FIELD REPORT

EL SALVADOR: PROGRAM FOR MONITORING SURFACE AND GROUNDWATER IN THE WATERSHED BETWEEN THE BARRA DE SANTIAGO AND EL IMPOSIBLE

WASH Field Report No. 425
September 1993

WATER AND SANITATION for HEALTH PROJECT

Sponsored by the U.S. Agency for International Development
Operated by CDM and Associates

Field Report WASH No. 425

EL SALVADOR: PROGRAM FOR MONITORING SURFACE AND GROUNDWATER IN THE WATERSHED BETWEEN THE BARRA DE SANTIAGO AND EL IMPOSIBLE

Prepared for the USAID Mission in El Salvador
under WASH Task No. 471

by

L. Fernando Requena
and
Emilia de Quintanilla

September 1993

Water and Sanitation for Health Project
Contract No. 5973-Z-00-8081-00, Project No. 936-5973
is sponsored by the Office of Health, Bureau for Research and Development
U.S. Agency for International Development
Washington, DC 20523

TABLE OF CONTENTS

Page

ACRONYMS iii
ACKNOWLEDGEMENTS v
ABOUT THE AUTHORS vii
EXECUTIVE SUMMARY ix

1. INTRODUCTION 1

1.1 Purpose and Objective 1
1.2 Scope of Work 2
1.3 Project Description 2

2. STUDY AREA 3

2.1 Introduction 3
2.2 Physical Characteristics 3
2.2.1 Climate 3
2.2.2 Soils and Geology 4
2.2.3 Hydrology 7
2.3 Land Use 8
2.4 Natural Areas 8
2.5 Contamination of the Area 9

3. AVAILABLE DATA AND DATA ANALYSES 11

3.1 Introduction 11
3.2 National Data Bank on Water Quality 11
3.3. Other Sources of Data on Water Quality 11
3.4 Analysis of Available Data 12

4. MONITORING PROGRAM 13

4.1 Description of the Monitoring Program 13
4.2 Sampling and Measurement Sites 13
4.2.1 Sampling and Measurement of Surface Waters 14
4.2.2 Sampling Sites for Underground Waters 19
4.3 Parameters for Analysis, Frequency of Sampling and Methodology 21
4.3.1 Parameters for Analysis 21
4.3.2 Frequency of Sampling 22
4.4 Measurement of Flow 24
4.5 Existing Laboratories and Capacity for Analysis and Sampling 24

4.6 Sampling and Analysis Costs 25

5. CASE STUDY 41

5.1 Data Available for the Case 41
5.2 Analysis of Data 41
5.3 Sources of Contamination 41
5.4 Alternatives for Eliminating Contamination that the PROMESA Project Could Implement 42
5.5 General Recommendation 42

6. CONCLUSIONS AND RECOMMENDATIONS 47

6.1 Conclusions 47
6.2 Recommendations 48

APPENDICES

A. References
B. Summary of Interviews and Field Trips
C. Analysis by UNICO
D. Selected Newspaper Clippings
E. Results of Water Analysis and Flow Measurement Conducted by SalvaNatura
F. Data on Analysis and Equipment Costs
G. Quality Standards for Water Use
H. Scope of Work
I. Industrial and Agroindustrial Effluents

MAPS

1. Location Map of the Barra de Santiago-El Imposible Watershed 5
2. Map of the Barra de Santiago-El Imposible Watershed 17

TABLES

1. Frequency of Sampling in Rivers and Wells 23
2. Annual Sampling and Analysis Costs 27
3. Sampling and Analysis Budgets 28

ACRONYMS

A.I.D.	Agency for International Development (Washington, D.C.)
ANDA	Administración Nacional de Acueductos y Alcantarillados (National Aqueduct and Sewerage Administration)
ANR	Office of Agriculture and Natural Resources (A.I.D.)
BOD	Biochemical Oxygen Demand
CEL	Comisión Hidroeléctrica del Río Lempa (Lempa River Hydroelectric Commission)
CENTA	Centro Nacional de Tecnología Agrícola (National Agricultural Technology Center)
EPA	Environmental Protection Agency
FIS	Fondo de Inversión Social (Social Investment Fund)
FUSADES	Fundación Salvadoreña para el Desarrollo Económico y Social (Salvadorean Foundation for Economic and Social Development)
MAG	Ministry of Agriculture and Livestock
MI	Ministry of the Interior
MOH	Ministry of Health
MOP	Ministry of Public Works
PAHO	Pan-American Health Organization
PLANSABAR	Plan Nacional de Saneamiento Básico Rural (National Plan for Basic Rural Sanitation)
PROMESA	Protección al Medio Ambiente Salvadoreño
SEMA	Secretaría Ejecutiva del Medio Ambiente (Executive Secretariat for the Environment)
SETEFE	Secretaría Técnica de Financiamiento Externo (Technical Secretariat for External Financing)
UEDA	Unidad Especializada del Agua (Specialized Water Unit, adjunct to ANDA)
UNICO	Universidad Católica de Occidente
USAID	United States Agency for International Development (mission abroad)
WASH	Water and Sanitation for Health Project
WHO	World Health Organization

ACKNOWLEDGEMENTS

We would like to give recognition to the willingness and support provided by the USAID Mission to El Salvador in the preparation of this report. We especially wish to mention the assistance provided by Peter Gore and Rodolfo Cristales of the Office of Agriculture and National Resources (ANR). We would also like to recognize the assistance provided by Mrs. Gloria Oliva of ANR, who arranged for transportation that enabled us to visit the project site.

Finally, we would like to extend out appreciation for the assistance and guidance provided by numerous organizations during the course of our research, chief among which are SalvaNatura, ANDA, FUSADES, UNICO, CENTA, PAHO, UEDA, CEL, SEMEH/MAG, OSPA/MAG, PLANSABAR and the Department of Environmental Sanitation of the Ministry of Health.

ABOUT THE AUTHORS

L. Fernando Requena, born in Bolivia in 1942; United States citizen; BS, University of Oruro, National School of Engineering of Bolivia (Civil Engineering, 1965); MS, University of Cincinnati, Ohio (Environmental Engineering, 1968). Currently Senior Engineer with Camp Dresser & McKee (1968-93), except from 1970-71 when he served as Project Engineer with Ingetec, Bogotá, Colombia. Expert in the design, evaluation, and preparation of feasibility reports for domestic and industrial water and toxic waste projects. Experience in preparing feasibility studies and environmental impact studies for water and wastewater projects in the United States and other countries, including Guatemala, El Salvador, Bolivia, Colombia, Venezuela, Chile, Puerto Rico, Dominican Republic, India and Oman. Recently conducted an assessment of surface and underground water pollution in a number of different watersheds in El Salvador. Additional experience includes the design of facilities for the collection and treatment of wastewater, as well as water treatment and distribution systems. Recent projects include the preparation of environmental assessment standards for water and sanitation projects in the Dominican Republic; environmental assessments for water and sanitation projects in El Salvador; preparation of feasibility studies and water and sanitation plans, including environmental assessments in Guatemala and Chile; and feasibility studies for projects to supply water to rural communities in Oman. Other projects include water and sanitation plans for rural communities in Santa María, Boyacá and Chingaza in Colombia, Aibonito and Villalba in Puerto Rico, and Pune in India.

Emilia Viera de Quintanilla, born in 1956; national of El Salvador with studies in architecture (4/6) at the University of El Salvador; graduated in architecture from the Polytechnic University of El Salvador (UPES), with studies in administration and implementation of public projects in Costa Rica (ICAP-CINDER) and project preparation and evaluation in the Universidad José Matías Delgado. Member of the teaching staff of the UPES and consultant on environmental projects in the area of water provision (SEMA). Currently Executive Director of the Salvadorean Association of Water Professionals (ASPAGUA), an affiliate of the Salvadorean Association of Engineers and Architects (ASIA). Former member of the Executive Committee for the Protection of Water Resources (CEPRHI) (1989-92), former member of UEDA/ANDA, Advisory Unit of the National Commission of Water and Sanitation Sector Organizations and of the general management staff of ANDA, coordinator of GOH/A.I.D. Project No. 519-0303 "Water Management" (1987-92), and technical analyst for water supply projects in the Specialized Water Office (OEDA/MIPLAN) (1983-86). Actively involved in the Master Plan for the Development and Utilization of Water Resources (PLAMDARH), CENREN/MAG and the United Nations (1978-83), and the Water Project for the Northern Sector of San Salvador for ANDA, with Borns & Roe International-Mauricio Lara.

EXECUTIVE SUMMARY

Background

The government of El Salvador is aware of the environmental contamination that has taken place over the past decade and threatens the poorer population segments with higher living costs as a result of the avoidable shortage of clean water. In addition, the government feels that it would be possible to obtain both significant direct benefits (for example, the conservation and sustainable development of the Barra de Santiago/El Imposible watershed, one of the most important areas of the country) as well as collateral benefits (for example, an improvement in morbidity rates) through the rational management of existing water resources and the elimination of established sources of contamination.

In 1991, the Water and Sanitation for Health Project (WASH) implemented a task (Field Report No. 354) in which data related to the contamination of water, soil and living organisms in the watershed that drains into the Barra de Santiago was compiled and evaluated. In addition, samples of sediments and organisms from the Barra Salada, La Herradura, Jiquilisco and Puerto Parada were obtained and analyzed in order to compare pollution levels in these areas with those found in the area of the Barra de Santiago.

The objective and purpose of the current assignment was the preparation of this report, which includes a monitoring plan for the Barra de Santiago-El Imposible watershed covering a period of six years, based on physical, chemical, bacteriological and hydrological parameters. This monitoring plan includes both surface and underground water in the subject watershed and will constitute one element of the PROMESA Project to be implemented in the Barra de Santiago-El Imposible watershed. In addition, it will serve as a model for subsequent studies to be carried out in major watersheds located in other areas of the country.

Conclusions

- The results of the study of the pollution of surface and underground water conducted by WASH in 1991 identified the existence of pervasive fecal contamination throughout the sampled area. It was concluded that rivers contained high concentrations of biological oxygen demand and ammonium and low concentrations of dissolved oxygen.

- It was also determined that, with the exception of metamidophos (Tamaron), concentrations of pesticides and herbicides were low. Also, high concentrations of boron and arsenic were detected in the soil in the area adjacent to the canal conveying wastewater from the geothermal plant at Ahuachapán.

- Subsequently, in April 1993, SalvaNatura conducted a sampling survey in the area that produced results similar to those generated by the WASH study.

- The primary activities polluting the water resources in the area involve wastewater disposal and washing of clothes in the rivers, domestic activities such as livestock raising and agriculture, and geothermal effluents from the plant at Ahuachapán.

- The Ministry of Health conducted a national level inventory of industrial and agroindustrial runoff. The results of the inventory for the area in question indicated that most runoff is agroindustrial in nature.

- With the exception of the study conducted by WASH in 1991, which covers a limited period of sampling and analysis, and the sampling survey carried out by SalvaNatura in April 1993, to date no systematic study has been conducted of the contamination of water, soil and fauna in the watershed.

- The appropriate management of the water used for agricultural activities and the precautions that should be taken to avoid contamination of rain water can produce much more satisfactory results than treatment of the contaminated water, and at a much lower cost.

Recommendations

Monitoring Program

- The program for sampling surface water includes the following nine rivers: El Rosario, El Naranjo, Cuilapa, Guayapa, Aguachapío, Izcanal, Cara Sucia, La Palma and San Francisco. This would be the maximum coverage program, whereas a medium coverage program might include half of the proposed sites and a program to provide minimum coverage might include only a third of the above rivers. Choice of a program will depend on the availability of funds.

- In the medium coverage program, it would be possible to sample five rivers that are representative of the entire watershed. Sampling sites located on the following rivers are proposed for such a program: El Rosario, El Naranjo, Cara Sucia, Aguachapío and Guayapa.

- The minimum coverage program would include only the El Rosario, Cara Sucia and Aguachapío rivers.

- The program for sampling underground water includes the following 11 wells: Hacienda Cara Sucia, the village located near Zanjón La Danta, the village of Guayapa Abajo, Hacienda La Danta, the town of Cara Sucia, the town of San José,

El Naranjo, Hacienda Santa Rita, El Achiotal, Hacienda El Camalote, the village of El Porvenir and the village of Embarcadero de Guayapa. As is the case with surface water, the above-mentioned sampling wells would be included in a program designed to achieve maximum coverage.

- A program for achieving medium coverage might include only those wells with the greatest production, which are those serving ranches and stables. These would be the wells located at Hacienda Cara Sucia, Hacienda La Danta, Hacienda Santa Rita, El Achiotal and Hacienda El Camalote.

- A minimum coverage program might include only the following three wells: Hacienda Cara Sucia, Hacienda Santa Rita and Hacienda El Camalote. Choice of program will depend on the availability of funds for such a monitoring program.

- It is recommended that analyses be conducted of the following parameters:

  - Physical parameters: odor, temperature, electric conductivity, pH, turbidity, color, settleable solids, suspended solids and total solids.

  - Chemical parameters: dissolved oxygen, biochemical oxygen demand (BOD), nitrogen from nitrates, organic nitrogen, ammonium nitrogen, phosphates, detergents, arsenic, boron, sodium, potassium, organochlorinated compounds and organophosphorized compounds.

  - Bacteriological parameters: total coliforms and fecal coliforms.

- After considering a number of different options, the team recommends a monitoring program to analyze certain parameters intensively and others a lesser degree of frequency. Specifically, suspended or settleable solids, which are indicators of erosion in the watershed, should be analyzed intensively in surface water, particularly during the rainy season, whereas fecal coliforms, herbicides, pesticides and metals could be analyzed on a monthly basis.

- With regard to the monitoring of underground water, the parameters to be studied would consist of contaminants resulting from agricultural and domestic activities, i.e., herbicides, pesticides, fertilizers and fecal coliforms. Sampling sites would be located close to areas where agricultural activities are carried out or close to population centers. Some of the wells are located near the conduit that conveys geothermal effluents from the plant at Ahuachapán and may possibly be contaminated by boron and arsenic.

- The team recommends monthly sampling of rivers and wells for the large majority of parameters, except for the physical parameters of temperature, turbidity, settleable

solids, suspended solids and dissolved oxygen in the rivers, which should be sampled daily during the rainy season and after every rainfall in other periods during the year.

- Suspended solids should be analyzed together with settleable solids until a correlation can be established between these two parameters. Once such a correlation is established, settleable solids should be analyzed on a daily basis, while suspended solids should be analyzed monthly.

- As a result of the large number of samples to be taken and analyzed, the team recommends that a small field laboratory be set up in the area of the study. Such a laboratory could conduct analyses of settleable solids, suspended solids, pH, dissolved oxygen and conductivity. The Hach Company manufactures field laboratories that can perform all necessary analyses, with the exception of pesticides and herbicides. The approximate cost of such laboratory equipment is C/175,000.

- Approximately 65 percent of the costs of analyzing surface water and 85 percent of the costs of analyzing underground water represent the cost of analyzing herbicides and pesticides. Accordingly, a determination will need to be made, during the first year of monitoring, as to whether such analyses should continue. If the results consistently indicate that no such contaminants are detected, then these analyses would cease to be conducted on a monthly basis; rather, they would be carried out intermittently as well as when circumstances warrant.

- As indicated previously, it is recommended that a field laboratory be set up in the study area. This would require personnel to perform the sampling and analytical work. Students from the UNICO could participate in the project while writing their theses. It is possible that sampling and analysis costs could be reduced if such participation were to materialize.

- Generally speaking, the appropriate management of the water used for agricultural purposes and the precautions that need to be taken to avoid contaminating rain water runoff can produce much more satisfactory results than the treatment of the polluted water, and at a much lower cost. Specifically with regard to the case of stables, the following recommendations are submitted:

  - Latrines should be provided in appropriate areas for use by workers. Such latrines could be of the simple pit type or compost latrines, depending on the level of the water table in the area.

  - The amount of water used to supply livestock drinking troughs and to clean stables should be minimized, and unnecessary contamination should be avoided.

- Steps should be taken to avoid the contamination of rain water falling on the stables. Many of the stables are fully exposed and located on sloping land; the rain washes large quantities of manure from the stables into rivers or other surface water flows. Stables should be built with roofs to prevent rain water from being contaminated. The task of cleaning the stables should take place using "dry" methods.

- Manure should be stored in appropriate areas that will not create problems with regard to rain water contamination. These storage areas should be located far from water flows, on level land. The manure can be used as fertilizer and its final disposition should be done promptly.

Chapter 1

INTRODUCTION

1.1 Purpose and Objective

The purpose and objective of this study is to prepare a report containing a design for a six-year monitoring plan for the Barra de Santiago-El Imposible watershed, taking into account chemical, physical, bacteriological and hydrological parameters.

This monitoring plan covers both surface and underground water in the above-mentioned watershed and will be included in the A.I.D.-sponsored PROMESA Project. The PROMESA Project and the Barra de Santiago-El Imposible watershed are important in terms of the ecology of the country, as substantiated by the newspaper articles included in Appendix D.

1.2 Scope of Work

The Scope of Work is presented in its entirety in Appendix H. Presented below is a summary of the Scope of Work, which includes the following tasks:

- Review of information available in ANDA, PLANSABAR and the MAG to determine contamination sites in the watershed,
- Based on such a review, propose a sampling plan for quantifying contaminants,
- Using data taken from the preliminary WASH report, design a sampling program to identify changes to be made to water resources over the life of the PROMESA Project,
- Identify local laboratories and ways to obtain samples and conduct analyses, and also provide appropriate cost indications,
- Provide an example of how monitoring data should be used to guide decision-making. This illustrative example should provide ideas with regard to appropriate policies, technologies and other alternatives that might be implemented under the PROMESA Project with a view toward solving problems,
- Recommend a monitoring plan for water flows in the study area,

- Identify laboratory, equipment and personnel needs for carrying out the monitoring plan at the local level, and

- Lastly, prepare a report describing the monitoring plan and make a verbal presentation of the program.

1.3 Project Description

The project involves preparing a plan for monitoring surface and underground waters in the subject watershed. In preparing this plan, we reviewed data available in ANDA, PLANSABAR and the Ministry of Agriculture (MAG) in the region. The plan includes the selection of parameters to be measured, sampling frequency and sites, laboratory location and requirements, and methods and sites for measuring water flow. In addition, field trips were made to identify typical polluting activities currently existing in the watershed and ways to eliminate them.

Chapter 2

STUDY AREA

2.1 Introduction

The study area includes the Barra de Santiago-Bosque El Imposible watershed, which is located in the southwestern region of El Salvador, in the Department of Ahuachapán, near the Guatemalan border (Map No. 1), with a north-to-south orientation with regard to the Pacific Ocean. The rivers in the subwatersheds flow from north to south. The watershed measures approximately 20 kilometers from north to south and 15 kilometers from east to west, with an approximate area of 366.5 square kilometers (equivalent to 36,650 hectares) in accordance with the detailed study of this watershed recently conducted by SalvaNatura, with financing from A.I.D.

2.2 Physical Characteristics

The Barra de Santiago-Bosque El Imposible watershed extends from the water divide in the Apaneca mountain chain, which forms a part of the coastal mountain range of El Bálsamo, which in turn closely and uninterruptedly follows the coastline of El Salvador. This watershed was delimited on the basis of its many sources of fresh water, such as rivers and streams, that drain into the Barra de Santiago estuary.

From a topographical standpoint, the watershed is made up of three clearly distinguishable areas: a coastal plain surrounding the mangrove swamp and estuary, low sloping hills, and a high mountainous area with steeps slopes and large outcrops oriented from north to south, as a result of which there are many hillsides with an east or west orientation with regard to the rivers, and very marked differences with regard to solar exposure. The range in altitude in the watershed varies from south to north and from sea level to 1,400 meters above sea level (masl). The watershed contains thirteen subwatersheds (ten primary and three secondary), in six of which the rivers have their source in the highest altitudes. Of these rivers, the Guayapa River may possibly be the most attractive coastal river because it presents a lesser degree of contamination (both upstream and in its middle reaches). The boundaries of the watershed are said to disappear upon reaching the coastal plain.

2.2.1 Climate

El Salvador has three meteorological zones, which are dependent on their height above sea level. In accordance with the classification developed by Koppen, Sapper and Lauer, these

zones are as follows: "warm or hot tropical savannahs", "warm or temperate tropical savannahs" and "the high tropics".

The Barra de Santiago-El Imposible watershed is located in the region of Central America that has a dry season (from November to April, with a total rainfall of 300 mm) and a rainy season (from May to October, with a total rainfall of approximately 1,000 mm). The rainfall varies within the watershed as we proceed from sea level to the higher regions, with an average annual precipitation of 1,600 mm to 2,400 mm. Average annual relative humidity is 75 percent in the lowlands, reaching about 85 percent in the highlands. Annual median temperature is 27.5° C. on the coastal plain, dropping to 20° C. in the higher altitudes. Estimated average highs and lows are 35° C. and 22.6° C. in the coastal plan and 15.2° C. in the highlands, respectively. The most salient aspects of this situation are the increased variation in the coastal plain area and the lower temperatures in the highlands, which influences vegetation and water infiltration.

