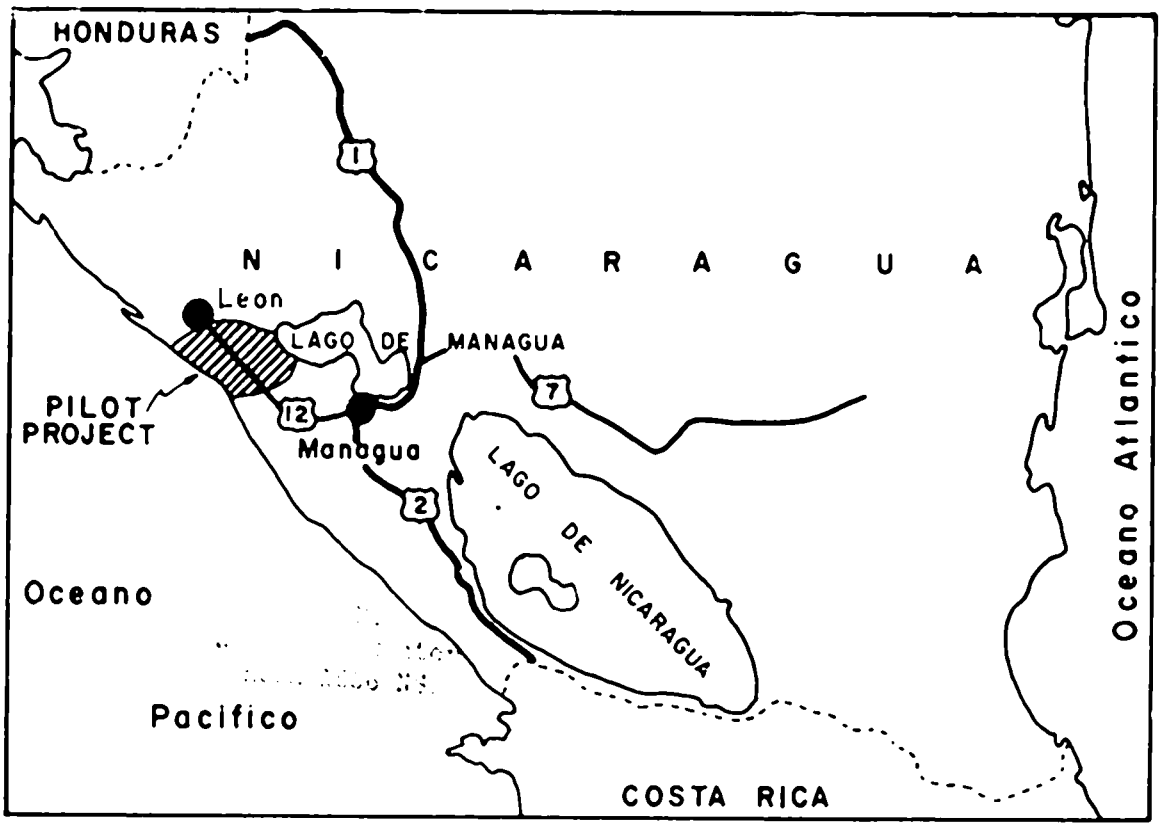
NATURAL RESOURCES-CADASTRAL INVENTORY NICARAGUAN PILOT PROJECT



U.S. DEPARTMENT OF STATE
USAID MISSION
NICARAGUA

OFICINA DE PLANIFICACION
CONSEJO NACIONAL DE ECONOMIA
NICARAGUA

U.S. ARMY
INTER AMERICAN GEODETIC SURVEY
NATURAL RESOURCES DIVISION
FORT CLAYTON-CANAL ZONE

Mar. 1966

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PILOT PROJECT

NATURAL RESOURCES - FISCAL CADASTRAL INVENTORY

I. INTRODUCTION

A - History of the Project

The Government of Nicaragua is preparing for a comprehensive cadastral and natural resources inventory. Thus, it will become the second country to implement a policy recommended by the foreign ministers of Central American Common Market countries and Panama in 1963. The loan proposal for the initial three-year program was developed with the assistance of technical advisors from CABEI, ROCAP and IAGS.

The Nicaraguan program will be the largest to date in Latin America, extending over a period of ten years and requiring an investment of about $28 million. Eventually, it will cover the entire country.

A program of this magnitude required most careful advance preparation. For this reason, the Government of Nicaragua and the Nicaraguan Mission of the lending agency-USAID - requested the specialized Natural Resources Division of the Inter American Geodetic Survey, as well as a specialist from U.S. Bureau of Internal Revenue, to assist in the orientation of those Nicaraguan specialists expected to occupy leading roles in the planning and execution of the cadastral and natural resources inventory. To accomplish this orientation, it was decided to conduct a pilot project in an agricultural area in the vicinity of Leon, not only because this area presents typical conditions but also because it had recently been subjected to a drought and serious consideration was being given to proposals of irrigation. This Pilot study was conducted over a period of 4 months beginning in October 1965.

B - Objectives and Scope

Evaluated data resulting from the main program is expected to be of fundamental importance to sound national planning and to a rational system of land appraisal and tax assesment. It is essential,

however, that the agencies involved provide competent technical personnel, who will function as an integrated team to collect the necessary natural resources data and cadastral data.

The pilot project was expected to provide administrative and operating experience for the executive director and the specialists from the various participating agencies. It was expected also to test accepted inventory procedures under Nicaraguan conditions and provide information which could be used by the Nicaraguans and contracting agencies to develop realistic specifications and work plans for the main program. Finally, it was anticipated that the Pilot Project would develop data useful to the solution of specific problems of the Pilot Area, such as the use of water for irrigation. Most of this report will be devoted to this last objective and to the data collected to meet its requirements.

C - Organization and Operation

It was planned that the organization of the Pilot Project would be similar to that contemplated for the main program. The prospective Nicaraguan leaders for each field of study were grouped with counterparts from the Inter American Geodetic Survey into a working unit under the direction of the Director-designate. During the first three years of the main program, the Nicaraguans would have foreign contract technicians as counterparts. In both the Pilot Project and the main program, Nicaraguan technicians in each discipline would remain as members of their respective agencies on assignment to the Director, who with his staff would direct and coordinate their efforts.

For the Pilot Project, the appropriate ministers authorized the participation of technicians as follows:

Soil Scientists, Department of Soils, Ministry of Agriculture

Vegetation Specialists, Department of Forestry, Ministry of Agriculture

Hydrologist and Geologist, National Geologic Service, Ministry of Economy

Hydrologist, National Commission of Energy, Ministry of Public Works

Climatologist, National Meteorological Service, Ministry of Defense

Property Specialist, Cartographic Institute, Ministry of Public Works

Hydrologist, Municipal Services, Ministry of Public Works

Tax Specialist, Tax Office, Ministry of Hacienda

Technicians, Cartographic Institute, Ministry of Public Works

The Director of the Pilot Project then met with the designated representatives of each agency and plans were made for the assignment of specific technicians and other support required for the studies.

From the Inter American Geodetic Survey, the following counterparts were assigned:

Chief of the Natural Resources Division
Chief of the Soils Branch
Chief of the Geology Branch
Chief of the Hydrology Branch
Chief of the Land Use and Vegetation Branch

The U.S. Bureau of Internal Revenue provided the advisor in the cadastral portion of the study. Both the Operations Division of IAGS and the German aid mission to Nicaragua cooperated in supplying technical assistance to the Cartographic Institute in the production of the first mosaics to be made in Nicaragua. The USAID Coordinator for the cadastral and natural resources program provided administrative, logistical and other support to the project.

From aerial photographs of the pilot area taken in January 1964 at an approximate scale of 1:20,000, partially controlled mosaics (three sheets) at 1:20,000 were prepared, as previously mentioned.

Thus, at the beginning of the pilot project, there were available aerial photo contact prints, three mosaic sheets at 1:20,000 and topographic base maps (Leon and La Paz Centro sheets) at scale 1:50,000.

The first step was to arrange the photos in numerical order by flight lines (flown NW-SE), and the approximate center point of each print was located and marked on the 1:50,000 map sheets. Then, the center points on each flight line were joined by a line, forming an index map for ready location of the photos with respect to position on the topographic base map. With the index map completed, the photos were ready for interpretation by the teams in the various disciplines.

All disciplines recognized the value of aerial photo interpretation in reducing the amount of field work required and also in producing data of greater accuracy than is often possible with extensive field surveys. Within the limitations imposed by the scale and quality of the photos and the time available for intensive study, photo interpretation was a major factor in data collection.

D - The Project Area and the Leon Area

Selection of an area for study involved many considerations. An effort was made to select an area which was somewhat typical of the Pacific coastal area with a diversity of physical conditions and a wide range in land use and land tenure. Early in the planning a reconnaissance team of Nicaragua and IAGS specialists (Figure ID-1) made a preliminary trip to the drought-affected area near Leon and La Paz Centro. This area finally was slected for the Pilot Project study because it was representative of the Pacific coastal area and also because it was receiving special attention, owing to the drought. It was decided to include the entire Tamarindo watershed and some smaller adjacent watersheds, since water and geologic problems in the Leon - La Paz Centro area could not be understood without data on this surrounding area. Therefore,

FIGURE ID-1 NICARAGUAN AND NRD/IAGS TECHNICIANS ON PRELIMINARY RECONNAISSANCE OF PILOT AREA; HERE, EXAMINING ONE OF THE FEW IRRIGATED AREAS NEAR LEON.

FIGURA ID-1 TÉCNICOS NICARAGÜENSES Y EXPERTOS DE NRD/IAGS EN UN RECONOCIMIENTO PRELIMINAR DEL ÁREA PILOTO. AQUÍ EXAMINAN UNA DE LAS POCAS ÁREAS IRRIGADAS CERCA DE LEÓN

the Pilot Project involves approximately 870 Km^2. Geologic, meteorologic and most of the hydrologic studies covered the entire Project Area.

The areas most intensively cultivated are near Leon and La Paz Centro. Here, the effects of the drought were more severe, and to facilitate study it was decided to prepare mosaics covering a major portion of these areas; this is called the Leon Area for reference purposes. Three mosaic sheets (Leon SE, Leon SW, and La Paz Centro SW) were prepared.

Owing to time and financial limitations the report which follows concerns itself with the entire Project Area in the fields of geology, geomorpholgy, climate and hydrology, but only with the Leon Area (Figures ID-2, ID-3) in the fields of soils, land use and cadastre. In each field there are definite shortcomings which could have been corrected, if time had been available for additional data collection, field checking and evaluation. Despite these features, however, it is hoped that the report will provide a useful guide to procedures and practices that would be of value in the planning and operation of other natural resource - cadastral inventories.

II. RESOURCES OF THE LEON AREA

A - GEOLOGY AND GEOMORPHOLOGY

1. Survey Procedures

With the aerial photos, index map and mosaics described in the Introduction, the survey of geology and geomorphology was accomplished largely by photo interpretation of the 1:20,000 aerial photos covering the Leon and La Paz Centro mosaics and the Rio Tamarindo and adjacent watersheds.

Rock types are based only on general knowledge and visual comparisons with type samples that have been classified previously by laboratory analysis, resulting in classifications that are only approximations. Additional laboratory analysis would have been desirable. The accuracy and detail of the map are of reconnaissance level, since the geologic and

geomorphologic data were transferred from the 1:20,000 scale mosaics onto the 1:50,000 scale topographic maps using prominent features as a guide; these were later combined and reduced to a 1:100,000 scale watershed map (Fig. IIA-1). The accuracy of construction and detail shown are probably consistent and adequate for the 1:100,000 scale. Geomorphologic and geologic maps also were prepared for the Leon Area at a scale of 1:20,000 (Figures IIA-3, IIA-4). The geomorphic units include descriptions of geology as well as geomorphology.

2. The Pilot Project Area

"Most of Nicaragua is covered by volcanic rocks and tuffacious sediments that were laid down almost uninterruptedly from Cretaceous to Recent times. Late Cretaceous and early Tertiary volcanism was concentrated near the axis of what is now the Central Nicaraguan Highlands."

"During Miocene time, great sheets of andesitic and dacitic ignimbrites (lave flow and welded tuff) poured over an area of at least 5,000 square kilometers. The Mioceno Tamarindo formation of the coastal belt consists mainly of ignimbrites that have been correlated with similar rocks east of the Nicaraguan Depression. Sedimentation continued throughout the period of volcanism. It is best recorded in a thick sequence of tuffaceous elastic beds on the Pacific Coastal Plain."

"Downfaulting responsible for the Nicaraguan Depression began soon after the close of the voluminous ignimbrite eruptions that marked the end of the cycle of Tertiary volcanism in Central Nicaragua. Subsidence has continued to the present, the greatest displacement taking place along faults and flexures that mark the southwest boundary of the graben; concurrently, the Pacific Coastal Plain has been elevated and tilted seaward."

"Pliocene and later volcanism has been concentrated along a line of large composite cones and calderas near the southwestern margin of the depression, but a few recent volcanoes have been found along the opposite side of the graben and near the Atlantic

Coast. Most of the Quarternary rocks are iron-rich andesitic basalts, but dacite pumice has been erupted from several explosive type calderas."

The foregoing descriptions, as well as the geologic and geographic provinces of Nicaragua illustrated by the generalized geologic sections (Figure IIA-2) were taken from "Volcanic History of Nicaragua" by Alexander R. McBurney and Howel William, Vol.55, University of California publication in Geological Sciences, University of California Press, Berkeley and Los Angeles 1965.

The provinces consist of the Pacific Coastal Plain, the Nicaraguan Depression, the Interior Highlands and the Atlantic Coastal Plain. The Pilot Project Area is located on the Pacific Coastal Plain.

The structure and stratigraphic relationships of the rocks exposed in the pilot project area are illustrated by generalized geologic sections on the geology and geomorphology overlay.

As previously mentioned, the area selected for the Pilot Project encompasses an entire large watershed and adjoining smaller ones. In the discipline of geology and geomorphology, it was necessary to treat the entire drainage basin in order to observe relationships of geologic and geomorphic forms on a broad scale. Observations in the Leon Area then could be interpreted in terms of their significance to the soils and land-use disciplines which concentrated on that area.

The Pilot Project is located southwest of Las Pilas volcano, one of a series of volcanoes forming a chain of mountains separating the Pacific Coastal Plain from the Nicaraguan Depression, the geologic province to the east.

With the exception of a very small area near the coast, where some sedimentary rocks are exposed, the entire drainage basin is underlain by volcanic material. For the most part, it consists of pyreclastic debris from recent explosive volcanoes which have deposited pumice and ash beds exceeding a depth of several hundred meters over the easterly and central portion of the Pilot Project Area. A few minor lava flows are associated with the ash and tuff beds. The large flatland area in the central portion of the drainage basin is covered by a deep overburden with a few exposures of ash beds and tuff beds. Portions of the basin may contain

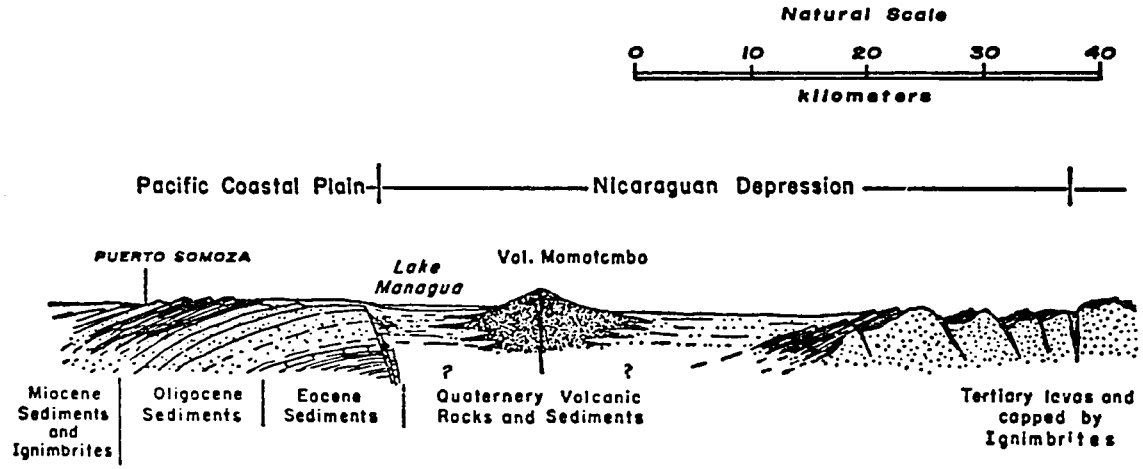

FIGURE IIA-2 GENERALIZED GEOLOGIC SECTION ACROSS WESTERN NICARAGUA.
McBIRNEY-WILLIAMS : VOLCANIC HISTORY OF NICARAGUA

FIGURA IIA-2 SECCION GEOLOGICA GENERALIZADA A TRAVES DE LA PARTE OCCIDENTAL DE NICARAGUA.
McBIRNEY-WILLIAMS : HISTORIA VOLCANICA DE NICARAGUA

some lake beds, but no conclusive evidence for this was observed. Eroded remnants of lava flows and tuff beds from flat-topped mountains that lie between the central portion of the drainage basin and the Pacific Coast, except where the streams have eroded and extended the flat bottomed basin toward the sea.

The mountain areas lying generally southwest of Leon are composed of bedded andesitic lava flows and tuff, which are nearly horizontal and quite erosive. They have been described as part of the volcanic Tamarindo formation of ignimbrite (welded tuff) and lava flows. Possibly, there is a geologic difference or separation of these rocks from the typical Tamarindo formation at the southeastern part of the drainage basin, as they are more massive and essentially horizontal whereas the Tamarindo beds to the south are part of the northwesterly plunging anticline on sedimentary rocks. The hilly table-land terrain at the southeast portion of the drainage basin is capped by layers of hard ignimbrites and lava flows. The terrain is eroded and faulted into small mesa forms. Along the coast, the formations dip southwesterly toward the shoreline, where they are overlain by younger sedimentary rocks of tuffaceous siltstone, sandstone and ash beds.

To the northwest, the hard lava beds dip beneath the valley, where they are covered by the valley fill overburden. Similar and probably stratigraphically higher flows of the ignimbrites series are exposed to the northwest of the valley plain. Generally, the surface of the hard ignimbrites is eroded into rolling swales and ridges. Soil cover on the ridges is thin with bedrock often exposed. Soil cover in the swales is usually dark and develops many deep shrinkage cracks when it becomes dry. As the rock is relatively hard, it provides poor vertical drainage, which may contribute to the poor growth of trees and grass.

3. Geomorphic Units (Figure IIA-1)

Unit I - Central Valley Area

This consists of flat to gentle slopes, alluvial and slope-wash soils overlying a deep accumulation of pyroclastic debris of tuff and ash; minor lava flows and perhaps some lake-bed deposits; thickness of pyroclastic material exceeds several hundred meters. Materials are porous, soft to firmly cemented, and prob-

ably will make a good groundwater source of moderate yield. Few bedrock exposures occur in the central valley area. Gradients are sufficiently flat in some places to create poorly drained areas during the rainy season.

Unit II - Pumicious Tuff Plateau

This is highly dissected into ridges and valleys. Ridges consist of residual pyroclastic volcanic debris from explosive-type volcanoes. The ridges of tuff erode rapidly and bear a thin soil cover. Erosion and transportation of the light density soils is rapid. The transition zone between the dissected plateau and the bottom valley lands of Unit I is characterized by isolated and widely spaced remnants of residual tuff, rising above the valley surface. Several volcanic craters, under different stages of erosion, were the vents which supplied the pumice and ash deposits of the plateau. Older eroded surfaces, geologic structures and geomorphic forms are buried by the tuff.

Unit II (a)

This is a recent volcanic mud and lava flow that originated from a crescent shaped volcanic cone, rising above the general elevation of the tuff plateau.

Unit III - Slope plains

These present a deeply entrenched drainage. The plains of Las Pilas volcano are believed to have been formed by mud flows originated near the crest of the volcano. Thin consolidated layers of ash and secondary deposits or hardpan materials underlying the top soils have retarded lateral erosion. The streams have become deeply entrenched by vertical erosion. Where the streams reach the lower slopes and flatter gradients, they have shifted laterally and have deposited their sediments, forming broad, coalescing fan deposits which extend into the valley lowlands.

Unit III (a)

This is a small mud or lava flow which formed a small flat-bottomed valley.

Unit IV - Ridge and Valley Slopes

The erosion forms of long narrow ridge and valley located on the southwest side of the volcano are probably normal erosion forms in volcanic ash. Stream channels are not deeply entrenched and many disappear before reaching the lower slopes. Possibly the materials are sandy and streams go underground, later emerging as large springs in the vicinity of Leon.

Unit V - Mountainous Area Southwest of Leon

The mountains are remnants of horizontally-bedded, massive andesite lava beds with minor separations of tuff. The area is divided into two major parts by a northwest-southeast valley suggesting that a major fault follows the alignment of the valley. Additional evidence for the displacement is the fact that the higher easterly portion has four prominent beds, whereas the lower westerly ridge has only two. The terrain is too steep for intensive cropping and is covered with brush and grass. Swampland lies along the Pacific shore.

Unit VI - Hilly Table land Southwest Portion of Drainage Area

The terrain is capped by hard ignimbrites and lava rock of the Tamarindo formation; it is eroded and faulted into small mesas. Underlying it are the upper portions of a northwesterly plunging anticline composed of sedimentary rocks. The ignimbrites are eroded into ridges and swales, the first supporting a thin soil cover. Soils in the swales are usually dark. The area supports a relatively sparse growth of natural vegetation.

4. Practical Applications

The areas underlain by the ignimbrite volcanic rocks have definite limitations for agriculture, because the terrain is usually rough and supports shallow, poor quality soil. Run-off is rapid except in the lowland of the basin where surface drainage is a problem.

The deep permeable deposits of ash and tuff beds provide a huge storage basin for groundwater. This is an important resource in the development of the area. Its use should be carefully analyzed and controlled to prevent unwise exploitation.

Existing geomorphic and topographic conditions in the basin present few apparent opportunities for the development of irrigation from a surface-water supply. Few sites are available for storage reservoirs and dams; furthermore reservoirs located in areas underlain by tuff probably would not hold water.

One location which may have potential as a surface-water development is on the Rio Grande de Atoga where it crossed the ignimbrites near the coast. At the lower end of a small canyon section, the river has deposited alluvial soils that cover an area about four kilometers long and two kilometers wide, this might be irrigated.

The mineral resources in the Pilot Area are salt produced in the coastal area in the vicinity of Puerto Somoza and rock used as road surfacing, building stone and crushed aggregates for concrete. Most of the rock shown on the geology and geomorphology map as lava, or andesite is hard rock which has potential value as construction material. Among the quarries that have been opened are those in Leon Area producing pumice block which are in common use for building stone.

B - CLIMATOLOGY AND HYDROLOGY

1. Survey Procedures

After the initial work in preparation of aerial photos, mosaics and maps, field studies began for the purpose of becoming acquainted with field conditions, as seen on the aerial photos, and developing a working relationship with counter-parts and specialists in the other disciplines.

Data collection was undertaken, utilizing the records of the various agencies concerned with climatology and hydrology; this was supplemented by field measurements to the extent that time and existing

facilities (e.g., observation stations) permitted.

The second half of the survey was given largely to the collation and tabulation of collected data, preparation of graphic illustrations and development of the report. The last included evaluation of the significance of the data with special reference to the needs of the Pilot Area and Leon Area.

2. Climatology

a. Meteorological Stations

The Leon Area alone was too small for a climatological study, especially since records within that area were poor and scattered. It was necessary, therefore to make use of the stations in the Pilot Project Area (Figure IIB-4) and its surroundings.

Records date back only to the year 1957 when the National Meteorological Service was founded, and a meteorological station was established in Managua. In subsequent years, stations were also established in Bluefields, Puerto Cabezas, Juigalpa (Chontales), Chinandega, Leon and San Lorenzo. Although the National Meteorological Service does not have a sufficient number of first-order meteorological stations, it does have a moderately high density of stations of second order. In addition, there are many rainfall stations that are not operated by the Meteorological Service. As shown on the overlay (Figure IIB-1) there is only one station with records of rainfall near the Pilot Area; this is Leon. At Managua, San Lorenzo and Chinandega, however, there are permanent first-order stations with records of precipitation, relative humidity, temperature, and evaporation.

b. Rainfall

Of the many types of tropical storms which occur in this region, only a few are important. The most common of these is the "aguacero" or convective storm which occurs during the afternoons or evenings; it is of short duration and provides a small quantity of

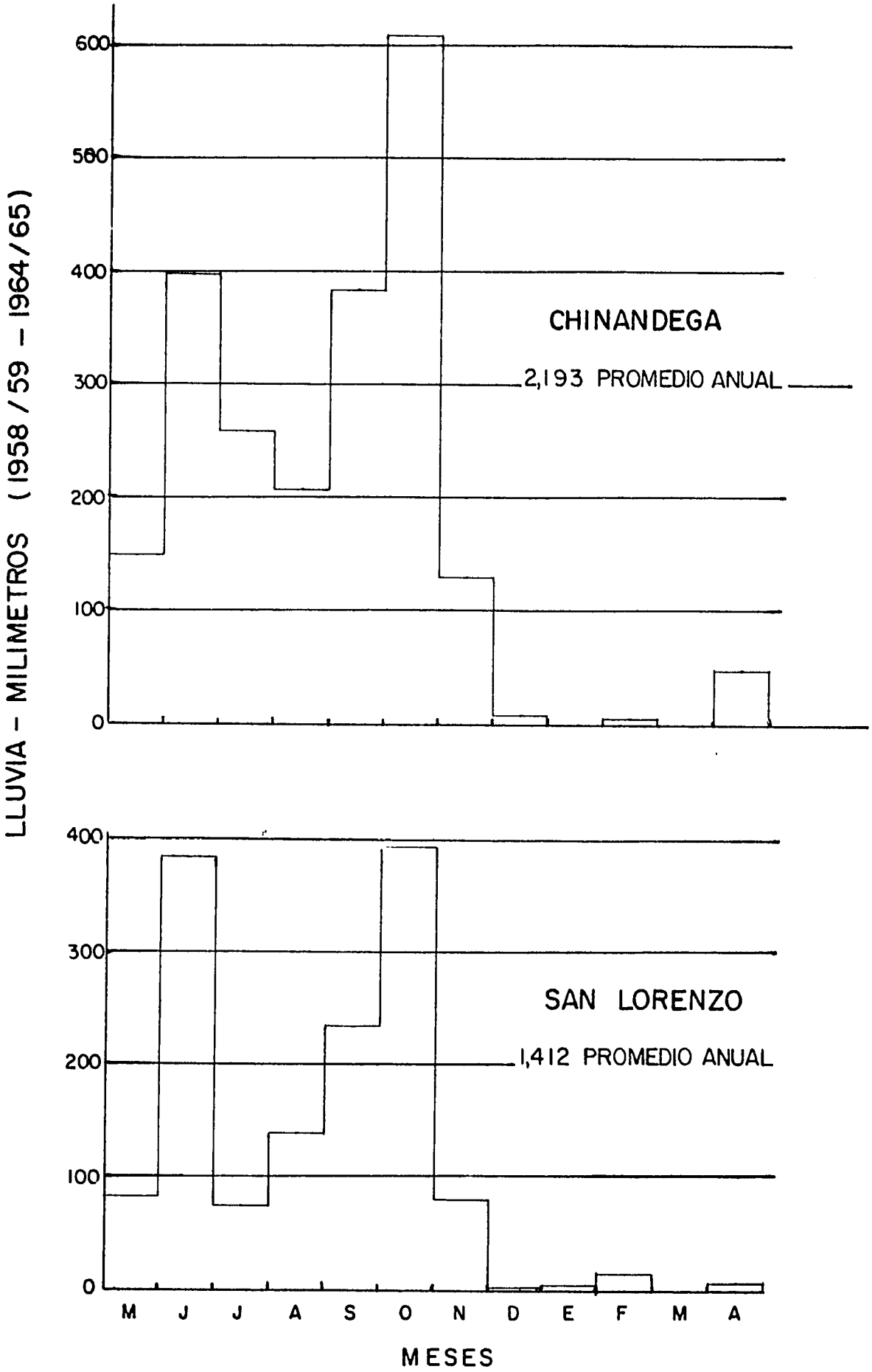

Figure IIB-18

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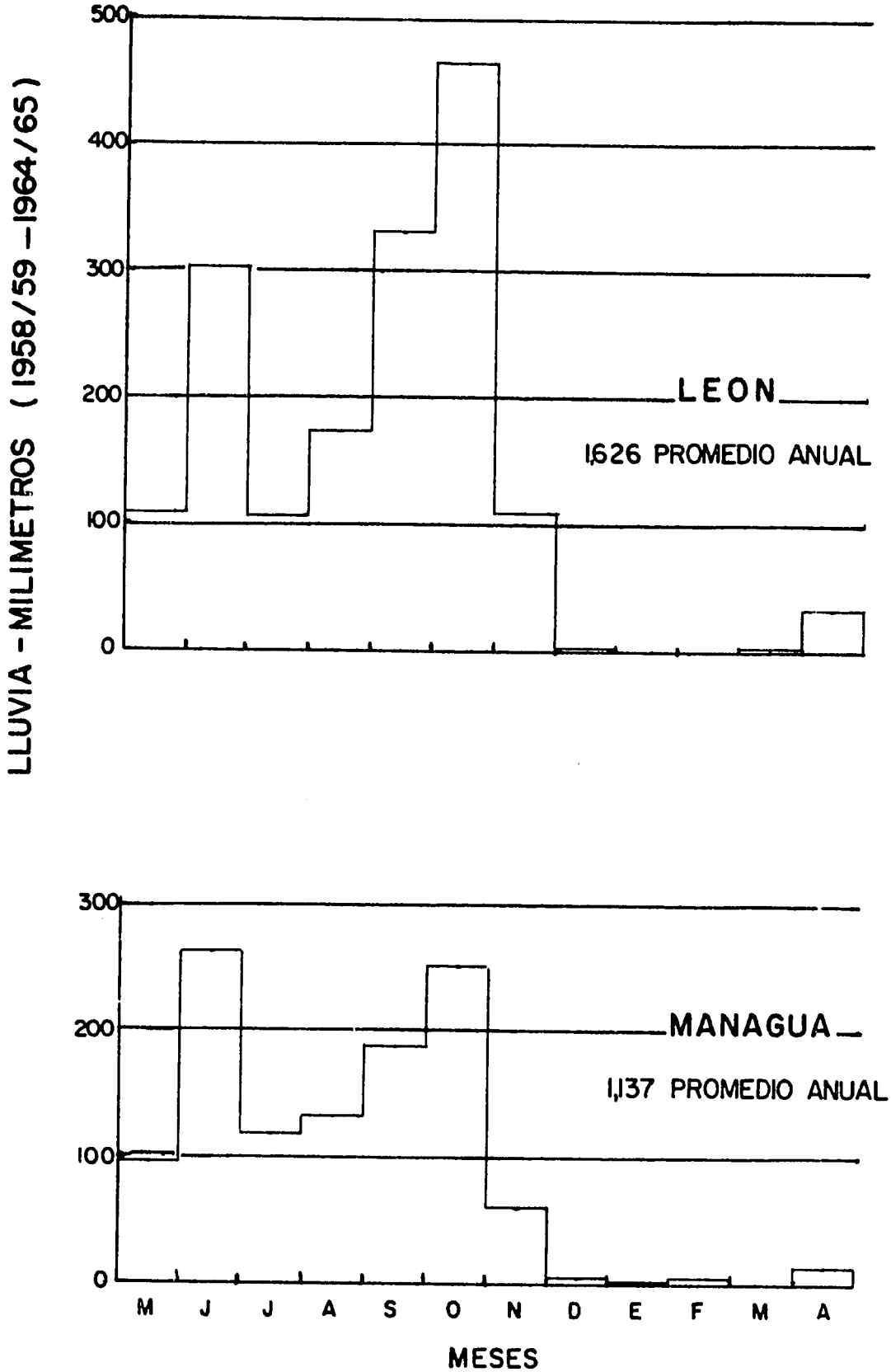


Figure II B-19

12-B

rainfall. The storm that bring a large quantity of rainfall and has a more extended duration is the "temporal ", one of which occurred in October 1960 with a duration of three days. Occasionally, rains are carried by the trade winds across the mountains of Nicaragua from the east, and others are brought by cold fronts moving southwest from the United States. At rare times, hurricanes from the Caribbean cross Nicaragua, but most of their rain and high winds is generally expended on the Atlantic side of the continental divide.

There are 71 rainfall stations, including those of the National Meteorological Service, the General Direction of Statistics, the Ministry of Economy and those of individuals. Only two are situated in or near the area of the Pilot Project. Of the four stations being studied (Leon, San Lorenzo, Managua, Chinandega) the annual rainfall ranges from 1,100 mm at Managua to 2,200 mm at Chinandega. It is interesting to note that the Atlantic Coast has rainfalls between 3,000 and 6,000 mm per year. The months of greatest intensity of rainfall are June, October and September, according to the information shown in Figures IIB-18 and 19. The bar diagrams present information collected during seven years and have been averaged for comparative purposes. The temporal which took place from 27 to 30 October 1960 produced 800 mm of rain in the three days, the greatest intensity being 81 mm per hour. This was determined from a mass curve. The small-scale isohyetal overlay (Figure IIB-2) presents a fair picture of the annual rainfall; however, it was constructed from another isohyetal map for the entire country (Nicaragua) and, therefore, it is rather generalized for this Pilot Area.

