ENVIRONMENTAL ASSESSMENT

PANAMA WATERSHED MANAGEMENT PROJECT

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I. INTRODUCTION

A. Background

The Republic of Panama forms the narrowest and lowest portion of the Isthmus that links the continents of North and South America. Except for the relatively low agricultural capacity of its soils in many areas, the country is fortunate to possess a fairly rich natural resource base. Rivers are numerous, and for the most part, provide sufficient amounts of water to meet domestic, industrial, agricultural and power generation needs. Both inland and coastal water resources contain a great abundance and variety of aquatic species. Over 50% of the country is still covered by forests, that are valuable form an economic, as well as an environmental standpoint, because they protect much of the country's steeply sloping land from forces of erosion. Also, due to the country's unique geological location as a "bridge" between two continents, the terrestrial flora and fauna and the tropical ecosystems which they comprise are extremely complex and unique, and provide excellent opportunities for education, tourism and research into the tropical environment.

Recent population pressures in rural areas, however, have led to the abuse of the country's natural resource base-its soils, waters, forests, and wildlife-in a manner that maximizes short-term economic gains at the expense of degrading these valuable resources. Eventually the damage or loss of many of these resources will limit the country's prospects for future development and, inhibit the achievement of better socio-economic conditions for the country's rural poor population.

Already, large areas of natural and secondary growth forests along the Pacific coast of the country's central and western provinces have been replaced by traditional "slash and burn" cultivation and extensive pasture lands. Inappropriate use of "slash and burn" agricultural technology and poor pasture management practices, combined with steeply sloping land, low soil fertility and high precipitation rates have led, in many areas, to severe erosion problems, further loss of soil fertility, and degradation and depletion of water resources used for domestic consumption, irrigation, power generation and transportation.

The Panama Watershed Management Project seeks to initiate solutions to some of these natural resource problems through building the institutional and educational capabilities of RENARE (Dirección de Recursos Naturales Renovables), the project's implementing agency, and through the establishment of watershed management programs that lead to optimal management, conservation and use of renewable natural resources. Under the project, watershed management programs will be developed for three of Panama's priority watersheds: 1) The Panama Canal Watershed, which covers 326,000 hectares* in the central, urban provinces of Panama and

* All lands within the Canal Zone (excluding the 11,000 hectare pipeline road area) are not included in the project area.

Colon; 2) the Rio La Villa Watershed which covers 80,000 hectares in the provinces of Los Santos and Herrera on the Azuero Peninsula; and 3) the Rio La Caldera Watershed which covers 22,000 hectares in the country's northwestern province of Chiriqui. Locations of these watersheds within the country are provided in Figure I - 1.

The major focus of the project will be on the Panama Canal Watershed where it is essential to reduce high erosion and sedimentation rates to ammeliorate the economic condition of the area's rural population, and perhaps more importantly, to maintain the area's hydrologic balance for effective operation of the Panama Canal, one of the country's most valuable economic resources. A detailed map of this watershed showing water resources, population centers and the Administrative Units, developed by RENARE to facilitate project implementation, is given in Figure I-2.

In this watershed a management plan has already been developed which prescribes a mix of reforestation, park and reserve management activities, site-specific soil conservation measures and pasture improvement activities to address erosion and sedimentation problems in the watershed's most critical areas. It is projected that if no action is taken to stop high erosion rates that 80% of the storage capacity of Lake Alajuela, which supplies water for Canal operations during periods of low runoff, may be lost by the year 2040.

Specific watershed management activities of the Rio La Villa and Rio La Caldera Watersheds have not yet been precisely identified and watershed management plans for these areas will be developed during project implementation.

The major resource problem of the Rio La Villa Watershed, which is an important source of water supply for domestic, industrial, and agricultural use, in the Chitre-Los Santos area, is that conversion of forested lands on steep slopes to extensive and poorly managed pasture lands has caused high runoff and erosion rates, rapid land deterioration and possible stream flow damage.

In the Rio La Caldera Watershed, which is the source of water for the La Estrella-Los Valles hydro-electric power generation project, as well as several irrigation systems, the major resource problem again is high erosion, runoff and sedimentation rates, due to extensive slash and burn activities on steep slopes, and lack of conservation practices in the watershed's small areas of intensive agriculture. High erosion rates are jeopardizing the agricultural capacity of what is considered to be Panama's best agricultural lands. High runoff rates during intense rainstorms are increasing the probability of serious flooding and sedimentation may affect the intake of the hydroelectric power plant.

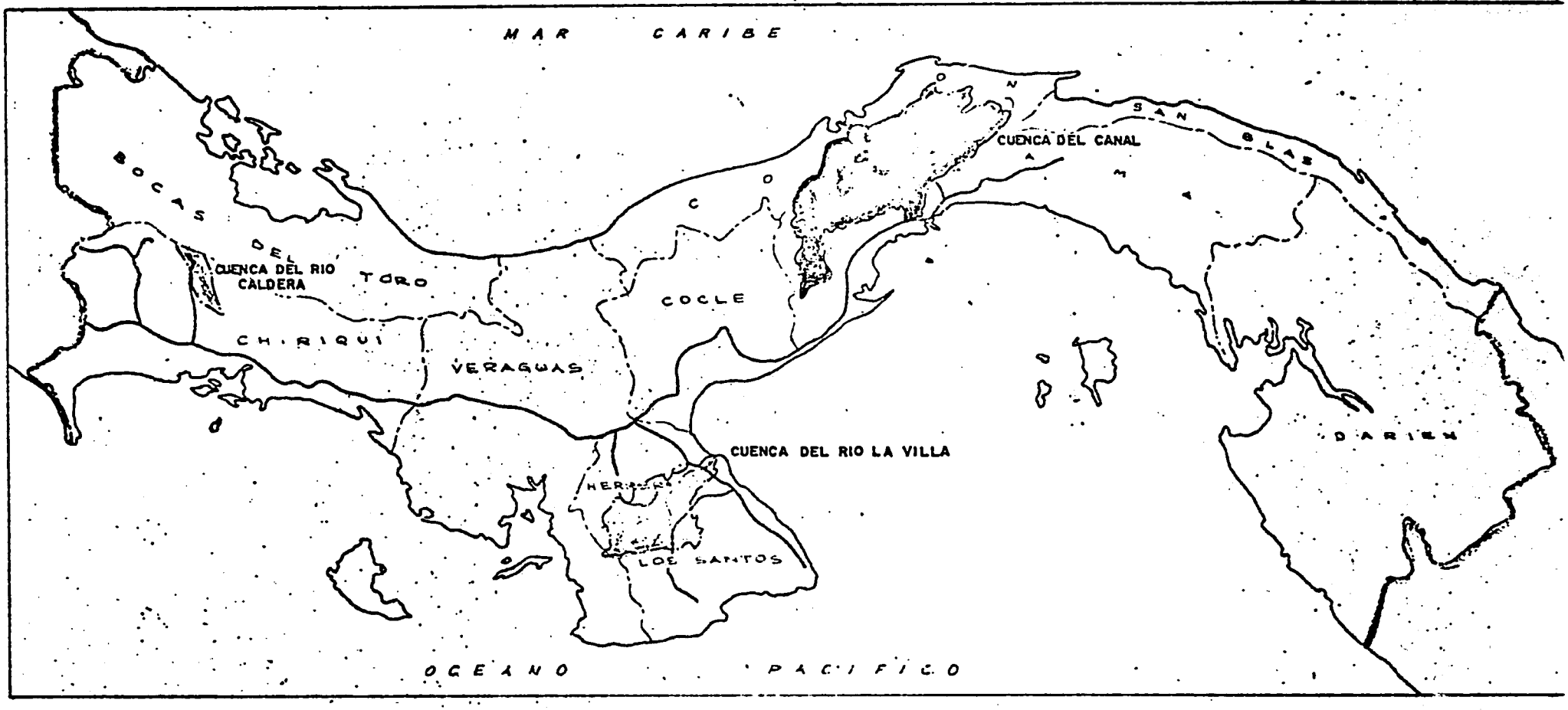
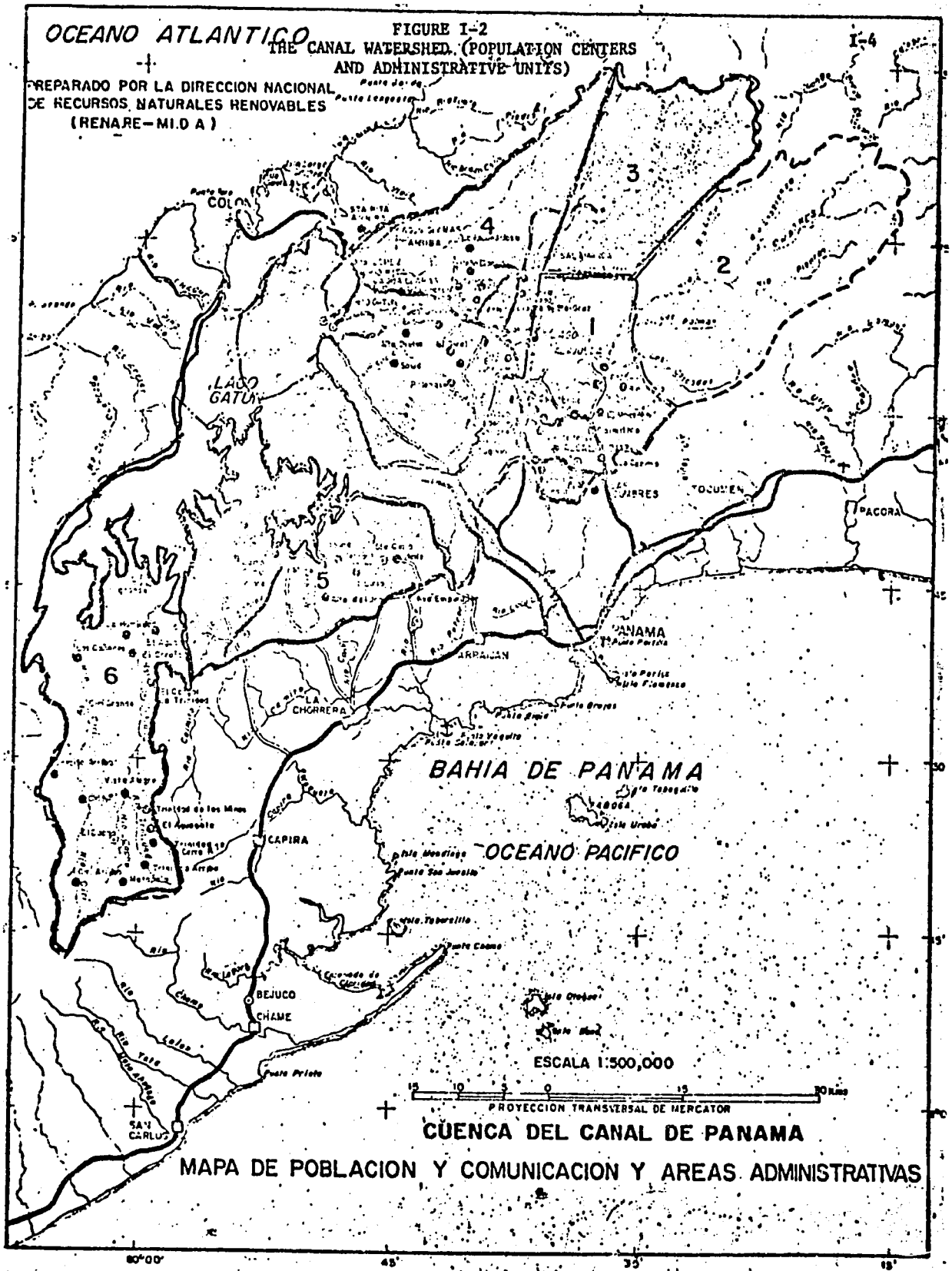


FIGURE - I-1
LOCATION OF
PROJECT WATERSHEDS

LOCALIZACION REGIONAL

FIGURE I-2
THE CANAL WATERSHED (POPULATION CENTERS AND ADMINISTRATIVE UNITS)



Preparado por la Oficina de Cartografía de la Dirección Nacional de Recursos Naturales Renovables (RENARE) del Ministerio de Desarrollo Agropecuario (MIDA) en base a la mapa existente en el Instituto Geográfico Nacional Tomy Guardia.

LUGARES POBLADOS
CAPITAL DE REPUBLICA ____ PANAMA ____
CABECERA DE PROVINCIAS ____ COLON ____
CABECERA DE DISTRITOS ____ LA CHORRERA ____
CABECERA DE CORREGIMIENTO ____ CHILIBRE ____
OTRAS POBLACIONES ____ PARAISO ____

CARRETERAS Y CAMINOS
PANAMERICANA Y TRANSISTMICA ____
RESTO DE CAMINO TRANSITABLE EN TODO TIEMPO ____
FERROCARRIL
RIO PRINCIPAL ____
LIMITE DE PROVINCIA ____
LIMITE DE CUENCA (OPCIONAL) ____
AEROPUERTO, PISTA DE ATERRIZAJE (OPCIONAL) ____
PUERTO (OPCIONAL) ____

SIGNOS CONVENCIONALES

Administrative Units
1. Alajuela
2. Cerro Azul
3. Salamanca
4. Buena Vista
5. Cerro Cama
6. El Cacao

B. Methodology for Environmental Assessment

This Environmental Assessment (EA) focuses on the impacts of the Watershed Management Project in the Panama Canal Watershed. Impacts of project activities in the Caldera and La Villa Watersheds are only analysed in a brief qualitative manner because, although the types of activities to be undertaken in these two watersheds are generally agreed to, the precise scope of these activities will not be detailed until comprehensive management plans for these watersheds are developed during project implementation. To assure a sufficient and satisfactory environmental assessment of these activities to be undertaken outside the Canal Watershed, the loan agreement contains a condition precedent which requires that project activities in these two watersheds receive detailed feasibility and impact analyses prior to their implementation. Thus, the approach taken in this document, with its concentration on the Canal Watershed, suggests that, with few exceptions, environmental impacts in the Caldera and La Villa Watersheds will parallel the effects of project activities on the Canal Watershed's environment.

The methodology utilized for the EA included a review of existing literature and data, as well as site visits and interviews with Government of Panama and Canal Zone officials involved in planning for the management of resources in the Canal Watershed, to become acquainted with existing environmental conditions, problems and trends in the project area and to establish a baseline for the impact assessment of project activities. A description of existing conditions and trends in the Canal Watershed is presented in Section II.

Various alternative plans were developed to address the Canal Watershed's most critical resource problems. The proposed project (or Selected Plan) is described in Section III and the alternative plans, which were developed without regard to USAID timing and funding contraints, are presented in Section VI. To adequately assess the impacts of each of these alternative plans for resource management in the Canal Watershed, future conditions without a project (the "No Action" Alternative described in Section IV) were projected. A comparison was then made between each watershed management alternative and the No-Action Alternative, and a trade-off analysis among the various plans was performed according to the requirements of the Water Resources Council's Principles and Standards for Water and Related Land Resources. Assessment of the Selected Plan and its alternatives are given in Section V and VII and the Principles and Standards analysis may be found in Annex IV of the Project Paper.

II. THE ENVIRONMENTAL SETTING

A. The Panama Canal Watershed

1. Physical Characteristics

a. The Land

(1) Topography

The topography of the Canal Watershed is extremely varied. Elevations range from sea level, at the mouth of the Chagres River, to nearly 800 meters above sea level at the head of the Ciri River, southwest of Lake Gatun, and to approximately 1000 meters in the Continental Divide, east of Lake Alajuela.

Most of the Watershed area of the Ciri and Trinidad Rivers is part of Panama's Cordillera Central or Western Highlands, and consists, for the most part, of rolling hills. Lake Gatun and vicinity occupy part of the Northwestern Atlantic Coastal Lowland, which typically has slopes of 10% to 30% with approximately 100 meters of local relief. The Chagres and Gatun Rivers, Lake Alajuela and their many tributaries are located in the Easter Highlands west of Lake Gatun. Except for an area of rolling plains west of Lake Alajuela, this region is quite mountainous with slopes greater than 45%.

A very significant feature of the watersheds topography is the high proportion of area in steep slopes (See Figure II- land Table II-1). Over 63% of the area is characterized by slopes greater than 45%, while slopes of less than 8% cover only 3% of the area.

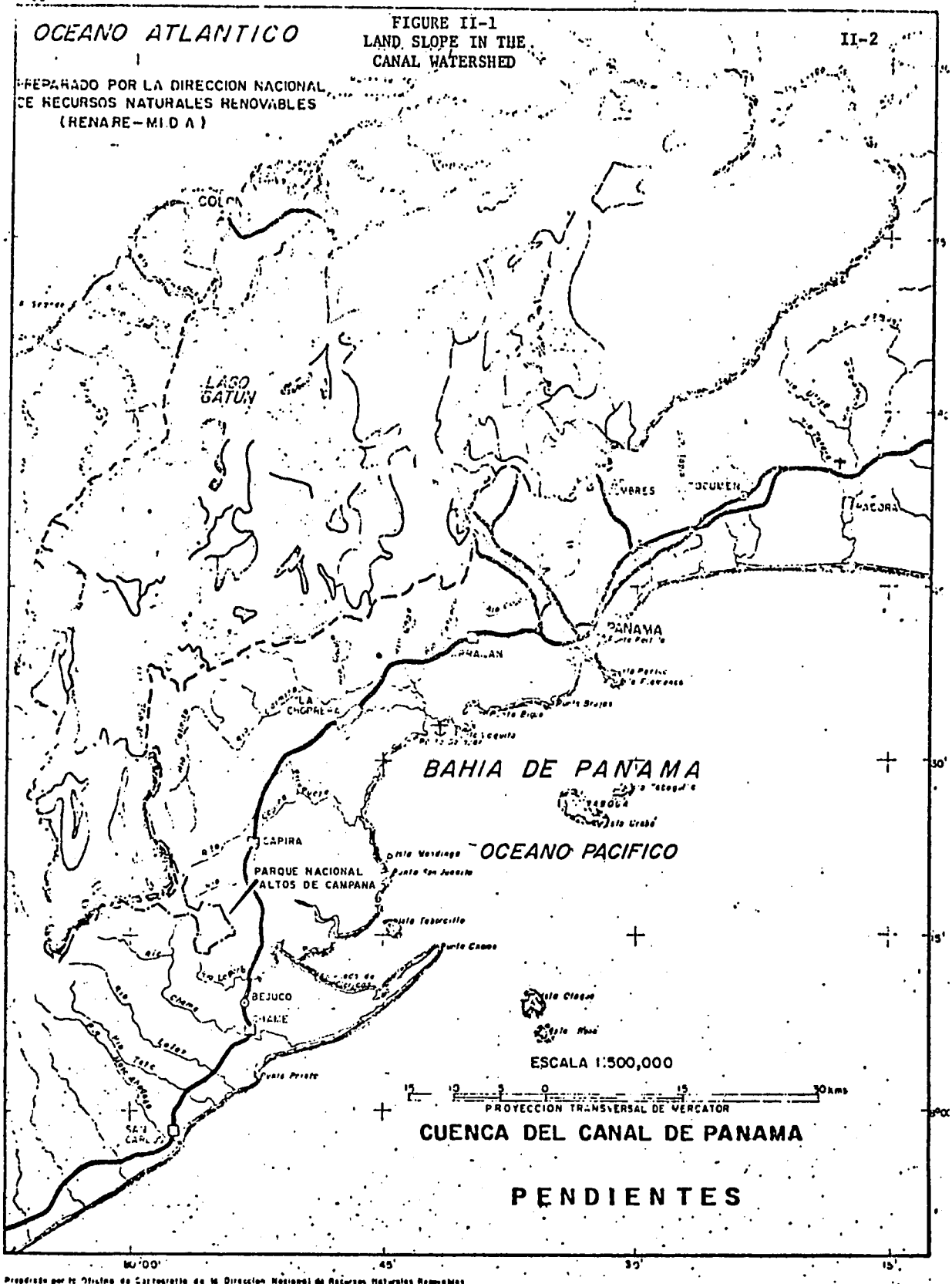
(2) Geology

The Project Area lies in Central Panama which is generally composed of rock of Tertiary age. The underlying basement complex consists of altered lavas and tuffs which are presumed to be of Cretaceous age.

During the early Tertiary the basement was deformed and intruded by igneous rock. After a period of erosion, sedimentary rock of the Gatuncillo formation was deposited over the basement. During the following Oligocene Epoch, clastic and extrusive volcanics covered the southern and western part of the area with marine deposition in the remaining portions. Alternating marine deposits and volcanics were laid down during the mid-Miocene and Later Miocenes; and Pliocene submergence produced wide-spread shallow marine deposits. Pleistocene and Recent deposits consist of low lying fill limited to valleys and some corals just above the present shoreline.

Regional structural trends (the general alignment of faults and fold axes) tend to be along either North-South

FIGURE II-1
LAND SLOPE IN THE
CANAL WATERSHED



Preparado por la Oficina de Cartografía de la Dirección Nacional de Recursos Naturales Renovables (RENARE) del Ministerio de Desarrollo Agropecuario (MIDA) en base a fotomosaicos obtenidos en el Instituto Geográfico Nacional Tommy Guardia.

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OTRAS POBLACIONES ..... PANAIRO

CARRETERA Y CAMINOS
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FERROCARRIL
VIA NORMAL

LIMITES
LIMITE DE CUENCA (OPCIONAL)
AEROPUERTO, PISTA DE ATERRIZAJE (OPCIONAL)

SIGNOS CONVENCIONALES

LEYENDA

	45 %	PENDIENTE
	20-45%	PENDIENTE
	8-20 %	PENDIENTE
	0-8 %	PENDIENTE

TABLE II - 1

LAND SLOPE IN THE CANAL WATERSHED

% SLOPE	AREA (HECTARES)	PERCENT OF TOTAL AREA
0-8%	7,000	3%
8-20%	36,400	14%
20-45%	54,500	20%
More than 45%	168,300	63%
T O T A L	266,200*	100%

* Does not include the Canal Zone (except for Pipeline Road Area), bodies of water, or other uses such as roads.

or an East-Northeast direction, which approximates the alignment of the isthmus. The most prominent structural features of the study area are; the complex of faults in the vicinity of Gaillard Cut, the Madden basin occupied partly by Alajuela Lake and the Quebrancha, and the Syncline which underlies the lowland area to the north of the Chagres River.

Gravel, which is suitable for use as road surface or aggregate, is present in bar deposits in many of the area streams. Sand is also present in small quantities but is generally of poor quality due to a low quartz content. Much of the intrusive rock (dacite and diorite) and some of the extrusive basalt is suitable for use as dimension stone or may be crushed for aggregate. The limestone member of the Caimito formation exists in considerable quantities and is being quarried for cement manufacture.

Gold has been mined from both vein and alluvial deposits at several locations within the area. Vein deposits generally occur as quartz-sulfide associations in intrusive igneous rock. Quantities are not great and the general grade of the ore is low. There are manganese deposits with some associated copper mineralization in the area of the Boqueron and upper Gatun Rivers. Some of the deposits are of fairly high grade; however production has been intermittent.

Panama is a region of moderate seismic risk. Earthquakes are not common and surface effects have not exceeded Level V on the Modified Mercalli Scale.

(3) Soils

The warm humid climate of Panama promotes rapid chemical weathering of rock to a considerable depth. The low quartz content of both the igneous and sedimentary rock of the area results in the formation of soils with a high silt and clay content with relatively little sand. Topsoils vary locally in both texture and structure, however, most are shallow and stony, and highly susceptible to erosion. The continued fertility of these topsoils depends not only on forest cover to stop the leaching and weathering action of the area's high temperatures and precipitation, but also on both the deep forest root systems which restore minerals to the soil's surface from deeper soil levels or parent materials and on rapidly decomposing forest litter which recycles nutrients back to the soil.

Figure II-2 classifies the soils of the watershed according to their Land Capability. This classification takes into account both climatic factors and permanent soil characteristics such as soil texture, depth, slopes, permeability, and categorizes the soil according to risk of soil damage, limitations on use, productive

productive capacity and soil management requirements. As shown in Fig. II-2 and Table II-2, below, most soils in the watershed are class VI and VII, which means their use for agricultural pursuits should be restricted.

TABLE II-2

LAND CAPABILITY OF SOILS BY % OF LAND AREA IN THE WATERSHED

CLASS	I	II	III	IV	V	VI	VII
%	-	02	4	9	-	18	68

A description of Land Capability classes is given in Appendix 1.

b. Land Use

(1) General Description

Until the late 1950's natural forest cover was the most significant land use category in the watershed. However, due to the high rates of immigration and deforestation during the 1960's, other land uses, that reflect the influence of man, have assumed increasing importance. In 1977, natural forests covered only 29.7% of the watershed's land while secondary growth (following agricultural abandonment) and pastures characterized 23.7% and 26.6% of the area's land respectively. Table II-3 shows current estimated land use for the entire watershed, and the tables in Appendix 2 give a breakdown of land use and land slope characteristics for each of the watershed's Administrative Units (See Figure I - 2).

(2) Land Use by Administrative Unit

The Cerro Azul Administrative covers almost 52,000 hectares in the eastern portion of the watershed, of which over 90% is in slopes greater than 45%. It has the largest proportion of area (86%) in natural forests than any other Administrative Unit and contains a major part of the Chagres Forest Reserve, established in 1963 to protect the watersheds of the Chagres River and a number of other tributaries to Lake Alajuela. Approximately 10% of the area is currently devoted to agricultural use or secondary growth forest.

The Salamanca Administrative Unit covers 29,000 hectares in the northeast portion of the watershed, of which over 85% is in slopes greater than 45%. This area still has a significant amount of land in natural forests (over 67%). Approximately

C. Findings and Conclusions

For the Canal Watershed, the Selected Plan was justified on the basis that, with the exception of the EQ plan, it was the only plan that fit within USAID funding and timing constraints. In addition, it will generate many significant beneficial economic and environmental impacts, and will create the least adverse social impacts of all plans because it requires the least amount of resettlement and occupational change for the area's residents.

Although the Selected Plan does not achieve the highest reduction in erosion rates, nor the highest economic benefits, it will create many beneficial changes in the watershed, and will represent the beginning of what is planned to be a long-term resource management effort. Some of the plan's most beneficial impacts are:

1). The preservation of 93616 hectares of forest land which currently provide habitat for numerous terrestrial wildlife species (including 26 which are classified as threatened or endangered by U.S. and/or Panamanian law).

2). A reduction in annual sediment yield in the watershed to 7.8 million m^3 by the year 1983 (compared to projections of annual sediment yields of 11.5 million m^3 and 160 million m^3 for the years 1983 and 2000, respectively without implementation of a plan).

3). The maintenance of 72% of Lake Alajuela's active storage capacity in the year 2040 (compared to estimates that only 16% of the Lake's Active storage capacity will remain in the year 2000 without a project).

4). The prevention of water quality degradation and hence damage to aquatic ecosystems and pollution of water used to supply the domestic systems of the Panama-Colon metropolitan area.

5). The provision of 2300 intermittent unskilled jobs paying an average of B/300/year for 5 years to low income residents of the watershed.

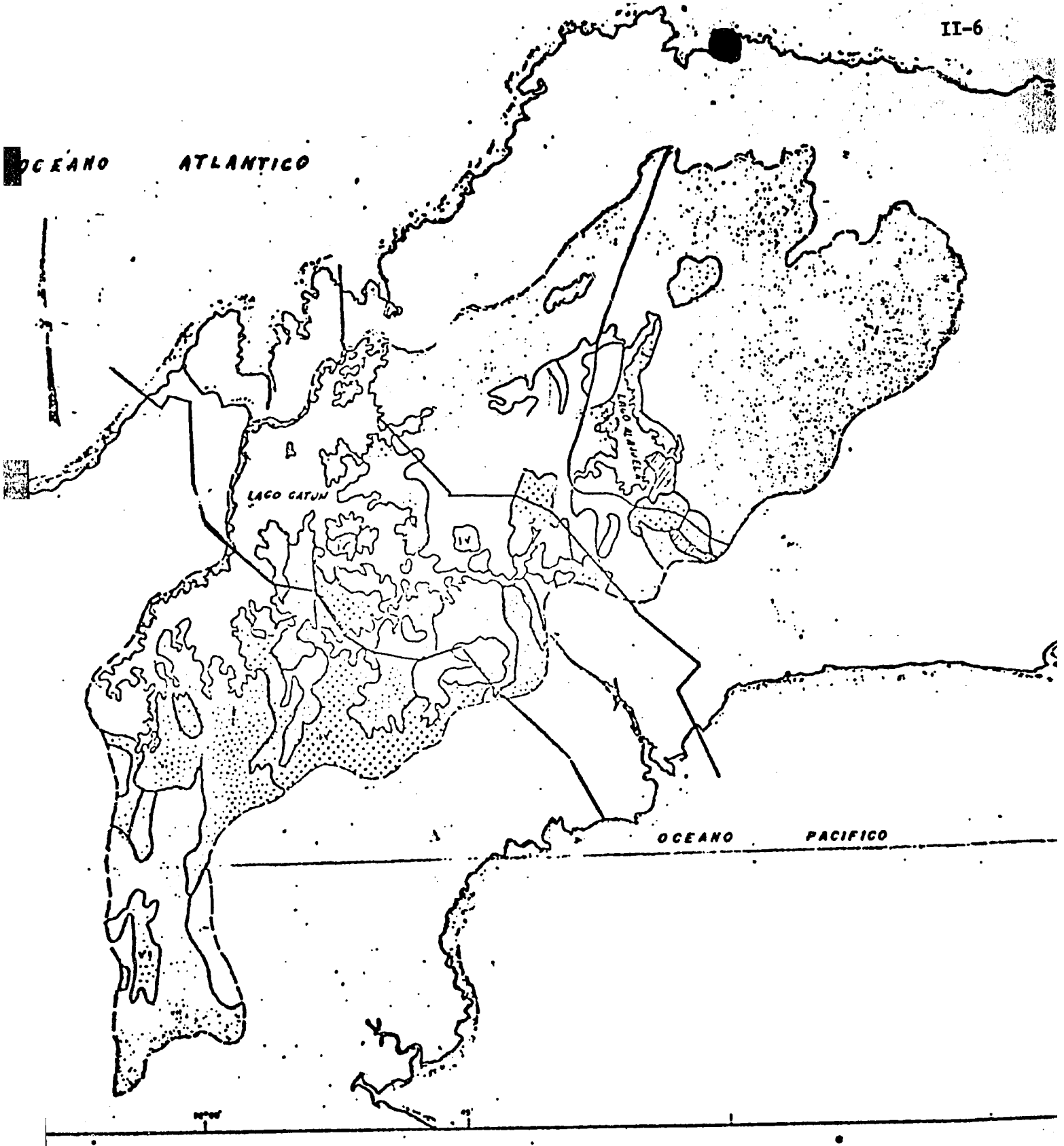
Despite the many beneficial impacts of the Selected Plan, some areas of concern were identified:

1). Possible contamination of the watershed's environment with herbicides used in reforestation and pasture improvement activities. This contamination will be minimal because herbicides will only be utilized by experienced RENARE personnel under highly controlled conditions in nurseries and experimental plots. In addition this project's loan agreement will require RENARE to obtain prior USAID approval for the use or procurement of any pesticide for project purposes, to ensure such pesticides comply with U.S. Environmental Protection Agency regulations.

2). Possible adverse social impacts caused by resettlement of some of the area's residents currently living in the most critical environmental areas. Resettlement proposed by the Selected Plan will be minimal, however, and on a voluntary basis.with compensation.

3). Possible undermining of project efforts through failure to develop zoning regulations and enforcement procedures for lands outside the plan's proposed activity areas. Zoning and land use controls are beyond the control of this project. In the Canal Watershed they must be developed under the policy guidance of the Panama Canal Authority. It is expected that the Authority will adopt the technical recommendations of RENARE as well as those of other GOP technical Agencies involved in the zoning of Canal Watershed's lands.

For the La Villa and Caldera watersheds, project impacts will be favorable. In the La Villa watershed soil conservation and reforestation activities will reduce sediment yields and generate intermittent unskilled jobs. In the Caldera watershed soil conservation will protect some of Panama's most fertile land, and these activities will protect the La Estrella-Los Valles hydro-electric facility.



CUENCA DE LOS LAGOS ALAJUELA Y GATUN
MAPA DE CAPACIDAD AGROLOGICA

CLASE AGROLOGICA	AREA DENTRO DEL AREA DE LA CUENCA DEL LAGO GATUN	AREA DENTRO DEL AREA DE LA CUENCA DEL LAGO ALAJUELA	TOTALES

TABLE II - 3

CURRENT LAND USE IN THE CANAL WATERSHED

(Hectares)

Present Land Use	SLOPES 0-8%	8-20%	20-45%	45%+	TOTAL
Natural Forest	400	3,300	9,800	79,500	93,000
Plantations		30			30
Secondary Growth	2,400	10,670	23,000	40,100	76,170
Forest Sub-Total	2,800	14,000	32,800	119,600	169,200
Intensive Agriculture	100				100
Traditional Agriculture	1,200	2,700	2,100	4,000	10,000
Agriculture Sub-Total	1,300	2,700	2,100	4,000	10,100
Improved Pasture	500				500
Faragua Grass	900	17,600	15,600	20,800	54,900
Imperata Grass	1,500	2,100	4,000	23,900	31,500
Pastures Sub-Total	2,900	19,700	19,600	44,700	86,900
TOTAL AGRIC. PAST. FOREST	7,000	36,400	54,500	168,300	266,200
Other Uses					60,025
GRAND TOTAL					326,225

9% of the area is in agricultural use, and almost 20% is in secondary growth forests.

The Buena Vista Administrative Unit is located east of the Canal in the Central and Northern part of the watershed. It covers almost 59,000 hectares of which all but 15,200 hectares (or 22%) have been cleared. (Approximately 11,000 of these forested hectares belong to the Pipeline Road Area of the Canal Zone, which will revert to Panama upon implementation of the Panama Canal Treaties). Currently, 21.5% of the area is in secondary growth and 27,000 hectares (or 39.2% of the area) is devoted to pastures. Almost 20,000 hectares of this pastureland are in a degraded state and have been invaded by Imperata grass, which usually economically forecloses the use of such lands. The rest of the area is primarily devoted to both traditional and intensive agriculture. This area also has a high percentage of land (over 70%) in slopes greater than 45%.

The Alajuela Administrative Unit covers almost 41,000 hectares of the watershed around Lake Alajuela, of which over 63% are in slopes steeper than 45%. It has the largest amount of land devoted to urban use than any other Administrative Unit and contains the rapidly growing towns of Alcalde Diaz, Chilibre and Nuevo Vigia. Only 11.8% of the area remains in natural forests, while almost 10% is devoted to traditional agriculture and 44.5% is devoted to pasture. Already over half of the pasturelands in this area are classified as degraded, and suffer from the encroachment of Imperata grass.

The Cerro Cama Administrative Unit is located in the southwest part of the watershed and covers an area of almost 49,000 hectares. The topography of the area is mostly rolling hills with slopes between 8 and 45%. More than 50% of the area is dedicated to faragua grass pastures, and over 10% of the area is used for traditional agriculture. The remainder of the land area is either natural or secondary growth forest.

The El Cacao Administrative Unit is located in the extreme southwest portion of the watershed. It covers over 60,000 hectares, of which over 35% are in slopes greater than 45%. It contains the headwaters of the Ciri and Trinidad Rivers, major tributaries to Lake Gatun, and 4816 hectares of the Altos de Campana National Park and Biological Reserve established in 1966 to provide a natural recreation area close to Panama's metropolitan area. Virtually no primary forest remains in this area. Approximately 21% of the area (12,650 hectares) is faragua pasture, and most of the remaining 36,000 hectares are secondary growth forest, in which traditional agriculture has been recently practiced.

The Canal Zone covers over 26,000 hectares (excluding Pipeline Road Area) of the watershed of which over 75% constitues Lake Gatun. Over 80% of the remaining land area is covered by nature forests.

The land classified under other uses in each Administrative Unit includes: roads; urban areas; lakes; rivers; and tourist or recreational projects. With regard to recreational projects, two such projects have been developed in the past 10 years.

The first project, planned at Lake Alajuela, was the parceling of "Altos del Lago", presented to the IVU (now the Ministry of Housing), on April, 1969, for its approval. The project consists of the development of 530 hectares for residential and recreational purposes, with lots of approximately 4,000 m^2 (minimum). The project is located in the area that borders Lake Alajuela across from Garrapata Island.

At the end of 1974, the draft of another residential-recreational development designated "Isla Verde", consisting of 130 hectares located on the banks of Lake Alajuela, was submitted to the Ministry of Housing for consideration. This project was approved under terms similar to those for "Altos del Lago".

