JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)

REPUBLIC OF NICARAGUA

INSTITUTO NICARAGÜENSE DE
ACUEDUCTOS Y ALCANTARILLADOS

THE STUDY ON WATER SUPPLY PROJECT IN MANAGUA

SUMMARY

SEPTEMBER 1993

Kokusai Kogyo Co., Ltd., Tokyo

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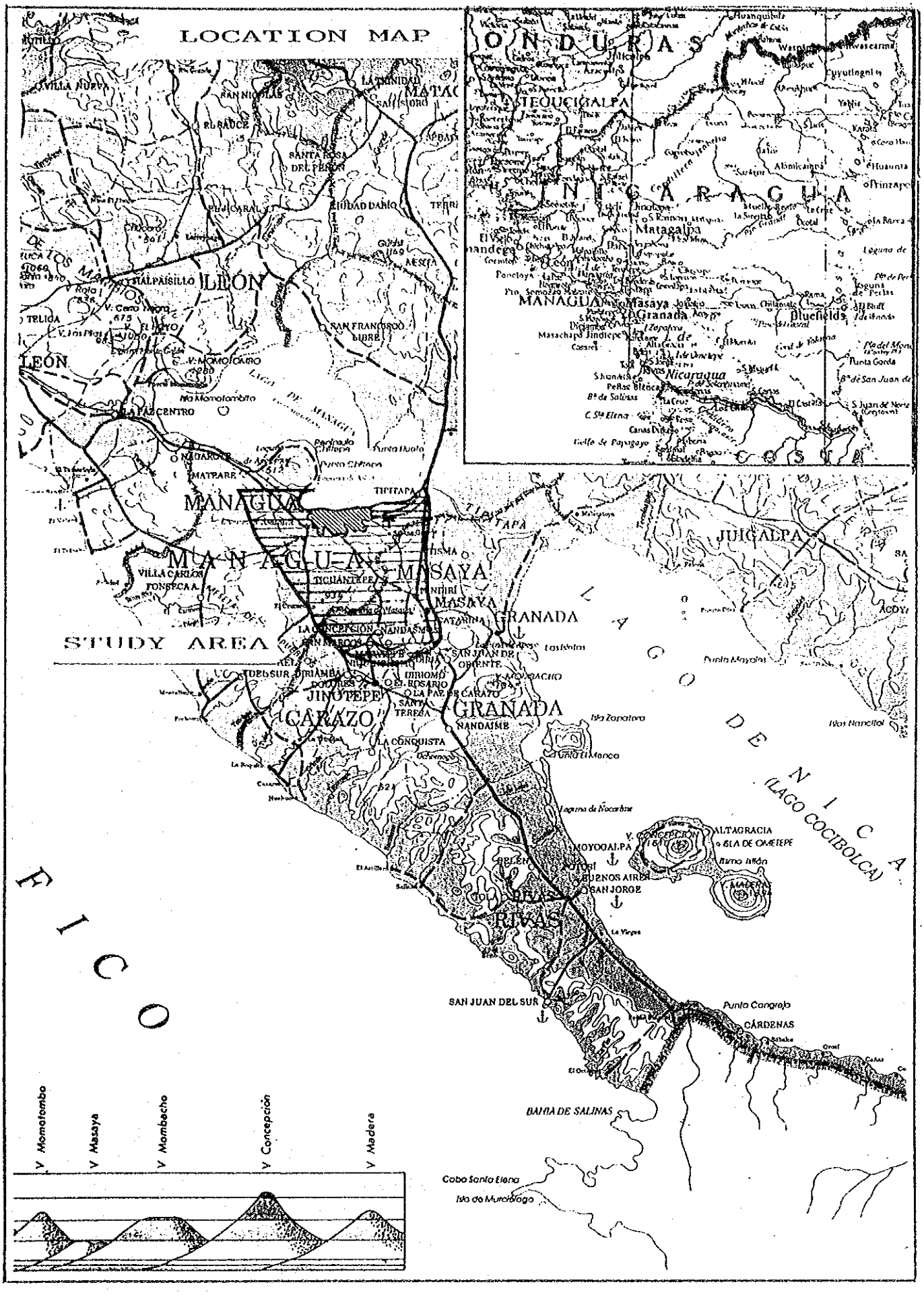
LOCATION MAP
HONDURAS
TEGUCIGALPA
NICARAGUA
Matagalpa
MANAGUA
Masaya
Granada
Bluefields
Nicaragua
COSTA
LEON
MANAGUA
MASAYA
GRANADA
JUIGALPA
CARAZO
JINOTEPE
RIVAS
STUDY AREA
LAGO DE NICARAGUA
(LAGO COCIBOLCA)
PACIFICO
SAN JUAN DEL SUR
BAHIA DE SALINAS
Punta Gorda
Punta Mayales
Isla Zapatera
Isla El Manco
Laguna de Nicaragua
Isla de Ometepe
Punta Jesús
Punta Cangrejo
CÁRDENAS
Cabo Santa Elena
Isla de Murciélago
V. Momotombo
V. Masaya
V. Mombacho
V. Concepción
V. Madera

SUMMARY REPORT

STUDY AREA
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CHAPTER 1 INTRODUCTION

1.1 General

This Report was prepared in accordance with the stipulations contained in the Scope of Work as agree upon between the "Instituto Nicaragüense de Acueductos y Alcantarillados (INAA)" and the Japan International Cooperation Agency (JICA) for the conduct of the "Study on the Water Supply Project in Managua".

The Study Area is the hydrogeological basin (about 880 km2) of Managua, about 200 km² of which in the northern part is occupied by the urban area of the capital city "Managua".

1.2 Outline of the Study

1.2.1 Background of the Project

Managua city, the capital of the Republic of Nicaragua, has nearly one third of the total population of the country with a remarkable population increase ratio of 7%. Within the last decade, the population of the capital city doubled from 0.5 million to over 1 million.

Since the water supply system was initially constructed to serve a population of several hundred thousand, very frequent improvement or expansion of the system has been required to catch up with the rapidly increasing water demand, which has made the maintenance of the supply facilities very difficult.

In addition, since the groundwater, including the lake water of Asososca crater lake, has been the sole source of the city water supply, over pumping is causing the draw-down of water level, which will be lead to deterioration of the water quality, if affected by the contaminated water of Lake Managua.

Therefore, a drastic rehabilitation of the water supply system as well as the development of a new water source have become very important and urgent subjects in Managua.

In order to cope with the above situation, a water supply

program targeting 1994 was formulated in 1989 through the detailed design study assisted by BID and USSR.

For the acceleration of the program implementation, and also for the establishment of a new water supply source development plan for after 1994, the Nicaraguan Government requested on economical and technical assistance to the Japanese Government in October, 1989.

In response to this request, JICA executed the project formulation study in September, 1990, then dispatched a preliminary study team in March, 1991. The scope of work related to the study on rehabilitaion of water supply system and groundwater development was agreed in this time. However, since the loan for the rehabilitation of the city water supply system was pledged by the BID, " the scope of work" was amended in October, 1991, resulting that the scope was focused mainly on groundwater development.

1.2.2 Objectives of the Study

The three major objectives of the Study are:

- To evaluate the groundwater potential in the Study area, and formulate a groundwater development plan

- To make a concrete plan for a partial expansion/ improvement of the water supply system including the facility design, and

- To tranfer technology to the counterpart personnel through the coarse of the Study.

1.2.3 Study Area

The Study area was expanded from 530 Km^2 to about 880 km^2 in accordance with the request from INAA and INETER, and in order to cover the entire hydrogeological basin of Managua for the groundwater potential study.

1.2.4 Study Team

The Study was practically implemented by a joint study team composed of JICA Study Team members, INAA personnel and INETER

personnel. JICA organized a study team consisting of a team leader and 9 experts in various fields.

For the smooth conduct of the study and effective transfer of technology, INAA provided counterpart personnel from its staffs, and INETER also provided coordinating counterpart of hydrogeology specialists. The JICA study team members and the counterpart members are shown in Fig. 1.2.1 and are listed below:

JICA Study Team

Name	Speciality
FUJIWARA Kunio	Team Leader/Hydrogeologist
KANDA Atsuo	Co-Team Leader/Hydrogeologist
YAMAGUCHI Masahiro	Hydrologist/Computer specialist
TANAKA Masatoshi	Geophysicist/Hydrologist
AOYAMA Takashi	Geophysicist
SUEMATSU Kakuji	Geologist/Drilling Supervisor
NAOTSUKA Akira	Water Supply Engineer
ARAKAWA Shuji	Water Supply Engineer
KINA Masaharu	City Planner/Architect
OBARA Masaru	Socio-Economist

INAA

Gustavo MARTINEZ	Vice Minister of INAA/Chief of INAA Team/Hidrogeologist
Francisco SAAVEDRA	Chief of Maintanence engineer/Advisor
Carlos VALLE G.	Chief Counterpart/Hydrogeologist
Walter MAYORGA	Water Supply Engineer
Mario CALDERA	Water Quality Analyst
Santos MARTINEZ	Drilling Supervisor
Fernando VARGAS	Chief of Information and Statistics/Socio-Economist
Juan Carlos VALLE	Geophysicist
Donaldo R. UGARTE	Assistant Engineer

INETER

William Montiel FERNANDEZ	Hydrogeologist
Luis Sandor Palacios RUIZ	Hydrogeologist

1.3 Study Description

1.3.1 Study Components and Sequence

Basically, this Study is to develop groundwater as a water supply source to meet with the rapidly increasing demand in the capital city of Nicaragua. Therefore, the major purposes of the Study are to evaluate the groundwater potential in Managua City and its surrounding and to plan groundwater development in this area to meet with the water demand after 1994 without causing serious problems such as excessive water level drawdown and the water quality deterioration.

Consequently, the Study comprises the following 3 major components;

1) Groundwater development study component including such sub-components as

   - Hydrogeology
   - Meteorology, hydrology and water quality
   - Evaluation of groundwater development potential

2) Water demand study component with sub-components of

   - Existing condition of groundwater use
   - Water demand projection

3) Water plan study component with sub-components of

   - Groundwater development (Well construction) plan
   - Facility designing as as case study

The field surveys for these components were completed within 11 months from December 1991 and followed up by the detailed analysis work and the report preparation in Japan until July 1993.

The study flowchart along with the work items are presented in Fig. 1.3.1 and the work schudule is shown in Fig. 1.3.2. Outline is briefly described below:

(Phase I) : 3.5 months from December, 1991 to March, 1992

The first field surveys for basic understanding of the Study components. Progress Report (1) was prepared in Managua.

(Phase II) : Phase II: 5.5 months from June to November in 1992

The detailed field surveys on hydrological and hydrogeological components including test well construction were conducted in this Phase. The supplementary field survey and the comprehensive analysis on components 2) and 3) mentioned above were also conducted in this period. The results obtained arranged in Progress Report (2).

(Phase III) : 9 months from November, 1992 to July,1993.

Overall analysis on hydrology and hydrogeology of the area was made resulting to the evaluation of groundwater potential and the preparation of the draft of hydrogeological map. Combined with the output of the components 2) and 3), a draft of the groundwater development plan was prepared and represented in the Interim Report.

After a discussion on the Interim Report with the Nicaraguan Agencies concerned, a further analysis was made to finalize the groundwater development plan and the monitoring plan. The two types of groundwater development plan were prepared to cope with the demand of the year 2000 including preliminary facility design as a case study.

Incorporating the INAA's comments on the Draft Final Report, the Final Report was prepared in September, 1993.

Figure 1. represents the flow chart of the Study.

1.3.2 Technology applied

The following technologies were applied in this Study.

(a) Methods in hydrogeological investigation

(Phase I)

- Aerial photograph interpretation (topography and geology)

- Geological reconnaissance survey
- Geophysical prospecting (geoelectric sounding)
- Review on existing drilling data (lithology and pumping rate)
- Interview survey on groundwater use

(Phase II)

- Supplemental geoelectric sounding to confirm geological formation
- Test drilling and geophysical logging
- Pumping test to determine the hydraulic parameters of aquifers

(b) Methods in hydrological survey

(Phase I)

- Installation of monitoring equipment (automatic water level recorder, gauging staff, rainfall gauge) and start monitoring
- Discharge measurement of springs and perennial river
- Simultaneos groundwater leveling in dry season
- Water quality anylisis

(Phase II)

- Monitoring of groundwater level, river water level and precipitation
- Discharge measurement of springs and rivers in wet season
- Water quality analysis including tritium isotope dating method

(c) Preparation of database system

- Collection and arrangement of hydrological / hydrogeological data

- Design and coding of a database program and processing of arranged data

(d) Computer simulation of groundwater flow and formulation of the groundwater development plan

(e) Review on water supply system of Managua

- Data collection and arrangement on water demand projection based on Managua City Plan and population projection

- Survey on functionning of major existing water supply facilities

(f) Determination of the development scale

- Discussion on prioritization of supply zone
- Projection of population and water demand by zone
- Consideration of the safety groundwater yield

(g) Case Study on partial expansion of the water supply system

- Topographic survey for water conveyance system of the target and alternative sites
- Design of the wells, storage tank and conveyance pipe line to the existing reservoir with independent functions of intake and conveyance pumps
- Cost estimation for above construction

1.3.3 Study Schedule

The Study will be conducted for a period of twenty two (22) months from December, 1991 to September, 1993.

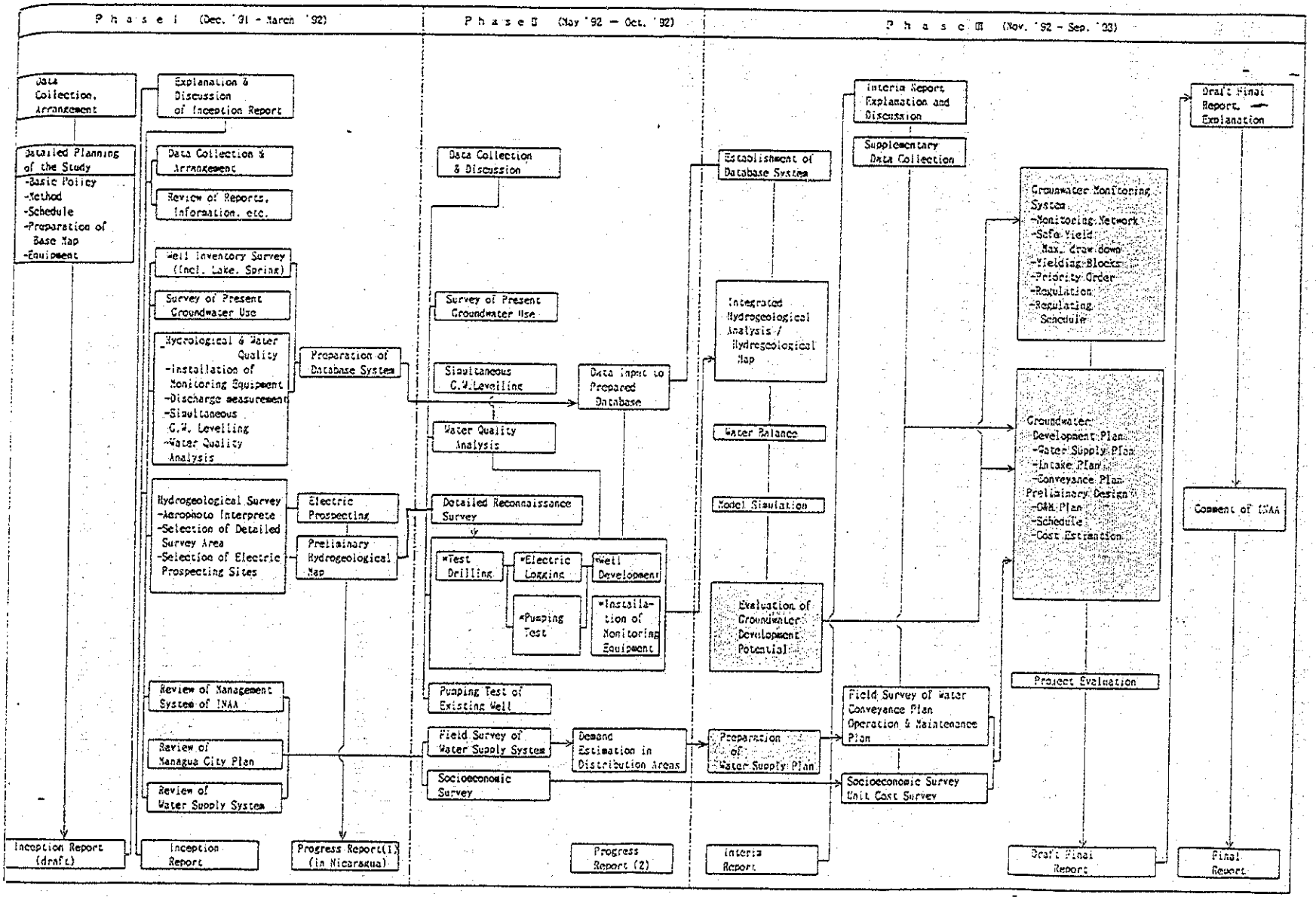
Figure 1.3.1 represents the general work schedule covering the entire study period. The study period was divided into the following three phases:

- Phase I : Basic research period
  (December, 1991-March,1992)

- Phase II : Detailed research period
  (June,1992- November,1992)

- Phase III: Analysis and planning period
  (November, 1992-September, 1993)

Fig. 1.3.1 Study Flow Chart



Chapter 2 SOCIOECONOMIC AND SECTORAL BACKGROUND

2.1 General

Nicaragua is situated in the Central American isthmus, bordered by Honduras, Costa Rica, the Atlantic Ocean and the Pacific Ocean. The total area of the country covers 130,682 km2, of which 10,333 km2 are water surface area, mostly comprised of the two big lakes of Managua (Xolotlan) and Nicaragua (Cocibolca).