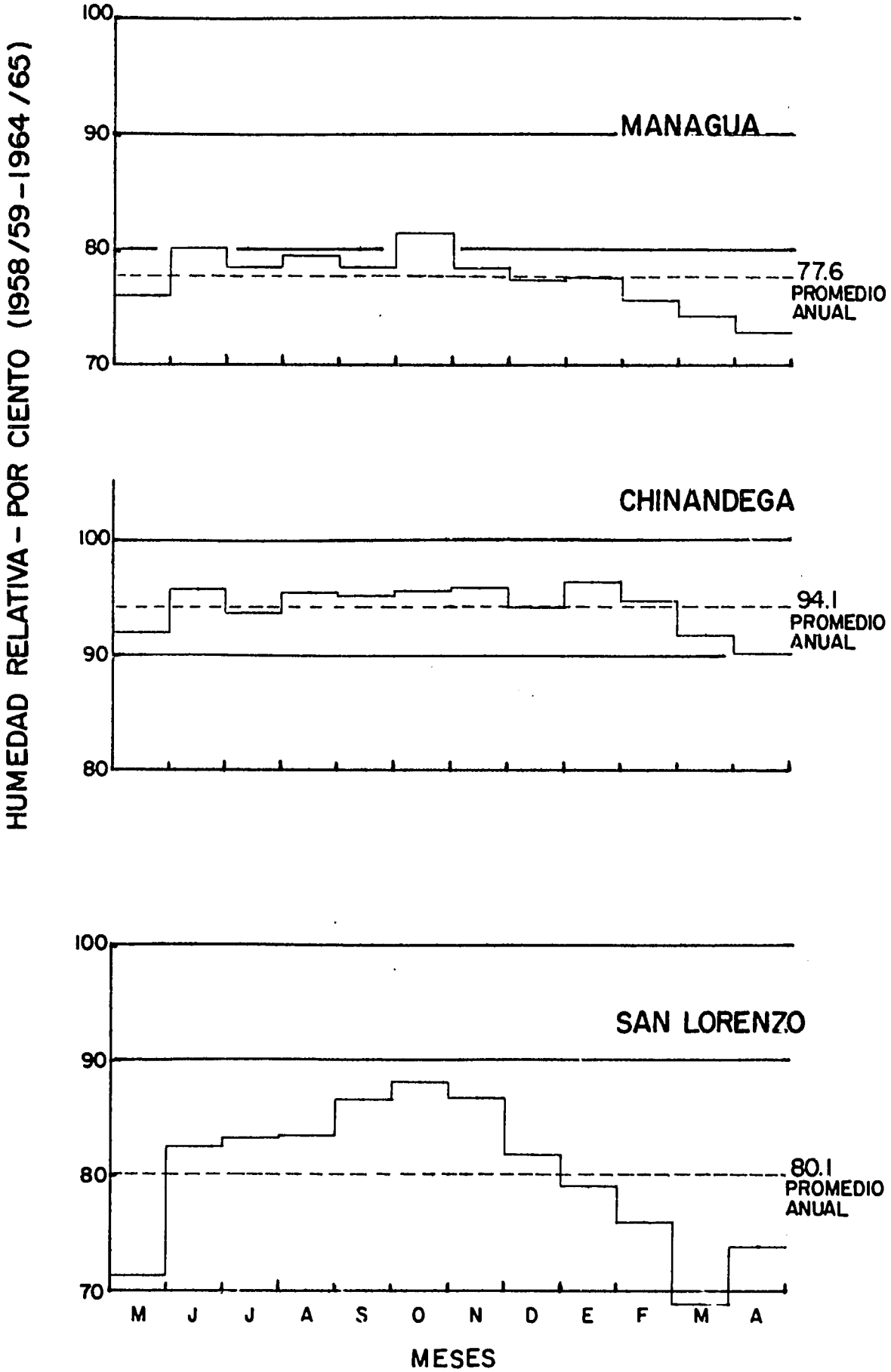


Figure II B-20

13-A

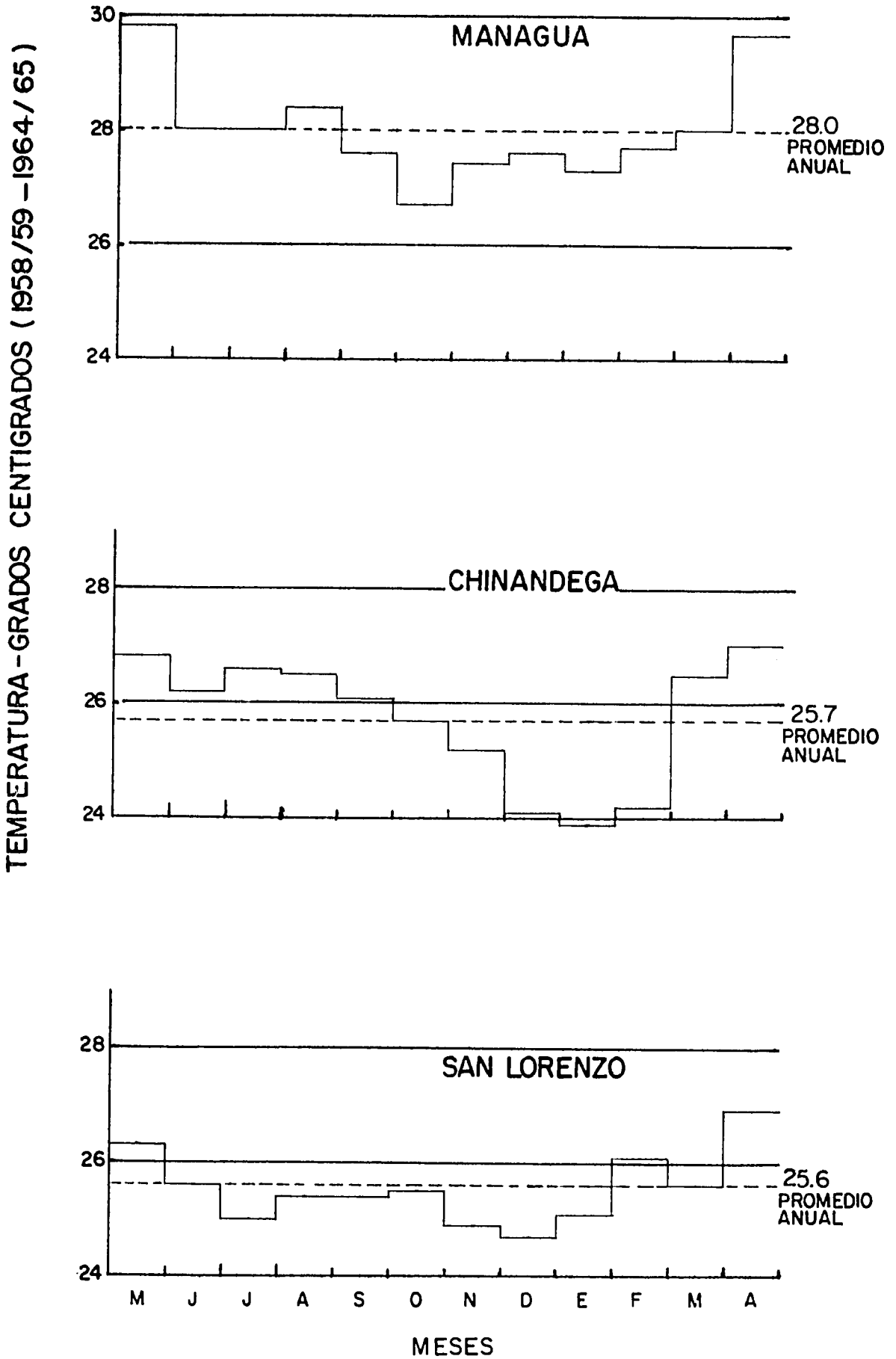


Figure II B-21

c. Relative Humidity

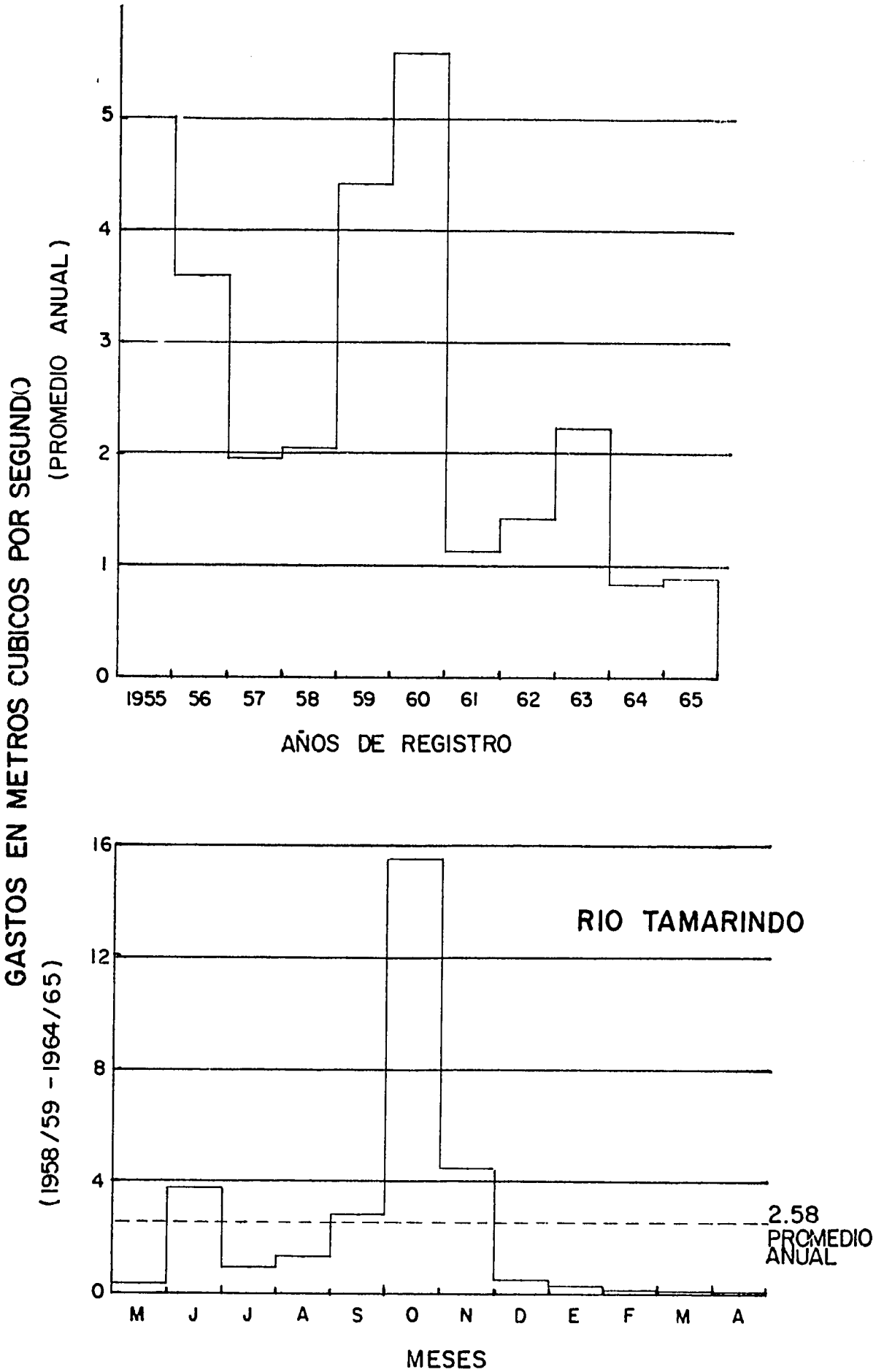
There are 21 stations that collect data on relative humidity, but none is within the Pilot Area. The relative humidity is low in Managua, high in Chinandega and medium in San Lorenzo, although the actual range is small. During large storms, the relative humidity is close to 100%, but during the dry periods of the year the monthly average has been as low as 53% (Figure IIB-20). More data on relative humidity are needed to study evaporation of water, the degree of descomposition of organic materials, corrosion and conditions affecting the comfort of man.

d. Temperature

As was the situation for relative humidity, there are 21 stations that record temperature but none is within the Pilot Area. Therefore, it has been necessary to use a temperature lapse rate to construct the isothermal lines shown on the small-scale overlay (Figure IIB-3). The lines are based on temperatures for San Lorenzo, Chinandega, and Managua. Temperatures are high in Managua, medium in Chinandega and somewhat low in San Lorenzo with a registered minimum of 22 degrees Centigrade for the month of December and a maximum of 29 degrees Centigrade for the month of April (Figure IIB-21). On the overlay (Figure IIB-3) the isothermal line of 26-1/2 degrees shows the common temperature found along the Pacific Coast in tropical regions; it is not comfortable to man. In the area northeast of Leon, a temperature of 25-1/2 degrees Centigrade is more agreeable. The adiabatic lapse rate used for constructing the isotherms was 6-1/2 degrees Centigrade for each 1,000 meters of elevation.

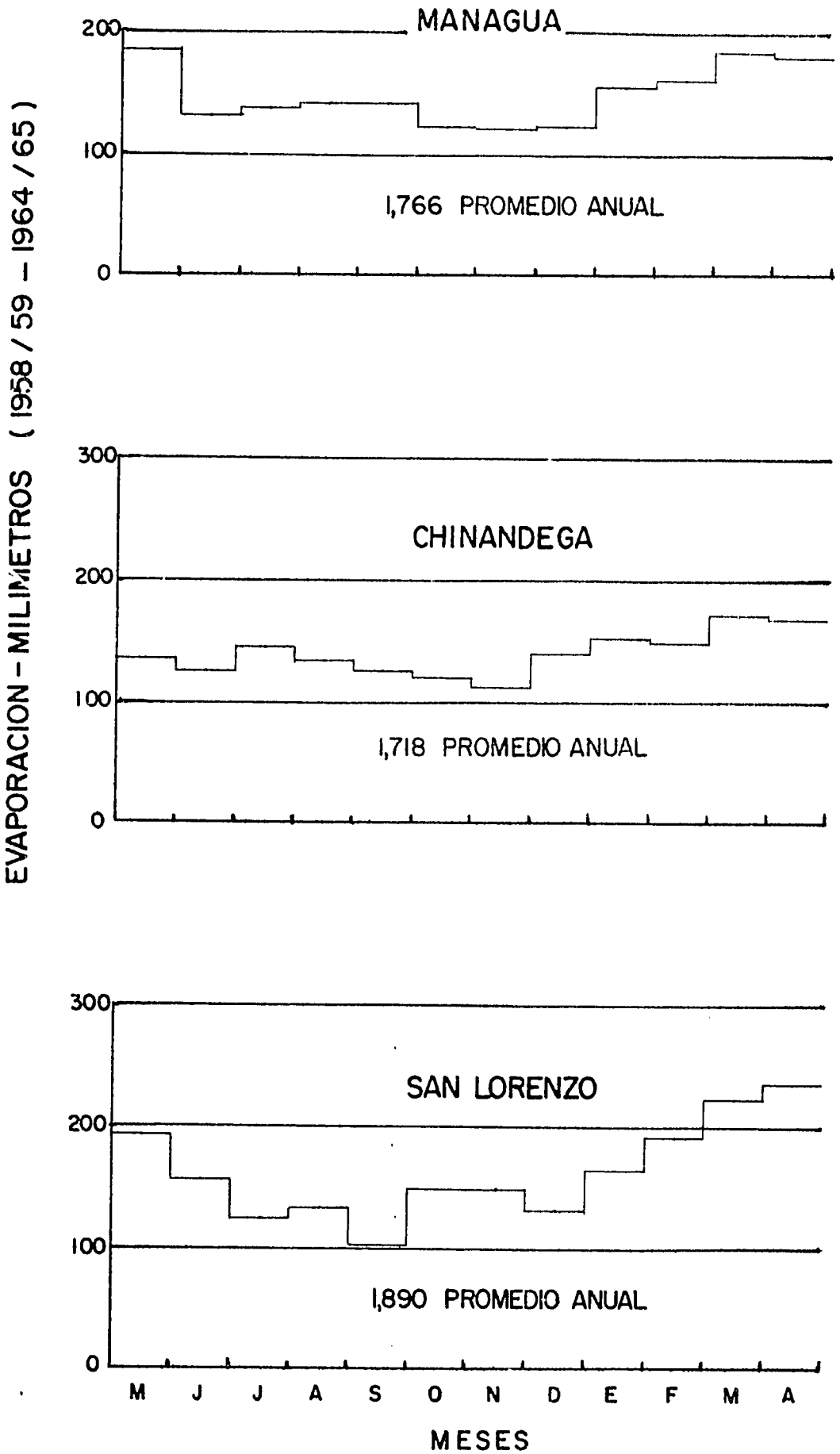
e. Evaporation

As shown in Figure IIB-22, and overlay Figures II-B, 7, and 8, the evaporation tends to increase toward the southeast; however, these maps also were constructed from the very general information collected over the



14-A

Figure II B-14



14-5

Figure II B-22

entire country. Studies made in the vicinity of the mountains indicate that evaporation is less than in the plains and lower elevations. Monthly evaporations range between 45 mm and 458 mm. The annual range is between 1,300 and 3,000 mm. These figures represent readings from the standard evaporation 'pan, class "A". If they are multiplied by the standard coefficient of 70%, the result will be close to actual evaporation from a free natural surface, such as a lake or to potential evapotranspiration from vegetation.

f. Winds.

There are six stations that measure surface-wind velocity, but only the station at Managua has been used in this study; its eight years of record were used in making the wind rose, or circle diagram, has been constructed from the predominant direction of the wind each day without considering variations from that direction during that day. The radius of the circle is a measure of the frequency with which the wind blows from each direction. It blows from the east during the major part of the time, coming from the west only during a short period that coincides with temporal storms. The velocity of the wind is moderate except for one or two months during the dry season, when it is so strong that it sometimes causes crop damage. Wind velocities are highest in January and lowest in September, but this information applies only in a general way to the Pilot Area.

g. Climate in Relation to Agriculture

A diagram shown on the overlay for isotherms (Figure IIB-3) is related to the percentage of precipitation for each month. The main purpose of the diagram is to show the period of seeding, cultivation and harvesting for four principal crops in relation to rainfall.

3. Surface Water

a. Runoff and Drainage

Figure IIB-14 shows the monthly and annual flow for the Tamarindo River. This River has the only gaging station in the Pilot Area; it is equipped with a recorder and has been operating since 1954. The average annual flow during the seven years from 1958 to 1964 was 2.58 cubic meters per second. The maximum monthly averaged 15,500 cubic meters per second. The minimum year had

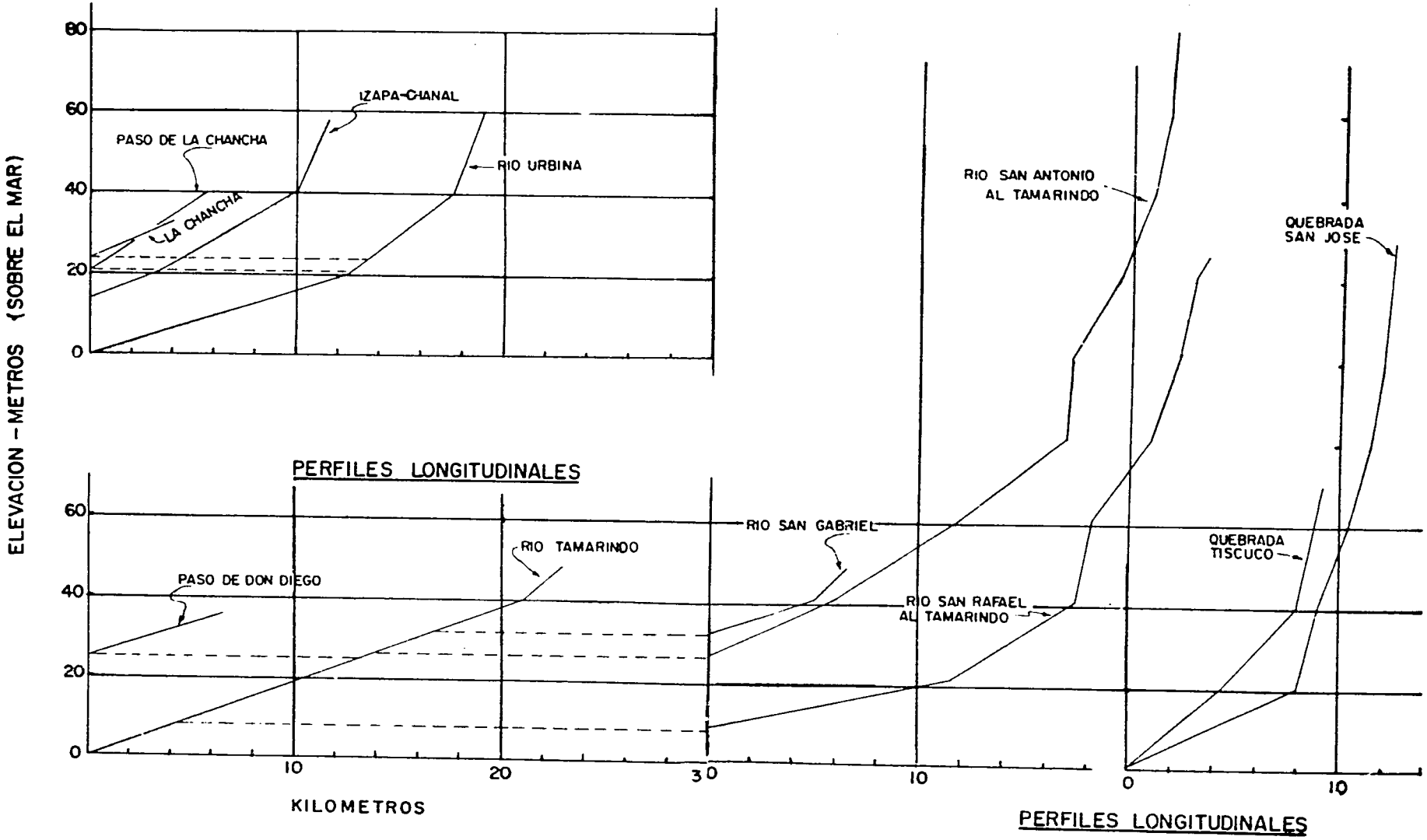


Figure IIB-15

4-51

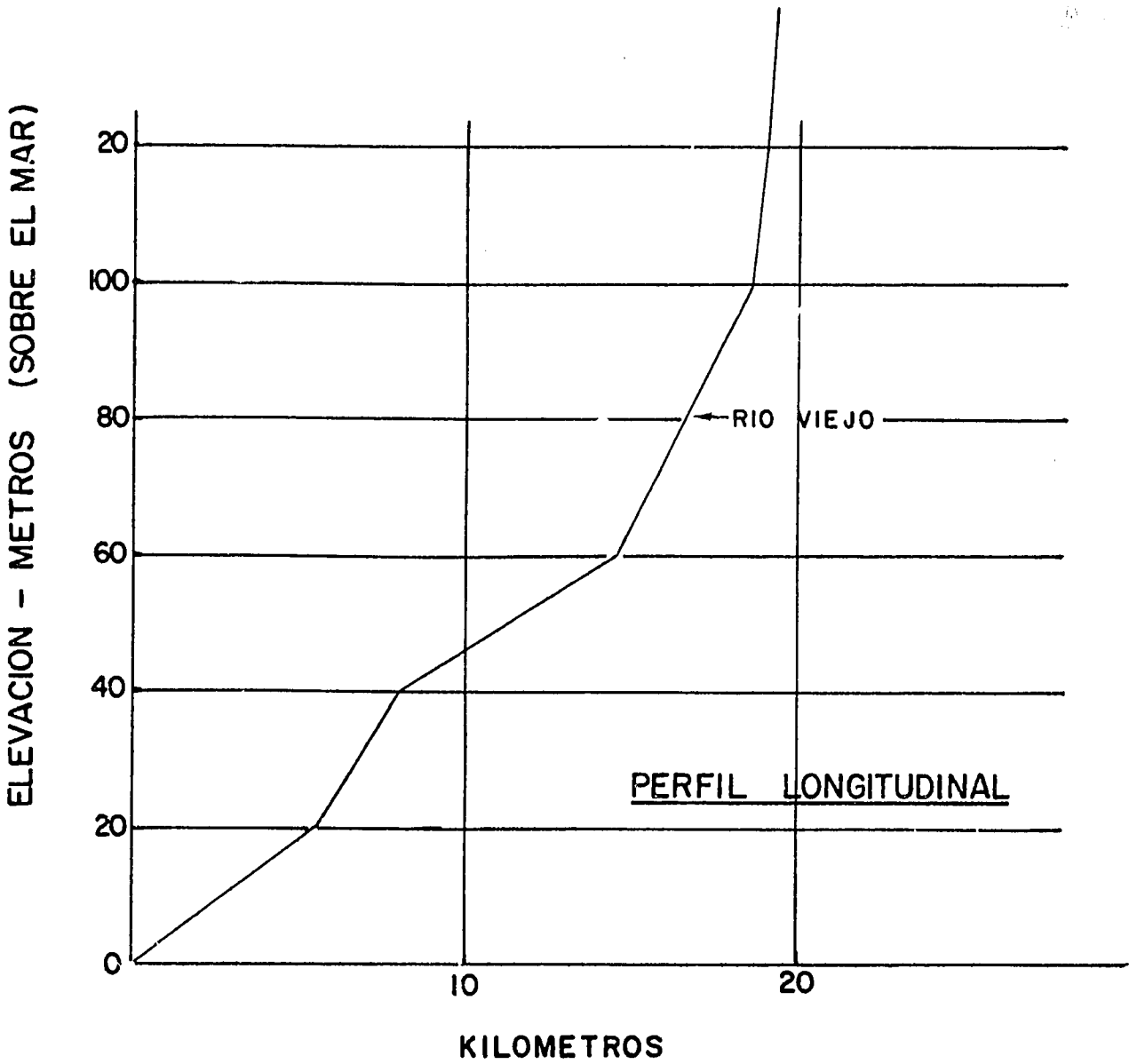


Figure II B-16

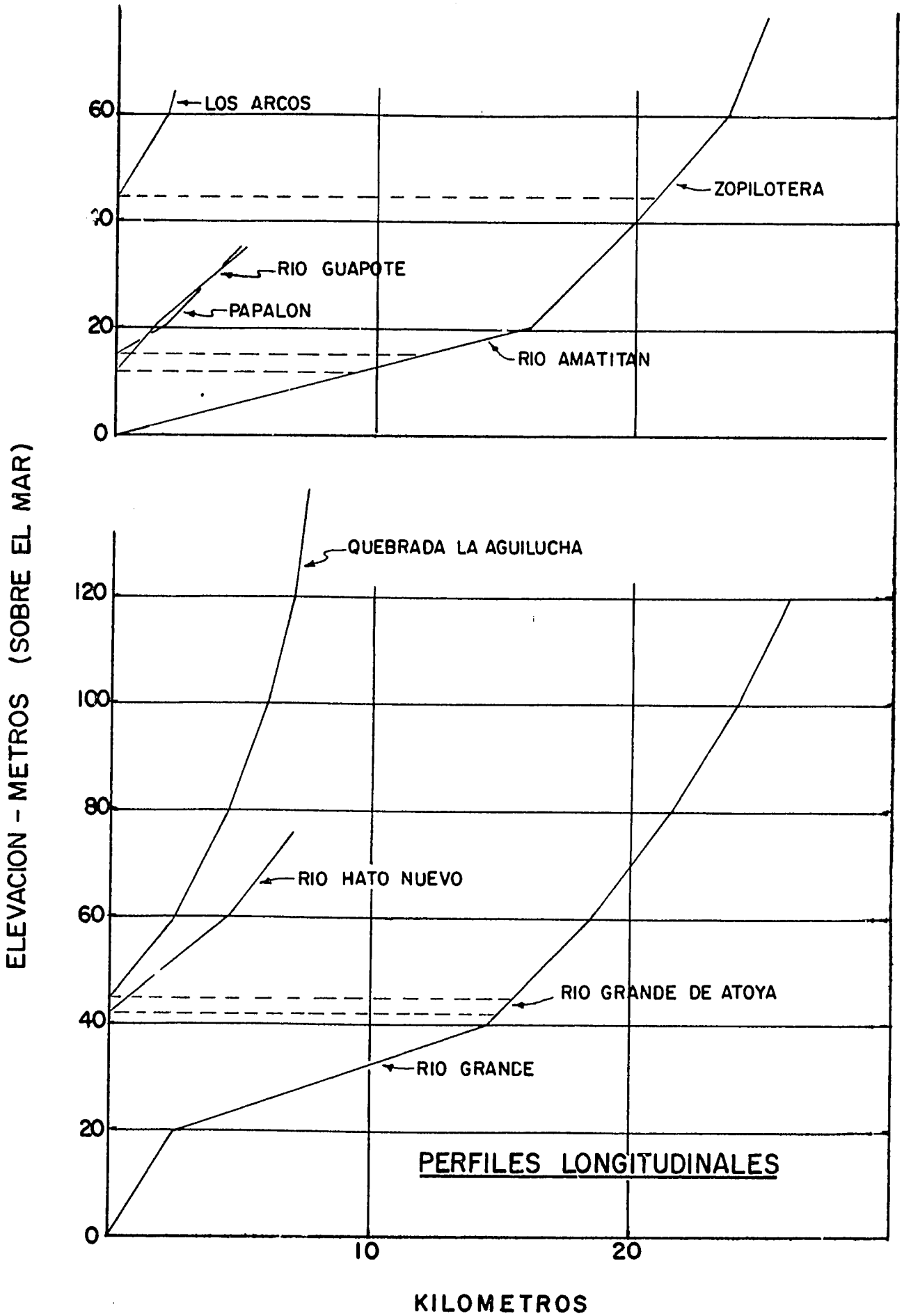


Figure II B-17

an average of o.84 and the maximum year 5.58 cubic meters per second. In general, flows during more recent years have tended to be lower.

The runoff for December 1965 is indicated on the small-scale overlay (Figure IIB-6). It has been developed from measurements at 25 points and is representative only of the beginning of the dry season.

As shown on the mosaic overlays for drainage (Figures IIB-9 and 10) there are many small rivers, but the gradual slopes limit velocities of flow to low values. When the dry season is long, many of the rivers become intermittent. The following profiles (Figures IIB-15 to 17) demonstrate typical slopes of the rivers. The above Leon Area overlays shows the drainage for the centers of maximum interest, and a small-scale overlay (Figure IIB-5) shows the areas subject to inundation and erosion. Inundation is indicated in areas below La Paz Centro and on the divide between La Paz Centro and Nagarote.

Twelve dams have been built in the Pilot Area; two of these -- El Carmen and Los Mangos -- have been damaged. The principal dam, the Salto on the Río Grande, is designed for both irrigation and hydroelectric power. There are no dams in the Leon Area.

b. Flood Characteristics

The flows of the rivers in this region are very changeable. Many times they rise to peak levels and then fall to low levels within a few hours. Occassionally as in the temporal of October 1960, the high water of the Tamarindo River lasts for three or more days. Normally, these waters drain away at once, but in certain flat or constricted areas the water may collect in swamps or form a high water table. These areas are shown on a small-scale overlay (Figure IIB-5).

The hydrograph of surface runoff for the October storm on the Tamarindo River had a volume of 162 mm.. Rainfall over the drainage basin was a little more than 600 mm.; thus the surface runoff was 26% of the rainfall. The sub-surface runoff, including base flow, was about 24%.

c. Erosion

The more severely eroded and erodible areas of the Pilot Area are shown also on Figure IIB-5. These include

the cinder area near the volcanoes, the areas of steep slopes, the areas exposed to heavy rainfall, and the areas of either potential or actual erosion. The map was constructed by considering topographic relief, rainfall intensity and conditions of the soil.

d. Sedimentation and Water Quality

There are few observations of the quality of the water in the Pilot Area, but observations in nearby areas indicate that the amount of suspended solids in the river water is within the permissible limits for potable water. Smell and taste are also allowable. During storms of the rainy season, sedimentation is severe and can cause problems with reservoirs and irrigation works. In general, the chemical and biological quality appears to be good.

e. Water Balance

A short study has been made of the water balance in the Tamarindo River basin. For the seven years 1958-64, the average annual surface runoff was 380 mm; since the rainfall was 1,300, and interception loss about 90, the infiltration retained must have been 830 mm. A study made for each month on the annual pan evaporation of 1800 mm. showed that the associated potential evapotranspiration of 1,300 mm. was limited by the dry season to 700 mm. of actual evapotranspiration. Therefore, 130 mm. remained in the ground. Assuming that this flow is in annual balance, it represents a 10% recharge from rainfall to the underground waters. In addition to the 380 mm. runoff (29% of rainfall), there was a base flow of about 50 mm. (4%) that is the part of the annual groundwater recharge that appears in the river. The other 80 mm. (cut of the 130) is the recharge which flows to the ocean below the river bed.

4. Groundwater

a. Development

The groundwater supply is a very important water source for western Nicaragua, where perennial surface-water streams are scarce. Whenever a project for groundwater development is proposed, it should be proceded by hydrologic, geophysical and chemical studies, among

FIGURE 11B-13A DRAWING WATER FROM A DEEP WELL BY MEANS OF AN OX, A LONG ROPE AND A 25 GALLON DRUM

FIGURA 11B-13A EXTRACCION DE AGUA DE UN POZO PROFUNDO, POR MEDIO DE UN BUEY, UNA CUERDA LARGA Y UN BARRIL DE 25 GALONES

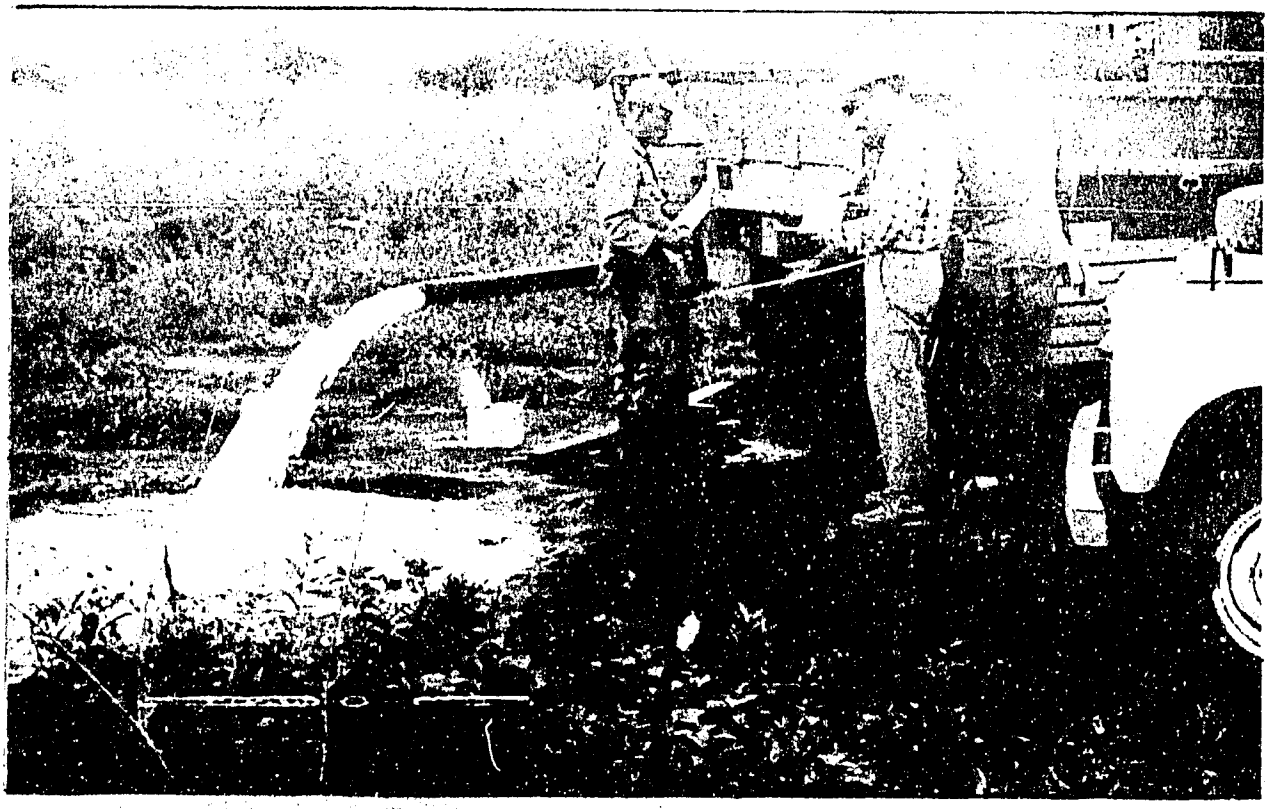


FIGURE 11B-13B PUMPING TEST ON RECENTLY DRILLED WELL

FIGURA 11B-13B PRUEBA DE BOMBEO EN UN POZO RECIEN PERFORADO

others, to insure economic feasibility. The first studies should provide basic information on the characteristics of the aquifers and the availability of subterranean water. Studies later in the phase of development will serve in the planning of programs for irrigation and potable water supply.

The present study refers principally to the mosaic of Leon SE of the Leon Area. In the Leon Area, the underground water is used chiefly for dometic consumption and for livestock. For these purposes, wells are dug with depths ranging from three to more than 60 meters; the diameters in general are from one to one-and-a-half meters. Many of these wells are provided with a concrete curbstone, which constitutes a good reference for points of measurement. Water is obtained from shallow wells by hand, using a rope and a 5-gallon container. As the depth to water increases, it becomes necessary to use a horse or a pair of oxen for extraction; in this case a 25-gallon container is required (Figure IIB-13) A small percentage of the wells mapped here are provided with pumps driven by electricity, diesel motors or even by windmills. The flows of these wells range between 100 and 200 gallons per minute. For a description of the wells mapped in the Leon area, see Table IIB-4 and overlay Figures IIB-11 and 12.

b. Occurrence

As previously stated, groundwater is the principal source of supply. Some stream channels carry a regular volume of runoff during the rainy season, but during the rest of the year they merely carry groundwater outflows and some filtrations of minor importance.