As a result of these two cases of urbanization, a mixed commission (Ministries of Housing and Health and RENARE) was created to regulate the establishment of new suburban communities in the area and to develop zoning ordinances for the two lakes. Draft technical standards for the Lake Alajuela area have been completed and are being reviewed within the Government. Those for Lake Gatun are not yet completed.

c. Land Resource Trends

(1) Land use

Although it is known that the amount of natural forests in the watershed has declined from 85% of the watershed's area in 1952 to 32% of the watershed's area in 1978 (see Sec. II 3e, Biological Trends) no quantitative data exists on the rates of conversion of these forested lands to agricultural and pasture use. The above-mentioned section on Ecological Trends does, however, discuss in qualitative terms land use trends, as well as the impacts of these trends on soil erosion and fertility.

(2) Soil Erosion

Soil erosion related to various land uses was quantified during the development of the project, and it was determined

that the conversion of forested lands to agricultural use and pastures has already caused widespread erosion of the watershed's soils. Table II - 4, which displays sediment yield rates by land use and slope, shows that lands in intensive agriculture and faragua pasture are producing the highest rates of sedimentation. Calculation of these sediment yield rates is explained in Annex VI D of the Project Paper.

Using data on sedimentation yield rates and actual land use, it can be calculated that the current sediment yield in the watershed is almost 9.5 million m^3 (Table II - 5). Since only 2% of the land in the basin is devoted to intensive agriculture, the contribution of this land type to the total sediment yield is small. However, the 23% of the watershed's land devoted to pastures planted with faragua is causing over 50% of the entire sediment yield.

These sediment yield calculations may be low as they do not include estimates of erosion caused by the area's poorly constructed roads, which contribute substantially to gully erosion in the basin due to extensive fills and cuts which create steep embankments. These embankments are usually left unvegetated, and are quickly eroded by surface runoff, allowing poorly constructed road beds and ditches to act as direct channels for this highly sedimented run-off into the watershed's streams and lakes.

TABLE II - 4

ESTIMATED SEDIMENT YIELDS PER UNIT AREA FOR THE CANAL WATERSHED ACCORDING TO LAND SLOPE AND TYPE OF LAND USE

(M^3/Hectare/Year)

Land Use	0-8%	8-20%	20-45%	45%+
Natural Forest	3	6	8	10
Plantations	5	10	16	22
Secondary Growth	5	10	16	22
Intensive Agriculture (without erosion control practices)	80	160	230	300
Traditional Agriculture (slash and burn) and perennial crops	20	40	60	80
Improved Pasture (Stoloniferous grass)	6	13	20	27
Faragua Grass Pasture	30	60	100	150
Imperata Grass	7	15	23	30

TABLE II - 5

ANNUAL SEDIMENT YIELD IN THE CANAL WATERSHED WITH CURRENT LAND USE

M^3

Land Use	0-8%	8-20%	20-45%	45%	Total
Natural Forest	1,000	20,000	78,000	795,000	894,000
Plantations					
Secondary Growth	12,000	107,000	368,000	884,000	1,369,000
Forest Sub-Total	13,000	127,000	446,000	1,677,000	2,263,000
Intensive Agriculture	8,000				8,000
Traditional Agriculture	24,000	108,000	126,000	320,000	578,000
Agriculture Sub-Total	32,000	108,000	126,000	320,000	586,000
Improved Pasture	3,000				3,000
Faragua Grass	27,000	1,056,000	1,560,000	3,120,000	5,763,000
Imperata Grass	11,000	32,000	92,000	717,000	852,000
Pasture Sub-Total	41,000	1,088,000	1,652,000	3,837,000	6,618,000
T O T A L	86,000	1,323,000	2,224,000	5,834,000	9,467,000

d. Water Resources

(1) Surface Water

(a) General Description

The Canal Watershed contains two large man-made lakes and numerous tributary rivers and streams.

Lake Gatun, the largest of the two lakes, was formed by the construction of Gatun Dam near the mouth of the Chagres River during the building of the Panama Canal in 1914. The lake actually constitutes a little over 50% of the Canal's length, and has a surface area of approximately 43,400 hectares and an elevation that varies between a high of 26.5 meters (87 ft.) at the end of the rainy season and a low of 25.3 meters (83 ft.) at the end of the dry season. Its usable storage capacity (above elevation 25 meters or 82 ft.) is approximately 641.3 million cubic meters (MCM)(520,000 acre ft.), while its dead storage is 4,810.7 MCM (3,900,000 acre ft.) The lake has 4 major tributaries: the Ciri and Trinidad Rivers to the southwest; the Gatun River to the northeast; and the Chagres River, which flows through the central western portion of the watershed.

Lake Alajuela was formed in 1934 by the construction of Madden Dam on the Chagres River, 16 kilometers upstream from where the river empties into Lake Gatun. The watershed area of this lake is approximately 102,600 hectares, or 31% of the entire Canal Watershed area and contains several subwatersheds of significant size including those of the Chagres, Indio, Pequeni and Boqueron Rivers. The elevation of the Lake varies according to requirements for operation of the Panama Canal and averages between 76.8 meters (252 ft.) and 60.9 meters(210ft.) above sea level. The lake's corresponding surface areas at these levels are 4,900 hectares and 2,820 hectares respectively. Its usable water storage capacity, at the 76.8 meter level, is 579.7 MCM (470,000 acre feet) and its dead storage is less than 222.0 MCM (180,000 acre feet), at the 60.9 meter level.

With its many rivers and streams the watershed can be considered to be well drained. Average annual runoff for the entire watershed is 1,757 mm. Much of this runoff occurs during the rainy season as brief unpredictable flood flows of a few hours duration.

Three major factors influence the flow regime of the area's streams:

1. Most rainfall originates from individual storm cells of limited size. Therefore one stream may receive a large amount of rain, while an adjacent stream receives little or none.

2. Land slopes and stream gradients are very high, causing runoff to move quickly into streams and flood flows to travel downstream rapidly.

3. Most streams are relatively short, causing flood waters to discharge through individual tributary systems within a comparatively short time.

Toward the end of the rainy season, when the ground is saturated with water, small streams commonly rise 20 feet or more in two hours or less. Even the larger tributaries such as the Trinidad River rise 6 feet or more during heavy rains.

During the dry season (January through April) rainfall dismishes to less than 60 mm. per month and stream flow is greatly reduced. Figure II - 3 shows typical annual discharges for some of the area's streams.

(b) Water quality

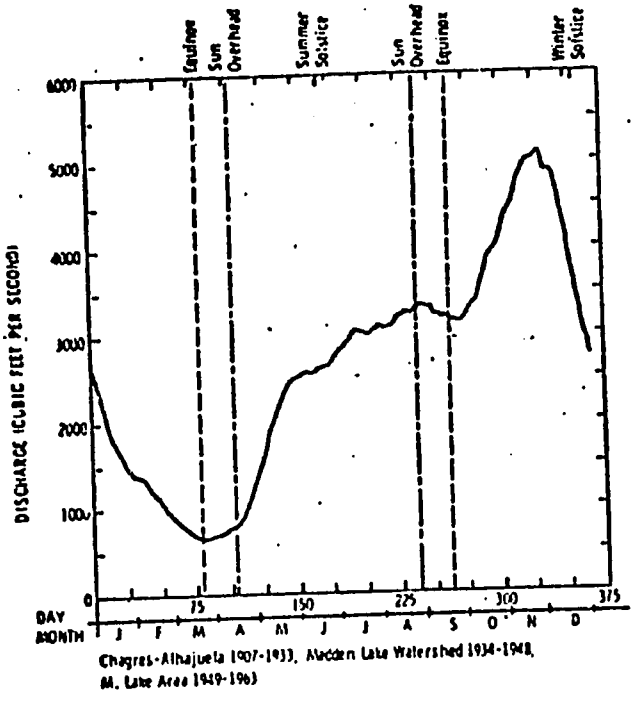
The most recent water quality data for the watershed was collected in 1972-1974 by the Panama Canal Company for the Canal Zone Water Quality Study. This study maintained over 500 sampling stations, located mainly in Lakes Gatun and Alajuela, for a 31 month period. The results of the study are summarized below.

Lake Gatun is a thoroughly mixed lake with litte variation in dissolved oxygen (DO), temperature, pH and turbidity from top to bottom. The Study found that, in most areas, average DO levels were near saturation, with less than .5 ppm. difference between surface and bottom strata. However, average DO values below 4.0 ppm. (the level considered satisfactory for propagation of fish and wildlife) were found in bottom strata waters near townsites, at the mouths of tributaties, in both the southwest and northeast sections of the lake. Water temperature varied from 25.5° to 29.5° C throughout the year, and pH varied from 6.0 to 7.8. The waters were found to be quite soft (50 ppm. $CACO_3$), of low alkalinity (8 ppm.) and low turbidity (average of 1.3 and 3.0 JTU's in dry and wet seasons respectively). Higher turbidity values were found along the shores, at the mouths of tributaties, after periods of heavy rain.

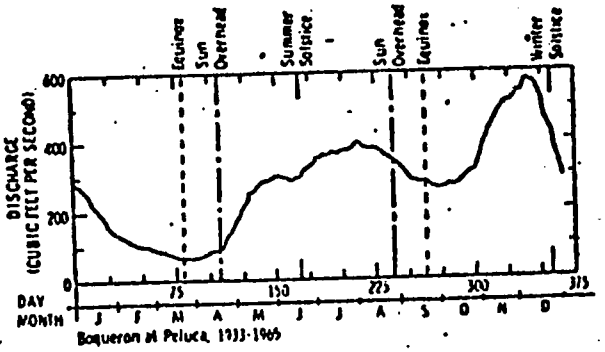
Total coliform counts in the deep sections of the lake ranged from 0 to 5 counts/100 ml. throughout the year, although occasional increases in concentration, ranging from 100 to 400 counts/100 ml., occured along the shores near townsites.

From a nutrient standpoint, the lake was found to be mesotrophic, with average total phosphorous concentrations varying, according to area, from .013 to .034 ppm. and nitrate nitrogen concentrations varying from .010 to .32 ppm. Higher nutrient

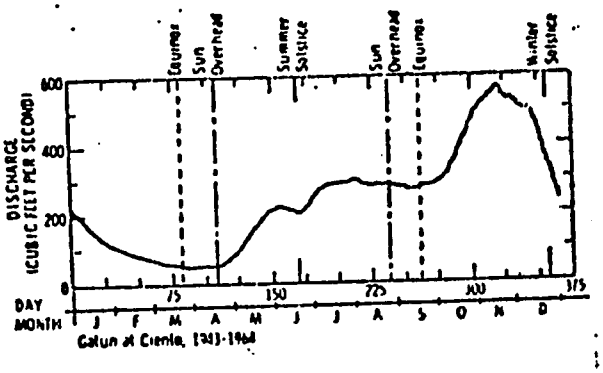
FIGURE II - 3
AVERAGE ANNUAL DISCHARGE OF SELECTED STREAMS IN THE CANAL WATERSHED



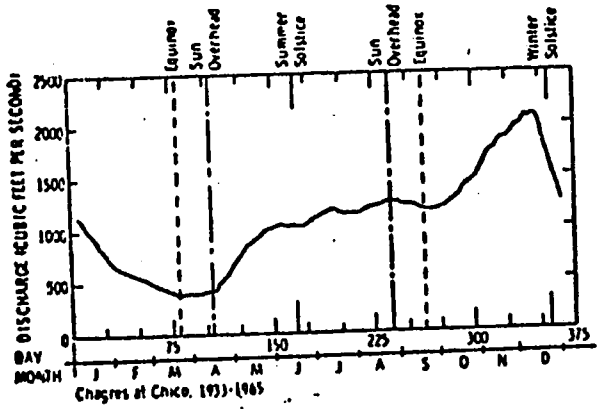
Chagres-Alhajuela 1907-1933, Madden Lake Watershed 1934-1948, M. Lake Area 1949-1963



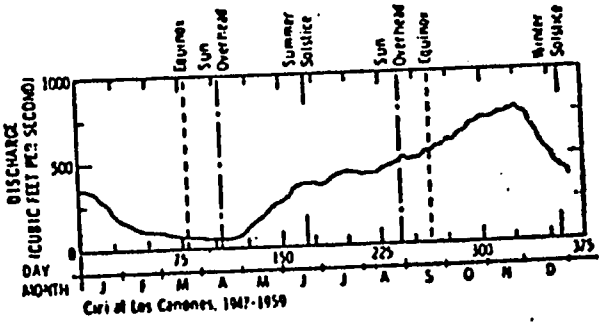
Boquerón at Peluca, 1933-1965



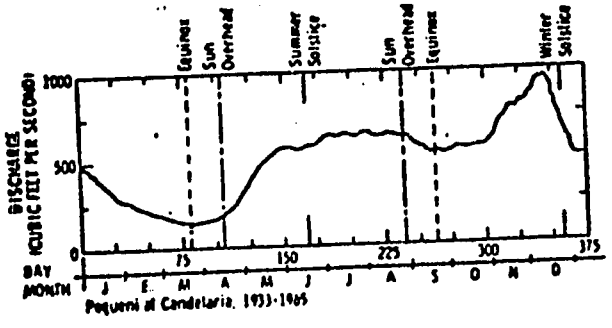
Gatun at Cienia, 1943-1964



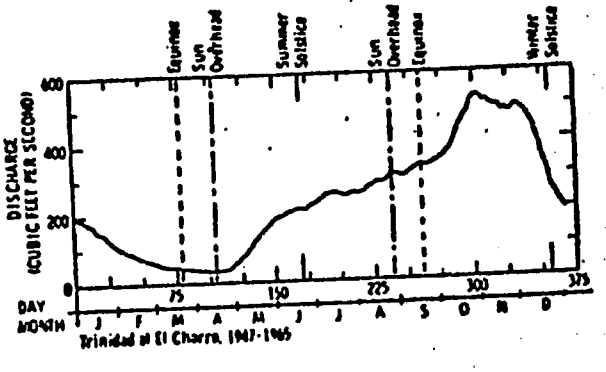
Chagres at Chico, 1933-1965



Curí at Las Cañones, 1947-1959



Pequení at Candelaria, 1933-1965



Trinidad at El Charco, 1947-1965

levels and aquatic weed growth were sometimes found in the waters bordering small towns on the lakes shores.

Lake Alajuela is a stratified lake due to density gradient currents from the flow of the Chagres and Pequeni Rivers through the lake. The Canal Zone Water Quality Study found that during the wet season a temperature difference of up to 4°C existed between top and bottom levels and pH varied from an average of 8.0 on the surface to 6.5 on the bottom. During the dry season, differences in pH and temperature were less pronounced.

Dissolved oxygen in the incoming Chagres and Pequeni River waters averaged above 6.0 ppm. throughout the year, and the top layer of the Lake contained good D.O. levels (6.1-7.7 ppm.) in both wet and dry seasons. However, D. O. values in the bottom layers of the lake were significantly lower at all times of the year, and the level in the bottom strata in front of Madden Dam averaged 1.8 ppm. during the wet season. These oxygen deficient waters are withdrawn from the Dam to form the Chagres River flow between Lakes Alajuela and Gatun.

As for nutrients, total phosphorous levels, ranging between .013 and .044 ppm., placed the lake on the borderline between mesotrophic and eutrophic. Phosphorous values in incoming river water were usually found to be about twice as high as levels found near Madden Dam. Nitrate levels increased with depth.In the wet season nitrate values ranged from .010 ppm. to .80 ppm. in the bottom waters; however such values were much less during the dry season. The exact source of nutrients was not detected but it was speculated that they originated from surface runoff through major tributaties.

Average turbidity levels were highest in the bottom strata of both the Chagres and Pequeni Rivers (5.3 and 9.2 J.T.U.s respectively) and in the Lake itself(approximately 4 J.T.U.s) during the wet season. During the dry season levels were lower and more homogeneous.

Fecal coliform counts were also higher during the wet season, especially in incoming river waters and at bottom levels of the Lake. High counts in bottom levels on the rivers appeared to have originated in surface runoff from nearby towns.

The Canal Zone Study also maintained waters quality sampling stations in the segment of the Chagres River between the two Lakes. Flow in this section of the river is highly variable as it depends on releases at Madden Dam. Water quality here was found to be generally poor as these waters stem from the bottom strata of Lake Alajuela, and receive waste polluted flows from several tributaties.

During the rainy season D. O. levels averaged below 4.0 ppm., with lowest levels (1 ppm.) found at the mouth of the Chilibre River, which carries surface runoff from urban areas along both the Chilibre and Chilibrillo Rivers. During the dry season, D. O. levels in the river ranged from 4.0, to 5.0 ppm. Average turbidity also varied with season; average turbidity in the Chagres River was 9.5 J.T.U.s during the wet season and 2.3 J.T.U.s during the dry season.

This section of the river also was found to have significant weed problems due to high nitrate levels. During the wet season nitrate values averaged as high as .200 ppm. for several miles below Madden dam. High nitrate levels in combination with the levels of phosphorous that were available (average .040 ppm. throughout the year) were provinding an ideal situation for the proliferation of aquatic weeds in this area.

During the rainy season, fecal coliform counts near Madden Lake outlet averaged less than 10 counts/100 ml. Upon leaving Madden Lake, however, they increased to an average of over 100 counts/100 ml., after receiving Gatuncillo and Limon River flows, and to average of over 200 counts/100 ml. upon receiving Chilibre River waters. Bacteria counts on the Chilibre River were found to average over 1100 counts/100 ml. during the wet season. Average fecal coliform distribution during the dry season was similar, but levels were lower.

Concentrations of heavy metals and pesticides sampled in the study area were below detection limits of testing methods used.

In conclusion, the study found the water of both lakes to be of generally good quality. High coliform counts, high nutrient levels and turbidity levels and low D.O. concentrations were, for the most part, found along the shoreline near townsites and near mouths of tributaries which drained populated areas, indicating the influence of man's activities on water quality. The water in the segment of the Chagres River between Lake Alajuela and Lake Gatun was of exceptionally low quality because the river, at this point, in addition to deriving its waters from the oxygen-deficient bottom layers of Lake Alajuela, receives much polluted surface runoff from towns located along its major tributaries.

(c) Water Use

Over the past ten years average annual run-off in the Canal Watershed has averaged 1757 mm. or 5391 MCM. Most of this run-off is stored in Lake Gatun where it is utilized or lost in several ways, as indicated as follows:

	Volume $m^3 \times 10^6$	% of Water Yield
Annual Run-off	5391	
Evaporation	628	
Net Water Yield	4763	100
Canal Lockages	2604	54.7
Hydropower (Gatun)	1570	33
Spillway Discharge (Gatun)	481	10
Municipal Water Supply	81	1.7
Miscellaneous	27	.6

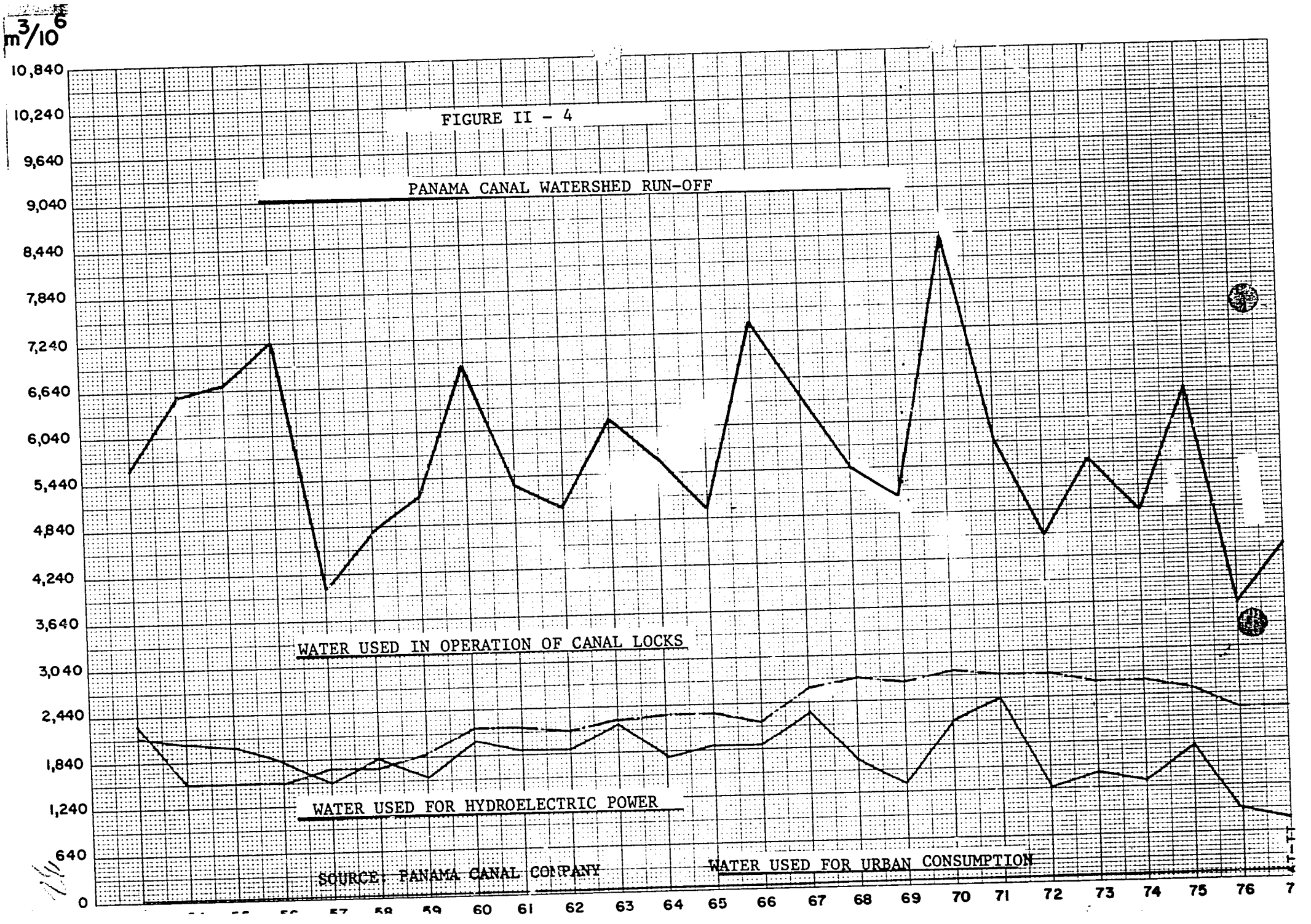
Water for canal operation is clearly the highest priority use for Lake Gatun's waters. Approximately 1.97×10^5 cubic meters of water are needed for each ship transit, and in recent years an average of 36 ships have transited the Canal each day. Reduction in the elevation of Lake Gatun below the 25.7m. level requires a draft reduction of ships entering the Canal. Two years of unusually low rainfall in 1976 and 1977 caused the lake to reach a record low level of 24.6 meters (80.5 ft.) in May, 1977, causing a record draft reduction of 3.1 ft. When the elevation of Lake Gatun is below 25.7 meters, Lake Alajuela waters are released over Madden Dam to minimize the necessity of draft reductions.

Use of Lake Gatun water to supply water to two water supply systems: one on the Atlantic side of Lake Gatun, serving the Atlantic side of the Canal Zone and the city of Colon; and one on the Pacific side serving the Pacific portions of the Zone and parts of the city of Panama, is another priority use. However, quantities needed for water supply are quite small (58 MGD).

Water for hydroelectric power generation is the second major use of Lake Gatun water; however, it has a lower priority than water supply, as power can be generated elsewhere in Panama's integrated power system. Amounts of water for hydroelectric power generation are usually decreased in dry years to satisfy demands of ship lockages and urban use.

Water is discharged over the spillway at Gatun only to eliminate flooding when the lake reaches its maximum level during the rainy season. Figure II - 4 shows the variation in water use from Lake Gatun for the 1953-1977 period.

Mean annual run-off in the Lake Alajuela Watershed is 2,274 mm., which amounts to 2,333 MCM. Thus, although the Lake Alajuela Watershed covers only 31% of the total watershed area, it contributes a little over 40% of the annual water supply of Lake Gatun. Run-off from the lake is utilized or lost, as indicated as follows:


$m^3/10^6$
10,840
10,240
9,640
9,040
8,440
7,840
7,240
6,640
6,040
5,440
4,840
4,240
3,640
3,040
2,440
1,840
1,240
640
0
FIGURE II - 4
PANAMA CANAL WATERSHED RUN-OFF
WATER USED IN OPERATION OF CANAL LOCKS
WATER USED FOR HYDROELECTRIC POWER
WATER USED FOR URBAN CONSUMPTION
SOURCE: PANAMA CANAL COMPANY
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76

	Volume $m^3 \times 10^6$	% of Water Yield
Annual Run-off	2333	-
Evaporation	625	
Net Water Yield	1705	100
Canal operation and hydroelectric power generation	1500	88
Municipal Water Supply	17	1
Spillway Discharge into Lake Gatun	188	11

The major use of water from Lake Alajuela is the maintenance of adequate levels in Lake Gatun for ship transit. At the same time water is released over Madden Dam to help maintain Lake Gatun water levels, power is also generated. A very small amount (1%) of Lake water is used to provide domestic water supply to part of the city of Panama. This water is treated at the Chilibre Treatment Plant operated by IDAAN (Instituto de Acueductos y Alcantarillados Nacionales), a semi-autonomous institute within the Government of Panama. To protect the water supply for Panama City, the Panama Canal Company has agreed not to let the lake's level fall below 200 ft. During high rainfall years, the reservoir fills and sizeable amounts of water are discharged over the spillway. Fig. II - 5 shows variation in water use at Lake Alajuela for the 1953-1977 time period.

In addition to the consumptive uses of water discussed above, both lakes are frequently used for recreation such as swimming, boating, fishing and water skiing.

(2) Groundwater

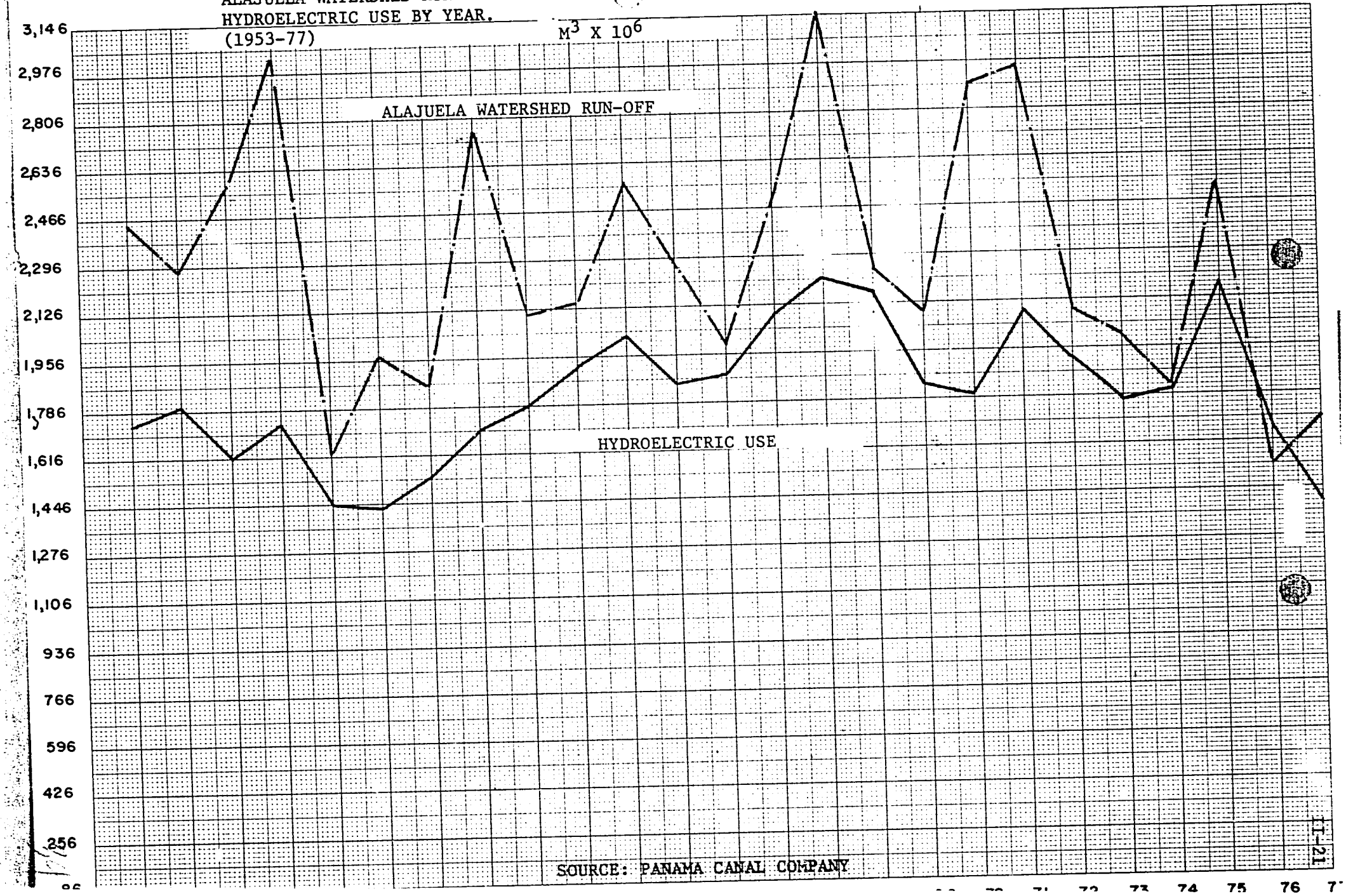
The quantity and quality of groundwater has not been measured in the Canal Watershed. However, it is known that present use of groundwater is limited to domestic wells of low capacity, and small local water systems. These waters are usually of variable quality, and may require treatment in order to be potable.

Most soils and bedrock of the area are of low permeability so that infiltration of ground water to replenish well supplies is very slow. The only locations where even moderate supplies of groundwater are available are alluvial deposits in stream valleys and deltas on the Lake margins. Small amounts of groundwater are sometimes available where the bedrock is sandstone or cavernous limestone. Otherwise wells can be expected to yield only meager amounts of water (sufficient only for a hand pump).

In view of the abundant supplies of surface water in the area and the limited supply of groundwater there does not appear to be any potential for development of major groundwater

FIGURE II - 5

ALAJUELA WATERSHED RUN-OFF AND HYDROELECTRIC USE BY YEAR. (1953-77)



SOURCE: PANAMA CANAL COMPANY

supplies. Groundwater will remain the best source for individual domestic systems.

e. Water Resource Trends

(1) Water Quality

No information exists water quality trends within the basin, as the Canal Zone Water Quality Study was the first of its type. However, results of the study show that increased urbanization along lake shores and tributaties has played a significant role in water quality degradation.

(2) Water Quantity - Sedimentation

Changes in land use patterns have caused sedimentation of the watershed's major lakes to increase at accellerated rates. A study of sedimentation rates in the Lake Alajuela Watershed, based on sediment soundings made by the Panama Canal Company in 1957, 1973, 1975 and 1978, revealed that, between the years 1934 and 1978 the Lake had accumulated a mean of 5.461 ft. of sediment,at an average rate of .124 ft./yr. However, sedimentation rates were not constant throughout these years. During the time period 1934 to 1973, which is considered the lake's predevelopment period, the average sedimentation rate was .109 ft./yr., while the average rate between the years 1973 and 1978, a time period which reflects current land use trends, was .240 ft./yr.

Assuming that 1 ft. of sediment equals a volume of 8.60 MCM (at the lake's 60.9 m. level) it is calculated that 46.96 MCM of sediment have accumulated to date. Subtracting this sediment accumulation from the Lake's total storage capacity of 799.8 MCM, reveals that the Lake has already lost 5.9% of its storage capacity. Over 20% of this sediment has accumulated in the last five year period (1973-78). A more detailed discussion of sedimentation rates in the watershed may be found in Annex VI C of the Project Paper.

f. Climate

Most of the Canal Watershed has a Wet Tropical Climate (Koeppen classification) which is characterized by abundant rainfall throughout most of the year, with a season of lower precipitation (less than 60 mm. per month) from December through April. The south central part of the area has a more pronounced dry season and is classified as having a Tropical Savanna Climate.

Total annual precipitation for the area ranges from highs of 4200 mm. per year in the Eastern Highlands and 3200 mm. per year in the Western Highlands to a low of 2000 mm./yr. in the

south central area around Cerro Balboa.

Rainfall records, maintained by RENARE over 29 years of record, show, in Table II - 6, monthly precipitation trends in the watershed:

TABLE II - 6

AVERAGE ANNUAL PRECIPITATION - LAKE ALAJUELA

7 Stations, 29 years of record

Month	Average (MM)
January	103.4
February	39.2
March	44.1
April	125.4
May	304.1
June	311.5
July	296.7
August	316.7
September	300.4
October	334.3
November	365.8
December	230.8
	2,771.9 mm.

Average temperatures range from 20 to 30 degress Celsius throughout the year with a daily range of about 5 degrees.

Relative humidity is high throughout the year varying from a daily mean minimum of 50% during the dry season to a mean maximum of 95% during the wet season.

g. Air Quality

The central part of the study area contains or adjoins the most developed areas of Panama. Emission sources which might lower air quality include; heavy auto and truck traffic, thermal electric generating plants, ships in transit, industry, cement manufacturing and extensive open burning for trash disposal and land clearing. Little is known of the actual air quality, except that conditions do not appear to be severe. There is evidence of degraded air quality only in the immediate vicinity of roads and other emission sources, and slash and burn agricultural activities.

Because Panama is relatively narrow in this region, the prevailing winds off the ocean are able to promote atmospheric mixing and keep air quality relatively high.

2. Biological Characteristics

a. Vegatation

For purposes of description, the Canal Watershed will be divided into three areas:

(1) the section south of Gatun Lake and west of the Canal Zone;

(2) the Canal Zone including Lake Gatun;

(3) the section east of the Canal Zone which includes Lake Alajela.

Of the three areas,only certain areas within the Canal Zone (Barro Colorado Island, the Pipeline road area and Madden Forest) are well known ecologically.

The watershed contains extreme altitude differences (from 0 m. to over 1000 m.)and extremes in human activities. Ideally the area might contain four major life zones. The highest elevations, which cover 3% of the watershed's area, could be considered Premontane Rain Forest, while the lowest elevations, which account for 50% of the area, could be considered Tropical Moist Forest. The remaining 47% could be divided almost equally between Tropical Wet Forest and Premontane Wet Forest. (See Figure II - 6).

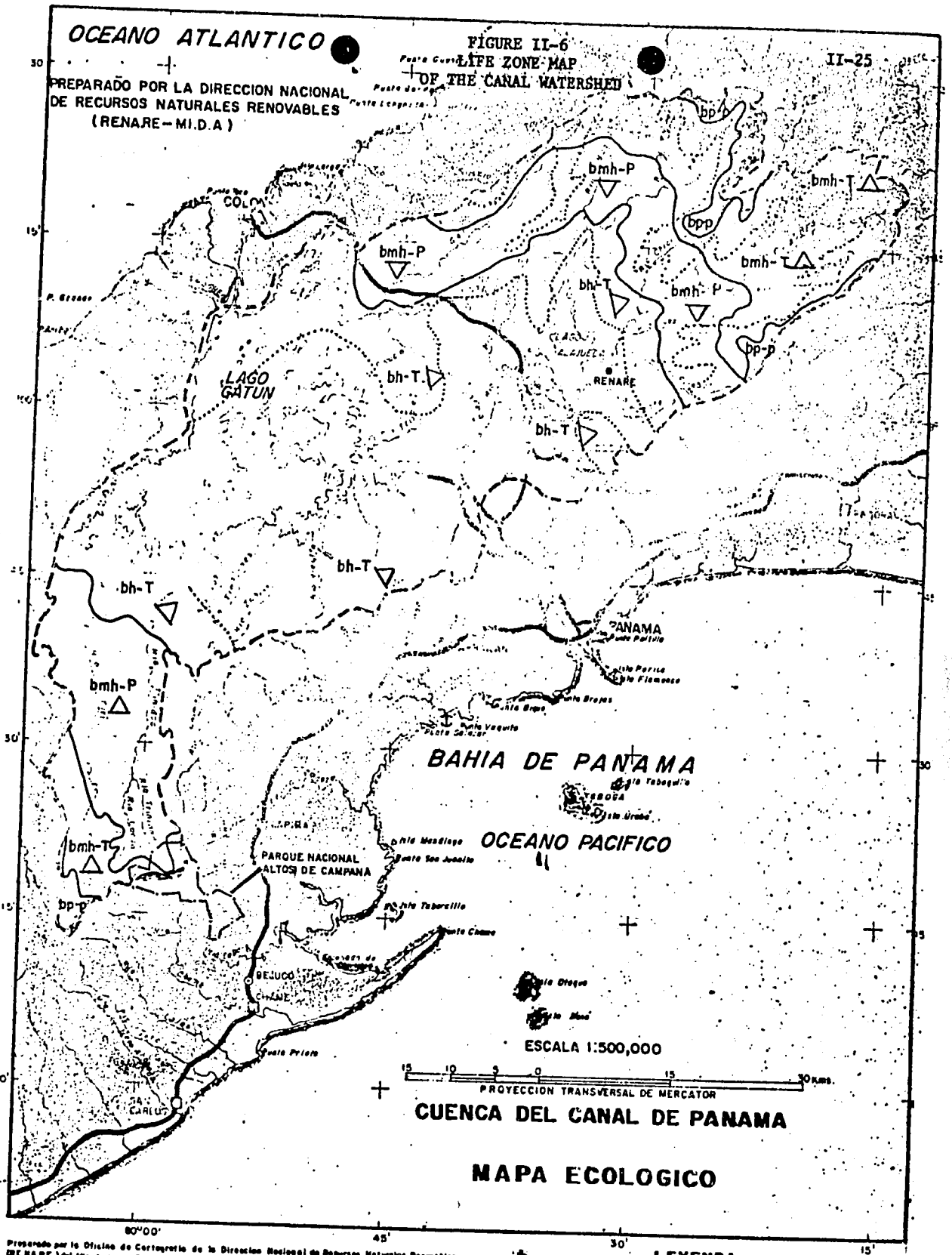
However, these ideal life zone conditions have been greatly altered by man's activities. Only areas of Premontane Rain Forest remain intact because human activity has been discouraged by rugged terrain, heavy rainfall and limited access.