The country is divided into three Macro-Regions: Pacific, Central and Atlantic, with climatic characteristics ranging from tropical savannah to tropical humid forests and highland climate. The average yearly temperature is 27 degrees centigrade and the average yearly rainfall is 1,300mm.

Administratively, the country is divided into Regions, Departments and Municipalities. The basic political-administrative unit of the country is the Municipality. Municipal authorities are autonomous of the Central Government and are elected by popular, direct and secret vote for a six-year term (Articles 175, 176, 177, 178 of the 1987 Constitution).

In practice, the country is divided into 9 Regions, 16 Departments and 142 Municipalities. Two of the 9 Regions are regarded as autonomous due to their peculiar ethnic and sociocultural characteristics: the North Atlantic Autonomous Region (RAAN) and the South Atlantic Autonomous Region (RAAS).

The Central Government organization rests upon four independent branches: Legislative, Executive, Judicial and Electoral (Article 129 of the 1987 Constitution). The Legislative Power is exercised by the National Assembly comprised of 90 Representatives and 90 Alternates, who are elected by popular, direct and secret vote for a six-year term (Articles 132 and 136 of the 1987 Constitution).

The Judicial Power is administered through Tribunals of Justice, of which the highest is the Supreme Court of Justice. The latter is composed of a minimum of seven members who are appointed by the National Assembly for a six-year term. The President of the Republic appoints one member of the Supreme Court of Justice as its President (Articles 158, 159, 162, and 163 of the 1987 Constitution).

The Electoral Power has exclusive jurisdiction over elections, plebiscites and referenda, being in charge of the organization, direction and supervision of electoral processes. The Electoral Power is composed of the Supreme Electoral Council and other supporting agencies. The National Assembly appoints the five members of the Supreme Electoral Council, one of whom is selected as its President, for a six-year term (Articles 168, 169, 170, 172 of the 1987 Constitution).

The duties of the Executive Power are discharged by the President of the Republic, who is the Chief of State, the Chief of Government, and the Supreme Chief of the Armed Forces. The President and the Vice-President of the Republic are elected by direct, secret vote, where a simple majority of votes decides the winners for a six-year term (Articles 144, 146 and 148 of the 1987 Constitution).

2.2 Economic Characteristics

2.2.1 Nicaragua

The economically active population (EAP) was estimated at 1,331,200 in 1990, representing 34% of the total estimated population of 3,858,900. Between 1988 and 1990, while the total population grew at a 2.14% annual rate, the EAP grew at 4.46% annual rate (Table 2.2.1).

Tables 2.2.1 and 2.2.2 show the sectoral distribution of employment of the economically active population in 1990, which is as follows.

Sectoral Employment	Percentage
Primary sector	33
Secondary sector	20
Tertiary sector	47

Within the secondary sector, manufacturing employed 16%, while within the tertiary sector, commerce employed 16% and other services 19%. In 1990, 160,000 persons were unemployed (12% of EAP) and 599,600 persons were under-employed (45% of EAP), showing that well over half of the EAP of the country faced serious employment problems (Table 2.2.2).

Measured in constant 1980 Cordobas, the overall gross domestic product (GDP) decreased from 17,936.2 Million in 1988 to 16,666.9 Million in 1990, equivalent to a 2.4% yearly contraction rate. The per capita GDP in 1990 was estimated at 4,319 Cordobas, having declined at a 5.2% yearly rate since 1988. Table 2.2.1 shows the GDP composition to be roughly the following.

GDP Composition	Percentage
Primary sector	25
Secondary sector	25
Tertiary sector	50

(1) Primary Sector

Agricuture in Nicaragua is recognized to have a dual structure composed of commercial farms for exports on one hand, and farms for the domestic market on the other. Cropping area in 1990 was distributed as follows.

Type of Farms	Cropping Area (Mz.)	%
For exports	299,000	38
For domestic market	471,000	62

Main export crops were coffee 106,000Mz., cotton 64,000Mz., sugar cane 66,000Mz., sesame 51,000Mz. and banana 3,000Mz., which generated US$170 Million, that is, 59% of total exports in 1990, when agriculture comprised 15% of GDP. On the other hand, main crops for domestic consumption were corn 223,000Mz., beans 130,000Mz., and rice 54,000Mz. in 1990 (Table 2.2.3).

Livestock activities center around cattle, which was estimated at 1,600,000 heads in 1988. Cattle slaughtered in 1989 numbered 210,900 heads, producing 66.8 million lb. of beef, of which 37 million lb. were exported. Livestock accounted for 8% of the GDP in 1989.

Shrimp and lobster were two promising non-traditional export products. Even though catch and exports of these two products declined in 1990, their rate of decline was less than the

contraction rate for fish (Table 2.2.4). The export values of these two products ranged from US$9 Million to US$12 Million between 1988 and 1990. Given the high demand for shrimp and lobsters in the international market, export values of these two products are wide open for future expansions.

(2) Secondary Sector

Manufacturing was badly hit by the armed conflict, which destroyed plants, raw materials, final goods, caused loss of markets, and discouraged investments in plants. Manufacturing comprised around 20% of the GDP in 1990.

Located in Managua were 37 manufacturing firms which were main causes of pollution in the Managua Lake. Important manufacturing types in terms of production values in 1990 were foodstuff 20%, chemicals 18%, beverage 13%, metal products 10%, and tabacco 8% (Table 2.2.5).

(3) Tertiary Sector

The tertiary sector in Nicaragua employed nearly half of the EAP and accounted for half of the GDP in 1990 (Table 2.2.1 & 2.2.2). In terms of employment, commerce occupied 16% of EAP, Central Government 6%, transport and communications 4%, finance 2% and other services 19%.

The relative weight of the tertiary sector in the GDP and employment seems to be exaggerated for the present stage of development of the Nicaraguan economy. The high employment rates in commerce and other services suggest that these may in reality be cases of additional under-employment, taken as non-optimal employment by the people who are unable to find suitable jobs in the primary and secondary sectors.

(4) International Trade

Nicaraguan exports increased from US$235.7 Million in 1988 to US$321.3 Million in 1990, that is, an overall 10.9% annual growth rate. During the same period, traditional export products decreased from 85% to 81%, with the corresponding growth in non-traditional export products.

Traditional export products were coffee, cotton, sugar, beef, banana and gold. Between 1988 and 1990, exports of coffee and cotton declined both in absolute and relative terms, while

sugar exports increased six-fold and beef exports three-fold. Coffee, cotton, sugar and beef accounted for 63% of total exports in 1990 (Table 2.2.6).

Imports, on the other hand, decreased from US$807.1 Million in 1988 to US$664.7 Million in 1990, whereby trade deficits declined from US$571 Million to US$343 Million. Imports were classified into consumption goods, petroleum, intermediate goods and capital goods, which accounted for 28%, 19%, 24%, and 28%, respectively, of total imports in 1990 (Table 2.2.7).

(5) Foreign Debt

The Nicaraguan foreign debt increased from US$7.2 Billion in 1988 to US$8.7 Billion in 1990, that is, a 6.2% annual growth rate. The foreign debt consisted of 93% medium and long-term debt and 7% short-term debt. Around two-thirds of total debt was incurred by the Central Government, about one-fifth by the Central Bank, and the remainder by other public sectors and the financial system (Table 2.2.8).

Creditors were mostly bilateral organizations which held around 65% of total debt, while multilateral agencies accounted for 12%, commercial banks for roughly 15% and the remainder comprised by suppliers and short-term debt (Table 2.2.8).

(6) Central Government Finances

The Central Government incurred fiscal deficits amounting to more than 300 Million Cordobas Oro in 1988 and 1990, and around 30 Million Cordobas Oro in 1989. During these three years, tax revenues amounted to more than 90% of the Central Government income, while capital income comprised less than 2% of total income (Table 2.2.9).

Current expenses exceeded total income and comprised between 92% and 95% of total expenditures. Within current expenditures, Goods & Services accounted for 60% to 70%, Salaries & Wages for 13% to 20%, and the remainder was comprised by Transfer payments and Interests. Salaries & Wages and Transfer payments showed increasing trends, while other categories of income and expenditures showed declining trends (Table 2.2.9).

Table 2.2.10 shows a more detailed breakdown of the Central Government income during the 1988-1990 period. Tax income comprised more than 90%, broken down into direct tax: 20%-25%,

tax on goods and services: 50%-60%, and import tax: 7%-14%. The most important direct tax was income tax with around 20%, while among taxes on goods and services, consumption tax accounted for 34%-46%, and sales tax for 10%-12% of tax revenues.

2.2.2 The Study Area

Within the Study Area, main cities are Managua and Masaya, with a combined population of well over one million. As the Study Area is the most urbanized area of the country, an estimated 65% of the labor force are employed in the tertiary sector, 31% in the secondary sector, and 4% in the primary sector. In urban Managua in 1989, the top three employments were services 39%, commerce 24% and manufacturing 21%.

Manufacturing is especially strong in the Study Area, having been estimated that 80% of the nation's industrial firms are located in Managua. Manufacturing plants of all sizes are predominantly located in the following six zones.

1. Carretera Norte	Textiles
2. Acahualinca	Food processing
3. Sarretera Sur	Chemicals, textiles
4. Cuesta Heroes y Martires	Chemicals, petroleum
5. Carretera Nueva a Leon	Metal mechanics, food
6. Carretera a Masaya	Chemicals, pharmaceutical

In addition, small manufacturing plants are scattered all over the residential areas.

Typically, 90% of industrial plants employ less than 4 workers, thereby falling under the category of small scale manufacturing, which accounts for 13% of industrial employment. On the other hand, less than 10% of industrial firms employ more than 25 workers. Predominant industry types are food processing 49% and clothing 25%.

2.3 Social Conditions

In 1985, there were 533,446 households, with an average household size of 6.2 persons. They were housed in 507,984 units of dwellings, giving an average of 6.5 persons per dwelling. The

dwellings were located 53% in urban areas and 47% in rural areas. Managua Department accounted for 146,012 units of dwellings, or 29% of the country, located 86% in urban areas and 14% in rural areas (Table 2.3.1). Dwelling shortage is estimated at 400,000 units in Nicaragua. In addition, housing demand is estimated to grow by 20,000 units per year.

Dwelling units in Managua City were estimated at 118,000 in 1987 and 157,607 in 1991, the latter figure without District 7, where 7,000 dwelling units were assumed to be located. Managua is particularly affected by the housing shortage, due to the high migration rate from rural areas into the capital city.

The high rural-urban migration into Managua gave rise to "progressive" and "spontaneous" settlements, with all the implications on the expanded demand for basic services, especially water supply. While progressive settlements have been receiving some kind of assistance, such as water supply by public standposts, spontaneous settlements consist of illegal land occupation in areas generally considered as unsuitable for housing development. The 1991 population was estimated at 126,942 persons in progressive settlements, and 139,148 persons in spontaneous settlements.

Regarding available water supply types, 49% of dwellings in Nicaragua had water supplied by house connections from public systems, 9% by public standposts, 20% by wells and 22% by other water supply systems. In Managua Department, 69% of dwellings had water supply by house connections, 19% by public standposts, 4% by wells and 8% by other systems. The corresponding figures for urban Managua were 74% by house connections, 20% by public standposts, 1% by wells and 5% by other systems (Table 2.3.1).

Similarly, with regards to toilet facilities available to dwelling units, 52% of houses in Nicaragua had flush toilets, 23% had latrines and 25% had no toilet facilities. In urban areas, flush toilets increased to 55% and latrines to 41%, while dwellings without toilet facilities decreased to 4% (Table 2.3.1).

Likewise, dwellings with electricity amounted to 63% for the whole country and 92% for urban areas. In Managua Department, 88% of houses had electricity, and this percentage went up to 95% of dwellings in urban areas (Table 2.3.1).

The above described deficiency in the quality and coverage of water supply and sanitation, even in urban areas, adversely affects the people's health. This situation is evidenced by the high incidence of intestinal disorders such as acute diarrhea, which was the top cause of infant mortality in 1989. The rate of infant mortality per thousand live birth increased from 61.0 in 1986 to 71.8 in 1989. Eighty percent of infant mortality occurred within the first year of birth (Nicaraguan Report for the UNCED).

2.4 National Development Plan

The 1992-1996 Medium-term Development Plan

The present Government, which was elected in February 1990 for a six-year term, has recently formulated the development strategy for the 1992-1996 period, to build upon the achievements of the first two years. These achievements include pacification of the country, control of hyperinflation, stabilization of the exchange rate, deregulation and liberalization of the private sector, and foreign debt rescheduling.

2.4.1 Objectives

The 1992-1996 Development Plan categorized objectives into those for the short-run and for the medium-term.

(1) Short-run objectives 1992-1993

1) Consolidation of economic and political stability
2) Transition from stability to sustained development
3) Employment generation
4) Preservation and rational use of natural resources
5) Public sector institutional reform
6) Foreign debt rescheduling

(2) Medium-term objectives 1994-1996

1) Definition of the legal and institutional framework for the private sector
2) Export based growth
3) Improvement of human resources
4) Institutional reform
5) Promotion of domestic savings and investments

6) Consolidation of democracy

2.4.2 Growth Target and General Strategy

The GDP growth target by year during the four-year period of the Development Plan is shown below.

Year	GDP Growth Target (%)
1992	4.0
1993	4.5
1994	5.0
1995	5.0

The general strategy for development is based on creation of favorable conditions for sustained and equitable growth. These conditions refer to the freedom and responsibility to work, which should be given back to the private sector, be it individuals, families, business or voluntary associations.

The above strategy requires the development of self-help schemes, transition from a state-run economy to a market economy, transition from a militarized society to a civilian society, reduction of an oversized bureaucracy, restriction of Government intervention to strictly indispensable areas, and monetary stability as bases to promote savings and long-term investments.

2.4.3 Sectoral Strategy

High mortality rates in Nicaragua result from diseases associated with contaminated water, especially among children in rural areas. Main problems concerning water supply and sanitation are obsolete infrastructure, pollution of water bodies and human habitat, insufficient water supply especially in Managua City, and high rates of water losses which are estimated at around 50% in the capital city.

The Government strategy for the water supply and sanitation sector consists of the following.