The groundwater reservoir of the Leon Area consists of pyroclastic material and volcanic ash, covered with a thick layer of soil. The slight coherence of these materials and the existance of sandy soils insure good permeability. The reservoir size is estimated at 40 kilometers in length and 20 to 25 in width. Its thickness is unknown and should be determined by drilling or geophysical studies. According to field observations and some drilling in

the area, the groundwater is found in a water-table situation, i.e., the upper part of the saturation zone is free. Nevertheless, there is the possibility that some groundwater at greater depth can develop artesian conditions, at least locally. Actually, intensive use of subterranean water in this area consists only of that water found in a state of natural equilibrium; in other words, there exists a balance between the rainwater that penetrates the subsoil and the groundwater that leaves its reservoir laterally to discharge into water courses or to be lost by evapotranspiration.

c. Water Table

The depth to the water table in the Leon Area ranges from one meter to more than 65 meters. The lesser depths are found adjacent to the Managua-Leon highway. From there, depths increase in the direction northeast of La Ceiba to Comarca de Chacara Seca, where the greatest depths have been registered. On the mosaic overlay (Figure IIB-11) isolines have been drawn showing the depths in meters below the ground surface. Most of the measurements were taken in the months of November and December 1965, but some from January 1966 have been included.

The elevation of the ground at the wells used in construction of the water table map (Figure IIB-12) were determined by the Office of Cartography, taking as a base the topographic map at a scale of 1:50,000 with field observations. Therefore, the probable error of these estimated elevations should be from two to five meters.

The subterranean water moves under pressure of the hydraulic gradient in a direction perpendicular to the curves of the watertable (phreatic level). In the Leon Area, the ground-water flows from the north and northeast toward the south; for the rest of the Pilot Area it moves from the northeast to the southeast, starting from the Cadena de Cerros, which lies in the meridional region of Leon. In the area of La Paz Centro, the depth to water table increases towards the north from six meters to more than 55 meters near the Laguna de Asososca. This water also flows towards the south, part probably discharging into Lake Managua. The greatest volume of subterranean water flowing towards the sea comes from the northern and western side of the chain of volcanoes that lie to the northeast of the Pilot Area.

d. Recharge and Discharge

The only source of recharge of the groundwater reservour is rainfall that occurs over the whole area. In the central part where the plain is of slight slope, there is greater opportunity for infiltration and the sandy soils of the area permit a greater percolation of the water toward the zone of saturation. The recharge that occurs over the western side of the chain of volcanoes to the northeast is reduced somewhat because of the greatly increased slope.

Pumping tests indicate that transmissibility of the aquifer near Leon, with water table slope of one percent, yields 250 to 500 gallons per day per foot of aquifer width. This applies to the 70 meters of aquifer above mean sea level. The volume for a year is in balance with rainfall on the one-foot strip for 15 kilometers; spread over the strip it is 75 to 150 mm. This confirms the 130 mm. annual recharge determined in the Tamarindo water-balance study in the Surface Water Section. Another check consists of applying the computed storage coefficient of 6 percent to the annual water table recession of about two meters, which gives a recharge of 120 mm.

The subterranean water generally moves toward the south, with a light component towards the southeast; it flows towards the lowest points for final discharge into the sea. In some places, subterranean water emerges on the surface as springs. In the town of La Esperanza, there are two springs with discharges estimated at 100 and 150 gallons per minute in December.

The greatest loss of water by evapotranspiration occurs in the meridional part of the Leon Area where superficial water is found at depths ranging between one and five meters.

e. Hydraulic Properties of the Aquifer

To determine the hydraulic properties of the aquifer, four pumping tests have been made in the Central Valley area situated to the southeast of Leon. Hydraulic properties refer in the aquifer system studies to the coefficient of transmissibility, which determines the case with which the aquifer will transmit water; and the coefficient of storage, which determines the capacity of the aquifer to release water from storage. These coefficients influence the yield of water from wells and the fall of the water level; they are of great use in quantitative hydraulics.

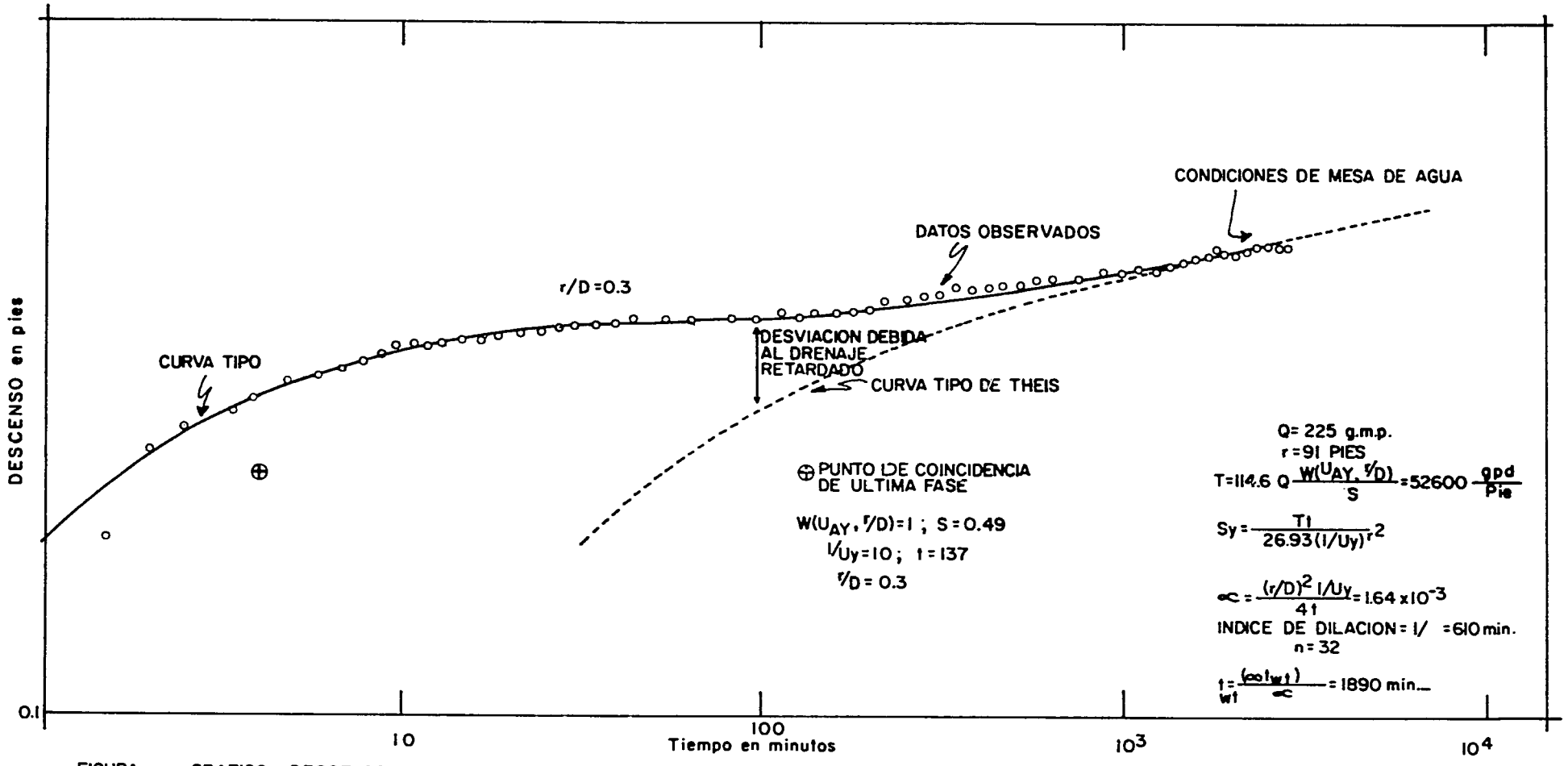


FIGURA - GRAFICO: DESCENSO-TIEMPO DEL POZO DE OBSERVACION: 17.4.67.9 · Km. 83

FIGURE II B-23

A-02

The pumping tests were made in collaboration with the Civic Action of the National Guard, which drilled the wells. The data have been analyzed for the pumping tests made in the vicinity of well number 17.4.67.9 (property of Don Oscar Teran) near kilometer 83 of Managua-Leon highway and in the vicinity of well number 14.4.68.10 (property of Don Anibal Mayorga) of the Hacienda Guadalupe. Both tests lasted for 48 hours, including measurements of the descent and recovery. A resume of the tests is given in Table IIB-1.

The coefficients of transmissibility and storage and specific yields have been calculated by the method of the "Type Curve" for unconfined conditions of the water table or aquifer. Analysis of the data taken in the pumping tests shows that the classic method of "Theis" is not applicable, because the water is not released immediately to the well. This is the result of an unconfined aquifer system, where drainage is affected by gravity and has a slow rate of displacement. It is particularly true in the present case, because during the first minutes of pumping, in the graph of descent versus time the data observed depart from the type curve of non-equilibrium in a system of flow of non-permanent regime (See Figure IIB-23).

As the time increases, the observed data have to be identified with the type curve of non-equilibrium. As a result, there is a lapse of time during which the retarded drainage by gravity has a marked effect on the observed descent of the water level; thereafter, true water table conditions take place. In this connection, PRICKETT (1965) introduced the concept of "Index of Dilation", which is intimately related to the time that should transpire until the effect of retarded drainage would not be appreciable in the observation wells. This parameter has an apparent relation to the character of the material through which the drainage by gravity takes place; as the grain size of the material decreases, the index of dilation increases.

In the Leon Area, it will be necessary to make more pumping tests and granular analysis of the samples from the wells to confirm this relationship.

It is certain that there is an influence of retarded gravity drainage during the first part of pumping;

there may be also an effect produced by some means of recharge, such as the proximity of a lake or reservoir, or by a filtered artesian aquifer system. In the Leon Area, however, these possibilities have been discarded, because geologically it has been established that the aquifer system is unconfined, that is to say, the water table presents a free surface. Table IIB-1 presents a resume of results of the analysis of the pumping test data.

TABLA IIB-1

RESUMEN DE LOS RESULTADOS DEL ANALISIS DE LAS PRUEBAS DE BOMBEO

POZO	KM 83	Guadalupe
Coeficiente de Transmisividad T gpd/pie	52,600	39,000
Rendimiento Específico, S_y	.03	.063
Indice de Dilación, en Minutos	610	751
T_{WT}, en Minutos	1,890	2,330

The value of T_{WT} shows that in future pumping tests in the area under investigation the duration should be 72 hours (3 days) in order to realize true behavior of the aquifer under non-confined conditions.

TABLA IIB-2

DATOS DE LOS POZOS UTILIZADOS EN LAS PRUEBAS DE BOMBEO

	KM 83		GUADALUPE	
	Pozo Bombeado	Pozo de Observacion	Pozo Bombeado	Pozo de Observacion
Profundidad en pies	92	65	150	110
Diametro, en pulgadas	6	8	6	8
Tubería ranurada, pies	80	-	80	-
Descarga, GPM	225	-	180	-
Fecha en que se Efectuo la Prueba	Nov.15-17 1965	-	Nov.23-25 1965	-
Duracion, Horas	48	-	48	-

f. Chemical Quality

In general, the water that is consumed in the Laon Area is of good quality and the inhabitants do not have difficulty in using it domestically. In some places, however, there is danger of bacteriological contamination, because the wells have been dug near livestock ponds. As a rule, such wells are not provided with a top or other means of protection.

The propietors of well 21.1.68.2 (El Carmen) report that in the rainy season they extracted water that was a "little hard" and with a disagreeable taste.

Table IIB-3 presents the chemical analysis of four samples of water, prepared by the laboratory of the Empresa de Luz y Fuerza de Managua. According to these results, the water is bland and of slightly basic character, except sample number 1. The content of total dissolved solids is within the limits permitted for domestic consumption.

5. Significance of Climatology and Hydrology to the Pilot Area

Climatology confirmed the uniform semi-humid, tropical conditions expected for the area. Sunshine and rainfall are adequate for agriculture but the 6-month dry season constitutes a problem. Evapotranspiration loss is only moderate here, so that a large part of the rainfall is available as groundwater below the evaporation zone. Wind is moderately destructive at times.

The surface runoff is low because of the high infiltration and storage capacity of the region, therefore, only a few streams flow throughout the year with moderate volume. This runoff is flashy and for short periods can amount to 25% of the rainfall, causing severe flooding, erosion, and ponding for long periods in areas of restricted drainage.

Groundwater of good quality is available in the central part of the area at 5 to 30 meters of depth with a lowering of only about two meters during the dry season. The water table slopes about 7 meters per kilometer towards the ocean. Existing wells and aquifer studies indicate that yields of at least 100 to 200 gallons per minute can be expected. The safe yield based on annual recharge from rainfall is from 75 to 150 mm. per year over the entire area. In other words, it is likely that this amount could be used for irrigation without depleting the supply.

As a result of these hydrologic ivestigations, in combination with integrated information from the other disciplines, many development possibilities can be considered. Ground-water is plentiful and not too deep, but the costs of wells must be balanced against the increased crop yields they might make possible. Two irrigation-well projects are operating in the area and should be studied. Another possibility is increased farm-water supply, especially for livestock. More windmills might prove feasible, especially low-cost types.

Surface water uses may have possibilities, but more study is needed. Ten dams and reservoirs within the Pilot Area should be studied for water-holding capacity and performance in their intended purposes. The project on the Rio Grande shows promise for increased irrigation. A larger dam here possibly could provide more hydroelectric power. In general, adequate dam sites for surface water storage in the area are rare.

A number of possibilities for improvements in drainage and erosion control were revealed by this study.

TABLE IIB-3

RESULTADOS DEL ANALISIS QUIMICO DEL AGUA

(Fecha: 6 de Enero de 1966)

Caracteristicas Quimicas	POZO			
	13.4.69.1 El Socorro A. Hernandez	17.4.67.9 KM 83	23.3.65.2 Los Castillos	13.569.1 H. Hernandez
Conductividad a 78º F. micromhos	400	200	220	180
Solidos Disueltos, PPM	300	150	165	135
Cloruros, PPM	25	7	7	6
Dureza PPM	162	79	79	72
Silica, PPM	90	90	90	90
Alcalinidad P. PPM	0	0	0	0
Alcalinidad MO, PPM	90	100	100	83
p^H	6.9	7.1	7.1	7.1

TABLE IIB-4

DESCRIPCION DE LOS POZOS EN EL AREA DEL MOSAICO LEON S.E.

Ubicacion	Nombre	NIVEL DE AGUA Bajo la Superficie	Fecha de Medida	Tipo de Fuerza *	Uso de Agua **	Temperatura F°
13.7.68.5	San Cayetano	8.41	20-11-65	M	D	--
13.7.67.1	Santo Domingo	4.36	20-11-65	M	D	--
14.4.72.4	La Caballera	12.64	26-11-65	MV	DA	--
14.5.68.10	Guadalupe	6.71	22-11-65	M	D	--
14.4.68.10	Guadalupe			--	--	--
14.2.66.6	La Bellisima	6.53	20-11-65	M	D	--
14.4.66.3	San Jeronimo	2.96	20-11-65	M	D	--
14.10.65.10	La Delicias	3.24	18-11-65	M	D	--
15.8.70.7	Chiriqui	5.39	25-11-65	D	DA	--
16.8.70.7	Santa Clara	9.78	9-12-65	E	D	--
16.2.68.3	San Francisco	2.85	26-11-65	M	D	--
17.1.72.3	Vicente Medina	19.36	26-11-65	M	D	--
17.1.69.2	San Pedro	4.90	9-12-65	M	D	--
17.4.67.9	Km. 83	1.50	9-12-65	--	--	--
17.9.66.7	P. Caballero	6.55	9-12-65	M	D	--
17.9.65.9	San Carlos	8.45	26-11-65	M	D	81
17.10.64.6	Los Ranchos	6.35	26-11-65	M	D	81
18.1.71.7	Angela Chavez	17.80	26-11-65	M	D	82.5
18.3.69.8	Sta. Isabel	6.60	9-12-65	M	DA	--
18.1.68.1	El Carmen	4.93	9-12-65	M	D	--
18.1.67.4	A. Juarez	4.19	9-12-65	M	D	--
18.1.66.3	F. Caballero	7.69	9-12-65	M	D	--
18.5.65.5	La Cruz	7.85	26-11-65	M	D	82.5
19.371.4	Las Mercedes (Marina Reyes)	18.58	26-11-65	M	D	82.5
19.10.71.4	San Benito	22.00	26-11-65	M	D	82.5
19.8.67.8	La Esperanza	3.98	26-11-65	M	D	82
19.10.67.4	Humberto Herdocia	5.37	26-11-65	E	I	--
19.5.64.2	El Ranchon	3.86	19-11-65	E	D	--
20.5.61.7	San Martin	21.00	26-11-65	M	D	--
20.4.70.5	Estacion La Ceiba	16.34	26-11-65	M	D	82.5

TABLE IIB-4 (Continuacion)

Ubicacion	Nombre	NIVEL DE AGUA Bajo la Superficie	Fecha de Medida	Tipo de Fuerza *	Uso de Agua **	Temperatura F°
20.8.69.1	Rosaura Castellon	14.46	26-11-65	M	D	82.5
20.10.67.4	Gancho de la Rosa	3.46	26-11-65	M	D	82
20.8.66.5	Apolonio Gomez	4.00	26-11-65	M	D	81
20.3.64.8	El Caguano	3.41	19-11-65	E	D	--
21.7.69.1	San Jorge	23.39	19- 1-66	M	D	--
21.2.68.2	El Carmen	13.34	26-11-65	M	D	83
21.2.68.1	El Carmen	13.54	26-11-65	--	--	--
22.4.71.5	Santa Ana (Leandro Gutierrez)	39.17	18- 1-66	C	D	83.5
22.3.70.1	El Socorro (Felipe Espino)	31.7	18- 1-66	C	D	--
22.8.68.2	Buenos Aires (Manuel Melendez)	18.24	19- 1-66	M	D	--
22.2.65.10	San Antonio	4.68	26-11-65	M	D	81
23.2.71.5	San Francisco (Francisca Gutierrez)	46.1	18- 1-66	C	D	83
23.7.67.7	San Isidro (Juan Rodriguez)	17.04	19- 1-66	M	D	--
23.3.65.2	Las Castillas	5.58	19-11-65	D	I	--
24.3.61.1	Las Mercedes (Bernabe Oliva)	46.30	19- 1-66	C	D	--
24.6.69.10	Santa Marta	35.68	19- 1-66	D	D	--
25.1.61.9	Refugio Guido	67.98	19- 1-66	C	D	--
25.3.61.1	Rigo Munguia	50.31	19- 1-66	C	D	--
25.10.68.10	Salome Munguia	38.60	19- 1-66	C	D	--
25.3.67.7	Romilia Hernandez	27.34	19- 1-66	M	D	--
25.2.67.2	Estación Amatitan	25.47	19- 1-66	M	D	--
26.6.70.1	Santa Maclobia (Jose Hernandez)	46.21	19- 1-66	C	D	--
26.1.70.6	Santa Anita (Jenaro Munguia)	49.87	19- 1-66	C	D	--
26.7.66.7	Santa Barbara	29.68	19- 1-66	D	D	84

* Tipo de Fuerza:

A mano	M
Molino de viento	MV
A caballo	C
Diesel	D
Electrica	E

** Uso del Agua:

Domestico	D
Irrigacion	I
Abrevadero	A
Domestico y Abrevadero	DA

FIGURE 11C-1 AN INTERDISCIPLINARY GROUP EXAMINING SOILS IN A DEEPLY ERODED ROAD

FIGURA 11C-1 UN GRUPO INTERDISCIPLINARIO EXAMINA EL SUELO EN UN CAMINO PROFUNDAMENTE EROSIONADO

C - SOILS

1. Soil Survey Procedures

To begin this survey, photographs were examined stereoscopically to determine the areas which had similar topographic features. In addition to similar topographic features, areas which had similar photographic patterns were selected for initial field examination. Photo examination also revealed probable accessibility of areas.

An early decision was made to confine the soil survey to the areas covered by mosaics of Leon SE and La Paz Centro SW because of time limitations.

The initial field work consisted of making traverses of the area with frequent stops to examine the soils. These were examined by cutting back the face of exposed road or ditch banks. Holes were dug were exposed banks were not available in the places that needed examination. At all sites examined, notes were made on those soil characteristics which would help define or differientiate one series from another. Soil scientist made notes on soil color, depth of soil, thickness of horizon, soil texture and soil structure. These field notes were used to differentiate one soil from another and to delineate the several series that were identified.

From these observations a determination was made as to which soil, with what specific characteristics, occupied the largest area in each mapping unit. This was then considered the typical profile. The typical profile was described in detail for a freshly dug pit. Samples were collected of each horizon for laboratory analysis. Descriptions of these typical profiles are included in this report. From these field observations, mapping unit descriptions were written. Most of the mapping units consists of soil associations. Because the study is a reconnaissance survey, however, only the dominant soil is listed in each mapping unit.

Soil series as identified in this report must remain provisional until their validity is verified by determining: (1) that they are sufficiently extensive; (2) that the characteristics of the typical profile are truly representative of this soil over a much larger area; (3) that the distinguishing characteristics have been properly identified and verified by recorded field observations and laboratory data;

FIGURE IIC-2 NICARAGUAN AND NRD/IAGS PERSONNEL EXAMINING SOILS IN A TEST PIT.

FIGURA IIC-2 PERSONAL NICARAGUENSE Y DEL NRD/IAGS EXAMINAN EL SUELO EN UN HOYO DE PRUEBA

(4) that the series, as presently conceived, do not infringe upon series already established in Nicaragua or neighboring countries. Finally, they must remain provisional until they have been completely described in a formant normally accepted by soil scientists.

Owing to inadequate laboratory facilities, analysis of soil samples was limited to p^H determinations. It is hoped that additional laboratory analyses will be made on these samples as time and facilities permit.

Owing to limitations previously mentioned, this soils survey was not made in the detail necessary for recommendations on a farm-to-farm basis. It does define the general characteristics and locations of the soils, however, and provides a basis for indicating additional soil studies where conditions warrant them. These soils data, when integrated with the data collected by the other disciplines, are of value in defining areas of potential improvement in land use.

2. Definitions

Properties such as texture and color generally vary in the different horizons of the soil. The surface layer is usually darker than the lower horizons. The subsoils usually have more clay if pedogenetic development has occurred. If no development has occurred, the subsoils are usually the same texture, though this may not always be true. The following definitions are presented to facilitate understanding of elements considered by soil scientists in studying soils.

Soil is that part of a natural body of land occupying a portion of the earth's surface which supports plants and has properties resulting from the integrated effect of climate and living matter acting upon parent material, as conditioned by relief over periods of time.

Texture refers to the relative proportions of clay, silt, and sand in the soil. It is determined by the way the soil feels when rubbed between the fingers. These results are later checked by laboratory analyses. The finest particles in the soils are clay. Individual clay particles are so fine that they can be seen only with an electronic microscope. Soils that consist mostly of clay are sticky when wet and hard when dry. Water moves slowly through clayey soils, but they retain moisture and plant nutrients well. Medium-sized particles, those that are large enough to be seen with a microscope, are silt. Silty soils are smooth and velvety. They are less hard when dry and less sticky when wet than the clayer soils. The largest particles in the soil are sand. Individual sand particles are readily discernible. Sandy soils retain little water for plant use; water moves rapidly

FIGURE IIC-3 EXAMINING BURIED PROFILES CUT IN A ROAD BANK.

FIGURA IIC-3 EXAMINANDO LOS PERFILES DE UN CORTE EN LA ORILLA DEL CAMINO

through them. Very sandy soils are low in fertility.

Structure is the arrangement of the individual soil particles into aggregates. When dry, some soils are block-like and others are platy. Soils that do not have structure may be massive or loose when dry. Structure determines the ease or difficulty with which water, air and plant roots penetrate the soil.

Color indicates various soil properties. Dark-colored soils usually have higher organic content than light-colored soils of comparable parent material. Well-drained soils usually have reddish brown and brown subsoils, whereas poorly drained soils usually have subsoils that are gray or mottled with gray and reddish brown. Soil color is determined by comparison to standard "Munsell Soil-Color Charts".

Chemical properties, such as acidity and plant nutrient status, are measured by laboratory tests. These tests also indicate the processes through which the soil developed and how productive it might be.

Drainage refers to the rapidity and extent of water removal from the soil, primarily by surface runoff and by seepage through the soil. It is largely influenced by position on the landscape and is often indicated by soil color.

Permeability is the rate at which water will move through a soil after it has been wet for several hours.

3. Classification

"The purpose of classification is to organize our knowledge of properties of objects and relationships so that they may be more easily understood. 1/ Different combinations of soil characteristics form the basis for separating one soil from another. In determining the kind of soil to map in the Leon Area, combinations of those soil properties which are important to crop production and management were emphasized. The soils were then classified by soil series and phases.

1/ Cline, Marlin G. Basic Principles of Soil Classification. Soil Science. Vol. 67, No.2, pp. 81-91. 1949.

FIGURE IIC-4 IDENTIFYING SOIL HORIZONS

FIGURA IIC-4 IDENTIFICANDO HORIZONTES DE SUELOS

A Soil Association is a group of soils, occurring in characteristic patterns and properties, which have been defined and recognized.

A Soil Series is an area of soil that may vary in surface texture but otherwise has genetic horizons which are similar in differentiating characteristics and have the same arrangement in the soil profile. Soils within a series have developed from the same kind of parent material. They may vary in slope or in other features external to the soil profile. 2/ Each series is generally given the name of the most prominent topographic feature in the locality where it is found.

A Soil Type is a subdivision of the soil series based on the texture of the surface soil. 3/ It has the same profile characteristics as the series except texture of surface soil, which differentiates one type from another. Soil types were not mapped during this survey. The surface texture listed for the series in this report is the texture most commonly encountered.

A Soil Phase is a variation within the soil type, mainly on such characteristics as relief, stoniness, accelerated erosion, wetness, or depth of surface soil.

A miscellaneous land type is a land area that has little or no natural soil, that is inaccessible or that for some other reason cannot be feasibly classified and mapped in detail.

4. Mapping Unit Descriptions

The mapping units described in this report consist of areas of significant size wherein there is a predominant soil with specific characteristics, as described in the typical soil profiles. Fifteen mapping units (Figure IIC-5) were recognized within the survey area. They ranged in size from 60 to 9,031 manzanas. The smaller units were identified because they were distinctly different and exist in larger areas outside of the Leon Area.

2/ Riecken, F.F. and Smith G. Lower Categories of Soil Classification: Family, Series, Type and Phase. Soil Science, Vol. 67, No.2, pp. 107-115. 1949

3/ Soil Survey Staff. Soil Survey Manual. USDA Handbook No.18.1951

The typical profiles mentioned in the mapping unit descriptions appear in the report following Table IIC-1.

Amatitan clay loam (Amt). The soils of this mapping unit are deep to moderately deep, well-drained permeable, loamy surface soil with a clayey subsoil having discontinuously indurated talpetate. They occur on a level to slightly undulating plain which slopes to the south and is dissected by deep drainageways. The slope range is 0-5 percent.

Soils of this unit are very dark brown to dark reddish brown; they are genetically well-developed. The surface soil texture varies from loam to clay loam. The subsoil has a higher clay content and a well-developed soil structure, which is characteristic of well-developed B_2t horizons. Underlying the B_2t horizon is found a discontinuously cemented horizon of talpetate, which exists as an indurated layer in places. In other places, it consists of cemented fragments found in a layer. It is a horizon of secondary enrichment. The typical reaction is neutral.

The major variations from the typical profile are the degree of consolidation of the talpetate and the form in which it occurs. It may range from a few aggregates of gravel size to a consolidated hardpan of irregular upper and lower limits. Thickness of the surface horizon is also variable, principally because of erosion.

Major inclusions within the mapping unit are small areas of poorly developed soils, including grumosols. Inclusions of grumosols occur mainly around the head of drainageways.

Much of this mapping unit is in cultivated crops and pasture. Erosion of the more friable surface soil should be controlled to prevent exposure of the fine textured subsoil; the latter is more difficult to work and has a slower water intake rate. These soils have a high water-holding capacity. Roots are restricted by the talpetate where it is consolidated. Crop growth indicates that these soils are highly fertile.

Chacara clay loam (Chr). The soils of the mapping unit are deep, moderately well drained to poorly drained, slowly permeable and clayey. They occur on nearly flat to gently sloping land which has had poor drainage. The lowering of the river levels has materially improved drainage within this mapping unit. Slope ranges from 0-5 percent.

These soils are very dark grayish brown near the surface and light gray in the subsoil. Surface soils are loam and clay; the subsoils are clayey, becoming light gray clay loam at lower depths. These soils crack when dry and may have blocky structure as a result of alternate wetting and drying of the fine-textured material. Abrupt changes in texture occur from one horizon to another. A high water table occurs over large portions of this mapping unit during the rainy season. Typically, the soil reaction is neutral. Major variations from the typical profile is the textural differences between comparable horizons and the difference in structure of the subsoil. Depth to the light gray horizon varies from 50 to 90 centimeters.

The dominant inclusion within this mapping unit is an area around La Leona of a soil which has a hardpan at 70-90 centimeters. This inclusion is mostly La Paz Vieja soils. Other inclusions are small areas of the Concepcion and Leon series in the more elevated and better drained areas. Areas of a wet phase are also included, but would require a more detailed study to separate.

The Chacara clay loam soils are in pasture and in cultivated crops. The better drained crop areas are usually planted to cotton. Some parts are inundated during part of the rainy season. Use of machinery when the soil is wet results in soil compaction.

Chacara clay loam, wet phase (Chr H). The soils of this mapping unit are deep, poorly drained, slowly permeable, and clayey with a high water table during the rainy season. They occur on a very level, low, concave area which serves as an accumulation basin for waters from the surrounding higher ground. It has very shallow drainageways and is the location of several springs. Slopes range from 0-1 percent.

Soils of the unit are very dark in the surface and light gray in the subsoil. Dominant textures are clay loam and clay, with a high content of organic matter. A light gray horizon is found within one meter. Occasional strates of sand may be evident. During the wet season, these soils remain saturated and the water table may rise to the surface. Typically, the soil reaction is neutral.

Major variations from the typical profile are the occurrence of stratas of materials-which vary in texture from loam to sandy loam. Depth to the light gray horizon, which indicates the occurrence of a high water table, varies from 50 to 90 centimeters.

Inclusions found within the mapping unit consist of small areas of recent alluvial accumulations.

These soils are very limited in their adaptability to cultivated crops. The high water table during the rainy season precludes the use of machinery and sometimes cultivation by any means. On the other hand, the fine-textured soil makes seed-bed preparation difficult while the soil is dry, at least without mechanization. Crops must be limited to those which require little or no cultivation until drainage is corrected.

Concepcion loam (Cpe). The soils of this mapping unit are deep, well-drained and moderately permeable with a loam surface, a silt loam subsoil and a high waterholding capacity. They occur on nearly level to gently sloping land having a gradual slope from north to south; the slope range is 0-5 percent.

These soils are very dark grayish brown with little color change in the soil profile. The surface soil is usually loam or silt loam, the subsoil is silty, the substratum may by silty or sandy. Except for slight darkening of the surface soil, pedogenic development is not evident. Only occasional small gravel is present. Slight stratification is sometimes noted, and buried profiles occur. The soil reaction is neutral.

Among the major variations from the typical profile is the wide variance in surface textures which may include fine sandy loam, loam, or silt loam. The depth to the silt loam subsoil is variable, though usually it is within 70 centimeters. Pronounced stratification is not typical but is evident in small areas of the unit. Where pockets of brittle material occur (believed to be the initial stages in the formation of talpetate) they are included if the profile is similar to that of this mapping unit. The major inclusions within the mapping unit are areas of the Leon and La Paz Vieja soils, the latter occurring as isolated small areas. The Leon soils normally occur along the outer edges of the mapping unit.

Most of this mapping unit is cultivated, but portions of it are in pasture. These soils usually supply sufficient water for plant use; tilth and crop growth indicate sufficient organic content and high fertility. They are quite susceptible to wind and water erosion, however, and a very high portion of the unit has been terraced.

Hato Grande clay (Hg). These soils are deep, slowly to poorly drained, very slowly permeable, clayey grumosols. They occur on a slightly concave to very flat broad alluvial fans. Surface drainage is poorly developed and the area generally is inundated by runoff during the rainy season. The slope range is 0-1 percent.

Typically, they have black surface soils and olive-brown subsoils. Surface soils are clay loams and clays; subsoils are clay. These soils have no genetic profile development. The clay parent material is montmorillonite and forms cracks from 5 to 10 centimeters wide when dry. A neutral to weakly alkaline reaction is typical.

Major variations from the typical profile are the thickness of the horizons. The amount of cracking and depth to calcareous material are also variable. Small areas of alluvial soils occur as inclusions where drainages flow into the flatter areas of these grumosols.

Soils of the unit are used generally for native pasture, but they are also adapted to rice culture. The high clay content makes them difficult to work when dry, and to avoid compaction they should not be cultivated when wet. These characteristics place severe restrictions on both the kind of crops and when they can be cultivated. The area is partially inundated during the rainy season, when it is practically inaccessable to animals as well as vehicles.

Karawala stony silt loam (Krl). The soils of this mapping unit are well drained, permeable, shallow to moderately deep extending to weathering basalt bedrock or pumice. They are stony and/or gravelly, occurring in an area consisting of ancient lava flows which are stony. Areas that are very stony and rough are interspersed with those having a generally flat topography. The dominant slope ranges from 5-15 percent.

These soils are very dark grayish-brown to brown in color. They are stony with silt loam and very fine sandy loam textures. There is no significant profile development. In the subsoil, soil occurs chiefly as filler material between the rocks. At 50-80 centimeters is found either bedrock or a very stony horizon. These soils have a neutral soil reaction.

Major variations from the typical profile are depth to rock, amount and size of rock, as well as differences in topography. Rock or gravel content may range from 5-95 percent. Inclusions in this unit are rock outcrops and deep soils that are stony and unnamed.

Soils of the unit are mostly in native pasture. Cotton is grown on the deeper soils included within this mapping unit. Shallow depth and stoniness are the main limitations to cultivation. Removal of some rocks has taken place, but it is usually impractical to develop large areas for agricultural use.

La Paz Centro loam (LPc). The soils of this mapping unit consist of a soil association having more than one soil as a major component. The soils named La Paz Centro are deep, well drained, moderately permeable soils of loam and clay textures. Unidentified soils of the unit consist of loamy soils shallow to moderately deep over pumice rock, or deep gravelley soils which show no genetic development.

These occur in a hilly area of low rounded hills with shallow drainageways. Slopes range between 5 to 10 percent within the drainages and from 10 to 30 percent on the hills.

The La Paz Centro soils occur within the valleys. They are very dark brown to very dark grayish brown. Surface soils are deep, dark loams, with small amounts of fine pumaceous gravel and a high organic content. A slight accumulation of clay occurs in the subsoil, especially on the more gentle slopes near the valley bottoms.

The soils on the rounded hills are shallow loam and clay loam underlain at varying depth by pumice. Deep loamy and gravelly soils occur in intermediate positions between the valley bottoms and the hills. All soils within this mapping unit have a neutral soil reaction.

Variations from the typical profile within the valleys consist mostly of recent alluvium with considerable range in texture. Stratification and gravel content also vary.

Dominant inclusions in the valley are unnamed alluvial soils. On the hills the inclusions consist chiefly of rock outcrops. Detailed surveys could easily separate some of these soils.

The soils in the drainageway are generally cultivated in corn and sorghum with some improved pasture. Soils on the hills are mostly in pasture. Very little cotton is grown in this mapping unit. The valley soils are subject to considerable erosion because of steep slopes and the clean cultivation required for corn and sorghum. Fertility is generally depleted as a result of this erosion and the failure to apply fertilizer. Small size of farm units, lack of erosion control, lack of fertilization and inadequate pest control contribute to a relatively low level of agricultural production.

La Paz Vieja, fine sandy loam (LPv). These soils are moderately deep to deep, rapidly drained, moderately to rapidly permeable soils of medium texture, underlain by a discontinuously cemented horizon. They occur on a slopping small area west of La Paz Vieja. The slope range is from 5 to 10 percent.

