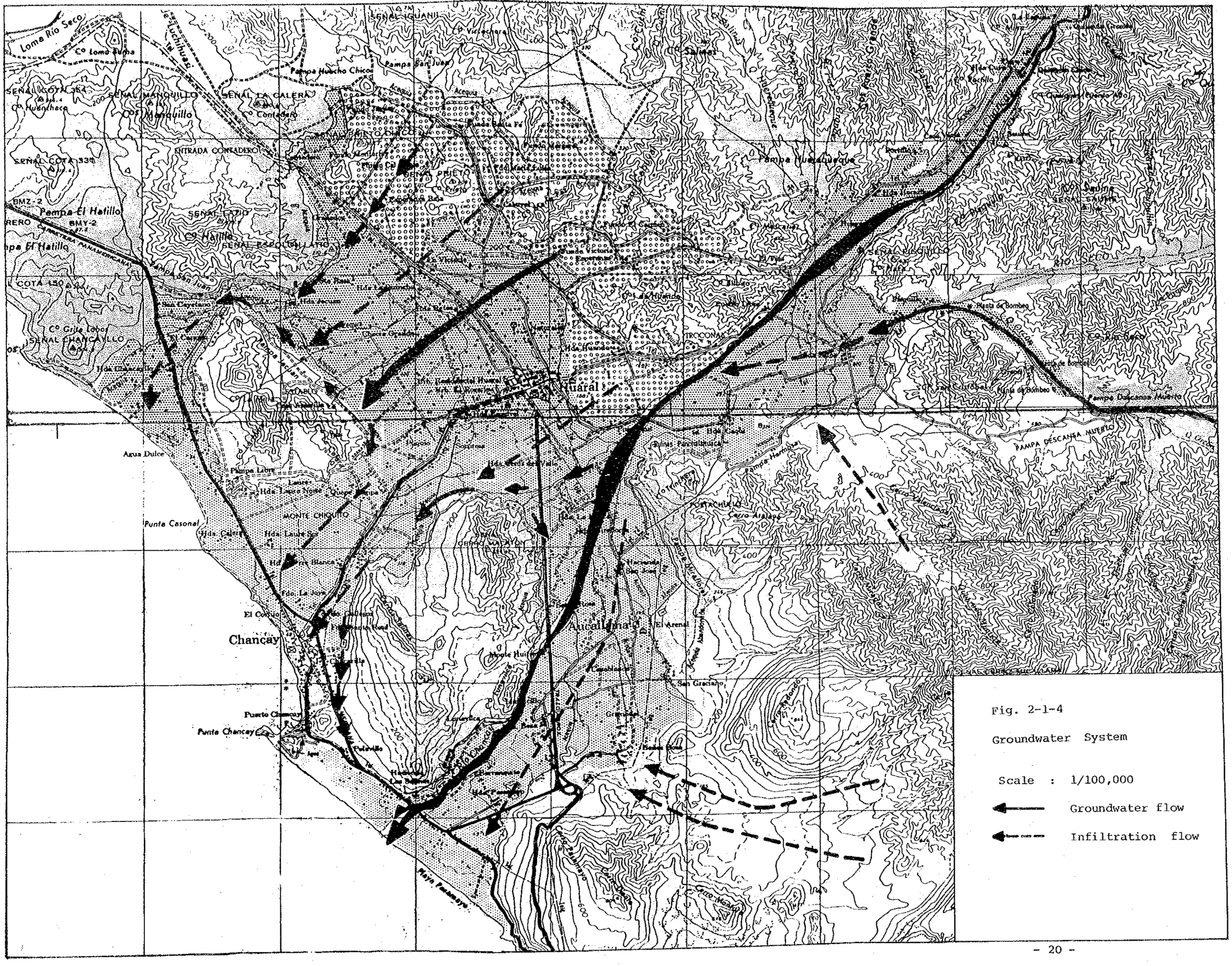


Fig. 2-1-3 Key Diagram


Huaral
Chancay
Aucallama
Pampa Huaquerque
Pampa El Hatillo
Pampa Libre
Agua Dulce
Punta Casonal
Punta Chancay
Playa Pasamayo
Ruinas Pancalahuaca
PAMPA DESCANSA MUERTO
Fig. 2-1-4
Groundwater System
Scale : 1/100,000
Groundwater flow
Infiltration flow

2-1-4 Soil

(1) General

Distribution of ten soil series is recognized in the Project area. These soil series are classified into four groups on the basis of texture classes of surface soil (0-30cm) and the origin of parent materials (Table 2-1-4).