(1) Expanded coverage of water supply in rural areas
(2) Minimization of water losses and contamination, to be achieved by rehabilitation of water supply facilities

(3) Strengthening of administrative capabilities so as to attain financial self-sufficiency
(4) Reduction of illegal connections and expansion of water-meter coverage
(5) Environmental protection through strict regulation and improved sewer system
(6) Mobilization of local resources to implement rural water supply and sanitation works
(7) Provision of facilities for sanitary disposal of wastes from the rural population
(8) Expanded education on personal hygiene and public health

2.5 Water Supply and Sanitation Sector

2.5.1 Service Coverage

Table 2.5.1 shows the water supply coverage by Macro-Region and by urban and rural areas of Nicaragua in 1989. Of the total population, 2,024,111 persons or 53% had water supply services, broken down into 39% by house connections and 14% by public standposts. The coverage was a lot higher in urban areas reaching 78%, of which 64% by house connections and 14% by public standposts. The Pacific Macro-Region, which includes Managua, had the highest coverage among Macro-Regions with 67%, broken down into 52% by house connections and 15% by public standposts.

Table 2.5.2 shows coverage of water supply and sewer services by Region of the country in 1987. Region III, Managua, had an estimated total population of 949,920 persons, of which, 836,325 or 88% was estimated to have water supply service. This percentage of water supply service coverage was estimated to be 98% in urban areas. Sewer service was estimated to cover 61% of the urban population of Region III in 1987.

2.5.2 The Service Institution: INAA

(1) Legal Basis and Functions

The official institution with national jurisdiction over water supply is the Nicaraguan Institute for Waterworks and Sewerage (INAA), which was established by Executive Decree No.20

of July 25, 1979. The Decree conferred INAA autonomy, juridic personality,own assets, indefinite duration, and full capacity and right to contract obligations.

INAA inherited functions formerly performed by the National Waterworks and Sewerage Department (DENACAL) and the Managua Water Corporation (EAM). Executive Decree No. 123 of October 23, 1979 specified INAA responsibilities as planning, implementation, operation and management of municipal and local water supply and sewer systems in the whole country.

More specifically, main INAA functions include the following.

1) To solve water supply and sewerage problems of the country

2) To dictate standards and specifications for the design, construction, operation, maintenance and management of water supply and sewer works

3) To ensure compliance with these standards, and to require amendments in case of violations

4) To examine and approve works to be undertaken by natural and juridic persons in the fields of water supply, use of surface or groundwater, and discharge of waste water

5) To set guidelines for water supply and sewer service charges to be applied by INAA or by other authorities

6) To cooperate with the Ministry of Health in the passage of the National Health Code, and subsequently participate in the quality control of water for different uses

7) To provide technical and financial assistance to dispersed rural communities seeking to solve their water supply and waste disposal problems

8) To obtain loans or to find other means to finance projects, such as bond emission, with prior approval by proper authorities

(2) Organization

INAA has a pyramidal organization divided into five major levels which from top to bottom are decisional-determinative, advisory and support, normative-executive, executive-operative, and operative. The top three levels comprise the Central System, while the remaining two levels comprise eight Regional Subsystems and a number of local Subsystems (Figure 2.5.1).

The functions at the "decisional-determinative" level are discharged by the High Directorate which is headed by a Director and a Deputy Director, who have the ranks of Minister and Vice-Minister, respectively. They are assisted by four Committees, namely, Institutional Development, Budget, Bidding, and Coordination. The top level of the organization sets objectives and policies concerning all aspects of INAA activities, and makes decisions and recommendations.

The "advisory-support" level comprises nine organization units in three sub-levels: five units with the rank of General Division, two with the rank of Specific Division, and two with the rank of Office. The five General Divisions pertain to Organization and Systems, Planning, administrative Services, Human Resources, and Internal Audit. The two Specific Divisions refer to Community Works and Legal Assistance. Finally, the two Offices pertain to Foreign Matters and Public Relations or Press Service.

The "normative-executive" level conforms the core organization units of INAA. The seven General Directorates comprising this level are: Financial, Commercial, Rural Waterworks, Control of Regional Systems, Study and Construction, Operation and Maintenance, and Region III.

The "executive-operative" level pertains to Regional Subsystems comprising the INAA representative offices in each of the nine political-administrative Regions of the country. Each Region has a Regional Delegate who represents the INAA Director and is responsible for the operation and maintenance, commercial matters and management of Regional water supply systems.

The "operative" level pertains to local subsystems, including operation and maintenance, commercial and administrative matters.

(3) Human Resources

As of June 30, 1992, INAA personnel numbered 2,606 employees, down 364 from the peak of 2,970 employees in 1990. The breakdown by category is as follows.

Category	Number	Percentage
Managemente & Staff	364	14
Professionals	113	4
Mid-level Technical	781	30
Laborer	1,348	52

The Central System accounted for 936 employees (36%) and the Regional Subsystems 1,670 (64%). The largest was Region III with 561 or 22% of employees, followed by Region IV with 345 or 13%. Permanent employees comprised 2,207 or 85% and temporary 399 or 15%.

(4) Operating Characteristics

1) Water Supply

INAA is responsible for the operation, maintenance and management of 148 systems supplying water to 170 cities and communities. Water sources of the 148 systems are 107 drilled wells, 15 infiltration galleries, 18 surface water sources and 8 mixed systems. The capital city Managua depends on a mixed system composed of 83 drilled wells and the Asososca crater lake.

The high incidence of illegal connection in Managua City, estimated at 30,000, causes damage to the pipeline, thereby increasing water losses, reducing income, and increasing the risk of contamination. Water quality is regarded poor in 38 (26%) of 148 systems.

2) Sewerage

INAA is also responsible for the operation, maintenance and management of 20 sewer systems, but the service covers only urban areas, mostly concentrated in Region III. Main cities covered by sewer service are Managua, León, Granada, Masaya, Rivas, Chinandega, Corinto, San Juan del Sur, Somoto and Estelí. in the remaining sewer systems, the service is usually available only

along main streets of the cities.

Of the 20 sewer systems, only 8 are equipped with sewage treatment plants, and the remaining 12 discharge raw sewage into water bodies. In general, deficient maintenance makes it necessary urgent improvements in collection network, repair and expansion of sewer lines.

(5) Finances

The Balance Sheets and Income Statements for 1990 and 1991 are shown in Tables 2.5.3, 2.5.4 and 2.5.5. Even though figures for the two years are shown side by side, the inter-year comparison and financial analyses are rather difficult due to the following reasons.

As of December 31, 1990, two currency units were in circulation: (1) Cordoba Oro (1US$=1C$O) put into circulation in August 1990, and (2) Cordoba Corriente (1US$=3,000,000C$C). The Cordoba Corriente was to remain in circulation up to April 30, 1991.

As of December 31, 1990, INAA undertook revaluation of inventory by the method of replacement costs, because historical costs were grossly distorted by the hyperinflation. This gave rise to revaluation profits on assets, but the other side of the coin was currency devaluation losses on liabilities.

The Monetary Adjustment Law was passed on March 3, 1991. This law mandated adjustments in accounting records by applying a variety of correction factors, including the following exchange rates: 1US$=5C$O=5,000,000C$C. As of December 31, 1991, losses from adjustments amounted to C$60,145,633.

In a letter dated September 3, 1991 from the Finance Ministry, the Government of Nicaragua decided to take over payment of all foreign debt held by INAA, which as of May 31, 1991 amounted to C$95,265,946 (US$19,053,182) in principals and C$23,503,645 (US$4,700,729) in interests. Consequently, INAA assets increased by C$118,769,591 (US$23,753,911) due to this political decision which had nothing to do with INAA operating performance.

The above factors make financial comparison and analyses rather difficult between 1990 and 1991. However, some financial

characteristics can be described as follows.

Water rates were increased 240%-340% in May-June 1990, then in November 1991 with partial adjustments in February 1992, and finally in January 1993. These frequent changes in water rates indicate that INAA enjoys the privilege of freely adjusting water rates ro reflect changes in operating costs. Sewer charges were increased from 17% of water charges in 1990 to 30% in 1991. Water sold was 79,006,425 m3 in 1990 and 76,151,000 m3 in 1991.

Water service charges differ according to the following user categories: residential, commercial, industrial, multi-family, public standposts, and government. Each category has its own block structure, and water charges rise with increasing consumption blocks, thereby inducing rational water use.

Accounts Receivable worsened not only in total amount but also in the length of overdue accounts, as shown below.

Overdue Accounts	1990	1991
1 month	33%	28%
2 months	26%	5%
3 months	41%	67%

Allowance for bad debt is based on Accounts Receivable which are more than 180 days overdue.

Although detailed financial information for 1992 is not available, it is certain that INAA made a dramatic financial improvement, since it is known that collection increased to 86% of billings in Managua.

Of the 1990 operating expenses, electricity comprised about one-third, and salary and wages nearly one-fifth of total expenses, as shown below.

Electricity	32.3%
Salary & Wages	19.2%
Maintenance & Repair	16.0%
Fuel & Lubricants	5.5%

2.5.3 Sectoral Perspectives

(1) INAA Policy and Objectives

The general policy framework is the UN sponsored "Health for all in the year 2000", which seeks to provide water supply and sanitation services to the totality of the population in the year 2000. This is quite an ambitious goal, given the present situation where 47% of the population have problems with safe water supply and 81% have problems for adequate disposal of excreta and waste water. Therefore, the goal for the 1990 decade is to surpass 80% coverage in water supply and 50% in sewerage.

Accordingly, INAA set sectoral objectives as follows.

1) Urban Areas

   a) Reduction of unaccounted-for water to reasonable levels
   b) Legalization of 24,000 illicit connections in 62 progressive settlements
   c) Rehabilitation of existing water supply and sewerage systems to improve service quality
   d) Expansion of water supply and sewerage system to improve coverage

2) Marginal Urban and Concentrated Rural Areas

   a) Reduction of unaccounted-for water to reasonable levels
   b) Rehabilitation of existing water supply systems to improve service quality
   c) Expansion of water supply systems and construction of latrine to improve coverage

3) Rural Dispersed Areas

   Expansion of water supply and latrine coverage, with community participation, and preferably as a component of integrated rural development projects

(2) INAA Specific Projects

INAA has a number of specific projects which need to be urgently implemented and include the following.

1) Water Supply in 27 Rural Communities: construction of 16 small scale pump based and 3 gravity waterworks

2) Water Suply in Region I: construction of 53 small scale waterworks, 101 dug wells and 3,430 latrines

3) Water Supply for Rural Matagalpa: construction of 230 water supply systems and 6,519 latrines

4) Five-year Integrated Rural Development Program (PQDRI): construction of 25 small scale waterworks, 350 drilled wells, 150 dug wells and 7,000 latrines

5) National Program for Water Quality Control (PRONCAGUA): water treatment plants in selected water supply systems

6) Water Supply in 17 Communities: expansion and improvement of 17 water supply systems

7) Installed Capacity Maintenance Program of 6 Water Supply Systems: improvement of water supply systems of Masaya, Granada, Diriamba, León, Chinandega and Estelí.

8) Operating Improvement and Rehabilitation Program of Water Supply and Sewer Systems: rehabilitation of 20 water supply systems and 7 sewer systems, including Managua and rural communities

9) Expansion and Improvement of Masatepe Water Supply System

10) Ocotal Sewer System

11) Expansion and Improvement of Bluefields Water Supply Systems: construction of dams, pump stations, treatment plants, conduction and distribution pipelines

12) Increasing Water Sources: drilling of 40 wells per year

13) IV Stage Managua Water System Expansion and Improvement Plan: drilling of 47 wells, construction of 50 km conduction pipeline, 6 storage tanks, 2 pump stations, and improvement of distribution pipeline

14) Managua Sewerage Master Plan: construction of 170 km of sewer network, 6 pump stations, sewage treatment

plants, 9.2 km of secondary pipeline and 3 km of impulsion pipeline

International aid, which has been increasing in the past few years, is essential for the implementation of the above projects. Bilateral assistance has been forthcoming from such countries as Canada, Italy, France, Switzerland and Japan. The types of assistance from these countries range from studies to donation of equipments and project implementation.

On the other hand, multilateral assistance to Nicaragua has been resumed after having been cut off during the first half of the past decade. A case in point is assistance from the Inter-American Development Bank (IDB). As a matter of fact, on February 27 and April 7 of 1992, INAA signed a loan agreement with the IDB for up to US$53.5 million, which together with US$5.0 million from OPEC and US$5.7 million of Nicaraguan funds, make up a US$64.2 million project. The President of IDB, during his official visit to Nicaragua in June 1992, formally pledged the IDB commitment to this project, which is now in the implementation stage.

Table 2.2.1 Selected Economic Indicators

Item	Unit	1988	1989	1990
Population				
Total	1000 Persons	3,621.6	3,746.5	3,858.9
Economically Active	"	1,168.0	1,276.9	1,331.2
Gross Domestic Product				
Total	Mill.1980 C$	17,936.2	17,433.5	16,666.9
Primary Sector	"	4,092.8	4,203.6	4,060.0
Secondary Sector	"	4,762.8	4,420.9	4,208.2
Tertiary Sector	"	9,080.6	8,809.0	8,398.7
Per Capita	1980 C$	4,952.6	4,653.3	4,319.1
Exports	Million US $	235.7	290.1	321.3
Imports	"	807.1	614.3	664.7
International Reserves	"	75.0	83.6	102.6

Source: Informe Anual 1990, BCN, Managua, 1991

Table 2.2.2 Population and Employment

Item	Unit	1988	1989	1990
Total Population	1000 Persons	3,621.6	3,746.5	3,858.9
Economically Active Popula.	"	1,168.0	1,276.9	1,331.2
Employment	"	864.0	1,169.8	1,171.2
Primary Sector	"	358.5	387.5	387.5
Secondary Sector	"	113.8	229.5	229.5
Manufacturing	"	90.3	188.7	188.7
Construction	"	20.2	31.2	31.2
Mining	"	3.3	9.6	9.6
Tertiary Sector	"	391.7	552.8	554.2
Commerce	"	99.3	182.3	182.3
Central Government	"	81.7	71.3	72.7
Transport & Communic.	"	22.8	42.6	42.6
Finance	"	16.4	24.7	24.7
Electricity & Water	"	8.5	10.3	10.3
Service	"	163.0	221.6	221.6
Open Unemployment	"	304.0	107.1	160.0
Under-employment	"	-	509.0	599.6
Rate of Open Unemployment	"	26.0	8.4	12.0
Rate of Under-employment	"	-	39.9	45.0

Source: Informe Anual 1990, BCN, Managua, 1991

Table 2.2.3 Agricultural Production

Crop Type	Area (1,000 Mz)			Production (1,000 cwt)		
	1988	1989	1990	1988	1989	1990
Export Mkt.	230.8	275.3	299.2	n.a	n.a	n.a
Coffee	102.1	105.0	106.0	944.5	932.2	837.4
Cotton	57.6	49.0	64.1			
Fiber				567.1	490.0	641.0
Seed				935.7	808.5	899.0
Sesame	13.8	45.0	51.2	71.9	315.0	456.1
Sugar cane	46.4	56.3	65.6			
Cane				38,500.6	47,832.5	65,600.0
Sugar				3,850.0	4,360.6	5,469.3
Banana	3.2	3.2	3.2	4,990.0	5,290.6	5,681.3
Tobacco	1.8	1.7	2.0	35.9	45.1	53.9
Peanuts	2.0	6.5	7.1	76.3	260.0	248.0
Soybeans	3.9	8.6	-	96.5	195.2	-
Domestic Mkt.	627.2	606.8	471.0	n.a	n.a	n.a
Rice	55.3	58.0	53.6	1,402.0	1,493.6	1,579.6
Irrigated	-	22.0	26.9	-	743.8	968.6
Non-irrig	-	36.0	26.7	-	748.8	611.0
Corn	315.7	326.4	223.3	6,471.9	6,364.8	3,629.6
Beans	156.8	150.9	130.0	1,332.8	1,360.2	1,209.0
Sorghum	99.4	71.5	64.1	2,244.9	1,697.1	1,844.0
Total	858.0	882.1	770.2	n.a	n.a	n.a