These soils are very dark brown to brown underlain by a discontinuously cemented hardpan at depths of 80 to 150 centimeters. The texture of the soil above the hardpan is usually very fine sandy loam. It shown no pedogenetic development. Typically, the soil reaction is neutral. Major variation is the depth to the hardpan. The surface texture may include loam, sandy loam and silt loam.

The dominant inclusions are small areas of Leon and Concepcion series, which lack the hardpan. Also included are very small areas of grumosols (Hato Grande soils). Soils of the unit are usually suitable for cultivation, since the hardpan is not continuous and lies at considerable depth. Because the hardpan occurs on a slope the soil drains without creating a perched watertable. Though fertility is moderate, the soil is susceptible to both wind and water erosion.

Leon fine sandy loam - nearly level (Ln).

The soils of this mapping unit are deep, well drained, rapidly permeable, fine sandy loams having a low water-holding capacity. They occur on a nearly level to gently undulating plain, which slopes slightly (0 to 5 percent) from north east to south.

These soils are very dark brown to dark yellowish brown and consist of a series of buried profiles having very little profile development. Only an A and a C horizon sequence is found. As many as five buried profiles have been detected on road cuts 15 to 20 feet in depth. The gravel content seems to be related to volcanic eruptions and is generally greatest just above the buried, darkened A_1 horizon. Size and amount of gravel increases with proximity to volcanic cones. Typically, the soil reaction is neutral. The major variation from the typical profile is in the thickness of the A_1 horizon, and the amount and size of gravel. The texture may range from sandy loam to silt loam. The major inclusions in this mapping unit are areas of Concepcion soils, which occur in the flatter areas

A major portion of the mapping unit is either cultivated or is permanent pasture. Because of the rapid water intake rate and low-water-holding capacity, crop production is dependent on rainfall distribution during the growing season; extended periods of drought often result in serious losses. These soils are also highly susceptible to wind erosion. Poor plant growth and low productivity generally can be traced to low fertility and inadequate moisture.

Leon fine sandy loam, undulating (Ln O). The soils of this mapping unit are deep, well-drained, rapidly permeable, fine sandy loams having a low water-holding capacity. They occur on strongly undulating topography which extends northward from the nearly level phase toward the volcanic cones. This mapping unit was differentiated from the nearly level phase on the basis of steepness of slopes -- 5 to 25 percent. Characteristically, it has more accelerated erosion than the level phase. These soils are the same as the Leon fine sandy loam nearly-level phase. The soil reaction is neutral.

The principal variation from the typical profile is in the thickness of soil horizons, but the subsoil often is not as clayey as it is for the typical profile.

The major inclusions in this mapping unit are the deep, very sandy alluvial soils found along the bottom of drainageways. Truncated profiles, the result of accelerated erosion, are also included.

A large portion of the unit is cultivated or in improved pasture. Steepness of slope results in excessive runoff and erosion; additional erosion is caused by wind. Low water-holding capacity has serious effects on crops during prolonged dry periods. Low soil fertility is indicated by inferior plant growth.

Momotombo sand (Mtb). The soils of this mapping unit are deep, well drained, rapidly permeable, sandy soils with a low waterholding capacity. They occur in gently sloping to nearly level areas or plains between the lake shore, and the nearby hills. Slope ranges from 0 to 5 percent.

These soils are very dark brown on the surface and dark yellowish brown in the subsoil. Except for the darkened surface horizon, no profile development is evident. The textures are dominantly sand and sandy loam. Occasional stratification is evident. Typically, the soil reaction is neutral. Major variations from the typical profile are the thickness of the dark surface horizon and the amount of stratification.

The principal inclusion within the mapping unit is highly stratified recent alluvium. Small areas of finer-textured soils, are also included, but in the aggregate they are not significant.

Although some areas of this mapping unit have been cultivated, much of the cultivation now has been abandoned. Sizeable areas of forest and pasture occur. These soils are droughty, of low inherent fertility, and highly susceptible to wind erosion.

Silvanos loam (Sl). The soils of this mapping unit are deep, slowly drained, slowly permeable, loamy soils with clayey subsoils. They occur on flat to gently sloping land -- 0 to 5 percent -- which forms the slopes of an alluvial fan.

These soils are very dark brown to dark brown and are moderately well-developed. The surface is loamy and high in organic matter. Clay movement has resulted in a more clayey subsoil which extends to a depth of about one meter. Usually, no structure nor clay increase is evident below these depths. Many cracks form on these soils when they are dry. Typically, the reaction is neutral. Major variations from the typical profile are the depth of the dark surface horizon and the amount of fine gravel present.

Within this mapping unit are included recent alluvial soils, which have no profile development, and small areas of grumosolic Hato Grande soils.

These very fertile soils have a high organic content and are largely in pasture and cultivated crops. For the most part, they are moderately well-drained, but low areas are inundated during the rainy season. Cultivation, when wet, results in compaction. They retain a good supply of water for plant use.

Escoria (ESC). This mapping unit constitutes the terminal end of a basalt lava flow which entered the Leon Area from the north, leaving a deposit of hard rock. The surface is very rough and rocky, and is characteristic of this type of flow. Aeolian deposition has filled some of the cracks and pockets that occur in the rocks. The dominant slope ranges from 3 to 10 percent.

Natural forest with a dense understory covers most of the area. There is no agricultural potential for this unit, and excessive stoniness will be an obstacle to the harvesting of forest products.

Miscellaneous Colluvial Lands (TMC). This mapping unit consists of colluvial slopes, escarpments and talus slopes along the rivers and other drainageways, resulting in truncated soil profiles and deep colluvial accumulations.

Deep drainageways may contain excarpments and talus slopes, ranging from 10 to 50 percent.

Waterways having very steep slopes and escarpments are often bordered by gallery forest. Slopes of lower percent have sometimes been cleared for pasture and only occassionally for cultivation. This mapping unit usually is not suited for cultivation, owing to steepness of slopes and periodic large floods. The area is also highly susceptible to erosion particularly when the cover of forest and grass has been removed or burned.

Miscellaneous Rough Broken Lands (TMQ). This mapping unit consists of mountainous country consisting of escarpments, talus slopes and colluvial slopes, often dissected by deep narrow drains or valleys having steep walls. Soils, for the most part, are undeveloped stony soil materials, consisting of shallow, truncated profiles in the eroding portions and of deep colluvial material in the accumulating areas. Slopes range from 20 to 70 percent.

Vegetation consists mostly of natural forest with scattered small areas on gentle slopes that may be suitable for cultivation. The area, as a whole, is not suitable for cultivation because of its dissected, steeply sloping terrain. It is also highly susceptible to erosion, as mentioned above.

The significance of the soil survey to the Leon Area is that it defines the soils which are found within the area and delineates their location and extent. It identifies the soils which are more affected by drought, by indicating their low waterholding capacity. The soil survey also identifies those soils with a high water table that affects land use. Some areas having topographic and geographic limitations for agriculture were not as closely investigated as those obviously adapted to agriculture. Each mapping unit is identified by soil characteristics pertinent to the use of land and by the major problems encountered in its use, especially for agriculture.

Genetic and agricultural considerations entered in the design of mapping units. Thus, the information presented is adapted to further, more intensive studies which will lead to improve agricultural and other land-use practices. The information on soil characteristics supplied in mapping unit descriptions when coupled with information from other disciplines provides a basis for evaluation of land-use potential.

SOIL PROFILE DESCRIPTIONS

Typical Profile	Amatitan Clay Loam
A11 0-15 cm	Dark brown (7.5YR 3/2) moist: loam; massive to granular structure; soft, friable, slightly sticky; p^H 6.9; clear smooth boundary.
A12 15-30 cm	Very dark brown (10YR 2/2) moist; silty clay loam; weak, fine, subangular and granular structure; soft, very friable, slightly sticky; p^H 7.2; clear smooth boundary.
B1 30-42 cm	Very dark brown (5YR 3/2) moist; silty clay loam. moderate, medium, subangular blocky structure; slightly hard, friable to firm, sticky; p^H 7.2; clear smooth boundary.
B21t 42-66 cm	Dark reddish brown (5YR 3/2) moist; clay; moderate, coarse, subangular blockly structure; hard, firm, very sticky; p^H 7.1; clear wavy bound
B22t 66-77 cm	Dark reddish brown (5YR 3/3) moist; clay in 60% talpetate; strong medium subangular and angular blocky structure; hard, firm sticky; p^H 7.1; clear wavy boundary.
B23t 77-102 cm	Dark reddish brown (5YR 3/3) moist; gravelly clay 15 to 20% gravel; moderate, medium, subangular blocky structure; hard, firm, sticky, p^H 6.7; gradual smooth boundary.
B3 102-145 cm	Dark brown (7.5YR 3/2) moist; clay; weak medium sub-angular structure; hard, firm, sticky, p^H 6.5; gradual smooth boundary.
C 145-167 cm	Dark yellowish brown (10YR 3/4) moist; loam; massive; soft, very friable, slightly sticky.
	Chacara Clay Loam
A11 0-20 cm	Dark brown (7.5 YR 3/2) moist; loam; massive; slightly hard, friable, sticky; p^H 6.7; clear smooth boundary.
A12 20-33 cm	Very dark grayish brown (10YR 3/2) moist; clay loam; weak, fine, subangular blocky structure; soft, friable, slightly sticky; p^H 7.1; clear smooth boundary.

Typical Profile	Chacara Clay Loam (cont'd)
B2t 33-69 cm	Very dark grayish brown (10YR 3/2) moist; clay; strong medium angular blocky structure; hard, firm, sticky; p^H 6.9; clear smooth boundary.
C1 69-93 cm	Dark grayish brown (10YR 4/2) moist; sandy clay loam; massive, many fine pores; soft, very friable, sticky; p^H 7.3; clear smooth boundary.
C2 93-153 cm	Light gray (10YR 6/1) moist; silt loam; massive, many fine pores; soft, very friable, slightly sticky; p^H 7.2.
	Concepcion Loam
A1 0-31 cm	Very dark brown (10YR 2/2) moist; silt loam; massive, many fine pores; soft, friable, slightly sticky; p^H 6.5; clear smooth boundary.
C1 31-56 cm	Very dark grayish brown (10YR 3/2) moist; sandy loam; massive, many fine pores, loose, very friable, non-sticky; p^H 6.9; clear smooth boundary
C2 56-73 cm	Very dark grayish brown (10YR 3/2) moist; silt loa massive, many fine pores; soft, friable, slightly sticky; p^H 6.7; clear smooth boundary.
II A1b73-96 cm	Very dark brown (10YR 2/2) moist; silt loam; massive, many fine pores, soft, friable, slightly sticky; p^H 6.7; abrupt smooth boundary.
II C1 96-113 cm	Very dark grayish brown (10YR 3/2) moist; sand; loose, non-sticky; p^H 6.8; abrupt smooth boundary.
II C2 113-145 cm	Very dark grayish brown (10YR 3/2) moist; silt loam; massive, many fine pores; soft, friable, slightly sticky; p^H 6.4; abrupt smooth boundary.
IIC3 145-167 cm	Very dark gray (2.5Y 3/0) moist; gravelly sand; loose, non-sticky; p^H 6.8.
	Karawala Stony Silt Loam
A11 0-27 cm	Very dark grayish brown (10YR 3/2) moist; fine sandy loam; massive ; soft, friable, non-sticky; p^H 7.6; clear boundary.

Typical Profile	Karawala Stony Silt Loam (cont'd)
A12 27-45 cm	Very dark grayish brown (10YR 3/2) moist; fine sandy loam; massive, soft, very friable, non-sticky; p^H 7.2; abrupt smooth boundary.
C1 45-69 cm	Dark brown (10YR 4/3) moist; gravelly very fine sandy loam; massive; soft, very friable, non-sticky; p^H 7.2; abrupt wavy boundary.
C2 69+ cm	Consists of 90% dark gray (2.5Y 4/0) stones with soil material between the stones.
	Leon Fine Sandy Loam
A1 0-47 cm	Very dark Brown (10YR 2/2) moist; fine sandy loam; massive; soft, friable, non-sticky; p^H 6.7; gradual smooth boundary.
C1 47-82 cm	Very dark grayish brown (10YR 3/2) moist; fine sandy loam; massive; soft, friable, non-sticky; p^H 6.8; clear smooth boundary.
C2 82-110 cm	Dark yellowish brown (10YR 3/4) moist; fine sandy loam; massive; slightly hard, friable, non-sticky; p^H 6.5; clear smooth boundary.
II A1 110-127 cm	Dark brown (10YR 3/3) moist; silt loam; massive; soft, friable, slightly sticky; p^H 6.6; clear smooth boundary.
II C1 127-153 cm	Dark yellowish brown (10YR 3/4) moist; silt loam; massive; soft, friable, slightly sticky; p^H 6.7.
	Momotombo Sand
A11 0-16 cm	Very dark brown (10YR 2/2) moist; gravelly sandy loam; massive; loose, non-sticky; p^H 7.1; clear smooth boundary.
A13 32-55 cm	Dark brown (10YR 3/3) moist; sandy loam; massive soft, very friable, non-sticky; p^H 7.4; clear smooth boundary.

Typical Profile	Momotombo Sand (cont'd)
AC 55-73 cm	Dark brown (10YR 3/3) moist; sandy loam; massive; soft, very friable, non-sticky; p^H 7.3; clear smooth boundary.
C1 73-83 cm	Brown (10YR 4/3) moist; sandy loam, massive; soft, very friable, non-sticky; p^H 7.2; clear smooth boundary.
C2 83-101 cm	Dark yellowish brown (10YR 4/4) moist; gravelly sandy loam; massive; soft, very friable, non-sticky; p^H 7.2; clear smooth boundary.
II A1 101-128+ cm	Dark brown (10YR 4/3) moist; loam, weak, fine, sub-angular structure; soft, friable, slightly sticky; p^H 7.0.
	Silvano Loam
A1 0-14 cm	Very dark brown (10YR 2/2) moist; loam; moderate, medium, platy structure; slightly hard, friable, slightly plastic; p^H 5.5; clear smooth boundary.
AB 14-45 cm	Very dark grayish brown (10YR 3/2) moist; clay loam; weak, medium, subangular blocky structure; slightly hard, friable, sticky; gradual smooth boundary.
B2 45-81 cm	Brown (7.5 YR 4/2) moist; clay; weak, medium, subangular blocky structure; hard, firm, sticky; gradual smooth boundary.
B3 81-106 cm	Brown (7.5YR 4/2) moist; clay; very weak, medium, sub-angular blocky structure; hard, firm, sticky; gradual smooth boundary.
C1 106-128 cm	Dark brown (7.5YR 3/2) moist; sandy clay loam; massive, many fine pores; slightly hard, friable, slightly sticky; clear smooth boundary.
C2 128-172 cm	Dark brown (7.5YR 3/2) moist; loam; massive, many fine pores; slightly hard, friable, slightly sticky; abrupt smooth boundary.
C3 173-175+ cm	Brown (7.5YR 4/2) moist; sand; massive to single grain; loose, non-sticky.

Typical profile	Chacara clay loam, wet phase
A11 0-14 cm.	Black (5YR 2/1) moist; fine sandy loam; massive; soft; very friable, non-sticky; pH7.6; clear smooth boundary.
A12 14-66 cm.	Very dark brown (10YR 2/2), gravelly silty clay loam; massive; soft, friable, slight, slightly sticky, pH 6.4, clear smooth boundary.
A13 66-86 cm.	Black (10YR 2/1) moist; silty clay loam; subangular blocky structure; soft friable, slightly sticky; pH 6.5; abrupt boundary
C1 86-101 cm.	Very dark gray (10YR 3/1) moist; sandy clay loam; massive; soft, friable slightly sticky; pH6.8; abrupt boundary.
C2 101-139 cm.	Black (10YR 2/1) moist; sandy; massive; loose, non-sticky; pH7.1.
	Hato Grande Clay
A11 0-50 cm.	Very dark gray to black, (5Y 3/1 to 5Y 2/1) moist; clay; very strong, subangular blocky structure; massive; very hard, sticky; pH6.6; abrupt boundary.
A12 50-70 cm.	Block (5Y 2/1) moist; clay; stong subangular blocky structure; massive, very hard, sticky; pH8.2, clear boundary
A13 70-92 cm.	Black (5Y 2/1) moist; clay; subangular blocky structure; massive; sticky; pH8.3; abrupt boundary.
C 92- cm.	Dark grayish brown (10YR 4/2); moist; sandy clay loam; massive; slightly hard, friable, non-sticky; pH 8.5.
	La Paz Centro Loam
A11 0-25 cm.	Very dark grayish brown (10YR 3/2); moist; medium subangular blocky structure, many pores; slightly hard, and sticky; pH6.8; clear boundary.
A12 25-40 cm.	Dark brown to very dark brown (10YR 3/3 - 10YR 2/2); moist; loam, many fine gravels; slightly hard, friable, slightly sticky; pH6.8; gradual boundary
A13 40-61 cm.	Very dark grayish brown to very dark brown (10YR 3/2 - 10YR 2/2); moist; silty clay loam; slightly hard, friable, sticky; pH6.8, clear smooth boundary

Typical profile	La Paz Centro Loam
B1 61-71 cm.	Very dark grayish brown (10YR 3/2) moist; silty clay loam; weak to massive subangular structure; slightly hard friable sticky; pH6.9; clear boundary.
B21 71-100 cm.	Dark to very dark grayish brown (10YR 4/2 to 10YR 3/2) moist; clay loam medium subangular blocky structure; hard very sticky pH6.5; irregular clear boundary
B22 100-113 cm.	Very dark grayish brown (10YR 3/2)moist loam to clay loam; medium subangular blocky structure hard very sticky pH6.6 clear boundary
C 113-140	Very dark grayis brown (10YR 3/2) moist; weak on medium subangular blocky structure; soft to slightly hard non-sticky pH6.7.
	La Paz Viejo Fine Sandy Loam
A11 0-12 cm.	Very dark grayish brown loam (10YR 3/2) moist; massive; soft, friable slightly sticky; pH6.8; abrupt boundary
A12 12-22 cm.	Very dark grayish brown (10YR 3/2) moist; loam; masive; soft slightly sticky; pH7.0; abrupt boundary.
C1 22-46 cm.	Dark yellowish brown (10YR 4/4) moist sandy loam; massive; soft. friable non-sticky; pH6.9; abrupt boundary.
	Leon Fine Sandy Loam. Ondulating
A11 0-16 cm.	Very dark grayish browh (10YR 3/2) moist; fine sandy loam; massive; soft friable non-sticky; pH6.9 clear smooth boundary
A12 16-38 cm.	Very dark grayish brown to very dark brown (10YR 3/2 to 10YR 2/2) moist; fine sandy loam; massive; friable non-sticky; pH7.1; clear smooth boundary.
C1 38-70 cm.	Dark brown (7.5YR 3/2) moist; very fine sandy loam; massive; soft friable non-sticky; pH6.9; clear smooth boundary.
C2 70-107 cm.	Dark yellowish brown (10YR 3/4) moist very fine sandy loam to silty loam subangular blocky structure; soft friable non-sticky pH7.2; clear smooth boundary.

Typical profile	Leon Fine Sandy Loam Ondulating
IIA1 107-161 cm.	Dark yellowish brown (10YR 3/4) moist; loam; medium subangular blocky structure; soft friable slightly sticky; pH7.0

SOIL CHARACTERISTICS FOR AGRICULTURAL USE

TABLE IIC-1

Name of Mapping Unit	Symbol of Mapping Unit	Distribution (in Leon Area)	Area (Manzanas) Percent of Total*	Relief	Slope Percent	Parent Material	Summary of Fundamental Soils Characteristics	Principal Crops and other Use	Management Problems
Amatitan clay loam	Amt	Extensive, occurs in vicinity of Amatitan.	5508 15.4%	Level to slightly undulating, dissected by deep drainageways.	0-5	Volcanic and alluvium of Quaternary age.	Soils with loam or clay loam surface; a reddish clayey subsoil (B2t) at depths of 50-60 cms. The B2t is underlain by a horizon of discontinuously indurated volcanic materials (talpetate). Includes small areas of grumosols near drainages.	Cotton, corn, sorghum, pasture.	Limitation in use of machinery during periods of excessive rain. Erosion, rapid surface drainage, slow internal drainage. Compaction of soil if cultivated wet. Pest control.
Chacara clay loam	Chr	Extensive, southeast of Leon.	4394 12.3%	Flat to gently sloping land disected by shallow permanent streams. Location of several springs.	0-5	Alluvium of volcanic origin of Quaternary age.	Loam and clay loam surface with clayey subsoils. Surface drainage less serious than on wet phase because the stream beds are below the land surface. Gray subsoil indicating water table at 50 to 70 cms.	Cotton, corn, sorghum, pasture.	Poor internal drainage, slow permeability, ponded water in some areas during rainy season. High water table during part of rainy season. Use of machinery limited during the rainy season. Pest control.
Chacara clay loam, wet phase.	Chr H	Not extensive, lowlying flat area south of Leon.	436 1.2%	Concave, low flat area with springs and shallow drainageways.	0-1	Volcanic alluvium of Quaternary age.	Loam and clay loam surface with clayed subsoil. A light gray horizon is found at depths below 50 and 90 cms. The water table rises to the surface during periods of the rainy season.	Banana, cutover forest, with sorghum, cotton and corn on the outer edges of the area.	Inundation or high-water table during portion of rainy season. Difficulty in use of machinery due to wetness. Limited choice of crops. Slow permeability. Pest and plant disease control
Concepcion loam	Cpc	Moderately, extensive, occurs in vicinity of railroad station of La Concepcion.	2645 7.4%	Gently sloping land with gradual slope from north to south.	0-5	Volcanic and alluvial of Quaternary age.	Loam surface silt loam subsoil, good water-holding capacity, moderate permeability, good organic matter content, moderate to good fertility. Easily eroded by wind and water. Profile pedogenically undeveloped.	Mostly cotton, other crops--sorghum, corn, pasture.	Erodes easily by wind and water. Drainage waterways needed as well as erosion control measures. Pest control.

* Refers to Leon Area covered by 2 mosaics.

SOIL CHARACTERISTICS FOR AGRICULTURAL USE

TABLE IIC-1

Name of Mapping Unit	Symbol of Mapping Unit	Distribution (in Leon Area)	Area (Manzanas) Percent of Total*	Relief	Slope Percent	Parent Material	Summary of Fundamental Soils Characteristics	Principal Crops and other Use	Management Problems
Hato Grande clay	Hg	Not extensive, occurs southwest of La Paz Centro	437 1.2%	Flat to slightly concave with gentle slope to the south. Streams are ill defined.	0-1	Clayey alluvial material of volcanic origin of Quaternary age.	Grumosols with clayey surface and subsoil. Difficult to cultivate. Very low permeability. High water holding capacity. High organic matter content. Cracks when dry.	Jicaro pasture, sorghum, cotton.	Water accumulates and ponds in whole general area. Difficult to get into area during rainy season. Soil difficult to work when dry (cloddy), will compact if worked when wet. Deposition occurs in low areas near drainageways.
Karawala stony silt loam	Krl	Moderately extensive, occurs around Karawala southeast of Lake Asososca	1852 5.2%	Undulating to rough, sometimes stony, surface of old lava flow sloping to southeast.	5-15	Lava, scoria and pumice of Quaternary age.	Surface stony silt loam. Stony throughout the profile, shallow to moderate depth to bedrock or large rocks. Rocks range in size from gravel to boulders and in amount up to 95%.	Pasture, cutover forest, cotton, corn, sorghum.	Limited size of areas that can be cleared for farming. Stoniness, shallow soils, low waterholding capacity.
La Paz Centro loam	LPc	Extensive, occurs north of La Paz Centro. Small areas elsewhere.	9069 25.4%	Low hills with small shallow valleys having short valley-filling side slopes.	5-30	Volcanic ash, cinders and local alluvium of Quaternary age.	Valley soils have loam and clay loam surfaces and clayey subsoils. Stratification occurs. Pumaceous gravel varies from 5 to 40% throughout the profile.	Pasture, corn, cotton, sorghum.	Erosion and rapid runoff on slopes. Slow runoff, water concentration and deposition in low areas. Soils on hills steep and shallow to pumice. Wide variety of soils found within mapping unit. Pest control.
La Paz Vieja fine sandy loam	LPv	Not extensive, occurs west of La Paz Vieja.	160 0.4%	Broad, gentle slope bordering flat area which occurs at lower elevations.	5-10	Alluvial and wind deposits of volcanic origin of Quaternary age.	Fine sandy loam surface and subsoil with a cemented hard pan at depths of 80-150 cms. Rapid surface runoff. Moderate to rapid permeability.	Cotton, pasture, corn, sorghum.	Waterholding capacity and root zone limited by cemented horizon. Moderate waterholding capacity. Susceptible to water erosion due to slope. Fertilization needed. Pest control.

* Refers to Leon Area covered by 2 mosaics.

SOIL CHARACTERISTICS FOR AGRICULTURAL USE

TABLE IIC-1

Name of Mapping Unit	Symbol of Mapping Unit	Distribution (in Leon Area)	Area (Manzanas) Percent of Total*	Relief	Slope Percent	Parent Material	Summary of Fundamental Soils Characteristics	Principal Crops and other Use	Management Problems
Leon fine sandy loam, nearly level	Ln	Extensive, occurs in the vicinity of Leon.	6115 17.1%	Level to gently undulatingplains. Less rolling than undulating phase.	0-5	Volcanic materials of Quaternary age.	Deep sandy soils having small amounts of gravel-sized volcanic scoria. Buried profiles and very little pedognic development are typical.	Cotton, corn, pasture, yuca, sesame, sorghum.	Rapidly permeable soils, droughty because of low water-holding capacity, low fertility, easily eroded by wind and water. Pest control.
Leon fine sandy loam, undulating	LnO	Not extensive, occurs east of Leon.	60 0.2%	Undulating to strongly undulating.	5-25	Volcanic materials of Quaternary age.	Deep sandy soils with small amounts of volcanic scoria. Soils consist of a series of buried profiles with very little pedogenic development. Permeability moderate to rapid.	Cotton, corn, pasture, yuca, sorghum.	Soils on steeper slopes are badly eroded and gullied. Rapid surface drainage. Low fertility. Lack of conservation measures. Soil deposition and water concentration in drainageways. Pest control
Momotombo sand	Mtb	Not extensive, occurs west and southwest of Momotombo.	1211 3.4%	Plain near Lake Managua with gentle slope to west. Slightly undulating in places.	0-5	Alluvial and wind blown sands of volcanic origin of Quaternary age.	Sandy soils with rapid water intake and permeability rates. Low waterholding capacity. Low fertility. Low organic matter content. No pedogenetic development of soil profile.	Pasture, cotton	Droughty, takes and releases water rapidly, low fertility. Very susceptible to wind and water erosion. Pest control.
Silvanos loam	Sl	Not extensive, occurs south of La Paz Centro.	790 2.2%	Flat to gently sloping land bordered by hilly land to the north and flat land to the south.	0-5	Alluvium of volcanic origin of Quaternary age.	Loam and clay loam surface, clayey subsoil, slow permeability, subsoil cracks when dry. Slow drainage. Pumaceous gravel may occur in strata or throughout the profile. High in organic matter content.	Pasture, cotton, corn, sorghum.	Slow permeability and poor surface runoff in places. Alluvial deposition in low areas. Compaction when cultivated wet. Vehicular travel difficult in rainy season. Pest control.

* Refers to Leon Area covered by 2 mosaics.

SOIL CHARACTERISTICS FOR AGRICULTURAL USE

TABLE IIC-1

Name of Mapping Unit	Symbol of Mapping Unit	Distribution (in Leon Area)	Area (Manzanas) Percent of Total*	Relief	Slope Percent	Parent Material	Summary of Fundamental Soils Characteristics	Principal Crops and other Use	Management Problems
Escoria Basaltica	ESC	Not extensive, extends to northeast of El Mojon.	232 0.6%	Lava flow with folding. Rough surface generally sloping to the southwest.	3-10	Volcanic flow of molten lava.	Consists of rocky very rough flow of lava with pockets of aeolian soils which support native forest vegetation. The lava rock is hard and unweathered.	Natural forests and understory vegetation.	Not suitable for cultivation. Cannot be easily traversed. Management and harvest of forests difficult.
Miscellaneous Colluvial Lands	TMC	Not extensive, along drainageways throughout the area.	971 2.7%	The steep slopes between the land surface and the drainageway bottom of deep drains.	10-50	Material resulting from colluvial actinn volcanic in origin of Quaternary age.	Lands having a wide variety of soil texture and for the most part truncated by erosion. Very little pedogenetic development. Has inclusion of soils described in this report.	Gallery forest with occasional small areas of corn and pasture	Vary with local conditions and steepness of slope. Mostly not adapted to use of machinery. Excessively drained. Subject to severe erosion when denuded.
Miscellaneous Rough Broken Lands	TMQ	Moderately extensive, occurs south of Leon.	1874 5.3%	Rough broken land consisting of escarpments, tallus slopes, colluvial slopes and narrow steep walled.	20-70	Rock formations, ash and other pyroclastic materials of basaltic origin.	Rocky lands of wide textural variety. Mostly truncated by erosion or deep colluvial accumulation. Very little pedogenetic development.	Natural forest and cleared pastures. Cultivation confined to small areas on more gently slopes.	Problems vary principally with steepness of slopes and shallowness of soils. Erosion severe, particularly when denuded.

* Refers to Leon Area covered by 2 mosaics.

D - LAND USE

1. Survey Procedures

A basic element of the resources of any area in the use to which the land is put. It was necessary, therefore, to determine the types of land use in the Leon Area, the approximate number of manzanas in each and the relative importance of these types. The most rapid and efficient means of accomplishing this was through study of the aerial photos of the area.

After the preparation of the aerial photos, as described in the Introduction, the next step was to study stereoscopicaly the photos in each flight line to: (1) develop a general classification of the images into crop land, forest land, pasture land, urban areas, and industrial areas; (2) select readily accessible points to be studied on the ground for the purpose of determining within each general classification the distinctive types which might be significant and consistently identified on the aerial photos. The points were marked on the 1:50,000 index map.

Several days were spent in visiting the selected points in company with an agricultural economist and land-use authority from the Inter American Institute of Agricultura Sciences, Turrialba, Costa Rica. Some were found to be closely related both in image characteristics and in significance (e.g., corn, sorghum, sugar cane); these were grouped together as a type. Others could be recognized consistently only at certain short periods of the year (as when harvested and in shocks or piles); these, also, had to be grouped with others of similar image.

In the case of one crop, cotton, it was found that this crop could be recognized readily on the photos when the foliage was present. Unfortunately, the photography had been flown in early January when some defoliation had already taken place. Of necessity, therefore, the photos interpreter had to delineate defoliated cotton under corn and other annual crops, from which it could not be consistently distinguished. (see footnotes to Table IID-1).

In some instances the feature and its image had definitely changed in the 22 months since the photography was flown (e.g., a forested area cleared and planted to cotton). The visit to such a point was of value only to emphasize that field study should be conducted as soon as possible after photography is flown, since significant changes in land use can occur in two growing seasons. A check of photo interpretation often must depend on the memory of a local farmer.

Following the field study, it was possible by stereoscopic study of the photos to refine the general classification into types which would have significant differences and could be consistently identified on the available photography. Forest types were classified quite broadly, because of the relative small area occupied by forest and the degraded condition which prevailed in those stands observed in the field. Although not actually found in the pilot area, some types were included because they had definite recognition features and were known to occur not far outside the pilot area.

After delineation of the land-use types on the aerial photos, as indicated later, the delineation were transferred to the mosaics, from which the necessary overlays were made (Figures IID-2, IID-3). Using the dot-grid system, the areas in each land-use type were determined by orienting the dot overlay on the land-use overlay and counting the dots -- each equivalent to one hectare at scale 1:20,000.

It then became necessary to determine the significance of the various types of Land use, after computing the area in each. For this purpose, reliance was placed on data available in several agencies -- Ministry of Agriculture and Livestock, Ministry of Economy - Director General of Statistics and Census, Agricultural PASA Group of AID, General Collector of Customs, National Bank of Nicaragua, and Cadastral Group of the Pilot Project.

Data collected in 1965 by the Cadastral Group on land ownership and land use of 338 properties (Figure IID-4) was compared with data collected in 1963 by Statistics and Census. Correlation could be made with only 127 owners in the Census data, but from the latter it was possible to reach certain conclusions relative to

socio-economic conditions in the Leon Area. Obviously, if time had permitted, field contacts could have brought the land-use data and socio-economic data to a much sharper focus on the Leon Area.

Based on aerial photo interpretation, therefore, the following classification of land-use types was developed and used in the delineation of land use in the Leon Area (two mosaics -- Leon SE and La Paz Centro SW), as shown in the Land-Use overlays.

LAND USE

PHOTO INTERPRETATION LEGEND

A - Cultivated Areas
- 1. Cotton
- 2. Rice
- 3. Vegetable crops
- 4. Corn, sorghum and other annual crops
- 5. Tree and shrub crops
  - a. Bananas, Platanos
  - b. Coffee
  - c. Citrus and other fruits
- 6. Recently plowed

B - Pasture
- 1. Fenced pasture
  - a. Improved - relatively free of weeds and brush; green fodder or hay
  - b. Unimproved -- tree crowns cover less than 40 of the area
  - c. Jicaro -- on grumosol
- 2. Grasslands, unfenced

C - Brush -- Little or no evidence of grazing

D - Weeds -- Little or no evidence of grazing

E - Forest
- 1. Understocked -- area 40-70% crown covered
  - a. Sawtimber and poles: sawtimber 10" (25.4 cm.) and larger in diameter at breast height (d.b.h.); poles 4.5" (11.4 cm.) to 9.5" (24.1 cm.) d.b.h.
  - b. Saplings: 6' (1.8 m.) in height to 4.5" d.b.h.
- 2. Well-stocked -- area more than 70% crown covered

a. Sawtimber and poles
b. Saplings

3. Gallery Forest
4. Mangrove

F - Marsh

G - Vegetation Lacking

1. Rock outcrops or boulders
2. Bare soil

H - Urban Areas -- villages, towns, cities

J - Industrial Areas

1. Cotton gin
2. Sugar mill
3. Brick and tile plant
4. Salt pans

K - Water -- ponds, lakes, seas, rivers

SUPPLEMENTARY SYMBOLS:

X - Erosion

T - Terraced

2. <u>Land Use Types</u>

a. General land use and farm practices

As shown in Table IID-1, almost 90% of the land in the Leon Area is being used for cultivation and pasture, indicating the importance of farming and livestock-raising in the economy of the area. This parallels the importance of agriculture in the national economy, for agricultural products comprise roughly 80% of the value of all exports.