1) Coarse-textured soil/alluvial & colluvial deposits

Coarse-textured soil derived from alluvial deposits of the Chancay River and colluvial deposits of neighbouring hills is distributed widely in the right bank-upper irrigation block, particularly, in the irrigation subsector Esperanza. The soil is immature with no morphological development and is characterized by a coarse-textured surface layer and coarse sandy to gravelly subsoil. Effective soil depth is shallow and moisture holding capacity is very low. Almost all land covered with the soil is used for fruit cultivation such as citrus and apple. Slight to moderate salt accumulated land is found in areas adjacent to deserts which were developed in relatively recent years.

2) Coarse-textured soil/alluvial & eolian deposits

Along the isolated hills in the Project area and on gently sloping to nearly flat areas at the foot of Cerro Halillo, Cerro Arana and Cerro Pasamayo, coarse-textured soil derived from coarse alluvial deposits and eolian deposits is distributed. The soil has uniform fine-sandy horizons (sand to loamy sand) in the entire profile and morphological development of the soil profile is not clear. Effective soil depth is deep but moisture holding capacity is low. Sloping land is commonly utilized for fruit production and flat land for annual crop production. In the coastal area, vegetables are extensively cultivated while poorly drained salt accumulated land is distributed in Boza.

3) Medium-textured soils

Soils with a medium-textured surface layer (0-30cm) overalluvial deposits are distributed throughout most of the flat to nearly flat areas, which occupy the greater part of the Project area. This soil group is divided into two subgroups; i) soil series with a coarse-textured horizon or horizons in soil profile (Tucume, Esquivel-Trujillo, Clemencia, Huaral); and ii) soil series with no coarse-textured horizon in soil profile (Mochumi, Ocuaje, Lambayeque). Corresponding to physiographic conditions, poorly drained salt accumulated land are distributed in some areas, such as Quincha and Donoso. Drainability of most of the land covered with this soil group, however, is moderate to good. Effective soil depth of the soils of this group is generally deep, although there are distributions of gravelly surface soils and soils with gravelly layers close to the ground surface. The land is mainly utilized for production of cotton and maize, while vegetables and fruit are also cultivated.

4) Fine-textured soil

Fine-textured soil derived from fine alluvial deposits is distributed over a limited acreage mainly in the poorly drained areas in Quincha and Donoso. The soil, as the series named Quepecaliche indicates, usually has a continuous or discontinuous caliche (ca-pans) layer of about 10cm in thickness at a depth of about 100cm. In low lying areas with a high subsurface water table, a high concentration of salt accumulation is recognized.

The distribution of each soil series is shown in Table 2-1-5 and the soil map of the Project area is presented in Annex C.

Table 2-1-5 SOIL DISTRIBUTION IN THE PROJECT AREA

Soil Series	(ha)	%
Aucallama	2,542	12.6
Esperanza	4,020	19.9

Tucume	1,962	9.7
Esquivel-Trujillo	5,262	26.0
Clemencia	695	3.4
Huaral	309	1.5
Mochumi	3,850	19.1
Ocuaje	360	1.8
Lambayeque	605	3.0
Quepecaliche	595	2.9
Total	20,200	100.0

(2) Distribution of salt accumulated soils

Salt accumulated soils in the Project area are grouped into two types according to the formation processes of salt accumulation. The first type is found in poorly drained areas with high ground-water tables. Salt accumulation was brought about by the upward movement of ground-water. The distribution of the second type is generally found in slightly sloping areas with good drainage conditions. The main sources of salts are considered to be the residues of salts accumulated in the process of land formation and left behind due to insufficient leaching at the time of land development. The distribution of two types of salt accumulated soils are shown in Table 2-1-6. Salt accumulated soils is accounted at about 22% of the total arable land.

