THE DOMINICAN REPUBLIC
INSTITUTO NACIONAL DE RECURSOS HIDRAULICOS

FEASIBILITY STUDY ON THE CONSTANZA VALLEY IRRIGATION PROJECT FINAL REPORT

ANNEX

VOLUME I

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

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ANNEX A : BACKGROUND OF THE PROJECT

1. Introduction

1.1 Background of the Study

In the Dominican Republic, agriculture and animal husbandry play an important role as the key industries of the domestic economy, accounting for 19.8% of gross domestic product (GDP) and employing 27% of the population in economic activities and agricultural products contribute 70% of the total exportation. Hence, the production trend of these prime industrial sectors has serious influence on the economy and the society of the Dominican Republic.

However, the index of agricultural production has decreased in these years. Especially the international balance of payments of the Dominican Republic is stagnated due to low international price of the commodities i.e. sugar, coffee, cacao etc. and the curtailment of the sugar export quota to U.S.A.

For this reason, the government of the Dominican Republic gives priority to the agricultural sector in the National Development Plan (1987-1990) and focus towards the following target.

1. Increase of agricultural production through the enlargement of arable land and irrigated area

2. Augment of agricultural export, especially the non-traditional goods.

With this background, the government of the Dominican Republic recognizes the "Constanza Valley irrigation project" (hereinafter referred to as "the project") as a part of the irrigation expansion project. In Constanza Valley, the irrigation and drainage system with the head works was built about 40 years ago.

However, shortage of water because of the enlargement of arable land and superannuation of the irrigation facilities, has serious influence on the agricultural production. Therefore the government of the Dominican Republic requested the Government of Japan for the technical cooperation of the study of the said project in May, 1987. In compliance with the request, the Government of Japan through the Japan International Cooperation Agency (JICA) dispatched a preliminary survey team to the Dominican Republic in November, 1988 prior to the full-fledged study, and concluded the agreement on the Scope of Work (S/W) for the full-fledged study with the Government of the Dominican Republic through discussion. As a result, the feasibility study has started in August, 1989.

1.2 Objectives of the Project

The main objective of the study is to review the technical, economical and socio-economical validity of the irrigation project in Constanza Valley, in La Vega province situated at the central of the Dominican Republic, through the feasibility study of the irrigation project for promoting the agricultural development.

The government of the Dominican Republic concentrates on the following points to be fulfilled through the feasibility study.

1. Establishment of facilities for the economical use of irrigation water and review of operation and maintenance system;

2. Improvement of productivity of the existing crops and introduction of new crops; and

3. Review of the agricultural organization and marketing mechanism.

1.3 Scope of Work for the Study

The scope of work for the study made and agreed upon by the Governments of Japan and the Dominican Republic are summarized as follows:

- Preliminary design of irrigation/drainage facilities
- Implementation schedule of the Project
- Estimation of cost and benefit of the Project
- Evaluation of the Project

1.4 Description of the Study

1.4.1 Objectives of the Study

The main objective of the study is to review the technical, economical and socio-economical validity of the irrigation project in Constanza Valley.

The objectives of the study are briefly summarized below:

- To investigate land and water resources in the study area and to examine their development possibilities.

- To formulate an irrigation development project, to establish an optimum development area and plans, and to verify its technical, economic and financial feasibility.

- To provide on-the-job training and transfer of technology to the Dominican counterpart personnel during the course of the study.

1.4.2 Outline of the Study

The study is conducted in two phases, each of which comprises of field works in the Dominican Republic and the home office works in Japan. The work flow and schedule is shown in Fig. 1.4.2-1 and 2 respectively.

(1) Phase I Study

Phase I Study is divided into two components:

1) Field Works (Aug. 1989 - Oct. 1989)

a. Field survey and collection of data and information necessary for the study (climate, hydrology, irrigation and drainage, land use, soils, geology, agriculture and agro-economy).

b. Preparation of the Progress Report (I).

2) Home Office Works (Nov. 1989 - Dec. 1989)

Based on the data and information collected in the course of the field work, the home office study was carried out focusing on the following items.

a. Review and analysis of the data and information collected during the field survey,

b. Formulation of the basic development concepts, and

c. Preparation of the Interim Report.

(2) Phase II Study

1) Field Works (Dec. 1989 - Jan. 1990)

The Interim Report comprising of the basic development concepts was presented to the Government of the Dominican Republic for review and discussion. After an agreement on the contents of the Interim Report between the relevant parties, the following studies were carried out so as to supplement the Phase I Study.

a. Collection of necessary data and information (irrigation and drainage, soils, land use, facilities plan, implementation plan, cost estimation, farming plan, agro-economy and socio-economy) required to formulate the development plan.

b. Review of the basic development concepts and formulation of alternatives for the development area and water resources development plan.

c. Preparation of the Progress Report (II)

2) Home Office Works (Jan. 1990 - March 1990)

By means of review and analysis of the data and information collected in the course of Phases I and II field works together with agreements between the study team and relevant Dominican authorities, a farming plan, irrigation plan, facilities plan and estimation of the costs and benefits of the Project have been prepared. These are to make economic, financial and social evaluations of the Project. Specific recommendations for the implementation and development of the Project have also been presented.

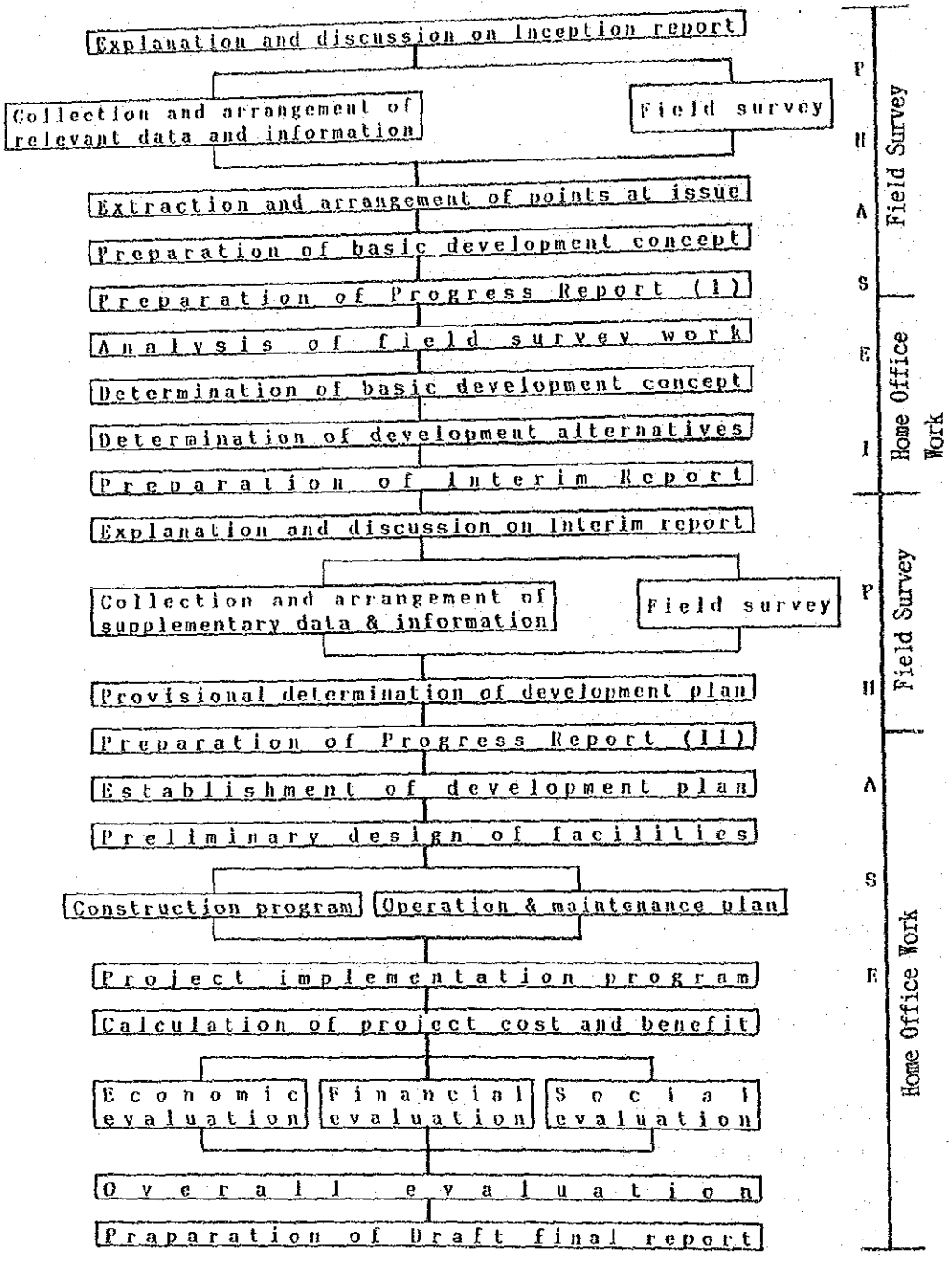

Fig. 1.4.2-1 Overall Work Flow of the Study

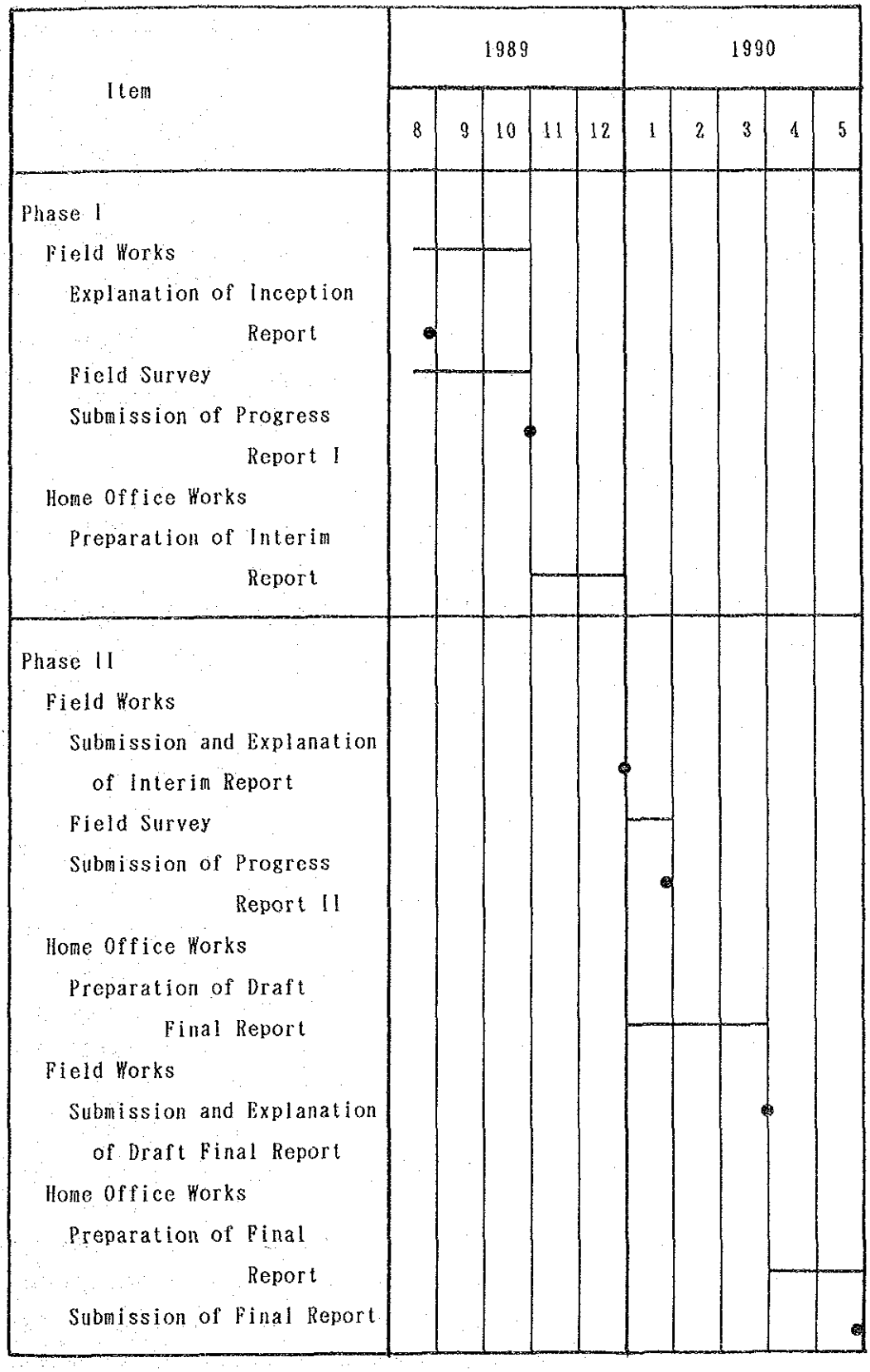

Fig. 1.4.2-2 Overall Work Schedule of the Study

2. Socio-economical Background

2.1 Geography and Population

2.1.1 Location, Topography and Climate

The Dominican Republic is situated in lat. 17°36'N - 19°56'N and long. 68°19'W - 72°01'W, and occupies the eastern two-thirds of the Island of Hispaniola which is situated at the center of archipelago of Antillas and in the west, it is flanked by the Republic of Haiti. The Dominican Republic covers an area of 48,442km^2, extending for about 265km from north to south, about 390km from east to west and about 338km of boundary line with the Republic of Haiti.

Four major parallel mountain ranges which extend from northwest to southeast are northern mountain range (Cordillera Septentrional), central mountain range (Cordillera Central), Neiba mountain range (Cordillera de Neiba) and Bahoruco mountain range (Cordillera de Bahoruco). The Cibao plain which is a granary zone in the Dominican Republic extends between northern mountain range and central mountain range. The eastern part of the country at the Caribbean sea side extends over a plain of sugar cane plantation.

The climate of the country is dominated by the tropical monsoon. The mean yearly temperature measured at 40 meteorological stations of the country is 23°C to 28°C and is 18.2°C at the Constanza Valley. There are two seasons i.e. rainy season which is from May to October and dry season which is between November to April, but these seasons are not definite. The mean yearly rainfall varies between 500mm to 2,000mm depending on the area.

2.1.2 Political and Regional Administration

The political system of the Dominican Republic is of Constitutional republic type i.e. the separation of three powers (administration, legislation and judicature). The President, Vice-president of the Dominican Republic and the members of National Congress are selected by a national referendum.

In terms of regional administration, the Dominican Republic is divided into one National District and 29 provinces which are composed of 136 local municipalities (Municipio). The city, village and hamlet are classified by the law as follows:

1. City : The capital of the Dominican Republic, and the capital of the province which has more than 10,000 inhabitants.

2. Village: Main place of the province and the number of inhabitants between 1,000 to 10,000.

3. Hamlet : A place which is not classified in the above two categories

2.1.3 Population

According to the sixth national census in 1981, the Dominican Republic has a population of 5,648 thousand and the population density in national average is 116.6 persons/km^2. (Refer to Table 2.1.3-1)

The rate of population increase from the census data of 1970 to 1981 is 3.4% per annum. The estimated population in the middle of 1985 is 6,416 thousand and the rate of population increase during 1980 to 1985 is 2.61% per annum. Oficina Nacional de Estadistica (ONE) has modified the estimated population and estimated about 2.25% per annum of population increase until the year of 2,000. According to the modification, the total population will be 7,169 thousand in 1990, 7,915 thousand in 1995 and 8,620 thousand in 2000.

According to 1981 census, the urban and rural population, in male and female category are as follows:

		Male	Female
Urban	2,935,860	1,405,808	1,530,052
Rural	2,712,117	1,424,487	1,287,630
Total	5,647,977	2,830,295	2,817,682

Table 2.1.3-1 Population Parameters According to Census of 1960, 70 and 81 and Population Estimate for 1985 - 2000

Year	Total Population		Male	Female	Population density (Persons/km)
1960	3,040,070		1,535,820	1,511,250	62.9
Urban	922,090	(30.3%)	430,500	491,590	
Rural	2,124,980	(69.7%)	1,105,320	1,019,660	
1970	4,009,458		2,000,824	2,008,634	82.8
Urban	1,593,299	(39.7%)	752,653	840,646	
Rural	2,416,159	(60.3%)	1,248,171	1,167,988	
1981	5,647,977		2,830,295	2,817,682	116.6
Urban	2,935,860	(52.0%)	1,405,808	1,530,052	
Rural	2,712,117	(48.0%)	1,424,487	1,287,630	
1985	6,416,289		3,260,304	3,155,985	
1986	6,560,381		3,333,618	3,226,763	
1987	6,707,710		3,408,581	3,299,129	
1988	6,858,347		3,485,229	3,373,118	
1989	7,012,367		3,563,601	3,448,766	
1990	7,169,846		3,643,735	3,526,111	
1995	7,915,317		4,023,014	3,892,303	
2000	8,620,870		4,382,029	4,238,841	

Population from 1985 to 2000 is preliminary estimate modified by ONE in 1985

Source : Republica Dominicana en Cifras 1988

Comparing with the census of 1970, the urban population increased extremely from 39.7% to 52% of the total population, which clearly implies the emigration of rural people to the cities.

The number of population engaged in economical activities is about 1,920 thousand, which accounts for about 34% of the total population. The population working in agriculture sector is about 430 thousand which accounts for about 22% of the population engaged in economical activities. The rate of unemployement increases to the extent that number of unemployment is about 350 thousand and reaches to 18% of the population engaged in economic activities in 1981.

2.2 National Economy and Agriculture

2.2.1 National Economy

(1) Present Conditions

The growth rate of gross domestic product (GDP) from 1982 to 1987 was about 2.3% per annum and its rate is lower than the rate of population increase (2.8%) during the same period. The GDP in 1987 was about RD$19.3 billion (US$5.5 billion) with increased high rate of economic growth of 8.1% compared to the year of 1986, and recovered the declined economic growth of 1984/85. The low economic growth was caused by reduction of sugar products due to the reduced United States quota of sugar sector, the lower price of sugar exportation and the inactivity of ferronickels production. The high growth rate in 1987 was due to the increase of mining sector (24% up from 1986) which improved the production of ferronickel and reproduced bauxite suspending from 1982, and the construction sector (34% up from 1986) because of construction rush of housing and buildings.

The share of GDP by sector is almost constant from 1975 to 1988, the agricultural sector has a tendency to fall slightly from 1984 and the construction sector is rising in recent years. (Refer to the Table 2.2.1-1 and Fig. 2.2.1-1)

Table 2.2.1-1 Gross Domestic Product by Sectors (1970-1987)

(Unit:RO$ Million of 1970's price)

Sector \ Year	1970 amount	1970 %	1975 amount	1975 %	1980 amount	1980 %	1982 amount	1982 %	1983 amount	1983 %	1984 amount	1984 %	1985 amount	1985 %	1986* amount	1986* %	1987* amount	1987* %
Agriculture & Livestock	345.1	23.2	339.9	11.5	481.2	14.7	534.3	11.4	550.8	11.2	550.9	11.1	523.1	10.1	528.5	10.3	543.7	10.5
Mining	22.7	1.5	131.7	3.3	133.6	4.5	93.6	2.1	124.8	2.5	135.1	2.7	135.0	2.5	119.7	2.3	149.3	2.8
Manufacture	275.4	18.5	428.5	14.7	530.2	18.3	562.3	14.3	568.1	17.7	551.4	11.2	515.0	14.5	550.8	17.0	611.3	17.6
Constructions	72.7	4.9	152.6	6.7	137.6	6.8	183.1	6.0	234.3	5.1	285.6	5.8	192.0	6.1	221.8	6.9	297.4	8.5
Commerce	237.6	16.0	385.9	16.9	493.3	15.3	520.2	16.9	522.8	16.3	514.4	16.0	485.4	15.5	497.1	15.4	501.1	15.5
Transport	104.5	7.0	161.4	7.1	199.6	8.9	221.8	7.2	222.5	6.9	217.7	6.8	206.9	6.5	212.5	6.6	223.2	6.9
Communications	10.3	0.7	21.2	0.9	30.9	1.1	36.8	1.1	37.0	1.2	39.3	1.2	41.4	1.3	44.9	1.4	50.7	1.6
Electricity	17.5	1.2	30.0	1.3	45.0	1.7	48.4	1.6	50.5	1.6	58.6	1.8	59.4	1.9	62.1	1.9	65.5	2.0
Finance	31.1	1.8	48.3	2.1	70.4	2.6	78.5	2.5	81.7	2.5	120.0	3.8	138.5	4.8	150.5	4.7
Housing	100.2	6.7	148.9	6.5	198.1	6.8	201.2	6.8	208.1	6.4	210.2	6.5	212.2	6.8	214.5	6.6	219.4	6.5
Government	151.1	10.2	183.1	8.0	210.3	9.7	311.9	10.2	320.5	10.0	330.6	10.3	334.1	10.7	331.9	10.3	332.6	9.1
Other services	120.3	8.1	206.1	9.0	265.4	9.1	280.8	8.2	300.3	9.4	300.4	9.3	305.3	9.8	313.7	9.7	321.4	9.2
Total	1,485.5	100.0	2,288.5	100.0	2,909.5	100.0	3,053.2	100.0	3,209.4	100.0	3,216.1	100.0	3,128.4	100.0	3,234.0	100.0	3,491.5	100.0
GDP per capita	370		487		517		511		521		507		487		493		521	
Growth rate (%)			5.0		5.2		1.8		1.5		0.2		-1.8		1.1		8.1	

* Preliminary estimate
Source : Cuentas Nacionales, Banco Central

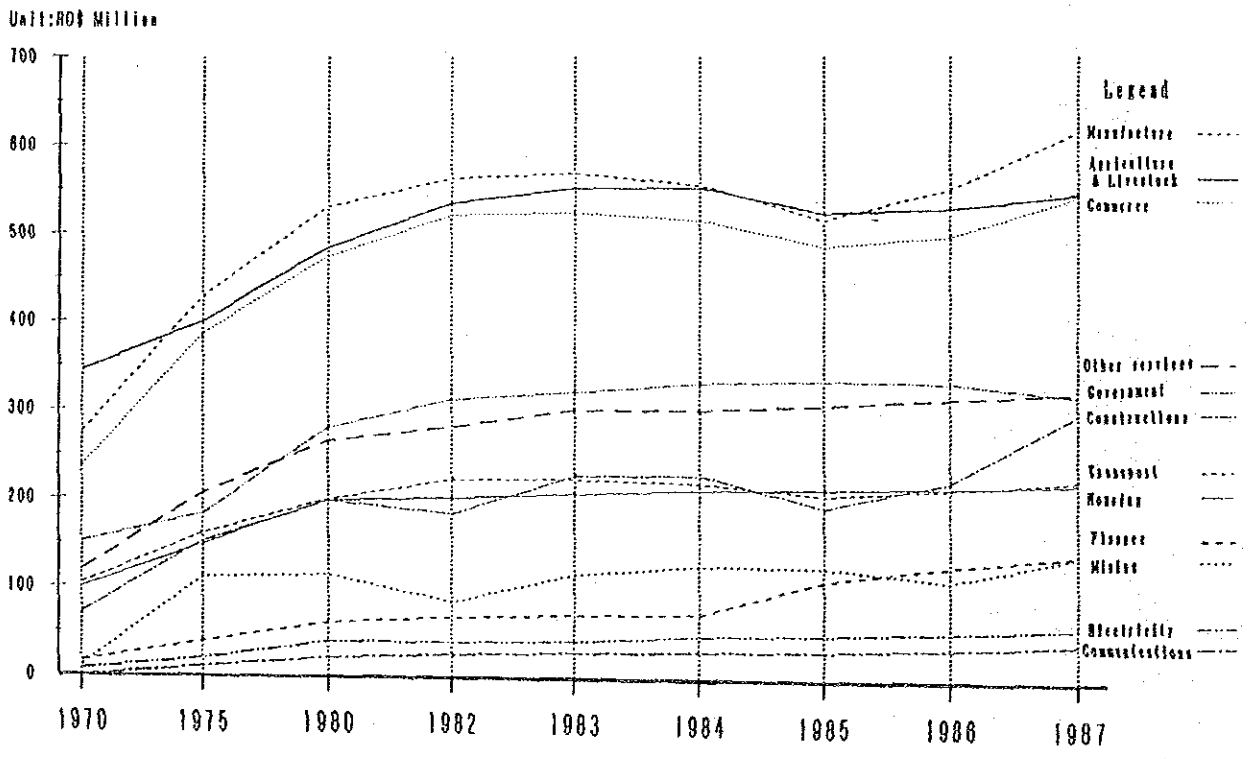

Fig.2.2.1-1 Gross Domestic Product by Sector

(2) Balance of Payments

In the Dominican Republic the balance of payments is continuously worse due to the international trade deficit.