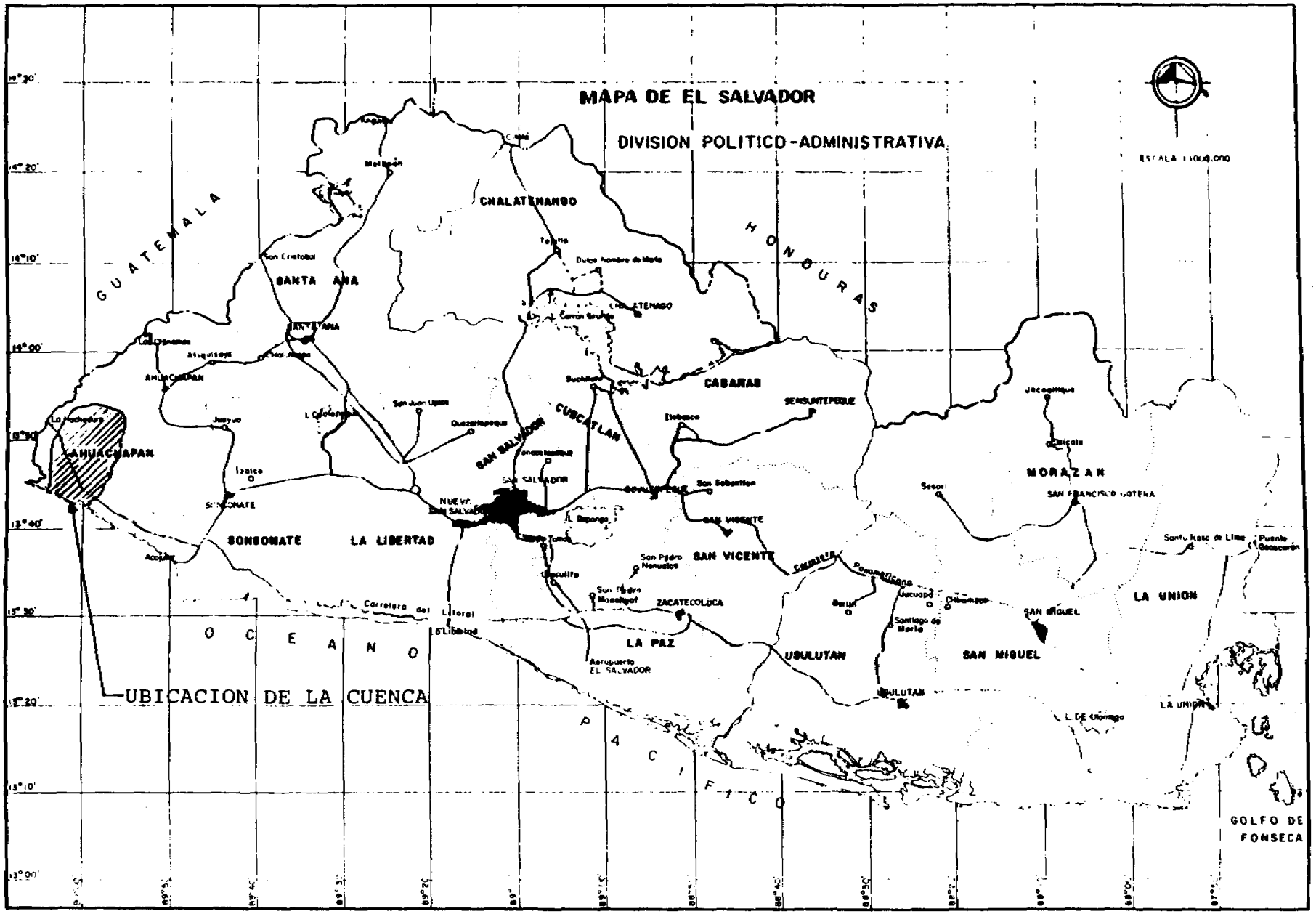
Potential evapotranspiration is 1,900 mm on the coastal plain and 1,500 mm in the highlands. In the highest reaches of the watershed, there are ocean breezes and winds that blow from south to north, which causes cloudiness and showers, even in the dry season. The winds, which blow down through the canyons and narrow valleys, range from strong to very strong and can attain speeds of up to 150 km per hour. In the stormy season, overflowing, flooding and washouts are frequent, almost always at the higher altitudes. The most recent occurrence of hurricane-force winds in this region took place in October 1983, as a result of which some 40 percent of the mangrove swamp at the Barra de Santiago was lost and a number of rivers, including the Guayapa, changed channel, emptying out as far as one kilometer below their normal outlet.

The factors that determine climatic differences in the study area are altitude and the presence of the ocean. At the mesoclimatic level, factors include slope and orientation of the surface area. As in the country as a whole, the area has a dry season and a rainy season, which are separated by lengthy transition periods.

2.2.2 Soils and Geology

There are a total of 15 different types of soil in the watershed, which can be divided into four groups that account for 89 percent of the soil types in the country. This classification is consistent with that used by the U.S. Soil Conservation Service.

The soils that make up the watershed reflect geological base (country rock, alluvial deposits and ocean sand), topography, current use and climate. In many areas, the soil has been altered as a result of its current use, particularly in areas having steep slopes planted to inappropriate crops and without the benefit of any significant soil conservation efforts, as well as in level and very sandy areas, in which plowing has virtually eliminated the thin and delicate topsoil.



Map 1
Location Map of the Barra de Santiago-El Imposible Watershed

The watershed contains three distinguishable soil zones characterized by their origin and slope, as follows:

a)	Coastal plain (0-10 masl)	Marine and terrestrial alluvial base. This alluvium is generally coarse-textured as it extends into the coastal plain, becoming finer as its approaches the coast.
b)	Peneplain (10-200 masl)	Light slopes of 3-5 percent from north to south and 3-25 percent toward the streams running east to west.
c)	Mountainous region (200-1,400 masl)	Moderate to very steep slopes, with a number of vertical outcrops on the hillsides.

Geological materials are of volcanic origin, and were deposited as follows (from oldest to most recent):

a. Volcanic agglomerates and tuff with pumice lapilli. These are the oldest formations and together form a single rock mass, extremely hard and virtually impermeable. Where it exists at all, vegetation is scarce and the land is dry. Water-bearing strata are also quite poor.

b. Andesitic and basaltic lava, formed by eruptive manifestations in areas of volcanic activity located in the northern regions of the watershed, which give way to soils appropriate for agricultural activities, which in turn give way to forest land, a situation which facilitates the infiltration of rain water which feeds the rivers and streams that flow toward the south.

c. Tuff with a 66 percent or greater silica content, interleaved with brown-colored tuff having a very fine, sandy matrix. The tuff covers only a small portion of the region.

d. Fluvial sediments that are the product of scouring and sedimentation caused by the river and stream waters flowing down through this watershed. They consist of coarse alluvial deposits with blocks, boulders, cobble, gravel and fine alluvial deposits, such as sand and silt, which together form a heterogeneous mix. They are permeable in nature, which makes it possible to store underground water for domestic and livestock use. Once they have weathered, these elements become excellent alluvial soils that allow vegetation to extract nutrients for their development.

El Salvador is located on the Pacific Ocean slope in the Central American complex, between the tectonic plates of Brazil and Canada. It was formed at the end of the Mesozoic era, when the convulsive activity of these plates lifted Mesozoic sediment and Paleozoic rock to sea level. Periodic seismic activity and recurrent volcanic eruptions are witness to the persistent instability of this region.

The Barra de Santiago-El Imposible watershed is crisscrossed on the northern edge of the El Imposible forest by a series of geological faults which are orientated toward the northwest, as well as from north to south and from east to west. These faults, when they release energy, produce earthquakes that on occasion reach an extremely high intensity. To a lesser extent, its morphology is the result of considerable volcanic activity and geologic faults. The former produces large volumes of materials and the latter elevate or depresses large portions of the surface area in the region, which in both cases generates negative influences as regards erosion.

The faults have fractured the andesitic and basaltic lava, thereby creating a secondary permeability that has facilitated the infiltration of rain water into the fractured plains, thus feeding the water-bearing strata in this area. In some places, underground water surfaces to swell the rivers and streams that flow down toward the coastal plain.

2.2.3 Hydrology

The watershed in the area of study is defined by the system of rivers, streams and deep ditches that drain from the Parque El Imposible into the Barra de Santiago. A total of nine different subwatersheds are located in this area. They range from 14 to 64 square kilometers in area and have their source in the mountainous area of El Imposible. With regard to the size of their respective drainage areas, the most important rivers are the San Francisco, Cara Sucia and Guayapa, which contain the greatest percentage area of forest land, whereas the Izcanal, La Palma and Aguachapío Rivers have a lesser percentage of forest area. The other rivers are the El Naranjo and Cuilapa.

The hydrology of the upper and middle portions of the watershed is simple and is based superficially on rock which is dense, well-formed and compact, more as a result of tectonic upheavals than volcanic eruptions.

Accordingly, most of the water falling in the form of precipitation that does not return to the atmosphere and is not assimilated by the soil and plants appears to flow toward the river beds and from there to the sea, rather than infiltrating the water-bearing strata.

In addition, the piedmont and the coastal plain contain volcanic rock and alluvial deposits which create high levels of infiltration and instability, as can be seen by the fact that the rivers disappear into the subsoil (as in the case with the San Francisco or El Imposible River, which disappears into the subsoil only to reappear subsequently) or flow into large ditches, which ultimately drain into the estuary or mangrove swamp. Others remain stored in the coastal aquifers, at which point their drainage areas merge and they undergo dramatic changes in their channels, particularly following hurricanes such as those previously mentioned (1983).

There is also considerable evidence, as provided by the residents of the area, that there have been dramatic changes (from 8 m to 3 m) in the depth of the primary channels of the Barra de Santiago. In this regard, a sedimentation study would shed light on the situation and explain the causes, which would facilitate the identification of potential solutions. It will also be necessary to monitor the volume of flow in order to establish a direct correlation with regard to precipitation and infiltration data and in this way characterize the yearly cycle of the watersheds covered by the study.

2.3 Land Use

There are large discrepancies in the area of the study with regard to potential soil use and current soil use. Of special note are the cultivation of basic grains on hillsides and the establishment of pasture land on the steep slopes located in the upper reaches of the watershed.

The highest lands in the watershed are used for more intensive agricultural activities involving production of cereal grains, cucurbitaceous crops, sugar cane, banana and pasture land, although agricultural and livestock activities are also present. The wooded river edges in the region are being fiercely harvested. In the flatter, lower areas, intensive, limited-extension agricultural activities produce corn, sorghum, some okra and on-farm fruit crops. In the valleys, sugar cane and pasture land predominate. In areas having slopes of 15 percent or more, residents pursue corn- and sorghum-based subsistence farming, and it is these areas that are the most severely damaged in the region as a whole as a result of poor management and the decimation of the forest.

It is estimated that more than 70 percent of the original vegetation has been eliminated and substituted by either permanent crops, pasture land or annual crops. However, valuable natural remnants still remain. The middle and upper reaches of the El Imposible forest are considered to be particularly valuable.

Those areas that are populated are low-density in nature and most of the population is characterized by low levels of income, as over the medium and long term they depend on a few small natural areas that lack adequate protection and management.

2.4 Natural Areas

The natural areas included in the subject watershed are the El Imposible forest, the forest located on the Hacienda Santa Rita, Cara Sucia and the Barra de Santiago mangrove swamp. There are corridors of wooded river edges and large swampy ditches of considerable biological value. Two of the most important areas for purposes of this study are analyzed below.

- **El Imposible:** This is the most important natural area. It is located in the Department of Ahuachapán, in the Apaneca mountain range. It is the most representative broadleaf jungle and is endowed with the greatest biodiversity (variety of naturally occurring flora and fauna) in the country. The inventory of trees for the area includes more than 400 species, particularly in the middle and upper reaches, where more than 300 species have been recorded — more than any other place in the country. Of the total number of species (465) recorded in the national bird inventory, 324 have been sighted in this watershed. This suggests that approximately 70 percent of the birds in the country are located in this watershed, which increases its value as a natural area for El Salvador.

- **Barra de Santiago:** This area is situated along the coast in the Department of Ahuachapán and contains a very diversified fauna consisting of many species of fish, mollusks and crustaceans, in addition to crocodiles and alligators. Of the 103 species of nonpasseriform birds in the Barra de Santiago, only 31 percent are migratory. Only wading species, such as the herons, ibises, and similar species, as well as the kingfishers, are resident.

2.5 Contamination of the Area

The results of the study of the contamination of surface and underground water conducted by WASH in 1991 indicated the existence of pervasive fecal contamination throughout the surveyed area. It was determined that the rivers contained high concentrations of biological oxygen demand and ammonium and low concentrations of dissolved oxygen. It was also determined that, with the exception of metamidophos (Tamaron), concentrations of pesticides and herbicides were low. Lastly, high concentrations of boron and arsenic were found in soils in the area adjacent to the canal conveying wastewater from the geothermal plant at Ahuachapán.

Subsequently, in April 1993, SalvaNatura conducted a sampling survey in the area, which produced results similar to those generated by the WASH study (see Appendix E).

The principal activities contaminating the water and resources in the area involve disposal of wastewater and washing of clothes, domestic activities such as agriculture or livestock production, and the discharge of geothermal effluents from the plant at Ahuachapán.

The Ministry of Health conducted a national level inventory of industrial and agroindustrial runoff. The results of that inventory for the study area are presented in Appendix I.

Chapter 3

AVAILABLE DATA AND DATA ANALYSIS

3.1 Introduction

The most significant environmental problems affecting the watershed that drains into the Barra de Santiago are deforestation and water and soil contamination.

These problems are intimately related, as deforestation causes erosion and sedimentation in lakes, reservoirs, rivers and estuaries, as well as climate changes resulting in lower rainfall, which in turn reduces agricultural productivity and increases the concentration of contaminants in bodies of water.

With the exception of the study conducted by WASH in 1991, which is limited in terms of sampling and the analyses conducted, and the sampling survey conducted by SalvaNatura in April 1993, to date there has been no systematic study conducted in the watershed with respect to contamination of water, soil and fauna.

3.2 National Data Bank on Water Quality

The Specialized Water Unit (UEDA), which is attached to the National Aqueduct and Sewerage Administration (ANDA), has a computerized data bank containing water quality information for the major rivers in the country, as well as data relating to underground water and springs. Unfortunately, this data bank does not contain any information pertinent to the area under study.

3.3 Other Sources of Data on Water Quality

The Ministry of Health and PLANSABAR have some data on water quality in the communities served by water systems within the area covered by the study. However, the data that are compiled by these organizations are limited primarily to residual chlorine at the point of consumption. In isolated cases, the Ministry of Health has taken samples from certain rivers in which contamination represented a threat to the health of the population groups that use the water in the rivers for washing clothes and other domestic uses. These data provide no information of any use for this project.

A number of researchers have studied the effect of the use of pesticides and herbicides on water quality in other areas of the country. This information was submitted in the previous study conducted by WASH in 1991. No information is available with regard to the presence

of these contaminants in the rivers located in this watershed, with the exception of the study conducted by WASH in 1991.

3.4 Analysis of Available Data

The results of the study of the contamination of surface and underground waters conducted by WASH in 1991 indicated the existence of pervasive fecal contamination throughout the survey area. It was determined that the rivers had high concentrations of biological oxygen demand and ammonium and low concentrations of dissolved oxygen. It was also determined that, with the exception of metamidophos (Tamaron), concentrations of pesticides and herbicides were low. Lastly, high concentrations of boron and arsenic were found in the soil of the area adjacent to the canal conveying effluents from the geothermal plant at Ahuachapán.

The WASH studies also identified the settleable solids that were not reported in the previous study. That information is included in Appendix C of this report. The results indicated relatively low levels of settleable solids, with a range of between 4 and 0 ml/l. Although these samples were taken during the months of September and October 1991, which are traditionally rainy season months, there was relatively little rainfall that year, which explains the low values obtained in this analysis. The highest readings were obtained for Zanjón La Danta (4 ml/l), downstream in the Cara Sucia River (3 ml/l), the Guayapa River (3 ml/l), downstream in the Aguachapío River (2 ml/l) and downstream in the Guayapa River (2 ml/l). The remaining samples generated values of 0.5 ml/l or lower. A ratio between settleable solids and suspended solids in this region was obtained empirically by observing the results obtained by ANDA in the Paz River, which provided a ratio of 50 mg/l, equivalent to 1 ml/l, indicating that the maximum level of suspended solids detected during the previous WASH study was approximately 200 mg/l in Zanjón La Danta.

Subsequently, in April 1993, SalvaNatura conducted a sampling survey in the area that produced results similar to those obtained in the WASH study (see Appendix E).

The primary activities that are contaminating water resources in the region involve the disposal of wastewater and the washing of clothes, activities involving agriculture or livestock raising, and the discharge of geothermal effluents from the plant at Ahuachapán.

Chapter 4

MONITORING PROGRAM

4.1 Description of the Monitoring Program

Based on the objective of the project, which is primarily to assess the ecological status of the watershed, the degree of contamination present, and the impact of future interventions in a number of different sectors aimed at improving or solving the ecological problems of the watershed, a number of different plans were considered for implementing a monitoring program that would both satisfy requirements and be implementable and sustainable over the life of the project.

The WASH team conducted two visits to the area to identify convenient sampling sites. Although the time available for this assignment did not allow the team to tour the most important rivers, a reconnaissance activity should be conducted during the initial stages of the PROMESA Project. Such an activity would include information about the river's wooded edges, sources of contamination, and other data of interest that could be plotted on a map of the watershed.

Described in detail below are the sampling sites, flow measurement, sampling frequency, parameters of interest, equipment and personnel needs, and estimated costs.

4.2 Sampling and Measurement Sites

Sampling sites should comply with the following requirements:

- be readily accessible,
- be easily measurable (flow or depth of the water table), and
- be representative.

Presented below are the sites selected for sampling surface and underground waters. All of these sites are indicated on the map of the watershed (Map No. 2 — scale 1:50,000). The sampling sites at the rivers were located along highway CA-2 and accordingly do not include areas of the watersheds located south of the highway. The area of the sectors not included totals 110 km^2, or about 30 percent of the total area.

4.2.1 Sampling and Measurement of Surface Waters

With the above requirements in mind, the WASH Project team traveled to the area and conducted an inspection of the rivers that traverse the Coastal Highway, with the following results:

1. Bridge on the Coastal Highway (CA-2) over the El Rosario River

This river has a large volume of flow. The bridge has three openings, although at average flow level, the river passes through only two of them. The color of the water was light brown, which indicates the presence of erosion solids upstream. This part of the river is used for commercial sand extraction, which is performed manually. (See photographs 1, 2 and 3.) According to the SalvaNatura study, average flow in this river during the dry season is 210 l/s, with a drainage area of 75.3 km^2. This river empties into the Barra de Santiago through Zanjón El Rosario after joining the El Naranjo and Cuilapa rivers. The El Rosario River is the biggest river in the watershed and accordingly should be included for consideration as one of the sampling and flow measurement sites.

2. Bridge on the Coastal Highway (CA-2) over the El Naranjo River

This river has a lower volume of flow than the El Rosario River. The bridge has two openings, although at average flow level, the river passes through only one. The color of the water during our visit was light brown-green, which indicates the presence of low levels of erosion solids upstream. This part of the river is used for commercial sand extraction, which is performed manually, as well as for washing clothes. (See photographs 4, 5 and 6.) Average flow in this river during the dry season is 55 l/s, with a drainage area of 37.5 km^2. According to the SalvaNatura study, this river empties into the Barra de Santiago through Zanjón El Rosario after joining the El Rosario River. The El Naranjo River is one of the medium-sized rivers in the watershed and should be included for consideration as one of the sampling and flow measurement sites.

3. Bridge on the Coastal Highway (CA-2) over the Cuilapa River

This river has a lower volume of flow than the two above-described rivers. The bridge has a single opening. The color of the water during our visit was light brown, which is indicative of a low level of conveyance of erosion solids upstream. This part of the river is used for washing clothes. (See photograph 7.) According to the SalvaNatura study, average flow in this river during the dry season is 25 l/s, with a drainage area of 20 km^2. This river empties into the Barra de Santiago through Zanjón El Rosario after joining the El Rosario River. The Cuilapa River is one of the smallest rivers in the watershed, but could be included for consideration as one of the sampling and flow measurement sites as a result of the configuration of the river and the form of the bridge, which lends itself to the construction of a crest (the washerwomen have already built a rudimentary crest made of stone — see

photograph 7) that could be used to measure flow by simply measuring the height of the water above the crest.

4. Bridge on the Coastal Highway (CA-2) over the Guayapa River

This river is one of the largest rivers in the watershed, second in size after the El Rosario River. Although the bridge has two openings, the river passes through only one of them, as the other is entirely obstructed by deposits of stones and vegetation. The color of the water during our visit was light green, which indicates low levels of erosion solids upstream. This part of the river is used for washing clothes. (See photographs 8, 9 and 10.) According to the SalvaNatura study, average flow in this river during the dry season is 130 l/s, with a drainage area of 25 km^2. This river empties into the Barra de Santiago through Zanjón Embarcadero. The Guayapa River should be included for consideration as one of the sampling and flow measurement sites.

5. Bridge on the Coastal Highway (CA-2) over the Aguachapío River

This river has the lowest volume of flow of all of the rivers in the watershed. The bridge has a single opening. The color of the water during our visit was cloudy green, which is indicative of low levels of erosion solids upstream. The color of the river is caused primarily by the soap used for washing clothes. (See photographs 11 and 12.) In a prior visit made upstream, upon returning from El Impossible, the river was clear and light-colored, as can be seen in photograph 13. This river is used along its entire length for washing clothes. According to the SalvaNatura Study, average flow in this river during the dry season is 15 l/s, with a drainage area of 16.7 km^2. The river empties into the Barra de Santiago by way of Zanjón Aguachapío, after joining Zanjón Tacachol. The Aguachapío River is one of the smallest rivers in the watershed, but it could be included for consideration as one of the sampling and flow measurements sites as a result of the configuration of the river and the form of the bridge, which lends itself to the construction of a crest that could serve to measure the volume of flow.

6. Bridge on the Coastal Highway (CA-2) over the Izcanal River

This river has one of the least voluminous flows of all of the rivers in the watershed. The bridge has a single opening. The color of the water during our visit was cloudy green-brown, which indicates low levels of erosion solids upstream. The color of the river is produced primarily by the soap used for washing clothes. (See photograph 14.) According to the SalvaNatura study, average flow in this river during the dry season is 30 l/s, with a drainage area of 16.8 km^2. This river empties into the Barra de Santiago through Zanjón Aguachapío after joining Zanjón Tacachol. Zanjón Izcanal is one of the smallest rivers in the watershed, but could be included for consideration as one of the sampling and flow measurement sites as a result of the configuration of the river and the form of the bridge, which lends itself to the construction of a crest that could serve to measure the volume of flow.

