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42039

UNCLASSIFIED

UNITED STATES INTERNATIONAL DEVELOPMENT COOPERATION AGENCY
AGENCY FOR INTERNATIONAL DEVELOPMENT
Washington, D. C. 20523

CARIBBEAN REGIONAL

PROJECT PAPER

ST. LUCIA GEOTHERMAL

AID/LAC/P-237

Project Number: 538-0137

UNCLASSIFIED

AGENCY FOR INTERNATIONAL DEVELOPMENT

PROJECT DATA SHEET

1. TRANSACTION CODE: A (A = Add, C = Change, D = Delete) — Amendment Number: _____

DOCUMENT CODE: 3

2. COUNTRY/ENTITY: St. Lucia

3. PROJECT NUMBER: 538-0137

4. BUREAU/OFFICE: Latin America/Caribbean (LAC) — 05

5. PROJECT TITLE (maximum 40 characters): St. Lucia Geothermal

6. PROJECT ASSISTANCE COMPLETION DATE (PACD): MM 08 DD 31 YY 87

7. ESTIMATED DATE OF OBLIGATION (Under 'B.' below, enter 1, 2, 3, or 4)

A. Initial FY 85 B. Quarter 4 C. Final FY 86

8. COSTS ($000 OR EQUIVALENT $1 =)

A. FUNDING SOURCE	FIRST FY ____ B. FX	C. L/C	D. Total	LIFE OF PROJECT E. FX	F. L/C	G. Total
AID Appropriated Total						
(Grant)	(1,500)	( )	(1,500)	(3,000)	( )	(3,000
(Loan)	( )	( )	( )	( )	( )	(
Other U.S. 1.						
Other U.S. 2.						
Host Country GOSL		80	80		80	80
Other Donor(s) UNRFNRE				2,200		2,500
TOTALS	1,500	80	1,580	5,200	80	5,580

9. SCHEDULE OF AID FUNDING ($000)

A. APPROPRIATION	B. PRIMARY PURPOSE CODE	C. PRIMARY TECH. CODE 1. Grant	2. Loan	D. OBLIGATIONS TO DATE 1. Grant	2. Loan	E. AMOUNT APPROVED THIS ACTION 1. Grant	2. Loan	F. LIFE OF PROJECT 1. Grant	2. Loan
(1) ESF	744	825				3,000		3,000	
(2)									
(3)									
(4)									
TOTALS						3,000		3,000	

10. SECONDARY TECHNICAL CODES (maximum 6 codes of 3 positions each)

11. SECONDARY PURPOSE (

12. SPECIAL CONCERNS CODES (maximum 7 codes of 4 positions each)

A. Code

B. Amount

13. PROJECT PURPOSE (maximum 480 characters)

To establish the economic and technical viability of the Qualibou Caldera as a long term geothermal resource capable of generating substantial quantities of electrical power and other forms of energy which can be developed by the private sector.

14. SCHEDULED EVALUATIONS

Interim MM 03 YY 87 MM YY Final MM 12 YY 87

15. SOURCE/ORIGIN OF GOODS AND SERVICES

[X] 000 [ ] 941 [ ] Local [ ] Other (Specify) _____

16. AMENDMENTS/NATURE OF CHANGE PROPOSED (This is page 1 of a _____ page PP Amendment.)

17. APPROVED BY

Signature: James L. Holtaway

Title: Director, RDO/C

Date Signed: MM 08 DD 14 YY 85

18. DATE DOCUMENT REC IN AID/W, OR FOR AID/W MENTS, DATE OF DISTRI

MM DD YY

PROJECT AUTHORIZATION

NAME OF COUNTRY: St. Lucia

NAME OF PROJECT: Geothermal Project

NUMBER OF PROJECT: 538-0137

1. Pursuant to Section 531 of the Foreign Assistance Act of 1961, as amended, I hereby authorize the Geothermal Project for St. Lucia (the "Grantee") involving planned obligations of not to exceed Three Million United States "U.S." Dollars ($3,000,000) in grant funds ("Grant") over a one year period from the date of authorization, subject to the availability of funds in accordance with the A.I.D. OYB/allotment process, to help in financing foreign exchange and local currency costs for the project. The planned life of the project is two years and one month from the date of obligation.

2. The Project ("Project") consists of assisting the Grantee as part of a multi-donor effort, in its program of exploring and developing geothermal energy production.

3. The Project Agreement, which may be negotiated and executed by the officer to whom such authority is delegated in accordance with A.I.D. regulations and delegations of authority, shall be subject to the following essential terms and covenants and major conditions, together with such other terms and conditions as A.I.D. may deem appropriate:

A. Source and Origin of Commodities

Commodities financed by A.I.D. under the Project shall have their source and origin in St. Lucia or in the United States, except as A.I.D. may otherwise agree in writing. Except for ocean shipping, the suppliers of commodities or services shall have St. Lucia or the United States as their place of nationality, except as A.I.D. may otherwise agree in writing. Ocean shipping financed by A.I.D. under the Project shall, except as A.I.D. may otherwise agree in writing, be financed only on flag vessels of the United States.

B. Conditions Precedent to Disbursement

(1) First Disbursement. Prior to the first disbursement under the Grant, or to the issuance by A.I.D. of documentation pursuant to which disbursement will be made, the Grantee will, except as the Parties may otherwise agree in writing, furnish to A.I.D. in form and substance satisfactory to A.I.D.:

(a) An opinion of counsel acceptable to A.I.D. that this Agreement has been duly authorized and/or ratified by, and executed on behalf

of, the Grantee, and that it constitutes a valid and legally binding obligation of the Grantee in accordance with all of its terms;

(b) A statement of the name of the person holding or acting in the office of representative of the Grantee, and of any additional representatives, together with a specimen signature of each person specified in such statement;

(2) Disbursement for Civil Works and Drilling Activities. Prior to any disbursement under the Grant, or to issuance by A.I.D. of documentation pursuant to which disbursement will be made for the civil works and drilling activities, the Grantee will, except as the Parties may otherwise agree in writing, furnish to A.I.D. in form and substance satisfactory to A.I.D.:

(a) A detailed, time phased implementation plan for the drilling activities, civil works, well repair and training to be financed under the Project;

(b) Evidence that the Grantee has obtained or has set in motion procedures to obtain all lands for the Project, including all necessary easements or other rights in property, to carry out the activity; and

(c) (1) an AID-approved environmental assessment (EA) prepared according to A.I.D. Reg. 16 (22 CFR Part 216) and (2) an environmental monitoring and safety plan designed to protect the human and physical environment in and around the proposed drilling sites.

C. Special Covenants

(1) Project Evaluation. The Parties agree to establish an evaluation program as part of the Project. Except as the Parties otherwise agree in writing, the program will include, during the implementation of the Project and at one or more points thereafter:

(a) evaluation of progress toward attainment of the objectives of the Project;

(b) identification and evaluation of problem areas or constraints which may inhibit such attainment;

(c) assessment of how such information may be used to help overcome such problems; and

(d) evaluation, to the degree feasible, of the overall development impact of the Project.

(2) Environment. The Grantee agrees to take steps to adhere to recommendations stemming from the environmental assessment and monitoring procedures to be carried out as part of the Project.

James S. Holtaway
Director

8/14/85
Date

Clearances:

D/DIR:TBrown
C/ENGR:MDeMetre (draft)
CONT:RLWarin (draft)
CPO:JNConnolly
C/DR:POrr (draft)

GLOSSARY

BASE LOAD	The average demand for electricity.
CALDERA	A deep cauldron-like cavity resulting from the explosion or collapse of the center of a volcano.
DRILLING PAD	The area of open ground on which the drill rig operations take place.
ENTHALPY	In thermodynamics, heat under pressure.
GEOTHERMAL	Pertaining to the internal heat of the earth.
GRID	The electricity transmission and distribution system.
PEAKING LOAD	The highest demand for electricity.
RESERVOIR	The volume of the heat resource in the caldera.
REINJECTION WELL	A well in which geothermal waste products are disposed for safety and for recharging, constituting a closed system.

ABBREVIATIONS AND ACRONYMS

AID	Agency for International Development
CDC	Caribbean Development Corporation
EC$	East Caribbean Dollars (US$ = EC$.37)
GOSL	Government of St. Lucia
GWh	Gigawatt Hours (1 million kilowatt hours)
IFC	International Finance Corporation
kv	Kilovolts
kW	Kilowatts
kWh	Kilowatt Hours (1,000 watt hours)
LANL	Los Alamos National Laboratory
LPG	Low Pressure Gas
LUCELEC	St. Lucia Electricity Services Ltd.
MW	Megawatts (1 million watts)
PACD	Project Assistance Completion Date
PIO/T	Project Implementation Order/Technical
PUC	Public Utilities Commission - St. Lucia
RDO/C	Regional Development Office/Caribbean
RFQ	Request for Quotations
RFTP	Request for Technical Proposals
UNRFNRE	United Nations Revolving Fund for Natural Resources Exploration
UNDP	United Nations Development Program
$	United States Dollars

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Exhibit 1	Map of St. Lucia Indicating the General Project Area
Exhibit 2	Map Indicating the Recommended Sites for Geothermal Drilling
Exhibit 3	Map Indicating the LUCELEC Power System
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I. SUMMARY AND RECOMMENDATIONS

A. Recommendations

1. Funding

RDO/C recommends that an ESF grant of $3.0 million ($1.5 million of which will be from FY85 funds and $1.5 million from FY86 funds) be authorized for obligation for the St. Lucia Geothermal Development Project with a Project Assistance Completion Date (PACD) of August 31, 1987.

2. Geographic Code

The project authorization will specify that, except as AID may otherwise agree in writing:

a. Goods and services financed by AID under this project shall have their source and origin in AID Geographic Code 000 or St. Lucia.

b. Ocean shipping financed by AID under this project shall only be on flag vessels of the United States or St. Lucia unless the conditions specified in the Project's ocean freight waiver have been complied with and the appropriate certification is made.

3. Waivers

An ocean freight waiver and waivers for the procurement of right hand drive utility vehicles for project use will be obtained from AID/Washington's Office of Commodity Management.

B. Summary Project Description

The objective of the St. Lucia Geothermal project is to accelerate the economic development of St. Lucia through the establishment of an indigenous source of energy for the production of electricity. This project, which will be co-financed by AID and the United Nations Revolving Fund for Natural Resources Exploration (UNRFNRE), supports AID's private sector-led strategy for St. Lucia.

The availability of an indigenous source of energy will help St. Lucia attract private investment in productive enterprises and will diminish the foreign exchange burden of importing diesel oil. The objectives will be achieved by drilling production-sized exploration geothermal wells in the Qualibou Caldera near Soufriere. Management services will be provided by the UNRFNRE and financed in part by AID. The quality of the effluent and the effects of the geothermal activity on the environment will be monitored continuously, and mitigative measures will be taken as needed. Technical assistance will be provided to the GOSL to

prepare a Request for Technical Proposal (RFTP) to solicit private sector investment proposals for the development of the proven geothermal resource and the generation of electricity. Training will be provided for the St. Lucians who will administer the geothermal resource.

C. Summary Findings

This project is ready for implementation and is considered to be socially, financially and economically sound, and technically and administratively feasible.

D. AID/W Design Considerations

AID/W delegated the RDO/C Mission Director to approve the Project Identification Document and to authorize the Project. No specific concerns or issues were raised regarding Project development.

E. Contributors to the Development of the Project

RDO/C Project Committee

Michael DeMetre, Chief, Infrastructure Division
Joanne Connolly, Project Development Officer
Brinley Selliah, Engineer, Infrastructure Division

RDO/C Project Review Committee

Terrence Brown, Deputy Director
Peter Orr, Chief, Development Resources Division
Theodore Carter, Regional Legal Advisor
Richard Warin, Controller
Stanley Heishman, Regional Contracts Officer

Government of St. Lucia

John Compton, Prime Minister
Ausbert D'Auvergne, Deputy Director, Finance and Planning (Planning)
Aloysious Barthelmy, Energy, Central Planning Unit

Other Contributors to Project Development

Jem Carter, Secretary, Infrastructure Division, RDO/C
Robert Fedel, Contractor, PIR Project
Roy Grohs, Program Economist, RDO/C
Robert Hendron, Los Alamos National Laboratory
Cecelia Karch, Contractor, RDO/C
Patrick Sorensen, Environmental Specialist, TAMS
James Talbot, Regional Environmental Management Specialist/Caribbean
Percy Wicklund, AMAX

II. PROJECT RATIONALE AND DESCRIPTION

A. Rationale

1. Background

St. Lucia is a small island nation with a population of 124,000 and a land area of 616 km^2 in the central part of the Lesser Antilles of the Eastern Caribbean. The former British colony became independent in 1979 and now has a democratically elected, parliamentary form of government. St. Lucia is a member of the Organization of Eastern Caribbean States, the Caribbean Common Market (CARICOM), and the United Nations.

St. Lucia's economy is based on agriculture (primarily bananas), tourism, and increasingly on light manufacturing. Further development of the island's economy depends in part on the improvement and expansion of its physical infrastructure, and in particular on the development of a dependable source of electricity.

The national electric utility, St. Lucia Electricity Services, Ltd. (LUCELEC) is entirely diesel-based and relies on imported petroleum which costs the GOSL approximately $6.61 million per annum in hard currency. The hydropower potential of the island totals only 600 KW and is insignificant.

The only significant alternative to imported diesel is the geothermal resource in the Qualibou Caldera near Soufriere in the west-central part of the island (Exhibit 1). At Sulphur Springs, which is at the head of the Soufriere Valley, natural steam issues from the ground. Black pools of boiling water and the strong smell of sulphur make Sulphur Springs and the surrounding volcanic area one of the world's most impressive surface manifestations of geothermal activity. Until recently this had been regarded as mainly of interest to tourists.

The St. Lucia government has long been aware of the potential of geothermal steam to supply the island's energy needs, and a number of investigations have been undertaken. However, there was no incentive to embark on this high capital cost venture while imported fuel oil was relatively cheap. The situation changed in 1973 when oil prices rose. In 1974, the British Overseas Development Agency agreed to finance an exploration program in the Soufriere Valley which the GOSL hoped would lead to the commercial development of the geothermal resource.

The drilling ended in 1976, resulting in seven shallow, large diameter wells, two of which produced in sum only 1MW of steam. In 1977, consultant analysts Merz and Mclellan determined that with further drilling steam would be available in commercial quantity. The Caribbean Development Corporation (CDC) subsequently prepared a report for St. Lucia Electricity Services, Ltd. (LUCELEC)

which recommended the use of the steam for the production of electricity.

In 1982, further pre-feasibility work, financed by the European Investment Bank (EIB), was carried out by Aquater of Italy. Aquater used geothermometry to predict brines in excess of 350°C at depth, and carried out audiomagnetotelluric and gravimetric surveys. Aquater analysts identified five drilling sites and suggested that production could be expected over the entire 30 km^2 of the caldera area.

In 1984-85, the Los Alamos National Laboratory (LANL), financed by the U.S. Trade Development Program (TDP), carried out a dipole-dipole DC resistivity traverse across the caldera. The resistivity study, together with a review of the previous work and the updated geologic and geochemical interpretations, indicated three attractive drilling sites in the caldera. LANL concluded that the caldera offers excellent prospects for the discovery of producible high-enthalpy fluids at depths between 1 and 2 km. It is now proposed to drill a deep well at each of the three sites: Belfond, Sulphur Springs, and Etangs.

If the exploratory drilling and subsequent testing succeeds in identifying an economically viable source of geothermal power, the GOSL will pursue commercial electrical power generation. Geothermal development will also make available large quantities of process heat which could be used for coconut oil production at the copra plant in Soufriere, thereby replacing 100,000 gallons of imported bunker fuel each year. Excess hot geothermal fluids could be used for the production of dry ice, timber processing, concrete block production, a brewery, alcohol production from sugar cane, banana chip processing, and hot water service to hotels. Geothermal power could also be used for the desalinization of seawater.

The GOSL formally applied to AID for financing for the exploratory drilling phase in June 1984. Convinced of the likelihood of a major geothermal find and of the favorable impact of its development on the economy of St. Lucia, AID and the UNRFNRE agreed to co-finance further exploration up to the point of production and commercialization.

At a Tripartite Conference in April, 1985, the consultants brought by the GOSL (Aquater and Geothermal of New Zealand), AID (LANL) and the UNRFNRE (Geothermex), as well as geothermal specialists from the US Department of Energy, the US Geological Survey Service, and the UNRFNRE, agreed that Belfond would be the probable site of the first project-financed well.

Surface data of the Belfond area (Exhibit 2) indicate a deep-brine reservoir with temperatures in the range of 200-250°C, and possibly as high as 350°C, located some 1000 meters below the surface. Future plans to exploit the geothermal

resource for the generation of electricity depend on the results of this drilling. However, all available data indicate a geothermal potential to produce at least 10 MW of electricity.

2. The Power Sector in St. Lucia

a. The Power Generation System

Presently, electricity is generated, transmitted and distributed by the St. Lucia Electricity Services, Ltd. (LUCELEC). The LUCELEC system consists of two separate networks and has 16,000 customers. The northern system, commissioned in 1971, extends from the Union Power Station (installed capacity 12,105 MW) in Cap Estate in the North to Dennery in the East and Canaries in the West. The southern system, commissioned in 1965, extends from the Vieux Fort Power Station (installed capacity 4.12 MW) to Praslin in the East and Soufriere in the West.

The gap between the Northern and Southern grids is approximately 5 km on both the western and eastern sides of the island. Operating two separate grids is costly, and may not be suitable for long term power generation because of limitations posed by location, size, available area for expansion, and fuel delivery. It is likely that the Northern and Southern grids will be interconnected in the near future (Exhibit 3).

b. Power Generation Capacity

The Northern Grid is served by four aging generators with a nominal rating of 2.67 MW each. Recently, in 1980, an English Electric 16SVA generator with a nominal rating of 1.425 MW was installed, and a sixth unit, having a nominal rating of 2.75 MW, is expected to be commissioned in late 1985. This brings the total nominal capacity to 14.85 MW. Since the original generators are close to retirement, the total installed capacity will soon be drastically reduced.

The Southern Grid is served by four generators which were installed between 1965 and 1971, two with a nominal rating of 1.04 MW each, and two with a nominal rating of 1.02 MW each. The original generators are coming to the end of their economic life and the system will require new base load replacement generators (Exhibit 4).

c. Electricity Tariffs and Fuel Surcharge

The Public Utilities Commission (PUC) was established in 1973 to regulate and restructure tariffs. Tariffs are uniform in the northern and southern systems. The tariff structure for LUCELEC (Exhibit 5) distinguishes between four consumer categories: domestic, commercial, industrial and street lighting.