The global balance increased the deficit from US$250 million in 1986 to US$470 million in 1987. The deficit of international trade balance in 1987 increased about US$200 million than that of 1986 due to the excess of imports. Tourism sector is growing as the main foreign exchange earner and contribute to improve the balance of total international trade including services. The balance of payments during last three years is shown as follows:

Table 2.2.1-2 Balance of Payments (Unit: US$ million)

	1986*	1987*	1988**
1. Trade Balance	-143.5	-347.5	-154.0
Exports	1,407.0	1,562.9	1,776.3
Imports	1,550.5	1,910.4	1,930.3
2. Net services	-377.9	-480.0	-473.2
3. Transfer	271.0	355.4	349.0
4. Global balance	-250.4	-472.1	-278.2

* Preliminary estimate
** Projected estimate

Source: National Development Plan (1987-90)

(3) Foreign Trade

The exportation of the Dominican Republic has been dominated by six traditional products such as sugar, coffee, cacao, tobacco, ferronickel and doré (alloy of gold and silver), all of which account for about 80% of the total export.

In 1988, the total export amount to US$890 million (FOB) and increased by 25% comparing with 1987 due to rise of international price of ferronickel by 2.5 times (US$1,462/M.T to US$3,653/M.T) compared to 1987. Such as this situation, the unstability of international market price has influence on the Dominican economy.

The agricultural products occupy the biggest share of export products and account for about 70% of the total export amount until the year of 1987, however, in 1988 the share decreased to 56% due to high rise of price of ferronickel. (Refer to the Table 2.2.1-3 and Fig. 2.2.1-2)

The import amount is more than the export amount from year of 1976 and the balance of foreign trade is continuously in deficit. The main import product is petroleum and refined products which occupy for 20% of the total import amount. Other import products are such as cars, provisions (rice, wheat, vegetable oil, etc) and medicine which occupy less than 6% each of the total import amount. The import quantity of the agricultural products are about 230 thousand ton of wheat, 140 thousand ton of maize, 66 thousand ton of rice and 5 thousand ton of beet.

The exports have a tendency to decrease due to the deduced United States quota of sugar and lower international market products. On the other hand, the imports is increasing year by year. Especially in years of 1987 and 1988, the import amount was about two times more than the export amount. (Refer to the Table 2.2.1-4(1),(2)). Under this situation, the external debt has increased yearly and reached US$3.65 billion at the end of 1986

The biggest country of foreign trade is the U.S.A. which occupy for 65.8% of exportation and 39.5% of importation in 1987.

Table 2.2.1-3 Principal Exportation Products

(Unit:US$ Million, %)

	1982	1983	1984	1985	1986		1987		1988	
Sugar ※	306.8	297.8	306.6	184.7	166.2	23.0	160.0	22.5	168.8	19.0
Coffee	90.6	76.3	95.1	86.1	112.8	15.6	63.3	8.9	64.3	7.2
Cacao	52.9	55.5	70.1	58.1	58.9	8.2	66.3	9.3	64.1	7.2
Tobacco	21.4	21.8	24.2	17.6	18.6	2.6	14.1	2.0	18.3	2.1
Bouxite	5.3	0.0	0.0	0.0	0.0	0.0	4.1	0.6	1.4	0.2
Ferronickel	24.2	83.5	108.5	120.7	77.8	10.8	115.3	16.2	306.1	34.4
Doré .	163.6	164.5	131.8	113.6	111.8	15.5	120.0	16.9	98.1	11.0
Others	102.9	85.8	132.4	157.7	176.0	24.4	168.2	23.6	169.3	19.0
Total	767.7	785.2	858.7	738.5	722.1	100.0	711.3	100.0	899.4	100.0

Source : Monthly Report, Central Bank
※ Including crude sugar, furfural and molasses

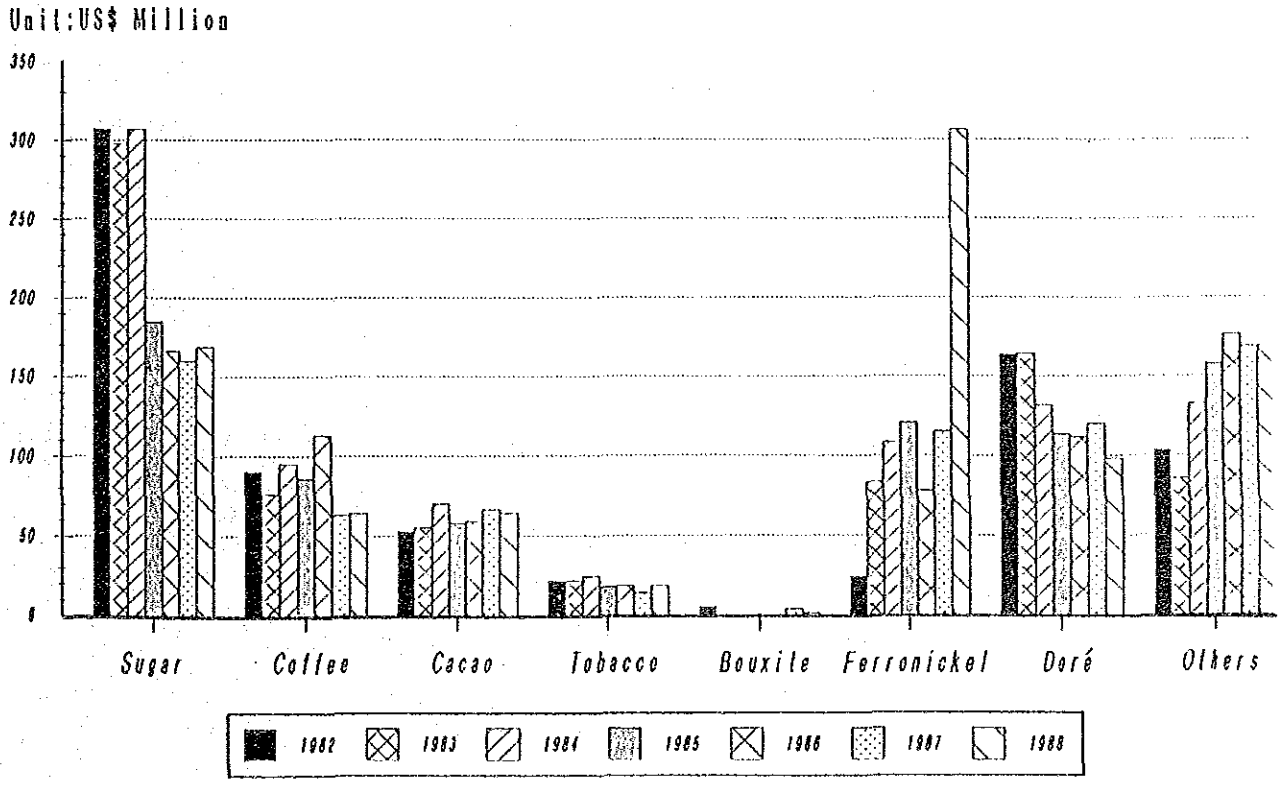

Fig.2.2.1-2 Principal Exportation Products

Table 2.2.1-4(1) Balance of Foreign Trade (only goods)

(Unit: US$ million)

	1984	1985	1986	1987	1988
Export (FOB)	868.1	738.5	722.1	711.3	863.5
Import (FOB)	1,257.1	1,285.9	1,351.7	1,591.5	1,596.5
Balance	-389.0	-547.4	-629.6	-880.2	-733.0

Table 2.2.1-4(2) Principal Export and Import Goods (1986)

(Unit: US$ million)

Export		Import	
Sugar	166.2	Petroleum and	
Coffee	112.8	refined products	256
Cacao	58.9	Cars	87
Tobacco	18.6	Wheat	29
Ferronickel	77.8	Medicine	30
Dore	111.0	Provisions	28
Others	176.8	Maize	15
		Mechanical parts	14
		Others	892
Total	722.1	Total	1,351

Source: Cifras 1988, ONE

2.2.2 Agriculture

(1) Agricultural Land and Scale

According to the national census of 1970 and 1981, the total agricultural land decreased from 2,737 thousand ha to 2,676 thousand ha. The area of agricultural land in three regions are as follows:

(Unit: Thousand ha)

Region	1970	1981	Percent
Total	2,737	2,676	(100%)
Cibao	1,270	1,199	(46.4%)
South-west	340	350	(12.4%)
South-east	1,127	1,127	(41.2%)

The agricultural land occupies 55.25% of the total national land, and among this agricultural land, 49.3% is cultivated land, 44.7% is pasture land, and 6% is the mountain, forestry and others. The details of the agricultural land are as follows:

(Unit: Thousand ha)

Type	Area	Percent
1. Cultivated land	1,318	(100%)
-Arable land	1,009	(76.5%)
-Non-cropping land	179	(13.6%)
-Waste land	130	(9.9%)
2. Pasture land	1,197	(100%)
-Cultivated	599	(50%)
-Non-cultivated	598	(50%)
3. Mountain, Forestry and Others	161	
Total:	2,676	

Source: Government of Dominican Republic Census Data, 1981

The major farmers are the small-scale farmers who own farms of less than 5ha size which corresponds to about 81.7% of the total farm families and hold only 21% of the total agricultural lands. On the other hand, the large-scale farmers who own more than 50ha area is only 1.8% of the total farm families and hold 45.5% of the total agricultural lands.

Farm Holding Size	No. of Farm Families	%	Property Area (ha)	%
<0.5 ha	61,670	16.0	11,698	0.9
0.5- 5ha	252,995	65.7	262,623	19.9
5-10ha	32,543	8.5	155,876	11.8
10-50ha	30,815	8.0	288,258	21.9
>50ha	7,037	1.8	599,637	45.5
Total	385,060	100.0	1,318,092	100.0

Source: Government of Dominican Republic Census Data, 1981

In the Cibao Region, there are 201,911 farm families which account for 52.4% of the total farm families and in Central Cibao Sub-region, there are 104,448 farm families which account for 52% of the farm families in Cibao region.

(2) Agricultural Production

Agriculture is the most important sector of the national economy, and its contribution to the GDP has been declined from 23.2% (1970) to 15.5% (1987). As shown in the Table 2.2.2-1, there is a declining tendency in the production of main agricultural products.

The production of sugar was reduced by 4.1% per annum from 1970 (12.2 million ton) to 1987 (8.8 million ton).

The area of cultivated land diminished yearly and reached to 230 thousand ha by 1988. This was caused by the reduced United States quota and the lower international market price. Sugar cane is cultivated in eastern and central parts of the country.

The yearly production of coffee is constant at 130 to 140 thousand tons. It is cultivated in mountainous part especially in central and southern mountain ranges. The cultivated area is about 150 thousand ha and the number of farm families is about 70 thousand, of which most are small-scale farms. The quality of coffee is not so good because of poor facilities for harvest, fermentation and drying in small-scale farms.

Cacao is cultivated in northern, central and eastern parts of the country, over an area of about 90 thousand ha. The number of farm families are about 40 thousand and the small-scale farm families who own less than 5ha corresponds to 72% of total cacao farm families.

The plants of cacao are more than 35 years old, and its density is low. The production and profit of cacao is low caused by low technology level of small-scale farms and abandoned cultivation in some zones. Recently, some farmers introduced hybridization technology and its production has increased by 4 times. The total cacao production is increasing gradually by the introduction of this new technology.

The cultivation of tobacco is concentrated in the surrounding of Santiago and the average cultivated area of farm is about 1 ha. The production was decreased because of the importation limit of Spain and the cultivated area has also diminished from 28 thousand ha (1985) to 12 thousand ha (1987).

The area of cultivated land and production of the non traditional agricultural products (which are mainly for domestic consumption) such as rice, maize, kidney bean, cassava, banana and vegetables, etc. are increasing.

Until 1987, the exportation amount of agricultural products accounted for about 70% of the total exportation. The exportation of sugar accounted for 53% of the agricultural exportation in 1982 and decreased to 33% in 1987, due to the reduced United States quota. The exportation of coffee has also decreased and that of cacao is increasing year by year. Recently, the exportation of non traditional agricultural products is notable except a slight increase from 13% in 1982 to 17% in 1987 of the total exportation amount. Basic crops for the domestic consumption such as rice, kidney bean and wheat are imported partly due to increasing domestic demand for the above products.

Table 2.2.2-1 Production of Main Agricultural Products

(Unit: Thousand ton)

Agricultural Product	Year				
	1983	1984	1985	1986	1987
1. Traditional Exportation Products					
-Sugar	11,520	10,995	8,217	8,208	8,772
-Coffee	136	144	144	137	134
-Tobacco	34	28	31	26	29
-Cacao	33	33	35	36	36
2. Domestic Consumption Products					
-Rice	501	507	494	468	514
-Kidney Bean	61	67	48	49	52
-Cassava	99	124	135	143	143
-Potato	23	17	16	16	15
-Onion	15	18	19	20	21
-Garlic	3	3	3	3	3

Source: Monthly Report of Central Bank, Jan. 1989/ Cifras, 1988

2.3 National Development Plan

(1) Background

The present government started on August, 1986 have implemented "The National Development Plan (1987-1990) - Repercussion of Public Investment Program" on September, 1987 under the national economic development policy such as extension of public investment and agriculture sector. Based on the National Development Plan, the government published "Evolution Program of Public Investment and Perspective in 1988" on July, 1988 and "Perspective of Dominican Economy for the Period 1989-1992".

(2) Objectives of the Plan

The basic policy of the National Development Plan is to recover and develop the national economy with the following objectives:

- Activation of national economy
- Extension of production by public investment
- Improvement of social welfare

The short and medium term plans are established in order to realize the above objectives.

1) Short Term Plan

The short term plan of economic recovery strategy emphasize on public investments of non financial public sector. By means of aggressive policy for taxes collection, operation cost control, and by improving the efficiency & efficacy of principal public companies the internal saving of the government will be increased, and this saving will be used for new public investment without external loan. The main strategies are as follows:

- Expansion of internal saving
- Deduction of external debt
- Extension of GDP per capita by increasing public investment

2) Medium Term Plan

The medium term plan of economic development strategy is a continuance of the short term plan for progressing economic growth without increasing the unemployment and stagnation of social development. The main strategies are as follows:

- Constant supply of electricity
- Expansion of agricultural production
- Expansion of exportation

The realization of the above strategies is established by an annual GDP growth rate of 6.3% from 1987 to 1990 and necessary public investments for the strategy is shown as follows:

Public Investment Program 1987/90

(Unit: RD$ Million of 1987's Price)

Sector	Amount	%
-Electricity energy etc.	2,638.4	36.8
-Agriculture, hunting, forestry and fishery	1,626.8	22.7
-Transportation and communication	993.8	13.8
-Industry, commerce and finance	756.1	10.5
-Welfare	568.4	7.9
-Housing	429.7	6.0
-Education	140.6	2.0
-General administration	17.7	0.2
Total	7,171.5	100.0

(3) Development Plan in Agricultural Sector

The progress of the agricultural sector has been stagnated with a growth rate of 0.4% per annum during the last 10 years and the agricultural production was not sufficient to meet the domestic demand. In the above situation, there is continuous decrease of foodstuff supply and increased nutrition deficiency of poor people. It is difficult to increase the area of cultivated land under the short term plan, however, in the medium term plan (1987/90) this will be possible.

New cultivated land is planned as follows:

1. Extension of about 20 thousand ha of cultivated land under new irrigation infrastructure project and extension of existing irrigation system up to 150 thousand ha.

2. Liberation land of about 13 thousand ha of sugar plantation area, property of National Council of Sugar, for changing the agricultural crops which will be joined with private sector to promote as exportation products.

The growth rate of agricultural sector will be 5.1% (6.0% of agriculture, 3.8% of livestock, 4.0% of forestry and fisheries) from 1987 to 1990 under the extension of cultivated land and development of productivity. The production of agricultural crops will grow by about 525 thousand ton including domestic consumption such as about 46 thousand ton of rice, about 23 thousand ton of maize, about 46 thousand ton of kidney bean, about 184 thousand ton of root crops and about 92 thousand ton of vegetables. For succeeding the above objectives, the agricultural sector should be given high priority of public investment plan with budget of RD$1,626.8 million which accounts for about 22.7% of total public investment.

3. Brief Description of the Study Area

3.1 Location of the Study Area

The study area is Constanza Valley, which is located in latitude 18° 54' north and longitude 70° 45' west, in the middle of the Republic. The study area extends over an area of about 2,130ha out of the total valley area of 2,340ha. The elevation of the study area ranges between 1,140m to 1,300m above the sea level (A.S.L.) and is surrounded by mountains whose heights are about 1,400m to 1,700m A.S.L.

All of the Valley belong to Municipal Constanza of La Vega province. The center of the municipal constanza is located almost at the middle of Valley. The distance from the capital city (Santo Domingo) to Constanza is about 140km connected by national road No. 1 which is the principal road in Dominican Republic.

3.2 Socio-economic Characteristics of the Study Area

3.2.1 Population

According to the census of 1982, the population of Municipal Constanza is 38,524. The detail of the population is as follows:

Male	20,098	52%	Urban area	15,141	39.3%
Female	18,426	48%	Rural area	23,383	60.7%
Total	38,524	100%			100.0%

In accordance with "República Dominicana en Cifras" published by "Oficina Nacional de Estadística" in May, 1989, the population of Municipal Constanza from 1985 to 1988 is as follows:

Year	1985	1986	1987	1988
Population	41,075	41,453	41,816	42,163

The population in the study area of the Valley is 29,200 and the number of families is 4,859 based on the final report of "Estudio Integrados de Recursos Naturales de la Cuenca del Río Grande o del Medio" submitted to the Ministry of Agriculture, in Sept. 1988.

3.2.2 Socio-economic Characteristics

Agriculture is the main industry of the Valley and 58% of the head of family in the study area is engaged in agriculture. The main agricultural products are garlic, potato, onion, beans and vegetables. The scale of commercial activity is small comparing with the agriculture which is the main economic activity in the Valley, and the proportion of the head of the family employed in commercial business is approximately 15% of the total population.

The scale of farm business is comparatively small and the number of small-scale farmers who own less than 1 ha correspond to about 60% of the total number of farmers and the farmers who own 1 ha to 5ha correspond to only about 30%. More than 90% of the total agricultural production are shipped to the capital of Santo Domingo city and Santiago city.

3.2.3 Social Infrastructure

The main road of access to the Valley is the mountain road Carretera Casabito which is branched from the National Road Route No.1 (Carretera Duarte).

Electricity and water services are supplied to the center and most part of the Valley; however a portion of the higher part of the rural area has no such services. Those who have no water supply services depend on wells or rivers for their domestic water. Facility of water services has been installed in 1953 and administrated by Instituto Nacional de Aguas Potables y Alcantarillado (INAPA). Drainage facilities are very few and not in good condition.

At the entrance of Constanza City, there is a public hospital administrated by the Ministry of Health, and there are several clinics in the City.

There are three elementary schools (Escuela Primaria Padre Fantino, Escuela de Palero and Escuela de la Colonia Japonesa), one secondary school (Liceo Gaston Fernando Deligne) and one high school (Colegio Nuestra Señora Del Valle) in the City.

In the center of Constanza City, there are several public offices such as municipality, post office, police station, fire station, banks and military office.

3.3 Natural Features and Characteristics

3.3.1 Topography

The project area is about 4km wide from north to south and about 8km long from east to west. The farm land has a gentle slope with an undulation of 100m (altitude: from 1150 to 1260m). The Arroyo Constanza flows at the middle of the Valley from east to west.
The Valley is divided into two parts, one is a farm land at the bottom with 2-3% slope and the other is the montainous area with steep slopes. It belongs to the late mature stage in the landform.