7. Bridge on the Coastal Highway (CA-2) over the Cara Sucia River

This river is one of the largest in the watershed, after the El Rosario and Guayapa rivers. The bridge has two openings. The color of the water during our visit was dark green, which is indicative of a low volume of erosion solids upstream. Rather, it indicates contamination from the discharge of agricultural and domestic effluents upstream. This part of the river is contaminated and is not used except to discharge storm water and sanitary waste and dump garbage. (See photographs 15, 16 and 17.) According to the SalvaNatura study, average flow in this river in the dry season is 120 l/s, with a drainage area of 32.5 km^2. This river empties into Zanjón Madre Vieja, the Salado Tihuilote Forest and, finally, the Barra de Santiago. The Cara Sucia River is one of the larger rivers in the watershed and should be included for consideration as one of the sampling and flow measurement sites.

8. Bridge on the Coastal Highway (CA-2) over the La Palma River

This river has a medium volume of flow in relation to the rest of the rivers in the watershed. The bridge has a single opening. The color of the water during our visit was cloudy green-brown, which indicates a low volume of erosion solids upstream. The color of the river is caused primarily by the soap used for washing clothes. (See photograph 16.) According to the SalvaNatura study, average flow in this river during the dry season is 60 l/s, with a drainage area of 16.8 km^2. This river empties into the area surrounding Lake Gamboa. The La Palma River is one of the smallest rivers in the watershed, but could be considered as a sampling and flow measurement site, based on the configuration of the river and the form of the bridge, which lends itself to the construction of a crest that could serve to measure the volume of flow.

9. Bridge on the Coastal Highway (CA-2) over the San Francisco River

This river has one of the least voluminous flows of all of the rivers in the watershed. The bridge has a single opening. The color of the water during our visit was cloudy green-brown, which indicates a low volume of erosion solids upstream. The color of the water is caused largely by the soap used for washing clothes. (See photographs 17 and 18.) According to the SalvaNatura study, average flow in this river during the dry season is 15 l/s, with a drainage area of 14.1 km^2. This river empties into the area surrounding Lake Gamboa. The San Francisco River is one of the smallest rivers in the watershed, but could be considered as a sampling and flow measurement site due to the configuration of the river and the form of the bridge, which lends itself to the construction of a crest that could serve to measure the volume of flow.

All of the above-mentioned sampling sites were sampled during the previous WASH study (1991) and were sampled again in order to compare results in the future. The above-indicated sites are relatively accessible, due to their location along the Coastal Highway. For that reason, it will be relatively easy to measure the flow of these rivers, as the bridges provide a geometric constant that can be used to facilitate calculations.

The El Rosario, El Naranjo, Guayapa, Izcanal, Cara Sucia, and San Francisco rivers were surveyed in April 1993 for the SalvaNatura study. The results of that survey are similar to those obtained by WASH in 1991 and are included in Appendix E.

The above-described surface water sampling program would be a maximum coverage program. A medium coverage program might include half of the proposed sites, and a minimum coverage program might include only a third of the rivers. The choice of a program will depend on the availability of funds.

In the medium coverage program, it would be possible to sample five rivers that would be representative of the entire watershed. The sampling sites proposed for this program are the El Rosario, El Naranjo, Cara Sucia, Aguachapío and Guayapa rivers.

The minimum coverage program would include only the El Rosario, Cara Sucia and Aguachapío rivers.

The costs of these programs are presented at the end of this chapter.

4.2.2 Sampling Sites for Underground Waters

During the course of the previous WASH study, 11 wells were sampled in communities and haciendas located within the watershed. The wells sampled were as follows:

1. Well at Hacienda Cara Sucia

   This well supplies water to the Hacienda Cara Sucia, located on the highway from Cara Sucia to Garita de Palmera.

2. Residential well located near the conduit conveying geothermal effluents and Zanjón La Danta.

3. Well in Guayapa Abajo

   This well is located in the village of Guayapa Abajo next to a wall, along side the highway.

4. Well at Hacienda La Danta

   This well supplies water for the livestock at Hacienda La Danta, located near Zanjón La Danta and the conduit conveying geothermal effluents from the plant at Ahuachapán.

5. Well in the town of Cara Sucia

   This is a residential well that provides water to a family in the town of Cara Sucia on the road to Tacuba.

6. Well in San José El Naranjo

   This is a residential well that provides water to a family in the town of San José El Naranjo on the southern edge of the town.

7. Well at Hacienda Santa Rita

   This well provides water to Hacienda Santa Rita, located near the town of the same name along the Coastal Highway, north of the entrance to San Francisco Menéndez.

8. Well in El Achiotal

   This well provides water to the San Antonio livestock breeding stable in the area of El Achiotal along the road from Santa Rita to El Morral in the village of La Hachadura.

9. Well at Hacienda El Camalote

   This well provides water to Hacienda El Camalote along the Coastal Highway, to the south of Cara Sucia.

10. Well in El Porvenir

    This is a residential well that provides water to a family in the village of El Porvenir near the area where geothermal effluents from Ahuachapán are discharged into the sea.

11. Well in Embarcadero de Guayapa

    This is a residential well that provides water to a family in the village of Embarcadero de Guayapa, located above the Barra de Santiago.

All of these wells showed signs of bacteriological contamination, although some samples indicated the presence of pesticides, especially metamidophos, @BHC and yBHC in Guayapa Abajo, Hacienda La Danta, El Achiotal, Hacienda El Camalote and El Porvenir.

As in the case of surface water, the above-described sampling wells represent a maximum coverage program. A medium coverage program might include only those wells with greatest production, which are those supplying haciendas and stables. These wells are

identified by numbers 1, 4, 7, 8 and 9. The minimum coverage program would include only wells numbers 1, 7 and 9. The costs of these programs are presented at the end of this chapter. Choice of a program will depend on the availability of funds for this monitoring program.

4.3 Parameters for Analysis, Frequency of Sampling and Methodology

4.3.1 Parameters for Analysis

The parameters for analysis can be classified as physical, chemical and bacteriological.

The **physical parameters** of greatest interest are the following:

Odor
Temperature (° C.)
Electric conductivity (mhos/cm)
pH
Turbidity (NTU)
Color
Settleable solids (ml/l)
Suspended solids (mg/l)
Total solids (mg/l)

The **chemical parameters** of greatest interest are as follows:

Dissolved oxygen (mg/l)
Biochemical oxygen demand (BOD) (mg/l)
Chemical oxygen demand (COD) (mg/l)
Nitrogen from nitrates (mg/l)
Organic nitrogen (mg/l)
Ammonium nitrogen (mg/l)
Phosphates (mg/l)
Detergents (mg/l)
Arsenic (mg/l)
Boron (mg/l)
Sodium (mg/l)
Potassium (mg/l)
Organoclorinated compounds (ug/l)
Organophosphorized compounds (ug/l)

Lastly, the **bacteriological parameters** of greatest interest are as follows:
Total coliforms (MPN/100 ml)
Fecal coliforms (MPN/100 ml)

Physical parameters are easier to analyze and accordingly can be performed quickly and frequently. Chemical and bacteriological parameters, however, require considerable time and effort and for this reason cannot be conducted with the same speed or frequency as physical parameters.

After considering a number of different options, we concluded that the most recommendable monitoring program would be one that included some parameters that would be analyzed intensively and others that would be studied with less frequency. Specifically, suspended or settleable solids, which are indicators of erosion in the watershed, should be analyzed intensively in surface waters, especially during rainy season, while fecal coliforms, herbicides, pesticides and metals should be analyzed less frequently.

The sampling sites recommended for surface waters are located along the Coastal Highway at the bridges over the rivers in the watershed. These sampling sites are easily accessible and will allow intensive sampling.

With regard to the monitoring of underground waters, the parameters that should be studied are the contaminants resulting from agricultural and domestic activities, i.e., herbicides, pesticides, fertilizers and fecal coliforms. The sampling sites are located near the places where agricultural activities are performed or, alternately, close to population centers. Some wells are located near the conduit conveying geothermal effluents from Ahuachapán and, in these cases, the analysis should include the boron and arsenic content of the water as well.

4.3.2 Frequency of Sampling

The recommended frequency of sampling for rivers and wells is shown in Table 1. It is proposed that sampling be conducted monthly in wells and rivers with regard to most of the parameters, with the exception of the physical parameters of temperature, turbidity, settleable solids, suspended solids and dissolved oxygen, in which case it is proposed that sampling be performed daily during the rainy season and after every rainfall at other times during the year.

Suspended solids should be analyzed in conjunction with settleable solids until such time as it is possible to determine the correlation that exists between these two parameters. Once this relationship has been established, only settleable solids will be analyzed on a daily basis, while suspended solids will be analyzed monthly.

Table 1

Frequency of Sampling in Rivers and Wells

	RIVERS		WELLS
	Daily[1]	Monthly	Monthly
Physical Parameters			
Odor		X	X
Temperature (° C.)	X		
Conductivity (mhos/cm)		X	X
pH		X	X
Turbidity (FTU)	X		X
Color		X	X
Settleable solids (ml/l)	X		X
Suspended solids (mg/l)	X[2]		
Total solids (mg/l)		X	X
Chemical Parameters			
Dissolved oxygen (mg/l)	X		
BOD (mg/l)		X	
Nitrogen from nitrates (mg/l)		X	X
Organic nitrogen (mg/l)		X	
Ammonium nitrogen (mg/l)		X	
Phosphates (mg/l)		X	X
Detergents (mg/l)		X	
Arsenic (mg/l)		X	X
Boron (mg/l)		X	X
Sodium (mg/l)		X	X
Potassium (mg/l)		X	X
Organoclorinated compounds (ug/l)		X	
Organophosphorized compounds (ug/l)		X	X
Bacteriological Parameters			
Total coliforms (MAN/100 ml)		X	X
Fecal coliforms (MAN/100 ml)		X	X

Notes:

(1) It is proposed that analyses be conducted daily during the rainy season and after every rainfall at other times during the year.

(2) Suspended solids should be analyzed together with settleable solids until such time as it is possible to determine the correlation that exists between these two parameters. Once this relationship has been established, only settleable solids will be analyzed on a daily basis, while suspended solids will be analyzed monthly.

4.4 Measurement of Flow

Measurement of the flow of the rivers should be conducted at the same sampling sites. To this end, a topographic survey should be made of the rivers at the point where they intersect with the bridges, and in one or two cases crests could be built that would make it possible to easily measure flow simply by measuring the height of the water above the crest. In addition, a rain measurement (pluviometric) system will be required in order to correlate precipitation with runoff reaching the rivers. This could, in the future, indicate the amount of flow in the rivers merely by measuring precipitation.

The depth of the water table in the wells should also be measured and information should be gathered with regard to the amount of water pumped, in order to estimate the contaminant load. However, in order to obtain significant information with respect to the water table in the area under study, it would be necessary to take many more measurements than those proposed in the 11 wells, because of the multiple variables that can affect the water table, including soil porosity, the amount of water pumped, the recharge rates, the vegetation in the area, etc. For this reason, measurement of the depth of the water table is not as important, and could be conducted on an intermittent basis.

The meteorology and Hydrology Service (SEMEH) of the Ministry of Agriculture is interested in participating in the PROMESA Project and has submitted proposals for the installation of a hydrometric station, 12 stream gages to be located throughout the watershed, one weather station in El Impossible, two topo-climatic stations, six rain gage stations and three automated stations. The Hydrology Section of SEMEH has offered its services in performing gaging operations in the rivers, taking samples and calculating the sediment loads, while the Meteorology Section has offered to create a meteorological data base if provided with the necessary equipment and training.

4.5 Existing Laboratories and Capacity for Analysis and Sampling

There are several laboratories that have the capacity to conduct most of the analytical and sampling tasks for the project, including the Universidad Católica de Occidente (UNICO) at Santa Ana, which was responsible for the samplings and analyses in the preceding WASH project conducted in 1989.

UNICO does not have the capability to conduct analyses of pesticides or herbicides. These analyses were conducted by CENTA. UNICO is interested in participating in the project by conducting analytical and sampling tasks. CENTA is currently in a period of transition and there is some degree of uncertainty regarding its future.

FUSADES has a brand new laboratory that can perform most of the analyses required, especially those involving pesticides and herbicides.

As a result of the large number of samples to be taken and analyzed, it is recommended that a small field laboratory be installed in the area of the study. Such a laboratory could conduct analyses of settleable solids, suspended solids, pH, dissolved oxygen and conductivity. The Hach Company manufactures field laboratories with the capability to conduct all such analyses with the exception of those involving pesticides and herbicides.

The Environmental Laboratory of the MAG is also interested in participating in the PROMESA Project. In this regard, they have submitted a proposal (Appendix F) for supplying laboratory equipment that would allow them to conduct the analyses required by this and other similar projects to be implemented in other areas of the country in the future. However, difficulties with respect to the transportation of samples make this idea somewhat impractical.

4.6 Sampling and Analysis Costs

The costs of the analyses conducted by UNICO and FUSADES are presented in Appendix F.

The cost of the analyses to be conducted by CENTA per element of herbicide and pesticide is C/415. This does not include sampling, which would have to be contracted out separately.

FUSADES's cost of sampling is C/500 per four-hour visit to the sampling site. This does not include the cost of the analyses to be conducted.

The team analyzed three sampling and analysis options for the monitoring program.

- Option 1 involves contracting UNICO and FUSADES to conduct the sampling and analysis required by the program.
- Option 2 involves installing a field laboratory and contracting a laboratory/chemical technician to conduct the required sampling and analysis. Analysis of pesticides and herbicides would by conducted by the FUSADES laboratory.
- Option 3 involves the participation of UNICO students.

These three options are detailed below. Table 2 presents a summary of the annual costs for each of the options and Table 3 contains budgets for the first three years of the program.

Option 1. Sampling and Analysis Contracts with UNICO and FUSADES

The sampling and analysis costs that would be incurred if UNICO and FUSADES were contracted under the various sampling programs are shown in Table 2. These costs include sampling costs, which were calculated at an average of C/500 per day.

Approximately 60 percent of the costs of analyzing surface waters and 85 percent of the costs of analyzing underground waters are for analyzing herbicides and pesticides. For this reason, it will be necessary to determine, during the first year of monitoring, whether such analyses should continue. If the results consistently indicate that no such contaminants are detected, then these analyses would cease to be conducted on a monthly basis during the second year and rather take place only sporadically and when circumstances warranted.

Option 2. Minilab with Personnel Contracted for the Project

As indicated above, one option would be to consider the possibility of installing a field laboratory in the area of the study. This would require personnel to conduct the sampling and perform the analyses.

The approximate cost of the laboratory equipment is C/175,000. Additional costs in this case would include the laboratory technician, who would also take the samples, and the cost of reagents. The laboratory technician should be a specialist in chemistry living in the area of the study. The costs of this option include C/175,000 for the purchase of a vehicle to conduct sampling activities. These equipment purchase costs are included in the annual costs, and are amortized at a rate of 10 percent over a period of six years.

The annual costs of the laboratory technician and reagents will vary in accordance with the coverage of the program. They include a full-time technician in all cases, with the variable being the amount of reagents required.

Option 3. Participation of UNICO Students in the Project

UNICO students could participate in the project while writing their theses. It is possible that the sampling costs under Option 1 could be reduced if such participation could be ensured. Under the assumption that the students would provide their labor free of charge, sampling costs would be reduced to the cost of transporting the samples.

From a practical standpoint, it is unlikely that student participation can be obtained on a continuous, daily basis for the entire six years of the project. Daily collection of samples of surface water would have to be done by an individual contracted by the project in order to be certain that the samples would be taken and analyzed continuously and without interruption. The monthly samples could probably be entrusted to the students. For this reason, the savings in sampling costs that could be generated as a result of the participation of UNICO students are not considered to be significant. The costs of this option are not included in Table 2.

Table 3 presents the budgets for the first three years of the monitoring program. Although the costs of analyzing pesticides and herbicides are included in the first year budget, they are not included in the second year budget, under the assumption that such analyses will be conducted only during the first year. In Option 2, the budget for the first year includes the costs of purchasing the laboratory and vehicle. The costs for the third year are the same as those for the second year.

Table 2

Annual Sampling and Analysis Costs

(Colones)

	Maximum Coverage		Medium Coverage		Minimum Coverage	
Rivers	Sampling	Analysis	Sampling	Analysis	Sampling	Analysis
Option 1						
Routine	170,000	236,000	92,000	133,000	54,000	78,000
Pesticides	6,000	288,000	5,000	160,000	3,000	95,000
Subtotal	176,000	524,000	97,000	293,000	57,000	173,000
Total		700,000		390,000		230,000
Option 2						
Routine	24,000	139,000	19,000	125,000	14,000	121,000
Pesticides	6,000	288,000	5,000	160,000	3,000	95,000
Subtotal	30,000	427,000	24,000	285,000	17,000	216,000
Total		457,000		309,000		233,000
Wells						
Option 1						
Routine	3,000	47,000	2,500	20,000	2,000	9,000
Pesticides	3,000	262,000	2,500	120,000	2,000	72,000
Subtotal	6,000	309,000	5,000	140,000	4,000	81,000
Total		315,000		145,000		85,000
Option 2						
Routine	1,000	6,000	700	5,000	500	4,000
Pesticides	3,000	262,000	2,500	120,000	2,000	72,000
Subtotal	4,000	268,000	3,200	125,000	2,500	76,000
Total		272,000		128,200		78,500
Total Rivers and Wells						
Option 1		1,015,000		535,000		315,000
Option 2		729,000		437,200		311,500

Table 3

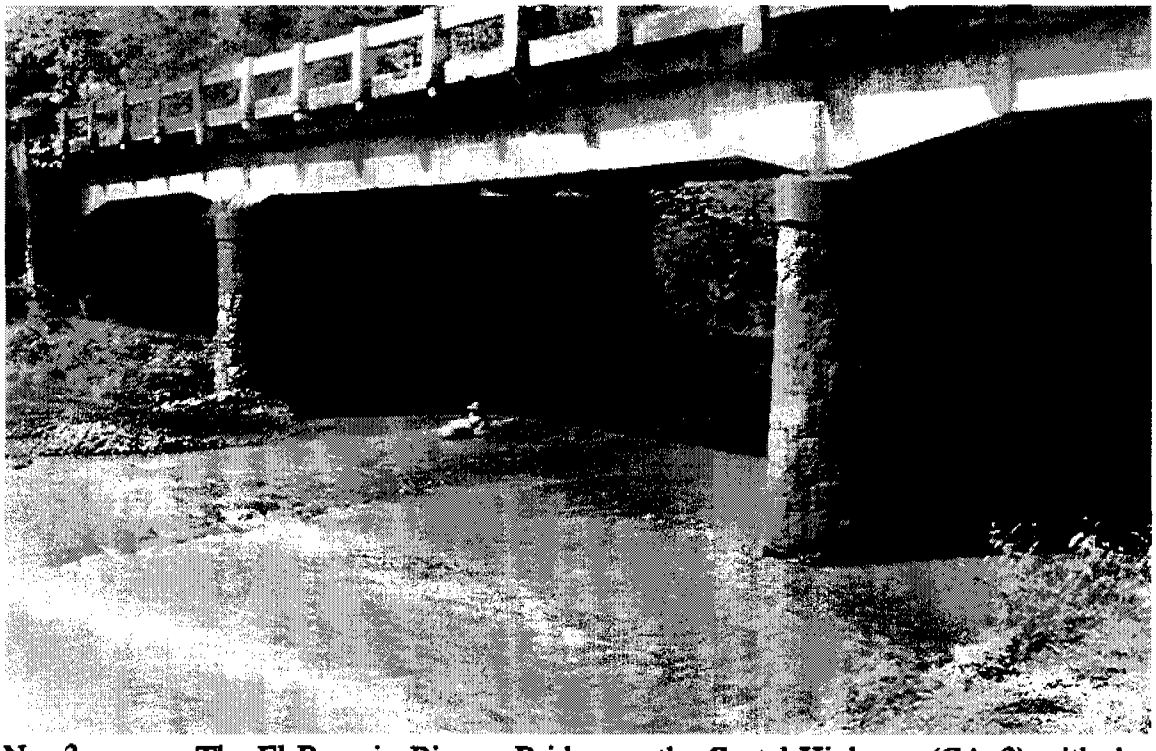
Sampling and Analysis Budgets

(Colones)

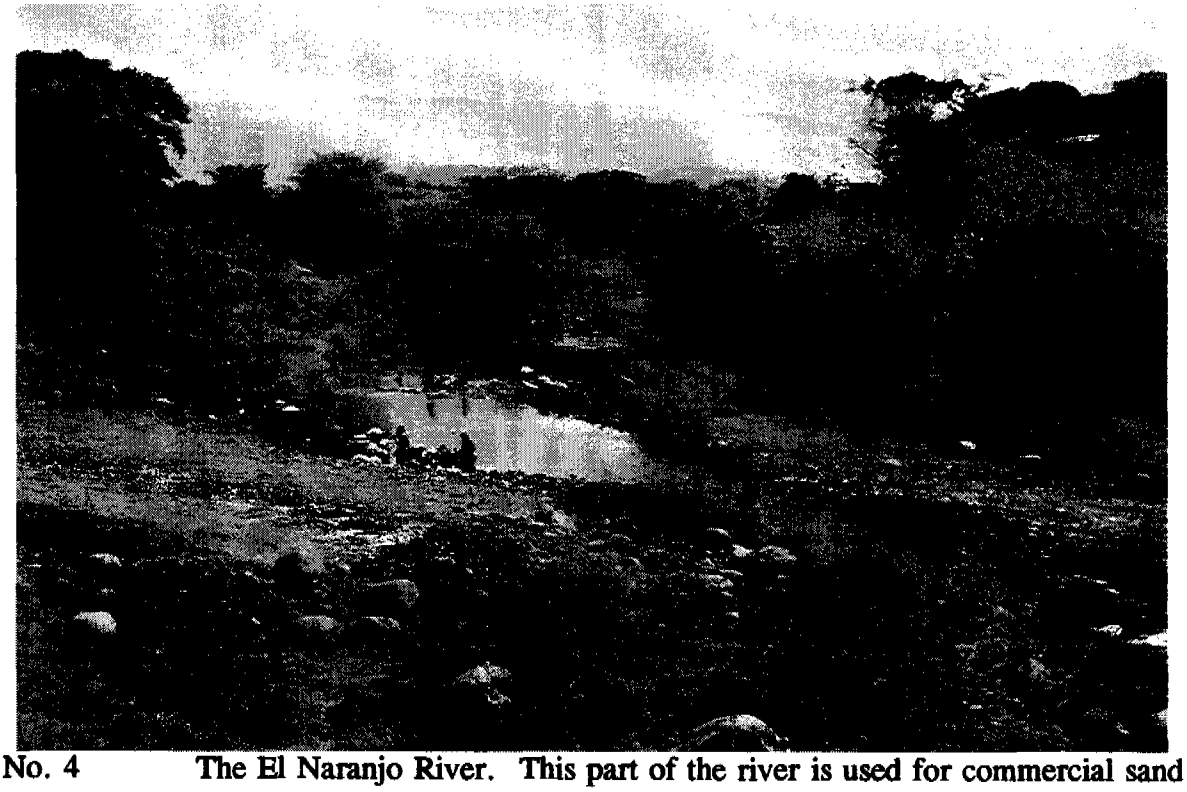
	Maximum Coverage	Medium Coverage	Minimum Coverage
First Year			
Option 1	1,015,000	535,000	415,000
Option 2	999,000	707,000	582,000
Second Year			
Option 1	456,000	248,000	143,000
Option 2	90,000	70,000	60,000
Third Year			
Option 1	456,000	248,000	143,000
Option 2	90,000	70,000	60,000