The area of the watershed south of Gatun Lake and west of the Canal Zone is one of the most heavily affected by man. Ideally it might contain all four life zones but agricultural activities have deforested most of the area. Only about 14% of the area remains in natural forest, while 45% is early secondary growth following abandoment of agriculture and 41% is devoted to cropland or pasture.

The area to the east of Lake Gatun, which includes Lake Alajuela, has also experienced considerable human activities. Approximately 62% of the area remains as natural forest, while 16% is covered by early secondary forest and 22% is in cropland or pasture.

The Canal Zone, including Gatun Lake and the area of a major tributary, the Gatun River,is somewhat less disturbed. The Canal Zone itself has relatively large areas of natural forest

FIGURE II-6
LIFE ZONE MAP
OF THE CANAL WATERSHED



Preparado por la Oficina de Cartografía de la Dirección Nacional de Recursos Naturales Renovables (RENARE) del Ministerio de Desarrollo Agropecuario (MIDA) en base a los mapas existentes en el Instituto Geográfico Nacional Tomy Guardia.

LUGARES POBLADOS
- CAPITAL DE REPUBLICA — PANAMA
- CABECERA DE PROVINCIAS — COLON
- CABECERA DE DISTRITOS — LA CHORRERA
- CABECERA DE CORREGIMIENTO — CHILIBRE
- OTRAS POBLACIONES — PARAISO

CARRETERA Y CAMINOS
- PANAMERICANA Y TRANSISTMICA
- REVESTIMIENTO SUELTO TRANSITABLE EN TODO TIEMPO

FERROCARRIL
- VIA NORMAL

LIMITES
- LIMITE DE CUENCA (OPCIONAL)
- AEROPUERTO, PISTA DE ATERRIZAJE (OPCIONAL)
- PUERTO (OPCIONAL)

SIGNOS CONVENCIONALES

LEYENDA
- BOSQUE PLUVIAL PREMONTANO — bp-p
- BOSQUE HUMEDO TROPICAL — bh-T
- BOSQUE MUY HUMEDO PREMONTANO — bmh-P
- BOSQUE MUY HUMEDO TROPICAL — bmh-T
- TRANSICION FRESCA
- TRANSICION CALIDO
- TRANSICION SECA
- TRANSICION HUMEDA
- LIMITE DE ZONAS DE VIDA
- LIMITE DE TRANSICION

(Madden Reserve, the Pipeline Road area and Barro Colorado Island). However, the drainage area of Gatun River, beyond the boundaries of the Canal Zone has been seriously altered. Here, 53% of the area remains as natural forest, 17% is early secondary growth and about 30% is devoted to cropland and pastures.

It must be understood that the term "natural forest" does not indicate complete lack of human activity. Except for the areas of Premontane Rain Forest, at the extreme altitudes in area, the remaining natural forest is actually mature or late secondary forest which has not been disturbed for many years. Typical trees and shrubs include Bombacopis quinata, Ficus insipida, Traebina spp., and various members of the families Palmae and Gesneriaceae. Also present are lianas such as Bauhinia excisa and a variety of forest floor plants including members of the families Filicinae and Marantaceae and Selaginella spp. A more complete list is given in Appendix 3.1.

The early secondary forest, which establishes itself after agricultural land is abandoned, is a combination of trees and shrubs such as Bombacopis quinata, Cecropia longipes and C. obtusifolia, Miconia argentea and Trema micrantha. A more complete list is given in Appendix 3.2.

A different type of vegetation can be expected within and near lakes in the watershed. However, Lake Alajuela has a poorly developed aquatic vegetation community because its level fluctuates almost 15 meters each year between wet and dry seasons. Lake Gatun,on the other hand, has a much more stable level and has a well developed aquatic community. A complete list of lake-associated vegetation is shown in Appendix 3.3.

b. Wildlife

(1) Terrestrial

Detailed wildlife studies exist for only three areas of the watershed: Barro Colorado Island; the Pipeline Road Area; and Madden Forest. Although these areas are not truly representative of the entire watershed, because they are forests that have not been greatly disturbed by man's activities for more than 50 years, most information presented in this section has been derived from studies of these areas to portray the range of fauna that may be encountered throughout the watershed.

Birds comprise the largest number of species of fauna in the area. Birds most frequently seen in the Barro Colorado Island, Madden Forest and Pipeline Road areas include:

Grebes	Mealy Parrot
Vultures	Hummingbirds
White Hawk	Trogans
White-Throated Rail	Rufous Motmot
Gray-necked rail	White-whiskered Puffbird
Common Gallinule	Toucans
Purple Gallinule	Woodpeckers
Doves	Buff-throated creeper
Orange-chinned Parakeet	Least Ovenbird
Flycatchers	Tanagers
Plain Wren	Blue-back Grosbeak
Honeycreepers	Variable seedeater

The 1977 Audobon Society Christmas Bird Count, conducted in the Pipeline Road area, recorded 333 species of birds. This count, listed in Appendix3.4is a good representation of the variety of species that may be encountered in the lower forested areas of the watershed.

Birds which might be encountered in higher elevation forests are listed in Appendix 3.5.

The watershed of the Canal, due to its wide ranges in altitude, availability of water, and variety of available habitats, is rich in mammalian species. Most of the mammalian fauna are lowland in nature. The highland fauna is restricted to the higher altitudes found at Cerro Trinidad and Cerro Campana, south of Lake Gatun, and to the higher ridges stretching from Cerro Azul to high peaks near the headwaters of the Boqueron River. A list of some of the mammals found in the area appears in Appendix 3.6.

The herpeto-fauna of the watershed is also quite rich. Approximately 100 species of reptiles and amphibians have been recorded on Barro Colorado Island. Appendices 3.7 and 3.8 list the herptiles observed on the Island. Again, since much of the project area has not been throughly studied, the species listed in the appendices are only an indication of the variety and species composition likely to be found throughout the watershed. Particular species found in a given area may vary due to factors such as altitude, rainfall, and presence of human activity, which have significant effects on available habitat.

(2) Aquatic

The fishes in the Chagres River system have been relatively well catalogued compared to many other rivers and streams in Panamá. Zoogeographic evidence indicates that the Chagres River system fish-fauna is related to those of the Tuira and Bayano Rivers in the Darien Province andthat the three river systems were connected at

one time. Considering only the primary and secondary freshwater fishes (Appendix 3.9),the Chagres contains 8 families, 29 genera and 32 species and consequently contains the most diverse fish population in Panamá. Including the peripheral freshwater fishes (Appendix 3.10) the Chagres contains 21 families, 49 genera and 59 species of fish.

Some of the fishes listed in Appendices 3.9 and 3.10 are restricted to the upper reaches of the watershed but many also inhabit Lakes Alajuela and Gatun. Lake Gatun presents a special condition since it is open to both the Atlantic and Pacific Oceans. Gatun Locks on the Atlantic side, and the Pedro Miguel and Miraflores locks on the Pacific, do constitute somewhat of a barrier to marine forms entering Gatun Lake, however, marine forms do frequently inhabit the

The aquatic invertebrates of the watershed are not well known. The zooplankton of Lake Gatun has been characterized as predominantely crustacea with lesser numbers of rotifers. The larvae of decapod crustaceans (shrimp) also occur in the plankton community. The mosquito Anopheles albimanus breeds in Hydrilla verticillata beds while larvae and pupae of Mansonia and Coquillettidia are found among the water lettuce and hyacinth close to shore. Mollusks contribute the greatest biomass of the bottom dwelling organisms in the lake, with as many as 51 bivalves and 70 snails per square meter in some areas.

One can assume that the "usual" variety of invertebrate phyla are well represented in the streams,with aquatic insects being quite numerous.

c. Threatened and Endangered Species

The watershed provides habitat for 2 reptiles, 1 bird and 10 mammals listed under the U. S. Law on Endangered Species (PL93-205) and an additional 1 bird and 5 mammals listed in the Convention on International Trade (1973). Thus a total of 19 species in the watershed (Table II-7) are protected by U. S. Law and must be considered during actions by U.S. Government Agencies. Also, an existing Panamanian Law (Decreto No. 23, Jan. 30, 1967) extends protection to an additional 3 birds and 3 mammals and one reptile not listed by U. S. laws. An expanded wildlife protection law has been proposed but has not yet been passed by the Panamanian Government. This law would extend coverage to many other species not presently protected by the Government of Panama. The current Panamanian law (No. 23) sets fines to be levied, in cases of infraction, which range from B/.2.00 to B/.5.00 (2.00 to 5.00 U.S. Dollars). The proposed law would increase the fines to range from B/20.00 to B/300.00.

The occurrence of the West Indian manatee (Trichechus manatus) in Lake Gatun may not be a natural phenomenon. Formerly it was known to inhabit the lower reaches of drainage basins along the Atlantic coast. Recently, it has only been observed in

TABLE II - 7

THREATENED AND ENDANGERED SPECIES IN THE CANAL WATERSHED

A. Listed in the Endangered Species Act (1973).

1. Reptiles

Crocodylus acutus	American Crocodile
Caiman crocodilus fuscus	Brown Caiman

2. Birds

Harpia harpyja	Harpy Eagle

3. Mammals

Alouatta villosa	Howler Monkey
Ateles geoffroyi	Red spider Monkey
Saimiri oerstedii	Red-backed Squirrel Monkey
Felis concolor costaricensis	Costa Rican Puma
Felis onca	Jaguar
Felis pardalis mearnsi	Ocelot
Felis wiedii	Margay
Felis yagouaroundi panamensis	Jaguarundi
Trichechus manatus	West Indian Manatee
Tapiris bairdii	Tapir

B. Listed by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973).

1. Birds

Crax rubra	Great Curassow

2. Mammals

Choloepus hoffmanni	Two-toed Sloth
Cabassous centralis	Naked-tailed Armadillo
Bassaricyon gabbii	Olingo
Galictis allamandi	Grison
Lutra annectens	Long-tailed Otter

TABLE II - 8

SPECIES IN THE CANAL WATERSHED PROTECTED BY PANAMANIAN LAW

A. Protected by Existing Law (Decreto No. 23, Jan. 30, 1967)

1. Birds

Tinamous major	Greater Tinamon
Crypturellus soui	Lesser Tinamou
Crax rubra*	Great Curassow
Pendope purpurascens	Crested Guan
Harpia harpyja*	Harpy Eagle

2. Mammals

Agouti paca	Paca
Trichechus manatus*	West Indian Manatee
Tapirus bairdii*	Tapir
Odocoileus virginianus chiriquensis	White-tailed Deer
Mazama americana reperticia	Red Brocket Deer

3. Reptiles

Iguana iguana

* Protected by U. S. Law.

isolated areas along the coast of Bocas del Toro Province. However, in 1964 the Panama Canal Company re-introduced the West Indian manatee (9 individuals) to Lake Gatun as an experiment to help control aquatic vegetation. Thus, recent sightings in Lake Gatun are probably of these introduced individuals.

The remaining protected species, as would be expected, are animals which were never very numerous and/or require forest habitats which have not been disturbed by man.

d. Biological Trends

(1) Deforestation

Agriculture and other human activities have greatly disturbed and reduced forested areas within the watershed. In 1900, most of the watershed was uninhabited and almost totally covered by mature forest. In 1914 the construction of Gatun Dam and the formation of Lake Gatun caused the Chagres River to flood a large region (about 43,000 ha.) of floodplain and forested hills. Compared to the 326,000 ha. area of the drainage basin this was a relatively large loss (about 13%) of forested land.

Conditions then remained stable until the mid-1930's when the Chagres River was again impounded by Madden Dam, to form Lake Alajuela. Lake Alajuela (5027 ha.) removed an additional 1.5% of the watershed. Again, the area innundated was composed of river valleys and forested slopes.

However, increasing trends of in-migration to the watershed, especially during the past 20 years, have had the most devastating effect on the area's forested lands. Figures II-7 through II-9 show the approximate conditions of deforestation in 1952, 1976 and 1978. During this time period the amount of the watershed's land area in natural forest cover decreased from 83% to 32% at an average rate of 5700 hectares/year (2%/year). However the deforestation rate between 1976 and 1978 was over 4 times the average rate for the 1952-1978 period, indicating that the deforestation rate has accelerated significantly over time.

(2) Habitat Destruction

As described above, the watershed was once almost continuous stands of mature forests which had not been disturbed by man for more than 50 years. The flora and fauna of this area was extremely varied. No man-made barriers existed to the natural movements of wildlife so that distributions and population were "naturally stable". Construction of the Canal and Lake Gatun in 1914 presented a significant barrier to wildlife movement and reduced habitat significantly. The formation of Lake Alajuela and massive deforestation that has occured in last 20 years have led to even more serious effects. These effects have been twofold. First, the removal of large areas of mature forests, in association with the construction of Lake Alajuela, has presented another disruptive barrier to the natural distribution and movement of wildlife. Second, man's activities have drastically reduced the available habitat of mature forest species. This reduction has interrupted the normal distribution and reduced the population size of these species. Thus, a "naturally stable" condition no longer exists within the watershed and in its place, a "man-made instability" predominates.

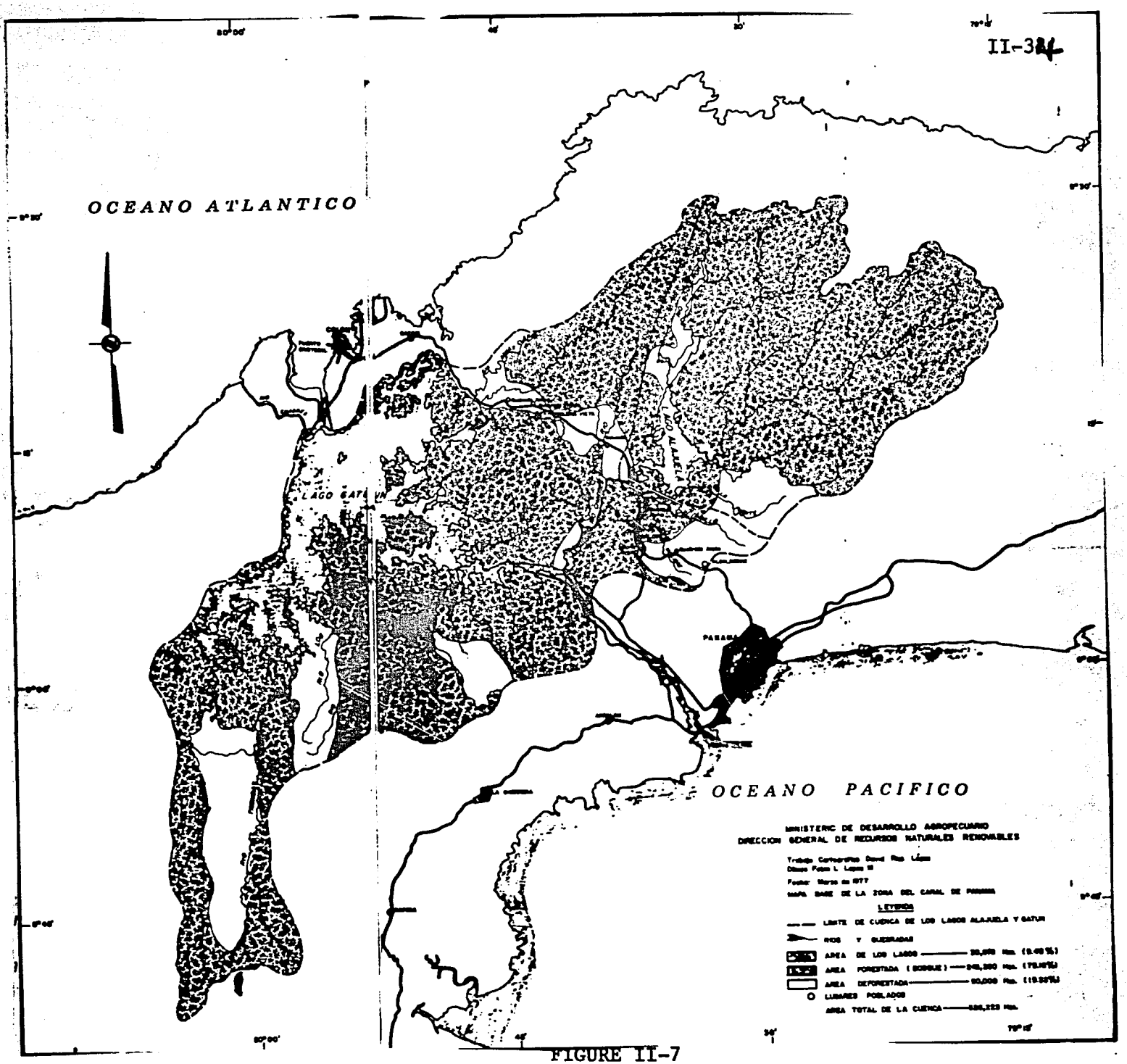


FIGURE II-7
DEFORESTATION IN THE
CANAL WATERSHED, 1952.

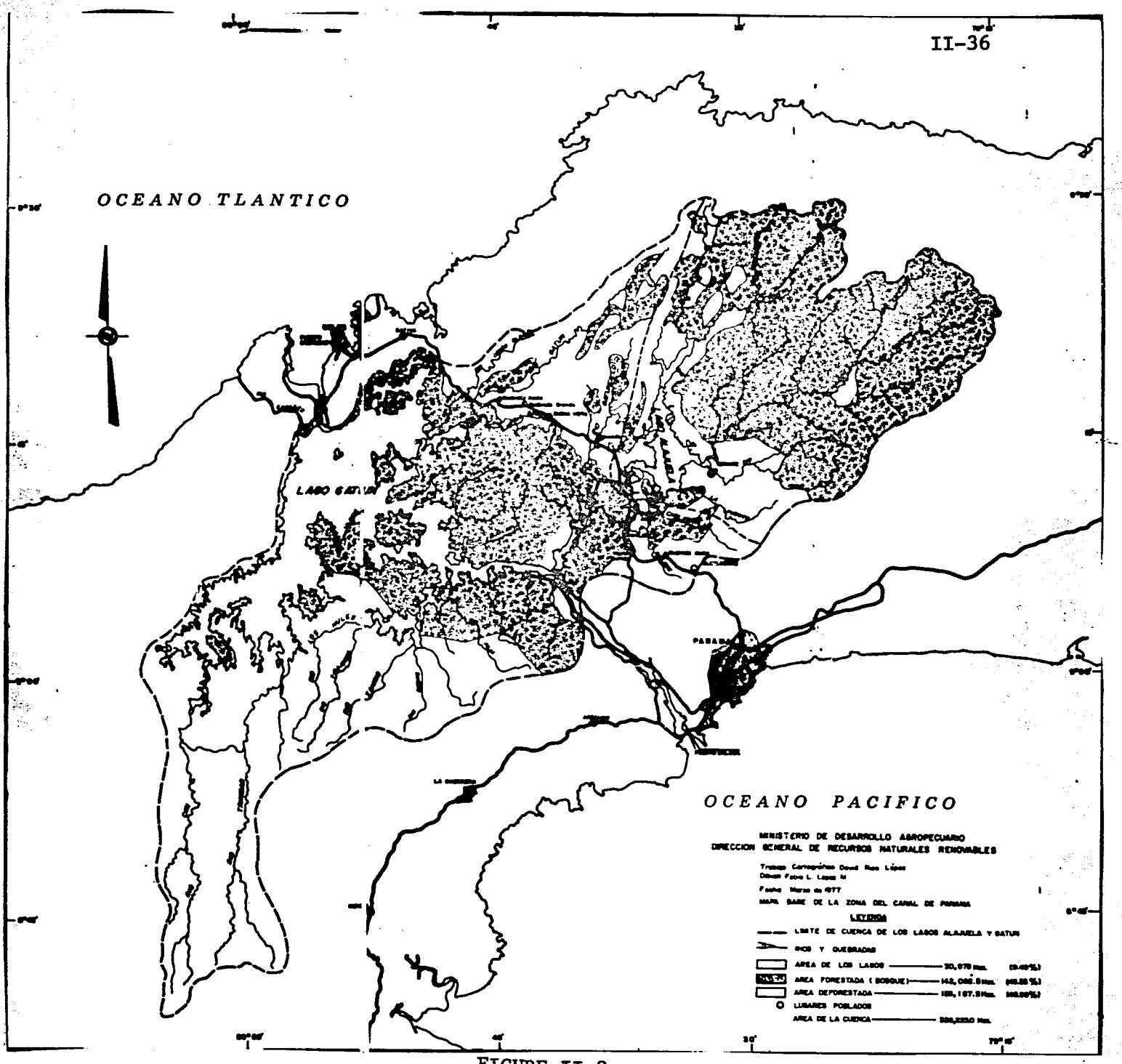
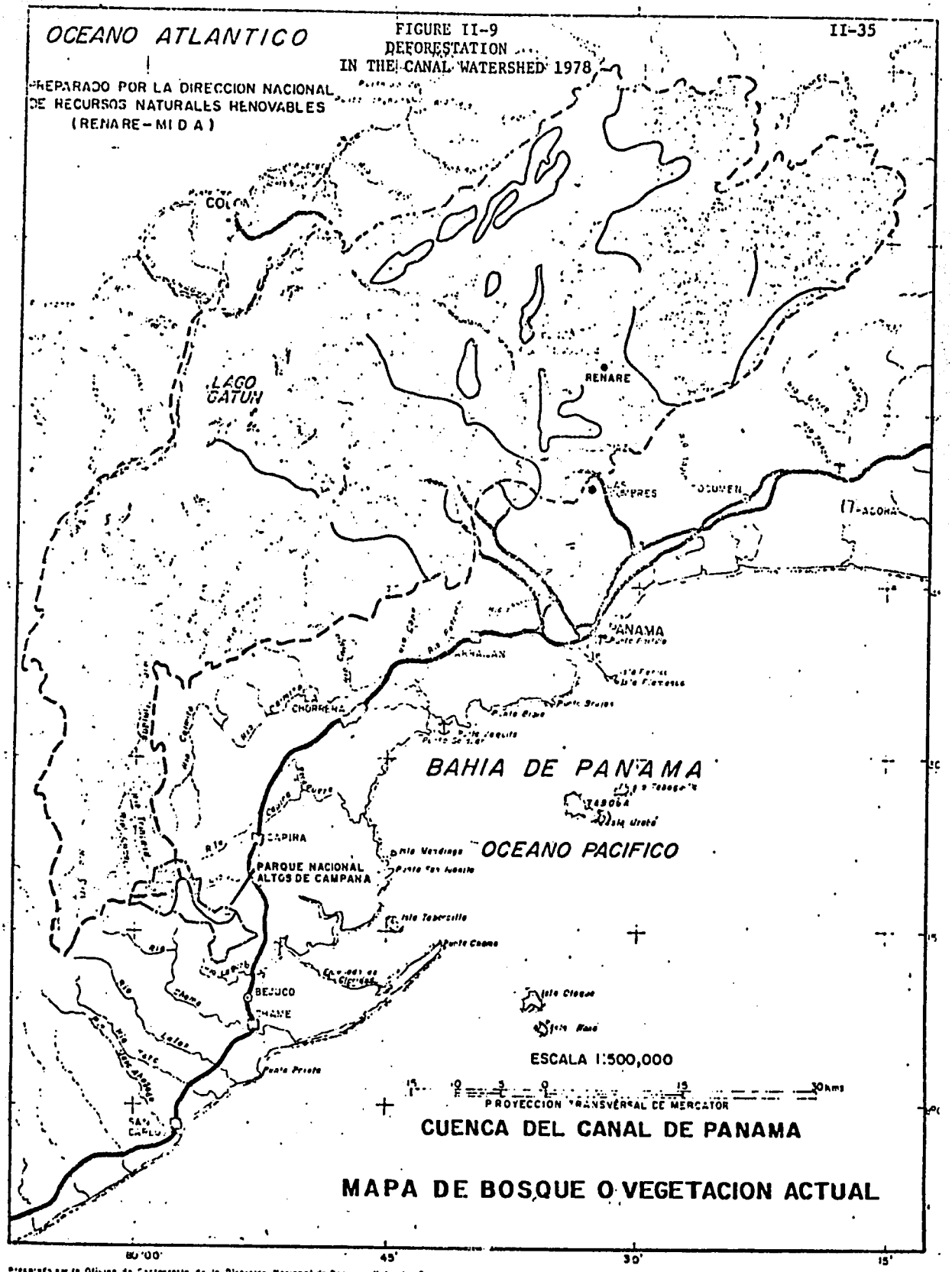


FIGURE II-8
DEFORESTATION IN THE CANAL
WATERSHED, 1976

FIGURE II-9
DEFORESTATION
IN THE CANAL WATERSHED 1978



(3) Alteration of Natural Ecosystems

Agricultural and cattle ranching activities have led to an ecosystem imbalance in some areas, which, if no precautionary measures are taken, may lead to irreversible damage to the area's natural resources. These activities have resulted in the clearing of large extensions of natural forest. In addition to providing habitat for numerous wildlife species, forest cover can be a key factor in soil conservation because it shields soils from the full impact of high energy raindrops by intercepting them on the canopy and allowing them to reach to soil only after running along trunks of trees or dripping from leaves. When forest cover is removed, soils are left unprotected from the erosive forces of rain. This is especially true in the Canal Watershed where average annual precipitation varies, according to area, from 1,200 mm to over 4,000 mm and over half of the land area is in steep slopes (45% more) which, if not covered, are quite subject to erosive impacts of heavy rains. During heavy downpours unprotected soil particles and soil litter are washed away. Elements such as calcium, magnesium and silicon, which promote soil structure, are easily dissolved in rainwater and are quickly leached out of the soil. The soil begins to lose its structure and fertility and becomes compacted and less permeable. Lower soil permeability results in an increase in both the volume and velocity of overland flow during wet seasons, which in turn, accelerates soil erosion.

In addition forest and cover protect soils from solar radiation which can "bake" soils and cause them to become compacted, impermeable, less fertile and more susceptible to erosion by runoff.

Traditional shifting slash and burn agriculture can nearly eliminate the adverse effects caused by deforestation and human intervention if forests are only partially cleared and, most importantly, if the crop production period is short compared to the fallow or rest period.

In the Canal Watershed agricultural ecosystems created by traditional slash and burn farmers consists of small plots of land which are deforested, cleared of vegetation, and burned during the dry season and planted in crops such as yucca, corn, and rice just before the rainy season begins. In most areas low soil fertility combined with rudimentary agricultral technology, in which no fertilizer is used, has caused farmers to cultivate plots of land for only one to two years and then to move on either leaving their land in fallow or directly selling their usufructory rights to the land to cattle ranchers. In the long term, however, much of this land is eventually "bought" by the cattle rancher.

Usually fallow land may be cleared and replanted again after 7 or 8 years with little damage to the-area's land and soils because this fallow period allows the soil to regain a sufficient degree of fertility for crop cultivation. However, in many areas of the watershed population pressures are forcing more frequent rotation of fallow land into cultivation. Since land which is not given a sufficient rest period is less fertile, requires more weeding, and produces lower crop yields, increasing numbers of slash and burn farmers eventually move on to untouched areas and to sell their rights to cattle ranchers.

The ecosystems established by these cattle ranchers are often highly unstable. Most pasture lands in the watershed are planted with a grass commonly known in Panama as faragua (Hyparrhenia rufa). This grass is not conducive to erosion control for many reasons. First of all, its bunch-like growth habit leaves areas of land open to the forces of wind and rain throughout the year. Secondly, the grass goes to seed at the beginning of the dry season, thus loosing its protein content (contained in seeds) and its moisture content. As the seeds withstand burning it is common practice for the cattle rancher to burn his pastures at this time to consume the stemmy low quality dry faragua, as well as to control the growth of any unwanted vegetation. Thus as the rainy season begins a faragua pasture can have as much as 40 to 50% of its surface exposed to the forces of erosion. In addition burning of pasture lands destroys humidified organic matter in the soil, and, through changes in soil acidity, surface-temperature, evaporation and moisture content, drastically alters the population density of the soil micro-flora. This leads to "laterization" which results in loss of soil structure and soil fertility, compaction, an increase in volume and velocity of overland flow during the wet season, and hence, accelerated erosion. Continous burning and resultant erosion has resulted in such a complete modification of the soils surface that some areas of the watershed can barely recover and support secondary vegetation. Thirdly, because the grass has a low nutritive value, especially during the dry season, cattle are often forced to move on to steeper slopes to obtain an adequate diet. Already 40% of the watersheds pastures are on slopes greater than 45%. Erosion is more severe when these steeply sloping lands are bared of vegetation and compacted. Gullies quickly form in cattle paths and linear depressions, sheet erosion increases and hillside slumping becomes more prominent. In many areas of the watershed faragua pastures are eroded and degraded to such a state that they have been abandoned. In almost 35% of the watershed's pasturelands this situation has led to the invasion of a tall Asian grass, Imperata cylindrica var. major which was originally introduced by trade ships during the 1800's. This grass, due to its dense network of roots and underground stems, crowds out other vegetation and is very difficult to eliminate once it takes over an area. In addition it is a prolific seed producer and its light seeds are easily transported to susceptible lands in other areas.

Thus the invasion of Imperata grass may bring stability to an area because it keeps out other types of vegetation and, because of its extensive root system, is a good source of erosion control. However, this stability is attained only through the loss of a diverse natural forest ecosystems rich in plant and animal life.

3. Social and Economic Characteristics

a. Demography

(1) Current Situation

According to 1970 census data, the watershed had a total population of 61,569 (approximately 11,000 families), and a population density of 23.1 per Km^2. Population distribution, by Administrative Unit, is shown in Table II-9. Analysis of these data shows that Alajuela and Buena Vista, which constitute 36% of the watershed area, and contain its only urban centers (Alcalde Díaz and Las Cumbres in Alajuela and Puerto Pilón in Buena Vista), contain 70% of the population. In contrast Cerro Azul and Salmanca, which are totally rural, represent 29% of the area and contain only 3% of the population.

More recent population data (1977) extracted from the records of SNEM (Servico Nacional para la Erradicación de la Malaria) show that the population of the watershed may now be as high as 96,000. This fugure, however, is an estimate based on the number of houses in each population center multiplied by the number of inhabitants/house that existed in the population center according to the 1970 census. The SNEM data also estimate that a total of 18,000 families reside in the watershed, and that population distribution among administrative units in 1977 is approximately the same as it was in 1970.

(2) Trends

Before the construction of the Panama Canal, the population of the watershed was quite sparse, and, for the most part, was located in small settlements on the alluvial plains of the Chagres River. With the creation of Lake Gatun, the inhabitants of these small towns were forced to move outward to higher areas, outside the limits of the Canal Zone. Here they re-established small settlements and continued their traditional agricultural practices, most notably, the cultivation of coconut trees. 1/

During the 1920's many small scale business operations, such as commercial cattle ranches and banana plantations, were established along the western shores of Lake Gatun by entrepreneurs from the city of Colon. These activities stimulated the first true wave of migration to the watershed. Most of the first immigrants to the area originally inhabited the mountainous regions of the province of Cocle just outside of the watershed. They first established themselves on the western shores of Lake Gatun close to the small business operations. However, the decline in banana commerce in the late 1930's stimulated their movement southward to the unpopulated virgin forests southwest of the Lake. Here they

1/ McKay, Alberto, Salud Comunitaria y Colonización Rural, el caso de Cerro Cama en Panamá.

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TABLE II-9

POPULATION DISTRIBUTION IN THE WATERSHED (1970 CENSUS)

Administrative Unit	Area (Km^2)	Population	%	Density (per Km^2)
Alajuela	407	25,939	42.2	63.7
Cerro Azul	489	213	0.3	0.4
Salamanca	277	1,691	2.7	6.1
Buena Vista	541	17,426	28.3	32.2
Cerro Cama	466	7,087	11.5	15.2
El Cacao	489	9,213	15.0	18.8
TOTAL	2669	61,569	100.0	23.1

Source: Ministry of Planning and Economic Policy, Government of Panama.

established small agricultural towns in the district of Cerro Cama, and took up their customary "slash and burn" or swidden agricultural practices establishing usufructory rights through utilization of their land. Typical crops cultivated were rice, corn, tubers, coffee, and orange trees.

The success of these farmers in the commercialization of their produce continued to attract more immigrants from Coclé, and, although the economic boom experienced by both Panama City and Colon during World War II stimulated some outmigration towards these urban centers, the migratory wave to the southwestern shores of Lake Gatun did not stop until 1955. At this time the agricultural population overburdened the carrying capacity of the land, the soil began to loose its fertility and many inhabitants were forced to move further southward to untouched forested lands.

In the 1960's, the southwestern portion of the watershed experienced another wave of immigrants, this time from the provinces of Los Santos and Herrera. These migrants, with their background in cattle ranching and their greater aptitude for business matters, rapidly took control of the area, bought the usufructuary rights of the Coclesanos and gradually combined small parcels of land into the larger ranches, ranging up to 50 hectares, that they were accustomed to in their place of origin. Many of the original farmers were again forced to move on to new areas of the watershed, or to take up day work on the newly established cattle ranches. Although the new colonists brought many new innovations to the area, they continued to practice their traditional pasture management techniques, sowing their land in faragua grass and burning their pastures before each rainy season as a means of weed control. These techniques (as explained in Sec. II-2, e.) have led to widespread erosion problem, and in some areas, the invasion of a grass called Imperata which has no economic value for cattle raising. Expansion of ranching activities as well as degradation of pastures on same lower slopes soon led to the establishment of pastures on steeper slopes, abandonment of most of the coffee and orange tree farms, and ultimately to greater erosion. Presently, approximately 40% of the land in the southwest portion of the watershed (El Cacao and Cerro Cama) is devoted to faragua pastures, and almost 50% of the land is either currently used for agriculture or is in early secondary growth forests, indicating recent agricultural activities.

The area east of the Canal remained essentially unpopulated until after World War II, when the Transisthmian Highway was built, and unemployment and economic recession forced farmers from the country's more rural provinces to seek new lands, nearer Panama City, where they hoped to find better economic opportunities. These colonists first settled along the margins of the highway where they took up their traditional slash and burn agricultural techniques.

The immigration rate slowed down, however, between 1950 and 1960 when the area became overpopulated relative to the land base available for traditional agricultural use and the productivity of the land became depleted. Only suburban settlements such as Chilibre and Las Cumbres, next to Panamá and Colón, experienced growth during this time period. However, since the middle 1960's another great wave of farmers from such provinces of Coclé, Chiriquí and Veraguas has migrated to the area, again looking for more and better lands closer to urban markets and other opportunities. This time the colonists penetrated further and further into the once virgin forests east of the Canal; and a small access road network began to develop, stimulating further movement into untouched forest land. Finally, as was the case in the southwestern portion of the watershed, cattle ranching began to spread over portions of the area. Today almost 45% of the land in the Alajuela Administrative Unit and almost 40% of the land in the Buena Vista Administrative Unit are devoted to faragua pastures. Already over 50% of the pastures in these areas are in a degraded state due to poor pasture management techniques.

Table II-10 shows the average annual growth rate by Administrative Unit for the 1960 to 1970 period. Between these years total population increased by over 64%, and the average annual growth rate varied, by area, from 2.09% to 7.95%. The average annual rate for the entire area for this ten-year period was 5.37% which was almost 3 times the average annual growth rate for entire rural Panama for the 1960-1970 period.