3.3.2 Geology

The bed rock in the study area is composed of the andesitic pyroclastic rock, andesitic lave, the sedimentary rock and tonalite in the cretaceous.
Andesitic pyroclastic rock is mainly found in the Valley and characterized by its color of red or dark gray.
The sedimentary rock is mainly composed of dark gray colored shale and sand stone lain partly between shale. The sedimentary rock is called as Tireo stratum.

Tonalite stratum is mainly distributed in the northern mountain part and a part of the southern mountain. The small tonalite in the southern side touches with Tireo stratum by faults. On the other hand, Quaternary sediment is found in the Valley and along the Río Grande. Quaternary sediment is composed of gravel, sand and clay, about 10 to 40m deep, and forms the water-bearing layer in the Valley.

Quaternary sediment distributed along the Río Grande is characterized by greats boulders of 30-50cm in diameter, and is called as Guayal stratum.

ANNEX B : METEOROLOGY

ANNEX B: METEOROLOGY

LIST OF TABLES

LIST OF FIGURES

ANNEX B : METEOROLOGY

1. Existing Data

In course of the study, the following data collection and analysis were carried out for the water resources study and irrigation planning.

Irrigation planning : Constanza Climatological Station
Water Resources Study : Rainfall data of the Yaque del Sur Basin

In the study area, the climatological station was installed at the central part of the study area in 1931 and since then, the climatological data of rainfall, temperature, wind direction and evaporation have been observed. On the other hand, the rainfall data of the Yaque del Sur Basin were collected in the course of the study in order to estimate the discharge of the Rio Grande Basin, which is the main water resource of the study area. The locations of the observation stations are shown in Fig. 1.1.1-1. The collected meteorological data are shown in the Table 1.1.1-1.

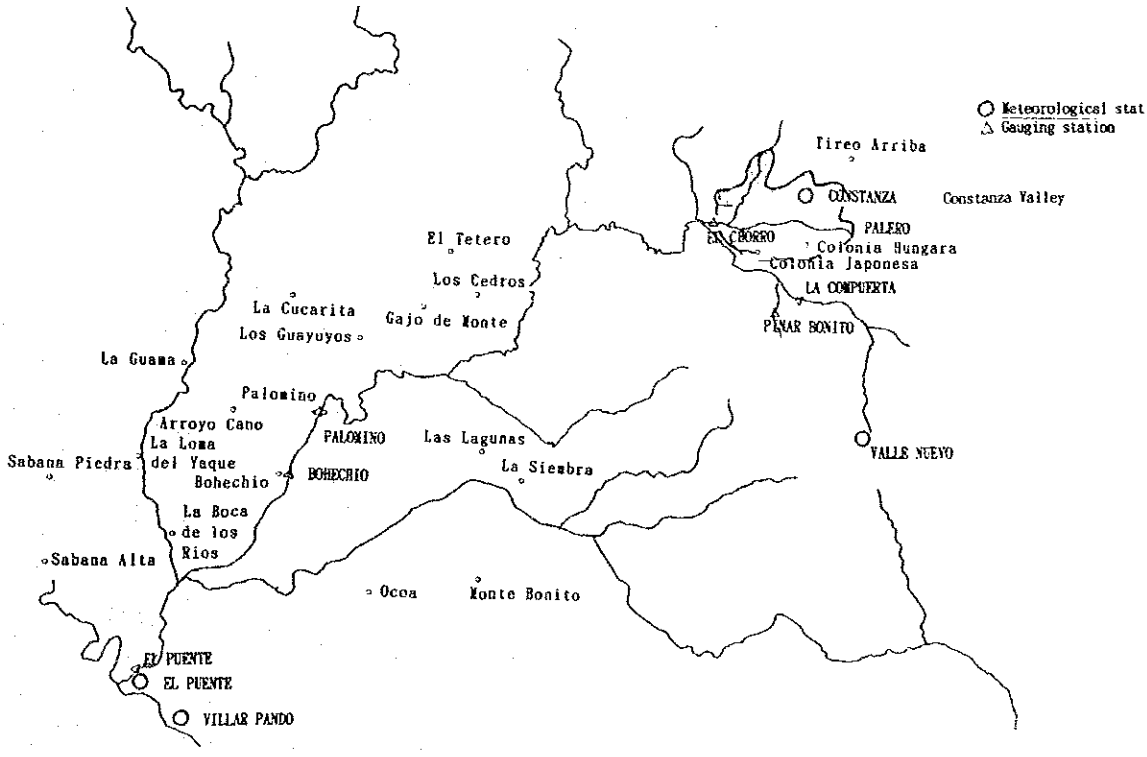

Fig. 1.1.1-1 Location of the Climatological Observation Stations

Table 1.1.1-1 List of Collected Data

Station	Contents	Observation Period
Constanza	Monthly rainfall	Jan.1931 - Dec.1988
	Daily rainfall	Jan.1931 - Dec.1988
	Temperature (Max. Min.)	Jan.1968 - Dec.1988
	Relative humidity	Jan.1968 - Dec.1988
	Nuevosity	Jan.1968 - Dec.1988
	Wind direction/velocity	Jan.1968 - Dec.1988
Nuevo Valle	Monthly rainfall	Jan.1968 - Dec.1974
Villar Pando	"	Jul.1967 - Apr.1988
El Puente	"	May 1967 - Jul.1970

2. Monthly Rainfall at the Rio Yaque del Sur Basin

Mean monthly rainfall at the climatological stations of the Rio Yaque del Sur basin are as follows:

Table 2.1.1-1 Mean Monthly Rainfall

Station	Observation Period	1	2	3	4	5	6	7	8	9	10	11	12	Annual
Constanza	1931-84	37.8	37.3	33.9	69.6	190.5	111.8	69.8	102.9	122.5	111.5	69.3	56.6	1013.5
Valle Nuevo	1968-74	59.7	40.6	42.7	65.7	92.0	117.6	70.9	117.7	112.9	98.5	88.9	70.0	977.2
El Cacheo	1960-88	14.6	21.0	39.8	71.4	128.9	88.2	85.0	117.8	141.0	131.7	65.8	15.7	920.9
El Puente	1967-70	24.9	15.1	4.7	63.8	42.0	48.8	34.5	44.0	130.9	44.5	18.8	27.3	499.4
Villarpando	1967-88	9.4	9.2	31.7	61.2	76.7	56.2	36.7	61.5	83.3	78.8	38.3	12.4	555.4

The distribution of the annual rainfall in the Rio Yaque del Sur Basin is shown in Fig. 2.1.1-1.

The study area is located in the relatively rainy zone of the Rio Yaque del Sur Basin.

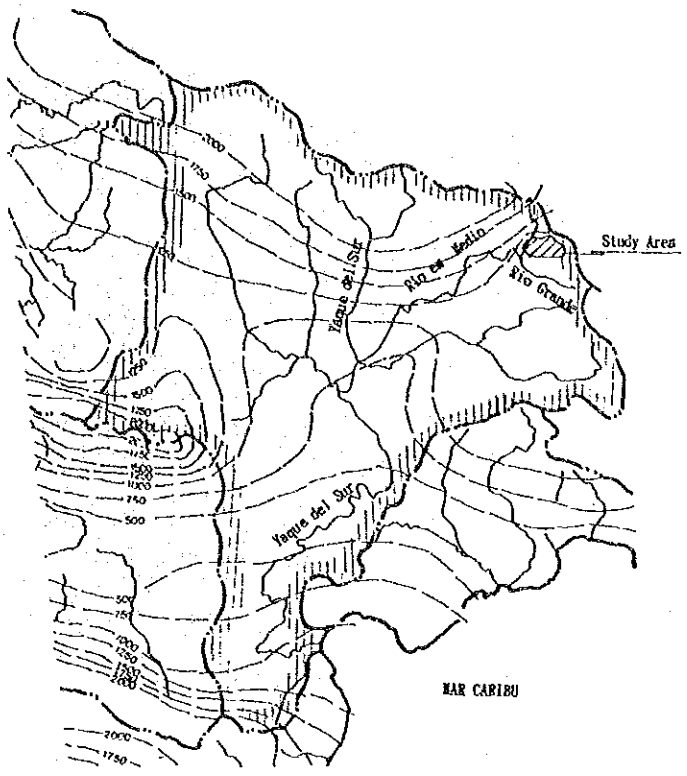

Fig. 2.1.1-1 The Distribution of the Annual Rainfall in the Rio Yaque del Sur Basin

3. Climatological Characteristics of the Constanza Valley

3.1 General Description

The climatological characteristics of the Constanza Valley are shown in Table 3.1.1-1 and Fig. 3.1.1-1. The most rainy month is May, covering 18% of the annual rainfall. The dry season is observed during December to March, covering only 13% of the annual rainfall. The wet season is from May to October, covering 75% of the annual rainfall.

The rainy day is observed scarcely during January to March, with 16 days. The rainy day is observed most frequently in May with 15.1 days in average. The mean temperature is 18.2°C and the mean monthly temperature varies between 16.4°C and 19.5°C. The variation of the mean monthly temperature is small, but the variation of daily difference is very high; minimum and maximum temperature are recorded as -1°C and 35°C respectively. The relative humidity is generally stable at 76% with a variation of ±3%.

The monthly evaporation varies from 100mm to 150mm. The high evaporation is recorded in March, July and August. The annual evaporation is 1,466mm and it shows higher value than the annual rainfall.

Table 3.1.1-1 Constanza Climatological Data

	1	2	3	4	5	6	7	8	9	10	11	12	Annual
Rainfall(mm)	36.7	35.8	33.0	69.1	185.1	112.5	70.9	100.8	122.3	110.7	68.8	54.7	1000.4
Rainy day(day)	6.2	4.4	5.3	7.3	15.1	10.6	8.6	9.2	12.2	11.6	9.6	8.1	9.0
Air temperature(C)	16.5	16.4	17.3	18.0	18.8	19.2	19.3	19.5	19.4	19.0	18.0	16.6	18.2
Humidity(%)	76.2	75.4	73.0	75.1	78.0	75.8	73.2	74.6	76.3	77.3	78.7	78.8	76.0
Sunshine hour(hour)	222.0	195.4	226.5	191.0	197.5	208.2	211.1	214.2	187.1	191.2	190.2	223.5	204.8
Evaporation(mm)	117.9	110.0	144.4	134.4	99.9	121.8	153.4	144.1	118.3	111.6	104.1	106.3	1,466.20
Wind velocity(km/h)	10.1	9.7	11.2	10.4	7.9	9.4	13.3	11.9	9.4	8.6	9.4	10.1	10.1
Wind direction	ENE	ENE	ENE	ENE	ENE	ENE	ENE	ENE	ENE	ENE	ENE	ENE	

Oficina Nacional de Meteorologia (1971~1988年)

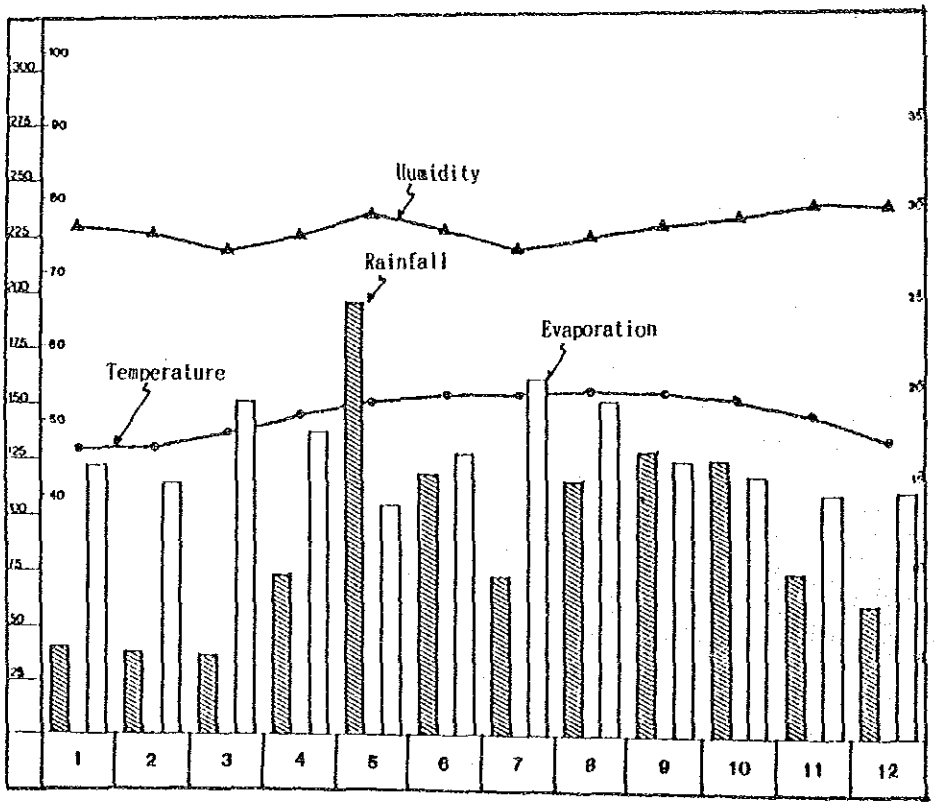

Fig. 3.1.1-1 Climatological Characteristics at Constanza Valley

3.2 Rainfall

3.2.1 Annual Rainfall

The distribution of the annual rainfall at the Constanza station is shown in Table 3.2.1-1, and monthly rainfall data for 1931 - 1988 is shown in Table 3.2.1-2. The rainfall of the area is characterized by the localized distribution of rain influenced by the topographic factor. The rainfall varies from 700mm to 1,400mm. The minimum annual rainfall during the observation period was recorded to be 617.8mm/year in 1976 and the maximum was recorded to be 1,521.2mm/year in 1943. The mean annual rainfall is 1,006.5mm/year.

Table 3.2.1-1 Distribution of the Annual Rainfall

Annual Rainfall	No. of times Observed	Frequency	Frequency Accumulated
600 - 699	2	3.8%	3.8%
700 - 799	7	13.2%	17.0%
800 - 899	8	15.1%	32.1%
900 - 999	11	20.8%	52.9%
1,000 - 1,099	11	20.8%	73.7%
1,100 - 1,199	4	7.5%	81.2%
1,200 - 1,299	4	7.5%	88.7%
1,300 - 1,399	3	5.7%	94.4%
1,400 - 1,499	-	0.0%	94.4%
1,500 -	3	5.7%	100.0%
Total	53	100.0%	100.0%

On the basis of annual rainfall data, the probability of annual rainfall was estimated as follows:

Probability of Annual Rainfall

Return Period	Annual Rainfall
50 years	648 mm/year
20 years	705 mm/year
10 years	760 mm/year
5 years	832 mm/year
2 years	987 mm/year

Table 3.2.1-2 Annual Rainfall Amount at the Constanza Meteorological Station (1931～1988)

Unit(mm)

Year/Month	1	2	3	4	5	6	7	8	9	10	11	12	Total
1931	70.4	0.0	0.0	138.9	245.4	208.1	89.4	18.8	169.1	143.6	162.6	76.7	1323.0
1932	156.6	0.0	5.3	177.0	212.3	86.1	103.7	198.5	183.5	61.6	184.7	145.1	1514.4
1933	41.9	0.0	45.1	52.1	197.9	123.1	83.7	166.1	151.9	81.7	93.2	140.7	1177.4
1934	15.5	92.1	30.2	75.0	254.3	79.2	134.0	51.8	155.5	86.3	121.2	82.8	1177.9
1935	77.7	32.3	25.7	39.8	177.5	125.0	82.4	146.3	108.5	168.3	13.0	94.7	1091.2
1936	4.8	12.4	13.7	62.3	434.6	134.0	115.3	115.7	128.2	52.2	24.8	117.9	1215.9
1937	232.3	0.0	16.4	53.6	336.0	0.0	47.7	132.7	12.7	85.4	100.0	53.9	1070.1
1938	33.4	101.9	3.8	34.3	130.3	135.0	54.4	127.5	130.8	169.5	68.3	42.7	1031.9
1939	49.9	14.5	52.1	16.5	86.1	169.6	65.6	46.3	168.5	185.5	143.9	8.4	1006.9
1940	–	0.0	11.0	29.9	133.6	191.1	42.0	61.5	46.5	202.7	6.8	36.6	–
1941	1.2	5.6	1.3	211.2	144.9	81.4	12.4	63.2	99.1	16.8	36.2	40.0	713.3
1942	12.7	1.3	52.6	65.2	187.6	143.7	93.0	110.9	74.3	180.4	156.0	268.1	1345.8
1943	258.0	358.2	271.9	99.9	145.4	141.0	39.9	24.7	16.9	148.4	14.2	9.7	1528.2
1944	16.7	6.0	18.1	29.0	233.6	189.3	42.6	21.1	125.4	45.9	17.5	31.5	770.7
1945	5.1	14.9	20.3	84.8	247.7	38.9	124.6	147.1	120.1	53.2	40.4	57.1	954.2
1946	7.6	17.7	61.1	14.7	117.6	250.4	64.5	61.0	139.2	181.8	87.9	22.8	1026.3
1947	39.0	3.3	0.0	11.0	257.4	160.0	35.5	91.5	172.3	186.5	15.2	17.3	989.0
1948	24.9	32.7	9.4	64.2	329.6	77.5	112.4	62.0	80.7	137.5	120.6	13.2	1064.7
1949	27.5	20.8	106.0	13.5	128.7	56.9	143.3	63.3	147.3	100.1	53.1	123.4	983.9
1950	137.8	138.7	1.5	124.2	50.5	106.4	39.9	176.1	182.1	120.4	73.9	63.7	1215.2
1951	37.9	10.7	0.0	207.8	197.2	108.4	78.5	110.5	229.5	184.0	64.5	–	–
1952	21.8	7.6	42.5	241.7	296.4	62.0	111.2	45.7	158.8	28.2	12.4	6.9	1035.2
1953	33.5	6.2	17.5	22.1	251.2	145.7	83.5	51.6	78.3	156.1	55.3	43.9	944.9
1954	9.6	137.1	30.0	53.6	292.1	168.1	100.1	29.9	66.1	237.1	60.3	13.4	1197.4
1955	18.5	29.5	0.0	36.5	190.7	125.9	128.3	47.4	89.8	115.6	41.6	39.8	863.6
1956	29.7	278.2	81.9	12.4	90.1	99.6	23.6	6.7	60.7	142.7	31.3	61.1	918.0
1957	26.2	19.0	11.5	15.1	244.3	94.3	67.9	92.5	148.3	108.3	49.0	82.8	959.2
1958	69.3	5.0	15.2	2.5	277.2	209.9	67.2	65.9	114.5	89.8	42.4	8.9	967.8
1959	13.1	6.7	0.0	123.5	44.4	163.1	95.8	125.0	115.5	93.0	99.2	6.2	885.5
1960	53.4	57.8	118.0	132.2	201.1	98.6	104.7	97.9	56.5	69.1	65.8	28.8	1083.9
1961	19.5	56.0	89.9	56.0	189.0	138.3	84.8	108.1	214.2	149.2	98.6	56.0	1259.6
1962	13.2	0.0	10.6	75.5	136.2	142.5	53.1	96.0	113.2	65.5	71.9	24.5	802.2
1963	22.2	6.4	37.2	48.8	139.9	75.9	43.9	39.9	210.3	162.2	36.4	4.6	827.7
1964	19.9	1.3	19.1	112.5	84.7	85.1	40.1	112.3	183.7	84.8	87.6	69.2	900.3
1965	13.3	12.7	10.7	–	227.6	–	6.5	93.0	75.8	98.7	52.8	90.5	–
1966	26.6	7.1	37.2	15.8	153.3	17.9	64.8	27.1	114.4	80.0	87.4	47.5	679.1
1967	37.8	24.4	27.5	47.1	54.0	160.8	59.2	124.9	127.8	50.9	56.4	10.9	781.7
1968	33.6	13.6	12.2	14.6	124.9	96.6	56.2	204.5	88.4	10.9	187.2	81.1	923.8
1969	21.4	5.6	32.1	167.2	144.8	85.5	23.6	57.7	78.9	161.7	73.7	39.6	891.8
1970	30.6	30.1	7.7	32.9	166.6	81.5	114.1	143.8	137.1	96.3	111.6	110.4	1062.7
1971	9.4	124.0	29.1	75.2	177.1	97.1	40.9	82.1	231.2	103.0	56.7	54.5	1080.3
1972	18.4	12.3	92.9	30.2	220.0	131.1	145.4	159.2	157.5	107.7	37.8	75.4	1187.9
1973	9.2	23.0	10.2	15.4	125.0	110.5	107.1	92.5	138.0	113.1	61.8	42.4	848.2
1974	45.1	36.7	53.0	65.4	149.6	62.5	39.0	266.9	105.4	154.1	37.4	38.8	1053.9
1975	10.3	11.0	9.8	16.5	120.7	7.4	21.4	64.6	157.8	58.7	128.5	152.7	759.4
1976	12.3	38.6	21.0	75.8	36.4	67.6	37.1	96.6	87.0	58.0	51.6	35.8	617.8
1977	15.0	12.7	3.5	36.9	230.5	4.9	55.3	98.5	50.2	58.4	116.7	54.3	736.9
1978	2.0	3.7	99.1	137.1	181.8	124.5	10.4	119.1	59.8	101.5	38.4	31.2	908.6
1979	18.2	29.1	57.0	72.6	318.0	101.5	76.2	153.7	124.8	100.1	73.8	12.2	1137.2
1980	21.6	18.6	26.4	126.7	204.2	35.5	31.5	433.1	97.5	108.0	14.6	49.0	1166.9
1981	26.2	31.0	32.5	83.2	375.5	182.1	116.8	118.1	92.0	211.7	51.4	17.9	1341.4
1982	11.3	39.5	1.8	45.3	245.9	157.6	36.8	76.2	50.4	86.8	74.0	95.6	921.2
1983	12.1	8.4	13.5	–	199.9	88.6	76.3	73.0	148.1	82.6	43.3	11.4	–
1984	29.6	65.1	32.9	23.7	144.5	95.6	41.1	159.2	239.8	85.7	36.3	–	–
1985	7.3	37.2	32.0	83.3	110.7	78.9	104.2	122.1	66.8	118.1	106.5	25.7	892.8
1986	46.1	20.3	41.4	106.6	126.2	58.8	88.5	85.9	69.2	28.8	37.0	7.0	715.8
1987	2.3	0.8	5.5	30.3	131.2	230.1	32.0	2.4	142.3	142.3	34.3	33.4	786.9
1988	29.1	5.2	5.6	33.1	83.9	121.6	114.0	74.7	200.5	–	–	–	–
Average	36.7	35.8	33.0	69.1	185.1	112.5	70.9	100.8	122.3	110.7	68.8	54.7	1006.5
Standard deviation	2373.9	3975.8	1820.4	3076.2	6850.8	2984.4	1294.3	4630.7	2811.3	2675.6	1872.9	2275.7	41227.7
	48.7	63.1	42.7	55.5	82.8	54.6	36.0	68.0	53.0	51.7	43.3	47.7	203.0

3.2.2 Monthly Rainfall

The mean monthly rainfall data is shown in Fig. 3.2.2-1. The driest month is March and the wettest month is May.