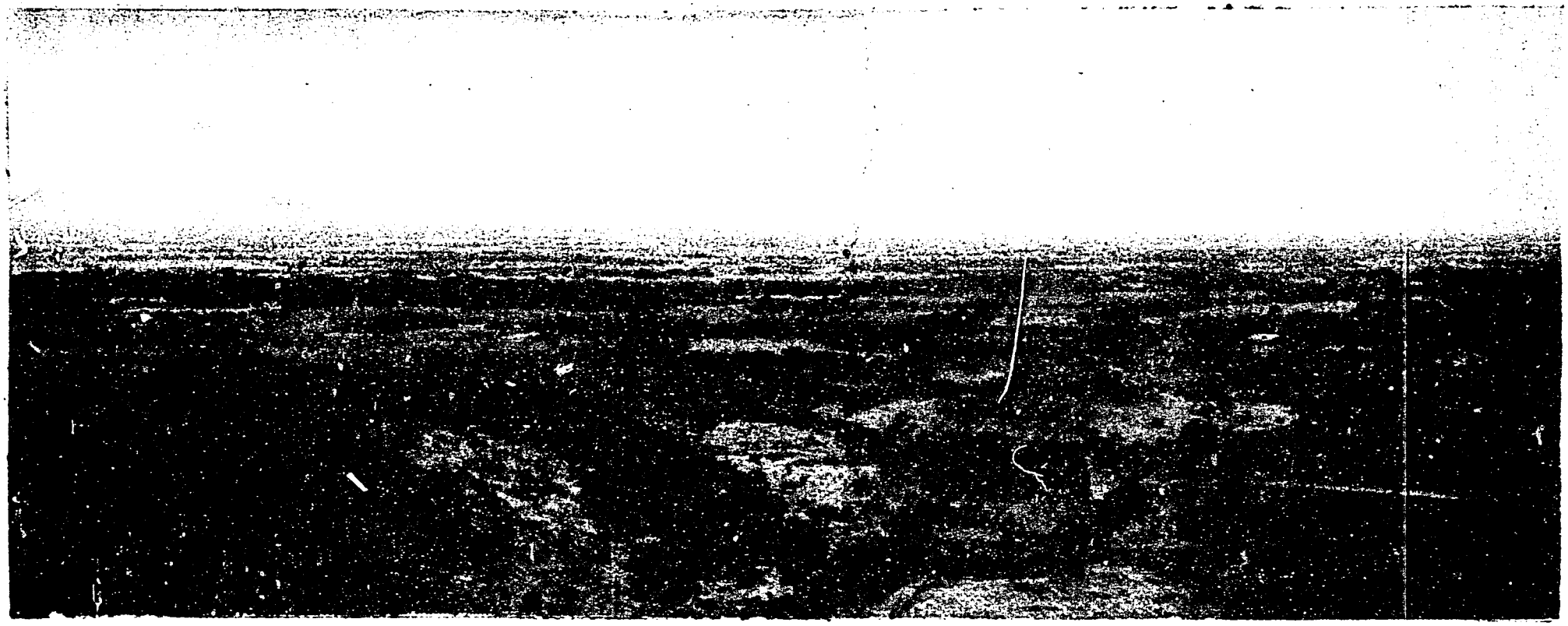


FIGURE II-D-2 VIEW EASTWARD FROM LEON VICINITY -- TERRACED COTTON LOWER RIGHT, IMPROVED PASTURE ON GRASSY KNOB CENTER, UNIMPROVED PASTURE LOWER LEFT.

FIGURA IID-2 VISTA AL ESTE, EN LAS CERCANIAS DE LEON: INFERIOR DERECHA, ALGODON CON TERRAZAS; PROMONTORIO DEL CENTRO, PASTOS MEJORADOS; INFERIOR IZQUIERDA, PASTOS NO MEJORADOS.

Most of the remaining land is in forest, but it is of little commercial importance, as will be discussed later.

Although the Pilot Area is located in one of the drier parts of Nicaragua, with almost no rainfall between November and June, little irrigation is practiced, and there has been little development of available water for livestock or other purposes. Commercial cultivation is confined for the most part to a relatively few main crops capable of producing adequate yields under occasional drought conditions; these crops are cotton, corn, sorghum, and sesame.

Up to the present, fertilizers have been in general use only for cotton in the Leon Area, and the kind and amount applied usually has been based on soil tests. Demonstrations under bank loans have shown the value of fertilizer in raising the yield of other crops, especially corn and sorghum; this is producing a trend toward wider use.

Tractors, seeders, harvesters, and other forms of mechanization are used mainly on the larger farms (over 100 manz) producing cotton. Mechanical cotton pickers, especially, are increasing in number as a result of the competition for labor offered by the coffee and sugar cane harvest. The smaller farmers have not formed cooperatives to provide pools of farm machinery, but some manage to obtain the service of a tractor or other power equipment on a rental basis. Generally, the small farmer still relies on animal power (oxen or horses) and hand labor.

b. Cultivated Areas

(1) Cotton

As indicated in the footnote to Table IID-1, cotton occupies approximately half of the entire area in cultivation. Areas planted to

cotton range in size from 15 to more than 2,000 manzanas. It requires better soil than corn and sorghum, and most of it receives applications of fertilizers. In general, the land on which cotton occurs is gently sloping and widely spaced (20-30 meters) low terraces are built to retard runoff and reduce erosion; see Figure IID-2.

To control insects (Bellotero, Langosta, Picudo) the cotton crop may be sprayed with insecticide (DDT, Parathion, Toxalene) from 15 to 25 times during the growing season, the frequency depending on severity of insect infestation, which is influenced to a large extent by weather. Most of the crop is sprayed by airplane, but owners of small areas often use portable pumps, and some even rely on the drift of aerial spray for adjoining large areas. When prolonged dry weather is affecting the condition of the crop, nitrogen is sometimes added to the insecticide as a means of restoring vigor to the plants. In some years, as in 1965, the drought may be of such severity that a substantial part of the cotton crop is lost. When this occurs, the failed area may be planted in September or early October to sorghum or corn. A week or two before the cotton is picked by machine, the crop is given final spraying, this time with a defoliant to remove the leaves and facilitate picking. Yields average from 30 to 40 quintales per manzana. Roughly 60% of the yield is comprised of the cotton seed.

One study of production costs for cotton revealed a total cost of approximately 1,600 Cordobas per manzana. With a yield of 38 quintales at a selling price of 60 Cordobas, however, there was a net profit of 480 Cordobas per manzana. Thus, cotton is favored as the most profitable as well as most extensive crop in the area. In the national economy, it comprises almost half the value of all agricultural exports.

AREAS OF LAND USE TYPES

Table IID-1

Sym-	Land Use Type	Leon S.E. (Mnzs)	La Paz Centro (Mnzs)	Total Mnzs.	Total Has	Percent of Total
	Cultivation					
*A1	Cotton	818.45	1.42	819.87	579	2.30
A1	Cotton terraced	2,489.30	2,451.05	4,940.35	3,489	13.80
A4	Corn, other annual crop	7,596.68	2,779.55	10,376.23	7,328	29.10
A5a	Bananas	15.58	8.52	24.10	17	0.07
A5c	Citrus, other fruits	19.83		19.83	14	0.06
Sub-total		10,939.84	5,240.54	16,180.38	11,427	45.33
	Pasture					
B1a	Pasture, improved	1,778.46	3,191.60	4,970.06	3,510	13.90
B1b	Pasture, unimproved	2,668.93	7,193.13	9,882.06	6,979	27.70
B1c	Pasture, jicaro	65.14	92.04	157.18	111	0.41
B2	Grasslands, unfenced	76.47	--	76.47	54	0.20
Sub-total		4,589.00	10,476.77	15,085.77	10,654	42.26
	Forest					
E1a	Forest, Sawtimber understocked	1,270.13	803.50	2,163.63	1,528	6.21
E1b	Forest, saplings understocked	114.70	--	114.70	81	0.30
E2a	Forest, sawtimber well stocked	247.80	484.27	732.07	517	2.00
E2b	Forest, saplings well stocked	--	21.25	21.25	15	0.07
E3	Gallery Forest	532.41	164.26	696.67	492	1.95
Sub-total		2,165.04	1,563.28	3,728.32	2,633	10.44
	Other Types					
C	Brush	86.38	370.99	457.37	323	1.21
D	Weeds	12.75	--	12.75	9	0.05
G1	Rock	5.67	24.08	29.75	21	0.09
H	Urban areas	14.16	160.01	174.17	123	0.50
J1	Cotton gins	14.16	11.33	25.49	18	0.08
Sub-total		133.12	566.41	699.53	494	1.97
TOTALS		17,847.00	17,847.00	35,694.00	25,208	100.00

(*See footnote on following page.)

(2) Corn, sorghum, other annual crops

The principal crops comprising this type are corn, sorghum and sesame. Some sugar cane is grown, alone or in mixture with sorghum, but it is of minor importance. An estimated 7876 manzanas were planted in these crops in the Leon Area during 1963-64 season or almost 49% of the total area in cultivation. Planted areas range in size from less than one manzana for home consumption to several hundred manzanas for the market. Some farmers plant two crops of corn, sorghum or sesame in the growing season, the first being sown in June and the second in August or September. The area in the second crop of corn or sorghum is only a fraction of the first, and yield per manzana is usually lower. With sesame, the reverse is true.

Corn, the most important of these crops, has reported yields ranging from 13 to 50 quintales per manzana. Of course, the higher yields are obtained with fertilizing and other good farming practices. Foreign trade statistics for 1962 and 1963 show relatively small quantities being imported as well as exported. Despite increases in planted area and increased yield since 1963, consumption is expanding at a rate, which requires a rising level of imports.

Because of its grater resistance to drought conditions and also because of new support prices,

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Footnote for Table IID-1

The cotton crop was in process of defoliation in January 1964 at the time aerial photos were taken. That part of the crop which had been defoliated could not be identified definitely as cotton on the aerial photos, and much of it was classed among the other annual crops.-A4. It is estimated roughly that 2500 manzanas (1750 hectares) of A4 was actually in cotton without terraces, thus bringing the total area in cotton to about 8200 manzanas (5800 hectares)

sorghum planting is increasing in this area. Although very little fertilizing has been practiced with this crop, demonstrations have shown that fertilizer can raise the yield to 40 or more quintales per manzana in contrast with the usual range of 15 to 25 quintales. Sorghum production is entirely for domestic consumption, chiefly as livestock feed; no exports are reported. Significant areas of sesame are cultivated, especially in the eastern part of the Leon Area. Although it requires good soil and involves some risk, owing to the possibility of damage by rain during harvest, the trend is toward increased planting of this crop. Generally, the yield in sesame seed ranges from 6 to 10 quintales per manzana. The importance and value of sesame as a crop is illustrated by its place as an export product. In 1962 and 1963, almost 6,000 metric tons were exported each year at a price of more than $350 per ton.

(3) Trees and shrub crops

This type, comprised mainly of bananas and citrus fruits, is of little commercial importance in the area; such products are grown chiefly for home consumption. Less than 0.2% of the cultivated area is in fruit crops.

(4) Other cultivation

Very small areas of beans, yuca (cassava), tomatoes and other vegetable crops are cultivated, but the production is small and only for local consumption.

c. Pasture

(1) Improved pasture

As indicated in Table IID-1, almost 14% of the total land in the Leon Area consists of improved pastures. These are fenced areas which have been improved for grazing of livestock by cutting of brush and trees and sowing to forage grasses, mainly jaragua and guinea grass. The area is usually burned and the

grass seed is broadcast. Occasionally, the area may be plowed before sowing, but this practice is confined largely to the more fertile, moist sites where para grass is planted on some pastures to be cut at maturity for green fodder. By far the greater part of the improved pastures, however, consists of jaragua, which tolerates soils of low fertility and tends to crowd out other species. Production of silage and baling of fodder for the dry season are practices which are restricted at present to a relatively few progressive dairy farms and cattle ranches. Thus far, few pastures have been fertilized, and there are no known experiments that might indicate whether this practice would be economically feasible in view of the high local cost of fertilizer.

Beyond the periodic cutting of brush and the sowing of grasses, little is undertaken in the field of good pasture management. Commonly, a specific fenced pasture is grazed for three months and then the stock is removed to another pasture for about the same period. Knowledge of carrying capacities for various pasture conditions is very limited and overgrazing is widespread, resulting in deterioration of pasture. This becomes critical in the dry season when heavy stocking on already closely grazed, dormant grasses ends in the stock becoming severely emaciated and even in substantial losses through starvation. A further loss of weight occurs as a result of the failure to provide adequately distributed water for stock. In some cases, the animals may have to walk two or more kilometers for water. Beef cattle under advanced management practices in the United States increase in weight at four times the local rate. Another practice contributing to pasture deterioration is annual burning for the ostensible purpose of destroying snakes and ticks and encouraging earlier green forage. Here, qualified technical advice is needed to discourage this practice.

Part of the overgrazing problem is the failure to understand that with a given amount of avail-

able pasture and feed, it is better practice to improve the quality of the stock and graze fewer head. This situation points up the need for technical advice, such as might be provided by qualified extension agents.

Spraying stock to control ticks is standard practice. Another insect, torsalo - a grub, is a serious pest in some areas; it is controlled by a chemical compound administered orally.

(2) Unimproved pasture

Totaling roughly twice the area of the foregoing type, unimproved pasture consists of fenced areas bearing scattered trees, brush, patches of weeds and grass. The last is usually a mixture of annual grasses, sometimes invaded by jaragua. Such forage is quite low in nutritive value, requiring extensive areas to support small herds.

Poor management practices mentioned under the preceding type -- overstocking, inadequate water, lack of forage and feed in the dry season -- are even more acute when the rancher relies heavily on unimproved pasture.

Jicaro pasture and unfenced grass lands total a minor area; their conditions and value for forage approximate those of the unimproved pasture.

d. Forest

The original forest vegetation of the Leon Area was in the ecological class of tropical dry forest, containing both evergreen species and those which are decidous during the dry season. Generally, the forest were densely stocked and at maturity the trees often exceed 30 meters in height and 100 centimeters in diameter (at breast height). Owing to man's activities, the forests have shrunken to a fraction of the original area. They now occupy slightly more than 10% of the Leon Area, but as a result of burning, grazing, over-cutting and removal of the trees of better species and higher

quality, they are in a very degraded condition. Further, the area of forest continues to shrink through clearings for agriculture. Probably, the forest type in best condition is the Gallery Forest, which occurs on the moister sites bordering streams.

In the drier forests away from the streams, the most common tree species are:

Scientific Name	Common Name
Lueha candida	Guacimo de molenillo
Guazuma ulmifolia	Guacimo de ternero
Tabebuía chryanthe	Cortez
Cordía allidora	Laurel negro
Enterolobium cyclocarpum	Guanacaste de oreja
Pithecolobium saman	Genizaro
Bursera simaruba	Jiñocuabo
Calycophyllum candidissimum	Madroño
Albizzia caribaea	Guanacaste blanco

In the gallery forest the most common species are:

Andira inermis	Almendro de Rio
Ficus spp.	Chilamate
Guarea excelsa	Tololo
Licamia arborea	Sapotillo
Hymenaea courbaril	Guapinol
Inga spuria	Guabillo

Except for minor quantities of logs going to small local sawmills and wood-working shops, the forests are of little commercial importance to the Leon Area. Probably, their principal value lies in the fuelwood, posts and poles which they provide for the farms and ranches of the area. Even these products are in short supply in many places where farmers are located at an appreciable distance from the nearest woodlot.

The general shortage of forest products in the Leon Area, the relatively small area in forest and its deteriorating conditions all point to the need for a reforestation program as well as a program for the introduction of good forest management practices.

e. Other land-use types

The remaining types found in the Leon Area form less than 2% of the total area. They consists of such disparate features as brush, weeds, rock, urban areas and cotton gins. The small areas occupied by the first three render them of little importance.

Many very small villages, are scattered throughout the area, but there is only one community of significant size -- La Paz Centro, administrative center for the municipio of that name. This is a town of 5,784 population (1964) located on the railroad and a hard-surface road. In addition to being a trading and shipping center for the surrounding agricultural area, it is a producer of pottery, brick, tile and pumice blocks. Although the city of Leon lies just west of the area in which the inventory was made, it exercises more influence on the area than La Paz Centro, owing to its much larger size - 49,435 population (1964) - its industries, and its political importance as headquarters of both a departamento and a municipio. Being located on both the railroad and the main national highway, it serves as a commercial center for much of western Nicaragua. Industrially, Leon has a leather factory, machine shops, textile plants, insecticide plant, paper-products factory, dairy products plant, and cotton gins.

Within the Leon Area, three cotton gins are located near the railroad at La Ceiba, at la Concepcion and at San Jose. Annual production of each averages roughly 70,000 quintales of baled cotton and 100,000 quintales of cotton seed.

E - CADASTRAL SURVEY

1. Survey Procedures

The cadastral phase of the Pilot Project had three functions: identification of properties, investigation of titles, and investigation of land values.

An effort to make use of ownership data from the Property Registry Office and Property Tax declarations to initiate property delineation proved futile -- too much information was inexact or lacking. The alternative was to

gather the necessary data in the field and later verify as much of it as possible in the Registry Office.

The field crews carried the photo mosaics and enlarged copies of the aerial photos at scale 1:10,000 to the Leon Area where a property to property investigation was started. Where a property was inhabited, questions were asked concerning ownership and description of property, and names of adjoining owners. The individual was also requested to show the property boundaries. These were traced on the aerial photo and a number was assigned to the parcel. Area of each parcel was later computed by planimeter. Those smaller than two manzanas and those with very irregular boundaries were actually measured in the field.

Where the property was uninhabited, inquiry as to ownership was made in the vicinity. Then the owner was contacted and requested to show the property boundaries.

The survey covered 340 parcels of rural property, chiefly in the area of mosaic Leon SE, as well as 44 properties in the city of Leon (Figure IID-4).

Access to many parcels was very difficult, owing to lack of roads suitable for motor vehicles. Horses were used in many instances.

Title investigation also was difficult, owing to illegibility of records, an inadequate recording system, and destruction of some records prior to 1953. Of the 340 rural properties checked in the Registry Office only 91, or 26.7 percent, were found. The importance of these property records and their present unsatisfactory condition point to the urgent need for a study to modernize the operation of Registry Offices.

2. Property Evaluation

Data as a basis for property evaluation was scarce and generally unreliable. This was true especially of recorded sales prices and incomes. For evaluation in future cadastral surveys, it would be very helpful, if the natural resources inventory could be completed first, thus making available the classification of land-use potential and the data collected on crop production, costs and selling prices.

III. EVALUATION OF RESOURCE DATA

A. Land-Use Potential Classification

In most underdeveloped countries, the main emphasis has been on the classification of land for agricultural purposes and, sometimes, as a basis for tax assessment. The development of a systematic approach to a land-use potential classification has been given attention in several countries of Latin America. It appears that the approach may well vary with the conditions of the individual region or country, as well as the type of land-use one is seeking to classify. If a country has a climate with adequate rainfall in all seasons, then irrigation is not a requirement. The factors evaluated would differ considerably from those that would be studied in a country with a prolonged dry season or semi-arid conditions. If a broad forested region were being classified, attention might be given to site conditions for timber production, erodibility of soils, ease of access, values for watershed protection, recreation, or agricultural potential.

It is suggested, therefore, that prior to data collection, a preliminary reconnaissance should be conducted to determine the major land uses of the area. With this general view of the potentials of the region, it is possible to list the principal forms of use which the region would appear capable of supporting, perhaps at a higher rate of production than now prevails.

Such uses would be in accord with the social, economic, conservation and planning objectives of the country. The inventory should then be designed to obtain the data required to evaluate the land for these potential uses.

After the inventory is completed, the region can be divided into areas of some degree of uniformity -- in present use, in physiography, in availability or lack of water, in accessibility -- and each area would be evaluated for potential use in terms of the factors of the various disciplines, which would preclude, sustain, or improve that use. The factors can be weighted according to their relative importance in affecting a particular use in the particular areas.

B. Leon Area - Determination of Land-Use Potential

1. Procedure

Utilizing the mosaic and overlay for Leon SE, as well as the topographic map covering that area, the various disciplines, operating as a team, applied their respective overlays and knowledge of conditions to the mosaic and topographic map. They were able to delineate significant areas that were relatively uniform and distinctly different in important respects from adjoining areas. Three of the areas shown on the Land Use Potential overlay (Figure IIIB.1) were selected to represent distinctive physical characteristics and different requirements to effect improved use of the land.

Since these subdivisions are part of a broad agricultural area, it seemed appropriate to evaluate them for agricultural use. Therefore, the factors considered in each case are those that have a direct bearing on the value of the land for farm crops. For another part of the country, some change in factors might be necessary. For the Leon Area, however, the following land-use potential classification was developed.

2. Land-Use Potential Classes - Agriculture

Class I (Evaluation rating 1.0 - 1.5)

Good to excellent for cultivation, including fruit; deficiencies could be overcome at feasible cost.

Class II (Evaluation rating 1.6 - 2.0)

Fair for cultivation; substantial improvement would require considerable investment. Fruit trees or improved pasture may be preferable to cultivation in places.

Class III (Evaluation 2.0 and higher)

Should be in improved pasture or managed forest, though some areas are now being farmed on a subsistence level.

Each of these classes would be supplemental by a suffix to indicate its present land-use status:

1. Already at or near highest potential use.
2. Present use adequate but might be improved
3. Present use inadequate and should be changed or greatly improved.

Thus, Class II-B could mean fair for cultivation but might be improved by irrigation, if feasible.

3. Factors of Evaluation

		Estimated Value
S - Soils		
Texture:	Good, moderate to medium coarse loam	1
	Fair to poor - fine or course	2
	Very fine, very coarse	3
Acidity:	Acceptable or easily corrected, p^H 5.5-8.4	1
	Costly to correct	2
Salinity:	Acceptable or easily corrected, below 0.22% TSS	1
	Costly to correct	2
Stoniness:	Few or no stones	1
	Somewhat stony, not serious	2
	Many stones, difficult to work	3
Fertility:	Fertile or needing little fertilizer	1
	Moderate quantities fertilizer needed	2
	Seriously lacking in fertility	3
Average Depth:	Good, over 1.0 meter	1
	Fair, 0.5 to 1.0 meters	4
	Poor, less than 0.5 meters	6
Water Table:	At proper level	1
	Slightly high in growing season	4
	Generally too high, needs drainage	6

Suitable for Irrigation:

Suitable	1
Suitable, but costly	4
Unsuitable (do not consider under Water-Irrigation Required)	6

L-LANDFORMS:	Slopes 0- 5%, surface smooth	1
	Slopes 6-15%, surface moderately irregular	2-3
	Slopes over 15%, or surface very rough	4-5

CLIMATOLOGY

Cr-Rainfall:	Adequate for year long cultivation	1
	Adequate for most seasonal cultivation	2
	Inadequate for most cultivation	3-5
Ct-Temperature:	Suitable for most crops	1
	Suitable for only a few crops	2

W-WATER:	Irrigation not required	1
	Irrigation required, soil suitable	
	Water by shallow wells, less than 30 meters or Streams yearlong	2
	Water by deep wells, 30-100 meters or Stream impounding feasible	3-5
	Wells of doubtful feasibility or Stream impoundment of doubtful feasibility	6-10

4. Examples of Land-Use Potential Classification
(See Figure IIIB-1)

		Area No.1	Area No.2	Area No.3
Soils - Texture -	Topsoil	3	2	2
	Subsoil	2	2	2
Acidity -	Topsoil	1	1	1
	Subsoil	1	1	1
Salinity -	Topsoil	1	1	1
	Subsoil	1	1	1

	Area No.1	Area No.2	Area No.3
Stoniness - Topsil	2	1	1
Subsoil	2	1	1
Fertility - Topsoil	1	2	1
Average Depth-all soil	4	1	4
Water Table	1	1	4
Suitability for irrigation	6	4	1
Subtotal	25	18	20
S Average	2	1.5	1.7
L	5	1.0	1.0
Cr	2	2.0	2.0
Ct	1	1.0	1.0
W	-	2.0	1.0
Total	10	7.5	6.7
Average	2.5	1.5	1.3
Land-Use Potential Class	III	I	I

(To these classes must be added the suffix numbers, indicating the present land-use status; this may result in the delineation of two or more subdivisions within a class.)

The foregoing examples serve to illustrate the application of a classification system. These areas are indicated by number on Figure IIIB-1; the remaining areas of this mosaic overlay were classified in the same manner.

It should be borne in mind that this is a new classification system developed for agriculture in the Leon Area. How well it would apply to other regions has yet to be determined, and any attempt to use it elsewhere should be done first on a test basis. Some modification might be found desirable. Other classification systems might be found preferable, depending on the objectives of the evaluation and the degree of detail required.

C. Problems, Potentials

1. The three classified areas

The land-use potential classification is of value only if it emphasizes the problems and potentials for improvement of specific areas and suggests recommendations leading toward the solution of the problems or to the improvement of conditions. The three classified areas described previously can be considered with that aim in mind.

Area No.1

With a land-use potential of Class III-3, this area cannot be adapted to good farming, The analysis showed four main factors in which it was deficient: slopes too steep for cultivation, topsoil course and stony, soil unsuitable for irrigation, and wells for irrigation of doubtful feasibility.

This hilly area is not suited to cultivation, but because of the erosive nature of the soil, it is essential that it be kept under good vegetative cover. It is now largely in understocked forest and unimproved pasture, and it can be assumed that it is subject to overgrazing and annual burning, both common practices in the Leon Area. Therefore, it can also be assumed that some erosion is occurring and that there is a continuing deterioration of the grass and forest cover.

With considerable investment in seed and labor, the parts now in unimproved pasture probably could be made more productive, but unless good grazing practices were introduced, the improvement would be only temporary. On the other hand there is a definite need for more forest products in the Leon Area, especially fuelwood, posts, poles and lumber. Therefore, it is recommended that Area No.1 be studied closely by qualified range and forestry technicians to determine whether: (1) the entire area should not be in forest, involving reforestation and the institution of sound forest management practices; or (2) the areas of less slope should be converted to improved pasture under controlled grazing, providing water for stock can be made available at reasonable cost; the balance of the area to be in managed forest.

Area No.2

A land-use potential of Class I-2 was derived for this area. It has no serious deficiencies, though its fine textured soils are relatively low in water-holding capacity. As a result of the latter condition, prolonged dry periods have a serious effect on cotton and some effect, though less, on corn and sorghum production.

It would seem, therefore, that an investigation should be made of the economic feasibility of irrigating by drilled wells. It is recommended that a study be made of the costs of well drilling and pump operation, the water-table draw-down to be expected, and the increase in crop yields that would result from irrigation; in other words, a cost-return study.

Area No.3

The evaluation of factors for this area indicated no serious deficiencies and, as Class I-3, it should be good for cultivation with a prospect for improvement. At present, however, the area is largely in unimproved pasture and degraded forest. These are low forms of use where the land is good for crops. Knowledge of th area revealed that it is almost entirely in one ownership. With the large number of farmers in the Leon Area living at a bare subsistence level on poor land, it would seem that Area No.3 should be contributing more to the economy. It is recommended, therefore, that this area be studied by the Instituto Agrario de Nicaragua as a potential subject under the program of agrarian reform.

2. The general Leon Area

The Leon Area, is common with other rural areas of Nicaragua, faces many problems which must be solved, if the living standard of the average farmer is to be raised to a more acceptable level. Although per-capita income for this specif c area is not available, observations of living cond tions would indicat that it is very little above annual per capita income for the nation's rural population, a meager 385 Cordobas.

From observations made during the course of the field studies and, more specifically, from data collected in 1965 by the Cadastral group of the Pilot Project on 340 properties in the Leon Area, supplemented by 1963

data from the Director-General of Statistics and Census on 127 of the same properties, several deficiencies were evident.

The chief needs of this agricultural area can be listed as follows:

(1) Reduction of illiteracy -- now at an estimated 70% for the rural population of the nation. A census sampling of 127 farmers in the Leon Area showed 67% without schooling and 30% w no more than three grades of primary school.

(2) Increased technical assistance -- to introduce better farming practices as well as an understanding of hygiene and sanitation measures. A sampling of 112 farms in the area revealed that 81% had no toilet facilities.

(3) Development of water facilities where feasible and needed for increased agricultural production and to supply rural communities.

(4) Increased credit facilities, especially for operators of the smaller farms.

(5) Development of farmer cooperatives for improved purchasing and marketing conditions and also for availability of farm machines at reasonable rates. In a sample of 114 farmers, 77% reported that they operated without farm machinery.

(6) Improved roads -- most farms are accessible only by ox-cart, horse back, or jeep in the rainy season.

(7) Larger supply of forest products at reasonable cost -- through a program of reforestation, fire control and forest management.

NICARAGUA 1:20.000

LEÓN SE

EDICIÓN PROVISIONAL

HOJA 2853 III SE

Escala 1:20.000

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PROYECCIÓN TRANSVERSAL DE MERCATOR

Impreso por la Dirección General de Cartografía, Managua, Nicaragua, C. A. 1988

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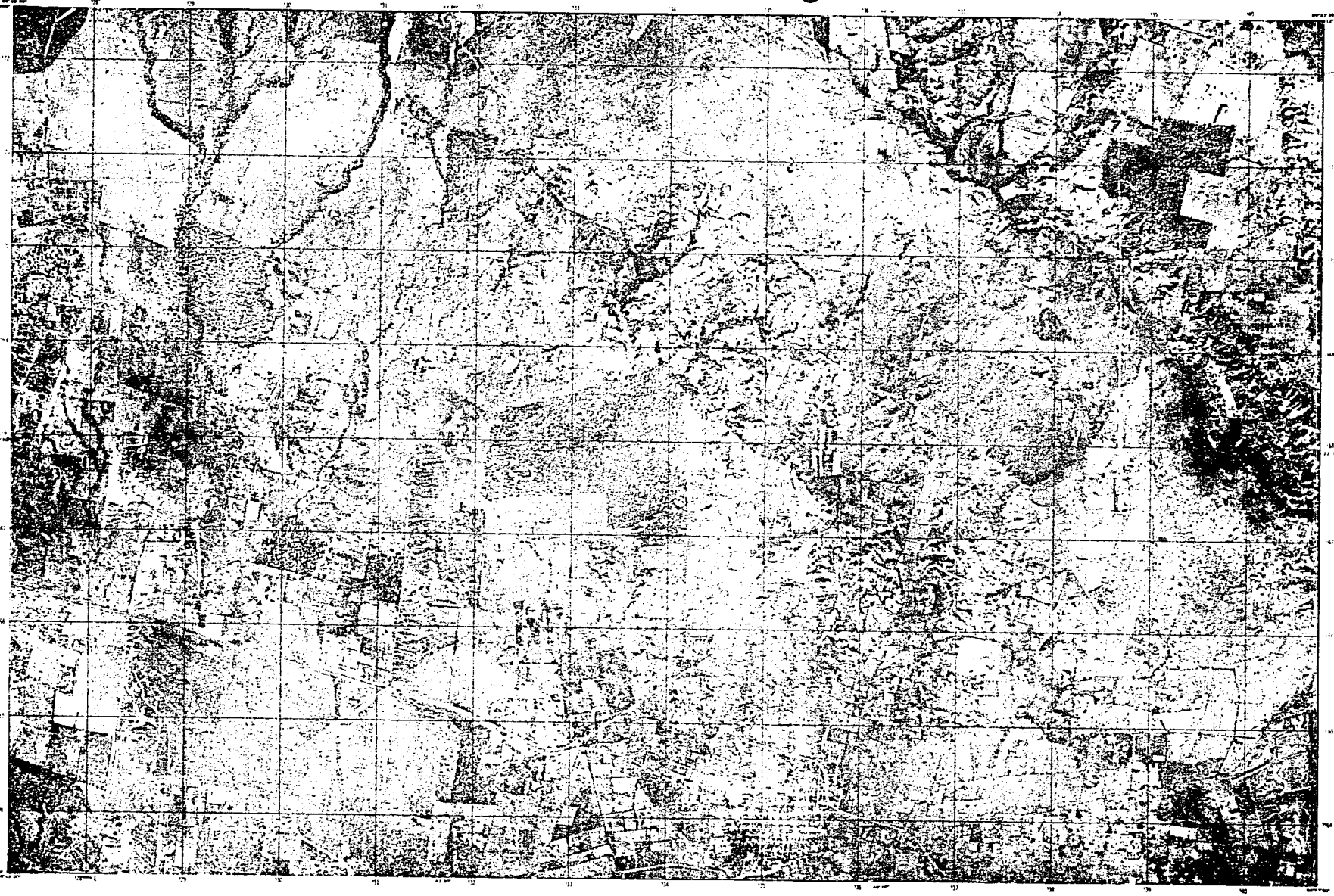
EDICION PROVISIONAL

HOJA 2853 II SW



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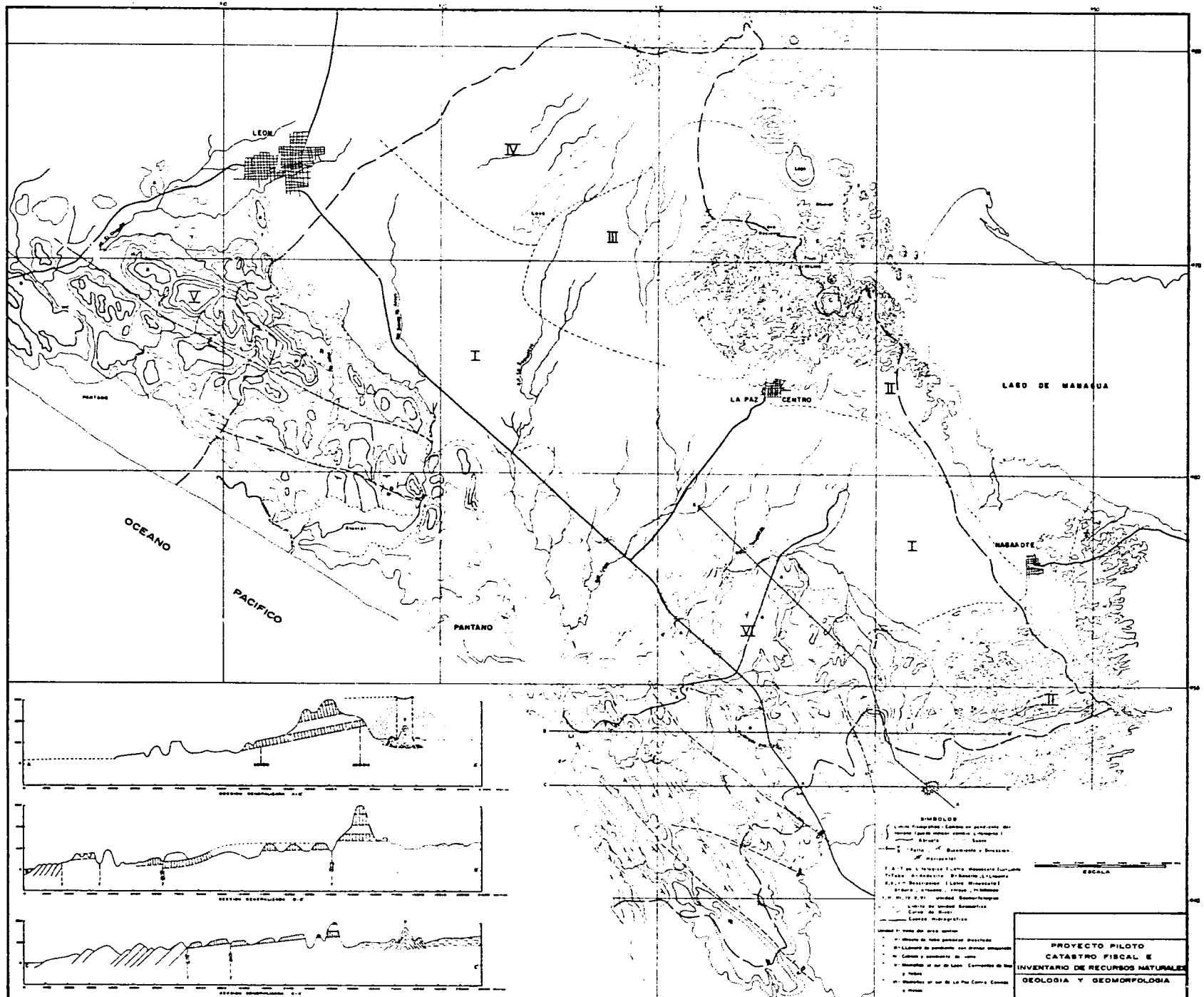
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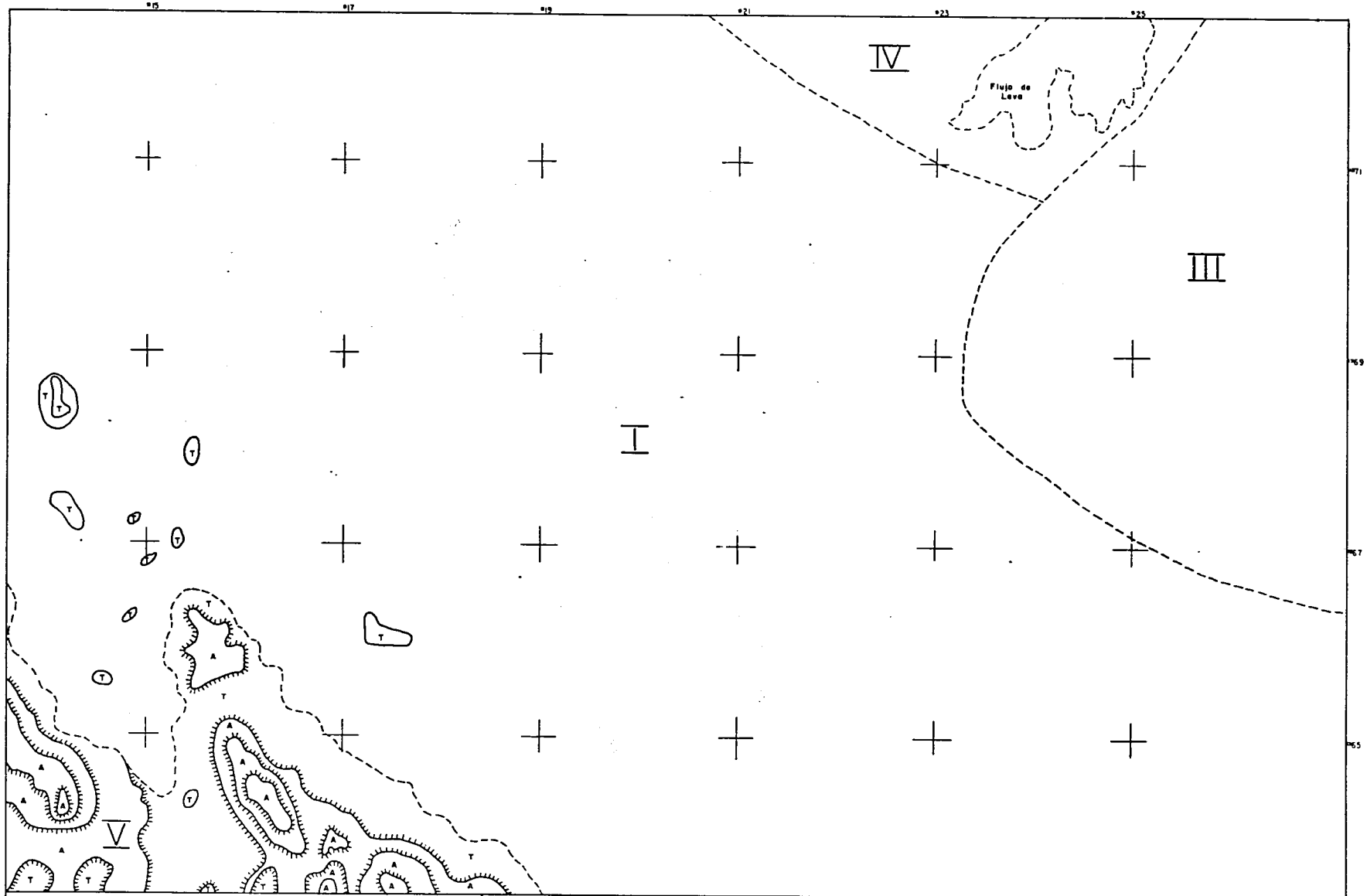
INVENTARIO DE RECURSOS NATURALES
GEOLOGIA Y GEOMORFOLOGIA

73

LEON SE



LEYENDA DE GEOMORFOLOGIA

Limite Fisiografico – Cambio en pendiente del terreno.
(puede indicar cambio Litologico) Abrupto Suave

Falla Forma Estructural

Buzamiento y Direccion 0°-30° 30°-90° Horizontal

Unidad : Limite de Unidad Geografica

(I) ALUVION DE PENDIENTE SUAVE A PLANA, CUBIERTO DE SUELOS PROFUNDOS

(II) TOBA VOLCANICA POMACEA EROSIONADA PRESENTANDO TOPOGRAFIA ESCARPADA Y DEPOSITOS RESIDUALES VOLCANICOS

(III) LLANURA, CON PENDIENTES SUAVES EN LOS ESTRATOS DE TOBA VOLCANICA Y CORRIENTE DE LAVA, CORTADO POR DRENAJE PROFUNDO.