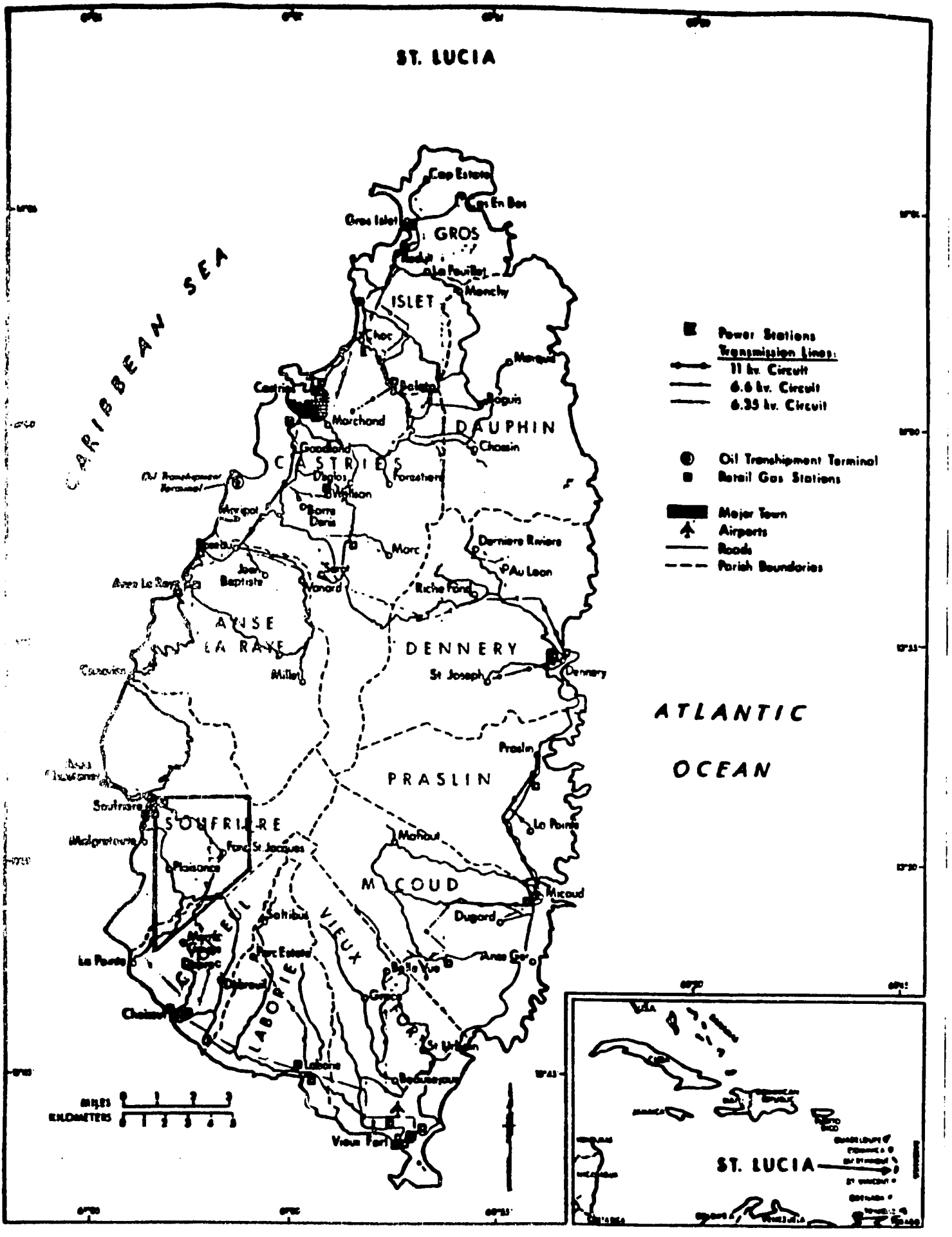

EXHIBIT 1 - ST. LUCIA AND [illegible]

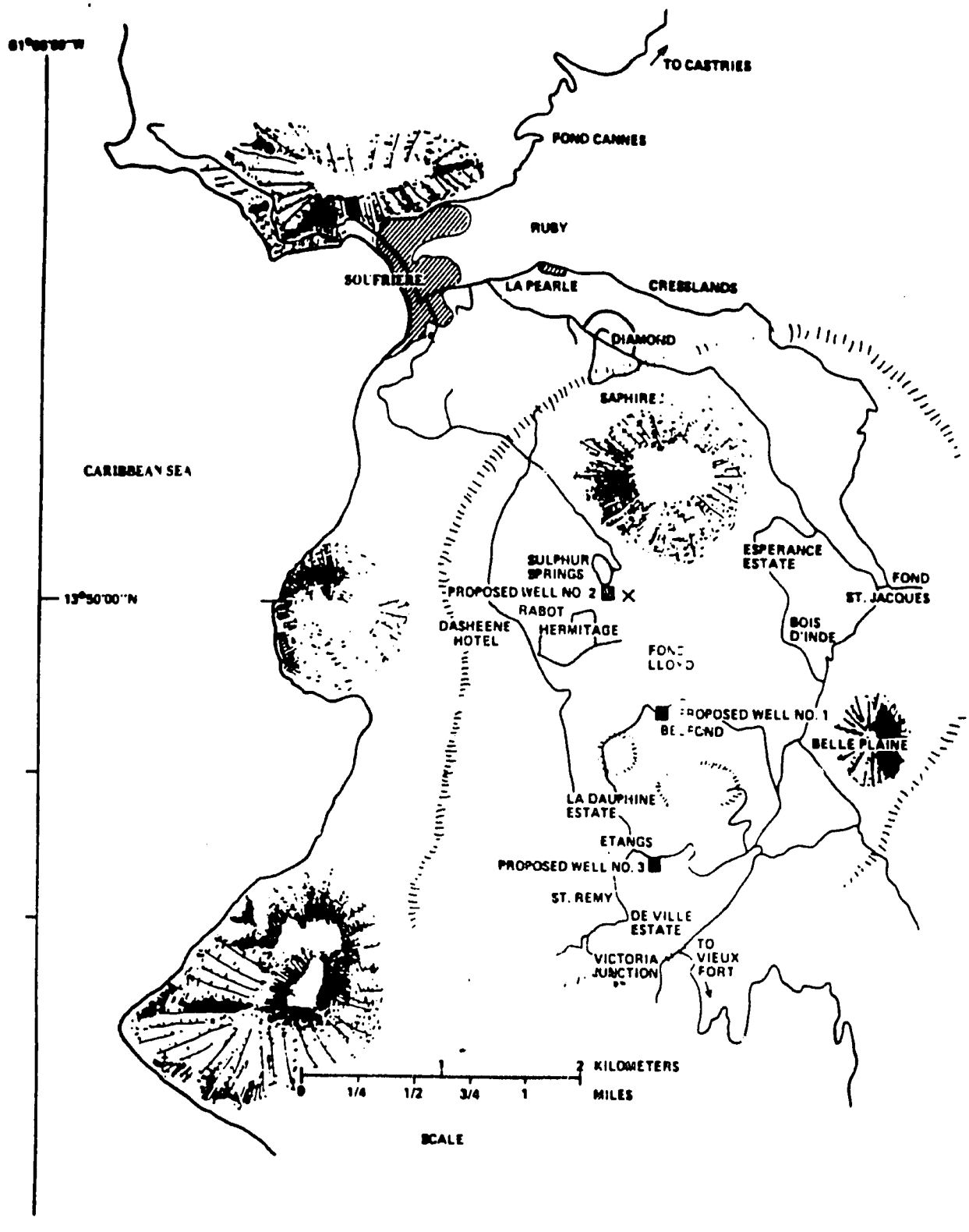

EXHIBIT 2 - RECOMMENDED SITES FOR EXPLORATORY DRILLING

5C

IBRD 17612
NOVEMBER 1983

ST. LUCIA
POWER SYSTEM

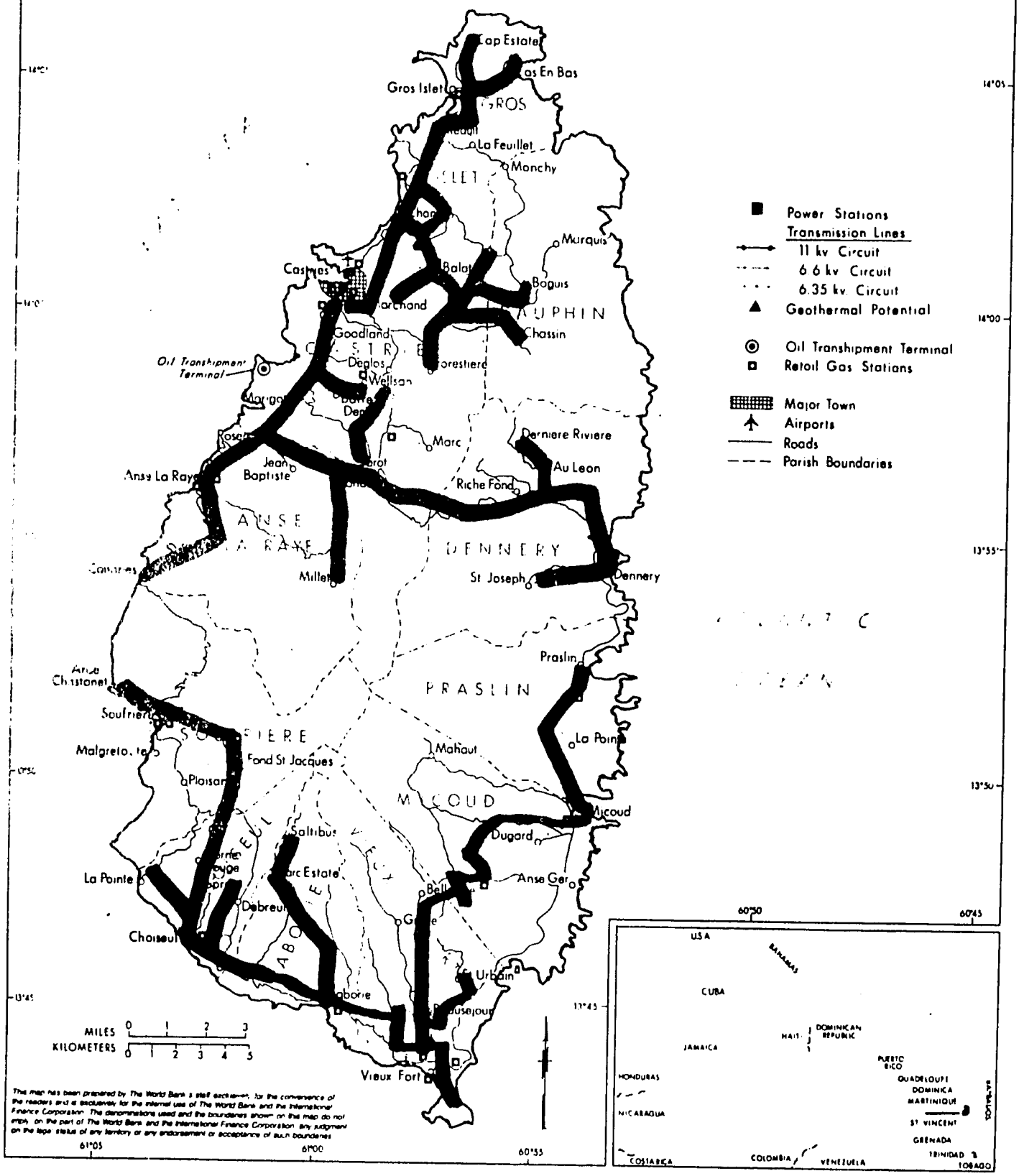

EXHIBIT 3

TABLE C.1

ST. LUCIA ELECTRICITY SERVICES LIMITED
GENERATION PLANT DATA AT DECEMBER 31, 1984

	Unit Description	Year of Commissioning	Retirement Date	Installed Capacity	Economical Rating or Continuous Capacity	Lifetime Hours Run to 12/31/84	R.P.M.
	Union						
1	Allen VBCF 37F	1972	1990	2,670	2,500	60,769	600
2	Allen VBCF 37F	1971	1989	2,670	2,500	73,699	600
3	Allen VBCF 37F	1971	1989	2,670	2,500	76,739	600
4	Allen VBCF 37F	1976	1994	2,670	2,500	50,065	600
5	English Electric 16 SVA	1970	1988	1,425	1,250	40,086	750
				12,105	11,250		
	Vieux Fort						
1	English Electric 12 SVA	1971	1989	1,040	1,000	72,146	750
2	English Electric 12 SVA	1971	1989	1,040	1,000	76,240	750
3	English Electric 12 SVA	1964	1985	1,020	1,000	86,811	750
4	English Electric 12 SVA	1965	1985	1,020	1,000	90,000	750
				4,120	4,000		

EXHIBIT 4

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The domestic tariff consists of a minimum monthly charge of EC$5.0, a first block rate of EC$0.20/kWh for the first 180 kWh each month, and EC$0.21/kWh for all additional units. Commercial users (including the Government) pay a minimum monthly charge of EC$25.00, EC$0.50/kWh for the first 75 kWh and EC$0.237/kWh for all additional units. The Government pays EC$0.365/kWh for electricity used for street lighting and enjoys a 10% discount on all its bills. Industrial consumers pay a fixed monthly charge of EC$100 with all units costing EC$0.232/kWh. They also pay EC$5.00 per kW of installed capacity of electrical equipment (Exhibit 5).

EXHIBIT 5

LUCELEC ELECTRICITY TARIFFS [a]

(October 1983)

Category	Monthly Charge (EC$/kWh)
Domestic	
Minimum Charge (0-25 Units)	5.00
Block I 0-180 Units	0.20
Block II Above 180 Units	0.21
Commercial	
Minimum Charge (0-50 Units)	25.00
Block I 0-75 Units	0.50
Block II Above 75 Units	0.237
Industrial	
Minimum Charge	100.00
All Units Energy Charge	0.232
Demand Charge [b]	3.00/kW
Street Lighting	
All Units	0.365

[a] Excludes fuel surcharge, which in 1983 averaged EC$25/kWh.

[b] Based on the installed horsepower rating of connected motors and appliances.

Although several large consumers are primary metered, this is not reflected in their tariff, and the energy charge to industrial users is 10-15% higher than that to domestic consumers. These charges bear no relation to the long-run marginal costs (LRMC) of supply to different consumer categories.

Recently, some of the large industrial electricity users have become concerned about the level of the industrial tariff, and are considering purchasing their own diesel units for self-generation. The present level of this tariff appears to be close to the point where autogeneration could become cheaper for these large users.

Over the 1976-82 period, LUCELEC's fuel cost increased by 17.9%. The major increases occurred after 1978 when petroleum import costs more than doubled. In 1974, a fuel surcharge was introduced to meet the rapid increases in fuel costs. This surcharge, calculated on a per kWh basis, in 1983 averaged EC$0.25 per kWh.

d. Demand for Electric Power

The present demand for electrical power in St. Lucia is approximately 9 MW of base load power and 13 MW of peak load power. Between 1976 and 1982 sales to consumers grew by 4.5%. The fastest growth occurred in the domestic sector which averaged an increase of 7.6% per year. This growth rate reflects both an increasing number of consumers and higher consumption per consumer. Domestic consumption is 31.2% of total sales.

Growth in commercial sales averaged an increase of 4.3%, and in 1982 accounted for 53% of total sales. Eight hotels made up almost half of commercial sales, principally for air-conditioning. The Central Water Authority accounts for about 40% of industrial sales (Exhibit 6).

The UNDP/World Bank has estimated future sales, generation and demand for the period 1983-90. The forecast of electricity demand is shown in Exhibit 7. Sales growth for the northern and southern systems between 1982 and 1990 is predicted to be 4.4% and 5.7%, respectively, with total sales increasing at 4.7%. Interconnection of the two systems is expected to occur in 1989 when total sales are projected to be 66,000 MWh.

Total generation is projected by the World Bank Study to rise at the rate of only 1.7% between 1985 and 1987 and 4.2% between 1987 and 1990 (Exhibit 8). The lower growth in the medium-term reflects the reduction in technical losses arising from the loss reduction program.

LUCELEC's projections of peak demand for both the northern and southern systems are based on 3% per annum increases (Exhibit 8). It is estimated that peak demand in the

north will increase at the rate of 3.7% per annum and in the south by 5.4% per annum. The effect of reduced technical losses in slowing the growth rate of peak demand has been included in the forecasts. However, the energy conservation program at the end-use level is assumed to have only a small impact on system peak demand because the commercial and industrial sectors are not major contributors to the evening peak. Any impact it would have on peak demand would arise largely from the hotel sector.

EXHIBIT 6

MAJOR ENERGY CONSUMERS IN ST. LUCIA - 1982

	Electricity	Diesel	LPG
	('000 kWh)	(Gallon)	(Lbs)
Hotels			
Halcyon Days	2,020	17,000	190,000
La Toc	2,927	6,900	125,000
St. Lucian	1,540	-	165,000
Halcyon Beach	827	-	186,000
Cariblue	950	1,500	71,300
Couples Malabar	640	7,200	43,000
Red Lion	260	2,300	21,000
Industry			
WLBL (Brewery)	1,030	91,500	-
Winera (Packaging)	580	103,000	-
Copra Manufacturing Ltd. b/	350	80,000	-
Commercial			
Cable and Wireless Ltd.	1,300	5,000	-
St. Lucia Cold Storage	350	-	-
Canadian Imperial Bank of Commerce	160	500	-
Government			
Central Water Authority	2,860	-	-
Victoria Hospital	250	11,700	17,000

EXHIBIT 7

ELECTRICITY SALES FORECASTS, 1983-90

(GWH)

	Actual 1982	1983	1985	1987	1990	Growth %
Mission						
North	35.5	38.3	41.6	44.3	50.0	4.4
South	10.3	11.5	12.5	13.5	16.0	5.7
TOTAL	45.8	49.8	54.1	57.8	66.0	4.7

EXHIBIT 8

PEAK DEMAND FORECASTS, 1983-90

(MW)

	Actual 1983	1985	1987	1990	Growth %
World Bank Estimates					
North	8.90	9.40	10.0	11.50	4.1
South	2.83	3.10	3.40	3.87	5.0
LUCELEC Estimates					
North	8.60	9.12	9.68	-	3.0
South	2.75	2.92	3.04	-	3.0

e. Forecasted Expansion of the Grid System

In 1980, CDB financed a generation expansion study which focused on the 1981-86 period. Requirements for high-speed diesel generators for the years 1981-90 also were evaluated. The actual sequence and sizing of plant additions are presently under review. The British consulting firm of Kennedy and

Donkin, funded by the CDB, is presently preparing a system expansion plan for 1985-1990 which will be based on demand and sales forecasts. Priority is being given to the interconnection and redistribution of energy, including that which is expected to be generated by the development of the geothermal resource.

The objectives of the present CDB assistance are:

- to review the existing generating plant retirement program;
- to advise on the long term suitability of both power stations in terms of location and plant use;
- to formulate a plan for servicing the entire island with a secure power supply for the period up to 1990, with provisions for easy expansion in the long term;
- to advise on the suitability of interconnecting the northern and southern systems, including consideration of the timing, voltage and capacity of such interconnection;
- to formulate a plan for upgrading or expanding the existing 11 KV system or consideration of a higher voltage system;
- to provide a least cost investment plan for any generation expansion and transmission development.

A preliminary analysis of the power plant and transmission system requirements has indicated that an interconnector may be routed from Union via Soufriere to Vieux Fort, thus linking the geothermal facility with the existing power stations. The exact route of the transmission line can only be known after a detailed survey is undertaken.

Preliminary indications are that the interconnector should operate at either 33 or 69 KV, and that power would be transformed to 11KV at substations to link with the existing 11 KV distribution systems in the north and south. No information is presently available on the method of transmitting power from the geothermal site to the nearest connecting point on the grid. A stability study is necessary to address power flows, voltage levels and frequency resulting from the use of more than one generating source linked to many load centers via an interconnected transmission system.

f. The Future Role of Geothermal Power

The substitution effect of geothermal powered baseload generation will offset the need to purchase most of the replacement diesel generators. The privatization of a new generating utility will remove the capital burden from LUCELEC, allowing it to assume the reduced role of transmitting and distributing blocks of electrical power. In time, the major baseload generation for St. Lucia will be taken over by the geothermal entity, while LUCELEC provides peak demand with high speed diesel generators. This configuration will maximize the geothermal resource while at the same time increase efficiencies in LUCELEC's monitoring and service role.

3. Conformity of Project to the GOSL's Development Strategy

The GOSL strongly supports the development of geothermal power because it will result in a reduced fuel import burden on its foreign exchange reserves and will attract local and foreign investment in productive enterprises, which create jobs, by providing power to generate electricity. The GOSL has proceeded with plans to exploit St. Lucia's geothermal potential with some urgency.

At present, demand for petroleum is increasing at roughly 3% per annum and has reached a level in 1985 where annual expenditures of foreign exchange approach US$18.0 million each year for fuel oil, Bunker "C", and diesel fuel. When geothermal power is finally used to generate electricity, import savings for petroleum will amount to US$77.4 million in foreign exchange savings over the projected life of the geothermal wellfield.

Unemployment is St. Lucia's principal domestic problem. Current labor statistics indicate that an estimated 25% of the labor force is unemployed. While the agriculture sector continues to be the primary source of jobs, it cannot absorb the growing numbers of unemployed youth. The growth areas of the economy for the creation of jobs are therefore tourism and light manufacturing, particularly the latter which now employs some 8% of the labor force.

St. Lucia is the most industrialized of the smaller Eastern Caribbean countries. Its diversified manufacturing sector produces a variety of commodities for both local and export markets. The Government realizes the importance of infrastructure for attracting foreign investors, and stresses in its promotional literature St. Lucia's 464 miles of all-weather paved roads, two commercial airports, two deep-water ports, nation-wide water and electricity systems, and four industrial parks, and its plans to develop free ports at Soufriere and Castries.

The GOSL has long considered infrastructure essential to its economic development and has pursued donor assistance for infrastructure projects. AID provides assistance for

the rehabilitation of roads. The British Development Division presently sponsors water systems development and has proposed projects in road rehabilitation, drainage, and electrical systems. The Caribbean Development Bank sponsors the development of the water supply system and of air cargo facilities at Hewanorra, and is planning a road construction project. CIDA has planned airport improvements and reservoir construction, and the European Economic Community plans assistance in rehabilitating the southern road network. The development of a reliable source of electricity through the proposed geothermal project is expected to further increase St. Lucia's appeal to private investors.

The GOSL is committed to support foreign investment through a policy package which includes fiscal incentives, permission to repatriate earnings and imported capital, and a treaty with the U.S. preventing double taxation of income earned in St. Lucia. The government has strongly indicated its support for foreign private sector investment in the exploration and development of geothermal power.

4. Relationship of Project to AID and Mission Strategy

AID encourages private sector investment in productive enterprise because it creates new jobs, increases export revenues, and lessens the financial burdens on government. The proposed project is among many AID interventions which encourage private sector investment, enhance St. Lucia's ability to compete in the international marketplace, and facilitate the country's participation in the Caribbean Basin Initiative.

AID supports the privatization of those services which are more efficiently provided by the private sector. It is expected that the construction of a geothermal power plant and the management of the electrical generation will be undertaken by private geothermal developers. The proposed project is consistent with AID's policy to mobilize private funds by paving the way for the commercial development of St. Lucia's geothermal potential.

Reliable infrastructure is required to attract private sector investment in productive enterprise, and AID has given considerable support to the development of infrastructure in St. Lucia. The Productive Infrastructure Rehabilitation Project (538-0082) has provided $8.65 million for road repair in agriculturally productive areas. With the provision and maintenance of well planned infrastructure, the Mission expects that St. Lucia's manufacturing sector will grow at an average of 8% per year.