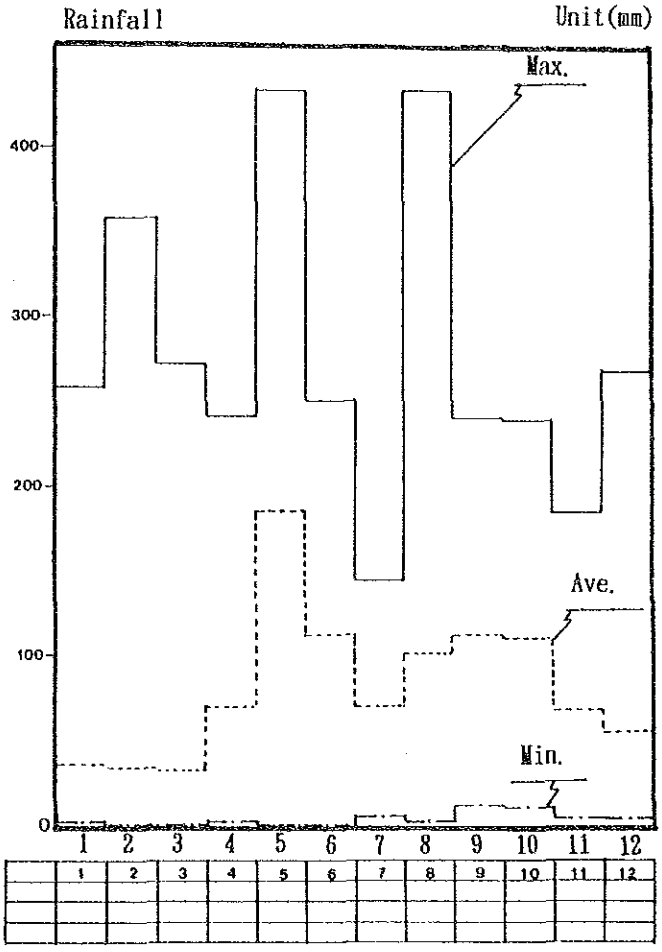

Fig. 3.2.2-1 Mean Monthly Rainfall

The mean monthly rainy days during 1931 - 1988 is shown in Table 3.2.2-1.

Table 3.2.2-1 Mean Monthly Rainy Days

	1	2	3	4	5	6	7	8	9	10	11	12	Year
Rainy days	6.6	4.9	5.7	7.6	15.4	10.9	8.9	9.5	12.1	11.6	9.8	8.2	111.2
No rainy days	24.4	23.1	25.3	22.4	14.6	19.1	22.1	21.5	17.9	19.4	20.2	22.8	253.8

3.2.3 Daily Rainfall

The maximum daily rainfall for the return period of 2, 5, 10, 30, 50 and 100 years are shown in Table 3.2.3-1.

Table 3.2.3-1 Probability of Maximum Daily Rainfall

Return Period	Rainfall (mm/day)
2 years	20.9
5	56.3
10	90.7
30	161.7
50	202.8
100	268.1

The daily rainfall distribution was carried out, using the 10 years data from 1964 to 1973 and is shown in Table 3.2.3-2.

Table 3.2.3-2 Distribution of the Daily Rainfall (1964 - 1973)
(monthly wise)

Unit:days

		1	2	3	4 *	5	6 *	7	8	9	10	11	12	Total
No rainy days		240	234	246	199	147	166	218	207	179	194	191	199	2,410
Rainy days		70	49	64	71	163	104	92	103	121	116	109	111	1,173
Observation days		310	283	300	270	310	270	310	310	300	310	300	310	3,583
Distribution	1~ 5mm	59	37	47	33	81	56	57	48	53	67	65	74	677
	6~10mm	9	6	12	19	32	23	19	27	24	20	20	21	232
	11~15mm	2	4	3	7	26	10	5	10	17	13	9	10	116
	16~20mm	–	–	1	4	7	4	2	3	7	9	4	3	44
	21~ mm	–	2	1	8	17	11	9	15	20	7	11	3	104
Rainfall amount		220.1	254.1	278.7	510.9	1,478.0	866.1	809.0	1,097.1	1,332.8	872.4	813.0	591.8	(8,924)
>15mm/day rainfall amount		–	72.5	41.0	213.0	724.5	407.3	304.7	622.2	353.9	381.6	360.6	216.8	(4,198.1)

Note : April and June are short in for one month.

Table 3.2.3-3 Distribution of Daily Rainfall (1964 - 1973)

Rainfall (mm)	Rainy days (day)	Distribution of rainy days (%)	Distribution of rainfall
0	2,410	67.3%	
1 - 5	677	18.9%	
6 - 10	232	6.5%	53%
11 - 15	116	3.2%	
16 - 20	44	1.2%	
21 -	104	2.9%	47%
Total	3,583	100.0%	

Table 3.2.3-4 Number of Rain Days

	1	2	3	4	5	6	7	8	9	10	11	12	Total
1931	6	0	0	10	16	14	8	2	12	14	18	12	112
1932	16	0	1	15	14	8	9	13	10	9	11	12	118
1933	5	0	8	6	13	11	9	18	17	11	14	16	128
1934	4	10	5	9	12	7	7	4	18	12	7	10	105
1935	9	5	7	4	14	10	8	12	9	17	3	6	104
1936	1	3	1	5	28	10	7	9	12	5	4	6	91
1937	21	0	4	3	17	12	8	10	4	7	12	8	106
1938	6	10	1	5	8	10	5	8	10	10	14	10	97
1939	8	3	5	1	9	18	8	7	15	7	11	1	93
1940	2	0	1	3	9	6	6	5	3	10	3	4	52
1941	1	3	1	9	8	10	5	6	9	5	5	4	66
1942	2	1	3	7	18	11	8	7	5	10	11	6	89
1943	6	1	9	13	11	14	9	8	9	16	6	5	107
1944	5	0	3	6	18	14	5	2	15	11	5	7	91
1945	3	7	3	7	23	5	11	11	14	10	9	5	108
1946	2	3	12	3	14	10	7	10	12	12	9	9	103
1947	11	2	0	4	18	11	6	10	20	12	1	2	97
1948	3	5	2	5	19	13	12	6	10	10	10	2	97
1949	6	4	9	2	14	6	11	9	18	13	4	13	109
1950	19	7	1	7	8	9	7	13	11	13	12	7	114
1951	4	2	0	13	16	12	16	10	16	8	4	11	112
1952	2	4	6	10	18	7	13	5	14	3	3	4	89
1953	1	3	6	5	18	16	7	5	5	11	8	5	90
1954	2	10	4	8	13	12	9	4	10	13	8	2	95
1955	3	4	0	4	10	9	7	9	15	15	12	11	99
1956	5	8	8	5	13	9	2	4	8	12	8	15	97
1957	7	7	5	5	11	14	8	8	14	11	10	12	112
1958	6	2	2	1	21	13	8	6	11	15	8	3	96
1959	8	6	0	13	9	6	6	9	12	10	18	6	103
1960	8	8	13	10	15	12	11	10	10	12	7	5	121
1961	4	11	15	7	11	7	12	10	13	13	11	6	120
1962	2	0	3	0	13	11	6	7	9	10	7	3	71
1963	3	1	4	5	14	9	5	5	13	18	5	1	83
1964	5	1	4	10	11	12	6	10	18	11	10	10	108
1965	3	3	3	--	18	--	1	11	9	11	6	9	74
1966	4	2	5	3	21	6	14	7	10	13	16	14	115
1967	13	7	11	7	14	16	11	6	9	10	11	6	121
1968	11	4	5	3	18	12	15	14	11	5	15	13	126
1969	8	2	6	18	20	14	7	9	15	16	13	6	134
1970	8	1	4	4	20	12	12	13	13	15	12	16	130
1971	3	10	7	8	17	10	10	10	17	11	5	15	123
1972	10	4	13	9	14	10	10	14	13	12	7	10	126
1973	6	8	6	5	10	12	9	11	14	13	14	12	120
1974	14	7	9	7	16	16	10	13	16	11	13	9	141
1975	7	4	6	5	16	7	7	13	13	12	17	15	122
1976	7	17	9	12	12	12	9	12	16	13	9	6	134
1977	7	3	2	10	14	2	11	17	15	14	16	9	120
1978	2	5	12	14	17	10	7	13	12	13	14	7	126
1979	9	7	15	11	21	11	14	19	17	16	15	9	161
1980	8	6	8	17	20	9	12	11	15	12	9	11	138
1981	10	10	8	17	26	12	13	12	11	15	6	7	147
1982	6	11	3	6	18	8	8	9	7	10	10	17	113
1983	6	4	8	10	22	13	12	11	9	13	14	12	131
1984	15	12	9	6	16	21	18	14	20	17	12	--	160
1985	5	15	12	13	10	11	7	14	12	19	16	6	140
1986	12	7	10	18	22	11	6	8	8	10	11	1	121
1987	3	3	3	5	15	17	10	3	8	7	10	12	96
1988	8	3	10	5	11	13	9	12	9	9	--	--	89
Ave.	6.57	4.93	5.69	7.60	15.38	10.93	8.86	9.45	12.07	11.60	9.81	8.23	110.31
Std. dev.	4.37	3.92	4.05	4.39	4.52	3.40	3.20	3.77	3.83	3.25	4.18	4.25	21.58

3.3 Temperature

The mean monthly temperature characteristics is shown in Fig. 3.3.1-1, and the data of the mean monthly temperature, absolute minimum and maximum temperature are shown in Table 3.3.1-1, 3.3.1-2 and 3.3.1-3 respectively. The mean annual temperature is 18.2°C with maximum in August and minimum in January. The difference of the temperature during the year is small, but the difference of the daily maximum and minimum is significant.

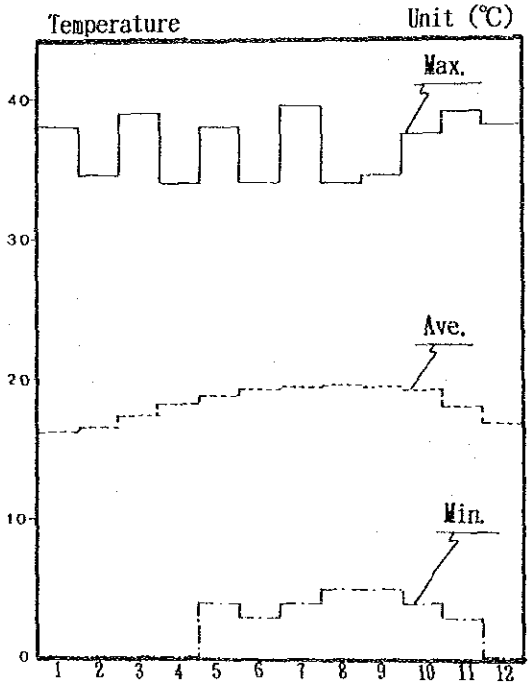

Fig. 3.3.1-1 Temperature Characteristics

Table 3.3.1-1 Mean Monthly Temperature

℃

	1	2	3	4	5	6	7	8	9	10	11	12	Ave.
1931	20.0	21.9	22.9	23.2	25.0	25.2	23.8	23.7	22.8	22.7	23.9	22.1	23.1
1932	22.7	21.0	23.5	19.6	18.3	19.4	19.5	20.2	20.1	19.9	20.1	18.0	20.2
1933	17.4	17.2	16.3	17.5	18.2	17.7	18.3	17.9	18.5	17.9	17.9	16.5	17.6
1934	15.7	16.0	16.1	17.4	17.2	17.1	17.3	17.9	18.3	17.4	16.9	17.2	17.0
1935	16.0	16.9	16.4	18.1	18.3	18.8	18.8	19.1	19.1	18.5	17.5	16.5	17.8
1936	16.1	16.1	17.5	17.4	17.1	17.8	17.7	17.9	17.9	17.4	16.9	16.4	17.2
1937	16.5	16.3	18.1	19.3	19.2	20.1	20.1	20.5	20.8	19.9	19.5	18.3	19.1
1938	18.1	17.9	18.1	17.1	18.3	18.5	19.0	18.7	19.1	19.0	17.7	16.0	18.1
1939	16.1	14.4	16.5	17.1	18.1	17.5	17.9	18.9	19.1	19.2	18.5	18.3	17.6
1940	—	17.5	17.5	18.7	18.3	18.3	19.2	19.4	19.3	19.0	18.5	18.1	18.5
1941	17.2	17.3	17.9	18.3	19.3	19.1	19.7	20.1	19.3	19.1	18.9	18.1	18.7
1942	17.7	17.8	18.4	18.9	18.9	19.1	18.9	18.9	19.0	18.6	18.1	17.0	18.4
1943	16.5	17.7	18.1	19.6	19.7	18.5	18.9	19.3	19.9	19.1	18.5	16.2	18.5
1944	15.5	16.1	17.3	19.2	19.7	20.4	19.9	19.3	20.1	20.6	16.7	15.8	18.4
1945	16.6	16.4	17.1	18.3	19.9	20.5	19.9	20.4	19.7	20.4	18.7	17.6	18.8
1946	17.1	16.9	18.1	19.0	19.7	20.5	20.4	20.7	20.5	21.6	19.9	17.9	19.4
1947	18.3	19.5	18.9	19.8	20.0	20.9	19.9	20.6	21.3	20.9	18.5	18.5	19.8
1948	18.7	18.7	17.0	18.1	19.9	19.8	19.3	19.5	19.5	19.5	18.9	17.7	18.9
1949	16.5	16.5	18.1	18.1	19.1	19.1	19.2	20.0	20.1	19.3	18.5	16.1	18.4
1950	14.5	16.1	16.1	18.3	18.5	19.7	20.1	21.1	20.8	20.3	18.3	17.2	18.4
1951	15.1	14.9	16.1	17.9	18.7	18.1	19.1	19.5	19.3	19.7	17.1	16.7	17.7
1952	14.5	16.7	17.7	19.1	19.6	19.4	19.5	20.3	20.9	18.9	18.1	15.8	18.4
1953	15.8	16.3	17.7	18.9	18.9	19.1	19.5	19.1	19.1	17.7	16.7	15.7	17.9
1954	15.2	15.3	15.1	16.3	18.6	20.3	20.1	20.5	19.0	18.4	17.3	14.7	17.6
1955	15.6	15.6	15.5	16.3	17.5	18.3	18.6	18.2	17.9	18.1	16.3	14.8	16.9
1956	13.1	13.8	14.9	16.5	16.9	16.9	16.3	17.3	16.6	16.1	14.6	13.3	15.5
1957	10.9	10.1	13.7	15.5	17.4	18.1	17.7	18.5	19.1	17.7	17.1	14.9	15.9
1958	12.1	11.9	15.3	16.1	17.7	18.6	19.1	17.4	16.5	16.7	16.2	14.7	16.0
1959	12.5	12.7	14.3	14.2	14.5	14.5	15.2	15.3	15.9	15.3	15.9	15.0	14.6
1960	14.0	15.3	15.7	16.1	16.3	17.1	16.8	17.3	18.3	17.9	17.3	14.5	16.4
1961	12.5	14.2	16.3	16.9	17.9	19.3	20.7	20.9	19.9	18.9	16.1	15.1	17.4
1962	15.4	16.5	17.5	18.8	18.2	18.5	19.6	20.1	19.1	17.9	16.3	15.9	17.8
1963	15.4	16.9	17.8	17.6	17.3	17.9	17.9	17.3	16.9	16.8	16.1	15.4	16.9
1964	15.9	15.3	15.9	16.1	17.3	18.5	19.5	17.9	19.1	17.9	16.4	15.8	17.1
1965	15.1	14.9	17.6	—	18.6	—	20.6	21.9	21.1	20.7	19.3	17.0	18.7
1966	16.1	15.9	18.9	19.1	19.6	19.8	20.2	20.3	19.9	19.3	17.7	16.7	18.6
1967	15.9	16.3	16.8	17.3	19.1	19.6	20.5	19.6	19.4	18.5	18.7	16.5	18.3
1968	15.9	17.3	17.3	17.4	19.7	19.5	20.0	19.7	19.3	19.2	18.9	17.7	18.5
1969	15.9	16.9	19.1	20.0	20.7	20.9	20.5	20.4	20.5	20.1	13.3	12.4	19.3
1970	17.1	17.1	17.1	18.7	19.7	19.8	20.3	19.9	19.5	19.9	17.5	16.7	18.6
1971	15.7	16.0	17.0	17.5	19.0	19.0	19.4	19.5	19.6	18.9	17.7	16.4	18.0
1972	15.6	16.1	17.1	17.8	19.1	19.9	19.9	19.3	18.7	19.8	19.1	17.5	18.3
1973	16.9	17.5	18.5	19.1	19.5	19.9	19.9	19.9	20.0	19.7	17.2	15.9	18.7
1974	15.7	16.1	16.1	17.1	18.3	19.2	19.0	18.8	19.3	18.9	19.2	16.7	17.9
1975	15.8	15.6	17.6	18.1	19.4	19.8	19.8	20.0	19.5	19.0	18.1	15.5	18.2
1976	14.4	16.2	16.2	18.2	19.5	19.4	19.8	20.2	19.6	19.4	18.9	17.6	18.3
1977	17.3	17.5	17.5	18.4	18.8	19.5	18.9	19.3	19.2	19.0	18.6	17.6	18.5
1978	—	—	—	—	—	—	—	—	—	—	—	—	—
1979	16.9	17.0	17.0	18.0	19.0	19.8	20.1	20.2	20.0	21.4	18.5	23.9	19.3
1980	16.5	16.8	17.0	19.5	20.3	20.9	20.5	20.0	20.2	20.0	18.9	17.2	19.0
1981	17.2	17.6	19.2	18.0	20.0	19.3	19.4	19.4	20.3	19.7	18.6	18.6	18.9
1982	18.1	17.2	18.4	19.4	18.7	20.1	19.8	20.3	20.7	19.5	17.8	17.1	18.9
1983	17.6	17.8	19.8	18.8	18.9	19.9	19.4	19.3	19.3	18.8	17.8	17.1	18.7
1984	16.9	16.4	17.7	18.4	18.5	18.9	18.6	18.6	18.7	18.5	17.7	15.7	17.9
1985	15.9	15.8	16.9	17.4	18.7	19.3	19.4	19.3	19.3	19.3	17.6	16.2	17.9
1986	15.8	16.1	16.9	17.6	18.5	18.8	19.4	19.8	19.1	19.5	19.4	18.6	18.3
1987	17.6	18.1	19.5	20.5	20.2	19.7	20.5	21.4	21.5	20.5	20.0	19.7	19.9
1988	19.3	20.0	20.0	21.2	21.0	21.4	21.4	20.9	20.9	—	—	—	20.7
Ave.	16.15	16.49	17.41	18.16	18.85	19.24	19.38	19.50	19.46	19.09	18.04	16.88	18.24
Std. dev.	1.90	1.87	1.69	1.45	1.39	1.42	1.26	1.31	1.22	1.31	1.40	1.72	1.27