Escala 1:25,000

PROYECTO PILOTO

CATASTRO FISCAL E INVENTARIO DE RECURSOS NATURALES

GEOMORFOLOGIA Y GEOLOGIA

LEYENDA DE GEOLOGIA

T,R – Tipo Litologico (Letra Mayuscula) T=Toba, R=Riolita, GR=Grava
A=Andesita, B=Basalto, BV=Brecha Volcanica, CLS=Arcillita, SLS=Limolita,
SS=Arenisca, LMS=Caliza SH=Lutita, AL=Aluvial, CL=Arcilla, SD=Arena
h,s,r – Descripcion (letra minuscula) h=dura, s=suave, r=roja
m=masiva, v=vesicular, t=tabocas, e=erosionada, tb=capas delgadas.

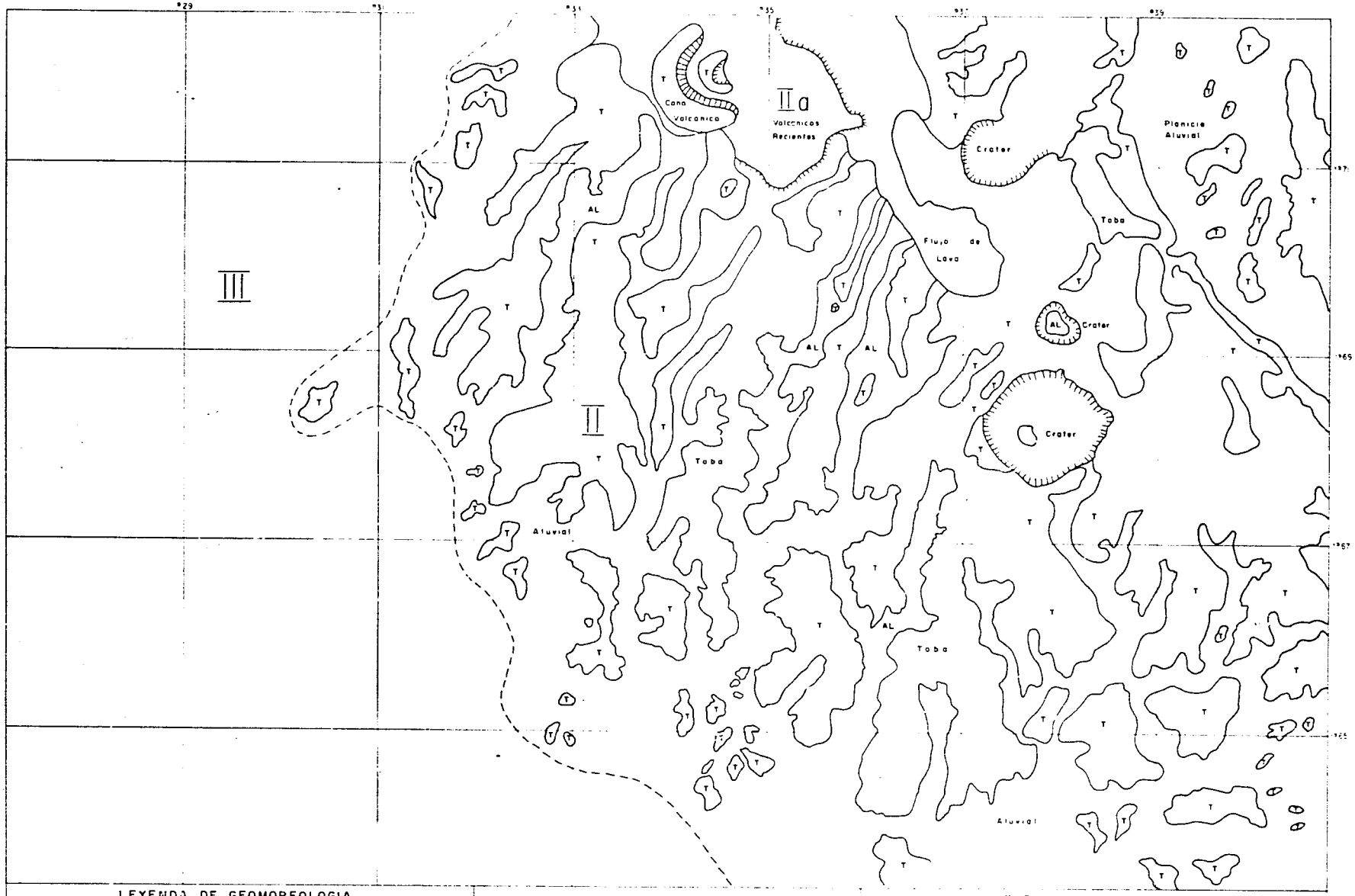
Unidad :

(IV) COLINAS Y VALLES ESTRECHOS Y LARGOS CON DRENAJE DE POCA PROFUNDIDAD

(V) MONTAÑAS EROSIONADAS CON ESTRATOS DUROS HORIZONTALES DE LAVA Y TOBA VOLCANICA

(VI) MESETA DE ROCAS VOLCANICAS POTENTES Y SEDIMENTARIAS, EROSIONADA Y FALLADA FORMANDO PEQUEÑAS MESAS.

LA PAZ CENTRO SW



LEYENDA DE GEOMORFOLOGIA

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U D Falta — Forma Estructural

Buzamiento y Direccion — 0°-30° — 30°-90° — Horizontal

Unidad — Limite de unidad geografica

(I)

(II)

(III)

PROYECTO PILOTO

CATASTRO FISCAL E INVENTARIO DE RECURSOS NATURALES

GEOMORFOLOGIA Y GEOLOGIA

LEYENDA DE GEOLOGIA

T,R — Tipo Litologico (Letra Mayuscula) T=Toba, R=Riolita, GR=Grava A=Andesita, B=Basalto, BV=Brecha Volcanica, CLS=Arcillita, SLS=Limolita, SS=Arenisca, LMS=Caliza, SM=Lutita, AL=Aluvial, CL=Arcilla, SD=Arena h,s,r — Descripcion (letra minuscula) h=dura, s=suave, r=roja, m=masiva, v=vesicular, t=tobacea, e=erosionada, fb=capas delgadas

Unidad

(IV)

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(VI)

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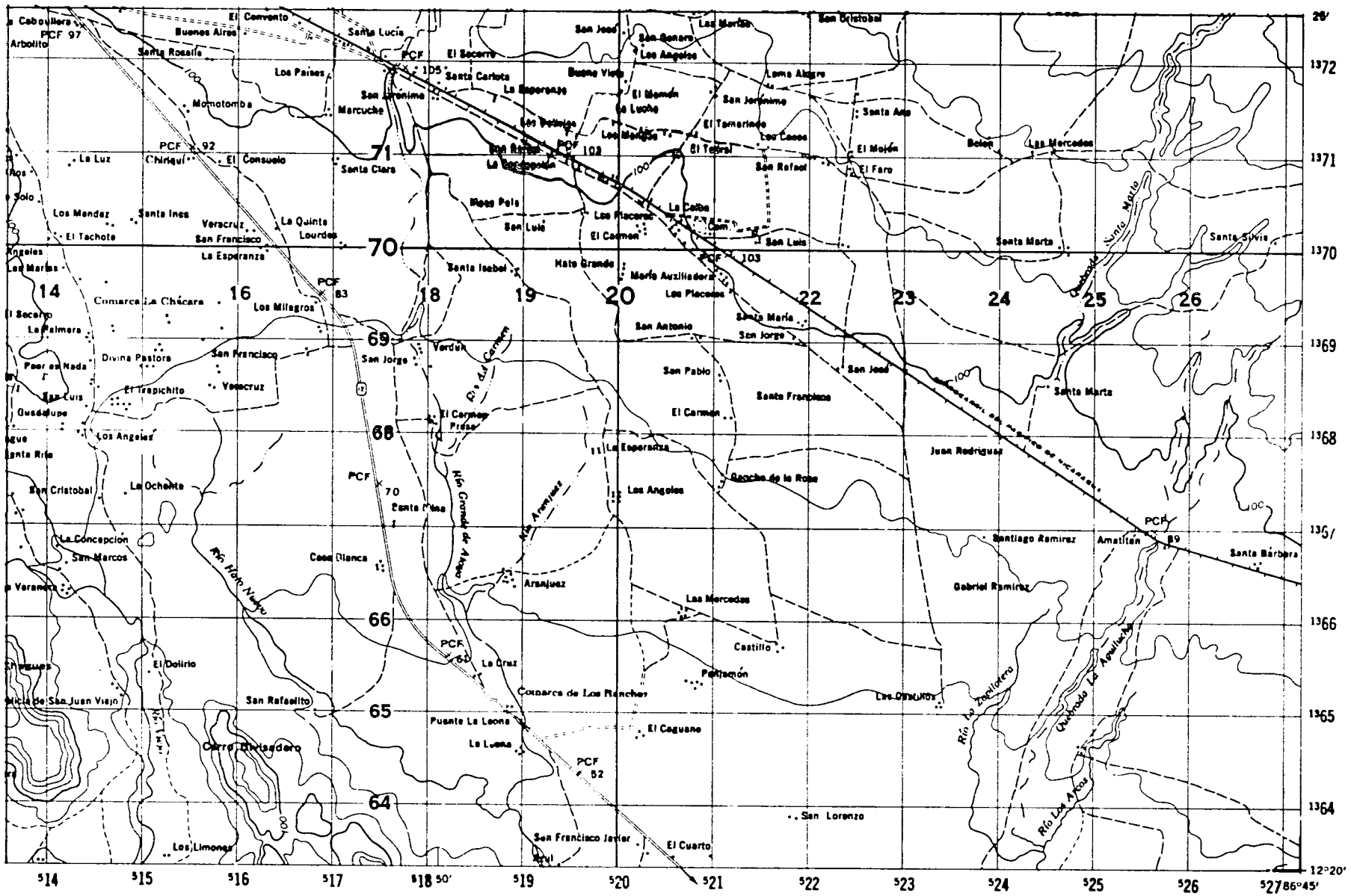
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Arbolito
Buenos Aires
El Convento
Santa Rosalía
Santa Lucía
PCF
El Socorro
San José
San Genaro
Las Angelas
Las Marías
San Cristobal
Los Países
Santa Carlota
La Esperanza
Buena Vista
El Mamón
La Lucha
Lomas Alegres
San Jerónimo
Momotomba
Marcucha
Santa Ana
El Tamarindo
Los Cacos
El Molón
Belén
Las Mercedes
PCF 92
Chiriquí
El Consuelo
La Luz
Santa Clara
El Tejral
San Rafael
El Faro
Los Mendez
Santa Inés
Veracruz
La Quinta
Lourdes
San Francisco
La Esperanza
El Tachote
Mesa Pela
San Luis
Los Placeres
La Calba
El Carmen
Santa Marta
Santa Silvia
Santa Isabel
Hato Grande
María Auxiliadora
Comarca La Chácara
Los Milagros
Los Placeres
Santa María
San Antonio
San Jorge
Verdún
Divina Pastora
San Francisco
Veracruz
El Trapichito
San Pablo
Santa Francisca
El Carmen
Los Angeles
La Esperanza
Juan Rodríguez
Gaucho de la Rosa
San Cristobal
La Ochenta
Santa Rita
Los Angeles
La Concepción
San Marcos
Casa Blanca
Arenjuez
Santiago Ramírez
Amatitlán
Santa Bárbara
Gabriel Ramírez
Las Mercedes
Castillo
El Dolirio
La Cruz
Pellamón
Comarca de Los Ranchos
San Rafaelito
Puente La Leona
El Caguano
La Leona
Cerro Montadero
San Lorenzo
San Francisco Javier
El Cuarto
Los Limones
Río Grande de Arenjuez
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Río Hato Nuevo
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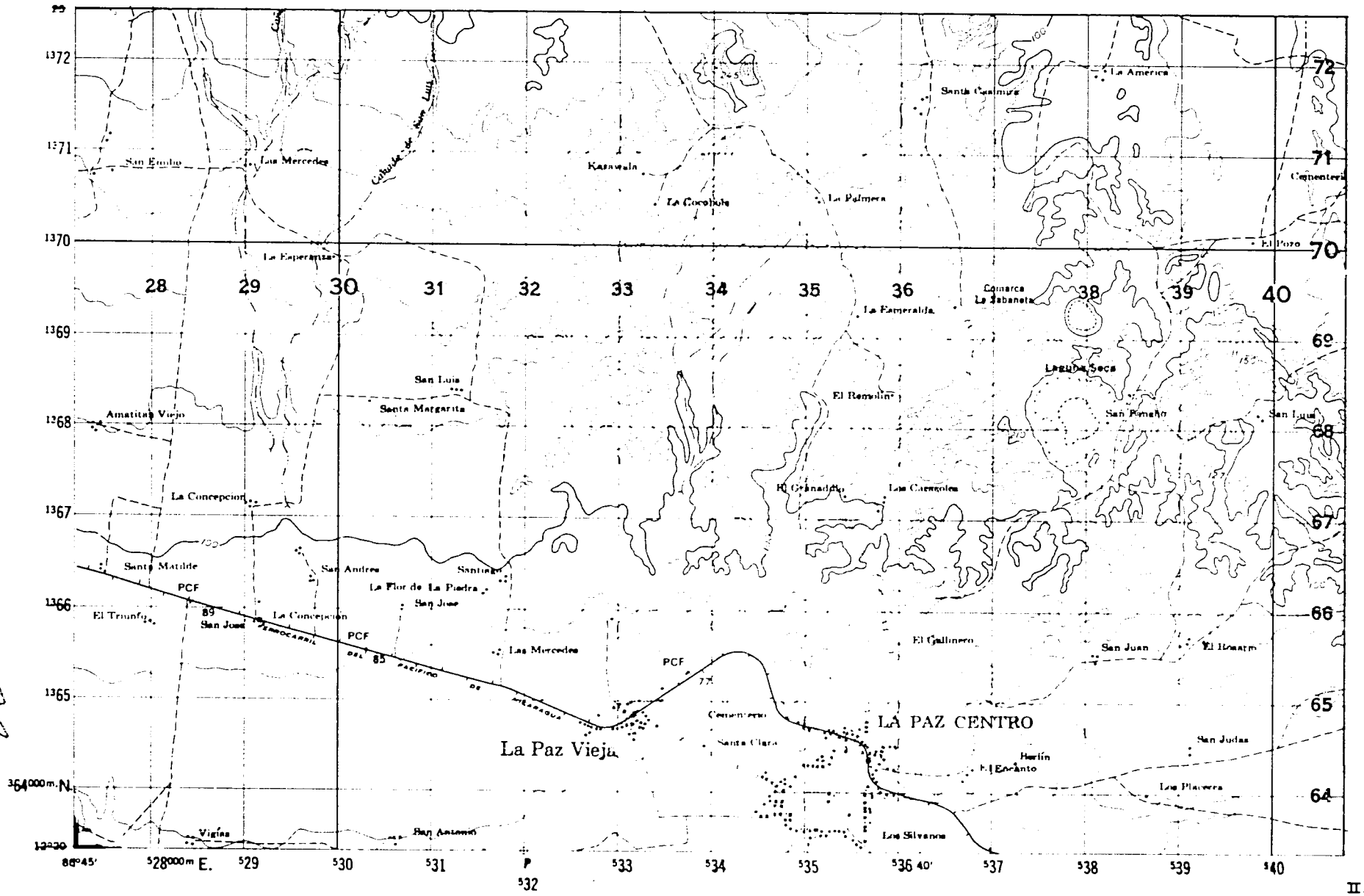
527 86°45'
A ENCALME CON LA CARRETERA A PUERTO SOMOZA 15.4 KM

IIA-5


LA PAZ CENTRO
La Paz Vieja
Comarca La Sabaneta
Laguna Seca
La Esperanza
Las Mercedes
Kasawala
La Cocobola
La Palmera
La Esmeralda
El Remolino
El Granadillo
Los Caracoles
El Gallinero
San Luis
Santa Margarita
Amatitán Viejo
La Concepción
Santa Matilde
San Andrés
Santiago
La Flor de La Piedra
San José
El Triunfo
Vigía
San Antonio
Cementerio
Santa Clara
Los Silvanos
San Judas
Los Plateros
El Rosario
San Juan
PCF
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85
77
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1372
1371
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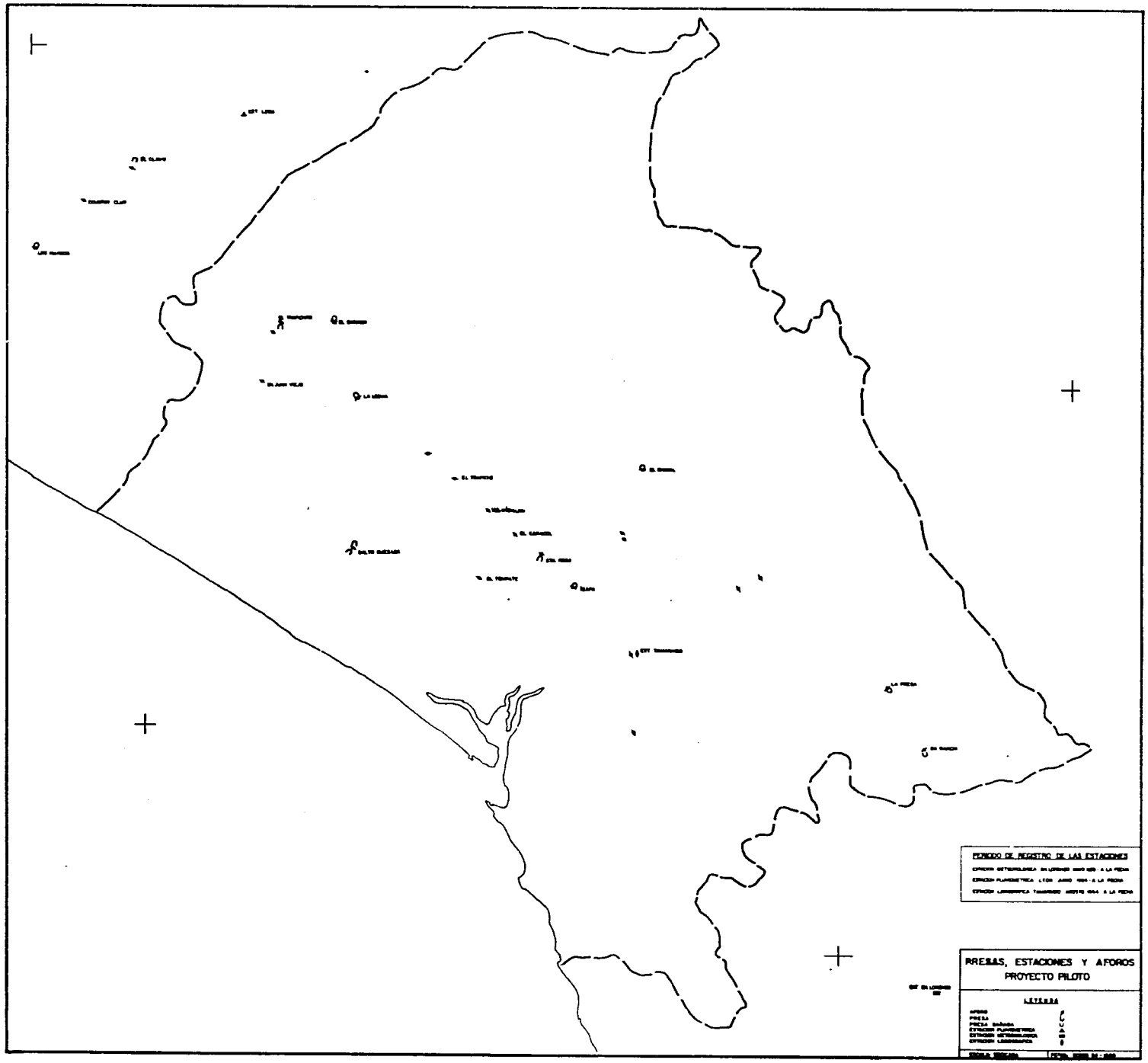
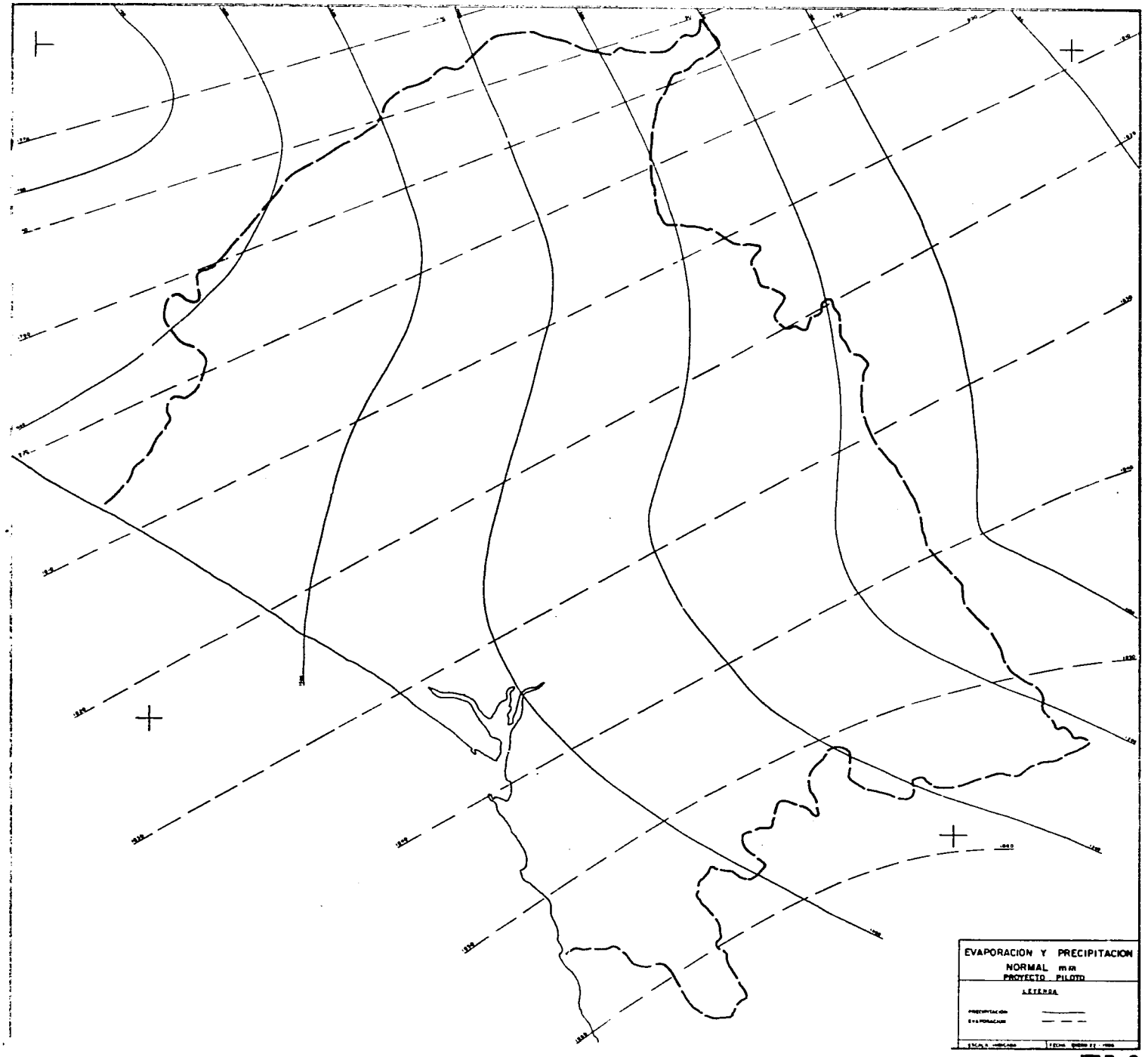
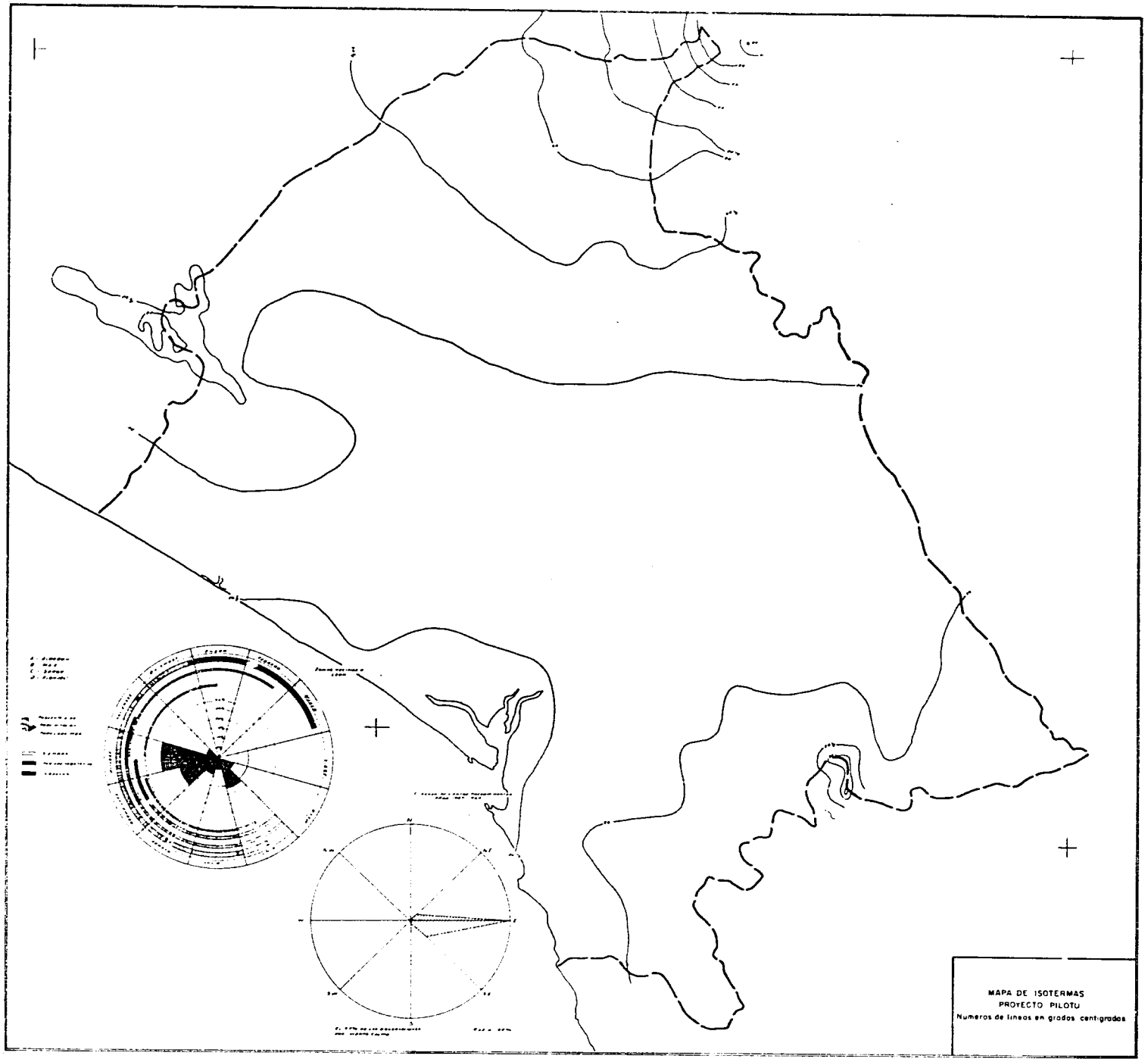
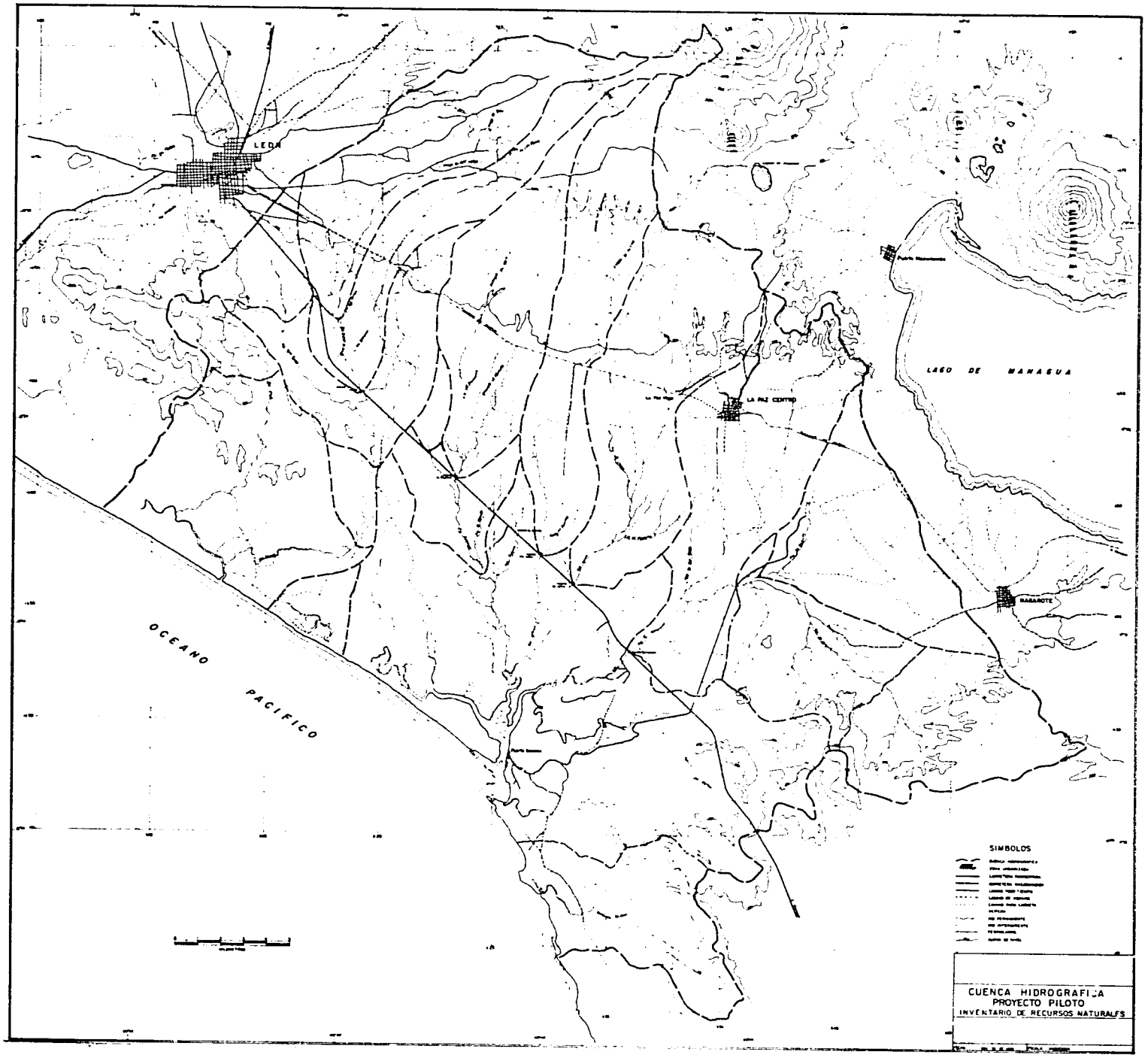
1369
1368
1367
1366
1365
364000m.N
528000m E.
529
530
531
532
533
534
535
536 40'
537
538
539
540
86°45'