B. Project Objectives

The goal of the project is to accelerate the economic development of St. Lucia through the development of an indigenous, reliable source of electricity for industrial and domestic use.

The purpose of the project is to establish the economic and technical viability of the Qualibou Caldera as a long-term geothermal resource capable of generating substantial quantities of electrical and other power which can be developed by the private sector.

C. Project Elements

1. UNRFNRE-Financed Activities

The United Nations Revolving Fund for Natural Resources Exploration will finance the following activities:

a. Supervision and Coordination - a contract for the overall supervision and coordination of all project activities.

b. Geo-scientific and Engineering Review - a contract for the pre-drilling geo-scientific and engineering review of all available data and a hydrological study to assist in the precise siting of the initial well, and continual review of data for siting subsequent wells.

c. Technical Advisors - a contract with a consultant project management group which will be responsible for the implementation and execution of the following activities: a) geological, geophysical and geochemical inputs, b) drilling engineering and superintendence, and c) reservoir engineering and testing.

d. Technical Services - technical service contracts for cementation, compressed air, mud engineering, mud logging, chemical analyses, formation and production logging, wireline logging and testing, production testing, well completion, and other special works.

e. Supplies - contracts for various supplies will be provided including bits, reamers, hole openers, expendable tools, rental tools, Totco gauges, and vehicle, and materials including chemicals required for well drilling (with the exception of casing and liners which will be financed by AID).

2. GOSL-Financed Activities

The Government of St. Lucia will finance and undertake the following activities:

a. Pad and Pond Preparation - the drill pad preparation, and preparation of ponds for drilling mud and waste disposal operations.

b. Water Supply - the supply of water for drilling to the site.

c. Property Rights - the procurement of property rights for the drill site and access to it.

3. AID-Financed Activities

AID will finance the following activities:

a. Drilling Activities, Procurement of Casings - the specifications and bid package for the drilling equipment have been prepared by an AID-financed specialist in geothermal drilling, and will be reviewed by the UNRFNRE as part of its management role. The contract for drilling the wells as well as the procurement of casings will be awarded according to AID Handbook 11 Host Country contract rules and procedures.

The review of drilling specifications, tendering, bidding and the award of the drilling contract are expected to take 3-4 months. Drilling will start early in 1986 after mobilization of the drilling team and supplies. Drilling three exploratory wells is expected to take about twelve months.

b. Civil Works - the transportation of the well drilling and other equipment from the harbour to the drilling site will require modifications to the harbour and the narrow roads leading to the drilling site, including minor realignments of the roads and some minor bridge repair. These will be financed within the drilling contract.

c. Environmental Monitoring and Safety Plan - The liquid effluent, waste water and thermal pollution will be analysed on a periodic basis throughout the drilling phase according to a schedule to be established by an Environmental Monitoring and Safety Plan which has been prepared in draft.

Because the environmental impacts are closely related to the social and cultural impacts on the caldera area's small farmers, hoteliers, and tourists, the Environmental Monitoring and Safety Plan will have a social aspect where it is warranted. A post-project environmental protection plan also will be developed during the drilling phase, and will lead to safety recommendations to be observed by all donors and the GOSL as well as provide the design criteria for future geothermal field development. For details of the Environmental Monitoring Plan, see Annex G/2.

d. Well-field Administration Training - St. Lucians who will assume permanent, professional-level positions in the administration of the geothermal resource will be trained in well-field maintenance and planning for future well drilling. It is expected that technical personnel for hands-on operations and maintenance will be trained largely by the private geothermal investor and developer.

e. Repairs to Existing Wells - Several of the seven geothermal wells which were drilled in 1975-77 have deteriorated to the extent of being a safety hazard. An assessment of the need for repairs will be made by the UNRFNRE-financed manager. It is anticipated that the UNRFNRE-financed cementation service contractor, under a contract line-item to be funded by AID, will cap these wells or prepare them for use as reinjection wells for the spent geothermal fluids.

f. Technical Assistance for Private Sector Investment Plan - AID will finance an advertisement in international geothermal publications to solicit letters of interest from the international geothermal community. AID will finance a host country contract for a consultant to assist the GOSL evaluate the expressions of interest, and to prepare a Request for Technical and Financial Proposals (RFTFP). The RFTFP will address, among other issues, the proposed institutional, technical and financial relationships between the potential private investor, the GOSL and LUCELEC, a plan for providing the required technical assistance and training, and draft legislation if required. The RFTFP concept as envisioned for this project includes the solicitation of a financial offer from the investor as well as the institutional and technical package. The consultant will also assist the GOSL to evaluate the proposals.

Depending on the criteria for design and the proposals from the private sector, the construction of the power plant could take approximately two years. The World Bank's International Finance Corporation (IFC) has been suggested as a facilitator for the financing of the private sector investment phase.

III. COST ESTIMATE/FINANCIAL PLAN

Summary costs estimates are as follows:

		AID	UNRFNRE	GOSL
1.	Personnel and Travel	-	84,000	-
2.	Civil Works (Harbor, Roads and Bridges)	170,000	-	-
3.	Relocating Utility services, Pad Preparation, Ponds, Water Supply and Acquisition of Land	-	-	80,000
4.	Pre-project Expenditure	-	65,000	-
5.	Project Supervision & Management	-	625,000	-
6.	Well Drilling & Casing	2,167,070	-	-
7.	Materials, Cementation, Mud Engineering, Well Completion Testing and other works	-	1,418,500	-
8.	Environmental Assessment and Monitoring	75,000	-	-
9.	Equipment Freight and Insurance (less residual)	-	4,400	-
10.	Technical Support, Management Services (fee to UNRFNRE)	65,000	14,000	-
11.	Training and Technical Assistance	90,000	-	-
12.	Repairs to Existing Wells	30,000	-	-
13.	Contingency	402,930	169,200	-
	TOTAL	3,000,000	2,380,100	80,000

IV. IMPLEMENTATION PLAN

A. Project Management, Supervision and Financial Management

The UNRFNRE will be responsibile for the management and supervision of all project activities. AID will contribute $65,000 to the UNRFNRE for this service, and AID grant funds for technical line items will be passed through the UNRFNRE for disbursement.

1. Management and Supervision

The UNRFNRE will finance a technical management consultant who will manage and coordinate all UNRFNRE, GOSL and AID project activities. AID-financed contracts will be awarded according to AID Handbook 11 Host Country contracting rules and procedures. UNRFNRE-financed contracts will be awarded according to UNRFNRE rules. The management consultant and AID will participate in the bid evaluation process for the purposes of advising and recommending to the GOSL on contractor selection.

All contractors shall be under the general supervision of the management consultant. All materials, supplies and equipment purchased, leased or rented for project activities shall be under the control of the management consultant. The management consultant will report to a project committee composed of equal representation of AID, the GOSL and the UNRFNRE.

2. Financial Management

AID will disburse upon receipt of the standard payment voucher (1034) approved by the management consultant and the GOSL, and certified by AID/RDO/C. The RDO/C Controller will certify the voucher for payment and mail the contractor's check to the UNRFNRE on behalf of the GOSL for pass through to the GOSL contractors financed by the AID grant. All financial transactions will be recorded by the UNRFNRE through a no-interest bearing account established for this purpose.

B. Implementation Schedule

All AID-financed project activities are scheduled to take place over a period of two years from the date of signing the Project Agreement. The Project Assistance Completion Date (PACD) is August 31, 1987. An Implementation Schedule for certain primary activities is given in Exhibit 9 and a more detailed bar chart is given in Exhibit 10.

The drilling bid documents, the setting of the bid evaluation criteria and the schedule for the drilling operations will be prepared through an AID financed contract using Project Development and Support funds. At the same time, the GOSL will

begin the prequalification of drilling contractors by advertising in the Commerce Business Daily and other major technical periodicals. Prequalification of well drillers will be completed with the assistance of the management consultant. AID will cooperate closely with the GOSL and the UNRFNRE on all aspects of the bidding process.

A pre-bid conference will be held in St. Lucia. The drilling contract will include all preparations to bring the drilling equipment to the drill site, including repairs and realignments of the harbour, town roads, and access roads. The drilling contractor will also undertake the civil works, which will be itemized separately as an aspect of the drilling contract. It is anticipated that the drilling contractor will sub-contract harbour and road work to local contractors. Preliminary road and harbour surveys indicate that road widening and horizontal curve realignment will be required.

Prior to disbursement for civil works and drilling activities, the environmental assessment will be approved by AID/W, and the environmental monitoring plan for the drilling phase will be prepared. An environmental technician will monitor the site activities on a periodic basis during the drilling phase.

During the mobilization phase, the drilling contractor will be responsible for all landing ramps and access work, and the GOSL will be responsible for acquiring the lands or the rights of way and easements for all project activities. The GOSL will also be responsible for excavating the water storage ponds and providing an adequate water supply to the drilling sites. The GOSL will provide electricity for lighting and domestic use to each of the sites.

Preparation of the drilling pads, which involves bull-dozing and leveling the drilling site, is the responsibility of the GOSL, as are pond preparation and water supply. The coordination of access work with the GOSL work will be the responsibility of the site manager under contract to the UNRFNRE.

All back-up services such as mud engineering, compressed air, special tools, chemical testing, production testing and all site management work will be carried out by contractors funded by UNRFNRE. These individual contractors will be responsible for all transport and services connected with their individual work.

Each well is expected to take three months to drill to a depth of approximately 1,500 meters where the heat resource is expected to be found. However there is provision to drill to a maximum depth of 2,000 meters. After the production tests are carried out, the acceptable wells will be converted into production wells. Each well will be provided with blow-out protection and shut down valves as soon as the testing is completed.

Monthly progress reports will be prepared by the project management consultant for presentation to the Project Committee. Well status reports will be submitted soon after testing on each well is carried out. These reports will provide the necessary data on the quality and quantity of the resource. At the end of the Project, a final report giving technical and financial details will be submitted to the Project Committee. Project evaluations will be carried out after the first well is drilled and about six months prior to the August 31, 1987 PACD.

During the drilling phase, the GOSL will advertise internationally for expressions of interest in commercializing the geothermal resource. An AID-financed contractor will prepare the Requests for Technical and Financial Proposals (RFTFP) and assist the GOSL to evaluate the expressions of interest in order to produce a short-list. RFTFPs will be sent to short-listed firms.

During project implementation, up to six eligible St. Lucians will be trained in the administration of the geothermal well-field and in utility management. Completion of training will coincide with the commissioning of the power plant and the integration of geothermal power into the LUCELEC system. It is expected that these trainees will be drawn from the well drilling program and will have had some hands-on experience prior to their training.

In summary, the implementation schedule is as follows:

EXHIBIT 9

August, 1985	:	Project Agreement GOSL/AID signed; Prequalification of drilling contractors begun, and draft bid documents prepared.
September, 1985	:	Environmental Assessment approved by AID/W; Environmental Monitoring Plan prepared. Initial CPs to Disbursement met.
October, 1985	:	Pre-bid conference. RDO/C and GOSL prepare terms of reference for private investment technical assistance.
November, 1985	:	Well design, management and supervisory contract awarded by UNRFNRE. Location of Well No. 1 selected.
December, 1985	:	All CPs met; Award Well Drilling Contract; Technical Assistance/Training Program begins; execution of Environmental Monitoring Plan begins;

January, 1986	:	Award well site contract. Award cementation contract. Award mud engineering contract. Award compressed air contract. Award analytical contracts.
February, 1986	:	All work necessary to start well drilling operations at Site No. 1 completed; well drilling at Site No. 1 started.
	:	Location of Well No. 2 selected.
April, 1986	:	Well drilling at Site No. 1 completed.
May, 1986	:	Environmental Analysis at Site No. 1 completed; Well Production Tests started.
	:	All work necessary to start well drilling operations at Site No. 2 completed; All Covenants met; Mid-term evaluation of project started.
July, 1986	:	Location of Well No. 3 selected.
	:	Private investment and commercialization of electricity production from geothermal wells begins;
August, 1986	:	Well drilling at Site No. 2 completed; Environmental Analysis at Site No. 2 completed; all work necessary to start well drilling operations at Site No. 3 completed; well drilling at Site No. 3 started.
November, 1986	:	Well drilling at Site No. 3 completed; Environmental Analysis at Site No. 3 completed.
	:	All recommendations of Environmental Analysis for all Sites met.
January, 1987	:	Well Production Report completed.
	:	Final Evaluation of Project started.
April, 1987	:	All work necessary to make sites into production sites completed.
August, 1987	:	Project ends.

C. Procurement Plan

The well drilling contractor will be selected under Handbook 11 Host country contract rules and procedures. Prequalification questionnaires will be issued to expressed parties and a short list of qualified companies will be requested to bid. The geographic code for the well drilling contract will be 000 and the host country. The drilling contractor will be responsible for all civil works necessary to enable the drilling rig and its accessories to be transported to the site. The civil works aspect of the drilling contract may be sub-contracted in order to permit the civil works to be undertaken during the mobilization period. It is likely that the drilling contractor will sub-contract the civil works to local contractors in St. Lucia.

The procurement requirements of the training component of the project will be met using AID Handbook 10, Pariticipant Training Rules and Procedures.

The Environmental Assessment was carried out by an Indefinite Quantity Contractor using Project Development and Support funds. Procurement for environmental monitoring of the project will be carried out using AID Handbook 11 Host Country Procurement Rules and Procedures.

Procurement of the technical assistance to write the RFTFP will be done as a work order to an Indefinite Quantity Contractor.

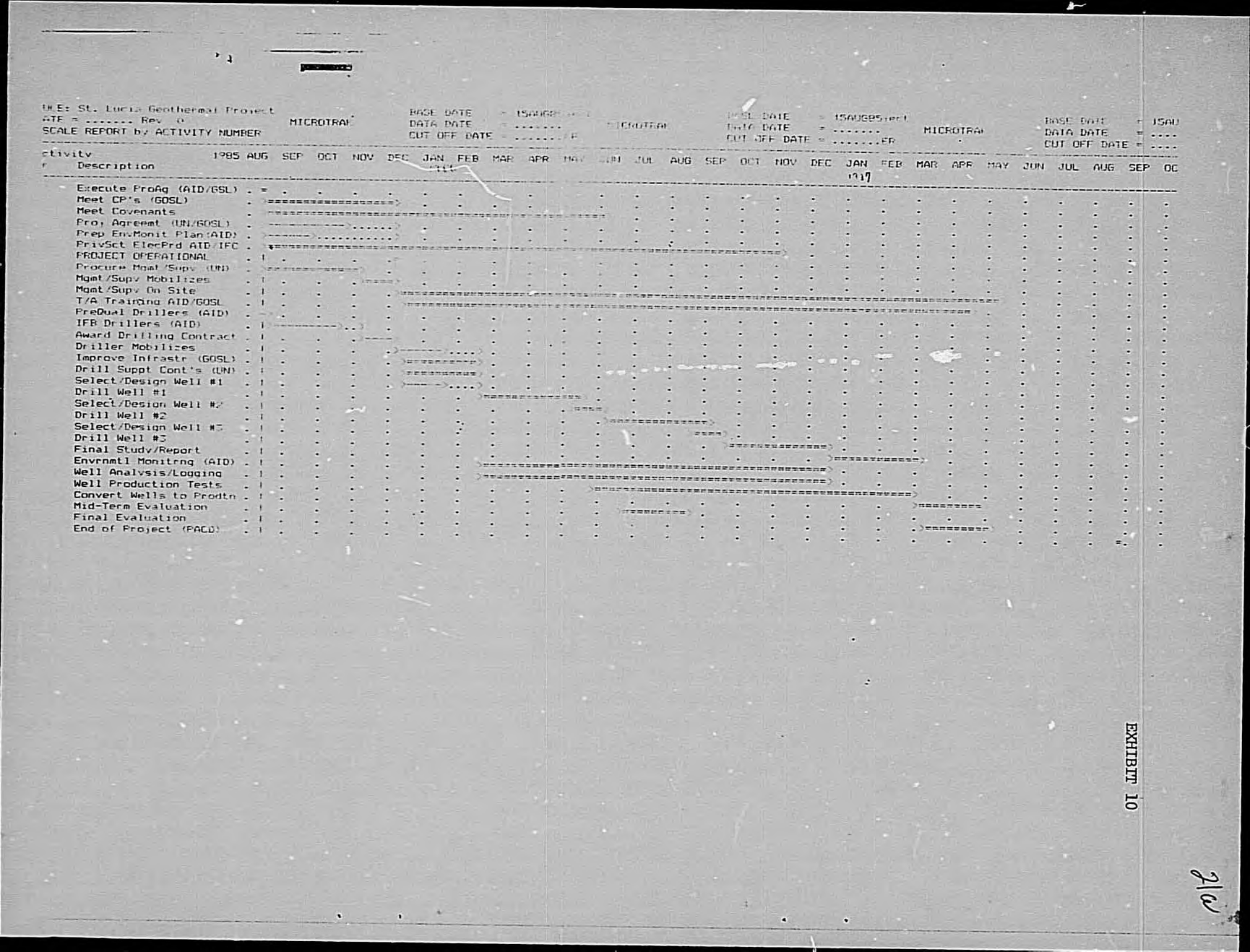

EXHIBIT 10

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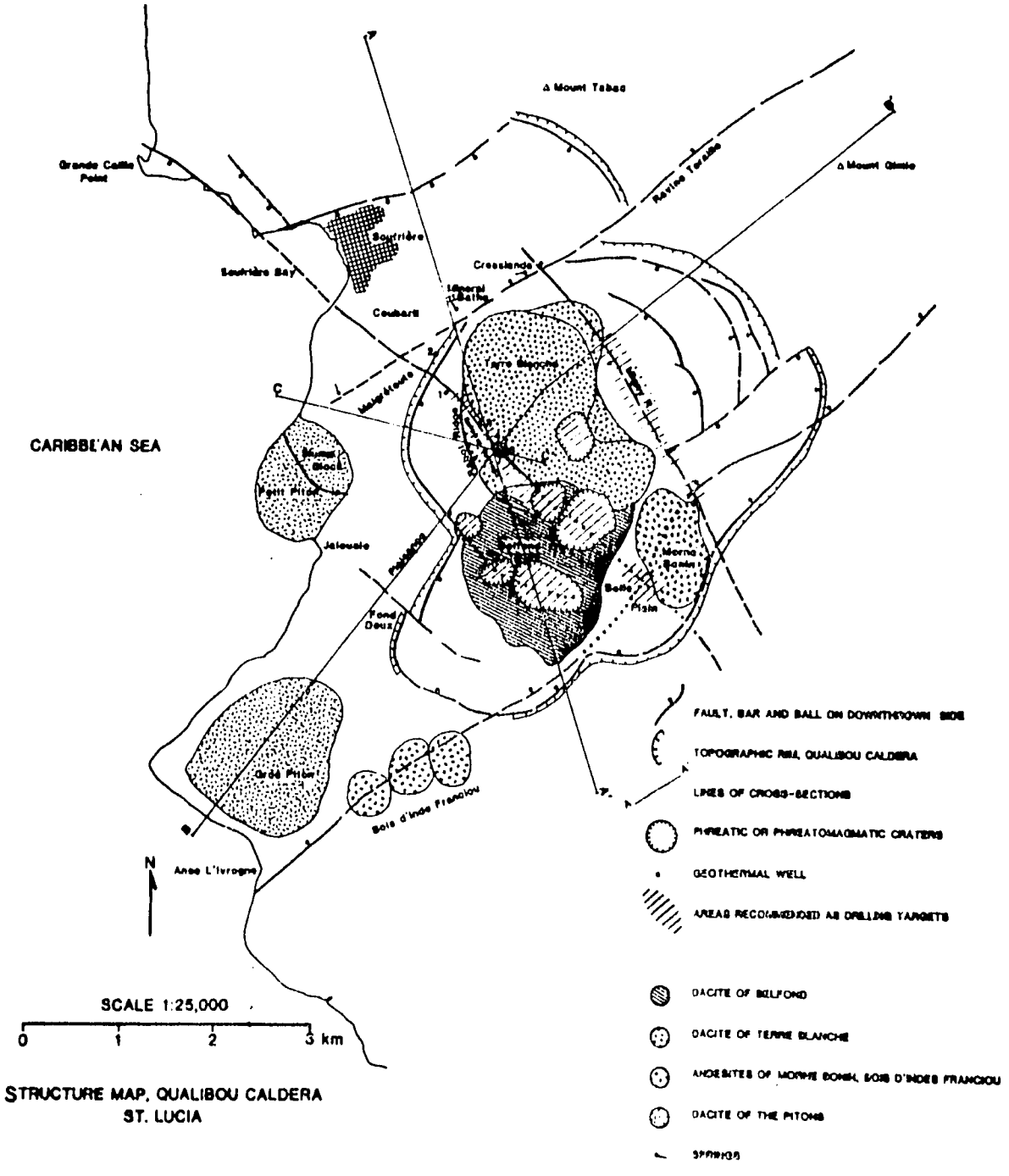

STRUCTURE MAP, QUALIBOU CALDERA
ST. LUCIA

EXHIBIT 11: Structural map of the Qualibou caldera showing regional northeast-southwest and northwest-southeast linear faults and curvilinear caldera faults. The last eruptive units are shown by the domes of Belfond and Terre Blanche.