Alajuela, Buena Vista and Salamanca experienced the largest population increases during these years. Growth in Alajuela and Buena Vista was primarily urban in nature, while population increases in Cerro Azul, Cerro Cama and El Cacao were exclusively rural.

Preliminary population data for the 1970's indicates continued high rates of population increase. However, these growth rates vary widely according to area. Some areas, such as Cerro Cama, are being gradually abandoned due to land degradation, while urban areas along the Highway, as well as the forested mountains regions, east of Lake Alajuela, are becoming more heavily populated.

b. Population Characteristics

Most inhabitants of the watershed are "slash and burn" or swidden peasants or cattle ranchers from rural areas of Coclé, Veraguas, Los Santos, Herrera and Chiriquí who have migrated to the area in search of land and a better way of life. A large number of these immigrants initially migrated to the cities of Panama and Colon, and were later forced to return to agricultural pursuits in the more rural area of the Canal Watershed due to lack of urban

TABLE II-10

AVERAGE ANNUAL RATE OF GROWTH IN THE CANAL WATERSHED (1960-1970)

Administrative Unit	Population 1960	Population 1970	Annual Growth Rate %
Alajuela	14,399	25,939	6.33
Cerro Azul	166	213	2.68
Salamanca	823	1,691	7.95
Buena Vista	9,464	17,426	6.70
Cerro Cama	5,712	7,087	2.31
El Cacao	6,919	9,213	2.09
TOTAL	37,483	61,569	5.37

Source: Ministry of Planning and Economic Policy, Government of Panama.

employment opportunities. The most numerous of this group is the swidden peasantry or slash and burn agriculturalists. They constitue approximately 80% of the population, and, as explained previously, represent a type of moving frontier, opening up new lands to corn and rice cultivation and then eventually moving on after "selling" their usufructory rights to the land to cattle ranchers.

Cattle ranchers, located mainly in the Cerro Cama region of the watershed, represent approximately 13% of the watershed population and occupy a proportionately larger land area than traditional agriculturalists. Many of these cattle ranchers were farmers in their place of origin. Their shift from traditional agriculture to cattle ranching is a matter of social prestige, as well as potential economic benefit, as cattle ranching is considered highly desirable by many inhabitants of the watershed because of its potentially superior economic returns and higher social status.

The third type of group in the watershed is the mixed rancher /farmer/swidden agriculturalist who live on state organized farms or asentamientos. The asentamiento program, which is strongest in the Salamanca region, is an attempt by the government to reorganize land tenure patterns and introduce improved agricultural technology. Large rice plantations and intensive vegetable crop production have been promoted through the asentamiento program since its inception. Later, during the 1970's cattle ranching was introduced on several of the asentamientos. Today, asentamientos in the Canal Watershed combine swidden farming for the production of subsistence crops with cattle ranching and/or intensive agriculture for the generation of cash income.

c. Employment and Economic Status

In 1970 the canal watershed had an economically active population of 18,000, of which 8,000 were engaged in agricultural activities. Only the more urban Administrative Units of Alajuela and Buena Vista had less than 50% of their workforce employed in agricultural pursuits. Although some non-agricultural employment activities exist within these more urban areas of the watershed, they are limited. Many of those employed outside of agriculture work in Panama City and Colon. As shown in Table II-11, the more urban Administrative Units of Alajuela and Buena Vista had the highest unemployment rates.

It is estimated that 6,500 of the 8,000 inhabitants, or 80% of those employed in agriculture in 1970 were swidden peasants. The estimated per capita income of these peasants is between $130 and $160 per year, and their average farm size is 7 ha., although only 1 to 2 hectares are cultivated at any one time.

TABLE II-11

EMPLOYMENT CONDITIONS IN THE WATERSHED

Administrative Unit	Total Population 10 yrs. +	Workforce		Employment			Unemployment	
		Number	Percent	Total	Agriculture	Percent	Total	Percent
Alajuela	17,430	8,215	43.2	6,088	1,682	28.0	2,127	26.0
Cerro Azul	146	79	54.1	69	64	92.8	10	12.7
Salamanca	1,066	548	51.4	482	377	78.2	66	12.0
Buena Vista	11,260	5,836	47.8	5,039	1,939	38.5	797	14.8
Cerro Cama	4,614	2,353	51.0	2,182	1,524	69.8	171	7.3
El Cacao	5,778	2,702	46.8	2,655	2,480	93.4	47	1.7
TOTAL	40,294	19,733	49.0	16,515	8,066	48.8	3,218	16.9

Source: Ministry of Planning and Economic Policy, Government of Panama.

Not more than 1,000 of the remaining inhabitants employed in agriculture were cattle ranchers. The economic situation of the cattle rancher is considerably better than that of the swidden farmer, with an average farm size of 39 ha. and an average per capita income above US$200 per year.

Over 300 families were members of asentamientos. For this group, average per capita income derived from communal production is approximately the same as that of the swidden peasant, although asentamiento members may gain extra income from sale of products from private plots.

d. Land Tenure

Farm land within the watershed is either owned, rented or farmed without title. According to the 1970 census, a great majority (77%) of the farmers in the watershed did not possess legal titles for their land. However, by working the land many have acquired usufructory rights (derechos posesiones)which are recognized in Panamanian Law.

e. The Local Economy

Most agricultural crops produced in the watershed are consumed within the area with little excess available for transport to markets in Panama City and Colon.

Major crops produced in the area are:

rice	corn	yams
sugar cane	green beans	tomatoes
pigeonpeas	plantain	yucca
garden vegetables.		

In addition, the following fruit crops are grown:

oranges	avocado	lemons
papaya	cacao	mangoes
cashews	coconuts	guavas
coffee	pineapple	

The production data shown in Table II-12 is based upon 1970 census information, as more recent data are not available. The crops with greatest production levels are yucca, corn and rice, the area's primary food staples.

No data exists on cattle, poultry or swine production for the total watershed, although such production is also known to play a significant role in the local economy.

TABLE II-12

PRINCIPAL CROPS AND PRODUCTION (1970)

CANAL WATERSHED

CROP	PRODUCTION
Yucca	10,014,900 lbs.
Corn	5,851,900 lbs.
Rice	5,218,700 "
Yams	5,162,800 "
Tomatoes	339,900 "
Green Beans	336,300 "
Sugar Cane	202,200 "
Pigeonpeas	180,000 "
Coffee	399,000 "
Oranges	34,395,700 fruits
Coconuts	257,051 "
Avocados	971,083 "
Pineapple	575,292 plants or trees
Cashews	50,668 "
Lemons	44,807 "
Guavas	25,345 "
Papaya	17,071 "
Mangoes	16,820 "

*Source: Dirección de Estadística y Censo, Government of Panama.

f. Public Facilities and Services

1. Drinking water supply

The watershed suffers from a deficiency of potable water supply systems. Surveys* involving approximately 2,700 households in the area found that only 52.4% of the dwellings received potable water; 33.2% received piped water; and 19.2% depended on community wells. The remaining 47.6% depended on superficial wells (17.2%), rivers and streams (24.1%) and cisterns (6.3%).

2. Sanitary Facilities

A total of 73.5% of the dwellings in the above mentioned surveys possessed either pit latrines (67.5%) or septic tanks (6.0%) for sanitary disposal, while the remaining 26.5% of the dwellings were without sanitary facilities.

3. Electricity

The above mentioned survey found electrical service within the watershed to be extremely limited with only 22.3% of the homes receiving electricity. This low level of service is due primarily to the great dispersion of homesites and population centers.

4. Education

Education within the watershed is relatively good and the illiteracy rate (21%) is approximately the same as the rate for entire Panama. Ninety four percent of the illiterates reside in the watersheds more rural areas. The educational system in the area is composed of elementary schools and Basic General Education (BGE) schools which offer the first 3 years of secondary school with complementary agricultural education.

According to 1977 data compiled by the Ministry of Education there are 138 elementary schools located in the watershed, with a total 1977 enrollment of 19,863 pupils. A total of 675 teachers serve these students for a student: teacher ratio of 1:29. There are 7 BGE schools in the area with 4,955 pupils and 193 teachers for a ratio of 1:26.

5. Transportation Facilities

a. Panama Canal

* Information taken from surveys carried out in PAOCAPA, PRODISACAP, and Alajuela in 1977.

The Panama Canal, which constitutes the principal communication route in the area, is devoted primarily to international activity. The Canal is approximately 50 miles long, deep water to deep water, and follows a northwesterly to southeasterly direction. The Atlantic entrance is approximately 27 miles west of the Pacific entrance. A ship entering the Canal from the Atlantic sails at sea level from Cristobal Harbor to Gatun Locks, a distance of 7 miles. It is then lifted 85 feet to Gatun Lake in three lockages or "steps." From Gatun it sails, 85 feet above sea level, to Pedro Miguel, a distance of 31 miles. A single lockage at Pedro Miguel lowers the ship 31 feet to Miraflores Lake. A mile further south the vessel enters Miraflores Locks, and in two lockages, is lowered 54 feet to the Pacific Ocean level. A ship sails 4 miles to the Balboa port area before entering the outer harbor.

The average time for a ship in Canal waters (including time spent at the anchorage awaiting transit) is approximately 20 hours. The average time spent in transit from port to port is approximately 7.4 hours. A profile of the Panama Canal is provided in Fig. II-10.

While the activity of the Canal is devoted to international acitivity, Lakes Gatun and Alajuela and their tributaries are used as means of transportation by the local population.

b. Railroad

The Panama-Colon Railroad, which crosses the Isthmus practically parallel to the Canal, has a length of 76 kilometers. Its principal activity operates between the two terminal cities (Panama City and Colón) with an approximate transit during 1977 of 170,400 tons of cargo and 798,000 passangers. This railroad is not used for intra-watershed activity.

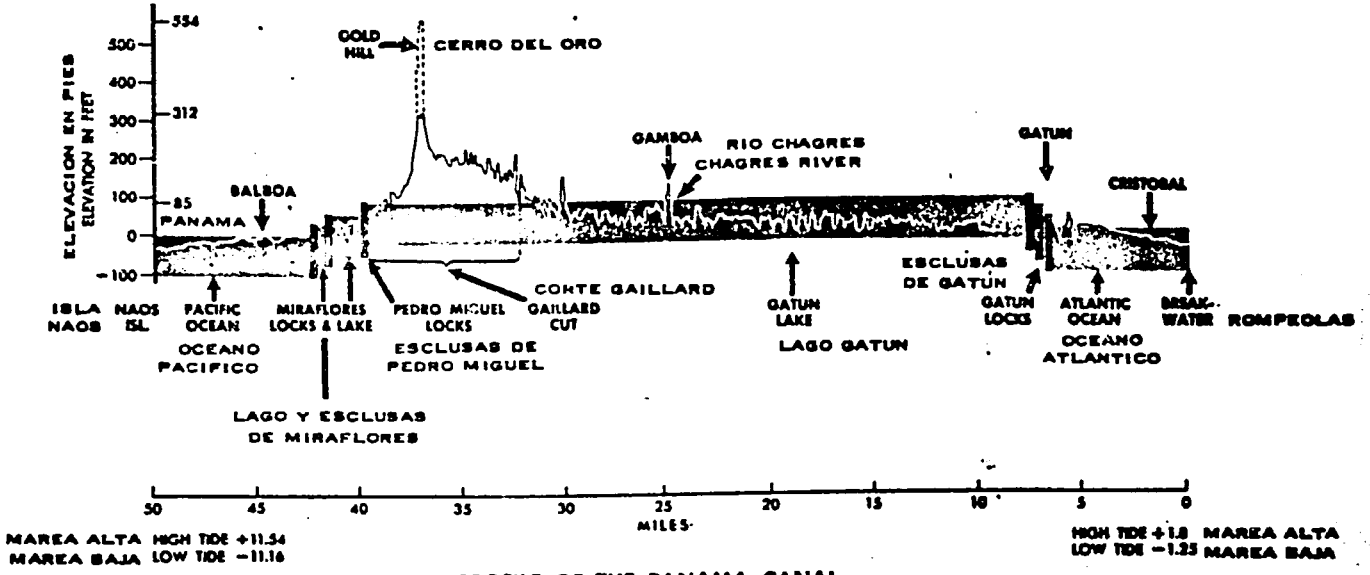
c. Airports

Air transportation is not utilized within the watershed. The only existing paved airport in the area is at Calzada Larga near Alajuela Lake, which is used by activities related to aviation training.

d. Roads

The network of roads in the Canal Watershed is poorly developed (Fig. I-2) The principal road is the Trans-Isthmian Highway between Panama City and Colón which was built during World War II. Other paved or gravel roads connect with the highway and have acted as a growth stimulus in areas some distance from the highway. A large majority of these roads were constructed

FIG. II-10



PROFILE OF THE PANAMA CANAL
PERFIL DEL CANAL DE PANAMA

by the Ministry of Public Works (MOP) or by private companies with prior approval from MOP. Despite efforts to keep roads maintained, they are frequently in need of repair due to adverse climatic conditions, as well as budgetary and equipment constraints.

The watershed also contains a large number of dirt roads constructed by private individuals or local authorities. These roads do not fall under MOP's jurisdiction and typically suffer from undefined alignment, narrow width and poor maintenance. The road network is a major contributor of sediment to Lakes Gatun and Alajuela.

g. Public Health

The watershed inhabitants are fairly well provided with health services. In addition to a wide range of health facilities in the nearby cities of Panama, Colon and Chorrera, four health centers, staffed by at least one doctor, provide a full range of inpatient and outpatient services in Chilibre, Alcalde Díaz, Nuevo San Juan and Sabanitas, all on the east side of the Canal. Five health subcenters, which provide primary health care and are usually staffed by nurse auxilliaries (and occasionally a doctor), are located in El Limón, Buena Vista, Sardinilla and Altos de Pacora (on the east side of the Canal) and Nuevo Emperador (on the west side of Lake Gatún). Health posts, which provide preventative health care and first aid and are staffed by health assistants, are located in Ciricito (west of Lake Gatun), Salamanca, Los Playones, El Giral, Nuevo Vigía and Gatuncillo (in the northeastern section of the Watershed). Certain areas do not have direct service, due to difficulties in access; however, inhabitants are able to receive care from medical tours provided by the Ministry of Health.

Some of the common ailments of the area are:

1. Allergies
2. Intestinal Disorders
3. Headaches
4. Fevers
5. Colds
6. Tuberculosis
7. Hypertension
8. Asthma
9. Anemia
10. Arthritis

Some rural inhabitants of the watershed suffer from chronic malnutrition. The major factor preventing improvement in their nutritional status is their dependency on subsistence agriculture. Because the major food crops of the area are yucca, corn

and rice, many of the inhabitants generally fail to get a well balanced diet.

h. Archaeological, Cultural and Historical Sites

The Canal Watershed contains few well known archaeological sites. Artifacts have been found along the Chagres River floodplain and it can be assumed that Precolombian civilizations, which inhabited the area, were concentrated within the river basins. Many of the potential sites were destroyed by the construction of the Panama Canal, through excavation of the Canal itself and the formation of Gatún and Alajuela Lakes. Other sites may be found upstream from the impoundments, but little investigation is presently under way.

Two areas of cultural or historical significance are located within the watershed. One is a remnant of the Las Cruces Trail, still in existence in the Madden Forest Preserve. The Las Cruces Trail was established during the 1500's as a route for the transportation of gold and supplies between the Pacific and Atlantic Coasts, and it was still in existence and used by gold-miners attempting to reach the California gold field in the mid-1800's. The construction of the old transisthmian railroad during the 1850's displaced the Las Cruces Trail as the major communication link between the coasts. The other area of historical significance is the remains of the old French Canal construction activities which are mostly covered by the waters of the existing Canal.

B. The Upper La Villa Watershed

The Rio La Villa Watershed is located in the province of Los Santos and Herrera in the Azuero Peninsula. From the river's headwaters and those of its tributaries, in the Canajagua and El Montuoso areas of the watershed, the Rio La Villa flows west to east, past the urban area of Chitre-Los Santos, into the Gulf of Panama.

Watershed management activities under this project will focus on the Canajagua and El Montuoso areas of the upper watershed. Canajagua is located in parts of the Las Tablas, Guararé and Macaracas Districts and comprises approximately 67,000 hectares of land. El Montuoso, which has been legally designated as a forest reserve, covers parts of the Las Minas District, and comprises approximately 13,000 hectares.

The topography of both these areas is broken, with extensive portions of land in the 20-40% slope category, and steeper slopes in the highest areas of the watershed. Most of the area's soils have a low productive capacity, are highly erodable, and have Land Capability Classifications of VI, VII and VIII (see Appendix 1).

In 1970, over 85% of the area's economically active population was employed in agricultural pursuits, and over 65,000 hectares of land in these two areas were devoted to agricultural use, of which almost 70% (4500 hectares) were devoted to pasture. The remaining 20,000 hectares were primarily devoted to traditional slash and burn agriculture. At this time approximately 8500 hectares were forested; however, more recent (1977) data indicates that only 200 forested hectares remain.

Currently over 50,000 hectares of land in these two areas are severely degraded due to erosion caused by poor pasture management techniques on the extensive pasturelands and by traditional agricultural activities on steep slopes.

Annual precipitation in the area is relatively low and varies between 1000 mm and 2500 mm. Severe droughts, which are frequent phenomenon, have occurred in 1965, 1973 and 1975, causing reduced flows in the Rio La Villa, the source of domestic and industrial water supply for the Chitre-Los Santos urban area, as well as the source of irrigation water for approximately 2000 hectares of cropland in the lower watershed. High sedimentation rates combined with low precipitation are making it increasingly difficult for the river to meet its water supply demands.

Most of the project area is rural and highly under serviced by roads, electricity and potable water supply systems. Most residents, which constitute one of the poorest populations in Panama,

(average per capita income less than $135 in 1969 dollars) live in houses with dirt floors and no sanitary disposal systems. Between 1960 and 1970, the population of the area declined from 13,700 to 11,300 as a result of out-migration to more productive areas.

C. The Rio Caldera Watershed

The Rio Caldera Watershed is located in the Chiriqui Province, Boquete District of north-western Panama. The river, which originates in the mountainous Volcan Baru area flows north to south, through the town of Boquete, into the Chiriqui River. It is the water source for the La Estrella-Los Valles hydroelectric power project, as well as for several irrigation activities.

The watershed's topography is characterized by steep slopes in its upper areas with more gently sloping land surrounding Boquete. Altitudes range from 250 meters above sea level to almost 2,500 meters above sea level.

A large portion of the area's soils have a Land Capability classifications of VI, VII or VIII, which signify low agricultural capabilities. However, there are many small areas of high fertility soils (classes II and III) scattered throughout the watershed, where vegetables are cultivated by modern techniques.

Of the watersheds total area of 22,000 hectares, approximately 2000 hectares are devoted to cultivation of annual crops, 1500 hectares are devoted to cultivation of coffee and other permanent crops, 9000 hectares are in pastures and 8500 hectares are in forests.

Erosion has become an increasing problem in the watershed due to poor soil conservation practices on croplands, tree harvesting, slash and burn agriculture on steep slopes and poor road construction practices. Eroded lands on steep slopes, combined with the area's high annual precipitation rates (varying from 3200 mm to over 4000 mm in the southern part of the watershed) have increased both the rapidity and amount of runoff into the La Caldera River, increasing the probability of severe floods that could cause property damage, loss of life and potential damage the intake of the La Estrella-Los Valles hydroelectric plant. Severe floods in 1969 and 1970 have already caused substantial damage.

Because of the floods in 1969 and 1970, census figures show a slight decrease in population between 1960 and 1970. The 1970 population of the area was approximately 8000. Over 60% of the area's economically active population is engaged in agriculture. Most agricultural producers are members of co-operatives or producers associations, and are quite receptive to technical assistance and modern techniques. The major source of income is coffee production, followed

by potato, vegetable and fruit production.

Living standards in the area are somewhat higher than other rural areas of Panama.

D. Existing Institutional Arrangements for Watershed Management.

The Directorate General of Natural Renewable Resources (RENARE) of the Ministry of Agriculture (MIDA) is an agency within the Government of Panama designated to administer programs related to natural renewable resources, and will be the primary implementing agency for this project. The establishment of RENARE as an organizaitional unit of MIDA is contained in Law #12, January 25, 1973.

This law empowers RENARE with the following functions:

1. To formulate and execute policies for the planning, coordination, development, conservation and administration of renewable natural resources;

2. In coordination with the other GOP agencies, identify and monitor private and/or public supported projects that utilize the renewable natural resources;

3. Inventory the renewable natural resources and clarify the various ecological, physical, climatic and economic conditions in Panama;

4. In coordination with other GOP institutions, promote education programs on conservation and the rational use of renewable natural resources; and

5. Promote the adoption of measures, agreements, and international conventions that support the protection of the renewable natural resources.

This law, as well as Decree Law #35 (September 1966) concerning the use of waters and Decree Law #39 (September 1966) covering the management of forests, gives RENARE broad powers to carry out effective resource management programs.

However, an analysis of RENARE's present institutional capacity to carry out such programs (see Annex VII, Project Paper) indicates that RENARE is constrained in its activities by lack of investment funds, a lack of trained personnel in areas other than forestry, a lack of travel allowances, vehicles, equipment and office facilities, as well as an inadequate organizational structure and management system.

The institutional analysis also determined that these constraints will be alleviated by the institution building component proposed by the project, which will provide for a more effective administrative organization and management system, technical assistance, training, additional personnel, office facilities and equipment (For greater detail, see Section II B2.(a) of the Project Paper).

Although RENARE will have the responsibility for implementing watershed management activities in the Canal Watershed, the recently created Panama Canal Authority (an autonomous Panamanian governmental agency which will administer those Canal Zone Government services that will be transferred to Panama upon implementation of the Panama Canal Treaties) will have policy-making responsibilities within the entire Canal Watershed, including those of the development of land use zoning and enforcement procedures. A draft agreement between the Canal Authority and MIDA has already been agreed to on a working level. It specifies that the Authority will coordinate with RENARE in the programming of its activities in the Canal Watershed.

III. PROJECT DESCRIPTION (THE SELECTED PLAN)

A. Goals and Objectives

The overall goal of the Watershed Management Project is to obtain a rational, productive, economic and equitable use of Panamá's renewable natural resources.

The project's major purposes are:

(1) To strengthen the technical, managerial and administrative capabilities of governmental institutions responsible for the management of renewable natural resources.

(2) To increase public awareness of the importance of natural resource conservation.

(3) To establish watershed management programs, that include involvement of the watershed's population, to the extent possible, in the resource management/conservation process, in three priority watersheds: the watersheds of the Panama Canal, Rio La Villa and Rio La Caldera.

The project will give top priority to development of a watershed management program in the Canal Watershed as it is of vital importance to the operation of the Panama Canal, and hence the economy of the country.

B. Project Components

The project consists of three components or types of activities: (1) institution building; (2) educational activities; (3) watershed management activities.

The institution building component will strengthen the capability of RENARE (Dirección de Recursos Naturales Renovables), the GOP institution responsible for project implementation, to plan and implement resource management projects. RENARE's present capacity to undertake watershed management projects is limited. First of all, its major area of experience and competence is almost completely restricted to reforestation activities. Secondly, it is currently structured, both in its national and regional offices, on a function basis, e.g., forestry service, soils, water and wildlife departments. This structure is not well suited to the design and implementation of projects which involve a mix of functions; and project design is often carried out on an ad hoc informal basis. Under this component RENARE will be reorganized on a program-oriented basis and its professional staff will be expanded. Substantial technical assistance and training will be provided in areas such as reserve and

park management and tropical forestry, as well as additional physical facilities and equipment.

The educational component will increase the Panamanian public's awareness of natural resource conservation and environmental concerns through the establishment of an educational center, located in the Canal Watershed, for (1) the development and dissemination of information on resource conservation for the general public and (2) the development of educational and training materials for both RENARE personnel and project beneficiaries.

The watershed management component will provide the GOP with actual experience in the design and implementation of programs aimed at achieving a more rational use of the natural resources of Panama's critical watersheds. Three watersheds were selected for inclusion in the project; the Canal Watershed, the Rio La Villa Watershed in the Azuero Península and the Rio Caldera Watershed in Chiriqui Province. These three watersheds were selected, from among Panama's nine "priority" watersheds, using a set of selection criteria that included: population size; level of social well-being; total area; area appropriate for agricultural use; hydrologic disequilibrium; deforestation; and existing, as well as planned, industrial and public sector investment.

In each of the selected watersheds a comprehensive land use management plan will be developed based on: (a) specific management objectives; (b) physical factors such as slope of land, soil conditions, climatic conditions; (c) current land use; and (d) other special factors, primarily of a socio-economic nature. Each plan will indicate potential land uses for the watershed and prescribe a mix of activities to be undertaken within the next five years to solve the watershed's most critical environmental problems. Activities prescribed by each plan will include one or more of the following: (1) establishment and management of parks and reserves; (2) reforestation, including contract reforestation and agro-silvicultural activities; (3) conservation oriented pasture improvement and management activities; (4) site specific soil and water conservation measures. The successful undertaking of all activities proposed for each watershed will not mean a solution to all of the watershed's natural resource problems. However, these activities will address each area's most critical environmental problems and serve as an initial phase of what must be an on-going program to achieve optimal conservation and management of the watersheds natural resource base. In addition, maximum success of these activities will depend on zoning regulations and enforcement procedures to be developed for the watershed by the Canal Authority in cooperation with RENARE and various other ministries involved in resource management.

A preliminary land use plan for the Canal Watershed has already been developed by the project design team, before project

implementation, because the critical importance of this watershed in the operation of the Panama Canal necessitates early planning and action. Land use plans for the Rio Caldera and Rio La Villa Watersheds will be developed during project implementation to provide RENARE with "hands on" experience in designing land use management plans, while specialized external technical assistance is available.

C. Watershed Management Activities in the Panama Canal Watershed.

1). Introduction

The primary objective of the land use management plan in the Canal Watershed is to reduce high rates of erosion which are causing accelerated sedimentation in Lakes Gatun and Alajuela. Based on this objective and on specific physical and socio-economic criteria, a potential land use plan displayed in Fig. III-1 was developed, which prescribes the following land uses for optimum resource management:

* Forest Cover. Approximately 60% of the total area of the watershed (195,000 hectares) should be left in forest cover. This forest cover should consist of:

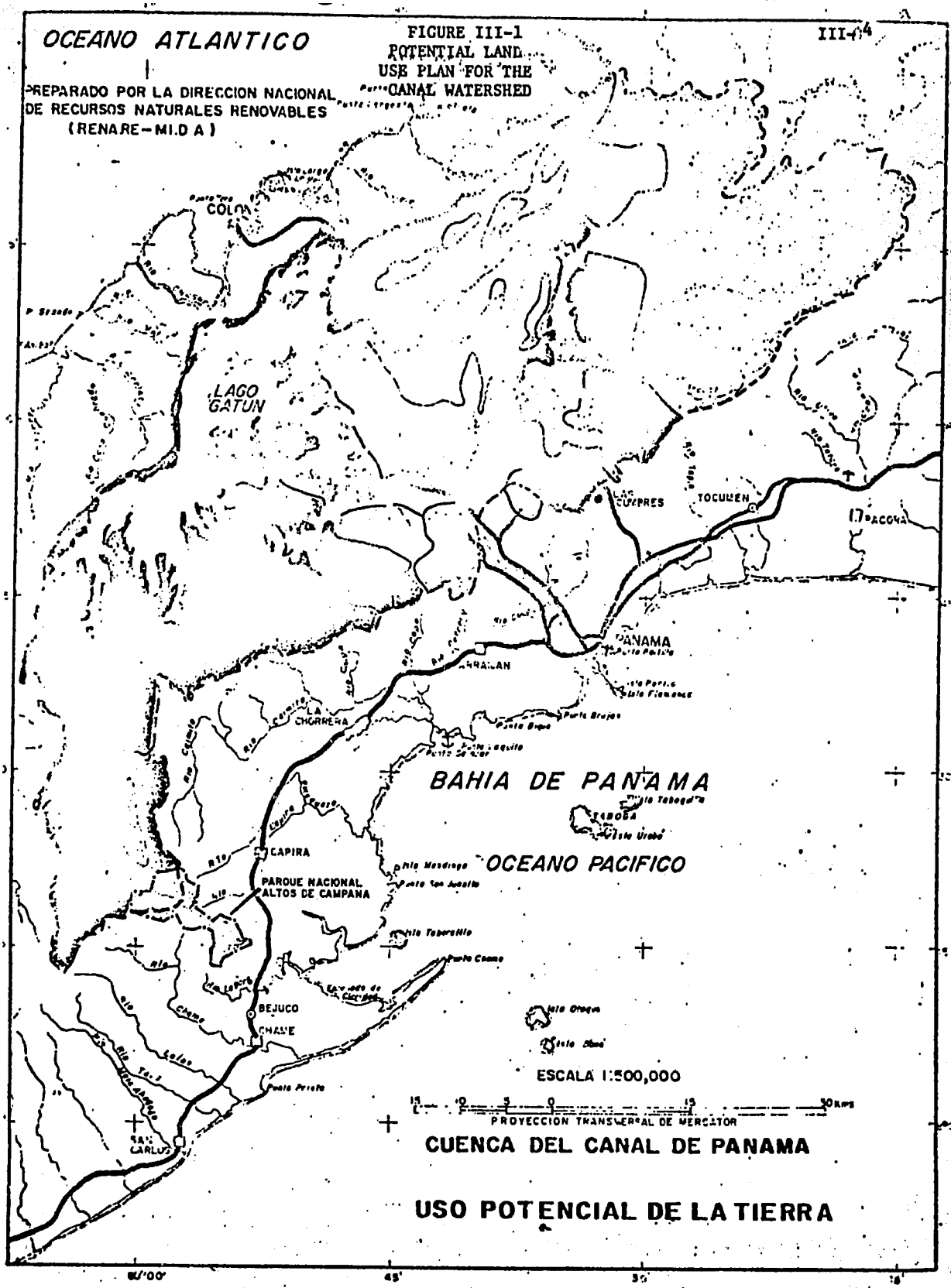
Natural (Protective) Forest. About 95,000 hectares, most of which has been, or will be, set aside as reserves or parks, should be left as natural forest to serve an environmental protection function. Land included in this category which is currently used for agriculture should be left idle so that it will revegetate naturally.

Commercial forest. Approximately 100,000 hectares, which are currently in pastures or secondary growth forests, are appropriate for commercial reforestation in the form of forest plantations or agro-forestry (taungya) activities using either annual or permanent crops. These lands are located around Lake Alajuela in the Gatun River basin, in the area of Buena Vista in the eastern part of the watershed, and along the Ciri and Trinidad river valleys in the western part of the watershed.

* Agricultural Uses. Approximately 70,000 hectares of the watershed can be used for agricultural purposes.

Farming Activities. Approximately 5,000 hectares, or less than 2% of the watershed's area, can be used strictly for farming. This land, which is characterized by 0-8% slopes and moderately deep alluvial soils, is located northwest of Lake Alajuela in the Buena Vista district. Suitable crops include rice and vegetables; however, soils in this area are erodable and conservation

FIGURE III-1
POTENTIAL LAND USE PLAN FOR THE CANAL WATERSHED



Preparado por la Oficina de Cartografía de la Dirección Nacional de Recursos Naturales Renovables (RENARE) del Ministerio de Desarrollo Agropecuario (MIDA) en base a los mapas generados en el Instituto Geográfico Nacional Tommy Guardia.

SIGNOS CONVENCIONALES

LUGARES POBLADOS
- CAPITAL DE REPUBLICA ——— PANAMA
- CABECERA DE PROVINCIAS ——— COLON
- CABECERA DE DISTRITOS ——— LA CHORRERA
- CABECERA DE CORREGIMIENTO ——— CHILIBRE
- OTRAS POBLACIONES ——— PARAISO

CARRETERA Y CAMINOS
- PANAMERICANA Y TRANSISTMICA
- RESTO DE SUELO TRANSITABLE EN TODO TIEMPO

FERROCARRIL
- VIA NORMAL

LIMITES
- LIMITE DE CUENCA (OPCIONAL)
- AEROPUERTOS, PISTA DE ATERRIZAJE (OPCIONAL)
- PUERTOS (MAR)

LEYENDA

COBERTURA BOSCOSA NATURAL: AREAS CON PENDIENTE MAYORES DE 45%, SUELOS POCO PROFUNDOS DE CLASES VII.

COBERTURA BOSCOSA ARTIFICIAL: AGROFORESTAL CULTIVOS PERMANENTES, AREAS CON PENDIENTE ENTRE EL 45% Y 75% SUELO POCO PROFUNDOS DE CLASES VII, VI, IV

AGRICOLA: (AG) TERRENOS CON PENDIENTES MENORES DE 8% SUELOS CON BAJA FERTILIDAD DE CLASE III Y MODERADAMENTE PROFUNDO.

PECUARIO (P) AREAS CON PENDIENTES ENTRE EL 20 Y 45% SUELOS POCO PROFUNDOS DE CLASES VI, IV.

RESERVA MILITAR.

MANEJO DEL CANAL.

practices are required.

Ranching Activities. Almost 65,000 hectares of land located primarily west of the Canal, can be used for cattle grazing with improved pasture grasses and management due to the more moderate slope characteristics of the area's lands and lower precipitation rates.

* Other Uses. Approximately 60,000 hectares are bodies of water (lakes and rivers) or are currently dedicated to urban or transportation uses including canal operations. Although the area utilized for urban activities will expand in the future, the GOP intends to restrict urban expansion within the watershed.

Specific activities proposed for implementation in the Canal Watershed over the next five years are:

2. Reserve and Park Management

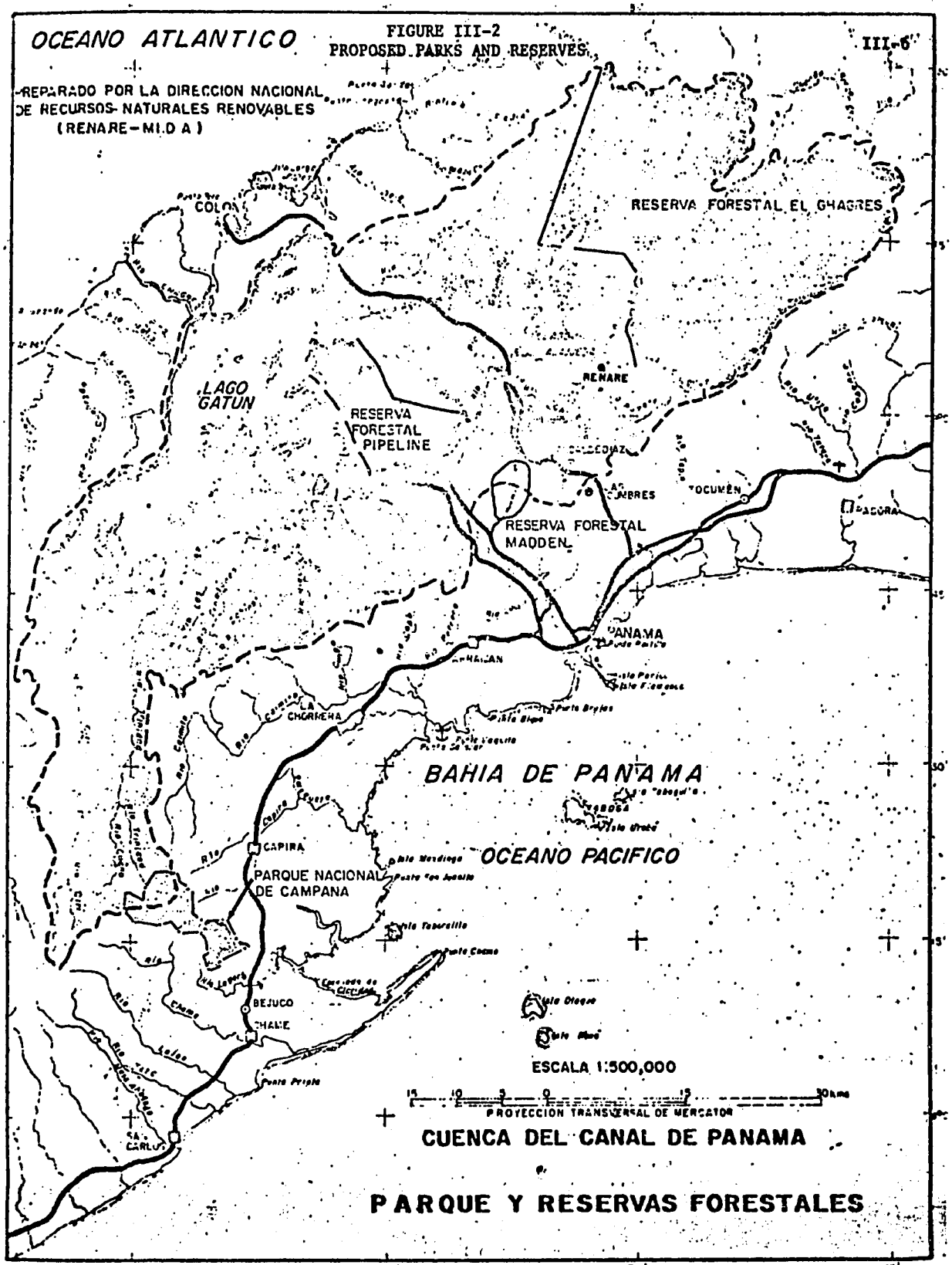
Reserve and park management plans will be developed and implemented by RENARE, with external technical assistance, for 94,000 hectares, or over 1/3 of the land area of the watershed. Included in these 94,000 hectares will be 78,000 hectares in the Chagres Reserve, 4816 hectares in the Altos de Campana National Park and 11,000 hectares in the Pipeline Road area of the Canal Zone. The Chagres Reserve and Altos de Campana National Park have already been designated reserve and park areas by Panamanian law, and the Pipeline Road area will be established as a national park once jurisdiction of this area reverts to Panama upon implementation of the Panama Canal Treaties. Figure III-2 displays the location of the proposed reserve and park areas.