Table 3.3.1-2 Absolute Minimum Temperature

℃

	1	2	3	4	5	6	7	8	9	10	11	12	yearly min
1931	10.0	12.0	13.0	14.0	16.0	18.0	17.0	15.0	13.0	14.0	16.0	12.0	10.0
1932	14.0	10.0	12.0	12.0	14.0	15.0	10.0	14.0	15.0	12.0	12.0	11.0	10.0
1933	7.0	4.0	8.0	10.0	11.0	11.0	10.0	9.0	12.0	11.0	10.0	3.0	3.0
1934	4.0	6.0	2.0	9.0	10.0	9.0	9.0	10.0	11.0	10.9	4.0	3.0	2.0
1935	0.0	3.0	0.0	6.0	9.0	11.0	9.0	11.0	10.0	9.0	3.0	3.0	0.0
1936	2.0	5.0	7.0	8.0	9.0	10.0	9.0	10.0	10.0	9.0	7.0	7.0	2.0
1937	8.0	5.0	3.0	6.0	11.0	9.0	9.0	9.0	8.0	10.0	10.0	4.0	3.0
1938	8.0	4.0	7.0	6.1	9.2	8.2	9.0	10.0	9.5	10.0	9.0	0.0	0.0
1939	0.0	0.0	2.1	7.0	10.1	8.2	8.1	9.5	10.1	10.2	10.1	5.1	0.0
1940	--	3.1	3.5	10.1	9.2	9.3	9.5	10.1	8.5	10.1	8.2	7.2	3.1
1941	3.1	3.1	7.1	7.2	10.2	9.1	9.5	9.1	11.1	9.1	9.1	6.1	3.1
1942	2.5	7.1	7.1	10.1	9.2	11.1	10.1	9.5	11.1	10.1	10.1	3.0	2.5
1943	4.0	4.0	0.0	8.0	8.0	8.0	7.0	10.0	9.0	8.0	7.0	3.0	0.0
1944	1.0	0.0	0.0	4.0	5.0	8.0	8.0	7.0	10.0	10.0	5.0	0.0	0.0
1945	2.0	2.0	1.0	7.0	9.0	6.5	8.5	9.0	10.0	9.0	6.0	1.5	1.0
1946	3.0	3.5	4.0	1.5	6.0	8.0	8.0	7.0	8.5	10.0	7.0	6.0	1.5
1947	4.5	3.0	2.5	4.0	7.0	9.5	9.0	8.5	9.0	10.5	5.0	4.0	2.5
1948	5.5	4.0	5.6	7.5	9.5	10.0	11.0	10.0	10.0	8.0	7.5	5.5	4.0
1949	3.5	2.0	6.5	6.5	9.5	8.5	8.5	7.0	9.5	10.5	4.0	3.0	2.0
1950	7.0	4.5	3.0	7.5	6.0	10.5	9.5	10.0	10.0	10.0	7.3	3.5	3.0
1951	3.0	1.5	3.0	5.5	10.5	9.5	7.0	9.0	10.0	10.0	8.0	3.0	1.5
1952	2.0	4.5	5.0	8.5	10.0	9.5	9.5	9.0	10.0	9.5	5.8	2.0	2.0
1953	2.0	3.0	5.0	4.5	8.5	9.0	10.0	10.0	9.0	11.0	9.6	5.0	2.0
1954	3.0	3.5	5.5	7.0	9.0	6.5	6.5	10.0	7.0	7.0	4.0	1.5	1.5
1955	4.0	5.0	5.0	9.0	12.0	10.0	12.0	11.0	12.0	12.0	7.0	6.0	4.0
1956	0.0	3.0	6.0	8.0	10.0	9.0	9.0	10.0	9.0	8.0	7.0	6.0	0.0
1957	1.0	1.0	3.0	4.0	8.0	10.0	9.0	11.0	11.0	8.0	9.0	4.0	1.0
1958	2.0	-1.0	5.0	6.0	10.0	11.0	12.0	9.0	8.0	8.0	7.0	2.0	-1.0
1959	1.0	1.0	4.0	4.0	4.0	3.0	4.0	5.0	5.0	4.0	8.0	6.0	1.0
1960	5.0	7.0	5.0	8.0	8.0	9.0	8.0	10.5	9.0	10.0	9.0	4.0	4.0
1961	3.0	4.5	8.0	0.0	10.0	12.0	13.5	13.2	12.0	9.0	4.0	3.0	0.0
1962	2.5	7.0	5.0	9.0	10.0	9.0	10.5	12.0	9.0	9.0	5.0	3.0	2.5
1963	4.0	6.0	5.0	9.0	10.5	12.0	11.0	10.0	10.0	9.9	8.0	5.8	4.0
1964	2.0	5.0	8.0	9.4	8.2	9.0	9.0	11.0	10.5	9.0	6.4	6.0	2.0
1965	3.0	4.0	8.0	--	10.1	--	13.0	14.0	13.0	13.0	9.0	9.2	3.0
1966	8.5	6.0	10.0	9.0	6.0	10.2	10.2	9.6	10.6	11.0	6.0	8.0	6.0
1967	2.1	2.5	5.3	3.0	9.0	9.0	11.3	8.7	9.6	10.2	8.8	5.0	2.1
1968	5.8	7.0	5.7	5.5	9.7	11.0	9.9	10.0	10.0	9.0	10.3	6.0	5.5
1969	4.0	4.0	7.0	10.4	11.0	12.6	9.9	10.0	12.0	10.3	11.0	4.9	4.0
1970	4.0	6.0	5.8	6.5	10.0	10.0	10.2	10.2	10.3	10.4	5.9	5.2	4.0
1971	4.5	6.3	5.5	5.0	10.0	9.9	8.5	9.0	10.0	7.7	6.0	5.5	4.5
1972	3.0	4.8	5.8	6.5	10.0	9.8	10.5	9.0	10.0	10.8	8.0	6.5	3.0
1973	4.8	3.4	5.0	6.0	9.2	11.5	10.0	10.0	11.0	12.0	7.0	3.5	3.4
1974	5.2	4.0	5.3	5.5	9.0	11.0	9.0	9.0	11.4	9.2	9.0	5.2	4.0
1975	3.3	2.5	5.0	6.9	10.0	9.9	8.3	8.0	10.9	10.0	7.4	4.5	2.5
1976	2.5	5.2	3.5	6.3	9.6	10.0	8.5	10.8	10.5	10.0	9.0	6.0	2.5
1977	6.0	5.0	6.0	6.5	10.0	10.0	10.0	10.0	10.0	10.0	10.0	6.0	5.0
1978	4.0	4.0	7.0	10.0	10.0	10.0	9.5	10.0	8.5	10.0	7.5	4.4	4.0
1979	5.0	4.2	6.0	5.5	10.0	11.0	10.5	10.0	11.0	10.5	7.0	4.0	4.0
1980	4.0	5.0	6.0	7.5	10.5	11.0	10.0	10.0	10.8	10.2	6.0	8.5	4.0
1981	4.0	7.5	6.6	9.0	11.5	8.5	10.6	9.0	9.0	9.0	9.0	7.5	4.0
1982	3.0	5.0	6.0	9.0	10.0	10.0	10.0	10.0	10.0	8.0	6.5	6.5	3.0
1983	5.5	4.0	9.0	7.0	10.0	8.5	10.0	10.0	--	--	--	--	4.0
1984	5.5	5.0	5.0	6.0	9.0	10.0	9.0	8.0	8.5	9.8	7.0	6.0	5.0
1985	6.0	4.0	7.0	8.5	10.0	10.0	11.0	10.0	10.5	10.0	7.0	4.5	4.0
1986	5.0	4.8	9.0	8.5	10.8	11.0	10.0	11.0	10.5	10.2	11.8	6.0	4.8
1987	5.0	6.0	9.0	11.4	12.4	12.0	12.0	13.0	12.4	11.5	7.0	11.0	5.0
1988	5.0	8.0	6.5	12.8	12.9	12.8	12.8	13.0	12.0	12.0	--	--	5.0
Ave.	4.08	4.39	5.54	7.28	9.64	9.93	9.76	9.95	10.16	9.82	7.68	5.04	2.99
Std. dev	2.48	2.25	2.57	2.57	1.87	2.03	1.80	1.72	1.55	1.51	2.30	2.43	2.04

Table 3.3.1-3 Absolute Maximum Temperature

C

	1	2	3	4	5	6	7	8	9	10	11	12	Yearly max
1931	31.0	31.0	33.0	33.0	32.0	33.0	31.0	34.0	34.0	30.0	31.0	31.0	34.0
1932	30.0	30.0	35.0	26.0	25.0	24.0	25.0	31.0	27.0	26.0	25.0	29.0	35.0
1933	25.0	25.0	35.0	25.0	26.0	25.0	27.0	26.0	24.0	25.0	25.0	24.0	35.0
1934	25.0	25.0	26.0	25.0	25.0	25.0	26.0	26.0	26.0	25.0	26.0	25.0	26.0
1935	26.0	26.0	28.0	27.0	27.0	26.0	26.0	27.0	27.0	27.0	25.0	25.0	28.0
1936	25.0	26.0	26.0	26.0	25.0	25.0	28.0	26.0	26.0	25.0	25.0	25.0	28.0
1937	24.0	27.0	30.0	30.0	31.1	31.0	28.0	30.0	32.0	29.0	28.0	28.0	32.0
1938	29.0	28.0	28.0	28.0	29.0	28.0	27.0	28.0	29.0	28.0	27.0	24.0	29.0
1939	25.0	23.0	25.0	25.0	26.0	26.0	27.0	29.0	29.0	28.0	27.0	28.0	29.0
1940	—	26.0	27.0	28.0	27.0	28.0	30.0	30.0	29.0	26.0	26.0	27.0	30.0
1941	26.0	28.0	27.0	27.0	28.0	28.0	28.0	28.0	28.0	27.0	27.0	26.0	28.0
1942	26.0	27.0	27.0	27.0	27.0	27.0	26.0	27.0	27.0	26.0	28.0	30.0	30.0
1943	27.0	31.0	31.0	31.0	30.0	30.0	28.0	30.0	31.0	30.0	30.0	28.0	31.0
1944	38.0	29.0	33.0	34.0	34.0	31.0	38.0	33.0	31.0	34.0	30.0	38.0	38.0
1945	29.0	27.0	32.0	29.0	37.0	34.0	31.0	34.0	34.0	33.0	34.0	28.0	37.0
1946	29.0	30.0	32.0	33.0	33.0	33.0	33.0	33.0	33.0	33.0	34.0	31.0	34.0
1947	33.0	34.0	35.0	33.5	38.0	32.5	30.5	32.5	31.5	32.5	31.5	32.0	38.0
1948	34.0	34.5	28.0	26.5	30.0	27.0	37.0	27.5	27.0	28.0	27.5	28.5	37.0
1949	27.5	27.0	39.0	27.0	27.5	27.5	27.5	30.5	20.5	27.5	28.5	26.0	39.0
1950	25.0	29.0	26.0	28.0	30.0	28.5	29.5	30.5	31.5	29.0	27.0	25.0	31.5
1951	25.0	25.5	26.5	29.5	28.5	27.3	29.0	30.0	34.5	30.0	27.0	22.5	34.5
1952	25.5	29.0	29.5	29.5	27.5	28.0	38.5	31.0	32.5	31.0	30.0	27.5	38.5
1953	27.5	28.5	28.5	29.5	29.5	29.5	39.5	30.0	29.0	25.0	24.5	25.0	39.5
1954	34.5	25.0	24.5	26.5	27.0	31.0	35.0	32.0	30.0	28.5	28.0	26.0	35.0
1955	20.0	25.0	25.0	23.0	24.0	25.0	25.0	25.0	24.0	24.0	24.0	24.0	25.0
1956	14.0	24.0	23.0	24.0	24.0	24.0	23.0	24.0	28.0	23.0	23.0	26.0	28.0
1957	29.0	23.0	25.0	26.0	27.0	27.0	36.0	27.0	28.0	28.0	27.0	24.0	36.0
1958	25.0	22.0	24.0	26.0	25.0	26.0	26.0	26.0	26.0	26.0	26.0	25.0	26.0
1959	25.0	25.0	25.0	26.0	25.0	25.0	26.0	26.0	26.0	26.0	25.0	22.0	26.0
1960	22.5	24.0	25.0	25.0	24.0	25.0	24.0	23.5	25.5	31.5	27.0	23.0	31.5
1961	22.0	23.0	25.0	24.5	25.5	27.0	28.0	28.5	27.0	26.0	23.5	23.0	28.5
1962	24.0	25.0	28.5	28.5	27.0	27.0	28.0	28.0	27.5	27.5	27.0	26.0	28.5
1963	26.0	28.0	28.0	27.0	24.5	24.0	23.3	28.4	23.2	24.3	33.0	25.3	33.0
1964	25.0	23.2	23.1	24.0	24.1	25.6	26.3	28.0	27.6	26.4	28.5	25.0	28.5
1965	28.0	25.0	28.0	—	26.5	—	27.0	29.1	29.0	28.3	39.0	25.1	39.0
1966	23.1	25.0	30.0	26.2	27.9	28.0	29.7	22.4	29.2	28.8	23.3	24.8	30.0
1967	24.9	24.3	26.3	27.0	28.5	28.3	27.3	28.0	28.7	28.0	26.3	25.2	28.7
1968	24.8	27.0	26.6	27.7	29.5	28.0	28.3	28.3	28.0	27.5	26.7	25.0	29.5
1969	24.7	26.4	29.9	28.0	28.6	29.0	29.0	29.9	27.3	27.0	27.0	25.2	29.9
1970	26.0	25.7	29.0	29.0	28.2	28.5	29.0	29.0	27.2	23.0	27.0	24.5	29.0
1971	25.3	25.3	26.5	27.3	27.2	26.8	27.5	27.7	28.8	27.2	27.0	24.8	28.8
1972	24.0	26.0	26.2	26.8	27.4	28.9	27.7	27.3	27.5	27.5	27.2	26.1	28.9
1973	26.3	26.8	29.5	29.8	20.1	27.9	29.0	28.2	28.5	27.5	27.3	24.0	29.8
1974	23.5	24.8	25.5	25.5	26.5	27.5	29.0	27.8	27.5	27.5	27.0	25.2	27.5
1975	24.0	25.0	26.2	28.0	27.9	29.0	28.5	28.3	26.8	26.5	26.0	23.6	29.0
1976	23.5	24.0	25.2	28.1	29.5	29.8	31.5	31.0	30.5	28.2	27.2	26.0	31.5
1977	26.8	26.5	28.2	28.0	31.0	28.0	29.0	28.0	29.0	28.2	25.8	26.5	31.0
1978	26.0	27.2	27.0	26.0	27.2	27.9	30.0	28.5	28.0	27.2	26.5	25.0	30.0
1979	28.2	27.5	27.2	27.0	27.5	28.0	28.4	27.0	30.0	27.8	23.9	28.0	30.0
1980	28.0	26.0	30.2	29.5	30.0	30.0	29.6	29.5	29.5	31.5	29.0	28.5	31.5
1981	27.5	27.0	30.2	28.5	29.2	30.0	28.2	29.5	32.8	32.5	29.5	28.0	32.8
1982	28.4	28.0	29.0	29.0	29.0	29.8	29.0	30.0	30.0	29.5	28.0	27.5	30.0
1983	28.0	30.0	31.5	28.5	29.5	30.0	30.0	29.0	29.0	29.0	29.0	27.2	31.5
1984	28.0	27.0	28.0	29.0	29.0	28.0	28.0	29.0	28.0	28.0	27.2	25.0	29.0
1985	26.0	28.0	27.0	27.0	28.0	29.0	29.0	28.0	29.0	26.0	28.0	26.5	29.0
1986	24.8	26.0	26.0	28.0	27.0	28.0	28.7	28.0	28.0	28.0	28.7	28.7	28.7
1987	28.7	28.5	28.5	29.5	29.0	29.0	29.0	29.8	30.0	29.5	29.5	28.8	30.0
1988	29.0	29.0	29.7	29.0	29.5	29.5	29.5	29.0	29.4	29.2	—	—	29.7
Ave.	26.44	26.72	28.19	27.73	28.00	28.07	28.88	28.67	28.62	28.15	27.62	26.35	31.51
Std. dev	3.52	2.50	3.17	2.29	3.00	2.27	3.62	2.33	2.61	2.80	2.80	2.64	3.66

3.4 Evaporation

The annual mean evaporation is 1,463mm with the higher evaporation recorded in July and the lower evaporation is in May. The data of the monthly evaporation is shown in Table 3.4.1-1.

Table 3.4.1-1 Monthly Evaporation

(mm/month)

	1	2	3	4	5	6	7	8	9	10	11	12	Ave.
1967	–	–	–	–	–	–	–	–	–	–	–	–	–
1968	–	88.7	–	133.0	–	–	–	–	–	104.8	–	–	108.8
1969	–	–	–	–	–	–	–	159.7	109.2	–	–	–	134.5
1970	–	–	–	–	–	–	–	–	110.6	–	83.5	–	97.1
1971	–	–	–	–	–	–	–	–	–	–	–	–	–
1972	79.1	90.7	102.8	98.5	–	–	–	–	–	–	–	–	92.8
1973	–	–	–	–	–	117.7	98.0	118.0	127.2	76.4	80.7	73.1	98.7
1974	80.3	84.5	116.4	–	91.0	55.0	126.0	–	–	–	–	–	92.2
1975	–	–	–	128.8	–	–	156.8	145.1	–	–	–	–	143.6
1976	83.3	–	146.5	–	144.8	124.5	–	–	–	109.7	–	–	121.8
1977	108.1	99.2	–	117.1	–	–	–	–	–	–	–	–	108.1
1978	–	140.8	–	–	–	–	–	–	136.7	124.6	–	–	134.0
1979	142.7	110.7	117.0	143.4	–	–	117.6	138.0	84.2	102.0	72.0	101.8	112.9
1980	113.5	125.1	146.6	97.0	79.0	160.5	157.0	127.1	128.0	126.0	109.5	128.0	129.8
1981	165.2	112.0	170.7	133.3	39.0	152.3	180.6	161.3	158.7	113.0	125.0	133.8	137.1
1982	160.4	110.2	186.7	150.0	99.8	157.6	201.2	159.4	147.0	143.3	126.0	83.0	143.7
1983	139.0	154.3	165.0	150.2	64.5	128.0	171.6	145.3	127.3	139.8	130.9	152.0	139.0
1984	154.1	105.5	179.9	195.8	147.5	109.8	151.5	129.9	98.0	–	–	–	141.2
1985	–	–	–	–	–	–	–	–	–	–	–	–	–
1986	123.7	120.5	120.1	28.5	96.5	102.5	187.5	142.0	111.5	117.5	89.5	10.9	104.2
1987	146.0	128.8	150.0	112.0	69.0	46.8	140.0	170.5	127.2	111.8	113.4	139.5	121.3
1988	–	–	–	–	–	–	–	–	–	–	–	–	–
Ave.	124.62	113.15	145.53	123.97	92.34	115.47	153.44	145.12	122.13	115.35	110.06	102.76	–
Std. dev.	30.18	19.79	26.94	38.49	33.69	37.38	29.89	15.59	19.82	17.68	29.62	43.42	17.93

3.5 Relative Humidity

The mean monthly relative humidity is shown in Fig. 3.5.1-1. The data of the monthly relative humidity is shown in Table 3.5.1-1.

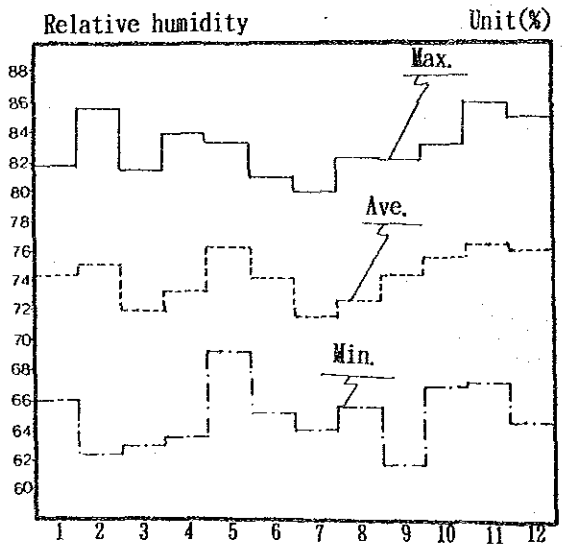

Fig. 3.5.1-1 Monthly Relative Humidity

Table 3.5.1-1 Mean Monthly Relative Humidity

(%)

	1	2	3	4	5	6	7	8	9	10	11	12	Ave.
1967	-	-	-	-	-	-	-	-	-	-	-	76.8	76.8
1968	78.5	78.7	77.7	73.5	75.3	76.9	74.7	75.4	78.2	77.3	86.1	85.0	77.8
1969	81.8	76.1	74.5	79.5	82.7	81.0	72.8	73.8	77.9	79.0	81.9	79.2	78.5
1970	79.4	78.5	71.1	71.7	80.1	77.4	74.5	78.7	82.2	80.8	82.3	-	77.9
1971	78.6	-	76.0	78.0	80.8	78.2	72.5	75.0	79.6	-	-	-	77.3
1972	80.2	74.0	77.5	74.1	79.1	-	74.7	79.8	82.2	83.2	80.6	83.9	79.0
1973	-	-	-	-	-	-	-	-	-	-	-	-	-
1974	75.9	76.2	-	-	74.1	75.4	-	-	79.6	81.5	77.7	79.1	77.1
1975	-	-	72.7	65.5	76.4	69.4	71.4	76.9	75.8	75.6	80.6	80.0	74.4
1976	73.3	76.8	71.3	71.1	72.2	72.4	69.1	72.8	74.5	78.4	77.6	75.5	73.8
1977	72.1	71.6	67.8	74.3	71.6	68.3	68.0	67.8	73.5	73.7	73.8	75.3	71.5
1978	73.8	73.6	76.9	77.3	74.6	73.4	-	71.3	73.8	75.0	77.2	77.0	75.0
1979	72.6	71.4	76.1	78.1	81.9	79.8	70.2	72.3	75.2	75.8	78.5	74.6	75.5
1980	72.7	76.0	69.1	70.3	74.9	65.2	64.1	69.7	75.1	75.7	73.1	77.5	72.0
1981	75.6	75.2	71.0	79.5	77.3	75.8	75.3	72.0	67.4	68.5	67.3	73.1	73.2
1982	71.6	72.9	62.9	63.5	72.0	66.3	66.7	65.7	61.8	68.3	74.2	76.1	68.5
1983	68.2	62.1	67.9	73.7	80.8	72.5	75.9	73.2	74.8	75.8	75.9	73.7	73.0
1984	73.1	75.9	75.1	70.8	70.7	77.3	70.9	70.0	77.9	75.4	74.8	79.0	74.2
1985	80.2	84.1	81.5	83.9	83.3	80.7	80.1	82.3	75.2	80.2	78.1	74.1	80.3
1986	73.7	72.1	71.0	74.5	75.1	71.2	70.0	70.3	67.6	67.0	68.1	61.6	70.5
1987	67.3	69.6	64.3	67.6	73.0	75.2	70.1	64.7	68.0	69.0	68.0	66.3	68.6
1988	66.0	85.6	67.3	66.2	69.3	74.6	68.2	71.0	67.3	-	-	-	70.6
Ave.	74.45	75.07	71.98	73.32	76.28	74.26	71.64	72.77	74.38	75.62	76.49	76.19	74.56
Std. dev.	4.40	5.06	4.63	5.21	4.15	4.50	3.74	4.44	5.32	4.64	5.02	4.91	3.36

3.6 Wind Velocity

The mean monthly wind velocity is shown in Table 3.6.1-1.