V. SUMMARIES OF ANALYSES

A. Technical Analysis

1. Geothermal Energy

Geologists theorise that the earth is formed of a relatively thin crust which is solid, underlain by a plastic magma and a solid core. The crust is formed of massive plates that move around, split apart and collide with catastrophic results. The boundaries of these plates are defined by the volcanic and earthquake belts and contain a large proportion of the geothermal areas of the world.

The force that drives the movement of these plates is a heat engine, the heat being derived from the earth's uncooled interior. Geothermal energy is the result of the earth's internal heat engine and represents not only a virtually limitless power source for the earth, but also a vast natural energy resource for man. Within the continental belts of relatively recent volcanism and deformation of the crust are found the most obvious "hot spots" where high temperature geothermal areas are found. The Qualibou Caldera in St. Lucia is one such spot. Further details on geothermal energy are given in the Basic Geothermal Model (see Annex M(a) - Technical Analysis, Basic Geothermal Model).

2. Eruption History of the Qualibou Caldera Region

The Qualibou Caldera, which is about 12 km^2, was first identified in 1964 during detailed geologic mapping near Soufriere. The Caldera is between 40,000 to 300,000 years old. The geothermal aspects of St. Lucia have long been apparent because of the Sulphur Springs and nearby hot springs that have been used for mineral baths since early European settlement. More recent investigations outline more ambitious uses for the geothermal fluids particularly the production of electricity.

Lavas 5.5 million years old are overlain by the composite volcanic cones of Mt. Gimie and Mt. Tabac, which form the highest ridges on the island of St. Lucia. Deposits from these cones include coarse gravels, lava flows, and associated sediments that form aprons reaching the sea. The cones are between 1.7 and 0.9 million years old.

Superimposed upon the cones of Mt. Gimie and Mt. Tabac are younger volcanic domes and cones located along coastal north-south trends, including the ridges of Rabot, Plaisance, and Malgretoute and the cone of Fond Doux. The most spectacular volcanic domes of this period of activity are the plug-domes of Petit Piton and Gros Piton, dated at 0.25 million years. The Pitons are located along the western side of the Caldera (Exhibit 11). The cones and domes of this period of activity erupted before formation of the Qualibou Caldera.

The major event in this volcanic field was the eruption of large volumes of ash (Qualibou Tuff) and formation of the Qualibou Caldera. Calderas form by the collapse of the ground surface during an eruption. Eruption of 15 cubic kilometers of volcanic ash, mainly as flows and surges, filled the entire area of the caldera, including the surrounding valleys. The magma body associated with this eruption is estimated to be a major source of geothermal heat.

After the caldera collapsed, volcanic eruptions continued and formed the domes (Terre Blanche, for example) and ash deposits filling the caldera. The most recent magmatic activity within the caldera was the eruption of a large volcanic dome (or domes) and the associated craters of Belfond (Exhibit 11). Dates of 20,000 to 32,000 years for the Belfond eruption have been reported.

3. Structural Framework and the Extent of the Qualibou Caldera

Two major northeast-southwest trending faults straddle the Qualibou Caldera (Exhibit 11). Caldera-related faulting began about 40,000 years ago as a response to volcanic field collapse into a shallow, partially evacuated magma chamber during eruption of the Qualibou Tuff.

Major caldera faults are best developed in the northern sections of the caldera. These faults define a nearly circular western caldera margin, whereas those of the southern margin are crescent shaped and form a scalloped caldera margin.

A conservative estimate of the volume of the caldera-forming Qualibou Tuff is 15 cubic kilometers (approximately equivalent to eruption of 9 cubic kilometers of magma) and the diameter of the caldera is about 4 kilometers. Subsequent volcanic activity of Belfond and Terre Blanche accounted for another 5 cubic kilometers of magma that may have allowed another several hundred meters of collapse in the caldera. As much as 1,000 to 2,000 meters of pre-caldera rock and post-caldera rock may exist below the level of today's caldera floor (e.g., Sulphur Springs, Belle Plaine, Fond Doux).

Faulting has controlled, for the most part, the location of thermal springs. Regional faults and caldera faults are the most important in providing pathways to the surface for thermal waters. Porous rock units such as those of the Terre Blanche vent appear to be near-surface steam collectors and therefore provide an intermediate reservoir for steam. Sulphur Springs occurs along a curved fault west of Terre Blanche; much hydrothermal alteration of the rock is apparent on the western flanks of Terre Blanche and on Rabot Ridge, where a northwest-southeast trending fault crosses the caldera.

The Los Alamos National Laboratory estimates that the caldera is over a magma body (or bodies) located at a depth of 3 to 4 kilometers. The magma body is in limestone, which is overlain by volcanic rock nearly 2.5 kilometers thick. The high carbon dioxide content of Sulphur Springs gases may result from magma contact with limestone (calcium carbonate).

4. Model of the Qualibou Caldera

The following model designed by the Los Alamos National Laboratory outlines the nature of the heat source, assuming that the cooling magma body is responsible for the volcanism associated with the Qualibou Caldera. A complex, multiple magma body underlies the caldera; the size of the magma chamber is estimated to be 100 cubic kilometers. Conductive cooling of the magma chamber requires about 300,000 years for the magma to reach 300°C (572°F) from its initial temperature of 900°C (1652°F). Assuming that the maximum age of the Qualibou Tuff is 40,000 years, then the magma chamber is between 300°C (572°F) and 800°C (1472°F). Since Belfond eruptions are even younger, temperatures near 900°C (1652°F) can still exist in the magma chamber.

The presence of dominantly carbon dioxide gas in the geothermal vapors at Sulphur Springs and the presence of limestone fragments in the young volcanic deposits indicate that the magma chamber exists in limestone. Furthermore, the temperature gradient of 220°C/kilometer (428°F/kilometer) measured in wells suggests temperatures of 600°C (1112°F) to 800°C (1472°F) at a depth of 3 to 4 kilometers. The pathway to the surface for steam, gases, and water is provided by the caldera faults west of Terre Blanche and by a fault cutting the north edge of Rabot Ridge. Hot waters not driven to the surface by steam or carbon dioxide gas appear to emanate at a lower water table level near 60 meters (above sea level) at Cresslands, Diamond mineral baths, and Malgretoute. LANL estimates that geothermal fluids and vapors should be found at a depth of about 1 to 2 kilometers under the entire caldera area and in abundance where permeable rocks allow greater fluid movement.

5. Geothermal Construction in the Qualibou Caldera

The surface terrain at the Geysers Geothermal field in California is similar to that in St. Lucia, rugged with few flat areas. As a result, many of the wells are directionally drilled (i.e. at a slant) from a common drill site. In the St. Lucia program a directional-drilling technique might also be used. The aggregate depth of the proposed wells is expected to be between 4,500 and 6,500 meters. Exhibit 12 shows typical costs of well drilling for three geothermal sites in the U.S. which are similar to those required for St. Lucia. A description of the wells from these three areas should provide some advance information as to what might be expected in St. Lucia.

EXHIBIT 12

TYPICAL GEOTHERMAL WELL COSTS IN THE U.S.

[Thousands of US$ (1983)]

Geothermal Area	Depth 1000 m	1500 m	2000 m
The Geysers, California	640	820	1200
Baca, New Mexico	740	900	1400
Rossevelt Hot Springs, Utah	570	910	1100

Sandia National Laboratories Report Sand. 81-2202 (Feb. 1983)

A typical well may start with a section of 1.07-m (42-in) diameter hole followed successively by 0.66-, 0.44-, 0.31-, and 0.22-m (26-, 17-1/2-, 12-1/4-, and 8-3/4-in) diameters. There would be four nested casings of 0.76-, 0.51-, 0.34-, and 0.27-m (30-, 20-, 13-3/8-, and 10-3/4-in) diameters starting at the wellhead but all extending to different depths. These are called the conductor, surface, intermediate, and tieback casings, respectively. Depending upon the nature of the formation in the lower part of the borehole, either the hole is left uncased or a slotted liner (or perforated casing) is installed to preclude hole-collapse problems at a later date.

At comparatively low temperatures around 150°C drilling mud will be used. Once the vicinity of the production zone is reached, air drilling will become the drilling technique. After drilling operations are completed cementation work will be carried out. The shallow wells drilled previously are in a state of deterioration. All these wells will be capped and sealed.

If the exploratory/production wells prove successful, subsequent commercialization, including the construction of a power plant, will be financed and undertaken through a program of private investment.

B. Financial Analysis and the Role of Private Investment

1. LUCELEC's Recent Financial Performance

The UNDP/World Bank study documented LUCELEC's very poor financial performance between 1979 and 1981. In that period, net after tax income fell from a small EC$14,000 surplus in 1979 to a loss of EC$ 530,000 in 1981. Reasons for this poor performance included tariff increases that were too little and too late, 1980 hurricane damage, an 8 percent sales decline, and higher

transmission and distribution losses. In 1982 and 1983, performance improved somewhat. After tax net income in 1982 was EC$ 343,000, and indications are that it was higher in 1983.

The Coopers and Lybrand Tariff Study established a basis upon which to determine future tariff requirements. However, the study did not model the cost and financial implications of geothermal generation, and would have to be updated to determine the tariff implications of the cost savings presented by the geothermal alternative. Estimates of reduced cost for geothermal power generation imply that this technology would improve LUCELEC's financial viability at lower tariffs than would be the case for diesel generated power. The Los Alamos study estimated a busbar cost of geothermal electrical generation of 6.2 U.S. cents per Kwh, compared to 9 to 10.2 U.S. cents per Kwh for diesel generation.

2. Summary Financial Plan.

Detailed project cost estimates are presented in Exhibit 14. Exhibit 13 summarizes these project costs:

EXHIBIT 13

COSTS, BY EXPENSE CATEGORY AND SOURCE OF FUNDING

($U.S.)

	USAID	UNRFNRE	GOSL	TOTAL
1. Consultants		84000		84000
2. Contracts				
a. Civil Works	170000			170000
b. Pad Preparation, Water			84000	84000
c. Project Supervision		625000		625000
d. Drilling	2167070	846000		3013070
e. Drilling Cont'gncy Fund	402930	169200		572130
f. Other	75000	572500		647500
3. Pre-project Expenditure		65000		65000
4. Miscellaneous	185000	184000		203400
GROSS TOTAL EXPENDITURE	3000000	2380100	80000	5460100

The total project is expected to cost approximately $U.S. 5.5 million, of which the UNRFNRE will contribute $2.32 million, AID $3.0 million, and the GOSL $0.2 million. AID's

ANNEX

Financial Table for St. Lucia Geothermal Project, Soufriere, St. Lucia

	TOTAL	PROJECT SHARES PART I USAID	PART II UNRENBE	GOSL
	$U.S.	$U.S.	$U.S.	$U.S.
1.000 PERSONNEL & TRAVEL				
1.100 INTERNATIONAL PERSONNEL				
1.108 Consultants	84000			
1.109 Sub-Total	84000			
1.000 COMPONENT TOTAL	84000		84000	
2.000 CONTRACTS				
2.100 INTERNATIONAL CONTRACTS				
2.101 Civil Works (Harbour, Roads, Bridges) for Rig Delivery	170000	170000		
2.102 Relocat. of Util., Pad Preparation, Storage Ponds	40000			40000
2.103 Water Supply and Obtaining Lands	40000			40000
2.104 Project Supervision & Management				
including: Principal Consultant & Back-up	136000			
Drilling Engineering Services	[illegible]			
Geological Services	31000			
Drilling Superintendence	120000			
Geophysical Services	16000			
Geochemical Services	30000			
Test/Reservoir Engineering	60000			
Accounting & Purchases	40000			
Secretarial & Office	16000			
Drafting	9000			
Sundries:	105000			
Including: Telephone				
Telex				
Travel				
Reproduction				
2.104 Total	625000		625000	
2.105 Drilling, including:				
Mobilization/Moving	290000	290000		
Conductor Mouse, Rat Holes	12000	12000		
Fuel & Oil	75000	75000		
Contractor Charges (Rig & Crew, Fuel)	1320000	1320000		
Materials (Bits & Reamers, Hole Openers)	201000		201000	
(Expendable Tools)	60000		60000	
(Other Rental Tools, TODCO Gas)	120000		120000	
(Casing & Liners)	470070	470070		
(Muds & Chemicals)	255000		255000	
Cementation & Cement	210000		210000	
2.105 Total	3013070	2167070	846000	
All-inclusive Cost per m:	$669.57			
2.106 Drilling Contingency Fund	572130	402930	169200	
2.107 Wellsite Mud Logging Services	65000		65000	
2.108 Electric Formation/Production Logging	100000		100000	
2.109 Well Completion, Supplies & Services	292500		292500	

EXHIBIT 14

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2.110 Production Testing & Reservoir Evaluation	[illegible]		[illegible]	
2.111 Chemical Analysis	[illegible]		[illegible]	
2.112 Environmental Impact Study and Monitoring	[illegible]	75000		
2.900 COMPONENT TOTAL	5487700	2815000	[illegible]	80000
4.000 EQUIPMENT, PREMISES, FREIGHT & INSURANCE				
4.200 NON-EXPENDABLE EQUIPMENT				
4.210 INTERNATIONAL				
4.211 Vehicle	10000			
4.289 TOTAL NON-EXPENDABLE	10000			
4.900 COMPONENT TOTAL	10000		10000	
5.000 MISCELLANEOUS				
5.101 Vehicle Maintenance & Fuel	4000		[illegible]	
5.201 Reporting Costs	10000		[illegible]	
5.301 Technical Support, H.Q. Administration, Proj. Mgt.	[illegible]	[illegible]		
5.401 Technical Assistance & Training	90000	90000		
5.501 Repairs and Safety Measures to Pre-existing Wells	30000	30000		
5.900 COMPONENT TOTAL	199000	185000	[illegible]	
9.100 GROSS TOTAL EXPENDITURE	5400700	3000000	[illegible]	[illegible]
80000				
9.200 CREDIT PROCEEDS OF EQUIPMENT				
9.300 CREDIT RESIDUAL VALUE OF EQUIPMENT	5600		[illegible]	
9.400 PRE-PROJECT EXPENDITURE	65000		[illegible]	
9.900 NET TOTAL EXPENDITURE	5460100	3000000	[illegible]	80000

NOTES: (1) DRILLING CONTRACT AS PCT OF TOTAL PROJECT COSTS: 55%

(2) RELATIVE PROJECT COSTS FOR VARIOUS DRILLING COSTS:

Drilling Cost per metre	Project Cost	Project Cost
$600.00	2003444	5147036
$650.00	2078444	[illegible]
$700.00	2153444	[illegible]
$750.00	2228444	[illegible]
$800.00	2303444	[illegible]
$850.00	[illegible]	[illegible]
$900.00	2453444	[illegible]
$950.00	2528444	[illegible]
$1,000.00	2603444	[illegible]
$1,050.00	2678444	[illegible]
$1,100.00	2753444	[illegible]
$1,150.00	2828444	[illegible]
$1,200.00	2903444	7547036

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NON-EXPENDABLE EQUIPMENT LIST AND DEPRECIATION SCHEDULE

Vehicle
Cost
Depreciation Rate
Residual Value after 18 months

	DIAMETER	COST/M	LENGTH	TOTAL
10000				
0.33	Conductor			
5595	20 inch	$213.00	[illegible]	6390
13 3/8	$103.00	300	[illegible]	
9 5/8	$80.00	900	[illegible]	
	7 inch	$49.00	[illegible]	29400
	Sub-Total:			138690
	Perforation:			18000
	TOTAL			[illegible]

EXHIBIT 14
(CONTINUED)

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contribution will be divided between civil works for rig delivery, drilling costs, and technical support. UNRFNRE will contribute to project supervision, wellsite services, well completion, production testing, and other costs. GOSL will provide pad preparation, water supply, a relocation of utilities and obtain lands for drilling operations.

Ultimately, the financial viability of geothermal development is expected to be put to the test of private profitability. Approximately 25 private investors have thus far indicated interest in tapping the resource.

3. Private Investment

Estimated private investment in the power sector over the next few years is expected to be the largest in that sector's history on the island. Total investments of about US$30 million, including physical and price contingencies, are needed to undertake the expansion program for the rest of this decade.

If it is decided in 1986 not to proceed with geothermal development, power sector investment would decline to about US$24 million, excluding physical and price contingencies. This lower estimate includes the addition of Cul-de-Sac No. 2 unit (5 MW medium speed diesel) in 1990 in the absence of geothermal No. 1.

Technical assistance to the GOSL to prepare and evaluate requests for technical and financial proposals will be a project activity. AID will assist the GOSL in advertising in the international press, in preparing the short list of eligible responses, and in developing the components of the RFTP, including the evaluation criteria. Preparation of the RFTP will include an examination of the institutional, technical and financial relationships between the investor, the GOSL, and LUCELEC.

The most probable scenario for the privatization of a geothermal utility would include activities such as the: 1) development and management of the steam and hot water resource, 2) process of the steam to electricity, 3) delivery of hot water to industry and 4) delivery and management of electricity through the existing transmission and distribution system (the electrical grid, which presently is managed by LUCELEC). The following sections outline relevant considerations related to each of these activities.

a. The Well Field Resource

Development and management of the steam and hot water resource has been shaped into a separate entity, LUCELEC, which protects the sovereignty of the government while fostering a partnership with the private sector. LUCELEC's control of the steam

and water "valves" protect the downstream abuse by a potential monopoly, but in the absence of a competitive utility, the Public Utilities Commission (PUC) will need to have authority to set the steam and hot water energy tariff as well as electricity tariffs.

During the initial stages of development, the management of the well field requires highly technical expertise available only from the international private sector. This could be achieved through a corporate merger or a partnership between the international capital investor and the government to form the geothermal well field management company.

b. The Geothermal Power Generating Company

Formation of the Geothermal Power Company presently appears to be emerging as a wholly-owned private utility, owned and controlled by international investors.

The GOSL will approach the international geothermal community and request proposals for the development of the geothermal power utility. Acting as a pass-through for the conversion of energy, this utility may become a simple private sector company producing the required baseload power in blocks of electrical energy at a set price. Once again, in the absence of a fully competitive market, the PUC will regulate tariffs of all energy producers.

At present, several U.S. geothermal companies are exploring the possibility of forming the private utility and are prepared to capitalize the firm without outside financial assistance. However, should private capitalization not become available immediately, the IFC and OPIC may support guarantees and insurance, and provide the necessary equity for the eventual privatization of the geothermal resource.

c. Process Heat and Process Heat Transmission Company

Processing, developing and transmitting hot water for industrial use is still far in the future. However, as with the geothermal "steam", hot water needs to be recognized as an energy resource and requires the same tariff controls applied to other energy sources.

d. LUCELEC: The Energy Delivery Mechanism

Finally, LUCELEC has an authorized share capital of EC$5 million, divided into 260,000 non-voting and 740,000 ordinary shares of EC$5 each. The company has issued 3,446,990 fully paid shares (Exhibit 15). LUCELEC's Board of Directors is

comprised of five Directors, one of whom is appointed by the Government, one by the Castries City Council (CCC) and the other three, including the Chairman, by Caribbean Development Corporation (CDC).

The agreement between CDC and LUCELEC provides for CDC to serve the company with technical and engineering services as required. This includes advice on accounting procedures, preparation of accounts, capital estimates and revenue needs. In addition, they ensure that an executive or engineer visits LUCELEC at least once a year to review company management and make recommendations. These services tend to reflect CDC's ownership role. CDC also recruits senior management staff for LUCELEC and provides buying agents to procure plant, machinery, and equipment on behalf of LUCELEC and to examine all shipping documents related to purchases.

EXHIBIT 15

ALLOCATION OF LUCELEC SHARES

Shareholder	Shareholding		Total
	Voting	Non-Voting	
St. Lucia Government	402,560 (18.8%)	1,300,000	1,702,560
Castries City Council	604,430 (28.1%)	-	604,430
CDC	1,140,000 (53.1%)	-	1,140,000
Total	2,146,990 (100.0%)	1,300,000	3,446,990

In the near future CDC intends to divest its preferred share holdings within LUCELEC. In preparation for this, CDC has secured management assistance and engineering assistance from the Commonwealth Fund for Technical Cooperation (CFTC) to train LUCELEC personnel in anticipation of the eventual withdrawal.

The removal of the power generating function for the base load from LUCELEC to the geothermal utility will allow LUCELEC to focus its remaining staff on administering the distribution of power rather than on the process of generation.

In sum, the capital requirements for LUCELEC will shift to electrical distribution and LUCELEC will become more efficient in its newly focused operations.

C. Summary Economic Analysis

1. Summary

The economic analysis of the St. Lucia project is primarily a simple engineering/economic replacement analysis (see Annex J for the complete Economic Analysis). This is a suitable approach because several diesel generators will soon be retired and can be replaced by geothermal units. The analysis is further simplified by the fact that except for the intergrid connection and the initial powerhouse connection, the transmission, distribution, and administrative institutions are the same as for the diesel-fired option. Thus, while total system cost is the economic measure that would normally be employed, in the present comparative analysis the shared components net out so that attention needs to focus only on the relative costs of power generation alone.