In conjunction with the development of management plans, a corps of 33 forest rangers will be established and trained to protect forest and other renewable natural resources. Using existing legislation they will control unauthorized entrance to reserve and park areas, enforce prohibitions against cutting, burning and hunting, and regulate agricultural and ranching activities. However, they will primarily serve an educational and information dissemination function.

The management plan for the Chagres Reserve will consist mostly of measures designed to limit access to the area. Infrastructure such as administrative centers, guard houses and access roads will be constructed primarily for surveillance purposes and approximately 16 forest rangers will be stationed at key points of access to the reserve to prohibit such illegal activities as colonization, slash and burn agriculture and hunting.

The management plan for the Pipeline Road area will partly consist of measures to limit access, such as fencing boundaries, constructing surveillance infrastructure, and establishing a 24 hour

FIGURE III-2
PROPOSED PARKS AND RESERVES



Preparado por la Oficina de Cartografía de la Dirección Nacional de Recursos Naturales Renovables (RENARE) del Ministerio de Desarrollo Agropecuario (MIDA) con base a los mapas existentes en el Instituto Geográfico Nacional Tommy Guardia.

SIGNOS CONVENCIONALES

LUGARES POBLADOS
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- CABECERA DE CORREGIMIENTO ——— CHILIBRE
- OTRAS POBLACIONES ——— PARAISO

CARRETERA Y CAMINOS
- PANAMERICANA Y TRANSITABLE
- ALIMENTADOR EJECUTO TRANSITABLE EN TODO TIEMPO

FERROCARRIL
- VIA NORMAL

LIMITES
- DE LA CUENCA (OPCIONAL)
- AEROPUERTO, PISTA DE ATERRIZAJE (OPCIONALES)

LEYENDA

PARQUE Y RESERVAS FORESTALES ——— 15

74

forest rangers surveillance system to prohibit unwanted activities. However, part of the park will be devoted to educational activities with the development of an educational center, didactic material, marked foot trails and tour guide services.

A park management plan has already been developed for Altos de Campana National Park with FAO and UNDP assistance. Under this project, management activities will primarily be directed at the establishment of a surveillance system, utilizing 16 forest rangers to prevent inappropriate land uses. In addition, the plan will include construction of visitors facilities to enhance public enjoyment of the area.

3. Reforestation

A total of 10,500 hectares will be reforested with fast growing commercial native species, especially laurel. Other native species such as Spanish cedar, spiny cedar, mahogany and teak, which are less disease and insect resistant than laurel, will be planted on a smaller scale. These reforestation activities will be implemented in one of the two following ways depending upon the significance of an area's current land use in the causation of high sediment yield rates:

a. Reforestation of critical areas for conservation or commericial use only.

This activity will be undertaken on plantations administered by RENARE. Arrangements will be made with asentamientos or private farmers, on a seasonal basis, to provide the necessary labor. In all, 6,500 hectares will be reforested, primarily on pasture lands with slopes greater than 45%, in: the Salamanca Administrative Unit near the mouths of the Boqueron and Pequeni Rivers; in the Rio Indio area of the Alajuela Administrative Unit; the area between the Ciri and Trinidad Rivers in the El Cacao Administrative Unit; and in the Buena Vista Administrative Unit.

b. Reforestation utilizing agro-forestry techniques.

Agro-forestry activities using annual crops will be promoted among traditional slash and burn agriculturists. Social promotion, technical assistance and materials such as seedlings and fertilizer will be provided to these farmers to plant fast growing native tree species at widely spaced intervals between their rice and corn plots. In addition they will be paid for their labor input for planting seedlings and weeding and pruning in subsequent years. A total of 2,500 hectares will be planted under this system in the Salamanca and El Cacao Administrative units. Agro-forestry activities with permanent crops will be promoted among cattle ranchers and traditional agriculturalists who must modify their current economic activity. This activity will be undertaken on 500 hectares in the

Salamanca Administrative Unit and 1000 hectares in the El Cacao Administrative Unit. Up to 400 small farmers will be offered 3-4 hectare plots, material inputs and technical assistance to plant permanent tree or bush crops under commercially exploitable species such as laurel. The primary permanent crops will be coffee (Robusta) which already grows satisfactorily with the prevailing climate and altitude found in this area. Some other permanent crops such as cacao, pixbae and maracuya will be planted on a smaller scale.

Table III-1 provides a breakdown of activities by Administrative Unit and Figure III-3 shows locations of all reforestation activities.

TABLE III-I
REFORESTATION ACTIVITIES BY ADMINISTRATIVE UNIT, CANAL WATERSHED (HECTARES)

Admin. Unit.	Reforestation for conservation	Reforestation with Agroforestry	
	state. pl.	annual crops	permanent
El Cacao	2000	1500	1000
Salamanca	2000	1000	500
Buena Vista	1500		
Alajuela	1000		

4. Site-specific Soil conservation measures

Site-specific erosion control activities will be implemented, especially in areas of watershed where gully erosion is high due to poorly designed roads, overgrazing on pastures, and land urbanization. Most activities will take place in: the upper area of the Indio and Chagres Rivers (Cerro Azul); the region of the lower Boqueron River (Salamanca); the Cerro Cama area; the Chilibre - Chilibrillo area in the Alajuela administrative unit; and the north side of Lake Gatun in the Buena Vista Administrative unit. Specific control measures will include grass waterways, land stabilization, gully control structures and construction of adequately designed roadway ditching.

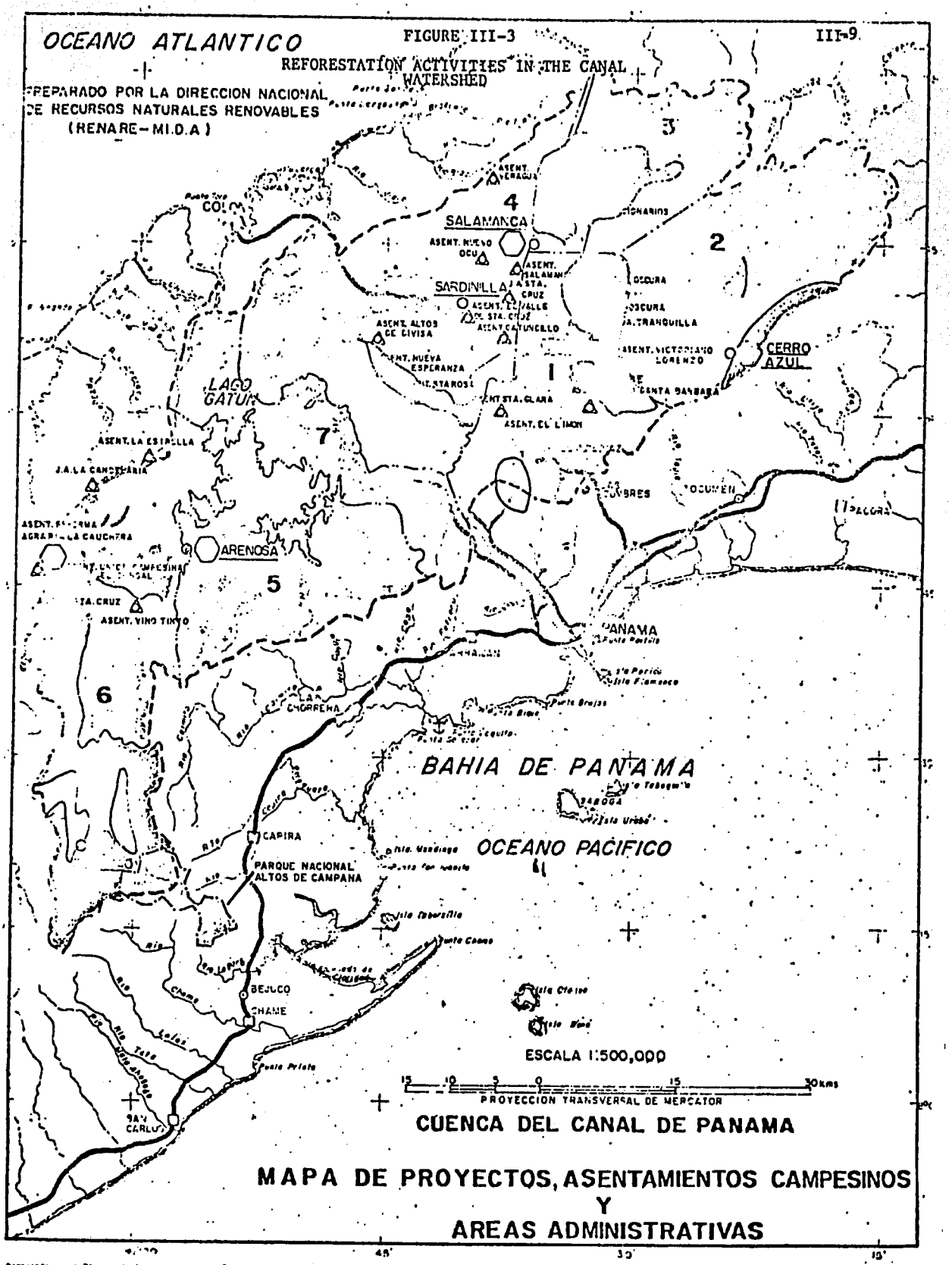
Specific locations for soil conservation activities will be identified by aerial photos and verified by site visits. Although up to 8000 hectares will be treated by these activities, a substantially larger number of hectares will be directly benefited.

5. Pasture Improvement Activities

The relatively large extensions of pastureland in the Cerro Cama and, to a lesser extent, in the El Cacao administrative areas must be converted from faragua grass to a stoloniferous grasses such as

FIGURE III-3

REFORESTATION ACTIVITIES IN THE CANAL WATERSHED



signal grass (Brachiaria decumbens) or tanner grass (Brachiaria radicans) in order to reduce the significant amount of sediment which comes from this area.

The pasture improvement program will be a pilot or demonstration program. It will consist principally of the establishment of a large number of demonstration parcels (up to 600-1/2 to 1 hectare) plots on the ranches in this area. It will also include a substantial amount of technical assistance to the ranchers oriented toward improved pasture management and the introduction of the stoloniferous grasses. Because a choice of technologies exists for the establishment of stoloniferous grasses, they will be field tested to determine which is the least cost method for the conditions of the area. RENARE and the Agricultural Research Institute (IDIAP) will cooperate in this effort.

Because the stoloniferous grasses are much more productive than faragua grass and, as a consequence, provide a greater financial return to the rancher, it is expected that the demonstration program will create a substantial demand for credit to establish larger extensions of the stoloniferous grass. Because the Agricultural Development Bank (BDA) is obtaining a $15 million loan from the Inter-American Development Bank, primarily for long-term lending to small and medium ranchers, no credit component has been included in this loan. The BDA has enthusiastically endorsed the pasture improvement effort and has assured that it will cooperate fully in meeting the expected credit demand. It is expected that 10 hectares for every hectare of demonstration plot, or approximately 5,000-6,000 hectares, will be established by the end of the loan disbursement period.

D. Watershed Management Plan for the Rio Caldera Watershed.

A long range management program will be developed for the Rio Caldera Watershed by RENARE personnel. As was done in the Canal Watershed, the plan will be based on major management objectives, the physical characteristics of the area's natural resources, current land use and various socio-economic factors. Critical areas will be identified, a potential land use or zoning plan will be developed, and priority activities will be identified for immediate implementation.

A Soil and Water District will be established to administer the plan, on a pilot basis. One of the major activities of this District will be the testing and demonstration of preventative and corrective soil conservation techniques to be used by RENARE personnel in their extension efforts. Also, a tree nursery will be established to provide seedlings to project participants.

Already, priority activities, such as stream bed cleaning, terracing, and the building of check dams, have been identified. However, satisfactory completion of the long term land use management plans will be a condition precedent to disbursement of funds for these priority activities.

E. Watershed Management Plan for the Upper Rio La Villa Watershed.

As in the Rio Caldera Watershed, a long range management plan will be developed for this watershed by RENARE personnel. Critical areas will be identified, a potential land use plan will be developed and priority activities will be identified for immediate implementation. Also, a Soil and Water Conservation District will be established to administer the plan.

Priority areas have been preliminarily identified as Cajagua (67,000 ha.) and Montuoso (13,000 ha.); both in the upper watershed.

It is anticipated that activities will focus on reforestation of the Montuoso Reserve (using Caribbean pine) and specific labor-intensive soil conservation measures for both areas. However, the precise scope and allocation of resources for both reforestation and soil conservation measures will be determined by the long range management plan, the completion of which will be a condition precedent for disbursement of funds for these activities.

IV. ASSESSMENT OF THE "NO ACTION" ALTERNATIVE

A. Introduction

The population of the Canal Watershed is increasing at an average annual growth rate of 5.37%, almost three times that of rural Panama. This high rate of population increase is largely due to immigration both by rural farmers from other areas of the country, in search of more and better lands close to urban markets and other opportunities, and by recent immigrants to the Panamá-Colón urban area, forced to return to agriculture by lack of employment opportunities in the cities. Human pressures within the watershed are causing significant land use changes. Forested lands are rapidly being converted to agricultural use and pasture development. In many areas of the watershed, poor agricultural and pasture management practices are causing the degradation and eventual abandonment of these lands, and further deforestation of lands critically needed to protect the watershed's natural resources. If these land use trends are allowed to continue, environmental degradation may become significant enough to affect Panama's economic development. A detailed analysis of impacts resulting from a decision not to implement a watershed management project in the Canal Watershed is provided in the following sections:

B. Impacts on Physical Resources

A decision not to implement the project will create significant long-term impacts on the watershed's physical resources. Without the project, current population and land use trends will probably continue, and the watershed's land, soils and water resources will be progressively damaged by erosion and sedimentation caused by: the clearing and burning of forested land for cultivation and pasture development; poor cultivation and pasture management techniques; and poor road construction practices.

1. Impacts on Land Use

If no action is taken to stop current rates of deforestation in the watershed, it can be predicted that a little over 20% of the area will be in natural forests by the year 1983, and that little or no natural forests will remain in the year 2000. If it is assumed that the conversion of deforested lands to agricultural use and pastures follows existing trends, it can be predicted that approximately 34% of the area will be devoted to pastures in 1983, and that over half of these pastures will be on slopes of greater than 45%. The land use situation in the watershed in the year 2000 is predicted to be far worse. Using existing trends, it is estimated that over 50% of the watershed area will be devoted to pasture use, and that approximately 56% of these pastures will be on slopes greater than 45%. Also, for both years it can be predicted that approximately 35% of the pasture land will be in a degraded state suffering from the invasion of Imperata grass.

Predicted land use changes for the years 1983 and 2000 are displayed in Tables IV-1 and IV-2.

2. Impacts on Soil

a. Erosion

The current annual sediment yield in the watershed is almost 9.5 million m^3. Using the land use changes presented in the previous section and the sediment yield rates for various land slope and land use type presented in Table II-4, Section II ., it can be calculated that, it no action is taken, the annual sediment yield in the area will rise to over 11.5 million m^3 by the year 1983 (see Table IV-3) and to over 16 million m^3 by the year 2000 (see Table IV-4). In the year 1983, erosion from pasture lands will account for 75% of this yield, with erosion from pastures on slopes greater than 45% responsible for over 50% of the total yield. In the year 2000, erosion from pasture lands will account for almost 83% of the total annual sediment yield, with pastures on slopes greater than 45% again responsible for over 50% of the total.

These erosion rates may be low as they do not include estimates of erosion coming from roads and other major sources of erosion such as urbanization, which produce high sediment yield rates.

To some extent, the erosive impact of the entire process of deforestation and conversion to pastures may be self-limiting due to the invasion of pasture lands with Imperata cylindrica. Although the grass has no economic use in terms of cattle ranching, it is very effective at controlling erosion. In fact, sediment yield rates from lands covered by Imperata are not much higher than such rates from natural forest lands. The spreading of this grass through the watershed and the reversion of abandoned lands back to secondary growth forest could eventually put a stop to accelerating erosion rates. This would not happen, however, until significant damage has been done to the area's water and biological resources.

b. Soil Fertility

One effect of erosion in the area is the removal of the superficial, organic-rich layer of soil which contains most of its nutrient constituents. Thus, whatever portion of the soil remains will have greatly diminished fertility. The formation of superficial rills and gullies will also greatly reduce the vegetative potential of the land. Consequently, as deforestation and other human activities continue to promote the process of erosion, the agricultural productivity of the land will decrease and the capacity of the land to recover its natural vegetation may be lost forever.

TABLE IV-1
PROJECTED LAND USE IN THE CANAL
WATERSHED IN 1983
WITHOUT PROJECT

(Hectares)

	S L O P E S				
Land Use	0-8%	8-20%	20-45%	45%+	Total
Natural Forest	200	1,000	3,000	62,000	66,200
Plantations		30		70	100
Secondary Growth	2,400	10,670	23,000	41,030	77,100
Forest Sub-Total	2,600	11,700	26,000	103,100	143,400
Intensive Agriculture	100				100
Traditional Agriculture	1,200	2,700	2,900	5,000	11,800
Agriculture Sub-Total	1,300	2,700	2,900	5,000	11,900
Improved Pasture	600	2,000			2,600
Faragua	900	17,600	20,100	31,100	69,700
Imperata	1,600	2,400	5,500	29,100	38,600
Sub-Total	3,100	22,000	25,600	60,200	110,900
Total Forest Agr.-Pasture	7,000	36,400	54,500	168,300	266,200
Other Uses					60,025
Grand Total					326,225

TABLE IV-2
PROJECTED LAND USE IN CANAL WATERSHED IN 2000
WITHOUT PROJECT

(Hectares)

Land Use	SLOPES 0-8%	8-20%	20-45%	45%	Total
Natural Forest	0	0	0	0	0
Plantations	0	30	0	0	30
Secondary Growth	1,300	6,470	6,900	66,400	81,070
Forest Sub-Total	1,300		6,900	66,400	81,100
Intensive Agr.	100	0	0	0	100
Traditional Agr.	1,300	2,700	6,000	8,000	
Agr. Sub-Total	1,400	2,700	6,000	8,000	18,100
Improved Pastures		7,000	1,000		9,400
Faragua grass	900	17,600	29,600	48,900	97,000
Imperata grass	2,000	2,600	11,000	49,000	60,600
Pasture Sub-Total	4,300	27,200	41,600	93,900	167,000
Total Agr. and Forest	7,000	36,400	54,500	168,300	266,200
Other Uses					60,025
Grand Total					326,225

TABLE IV-3

ANNUAL SEDIMENT YIELD IN THE CANAL WATERSHED IN 1983
WITHOUT PROJECT

M^3

Land Use	SLOPES 0-8%	8-20%	20-45%	45%+	Total
Natural Forest	1,000	6,000	24,000	620,000	651,000
Plantations				2,000	2,000
Secondary Growth	12,000	107,000	368,000	903,000	1,390,000
Forest Sub-Total	13,000	113,000	392,000	1,525,000	2,043,000
Intensive Agriculture	8,000				8,000
Traditional Agriculture	24,000	108,000	174,000	400,000	706,000
Agriculture Sub-Total	32,000	108,000	174,000	400,000	714,000
Improved Pasture	4,000	26,000			30,000
Faragua Grass	27,000	1,056,000	2,010,000	4,665,000	7,758,000
Imperata Grass	11,000	36,000	127,000	786,000	1,045,000
Pasture Sub-Total	42,000	1,118,000	2,137,000	5,451,000	8,748,000
Grand Total					11,5[illegible],000

TABLE IV-4
ANNUAL SEDIMENT YIELD IN THE CANAL
WATERSHED in 2000
WITHOUT PROJECT

M^3

Land Use	S L O P E S 0-8%	8-20%	20-45%	45%	Total
Natural Forest	0	0	0	0	0
Plantations	0	0	0	0	0
Secondary Growth	7,000	65,000	110,000	1,461,000	1,643,000
Forest Sub-Total	7,000	65,000	110,000	1,461,000	1,643,000
Intensive Agriculture	8,000	0	0	0	8,000
Traditional Agriculture	26,000	108,000	360,000	640,000	1,134,000
Agriculture Sub-Total	34,000	108,000	360,000	640,000	1,142,000
Improved Pastures		91,000	20,000		111,000
Faragua Grass	27,000	1,056,000	2,960,000	7,335,000	11,378,000
Imperata Grass	14,000	39,000	253,000	1,470,000	1,776,000
Pasture Sub-Total	41,000	1,186,000	3,233,000	8,805,000	13,265,000
Grand Total	82,000	1,359,000	3,703,000	10,906,000	16,050,000

3. Impacts on Water Resources

If no action is taken, the watersheds water resources will continue to be adversely affected in terms of both quality and quantity.

a. Water quantity:

Increased erosion and subsequent sedimentation will continue to reduce the storage capacity of the watersheds reservoirs, change the geomorphological characteristics of rivers and streams and increase flooding.

Reduction of storage capacity in Lake Alajuela, which provides storage for urban use, power generation and, most importantly, regulation of water levels in Lake Gatun, will be the most damaging result of increased sedimentation. Sediment accumulation was measured for Alajuela in 1957, 1972, 1973 and 1975 and 1978, by the Panama Canal Company. These measurements showed that between 1934 and 1973 (the Lake's predevelopment period) the average sedimentation rate was .109 ft/yr., while the average rate between the years 1973 and 1978 (a period representative of current land use practices) was .240 ft./yr. Future sedimentation rates were projected, as part of the development of this project, to determine the future storage capacity of Lake Alajuela (See Annex VI-C of Project Paper). To make such projections, the rate for the 1973-1978 period was adjusted "to normal" (.302 ft/yr) to account for unusually low rainfall and runoff for this time period. The increase in sedimentation rate was then calculated for the 1934-78 time period (.302 ft/yr - .109 ft/yr. = .193 ft/yr or 1.660 MCM/yr).

Since significant land clearing in the Alajuela Watershed has taken place only within the last ten years, it was assumed that this increase in sedimentation rate (1.660 MCM/yr) resulted from land use changes (the deforestation of 8300 ha.) that have occurred only within this 10 year time period. This increase in sedimentation rate was again adjusted upward to 1.992 MCM to account for added sediment yield resulting from gullies and landslides.

Future amounts of sedimentation and lake storage capacity were then calculated for 1980 and at 10 year intervals thereafter (see Table IV-5), assuming that the deforestation rate for each ten year interval would be same as the rate for the 1968 to 1978 period. This means that every 10 years the sedimentation rate would increase by 1.992 MCM/yr. Calculations in Table IV-5 show that if no action is taken, the reservoir will become useless somewhere between the years 2030 and 2040.

Such a loss of storage capacity means that the

TABLE IV-5

PRESENT AND ESTIMATED FUTURE TOTAL STORAGE IN LAKE ALAJUELA

Year	Sed. Rate Prec.Period[1]/ (MCM/yr.)	Sed. Depos. Prec. Pd. (MCM)	Remaining Storage (MCM)	Remaining Storage - % of Orig.
1934	--	--	799.8	100.0
1978	1.066[2]/	46.96	752.8	94.1
1980	(2.597)[3]/ 2.995	5.99	746.8	93.4
1990	4.987	49.81	696.9	87.1
2000	6.979	69.79	627.0	78.4
2010	8.971	89.71	537.3	67.2
2020	10.963	109.63	427.7	53.6
2030	12.963	129.55	298.1	37.3
2040	14.947	149.47	148.8	18.6

Notes: 1/ 1.0 ft. of sediment in Lake Alajuela
= 8.60 MCM (million cubic meters).
This is based on lake area at mean low water (Elev.210).

2/ Average rate, 1934-1978.

3/ Adjusted rate, 1968 - 1978.

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reservoir could no longer function to regulate water levels in Gatun Lake during extended dry seasons. This may affect Canal traffic (reduced drafts and/or fewer transits) or require construction of alternative storage sites or the institution of some equally costly measure to supply water i.e. channel deepening through dredging. In addition;

- Power generation at Madden Dam would change to a "run of the river" operation as the reservoir fills with sediment.
- Serious flooding would occassionally occur on the Chagres River above Madden Dam during periods of high runoff. Flood damage might occur around Gatun Lake.
- Finally, at some point in time, the withdrawal of municipal water supply for the Panama-Colon metropolitan area would be adversely affected, perhaps requiring costly changes in the supply system.

Another signficant impact of land clearing and increased sedimentation is increased potential for river flood peaks. Vegetative cover is an important regulator of stream flow. Continued deforestation and subsequent degradation of pasture lands will create higher runoffs rates that, in the wet season, will cause flood stages to crest sooner, and at a higher level, than at present, causing damage to crops, dwellings and livestock. Flood control plans, developed by the Panama Canal Company, have been designed for specific areas, and thus depend on hydrologic stability within the watershed. The rapid destruction of forest and concurrent changes in the hydrologic characteristics of the watershed affect the ability to make timely decisions about floods and raise serious questions about the ability of Canal officials to avoid flood damage if a serious flood were to occur. Because of the recent changes in the watershed, Canal officials responsible for flood control are already making plans to improve flood forecasting and control capabilities.

b. Water quality

At present, the quality of water resources in the watershed has not been significantly degraded. However, if no action is taken, and present land use trends continue, water quality degradation can be expected as increased quantities of (1) runoff and leached chemicals from agricultural and livestock production sites and (2) wastes from human settlements find their way into the areas waterways.

Little information exists on the effects of agricultural runoff on water quality in tropical areas. Studies in temperate climates, however, have found nutrient concentrations substantially higher in streams draining agricultural areas than in

streams draining forested areas. Such a large difference between nutrient concentrations in streams draining agricultural areas and streams draining forested areas may no exist the Canal Watershed, due to much lower use of both fertilizers and high-protein animal feed. However, nutrient concentrations in streams draining agricultural areas may still be significantly high, since high rainfall rates facilitate the washing of cattle wastes off steep slopes into nearby streams.

The Canal Zone Water Quality Study (1974) showed high nitrate and phosphorous concentrations in waters bordering small towns along Lake Gatun and in bottom waters of the northern portions of Lake Alajuela bordering agricultural areas near Salamanca. High nutrient concentrations were also found in the portion of the Chagres River, between the two lakes, just below the mouth of the Chilibre River. The exact sources of these high nutrient concentrations were not determined, however the authors suggested that they originated from the flow of surface water runoff either directly into the Lakes or indirectly through tributary streams. Already high concentrations of nutrients are causing high levels of productivity in Lake Alajuela and portions of the Chagres River.

With no action, there will probably be further increases in productivity of noxious aquatic weeds, algae and associated insect pests, and a decline in water quality in terms of taste, odor and color. Such changes will necessitate more costly measures for weed control for canal operations and/or higher treatment levels at IDAAN's water treatment plant in Chilibre. At a later point in time, higher treatment levels at the two water treatment facilities on Lake Gatun, operated by the Panama Canal Company,may be required.

Bacteriological contamination of the area's water resources will have more serious implications, as it will adversely impact the health of both residents of the watershed and the residents of the cities of Panama and Colon and surrounding areas. The Canal Zone Water Quality Study showed that fecal coliform counts, which indicate the presence of human wastes, were high in waters that drained many of the populated areas of the watershed. Counts were especially high during the wet season. Most residents of the watershed utilize pit latrines for waste disposal, although septic tanks are utilized in the more populated towns and lakeside recreational areas. During the rainy season these waste disposal systems become overloaded, overflow, and pollute surface runoff. If population is allowed to increase in an uncontrolled manner in the area around the lakes, surface runoff will contain higher levels of bacteria and other pathogens, such as viruses and parasites, which are far more difficult,if not impossible, to eliminate with the standard water treatment methods. Higher turbidity levels in the Lake due to increased erosion will also decrease the effectiveness of water treatment,

as turbidty interferes with the ability of chlorine to kill pathogenic organisms. Thus,no action will increase chances of disease outbreaks and further emphasize the need for more costly, higher levels of water treatment.

Finally, with no action, industrial development in the watershed may not be controlled. Chances of contamination of the area's waters with toxic industrial wastes will increase and there will again be an increased need for higher water treatment levels at the area's water treatment facilities, not only because many industrial wastes are toxic to man, but also because many industrial pollutants, especially metals, interfere with normal water treatment processes and decrease treatment plant efficiency.

C. Biological Impacts

If no action is taken in the watershed to prevent deforestation and to protect designated wildlife reserves and parks, almost the entire watershed will be devoid of natural forests by the year 2000.

As the natural forests are cut, practically all forest plant species will disappear, except for a few specialized species such as Cecropia and Ochroma which occur very sparsely in temporary gaps of climax forest and spread widely in secondary forests. This loss of natural vegetation will continue to propagate the following existing trends within the area: (1) the reduction in total area of natural habitat which harbors species dependent on natural forest ecosystems and (2) the fragmentation of formerly continuous habitats and distributional ranges, particularly needed by animals that range or migrate over large areas to breed. In combination, these processes will increase chances of extinction or relocation for many of the area's animal species (26 of which are classified as threatened or endangered by either US. or Panamanian law),because it will become more difficult for them to migrate between isolated vegetative islands containing species pools.

More specifically, numbers of terrestial and arboreal herbivores and frugivores, which constitute the areas greatest animal biomass, will rapidly decrease due to reduction in habitat ranges. Range reduction will consequently create greater competition for food and space, especially among animals that, at certain times of the year, have the same habitat and food preference. Ultimately the viability of these species as breeding populations will be lost. Furthermore, since herbivorous species such as the agouti, paca, capybara, coatimundi, opposums and rats are important in the diets of many carnivorous animals, breeding populations of carnivores will be adversely affected. Only animals such as jaguarondis, white-tailed deer and coatimundi , that tend to do well in cut cover and scrub areas, will be able to adapt to loss of forested land and encroachment of man's activities.

Many forest dwelling song and game birds will also suffer great reductions in numbers as many have unique food, habitat and space requirements. They soon die if their environment is altered, especially since many are poor flyers and cannot migrate to new areas.

Waterfowl and game bird populations will be less severely affected. Waterfowl populations in the watershed are generally quite low, with the exception of large migratory flocks of blue-winged teal that utilize the lakes as stopover areas on flights to overwintering sites. Large game bird populations are also quite low as a result of indiscriminate hunting and habitat disappearance. Increased deforestation and agricultural and urban development will further decrease numbers of game birds, but will have no immediate effect on migratory fowl due to the relatively small areas they use.

Aquatic ecosystems in the watershed will also be adversely affected by the deforestation and uncontrolled development which could occur without implementation of the project. Many rivers and streams will suffer severe fluctuations in flow due to increased runoff, siltation, stream impoundment and greater consumptive water use. Sudden high flows and flooding during the wet season will cause severe scouring, thus reducing the population of aquatic invertebrates that support fish. Increased flows of surface runoff containing sediment, nutrients and pesticides into the areas waterways will also cause adverse effects. Increased sediment loads could reduce light penetration in lakes and streams and thus inhibit photosynthesis required for the production of fish food. Sediment deposited on stream bottoms containing spawning beds will reduce the survival rate of eggs and young as well as kill such food sources as bottom living organisms. Increased nutrients will speed up the lake's eutrophication process, lower dissolved oxygen levels and lead to changes in animal and plant populations. In the long term, encroachment of industrial development in the watershed will create pollution of the area's waters resources with substances, such as heavy metals, that are toxic to aquatic life.

Forest destruction may also result in some climatic modifications. Removal of forests can effect an area's climate by trapping moisture and by affecting the radiation balance and hence possibly temperature and rainfall regimes.

Although there is too little information about many variables for confident predictions to be made about the effect of development activities on climate, it is clear that drastic changes of land use in the watershed have the potential to produce cumulative climatic changes.

Deforestation and human encroachment in the watershed will undoubtedly lead to easier access and an increase of uncontrolled recreational use. If no action is taken, such activities will augment wildlife damage through increases in illegal hunting and disturbance of vegetation, wildlife and aquatic ecosystems.

In the end the natural ecosystem of the watershed will be totally altered by agricultural and pasture lands and urban development. Such "man-made" ecosystems are less complex, and therefore less stable and less resistant to irreversible environmental degradation, if no precautionary measures are taken. Already over 31,000 ha. of the watersheds pasture lands have been overtaken by Imperata grass and it is predicted that Imperata will cover over 60,000 ha. by the year 2000. Invasion of lands by this grass will severely affect the ability of these lands to revert their former natural vegetational state.

D. Socio-Economic Impacts

Over the short-term, a decision not to implement the project will probably have few significant adverse effects on socio-economic conditions in the watershed. Farmers will continue to utilize shifting slash and burn agricultural techniques, and cattlemen will continue to take larger amounts of land for pastures. There may be some adverse impact resulting from (1) the government's inability to provide social benefits such as schools, health facilities, roads and water supplies to the area's rapidly increasing population, and (2) scarcity of food supply due to lowered land productivity.

However, severe socio-economic impacts will be felt over the long-term, as more land is put into pastures and then degraded due to poor pasture management techniques. The low productivity of these degraded lands may eventually force some residents to leave the watershed in search of better lands or other means of employment. This outmigration could cause social and economic pressures in other areas of the country, especially in the nearby Panama-Colon urban area.

Without the project, the economic development of the entire country may be affected. Increased sedimentation in Lakes Alajuela and Gatun will eventually make it more costly to operate the Canal. Either dredging costs will increase, or shipping revenue may be lost during the dry season when Lake Alajuela cannot supply enough water to Lake Gatun. Also, increased flows of runoff, containing sediment, bacteria and nutrient, into Lakes Alajuela and Gatun will create higher operation and maintenance costs at IDAAN's water treatment facility in Chilibre and at the two water treatments facilities currently operated by the Panama Canal Company. Eventually more complex and more expensive water treatment process may have to be installed.

Finally, increased sedimentation may reduce the operating capacity of the hydroelectric plant at Madden Dam.

At some point in time, the construction of a new reservoir to replace the storage lost in Lakes Alajuela and Gatun will be required. A new source of water for the water supply systems of Panama, Colon and surrounding areas may have to be sought and new water supply facilities may have to be constructed. If sufficient power cannot be generated elsewhere in Panama's integrated power system, a new power generating facility may have to be constructed.

These changes will require costly investments by the Government of Panama, and channel funds away from other programs and projects that are needed to improve the quality of life for all its people.

E. Rio La Villa and Rio Caldera Watersheds

In the Rio La Villa watershed a continuation of current land use trends would result in eventual irreversible degradation of the land resource. Currently the major land use, in terms of area, is extensive cattle grazing using faragua grass. Forested areas, even in the Montuoso Forest Reserve, have almost completely disappeared. Here the use of faragua pastures has created impacts similar to those experienced the Canal Watershed. While sedimentation is less of a problem than in the Canal Watershed, there are some small critical areas of erosion, primarily in areas which have been recently deforested.

The Rio Caldera watershed has significant erosion/sedimentation problems. The volcanic nature of the soil combined with tillage for vegetable crop production on very steep slopes has led to severe sheet erosion problems in most croplands, especially in the area above Boquete. In addition, cropping and grazing without erosion control measures has caused numerous landslides during years with above normal rainfall. Finally, the river itself is susceptible to flooding in such years with significant danger to human life and property in the Boquete area.

V. PROBABLE IMPACTS OF THE SELECTED PLAN

A. Impacts on Physical Resources

1. Impacts on Land Use

The Selected Plan prescribes two significant land use changes:

(1) The creation of 10,500 ha. of forest plantation for conservation, commercial or agroforestry purposes. Most of these plantations will be established on steeply sloping (45%+) lands in areas that are currently covered by secondary growth forests or degraded faragua pasture; and

(2) The conversion of 7100 hectares of faragua pasture on slopes less than 45% to improved pastures.

In addition this plan will establish a reserve and park management system on 93,616 hectares of land, in the Chagres Forest Reserve, Altos de Campana National Park and the Pipeline Road Area. Through a forest inspector surveillance system: (1) over 77,000 ha. of existing natural forests on these reserves will be protected and preserved; and (2) human activities will be controlled on the remaining 16,616 ha. of these reserves, thus allowing this remaining land to eventually revert to natural forests.