Table 2-1-6 DISTRIBUTION OF SALT ACCUMULATED SOILS

Type	Salinity Classes S1	S2	S3	Total
1st type (ha)	1,243	562	755	2,560
(% of Total)	(48.6)	(22.0)	(29.5)	(100.0)
2nd type (ha)	483	1,020	304	1,806
(% of Total)	(26.7)	(56.5)	(16.8)	(100.0)
1st & 2nd (ha)	1,725	1,582	1,059	4,366
(% of Total)	(39.5)	(36.2)	(24.3)	(100.0)

* Criteria for salinity classification

Electric conductivity of saturation extract at 25°C (ECe) of surface layer (0-15cm)

S1	ECe	4-8	m^S/cm
S2	ECe	8-15	m^S/cm
S3	ECe	>15	m^S/cm

(3) Land classification

The results of land classification based on land suitability for irrigation farming is presented in Table 2-1-7 and in the land classification map (Fig.2-1-5).

Table 2-1-4 Grouping of Soil Series

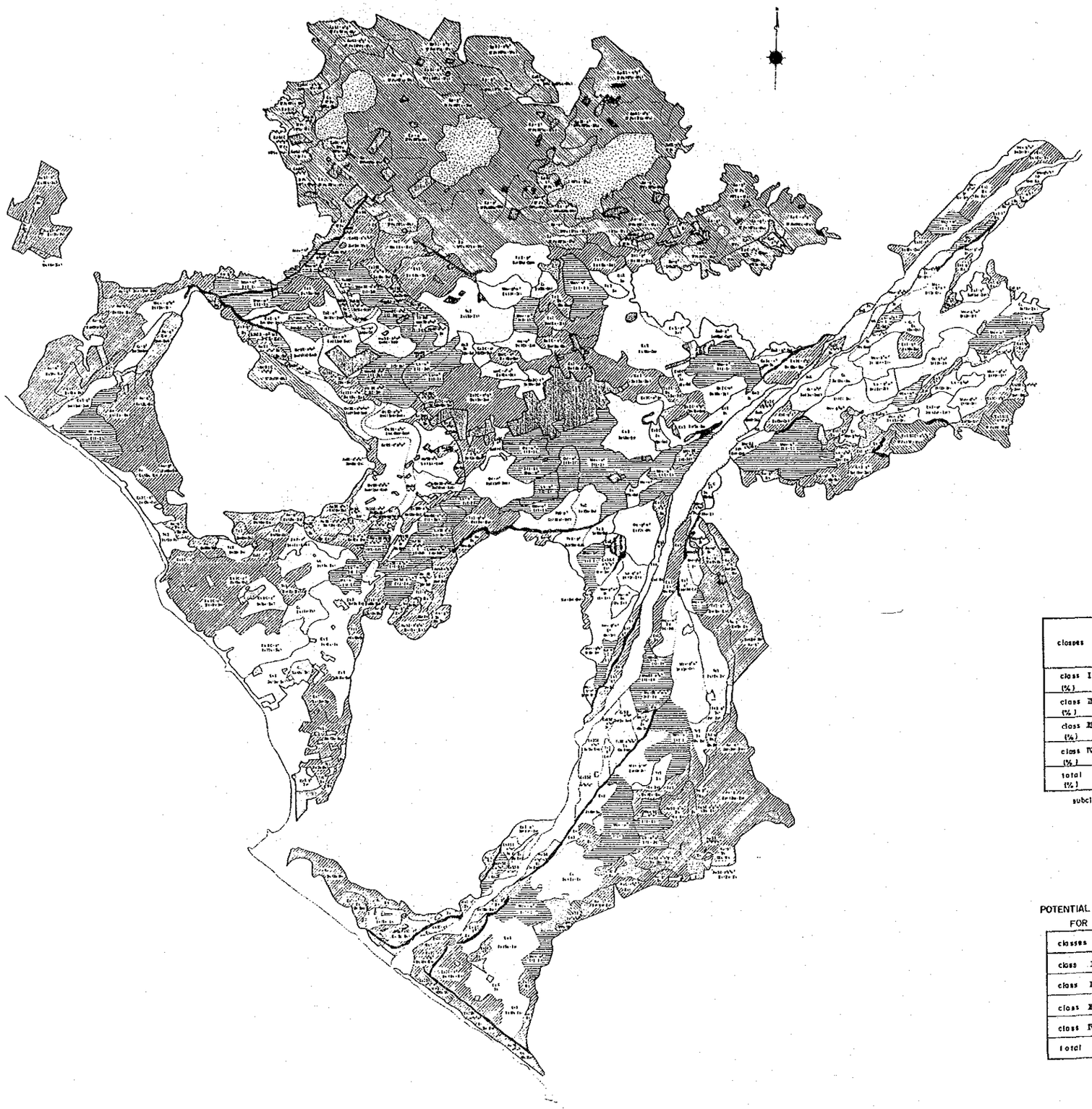
Texture classes	Parent materials	Soil series	Soil Classification 1/	
			Soil Taxonomy	FAO/UNESCO
Fine-textured	alluvial deposits	Quepecaliche	Ustiflurents	Fluvisol
Medium-textured	alluvial deposits	Tucume, Clemencia, Mochumi, Ocuaje, Lambayeque, Huaral, Esquivel-Trujillo	Ustiflurents	Fluvisol
Coarse-Textured	alluvial & colluvial deposits	Esperanza	Ustipsaments	Arenosol
	alluvial & eolian deposits	Aucallama	Ustipsaments	Arenosol