The economic analysis consists of two parts. The first is a least-cost analysis of the two most viable methods of meeting anticipated future energy needs. Then a cost-benefit analysis of the project is undertaken as data on benefits permitted.

A standard methodology has been employed, which utilizes the following format. First, forecasts of future Peak Demands for power are made. Next, a forecast of Firm Capacity (or "Base Load") is made. The latter is done in stages: From Nominal, (or "Nameplate") Capacity, an allowance is subtracted for deterioration of equipment and another deduction is made for planned shutdown and repair time. This yields Available Capacity. Finally, to allow slack in the system for emergencies the capacity of the largest plant is subtracted, yielding the Firm Capacity. Given this information, New Firm Capacity Needed (or additional Base Load needed) is calculated as the difference between Peak Demand and Firm Capacity. An allowance of from 15 to 30 percent is normally added to allow for wasteage and use of its own power by the plant. In the case of geothermal, this latter allowance will of course be smaller than for other types of plants.

The central element of the economic analysis is to ascertain the least-cost means of obtaining the New Firm Capacity Needed. This involves pair-wise comparisons of discounted cost streams for each alternative system. In principle, this can involve comparisions of many combinations of systems. However, technical or other constraints remove many forms of energy production from the reasonable choice set for St. Lucia for the period under consideration. Intensive deforestation, low seasonal flows, high sedimentation and other factors make hydro generation uneconomic at this time. Solar and wind energy have potential for some small-scale uses that should be explored, but at present do not present alternatives for large-scale energy production. Coal may offer long-term potential as a substitute for petroleum. This needs further analysis. However, it was determined that the most relevant comparison for St. Lucia at this time is that between diesel and

geothermal generation of the additional base load. The objective is to determine which of these two is the least-cost technique, including, where possible, allowance for exploration risk and negative externalities and spillovers.

The least-cost solution only identifies the most efficient way of obtaining a given benefit stream. It may be, however, that the benefits themselves are not sufficient to produce a reasonable rate of return to the nation's resources. To the extent that available data permitted, the next step was therefore to test the least-cost solution by a cost/benefit analysis, in order to determine whether the activity represents an appropriate use of national resources. Consideration was also given to potential external benefits and positive spillover effects.

As with any new energy technology, the viability of the overall success of a geothermal power plant depends very much on the administrative and institutional peripherals of private/public utility management. Within the short-term, plans for the support of a private geothermal utility station will address legislative, administrative and institutional arrangements. This support, through technical assistance to the GOSL, will be illustrated in a long-term development plan early in the project implementation phase.

Since the choice of a single discount rate always contains a degree of arbitrary judgement, Net Benefits were recalculated over a range of discount rates. Figures C.4 and C.5 in the Economic Analysis, Annex J, illustrate the net benefit streams over the range of discount rates. It can be seen from these that the Internal Rate of Return (the discount rate at which NPV is zero) is around 12 percent for the diesel alternative, and, depending upon the tariff structure, between 15 and 16 percent for the geothermal option. With an opportunity cost of capital of 10 to 12 percent, diesel generation produces negative, or only marginally positive, net benefits, while geothermal yields positive net returns. The geothermal results would be further improved by the addition of external benefits derived from the use of steam for other purposes. Since these external benefits are at present very difficult to quantify, they were not explicitly included in the calculations.

2. Import Substitution Effects

As indicated in the LANL analysis, a savings of EC$209 million (US$77.4 million) dollars over 30 years would be realized by substituting for the diesel fired generators. Annual peak demand was projected at 20% from 1983 to 1990, ranging from 11.73 MW in 1983 to 15.5 MW in 1990. This amounts to an average annual increase of 3%. When added to the reduced power losses (estimated by IBRD) the annual growth rate will approach 4.7% per

annum. The same Bank study indicated a petroleum import bill in 1978 of US$5.4 million and of $13.8 million in 1982. This increase reflects large c.i.f. price inceases as well as consumption patterns.

At this juncture, given that geothermal energy will reduce 36% of the petroleum import bill, annual maintenance savings of geothermal power to diesel will approach $4.69 million per year. This figure, derived from separate sources is consistent with the average annual expenditure over the 30 year useful life.

In conclusion, the comparative return on investment of geothermal over diesel represents a savings of over US$77.4 million over the life of the project.

D. Summary Environmental Assessment

1. Summary of the Environmental Assessment

An Environmental Assessment (see Annex H for the complete EA) was developed as an integral part of the geothermal exploration drilling project for the Qualibou Caldera in St. Lucia. The purpose of this assessment was to identify major environmental impacts caused by funding for the project.

This report evaluates potential environmental impacts of geothermal drilling and development on three locations in the Qualibou Caldera: Sulphur Springs, Belfond and Etangs. Impacts on land use, cultural resources, biological resources, tourism, air quality, noise, water resources, and waste management are identified for each of the three sites.

The main environmental impacts from the project will be increased hydrogen sulfide emission, noise, erosion, and waste storage and disposal requirements, and decreases in water quality and quantity. Additional concerns include archaeological sites. Most of the impacts of drilling will only occur in the short-term.

On the basis of this assessment, Etangs is identified as the preferred drilling location, since it will have the least impact on the existing environment.

Belfond is also an acceptable drilling location. The prime concern in Belfond is an archaeological site. However, mitigation measures are provided to minimize potential drilling and development impacts.

Sulphur Springs is the least preferred drilling site for several reasons identified. However, should it be necessary, mitigation measures are available to minimize impacts at this location.

In summary, the proposed project activities can be carried out in an environmentally sound manner, if remedial measures outlined in this study are incorporated into development plans.

2. Recommendations

Remedial measures to mitigate environmental impacts resulting from the Proposed Action were previously discussed. Additional recommendations are provided below to address environmental concerns regarding geothermal development on St. Lucia.

- Initial exploratory drilling at Etangs is recommended. This will minimize potential environmental impacts in the project area. Drilling in Belfond is also possible, since suitable mitigation measures are available to minimize impacts. However, impacts of drilling in Sulphur Springs will be more difficult to mitigate, and might result in potential environmental problems.

- Erosion control should be maintained throughout all phases of the project. In particular, permanent controls, such as stabilization with topsoil, mulch, seeding and planting of non-paved or graveled areas should be undertaken immediately following construction.

- Noise and air impacts on tourism should be mitigated by drilling and developing wells during the off-season (April - December).

- Surface and groundwater hydrology should be evaluated promptly to identify recharge areas, runoff patterns and aquifers of concern. This is critical for the proper siting of waste management facilities.

- Monitoring wells should be considered for each drilling site. This will permit a direct assessment of groundwater contamination resulting from geothermal development.

- Consideration should be given to developing multiple wells from a single platform, if the geothermal resource is sufficient. This will minimize requirements for additional land.

- o Contingency plans to develop alternate sources of water should be developed for potentially affected residents downstream from the drilling project.

E. Social Soundness Analysis

1. Socio-Cultural Feasibility

Geothermal exploration is not new in St. Lucia. In 1975 the British Government financed the drilling of seven test wells near Sulphur Springs. However, lack of care for the social and environmental effects of the drilling project appear to have earned the enmity of some local residents. As a result, while residents of the area support continued exploration, and in fact have shown considerable enthusiasm for the AID project, they have also raised issues and have suggested mitigative actions to diminish the potential negative social and environmental impact. These points have been considered, and measures designed to lessen negative impact have been included in the Environmental Analysis.

2. Social Impact

The Soufriere region of St. Lucia has a rich combination of natural beauty, natural "wonders" and historical/archeological sites. Thus, although the region is largely agricultural (the cultivation of bananas is the major agricultural activity on large estates as well as on small holder plots), there is good potential for additional tourism development. Soufriere is also near the expanding industrial development zone and the international airport in Vieux Fort.

The time is propitious for serious discussion of overall land use. The GOSL is drafting a National Physical Plan which cites the Soufriere area as a zone where tourist development will be carefully controlled and the natural and cultural attractions enhanced. Controlled tourist development should increase employment opportunities in the region.

Presently, however, the region is one of the more depressed areas of St. Lucia. Unemployment is considered to be higher than the national average and out-migration to Castries and Vieux Fort is significant particularly among those aged 15-25. In the short term, the drilling operations will provide temporary employment to local contractors, truck drivers and laborers.

The selection of the exact drilling sites should take into consideration the land ownership and land use of the area, and an effort should be made to disrupt the least number of small farmers. The three proposed drilling sites demonstrate different land use patterns. The Belfond area is characterized by small

farmer cultivation. The Etangs area is considered to be prime agricultural land and land ownership patterns are more diverse, with a few large estates as well as small farmers and subsistence plots. The Sulphur Springs area is less desirable agriculturally and is less populated.

The previous drilling program in the Sulphur Springs area did not require significant removal of the resident population, and is it expected that this project will not necessitate removing large numbers of families either.

However, should the selection of drilling sites necessitate the government acquiring land, the question of property rights and values will arise. Existing legislation on eminent domain and compensation should be sufficient; and an assessment of the value of property in the region should be carried out and meetings held with residents to ensure cooperation and satisfaction.

The GOSL is engaged in a land titling project with USAID which seeks to clarify land registration and titling. Co-ownership of land, termed "family land" in St. Lucia, is prevalent among smallholders. The Land Registration and Titling project is expected to begin soon in the Soufriere area, thus mitigating possible problems of delay should the question of land appropriation and compensation arise.

3. Archeological Site

A number of dolmens, middens and evidence of terracing indicate the presence of a pre-Columbian archaeological site in the Belfond area dating from about 800 A.D. Like Stonehedge in England and Machu Pichu in Peru, the site may have been used for the measure of time and for religious ceremonies marking the solstice. Examination of pottery shards is in progress.

The management and drilling contractors should collaborate with archeologists to determine drilling sites that will cause the least disruption to the archeological site. Archeologists have indicated that they are anxious to collaborate with technicians in determining the drilling sites and in suggesting mitigative measures (see Environmental Analysis). This collaborative effort must be a priority as there is a high level of consciousness among the population and within the government about preserving the nation's cultural heritage.

4. Spread Effects

a. Transfer of Technology

Geothermal exploration technology is highly specialized. Neither the drilling operations nor the commercialization of geothermal energy for domestic and industrial use will involve much transfer of technology to St. Lucians in the short term. However, this should not be viewed negatively as St. Lucia does not presently have the expertise to counterpart this project, and successful implementation necessitates using foreign specialists. In the long term, individual St. Lucians will be trained to function at technical and managerial levels in the commercialization phase. In the short term St. Lucians will gain some expertise working on-site in the drilling operations.

c. Communications

This project requires good public relations, including informing the general public and the residents of the Soufriere area through the media and through the local councils. St. Lucia has vibrant radio programming and the population is accustomed to Government Information Service broadcasting for information regarding events of national significance, particularly in development activities. Special programs could be developed by the GIS to provide both background information on geothermal potential and also information on activities at the drilling sites.

Local councils and disaster preparedness committees are organized to deal with a multiplicity of potential hazards including earthquakes and hurricanes, and would also serve as important disseminators of information. These councils and committees should be consulted in developing emergency plans in drilling areas in order to lessen the possibility of the spread of misinformation as well as to maximize the successful implementation of any mitigative measures that may be required.

VI. CONDITIONS PRECEDENT AND COVENANTS

A. Conditions Precedent to Disbursement

1. First Disbursement. Prior to the first disbursement under the Grant, or to the issuance by A.I.D. of documentation pursuant to which disbursement will be made, the Grantee will, except as the Parties may otherwise agree in writing, furnish to A.I.D. in form and substance satisfactory to A.I.D.:

(a) An opinion of counsel acceptable to A.I.D. that this Agreement has been duly authorized and/or ratified by, and executed on behalf of, the Grantee, and that it constitutes a valid and legally binding obligation of the Grantee in accordance with all of its terms;

(b) A statement of the name of the person holding or acting in the office of representative of the Grantee specified in Section 8.2., and of any additional representatives, together with a specimen signature of each person specified in such statement;

2. Disbursement for Civil Works and Drilling Activities. Prior to any disbursement under the grant, or to issuance by A.I.D. of documentation pursuant to which disbursement will be made for civil works and drilling activities, the Grantee will, except as the parties may otherwise agree in writing, furnish to A.I.D. in form and substance satisfactory to A.I.D.:

(a) A detailed, time phased implementation plan for the drilling activities, civil works and repair of pre-existing geothermal wells;

(b) Evidence that the Grantee has obtained or has set in motion procedures to obtain all lands for the Project, including all necessary easements or other rights in property, to carry out the activity;

(c) (1) an AID-approved environmental assessment (EA) prepared according to A.I.D. Reg. 16 (22 CFR Part 216) and (2) an environmental monitoring and safety plan designed to protect the human and physical environment in and around the proposed drilling sites;

(d) Evidence that the Grantee will provide necessary pad preparation, storage ponds and water supply for the drilling sites;

(e) Evidence of an executed contract or firm arrangement to secure such a contract for the technical services required to prepare a plan and parameters for private investment in geothermal exploitation, including, but not limited to, documents that could

provide a description of the proposed institutional, technical and financial relationships between the private investor, the Government of St. Lucia and the St. Lucia Electric Company (LUCELEC). The final outcome of this technical assistance effort will be a Request for Proposals for the selection of private sector investment and participation in the development of geothermal resources.

B. Covenants

1. Project Evaluation. The Parties agree to establish an evaluation program as part of the Project. Except as the Parties otherwise agree in writing, the program will include, during the implementation of the Project and at one or more points thereafter:

(a) evaluation of progress toward attainment of the objectives of the Project;

(b) identification and evaluation of problem areas or constraints which may inhibit such attainment;

(c) assessment of how such information may be used to help overcome such problems; and

(d) evaluation, to the degree feasible, of the overall development impact of the Project.

2. Environment. The Grantee agrees to take steps to adhere to recommendations stemming from the environmental assessment and monitoring procedures to be carried out as part of the Project.

3. Private Investment Plan. The Grantee agrees to make its best efforts to carry out the plan prepared pursuant to Section 4.2(e), except to the extent that any aspects of the plan are not endorsed by the Grantee and notification of the Grantee's specific objections are provided to A.I.D. in writing within 30 days of the Grantee's receipt of the plan.

4. Power Grid Linkage. The Grantee agrees to develop (a) a plan for transmission of 11 KV lines between the geothermal power house site and the southern grid and (b) a plan for interconnection of the two grids on St. Lucia.

5. LUCELEC Purchase of Electricity. Except as A.I.D. may otherwise agree in writing, the Grantee will enter into an agreement with LUCELEC for the purchase of the electricity produced from the geothermal resource.

VII. EVALUATION ARRANGEMENTS

A project evaluation program will be part of the project. The technical evaluation of the viability of the first geothermal well will be prepared immediately following completion of the drilling of that well. These data will be included in an interim project impact evaluation in which the progress toward attainment of the project objectives, the identification of problem areas, the proposal of solutions to overcome such problems, and an evaluation of the overall developmental impact will be assessed.

A final evaluation will be prepared approximately six months prior to the PACD.

ANNEX A

ACTION AID-7 INFO AMB DCM PE CHRON 10

JUGVZCZCWN0390
PP RUEHWN
DE RUEHC #0385 1201823
ZNR UUUUU ZZH
P 301820Z APR 85
FM SECSTATE WASHDC
TO AMEMBASSY BRIDGETOWN PRIORITY 9316
BT
UNCLAS STATE 130385

OFFICIAL COPY

- 1 MAY 1985

LOC: 08 899
30 APR 85 1824
CN: 08052
CHRG: AID
DIST: AID

AIDAC

E.O. 12356: N/A
TAGS:
SUBJECT: ST. LUCIA GEO-THERMAL PROJECT

REF: BRIDGETOWN 3278

1. PER REQUEST REFTEL, RDO/C IS GIVEN AUTHORITY TO APPROVE PID AND PP FOR SUBJECT PROJECT. PROJECT SUPPORTS AID'S DEVELOPMENT STRATEGY IN E. CARIBBEAN TO IMPROVE INFRASTRUCTURE BASE REQUIRED FOR PRIVATE SECTOR INVESTMENT, AND IS CONSISTENT WITH AGENCY POLICY TO UTILIZE AID RESOURCES TO MOBILIZE PRIVATE FUNDS BY PAVING WAY FOR COMMERCIAL DEVELOPMENT OF GEO-THERMAL RESOURCES IN ST. LUCIA. IT FURTHER REPRESENTS A MUTUALLY BENEFICIAL EFFORT TO COLLABORATE WITH ANOTHER DONOR (UNREWRE) WHICH CAN PROVIDE IMPORTANT TECHNICAL AND FINANCIAL SUPPORT FOR THIS EFFORT. LAC BUREAU AND PPC, THEREFORE, SEE NO POLICY ISSUES WHICH REQUIRE AID/W REVIEW.

2. CN IS BEING PREPARED. WILL ADVISE WHEN TRANSMITTED TO THE HILL.

3. APPORTIONMENT IS BEING REVISED TO INCLUDE THIS PROJECT. SHULTZ
BT
#0385

NNNN

ACTION	INFO
	EUG
DIR	✓
D/DIR	✓
MGT	✓
RLA	
RCO	
PROG	
ECON	
CONT	✓
CDO	✓
ENG	
AGR	
HRDC	
HLTH	
JAO	
DUE	05/02/85
TAKEN:	NAN
SIGN:	

Technical meeting before GOSL, UNRF, AID completed MOU ... agreed.

P.O. Box 302,
BRIDGETOWN, Barbados.

ANNEX B

Dear Mr. Wheeler,

Geothermal Development Project

As you may be aware, the Los Alamos National Laboratory (LANL) recently presented its final report on the Geothermal Development Project to the Government of St. Lucia. The report recommends that Government proceed immediately to the exploratory drilling phase of the project which is costed at approximately U.S. $6.0 million.

Following discussions in Washington during the presentation of the LANL report to interested agencies, we were informed that the United Nations Revolving Fund for Natural Resources Exploration was unable to make financing available for the immediate implementation of the exploratory drilling programme and while funds for this purpose might be available in the third quarter of 1985 a firm committment could not be given in this regard.

In the light of this development and given Government's concern to commence by January 1985 the exploratory drilling phase of this project which has been so long in development, approaches were made to representatives of USAID and the State Department for financing to be provided through USAID for this purpose. I therefore wish on behalf of the Government of St. Lucia to formally request USAID to give consideration to the provision of financing for the implementation of the exploratory drilling programme and also to provide financial support which would allow LANL to continue in its role as technical advisor to Government for the drilling and development phases of the project.

Dr. McRae

ACTION | INFO

CDO

While we have every reason to believe that an approach to the European Investment Bank (EIB) for financing for the exploratory drilling programme would be favourably received, the use of EIB funds would have implications for the utilization of European consultants and contractors. Given the strong support given by USAID for this project, Government would much prefer that the further development of the project take place in association with United States firms.

In the light of the present situation we would be grateful for a favourable response to our request for financial assistance to allow for the continued development of the geothermal project.

Yours sincerely,

AUSBERT D'AUVERGNE
Deputy Director,
Finance & Planning (Planning).

06/03/84

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5C(3) - STANDARD ITEM CHECKLIST

Listed below are statutory items which normally will be covered routinely in those provisions of an assistance agreement dealing with its implementation, or covered in the Agreement by imposing limits on certain uses of funds.

These items are arranged under the general headings of (A) Procurement, (B) Construction, and (C) Other Restrictions.