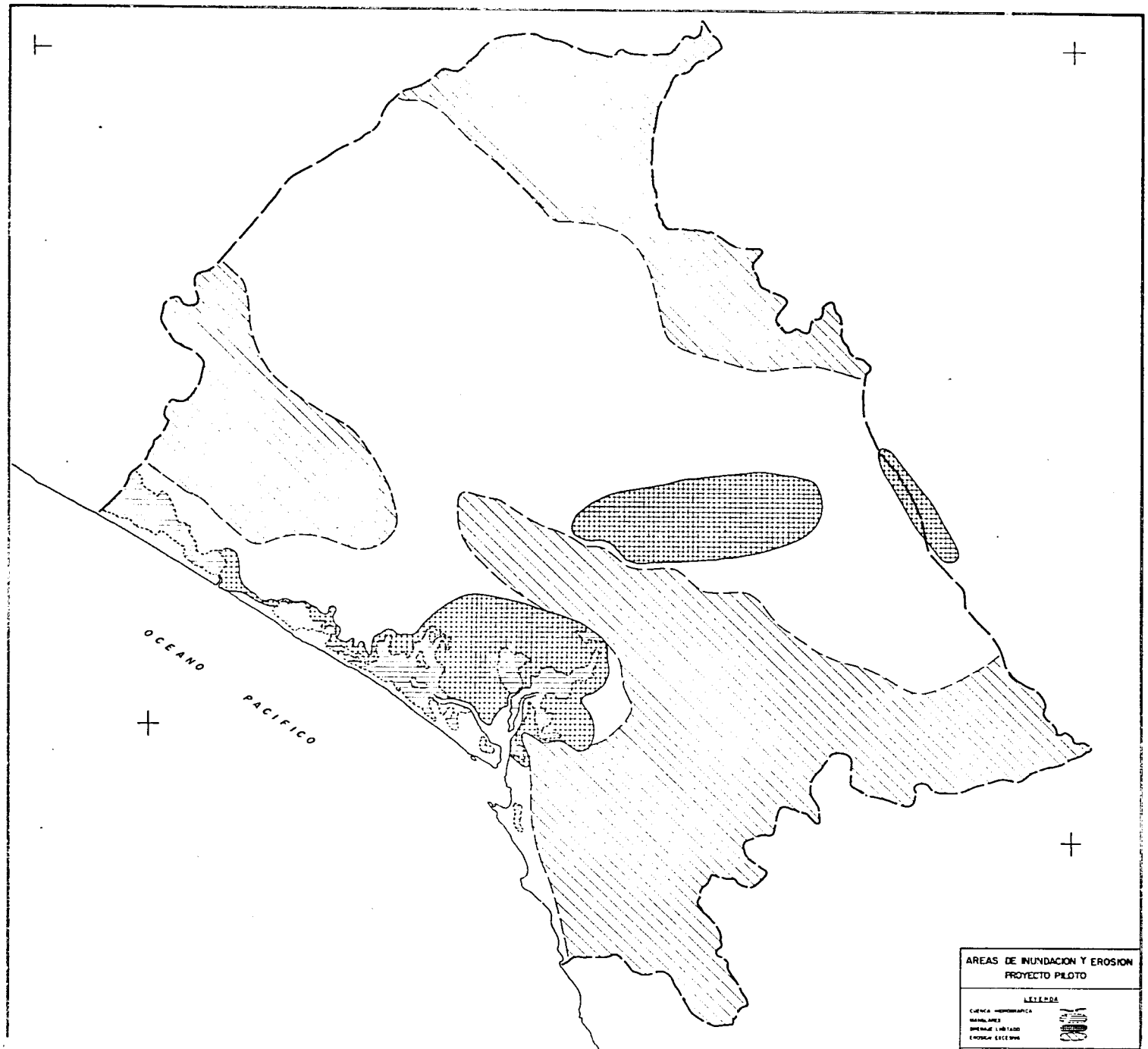

PRESAS, ESTACIONES Y AFOROS
PROYECTO PILOTO


EVAPORACION Y PRECIPITACION
NORMAL mm
PROYECTO PILOTO
LEYENDA

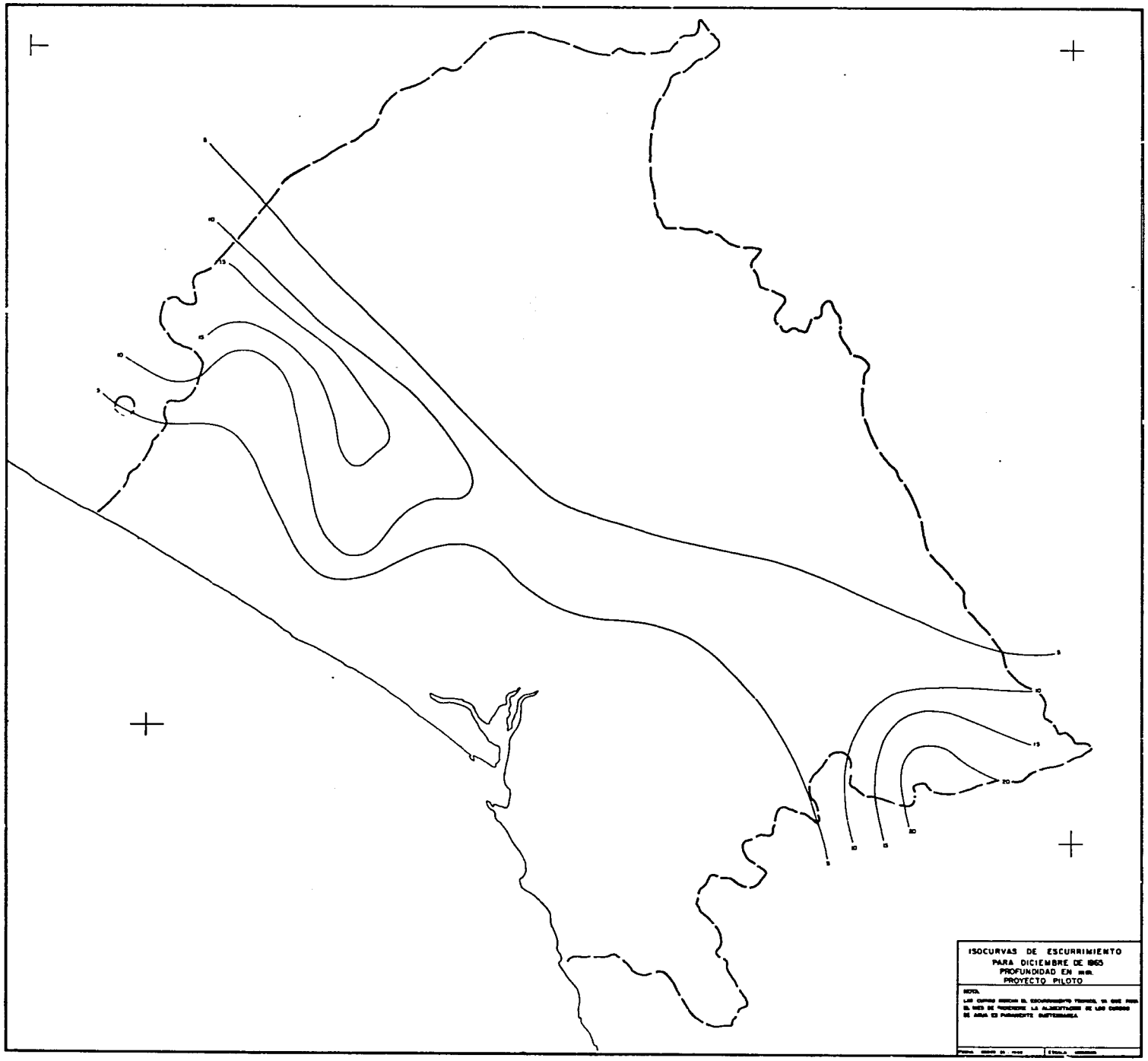
II B-2

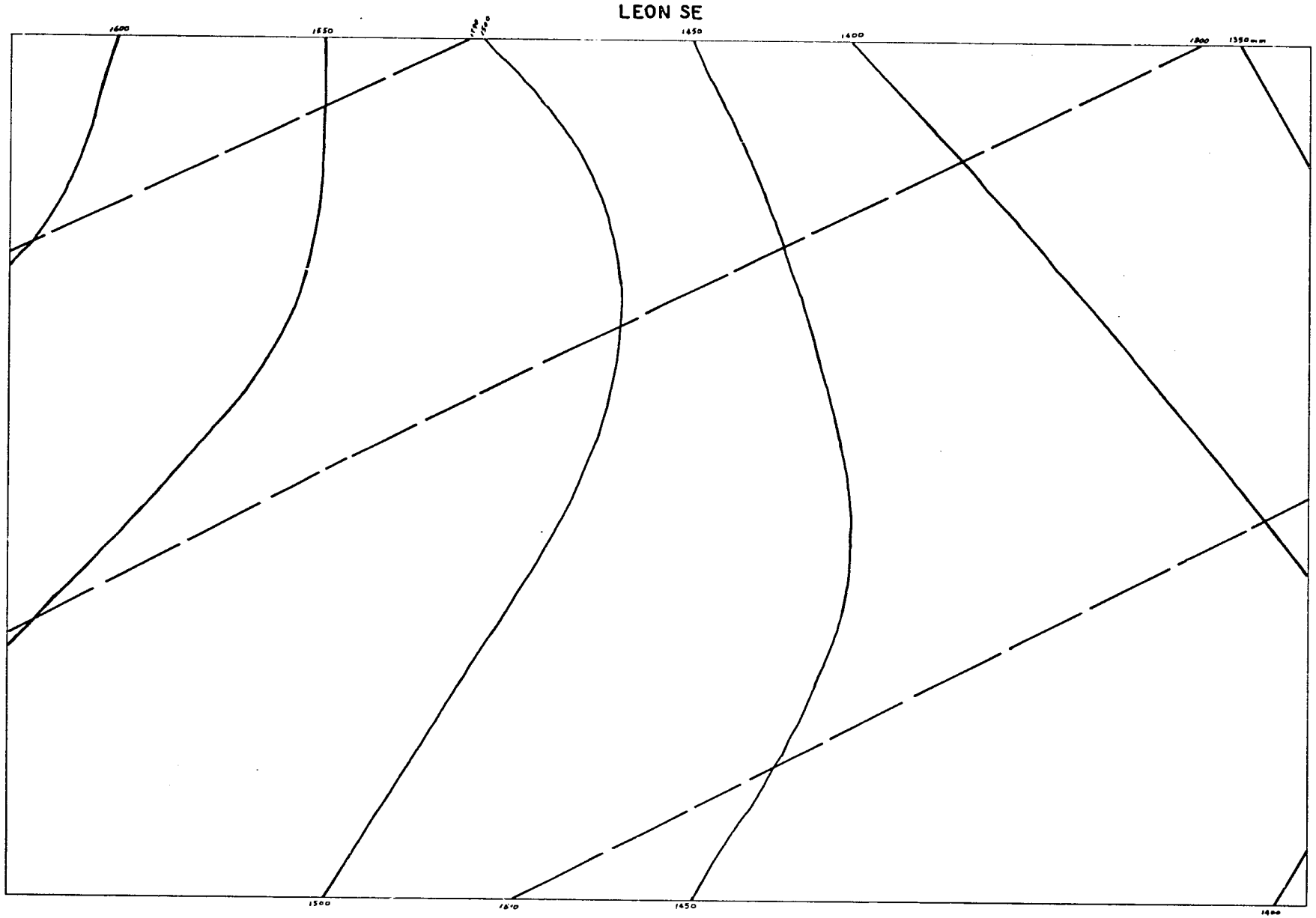

MAPA DE ISOTERMAS
PROYECTO PILOTU
Numeros de lineas en grados centigrados


LEON
LA PAZ CENTRO
LAGO DE MANAGUA
MASAYA
OCEANO PACIFICO
SIMBOLOS
CUENCA HIDROGRAFICA
PROYECTO PILOTO
INVENTARIO DE RECURSOS NATURALES


OCEANO
PACIFICO
AREAS DE INUNDACION Y EROSION
PROYECTO PILOTO
LEYENDA

68


ISOCURVAS DE ESCURRIMIENTO
PARA DICIEMBRE DE 1963
PROFUNDIDAD EN mm.
PROYECTO PILOTO
NOTA:



PROYECTO PILOTO

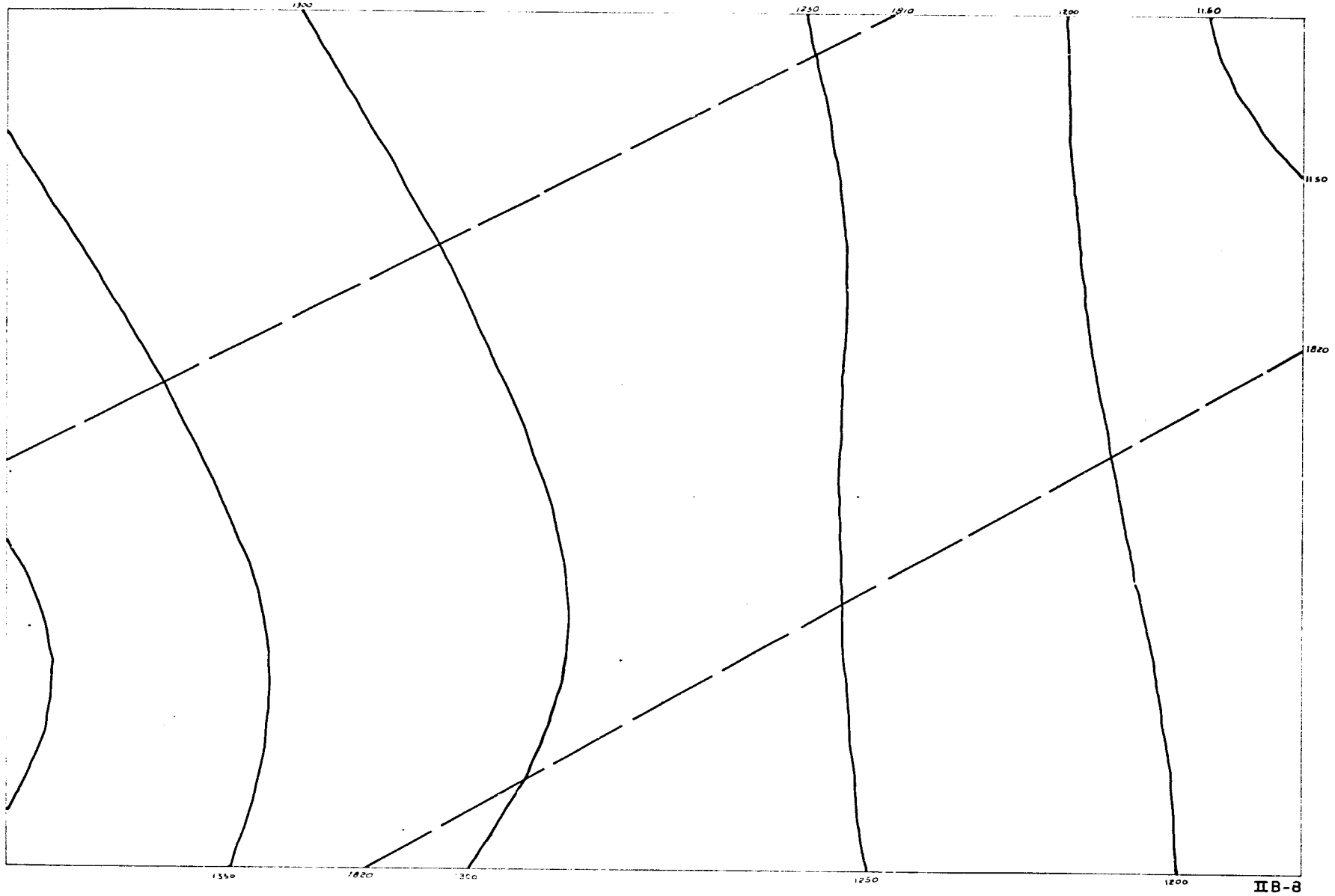
CATASTRO FISCAL E INVENTARIO DE RECURSOS NATURALES

ISOLINEAS DE LLUVIA Y EVAPORACION
(VALORES NORMALES ANUALES)
CANTIDADES EN MILIMETROS
1955 - 1964

——— LLUVIA
- - - - EVAPORACION

II B-7

LA PAZ CENTRO SW



IIB-8

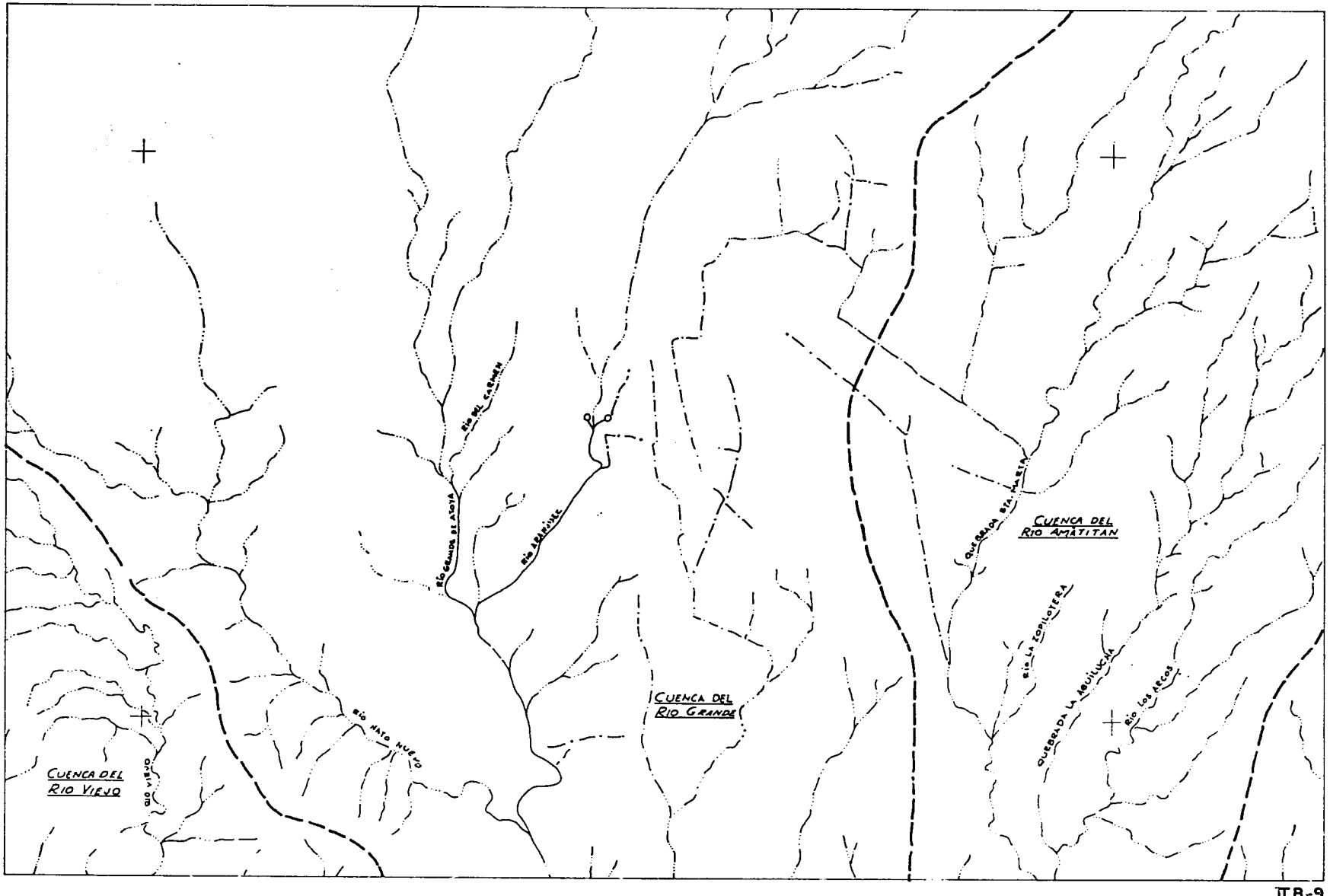
PROYECTO PILOTO

CATASTRO FISCAL E INVENTARIO DE RECURSOS NATURALES

ISOLINEAS DE LLUVIA Y EVAPORACION
(VALORES NORMALES ANUALES)
CANTIDADES EN MILIMETROS
1955 - 1964

——— LLUVIA
- - - - EVAPORACION

LEON SE



IIB-9

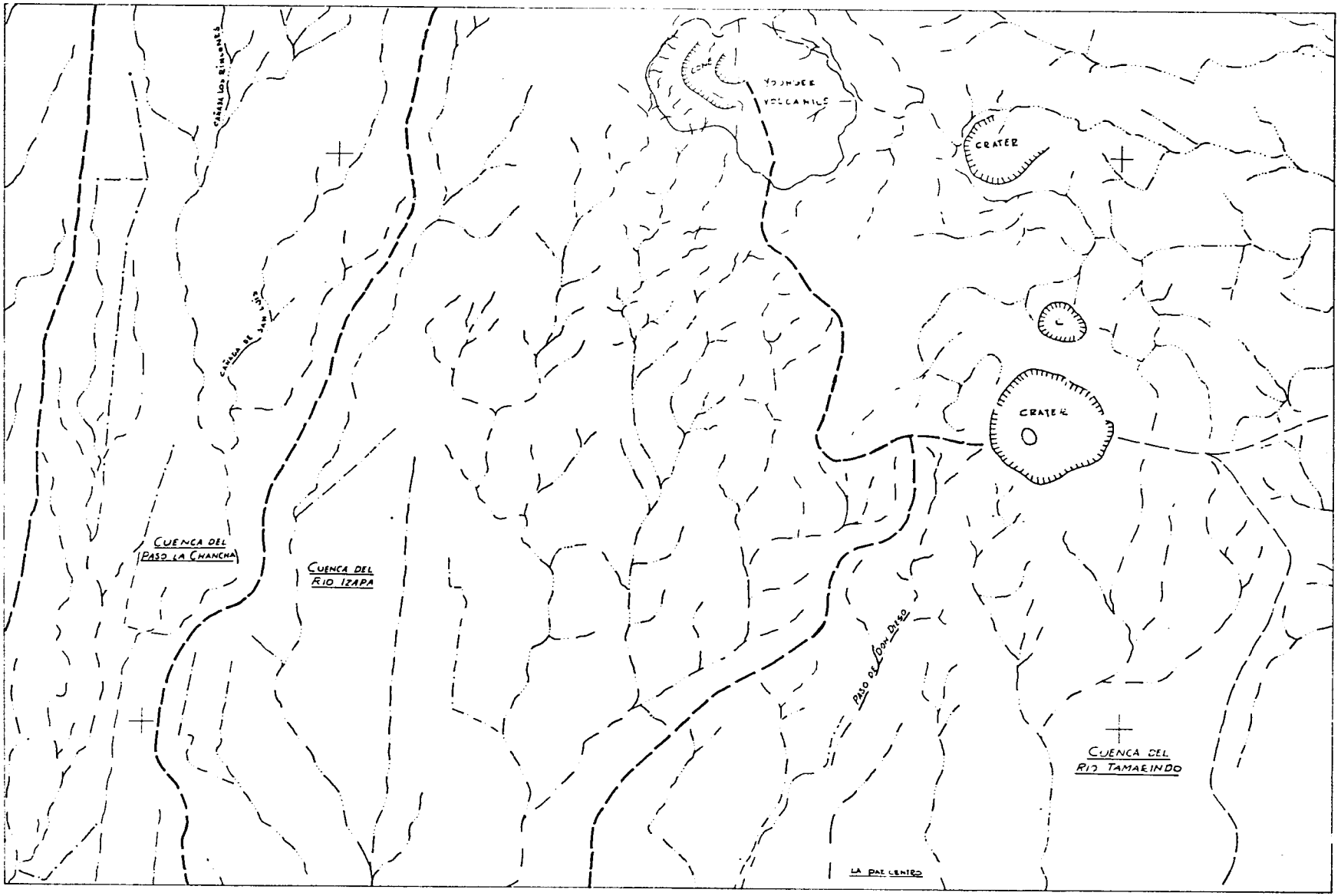
LEYENDA DE DRENAJES

- DRENAJE PERENNE
- DRENAJE INTERMITENTE
- DRENAJE ARTIFICIAL
- HONDONADAS
- CANAL
- FUENTE DE AGUA
- PRESA
- LINEA DIVISORIA DE DRENAJE

PROYECTO PILOTO

CATASTRO FISCAL E INVENTARIO DE RECURSOS NATURALES

LA PAZ CENTRO SW



IIB-10

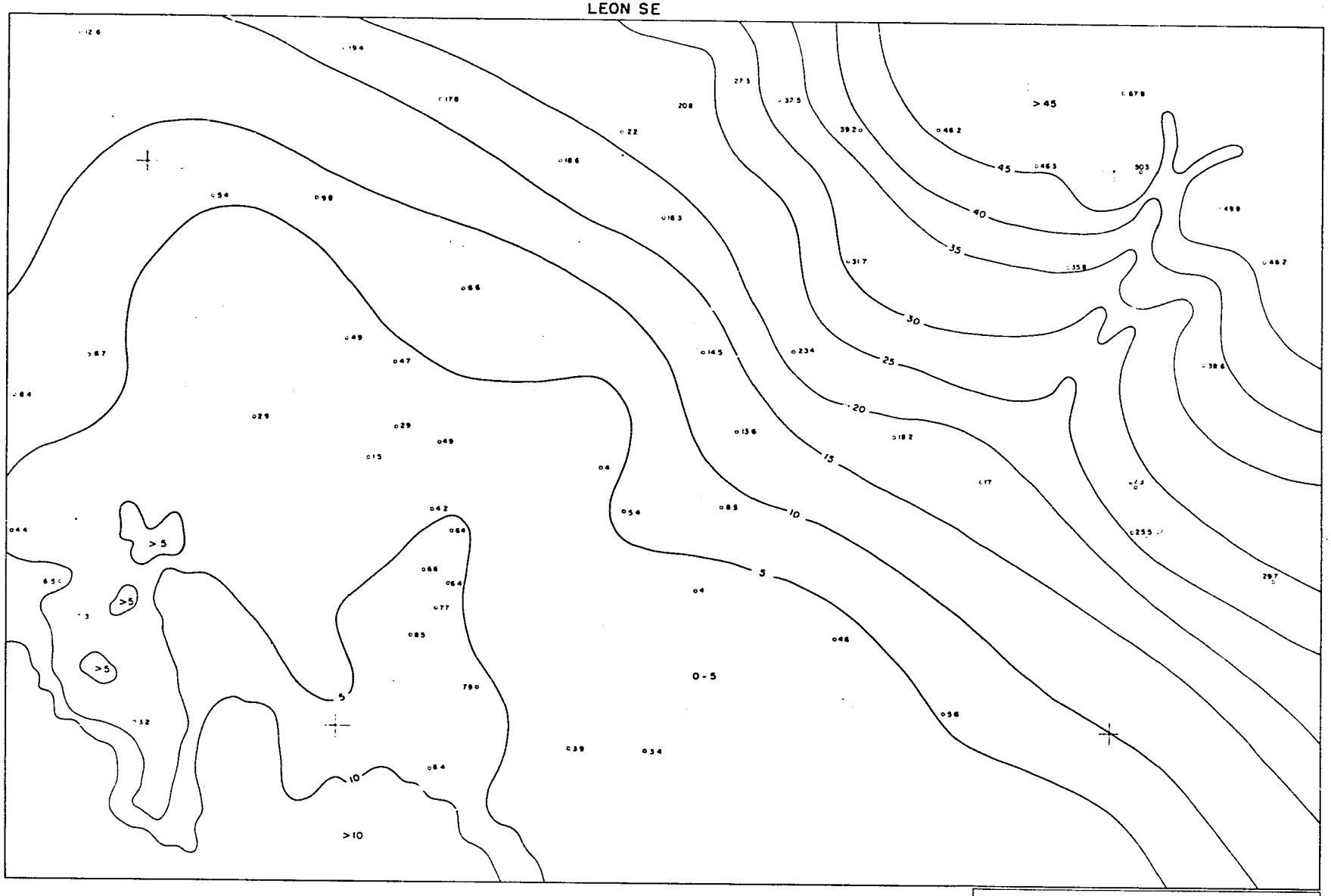
LEYENDA DE DRENAJES

- DRENE PERENNE
- DRENE INTERMITENTE
- DRENE ARTIFICIAL
- HOMDONADAS
- CANAL
- FUENTE DE AGUA
- PRESA
- LINEA DIVISORIA DE DRENAJE

PROYECTO PILOTO

CATASTRO FISCAL E INVENTARIO DE RECURSOS NATURALES

LEON SE



SIMBOLOS

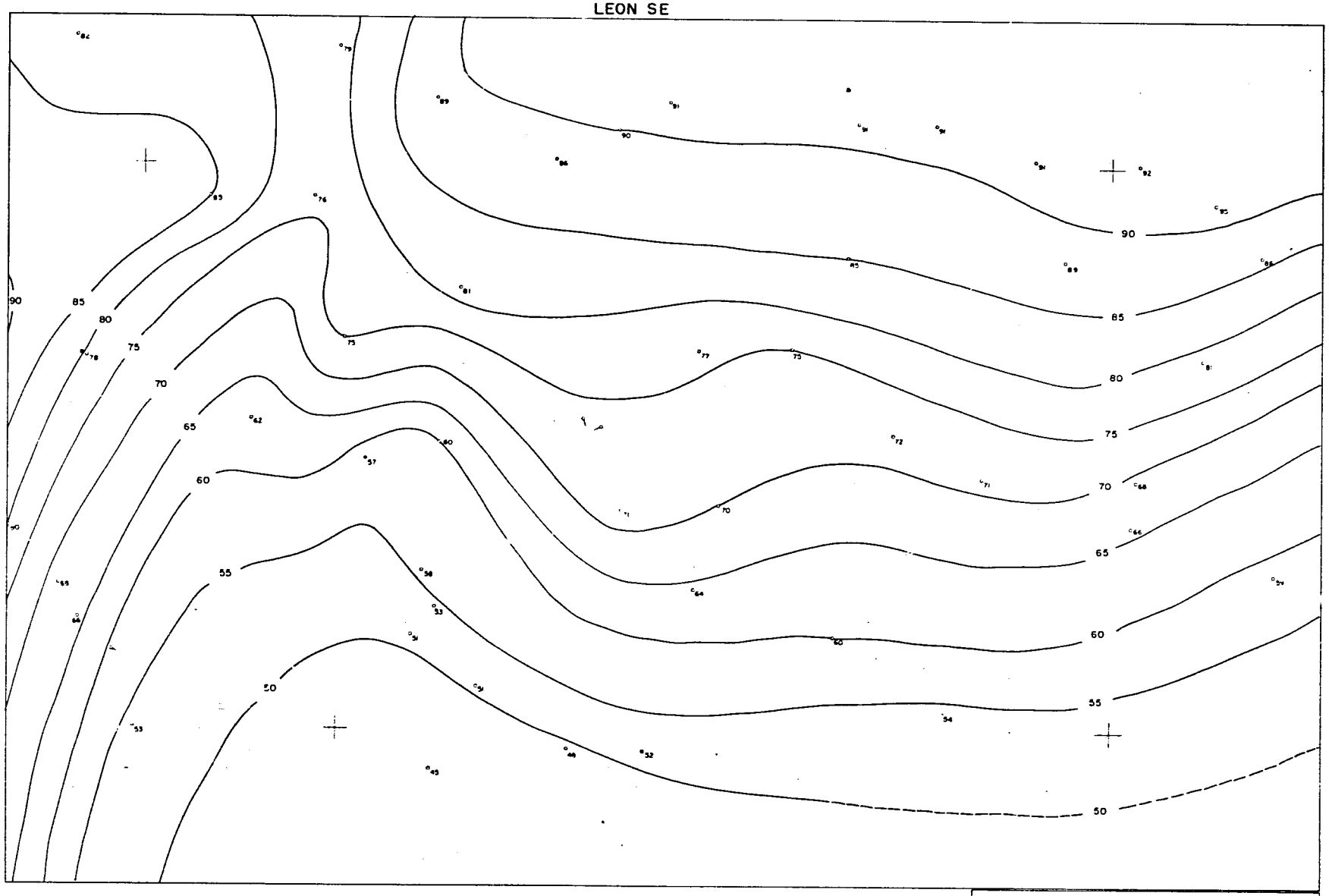
Pozo

—60— Línea que muestra la profundidad al nivel de agua en metros

PROFUNDIDAD AL NIVEL DE AGUA BAJO LA SUPERFICIE DEL SUELO, NOVIEMBRE – DICIEMBRE 1965, DEL SURESTE DE LEON

PROYECTO PILOTO
CATASTRO FISCAL E INVENTARIO
DE RECURSOS NATURALES

HIDROLOGIA DE AGUAS SUBTERRANEAS



SIMBOLOS

Pozo cavado, el número se refiere al dintel de la mesa de agua, en metros sobre el nivel del mar