Source: Informe Anual 1990, BCN, Managua, 1991

Table 2.2.4 Fishery Production

Item	Unit	1988	1989	1990
Shrimp				
Catch volume	1,000 lb	2,137.2	2,100.4	1,349.8
Export volume	1,000 lb	1,621.0	1,769.1	1,438.3
Export value	1,000 US$	5,689.5	5,156.4	4,137.7
Lobster				
Catch volume	1,000 lb	467.4	908.0	562.6
Export volume	1,000 lb	388.3	850.8	483.8
Export value	1,000 US$	3,650.6	6,708.7	4,572.8
Fish				
Catch volume	1,000 lb	735.7	2,520.7	1,176.1
Export volume	1,000 lb	167.9	625.0	192.0
Export value	1,000 US$	177.9	474.6	116.2
Total				
Catch volume	1,000 lb	3,340.3	5,529.1	3,088.5
Export volume	1,000 lb	2,177.2	3,244.9	2,114.1
Export value	1,000 US$	9,518.0	12,339.7	8,826.7

Source: Informe Anual 1990, BCN, Managua, 1991

Table 2.2.5 Manufacturing: Value-based Structure
Unit: % of Production Value

Manufacturing Activity	1988	1989	1990
Foodstuff	21.275	19.807	20.245
Beverage	10.44	11.754	13.123
Tobacco	8.314	8.782	8.083
Textiles	6.049	7.182	6.010
Clothing	1.582	0.917	0.385
Leather	0.965	1.616	1.502
Footwear	1.745	1.588	1.099
Furniture	0.715	0.422	0.522
Paper & Paper Products	2.064	2.302	2.183
Printing	2.224	2.168	1.917
Chemicals	13.181	18.417	17.856
Rubber	0.34	0.410	0.517
Non-metallic Minerals	8.153	7.597	7.713
Metal Products	15.988	10.665	10.255
Appliances	1.744	1.126	1.857
Transportation	0.324	0.202	0.120
Miscellaneous	4.898	5.045	6.613
Total	100.000	100.000	100.000

Source: Informe Anual 1990, BCN, Managua, 1991

Table 2.2.6 Main Export Products Unit: 1.000 US $

Export Product	1988	1989	1990
Traditional	201,408	233,338	260.322
Coffee	84,582	89,648	67,607
Cotton	53,067	27,892	36,597
Sugar	5,421	17,190	34,611
Beef	19,320	40,645	64,598
Seafood	8,547	12,009	9,838
Banana	14,681	20,968	23,037
Sesame	2,380	3,189	8,342
Gold	13,271	20,846	14,265
Silver	139	237	202
Non-traditional	34,337	56,783	61,010
Agricultural	3,685	10,738	12,053
Manufacturing	30,652	46,000	48,957
Total	235,746	290,121	321,332

Source: Informe Anual 1990, BCN, Managua, 1991.

Table 2.2.7 Main Imports Products Unit: 1,000 US$

Imports Products	1988	1989	1990
Consumption Goods	133,889	107,777	187,488
Non-durables	107,111	90,157	154,508
Durables	26,778	17,620	32,980
Petroleum	121,000	94,285	128,472
Crude Oil	73,540	80,803	109,028
Fuel & Lubricants	47,460	13,482	19,444
Intermediates Goods	284,905	212,763	160,277
Agriculture	100,101	64,915	24,715
Manufacturing	162,063	125,046	108,772
Construction	22,741	22,802	26,790
Capital Goods	259,797	199,870	188,420
Agriculture	34,605	12,132	12,047
Manufacturing	113,692	95,029	79,306
Construction	111,500	92,709	97,067
Miscellaneous	7,547	20	4
Total	807,139	614,716	664,661

Source: Informe Anual 1990, BCN, Managua, 1991 .

Table 2.2.8 Foreign Debt Outstanding Unit: 1,000 US$

Item	1988	1989	1990
Debt Holder A) Medium & Long-Term Debt	6,773,124.0	7,543,908.4	8,064,095.0
Central Government	4,879,959.1	5,249,402.4	5,680,143.3
C. Bank of Nic.	1,537,175.5	1,905,268.0	1,970,528.5
Rest of Financial System	143,927.9	143,233.6	147,692.9
Rest of Public Sector	212,061.5	246,004.4	265,730.3
B) Short-term	447,005.9	524,687.5	588,610.2
Total	7,220,129.9	8,068,595.9	8,652,705.2
Creditors A) Medium Long-Term Debt	6,773,124.0	7,543,908.4	8,064,095.0
Goverment Organizations	4,489,444.5	5,153,807.1	5,586,871.0
Multilateral Organizations	880,805.1	975,697.3	1,045,044.0
Commercial Banks	1,304,535.1	1,306,392.7	1,306,046.3
Supplies & Others	98,339.3	108,011.3	126,133.7
B) Short-term	447,005.9	524,687.5	588,610.2
Total	7,220,129.9	8,068,595.9	8,652,705.2

Source: Informe Anual 1990, BCN, Managua,1991.

Table 2.2.9 Central Government Finances

Item	Million Córdobas "Oro"			Percentage		
	1988	1989	1990	1988	1989	1990
Total Income	285.1	200.0	236.3	100.00	100.00	100.00
Current Inc.	281.5	199.7	236.3	98.74	99.85	100.00
Tax	266.9	188.7	212.8	93.62	94.35	90.06
Non-tax	10.5	4.1	6.6	3.68	2.05	2.79
1-Current Transfer from S.S	3.0	0.1	2.9	1.05	0.05	1.23
Other Tranfers	1.1	6.8	14.0	0.39	3.40	5.92
From P.Utilit.	0.0	4.5	6.9	0.00	2.25	2.92
From Others	1.1	2.3	7.1	0.39	1.15	3.00
Capital Income	3.6	0.3	0.0	1.26	0.15	0.00
TOTAL EXPENSES	644.8	230.3	552.1	100.00	100.00	100.00
Current Expens	594.5	213.6	526.0	92.20	92.75	95.27
Salaries/Wages	89.6	31.4	115.3	13.90	13.63	20.88
Goods/Servs.	438.5	165.3	340.0	68.01	71.78	61.58
Interests	0.4	0.0	0.0	0.06	0.00	0.00
Current Tranf.	66.0	16.9	70.6	10.24	7.34	12.79
To Govt.	5.2	3.6	20.3	0.81	1.56	3.68
To P.Utilities	4.9	0.1	4.3	0.76	0.04	0.78
To Others	55.9	13.2	46.0	8.67	5.73	8.33
C. Expenses	30.9	12.0	17.5	4.79	5.21	3.17
C. Transfer	9.3	4.6	8.5	2.99	2.00	1.54
To Govt	0.0	0.0	0.0	0.00	0.00	0.00
To P.Utilities	0.5	0.3	6.3	0.08	0.13	1.14
To Others	18.8	4.3	2.2	2.92	1.87	0.40
Loaned out	0.0	0.0	0.0	0.00	0.00	0.00
Current Account Defic.	313.0	14.0	289.8	na	na	na
Total Deficit W/O Donations	359.7	30.3	315.8	na	na	na
Donations	5.3	22.6	22.6	0.82	9.81	4.09

Source: Informe Anual 1990, BCN, Managua, 1991
(1) SS-Social Security; P-Public.

Table 2.2.10 CENTRAL GOVERNMENT INCOME

Item	Million Córdobas Oro			Percentage		
	1988	1989	1990	1988	1989	1990
TOTAL INCOME	285.1	200.0	236.3	100.00	100.00	100.00
CURRENT INCOME	281.5	199.7	236.3	98.74	99.85	100.00
TAX INCOME	266.9	188.7	212.8	93.62	94.35	90.06
Direct Tax	59.2	43.9	57.2	20.76	21.95	24.21
Income Tax	54.8	40.6	45.9	19.22	20.30	19.42
Property Tax	2.7	2.1	8.7	0.95	1.05	3.68
Real Estate Tax	0.8	0.4	1.0	0.28	0.20	0.42
Net Assets Tax	1.0	1.4	7.2	0.35	0.70	3.05
Motor Vehicules Tax	0.8	0.0	0.0	0.28	0.00	0.00
Others	1.8	1.2	2.7	0.63	0.60	1.14
Income & Property Surtax	1.8	1.2	2.7	0.63	0.60	1.14
On Goods & Services	174.6	113.7	115.9	61.24	56.85	49.05
Sales Tax	35.2	21.0	26.9	12.35	10.50	11.38
Consumption Tax	132.1	86.6	80.3	46.33	43.30	33.98
Petroleum	20.6	37.7	29.5	7.23	18.85	12.48
Beer & Alcohol	49.4	20.6	20.1	17.33	10.30	8.51
Tobacco	18.5	7.6	6.0	6.49	3.80	2.54
Others	43.6	20.6	24.7	15.29	10.30	10.45
Stamps	7.2	6.2	8.6	2.53	3.10	3.64
International Trade	22.1	19.5	32.5	7.75	9.75	13.75
Import Tax	22.0	19.4	32.4	7.72	9.70	13.71
Export Tax	0.1	0.1	0.1	0.04	0.05	0.04
Specific Tax	11.0	11.5	7.2	3.86	5.75	3.05
Managua City Govt. Tax	10.3	11.1	7.0	3.61	5.55	2.96
Other Specific Taxes	0.7	0.5	0.2	0.25	0.25	0.08
NON TAX INCOME	14.6	11.0	23.5	5.12	5.50	9.95
(1) Transfer (S.S., Lothery, Post)	4.1	6.9	16.9	1.44	3.45	7.15
Other Non -Tax Income	10.5	4.1	6.6	3.68	2.05	2.79
CAPITAL INCOME	3.6	0.3	0.0	1.26	0.15	0.00
TOTAL INCOME PLUS DONATION	290.4	222.5	258.9	101.86	111.25	109.56

Table 2.3.1 HOUSING & BASIC SERVICES IN 1985

Item	Nicaragua			Región III			Managua Dept.		
	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural
Dwellings (Number	507,984	270,133	237,851	149,857	127,081	22,775	146,012	126,297	19,715
Households (NUmber)	533,446	289,253	244,193	159,981	136,462	23,518	155,966	135,558	20,407
Residents									
Per Dwelling	6.5	6.5	6.5	6.3	6.3	6.3	6.3	6.3	6.4
Per Household	6.2	6.0	6.3	5.9	5.8	6.1	5.9	5.8	6.2
Dwellings with Water Supply									
Public System	249,367	212,287	37,080	102,472	94,244	8,229	100,043	93,506	6,536
Standpost	44,299	29,091	15,209	28,811	25,510	3,371	27,976	25,510	2,466
Wells	102,487	13,200	89,287	6,558	1,546	5,012	6,406	1,546	4,860
Others	111,831	15,555	96,276	11,945	5,781	6,164	11,586	5,734	5,852
Dwellings and toilet Facilities									
W.C.	264,875	149,656	115,219	69,700	54,555	15,215	66,829	53,937	12,892
Letrine	115,597	109,847	5,750	69,681	68,111	1,570	69,032	67,944	1,087
Nothing	127,512	10,630	116,882	10,405	4,415	5,990	10,151	4,415	5,736
Dwelling with Electricity	319,607	249,325	70,282	131,286	120,387	10,900	128,861	119,602	9,259

Source: ESDENIC 85, Vol. IV, UN/INEC, Managua, 1989

Table 2.5.1 POPULATION WITH WATER SERVICE BY MACRO-REGION IN 1989

Country & Macro-Regions (1)	Region (2)	Population (3)	Population with Water service					
			Total (4)	% (4/3)	House Connection (5)	% (5/3)	Public Standpost	% (6/3)
TOTAL								
Nicaragua	I II	3,807,925	2,024,111	53	1,503,311	39	520,800	14
Pacific	II, III, IV	2,340,814	1,561,356	67	1,214,406	52	346,950	15
Central	I, V, VI	1,247,898	431,682	35	259,932	21	171,750	14
Atlantic	VII, VIII, IX	219,213	31,073	14	28,973	13	2,100	1
URBAN								
Nicaragua	I IX	2,217,895	1,730,082	78	1,413,882	14	316,200	14
Pacific	II, III, IV	1,694,323	1,428,258	84	1,164,258	69	264,000	15
Central	I, V, VI	412,357	284,820	69	234,720	57	50,100	12
Atlantic	VII, VIII, IX	111,215	17,004	15	14,904	13	2,100	2
RURAL								
Nicaragua	I IX	1,590,030	294,029	18	89,429	5	204,600	13
Pacific	II, III, IV	646,491	133,098	21	50,148	8	82,950	13
Central	I, V, VI	835,541	146,862	18	25,212	3	121,650	15
Atlantic	VII, VIII, IX	107,998	14,069	13	14,069	13	-	-

SOURCE: Informe Sectorial Sector de abastecimiento de Agua y Saneamiento, INAA/OPS/OMS, 1990

Table 2.5.2 POPULATION WITH WATER & SEWER SERVICE BY REGION 1987

Country & Regions (1)	TOTAL (2)	%	URBAN (3)	%	RURAL (4)	%
Total Population						
Nicaragua	3,501,176	100	2,058,223	100	1,442,953	100
I	343,261	100	139,539	100	203,722	100
II	608,543	100	355,402	100	253,141	100
III	949,920	100	835,800	100	114,120	100
IV	624,973	100	397,935	100	227,038	100
V	321,972	100	98,750	100	223,222	100
VI	440,298	100	124,849	100	315,449	100
VII	114,250	100	45,700	100	68,550	100
VIII	58,553	100	46,842	100	11,711	100
IX	39,406	100	13,406	100	26,000	100
With Water Service						
Nicaragua	1,834,720	52	1,581,087	77	253,633	18
I	158,080	46	108,000	77	50,080	25
II	232,553	38	214,302	60	18,251	7
III	836,325	88	819,165	98	17,160	15
IV	361,949	58	273,198	69	88,751	39
V	84,147	26	64,536	65	19,611	9
VI	131,043	30	85,332	68	45,711	14
VII	8,808	8	8,808	19	n.a	n.a
VIII	2,589	4	1,722	4	867	7
IX	19,226	49	6,024	45	13,202	51
With Sewer Service						
Nicaragua	673,624	19	673,624	33	n.a	n.a
I	27,936	8	27,936	20	n.a	n.a
II	84,336	14	84,336	24	n.a	n.a
III	512,302	54	512,302	61	n.a	n.a
IV	48,120	8	48,120	12	n.a	n.a
V	930	-	930	1	n.a	n.a

SOURCE: Informe Sectorial Sector de ABastecimiento de Agua y Saneamiento, INAA/OPS/OMS, 1990

Table 2.5.3 INAA BALANCE SHEET: ASSETS

ASSETS	1991	1990
PROPERTIES & EQUIPMENTS		
Water Supply	71,090,922	1,465,033
Sewerage	1,655,850	393,442
General-Use Property	198,840,833	1,665,747
	271,587,605	3,524,222
Accumulated depreciation	148,120,898	1,171,432
	123,466,707	2,352,790
Construction in Progress	19,556,050	1,883,853
TOTAL PROPERTIES & EQUIPMENTS	143,022,757	4,236,643
CURRENT ASSETS		
Cash & Banks	23,181,873	5,595,097
Accounts Receivable		
Water Supply	42,829,553	6,668,336
Sewerage	2,916,685	1,485,299
Service Receivables	45,746,238	8,153,635
Other Receivables	12,610,023	2,587,292
Total Receivables	58,356,261	10,740,927
Estimated Bad Accounts	2,014,739	278,718
Net Receivables	56,341,522	10,462,209
Inventory		
Materials & Supplies	23,812,016	1,357,741
Materials in Transit	2,384,149	675,259
Total Inventory	26,196,165	2,033,000
Obsolescence Allowance	175,814	-
Net Inventory	26,020,351	2,033,000
TOTAL CURRENT ASSETS	105,543,746	18,090,306
OTHER ASSETS	363,253	2,863,411
TOTAL ASSETS	248,929,756	25,190,360