A. Procurement

1.	FAA Sec. 602. Are there arrangements to permit U.S. small business to participate equitably in the furnishing commodities and services financed?	YES
2.	FAA Sec. 604(a). Will all procurement be from the U.S. except as otherwise determined by the President or under delegation from him?	YES
3.	FAA Sec. 604(d). If the cooperating country discriminates against marine insurance companies authorized to do business in the U.S., will commodities be insured in the United States against marine risk with such a company?	N/A
4.	FAA Sec. 604(e); ISDCA of 1980 Sec. 705(a). If offshore procurement of agricultural commodity or product is to be financed, is there provision against such procurement when the domestic price of such commodity is less than parity? (Exception where commodity financed could not reasonably be procured in U.S.)	N/A

5.	FAA Sec. 604(g). Will construction or engineering services be procured from firms of countries which are direct aid recipients and which are otherwise eligible under Code 941, but which have attained a competitive capability in international markets in one of these areas? Do these countries permit United States firms to compete for construction or engineering services financed from assistance programs of these countries?	Technical services will be procured from Geographic Code 000 (United States) or Host Country only.
6.	FAA Sec. 603. Is the shipping excluded from compliance with requirement in section 901(b) of the Merchant Marine Act of 1936, as amended, that at least 50 per centum of the gross tonnage of commodities (computed separately for dry bulk carriers, dry cargo liners, and tankers) financed shall be transportd on privately owned U.S. flag commercial vessels to the extent such vessels are available at fair and reasonable rates?	NO
7.	FAA Sec. 621. If technical assistance is financed, will such assistance be furnished by private enterprise on a contract basis to the fullest extent practicable? If the facilities of other Federal agencies will be utilized, are they particularly	YES

suitable, not competitive with private enterprise, and made available without undue interference with domestic programs?	
International Air Transportation Fair Competitive Practices Act, 1974. If air transportation of persons or property is financed on grant basis, will U.S. carriers be used to the extent such service is available?	YES
FY1985 Continuing Resolution Sec. 504. If the U.S. Government is a party to a contract for procurement, does the contract contain a provision authorizing termination of such contract for the convenience of the United States?	N/A

B. Construction

1. FAA Sec. 601(d). If capital (e.g., construction) project, will U.S. engineering and professional services be used?	Yes. Procurement of technical services will be from Geographic Code 000 plus Host Country.
2. FAA Sec. 611(c). If contracts for construction are to be financed, will they be let on a competitive basis to maximum extent practicable?	Yes. Procurement of technical services will be made according to AID Handbook II - Host Country Contracting Procedures.
3. FAA Sec. 620(k). If for construction of productive enterprise, will aggregate value of assistance to be furnished by the U.S. not exceed $100 million (except for productive enterprises in Egypt that were described in the CP)?	N/A

C. Other Restrictions

1. FAA Sec. 122(b). If development loan, is intrest rate at least 2% per annum during grace period and at least 3% per annum thereafter? N/A

2. FAA Sec. 301(d). If fund is established solely by U.S. contributions and administered by an international organization, does Comptroller General have audit rights? N/A

3. FAA Sec. 620(h). Do arrangements exist to insure that United States foreign aid is not used in a manner which, contrary to the best interests of the United States, promotes or assists the foreign aid projects or activities of the Communist-bloc countries? N/A

4. Will arrangements preclude uses of financing:

   a. FAA Sec. 104(f); FY 1985 Continuing Resolution Sec. 527. (1) To pay for performance of abortions as a method of family planning or to motivate or coerce persons to practice abortions; (2) to pay for performance of involuntary sterilization as method of family planning, or to coerce or provide financial incentive to N/A

	any person to undergo sterilization; (3) to pay for any biomedical research which relates, in whole or part, to methods or the performance of abortions or involuntary sterilizations as a means of family planning; (4) to lobby for abortion?	
b.	FAA Sec. 620(g). To compensate owners for expropriated nationalized property?	N/A
c.	FAA Sec. 660. To provide training or advice or provide any financial support for police, prisons or other law enforcement forces, except for narcotics programs?	N/A
d.	FAA Sec. 662. For CIA activities?	N/A
e.	FAA Sec. 636(i). For purchase, sale, long-term lease, exchange or guaranty of the sale of motor vehicles manufactured outside U.S., unless a waiver is obtained?	N/A
f.	FY 1985 Continuing Resolution, Sec. 503. To pay pensions, annuities, retirement pay, or adjusted service compensation for military personnel?	N/A

g.	FY 1985 Continuing Resolution, Sec. 505. To pay U.N. assessments, arrearages or dues?	N/A
h.	FY 1985 Continuing Resolution, Sec. 506. To carry out provisions of FAA section 209(d) (Transfer of FAA funds to multilateral organizations for lending)?	N/A
i.	FY 1985 Continuing Resolution, Sec. 510. To finance the export of nuclear equipment, fuel, or technology or to train foreign nationals in nuclear fields?	N/A
j.	FY 1985 Continuing Resolution, Sec. 511. Will assistance be provided for the purpose of aiding the efforts of the government of such country to repress the legitimate rights of the population of such country contrary to the Universal Declaration of Human Rights?	NO
k.	FY 1985 Continuing Resolution, Sec. 516. To be used for publicity or propaganda purposes within U.S. not authorized by Congress?	N/A

5C(1) - PROJECT CHECKLIST

Listed below are statutory criteria applicable to projects. This section is divided into two parts. Part A. includes criteria applicable to all projects. Part B. applies to projects funded from specific sources only: B.1. applies to all projects funded with Development Assistance loans, and B.3. applies to projects funded from ESF.

CROSS REFERENCES: IS COUNTRY CHECKLIST UP-TO-DATE? YES
HAS STANDARD ITEM CHECKLIST BEEN REVIEWED FOR THIS PROJECT?

A. GENERAL CRITERIA FOR PROJECT

1. FY 1985 Continuing Resolution Sec. 525; FAA Sec. 634A; Sec. 653(b)653(b).

(a) Describe how authorizing and appropriations committees of Senate and House have been or will be notified concerning the project;	a) The waiting period for the Congressional Notification expired on June 12, 1985.
(b) is assistance within (Operational Year Budget) country or international organization allocation reported to Congress (or not more than $1 million over that amount)?	b) $1.5 million in FY 85 ESF Grant funds have been allocated per State 179740. The remaining $1.5 million will be allocated from FY 86 Grant Fund.

2. FAA Sec. 611(a)(1). Prior to obligation in excess of $100,000, will there be (a) engineering, financial or other plans necessary to carry out the assistance and (b) a reasonably firm estimate of the cost to the U.S. of the assistance?

(a) YES
(b) Yes, to the extend possible for a Geothermal Exploration Project.

3. FAA Sec. 611(a)(2). If further legislative action is required within recipient country, what is basis for reasonable expectation that such action will be completed in time to permit orderly accomplishment of purpose of the assistance?

N/A

4.	FAA Sec. 611(b); FY 1985 Continuing Resolution Sec 501 If for water or water-related land resource construction, has project met the standards and criteria as set forth in the Principles and Standards for Planning Water and Related Land Resources, dated October 25, 1973, or the Water Resources Planning Act (42 U.S.C. 1962, et seq.)? (See AID Handbook 3 for new guidelines.)	N/A
5.	FAA Sec. 611(e). If project is capital assistance (e.g., construction), and all U.S. assistance for it will exceed $1 million, has Mission Director certified and Regional Assistant Administrator taken into consideration the country's capability effectively to maintain and utilize the project?	YES
6.	FAA Sec. 209. Is project susceptible to execution as part of regional or multilateral project? If so, why is project not so executed? Information and conclusion whether assistance will encourage regional development programs.	The Project is financed by AID and the United Nations Revolving Fund for Natural Resources Exploration.
7.	FAA Sec. 601(a). Information and conclusions whether project will encourage efforts of the country to: (a) increase the flow of international trade; (b) foster private initiative and competition; and (c) encourage development and use of cooperatives, and credit	a) The Project will result in a reliable indigenous source of power to generate electricity for Tourism and light manufacturing as well as domestic use. The Project is expected to accelerate the development of export oriented private enterprise investment in St. Lucia. (b), (c), (d), (e), (f) - N/A

unions, and savings and loan associations; (d) discourage monopolistic practices; (e) improve technical efficiency of industry, agriculture and commerce; and (f) strengthen free labor unions.

8. FAA Sec. 601(b). Information and conclusions on how project will encourage U.S. private trade and investment abroad and encourage private U.S. participation in foreign assistance programs (including use of private trade channels and the services of U.S. private enterprise).

See No. 7 above.

9. FAA Sec. 612(b), 636(h); FY 1985 Continuing Resolution Sec 507. Describe steps taken to assure that, to the maximum extent possible, the country is contributing local currencies to meet the cost of contractual and other services, and foreign currencies owned by the U.S. are utilized in lieu of dollars.

The GOSL's construction to the Project will be paid in local currency. The United States Government does not own local curency.

10. FAA Sec. 612(d). Does the U.S. own excess foreign currency of the country and, if so, what arrangements have been made for its release?

N/A

11. FAA Sec. 601(e). Will the project utilize competitive selection procedures for the awarding of contracts, except where applicable procurement rules allow otherwise?

All procurement will be from Geographic Code 000 and Host Country and awarded according to AID Handbook II - Host Country Contracting Procedures.

12.	FAA 1985 Continuing Resolution Sec. 522. If assistance is for the production of any commodity for export, is the commodity likely to be in surplus on world markets at the time the resulting productive capacity becomes operative, and is such assistance likely to cause substantial injury to U.S. producers of the same, similar or competing commodity?	N/A
13.	FAA 118(c) and (d). Does the project comply with the environmental procedures set forth in AID Regulation 16. Does the project or program taken into consideration the problem of the destruction of tropical forests?	An Environmental Assessment has been made and an Environmental Monitoring Plan is an integral part of Project Implementation.
14.	FAA 121(d). If a Sahel project, has a determination been made that the host government has an adequate system for accounting for and controlling receipt and expenditure of project funds (dollars or local currency generated therefrom)?	N/A
15.	FY 1985 Continuing Resolution Sec. 536. Is disbursement of the assistance conditioned solely on the basis of the policies of any multilateral institution?	Although Grant Funds will be passed through the UNRFNRE, no disbursement of AID Funds will be made without RDO/C certification.

B. FUNDING CRITERIA FOR PROJECT

1. Development Assistance Project Criteria

a. FAA Sec. 102(b), 111, 113, 281(a). Extent to which activity will (a) effectively involve the poor in development, by extending access to economy at local level, increasing labor-intensive production and the use of appropriate technology, spreading investment out from cities to small towns and rural areas, and insuring wide participation of the poor in the benefits of development on a sustained basis, using the appropriate U.S. institutions; (b) help develop cooperatives, especially by technical assistance, to assist rural and urban poor to help themselves toward better life, and otherwise encourage democratic private and local governmental institutions; (c) support the self-help efforts of developing countries; (d) promote the participation of women in the national economies of developing countries and the improvement of women's status, (e) utilize and encourage regional cooperation by developing countries?

Although short-term job opportunities for un-skilled and semi-skilled rural workers will result from project activities, the primary project benefit will be to the St. Lucia economy as a whole through the provision of reliable electricity.

b.	FAA Sec. 103, 103A, 104, 105, 106. Does the project fit the criteria for the type of funds (functional account) being used?	YES
c.	FAA Sec. 107. Is emphasis on use of appropriate technology (relatively smaller, cost-saving, labor-using technologies that are generally most appropriate for the small farm, small businesses, and small incomes of the poor)?	N/A
d.	FAA Sec. 110(a). Will the recipient country provide at last 25% of the costs of the program, project, or activity with respect to which the assistance is to be furnished (or is the latter cost-sharing requirement being waived for a "relatively least developed country)?	N/A
e.	FAA Sec. 110(b). Will grant capital assistance be disbursed for project for more than 3 years? If so, has justification satisfactory to Congress been made, and efforts for other financing, or is the recipient country "relatively least developed"? (M.O. 1232.1 defined a capital project as "the construction, expansion,	N/A

equipping or alteration of a physical facility or facilities financed by AID dollar assistance of not less than $100,000, including related advisory, managerial and training services, and not undertaken as part of a project of a predominantly technical assistance character."	
FAA Sec 122(b). Does the activity give reasonable promise of contributing to the development of economic resources, or to the increase of productive capacities and self-sustaining economic growth?	YES
FAA Sec. 281(b). Describe extent to which program recognizes the particular needs, desires, and capacities of the people of the country; utilizes the country's intellectual resources to encourage institutional development; and supports civil education and training in skills required for effective participation in governmental processes essential to self-government.	The Project responds to the long held aspirations of St. Lucia to develop its Geothermal potential. The Project will train St. Lucians in Geothermal Well Field Administration.

2. Development Assistance Project Criteria (Loans Only)

a. FAA Sec. 122(b). Information an conclusion on capacity of the country to repay the loan, at a reasonable rate of interest.	N/A
b. FAA Sec. 620(d). If assistance is for any productive enterprise which will compete with U.S. enterprises, is there an agreement by the recipient country to prevent export to the U.S. of more than 20% of the enterprise's annual production during the life of the loan?	N/A

3. Economic Support Fund Project Criteria

a. FAA Sec. 531(a). Will this assistance promote economic and political stability? To the extent possible, does it reflect the policy directions of FAA Section 102?	The establishment of a reliable, indigenous source of energy will promote economic stability.
b. FAA Sec. 531(c). Will assistance under this chapter be used for military, or paramilitary activities?	N/A
c. FAA Sec. 534. Will ESF funds be used to finance the construction of, or the operation or	N/A

	maintenance of, or the supplying of fuel for, a nuclear facility? If so, has the President certified that such use of funds is indispensable to nonproliferation objectives?	
d.	FAA Sec. 609. If commodities are to be granted so that sale proceeds will accrue to the recipient country, have Special Account (counterpart) arrangements been made?	N/A

ANNEX D

CERTIFICATION PURSUANT TO SECTION 611(e) OF THE
FOREIGN ASSISTANCE ACT OF 1961, AS AMENDED

I, James Holtaway, as Director of the Regional Development Office/Caribbean of the Agency for International Development, having taken into account, among other things, the utilization and maintenance of projects in the Caribbean region previously financed or assisted by the United States, do hereby certify that in my judgement the Government of St. Lucia has both the financial capacity and the human resources capability to use and maintain the goods and services procured under the proposed capital assistance grant project entitled St. Lucia Geothermal Project.

This judgement is based on the implementation record of externally financed projects including AID-financed projects in St. Lucia, the committment from the Government of St. Lucia, and the quality of planning wich has gone into this new project. The technical pre-feasibility for geothermal exploration in the Soufriere Caldera of St. Lucia, and the environmental assessment and environmental safety and monitoring plan which has been designed to assure the safety of human beings and the rest of the natural environment, have been prepared by well-qualified American specialists. The specifications for the drilling equipment will be prepared by an American specialist in geothermal drilling.

The co-financing agency, the United Nations Revolving Fund for Natural Resources Exploration, will provide management and supervisory services, as well as materials and equipment, for the pre-drilling and drilling phases of the project. The Government of St. Lucia has demonstrated its capability to provide and maintain infrastructural support.

The Project Agreement includes provisions designed to assure that the geothermal resource will be developed through private investment in order that the GOSL is not burdened with the management of the resource. The Government of St. Lucia appreciates the economic, social and environmental importance of the project and is fully committed to its proper implementation and effective utilization.

(signed): _____

James Holtaway
Director

(date): _____

July 5, 1985

Project Title & Number: St. Lucia Geothermal Development

FY 85 $1.5 million and FY 86 $1.5 million = $3,000,000 ESF Grant
PACD August 1987

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal: The broader objective to which this project contributes: Goal: To accelerate the economic development of St. Lucia	Measures of Goal Achievement: 1. More private investment in manufacturing & tourism 2. More jobs 3. Less unemployment	1. Chamber of Commerce data 2. Jobs advertised, C of C data 3. GOSL data 4. GNP	Assumptions for achieving goal targets: Political stability Present infrastructure constrains development
Sub-Goal: To establish an indigenous, abundant, reliable source of electricity	1. Power generation from a local source 2. Greater power capacity 3. Lower power cost	1. Site inspections 2. Technical reports 3. LUCELEC rates	St. Lucia's Geothermal is useable to generate electricity Geothermal power is cheaper than diesel power
Project Purpose: To establish the economic and technical viability of the Qualibou Caldera as a long-term geothermal resource capable of generating substantial quantities of electrical and other power which can be developed by the private sector.	Conditions that will indicate purpose has been achieved: End of project status. 1. The Caldera has been drilled and tested, and proven to be adequate for the economic production of electricity. 2. GOSL has accepted a plan for private investor to construct and operate a power plant. 3. LUCELEC has agreed to purchase the electricity.	1. Geoscientist's report economist's report 2. Evidence of GOSL approval of private investment plan. 3. LUCELEC contract to purchase	Assumptions for achieving purpose: 1. The driller chose the correct site in the Caldera. 2. GOSL policy supports private sector investment in its natural resources.
Outputs: 1. Geothermal wells; drilled, tested, capped. 2. Environmental safety assured. 3. Private geothermal corporation. 4. Power supply agreement with LUCELEC	Magnitude of Outputs: 1. Three wells, each with at least 2.5 mw potential. 2. Environmental monitoring plan to cover LOP and beyond. 3. Plans to construct a 10 mw power plant. 4. LUCELEC agrees to buy 10 mw electricity.	1 Geoscientist's reports and evaluation of drilling 2. Contract with a qualified geothermal environmentalist. 3. Corporate charter. 4. LUCELEC contract or agreement	Assumptions for achieving outputs: 1. Caldera is hot. 2. Wells produce safe useable effluent. 3. GOSL laws permit private sector to invest in natural resources & to sell power. 4. LUCELEC financially capable to buy geothermal power.
Inputs: AID: $3 million grant to finance: drilling contract, environmental program, training & TA, access roads. UNRFNRE: $2.3 million to finance: drilling supervision and subcontracts. GOSL: Preparation of harbour, water supply, drilling pads.	Implementation Target (Type & Quantity): AID: 1 host country drilling contract. Other HC and AID direct contracts. UNRFNRE: Supervision contracts and subcontracts - unprocurement GOSL: Local contracts or force account.	AID and UNRFNRE signed contracts work performed (site visits) GOSL: Work performed (site visits)	Assumptions for providing inputs: AID: FY 86 $1.5 million is alloted. Drilling bids are within budget. UNRFNRE participates as planned. GOSL delivers inputs in timely fashion.

ANNEX E

UNCLASSIFIED STAT 228364 ANNEX F

ACTION AID-7 INFO AMB DCM PE CHRON 10

VZCZCWN0666
PP RUEHWN
DE RUEHC #8364 2062052
ZNR UUUUU ZZH
P R 252053Z JUL 85
FM SECSTATE WASHDC
TO RUEHWN/AMEMBASSY BRIDGETOWN PRIORITY 0435
INFO RUESPR/AMEMBASSY PORT AU PRINCE 8829
BT
UNCLAS STATE 228364

LOC: 06 021
26 JUL 85 2052
CN: 02860
CHRG: AID
DIST: AID

26 JUL 1985

AIDAC BRIDGETOWN FOR JCONNOLLY; PORT AU PRINCE FOR JTALBO

E.O. 12356: N/A
TAGS: N/A
SUBJECT: ST LUCIA GEOTHERMAL ENVIRONMENTAL ASSESSMENT

REF: BRIDGETOWN 6198

1. LAC CHIEF ENVIRONMENTAL OFFICER CONCURS IN MISSION'S PROPOSED CONDITION PRECEDENT AND COVENANT TO ENSURE ENVIRONMENTAL ASSESSMENT IS COMPLETED AND ITS RECOMENDATIONS ARE FULLY INCORPORATED INTO PROJECT PRIOR TO BEGINNING ANY ACTIONS THAT MAY AFFECT THE ENVIRONMENT.

2. PLEASE FORWARD COMPLETED ASSESSMENT TO LAC/DR WHEN COMPLETED FOR REVIEW AND APPROVAL. WHITEHEAD

UNCLASSIFIED STATE 228364

UNCLASSIFIED

STATE 278040 ANNEX G

ACTION AID-7 INFO AMB DCM PE CHRON 10

VZCZCWN0994
RR RUEHWN
DE RUEHC #8040 2532044
ZNR UUUUU ZZH
R 102042Z SEP 85
FM SECSTATE WASHDC
TO RUEHWN/AMEMBASSY BRIDGETOWN 1033
INFO RUESPR/AMEMBASSY PORT AU PRINCE 9426
BT

LOC: 01 038
10 SEP 85 2043
CN: 00957
CHRG: AID
DIST: AID

UNCLAS STATE 278040

AIDAC PORT AU PRINCE FOR JTALBOT

F.C. 12356:N/A
TAGS:
SUBJECT: ENVIRONMENTAL ASSESSMENT - ST. LUCIA GEOTHERMAL

11 SEP 1985

1. LAC CHIEF ENVIRONMENTAL OFFICER HAS REVIEWED AND HEREBY APPROVES ENVIRONMENTAL ASSESSMENT (EA) DONE BY CONTRACTOR SORENSON FOR ST. LUCIA GEOTHERMAL EXPLORATION DRILLING PROJECT SUBJECT TO INCLUSION OF E.A. RECOMMENDATIONS INTO PROJECT.

2. ALSO, LINE 9 ON PAGE 8 OF THE EA IS HEREBY REVISED TO READ QUOTE, BY LANL SHOW CARBON DIOXIDE (CO_2) TO BE THE DOMINANT, UNQUOTE. SHULTZ
BT
#8040

NNNN

UNCLASSIFIED STATE 278040

Excl

85/09/1

Concur
C Connolly

60

ANNEX H

ENVIRONMENTAL ASSESSMENT

GEOTHERMAL EXPLORATION DRILLING PROJECT

QUALIBOU CALDERA, ST. LUCIA

SUBMITTED TO

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

PREPARED BY

TIPPETTS - ABBETT - McCARTHY - STRATTON

AUGUST 1985

E. PATRICK SORENSEN, PH.D.

ENVIRONMENTAL ASSESSMENT
GEOTHERMAL EXPLORATION DRILLING PROJECT
QUALIBOU CALDERA, ST. LUCIA

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ENVIRONMENTAL ASSESSMENT
GEOTHERMAL EXPLORATION DRILLING PROJECT
QUALIBOU CALDERA, ST. LUCIA

I. SUMMARY

An Environmental Assessment (EA) was conducted as an integral part of this project. The purpose of this assessment was to identify any major environmental impacts caused by funding for exploratory drilling for geothermal energy in the Qualibou Caldera, St. Lucia. Recommendations for mitigation of identified impacts were also identified.