No. 1 The El Rosario River

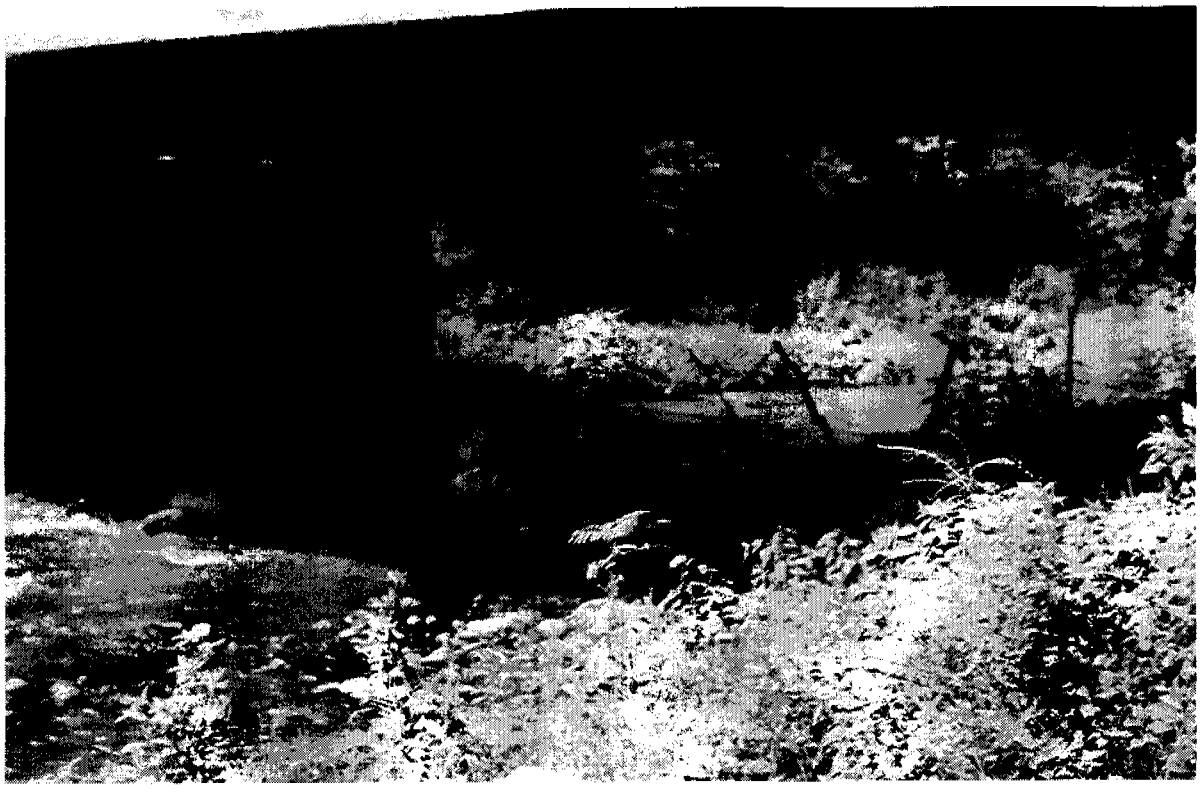
No. 2 Bridge on the Costal Highway (CA–2) over the El Rosario River.



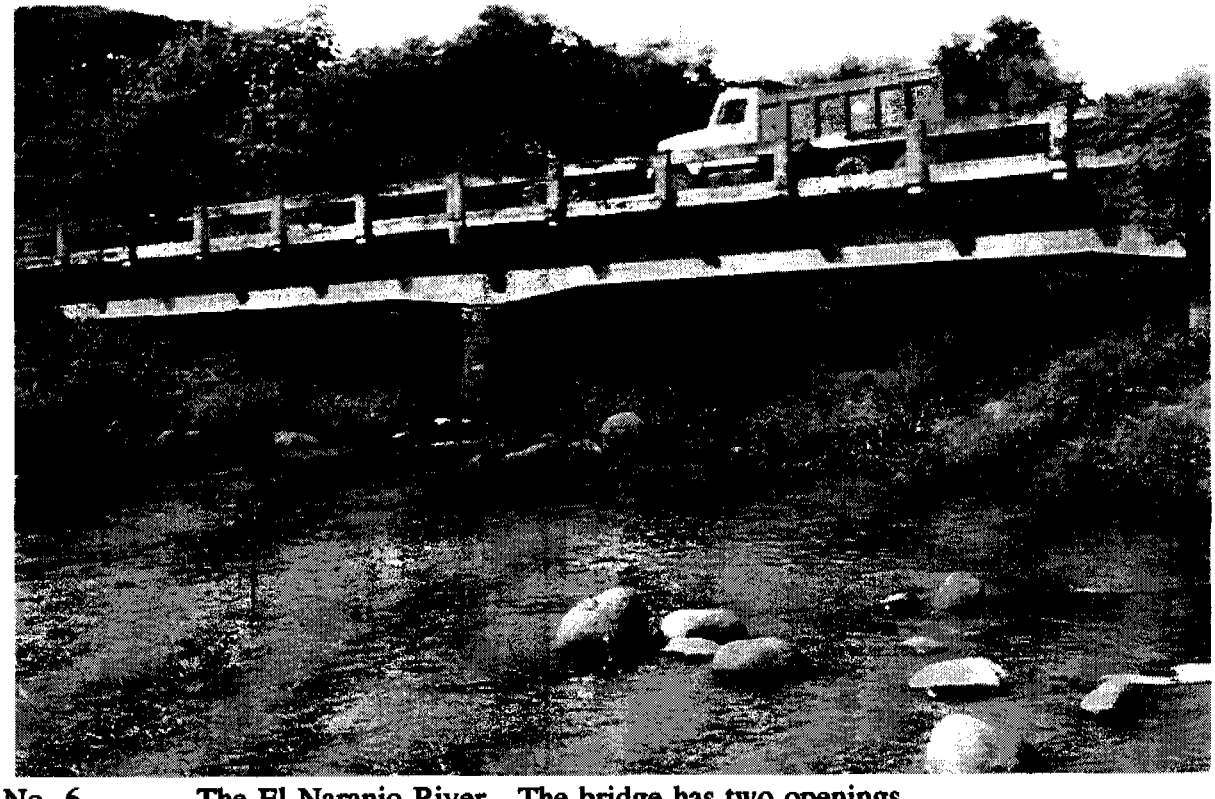
No. 3 The El Rosario River. Bridge on the Costal Highway (CA-2) with three openings. This river is the largest in the watershed.



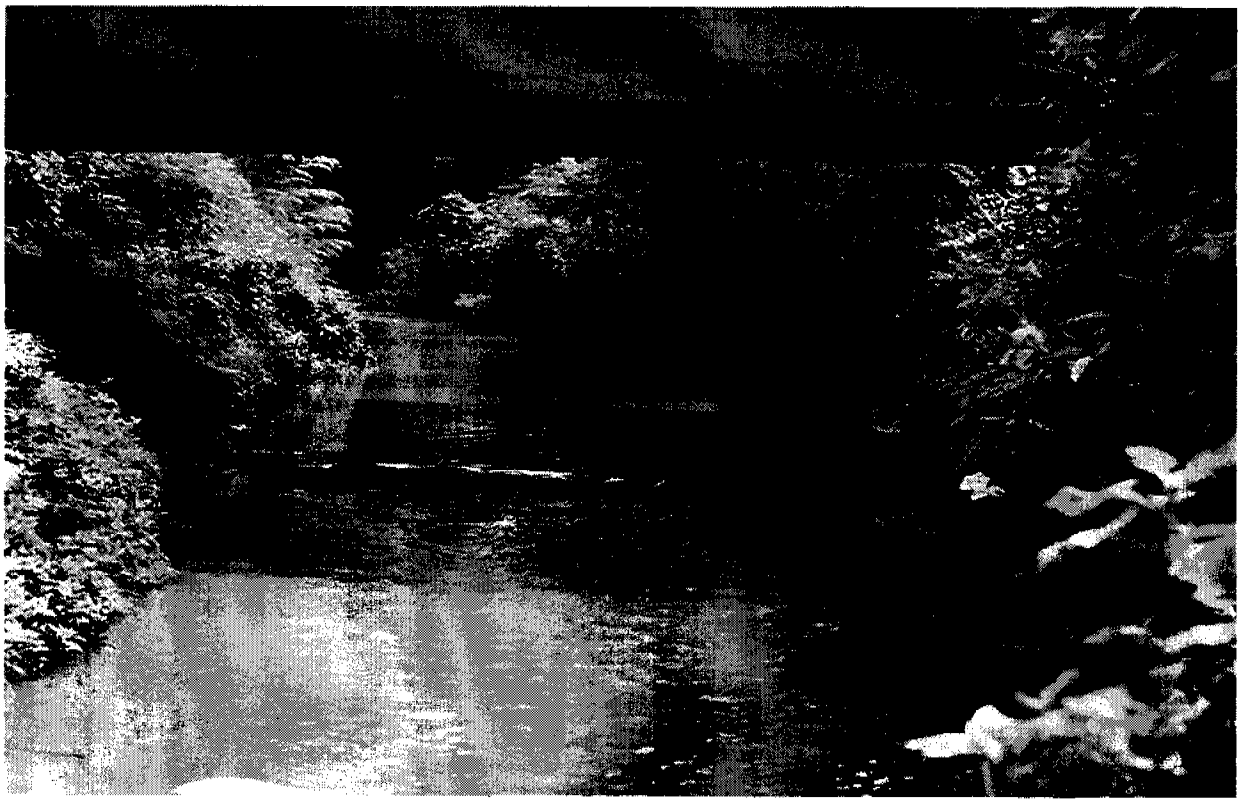
No. 4 The El Naranjo River. This part of the river is used for commercial sand extraction, which is performed manually, and for washing clothes.



No. 5 Bridge on the Costal Highway (CA-2) over the El Naranjo River. This river is one of the medium-sized rivers in the watershed.

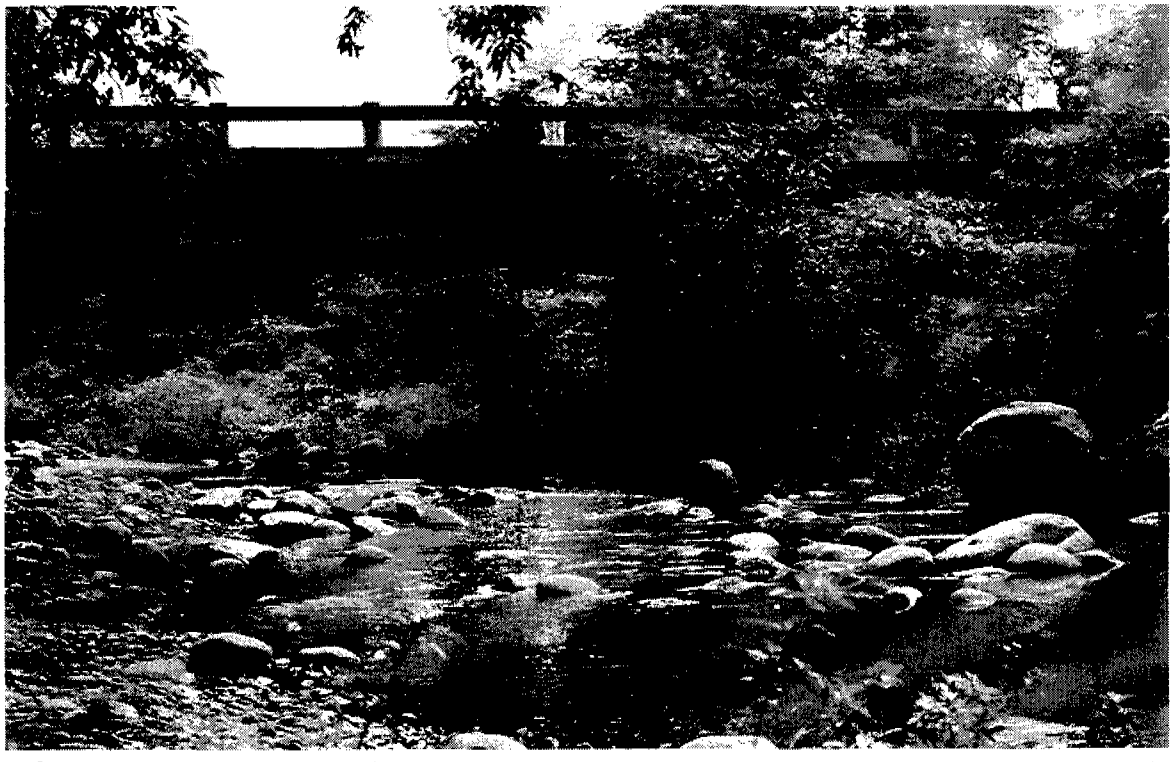


No. 6 The El Naranjo River. The bridge has two openings.

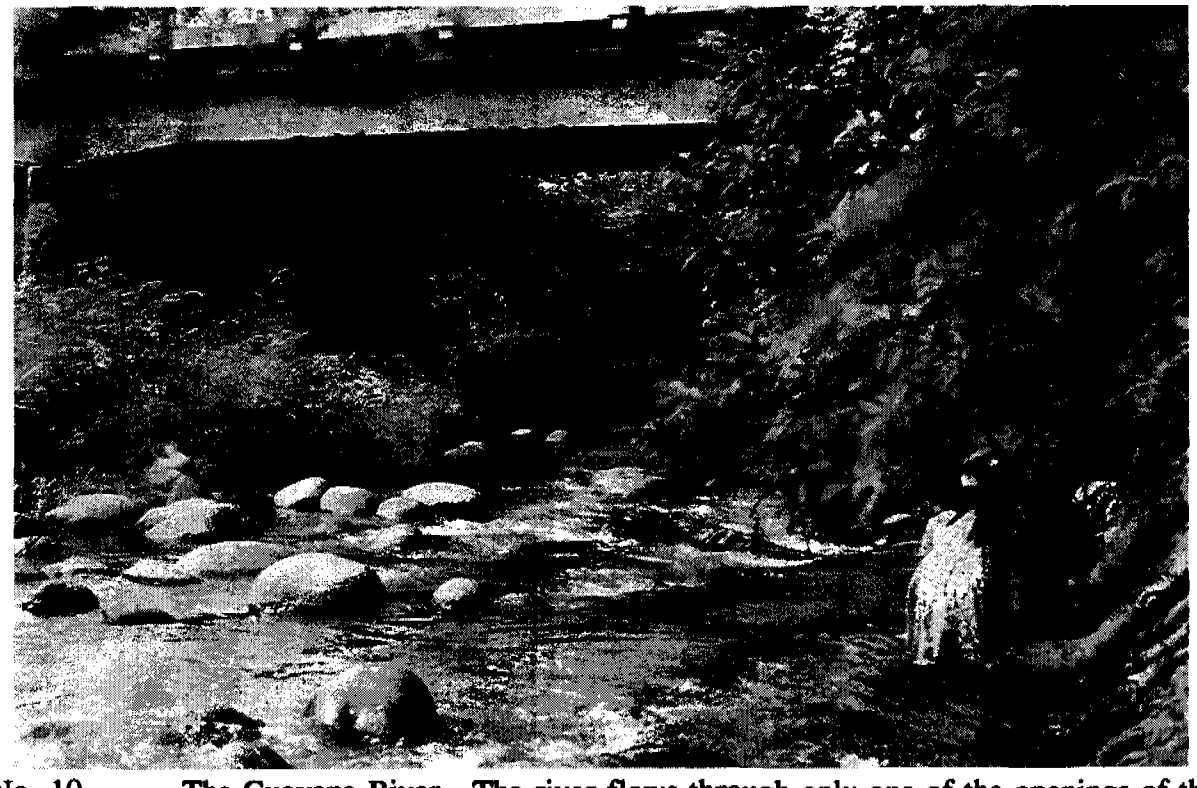


No. 7 Bridge on the Costal Highway (CA-2) over the Cuilapa River. The bridge has a single opening, and water flow is average. This part of the river is used for washing clothes.

No. 8 Bridge on the Costal Highway (CA-2) over the Guayapa River, which is the second largest river in the watershed.



No. 9 The Guayapa River. The bridge has two openings, one of which is completely obstructed.

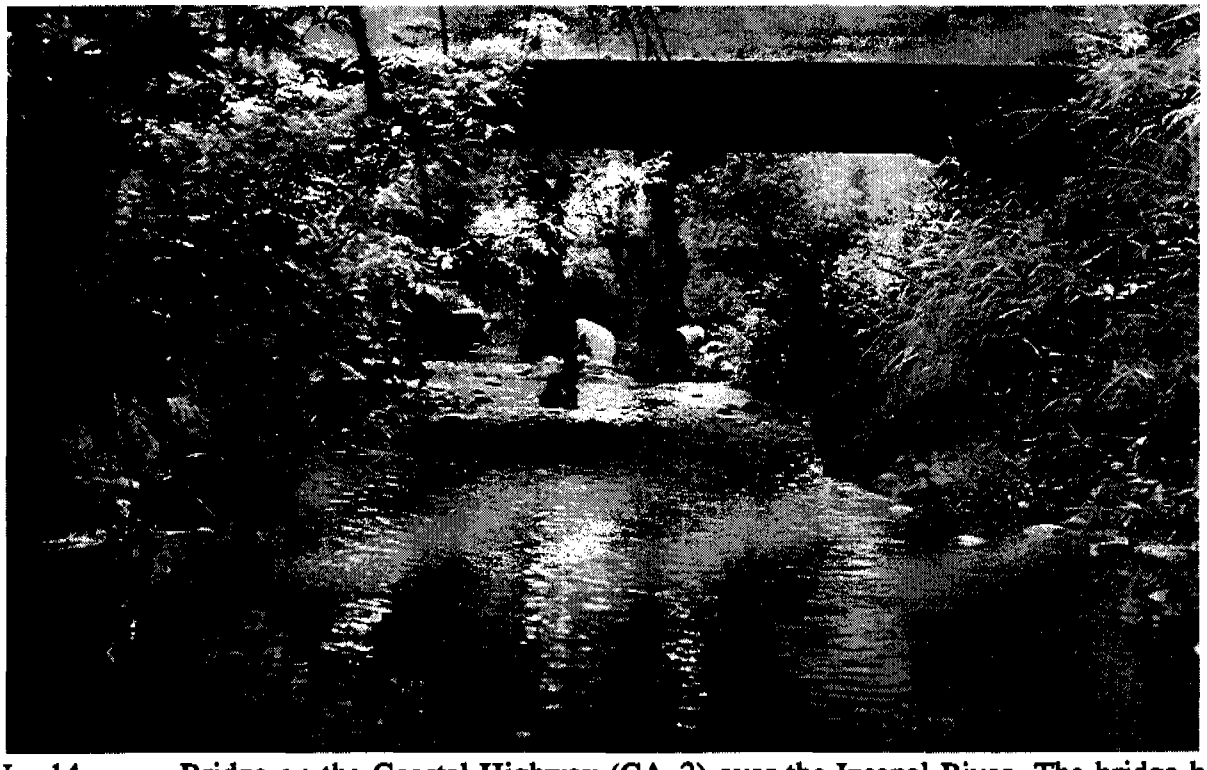


No. 10 The Guayapa River. The river flows through only one of the openings of the bridge. This part of the river is used by local residents for washing clothes.

No. 11 The Aguachapío River. The bridge has only one opening. This river has the least flow of all the rivers in the watershed.

No. 12 The Aguachapío River. The color of the water is produced by the soap used for washing clothes.

No. 13 Upstream on the Aguachapío River, coming back from El Impossible. As can be observed, the river water was clean and clear. This is one of the smallest rivers in the watershed.



No. 14 Bridge on the Coastal Highway (CA-2) over the Izcanal River. The bridge had only one opening, and the river is one of the smallest in the watershed.

No. 15 Bridge on the Coastal Highway (CA-2) over the Cara Sucia River. The bridge has two openings.

No. 16 The Cara Sucia River. This river is contaminated by agricultural and domestic effluents discharged upstream.

No. 17 The Cara Sucia River is contaminated by solid waste and domestic sewage.

No. 18 The La Palma River. The bridge has only one opening. Water flow is average among the rivers in the watershed. The color of the water is produced by the soap used for washing clothes.

No. 19 The San Francisco River. The bridge has only one opening. This river has one of the smallest flows of all the rivers in the watershed.