SOURCE: INAA Annual Financial Reports 1990 & 1991

Table 2.5.4 INAA Balance Sheet : Liabilities

Liabilities	1991	1990
CAPITAL		
Goverment Contribution		
Initial Contribution	10,256,770	2,772,100
Subsidies	136,369,680	2,156,697
Revaluation of Assets	106,014,160	2,666,856
Donations	12,675,280	861,143
Accumulated Loses	(24,170,448)	(7,140,193)
Net Capital	241,145,442	1,316,603
Deposit from Consumers	4,182,688	54,519
Long-Term Debt	-	9,528,795
Current Liabilities		
Current Portion of Long Term Debt	-	8,110,003
Account Payable	3,232,988	1,163,104
Other Liabilities	368,638	565,336
Accumulated Interests	-	4,452,000
Total Current Liabilities	3,601,626	14,290,443
Total Liabilities	248,929,756	25,190,360

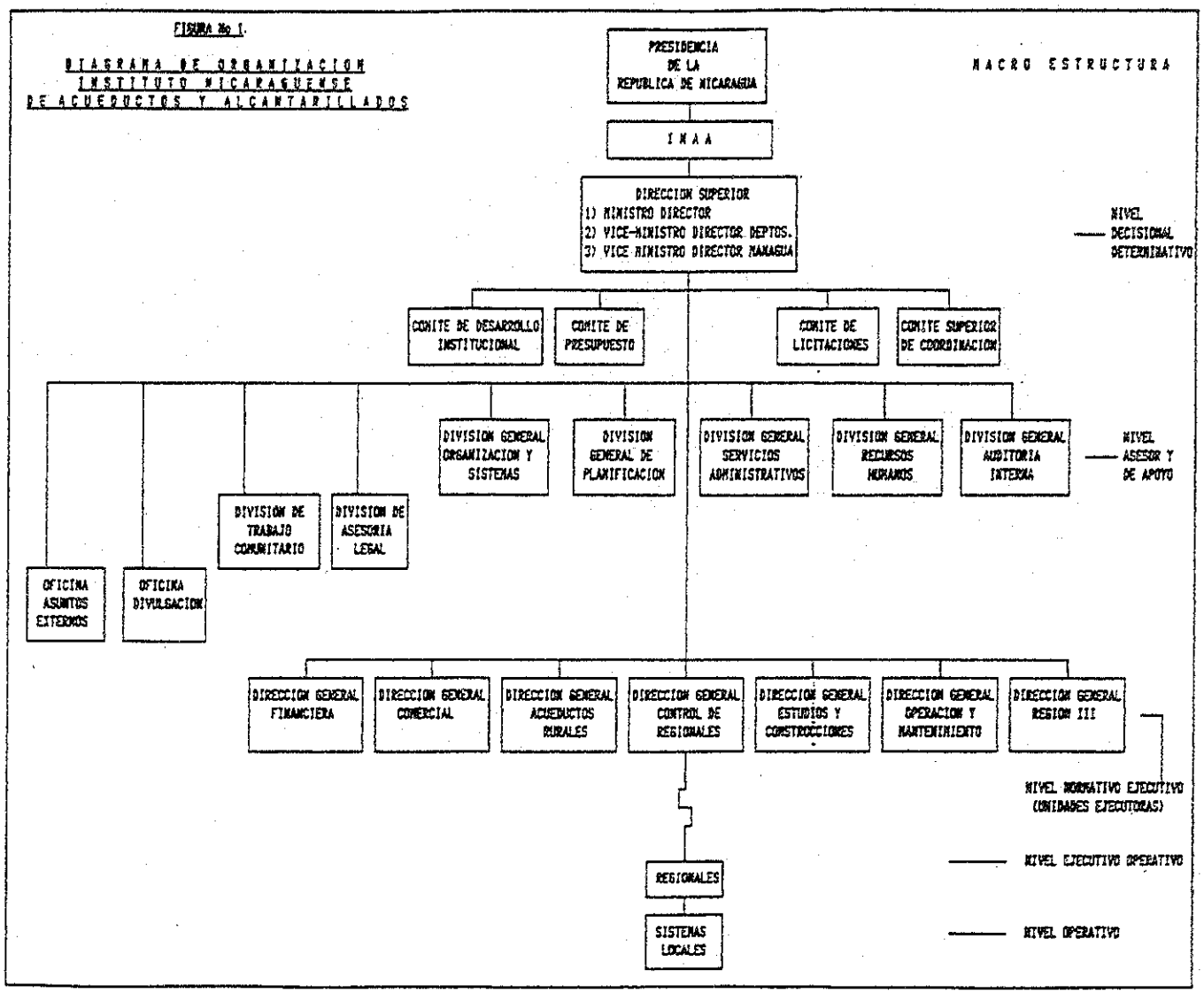
Source : INAA Annual Financial Reports 1990,1991.

Table 2.5.5 INAA INCOME STATEMENT

	1991	1990
REVENUES		
Water Supply	107,689,217	23,283,632
Sewerage	26,108,930	4,197,661
Service and Reconnection Fee	11,291,484	233,920
Service Revenues	145,089,631	27,815,213
Discounts	2,825,759	665,449
Net Revenues	142,263,872	27,149,764
Other Revenues	-	-
TOTAL REVENUES	142,263,872	27,549,478
OPERATING & GENERAL EXPENSES		
OPERATION		
O & M	44,653,004	4,985,300
Depreciation	2,874,083	282,181
General		
Registration & Collection	7,188,040	1,032,171
Transport & Workshop	1,298,071	535,952
Administrative	13,550,315	1,460,082
Other Expenses	-	309,207
	22,036,426	3,337,412
TOTAL OPERATING & GENERAL EXPENSES	69,563,513	8,604,893
Earning before interests	72,700,359	18,944,585
INTERESTS ON LONG-TERM DEBT	9,407,841	716,351
Operating Profit	63,292,518	18,228,234
OTHER EXPENSES	898,619	-
Profits before Exchange rate Adjustment	62,393,899	-
EXCHANGE RATE ADJUSTMENT	(60,145,633)	(23,254,873)
Net Profit	2,248,266	(5,026,639)

SOURCE: INAA Annual Financial Reports 1990 & 1991

Fig. 2.5.1 Organization Chart of INAA



CHAPTER 3 WATER SUPPLY

3.1 General

Managua City, an area of 200km^2 with a total population estimate at about 1.2 million, has a total water production of about 268,000m^3 per day (71MGD) as of 1991. The daily average supply quantity per head is about 230 l/c/d (61 g/c/d), and the actual average consumption rate is about 170 l/c/d (44.6 g/c/d).

It can be said that the area is entirely dependent on groundwater as its water supply source, because even though about one fourth of the total production originates from the Asososca crater lake. This lake is recharged mostly by groundwater. The remaining three fourths of the production is pumped up from 65 boreholes wells located within the city area. (Over 90 wells have been drilled in the city area, of which some are abandoned and some are under rehabilitation.) The quality of water both from the Asososca crater lake and the borehole wells is fairly good, so that the pumped up water is distributed without any treatment other than chlorination. Pumping from Asososca has recently been controlled for fear that the contaminated water of Lake Managua would intrude if the level of Asososca is excessively lowered by overpumping.

As a result of a rapidly increasing population, development of water source has not caught up with the demand. The absolute shortage of the supply resulted in a 2-day-a-week water suspension in every zone. The development of a new source is, therefore, a very urgent matter. Some of the facilities damaged in the 1972 earthquake or the superannuated distribution facilities contribute to a loss amounting to nearly one fourth of the total production. A big portion (53.5% of the total production) of unpaid water in 1991 was also a big problem. It was, however, drastically improved in 1992 to lower the unpaid portion to 14% of the effective water.

3.2 Service area and population

The water supply system of Managua city covers the entire city area, supplying domestic water to a total population of about 1,164,000. The supply area comprises seven (7) Districts

amount which District 1 is the major independent supply area and District 2 to 7 are divided into stepwise zones by elevation. The urban water supply service covers District 1 to 6, while District 7, which is a mountainous area, is left at the semi-urban service level as it is difficult to extend pipelines to mountainous area. The situation of the 'Districts' and 'Zones is shown in Fig. 3.1.

The population of every supply district has been estimated from the latest CSE (Supreme Electoral Council of Managua City) data prepared in 1991. The estimated population by District/Zone is shown in Table 3.1.

3.3 Water source and pumping amount

The sources of water supply in Managua City in 1992 are Asososca Crater Lake and 65 functioning borehole wells among the so far drilled number of over 90 wells within the City Area. The pumping rate in 1991 was about 65,700 m^3/day (17.36 MGD) on the average, nearly one fourth of the total water production. In 1992, the pumping rate from Asososca was reduced to about 380,000 m^3/d (10.06 MGD), which is less than 15% of the total production.

The total daily production from the 65 wells in Managua in 1991 was about 202,800 m^3/day (53,577 MGD) on average. Fig. 3.2 presents the location of the wells and Fig. 3.3 shows the existing water supply system.

The average daily production from all sources in Managua as of 1991 totals 268,525 m^3/day (70,937 MGD), and the production from each source is shown in Table 3.2.

Instead of reducing production from Asososca, an increase of production from borehole wells was observed in 1992, and the total production in 1992 was almost the same as in 1991.

3.4 Water supply quantity by zone

The raw water pumped up from the Asososca Lake and the borehole wells is transmitted to the reservoir tanks and of the total production of 268,500 m^3/day (70.937 MGD), the amount supplied to every zone is shown in Table 3.2 and summarized

below.

To Low Zone:	103,095 m^3/day	(27.235 MGD)	287 l/c/d
To High Zone:	84,668 m^3/day	(22.367 MGD)	233 l/c/d
To Highest Zone:	65,306 m^3/day	(17.252 MGD)	184 l/c/d
To Independent Zone:	15,456 m^3/day	(4.083 MGD)	178 l/c/d

The amount to every zone is also shown in Fig. 3.3 which schematically presents the water flow of the Managua water supply system. The average supply quantity per head for the whole of Managua is about 230 l/c/d(60.7 g/c/d), varying by zone from 287 l/c/d (largest) in the low zone to about 180 l/c/d (smallest) in the Highest zone and Independent zones.

3.5 Actual water consumption and leakage

In order to formulate the plan of water supply, the actual domestic consumption rate was studied by 2 methods. One is the estimation from the water charge collection data of 1991, and the rate estimated was 170 l/c/day. The other is by the actual measurement of the water meter reading of 28 houses for 3 days. The average rate of middle class homes was 174 l/c/day.

Therefore, 45 galleon (170 liters) was determined as the rate of the daily average consumption per head.

The ineffectively used water, that is, leakage, was estimated from the water charge collection data, and was observed to cover 27.0% of what was estimated to be totally produced.

3.6 Consumption classified by type of use

According to one of the water charge collection data shown in Table 3.5, water use is categorized into the following 4 purposes with the respective share in total consumption volume.

1.	Domestic use (House connection)	80.0%
	(Communal faucet)	2.9%
2.	Government/Municipal use	10.9%
3.	Commercial use	5.8%
4.	Industrial use	0.5%

3.7 Paid for and unpaid for water

According to the water collection data of 1991, the portion of paid for water was 46.3%, which corresponds to 33.88 MGD among total production of 70.97 MGD. Whereas the effectively used water was estimated at 73.3% (52 MGD) of the total production, the portion of paid for water in 1991 was about 65% of effectively used water. The percentage of paid for water has increased up to 86% in 1992; 45 MGD was paid for out of a total production of about 71 MGD.

3.8 Distribution and water service facilities

The distribution facilities in the Managua water supply system comprise 54 distribution reservoirs, 96 well pumps and 21 relay pumps and about 1500 km in total length of distribution piplelines. The reservoir tanks are made of concrete and steel plate with a volume totaling 84,700 m^3 (22.38 MG). The distribution pipes are of cast iron (11.6 inches in diameter and bigger), or asbestos cement (2 to 12 inches in diameter). About 5,000 of the control valves (sluice/gate valves) are attached to the distribution pipleline, and the operators manually control the valves for distribution or suspension. Some of the above facilities have been superannuated, and rehabilitation works are considered an urgent necessity.

3.9 Pumping rate of the well

Some of the wells are directly connected to the distribution pipeline without passing the reservoir. Due to the heavy load of the well pump, specially in the night time, tbe pump efficiency seems to have been lowered. In order to confirm the pumping rate of the wells, the flow rate of 24 boreholes were measured for 1 week. Figure 3.5 indicates that the pressure is higher in the night time than in day time, which means pumping rate is smaller in the night even though pumps are constantly operated.

3.10 Function of the reservoir tank

Concerning with the functioning on the hourly peak control by the reservoir tanks, the water level of the 3 major reservoir tanks were checked 2 times by reading the water level of the tanks and by picking up the consecutive 1 week record from the monthly records. The water level variation graphs are shown in Fig. 3.5 and the finding on the graphs are as follows:

	1 week record in June, 1992	1 week record in February 1993
Altamira Reservoir	Very queer variation of water level, probably due to the complicated valve control. Difficult to analyze the in-flow and out-flow of the tank	Similar to left
Santo Domingo Reservoir		Essential functioning has been recovered, but the shortage of the tank capacity is obvious.
Las Americas No. 4 reservoir	Water level is constant, which mens no essential functioning as the reservoir	Same as above.

The variation graph on Las Americas No. 4 reservoir shows the ideal curve in day-night variation, but regardless with the alternating water suspension by area, the tank becomes empty frequently, indicating the shortage of the tank capacity.

3.11 Operation and maintenance

The Operation and Maintenance Division of INAA has 18 special engineers and 800 operators, and 4 workshop for maintenance, plus 1 laboratory for water quality control.

The total operation and maintenance cost as of 1992 was 28,771,000 Cordoba (about USD 6.46 million), in which the share of electricity is particularly high, as shown in the following breakdown.

Electricity	21,600,000	Cordoba	56%
Maintenance/repair	11,238,000		28
Salary/wages	4,944,000		12
Fuel/lubricant	476,000		2
Calories	508,000		2
Total	38,771,000		100 %

The cost of water per cubic meter in 1992 was 0.4 Cordoba. (38,771,000 Cordoba/Total production of 97,909,000 m^3 = 0.4)

3.12 Rehabilitation program

As component of the rehabilitation program of Managua water supply system, the increase of water production was planned in 1992 by the rehabilitation of the borehole wells. The plan is production increase of 9.0 MGD by rehabilitation of 11 boreholes, as shown in Table 3.5.