1/ Based on soil classification system of Soil Taxonomy and FAO/UNESCO
fine-textured soil ; clay loam - clay
medium-textured soil; sandy loam - loam
coarse-textured soil; sand - loamy sand

Table 2-1-7 Summary of land classification ——potential land irrigability class for irrigation farming

Soil series		Land Irrigability Class							Total Area
		Class I	Class II	Class III	Class IV			Class VI	
Aucallama	ha	-	-	2,445	97	97	-	-	2,542
	(%)			(96)	(4)				(100)
Esperanza	ha	-	-	88	3,932	3,932	-	-	4,020
	(%)			(2)	(98)				(100)
Tucume	ha	-	938	1,024	-	-	-	-	1,962
			(48)	(52)					(100)
Esquivel -Trujillo	ha	-	2,399	2,709	154	128	26	-	5,262
	(%)		(46)	(51)	(3)				(100)
Clemencia	Ha	-	695	-	-	-	-	-	695
	(%)		(100)						(100)
Huaral	ha	-	309	-	-	-	-	-	309
	(%)		(100)						(100)
Mochuml	ha	2,420	1,430	-	-	-	-	-	3,850
	(%)	(63)	(37)						(100)
Ocuaje	ha	141	219	-	-	-	-	-	360
	(%)	(39)	(61)						(100)
Lambayeque	ha	426	136	24	19	-	19	-	605
	(%)	(70)	(22)	(4)	(3)				(100)
Quepecali- che	ha	-	595	-	-	-	-	-	595
	(%)		(100)						(100)
Total	ha	2,987	6,721	6,290	4,202	4,157	45	-	20,200
	(%)	(15)	(33)	(31)	(21)				(100)

IVF -- special use for fruit cultivation
IVR -- special use for salt tolerant crop cultivation
IVRI-- special use for salt tolerant crop cultivation under intensive irrigation methods
IVI -- limited arable under intensive irrigation methods
IVP -- limited arable due to flooding possibility



S=1: 100,000

L E G E N D

land use categories	area (%) ha	%	symbol
arable land	20,200	(87)	EpSIC
nonarable land			
hilly area	810	(4)	
precipices, drains, ponds	80	(-)	
stony land	70	(-)	MA
residential area, yards, others	790	(3)	
right-of-way	1150	(5)	—
project area	23,100	(100)	—
river and river land			
soil series/phase boundary			
soil unit boundary			
project area boundary			

(soil phase, soil unit code)

TcESIC — $e^4 a^2 c^2 g^2 w^3$ (soil unit code)

soil phase code

Tcheme series, poorly-drained salt accumulated, gravelly surface, moderately deep phase

(land classification code)

Es (Ea — Ed)

potential land irrigability class for fruit production

potential land irrigability class for annual crop production

potential land irrigability class for irrigation farming

(soil unit code —— $e^4 a^2 c^2 g^2 w^3 (f^2)$)

e^4 —— salinity rating 4
a^2 —— alkalinity rating 2
c^2 —— coarse fragment content rating 2
g^2 —— slope and microrelief rating 2
w^3 —— drainability rating 3
f^2 —— flooding hazard rating 2

land irrigability class

I — class I (arable) II — class II (arable) III — class III (arable) IV — class IV (limited arable or special use) V — class V (noncrable)