No. 20 **The San Francisco River is one of the smallest in the smallest in the watershed. The color of the river is produced primarily by the soap used for washing clothes.**

Chapter 5

CASE STUDY

5.1 Data Available for the Case

The WASH team traveled to the study site and interviewed the Chief of the Agricultural Extension Agency in Cara Sucia, who indicated that the primary causes of contamination in the area are discharge from stables, the indiscriminate use of fertilizers and herbicides (Gramoxone, Paraquat) and pesticides by small farmers (most of whom worked between 1 acre and 10 acres of land), and poor agricultural practices (use of slash and burn techniques and lack of soil conservation measures). The area of jurisdiction of the extension agency is virtually the same as the area included in the watershed, and as a result it would be most beneficial for the PROMESA Project to closely coordinate its efforts with those of the agency, which is extremely interested in collaborating with the project.

The Chief of the Agency mentioned the case of the stables at Rancho Los Dos, which are polluting the Cara Sucia River, upstream from the village of Cara Sucia. We were informed that the Health Unit had a file containing background information.

The Cara Sucia Health Unit, through the Environmental Sanitation inspectors stationed at Cara Sucia, keeps a file on the problem, which was reported by the community following contamination of the waters of the Cara Sucia River by runoff from the stables at Rancho Los Dos.

5.2 Analysis of Data

In 1991, the Health Center took 10 water samples that were analyzed for bacteriological contamination. Seven of these samples taken downstream from Rancho Los Dos indicated the presence of bacterial contamination, while the three remaining samples, taken upstream from the Rancho Los Dos discharge, gave negative results.

5.3 Sources of Contamination

The sources of the contamination generated at Rancho Los Dos include two sources of continuous discharge and one intermittent discharge that occurs every time it rains. (See photographs 21, 22 and 23.) The continuous discharges come from the overflow of the livestock water troughs and from the water used to wash out the stables. The intermittent discharge comes from the contaminated runoff produced when rain water falls in the corral area and is washed into the river. The continuous discharges take place though a pasture

area, whereas the intermittent discharge drains directly into the river. In addition, there are no sanitary facilities at the stable or drinking water for the workers (an average of 15).

5.4 Alternatives for Eliminating Contamination That the PROMESA Project Could Implement

The contamination problems generated by the stables can be classified in accordance with the following categories:

- Wastewater management
- Management of the water used in the stable
- Rain water management

The lack of sanitary facilities for use by the workers creates a problem with fecal contamination in the area. As an initial step, latrines should be provided in appropriate areas for use by the workers. Such latrines should be of the simple pit type or compost latrines, depending on the level of the water table in the area.

Management of water in these stables is inefficient. The stables draw more water from the river than they need upstream and then proceed to discharge it after it becomes contaminated on its way through the stables, through the adjacent pasture land and, ultimately, into the river. A more efficient use of water, so as to prevent it from overflowing from the drinking troughs, would serve to prevent contamination.

Rain water management is another problem. A major portion of the stables are exposed to the elements and located on sloping terrain, such that when it rains the rain water washes the manure from the stables into the river. The obvious solution to this problem would involve covering the stables in such a way that rain water were no longer contaminated and cleaning out the stables using a "dry" method.

The solution adopted by the ranch has been to built a trap for solid materials in the drainage ditch that drains toward the pasture land. This will remove only the heaviest solids, but is not effective in removing small-sized solids, bacteria and dissolved contaminants.

5.5 General Recommendation

Generally speaking, the proper management of water used for agricultural activities and the precautions that should be taken to prevent contamination of rain water can produce much more satisfactory results than treatment of the contaminated waters, and at a much lower

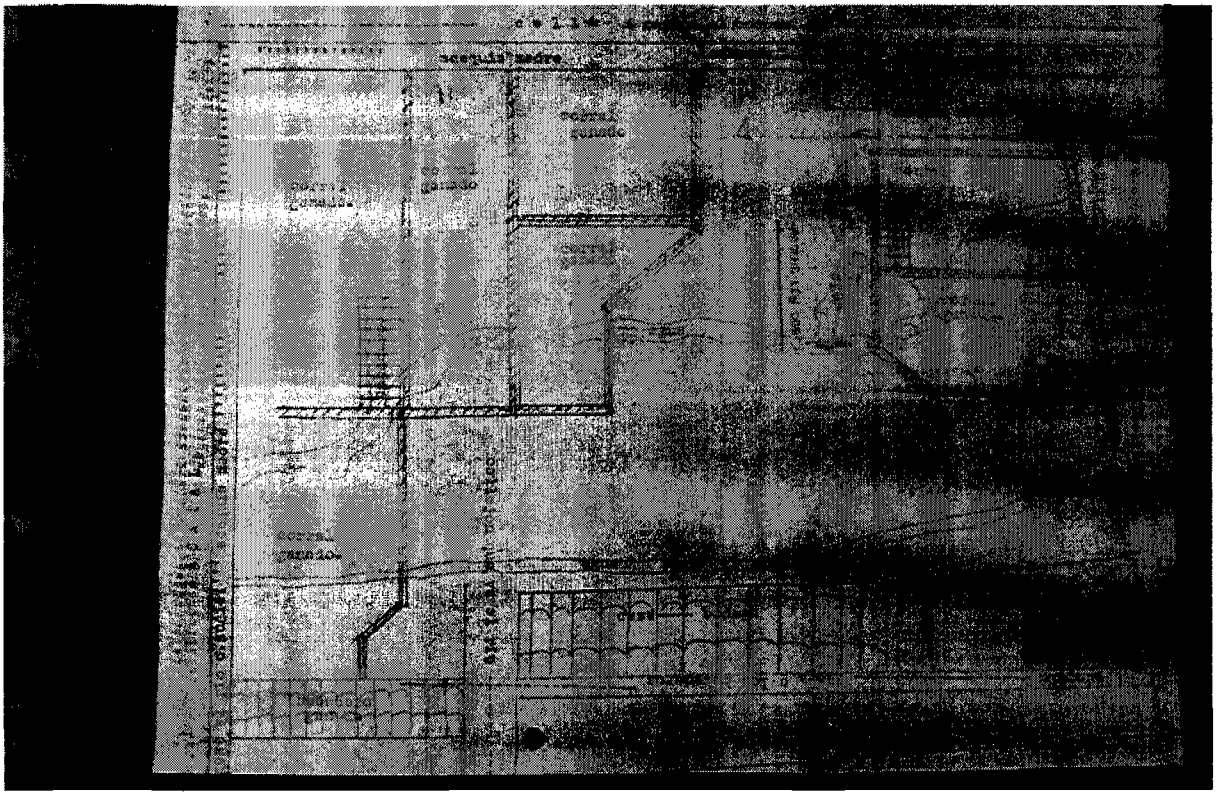
cost. With respect to the specific case of stables, the following recommendations are submitted:

- Latrines should be installed in appropriate areas for use by workers. Such latrines could be of the simple pit or compost type, depending on the level of the water table in the area.

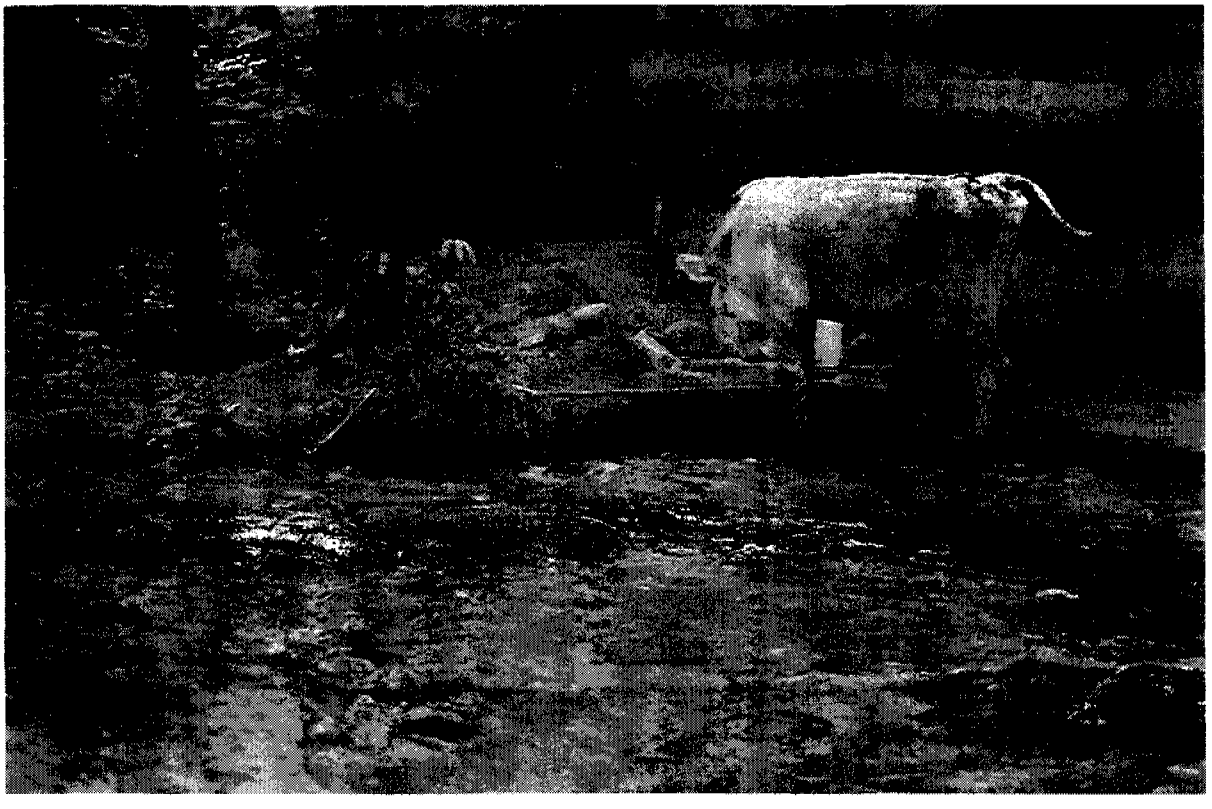
- Steps should be taken to minimize the amount of water used for drinking troughs and for cleaning, and unnecessary contamination should be prevented.

- Steps should be taken to prevent contamination of the rain water falling on the stables. A large portion of the stables are exposed to the elements and located on sloping terrain, with the result that the rain water washes the manure from the stables toward rivers or other surface water flows. A roof should be placed on the stables to prevent rain water from becoming contaminated. The stables should be cleaned using a "dry" method.

- The manure should be stored in appropriate areas so as not to generate problems involving contamination of rain water. The storage areas should be located at a distance from water flows, on level ground. The manure can be used for fertilizer and its final disposal should take place promptly.



No. 21 Schematic drawing of the stable at Rancho Los Dos, in Cara Sucia.



No. 22 Photograph of the watering trough at the stable in Rancho Los Dos.

No. 23 Photograph of the drainage ditch at Rancho Los Dos.

Chapter 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

- The results of the study of the pollution of surface and underground water conducted by WASH in 1991 identified the existence of pervasive fecal contamination throughout the sampled area. It was concluded that rivers contained high concentrations of biological oxygen demand and ammonium and low concentrations of dissolved oxygen.

- It was also determined that, with the exception of metamidophos (Tamaron), concentrations of pesticides and herbicides were low. Also, high concentrations of boron and arsenic were detected in the soil in the area adjacent to the canal conveying wastewater from the geothermal plant at Ahuachapán.

- Subsequently, in April 1993, SalvaNatura conducted a sampling survey in the area that produced results similar to those generated by the WASH study.

- The primary activities polluting the water resources in the area involve wastewater disposal and washing of clothes in the rivers, domestic activities such as livestock raising and agriculture, and geothermal effluents from the plant at Ahuachapán.

- The Ministry of Health conducted a national level inventory of industrial and agroindustrial runoff. The results of the inventory for the area in question indicated that most runoff is agroindustrial in nature.

- With the exception of the study conducted by WASH in 1991, which covers a limited period of sampling and analysis, and the sampling survey carried out by SalvaNatura in April 1993, to date no systematic study has been conducted of the contamination of water, soil and fauna in the watershed.

- The appropriate management of the water used for agricultural activities and the precautions that should be taken to avoid contamination of rain water can produce much more satisfactory results than treatment of the contaminated water, and at a much lower cost.

- According to the Chief of the Agricultural Extension Agency in Cara Sucia, the primary causes of contamination in the area are the discharge of effluents from livestock stables; the indiscriminate use of fertilizers, herbicides (Gramoxone,

Paraquat) and pesticides by small farmers (most of which worked between 1 acre and 10 acres of land); and poor agricultural practices (slash and burn techniques and failure to use soil conservation techniques).

6.2 Recommendations

- The WASH team conducted two visits to the area to identify convenient sampling sites. Although the time available for this assignment did not allow the team to tour the most important rivers, a reconnaissance activity should be conducted during the initial stages of the PROMESA Project. Such an activity would include information about the river's wooded edges, sources of contamination, and other data of interest that could be plotted on a map of the watershed.

- The area of jurisdiction of the extension agency is virtually the same as the area included in the watershed, and as a result it would be most beneficial for the PROMESA Project to closely coordinate its efforts with those of the agency, which is extremely interested in collaborating with the project.

- The program for sampling surface water includes the following nine rivers: El Rosario, El Naranjo, Cuilapa, Guayapa, Aguachapío, Izcanal, Cara Sucia, La Palma and San Francisco. This would be the maximum coverage program, whereas a medium coverage program might include half of the proposed sites and a program to provide minimum coverage might include only a third of the above rivers. Choice of a program will depend on the availability of funds.

- In the medium coverage program, it would be possible to sample five rivers that are representative of the entire watershed. Sampling sites located on the following rivers are proposed for such a program: El Rosario, El Naranjo, Cara Sucia, Aguachapío and Guayapa.

- The minimum coverage program would include only the El Rosario, Cara Sucia and Aguachapío rivers.

- The program for sampling underground water includes the following 11 wells: Hacienda Cara Sucia, the village located near Zanjón La Danta, the village of Guayapa Abajo, Hacienda La Danta, the town of Cara Sucia, the town of San José, El Naranjo, Hacienda Santa Rita, El Achiotal, Hacienda El Camalote, the village of El Porvenir and the village of Embarcadero de Guayapa. As is the case with surface water, the above-mentioned sampling wells would be included in a program designed to achieve maximum coverage.

- A program for achieving medium coverage might include only those wells with the greatest production, which are those serving ranches and stables. These would be the

wells located at Hacienda Cara Sucia, Hacienda La Danta, Hacienda Santa Rita, El Achiotal and Hacienda El Camalote.

- A minimum coverage program might include only the following three wells: Hacienda Cara Sucia, Hacienda Santa Rita and Hacienda El Camalote. Choice of program will depend on the availability of funds for such a monitoring program.

- It is recommended that analyses be conducted of the following parameters:

  - Physical parameters: odor, temperature, electric conductivity, pH, turbidity, color, settleable solids, suspended solids and total solids.

  - Chemical parameters: dissolved oxygen, biochemical oxygen demand (BOD), nitrogen from nitrates, organic nitrogen, ammonium nitrogen, phosphates, detergents, arsenic, boron, sodium, potassium, organochlorinated compounds and organophosphorized compounds.

  - Bacteriological parameters: total coliforms and fecal coliforms.

- After considering a number of different options, we concluded that the most recommendable monitoring program would be one that analyzed certain parameters intensively and others with a lesser degree of frequency. Specifically, suspended or settleable solids, which are indicators of erosion in the watershed, should be analyzed intensively in surface water, particularly during the rainy season, whereas fecal coliforms, herbicides, pesticides and metals could be analyzed on a monthly basis.

- With regard to the monitoring of underground water, the parameters to be studied would consist of contaminants resulting from agricultural and domestic activities, i.e., herbicides, pesticides, fertilizers and fecal coliforms. Sampling sites would be located close to areas where agricultural activities are carried out, or else close to population centers. Some of the wells are located near the conduit that conveys geothermal effluents from the plant at Ahuachapán and may possibly be contaminated by boron and arsenic.

- The recommended sampling frequency for rivers and wells is monthly for the large majority of parameters, except for the physical parameters of temperature, turbidity, settleable solids, suspended solids and dissolved oxygen in the rivers, which we propose be sampled daily during the rainy season and after every rainfall in other periods during the year.

- Suspended solids will be analyzed together with settleable solids until such time as a correlation can be established between these two parameters. Once such a correlation has been established, settleable solids will be analyzed on a daily basis, while suspended solids will be analyzed monthly.

- As a result of the large number of samples to be taken and analyzed, we recommend that a small field laboratory be set up in the area of the study. Such a laboratory could conduct analyses of settleable solids, suspended solids, pH, dissolved oxygen and conductivity. The Hach Company manufactures field laboratories that can perform all necessary analyses, with the exception of pesticides and herbicides. The approximate cost of such laboratory equipment is C/175,000.

- Approximately 65 percent of the costs of analyzing surface water and 85 percent of the costs of analyzing underground water represent the cost of analyzing herbicides and pesticides. Accordingly, a determination will need to be made, during the first year of monitoring, as to whether such analyses should continue. If the results consistently indicate that no such contaminants are detected, then these analyses would cease to be conducted on a monthly basis; rather, they would be carried out intermittently as well as when circumstances warrant.

- As indicated previously, it is recommended that a field laboratory be set up in the study area. This would require personnel to perform the sampling and analytical work. Students from the UNICO could participate in the project while writing their theses. It is possible that sampling and analysis costs could be reduced if such participation were to materialize.

- Generally speaking, the appropriate management of the water used for agricultural purposes and the precautions that need to be taken to avoid contaminated rain water can produce much more satisfactory results than the treatment of the polluted water, and at a much lower cost. Specifically with regard to the case of stables, the following recommendations are submitted:

    - Latrines should be provided in appropriate areas for use by workers. Such latrines could be of the simple pit type or compost latrines, depending on the level of the water table in the area.

    - The amount of water used to supply livestock drinking troughs and to clean stables should be minimized, and unnecessary contamination should be avoided.

    - Steps should be taken to avoid the contamination of rain water falling on the stables. Many of the stables are fully exposed and located on sloping land, such that the rain washes large quantities of manure from the stables into rivers or other surface water flows. Stables should be built with roofs to prevent rain water from being contaminated. The task of cleaning the stables should be done using "dry" methods.

    - Manure should be stored in appropriate areas that will not create problems with regard to rain water contamination. These storage areas should be located far from water flows, on level land. The manure can be used as fertilizer and its final disposition should be determined promptly.

APPENDIX A

REFERENCES

U.S. Agency for International Development. 1985. El Salvador, Environmental Profile, Field Study. San Salvador: EMTESCA de C. V.

U.S. Agency for International Development. 1989. Environmental and Natural Resource Management in Central America.

U.S. Agency for International Development. 1985. Environmental Profile for El Salvador.

Van Der Leedn, F., F. Troise and D. Todd. 1990. The Water Encyclopedia. Second Edition. Michigan: Lewis Publishers.

L. Fernando Requena and Becky A. Myton. 1991. WASH Field Report No. 354. Contaminación de las aguas superficiales y subterráneas en determinadas cuencas de la región sudoccidental de El Salvador. Arlington, Va.: WASH Project

SalvaNatura-USAID. July 1993. Biodiversidad y Ecología de la Cuenca de la Barra de Santiago-El Imposible.

APPENDIX B

SUMMARY OF INTERVIEWS AND FIELD TRIPS

1. Members of the Staff of the USAID Mission Interviewed

- Peter Gore
- Rodolfo Cristales

2. Laboratories Visited

Laboratory	Individual Visited	Capability
FUSADES Urbanización y Blvd. Santa Elena Antiguo Cuscatlán La Libertad 78-90-64	Ricardo Molina	Erosion parameters; physical, chemical and biological analysis of water. Analyses of all types (has available atomic absorption equipment and can provide sampling service and technical assistance for interpretation of results. Will be operating at full capacity within three weeks).
UNICO, 1a. Calle Poniente, Santa Ana 41-3217 40-8785	José Antonio Puig	Routine, chemical and microbiological analyses (they worked hard taking field samples with the WASH team under Task No. 354).
CENTA, Km. 33, Carretera a Santa Ana 38-4266	Luis Antonio Reyes and Rogelina Cárdenas	Analysis of pesticides and herbicides.

Of the laboratories visited having the capability to perform routine chemical analyses, the UNICO laboratory was selected. For all other types of analysis, the FUSADES laboratory will be used as a result of its considerable physical capacity and specialized staff.

It is recommended that a small field laboratory be set up at the site in order to conduct periodic samplings, such as measurement of solids, which indicate the presence of materials carried downstream by precipitation, and others such as BOD and COD.

3. Other Interviews

A. Administración Nacional de Acueductos y Alcantarillados (ANDA)

- Ing. Atilio Avendaño, Director of UEDA/ANDA

- Ing. Ana Elsa de Irula, UEDA Technician
- Ing. Manuel Merlos, in charge of the ANDA Data Bank on Water Quality. He has available chemical and microbiological information regarding the primary rivers and wells as well as regarding the contamination of water used for irrigation.
- Ing. Francisco Ortiz, Head of the Department of Sanitary Control at ANDA
- Lic. Magdalena de Aguilar, Head of the laboratory at ANDA
- Mr. Jorge Acosta and Mr. Jaime Pinel, technicians with the Department of Hydrology at ANDA. They have available information on hydrological studies and wells for certain areas of the country.
- Lic. Jorge Alberto Menjívar, Manager of the ANDA/AID Project

B. Ministry of Public Health and Social Welfare (MOH)

- Dr. Santiago Almeida, epidemiologist with the MOH, has available information on the Cholera Case Control Study conducted for Cara Sucia.

- National Rural Basic Sanitation Plan (PLANSABAR)
  Lic. Simón Tadeo Aguillón, in charge of the laboratory at PLANSABAR, has available information on analyses of water in aqueducts conducted by PLANSABAR.

- Ing. Patricia de Segurado, Chief of the Department of Environmental Sanitation, provided information on water resource contamination sites, based on 1993 data.

- Ing. Luis Ernesto Cuestas and Lic. Angel Reyes Tani, from the Western Region of the Office of Environmental Sanitation of the MOH.