Table 3.6.1-1 Mean Monthly Wind Velocity

(m/s)

	1	2	3	4	5	6	7	8	9	10	11	12	Ave.
1967	-	-	-	-	-	-	-	-	-	-	-	2.2	2.2
1968	1.9	1.6	2.6	2.6	1.9	1.9	3.0	2.5	1.9	1.6	1.8	1.9	2.1
1969	2.0	1.7	2.7	1.7	1.9	1.4	2.7	-	2.0	1.5	1.9	1.8	1.9
1970	2.3	2.3	3.0	2.6	1.8	2.3	3.8	2.5	1.7	1.6	1.7	-	2.3
1971	2.1	-	2.2	1.7	-	-	-	2.7	1.4	1.6	1.6	-	1.9
1972	2.1	2.4	2.0	2.6	-	1.7	3.0	2.2	1.3	1.4	1.4	2.0	2.0
1973	2.1	-	-	-	0.2	-	0.9	0.7	0.7	0.2	0.4	0.6	0.7
1974	-	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	2.8	2.8
1976	3.0	0.4	3.5	0.2	2.6	2.9	2.8	3.2	3.2	2.6	2.8	2.8	2.5
1977	2.6	2.6	3.6	3.5	1.8	3.7	3.8	3.0	3.0	2.3	3.3	3.2	3.0
1978	2.7	2.5	2.9	2.8	2.3	3.0	4.0	2.3	2.3	2.4	2.9	3.1	2.8
1979	3.3	2.8	3.6	-	2.3	-	-	-	-	-	-	-	3.0
Ave.	2.41	2.04	2.90	2.21	1.85	2.41	3.00	2.39	1.94	1.69	1.98	2.27	2.27
Std.Dev.	0.45	0.73	0.56	0.94	0.68	0.76	0.92	0.71	0.76	0.67	0.84	0.77	0.61

3.7 Nuevosity

The data of the nuevosity is shown in Table 3.7.1-1.

Table 3.7.1-1 Mean Monthly Nuevosity

(m/s)

	1	2	3	4	5	6	7	8	9	19	11	12	Ave.
1967	-	-	-	-	-	-	-	-	-	-	-	3.3	3.3
1968	3.8	4.4	3.9	-	3.9	3.9	4.4	4.6	4.6	3.8	5.1	4.8	4.3
1969	3.8	3.6	3.7	5.4	5.0	4.9	3.5	3.5	4.7	4.5	5.2	-	4.3
1970	4.2	4.6	3.0	3.6	5.0	4.0	4.1	4.0	4.3	4.2	4.5	-	4.1
1971	-	4.1	3.8	3.6	-	3.5	-	3.9	3.7	4.0	-	-	3.8
1972	2.6	3.3	4.5	3.2	-	4.3	4.3	4.1	4.2	4.3	3.3	4.2	3.8
1973	3.0	-	-	-	-	-	-	-	3.8	3.6	3.6	4.0	3.6
1974	3.6	3.6	3.4	3.7	3.2	3.7	2.9	-	4.3	4.4	4.1	3.7	3.7
1975	3.4	2.5	3.4	3.0	3.9	2.9	3.3	3.8	4.7	-	4.6	-	3.6
1976	3.8	4.6	3.7	4.2	3.6	4.2	3.6	3.7	4.0	4.1	3.7	3.1	3.9
1977	3.7	2.9	2.6	4.4	4.3	3.2	3.7	3.9	3.6	3.7	4.6	4.0	3.7
1978	3.0	3.7	4.5	4.7	3.2	3.5	3.4	-	4.0	3.5	-	-	3.8
1979	3.0	3.6	4.6	-	3.5	-	-	-	-	-	-	-	3.9
Ave.	3.45	3.72	3.74	3.98	4.09	3.81	3.69	3.94	4.16	4.01	4.30	3.87	3.87
Std.Dev.	0.46	0.64	0.60	0.72	0.59	0.55	0.47	0.30	0.38	0.33	0.63	0.53	0.28

ANNEX C : HYDROLOGY AND RIVERS

ANNEX C: HYDROLOGY AND RIVERS

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ANNEX C: HYDROLOGY AND RIVERS

1. General Description

The study area is located in Constanza Valley at the upper reach of the Rio Yaque del Sur Basin with elevation ranging from 1,140 to 1,300m. In the study area, the Arroyo Constanza flows from east to west in the central parts of the study area, confluent with various streams.

2. Existing Data

In course of the Study, the following data were collected, in order to estimate the available discharge of the concerned river.

Collected Hydrological Data

Discharge Data	Period
Mean monthly discharge at El Puente	1956 - 86
" Bohechio	1970 - 78
" Sabana Yegua	1955 - 66
" Palomino	1978 - 87
" El Chorro	1981 - 86
Daily discharge at Pinar Bonito	1964 - 66
" El Chorro	1981 - 86
" Parelo	1983 - 84
Discharge observation data of the Pantuflas stream	
(La Cienaguita)	1983 - 85
(Confluence)	1983 - 85
(Arroyo Arriba)	1983 - 84

The location and catchment area of the gauging station are shown in Table 2.1.1-1.

Table 2.1.1-1 Characteristics of the Gauging Station

Gauging Station	River	Location	Elevation (m)	Catchment Area(km^2)	Commencement of the Observation
El Puente	Yaque del Sur	18°40'44"/71°03'10"	300	1709	Jan'56-
Bohechio	Grande del Medio	18°45'38"/70°59'39"	404	678	Jul'70-
Sabana Yaque	Grande del Medio	18°43'47"/71°01'51"	338	703	Dec'55-Oct'66
Palomino	Grande del Medio	18°48'06"/70°58'26"	450	599	Dec'78-
El Chorro	Arroyo Constanza	18°53'58"/70°45'27"	1130	60	Aug'81-
Palero	Arroyo Palero	18°53'55"/70°41'23"	1250	4	Nov'83-'84
Pinar Bonito	Arroyo Pinar Bonito	18°52'27"/70°43'45"	1239	13	Aug'64-Nov'66
La Compuerta	Rio Grande	18°51'48"/70°42'47"	1290	25	Aug'64-Nov'66

3. Features of the Rio Yaque del Sur

The mean monthly discharge at the gauging station is shown in Table 3.1.1-1 and the specific monthly discharge is shown in Table 3.1.1-2.

Table 3.1.1-1 Mean Monthly Discharge (m^3/s)

Station	1	2	3	4	5	6	7	8	9	10	11	12	Annual
El Puente	16.15	14.17	11.92	12.87	19.37	27.50	22.88	19.66	29.10	32.12	26.62	20.91	21.13
Bohechio	6.01	5.45	5.04	5.76	7.69	8.37	6.68	7.03	9.99	12.76	10.41	8.12	7.91
Sabana Yegua	8.42	5.57	3.44	3.86	6.93	10.17	7.61	6.93	11.13	15.48	13.57	9.66	8.44
Palomino	4.08	3.81	3.36	4.30	12.86	15.88	10.54	10.86	11.22	11.04	8.46	5.42	8.76
Pinar Bonito	0.20	0.19	0.19	0.18	0.29	0.29	0.32	0.25	0.25	0.29	0.31	0.22	0.25
La Compuerta	0.53	0.42	0.39	0.40	1.05	0.76	0.53	0.37	0.61	0.58	0.59	0.56	0.56

Table 3.1.1-2 Mean Monthly Specific Discharge ($m^3/s/100km^2$)

Station	1	2	3	4	5	6	7	8	9	10	11	12	Annual
El Puente	0.95	0.83	0.70	0.75	1.13	1.61	1.34	1.15	1.70	1.88	1.56	1.22	1.24
Bohechio	0.88	0.80	0.74	0.85	1.13	1.23	0.99	1.04	1.47	1.88	1.54	1.20	1.17
Sabana Yegue	1.20	0.79	0.49	0.55	0.99	1.45	1.08	0.99	1.58	2.20	1.93	1.37	1.20
Palomino	0.66	0.64	0.56	0.72	2.15	2.61	1.76	1.81	1.87	1.84	1.41	0.90	1.46
El Chorro	0.85	0.83	0.71	1.00	1.52	1.93	1.27	1.28	1.62	1.68	1.33	0.97	1.25
Palero													
Pinar Bonito	1.54	1.46	1.46	1.38	2.23	2.23	2.46	1.92	1.92	2.23	2.38	1.69	1.92
La Compuerta	1.27	1.00	0.93	0.96	2.51	1.82	1.27	0.88	1.46	1.39	1.41	1.34	1.34

The mean monthly specific discharge is shown in Fig. 3.1.1-1.

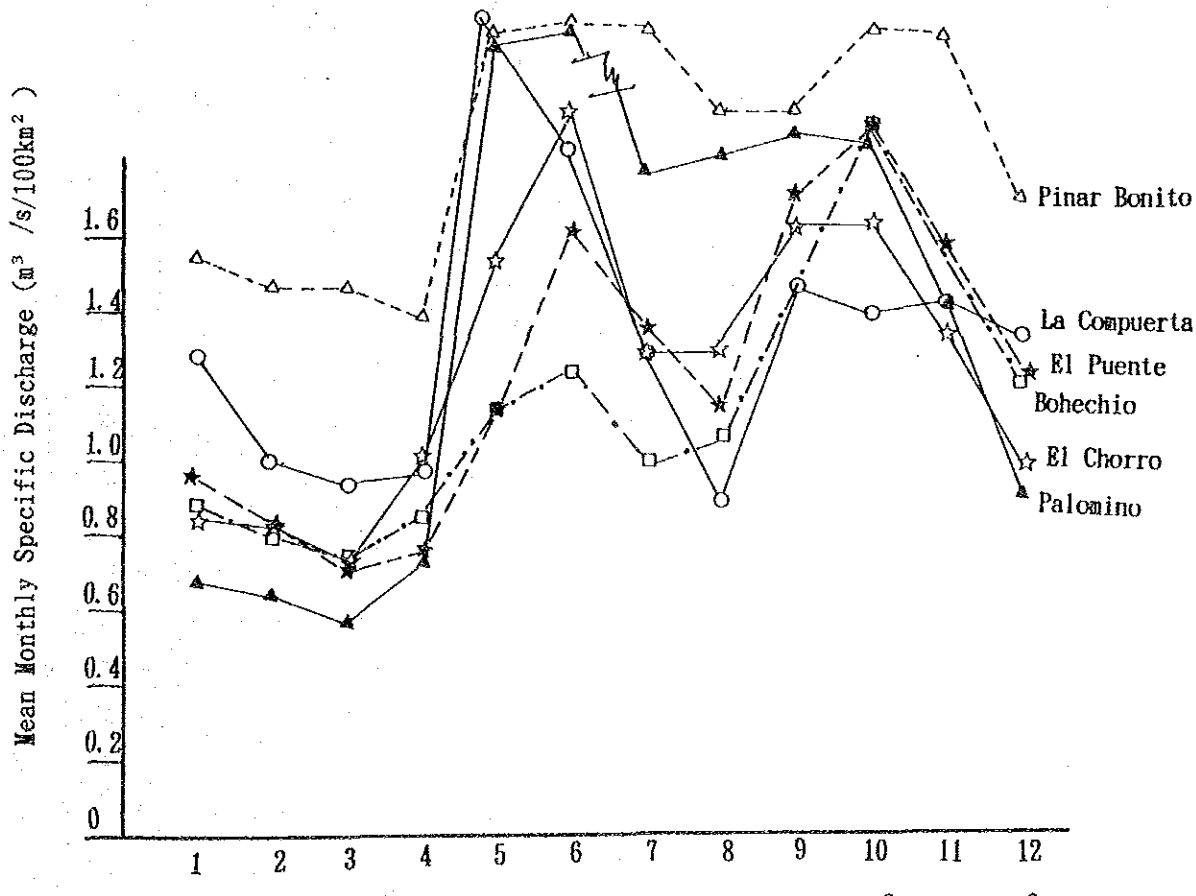

Fig. 3.1.1-1 Mean Monthly Specific Discharge ($m^3/s/100km^2$)

4. Features of the Related Catchment Area of the Study Area

The catchment area related with the study area is classified into two areas, those are the area inside the study area and outside the study area.

The inside catchment area is composed of Arroyo Constanza catchment area and Arroyo Pantuflas catchment area.

The outside catchment area is divided into Rio Grande catchment area and Pinar Bonito catchment area. The division of the catchment areas is shown in Fig. 4.1.1-1.

Total catchment area : 55.01 km^2

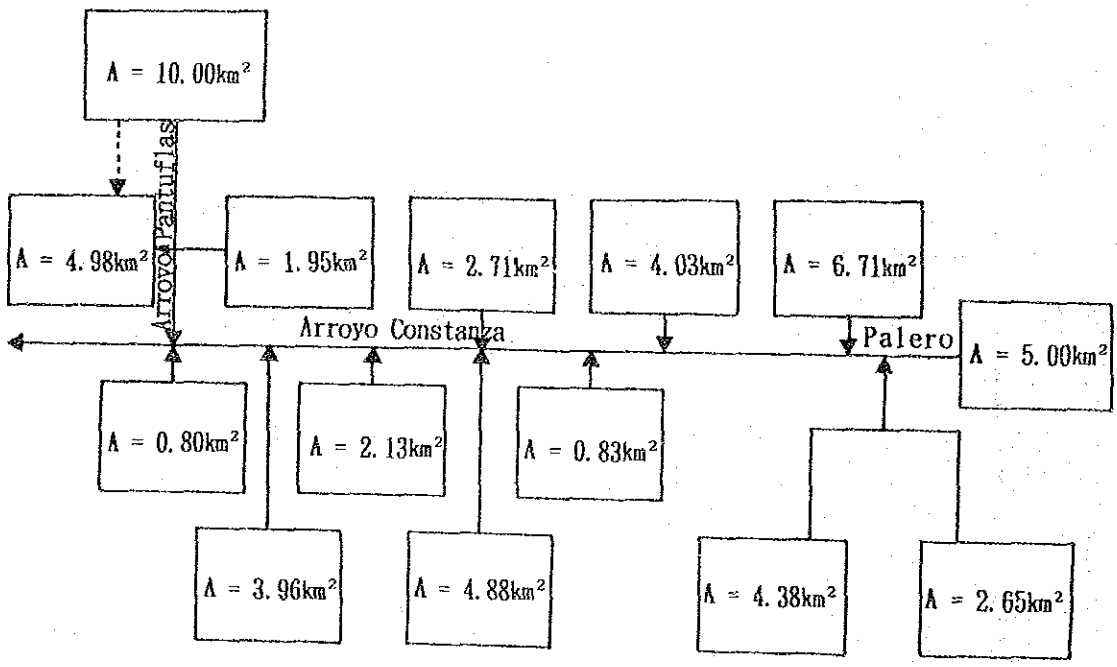

Fig. 4.1.1-1 Division of the Catchment Area in Constanza Valley

4.1 Arroyo Pantuflas Catchment Area

In the Pantuflas basin, the intake works was installed at the Arroyo Arriba site to irrigate 166ha of the irrigated area on El Cercado and Arenoso Sector.

In the Arroyo Pantuflas, the measurement of discharge data was carried out during April 1983 to October 1985 at the La Cienaguita, Arroyo Arriba and at the Confluence.

On the basis of the discharge observation data at Arroyo Arriba, the mean discharge was $0.079m^3/s$.

The specific discharge rate is estimated approximately $1.0m^3/s/100km^2$, considering the catchment area at the point as approximately $8km^2$.

4.2 Arroyo Constanza Catchment Area

The area of the river basin is $40.6km^2$ (mountainous part: $19.1km^2$, residential and cultivated area: $21.5km^2$). In the basin, various mountainous rivers flow into the study area, but most of them are formed in temporal stream style, since most of them pass through part of the alluvial fan at higher parts of the area.

It is estimated that most of them are springed up at the lower reach of the Arroyo Constanza. The discharge of the river is increasing at the lower parts of the river.

The irrigation water of the study area depends on the Rio Grande water resource and the utilization of water resource of the Arroyo Constanza is insignificant, except the intake work of the Arroyo Palero at Cerro de Monte site and the re-use of the drainage water of the Arroyo Constanza by the Canal Abud at El Valle site.

4.3 Rio Grande Catchment Area

Rio Grande which is the main water resource of the study area, is originated at the Alto Bandera and flows into the Rio Medio, catching the mountainous small rivers and the Arroyo Constanza near the western parts of the study area.

The intake works is located at 300m lower part of the confluence point with the Arroyo El Gajo de Maiz and its water is introduced to the study area for irrigation. The catchment area at this site covers approximately 42km^2 with mountainous regions.
The discharge observation data at the intake site was recorded for a period of 29 months, from August, 1964 to November, 1966.
The mean monthly discharge at the La Compuerta is shown in the following table.

Table 4.3.1-1 Mean Monthly Discharge at La Compuerta

Month	Discharge	Specific Discharge ($m^3/s/100km^2$)
1	0.53m^3/s	1.26
2	0.42	1.00
3	0.39	0.93
4	0.40	0.95
5	1.05	2.50
6	0.76	1.81
7	0.53	1.26
8	0.37	0.88
9	0.61	1.45
10	0.58	1.38
11	0.59	1.40
12	0.56	1.33
Mean	0.56	1.33
Minimum	0.24	0.57
Maximum	6.00	14.29

According to the climatological data by Constanza Climatological Station, the minimum rainfall was observed in 1965 and 1966 when the discharge was measured. Therefore it seems that more discharge can be expected in the Rio Grande in 5 years return period.

4.4 Arroyo Pinar Bonito Catchment Area

The Arroyo Pinar Bonito which is the main water resource for the potable water of the Constanza City has approximately 15km^2 of catchment area and flows into the Rio Grande at the Pinar Bonito site.

The intake works is located at 2km upper stream of the confluence site and supply the potable water to the Constanza City. The catchment area at the intake works site is 12.5km^2 and the discharge is estimated approximately 0.2m^3/s.

The discharge observation was carried out at the downstream of the intake works from August, 1964 till November, 1966.

The monthly mean discharge is shown in the following table.

Table 4.4.1-1 Discharge Data of the Arroyo Pinar Bonito

(unit: m^3/s)

Month	1964	1965	1966	Mean
Minimum	0.16	0.16	0.11	0.11
Maximum	0.39	0.92	0.66	0.92
Mean	0.22	0.25	0.24	0.24
1	-	0.20	0.20	0.20
2	-	0.19	0.19	0.19
3	-	0.18	0.20	0.19
4	-	0.17	0.18	0.18
5	-	0.31	0.27	0.29
6	-	0.37	0.22	0.29
7	-	0.31	0.32	0.32
8	0.21	0.27	0.23	0.24
9	0.22	0.28	0.21	0.24
10	0.25	0.25	0.32	0.27
11	0.22	0.27	0.34	0.28
12	0.22	0.22	-	0.22

The mean discharge during the observation period was $0.24m^3/s$ ($1.85m^3/s/100km^2$) and the minimum discharge was $0.11m^3/s$. On the basis of these data, the specific base flow is calculated to be $0.85m^3/s/100km^2$.

The mean discharge is $0.24m^3/s$ and it deserves approximately 580mm/year. Since annual mean rainfall of the catchment area is approximately 1,000mm/year, it is estimated that the run off coefficient is more than 50% and approximately 270mm/year is run off as the base flow.

On the basis of these data, the coefficient of the surface run off and the base flow run off are estimated to be 31% and 27%, respecitvely.

4.5 Discharge Observation in the Study Area

Water discharge was observed for the purpose of investigating water balance at nineteen points in the study area. Breakdown of the observation sites are as follows:

Pantuflas catchment area	:	6 sites
Arroyo Constanza catchment area	:	5 sites
Canal Constanza catchment area	:	6 sites
Rio Grande catchment area	:	1 site
Arroyo Pinar Bonito catchment area	:	1 site

The results of the flow observation and sketch of water flow are shown in Table 4.5.1-1 and Fig. 4.5.1-1 respectively. Locations of the observation sites are shown in Fig. 4.5.1-2.