The EA evaluated the environmental impacts of drilling on three potential locations: Sulphur Springs, Belfond and Etangs in terms of land use, cultural resources, biological resources, tourism, air quality, noise, water resources, and waste management. The main environmental concerns include air quality, noise, cultural resources (archaeological resources), and waste management. Remedial actions are described to mitigate potential impacts.

The preferred drilling alternatives in order of preference for minimizing environmental impacts are: Etangs, Belfond, and Sulphur Springs. Belfond was chosen by the Los Alamos National Laboratory as the preferred drilling alternative on the basis of probability of success. Mitigation measures are provided in this EA to make drilling in Belfond possible with minimal environmental impact.

In summary, implementation of the Proposed Action can be carried out in an environmentally sound manner if remedial measures outlined in this study are incorporated into development plans.

II. INTRODUCTION

2.1 Background

The U.S. AID Regional Development Office, Caribbean and the United Nations Revolving Fund for Natural Resources Exploration (UNRFNRE) will co-finance a project to perform exploratory drilling in the Qualibou Caldera of St. Lucia in an effort to evaluate the geothermal energy resources for purposes of electric power generation. Figure 1 provides a map of St. Lucia and the general Project Area.

Prefeasibility studies have been conducted by Aquater in 1982 and by Los Alamos National Laboratory (LANL) in 1983 - 1984 addressing the geologic, economic and engineering aspects of geothermal energy development. Their technical findings and recommendations indicate that geothermal potential exists and that several promising sites for production drilling are available. The purpose of the drilling operation is to identify the exact nature and extent of the geothermal fluids by testing wet samples of the fluids. Such analyses will provide estimates of well productivity, composition of geothermal fluids, and fluid conditions. When data are available from these wells, it will be possible to optimize the electric power generating system as well as the thermal energy system. If appropriate, these wells will be used for production.

This report was prepared in response to a request for technical assistance by the Agency through Tippetts - Abbett - McCarthy Stratton's (TAMS) Environmental Planning Indefinite Quantity Contract. The purpose of this assistance was to prepare an Environmental Assessment (EA) in compliance with 22 CFR 216 U.S. AID Environmental Procedures in order to examine the foreseeable impacts on the human and natural environment of activities undertaken by the proposed funding. It is intended that this EA will be incorporated into U.S. AID's Project Paper.

2.2 Scoping

The identification of the proposed actions by the Agency's Project Team suggested major environmental concerns to be addressed by this EA. One set of issues of particular concern to the Agency involves "unreasonable degradation", defined as any or all of the following (1) significant changes in biological or cultural diversity within the affected area; (2) threat to human health through direct exposure to pollutants; and (3) loss of aesthetic, recreational, archaeological, scientific, or economic values which is unreasonable in direct

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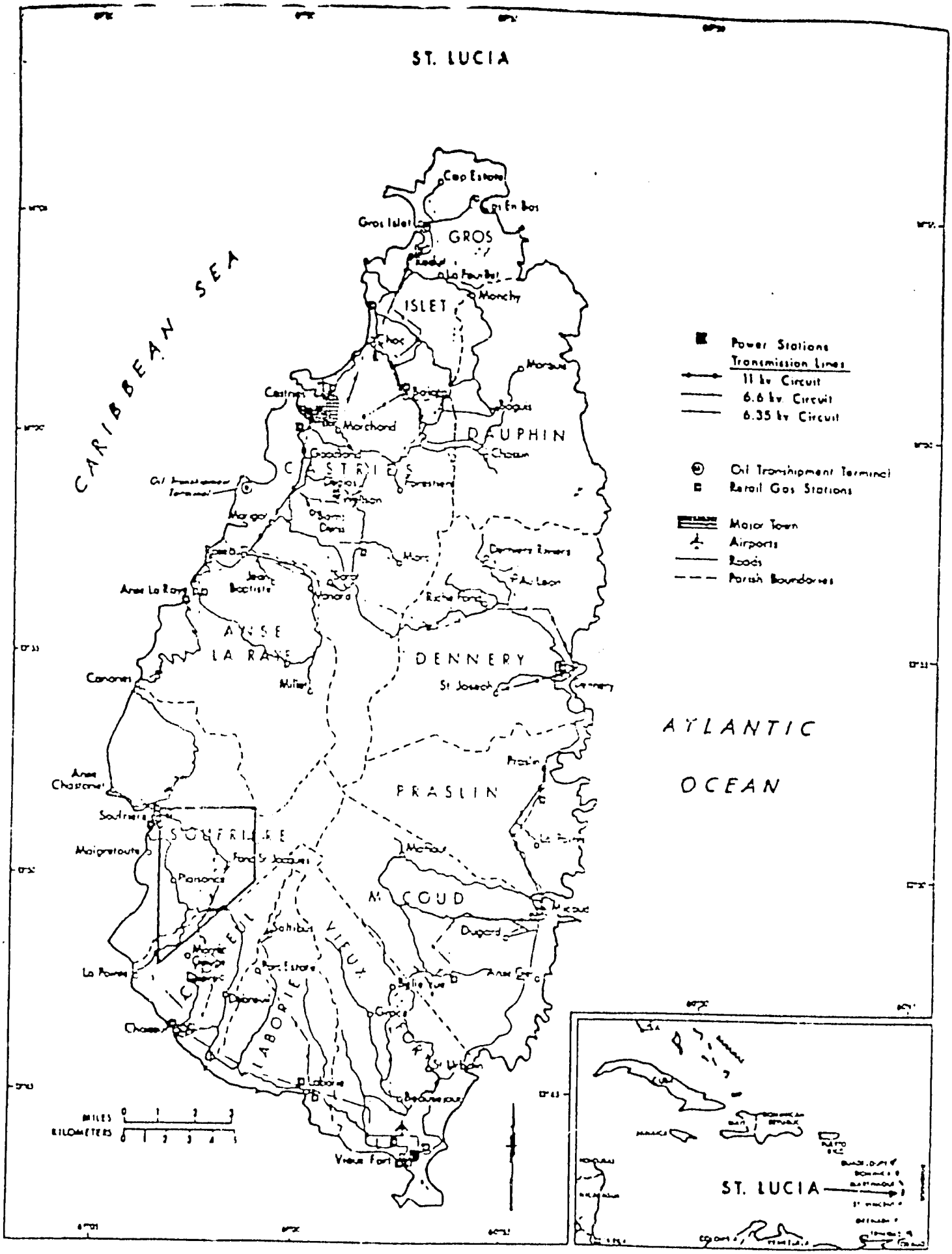

FIGURE 1 ST. LUCIA AND THE GENERAL PROJECT AREA

relationship to the proposed activity; as well as "irreparable harm", defined as significant undesirable effects occuring once the project is implemented, which are not reversed or reversible.

Specific issues scoped by the Project Team include land impacts, air impacts, noise impacts, liquid effluents, water use, and thermal pollution. Additional items to be addressed in the EA include: a provisional plan to monitor the environmental effects of any geothermal fluids recovered from the test wells, mitigation measures, and contingency plans.

2.3 Data Sources

The findings of this report are based on a 10-day visit to St. Lucia (July 16 to 25, 1985), which included field reconnaissance of three proposed exploratory drilling areas, and, due to the limited time frame, a review of only the most readily available information. Principal site specific data sources reviewed are provided below:

- LANL (1984). Evaluation of the St. Lucia Geothermal Resource. I. Summary Report (LALP-84-26). II. Engineering Investigation and Cost Estimate. (LA-10209-MS). III. Macroeconomic Models. (LA-10212-MS). IV. Geologic, Geophysical, and Hydrogeochemical Investigations. (LA-10234-MS). Los Alamos, NM.

- GeothermEX, Inc. (1984). Technical Review of the Los Alamos National Laboratory's Report: Evaluation of the St. Lucia Geothermal Resource. Richmond, CA.

- Geothermal Energy New Zealand Ltd. (1980). Field Work Proposal for Determining the Existence of an Economic Geothermal Resource in the Island of Saint Lucia, West Indies. Auckland, New Zealand.

- Commonwealth Development Corporation (1978). Appraisal of Proposed Geothermal Project. Barbados, W.I.

- Williamson, K. H. (1976). Steam Production Tests on Geothermal Wells at Sulphur Springs, St. Lucia. Institute of Geological Sciences, London.

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- Mertz and McLellan (1976). Geothermal Prospect at Soufrière: Results of Exploratory Holes 1 - 5; Results of Exploratory Holes 6 and 7, Appendices. Amberley, New Castle Upon Tyne.

- Devaux, R. J. (1984). Investigation of the Belfond Historic Site, Soufriere, St. Lucia. St. Lucia Archaeological and Historical Society, Castries, St. Lucia.

- Interviews with knowledgeable U.S. AID Staff, St. Lucian Government Officials, Naturalist Society Officials, Archaeological and Historical Society Officials, local hoteliers and others in the vicinity of the project site.

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III. ALTERNATIVES

Provided below are a discussion of the Proposed Action including alternative drilling sites and a No Action Alternative.

3.1 Proposed Action

As noted in the Introduction, the Proposed Action consists of exploratory drilling in the Qualibou Caldera of St. Lucia in an effort to evaluate othermal energy resources for purposes of electric generation. Three exploratory drilling locations have been selected and are described below.

3.2 Alternative Drilling Sites

On the basis of the recent LANL study, including a deep penetration dipole-dipole DC resistivity transverse across the caldera, a review of previous work and updated geologic and geochemical interpretations, three attractive target drilling areas were identified. Figure 2 provides the three drilling areas. They are described below in the order of drilling priority assigned by LANL.

- The Craters of Belfond - where caldera related faulting and recent phreatomagmatic volcanism indicate fracture permeability, and low resistivity suggests that geothermal brines might occur at a depth of less than 1 km.

- The Valley of Sulphur Springs - where the presence of hot springs and fumaroles, the fluid chemical compositions, and the low formation resistivity all indicate a geothermal brine reservoir near a depth of 2 km., with the additional possibility of a hot dry steam field above the brine reservoir.

- Etangs - where very low shallow resistivities (1 ohm-m) suggest a reservoir of geothermal brine at a depth as shallow as 1 km., associated with thermal upwelling along the caldera boundary fault.

3.3 No Action Alternative

The urgency and high priority placed by the Government of St. Lucia on the development of geothermal energy to decrease the country's dependence on imported oil dictates that the No Action Alternative cannot be considered a truly viable alternative. In any case, by not taking action for provision of new energy resources, the Government of St. Lucia will continue to experience energy shortages and balance of payments problems.

Because of the commitment by the Agency, UNRNRE, and the Government of St. Lucia to perform exploratory drilling in the Qualibou caldera, no additional consideration is given to the No Action Alternative in this report.

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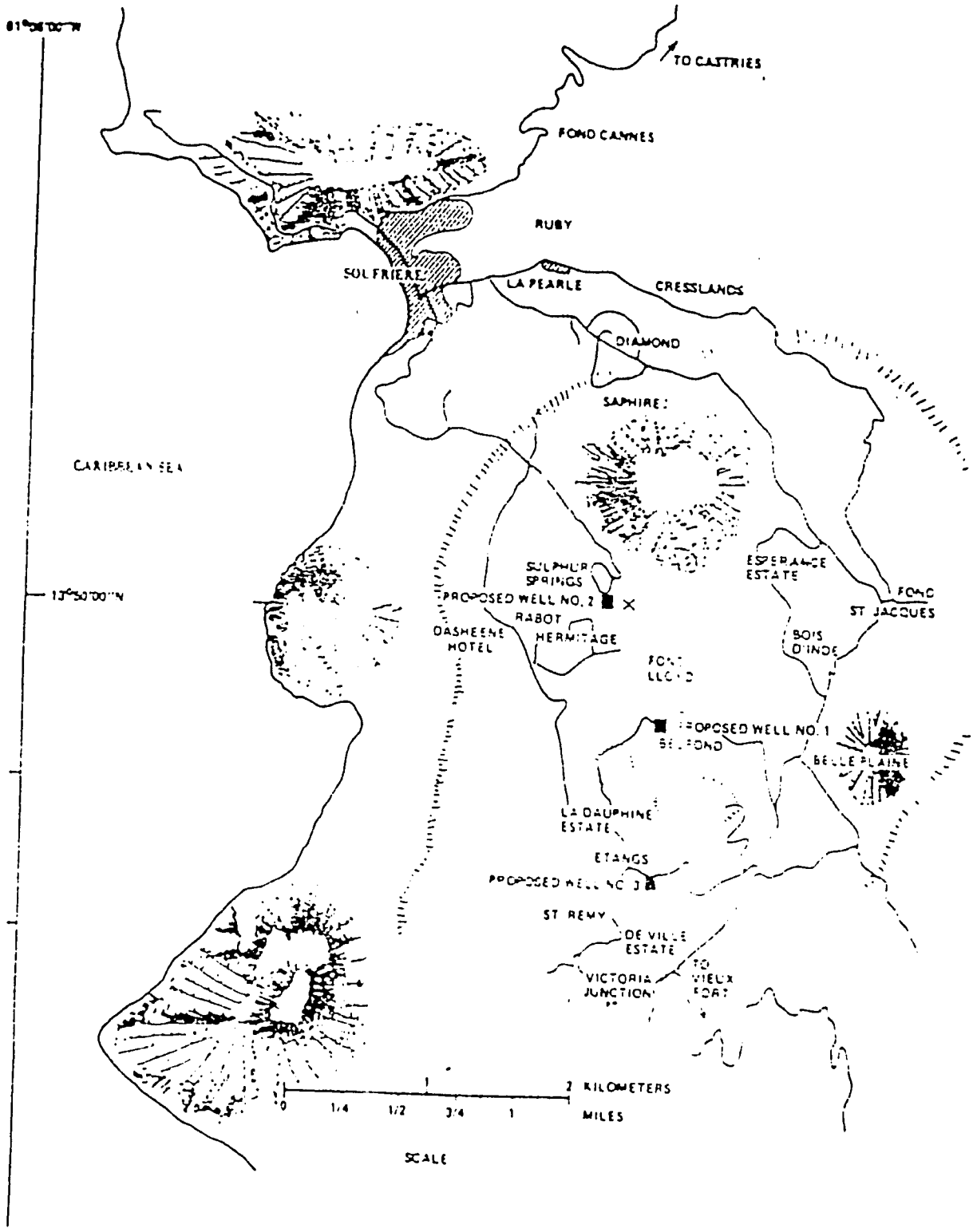

FIGURE 2 - RECOMMENDED SITES FOR EXPLORATORY DRILLING

IV. EXISTING ENVIRONMENT

Provided below is a description of the existing environment in the project area, including land use, cultural resources, biological resources, tourism, air quality, noise, water resources, and waste management. Highlighted are also pertinent characteristics of the Sulphur Springs, Belfond and Etangs exploratory drilling locations.

4.1 Land Use

A provisional land use plan prepared by the Ministry of Finance and Planning provides present and projected land use patterns for St. Lucia. Figure 3 provides land use in the vicinity of the project area.

Housing density throughout this rural region is low. Houses are typically widely scattered, although they tend to be concentrated along highways and valleys. Sulphur Springs and Belfond appear to have lower housing densities than Etangs.

Sulphur Springs and Belfond are characterized by steep, rocky, highly erodible slopes. Bananas, coconuts, other fruit and tubers are grown on relatively small tracts of land, and subsistence farming predominates. A small farmers cooperative has been recently organized in Belfond.

Prime agricultural lands, characterized by deep soils, good rainfall, gentle slopes and capable of sustaining intensive agriculture are primarily located in the vicinity of Etangs. Prime agricultural land is also found in a small strip near Hermitage.

4.2 Cultural Resources

In the immediate Sulphur Springs area there are several possible archaeological remains. These include a cave, a large platform, and terraces on Terre Blanche Dome, facing the thermal springs.

There are remnants of a fort in Hermitage, between Sulphur Springs and Belfond, near a shallow lake. A major battle was fought between French and English forces for control of St. Lucia here and remains and artifacts from the battle are still found. As such, this area is of historical concern.

In Belfond, a large Amerindian site including a midden, caves, terraces, artefacts, and several large boulders has been found recently on high ground facing the Pitons. A ritual function is suspected for the site, and its preservation is of major archaeological concern.

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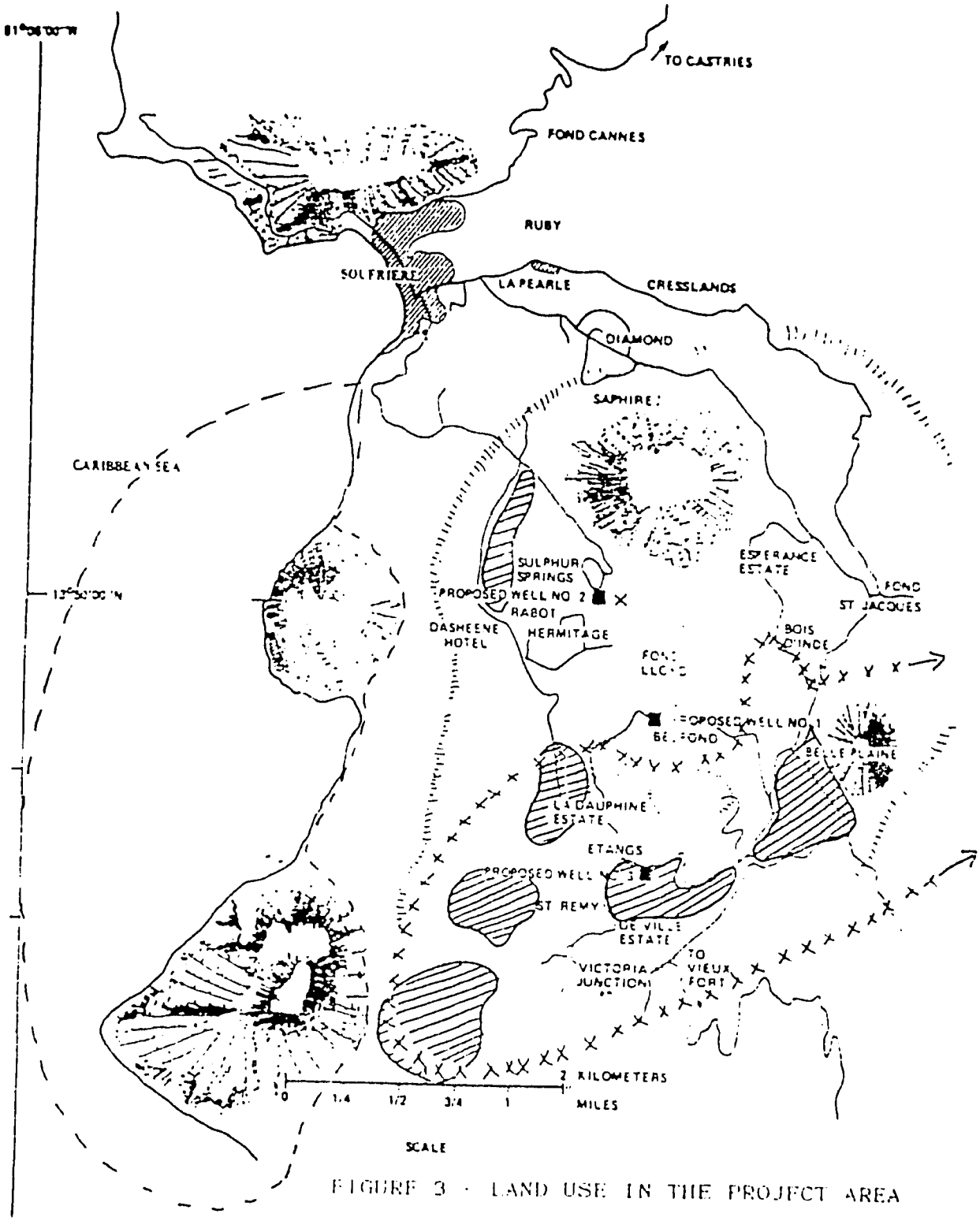

FIGURE 3 - LAND USE IN THE PROJECT AREA

KEY:

= PRIME AGRICULTURAL LAND

XXX XX = WATERSHED PROTECTION AREA

- - - - - ACTIVE CONSERVATION AREA

The archaeological site is located east of proposed drilling locations.

No archaeological or historical resources have been identified in the Etangs area.

4.3 Biological Resources

The most recent U.S. Department of Interior Endangered Species Act Amendments include the St. Lucia Parrot (Amazona versicolor) as endangered (under threat of extinction) on St. Lucia. In addition, the rare Semper's Warbler (Leucopeza semperi) and the endemic St. Lucian (Rufous) Night Jar (Caprimulgus rufus) are found on the Island. These species are not found in the immediate vicinity of the proposed drilling sites.

On Rabot Ridge, bordering the thermal pools in Sulphur Springs, there is a unique climax forest. In addition, much of the project area contains significant forest resources, which serve as critical watershed catchments. A large portion south of Belfond is identified in the provisional land use plan for watershed protection and permanent tree crops.

4.4 Tourism

The immediate area of the Pitons, including the Amphitheater between the peaks, provides an area of outstanding landscape quality and a major draw for tourism. In addition to ocean side recreation and hiking, major attractions in the immediate vicinity of Sulphur Springs, include the thermal springs.