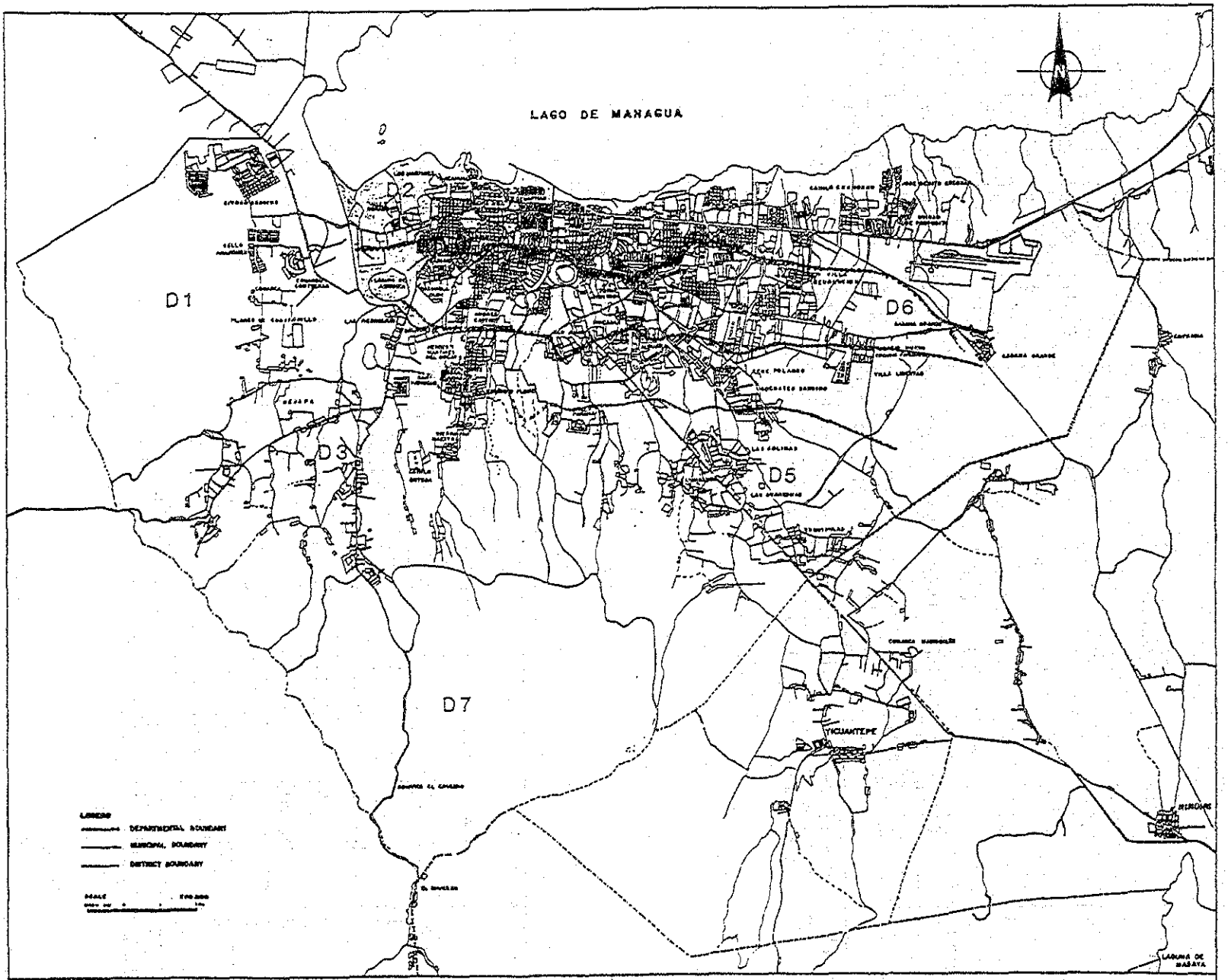
However, 8 wells out of the eleven targeted for rehabilitation are located in the over-pumping area of the Central sub-area, and therefore, the immediate implementation of this rehabilitation program is not recommendable. It is recommended to slowly implement this program, if the total pumpage from the Eastern sub-area can be kept at 50.27 MGD (over-pumping 20.16 MGD).

Table 3.1 Population estimated from CSE data, 1991

District	Low Zone		High Zone		Highest Zone		District 1		Total	
	CSE	Population	CSE	Population	CSE	Population	CSE	Population	CSE	Population
1	0	0	0	0	0	0	23,448	70,986	23,448	70,986
2	34,972	105,678	15,007	45,348	0	0	0	0	49,979	151,026
3	0	0	20,159	60,916	35,909	108,510	0	0	56,068	169,426
4	52,387	158,303	23,398	70,704	0	0	0	0	75,785	229,007
5	0	0	14,202	42,916	52,265	157,934	0	0	66,467	200,850
6	31,416	94,933	48,698	147,156	1,367	4,131	0	0	81,481	246,220
7	0	0	0	0	31,904	96,588	0	0	31,904	96,588
Total	118,775	358,914	121,464	367,040	121,445	367,163	23,448	70,986	385,132	1,164,103

CSE: Number of electorate over 16years

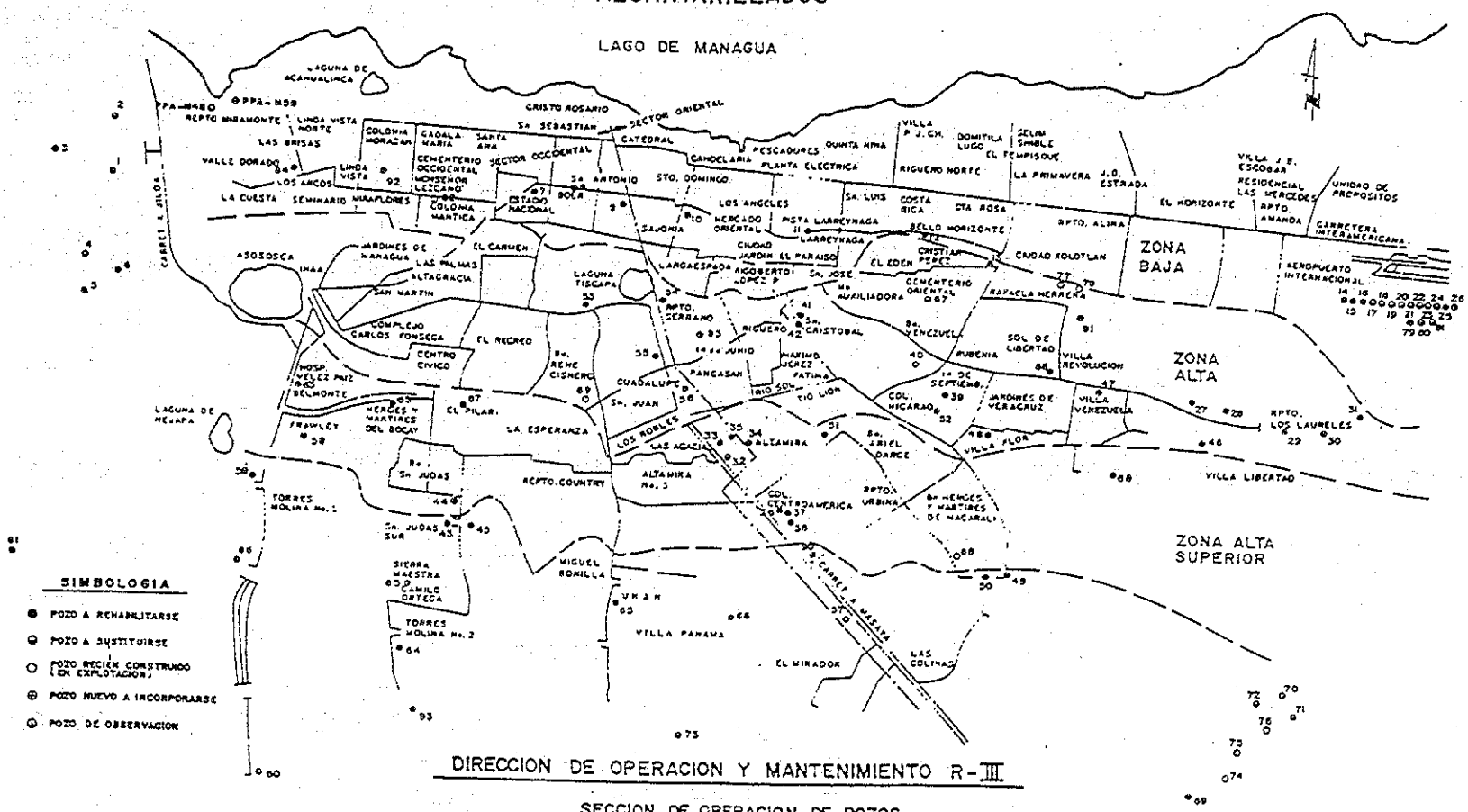
	Low Zone	High Zone	Highest Zone	High Highest Zone	Areas of Independent Supply System		Total
					District 1	Included in High and Highest Zone	
1	0	0	0	0	70,986	0	70,986
2	105,678	45,348	0	0	0	0	151,026
3	0	60,916	54,859	53,651	0	0	169,426
4	158,303	70,704	0	0	0	0	229,007
5	0	42,916	136,201	14,800	0	6,933	200,850
6	94,933	143,328	0	0	0	7,959	246,220
7	0	0	0	95,461	0	1,127	96,588
Total	358,914	363,212	191,060	163,912	70,986	16,019	1,164,103



THE STUDY ON WATER SUPPLY PROJECT IN MANAGUA

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.3.1 Divison of water supply area by District and Zone



SECCION DE OPERACION DE POZOS
Y ESTACIONES DE BOMBEOS

1	CIUDAD SANDINO No. 1	17	CARLOS FONSECA No. 1	33	ALTAMIRA No. 3	49	VILLA CUBA POZO No. 2	65	UNIVERSIDAD	81	CARLOS FONSECA No. 18
2	CIUDAD SANDINO No. 2	18	CARLOS FONSECA No. 2	34	ALTAMIRA No. 4	50	REPARTO SCHICK	66	VILLA PANAMA	82	MONSENOR LEZCANO
3	CIUDAD SANDINO No. 3	19	CARLOS FONSECA No. 3	35	ALTAMIRA No. 5	51	HOSPITAL MANOLO MORALES	67	CHRISTIAN PEREZ	83	PLAZA EL SOL
4	EDUARDO CONTRERAS No. 1	20	CARLOS FONSECA No. 4	36	CENTRO AMERICA No. 1	52	HOSPITAL LA MASCOTA	68	VILLA AUSTRIA	84	LAS BRISAS
5	EDUARDO CONTRERAS No. 2	21	CARLOS FONSECA No. 5	37	CENTRO AMERICA No. 2	53	PARQUE LAS MADRES	69	KM. 14.5 C.A MASAYA	85	SIERRA MAESTRA
6	EDUARDO CONTRERAS No. 3	22	CARLOS FONSECA No. 6	38	CENTRO AMERICA No. 3	54	LOS GAUCHOS	70	VILLA GOTBEL No. 2	86	KM. 11 C. SUR
7	EL ESTADIO	23	CARLOS FONSECA No. 7	39	NICARAO No. 1	55	GASOLINERA SHELL	71	VILLA GOTBEL No. 3	87	JULIO MARTINEZ
8	SAN ANTONNIO	24	CARLOS FONSECA No. 8	40	NICARAO No. 2	56	SANDY'S	72	VILLA GOTBEL No. 1	88	REPARTO SCHICK 3
9	BANCO AMERICA	25	CARLOS FONSECA No. 14	41	SAN CRISTOBAL No. 1	57	KM. 8 C.A MASAYA	73	SN ISIDRO DE LA C. VERDE	89	INE CENTRAL
10	MERCADE ORIENTAL	26	CARLOS FONSECA No. 15	42	SAN CRISTOBAL No. 2	58	KM. 8 C. SUR	74	VERACRUZ No. 4	90	KM. 7 C.A MASAYA
11	TENDERI	27	SABANA GURANNDE No. 1	43	SAN JUDAS No. 1	59	KM. 9.5 C. SUR	75	VERACRUZ No. 5	91	LAURIANO MAIRENA
12	CINE AMERICA	28	SABANA GURANNDE No. 2	44	SAN JUDAS No. 2	60	KM. 14.5 C. SUR	76	VERACRUZ No. 6	92	REPARTO ESPANA
13	RAFAELA HERRERA	29	SABANA GURANNDE No. 3	45	SAN JUDAS No. 3	61	KM. 14.5 C. LEON	77	VILLA FRATERNIDAD	93	PADRE FABRETTO
14	CARLOS FONSECA No. 5	30	SABANA GURANNDE No. 4	46	VILLA LIBERTAD	62	HOSPITAL YELEZ PAIZ	78	MARTIRES LEZCANO		
15	CARLOS FONSECA No. 12	31	SABANA GURANNDE No. 5	47	VILLA VENEZUELA	63	HOSPITAL BERTHA CALDERO	79	CARLOS FONSECA No. 16		
16	CARLOS FONSECA No. 13	32	ALTAMIRA No. 2	48	COL. 14 DE SEPTIEMBRE	64	TORRES MOLINA	80	CARLOS FONSECA No. 17		