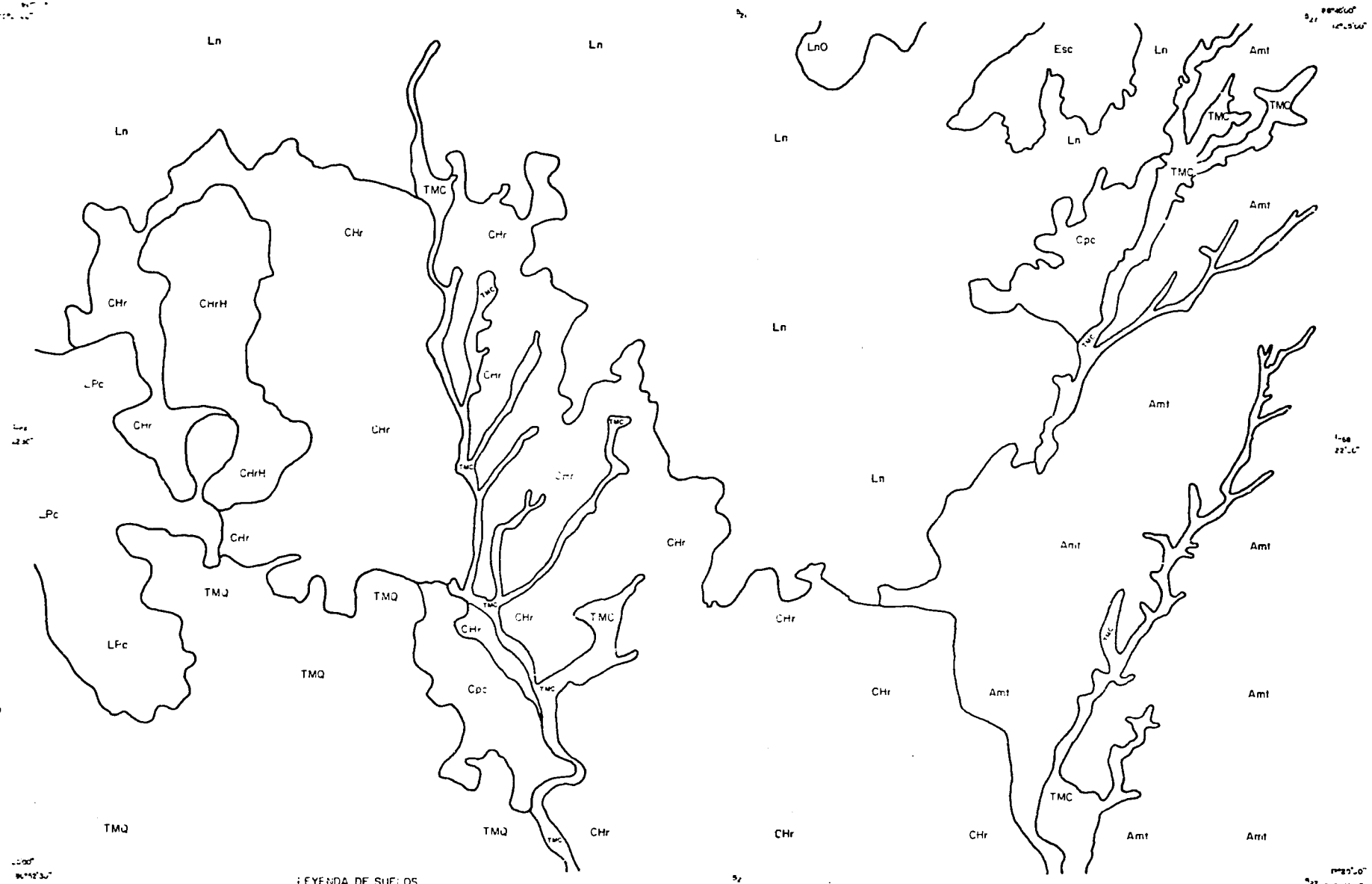
Pozo perforado

Curva de nivel freático

MAPA DE NIVEL FREATICO DEL SURESTE DE LEON, PARA LOS MESES DE NOVIEMBRE Y DICIEMBRE DE 1965

PROYECTO PILOTO
CATASTRO FISCAL E INVENTARIO
DE RECURSOS NATURALES

LEON SE



LEYENDA DE SUELOS

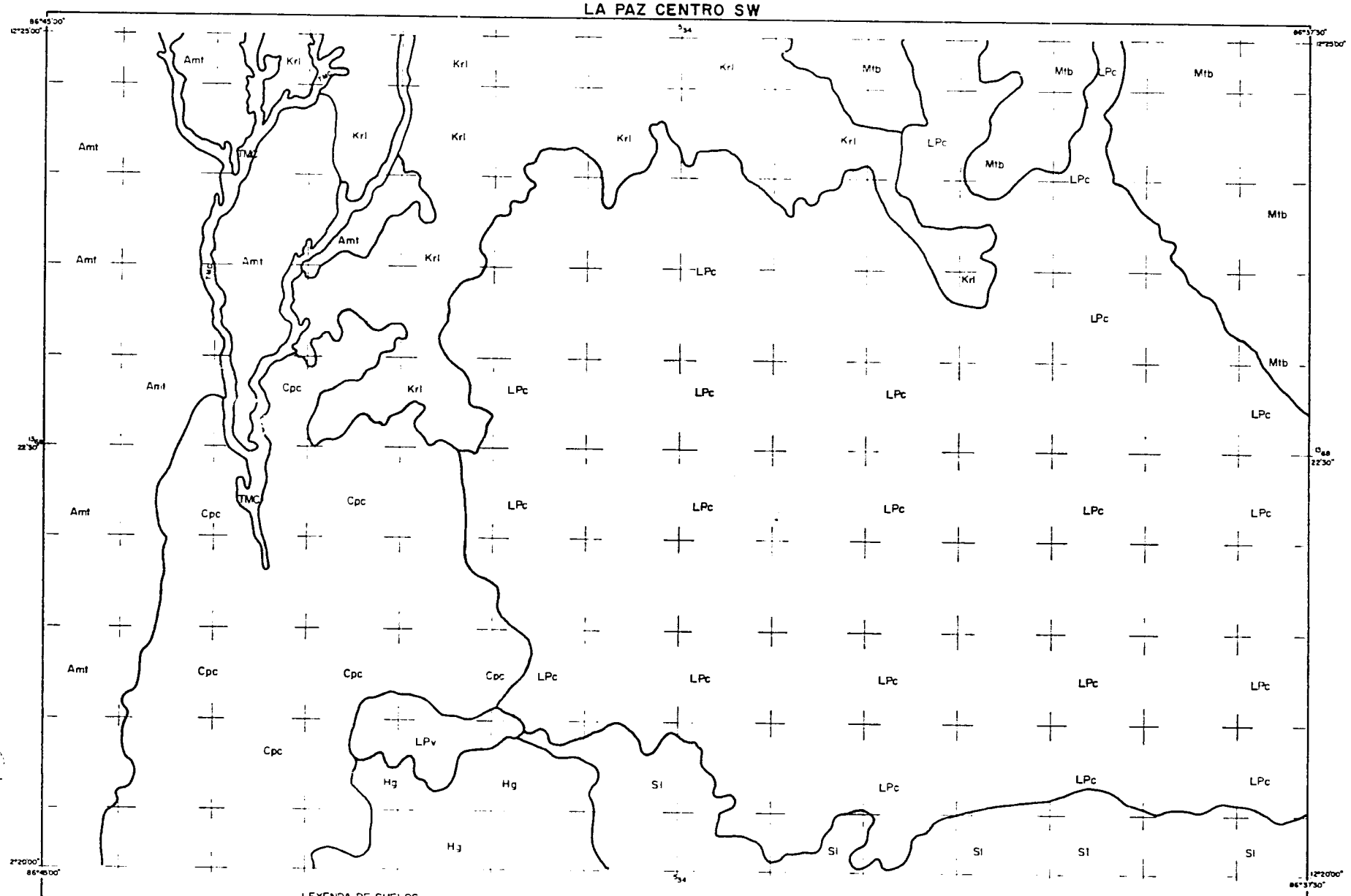
SIMBOLOS	NOMBRES
Ln	LEON FRANCO ARENOSO FINO
LnO	LEON FRANCO ARENOSO FINO, FASE ONDULADA
Amt	AMATITAN FRANCO ARCILLOSO
Cpc	CONCEPCION FRANCO
CHr	CHACARA FRANCO ARCILLOSO
CHrH	CHACARA FRANCO ARCILLOSO, FASE HUMEDA
LPc	LA PAZ CENTRO FRANCO
TMC	TIERRAS MISCELANEAS COLUVIALES
TMQ	TIERRAS MISCELANEAS QUEBRADAS
Esc	ESCORIA BASALTICA

PROYECTO PILOTO

CATASTRO FISCAL E INVENTARIO DE RECURSOS NATURALES

IIC-5

LA PAZ CENTRO SW



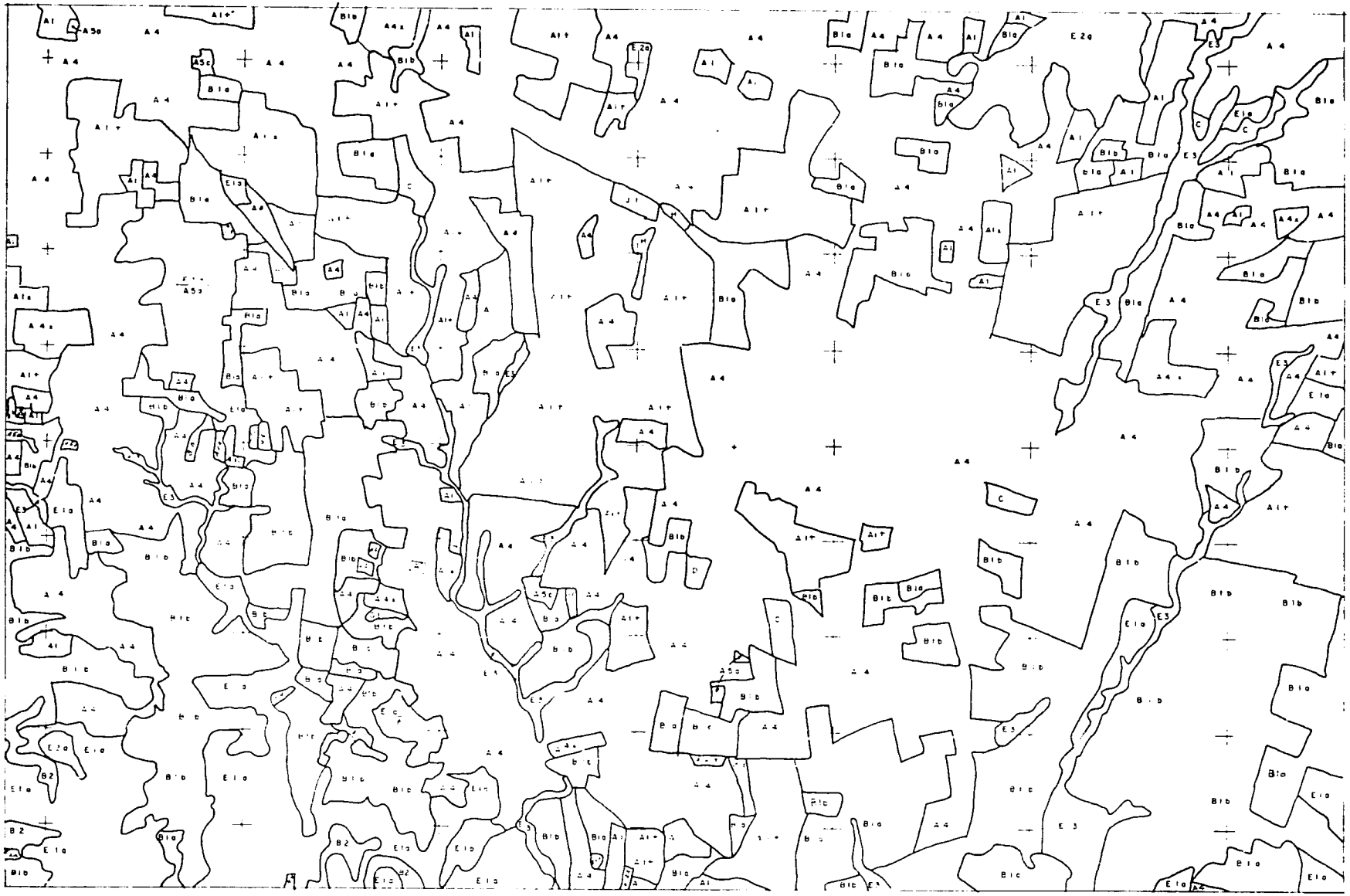
LEYENDA DE SUELOS

SIMBOLOS	NOMBRES
Amt	AMATITAN FRANCO ARCILLOSO
Cpc	CONCEPCION FRANCO
Krl	KARAMALA FRANCO LIMOSO CON GRAVA GRUESA
Mtb	MOMOTOMBO ARENOSO
Lpc	LA PAL CENTRO FRANCO
LPv	LA PAZ VIEJA FRANCO ARENOSO FINO
Hg	HATO GRANDE ARCILLOSO
Sl	SILVANOS FRANCO
TMC	TIERRAS MISCELANEAS COLUVIALES

PROYECTO PILOTO

CATASTRO FISCAL E INVENTARIO DE RECURSOS NATURALES

II C-6



A AREAS CULTIVADAS
1 Algodón
2 Arroz (de riego)
3 Cultivos de hortalizas
4 Maíz, Sorgo
5 Cultivos de árboles y arbustos
a Bananos, Guineos, Plátanos
b Café
c Cítrus y otros frutales
6 Recientemente arados

B TIERRAS CON PASTOS
1 Pastos cercados
a Pastizal mejorado libre de hierbas indeseables y de matorral, o menudo provee pasto de corte para ensilaje

B 1 b Pastos no mejorados: Las coronas de los árboles cubren menos del 40% del área
c Jicoral Grumoso:
2 Pastos sin cercas

C MATORRAL (Poco o ninguna evidencia de pastoreo)

D PLANTAS INDESEABLES (Poco o ninguna evidencia de pastoreo)

E BOSQUES
1 Algo abiertos (40-70% cubierto por la corona)
a Madera para aserrar (10" d.a.p. y muy grande) y madera rolliza para construcción (45" a 95" d.a.p.)

b Arboles jóvenes pequeñas (6 pies en altura a 45" d.a.p.)

ESCALA: 1:20 000

LEYENDA DE

FOTOINTERPRETACION PARA

EL USO DE LA TIERRA

PROYECTO PILOTO

CATASTRO FISCAL E INVENTARIO DE RECURSOS NATURALES

E2 Bien cerradas (mas del 70% cubierto por la corona)
a Madera para aserrar y madera rolliza para construcción
b Arboles jóvenes pequeños
3 De galería
4 Manglar

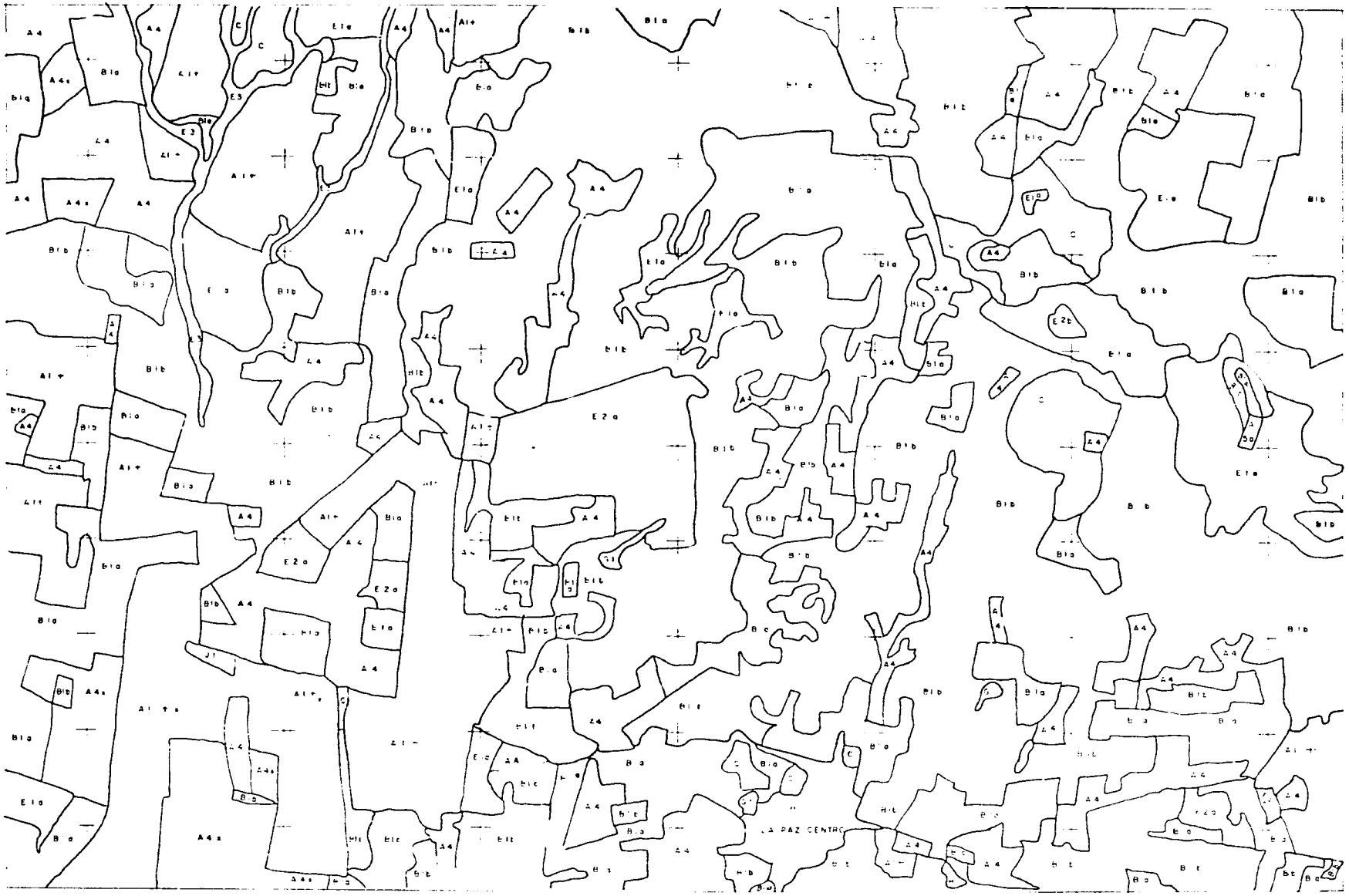
F MARJAL

G CARENTE DE VEGETACION
1 Rocas o piedras grandes esparcidas fuera de cultivos
2 Suelo desnudo
AREAS URBANAS (Villas, pueblos de segunda importancia, ciudades)

H Areas urbanas
J Areas industriales (fuera de areas urbanas)
1 Desmotadoras de algodón
2 Ingenios de azucar
3 Fabricas de tejas y ladrillos de cuartera o de barro
4 Salinas
K AGUA

SIMBOLOS ADICIONALES
e Erosión
+ Terrazas
NOTA: d.a.p = diametro a la altura del pecho

LA PAZ CENTRO SW



A AREAS CULTIVADAS
1 Algodon
2 Arroz (de riego)
3 Cultivos de hortalizas
4 Maiz, Sorgo
5 Cultivos de arboles y arbustos
a Bananos, Platanos
b Cafe
c Citricos y otras frutas
6 Recientemente arados

B TIERRAS CON PASTOS
1 Pastos cercados
a Pastizal mejorado libre de hierbas indeseables y de matorral o menudo provee pasto de corte para ensilaje

B 1 b Pastos no mejorados las coronas de los arboles cubren menos de 40% del área
c Vicorral (Grumosol)
2 Pastos sin cercas

C MATORRAL Poco o ninguna evidencia de pastoreo

D PLANTAS INDESEABLES (Poco o ninguna evidencia de pastoreo)

E BOSQUES
1 A Bosques (40-70% cubierto por la corona)
a Madera para aserrar (10 dap y muy grande) y madera rolliza para construccion (45 a 95 dap)
b Arboles jovenes pequeños (6 pies en altura a 45 dap)

E 2 B en cerrados (mas de 70% cubierto por la corona)
a Madera para aserrar y madera rolliza para construccion
b Arboles jovenes pequeños
3 De galeria
4 Manglar

F MARJAL

G CARENTE DE VEGETACION
1 Rocas o piedras grandes esparcidas fuera de cultivos
2 Suelo desnudo

H AREAS URBANAS (Villas, pueblos de segunda importancia, ciudades)

I AREAS INDUSTRIALES fuera de areas urbanas.
1 Desmotadoras de algodon
2 Ingenios de azucar
3 Fabricas de tejas y ladrillos de cuarterón de barro
4 Salinas

K AGUA

SIMBOLOS ADICIONALES
a Erosion
b Terrazas

NOTA dap = diametro a la altura del pecho

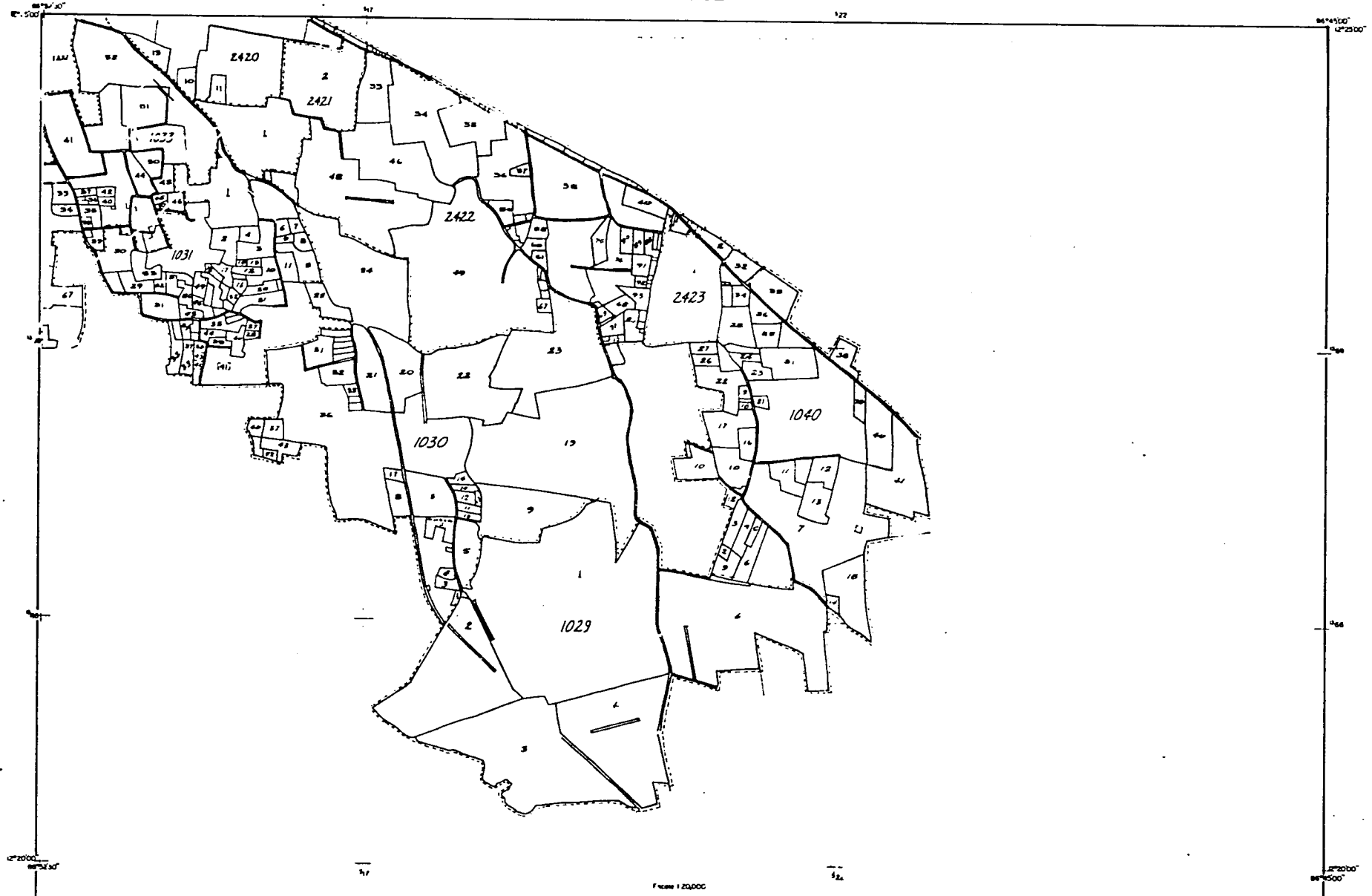
ESCALA 1:20.000

LEYENDA DE FOTOINTERPRETACION PARA EL USO DE LA TIERRA

PROYECTO PILOTO

CATASTRO FISCAL E INVENTARIO DE RECURSOS NATURALES

LEON SE



LEYENDA

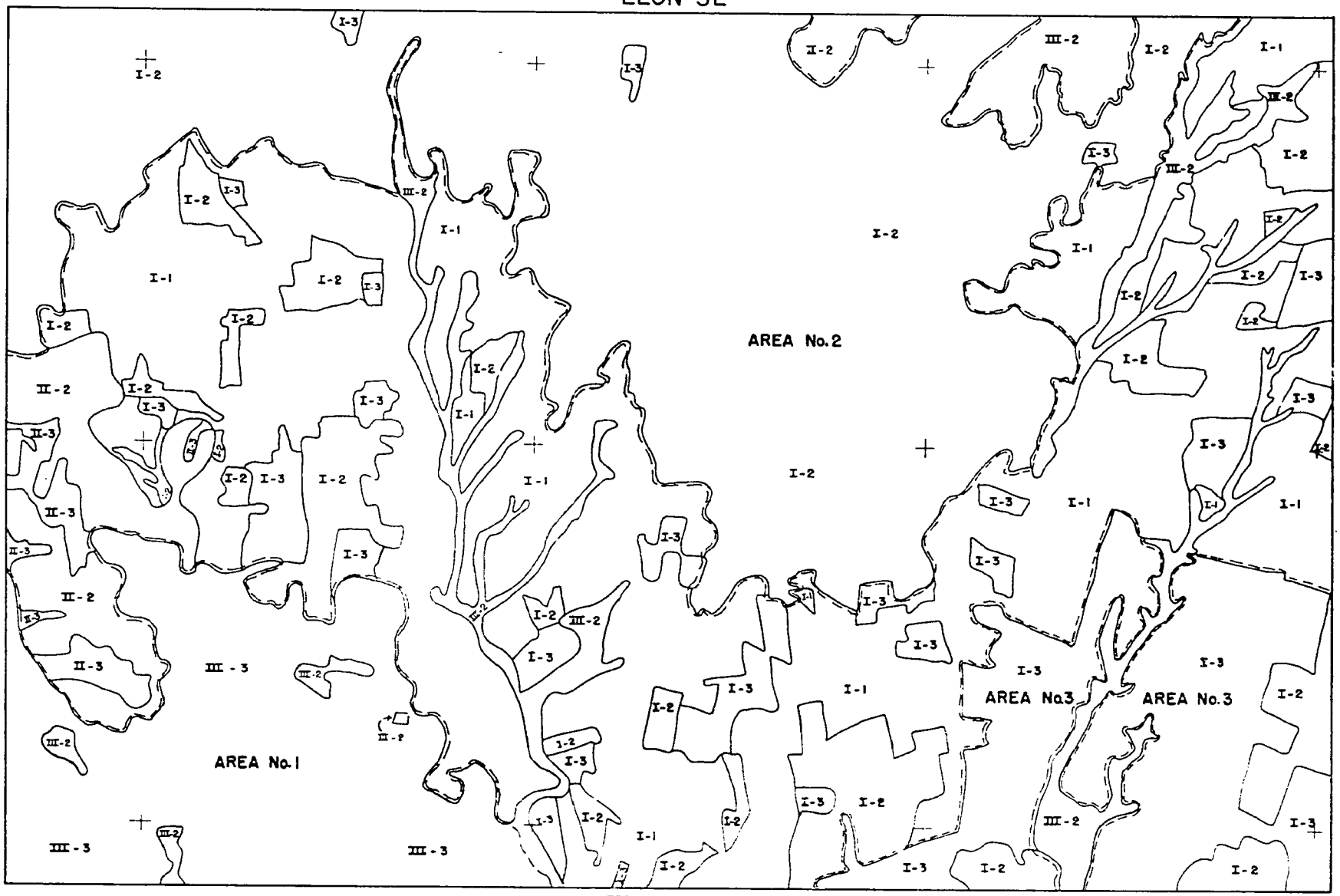
LINEA DE PROPIEDAD
LIMITE DE FOTOS
Nos de FOTOS: 1029 (LOTES 1-2-3-4-6)
1030 (" 1-2-3 43)
1031 (" 1-2-3 53)
1033 (" 1-2-3 71)
1040 (" 1-2-3 41)
2420 (" 1-2-3 22)
2421 (" 1-2 .)
2422 (" 1-2-3 94)
2423 (" 1-2 .)

CATASTRO FISCAL

DELINEACION DE PROPIEDADES

IID-4

LEON SE



ESCALA 1:20,000

III B-1

USO POTENCIAL AGRICOLA

PROYECTO PILOTO

CATASTRO FISCAL E INVENTARIO DE RECURSOS NATURALES

CLASE I De bueno a excelente para cultivos, incluyendo frutales. Las deficiencias pueden ser superadas a costo razonable.

CLASE II Regular para cultivos, para un mejoramiento substancial requeriría considerables inversiones. En algunos lugares los frutales o pastos mejorados pueden ser preferibles a los cultivos

CLASE III Son más convenientes los pastos mejorados o bosques de explotación controlada. Los cultivos existentes en algunas áreas son de subsistencia

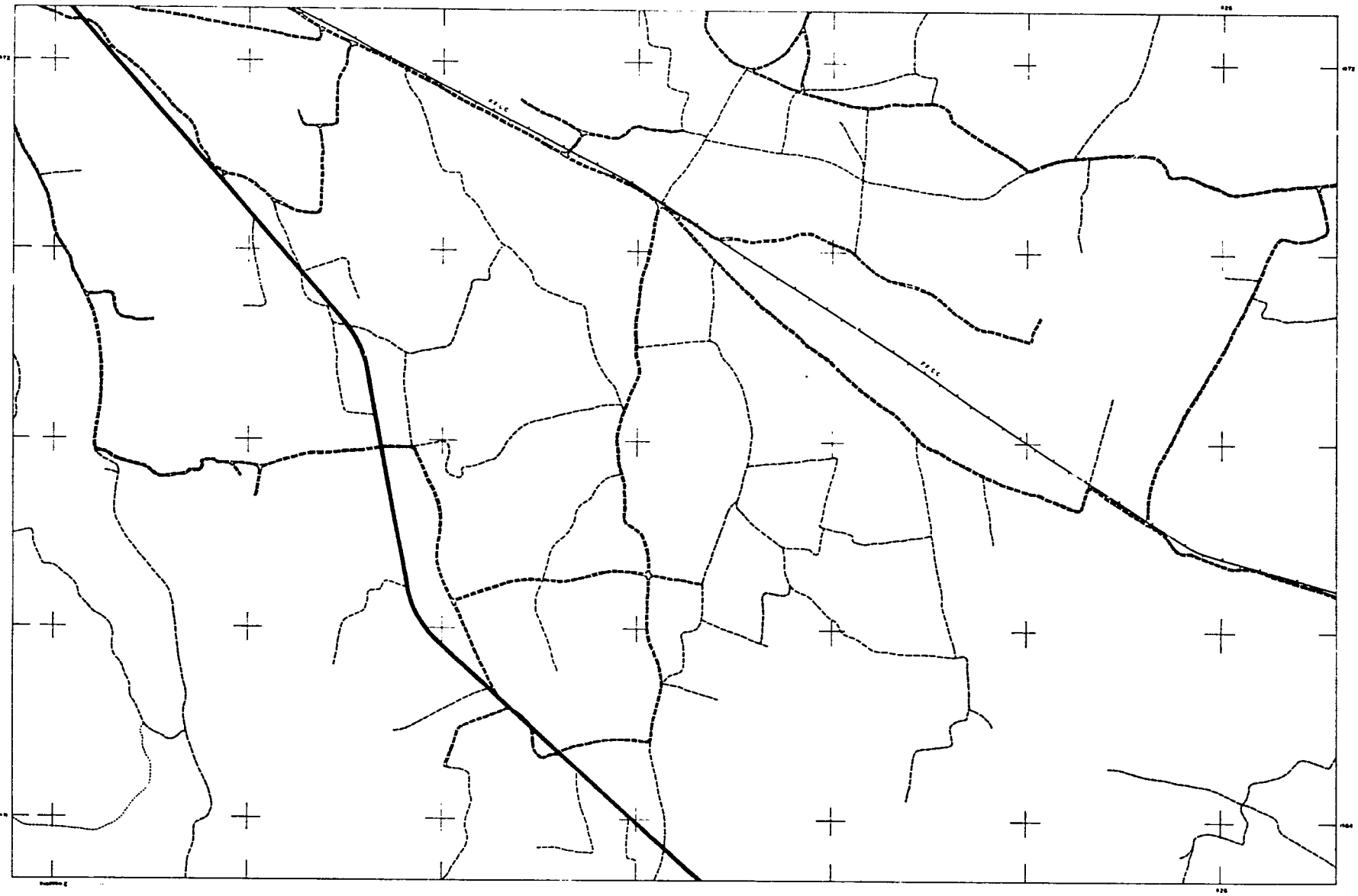
CLASIFICACION COMPLEMENTARIA – USO ACTUAL

1 Utilizado según su uso más indicado.

2 Uso adecuado con posibilidad de mejoramiento.

3 Uso inadecuado que debe ser cambiado o mejorado.

LEON S.E.



ESCALA 1:20,000

CAMINOS

SUPERFICIE PAVIMENTADA DE 2 VIAS TRANSITABLE EN TODO TIEMPO	
" DE GRAVA " " " " " " "	
" PAVIMENTADA " 1 " " " " "	
" DE GRAVA " 1 " " " " "	
SUPERFICIE DE TIERRA TRANSITABLE EN VERANO	
CAMINO PARA CARRETAS	
VEREDA	

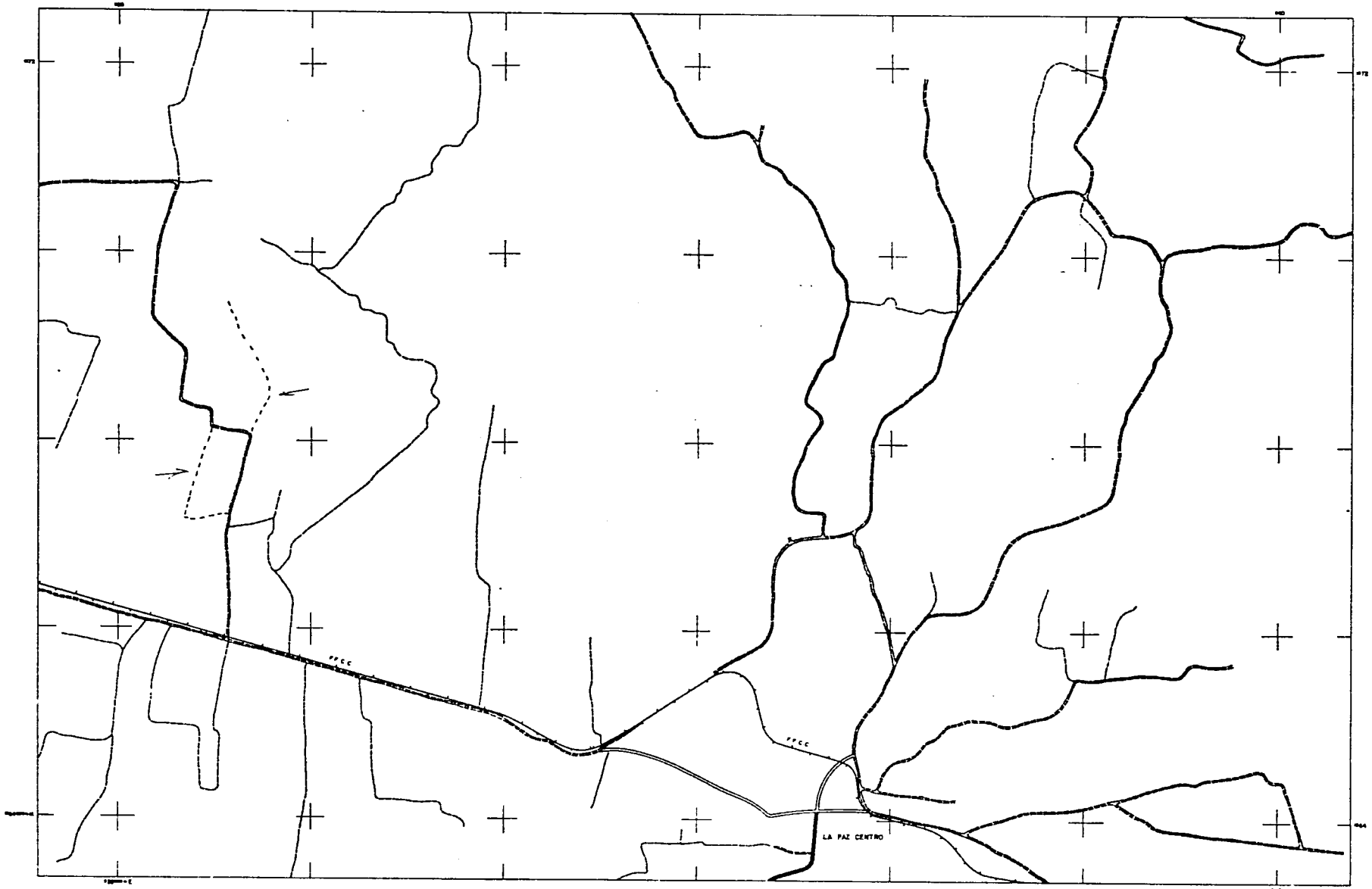
ROADS

	ALL-WEATHER ROAD, PAVED, TWO OR MORE LANES
	" " " GRAVEL SURFACE, TWO LANES
	" " " PAVED, ONE LANE
	" " " GRAVEL SURFACE, ONE LANE
	DRY-WEATHER ROAD, SOME GRAVEL SURFACE
	OX-CART ROAD
	TRAIL

PROYECTO PILOTO

CATASTRO FISCAL E INVENTARIO DE RECURSOS NATURALES

LA PAZ CENTRO S.W.



III C-2

PROYECTO PILOTO

CATASTRO FISCAL E INVENTARIO DE RECURSOS NATURALES

Escala 1 : 25,000

1000 500 0 1000 2000 Metros

CAMINOS	ROADS
SUPERFICIE PAVIMENTADA DE 2 VIAS TRANSITABLE EN TODO TIEMPO	ALL-WEATHER ROAD, PAVED, TWO OR MORE LANES
" DE GRAVA " " " " " " "	" " " GRAVEL SURFACE, TWO LANES
" PAVIMENTADA " 1 " " " " "	" " " PAVED, ONE LANE
" DE GRAVA " 1 " " " " " "	" " " GRAVEL SURFACE, ONE LANE
SUPERFICIE DE TIERRA TRANSITABLE EN VERANO	DRY-WEATHER ROAD, SOME GRAVEL SURFACE
CAMINO PARA CARRETAS	OX-CART ROAD
VEREDA	TRAIL