Projected land use for the year 1983 with the Selected Plan is displayed in Table V-1. These land use projections were based on proposed project activities and on existing land use trends in areas where no project activities are planned during the project's 5 year implementation period.

A comparison of projected land use in Table V -1 to current land use (Table II-3) shows that, while some natural forests will be lost, the overall amount of forest lands will increase due to reforestation projects. There will be a slight gain in the amount of lands used for traditional agriculture, and a significant loss in lands devoted <u>faragua</u> pasture use, due to their conversion to improved pasture and forest plantations. Also, existing trends will mean that over 7,000 hectares of faragua pasture will be overtaken by <u>Imperata</u> during this five year period.

It most be pointed out that these land use changes represent "the least case", because the Selected Plan is only the beginning of what is planned to be a long-term land use management program in the watershed. In addition, zoning regulations and enforcement procedures to be developed by the Canal Authority with RENARE's technical assistance should also reduce improper land use

TABLE V-1

PROJECTED LAND USE IN THE CANAL
WATERSHED IN 1983
WITH PROJECT

(Hectares)

	S L O P E S				
Land Use	0-8%	8-20%	20-45%	45%+	Total
Natural Forest	200	2,300	8,800	76,500	87,800
Plantations		30		10,570*	10,600
Secondary Growth	2,400	10,670	23,000	38,530	74,600
Forest Sub-Total	2,600	13,000	31,800	125,600	173,000
Intensive Agriculture	100				100
Traditional Agriculture	1,200	2,700	2,900	4,000	10,800
Agriculture Sub-Total	1,300	2,700	2,900	4,000	10,900
Improved Pasture	600	7,000			7,600
Faragua Grass	900	11,300	14,300	9,600	36,100
Imperata	1,600	2,400	5,500	29,100	38,600
Pasture Sub-Total	3,100	20,700	19,800	38,700	80,300
Forest Agric. Pasture Sub-Total	7,000	36,400	54,500	168,300	266,200
Other Uses					60,025
Grand Total					326,225

* Includes Agro-Forestry and Permanent Crop Activities.

activities during the 5 year period. A primary concern is that such regulations and procedures be developed early during project implementation to ensure maximum success of the Selected Plan.

A more striking and accurate assessment of the impacts of the Selected Plan may be gained by comparing projected land use with the project in 1983 to projected land use without the project in the years 1983 (Table IV-1) and 2000 (Table IV-2). These comparisons shows that without the Selected Plan there will be approximately 21,000 less hectares of natural forests in 1983 and no natural forests in year 2000. Also, without the Selected Plan there will be over 33,000 more hectares devoted to faragua pasture in 1983 and almost 61,000 hectares more hectares devoted to faragua pasture in year 2000. Finally, in year 2000 without the project there will be a substantial increase in lands devoted to traditional agriculture, especially in areas with slopes greater than 45%, and an increase of over 22,000 hectares of land dominated by Imperata grass. The increase in lands devoted to faragua and decrease in natural forests projected to occur without the project should cause significantly higher amounts of annual sediment yield than would occur with implementation of the Selected Plan.

2. Impacts on Soils

a. Soil Erosion

Although reforestation and pasture improvement activities may cause initial short-term increases in erosion, Table V - 2 shows that projected annual sediment yield in the watershed in 1983, with the Plan , is almost 7.8 MCM, a 1.7 MCM decline from the current sediment yield.

Again a better assessment of the Selected Plan's impact on erosion is gained through comparison of projected annual sediment yield with the Selected Plan in 1983 to projected annual sediment yield without a project for the years 1983 (Table IV-3) and the year 2000 (Table IV-4). With the Selected Plan sediment yield will be 3.7 MCM less in the year 1983 and over 8 MCM less in the year 2000 than predicted sediment yield in those years without a project. This lower amount of sediment yield may largely be attributed to the Selected Plan's reforestation, park and reserve management activities, and pasture improvement activities which will decrease amounts of land devoted to faragua pasture (especially on slopes greater than 45%).

In addition, the estimate of annual sediment yield in 1983 with the Selected Plan may be high because it does not take into account the implementation of site-specific conservation activities, which should greatly reduce gully erosion in the watershed,

TABLE V-2

ANNUAL SEDIMENT YIELD

IN THE CANAL WATERSHED IN 1983

WITH PROJECT

M^3

Land Use	SLOPES				Total
	0 - 8%	8-20%	20-45%	45+%	
Natural Forest	600	13,800	70,400	765,000	849,800
Plantations	0	300	0	232,540	232,840
Secondary Growth	12,000	106,700	368,000	847,000	1,333,700
Forest Sub-Total	12,600	120,800	438,400	1,844,540	2,416,340
Intensive Agriculture	8,000	0	0	0	8,000
Traditional Agriculture	24,000	108,000	174,000	320,000	626,000
Agriculture Sub-Total	32,000	108,000	174,000	320,000	634,000
Improved Pasture	3,600	91,000	0	0	94,600
Faragua Pasture	27,000	678,000	1,430,000	1,440,000	3,575,000
Imperata Grass	11,200	36,000	126,500	873,000	1,046,700
Pasture Sub-Total	41,800	805,000	1,556,500	2,313,000	4,716,300
Grand Total					7,766,640

nor does it consider the implementation of zoning regulations and enforcement procedures to be developed by the Canal Authority with the technical assistance of RENARE. Such regulations should further limit inappropriate land uses within the watershed.

b. Soil Fertility

Reduction of erosion through reforestation, improved pasture management activities and site specific conservation measures, as well as through the development of land use and zoning activities, should prevent the removal of the watershed's nutrient - rich topsoils and thus maintain soil productivity.

3. Impacts on Water Resources

a. Water Quantity

The Selected Plan will introduce activities (reforestation, pasture management, reserve and park management and soil conservation measures) that will decrease the amount of erosion and subsequent sedimentation in the watershed's lakes.

As part of the Principles and Standards Analysis (see Annex IV of the Project Paper) the reduction in storage capacity in Lake Alajuela with the Selected Plan was calculated, assuming an allocation of 65% of the estimated future sediment to live storage and 35% of the estimated future sediment to dead storage. These calculations showed that with the Selected Plan Lake Alajuela will loose 16% of its total storage capacity and 14% of its live storage capacity in the year 2000. This loss in storage capacity is slightly less than the loss in total storage capacity (22%) predicted to occur in 2000 without a watershed management project (see Table IV-5). However, if storage capacity reduction with the Selected Plan and without a project are compared for the year 2040, a better estimate of the project's beneficial impacts on the Lake's storage capacity may be gained. With the Selected Plan, it is predicted that Lake Alajuela will lose 55% of its total storage, but only 28% of its live storage by the year 2040, while without a project the Lake will loose approximately 78% of its total storage, and 84% of its live storage by the same year. Again, it must be pointed out that early development of zoning regulations and enforcement procedures are needed to ensure maximum maintenance of the Lake's storage capacity.

In addition to the Selected Plan's beneficial impact on the storage capacity of Lake Alajuela, it will also reduce the potential for damaging river flood peaks through reduction in runoff during periods of high rainfall.

b. Water Quality

The Selected Plan should have beneficial impacts on the quality of the watershed's water resources due to reduction in amounts of sediment, nutrients and pathogenic organisms and other hazardous substances in runoff.

All the proposed watershed management activities plus the anticipated zoning activities will achieve a reduction in sedimentation and thus prevent high turbidity levels in the area's waters.

The mix of activities proposed by the Selected Plan should also reduce the nutrient contamination of runoff. Forest ecosystems produce lower quantities of nutrients in runoff than agro-ecosystems. With the Selected Plan there will be 4000 more hectares of forested land in the watershed than there is at present, almost 32,000 more hectares of forested land than is projected for the year 1983 without a project, and 92,000 more hectares of forested land than is projected for the year 2000 without a project. Also, the conversion of faragua pastures to improved pastures should reduce the total amount of runoff from agricultural areas because stoloniferous grasses reduce erosion and high runoff rates. Lower concentrations of nutrients in runoff will slow down the eutrophication process in the lakes, decrease growth rate of noxious weeds, algae and associated pests, and prevent the degradation of water quality in terms of taste, odor and color.

The zoning regulations and enforcement procedures to be adopted by the Canal Authority to restrict urban and industrial development should also prevent further contamination of runoff and hence waterways,with nutrients, pathogenic organisms and toxic industrial wastes. Maximum reduction in water pollution will depend on early development and implementation of these regulations.

One area of significant concern in terms of the Selected Plan's impacts on water quality has been identified: the contamination of runoff and, hence, of the area's water resources with pesticides and herbicides. The only pesticides use proposed by the Selected Plan is the utilization of herbicides in tree nurseries under the reforestation activities and in both nurseries and experimental plots under the pasture improvement activities. However, in both cases these herbicides will be applied under controlled situations on small plots of land by highly trained RENARE personnel. In addition USAID will require that RENARE obtain USAID approval prior to the procurement or use of any pesticides for project purposes to ensure that these pesticides comply with U. S. Environmental Protection Agency regulations and that they provide information on environmental and health impacts. Thus the chance of contamination of the watershed's water resources will be minimal.

Pesticides used by RENARE in current projects, which do not receive USAID support, are: methyl bromide: diazinone; Aldrin; Posamine, and occasionally Dieldrin and Malathion.

B. Biological Impacts

The Selected Plan prescribes the establishment of a reserve and park management system on 93,616 hectares of the watershed's lands. Through a forest inspector surveillance system over 77,000 hectares of existing natural forest in these parks and reserves will be preserved, and the remaining area, currently devoted to other uses, will either be reforested or be allowed to revert to a natural vegetational state through prohibition of human activities.

The Selected Plan also proposes the reforestation of approximately 10,500 hectares. This activity will have a conservation impact as it includes the protection of an additional area of forest land outside lands designated as national parks or reserves. A comparison of projected land use with the Selected Plan to projected land use without a project in the years 1983 and 2000 shows with the implementation of the Selected Plan there will be over 21,000 more hectares of natural forest in 1983 and 87,800 more hectares of natural forest in the year 2000 than there would be without implementation of a project.

All the above mentioned watershed management activities will reduce existing trends toward the reduction and fragmentation of the watershed's existing natural forest ecosystem. Thus the diverse terrestial flora and fauna which comprise this system (including 26 terrestial vertebrates classified as threatened or endangered by U.S. and/or Panamanian law) will be preserved. In addition, the Selected Plan's educational component should increase public awareness of the importance of the preservation of the watershed's unique tropical forest ecosystem, thus decreasing chances of damage from such human activities as cutting of vegetation or illegal hunting.

Finally, all the watershed management activities proposed, especially the pasture improvement program, will prevent the encroachment of Imperata grass over larger area's of the watershed's lands. It is estimated that with the Selected Plan, 22,000 less hectares will be invaded with Imperata grass than without a project.

The Selected Plan will also have a beneficial impact on the watershed's aquatic ecosystems since all watershed management activities proposed will reduce high runoff rates during the wet season, as well as reduce the pollution of runoff with sediment, nutrients and other substances harmful to aquatic life. Reduced chances of high flows during the wet season (due to decreased runoff) will lower the probability of severe stream scouring which reduces the quantity

of aquatic invertebrates that support fish. Reduced sediment in runoff will allow sufficient light penetration in the area's waterways for the photosynthesis required for production of fish food. In addition, reduced sediment in runoff will decrease chances of sediment deposition in stream spawning beds,which can lead to reduction in survival rates of eggs and young,as well as reduction in such food sources as bottom living organisms.

Reduced amounts of nutrients in runoff will slow the euthrophication process in the Lake's and provide a healthier environment for the aquatic species they support.

Finally land use and enforcement procedures, if effectively implemented early in the project, should complement and maximize the Selected Plans beneficial ecological impacts by preventing encroachment of residential and industrial development in critical areas where such development could create adverse impacts to both the area's natural forest and aquatic ecosystems.

C. Socio-Economic Impacts

1. Social Impacts

A Social Soundness Analysis was performed on all activities proposed under the Selected Plan (Annex V). This analysis determined that there is no evidence that any of the Plan's proposed interventions will adversely affect the beneficiaries of the Plan within the watershed.

The analysis stated that the impact of commercial reforestation activities should be beneficial, and there is every reason to believe that both asentamiento members and slash and burn agriculturalists will participate because a great majority of this group is currently underemployed, wage levels offered for these activities will be attractive, and because most members of this group have already participated in wage labor.

The analysis also determined that the Selected Plan's agro-forestry activities should not produce any adverse social effects. The agro-forestry system proposed is essentially similar to the existing swidden system, except that trees are planted along with traditional crops. In addition the traditional farmers will paid for their labor input for planting seedlings and for weeding and pruning in subsequent years.

The Social Soundness Analysis also predicted that the cattle ranchers in the watershed will accept the pasture improvement program if it is shown to be cost beneficial because this group is oriented to production for sale on the market rather than self-subsis-

tance,and that they will invest in making improvements such as those proposed by the Selected Plan, if proven to create economic benefits. The impact on the cattle rancher, however, will be mediated by several factors beyond the control of the project such as; the availability of credit, market prices for beef and milk and the availability of secure market outlets for their products.

The Social Soundness Analysis did identify two potential adverse social impacts. The most significant of these adverse impacts is the project's plan to encourage the resettlement of slash and burn agriculturalists away from critical environmental areas. Such resettlement, however, will be limited to approximately 300-400 families primarily living in the area designated as the Chagres Reserve. Resettlement will be voluntary with an attractive compensation of 3-4 hectare plots elsewhere in the watershed along with material inputs, technical assistance and reimbursement for labor to set up an agro-forestry system utilizing permanent crops.

The Social Soundness Analysis indicates that this change from traditional agriculture to more intensive agricultural practices needs to be carefully planned and executed to prevent former slash and burn agriculturalists from returning to their former way of life.

The second potential adverse impact is the potential for reforestation activities to create a dependency on wage labor among the watersheds residents. This should not be an issue during the Selected Plan's five year implementation period, nor should it be an issue in later years if a long-term resource management program within the Canal Watershed is pursued.

In addition to impacts related to social change, the Selected Plan should also produce a positive impact on the security of life, health and safety of both residents of the watershed and the surrounding region through reduction in the potential for damaging flood peaks and through assurance of continued safe drinking water to the populations of the cities of Panama-Colon metropolitan area.

The Selected Plan's proposed activities should create no adverse impacts on cultural, historical or archeological sites within the watershed.

2. Economic Impacts

Virtually all economic impacts of the Selected Plan will be beneficial. The Selected Plan will, through its institution building component and its reforestation, park and reserve management and soil conservation activities, have a positive impact on income distribution within the Canal Watershed and the surrounding region through:

1) The creation of 18 more full-time professional medium to high income jobs and 39 sub-professional medium to low income jobs.

2) The creation of 33 more full-time unskilled jobs as forest inspectors.

3) The provision of 2300 more intermittent unskilled jobs averaging B/300 per year for 5 years primarily for families currently earning less than B/160 per year.

Compared to the future without a project, the Selected Plan will generate a total increased average annual income of B/196,000* due to utilization of underemployed labor.

In addition an average annual income, of over B/1.0 million* from the sale of agricultural and forestry products will be realized through implementation of the Selected Plan.

Added to the above mentioned economic benefits that will partially accrue to the watershed's residents, the Selected Plan will create two very significant economic benefits that will affect the entire country. Reduction in sedimentation under this Plan will 1) reduce average annual shipping costs by over B/186,700* and 2) reduce average annual power generation costs by over B/103,500*, compared to costs for such activities without implementation of a project.

The total average annual benefits of the Selected Plan are calculated to amount to B/1,692,400* compared to average annual cost for plan implementation of B/1,634,000* giving the Plan a benefit/cost ratio of 1.04.

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* discounted at 12%.

D. Rio Caldera and Rio La Villa Watersheds

Because comprehensive land use plans will be developed for these watersheds during project implementation, impacts of the selected plans can not now be precisely evaluated in quantitative terms. However, knowledge of the types of project activities planned permits an assessment of the kinds of benefits tc be obtained.

In the La Villa watershed soil conservation and reforestation activities will reduce erosion and sediment yield. The degree of reduction of sedimentation will be similar on a per hectare basis to that obtained from applying these activities to faragua pastures in the Canal Watershed, although the reduction will be somewhat less because of lower rainfall in the La Villa watershed. Reforestation (as contemplated) would generate sufficient economic benefits to yield an internal rate of return of 20%. The combined activities will also generate approximately 100,000 person days of casual labor on an intermittent basis.

In the Caldera watershed stream bed cleaning may be used if found effective in reducing the potential for flooding, bank scour and instream erosion. Soil conservation will help maintain productivity of the soil as well as help reduce sedimentation in the Caldera River. Terracing of volcanic soils may be undertaken to reduce erosion in areas with no current protection.

No significant adverse environmental, social or other impacts from these proposed activities are foreseen at this time. Relatively little unskilled labor is required for project activities in this watershed. Economic benefits will be substantially indirect.

VI. ALTERNATIVES TO THE SELECTED PLAN

A. Introduction

Three alternatives to the Selected Plan for the Canal Watershed were developed and assessed in terms of their potential environmental, economic and social impacts. One alternative, the National Economic Development (NED) Plan, places major emphasis on maximizing net income, through increasing the amount of land devoted to income producing activities, as well as maintaining the productive quality of the land. The second alternative, the Environmental Quality (EQ) Plan places emphasis on maintenance and enhancement of the watershed's natural environment without significantly altering the economic and social well-being of its residents. The final alternative is an expansion of the Selected Plan over a 20 year implementation period and is based on the same objectives and potential land use scheme prescribed for the development of the 5 year Selected Plan.

Projected land use in the Canal Watershed for all three plans in the year 2,000 is presented in Tables VI - 1 through VI - 3.

B. The National Economic Development (NED) Plan

Since it is the objective of the NED Plan to maximize net income, the watershed management activities prescribed by this plan involve the conversion of over 85% of the watersheds lands to either forest plantations (for commercial and agro-forestry use) or improved pastures. Such land uses provide average annual net benefits of B/156-hectare and B/27-hectare, respectively,discounted at 12 per cent.

Under this plan 161,000 hectares of land in the following categories would be converted to forest plantations:

1) All lands currently on slopes greater than 45% (except land currently dominated by or yielding to Imperata grass).

2) A little over 22,000 hectares of land on slopes between 20-45%.

3) Thirty hectares of existing forest plantation on slopes between 8-20%.

As in the Selected Plan, these plantations would be planted with fast growing commercial native species, especially laurel. On commercial plantations arrangements would be made with asentamientos or private farmers on a seasonal basis to provide necessary labor. On agro-forestry plantations, social promotion, technical assistance and materials would be provided to traditional agriculturalists to promote the planting of fast growing native species at widely spaced intervals between corn and rice plots. In addition, farmers would be paid for their labor input in subsequent years for planting seedlings, weeding

TABLE VI - 1

Projected Land Use in Canal Watershed with NED Plan, Year 2000
(Hectares)

Land Use	Slope 0 - 8	8 - 20	20-45	+45	Total
Natural Forest	0	0	0	0	0
Plantations	0	30	22,200	139,200	161,430
Secondary Growth	0	0	0	0	0
Intensive Agric.	100	0	0	0	100
Traditional Agric.	0	0	0	0	0
Improved Pasture	5,300	33,970	26,800	0	66,070
Faragua Grass	0	0	0	0	0
Imperata Grass	1,600	2,400	5,500	29,100	38,600
T O T A L:	7,000	36,400	54,500	168,300	266,200

TABLE VI - 2

Projected Land Use in Canal Watershed with EQ Plan, Year 2000
(Hectares)

Land Use	Slope 0 - 8	8 - 20	20 - 45	+45	Total
Natural Forest	200	2,300	8,800	139,200	150,500
Plantations	0	30	0	0	30
Secondary Growth	2,400	10,670	23,000	0	36,070
Intensive Agric.	100	0	0	0	100
Traditional Agric.	1,200	2,700	2,900	0	6,800
Improved Pasture	1,500	18,300	14,300	0	34,100
Faragua Grass	0	0	0	0	0
Imperata Grass	1,600	2,400	5,500	29,100	38,600
T O T A L:	7,000	36,400	54,500	168,300	266,200

TABLE VI - 3

PROJECTED LAND USE IN CANAL WATERSHED WITH EXTENDED SELECTED PLAN,

YEAR 2000

(Hectares)

Land Use	Slope 0-8	8-20	20-45	+45	Total
Natural Forest	200	2,300	8,800	76,500	87,800
Plantation Forest	0	30	11,070	62,700	73,800
Secondary Growth	0	0	0	0	0
Intensive Agric.	4,600	400	0	0	5,000
Traditional Agric.	0	0	0	0	0
Improved Pasture	600	31,270	29,130	0	61,000
Faragua Pasture	0	0	0	0	0
Imperata Grass	1,600	2,400	5,500	29,100	38,600
T o t a l	7,000	36,400	54,500	168,300	266,200

and pruning. As the NED plan calls for reforestation on a much larger scale than the Selected Plan, a greater amount of project funds would be needed for this activity.

Over 66,000 hectares of the watershed's land area would be converted to improved pastures. Lands in the following current categories would be utilized in this activity:

1) All existing lands in faragua pasture or traditional agricultural use (except those on slopes greater than 45% or those currently dominated by, or yielding to, Imperata grass).

2) Over 25,100 hectares of forest lands on slopes less than 45%.

As in the Selected Plan, cattle ranchers would be encouraged to move off slopes greater than 45% and to plant stoliniferous grasses which are much more effective at erosion control and have a higher nutritive value than faragua. Again, as the NED Plan prescribes pasture management activities on a much larger scale than the Selected Plan, a greater investment of project funds would be needed to implement these activities.

The NED plan proposes the same soil conservation activities as the Selected Plan. No reserve and park management activities would be undertaken because such activities do not provide net income.

The institutional and educational components of the NED Plan would be greatly expanded over the Selected Plan because of the larger amount of training, personnel and equipment that will be required to organize forest plantations and improved pasture management activities on such a large scale.

Activities proposed in this plan would be implemented over a five year period.

C. The Environmental Quality (EQ) Plan

The EQ Plan would place major emphasis on preservation and enhancement of the natural environment of the watershed without significantly altering the economic or social well-being of its residents. The plan prescribes placing over 150,500 hectares (70%) of the watershed's lands in protected natural forests. Lands utilized for this activity would be most of the lands currently covered by natural forests and secondary growth, all designated national park and reserve areas, plus all other lands in the watershed on slopes greater than 45% (excluding lands that are currently dominated by, or yielding to the invasion of Imperata grass). The plan would involve a reserve and park management program similar to that of the Selected Plan for Altos de Campana National Park, the Chagres Forest Reserve and the Pipeline Road area. A much larger forest inspection service and strict zoning and enforcement activities would be developed to protect forests outside designated park and reserve areas. For these reasons, a much larger investment of project funds would be required for this activity than is required in the Selected Plan.

The Plan would also involve the conversion of 34,100 hectares of land on slopes less than 45% to improved pastures. This activity would be basically the same as that prescribed in the Selected Plan, except that an increased investment of project funds would be required because of its larger scale.

The soil conservation activities proposed by the EQ plan would be the same as those proposed by the Selected Plan as they are in compliance with the Plan's objective of protecting the area's natural environmental resources.

The institutional and educational components of the EQ Plan would require a lower investment of funds than the Selected Plan

because the institution building and educational needs for park and reserve management are less than such needs for the establishment of forest plantations.

Activities proposed in this Plan would also be implemented over a five year period.

D. The Extended Selected Plan

The Extended Selected Plan would considerably increase the amounts of land devoted to forest plantations, improved pasture and intensive agriculture by converting essentially all land devoted to traditional agriculture and associated secondary growth to these three land uses. These changes would be made over a 20 year period, assuming the Government of Panama would finance total project costs after USAID's five year input. Institution building and educational components and both reserve and park management and soil conservation activities would be the same as those prescribed by the Selected Plan. Reforestation and pasture improvement activities would also be similar to those proposed in the Selected Plan, however, the investment of project funds in these activities would increase due to their larger scale. The intensive agriculture activities would involve 4,500 hectares of mechanized rice production and 500 hectares of vegetable crops.

E. Alternatives to the Selected Plan in the Rio La Villa and Rio Caldera Watersheds

The project design process for these areas will include an analysis based on Principles and Standards for Planning Water and Related Land Resources, which will be done by RENARE during the development of the comprehensive land use management plan. Consequently, no specific NED or EQ alternatives are proposed at this time.

Likely alternatives for the La Villa watershed are, however; an NED plan focusing strictly on reforestation, which represents the economic activity with the highest return for that area, and an EQ plan emphasizing protection and expansion of reserve areas.

For the Caldera watershed the NED alternative as well as the EQ alternative are likely to include the introduction of erosion control practices such as terracing and contour planting on the extremely fertile volcanic soil where vegetables are cultivated. An NED plan may also include reforestation and/or expansion of coffee plantations, as well as the introduction of irrigation in certain areas of the watershed. An EQ plan would set aside certain areas susceptible to severe erosion as forest reserves.

VII. PROBABLE IMPACTS OF ALTERNATIVES TO THE SELECTED PLAN

A. The National Economic Development (NED) Plan

1. Impacts on Physical Resources

a. Impacts on Land Use

The NED Plan prescribes a mix of reforestation and pasture improvement activities that would create the following significant land use changes in the watershed:

(1) The conversion of all lands* on slopes greater than 45% and 22,000 hectares of land on slopes between 20 and 45% to 161,400 hectares of forest plantations.

(2) The conversion of nearly all remaining lands* to improved pastures.

These activities, in addition to the establishment of effective zoning regulations and enforcement procedures, should create the land use pattern shown in Table VI - 1 by the year 2000.

A comparison of the NED Plan year 2000 land use pattern to current land use in the watershed, shows that all natural and secondary growth forests, traditional agricultural lands and faragua pastures would be eliminated by the NED Plan through conversion to forest plantations and improved pasture lands. During the 20 year period, however, over 7,000 hectares of land would be overtaken by Imperata grass.

A comparison of the year 2000 NED Plan land use pattern to land use in the year 2000 without a project shows that, without implementation of the NED Plan, there would be 80,330 hectares less forested lands and 56,000 hectares less improved pasture lands in the year 2000. Both these land use types produce low sediment yield rates in relation to other land uses. At the same time, without the NED Plan there would be large increases in amounts of lands devoted to uses that produce high sediment yield rates; lands devoted to traditional agriculture would increase to 18,100 hectares, and lands devoted to faragua would increase to 97,000 hectares. Degradation of faragua pastures would lead to the invasion of Imperata grass on over 22,000 more hectares of land.

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* With the exception of lands currently dominated by, or yielding to the invasion of, Imperata grass.

b. Impacts on Soils

(1) Soil Erosion

Table VII - 1 shows that annual sediment yield in the watershed with the NED Plan, in the year 2000, would be almost 5.5 MCM, almost 4 MCM less than the current annual sediment yield. A better assessment of impacts of the NED Plan on soil erosion is gained through comparison of annual sediment yield with the NED Plan to sediment yield without a project in the years 1983 and 2000 (Tables IV - 3 and IV - 4). With the NED Plan, annual sediment yield would be approximately 6.0 MCM less in the year 1983 and 10.5 MCM less in the year 2000, primarily due to the elimination of faragua pastures, especially on slopes greater than 45%. In addition the estimated annual sediment yield in year 2000 with the NED Plan may be high as it does not take into account impacts of the site specific soil conservation activities proposed under this plan, which would considerably reduce gully and sheet erosion.

(2) Soil fertility

As in the Selected Plan the NED Plan's proposed measures to reduce erosion should protect and increase the fertility of the watershed's soils. The NED Plan should have a more positive impact on soil fertility than the Selected Plan because it achieves a greater reduction in soil erosion.

c. Impacts on Water Resources

(1) Water quantity

Since the NED Plan would achieve a greater reduction in erosion and sedimentation than the Selected Plan, it should: (1) maintain a larger amount of storage capacity in Lake Alajuela, for a longer period of time and (2) create a lesser potential for damaging flood peaks in the watershed, than is predicted to occur with the Selected Plan.

(2) Water quality

The NED Plan should have similar, but more beneficial, impacts on the quality of the watershed's water resources than the Selected Plan because as it: (1) creates larger areas of forested lands (which are less conducive to contamination of runoff with sediment and nutrients) and (2) it converts all faragua pastures to improved pastures, thus creating a greater reduction in the total amount of runoff from agricultural areas in comparison to the Selected Plan. As in the Selected Plan, contamination of runoff with pesticides and herbicides is a concern, especially due to the larger scale of the forest plantation and pasture improvement activities proposed by the NED Plan.

TABLE VII - 1

ANNUAL SEDIMENT YIELD IN
THE CANAL WATERSHED WITH
THE NED PLAN, YEAR 2000

M^3

Land Use	S L O P E S				
	0-8%	8-20%	20-45%	45%+	Total
Natural Forest					
Plantations		300	355,200	3,062,400	3,417,900
Secondary Growth					
Intensive Agriculture	8,000				8,000
Traditional Agric.					
Improved Pasture	31,800	441,610	536,000		1,009,410
Faragua Grass					
Imperata Grass	11,200	36,000	126,500	873,000	1,046,700
					5,482,010

2. Biological Impacts

The impacts of the National Economic Development Plan on the watershed's terrestrial ecosystems may be significantly adverse, as it proposes that all natural and secondary growth forests be converted to either forest plantations or improved pastures. No reserve and park management activities would be undertaken under this plan. Many of the watersheds diverse plant species would be eliminated through the establishment of plantations of fast growing commercial, native tree species both with and without agro-forestry activities. Many of the terrestrial invertebrates (including 25 species which are classified as threatened or endangered by U. S. and/or Panamanian law) which presently inhabit the watershed's natural forest lands would be eliminated or forced to move on to areas outside the watershed, as they would not be able to adapt to the less diverse forest plantation ecosystem and the intervention of man. In addition, the establishment of forest plantations may upset pest-predator relationships that existed in natural forest. This loss of equilibrium between pests and predators could, at least initially, cause tree damage if predator populations are reduced or eliminated, allowing unchecked increases in pest populations.

The impacts of the NED Plan on the watershed's aquatic ecosystems would be beneficial and similar to those of the Selected Plan and EQ Plans. These impacts cannot be quantified. Nevertheless, comparison of sediment yield rates of the three plans shows that the NED Plan falls between the Selected Plan and the EQ Plan in terms of erosion reduction, and thus may create a more beneficial impact on aquatic life than the Selected Plan; however, these beneficial impacts would not be as great as those created by implementation of the EQ Plan.

3. Socio-Economic Impacts

a. Social Impacts

The NED Plan would essentially convert all the watershed's residents to cattle ranchers, "agro-foresters" or day workers on commercial plantations and would require additional unskilled labor from areas outside the watershed during its five year implementation period. Although the Social Soundness Analysis predicted that neither the pasture improvement nor the agro-forestry and commercial forestry interventions would create significant adverse social impacts, it is likely that the magnitude of reforestation activity proposed in the NED Plan would cause inmigration into the watershed, causing substantial long-term negative impacts if no precautionary measures were taken. It is likely that the NED Plan's large scale reforestation component would create a dependancy on wage labor among a large group of the watershed's residents because a continuing reforestation activities after the Plan's 5 year implementation period would not be feasible (since all suitable land would be reforested at once). The demand for wage labor

would decline rapidly after the project's implementation period, potentially creating a large group of dissatisfied landless and jobless workers within the watershed.

If no alternative means of employment were supplied, either within or outside the watershed, and strict zoning regulations and enforcement procedures were not developed for the watershed's lands, these workers could turn to the environmentally damaging means of earn a living that this Plan seeks to discourage, and negate many of the Plan's previously mentioned beneficial environmental impacts.

The Plan's impact on the security of life, health and safety is questionable. If alternative means of employment, compatible with the Plan's objective of maintaining the lands productivity, are supplied to forestry workers after the Plan's 5 year implementation period, greater reductions of erosion, sedimentation and contamination of runoff would be realized by this Plan in comparison to the Selected Plan, thus further reducing the potential for damaging flood peaks and providing better assurance of continued safe drinking water do the Panama-Colon Metropolitan region. Also, an abrupt increase in population in the watershed could cause short term negative impacts on social well-being if the government were not able to supply adequate social services to the increased population of the area over such a short time period.

The NED Plan's proposed activities should not produce adverse impacts on the watersheds cultural, historical or archeological sites.

b. Economic Impacts

The NED Plan would, through its institution building component and reforestation and soil conservation activities, create beneficial economic impacts in terms of personal income distribution both within the Canal Watershed and the entire Panama-Colon Metropolitan region through:

1) The creation of 180 more full-time professional medium to high income jobs.
2) The creation of 390 more full-time sub-professional medium income jobs.
3) The provision of 28,000 unskilled intermittent jobs paying an average of B/300/year for 5 years, to low-income watershed residents and others.

Compared to conditions without a project the NED Plan would generate an increased average annual income, of approximately B/3.6*million through utilization of the area's underemployed labor resources.

In addition an average increased income of B/26.4 million* from the sale of agricultural and forestry products would be realized through the implementation of the NED Plan. Benefits from changed agricultrual production would accrue to both the watershed and the region.

The NED Plan would also generate two more significant economic impacts that would benefit the entire country. Reduction in sedimentation through implementation of the NED Plan would:

1) reduce average annual shipping costs by over B/225,000* and
2) reduce electric power generation costs by B/125,500*, compared to costs for such activities without a project.

The total average annual benefits of the NED Plan were estimated to be over B/30.3 million* compared to an average annual cost of Plan implementation of B/12.2 million*, giving the NED Plan a benefit/cost ratio of almost 2.5

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* discounted at 12%.

B. The Environmental Quality (EQ) Plan

1. Impacts on physical resources

a. Impacts on Land Use

The EQ Plan prescribes a mix of reforestation and improved pasture activities that would create the following significant land use changes in the watershed:

(1) The natural revegetation, through control of human activities, of all lands* in the watershed on slopes greater than 45%.

(2) The conversion of 33,600 hectares of lands* on slopes less than 45% to improved pasture lands.

In addition, this plan would establish a reserve and park management system on 93,616 hectares of land in the Chagres Forest Reserve, Altos de Campana National Park and the Pipeline Road area. Through a forest inspection surveillance system, all existing natural forests in these parks and reserves would be protected and preserved, and the remaining hectares, presently devoted to other uses in these areas, would be allowed to revert to natural forests. Both natural revegetation and park and reserve management activities would result in 150,500 hectares of the watershed's lands in protected forests by the year 2000.

The above mentioned watershed management activities, in addition to the establishment of effective zoning regulations and enforcement procedures, should create the land use pattern shown in Table VI-2 by the year 2000.

A comparison of the EQ Plan year 2000 land use pattern to current land use in the watershed shows that with the EQ Plan there would be 57,500 hectares more natural forests, and 3,200 hectares less land devoted to traditional agriculture, and 33,600 hectares more land devoted to improved pasture. All land devoted to faragua pasture would be eliminated under the EQ plan. During this 5 year period, however, over 7000 additional hectares would be overtaken by Imperata grass.

A comparison of the year 2000 EQ Plan land use pattern to land use in the year 2000 without a project (Table IV-2) shows that without implementation of the EQ Plan there would be 150,500 less hectares of natural forests and 24,700 less lands devoted to improved pastures. Both these land use categories produce relatively low

* With the exception of lands currently dominated by or yielding to the invasion of, to Imperata grass.

sediment yield rates. At the same time, without the EQ Plan, there would be large increases in amounts of lands devoted to land use categories that produce high sediment yield rates; lands devoted to traditional agriculture would increase by 11,200 hectares, and lands devoted to faragua pasture would increase to 97,000 hectares. In addition, without a project, degradation of faragua pastures would lead to the invasion of Imperata grass on over 22,000 more hectares of land.

b. Impacts on Soils

(1) Soil Erosion

Table VII-2 shows that the annual sediment yield in the watershed in the year 2000, with the EQ Plan,would be almost 3.9 MCM, over 5.5 MCM less than the current annual sediment yield. Again, a better assessment of the impacts of this plan on erosion may be gained through comparison of annual sediment yield,with the EQ Plan, to sediment yield without a project in the years 1983 and 2000 (Tables IV-3 and IV-4). With the EQ plan, annual sediment yield would be approximately 7.6 MCM less in the year 1983 and 12.1 MCM less in the year 2000 again primarily due to the elimination of faragua pastures, especially on slopes greater than 45%. In addition, the estimated annual sediment yield in year 2000 with the EQ Plan may be high as it does not take into account specific soil conservation measure which will considerably reduce gully and sheet erosion.