Fig.3.2 Location map of the existing wells

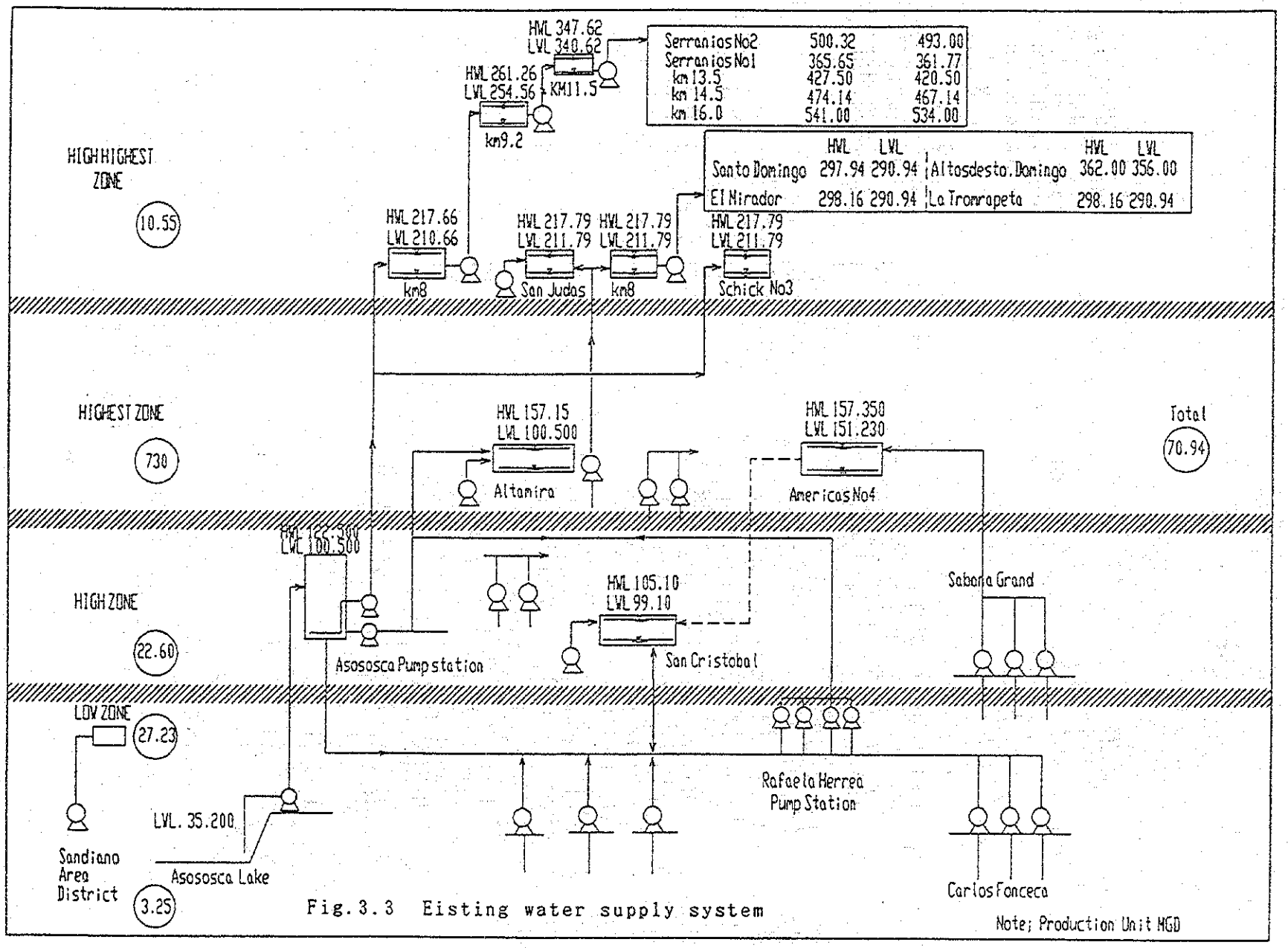


Fig. 3.3 Eisting water supply system

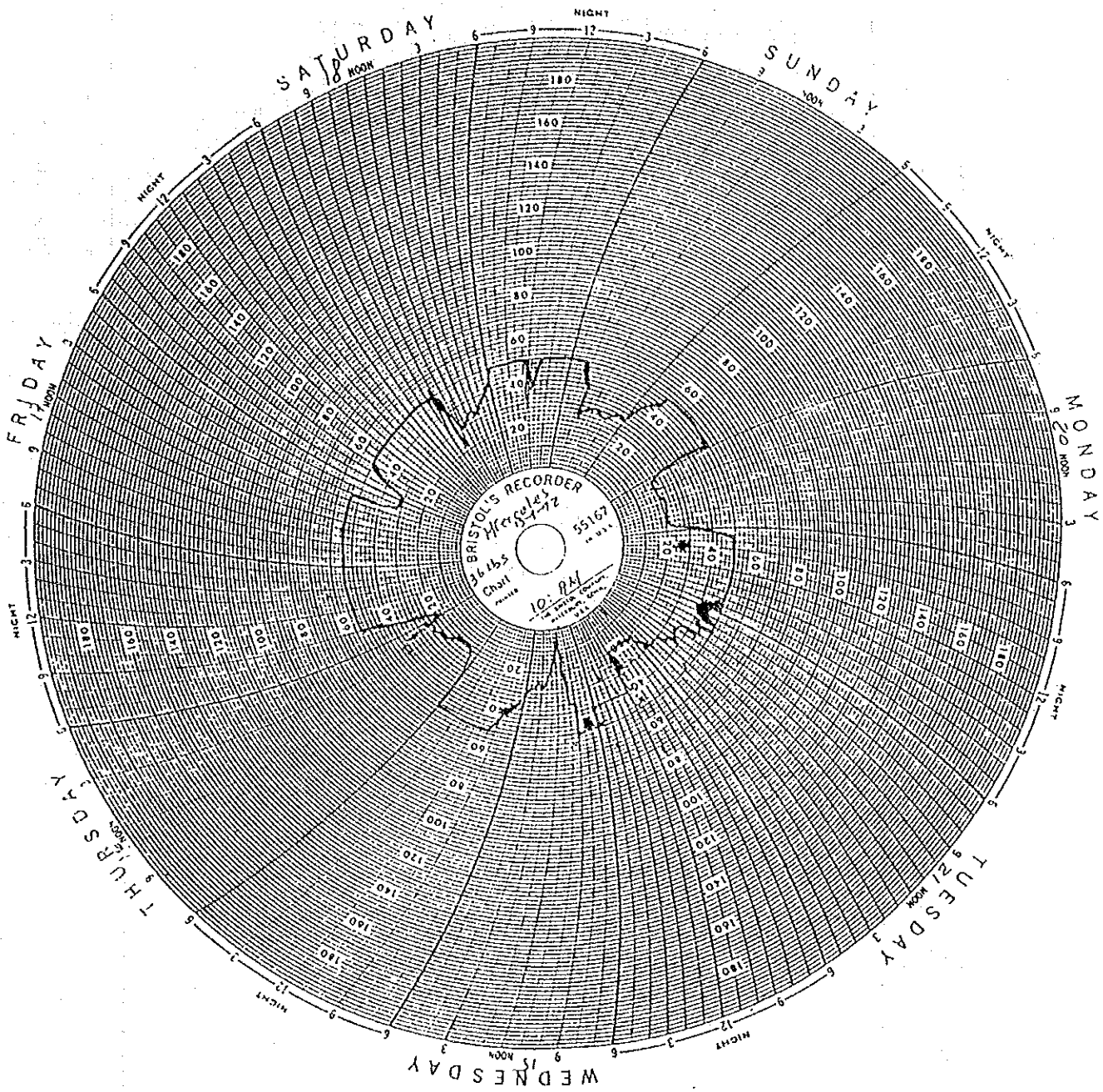
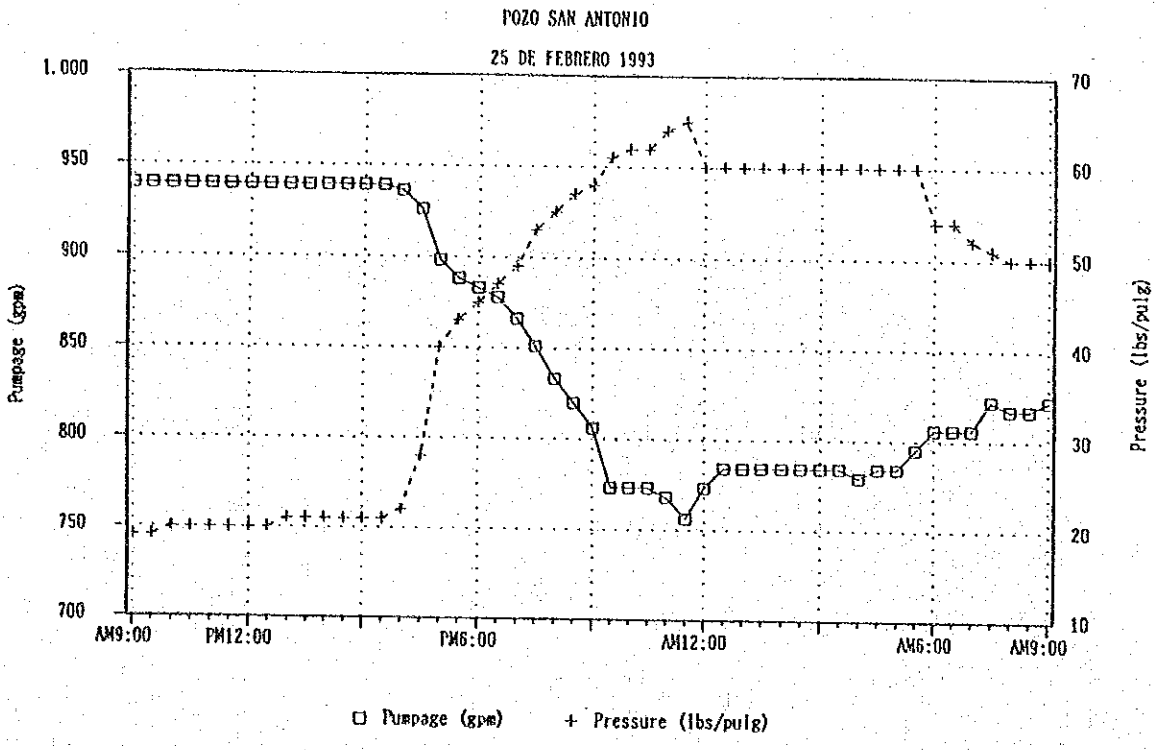


Fig.3.4.1 1week pressure measurement record of San Antonio Pump Station



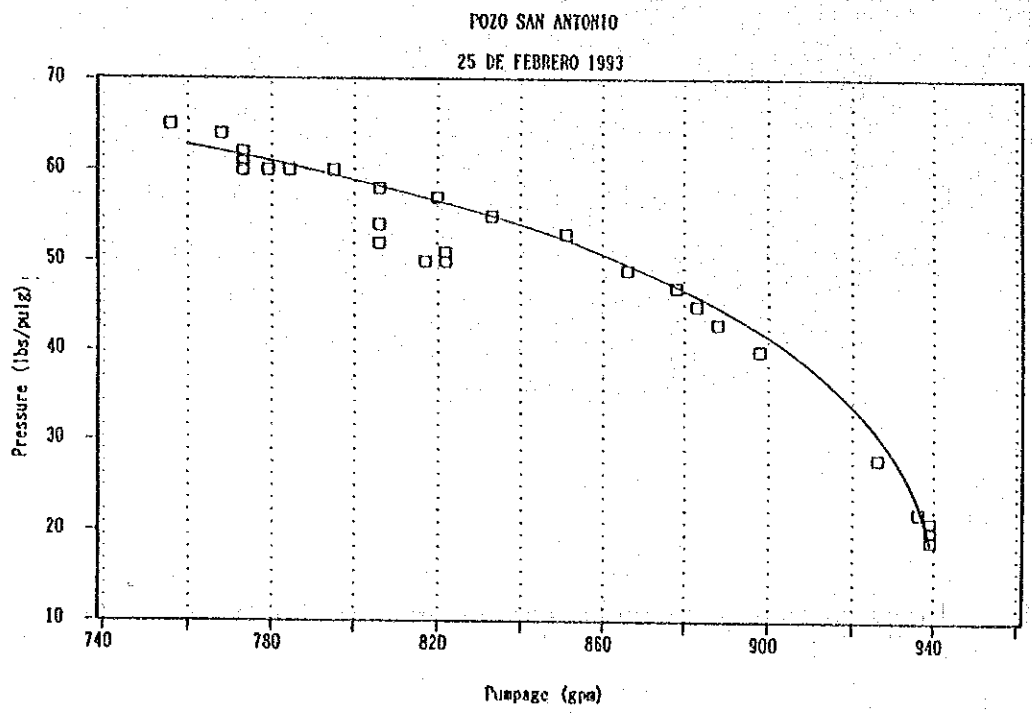
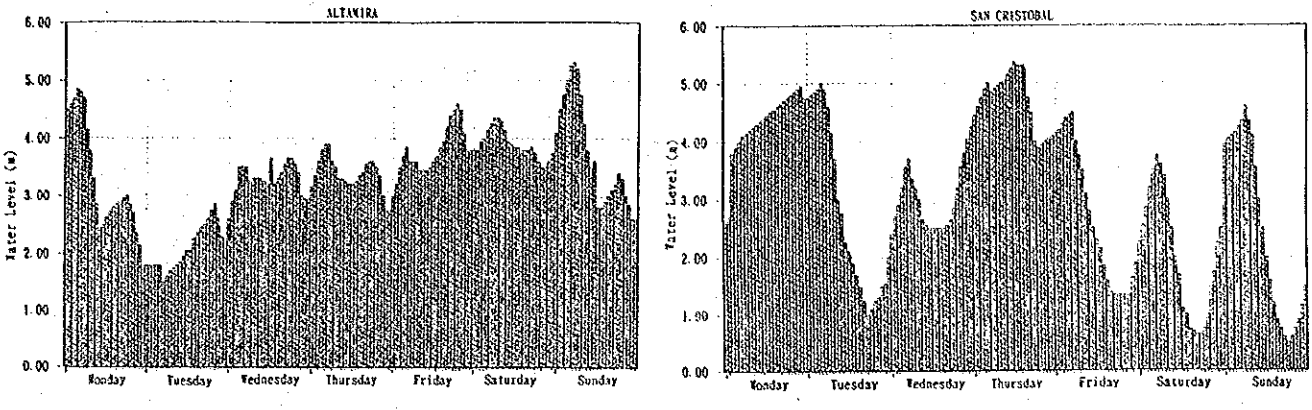


Fig.3.4.2 Relation between presure and pumping rate of San Antonio Pump Station

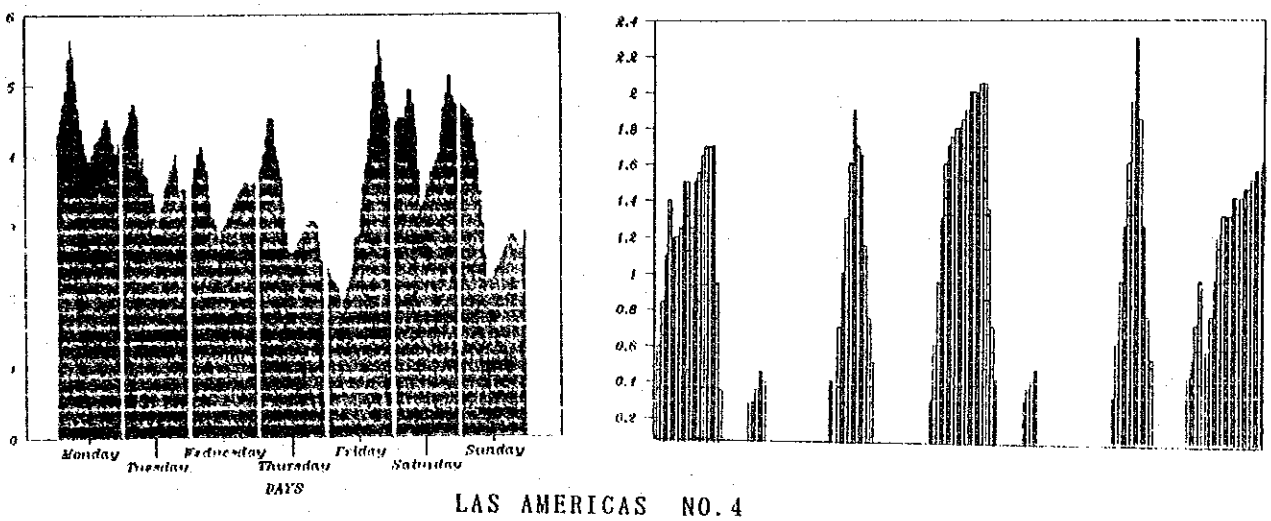
ALTAMIRA

SAN CRISTOBAL

June 8-16, 1992



February 16-21, 1993



LAS AMERICAS NO.4

February 22-28, 1993

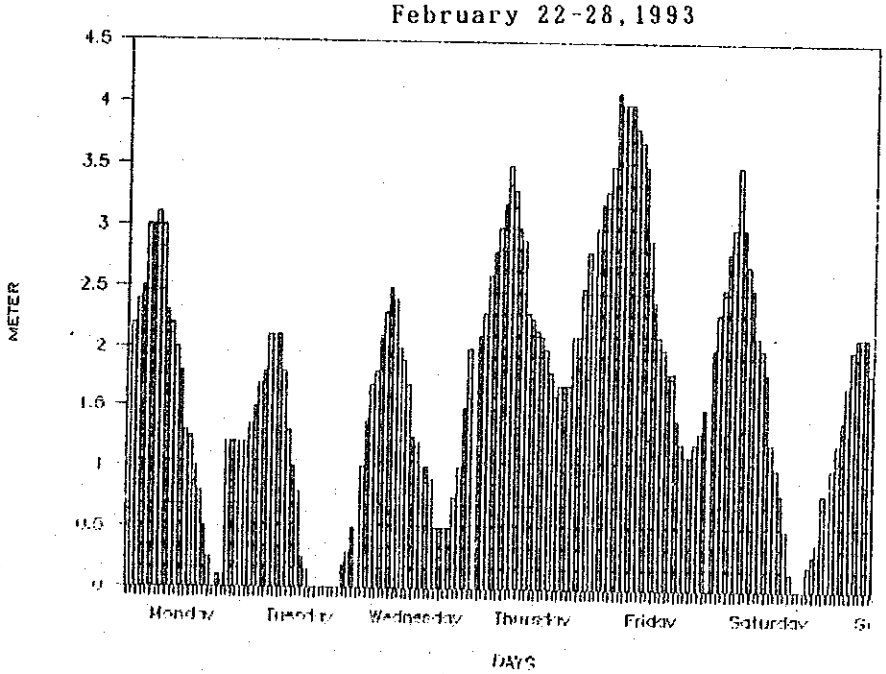


Fig. 3.5 Water level variation in reservoir tanks

CHAPTER 4 GROUNDWATER

4.1 Topography and Geology

4.1.1 Topography

The western part of Nicaragua is divided into 3 geologic and geographic provinces: the Pacific Coastal Plain, the Nicaraguan Depression and the Interior Highlands (Fig. 4.1.1 and 4.1.2). The Study area is located within the Nicaraguan Depression.

The Nicaraguan Depression is a tectonic low relief extending NW-SE direction, which is enclosed by the Pacific Coasta Plain and the Interior Highlands. About half of the depression area is occupied by the Lakes of Managua and Nicaragua.

Along the southwestern margin of the depression zone, a chain of young volcanoes extend from the northwest to the southeast. Many of the numerous volcanoes of this volcanic chain are composit cones, while several are cinder cones and some are calderas and craters with shapes that have varied through the years. Several volcanoes have either lakes within their craters or undergo continuous gentle fumarolic activity, while a few have occasionally erupted violently in the historic past.

The Study area is located in the southwestern margin of the Nicaraguan Depression and covers an area of 880 square kilometers at the south of Lake Managua.

The area is bounded by the ridges of the Sierras de Mateare and the Sierras de Managua in the southwest, by a divide of the Sierras de Carazo to the south and by a groundwater mound nearby the national road (No.11) connecting Tipitapa and Masaya to the eastern end.

The Study area is divided into 3 hydrologic and hydrogeologic sub-areas; the Western sub-area, the Managua Central sub-area and the Eastern sub-area (Fig. 4.1.3).