IVF —— special use for fruit cultivation
IVR —— special use for salt tolerant crop cultivation
IVI —— limited arable under intensive irrigation methods

subclasses —— s: deficiency or limitation in soil factor which determine irrigability class in the level
t: " " in topography factor " "
d: " " in drainage factor " "

phases —— I: shallow phase, M: moderately deep phase, SI: well-drained salt accumulated phase
SII: poorly-drained salt accumulated phase, C: gravelly surface phase

※ % of project area (23,100 ha)

POTENTIAL LAND IRRIGABILITY CLASSES FOR IRRIGATION FARMING

classes	area (ha)	symbol
class I	2987	
class II	6721	
class III	6290	
class IV	4202	
total	20200	

POTENTIAL LAND IRRIGABILITY CLASSIFICATION

classes	land irrigability for irrigation farming: class total ha	subclass ha: s	d	t	sd	st	dt	sdt	IVFs	IVRs	land irrigability for annual crop production: class total ha	subclass ha: s	d	t	sd	st	dt	sdt	IVIs	IVRs	classes for fruit production: class total ha	subclass ha: s	d	t	sd	st	dt	IVs
class I (%)	2987 (15)										2987 (15)										2153 (11)							
class II (%)	6721 (33)	3537	47	1673	630	775	25	34			6721 (33)	3537	47	1673	630	775	25	34			7488 (37)	2898	1469	1605	626	821	69	
class III (%)	6290 (31)	5487		24		779					6290 (31)	5487		24		779					6269 (31)	5218	141	24	107	779		
class IV (%)	4202 (21)								4157	45	3977 (20)								3932	45	4245 (21)							4245
total (%)	20200 (100)										20200 (100)										20200 (100)							

subclasses s: deficiency or limitation in soil factor which determine irrigability class in the level
t: " in topography factor "
d: " in drainage factor "

IVF special use for fruit cultivation
IVR special use for salt tolerant crop cultivation
IVI limited arable under intensive irrigation methods

Fig. 2-1-5 Land Classification Map

2-2 Social and Economic Situation

2-2-1 Population

The plain area of Chancay-Huaral valley, including the project area, is divided into three administrative districts of Chancay, Huaral and Aucallama.

According to the 1981 national census, population of the above mentioned districts was 82,000 persons and 13,600 households as shown in Table 2-2-1 and 2-2-2. About 70% of the persons live in the urban area (include group house).

Annual population growth rate in this area was 5.1% in average during a period of 10 years (1972-1981) which is higher than that of 3.5% in the Department of Lima and of 2.5% in national level. Annual growth rate in the same period shows that 8.5% in the urban and 0.8% in the rural. Therefore, it is going rapidly to concentrate to urban area.

The number of family is about six members in both of rural and urban area, and an area of farm land is 0.3 Ha. per person. Its rate is rather higher point in comparison with the coastal region in Peru, except Lima and Callao. Average rate is 0.11 Ha. per person in the national level and 0.14 Ha. per person in the coastal region.

The effective labor force (over 15 age) in this area is shown in Table 2-2-3 and number of labor force in the agricultural sector accounts at 46.1% among that of the whole sector, it exceeds the national average of 36% which is including labor force of forestry and fishery sectors.

Table 2-2-1 Population in the Chancay Huaral Valley

Administrative Districts	Total	Urban Area ha	%	Rural Area ha	%
Huaral	45,983	34,235	74.45	11,748	25.55
Chancay	25,250	18,993	75.22	6,257	24.78
Aucallama	10,835	3,349	30.86	7,491	69.14
Sub total	82,068	56,572	68.93	25,496	31.07
High land area	20,051	10,386	51.00	9,665	48.20
Grand Total	102,119	66,958	65.57	35,161	34.43

Table 2-2-2 Nos. of Household in the Chancay-Huaral Valley

Area	Population		Households		Family of a Household	
	Urban Area ha	Rural Area ha	Urban Area ha	Rural Area ha	Urban Area ha	Rural Area ha
Coastal Area	56,572	25,496	9,397	4,201	6	6
High land Area	10,386	9,665	2,134	1,871	4	4
Sub Total	67,958	35,161	11,531	6,072		
Total	102,119		17,603			

Source: 1981 census

Table 2-2-3 Industrial Population in the Huaral District (Over 15 years old)