(2) Soil Fertility

As in the Selected Plan, the EQ Plan's proposed measures to reduce soil erosion should protect and increase the fertility of the watershed's soils. The EQ plan should have a more positive impact on soil fertility than both the Selected and NED plans because it achieves a greater reduction in soil erosion.

c. Impacts on Water Resources

(1) Water Quantity

Since the EQ plan would achieve a greater reduction in erosion and sedimentation than both the Selected and NED Plans it should:

1.) maintain larger amount of storage capacity in Lake Alajuela for a longer period of time and 2.) create a lesser potential for damaging flood peaks during periods of high precipitation, than is predicted to occur with these two plans.

TABLE VII-2
ANNUAL SEDIMENT YIELD IN
THE CANAL WATERSHED WITH THE
EQ PLAN, YEAR 2000

M^3

Land Use	SLOPES 0-8%	8-20%	20-45%	45%+	Total
Natural Forest	600	13,800	70,400	1,392,000	1,476,800
Plantation		300			300
Secondary Growth	12000	106,700	368,000	0	486,700
Intensive Agric.	8000	-	-	-	8,000
Traditional Agric.	24000	108,000	174,000	-	306,000
Improved Past.	9000	237,900	286,000	-	532,900
Faragua Gr.	-	-	-	-	
Imperata Gr.	11200	36,000	126,500	873,000	1,046,700
Total					3,857,400

(2) Water Quality

The EQ Plan should have beneficial impacts on water quality almost equal in magnitude to the NED plan, because it also proposes the conversion of large areas of the watershed to forests and improved pastures.

2. Biological Impacts

The biological impacts of the EQ Plan will be similar yet more beneficial than the Selected Plan. By the year 2000,under the EQ plan, 150,500 hectares of natural forest would be created and protected through the establishment of parks and reserve and zoning regulations (compared to projections of virtually no natural forests in the year 2000 without a project). This would create a much larger area of forest habitat for the area's diverse terrestrial wildlife species. Also, under the EQ plan, the larger magnitude of reforested areas and pasture improvement activities should achieve a greater reduction in runoff rates during periods of high rainfall and a greater reduction in the amounts of sediment and nutrients in runoff than would both the Selected Plan and the NED Plan. Therefore less adverse impacts to aquatic life should be generated.

3. Socio-Economic Impacts

a. Social Impacts

Although the EQ Plan would allow the use of some of the watershed's lands for slash and burn agricultural activities and cattle ranching (with improved pasture management techniques) the total area devoted to these activities would be reduced. In addition, under the EQ Plan, over half of the watershed's area would be devoted to protected forests, where human activities would be prohibited or limited. Negative social impacts would most likely result because a large number of people currently living in designated protected forests would be forced to resettle either involuntarily or voluntarily (because their means to gain a living would be prohibited). The Plan proposes no compensation for residents forced to resettle. A large majority of these people would be forced to migrate to other watersheds, since remaining land designated for slash and burn and cattle ranching activities would be limited. This movement to areas outside the watershed could possibly cause social and environmental pressures elsewhere.

The Plan's impacts on the security of life, health and safety are questionable. Although the EQ Plan's land use pattern would reduce high erosion rates which lead to a reduction in damaging flood peaks and assurance of continued safe drinking water supply to the region, such positive impacts may be mitigated by degradation of lands elsewhere.

None of the Plan's interventions should adversely affect historical, cultural or archeological sites within the watershed.

b. Economic Impacts

The EQ Plan would, through its institution building component, and reserve and park management and soil conservation activities, create beneficial economic impacts in terms of personal income distribution both within the Canal Watershed and the entire Panama-Colon metropolitan region through:

(1) The creation of 10 more full time professional medium to high income jobs.

(2) The creation of 20 more full time, sub-professional, medium to low income jobs.

(3) The creation of approximately 50 full time unskilled jobs as forest inspectors.

(4) The provision of 460 intermittent jobs paying an average of B/360/year, for a 5 year period to low income watershed residents.

Compared to future conditions without a project, the EQ Plan would generate an increase in average annual income, due to utilization of underemployed labor resources, of B/71,700/year*.

In addition to the above mentioned beneficial impact that would accrue to both residents of the watershed and the Panama-Colon metropolitan region, the EQ Plan would beneficially impact the entire economy of country through reducing erosion rates and hence 1) reducing average annual shipping costs by B/282,200* and 2) reducing average annual electric power generation costs by B/157,200*, compared to costs of such activities without a project.

Despite the beneficial economic impacts of creation of employment, increases in average annual income and reduction in shipping and power generation costs, the EQ Plan would create one overriding adverse effect compared to future conditions without a project: average annual income from agricultural and forestry products would be over B/1.1 million* less with this Plan.

This decrease in average annual income from agricultural production offsets the Plan's beneficial effects, placing its average annual beneficial effects at B/-602,200*. Since the estimated average annual costs of implementing the plan is B/324.000* this plan would have a negative benefit/cost ratio.

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* discounted at 12%

C. The Extended Selected Plan

1. Impacts on Physical Resources

a. Impacts on Land Use

The Extended Selected Plan would create the following land use changes, over a 15 year period, upon completion of the 5 year Selected Plans implementation period:

(1) The conversion of all land on slopes greater than 45% to forests, including both natural forest and plantations.

(2) The conversion of all lands in the 20-45% slope category to either forest plantations or improved pasture.

(3) The conversion of all lands in the 8-20% slope category to improved pasture.

(4) The conversion of all lands in the 0-8% category to intensive agricultural use (with the exception of lands already devoted to improved pasture under the Selected Plan).

Projected land use for the year 2000 with the Extended Selected Plan is presented in Table VI-3.

Comparing this land use pattern to current land use, shows that: with the Extended Selected Plan there would be a 9000 hectare loss in forested lands due to conversion of secondary growth forests to improved pastures; a 4900 hectare gain in lands devoted to intensive agriculture;and a 60,500 hectare gain in lands devoted to improved pasture. At the same time, all traditional agricultural land and faragua pastureswould be totally eliminated. A better assessment of the Extended Selected Plans impact of promoting more compatible land use trends may be gained by comparing land use in the year 2000 with the Extended Selected Plan to lands use without a project for this same year. With the Extended Selected Plan, there would be 87,800 more hectares of natural forest, approximately 73,800more hectares of forest plantations, 4900 more hectares devoted to intensive agricultural use and 51,600 more hectares devoted to improved pasture. Due to this Plan's elimination of traditional agricultural lands and faragua pastures, therewould be 18,000 hectares and 97,000 hectares less land in these categories respectively.

Also, as is the case with all other plans, there wouldbe 21,600 less hectares dominated by Imperata grass.

Table VII-3

AVERAGE ANNUAL SEDIMENT YIELD

WITH THE EXTENDED SELECTED PLAN

YEAR 2000 (cubic meters)

	S L O P E				
Land Use	0-8%	8-20%	20-45%	45+%	Total
Natural Forest	600	13,800	70,400	765,000	849,800
Plantations		300	177,120	1,379,400	1,566,820
Secondary Growth					
Intensive Agriculture	368,000	64,000			432,000
Traditional Agriculture					
Improved Pasture	3,600	406,510	582,600		992,710
Faragua Grass					
Imperata Grass	11,200	36,000	126,500	873,000	1,046,700
	383,400	520,610	956,620	3,071,400	4,878,030

b. Soils

(1) Soil Erosion

Table VII-3 shows that the projected annual sediment yield with the Extended Selected Plan would be almost 4.9 MCM, 3.0 MCM less than the watershed's current annual sediment yield.

Again, a better assessment of the Extended Selected Plan's impact on erosion may be gained through comparison of projected annual sediment yield with the Plan and projected sediment yield without a project (Table IV-4) in the year 2000. With the Extended Selected Plan annual sediment would be approximately 11.1 MCM less than sediment yield without the Plan primarily due to elimination of all traditional agriculture and faragua pastures, especially on slopes greater than 45%.

Theestimated annual sediment yield, with the Extended Selected Plan, may be high as it does not take into account the beneficial effects of soil conservation measures.

(2) Soil fertility

The Extended Selected Plan would achieves a slightly higher level of erosion reduction than the NED plan, and therefore should be slightly more effective than the NED Plan in preventing the wearing away of nutrient-rich topsoils and maintaining soil productivity.

2. Impacts on Water Resources

(a) Water Quality

Since the Extended Selected Plan would achieve a slightly higher reduction in annual sediment yield than the NED Plan, it should be more effective than the NED Plan at maintaining storage in Lake Alajuela and preventing damaging flood peaks during periods of high precipitation.

(b) Water Quality

The Extended Selected Plan's impacts on water quality should be positive and slightly less beneficial than those of the NED Plan. Compared to the NED Plan, this Plan; 1) creates the same amount of forested lands, which generate lower quantities of nutrients in runoff, and 2) converts almost the same amount of faragua pasture (which produces high runoff rates) to improved pastures. However, the chances of pollution of the watershed's water resources with nutrient contaminated runoff may be slightly higher due to the establishment intensive agricultural plots which generate significantly higher quantities of nutrients in runoff.

3. Biological Impacts

As the reserve and park management activities and educational component of the Extended Selected Plan are the same as those proposed in the Selected Plan the extended plan should produce the same beneficial impacts on the watershed's forest ecosystems.

The Plan's impacts on the watershed's aquatic ecosystem should be beneficial and nearly equal in magnitude to those of the NED Plan.

4. Socio-economic Impacts

a. Social Impacts

The Extended Selected Plan should not create adverse social impacts on the watershed's residents. The Social Soundness Analysis for the Selected Plan indicates that forest plantation activities (both commercial and agroforestry) should not adversely affect the social conditions in the watershed unless the reforestation projects create a dependency on wage labor, which would terminate at the end of the Selected Plans 5 year implementation period. This concern should not be so great with the Extended Selected Plan, as it creates a larger number of reforestation jobs for a much longer time period.

Improved pasture activities proposed by this Plan should not produce adverse social effects on the area's residents as long as such activities are shown to produce economic benefits.

The Extended Selected Plan proposed intensive agricultural activities, which would probably involve many of the watershed s traditional farmers, may produce minor adverse social effects, as a small number of these farmers may have to relocate to participate in such activities. However this relocation would be a voluncary movement toward a new source of employment. In addition, the Plan's intensive agricultural activities would involve a change in technology. The Social Soundness Analysis for the Selected Plan indicates traditional farmers usually prefer swidden agriculture methods to intensive methods and that the introduction of intensive cultivation must be carefully planned and executed in order to provide for both the short and long term needs of these farmers and to avoid adverse social impacts.

In terms of protection of the life, health and safety of the watershed's residents the Extended Selected Plan should achieve a higher reduction in the potential for flood damage and a better assurance of safe drinking water supply to the Panama-Colon

metropolitan region than both the Selected and NED Plans.

Finally, the projects activities should not adversely affect any of the watershed's cultural, historical or archeological resources.

b. Economic Impacts

The Extended Selected Plan would, through its institution building component and its proposed watershed management activities create the same beneficial impacts as the Selected Plan in terms of personal income distribution both within the Canal Watershed and the entire Panama-Colon metropolitan region during the first 5 years of its implementation period, and create an additional 6000 intermittent unskilled jobs paying an average of B/300/year* to low income watershed residents over the following 15 years of Plan implementation.

Compared to the future without a project, the Extended Selected Plan would generate an increased average annual income, due to utilization of underemployed labor resources, of approximately B/ 1.8 million.*

Also, the Extended Selected Plan would generate an increased average annual income due to sale of agricultural and forestry products of approximately B/.13.6 million*.

In addition to the above mentioned beneficial impacts that would accrue to both residents of the watershed and the Panama-Colon metropolitan region, the Extended Selected Plan would beneficially impact the entire economy of the country through reducing erosion rates and hence; 1). reducing average annual shipping costs by B/.240,000* and 2). reducing average annual electric power generation costs by B/.130,000* compared to costs for such activities without a project.

The total average annual beneficial effects of the Extended Selected Plan were estimed to be approximately B/ 15.8 million*, compared to average annual plan implementation costs of B/ 5.4 million* giving the plan a benefit/cost ratio of over 3.9.

D. The Rio La Villa and Rio Caldera Watersheds

For the La Villa watershed, an NED plan might generate approximately twice the net economic benefits as the selected plan and might require approximately the same number of person days of unskilled

* discounted at 12%

labor. However, it would not reduce the sediment rate as much as the selected plan. An EQ plan might reduce sediment rates below those obtained in the selected plan but would yield negative economic benefits (even at a 0 interest rate), and would probably generate fewer unskilled jobs.

In the Caldera watershed, an NEP plan calling for irrigated agriculture, reforestation, and/or expansion of coffee plantations, all high value activities, would result in a significant increase in net economic benefits compared to the selected plan. An EQ plan would reduce the rate of sedimentation in the Caldera River and would also reduce the probability of flooding. It would generate gross economic benefits but the relation between these benefits and any adverse effects, or costs, cannot be precisely determined without a detailed plan.

VIII. SUMMARY OF FINDINGS

The Selected Plan is justified on the basis that it is the only plan that fits within USAID funding and timing constraints, and that it generates significant economic and environmental impacts, with the least adverse effects on the Canal Watershed's residents.

While the economic impacts of the NED Plan would be more beneficial than those of the Selected Plan, its implementation costs do not fit within USAID funding levels. In addition, its impacts on the watershed's terrestial wildlife as well as its social impacts on the watershed's population were predicted to be significantly adverse. The EQ Plan, although it could possibly fit within USAID funding constraints and would create the most beneficial environmental impacts, was calculated to generate negative net economic benefits. In addition, this Plan was also predicted to cause adverse social impacts on the watershed's residents, through forcing them to resettle without compensation. The Extended Selected Plan would not comply with either USAID's funding or timing constraints. However, it would provide more beneficial economic and environmental impacts than the Selected Plan, while creating relatively minor social impacts. If the Government of Panama's commitment to the optimal conservation, management and use of its natural resources continues, the Extended Selected Plan could serve as a basis for future watershed management activities.

The most significant positive impacts of the Selected Plan in the Canal Watershed are:

1. The preservation of 93,616 hectares of forest land which currently provide habitat for numerous terrestial wildlife species (including 26 which are classified as threatened or endangered by U.S. and/or Panamanian law).

2. A reduction in annual sediment yield in the watershed to 7.8 millions m^3 by the year 1983 (compared to projections of annual sediment yields of 11.5 million m^3 and 16.0 million m^3 for the years 1983 and 2000, respectively, without implementation of a plan).

3. The maintenance of 72% of Lake Alajuela's active storage capacity in the year 2040 (compared to estimates that only 16% of the Lake's active storage capacity will remain in the year 2040 without a project), thus reducing average annual shipping costs by B/.186,700* and average annual electric power generation costs by B/.103,500* compared to costs for such activities without a project.

4. The prevention of water quality degradation, and hence, damage to aquatic ecosystems and pollution of water used to supply the domestic systems of the Panama-Colon metropolitan area.

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* discounted at 12%

5. The provision of 2300 intermittent unskilled jobs paying an average of B/300 /year for 5 years to low income residents of the watershed, as well as the provision of an annual average increased income due to sales of agricultural and forestry products of B/.1.0 million.*

While these impacts are highly positive, especially compared to future conditions without a project, they do, in a sense, represent a "least case" condition. However, it is anticipated that this plan will be just the beginning of a long-term watershed management program. In addition, if effective and complementary zoning regulations and enforcement procedures are developed by the Canal Authority early during project implementation, impacts on both the watershed's human and natural environment can be predicted to be more beneficial.

As the Selected Plan seeks to improve the protection of Panama's natural resource base, with minimum impacts on the country's socio-economic conditions, few adverse impacts were identified.

Over the short term, reforestation activities may increase erosion rates within the watershed. This impact is unavoidable, yet minor, compared to the great reduction in erosion that this activity will create once in place.

Two other potential adverse impacts, of a more long term nature, were identified:

1. Possible contamination of the watershed's environment with herbicides used in reforestation and pasture improvement activities. This contamination will be minimal because herbicides will only be utilized by experienced RENARE personnel under highly controlled conditions in nurseries and experimental plots. In addition the project's loan agreement will require RENARE to obtain prior USAID approval for the use or procurement of any pesticide for project purposes, to ensure such pesticides comply with U.S. Environmental Protection Agency regulations.

2. Possible adverse social impacts caused by resettlement of the area's residents living in the most critical environmental areas. Resettlement proposed by the Selected Plan will be minimal, however, and on a voluntary basis. In addition these adverse impacts will be mitigated through compensation of those resettled with 3 to 4 hectare plots, technical assistance and materials.

These adverse impacts are minor compared to the projects positive impacts on the long-term productivity of Panama's natural resource base.

* discounted at 12%

The Environmental Assessment also identified an area of concern which is beyond the control of the Project: the possible undermining of project efforts through failure to develop zoning regulations and enforcement procedures for lands outside the Plan's proposed activity areas. Such zoning regulations and enforcement measures will be developed by the Government of Panama's newly created Panama Canal Authority. It is anticipated that the Authority will adopt the technical recommendations of RENARE as well as those of other GOP agencies involved in the management of Canal Watershed lands, and develop zoning regulations which are in compliance with this project's purposes.

APPENDIX 1

LAND CAPABILITY CLASSES

LAND CAPABILITY CLASSES*

Class I - Almost no limitations on use; very good land - suitable for a very wide range of cultivation.

Class II - Few to moderate limitations on use; good land - suitable for a wide range of cultivation. - This class includes good to very good lands with few to moderate limitations on cultivation and other uses. Lands require a few, easily applied management practices to correct, prevent, or overcome the effects of one, or a combination of factor(s) such as: gentle slopes; moderate susceptibility to wind or water erosion or moderate adverse effects of past erosion; less than optimum soil depth; slightly unfavorable tilth; occasional damaging inundation; correctible imperfect drainage; and only moderate fertility. They may also require special soil-conserving cropping systems, soil conservation practices, water-control devices, or tillage methods when used for cultivated crops.

Class III - Moderate to severe limitations; fairly good land with regular cultivation possible. - This class includes fairly good lands with moderate to severe limitations on use for cultivated crops. Lands require one intensive or several moderate management practices to correct, prevent, or overcome one or a combination of factor(s) such as: moderately steep slopes; high susceptibility to wind or water erosion or severe adverse effects of past erosion; frequent and damaging inundation; poor drainage with moderate to poor drainability; shallow depths to zones that limit rooting or water storage; moderate stoniness unfeasible to remove; low moisture-holding capacity; and low fertility not easily corrected. Each distinctive kind of soil in Class III has one or more alternative combinations of use and practices required for safe use, but the number of practical alternatives for average farmers is less than that for soils in Class II.

Class IV - Very severe limitations on use; poor to fairly good land suitable for occasional or limited cultivation or special crop.- This class includes poor to fairly good land with many limitations on cultivation. Restrictions in use are greater than on Class III lands; choice of plants is more limited; and when cultivated, very careful management and conservation practices must be used. In general, soils may be suited to only a few common crops, or output-input relationships may be expected to be low. Land-use for cultivation is limited because of one or more factor(s) such as: steep slopes; severe susceptibility to erosion; severe effects of past erosion; shallow depths; low moisture-holding capacity; moderate stoniness unfeasible to remove; frequent inundation with severe crop damage; excessive wetness with the continuing hazard of waterlogging after drainage; and low fertility difficult to correct.

* Source: Catastro Rural de Tierras y Aguas., Comisión de Reforma Agraria, República de Panamá, July 1970.

Class V - Limitations impractical of removal that effectively prevent cultivation but permit other uses; suitable for unlimited grazing - This class includes lands which are level and almost devoid of erosion hazard, but which suffer some other major, natural, permanent limitation(s) such as: excessive wetness impractical of correction; frequent destructive inundation; and extreme stoniness. Although cultivation of common crops is not feasible, benefits may be expected from proper management for other purposes.

Class VI - Severe limitations generally restricting safe use to pasture, range, or woodland - This class includes lands with major, natural, permanent limitation(s) due to factors such as: steep slopes; severe erosion hazard; effects of past erosion; stoniness; shallow rooting zone; excessive wetness or overflow; low moisture capacity. In general, the hazards which place land in Class VI are the same as those of Class IV. They differ only in severity or combination. Despite their non-arable classification, some lands in Class VI can be safely used for common crops, provided unusually intensive management is used. In addition, some are suited to one or more special crops.*

Class VII - Severe limitations on grazing; moderate limitations for woodlands. - This class includes lands with very severe limitations, such that it is impractical to apply such pasture and range improvements as seeding, fertilizing and water control by diversions or drainage ditches. Soil restrictions are more severe than those in Class VI because of one or more continuing limitations such as: very steep slopes; erosion; stoniness or rockiness; salts or sodium; or extremely poor drainability. Dependent on soil characteristics and local climate, soils in this class may be well or poorly suited to woodland. They are not suited to any of the common cultivated crops; in unusual instances some soils of this class may be used for special crops such as sodded tropical fruits, or coffee.

Class VIII - Unsuitable for commercial plant production - This class includes lands that can be used only for recreational or aesthetic purposes or in connection with water supply.

* Soils in this class are commonly used for slash and burn (Roza) farming and are only slightly harmed if they are rested sufficiently between cropping years.

APPENDIX 2

CURRENT LAND USE IN THE

CANAL WATERSHED BY ADMINISTRATIVE UNIT

CURRENT LAND USE IN THE CANAL WATERSHED
BY ADMINISTRATIVE UNIT

		B U E N A V I S T A					
		Hectares	% of the Area	Slopes (%)			
				0-8%	8-20%	20-45%	+45%
I.	FORESTS	30,195	43.4	1,500	1,330	6,500	20,865
	1. Natural Forest	15,200	21.9	--	1,000	3,500	10,700
	2. Plantations	30	0.0	--	30	--	--
	3. Secondary Growth	14,965	21.5	1,500	300	3,000	10,165
II.	AGRICULTURAL AND PASTURE LANDS	28,200	40.6	1,820	920	4,100	21,360
	1. Agricultural	980	1.4	200	320	200	260
	a. Intensive	100	0.1	100	--	--	--
	b. Traditional Agriculture	880	1.3	100	320	200	260
	(1) Annual	620	0.9	100	320	200	--
	(2) Perrenial	260	0.4	--	--	--	260
	2. Pastures	27,220	39.2	1,620	600	3,900	21,100
	a. Improved Pastures	420	0.6	420	--	--	--
	b. Faragua Grass	7,300	10.5	500	200	1,400	5,200
	c. Imperata Grass	19,500	28.1	700	400	2,500	15,900
	SUB-TOTAL I & II	58,395	84.0	3,320	2,250	10,600	42,225
III.	OTHER USES	11,105	16.0				
	1. Lakes	10,000	14.4				
	2. Rivers	500	0.7				
	3. Roads	125	0.2				
	4. Urban	480	0.7				
	TOTAL	69,500	100.0				

CURRENT LAND USE IN THE CANAL WATERSHED
BY ADMINISTRATIVE UNIT

		C E R R O A Z Ú L					
		Hectares	% of the Area	Slopes (%)			
				0-8%	8-20%	20-45%	+45%
I.	FORESTS	48,385	93.8	--	--	885	47,500
	1. Natural Forest	44,500	86.3	--	--	--	44,500
	2. Plantations	--	--	--	--	--	--
	3. Secondary Growth	3,885	7.5	--	--	885	3,000
II.	AGRICULTURAL AND PASTURE LANDS	1,400	2.7	--	100	200	1,100
	1. Agricultural	400	0.8	--	100	200	100
	a. Intensive	--	--	--	--	--	--
	b. Traditional Agriculture	400	0.8	--	100	200	100
	(1) Annual	300	0.6	--	100	200	--
	(2) Perrenial	100	0.2	--	--	--	100
	2. Pastures	1,000	1.9	--	--	--	1,000
	a. Improved Pastures	--	--	--	--	--	--
	b. Faragua Grass	1,000	1.9	--	--	--	1,000
	c. Imperata Grass	--	--	--	--	--	--
	SUB-TOTAL I & II	49,785	96.5	--	100	1,085	48,600
III.	OTHER USES	1,815	3.5				
	1. Lakes	--	--				
	2. Rivers	1,750	3.4				
	3. Roads	15	0.0				
	4. Urban	50	0.1				
	TOTAL	51,600	100.0				

CURRENT LAND USE IN THE CANAL WATERSHED
BY ADMINISTRATIVE UNIT

		CERRO		CAMA			
		Hectares	% of the Area	Slopes (%)			
				0-8%	8-20%	20-45%	+45%
I.	FORESTS	17,474	35.7	--	7,340	5,600	4,534
	1. Natural Forest	8,840	18.1	--	1,940	3,400	3,500
	2. Plantations	--	--	--	--	--	--
	3. Secondary Growth	8,634	17.6	--	5,400	2,200	1,034
II.	AGRICULTURAL AND PASTURE LANDS	28,906	59.1	780	16,366	7,500	4,260
	1. Agricultural	2,720	5.6	760	1,200	500	260
	a. Intensive	--	--	--	--	--	--
	b. Traditional Agriculture	2,720	5.6	760	1,200	500	260
	(1) Annual	2,360	4.8	760	1,200	400	--
	(2) Perrenial	360	0.8	--	--	100	260
	2. Pastures	26,186	53.5	20	15,166	7,000	4,000
	a. Improved Pastures	20	0.0	20	--	--	--
	b. Faragua Grass	26,166	53.5	--	15,166	7,000	4,000
	c. Imperata Grass	--	--	--	--	--	--
	SUB-TOTAL I & II	46,380	94.8	780	23,706	13,100	8,794
III.	OTHER USES	2,520	5.1				
	1. Lakes	1,700	3.5				
	2. Rivers	300	0.6				
	3. Roads	110	0.2				
	4. Urban	410	0.8				
	TOTAL	48,900	100.0				

CURRENT LAND USE IN THE CANAL WATERSHED
BY ADMINISTRATIVE UNIT

				E L C A C A O			
		Hectares	% of the Area	Slopes (%)			
				0-8%	8-20%	20-45%	+45%
I.	FORESTS	34,335	56.7	--	2,800	15,500	16,035
	1. Natural Forest	300	0.5	--	--	--	300
	2. Plantations	--	--	--	--	--	--
	3. Secondary Growth	34,035	56.2	--	2,800	15,500	15,735
II.	AGRICULTURAL AND PASTURE LANDS	14,150	23.4	--	1,300	6,850	6,000
	1. Agricultural	1,500	2.5	--	200	600	700
	a. Intensive	100	0.2	--	--	100	--
	b. Traditional Agriculture	1,400	2.3	--	200	500	700
	(1) Annual	1,200	2.0	--	200	450	550
	(2) Perrenial	200	0.3	--	--	50	150
	2. Pastures	12,650	20.9	--	1,100	6,250	5,300
	a. Improved Pastures	--	--	--	--	--	--
	b. Faragua Grass	12,650	20.9	--	1,100	6,250	5,300
	c. Imperata Grass	--	--	--	--	--	--
	SUB-TOTAL I & II	48,485	80.1	--	4,100	22,250	22,035
III.	OTHER USES	12,040	19.8				
	1. Lakes	11,625	19.2				
	2. Rivers	380	0.6				
	3. Roads	10	0.0				
	4. Urban	25	0.0				
	TOTAL	60,525	100.0				

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CURRENT LAND USE IN THE CANAL WATERSHED
BY ADMINISTRATIVE UNIT

		S A L A M A N C A					
		Hectares	% of the Area	Slopes (%)			
				0-8%	8-20%	20-45%	+45%
I.	FORESTS	25,113	87.5	--	360	2,253	22,500
	1. Natural Forests	19,400	67.6	--	--	2,100	17,300
	2. Plantations	--	--	--	--	--	--
	3. Secondary Growth	5,713	19.9	--	360	153	5,200
II.	AGRICULTURAL AND PASTURE LANDS	2,530	8.8	--	470	280	1,780
	1. Agricultural	760	2.6	--	300	200	260
	a. Intensive	--	--	--	--	--	--
	b. Traditional Agriculture	760	2.6	--	300	200	260
	(1) Annual	500	1.7	--	300	200	--
	(2) Perrenial	260	0.9	--	--	--	260
	2. Pastures	1,770	6.1	--	170	80	1,520
	a. Improved Pastures	--	--	--	--	--	--
	b. Faragua Grass	1,390	4.8	--	130	60	1,200
	c. Imperata Grass	380	1.3	--	40	20	320
	SUB-TOTAL I & II	27,643	96.3	--	830	2,533	24,280
III.	OTHER USES	1,057	3.7				
	1. Lakes	300	1.1				
	2. Rivers	700	2.4				
	3. Roads	12	0.0				
	4. Urban	45	0.2				
	TOTAL	28,700	100.0				

CURRENT LAND USE IN THE CANAL WATERSHED
BY ADMINISTRATIVE UNITS

	THE CANAL ZONE (EXCLUDING PIPELINE ROAD AREA)	
	Hectares	% of the Area
I. FORESTS	4,925	18.7
1. Natural Forest	4,000	15.2
2. Plantations	--	--
3. Secondary Growth	925	3.5
II. AGRICULTURAL AND PASTURE LANDS	--	--
1. Agricultural	--	--
a. Intensive	--	--
b. Traditional Agriculture	--	--
(1) Annual	--	--
(2) Perrenial	--	--
2. Pastures	--	--
a. Improved Pastures	--	--
b. Faragua Grass	--	--
c. Imperata Grass	--	--
SUB-TOTAL I & II	4,925	18.7
III. OTHER USES	21,375	81.3
1. Lakes	19,725	75.0
2. Rivers	50	0.2
3. Roads	100	0.4
4. Urban	1,500	5.7
TOTAL	26,300	100.0

APPENDIX 3

FLORA AND FAUNA OF THE CANAL WATERSHED

APPENDIX 3.1

COMMON VEGETATION IN MATURE SECONDARY FORESTS

A. Trees and Shrubs

Araceae
Bombycopis quinata
Castilla elastica
Coccoloba spp.
Dipteryx panamensis
Cyatheaceae
Danaea nodosa
Diffenbachia oerstedii
Ficus insipida
Ficus spp.
Gesneriaceae
Grias fenderli
Gustavia superba
Hura crepitans
Inga spp.
Iriartea exhorriza
Jacaranda copaia
Melastomataceae
Olemedia aspera
Palmae
Platypodium elegans
Polypodiaceae
Poulsenia armata
Prioria copaifera
Protium spp.
Sapium spp.
Spondias mombin
Sterculia apetala
Symphonia globulifera
Terminalia amazonia
Tabebuia guayacan
Tabebuia pentaphylla
Trichomones diversifrons
Virola sebifera
Zanthoxylum panamense
Zanthoxylum spp.

B. Lianas and Forest Floor Plants

Bauhinia excisa
Commelinaceae
Marantaceae
Filicinae
Selaginella spp.
Xiphidium caeruleum
Zingiberaceae

APPENDIX 3.2

COMMON VEGETATION IN EARLY SECONDARY FORESTS

Apeiba tibourbou
Bombacopis quinata
Bombacopis sessilis
Cecropia longipes
Cecropia obtusifolia
Cordia alliodora
Didymopanax morototoni
Heliocarpus popayanensis
Luehea seemannii
Miconia argentea
Ochroma pyramidale
Secheelea gomphococca
Trema micrantha

APPENDIX 3.3

LAKE - ASSOCIATED VEGETATION

A. Aquatic

Ceratopteris spp.
Chara kenayeri
Echinodorus spp.
Eichhornia azurea
Lemna cyclostosa
Ludwigia helminthorrhiza
Nymphaea spp.
Nymphoides humboldtiana
Pistia stratoites
Salvinia auriculata
Salvinia spp.
Utricularia mixta

B. Emergent

Acrostichum daneaefolium
Cladium jamaicense
Crinum erubescens
Hibiscus sorarius
Hydrolea spinosa
Miconia argentea
Pluchea purpurascens
Polygonum punctatum
Fontederia cordata
Sagittaria lancifolia
Typha angustifolia

C. Eroding Shoreline

Begonia filipes
Bryophyta
Gleichenia flexuosa
Kohleria tubiflora
Lycopodium cernuum
Musci
Phyllanthus niruri
Pityrogramma calomelanos
Tibouchina longifolia

D. Sedge Association

Cyperus giganteus
Cyperus luzulae
Fuirena umbellata
Cynerium sagittatum
Hymenachne amplexicaulis
Ludwigia octovalvis
Nephrolepis biserrata
Phragmites communis
Rhynchospora corymbosa
Scirpus cubensis
Scleria eggersiana
Thelyperis gongylodes
Thelyperis serrata

E. "Stump Islands"

Andropogon bicornis
Boehmeria cylindrica
Culsia spp.
Eclipta alba
Ficus spp.
Filicinae
Orchidaceae
Typha angustifolia
Vigna vexillata

APPENDIX 3.4

BIRDS OF PIPELINE ROAD, INDIGENOUS SPECIES

Great Tinamou
Little Tinamou
Chestnut-bellied Heron
Rufescent tiger-heron
King Vulture
Black Vulture
Gray-headed Kite
Hook-billed Kite
Double-toothed Kite
Plumbeous Kite
Tiny Hawk
Short-tailed Hawk
Gray Hawk
White Hawk
Semiplumbeous Hawk
Plumbeous Hawk
Ornate Hawk-Eagle
Black Hawk-Eagle
Collared Forest-Falcon
Slaty-backed Forest-Falcon
Barred Forest-Falcon
Red-throated Caracara
Great Curassow
Crested Guan
Gray-headed Chachalaca
Marbled Wood-Quail
Tawny-faced Quail
Gray-necked Wood-Rail
White-throated Crake
Sunbittern
Pale-vented Pigeon
Scaled Pigeon
Short-billed Pigeon
Ruddy Ground-Dove
Blue Ground-Dove
White-tipped Dove
Gray-chested Dove
Olive-backed Quail-Dove
Violaceous Quail-Dove
Orange-chinned Parakeet
Brown-hooded Parrot
Blue-headed Parrot
Red-lored Amazon
Mealy Amazon
Squirrel Cuckoo
Greater Ani
Smooth-billed Ani
Pheasant Cuckoo
Rufous-vented Ground-Cuckoo
Crested Owl
Vermiculated Screech Owl
Spectacled Owl
Mottled Owl
Black-and-White Owl
Oilbird
Great Potoo
Common Potoo
Short-tailed Nighthawk
Pauraque
White-collared Swift
Band-rumped Swift
Lesser Swallow-tailed Swift
Rufous-breasted Hermit
Band-tailed Barbthroat
Long-tailed Hermit
Little Hermit
White-neckedJacobin
Violet-headed Hummingbird
Rufous-crested Coquette
Crowned Woodnymph
Violet-bellied Hummingbird
Blue-chested Hummingbird
Snowy-breasted Hummingbird
Rufous-tailed Hummingbird
Purple-crowned Fairy
Slaty-tailed Trogon
White-tailed Trogon
Black-throated Trogon
Violaceous Trogon
Green-and Rufous Kingfisher
Pygmy Kingfisher
Borad-billed Motmot
Rufous Motmot
Blue-crowned Motmot
Great Jacamar
White-necked Puffbird
Black-breasted Puffbird
Pied Puffbird
White-whiskered Puffbird
Collared Aracari

APPENDIX 3.4 (CONT'd)

Keel-billed Toucan
Chestnut-mandibled Toucan
Yellow-eared Toucanet
Cinnamon Woodpecker
Lineated Woodpecker
Red-crowned Woodpecker
Black-cheeked Woodpecker
Crimson-crested Woodpecker
Crimson-bellied Woodpecker
Plain-brown Woodcreeper
Ruddy Woodcreeper
Long-tailed Woodcreeper
Wedge-billed Woodcreeper
Barred Woodcreeper
Buff-throated Woodcreeper
Black-striped Woodcreeper
Rufous-rumped Foliage-gleaner
Buff-throated Foliage-gleaner
Plain Xenops
Tawny-throated Leaftosser
Scaly-throated Leaftosser
Fasciated Antshrike
Great Antshrike
Barred Antshrike
Slaty Antshrike
Russet Antshrike
Spot-crowned Antvireo
Pygmy Antwren
Streaked Antwren
Checker-throated Antwren
White-flanked Antwren
Dot-winged Antwren
Dusky Antbird
White-bellied Antbird
Chestnut-backed Antbird
Dull-mantled Antbird
Bicolored Antbird
Spotted Antbird
Ocellated Antbird
Wing-banded Antbird
Black-faced Anttrush
Black-crowned Antpitta
Streak-chested Antpitta
Blue-crowned Manakin
Red-capped Manakin
Golden-collared Manakin
Thrushlike Manakin
Broad-billed Manakin
Blue Cotinga
Bright-rumped Attila
Speckled Mourner
Rufous Mourner
Rufous Piha
Cinnamon Becard
White-winged Becard
Masked Tityra
Black-crowned Tityra
Purple-throated Fruitcrow
Three wattled bellbird
Sirystes
Long-tailed Tyrant
Tropical Kingbird
Piratic Flycatcher
Streaked Flycatcher
Boat-billed Flycatcher
White-ringed Flycatcher
Social Flycatcher
Rusty-margined Flycatcher
Dusky-capped Flycatcher
Ruddy-tailed Flycatcher
Sulphur-rumped Flycatcher
Black-tailed Flycatcher
Northern Royal-Flycatcher
Golden-crowned Spadebill
Brownish Flycatcher
Yellow-margined Flycatcher
Olivaceous Flatbill
Common Tody-flycatcher
Slate-headed Tody-flycatcher
Southern Bentbill
Black-capped Pygmy-Tyrant
Yellow-green Tyrannulet
Yellow-bellied Elaenia
Lesser Elaenia
Forest Elaenia
Gray Elaenia
Paltry Tyrannulet
Yellow-crowned Tyrannulet
Brown-capped Tyrannulet
Olive-striped Flycatcher
Ochre-bellied Flycatcher
Gray-breasted Martin