Table 4.5.1-1 Observed Discharge Data

Catchment Area	Point	Discharge (m^3/s)
Arroyo Pantuflas	P-1	0.06
	P-2	0.08
	P-3	0.01
	P-4	0.05
	P-5	0.17
	CP-1	0.07
Arroyo Constanza	AC-1	0.89
	AC-2	0.72
	AC-3	0.45
	AC-4	0.14
	AC-5	0.02
Canal Constanza	CC-1	0.52
	CC-2	0.36
	CC-3	0.32
	CC-4	0.02
	CC-5	0.30
	CC-6	0.19
Rio Grande	RG-1	0.58
Arroyo Pinar Bonito	AP-1	0.21

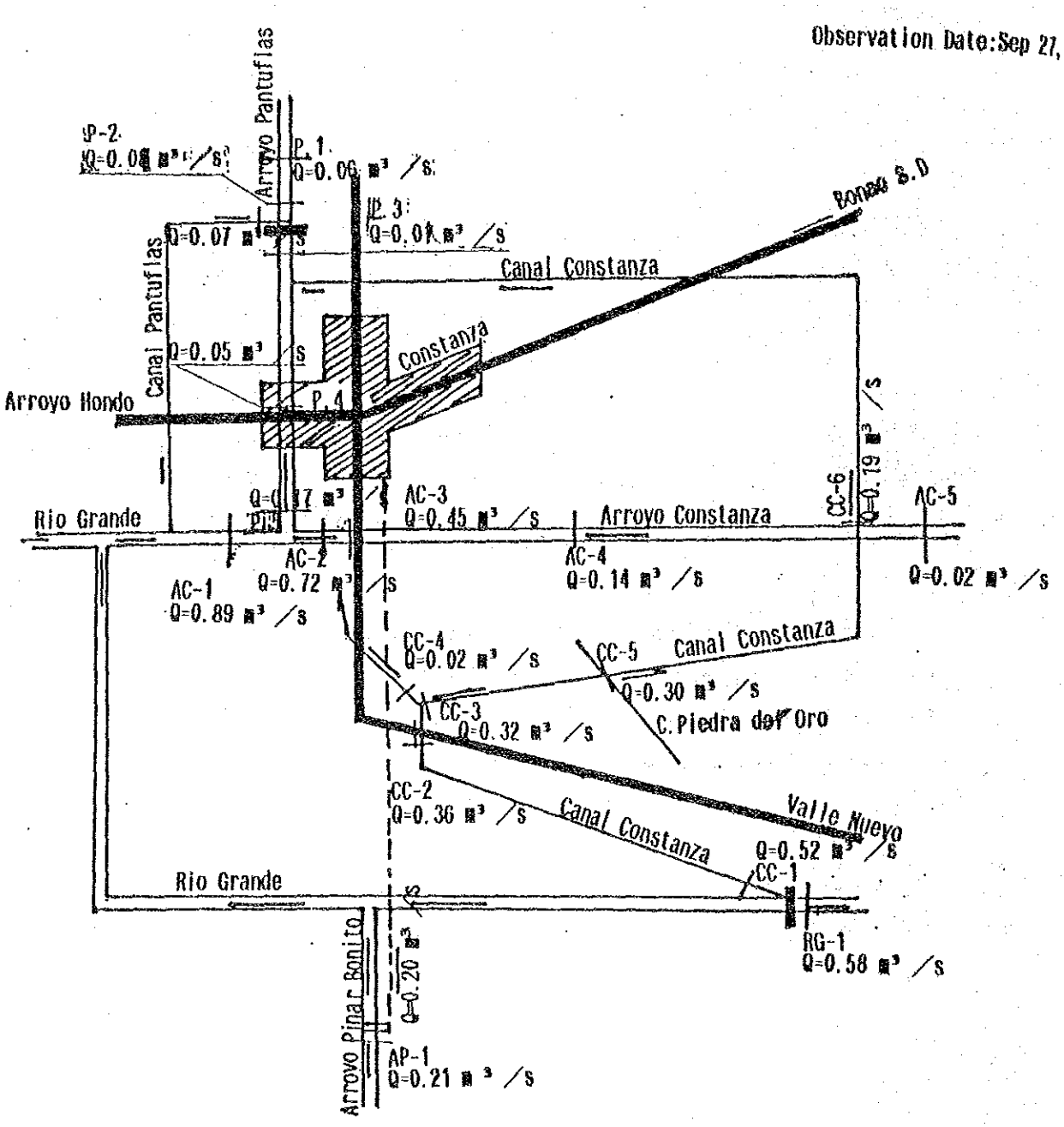

Fig. 4.5.1-1 Water Balance of the Study Area

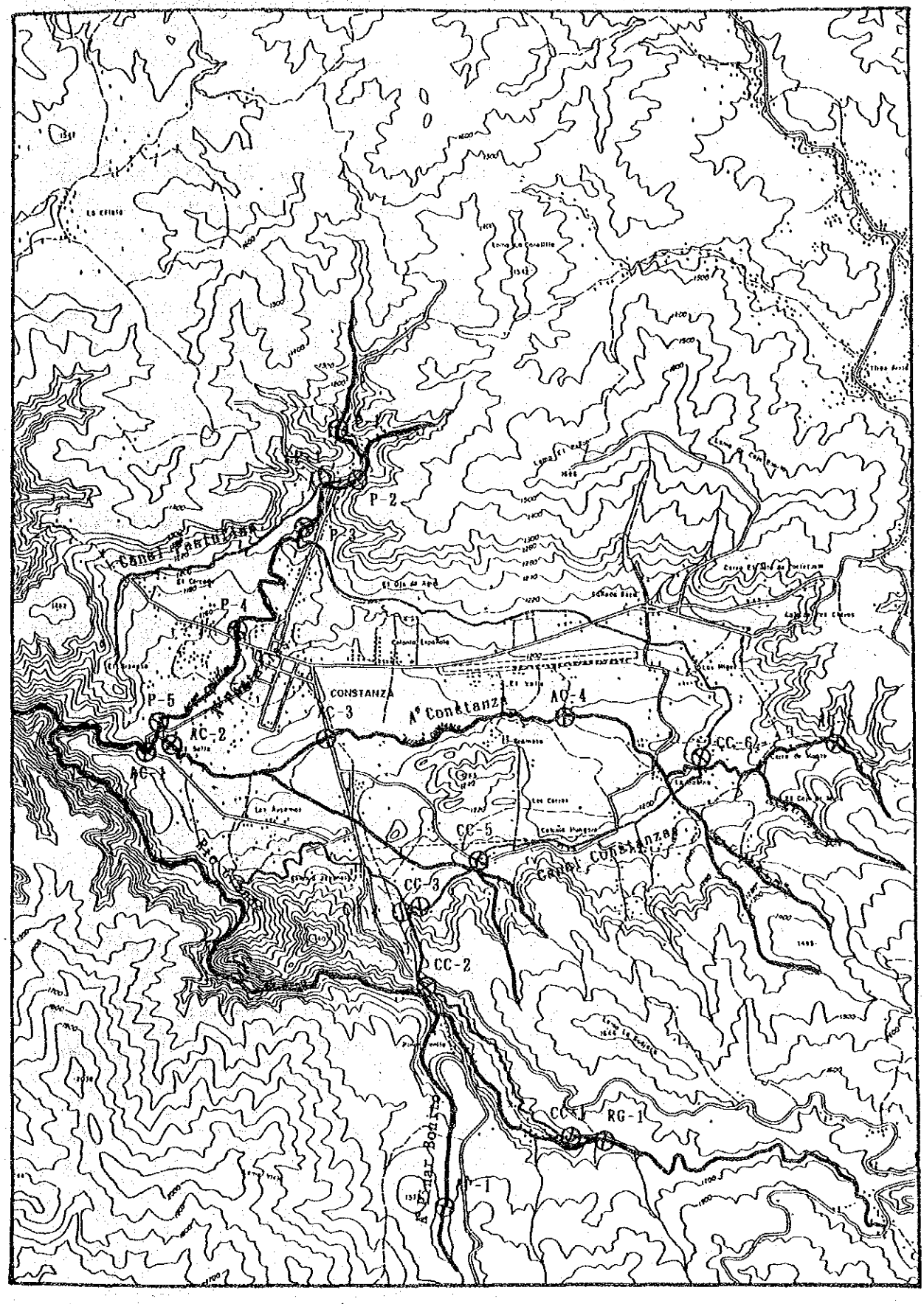

Fig. 4.5.1-2 Location of the Discharge Observation Site

The following points were clarified from the discharge observation.

(1) Arroyo Pantuflas Catchment Area

In the Arroyo Pantuflas catchment area, the major parts of the discharge is conducted to the Canal Pantuflas at the intake works installed at the Arroyo Arriba site, which is located in the upper reach of the Arroyo Pantuflas.

The drained water and the sewage water is collected at the lower reach of the Arroyo Pantuflas and increase the discharge of the Arroyo Pantuflas.

(2) Arroyo Constanza Catchment Area

In the Arroyo Constanza catchment area, the irrigation water and potable water are introduced constantly by the Canal Constanza and the Aqueducto Constanza, respectively. And the Arroyo Constanza collect the mountainous river discharge and run off to the outside of the study area at El Salto.

The following water balance was measured:

- Run off at El Salto $Q = 0.72\ m^3/s$
- Introduced irrigation water $Q = 0.36\ m^3/s$
- Estimated run off from the basin $Q = 0.36\ m^3/s$

Judging from the result of the water balance study, the discharge from the Arroyo Constanza basin is estimated as $Q = 0.36 m^3/s$. The discharge of the Arroyo Constanza increases rapidly between the AC-3 and AC-4. Hence, it is considered that water springs between AC-3 and AC-4.

(3) Others

In the Rio Grande, the major part of the water is conducted to the Canal Constanza by the head works. However, the conducted water to the study area is relatively small due to the conveyance loss of the head race. The following data were observed.

Discharge of the Rio Grande	Q = 0.58 m^3/s
Discharge of the head race after the head works	Q = 0.52 m^3/s
Introduced discharge to the study area	Q = 0.36 m^3/s

According to the discharge data, 90% of river discharge was taken by the head works but 30% of driving discharge was lost due to the deterioration of the head race. The discharge introduced to the study area is calculated to be 62% of the discharge of the Rio Grande.

4.6 Discharge at El Chorro

The discharge at El Chorro which is located at the lowest reach of the Arroyo Constanza is shown in Table 4.6.1-1.

Table 4.6.1-1 Discharge at El Chorro

	Mean Discharge	Minimum Discharge	Maximum Discharge
1982	0.79 m^3/s	0.34 m^3/s	11.55 m^3/s
1983	0.73 m^3/s	0.21 m^3/s	13.65 m^3/s
1984	0.68 m^3/s	0.17 m^3/s	9.55 m^3/s
1985	0.82 m^3/s	0.23 m^3/s	8.01 m^3/s
1986	0.77 m^3/s	0.24 m^3/s	6.17 m^3/s

4.7 Estimation of River Discharge

The river discharge was estimated on the basis of the Arroyo Pinar Bonito discharge data. The basic coefficient used for the estimation is shown in the Table 4.7.1-1.

Table 4.7.1-1 Basic Coefficient Used for the Estimation

	Pinar Bonito	Rio Grande	Pantuflas	Palero
Catchment area (km^2)	13	42	9.7	4.8
Specific discharge ($m^3/s/100\ km^2$)	1.85	1.33	1.0	1.0
Ratio with the specific discharge of Arroyo Pinar Bonito	1	0.72	0.54	0.54
Specific base flow ($m^3/s/100\ km$)	0.85	0.61	0.46	0.46
Base flow (m^3/s)	0.11	0.27	0.04	0.02
Coefficient of run off	0.3	0.3	0.3	0.3

The estimation of the mean monthly discharge at 5 year return period is shown in the Table 4.7.1-2.

Table 4.7.1-2 Estimated Mean Monthly Discharge at 5 Year Return Period

	Monthly	Specific discharge (m³/s/100km²)				Discharge (m³/s)			
Month	rainfall(mm)	Pinar Bonito	Rio Grande	Pantuflas	Parelo	Pinar Bonito	Rio Grande	Pantuflas	Parelo
1	15.8	1.03	0.79	0.64	0.64	0.13	0.33	0.06	0.03
2	24.9	1.16	0.92	0.77	0.77	0.15	0.38	0.07	0.03
3	26.8	1.15	0.91	0.76	0.76	0.15	0.38	0.07	0.03
4	54.0	1.48	1.24	1.09	1.09	0.19	0.51	0.10	0.05
5	152.1	2.55	2.31	2.16	2.16	0.33	0.96	0.21	0.10
6	88.9	1.82	1.58	1.43	1.43	0.23	0.66	0.14	0.07
7	59.0	1.51	1.27	1.12	1.12	0.20	0.53	0.11	0.05
8	125.6	2.26	2.02	1.87	1.87	0.29	0.84	0.18	0.08
9	108.1	2.10	1.86	1.71	1.71	0.27	0.77	0.17	0.08
10	89.0	1.85	1.61	1.46	1.46	0.24	0.67	0.14	0.07
11	52.4	1.46	1.22	1.07	1.07	0.19	0.51	0.10	0.05
12	39.9	1.30	1.06	0.91	0.91	0.17	0.44	0.09	0.04

ANNEX D : GROUNDWATER

ANNEX D: GROUNDWATER

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ANNEX D: GROUNDWATER

1. General Hydrogeological Features

The Valley is composed of the Quarternary stratum which lies over a depth of 10 to 40m or more. Quarternary stratum was originated from Cretaceous Andesitic Pyroclastic rocks, Andesitic lave and Tonalite.

Quarternary stratum in the Valley is classified into the upper and the lower aquifer. The depth of upper aquifer ranges from 2 to 16m and its thickness ranges between 3 to 7m. The upper aquifer is composed of sand and gravel in white and bluish green color.

The depth of lower aquifer ranges from 23 to 30m or more and its thickness is about 7m or more.

The lower aquifer is composed of sand in yellowish brown colour. The groundwater is found in the bed. The distribution of the bed is mainly in the western area of the Valley.

On the other hand, the bed rock is composed of Cretaceous andesitic pyoroclastic rocks and andesitic lag. These hard rocks are generally treated as the bed rock from hydrogeological point of view, because of not producing groundwater except fissure water. However, wells for mining groundwater are found in the northern part of the Valley, called "El Ojo de Agua", in spite of the thin Quarternary stratum. It is possible to produce the fissure water in the well.

2. Investigation of Existing Wells

Investigation of existing wells was carried out to understand the present condition of groundwater use and hydrological condition in the Valley.

The result of existing well investigation is shown in Table 2.1.1-1 and the location of the existing wells observed is shown in Fig. 2.1.1-1 .

The water quality of surface water was investigated at the same time of existing wells investigation.

The existing wells were distributed in the periphery of the Valley, especially in northern part of the Valley. The existing wells are 4 to 12 inches in diameter and 25 to 70m in depth.
The diameters of the existing wells are 6 to 8 inches in periphery of the Valley and 10 to 12 inches in the central of the Valley. The use of groundwater is about 130 to 1,300m^3/day. The discharge at Los Higos of eastern area and Las Auyamas of south-western area is low. On the other hand, there are many wells out of use in the Valley. The main reasons are as follows.

- The pumps are not equipped.
- The wells are filled with sand.

Grandwater levels of existing wells in the periphery of the Valley are 10 to 35m. On the other hand, the groundwater levels at the central Valley are similar to the ground level and some flowing wells are observed there. Regarding the water quality, the electrical conductivity (E.C) of groundwater is 290 to 650μS/cm and the E.C range of surface water is 150 to 500 μS/cm. pH range of groundwater and surface water is 6.8 to 7.4 and the water have a low-alkalinity.

Table 2.1.1-1 Result of Existing Well Investigation

Well No.	Well diameter (Inch)	Water depth from G. L. (m)	Water level from G. L.	Daily pumping rate (m³/day)	Area (Ha)	Result of Water Quality Test		
						T (℃)	E.C. (μs/cm)	pH
1	5	30.0	?	?	3.40	-	-	-
2	4"	40.0	?	1090	3.77	22.2	864	7.4
3	8"	32.5	10.00 (23.50)	818	2.83	22.2	561	7.4
4	8"	32.5	0.35	818	4.40	23.4	603	7.4
5	-	-	-	Dry	2.52	-	-	-
6	8"	37.5	10.45	300	2.64	22.9	475	7.2
7	-	-	(34.64)	?	1.26	22.8	448	7.4
8	8"	30.0	20.61	589	0.94	24.3	301	7.2
9	-	-	-	-	-	-	-	-
10	6"	42.0	17.83	245	1.09	20.9	559	7.2
11	8"	36.0	-	301	1.57	21.9	649	7.4
12	10"	40.0	-	1090	9.43	21.0	451	7.4
13	8"	25.5	20.00	?	4.4	23.5	420	7.2
14	8"	?	-	1090		-	-	-
15	8"	?	-	1300	7.55	21.5	440	7.4
16	8"	70.0	-	1300	4.40	21.3	445	7.4
17	-	25.0	-	out of use	-	-	-	-
18	6"	40.0	-	272	12.58	-	-	-
19	8"	45.0	0.29	109		21.6	422	7.4
20	10"	25.0	Flowing well	?		21.2	425	7.4
21	12"	42	10.00	1090	3.14	-	-	-
22	12"	42	5.00	1090	1.09	21.0	405	6.8
23	12"	22.5		?	1.57			
24	8"	36.0	-	?	8.81	-	-	-
25	8"	4.0	0.80	164	2.52	-	-	-
26	6"	?	32.50	out of use	0.94	22.5	569	7.2
27	8"	36.5	24.00	442	0.75	21.8	511	7.4
28	6"	?	25.65	out of use	1.26	21.5	785	7.2
29	6"	33.0	5.36	?	-	20.3	147	6.8
30	10"	26.0	0.92	?	-	19.9	200	6.8
31	8"	36.0	3.00	302	-	22.5	472	7.4
32	10"	21.0	?	?	1.26	21.5	472	6.6
33	6	25.4	20.00	?	-	21.5	533	6.0
34	6	42.0	12.00	210	0.63	22.3	400	7.2
35	12"	42.0	(20.65)	262	0.13	21.7	376	7.4
36	8	36.0	10.41	273	3.14	21.6	563	7.4
37	8	27.0	9.65	327	3.77	22.4	627	7.4
38	8	30.0	10.00	436	0.94	22.2	644	7.4
39	8	29.0	11.30	153	0.94	21.7	545	7.4
40	8	40.0	34.60	273	0.94	22.3	409	7.4
41	8	30.0	22.00	136	1.57	20.5	308	7.2
42	8	42.0	21.00	436	1.57	20.3	307	7.2
43	8	42.0	22.00	545	4.40	20.9	293	7.2

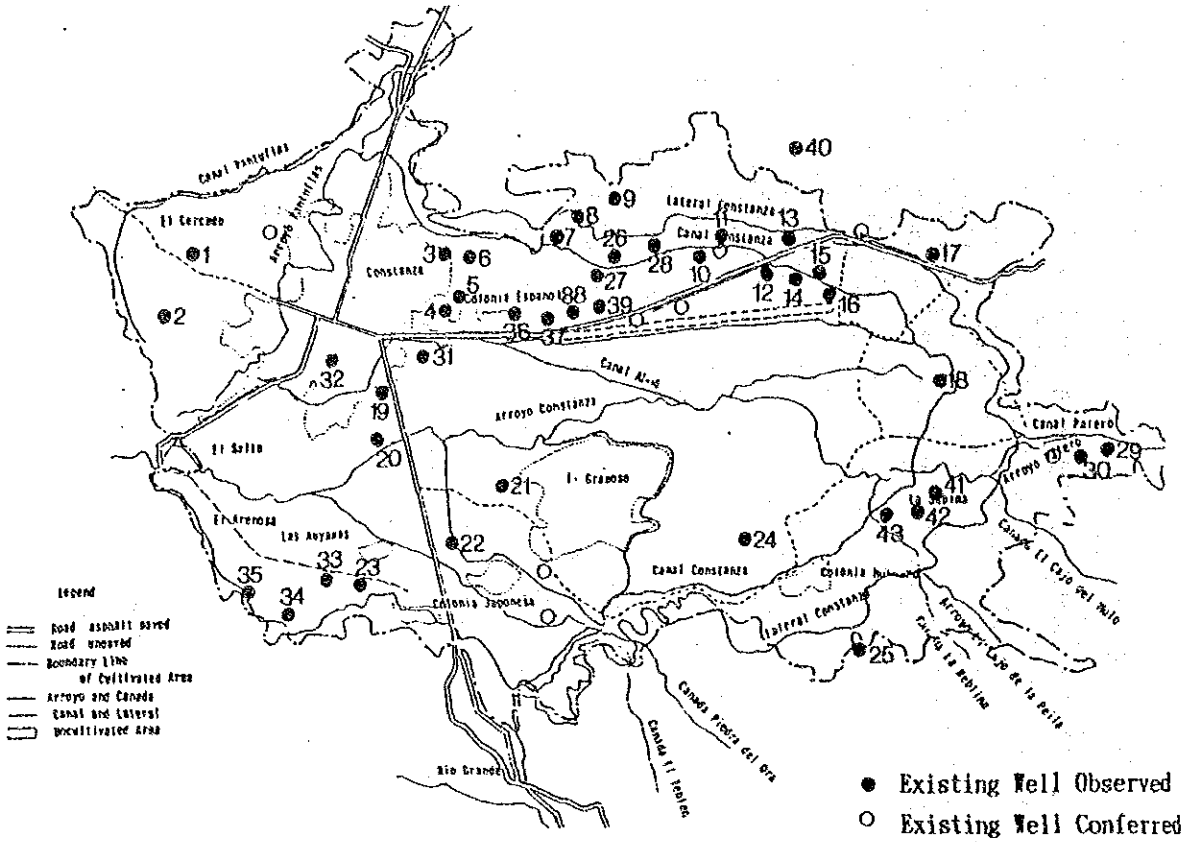


Fig. 2.1.1-1 Location Map of Existing Wells

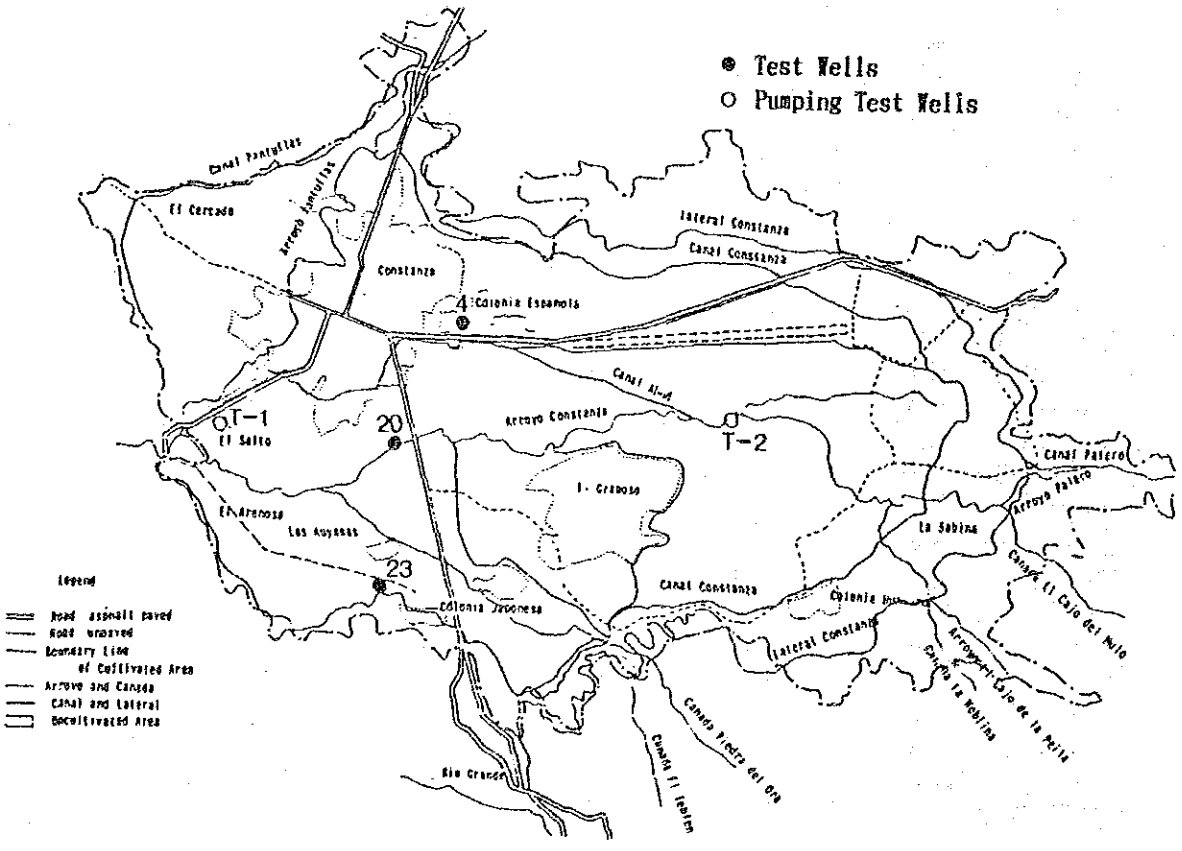


Fig. 3.1.1-1 Location Map of Test Wells

3. Feature of the Aquifer Stratum

3.1 Permeability Coefficient

The permeability coefficient characterized in the aquifer stratum of the Valley was determined from the results of the pumping test.