C. Pan American Health Organization (PAHO) in El Salvador

- Dr. Hugo Villegas, PAHO Representative in El Salvador
- Dr. Angel Valenzia, PAHO Epidemiologist

D. Lempa River Hydroelectric Commission (CEL)

- Ing. Carlos Escobar Bruno, Head of the Laboratory at CEL
- Ing. José Orlando Argueta Lazo, Superintendency of Environmental Control at CEL

E. Meeting at AID

- Peter Gore (AID)
- Rodolfo Cristales (AID)
- Eric D. Fajer (AID/Washington)

- José Rosa (OSPA)
- Jaime Arce, Head of the Department of Hydrology, CENREN/MAG
- Leonardo Merlos, Head of the Meteorology and Hydrology Service, CENREN/MAG
- Carlos Humberto Salazar, Head of Climatology and Agrometereology, CENREN/MAG
- Nelson Martínez, Environmental Laboratory, MAG
- Fernando Requena
- Emilia de Quintanilla

The purpose of this meeting was to present and discuss the monitoring program, the creation of a project coordinating unit, and proposed action plans for government agencies with regard to their involvement in the PROMESA Project, including the areas of hydrology, meteorology, climatology and agrometereology, as well as water and soil laboratories.

4. Field Trips

A. July 23, 1993

Participants: Fernando Requena
Emilia de Quintanilla

Sites visited: Santa Ana
San Andrés

A visit was made to the laboratory at the Universidad Católica de Occidente (UNICO). A review was made of the results of the analyses of settleable solids conducted for the previous report. These were made available to us by the Regional Office of the MOH Department Environmental Sanitation located in Santa Ana. In the afternoon, a visit was made to the laboratory at CENTA, which is currently in a process of transition following notification of its autonomy and a reevaluation of its entire staff.

B. July 24, 1993

Participants: Peter Gore
Eric D. Fajer
Emilia de Quintanilla
Fernando Requena

Sites visited: El Imposible Forest
Barra de Santiago

A visit was made to El Imposible Forest, and the consultants toured the site. A number of different stations were visited to verify altitude and conduct a reconnaissance of the drainage areas of the rivers. In the afternoon, a trip was made to the Barra de Santiago where we visited a turtle breeding project, which was built by school children and other local residents.

In this regard, it should be mentioned that when the turtles hatch, they are returned to the sea to ensure their survival.

C. July 28, 1993

Participants: Fernando Requena
Emilia de Quintanilla

Sites visited: Cara Sucia
San Francisco Menéndez

Interviews:

Ing. César R. Guerrero, Chief of the Agricultural Extension Agency in Cara Sucia. The subjects covered were the primary causes of contamination in the area. In this regard, the primary causes mentioned were livestock stables; the indiscriminate use of fertilizers, herbicides (Gramoxone, Paraquat) and pesticides by small farmers (most of which worked between 1 acre and 10 acres of land); and poor agricultural practices (slash and burn techniques and failure to use soil conservation techniques).

Dr. Mario López, of the Health Unit at Cara Sucia, and Messrs. Luis Adán Hernández and Fidel Torres, inspectors with the Office of Environmental Sanitation in Cara Sucia, who explained the background of the problem, which was reported by the community following contamination of the waters of the Cara Sucia River by runoff from the stable at Rancho Los Dos.

Sr. Ismael Villa Gómez, foreman at Rancho Los Dos, which pollutes the Cara Sucia River as a result of the runoff of water from the stables (they have approximately 500 steers).

An observational tour was made of the rivers and streams in the study area and several local residents were interviewed. Soil sediment was observed in the river and stream beds, along with detergents and lye from washing clothes in the river.

APPENDIX C

ANALYSIS BY UNICO (1991)

REPORTE FINAL DE LOS ANALISIS QUIMICOS DE AGUA REALIZADOS POR UNICO PARA CDM/WASH

Valores Normales	6.5-8.5	0-30 µs	****	** <0.01mg/l	*** <1.0mg/l	10 mg/l***	****

No. W.S.*	pH	CONDUC. µS	S.SED. ml/L	NH4 mg/L	NO2 mg/L	NO3 mg/L	PO4 mg/L
1	7.79	143	0.5	0.150	0.013	0.3	0.153
2	7.71	141	3.0	0.600	0.024	0.5	0.325
3	7.32	216	4.0	0.260	0.015	0.3	0.634
4	7.61	146	2.0	0.310	0.012	0.9	0.565
5	7.61	113	2.0	0.210	0.007	0.3	0.163
6	7.29	172	3.0	0.280	0.010	0.3	0.132
7	7.26	186	0.5	1.380	0.020	1.2	0.905
8	7.55	115	0.1	0.815	0.015	0.8	0.143
9	7.50	138	0.1	0.988	0.015	0.9	0.147
10	7.61	110	0.5	0.440	0.011	0.7	0.071
11	7.65	123	0.5	0.270	0.013	0.7	0.105
12	7.82	180	0.5	0.365	0.014	0.1	0.090
13	7.46	106	0.0	0.110	0.010	0.1	0.165
14	7.59	116	0.5	0.190	0.011	0.1	0.113
15	7.93	159	0.5	0.250	0.018	0.0	0.103
16	7.20	550	0.0	0.781	0.007	0.2	6.628
17	7.60	26000	0.5	8.504	0.012	0.4	0.200
18	7.67	206	0.5	0.885	0.015	0.4	0.122
19	7.30	360	0.5	0.000	0.016	3.0	0.296
20	7.60	1020	0.0	0.840	0.068	3.5	0.592

No. W.S.*	pH	CONDUC. µS	S.SED. ml/L	NH4 mg/L	NO2 mg/L	NO3 mg/L	PO4 mg/L
21	7.21	5420	0.0	0.500	0.012	19.3	1.741
22	7.20	5430	0.5	8.908	0.344	6.0	2.900
23	6.99	461	0.5	0.030	0.010	3.0	0.197
24	7.30	349	0.5	0.400	0.010	0.9	0.170
25	7.82	364	0.5	0.315	0.012	0.1	0.087
26	7.40	294	0.5	0.230	0.016	0.1	0.120
27	6.92	350	0.0	0.080	0.013	6.7	0.437
28	7.56	127	0.5	0.160	0.011	5.1	0.398
29	7.87	1001	0.0	0.587	0.053	23.5	0.300
30	8.05	570	0.0	0.810	0.084	12.3	0.275

METODOLOGIA DE LOS ANALISIS:

Sólidos sedimentables: Método del Cono de Imhoff.
Nitrógeno amoniacal: Método de Nessler.
Nitratos: Método de la reducción del Cadmio (según la versión de Hach Company).
Nitritos: Método de la Diazotización con ácido cromotrópico y ácido sulfanílico (según la versión de Hach Company).
Fosfatos: Método del molibdato de amonio y ácido ascórbico (según la versión de Hach Company).

---

*W.S.: Muestra de Agua Water Sample)
** en aguas naturales
*** agua potable
**** no hay valor estandar

APPENDIX D

SELECTED NEWSPAPER CLIPPINGS

Nacional

Salvanatura analiza recursos en cuenca Barra de Santiago

Identificar directrices para un desarrollo sostenible a largo plazo, que beneficie a la población dentro de la cuenca y hacer un sabio aprovechamiento de los recursos naturales existentes son algunos de los objetivos del estudio "Biodiversidad y Ecología de la Cuenca de la Barra de Santiago-El Imposible".

Dicho estudio, elaborado por técnicos naciones e internacionales, fue dado a conocer ayer en un seminario realizado en un hotel de San Salvador, donde se analizó, caracterizó la Cuenca de la Barra de Santiago-El Imposible.

El evento, organizado por la Fundación Ecológica Salvanatura, asistieron unas treinta personas representativas de organismos no gubernamentales, universidades y entidades que se dedican a la conservación del medio ambiente en el pais.

Según el Ing. Juan Marco Alvarez, Director Ejecutivo de Salvanatura, este estudio permite hacer énfasis en la geología, uso actual y manejo potencial de los suelos, las sub-cuencas de la zona, el clima, la conservación y manejo de los bosques de galería; cobertura y clasificación de bosques, y las principales actividades económicas humanas basada en los recursos naturales del lugar.

—Foto de LA PRENSA, por Ottoniel Pérez.

TECNICOS. Técnicos que disertaron en el seminario-taller "Biodiversidad y Ecología de la cuenca de la Barra de Santiago", organizado por la fundación ecológica Salvanatura. De izquierda a derecha Ing. Miguel Naves, Ing. Celio Guzmán, Dr. Francisco Serrano, Lic. Juan Marcos Alvarez, y Dr. Willian Pleitez.

En tal sentido, el estudio de una de las principales cuencas del país determina la diversidad biológica existente, a través de la caracterización adecuada de grupos representativos de flora y fauna, realiza una evaluación general de la degradación de los recursos naturales del área y su recuperación potencial e identifica las principales áreas naturales que requieren medidas conservacionistas dentro de la cuenca.

Además con este estudio, Salvanatura refuerza su actividad de protección y manejo del parque nacional El Imposible, que representa la parte alta de la cuenca de la Barra de Santiago: buscando con esto continuar gestionando ante el Gobierno de la República, en lo que respecta a la política nacional, sobre investigación de la biodiversidad, enfatizó el Ing. Marco Alvarez.

La cuenca de la Barra de Santiago, esta ubicada en la esquina Sur-Occidente de nuestro pais, casi fronterizo con Guatemala. Se extiende desde la cordillera de Apaneca hasta el Océano Pacífico. Posee tres zonas geográficas, una planicie costera que esencialmente rodea el manglar y la costa de la Barra.

Más del 70 por ciento de su vegetación original ha sido eliminada, siendo sustituida por cultivos permanentes, áreas de pastoreo o cultivos anuales; sin embargo existen remanentes naturales muy valiosos.

Posible explotación turística de parques

Nuestro país dispone de unas 106 áreas naturales identificadas por el Servicio de Parques Nacionales y Vida Silvestre, que podrían servir para fines turísticos.

Montecristo, El Imposible, Barra de Santiago, Los Andes y Laguna El Jocotal, Cerro Verde, Parque Walter T. Deininger y los sitios arqueológicos, constituyen una buena fuente de ingresos mediante su explotación turística.

Todos estos recursos naturales, se pueden aprovechar, siempre y cuando haya un diseño especial de programas, lugares e infraestructura, expresa el Lic. Carlos Roberto Hasbún, Jefe del Servicio de Parques Nacionales y Vida Silvestre, del Ministerio de Agricultura y Ganadería.

El turismo en los parques nacionales y otras áreas naturales, señala, ha tenido auge en varios países, pero su desarrollo plantea un problema bastante complejo, ya que no solo involucra numerosas y variables técnicas, sino que tiene una perspectiva más amplia que la convierte en una decisión política.

Diseños arquitectónicos, el desarrollo recreativo educacional y otras medidas de carácter técnico, deben guardar íntima relación, para evitar daños al sistema ecológico nacional o de algunas zonas en especial.

Las decisiones para el manejo de la naturaleza en función de bienestar económico y social, debe justificar prioridades, para no caer en el desbalance y causar serios efectos al medio ambiente, puntualizó Hasbún.

La mayoría de países latinoamericanos carecen de una política explícita en materia de desarrollo turístico en parques nacionales, o al menos no existen criterios uniformes. Esto resulta crítico cuando se desea tomar decisiones específicas de manejo y desarrollo, particularmente en momentos en que existe una creciente demanda por visitar los parques nacionales y en varios casos, por invertir en instalaciones para uso de turistas nacionales y extranjeros.

CONSERVACION. Personal técnico del Centro de Recursos Naturales y del Patrimonio Cultural, muestran caparazones y osamentas de tortuga de la especie golfina, que está en proceso de extinción. A través del Servicio de Parques Nacionales y Vida Silvestre, se realiza una campaña Pro-Conservación de la Tortuga Marina en la Barra de Santiago, Ahuachapán.

Avanza el plan para exportar mariposas

En su etapa final se encuentra el proyecto "Producción y exportación de mariposas" de la empresa salvadoreña Sociedad Bioproductores S.A., del biólogo Francisco Serrano y del economista Francisco Salvador Aquino.

Así lo da a conocer el Banco de Fomento Agropecuario por medio de un comunicado en el que expresa buenos augurios para esa rama de actividad.

La empresa mencionada, que funciona en el cantón El Corozo, de San Francisco Menéndez, Ahuachapán, exporta ejemplares de mariposas salvadoreñas a los zoológicos de Canadá, Estados Unidos e Inglaterra.

Mediante una sofisticada tecnología, se obtienen los capullos de las mariposas y son enviados por vía aérea en depósitos especiales, para que al llegar a su destino completen su metamorfosis y se conviertan en mariposas adultas.

en El Corozo, para atraer mariposas.

En este lugar se han sembrado plantas nativas de la zona boscosa y se dispone de plantas sembradas en macetas y bolsas, de cerca de 1,000 diferentes géneros, los cuales sirven en las jaulas de vuelo para que las mariposas en cautiverio puedan realizar sus ovoposiciones, además de servir de alimento a las larvas.

Se auguran resultados halagadores al proyecto, por la generación de divisas, la protección de una zona boscosa de altura media y por la ocupación de mano de obra que generará en beneficio de los habitantes del lugar.

La vida de estos insectos es efímera: no más de 15 días, por lo que los pedidos se mantienen constantes.

Para conocer dicho proyecto que comenzó en 1990, la Junta de Directores del BFA viajó al lugar de operación para observar las fases de producción y la biotecnología. La institución otorgó al inicio un crédito por 150 mil colones.

El proyecto tiene un componente ecológico que aprovecha la proximidad del bosque El Imposible para la captura de mariposas adultas o utiliza sus ovoposiciones para su reproducción.

Los directores del BFA recorrieron las instalaciones e infraestructura de un jardín de plantas

APPENDIX E

RESULTS OF WATER ANALYSIS AND FLOW MEASUREMENT CONDUCTED BY SALVANATURA

CUADRO No.2

CAUDALES MEDIOS DE LA EPOCA SECA

	Caudal Medio de la época Seca Q l/s.	Area Cuenca km2	Rendimiento Hidráulico 1/
Río San Francisco	15 l/s	14.06	1.1
Río La Palma	60 l/s	18.83	3.2
Río Cara Sucia	120 l/s	32.53	3.7
Río Ixcanal	30 l/s	16.81	1.8
Río Ahuachapío	15 l/s	16.69	0.9
Río Guayapa	130 l/s	24.83	5.24
Río Cuilapa	25 l/s	19.98	1.25
Río Naranjo	55 l/s	37.50	1.47
Río El Rosario	210 l/s	75.30	2.70
Total	660 l/s	256.50	

1/ litro/seg/km2.

CUADRO No.3
RESULTADOS DE LOS ANALISIS FISICO-QUIMICOS BACTERIOLOGICOS EFECTUADOS EN MUESTRAS DE AGUAS EN ABRIL DE 1993.

RIO	EL ROSARIO	LOS NARANJOS	GUAYAPA	IZCANAL	CARA SUCIA	SAN FRANCISCO EL IMPOSIBLE
Hora colecta	10:30 a.m.	11:00 a.m.	12:00 m	12:30 p.m.	16:00 p.m.	15:00 p.m.
Aspecto	lodosas-turbias	lodosas-turbias	cafesosas	cafesosas	cafesosas	cristalinas
Olor	inodora	inodora	inodora	inodora	inodora	inodora
Temperatura(C)	29.5	30	29	29	34.5	28
Conductividad Eléctrica(mhos/cm)	165	125	150	200	170	145
PH	7.75	7.35	7.85	7.4	8.5	8.0
Turbidez(FTU)	75	85	50	20	20	0
Color Aparente(Pt-Co)	250	260	150	50	60	5
Sólidos Sedimentables (mt/l)	0.3	0.7	0.2	0.2	0.2	0.05
Oxigeno Disuelto(ppm)	6.5	6.2	6.4	5.4	6.8	7.0
Acido Sulfidríco(ppm)	0	0	0	0	0	0
Alcalinidad Total(ppm)	62.5	50	75	87.5	50	62.5
Dureza Total(ppm)	66.3	71.4	86.7	107.1	76.5	81.6
Carbonatos(ppm)	0	0	0	0	7.5	0
Bicarbonatos(ppm)	76.3	61.0	91.5	106.8	91.5	76.3
Cloruros(ppm)	7.8	7.8	7.8	11.7	11.7	11.7
Coliformes totales N.M.P.(Cols/100ml)	2000	65000	45000	10000	60000	9000

C: Grados centígrados

ppm: partes por millón

mhos/cm: Micromhos por centímetro

N.M.P.: número más probable

FTU: Formazin Turbidity Units

Cols/100 ml: Colonias coliformes por cien mililitros.

Pt-Co: Platino - Cobalto

ml/l: milimetros por litro

APPENDIX F

DATA ON ANALYSIS AND EQUIPMENT COSTS

UNIVERSIDAD CATOLICA DE OCCIDENTE UNICO

LABORATORIO DE QUIMICA AGUAS Y LECHE
SOLICITUD DE ANALISIS

FECHA: _____ No.: _____
SOLICITANTE: _____
DIRECCION: _____
_____ TEL.: _____
FINCA/EMPRESA: _____
LOCALIDAD: _____

TIPO DE MUESTRAS:
* AGUA POTABLE ( )
* AGUA DE DESECHO ( )
* AGUA PARA RIEGO ( )
* LECHE ( )

No. DE MUESTRAS: _____
COSTO TOTAL: ¢_____ ANTICIPO (50%): ¢_____

ANALISIS DE AGUAS	COSTO ¢
Analisis Fisico	
( ) Turbidez	15.00
( ) Olor	5.00
( ) Sabor	5.00
( ) Color	15.00
( ) pH	8.00
( ) Solidos sedimentables	5.00
( ) Solidos totales	15.00
( ) Conductividad	5.00
Analisis Quimicos	
( ) Dureza	15.00
( ) Calcio	20.00
( ) Magnesio	20.00
( ) Acidez	25.00
( ) Alcalinidad	25.00
( ) Cloruros	15.00
( ) Sulfatos	30.00
( ) N. amoniacal	35.00
( ) Nitritos	30.00
( ) Nitratos	30.00
( ) Fosfatos	30.00
( ) Oxigeno disuelto	20.00
( ) Detergente anionico	60.00
( ) BOD	60.00

ANALISIS DE AGUA	COSTO ¢
Microelementos (cada uno)	30.00
(Mn, Fe, Zn, Cu)	
( ) B (Boro)	45.00
( ) SAR	65.00
( ) Na (Sodio)	20.00
Analisis Microbiologicos	
( ) Germenes totales (agar)	60.00
( ) Coliformes totales	50.00
( ) Coliformes fecales	60.00
( ) E. Coli	60.00

ANALISIS DE LECHE	COSTO ¢
( ) pH	8.00
( ) Densidad	5.00
( ) Crioscopia	15.00
( ) Proteinas	60.00
( ) Grasa (Gerber)	25.00
( ) Germenes totales	60.00
( ) Coliformes totales	50.00
( ) Coliformes fecales	60.00
( ) E. Coli	60.00

OBSERVACIONES: _____
_____
_____

Recibido por: _____

39	Contaminación externa de insectos y pelo de roedores en granos y semillas (AOAC)	110.00
40	Examen macroscópico en granos de cereales: maíz para popcorn, guisantes secos y frijoles. Método AOAC	70.00
41	Vitamina A. Método absorción ultravioleta	250.00
42	Vitamina A. Método Carr-Price (AACC)	640.00
43	Vitamina A en alimentos para ganado, premezclas y alimentos de consumo humano (método colorimétrico AOAC)	890.00
44	Curcumina	180.00
45	Humedad en cúrcuma	90.00
46	Cinameína (bálsamo)	125.00
47	Acidez en granos	160.00

UNIDAD DE RESIDUOS

#	DESCRIPCION	PRECIO¢
COMPUESTOS ORGANOCLORADOS EN AGUA, SUELOS Y VEGETALES.		
1	Aldrin	500.00
2	DDD	700.00
3	DDE	700.00
4	DDT	800.00
5	BHC	500.00
6	Dieldrin	500.00
7	Heptaclor	500.00
8	Heptaclor epóxido	500.00
9	Endrin	500.00
10	Lindano	800.00
11	Metoxiclor	800.00
ORGANOFOSFORADOS EN AGUA, SUELOS Y VEGETALES		
12	Diazinon	800.00
13	Ethion	500.00
14	Malathion	800.00
15	Etil paration	500.00
16	Metil paration	800.00
CARBAMATOS EN AGUA, SUELOS Y VEGETALES		
17	Aldicarb	850.00
18	Captan	850.00
19	Captafol	850.00
20	Carbaril	850.00
21	Carbofurano	850.00
PIRETROIDES		
22	Bifenthrin	800.00
23	Cipermetrina	800.00
24	Cyflutrin	800.00
25	Cyuhalotrin	800.00
26	Deltametrina	800.00

Precios a Junio, 1993.

27	Compuestos organoclorados (aldrin, BHC, DDD, DDE, DDT, dieldrin, heptaclor epóxido, endrin, lindano, metroxiclor) en agua y vegetales	1000.00
28	Compuestos organofosforados (diazinon, ethion, malation, etil y metil paration) en agua y vegetales.	1000.00
29	Compuestos fenoxi (herbicidas, 2-4D, 2-4, 5t) en agua y vegetales	1000.00
30	Compuestos organoclorados y organofosforados en agua y vegetales	1500.00
31	Aflatoxinas B-1,B-2,G-1,G-2 en harinas, cereales y concentrados	500.00
32	Colinesterasa en sangre	400.00
33	Pureza (alcoholes)	350.00
34	Contaminantes (alcoholes)	350.00
35	Pureza (licores)	400.00
36	Contaminantes (alcoholes)	400.00

...