Item	Person	%
Agriculture, Forestry and Fishery	15,486	48
(Agriculture)	(14,797)	(46)
Mining	540	2
Industry, Manufacturing	1,920	6
Electric, Gas and Water Service	82	-
Constructions	969	3
Commerce	3,819	12
Transport, Warehouse and Communication	1,463	5
Finance and Service	423	1
Others	6,589	21
Job Seekers	797	2
Total	32,088	100

2-2-2 Land holding

In Peru, a plantation (hacienda) system had been dissolved by the land reform which was enforced in the 1970's. Then its reformation has brought great change to the agricultural structure and land holding system. The liberated land was transferred to the cooperative's possession like as farmer's common ownership system. Thereafter, most of area owned by cooperatives have been parcelled in lots to each of the members equally in consequence of their social and economic situation. Accordingly, it has produced many farmers holding mini or small scale farm land through ramified allotment. 85% of their holding area is less than 6.0 ha. (Refer to Table 2-2-4)

Table 2-2-4 NUMBER OF FARMER'S LAND HOLDING

Farm scale	Percentage
less than	
0 - 1.5 Ha	18 %
1.5 - 3.0	31
3.0 - 6.0	36
6.0 - 10.0	9
10.0 - 15.0	4
15.0 - 20.0	2
20.0 - over	-

Remarks: 1. Number of farmers: 4,900
2. Excluding cooperatives of land ownership system.

2-2-3 Land use

According to the data of Ministry of Agriculture, the land use in Chancay-Huaral valley of approximately 345,000 Ha. is classified as follows;

Farm land (coastal area)	7.1%
Farm land (high land area)	0.6%
Natural pasture	26.9%
Forestal area	6.4%
Urban area	0.1%
Arid land, desert and no arable land	58.9%

Farm land of approximately 20,000 Ha. in the project area is mainly used for fruit growing, vegetables and general crops growing.

At present, the fallow land exists in the farm land because of water shortage and its area varies depending upon discharge of the Chancay River. The wild grass field is also left as fallow land due to poor drainage condition.

In surrounding of the project area, there exists some land which has owned by farmers but has no water right, called "Tierras Eriazas", to be used for farming only at rainy season. A part of the project area is also used for poultry and goat breeding .

2-2-4 Rural settlement

In the project area, there are two urban zones; Huaral and Chancay. Huaral is an administrative and commercial center of Chancay-Huaral valley and located in the center of the project area. Chancay is located in the coastal area and functioned as fishery port.

Such as Palpa, Caqui, Miraflores, Boza and Acucallama are dotted in the left bank of the Chancay River, and Huando, Jesus del Valle, La Huaca, Retes de Naturales, Jecuan and Los Laureles in the right bank. These settlements have been formed centering, cooperatives.

The public facilities in the Project area and its vicinity are as follows.

(1) Municipal water

A part of irrigation water is used for municipal water purpose in the urban zone of Huaral and Chancay. The public water supply is also provided. In other main rural area, water network has been diffused. However, domestic water of farm house in scattered housing area is taken from individual well infiltrated water and irrigation water.

(2) Electricity

All of villages in the project area has already been furnished electricity.

(3) Communications

The telephone and telegram offices exist in Chancay and Huaral, but are not prevailing in the whole area.

(4) Others

Hospital, regional health center and banks are found in the both urban zone of Chancay and Huaral. Schools are also founded in the urban zone and main villages.

2-2-5 Transportation

The Pan American highway is running through Chancay urban zone from south to north at the coastal side in the project area. From the highway, two routes of national road are branched off to Huaral, both of them are paved by asphalt.

There are many local roads in the project area to Acos and high land passing along the Chancay River; Trapiche of Lima Province via Palpa and to joint the Pan American highway at Rio Seco via La Esperanza from Huaral.

The road network in the project area is connected with villages each others and is well-functioned but the above roads including local main roads are neither paved by asphalt nor maintained well.

A means of transportation to the project area from Lima is very convenient. Long distance bus are shuttled to northern main cities through the Pan American highway. Huaral is the center of transport facilities in the project area, as for Andian high land and main villages in Chancay-Huaral valley.

Further the project area is conveniently sited for the transport condition as Jorge Chaves International airport in Lima and Callao port for shipping abroads and Chancay fishery port.