The location of the test wells is shown in Fig. 3.1.1-1 and the results of the pumping test are shown in Fig. 3.1.1-2 to Fig. 3.1.1-5.
On the basis of the pumping test analysis, the permeability coefficient varies from 1.0×10^{-3}cm/sec to 3×10^{-2}cm/sec.
Geological logging data of the existing wells and the test wells are shown in Fig. 3.1.1-6(1),(2) and (3).

3.2 Groundwater Discharge

The groundwater discharge in the Valley was calculated, on the basis of the pumping test result and the geological feature. The groundwater discharge is calculated with the following formula.

$$Q = A K I$$

Where; Q: Groundwater discharge
A: Sectional area of the aquifer stratum
K: Permeability coefficient
I: Hydraulic gradient

The estimation of the groundwater discharge was carried out in the western parts of the Valley with the following presumptions.

- The hydrogeological feature in the Valley is represented by the geological logging of the T-1 site wells since the Valley is small-scale and the geology is similar on the whole.

- The thickness of upper aquifer stratum and the lower aquifer is 8m and 6m respectively. The total thickness is 14m.

The sectional area of the aquifer is calculated as follows:

$A = 1200m \times 14m = 16,800m^2$

The permeability coefficient of the aquifer stratum is 1.0×10^{-2}cm/sec which is the mean value of the ones at No. 4 and T-2 wells. The hydraulic gradient is 25.4/4000.
The groundwater discharge was estimated as follows:

$Q = 16,800(m^2) \times 1.0 \times 10^{-4}(m/sec) \times 25.4/4000$
$= 0.01m^3/s.$

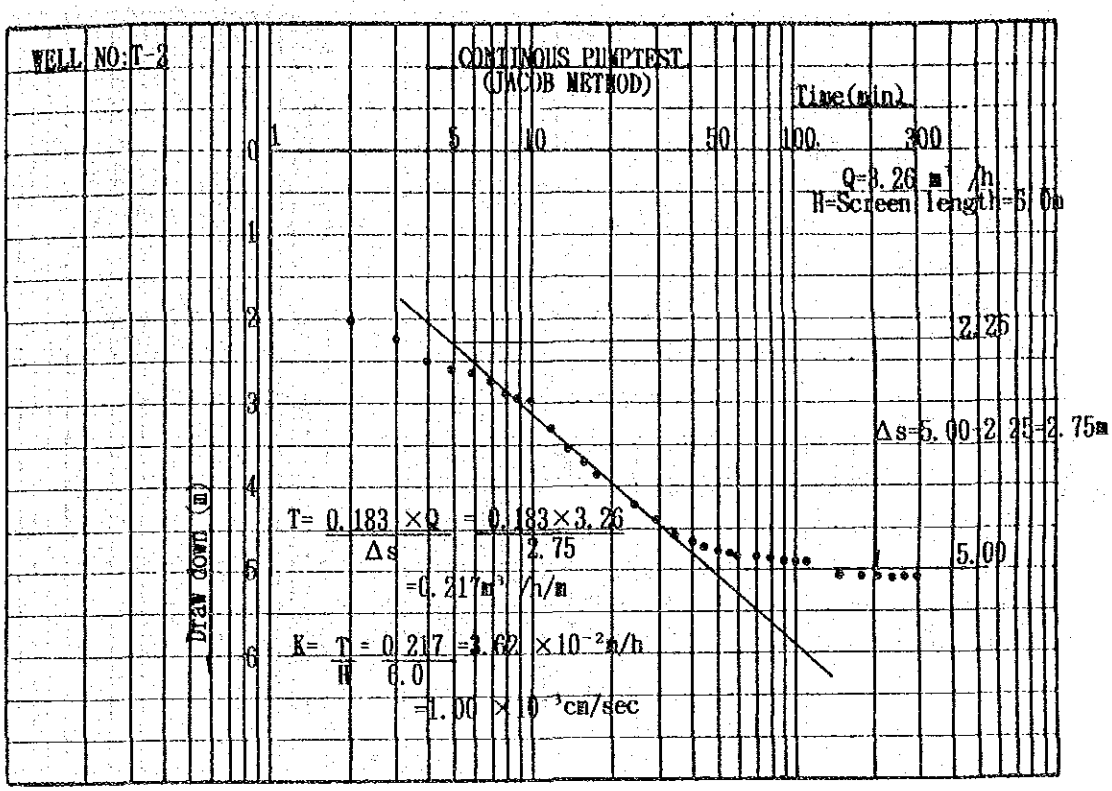


Fig. 3.1.1-2 T-2 Results of the Pumping Test (Continuous test JACOB method)

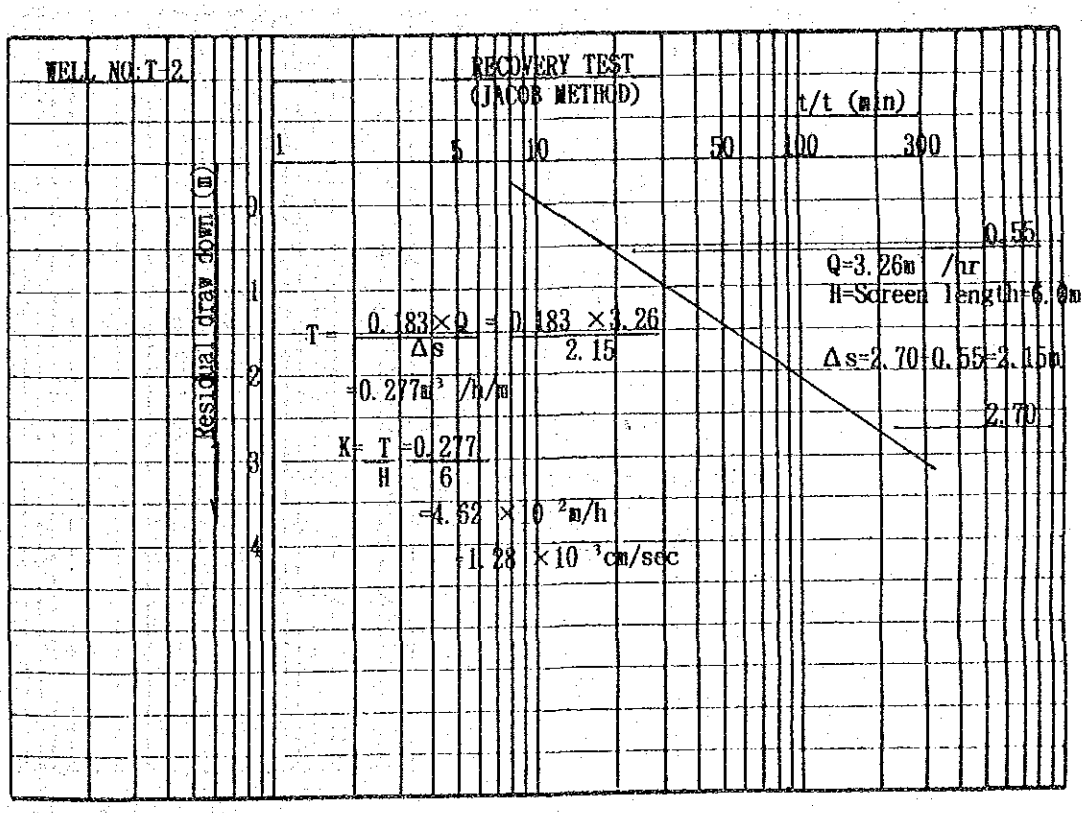


Fig. 3.1.1-3 T-2 Results of the Pumping Test (Recovery test JACOB method)

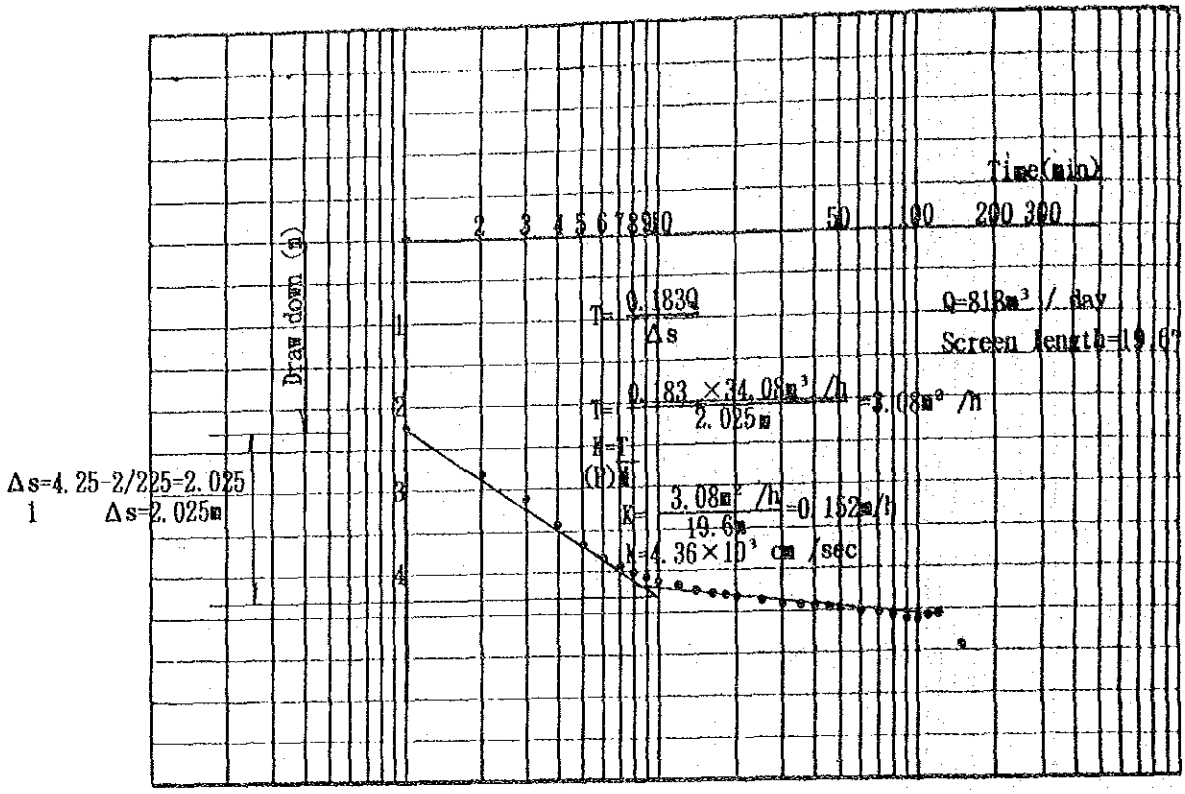


Fig. 3.1.1-4 No. 4 Results of the Pumping Test (Continuous test JACOB method)

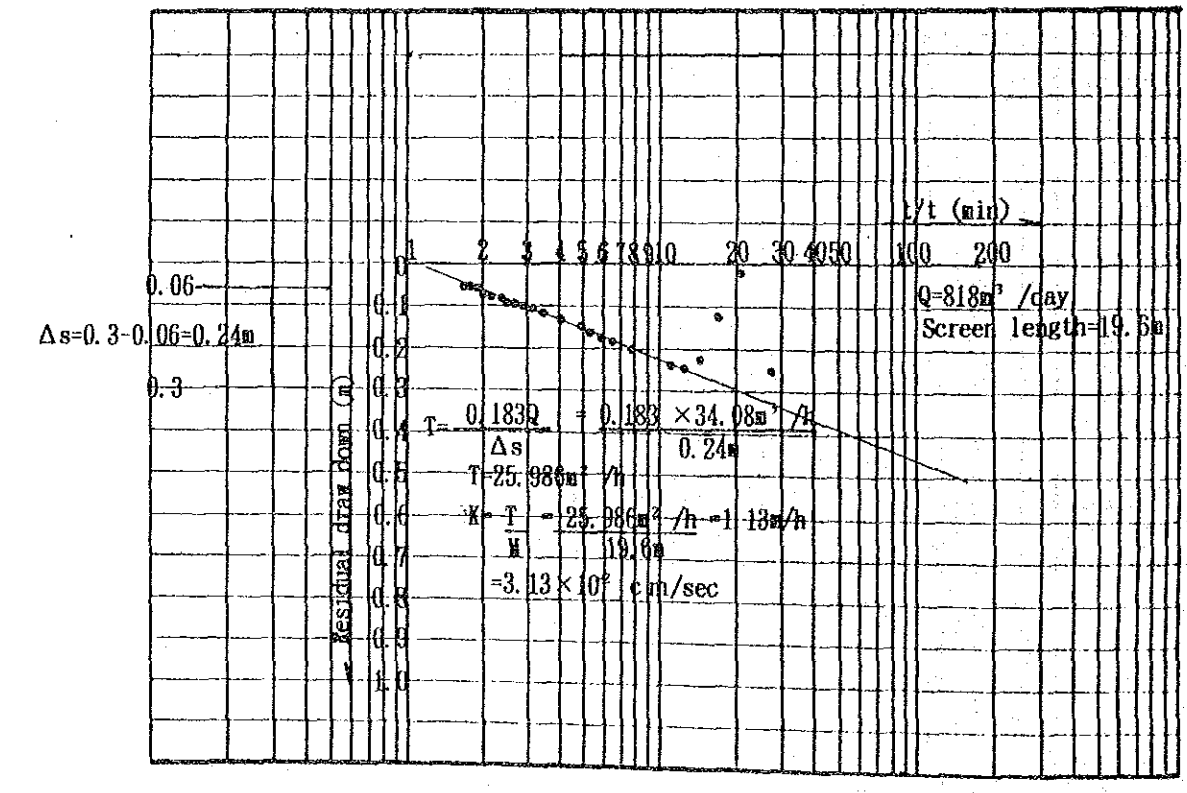


Fig. 3.1.1-5 No. 4 Results of the Pumping Test (Recovery test JACOB method)

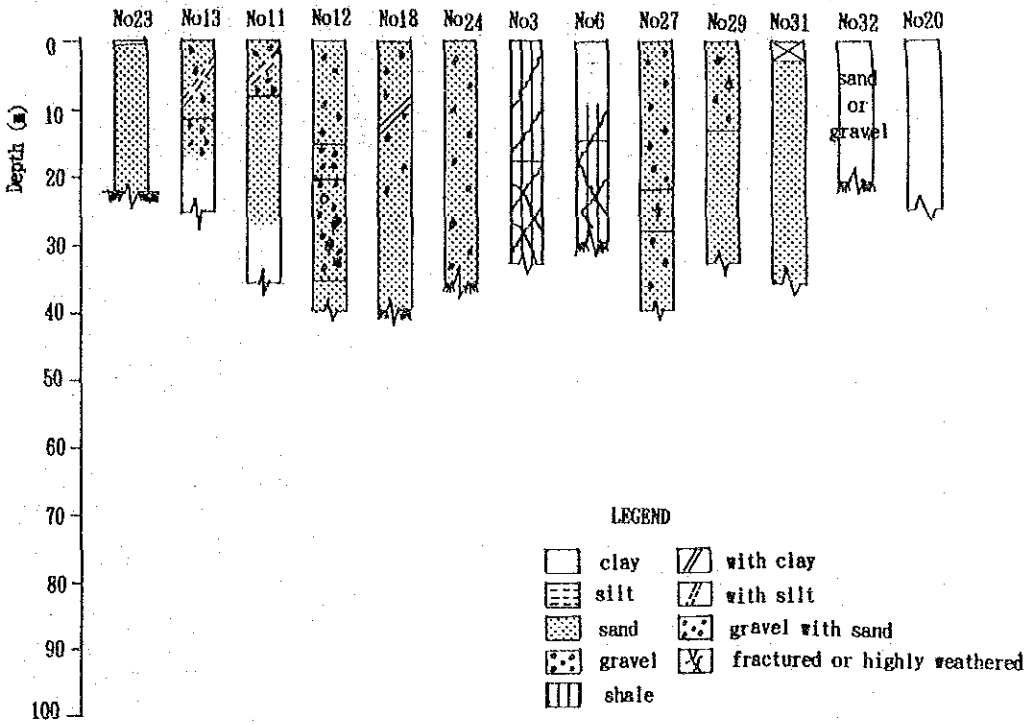
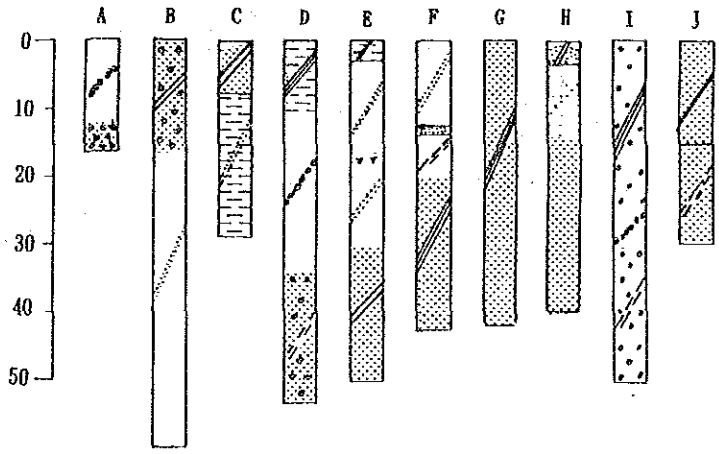


Fig. 3.1.1-6(1) Geological Loggings of Existing Wells



	WELL No	WELL DEPTH
A	ct 189207	16.76
B	ct 189206	60.98
C	ct 198301	28.96
D	〃	53.35
E	ct 209102	50.30
F	〃	42.68
G	ct 199102	39.62
H	〃	41.13
I	ct 199106	53.35
J	ct 209301	28.96

Fig. 3.1.1-6(2) Geological Loggings of Existing Wells

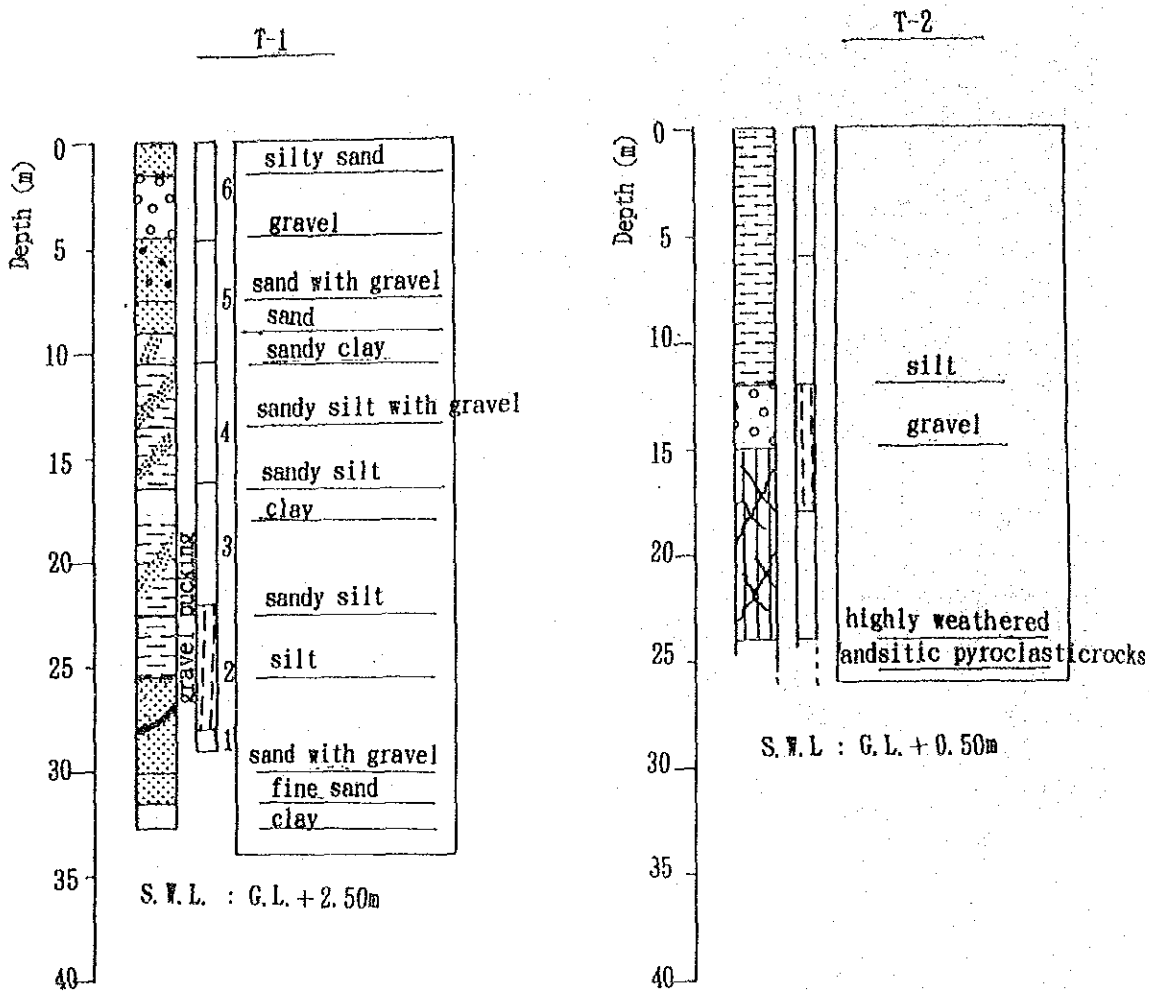


Fig. 3.1.1-6 (3) Geological Logging of Test Well