LABORATORIO DE CALIDAD INTEGRAL

Un Proyecto de Desarrollo, de la Fundación Salvadoreña para el Desarrollo Económico y Social

Urbanización y Boulevard Santa Elena,
Antiguo Cuscatlán, La Libertad, El Salvador
Apartado Postal 01-278

Tel.: (503) 78-9064
78-9065
78-3366

Fax.: (503) 78-3356
78-3369

Listado de Precios de Análisis

FUSADES

UNIDAD DE SUELOS/AGUA/FOLIAR

#	ANALISIS EN SUELOS	PRECIO¢
1	pH,P,K y textura al tacto(rutina)	50.00
2	pH en KCl 1N	20.00
3	pH en CaCl, 0.01 M	20.00
4	pH en agua	20.00
5	Fósforo asimilable	40.00
6	Potasio asimilable	20.00
7	Textura por Bouyoucos	40.00
8	Conductividad eléctrica	50.00
9	Calcio, Magnesio y Aluminio	60.00
10	Calcio	20.00
11	Magnesio	20.00
12	Aluminio	20.00
13	Acidez extractable	20.00
14	Hierro, cobre, manganeso y zinc	100.00
15	Hierro	35.00
16	Cobre	35.00
17	Manganeso	35.00
18	Zinc	35.00
19	Boro soluble en agua	80.00
20	Materia orgánica	50.00
21	Capacidad de intercambio catiónico	100.00
22	Azufre ext. con sol. 500ppm P	50.00
23	Boro ext. con sol. 500 ppm P	75.00
24	CICE	100.00
25	Sodio	20.00

#	ANALISIS EN AGUAS	PRECIO¢
1	pH	15.00
2	Conductividad	15.00
3	Alcalinidad	15.00
4	Calcio	30.00
5	Magnesio	30.00
6	Potasio	30.00
7	Sodio	40.00
8	Fosfatos	60.00
9	Sulfatos	60.00
10	Cloruros	60.00
11	Nitratos	60.00
12	Nitritos	60.00
13	Sólidos totales	25.00
14	Sólidos disueltos	25.00
15	Boro	60.00
16	Hierro	25.00
17	Manganeso	25.00
18	Carbonatos y bicarbonatos	30.00
19	Dureza total	75.00
20	Salinidad	75.00

#	ANALISIS FOLIARES	PRECIO¢
1	Nitrógeno total	60.00
2	Fósforo	50.00
3	Potasio	50.00
4	Calcio	50.00
5	Magnesio	50.00

6	Hierro	50.00
7	Cobre	50.00
8	Manganeso	50.00
9	Zinc	50.00
10	Boro	80.00
11	Azufre	80.00
12	Sodio	50.00
13	Aluminio	50.00

#	ANALISIS EN FERTILIZANTES	PRECIO¢
1	Macroelementos (N,P,K)	250.00
2	Nitrógeno	100.00
3	Fósforo	100.00
4	Potasio	100.00
5	Calcio	80.00
6	Magnesio	80.00
7	Boro	100.00
8	Azufre	100.00
	Microelementos:	
9	Hierro	80.00
10	Cobre	80.00
11	Manganeso	80.00
12	Zinc	80.00
13	Molibdeno	80.00
14	Cobalto	80.00
15	Humedad	50.00
16	Densidad	50.00
17	Granulometría	50.00

UNIDAD DE MICROBIOLOGIA

#	DESCRIPCION	PRECIO¢
1	*Bacillus cereus*	100.00
2	Coliformes fecales	80.00
3	Coliformes totales	75.00
4	Conteo bacteriano total	65.00
5	*Clostridium perfringes*	155.00
6	*Escherichia coli*	80.00
7	*Lactobacillus* sp.	75.00
8	*Listeria monocytogenes*	120.00
9	Recuento de hongos	75.00
10	Recuento de hongos y levaduras	80.00
11	*Salmonella* sp.	110.00
12	*Shigella* sp.	125.00
13	*Staphylococcus aureus*	115.00
14	*Vibrio cholerae*	160.00

UNIDAD DE CULTIVO DE TEJIDOS

#	DESCRIPCION	PRECIO$
1	Maquila de plantas	$0.40
2	Limpieza	$10.00
3	Producción	$0.40

NOTA: Para Cultivo de Tejidos, el precio al público se refleja en dólares, aunque se cobrará en moneda local al cambio del día.

FITOPATOLOGIA/ENTOMOLOGIA

#	DESCRIPCION	PRECIO¢
1.	Determinación hongos fitopatógenos	30.00
2	Determinación bacterias fitopatógenos	30.00
3	Determinación géneros bacterias fitopatogenos	80.00
4	Determinación e identificación de virus	150.00
5	Cualitativo de nemátodos	40.00
6	Cuantitativo de nemátodos	40.00
7	Cualitativo y cuantitavido de nemátodos	80.00
8.	Entomológico	30.00

UNIDAD DE CONTROL DE CALIDAD

#	DESCRIPCION	PRECIO¢
1	Azucares reductores	110.00
2	Contenido aparente de sacarosa	110.00
3	Humedad en miel	50.00
4	Sólidos insolubles (miel)	60.00
5	Cenizas (miel)	60.00
6	Acidez en miel	70.00
7	Actividad diastasa	150.00
8	HMF (AOAC)	110.00
9	HMF (Winkler - FAO)	150.00
10	Sacarosa en miel (cromatografía)	180.00
11	Fructosa en miel (cromatografía	180.00
12	Glucosa en miel (cromatografía)	180.00
13	Prolina en miel	150.00
14	Acidez libre en ajonjolí	160.00
15	Porcentaje de pureza (ajonjolí)	65.00
16	Humedad	55.00
17	Proteína (método Microkjeldahl)	80.00
18	Grasa	125.00
19	Fibra cruda	125.00
20	Ceniza	60.00
21	Acidez titulable (leche)	60.00
22	pH (leche)	30.00
23	Densidad (productos lácteos)	50.00
24	Prueba azul de metileno	50.00
25	Poder reductor leche	70.00
26	Nitrógeno proteico en suero	115.00
27	Sólidos totales (leche)	40.00
28	Humedad quesos	60.00
29	Humedad leche	60.00
30	Grasa en leche (Mét. Babcock)	60.00
31	Grasa en crema (Mét. Babcock)	60.00
32	Cloruro de sodio (lácteos)	130.00
33	Calcio, hierro, sodio por espectrofotometría Absorción atómica (leche)	125.00
34	Fósforo (leche) método colorimétrico	100.00
35	Brix	30.00
36	Determinación de suciedad ligera en annatto y pimiento molido. Suciedad granos. Método flotación (AOAC)	275.00
37	Suciedad ligera de especies y condimentos (método AOAC)	490.00
38	Excretas de roedores e insectos en semillas de condimentos. Método de sedimentación AOAC	450.00

SECRETARIA TECNICA DEL FINANCIAMIENTO EXTERNO

PRESUPUESTO EXTRAORDINARIO PARA REACTIVACION ECONOMICA

IDAD EJECUTORA: DIRECCION DE REC.NATURALES RENOVABLES. **NOMBRE DEL PROYECTO:** PROMESA (LAB.DEL AMBIENTE)

NTO SOLICITADO: ¢ 3,724.327.00 **FUENTE DE FINANCIAMIENTO:** PL-480

ERCICIO: 1.994 **PERIODO:** ENERO - DICIEMBRE DE 1994

DESCRIPCION GENERAL DEL PROYECTO Y POBLACION OBJETIVO

l proyecto comprenderá el desarrollo e implementación de normas y políticas ambientalistas ectivas, programas de concientización y educación sobre el medio ambiente a nivel nacional local y el diseño y ejecución de un área de demostraciones del proyecto adoptando mecanis-s de incentivos que sirvan para la adopción y repercusión de prácticas continuas de manejo recursos naturales. El área de estudio esta estimada en aproximadamente 35,000 hectáreas beneficiando a unas 10,000 personas.

CLASIFICACION GENERAL DEL PROYECTO

OGRAMA: **SUBPROGRAMA:**

DIGO DEL SECTOR: 1/ **UBICACION GEOGRAFICA:**

JUSTIFICACION ECONOMICA Y SOCIAL DEL PROYECTO

ecuperación de áreas de trabajo que estan siendo mal manejadas incidiendo en el bajo desa-o económico del área y del país; en lo social se proyecta mejorar la calidad de vida de a área enseñándoles en los buenos manejos de los recursos para obtener beneficios económi-s consecuentes que permiten el desarrollo socio-económico-cultural de las personas que abitan el área de estudio.

RMA "A"

Basarse en listado de códigos adjunto

SECRETARIA TECNICA DEL FINANCIAMIENTO EXTERNO

PRESUPUESTO EXTRAORDINARIO PARA REACTIVACION ECONOMICA

PROGRAMACION TRIMESTRAL DE METAS

UNIDAD EJECUTORA: DIRECCION DE RECURSOS NATURALES RENOVABLES

NOMBRE DEL PROYECTO: PROMESA (LAB.AMBIENTE)

PROGRAMA: 306-Proyecto Prioritarios Diversos para el desarrollo económico y social del país.

FUENTE DE FINANCIAMIENTO: PL-480

SUBPROGRAMA:

PERIODO: ENERO - DICIEMBRE 1994

META No	DESCRIPCION DE META	UNIDAD DE MEDIDA	PRIMER TRIMESTRE	SEGUNDO TRIMESTRE	TERCER TRIMESTRE	CUARTO TRIMESTRE	TOTAL 1994	COSTO	
								TOTAL	UNITARIO
1	Monitoreo	Muestreo							
2	Verificaciones Analíticas	Análisis	S E	G U	N D E M	A N D A			
3	Evaluación Analítica	Resultado							
4	Informes Trimestrales	Informe	1	1	1	1	4		
5									
6									
7									
8									
9									
10									

FORMULARIO No 5

ETARIA TECNICA DEL FINANCIAMIENTO EXTERNO

PRESUPUESTO EXTRAORDINARIO PARA REACTIVACION ECONÓMICA

UNIDAD EJECUTORA: DIRECCION DE RECURSOS NATURALES RENOVABLES.

MOMBRE DEL PROYECTO: PROMESA (LAB.AMBIENTE)

PROGRAMA: 30C-Proyectos,Prioritarios diversos para el desarrollo económico y social del país.

SUBPROGRAMA:

FUENTE DE FINANCIAMIENTO: PL-480

PERIODO: ENERO - DICIEMBRE 1994

PRESUPUESTO DE VEHICULOS

CARACTERISTICAS GENERALES

TIPO DE VEHICULO Y MARCA	COMBUSTIBLE	CAPACIDAD	No. DE UNIDADES	COSTO UNITARIO (¢)	COSTO PARCIAL (¢)
Pick Up doble transmisión TOYOTA Diesel, doble cabina.	Diesel	2 toneladas	2	160,000.00	320,000.00
TOTAL					

FORMULARIO No. 3-B

RETARIA TECNICA DEL FINANCIAMIENTO EXTERNO

RESUPUESTO EXTRAORDINARIO PARA REACTIVACION ECONOMICA

AD EJECUTORA: Dirección de Recursos Naturales Renovables./ NOMBRE DEL PROYECTO: PROMESA (LAB. DEL AMBIENTE)

RAMA: 306- Proyectos prioritarios diversos para el desarrollo económico y social del país. SUBPROGRAMA:

TE DE CIAMIENTO: PL-480 PERIODO: ENERO - DICIEMBRE 1994

PRESUPUESTO DE MOBILIARIO Y EQUIPO

OBJETO ESPECIFICO	DESCRIPCION	CANTIDAD	COSTO UNITARIO (¢)	COSTO PARCIAL (¢)
303	Fotocopiadora	1	30,000.00	30,000.00
303	Computadora con impresores y reguladores de voltaje.	1	30,000.00	30,000.00
311	Muebles para fotocopiadora	1	700.00	700.00
311	Mueble para computadora	1	2,000.00	2,000.00
311	Muebles para usar en computadoras	1	900.00	900.00
301	Máquina de escribir eléctrica	1	7,000.00	7,000.00
303	Aparato de aire acondicionado	3	20,000.00	60,000.00
332	Espectofotómetro de absorción atómica repuestos, accesorios.	1	200.000.00	200.000.00
332	Horno de grafito accesorios,repuestos	1	150,000.00	150,000.00
332	Cromato de gases con detector FID, ECD, repuestos accesorios,(columnas etc.)	1	300.000.00	300,000.00
332	Espectrometro UV-Visible, repuestos accesorios.	1	175,000.00	175,000.00
332	Incubadora, repuestos, accesorios	2	150,000.00	300.000.00
332	Fotómetro de llama, repuestos	1	125,000	125,000.00
332	Electrodo de iones selectivos, repuestos -accesorios (PB,Co2,A(NH3) BIS F2, F2	12	12,500.00	150,000.00

COSTO TOTAL

CRETARIA TECNICA DEL FINANCIAMIENTO EXTERNO

PRESUPUESTO EXTRAORDINARIO PARA REACTIVACION ECONOMICA

IDAD EJECUTORA: Direccion de Recursos Naturales Renovables

NOMBRE DEL PROYECTO: PROMESA (Lab. del Amb.)

OGRAMA: 306-Proyectos prioritarios diversos

SUBPROGRAMA:

ENTE DE FINANCIAMIENTO: para el desarrollo econ. y social. PL -480

PERIODO: Enero Dic. de 1994

PRESUPUESTO DE MOBILIARIO Y EQUIPO

OBJETO ESPECIFICO	DESCRIPCION	CANTIDAD	COSTO UNITARIO (¢)	COSTO PARCIAL (¢)
332	Peachimetros repuestos y accesorios	2	45,000.oo	90,000.oo
332	Peachimetros de campo	6	7,500.00	45,000.oo
332	Conductivimetros	2	45 000.oo	90,000.oo
332	Conductivimetros de campo	6	5,000.oo	30,000.oo
332	Dispensadores automaticos	2	6,000.oo	12,000.oo
332	Balanzas analiticas	3	28,000.oo	84,000.oo
303	Estufas	2	40,000.oo	80,000.oo
303	Horno	1	40,000.oo	40,000.oo
303	Refrigeradora	1	15,000.oo	15,000.oo
332	Macrokjeldhal	1	80,000.oo	80,000.oo
332	Auto clave	1	75,000.oo	75,000.oo
32	Balanza gravatoria	1	25,000.oo	25,000.oo
332	Laboratorios portátiles	6	30,000.oo	180,000.oo
	COSTO TOTAL			2,376.600.00

FORMULARIO No. 3-A

SECRETARIA TECNICA DEL FINANCIAMIENTO EXTERNO

PRESUPUESTO EXTRAORDINARIO PARA REACTIVACION ECONOMICA

UNIDAD EJECUTORA: DIRECCION GENERAL DE RECURSOS NATURALES RENOVABLES

NOMBRE DEL PROYECTO: HIDROLOGIA - PROYECTO PROMESA

MONTO SOLICITADO: Q 2,700,000.00

FUENTE DE FINANCIAMIENTO:

EJERCICIO: 1994

PERIODO: ENERO-DICIEMBRE 1994

DESCRIPCION GENERAL DEL PROYECTO Y POBLACION OBJETIVO

El proyecto en el componente hidrológico, comprende el establecimiento de una red de estaciones hidrométricas principal y secundarias, buscando con ello la cuantificación del recurso hídrico de la zona, a través de procedimientos hidrométricos. Este abarcara tanto el agua superficial como subterráneo. El recurso hídrico suterráneo se obtendrá a través de mediciones y estudios del comportamiento de la red de pozos del área de influencia. El proyecto beneficiará a los habitantes de la zona de estudio y a las poblaciones circunvecinas, al mismo tiempo será un antecedente importante para la ejecución de proyectos similares en otras zonas del país.

CLASIFICACION GENERAL DEL PROYECTO

PROGRAMA: 306-PROYECTOS PRIORITARIOS DIVERSOS PARA EL DESARROLLO ECONOMICO Y SOCIAL DEL PAIS

SUBPROGRAMA: 159-APOYO INSTITUCIONAL RIEGO Y DRENAJE

CODIGO DEL SECTOR: 1/ 03

UBICACION GEOGRAFICA: DEPTO. DE AHUACHAPAN

JUSTIFICACION ECONOMICA Y SOCIAL DEL PROYECTO

Dada la importancia prioritaria que tiene una adecuada optimización del uso y manejo del recurso hídrico, se hace necesaria la realización de los estudios hidrológicos pertinentes, a través del establecimiento de controles hidrométricos adecuados en la zona de estudio. Un adecuado manejo del recurso hídrico contribuirá a mejorar la condición socio-económica de los habitantes de la zona y, al mismo tiempo generará acciones en mejoramiento de los recursos naturales.

FORMA "A"

1/ Basarse en listado de códigos adjunto

SECRETARIA TECNICA DEL FINANCIAMIENTO EXTERNO

PRESUPUESTO EXTRAORDINARIO PARA REACTIVACION ECONOMICA

PROGRAMACION TRIMESTRAL DE METAS

UNIDAD EJECUTORA: DIRECCION GENERAL DE RECURSOS NATURALES RENOVABLES

NOMBRE DEL PROYECTO: HIDROLOGIA - PROYECTO PROMESA

PROGRAMA: 306- PROYECTOS PRIORITARIOS DIVERSOS PARA EL DESARROLLO ECONOMICO Y SOCIAL DEL PAIS

FUENTE DE FINANCIAMIENTO:

SUBPROGRAMA: 159-APOYO INSTITUCIONAL RIEGO Y DRENAJE

PERIODO: ENERO-DICIEMBRE 1994

META No	DESCRIPCION DE META	UNIDAD DE MEDIDA	PRIMER TRIMESTRE	SEGUNDO TRIMESTRE	TERCER TRIMESTRE	CUARTO TRIMESTRE	TOTAL 1994	COSTO	
								TOTAL	UNITARIO
1	Instalación de estación hidrométrica	Estación	-	1	-	-	1		
2	Instalación de limnímetros	Limním.	-	12	-	-	12		
3	Realización y cálculo de aforos	Aforos	-	-	78	78	156		
4	Muestreo y cálculo de sedimentos	Muestreo sedim.	-	-	24	24	48		
5	Muestreo de agua físico-químico	Muestreo calidad	-	-	21	21	42		
6	Recolección y corrección registros limn.	Cartas	-	-	3	3	6		
7	Diagnóstico aguas subterráneas	Docum.	-	-	1	-	1		
8	Curso corto de sedimentología	Participante	-	15	-	-	15		
9									
10									

FORMULARIO No 5

SECRETARIA TECNICA DEL FINANCIAMIENTO EXTERNO

PRESUPUESTO EXTRAORDINARIO PARA REACTIVACION ECONOMICA

UNIDAD EJECUTORA: DIRECCION GENERAL DE RECURSOS NATURALES RENOVABLES

NOMBRE DEL PROYECTO: HIDROLOGIA-PROYECTO PROMESA

PROGRAMA: 306-PROYECTOS PRIORITARIOS DIVERSOS PARA EL DESARROLLO ECONOMICO Y SOCIAL DEL PAIS

SUBPROGRAMA: 159-APOYO INSTITUCIONAL RIEGO Y DRENAJE

FUENTE DE FINANCIAMIENTO:

PERIODO: ENERO-DICIEMBRE 1994

PRESUPUESTO DE MOBILIARIO Y EQUIPO

OBJETO ESPECIFICO	DESCRIPCION	CANTIDAD	COSTO UNITARIO (¢)	COSTO PARCIAL (¢)
301	MAQUINARIA Y EQUIPO DE OFICINA			87,500.00
	Máquinas de escribir eléctricas	2	7,500.00	15,000.00
	Archivos metálicos 4 gavetas	5	1,500.00	7,500.00
	Contómetros estadísticos	5	1,000.00	5,000.00
	Computadora con accesorios	1	60,000.00	60,000.00
303	APARATOS ELECTRICOS DE SERVICIO			67,500.00
	Proyector de acetatos	1	6,000.00	
	Proyector de diapositivas	1	9,000.00	
	Aparatos aire acondicionado	2	25,000.00	
	Ventiladores de techo	5	500.00	
304	EQUIPO DE INGENIERIA Y DIBUJO			5,000.00
	Estuche de leroy completo	1	5,000.00	
359	OTRAS MAQUINARIAS Y EQUIPOS DE SERVICIOS BASICOS			207,000.00
	Limnígrafos	3	36,000.00	
	Molinete hidráulico	3	54,000.00	
	Teodolito	1	75,000.00	
	COSTO TOTAL			367,000.00

FORMULARIO No. 3-A

SECRETARIA TECNICA DEL FINANCIAMIENTO EXTERNO

PRESUPUESTO EXTRAORDINARIO PARA REACTIVACION ECONÓMICA

UNIDAD EJECUTORA: DIRECCION GENERAL DE RECURSOS NATURALES RENOVABLES

NOMBRE DEL PROYECTO: HIDROLOGIA-PROYECTO PROMESA

PROGRAMA: 306-PROYECTOS PRIORITARIOS DIVERSOS PARA EL DESARROLLO ECONOMICO Y SOCIAL DEL PAIS

SUBPROGRAMA: 159-APOYO INSTITUCIONAL RIEGO Y DRENAJE

FUENTE DE FINANCIAMIENTO:

PERIODO: ENERO-DICIEMBRE 1994

PRESUPUESTO DE VEHICULOS

CARACTERISTICAS GENERALES

TIPO DE VEHICULO Y MARCA	COMBUSTIBLE	CAPACIDAD	No. DE UNIDADES	COSTO UNITARIO (Q)	COSTO PARCIAL (Q)
Jeep	Diesel		1	110,000.oo	110,000.oo
Pick-Up doble tracción Toyota	Diesel	1.5 Ton.	1	200,000.oo	200,000.oo
Motos AG100 Enduro	Aceite/Gas.		3	25,000.oo	75,000.oo
				TOTAL	385,000.oo

FORMULARIO No. 3-B

SECRETARIA TECNICA DEL FINANCIAMIENTO EXTERNO

PRESUPUESTO EXTRAORDINARIO PARA REACTIVACION ECONOMICA

UNIDAD EJECUTORA: *DIRECCION GENERAL DE RECURSOS NATURALES RENOVABLES*

NOMBRE DEL PROYECTO: *METEOROLOGIA - PROYECTO PROMESA*

MONTO SOLICITADO: ₡ 3,800,000.00

FUENTE DE FINANCIAMIENTO:

EJERCICIO: *1994*

PERIODO: *Enero - Diciembre 1994.*

DESCRIPCION GENERAL DEL PROYECTO Y POBLACION OBJETIVO

El Proyecto comprende un Plan Piloto en el componente de Meteorología, estableciéndose una red meteorológica con los enlaces telecomunicativos, además se estudiará la relación entre los fenómenos atmosféricos y el desarrollo agrícola y su impacto sobre el medio ambiente.
Las metodologías y resultados podrán ser extrapolados a otros lugares del país.
El Proyecto beneficiará en primer lugar a los habitantes de la zona y por ende al resto del país que se encuentran en condiciones agroecológicas similares.