Mangrove Swallow
White-thighed Swallow
Plain Wren
Bay Wren
Black-bellied Wren
Rufous-breasted Wren
White-breasted Wood-Wren
Song Wren
Nightingale Wren
Clay-colored Robin
Tropical Gnatcatcher
Long-billed Gnatwren
Tawny-faced Gnatwren
Green Shrike-Vireo
Yellow-green Vireo
Lesser Greenlet
Tawny-crowned Greenlet
Bananaquit
Shining Honeycreeper
Red-legged Honeycreeper
Green Honeycreeper
Blue Dacnis
Scarlet-thighed Dacnis
Chesnut-capped Warbler
Buff-rumped Warbler
Chestnut-headed Oropendola
Yellow-rumped Cacique
Scarlet-rumped Cacique
Yellow-tailed Oriole
Yellow-backed Oriole
White-vented Euphonia
Yellow-crowned Euphonia
Fulvous-vented Euphonia
Thick-billed Euphonia
Golden-hooded Tanager
Plain-colored Tanager
Bay-headed Tanager
Blue-gray Tanager
Palm Tanager
Crimson-backed Tanager
Yellow-rumped Tanager
Carmiol's Tanager
Red-throated Ant-Tanager
White-lined Tanager
White-shouldered Tanager
Tawny-crested Tanager
Sulphur-rumped Tanager
Gray-headed Tanager
Dusky-faced Tanager
Buff-throated Saltator
Streaked Saltator
Slate-colored Grossbeak
Blue-black Grossbeak
Blue-black Grossquit
Variable Seedeater
Thick-billed Seed-Finch
Orange-billed Sparrow
Black-striped Sparrow

List compiled by Panama Audubon Society

APPENDIX 3.5

BIRDS COMMONLY FOUND AT HIGHER ELEVATIONS

Little Tinamou
King Vulture
Black Vulture
Turkey Vulture
Swallow-tailed Kite
Gray-Headed Chachaloca
Blue Ground-dove
White-fronted Dove
Orange-chinned parakeet
Blue-headed Parrot
White-Collared Swift
Green Hermit
White-bellied Hummingbird
Rufous-tailed Hummingbird
Orange-bellied Trogan
Violaceous Trogan
Rufous Motmot
Keel-billed Toucan
Blue-throated Toucanet
Black-cheeked Woodpecker
Spotted Antbird
Ochre-bellied Flycatcher
Plain Wren
Lowland Wood-Wren
White-throated Robin
Gray-headed Vireo
Blue Honeycreeper
Blue Dacnis
Yellow-backed Oriole
Silver-throated Tanager
Bay-headed Tanager
Blue Tanager
Jungle Tanager
Streaked Saltator
Chestnut-capped Finch
Andean Sparrow

APPENDIX 3.6

MAMMALS OF BARRO COLORADO ISLAND AND CHAGRES RIVER BASIN*

MARSUPIALIA

Caluromys derbianus derbianus	Woolly opossum
Marmosa robinsoni isthmica	Brown murine opossum
Philander opossum fuscogriseus	Four-eyed opossum
Methachirus nudicaudatus dentaneu	Brown-masked opossum
Didelphis marsupialis etensis	Common opossum
Chironectes minimus	Water opossum

CHIROPTERA

Rhynchonycteris naso	Tufted bat
Saccopteryx bilineata	Blackish two-lined bat
Saccopteryx leptura	Brownish two-lined bat
Cormura brevirostria	Wagner's sac-winged bat
Peropteryx kappleri	Greater dog-faced bat
Centronycteris maximiliani centralis	Shaggy-haired bat
Noctilio labialis labialis	Bulldog bat
Noctilio leporinus mexicanus	Fisherman bat
Pteronotus parnellii	Parnell's mustached bat
Micronycteris brachyotia	Sanborn's big-eared bat
Micronycteris hirsuta	Greater big-eared bat
Micronycteris megalotalus microtis	Lesser big-eared bat
Micronycteris nicefori	
Trachops cirrhosus	Fringe-lipped bat
Tonatia bidens	Spix round-eared bat
Tonatia sylvicola	D'Orbigny's round-eared bat
Mimon crenulatum	Hairy-leafnosedbat
Phyllostomus discolor discolor	Lesser spear-nosed bat
Phyllostomus hastalus	Giant spear-nosed bat
Phylloderma stenops	Northern spear-nosed bat
Vampyrum spectrum	False vampire bat
Glossophaga soricina leachii	Brown long-tongued bat
Glossophaga commissarisi	
Lonchophylla robusta	Orange long-tongued bat
Carollia castanea	Lesser short-tailed bat
Carollia subrufa	
Carollia perspicillata	Greater short-tailed bat
Uroderma bilobatum	Tent-building bat
Vampyrops helleri	Heller's striped-faced bat
Vampyrodes major	Great striped-faced bat
Vampyressa pusilla	Least striped-faced bat
Vampyressa nymphaea	Big yellow eared bat
Chiroderma salvini	Salvin's big-eyed bat

*Source: Smithsonian Tropical Research Institute.

Chiroderma trinitatum	Pygmie big-eyed bat
Artibeus watsoni	Lesser fruit bat
Artibeus phaeotus	
Artibeus jamaicensis jamaicensis	Common fruit bat
Artibeus lituratus	Greater fruit bat
Centurio cenex	Wrinkle-faced bat
Desmodus rotundus murinus	Long-thumbed vampire bat
Thyroptera tricolor albigula	Disk-winged bat
Myotis nigricans nigricans	Black bat
Myotis albescens	
Rhogeesa tumida	Trinidadian little yellow bat
Molossus molossus	Lesser mastiff bat
Tadarida yucatanica	

PRIMATES

Aotus trivirgatus	Night monkey
Ateles geoffroyi	Spider monkey
Alouatta palliata aequatorialis	Howler monkey
Cebus capucinus imitator	Capucin
Saguinus geoffroyi	Marmoset

EDENTATA

Tamandua mexicana	Vested anteater
Cyclopes didactylus dorsalis	Silky anteater
Myrmecophaga tridactyla	Anteater
Bradypus infuscatus griseus	Three-toed sloth
Choleopus hoffmanni	Two-toed sloth
Dasypus novemcinctus fenestratus	Nine-banded armadillo
Cabassous centralis	Five-toed armadillo

LAGOMORPHA

Sylvilagus brasiliensis	Rabbit

RODENTIA

Sciurus variegatoides	Squirrel
Sciurus granatensis	Red squirrel
Microsciurus alfari venustulus	Pigmy squirrel
Heteromys desmarestianus zonalis	Spiny pocket mouse
Heteromys desmarestianus panamensis	
Oryzomys fulvescens costaricensis	Pigmy rice rat
Oryzomys capito	Talamancan rice rat

APPENDIX 3.6 (CONT'D)

Oryzomys bombycinus bombycinus	
Oryzomys caliginosis idoneus	
Tylomys (panamensis) watsoni	
Oryzomys concolor	Climbing rat
Oryzomys bicolor	Climbing mouse
Zygodontomys microtinus ventriosus	Cane rat
Sigmodon hispidus chiriquensis	Cotton rat
Rattus rattus	Black rat
Mus musculus	House mouse
Coendou rothschildi	Porcupine
Agouti paca virgatus	Paca
Dasyprocta punctata isthmica	Agouti
Proechimys semispinosus panamensis	Spiny rat
Diplomys labilis	Tree rat
Hoplomys gymnurus	

CARNIVORA

Procyon lotor	Raccoon
Procyon cancrivorous panamensis	Crab-eating raccoon
Nasua nasua narica	Coati
Potos flavus chiriquensis	Kinkajou
Bassaricyon gabbii	Olingo
Galictis allamandi	Grison
Eira barbara bilogiae	Tayra
Lutra annectens repanda	Otter
Mustela frenata panamensis	
Felis concolor costaricensis	Puma
Felis onca	Jaguar
Felis pardalis mearnsi	Ocelot
Felis yagouaroundi panamensis	Yagouaroundi
Felis wiedii (recent sight record)	Margay

PERISSODACTYLA

Tapirus bairdii	Tapir

ARTIODACTYLA

Tayassu tajacu bangsi	Collared peccary
Odocoileus virginianus chiriquensis	White-tailed deer
Mazama americana reperticia	Red brocket

APPENDIX 3.7

REPTILES OF BARRO COLORADO ISLAND *

1. Testudines

Chelydra acutirostris
Geoemyda annulata
G. funerea
Kinosternon leucostomum
Pseudemys scripta ornata

2. Crocodilia

Caiman crocodilus fuscus
Crocodylus acutus

3. Sauria

Anolis auratus
A. biporcatus
A. capito
A. frenatus
A. limifrons
A. lionotus
A. pentaprion
A. vittigerus
Basiliscus basiliscus
Corythophanes cristatus
Iguana iguana iguana
Polychrus gutturosus
Thecadactylus rapicauda
Gonotodes albogularis fuscus
Lepidoblepharis sanctaemartae fugax
Spaherodactylus lineolatus
Lepidophyma flavomaculatum obscurum
Ameiva festiva
A. leptophrys
Leposoma southi
Mabuya mabouya
Amphisbaena fuliginosa

4. Serpentes

Anomalepis dentata
Liotyphlops albirostris
Boa constrictor imperator
Corallus annulatus
Epicrates cenchria maurus
Amastridium veliferum
Chironius carinatus
C. grandisquamis
Coniophanes fissidens
Dendrophidion percarinatus
Dryadophis melanolomus alternatus
Drymarchon corais melanurus
Enulius flavitorques
E. sclateri
Imantodes cenchoa
I. gemmistratus
Leimadophis epinephalus epinphalus
Leptodeira annulata rhombifera
L. septentionalis ornata
Leptophis ahaetulla occidentalis
Ninia maculata maculata
Oxybelis aeneus aeneus
Oxyrhopus petola sebae
Pliocercus euryzonus dimidiatus
Pseudodoba neuwiedii
Pseustes poecilonotus shropshireii
Rhadinaca decorata
R. pachyura
Siphlophis cervinus germinatus
Spilotes pullatus pullatus
Stenorrhina degenhardtii
Tantilla albiceps
T. armillata
Trimetopon barbouri
Xenodon rabdocephalus
Micrurus mipartitus
M. nigrocinctus nigrocinctus
Bothrops atrox asper
B . schlegelii

*Source: Smithsonian Tropical Research Institute.

APPENDIX 3.8

AMPHIBIANS OF BARRO COLORADO ISLAND*

1. Gymnophiona

   Oscaecilia ochrocephala

2. Caudata

   Oedipina complex
   Oedipina parvipes

3. Salientia

   Eleutherodactylus biporcatus
   E. bufoniformis
   E. cruentus
   E. diastema
   E. fitzingeri
   E. gaigeae
   E. longirostris
   E. molinoi
   E. ockendeni
   Engystomops pustulosus
   Leptodactylus insularum
   L. pentadactylus
   Bufo marinus
   B. typhonius alatus
   Dendrobates auratus
   Colostethus nubicolor flotator
   Hyla boulengeri
   H. phlebodes
   H. rufitela
   Agalychnis calcarifer
   A. callidryas
   A. spurrelli
   Phyronohyas venulosa
   Smilisca phaeota
   S. sila
   Centrolenella fleischmanni
   C. prosoblepon
   C. spinosa
   Rana palmipes

*Source: Smithsonian Tropical Research Institute.

APPENDIX 3.9

FRESHWATER FISH - CHAGRES RIVER BASIN

Pimelodidae

Rhamdia wagneri
Imporales sp.
Pimelodella chagrensis

Pygidiidae

Pygidium striatum

Loricariidae

Plecostomus plecostomus
Chaetostoma fischeri
Ancistrus chagresi
Loricaria uracantha

Characidae

Compsura gorgonae
Cheirodan affinis
Saccoderma sp.
Gephyrocharax articaudata
Astyanax fasciatus
Astyanax ruberrimus
Bryconamericus emperador
Hyphessobrycon panamensis
Creagrutus affinis
Roeboides guatemalensis
Brycon chagrensis
Brycon petrosus
Piabucina panamensis
Hoplias microlepis

Sternarchidae

Hypopomus occidentalis

Poeciliidae

Poecilia sphenops
Brachyrhaphis episcopi
Brachyrhaphis cascajalensis
Gambusia nicaraguensis
Neoheterandia tridentatis

Cyprinodontidae

Rivulus brunneus

Cichlidae

Aequidens cocruleopunctatus
Geophagus crassilabris
Cichlasoma maculicauda
Neetroplus panamensis
Chicla ocellatus

*Source: Smithsonian Tropical Research Institute.

APPENDIX 3.10

PERIPHERAL FRESHWATER FISH - CHAGRES RIVER BASIN

Synbrachidae

Synbranchus marmoratus

Anguillidae

Anguilla rostrata

Elopidae

Megalops atlantica
Elops saurus

Engraulidae

Anchoviella elongata
Anchoviella lucida
Anchoa spinifer

Belonidae

Strongylura marina

Syngnathidae

Oosthethus lineatus

Antherinidae

Thyrinops chagresi

Muglidae

Agonostomus monticola
Agonostomus macracanthus
Mugil curema

Carangidae

Caranx hippos

Centropomidae

Centropomus parallelus
Centropomus undecimalis
Centropomus armatus
Centropomus ensiferus

Pomadayidae

Pomadasys croco
Pomadasys bayanus

Eleotridae

Gobimorus dormitor
Dormitator maculatus
Eleotris amblyopsis
Leoptophilypnus fluviatilis

Gobiidae

Awaous tajasica
Sicydium antillarum

APPENDIX 4

COMMENTS AND RESPONSES ON

THE INITIAL ENVIRONMENTAL EXAMINATION

United States Department of the Interior

FISH AND WILDLIFE SERVICE
WASHINGTON, D.C. 20240

ADDRESS ONLY THE DIRECTOR
FISH AND WILDLIFE SERVICE

In Reply Refer to:
FWS/IA

April 26, 1978

Mr. Robert O. Otto
LA/DR/EAD, Room 2252
Agency for International Development
Washington, D.C. 20523

Dear Mr. Otto:

I have reviewed the Initial Environmental Examination on a proposed Agency for International Development project for watershed management in Panama, ER-78/318, forwarded to us by your letter of April 7, 1978.

I agree that the proposed project should be given a "Positive Determination" requiring further study in the form of an Environmental Assessment.

1. The Assessment should include a discussion of the wildlife resources, including plants, under existing conditions, as well as a determination of these resources anticipated under future conditions without the project. Included in this data should be information on the presence of endangered species and unique natural areas. The U.S. List of Endangered Species for Panama includes 15 species of birds, mammals, reptiles and amphibians.

2. The Assessment should also cover the potential impact on wetlands, expecially those that can be improved. Measures to enhance upland wildlife habitat included in the proposed project should be mentioned.

The U.S. Fish and Wildlife Service would appreciate receiving advance planning data on the proposed project as soon as it is available. We would also appreciate receiving a copy of the Environmental Assessment. This office is available to provide advice and details for loss prevention measures and to recommend wildlife enhancement features that could be incorporated into the work plan.

Thank you for the opportunity to comment.

Yours sincerely,

Lawrence N. Mason

Lawrence N. Mason
Deputy Chief, International
Affairs Staff

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U.S. FISH AND WILDLIFE SERVICE

Response to letter from Fish and Wildlife Service, dated April 26, 1978

1. A discussion of existing biological resources in the Canal Watershed, including threatened and endangered species, may be found in Section II (2), and lists of flora and fauna of the watershed may be found in Appendix 3.

Section IV, which discusses future conditions without a project (the "No Action" Alternative), provides an analysis of the impacts of "no action" on the watershed's vegetation and wildlife.

2. Management of all wetlands in the watershed will be the responsibility of the Panama Canal Commission, created under the Panama Canal Treaties. This commission has jurisdiction over all lands required for Canal operation.

Upland wildlife will be enhanced through the project's reserve and park management activities which will develop a reserve and park management system for almost 94,000 hectares of land in the Chagres Forest Reserve, Altos de Campana Park and the Pipeline Road AReа. (See Figure III-2 for locations). Greater detail on park and reserve management activities, which include the formation of a forest inspector corps to locate and control improper and illegal land use practices, is provided in Section III C (2).

DEPARTMENT OF STATE

Washington, D.C. 20520

BUREAU OF OCEANS AND INTERNATIONAL
ENVIRONMENTAL AND SCIENTIFIC AFFAIRS

April 28, 1978

Robert O. Otto
LA/DR/EAD, Room 2252
Agency for International
Development
Washington, D.C. 20523

Dear Mr. Otto:

Thank you for the opportunity to review AID's initial environmental examination of the Panama Watershed Management project. Departmental officers have reviewed the document with interest.

The Watershed Management Project will have an important short and long-term impact on Panama and the surrounding area. As the Department of State noted in its Environmental Impact Statement on the New Panama Canal Treaties the management of the Panama Canal and surrounding watershed is key to the operation of the Canal and to the preservation of the valuable forests and wildlife in the area. AID's Watershed Management Project is an essential step for assisting the Government of Panama to manage and protect this resource.

1. We believe the project outline covers the main elements required in the project. Our one suggestion is to make sure that the preservation of wildlife is included as an important feature of the management project. The staff of the Canal Zone Environmental Quality Committee calculates that five percent of all the endangered mammals in the world and 20 percent of those in the Americas occur in this area. We would urge you to list wildlife preservation as a specific

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project element in Annex I, 1.b and insure that the wildlife aspect of the project is included as an integral part of the management scheme.

Sincerely yours,

Bill L. Long
Acting Director
Office of Environmental
Affairs

BUREAU OF OCEANS AND INTERNATIONAL ENVIRONMENTAL AND SCIENTIFIC AFFAIRS, DEPARTMENT OF STATE.

Response to letter from Bureau of Oceans and International Environmental & Scientific Affairs, dated April 28, 1978.

1. Wildlife will be protected in this project through the implementation of reserve and park management activities on almost 94,000 hectares of the Canal Watershed's lands. For greater detail see Section III C (2).

SMITHSONIAN INSTITUTION
Washington, D.C. 20560
U.S.A.

May 2, 1978

Mr. Robert O. Otto
Environmental Advisor
Bureau for Latin America
Agency for International
Development
Room 2252
Washington, D.C. 20523

Dear Mr. Otto:

Thank you for sharing with the Smithsonian a copy of the initial environmental examination for watershed management in the Republic of Panama. I have read this document with considerable interest as have members of the professional staff of the Smithsonian Tropical Research Institute (STRI).

At the outset, I should indicate some reluctance in critiquing this document, since I feel much more information is needed in order to evaluate this project properly. I assume this information is being drawn up and will be provided for further comment in a draft environmental impact statement. Nevertheless, the document represents an admirable first step if the suggested impacts would occur as per the outline.

1. A major concern for all of us who read this document was whether the basic premises of this document were based on problems in the tropics or whether suggested strategies have been misapplied from temperate environments.

2. Our second concern centered on the feasibility of this plan based on our knowledge of the sociology of the population. We know that the indigenous populations can farm the slope areas and in fact prefer this mode versus farming a flat area. We fear that the populations will simply ignore the call for additional flat land farming and hence negate one of the major program strategies. The population must eat and a case cannot be made yet for convincing them that forest areas can or should sustain human populations.

3. The development of a highly skilled class of farmers is an admirable goal, but given the rate of land destruction, who is to say that areas

will be extant when the population reaches a level of technical proficiency? This document would seem to indicate that local farmers have had little or no input in the process and this could well cast doubt on the successful implementation of the plan. Further, considerable thought should be given to the sociological impact of this plan. Are we creating a class of landless laborers who may be entirely dependent on international economic conditions?

4. A central issue which must be resolved before this plan has a chance of success, is the question of adequate enforcement of laws which now exist in the area. It is incumbent upon AID to work closely with RENARE and the Guardia Nacional to see that intrusions into protected areas by local populations either for subsistence farming or poaching ends. We have witnessed over the past few months, extensive burning (in violation of the law) in areas of the Pipeline Road and area adjacent to Bohio Point. Considerable effort should be made to remove populations from this area before intensive farming is undertaken. In this regard, it is our considered opinion that the only real conservation strategy for this area of Panama is one of total protection of the remaining forested areas. While we realize that this will be a difficult task, we firmly believe that this is an essential step in the protection of the watershed.

5. A corollary issue to your proposed program, is that of education. The ability to carry out programs such as those proposed by AID, will be largely predicated on the success of instilling a conservation ethic throughout the population of Panama. In this regard, we believe as Dr. Rubinoff has stated to you, that our proposal for an educational park at Bohio Point will measureably assist in this task. We believe that AID should consider the park proposal as a corollary to its own plans. Education of the people must go hand in hand with any technical assistance program.

In closing, I would like to make clear that the Smithsonian does not oppose this plan in its conceptual mode, but we would encourage you to do more thinking and clearly delineate the priorities which you seek to accomplish.

Please feel free to call upon the Smithsonian for advice as you continue to refine your plans.

Sincerely yours,

David Challinor

David Challinor
Assistant Secretary for
Science

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SMITHSONIAN INSTITUTION

Response to letter from Smithsonian Institution, dated May 2, 1978.

1. The project design team consisted of experts in tropical forestry, tropical pasture management and tropical ecology. In addition, RENARE will receive substantial technical assistance, under the project's institution building component, from tropical experts in the many areas of expertise needed to develop effective resource management programs.

2. The project proposes that traditional slash and burn farmers will be encouraged to move out of the watershed's most critical areas with attractive incentives of 3 to 4 hectare plots elsewhere in the watershed, material inputs and technical assistance to plant permanent tree or bush crops along with commercially exploitable tree species. All these incentives will be supplied to the farmers without cost, and labor for tree planting will be reimbursed. Also, through the project's instituion building component, the technical assistance of a social anthropologist with experience in Latin America will be procured to assist in the design of agroforestry interventions. For greater detail, see Section III (3).

3. Although RENARE has made preliminary efforts to survey and educate the watershed's residents, a significant part of the project's educational component will be directed at educating and gaining the support of local farmers. The previously mentioned social anthropologist to be procured under the project's institution building component will assist in the design of RENARE's educational activities.

A Social Soundness Analysis, which addresses the concern that reforestation activities may create a dependancy on wage labor is found in Annex V of the Project Paper. This concern should not be a problem, as watershed management activities should continue beyond this project's 5 year implementation period.

4. The forest inspector corps, to be developed under the project's reserve and park management activities, will prohibit improper and illegal land uses in the project's designated park and reserve areas (see Section III C (2)). The Panama Canal Authority will have responsibility for developing land use zoning and enforcement procedures for watershed lands outside this project's activity areas and a draft agreement, providing for close co-ordination between the Canal Authority and RENARE on land use zoning in the watershed, has already been agreed to on a working level. Most recently, the Governmental of Panama has increased its commitment to preventing incursions by traditional "Slash and Burn" farmers into Canal Zone lands and has prepared a media program to prevent slash and burn activities.

5. The project's reserve and park management activities propose

the establishment of educational facilities for Altos de Campana Park and the Pipeline Road area . Also the project's educational component will include the development and dissemination of informational materials on resource conservation for the area's schools and for the educational facilities to be constructed in park areas.

IIED INTERNATIONAL INSTITUTE FOR ENVIRONMENT AND DEVELOPMENT
President: Barbara Ward (Baroness Jackson of Lodsworth, D.B.E.)

Suite 501
1302 Eighteenth Street, NW
Washington, DC 20036
(202) 462-0900
Telex: IIEDWASH64414

May 1, 1978

Mr. Robert O. Otto
Environment Protection Specialist
Agency for International Development
Room 2252
Department of State Building
Washington, D.C. 20523

Dear Mr. Otto:

I greatly appreciate receiving your letter of April 18 enclosing the project description of a proposed AID in Panama for Watershed Management and to requesting my views on the adequacy of the proposed scope of work for the Environmental Assessment on this project.

My first comment is to congratulate AID for its willingness to undertake this kind of a project in Panama. Such projects in areas under heavy population pressure are very difficult, but we must try.

In line with this, I would suggest several additional aspects which should very definitely be addressed in the environmental assessment of the project: a) the degree of village support for reforestation and soil control programs in the areas which would be affected, and the incentives that can be offered to induce additional cooperation; b) the nature of commitment of various key levels in the Panamanian Government; c) the alternatives which can be made available to farmers and herdsmen evicted from the land to be set aside for reforestation. Without a clear understanding, of these aspects, I fear your project will fail.

A different category question which should be addressed is the relation of the project to the program of the U.S. Panamanian Environmental Commission, set up by the recently ratified Panama Canal Treaty.

(1.) My comments on these points follow:
Strength of Local Support: Latin America is pock marked with failed reforesta projects, the chief cause of which has been disinterest of the local residents in projects because they could see no real personal gain. Experience shows that reforestation and soil control projects which are located near heavy populated are succeed only when they are so strongly desired by the local population that they a ready and able to provide effective policing. In the case of the Panama project, a project-area by project-area examination of local support needs to be undertaker before investments are made.

(2.) Strength of Central Government Commitment. In Panama, there is strong politi pressure to resettle "excess" rural population in marginal tropical forest areas as an alternative to allowing such people to migrate to the city. If the Panaman Government is not committed to an anti-slash-and-burn policy, is not ready and pr

P.6

alternative employment, and is not ready and able to survey forest areas to determine which areas can be settled and then ready to take the political heat in trying to keep "spontaneous settlers" out of areas designated for reforestation, then the project is unlikely to survive. All of this calls for some previous very sociological and political analysis.

3. Another aspect which should be addressed is the Panamanian capability and willingness to undertaking simple but necessary land use planning of the kind which is essential for the success of such projects. If this capability does not exist or needs to be reinforced, then AID should include this requirement in their project.

4. Alternatives and Incentives. Farmers and herdsmen will not normally cooperate in reforestation projects, which almost always means denial of the use of these lands for a few years at least, unless realistic alternatives are offered, i.e. other areas made available for farming, grazing, or woodcutting; arrangements for purchase of extra cattle; and possession of other material or social incentives. This subject should be given the most honest attention.

5. Institution Building. Like other Latin American countries, the Panamanian Government's forestry service is probably weak, although I don't know this for sure. This presumption institutional weakness may not be applicable to RENARE, which is broader in scope, but I understand it needs definite strengthening.

The difficulty and even probability of at least partial failure of first generation forestry soil conservation projects should certainly not keep AID from undertaking this project. However, to avoid disillusionment at home and in Panama, the social and environmental constraints which I have mentioned should be addressed before you go further.

I am ready to help you on this and other environmentally important projects in any way I can.

Sincerely,

Robert O. Blake

Robert O. Blake

INTERNATIONAL INSTITUTE FOR ENVIRONMENT AND DEVELOPMENT

Response to letter from International Institute for Environment and Development, dated May 1, 1978.

1. RENARE, the project's implementing agency, made preliminary efforts, before project implementation, to survey and educate the project's target group. Once the project is implemented, its educational component, administered by RENARE, will focus its educational activities on gaining support of the watershed's residents for watershed management activities (for more detail see Section II B). In addition, the technical assistance of a social antropologist with field experience in Latin America will be procured under the project's institution building component to ensure effective acceptance of the project's agro-forestry activities.

2. The Government of Panama has exhibited a strong commitment to "anti-slash and burn policy" and the prevention of enrironmentally degrading land use practices through the commitment of a significant amount of funds for this project (40% of the project implementation costs). A large amount of these funds will be used to reduce slash and burn activities in the critical areas.

Also, the government has substantially increased its commitment to prevention of incursions into Canal Zone lands by traditional farmers, and prepared a media campaign to prevent "slash and burn" activities.

3. The provision of technical assistance and training under the projects institution building component will increase RENARE's capabilities in land use planning.

4. The project will offer attractive incentives to watershed residents participating in reforestation activities.

Residents participating in commercial reforestation activities will be provided with attractive wages for a guaranteed number of years. Each resident participating in these activities should realize an increase in average annual income of B/360/year.

Residents participating in agroforestry activities with annual crops will be provided with cost-free materials and technical assistance to plant native commercial tree species on their corn and rice plots. In addition, they will be paid for planting seedlings and for weeding and pruning in subsequent years.

Residents participating in agroforestry activities (primarily those currently living in the Chagres Forest Reserve) will be encouraged

to resettle with attractive incentives of 3-4 hectare plots elsewhere in the watershed. In addition, material inputs and technical assistance will be provided without cost and labor inputs for tree plantings will be reimbursed.

Also, the previously mentioned technical assistance of a social anthropologist will help to ensure that the project's participants are given adequate alternatives and incentives.

5. The project contains a substantial institution building component to increase RENARE's capacity to undertake watershed management programs (for further detail see Section III B, and Section III B (2) of the Project Paper.)

New York State College of Agriculture and Life Sciences
a Statutory College of the State University
Cornell University

Department of Natural Resources
Fernow Hall, Ithaca, N. Y. 14853

Fishery Science
Forest Science
Wildlife Science
Natural Resources
Environmental Conservation

May 17, 1978

Mr. Robert O. Otto, Environmental Advisor
Bureau for Latin America
Department of State
Agency for International Development
Washington, D. C. 20523

Dear Mr. Otto:

Patricia Scharlin, Director of the Internation Affairs Program of the Sierra Club has asked me to review the Panama Watershed Management Project and the initial environmental examination. I am Director of the Sierra Club's Tropical Rainforest Program, and am happy to give you the benefits of some comments.

(1.) I am afraid my comments will be fairly critical. I am questioning the way the project is described, more than the initial environmental examination. As a matter of fact I don't think there can be any environmental assessment or environmental examination when the project is couched in such general terms. It is fine to say that agriculture should be in those places that can support it without degradation but the question is where are those areas in the watershed? Unless there is a basic land capability classification study and program as a precourser to the on-site activities described, we are simply blessing motherhood and apple pie.

I have in mind the kind of biophysical land type or land unit classification just recently done for the upper watershed of the Guanare River in Venezuela. This identifies basic landscape units and then talks about the capability, suitability and feasibility of different kinds of land uses on those units. This project proposal of AID keeps referring to "suitable lands" without any indication of a methodology for identifying them. I cannot identify impact until I know "where" something is taking place. Any impact identification form that simply does analysis in the abstract is hardly worth doing. Even in the abstract however I would question on the proforma that Ala-"increasing the population" will have a moderate positive impact on the environment. Certainly not where I've seen it occurring in Latin America.

What is written is all good, - particularly the section on page 4 which writes in glowing terms about the taking out of some areas of agriculture and promoting appropriate agriculture only on lands with soil classes and slopes capable of sustaining such activity, but it still doesn't answer the question of how are those areas going to be identified. Without that, I feel I am dealing with the will-o'-the-wisp. Without that, my reading of the impact

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identification and evaluation form is simply an abstract and somewhat useless exercise.

Am I so way off base in this? Give me a project that has a hard methodology on identifying the critical and suitable areas in the watershed.

Sincerely,

Lawrence S. Hamilton

Lawrence S. Hamilton
Professor
Natural Resources

LSH:jr

cc: Pat Scharlin

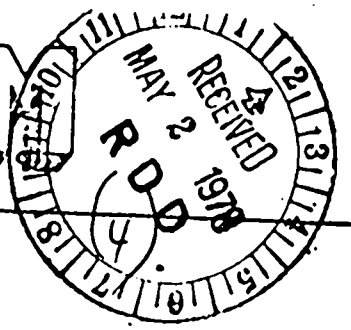
PROFESSOR LAWRENCE S. HAMILTON, NEW YORK STATE COLLEGE OF AGRICULTURE AND LIFE SCIENCES, DEPT. OF NATURAL RESOURCES.

Response to letter from Professor Hamilton, dated May 17, 1978.

1. The potential land use plan for the Canal Watershed was developed taking into account such factors as; specific management objectives, physical characteristics of the land, current land use and special factors primarily of a socio-economic nature. The methodology for developing the potential land use plan is discussed in Annex VI of the Project Paper and a map of potential land use may be found in Figure III-1 of this EA. The mix of activities proposed by this project was based on this potential land use plan.

TELEGRAM

UNCLASSIFIED
Classification



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TAGS:

SUBJECT: EAS FOR RURAL ACCESS ROADS AND WATERSHED MANAGEMENT.

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1. THE FOLLOWING COMMENTS ON MISSION'S IEES WERE RECEIVED FROM US DEPT. OF INTERIOR, GEOLOGICAL SURVEY.

(1) WATERSHED MANAGEMENT - WE SUGGEST THAT WATERSHED MANAGEMENT SHOULD INCLUDE MEASURES TO MONITOR THE CHEMICAL, PHYSICAL, AND BIOLOGICAL QUALITY OF STREAMS DRAINING SPECIFIC LAND-USE AREAS IN ORDER TO ADEQUATELY ASSESS THE EFFECTS OF LAND-USE PRACTICES ON SUBSEQUENT WATER QUALITY.

(2) SOIL AND WATER MANAGEMENT SHOULD ALSO INCLUDE CONSIDERATION OF THE SIGNIFICANCE OF GROUND-WATER STORAGE AND MOVEMENT. VARIOUS TYPES OF SOIL MANAGEMENT, FOR EXAMPLE, CAN INFLUENCE THE INFILTRATION TO GROUND WATER AND THUS INCREASE OVERLAND RUNOFF AND EROSION. SLOPE STABILIZATION MEASURES SHOULD INCLUDE ANALYSIS OF THE EFFECTS OF GROUND WATER ON SOIL AND ROCK MECHANICS. EVALUATION OF STRUCTURAL WATERSHED MEASURES SHOULD INCLUDE ASSESSMENT OF EFFECTS ON AND FROM GROUND WATER AS RESULTS OF THE CHANGED HYDROLOGIC REGIMEN. PROJECT PLANNING SHOULD ALSO INCLUDE RURAL USE OF GROUND WATER AS A SOURCE OF DOMESTIC SUPPLY. ROAD CONSTRUCTION CAN CHANGE SUBSURFACE FLOW PATTERNS AND CREATE DRAINAGE PROBLEMS. IN SHORT, WATERSHED MANAGEMENT PLANNING SHOULD INCLUDE BOTH SURFACE WATER AND GROUND WATER AND THEIR INTERRELATIONSHIPS.

UNCLASSIFIED
Classification

FORM FS-41
REV. 6/73

U.S. DEPT. OF INTERIOR, GEOLOGICAL SURVEY

Response to letter from U.S. Department of Interior, Geological Survey dated May 2, 1978.

1. Under the project's proposed education and research component RENARE will establish a small-scale research program which will consist of applied research activities in three areas related to a more rational use of renewable natural resources: erosion rates; water quality; and technology of tropical hardwoods. Research in water quality will consist of constant monitoring of Lake Alajuela and its tributaries. This research in combination with studies on land use changes will identify priority area's for the project's soil conservation program, as well as identify significant water pollution sources.

2. Data on groundwater in the Canal Watershed is extremely limited. Groundwater conditions are discussed in Section II-1. This section states that due to the abundance of surface water in the area and the limited supply of groundwater, there does not appear to be any potential for development of major groundwater supplies.

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE - P.O. Box 2890
Washington, D. C. 20013

APR 28 1978

Mr. Robert O. Otto
Environmental Advisor
Bureau for Latin America
Department of State
Agency for International Development
Washington, D.C. 20523

Dear Mr. Otto:

In accordance with your letter of April 7, 1978, the Soil Conservation Service has reviewed the initial environmental examination for the proposed Rural Access Roads and Watershed Management Projects in Panama.

We have no substantive comments to offer.

Thank you for the opportunity to review the proposals.

Sincerely,

Acting Glen H. Loomis
Director
Environmental Services Division

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Maps - ask Bob Mathia

		type
1) Capacidad Agricola	page II-6	Fig. - II-2
2) Pendientes	page II-1	Fig II-1
3) Mapa de Proyectos, Asentamientos y areas administrativas	page III-9	Fig III-3
4.) Mapa de Poblacion y Communicacion y areas administrativas	page I-4	Fig. I-2
5 Location of Project watersheds	page I-3	Fig. I-1