(1) Western Sub-Area

This sub-area is hydrogeologically bounded by the Mateare Fault Scarp in the southwest end. The eastern side of the scarp consists of Quaternary flat plain with a gradient of 1/40 (1.4 degree). The area is only blessed with many intermittent streams in the rainy season. The size of this sub-area is 54 square kilometers.

(2) Managua Central Sub-Area

This sub-area is bounded by the southern shore of Lake Managua to the north, and by the groundwater mounds and groundwater divide which are basically influenced by faults, fault scarps and the shape of the top surface of the impermeable basal layers to the west, southwest and southeast.

The main part of Managua city stands on a low and flat plateau with a gradient of 1/27 (2.2 degrees), and where many cones and craters of young volcanoes exist. Many of these craters are composit and of collapsed form, while some have formed lakes within.

Lake Asososca is one of the major sources of the INAA water supply system in Managua city.

The northern slope of the Sierras de Managua has a gradient of 1/16 (3.6 degree) in the montainous area behind Managua city. Its highest elevation is about 940 meters at the ridge of the Sierras de Managua protruding into the Nicaraguan Depression area.

Many deeply eroded valleys with steep flanks overlain by very permeable thick volcanic ash layer (scoria rich) and covered by a dense tropical rain forest and cultivated vegetations are formed in this slope. All streams in the valley are dry except at times of strong rainfall. Conclusively, the slope is considered to have good recharge conditions.

(3) Eastern Sub-Area

As shown in Fig. 4.1.3, this sub-area can be divided into two hydrologic districts: the groundwater recharge district including Masaya Caldera, and the groundwater storage and runoff

district.

The groundwater recharge district consists of the montainous areas of Sierras de Managua, Sierras de Carazo and Masaya volcano area with big caldera.

The southern flank of Sierras de Managua has steep-walled deep canyons and intense erosion is still evident all throughout. However, the majority of the area is under cultivation and most walls of the canyons are profused with wild vegetation.

The divide of Sierras de Carazo extends nearby national road No 18. To the north it is occupied by a flat highland with more than 400 meters elevation and is covered by dense tropical rain forest and cultivated vegetations.

Masaya Caldera covers an area of 47.5 square kilometers, and the water level of its lake is 135 meters in elevation. All canyons in this groundwater recharge district have no perennial streams. Some of the rainfall from Sierras de Managua infiltrate the ground near north of Ticuantepe, while the majority of the rainfall from Sierras de Carazo flows in Lake Masaya.

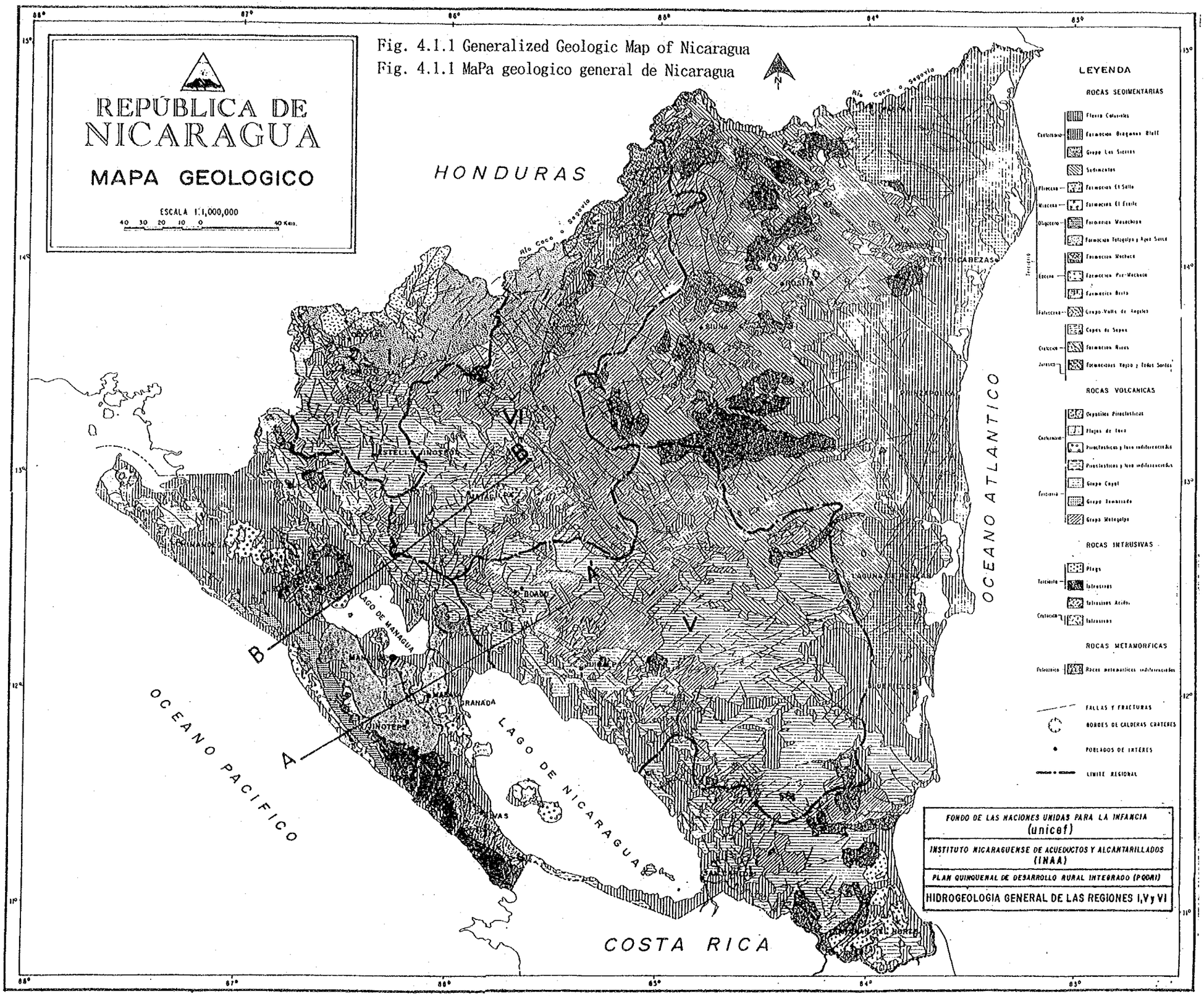
The groundwater storage and runoff district consists of a flat plain with a gradient of 1/62 (1.0 degrees) between the northern wall of Masaya Caldera and lake Managua. Although many intermittent streams exist, most of their flow routes disappear in the lower reaches even in the rainy season. There are many groundwater springs with elevations ranging from 50-60 meters, and they create many small perennial streams flowing in Lake Managua. There are many chains of young volcanoes extending in the north-south direction mostly consisting of small cones and collapse craters.

4.1.2 General Geology

(1) Western Nicaragua

The geological age relations and distribution of the principal rock units of Nicaragua and adjacent parts of Honduras and Costa Rica are summarized in Table 4.1.1.

Fig. 4.1.1 Generalized Geologic Map of Nicaragua
Fig. 4.1.1 MaPa geologico general de Nicaragua



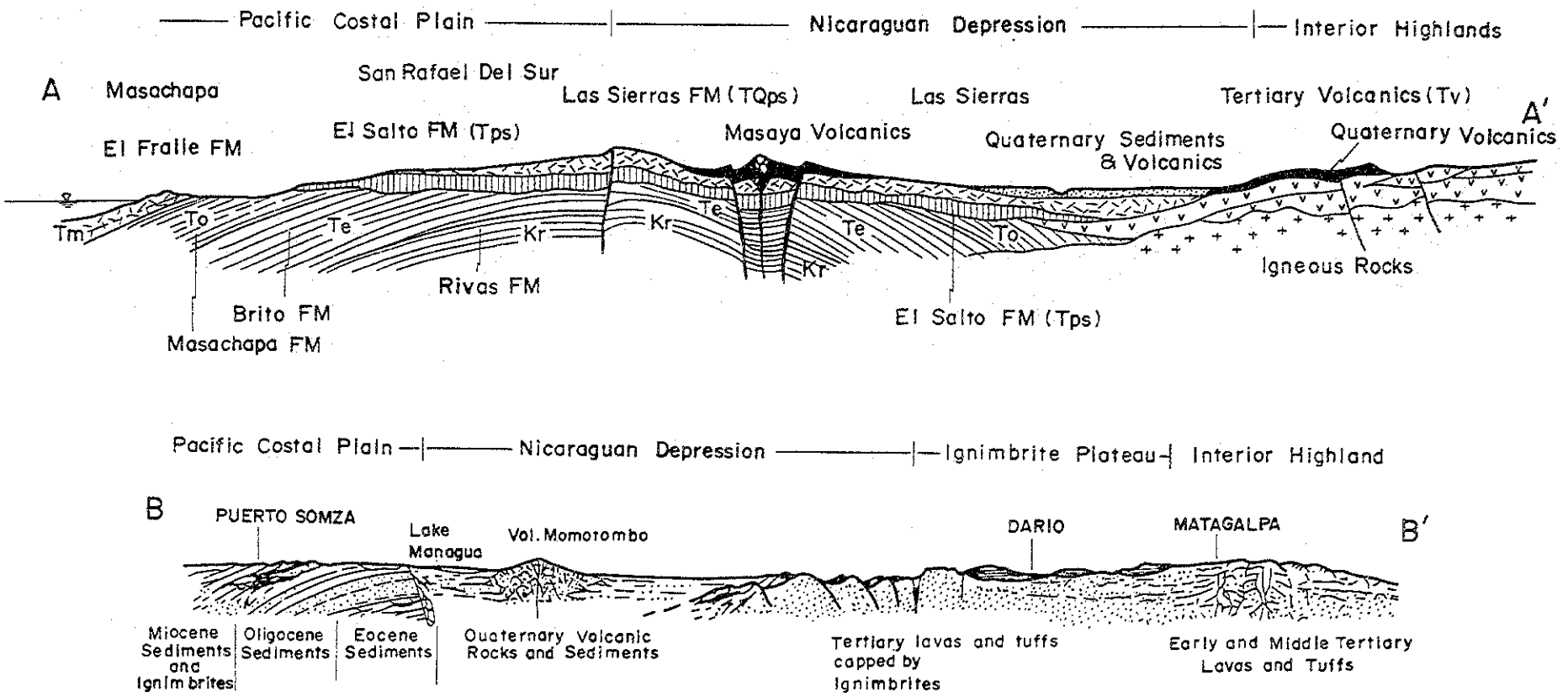


Fig. 4.1.2 Generalized Cross Sections

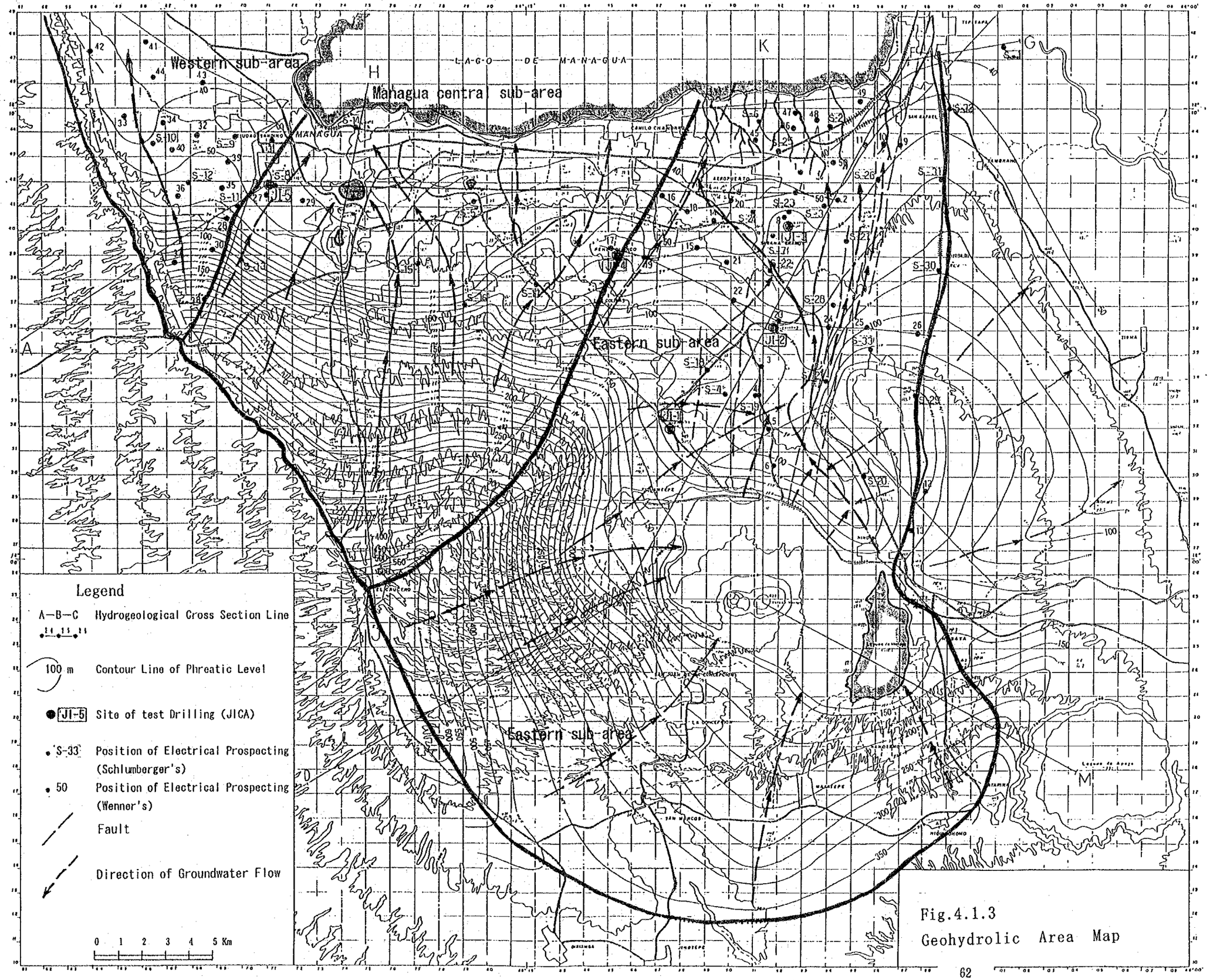


Fig.4.1.3
Geohydrolic Area Map

1) Sedimentary Rocks

The Pacific Coastal area of Nicaragua is underlain by sediments from the Upper Cretaceous to the Recent age.

Rivas Formation is the oldest exposed rocks and is exposed in the core of the Rivas anticline at the southern end of the Pacific Coastal Plain. It consists of arkosic sandstone, tuffaceous shale and sandstone, marl and graywacke, and its total thickness is estimated to be more than 2,370 meters.

The Rivas Formation is partially uncomformably overlain by the Brito Formation of the Paleocene to Eocene in southwest and northwest. This formation is composed of sandstone, nodular marls, green shales, black tuff and brown tuffaceous shale and also contains calcareous sand with interbedded graywacke, with thick limestones and limey shales at the base. The total thickness of the Brito Formation approximates 2,400 meters (Fig. 4.1.1 and 4.1.2).

The Brito Formation is partially uncomformably overlain by the Masachapa Formation of the Oligocene in the southwest and buried below the Las Sierras Group of the Plio-Pleistocene in the northeast. The Masachapa Formation is composed of tuffaceous mudstone, alternating gray and dark gray shales, well stratified thin beds of fine grained quartz sandstone. Toward the top of the formation, tuff and breccia become more abundant. Silicified wood is abundant in some of the tuffaceous beds and carbonized tree trunks are mixed with fragments of molluscs and volcanic debris near the base of the formation. This formation is approximately 2,600 meters thick.

The Masachapa Formation is comformably overlain by the Miocene El Fraile Formation and Tamarindo Group in the west and northwest and is uncomformably overlain by the Pleiocene El Salto Formation and the Las Sierras Group in the northeast.

Cuadro 4.1.1 Relaciones estratigráficas de Nicaragua y regiones adyacentes
Table 4.1.1 Stratigrphic Relations of Nicaragua and Adjacent Regions