CLASIFICACION GENERAL DEL PROYECTO

PROGRAMA: *306- PROYECTOS PRIORITARIOS DIVERSOS PARA EL DESARROLLO ECONOMICO Y SOCIAL DEL PAIS.*

SUBPROGRAMA: *159 - APOYO INSTITUCIONAL RIEGO Y DRENAJE.*

CODIGO DEL SECTOR: *1/ 03*

UBICACION GEOGRAFICA: *DEPTO. DE AHUACHAPAN.*

JUSTIFICACION ECONOMICA Y SOCIAL DEL PROYECTO

Los criterios climáticos son muy importantes no solo porque ayudan a incrementar la producción sino también a que las actividades agrícolas sean compatibles con el medio ambiente no incidiendo en su deterioro, ya que puede hacerse advertencias sobre aquellas practicas culturales que puedan considerarse amenazas para la calidad y cantidad de los recursos naturales.
La consideración del clima podrá ayudar a mejorar la dotación alimentaria y la calidad de vida de los habitantes que se traducirían economicamente en un incremento de la producción agropecuaria y de uso de los recursos naturales.

FORMA "A"

1/ Basarse en listado de código adjunto

SECRETARIA TECNICA DEL FINANCIAMIENTO EXTERNO

PRESUPUESTO EXTRAORDINARIO PARA REACTIVACION ECONOMICA

PROGRAMACION TRIMESTRAL DE METAS

UNIDAD EJECUTORA: DIRECCION DE RECURSOS NATURALES RENOVABLES

NOMBRE DEL PROYECTO: METEOROLOGIA-PROYECTO PROMESA

PROGRAMA: 306-PROYECTOS PRIORITARIAS DIVERSOS PARA EL DESARROLLO ECONOMICO Y SOCIAL DEL PAIS.

FUENTE DE FINANCIAMIENTO:

SUBPROGRAMA: 159- APOYO INSTITUCIONAL RIEGO Y DRENAJE

PERIODO: ENERO - DICIEMBRE 1994

META No	DESCRIPCION DE META	UNIDAD DE MEDIDA	PRIMER TRIMESTRE	SEGUNDO TRIMESTRE	TERCER TRIMESTRE	CUARTO TRIMESTRE	TOTAL 1994	COSTO	
								TOTAL	UNITARIO
1	Construcción e Instalación de Estación Meteorológica tipo A "El Imposible".	ESTACION		1			1		
2	Construcción e instalación de Estación topoclimática.	ESTACION		2			2		
3	Instalación de Estaciones pluviométricas.	ESTACION		6			6		
4	Construcción e instalación de estaciones automáticas.	ESTACION		3			3		
5	Creación de una base de datos	DATO			3,000	3,000	6,000		
	CAPACITACION EN EL EXTERIOR								
6	Curso sobre climatológica	Participant			2		2		
	Curso sobre agrometeorologia	Participant			2		2		
	Curso sobre procesamiento de datos Meteorologicos.	Participant			2		2		
	CAPACITACION LOCAL								
7	Curso sobre climatologia	Participant	10				10		
	Curso sobre agrometeorologia	Participant	10				10		
9	Curso sobre manejo y mantenimiento de estaciones automaticas agrometeorológicas.	Participant			10		10		
10	Curso sobre procesamiento de datos.	Participant				10	10		

FORMULARIO No 5

CRETARIA TECNICA DEL FINANCIAMIENTO EXTERNO

PRESUPUESTO EXTRAORDINARIO PARA REACTIVACION ECONOMICA

IDAD EJECUTORA: *DIRECCION GENERAL DE RECURSOS NATURALES RENOVABLES* NOMBRE DEL PROYECTO: *METEOROLOGIA - PROYECTO PROMESA.*

OGRAMA: *306 - PROYECTOS PRIORITARIOS DIVERSOS PARA EL DESARROLLO ECONOMICO Y SOCIAL.* SUBPROGRAMA: *159 - APOYO INSTITUCIONAL RIEGO Y DRENAJE*

ENTE DE IANCIAMIENTO:

PERIODO: *Enero - Diciembre 1994.*

PRESUPUESTO DE MOBILIARIO Y EQUIPO

OBJETO ESPECIFICO	DESCRIPCION	CANTIDAD	COSTO UNITARIO (¢)	COSTO PARCIAL (¢)
301	MAQUINARIA Y EQUIPO DE OFICINA			87,500.00
	Máquinas de escribir eléctrica	2	7,500.00	15,000.00
	Archivos metálicos de 4 gavetas	5	1,500.00	7,500.00
	Contómetros estadísticos	5	1,000.00	5,000.00
	Computadoras con sus accesorios	1	60,000.00	60,000.00
303	APARATOS ELECTRICOS DE SERVICIO			67,500.00
	Proyector de Acetatos	1	6,000.00	6,000.00
	Proyector de Diapositivas	1	9,000.00	9,000.00
	Aparatos de Aire Acondicionado	2	25,000.00	50,000.00
	Ventiladores de Techo	5	500.00	2,500.00
304	EQUIPO DE INGENIERIA Y DIBUJO			5,000.00
	Estuches de Leroy completo	1	5,000.00	5,000.00
359	OTRAS MAQUINARIAS Y EQUIPOS DE SERVICIOS BASICOS			970,000.00
	Estaciones Meteorológicas Automáticas	3	180,000.00	540,000.00
	Equipo de Radio Comunicación	1	250,000.00	250,000.00
	Equipo Instrumental Meteorológico para 9 Estaciones Meteorológicas	1	100,000.00	100,000.00
	Equipo para medir humedad del suelo	1	50,000.00	50,000.00
	Sonda de Neutrones	1	30,000.00	30,000.00
	COSTO TOTAL			1,130,000.00

HETARIA TECNICA DEL FINANCIAMIENTO EXTERNO

PRESUPUESTO EXTRAORDINARIO PARA REACTIVACION ECONOMICA

IDAD EJECUTORA: *DIRECCION GENERAL DE RECURSOS NATURALES RENOVABLES*

MOMBRE DEL PROYECTO: *METEOROLOGIA - PROYECTO PROMESA*

OGRAMA: *306- PROYECTOS PRIORITARIOS DIVERSOS PARA EL DESARROLLO ECONOMICO Y SOCIAL.*

SUBPROGRAMA: *159 - APOYO INSTITUCIONAL RIEGO Y DRENAJE*

ENTE DE ANCIAMIENTO:

PERIODO: *Enero - Diciembre de 1994.*

PRESUPUESTO DE VEHICULOS

CARACTERISTICAS GENERALES

TIPO DE VEHICULO Y MARCA	COMBUSTIBLE	CAPACIDAD	No. DE UNIDADES	COSTO UNITARIO (¢)	COSTO PARCIAL (¢)
EP	*DIESEL*		*1*	*110,000.oo*	*110,000.oo*
CK-UP - doble tracción marca TOYOTA	*DIESEL*	*1.5. Tn.*	*1*	*200,000.oo*	*200,000.oo*
TOS AG100 Enduro	*ACEITE/GAS*		*2*	*25,000.oo*	*50,000.oo*
TOTAL					*360,000.oo*

RMULARIO No. 3-B

APPENDIX G

QUALITY STANDARDS FOR WATER USE

Republic of El Salvador
Ministry of Health and Social Welfare
Quality Standards for Water

Maximum Content of Chemical Elements and Substances

Substance	Maximum Concentration
Arsenic (mg/1 As)	0.05
Chlorides (mg/1 C1)	250
Total Hardness (mg/1 Ca CO_3) (*)	350
Fluoride (mg/1 F)	1.5
Iron (mg/1 Fe) (*)	0.3
Manganese (mg/1 Mn) (*)	0.1
Nitrates (mg/1 NO_3)	45
Total Dissolved Solids (mg/1)	1500
Sulphate (mg/1 SO_4)	400
Boron (mg/1)	3.0
Cadmium (mg/1 Cd)	0.005
Cyanide (mg/1 Cn)	0.1
Copper (mg/1 Cu)	1.0
Zinc (mg/1 Zn)	5.0
Chromium (mg/1 Cr)	0.05
Mercury (mg/1 Hg)	0.001
Lead (mg/1 Pb)	0.05
Selenium (mg/1 Se)	0.01
Dissolved Oxygen (mg/1 0.D.)	pending

(*) The Ministry of Health permits water with a higher content of these substances.

TABLE NO. 4

QUALITY STANDARDS FOR WATER USE

GUIDE FOR ASSESSING WATER QUALITY FOR WATER FAUNA

DESCRIPTION	CONCENTRATION	
	FRESH WATER	SALT WATER
Totals Dissolved Solids (mg/lt)	2000	
Electric Conductivity (Mmhos/cm) @ 25 °C	3000	
Maximum Temperature C° Maximum for Salmonidae	34 23	34
pH Range	6.5-8.5	6.5-9.0
Dissolved Oxygen (D.O.), Minimum mg/lt	5.0	5.0
Floating Oil and Fats, mg/lt	0	0
Emulsifying Oil and Fats, mg/lt	10	10
Detergents, ABS, mg/lt	2.0	2.0
Ammonium (free), mg/lt	0.5	
Arsenic, mg/lt	1.0	1.0
Barium, mg/lt	5.0	
Cadmium, mg/lt	0.01	
Carbon Dioxide (free), mg/lt	1.0	
Chlorine (free) mg/lt	0.02	
Hexavalent Chromium, mg/lt	0.05	0.05
Copper, mg/lt	0.02	0.02
Cyanide, mg/lt	0.02	0.02
Fluorine, mg/lt	1.5	1.5
Lead, mg/lt	0.1	0.1
Mercury, mg/lt	0.01	0.01
Nickel, mg/lt	0.05	
Phenolic Compounds as Phenol, mg/lt	1.0	
Silver, mg/lt	0.01	0.01
Dissolved Sulphate, mg/lt	0.5	0.5
Zinc, mg/lt	0.1	

Source: Van Der Leedn, Troise and Todd, 1990.

TABLE NO. 5

CONCENTRATIONS OF LETHAL CHEMICALS OBSERVED IN SELECTED WATER ENVIRONMENTS

CHEMICAL PRODUCTS	ORGANISMS EXAMINED	LETHAL CONCENTRATIONS (mg/lt)	EXPOSURE TIME (in hours)
ABS (100%)	Fathead minnow	3.5-4.5	96
ABS (100%)	Bluegill	4.2-4.4	96
Household Syndetics	Fathead minnow	39-61	96
Alkaline Sulphate	Fathead minnow	5.1-5.9	96
LAS (C12)	Bluegill fingerlings	3	96
LAS (C14)	Bluegill fingerlings	0.6	96
Acetic Acid	Goldfish	423	20
Aluminum	Goldfish	100	12-96
Ammonium	Goldfish	2-2.5 NH3	24-96
Ammonium	Perch, roach, rainbow trout	3N	2-20
Sodium Arsenite	Minnow	17.8 As	36
Sodium Arsenate	Minnow	234 As	15
Barium Chloride	Goldfish	5000	12-17
Barium Chloride	Salmon	158	...
Cadmium Chloride	Goldfish	0.017	9-18
Cadmium Nitrate	Goldfish	0.3 Cd	190
CO^2	Several different species	100-200	...
CO	Several different species	1.5	1-10
Chloramine	Brown trout fry	0.06	...
Chlorine	Rainbow trout	0.03-0.08	...
Chromic Acid	Goldfish	200	60-84
Copper Sulphate	Stickleback	0.03 Cu	160
Copper Nitrate	Stickleback	0.02 Cu	192
Chlorine Cyanide	Goldfish	1	6-48
Sulphuric Acid	Goldfish	10	96
Hydrochloric Acid	Stickleback	pH 4.8	240
Hydrochloric Acid	Goldfish	pH 4.0	4-6
Lead Nitrate	Minnow, stickleback, brown trout	0.33 Pb	...
Mercury Chloride	Stickleback	0.01 Hg	204

CHEMICAL PRODUCTS	ORGANISMS EXAMINED	LETHAL CONCENTRATIONS (mg/lt)	EXPOSURE TIME (in hours)
Nickel Nitrate	Stickleback	1 Ni	156
Nitric Acid	Minnow	pH 5.0	...
Oxygen	Rainbow trout	3 cc/lts	...
Phenol	Rainbow trout	6	3
Phenol	Perch	9	1
Chromic Potassium	Rainbow trout	75	60
Potassium Cyanide	Rainbow trout	0.13 Cn	2
Sodium Cyanide	Stickleback	1.04 Cn	2
Silver Nitrate	Stickleback	70 K	154
Sodium Fluoride	Goldfish	1000	60-102
Sodium Hydrosulphide	Brown trout	15	...
Zinc Sulphate	Stickleback	0.3 Zn	120
Zinc Sulphate	Rainbow trout	0.5	64
Pesticides			
1. Chlorinated Hydrocarbons			
A Aldrin	Goldfish	0.028	96
DDT	Goldfish	0.027	96
DDT	Rainbow trout	0.5-0.32	24-36
DDT	Salmon	0.08	36
DDT	Brook trout	0.032	36
DDT	Minnow, guppy	0.75 ppb	29
DDT	Stoneflies (species)	0.32-1.8	96
BHC	Goldfish	2.3	96
BHC	Rainbow trout	3	96
Chlordane	Goldfish	0.082	96
Chlordane	Rainbow trout	0.5	24
Dieldrin	Goldfish	0.037	96
Dieldrin	Bluegill	0.008	96
Dieldrin	Rainbow trout	0.05	24
Endrin	Goldfish	0.0019	96
Endrin	Carp	0.14	48
Endrin	Fathead minnow	0.001	96
Endrin	Several species	0.03-0.05 ppb	...
Endrin	Stoneflies (species)	0.32-2.4 ppb	96
Heptachlor	Rainbow trout	0.25	24

CHEMICAL PRODUCTS	ORGANISMS EXAMINED	LETHAL CONCENTRATIONS (mg/lt)	EXPOSURE TIME (in hours)
Heptachlor	Goldfish	0.23	96
Heptachlor	Bluegill	0.019	96
Heptachlor	Redear sunfish	0.017	96
Methoxychlor	Rainbow trout	0.05	24
Methoxychlor	Goldfish	0.056	96
Toxaphene	Rainbow trout	0.05	24
Toxaphene	Goldfish	0.0056	96
Toxaphene	Carp	0.1	...
Toxaphene	Goldfish	0.2	24
Toxaphene	Goldfish	0.04	170
Toxaphene	Minnows	0.2	24
2. Organic Phosphates			
Chlorothen	Fathead minnow	3.2	96
Dipteryx	Fathead minnow	180	96
EPN	Fathead minnow	0.2	96
Guthion	Fathead minnow	0.093	96
Guthion	*Bluegill*	0.005	96
Malathion	Fathead minnow	12.5	96
Parathion	Fathead minnow	1.4-2.7	96
TEPP	Fathead minnow	1.7	96
3. Herbicides			
Weedex	Young roach	40-80	1 month
Weeda Zol	and trench	15-30	1 month
Weeda Zol T.I.		20-40	1 month
Simazine	Minnow	0.5	< 3 days
(plants not present)			
Atrazine (A361)	Minnow	5.0	24
(plants present)			
Atrazine in Gesaprime	Minnow	3.75	24
4. Bactericides			24
Albibiol	Minnow	20	24
Soricide Tetraminol	Minnow	8	48

Source: Van Der Leedn, Troise and Todd, 1990. WASH Field Report No. 354 dated December 1991. USAID/El Salvador.

APPENDIX H

SCOPE OF WORK

SCOPE OF WORK

EL SALVADOR: MONITORING PLAN FOR SURFACE AND GROUNDWATER CONTAMINATION

MAY 28, 1993

I. BACKGROUND

The government of El Salvador recognizes the environmental contamination which has taken place in the last decade, and which threatens the poor with increased living costs through a preventable scarcity of clean water. Further, it believes that important collateral benefits (e.g., reduced morbidity) could be obtained by the rational management of existing sources of water and by reversing longstanding sources of contamination.

USAID and the Secretaria Ejecutiva del Medio Ambiente (SEMA) are collaborating on a major new natural resource management project, PROMESA. One component of PROMESA is a Demonstration Area where the results of improved environment and natural resource management (E/NRM) policy and nationwide environmental education can be observed and results fed back to fine tune policies and education messages.

In September 1991, WASH carried out an assessment of water, soil, and marine organism contamination in the proposed demonstration area (TASK 256). Now that the PROMESA project is about to start, the USAID Mission has requested follow-up technical assistance from WASH in designing the six year plan to monitor the water resource in the Demonstration Area including physical, chemical, and hydrological parameters.

The purpose of this task is to develop a monitoring plan of surface and groundwater contamination in selected waterways in southwestern El Salvador for the Ministry of Agriculture.

II. TASKS

1. Review the ANDA, Plansabar, and Ministry of Agriculture records to determine the location of potential and actual organic and inorganic pollution in the department of Ahuachapan. Based on this review, determine a sampling plan for measurement of

sewage and other effluents, as well as pesticide residues leached from soil, which may be contributing pollutants to surface water or aquifers.

2. Using the data from the earlier WASH study (Field Report No. 354), devise a sampling program of the identified water sources to determine if there are changes in the contaminants in the water supply at appropriate intervals during the life of project (LOP) of PROMESA. Multiple samples will be necessary to estimate recurring levels or to estimate seasonal variations.

3. Identify local laboratories and the means to procure the samples to conduct the analysis during the LOP and estimate costs.

4. Provide an example of how the on-going monitoring data should be used to guide decisions. For example, based on the contaminants identified, trace in an illustrative way the contamination to one or more sources, and describe how the contamination enters the water source. Building on this illustrative example, give examples of appropriate policies, technologies, or other alternatives that could be carried out by the PROMESA project to address the problems.

5. Recommend a monitoring regime for the stream flow in the major rivers in the Demonstration Area and the placement of the appropriate gauges.

6. Identify the training and facilities needed (labs, field staff, interpretation) to carry out the monitoring program locally.

7. At the completion of field work, furnish a verbal briefing, in Spanish, to selected USAID, Ministry of Agriculture (MAG) and other Government of El Salvador (GOES) personnel as well as interested NGOs. The briefing will summarize work to date, both fieldwork and the literature review, and will provide initial impressions of the research team with respect to water contamination.

8. Before leaving the country, provide the USAID Agriculture and Natural Resource Office with a draft field report detailing the monitoring plan.

III. PRODUCT

The principal product of this activity will be a WASH Field Report containing a water monitoring plan for surface and groundwater contamination in selected waterways in southwestern El Salvador. WASH will provide USAID with 50 copies in Spanish and 20 copies in English and the respective diskettes.

IV. PERSONNEL AND LEVEL OF EFFORT

1. This task will require an environmental engineer with experience in environmental contamination measurement including basic hydrology and, statistical and survey experience. The consultant should have developing country experience and speak Spanish. (level of effort up to 24 days).

2. A Salvadoran research assistant will also be required to assist the WASH consultant. This assistant should have knowledge of the country as well as the institutions and individuals involved in water resource management. (level of effort up to 30 days)

V. SCHEDULE

1. Travel to El Salvador will commence on July 16 ,1993. Work will commence on July 17, 1993 and be completed by August 6, 1993. Return travel will take place on August 7, 1993.

2. A draft field report should be left with the USAID Mission before leaving the country. The final report will be submitted by the consultant to WASH one week after receiving Mission comments.

3. The final Field Report in both English and Spanish will be prepared by WASH within 30 days after receiving the final report from the consultant

APPENDIX I

INDUSTRIAL AND AGROINDUSTRIAL EFFLUENTS

FUENTE: Department of Environmental Sanitation, MOH, July 1993

INDUSTRIAL AND AGROINDUSTRIAL EFFLUENTS
WESTERN REGION, DEPARTMENT OF AHUACHAPAN
BARRA DE SANTIAGO-EL IMPOSIBLE WATERSHED

NAME	MUNICIPALITY	LOCATION	PROCESS	DISCHARGE
Porqueriza María Luisa Gómez	San Francisco Menéndez	Cton. Cara Sucia 1a. C. Ote. # 12	Pig fattening	Street
Porqueriza Ricardo García	San Francisco Menéndez	Colonia Nueva Esperanza Pasaje La Gloria	Pig fattening	Street
Granja El Camalote	San Francisco Menéndez	Cantón Cara Sucia	Chickens for fattening and egg production	Irrigation field
Barra de Santiago, Pescadores	Jujutla	Barra de Santiago	Seafood processing	Beach and estuary
Cremería Victoria Marín	San Francisco Menéndez	Cantón Garita Palmera, Calle a la Playa	Cream production	Street
Establo Cooperativa New York	San Francisco Menéndez	Cantón Cara Sucia	Milk production	Open field
Establo Ignacio Escalante	San Francisco Menéndez	Calle Principal	Milk Production	San Francisco Menéndez River
Establo Ana María Franco	San Francisco Menéndez	Cantón Cara Sucia	Milk production	Street
Establo San Antonio	San Francisco Menéndez	Cantón La Hachadura	Milk production	Open field
Establo Mauricio Vásquez	San Francisco Menéndez	Costado Norte de la Unidad de Salud	Milk production	Open field
Establo Rancho Los Dos Antonio Borja N.	San Francisco Menéndez	Caserío El Coyol, Cantón Cara Sucia	Milk production	Cara Sucia River
Establo Roberto Hernández	San Francisco Menéndez	Calle Principal	Milk production	San Francisco Menéndez River
Establo Francisco López	San Francisco Menéndez	Colonia La Esperanza	Milk production	Open field
Establo Rafael Escalante	San Francisco Menéndez	Calle Principal	Milk production	Quebrada Seca Creek
Establo San Pedro	San Francisco Menéndez	6 Km. Calle a Frontera La Hachadura	Milk production	San Pedro River
Productos Lácteos El Progreso	San Francisco Menéndez	Calle Frontera a Puente Arce	Cheese production	Paz River

Source: Department of Environmental Sanitation (MOH), July 1993