These springs are one of the most impressive areas of acid-sulfate hot springs and fumaroles in the world, characterized by numerous broad pools or cauldrons filled with bubbling and fountaining black water.

There is also a large waterfall located downstream from the springs in Diamond. At present there are no tourist attractions in Belfond or in Etangs.

The nearest tourist hotel to the proposed exploratory drilling sites is the Dasheene Hotel, located approximately one kilometer west of Sulphur Springs on the Amphitheater overlooking the Pitons. Plans are advanced for a major new luxury resort complex to be developed at the base of the Piton Amphitheater.

4.5 Air Quality

The project area is dominated by the Trade Winds, which consistently blow from the east. Rare gusts

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occasionally blow from other directions, although the prevailing air flow is toward the west.

In general, air quality is consistently good throughout the project area. Occasionally a trace of hydrogen sulfide (H_2S) is detectable west of Sulphur Springs.

In the Sulphur Springs proper, air quality is naturally poor. Gas samples collected from the springs by LANL show carbon dioxide (CO_2) to be the dominant non-condensible gas, comprising approximately 91 % of the gas by volume. Significant volumes of hydrogen (H_2) (5.2 %) and H_2S (1.5 %) were also identified. Other gasses detected included nitrogen (N_2), oxygen (O_2), methane (CH_4), and trace quantities of argon (Ar) and carbon monoxide (CO).

Analyses of condensed steam from two fumaroles in the springs show high pH (7.8, 8.2) and high sulfates (SO_4) (109, 121 mg/l) and boron (B) (95 mg/l). Toxic trace elements, including silver (Ag), arsenic (As), copper (Cu), mercury (Hg), lead (Pb), and uranium (U), were not detected.

4.6 Noise

There is little noise throughout the project area. The primary sources of noise are associated with normal road traffic.

4.7 Water Resources

4.7.1 Erosion

Road access throughout the project area varies considerably. The main road from Soufrière through Etangs has been improved and is in very good condition. This main road provides ready access to most of the project area.

Much of the land in the project areas is steep, rocky and highly erodible. Slope stability is a particular problem in the valley of Sulphur Springs, including Terre Blanche Dome and Rabot Ridge, and where most of the valley flanks are broken by numerous landslides. A section of the access road leading from the main Soufrière road to the springs has been lost in a landslide.

Access to Belfond is through a narrow, eroded, formerly paved road along a ridge bordering the craters. The road however is quite passable and provides adequate access to Belfond. Access to Etangs is excellent, since the region is served by the main road from Soufrière.

4.7.2 Water Quality

With the exception of samples collected by LANL in 1983 in the vicinity of Sulphur Springs, little information is available regarding water quality in the project area. Among the samples collected by LANL, three were from thermal springs (Diamond, Cresslands, and Malgretoute) and five were from cold water sources (Diamond Creek, Diamond Waterfalls, Cresslands Spring, Migny River, and Dasheene Spring). All eight samples showed generally good water quality, although some parameters fluctuated significantly.

For example, B was detected in all eight samples, but concentrations ranged from 0.10 to 26.2 mg/l. Chronic boron concentrations greater than 0.75 mg/l can harm sensitive crops, if used for irrigation. No other toxic concentrations were detected in these samples.

No water quality data are available for the Belfond or the Etangs area.

4.7.2 Water Supply

Surface water in the vicinity of Sulphur Springs is primarily collected from a stream leading to the springs, bordering Terre Blanche Dome and Rabot Ridge. This stream was dammed to provide water supply during the previous drilling effort. The low dam is in poor repair and heavily silted.

No information regarding groundwater patterns is available for Sulphur Springs, although the large number of springs in the area suggest a groundwater resource.

In the vicinity of Hermitage there is a small spring and a shallow lake which supplies Rabot and Hermitage, and provides drinking water for Belfond. Supplies, however, are limited. The supply for the Dasheene Hotel also taps into a small spring in this basin. Belfond supplements its water supply through catchments to collect rainwater and surface runoff. Water supplies in Belfond are very limited.

Rainfall from Belfond drains to two craters south and one crater north of the site. Drainage from the north crater leads to the lake in Hermitage. Drainage from one of the southern craters appears to discharge to an unnamed stream near St. Rémy, west of Etangs. The presence of several freshwater springs throughout the project area, suggest that the craters function as groundwater recharge zones. Detailed hydrological information is non-existent, however, historical sources indicate that all of the craters

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in the Belfond area served as lakes in the recent past.

Surface water in the vicinity of Etangs is abundant. In fact, the provisional land use plan for St. Lucia identifies the Etangs watershed as a critical protection zone for water collection and potable supplies. There is a water intake structure on the unnamed tributary west of Etangs, above its confluence with the L'Ivrogne River. Water from this intake leads to the Delcer Filterworks, which opened in 1982 with funding through U.S. AID's Basic Human Needs Program. No groundwater information is presently available for the Etangs area.

4.8 Waste Management

There are presently no significant liquid effluents in the project area, with the exception of those derived from the pools at Sulphur Springs. These thermal effluents (65 - 96 ^{o}C) are characterized by acid conditions (pH 1.6 to 6.2), high SO_4 levels (508 to 6750 mg/l), and, with the exception of B (15 to 26 mg/l), low trace element concentrations.

Solid waste collected from the Soufrière region is presently dumped off Rachette Point, into the bay overlooking the Pitons. A new sanitary landfill, to be located east of Soufrière, is planned.

V. IMPACT ANALYSIS

Provided below is a description of anticipated impacts on the project area from exploratory drilling. The analysis is concentrated on land use, cultural resources, biological resources, tourism, air quality, noise, water resources, and waste management issues. Recommendations for mitigation of impacts are also provided in this section.

5.1 Land Use

Housing will not be significantly affected by the proposed project, since drilling will occur in a very rural area. Few houses, if any, will have to be removed for site access and, depending on selected drilling sites, relocation may not be necessary. Detailed evaluation of specific housing impacts will proceed after specific drilling site are identified.

Sulphur Springs and Belfond are characterized by ownership of small parcels of land. As a result, several parcels may have to be acquired to provide sufficient area for site access and drilling pad development. Land parcels in Etangs are much larger. As a result, should Etangs be selected for drilling, less disruption of land ownership will result.

In terms of agricultural land, selection of Sulphur Springs or Belfond for drilling will have less agricultural impact than selection of Etangs. Since Etangs is located in a region of prime agricultural land, use of this highly productive land will remove it from production.

5.2 Cultural Resources

Site access and drilling in the Sulphur Springs area will not impact identified archaeological remains, since the remains are removed from possible drilling sites.

In addition, no impacts are anticipated on fort remains in Hermitage. However, should this site be selected for drilling, impacts on historical remains could be significant.

The large Amerindian site in Belfond could be seriously affected by drilling in the area. However, this site appears to be restricted to one hill. Thus, specific impacts depend on the site selected for drilling. Effects on this archaeological site can be mitigated by drilling west of the site, or by using directional drilling methods from a remote location.

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5.3 Biological Resources

Wildlife habitats throughout the project area have been substantially altered over the years and there are no known endangered or threatened species in the vicinity of drilling locations. As a result, there is no evidence to indicate that development of site access and drilling will have any deleterious effect on the critical habitat of any species.

There is a unique climax forest on Rabot Ridge, adjacent to the thermal pools in Sulphur Springs. Development of access to Sulphur Springs would not cross this forest, and there is no evidence to indicate that drilling in Sulphur Springs would affect this community.

Much of the project area contains significant forest resources, which serve as a critical watershed catchment. There will be impacts on forested resources from site access and drilling pad development, although these impacts are not anticipated to have major long-term consequences. These impacts can be mitigated by tight erosion control and reforestation. These methods are discussed below under water resources.

Development of the Etangs site would have the least impact on biological resources.

5.4 Tourism

The project area including the Pitons and the Amphitheater, is one of the most unique tourist attractions on St. Lucia. The drilling project will have no impact on these specific attractions.

The primary impact of drilling on tourism would be on Sulphur Springs. A proposed drilling site is located several hundred yards southeast of the thermal springs, where a former exploratory well is leaking. Development of access roads, heavy equipment operation and drilling noise from this drilling site might require closure of the springs to tourism. This could have serious impacts on the local economy.

Drilling in Belfond or in Etangs would not have a significant impact on tourism.

Impacts on tourism will be primarily short term, during the exploratory drilling phase. Primary effects on tourism are anticipated from air and noise pollution. These are addressed below.

In the long-term, the operating geothermal facility could provide a tourist attraction to the region.

5.5 Air Quality

Air quality is presently excellent in the project area. However, this resource could be affected by two emissions sources related to the exploratory drilling effort: (1) construction and (2) well drilling and development. These air emission sources are discussed below.

5.5.1 Construction

Two types of air emissions are anticipated from the geothermal well development: (1) emissions from vehicles and construction equipment; and (2) fugitive dust. Emissions from construction equipment and from vehicles will be insignificant and of a temporary nature.

Fugitive dust emissions could occur from vehicles using the access roads, during site excavation and leveling, and during drilling. Mitigation measures include dust control by controlled water application or paving working areas with gravel. Waste oil application for dust control is not recommended, since waste oil often contains toxic inorganic and organic substances which result in surface and groundwater contamination.

5.5.2 Well Drilling and Development

This section addresses direct releases of steam, non-condensable gases, particulate matter, and other emissions resulting from well drilling and development. Although the proposed geothermal wells will be much deeper than those of the previous drilling effort, the general types of pollutants expected are assumed to be similar in composition to those identified by LANL at Sulphur Springs.

Total suspended particulates (TSP) in the geothermal steam is not anticipated to present environmental problems, since evaluation of similar geothermal projects shows that no significant particulate problems have developed, since up to 98 percent of the total particulates are deposited within 200 meters of a site. Steam condensate is addressed in the Waste Management section below.

Non-condensible gas samples collected from the springs show CO_2 to be the dominant gas, comprising 91 percent of the gas by volume. This high concentration of CO_2 is typical of geothermal systems. Carbon dioxide does not constitute an environmental problem in exhaust gas streams from geothermal facilities, although it does contribute to the global atmospheric CO_2 budget.

Hydrogen sulfide comprises 1.6 percent of the

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non-condensible gas by volume, and is the main air pollutant of concern in the project area. Although H_2S continuously vents from Sulphur Springs, geothermal venting from drilling and development will add a significant new source of air pollution to the region.

Hydrogen sulfide is poisonous to humans in high concentrations. In general, however, H_2S will disperse rapidly in the prevailing wind, and the main problem will be the objectionable smell. Hydrogen sulfide is perceptible in air in concentrations as low as 0.002 parts per million (ppm).

Since H_2S is denser than air it may tend to accumulate in enclosed areas and trenches should there be little or no air movement. This would be of particular concern should drilling occur in a relatively sheltered area, such as the Belfond craters. This accumulation is highly unlikely, however, since highly pressurized steam will be vented to the air, constantly mixing and diluting H_2S.

Hydrogen sulfide is non-toxic to vegetation in concentrations anticipated. In fact, a healthy, unique climax forest grows near the edge of several bubbling pools at Sulphur Springs.

Hydrogen sulfide emission effects will be relatively short-term, primarily during drilling. In the long-term, a H_2S emissions control system will mitigate air quality impacts. Experience indicates that greater than 90 percent of H_2S emmisions can be removed with emissions control systems.

Other non-condensible gasses detected in Sulphur Springs emissions include H_2, N_2, O_2, CH_4, and trace quantities of Ar and CO. None of these gasses will cause environmental problems in the project area.

Radon-222 and mercury (Hg) are potential contaminants found in geothermal systems. Radon is a radioactive contaminant often found in trace amounts. Although concentrations vary widely within and between geothermal regions, no radon measurements have been taken in the Qualibou Caldera system.

Mercury is also found in geothermal systems. Although Hg was not detected in steam condensate samples tested by LANL, the detection limits used were not sufficiently sensitive to detect the presence or non presence of this element. Once radon and Hg levels are determined, environmental impacts can be assessed and mitigation measures developed. In the short-term no serious impacts from emissions are anticipated, since radon and Hg effects

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are cummulative. Long-term effects, however, are possible.

The main air quality impacts from emissions will be to those receptors located west of drilling operations, such as the Dasheene Hotel. This receptor will be especially vulnerable if drilling occurs in Sulphur Springs or in Belfond. The hotel will recieve little impact if drilling occurs at Etangs.

Drilling in Sulphur Springs, will contribute to the gaseous effluent from the springs and increased pollution may be less noticeable than those at other drilling locations. Other air pollution receptors will include houses downwind from the drilling sites. However, these houses will have to be identified and emissions impacts evaluated once specific drilling sites are selected.

Air pollution impacts on tourism can be mitigated by drilling and venting in the off-season (April - December), since impacts will be relatively short-term.

5.6 Noise Impacts

Sources of increased noise in the project area will include construction, well drilling and development. These sources are discussed below.

5.6.1 Construction

During access road improvement and pad development and drilling, noise from diesel engines and other heavy equipment will create localized noise levels of 80 - 90 dBA. Primary impacts of construction related noise will be on receptors in the immediate vicinity of the drilling site. To mitigate impacts, diesel engine and heavy equipment operation can be restricted to daylight hours.

5.6.2 Well Drilling and Development

Short-term impacts resulting from the initial drilling and well testing stages will have some of the most significant negative impacts of the geothermal project.

Noise from the first discharging of the wells will be intense and will create annoyance at distances of several kilometers. For example, during the initial drilling in Sulphur Springs noise complaints were received from as far away as Mailly Motète, three kilometer southwest of the site. Unsilenced geothermal wells may produce noise levels up to 120 decibels in the immediate vicinity of the drilling. These noise levels will be far above present levels in the project area.

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Once cleared from drilling mud and rock cuttings, wells can be discharged through efficient silencers that reduce the noise levels to below 100 dBA near the well, and at a distance, reduce the sound to a low rumbling, which has a soporific rather than a distressing effect. In addition to lowering the overall noise, the silencers remove the high frequencies that are typical of a geothermal well blasting steam and water into the atmosphere at supersonic speed.

Negligible noise impacts are expected on domestic animals and wildlife. In addition, since the project area is not known to support endangered or threatened species, no impacts are anticipated.

Primary short-term noise impacts will be on tourism, specifically on the Dasheene Hotel. If unmitigated, the effects of noise on tourism can have long-term negative consequences.

Several measures are suggested to mitigate noise impacts: (1) require workers near the drill rig to wear ear protectors to prevent damage to hearing; (2) restrict drilling to daylight hours. However, when noise from the geothermal well exceeds heavy equipment noise, 24-hour work shifts should be planned to expedite drilling and to minimize the lenght of time venting noise is generated; (3) time the start of exploratory drilling to coincide with the off-peak tourist season (April - December) to minimize impacts on tourism; (4) maintain all necessary geothermal silencing equipment at the drilling site, and install as soon as desired depth and geothermal conditions are reached.

By reducing the time of first blowing of wells to an absolute minimum and with early installation of efficient mufflers, short-term noise can be reduced. Long-term noise is not likely to be a major problem.

In terms of minimizing tourist impacts, the prefered drilling site would be Etangs. However, in terms of impact on the general population in the project area, the prefered drilling location would probably be at the base of one of the Belfond craters. This location would tend to muffle noise generated by drilling.

5.7 Water Resources

5.7.1 Erosion

The need for site access and drilling pad preparation will require the construction of new roads or upgrading of existing structures, earth moving, site grading,

paving and redirecting surface runoff for drilling pad preparation. These activities can combine to influence the potential for water degradation, flood hazard and increase soil erosion.

Initially access will require some minor modifications to Soufrière harbor and there may be disturbance of sand and sediments. However, these actions will be of short duration and very localized. No significant impacts are anticipated from these actions, since the harbor has been modified substantially in the past. Minor changes to houses and other structures in Soufrière will also be required to permit passage of drilling rigs and equipment. These actions will not have significant environmental consequences.

The transportation of drilling equipment from Soufrière to the project area will require realignments of roads and bridge repair and structural improvements. These actions will be relatively minor and will not have significant environmental impact.

Road or track vehicle access to selected drilling sites off the main Soufrière to Etangs road may result in substantial erosion, depending on the site being considered and the mitigation measures employed. Since most of the project area contains severely erodible soils, fill material when initially cut will be highly erodible when first placed. In addition to soil characteristics, erosion is also governed by rainfall energy, amount of ground cover, plus the length and steepness of surface slopes. Rainfall in the project area is characterized by occasional showers and torrential rainstorms. Annual precipitation is approximately 120 inches year.

Most of the flanks of the valley of Sulphur Springs, including Rabot Ridge and Terre Blanche Dome, are broken by numerous landslides, and it appears that the Sulphur Springs proper are within one of these landslides. There is an access road to the springs. However, a landslide has removed a section of the road and made it impassable. This road will have to be considerably improved, with extensive erosion expected.

The narrow, formerly paved road to Belfont, will have to be improved substantially prior to site access with heavy equipment. Erosion impacts from access road construction may be relatively minor if drilling is carried out on a flat section on a ridge near Belfont. However, should one of the craters be selected for drilling, access roads will have to be built into the crater and extensive erosion may result.

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Historically, the Belfond craters formed lakes. This suggests that location of drilling equipment in a crater could subject it to flood hazards. Flood hazard potential could imcrease should vegetation covering the hillsides be removed during site access development and drilling pad preparation.

Etangs is adjacent to the main road in a relatively level section. As a result, comparatively little erosion is anticipated from access road and drilling pad construction for this location.

Increased heavy truck traffic over existing and upgraded roads will result in increased road degradation. Although this is an unavoidable impact, mitigation might require increased road maintainance in the project area.

General mitigation measures suitable for the project area to control erosion and flood hazards include engineered cut and fill slopes for long-term stability with fill slopes benched, provided with under drains, and compacted. The slopes should be covered with suitable cut vegetative matter or mulch to minimize rainfall impacts, and be revegetated or reforested during or shortly after construction.

5.7.2 Water Quality

Water quality information for the project area is scant or non-existent, and limited to Sulphur Springs and adjacent springs and surface flows. However, water quality throughout the project area appears to be good. Baseline water quality data for drilling sites selected will be developed as part of the monitoring plan discussed below.

The Belfond craters appear to provide a groundwater recharge area, although detailed hydrological evaluations remain to be developed by UNRFNRE.

The Etangs watershed is considered critical to potable water supplies near the coast. Of primary consideration is the U.S. AID financed filterworks near Delcer. To maintain proper water quality and to protect these supplies from potential discharges from construction, drilling, and development, waste management methods have been identified. These are discussed in the waste management section.

5.7.3 Water Supply

Available water supply for construction, drilling operations and development varies considerably throughout the project area. Belfond has the most limited water supply. Sulphur Spring also has limited water resources,

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although the previous drilling effort was able to obtain sufficient drilling water by damming a nearby creek. Etangs has abundant water supplies.

Major impacts are possible with regard to water supply, should drilling and development needs exceed available supplies. This would likely be the situation in Belfond, and could develop in Sulphur Springs. Etangs has the best water supply and should be able to provide sufficient quantities for drilling and geothermal operation.

Mitigation measures for providing water in Belfond or Sulphur Springs include trucking water requirements from available sources, including Etangs.

5.8 Waste Management

Construction, drilling and development of geothermal energy will produce potentially hazardous liquid and solid wastes. These wastes may adversely impact public health and the environment.

Wastes from geothermal energy production are generated from well drilling, construction activities, condensate from spent geothermal steam, by-products from the H_2S abatement systems, sanitary wastes, and accidental spills.

5.8.1 Drilling Wastes

Drilling wastes consist of drilling mud used in developing geothermal wells and borings produced during drilling. Chemicals may be added to the drilling mud to improve drilling performance, and depending on chemical concentrations, drilling wastes can be hazardous.

The total waste volume, including drilling cuttings, drilling mud, water, cement and lost circulation materials can be significant, ranging in excess of 50,000 cubic feet (1400 cubic meters). These drilling wastes are generally discharged into waste sumps or ponds, and tested for toxicity. If the waste is deemed non-toxic, the sump is sealed to provide a permanent disposal site. If the waste is deemed toxic or hazardous, the wastes are removed to an appropriate disposal site or chemically fixed or neutralized in place. Sampling and testing for drilling waste in provided in the Monitoring Plan.

The sump should be a suitably lined disposal pond consisting of compacted clay layers or clay and plastic liners. Experiments indicate that clay structure is altered extensively with highly acid or alkaline wastes. This results in large increases in clay permeability and raises the potential for groundwater contamination

from the wastes. Although acid or alkaline concentrations probably will not be significant in this case, it is recommended that lime be available to neutralize wastes in the sump, if necessary.

5.8.2 Construction Wastes

Construction wastes include cleared vegetation, miscellaneous debris, oil, discharge and residues, unsalvageable wooden shipping crates and skids, cardboard boxes, lumber scraps, concrete wastes, paper and plastic wrappings. These types of wastes are generally considered to be inert and nonhazardous.

Significant quantities of construction wastes might be generated, although some of the waste may be reclaimed or scavenged. The rest of the waste will generally be disposed in an approved landfill. The Soufrière landfill is located off Rachette Point. This disposal location is unacceptable for the construction waste, since it is in a highly scenic location overlooking the Pitons.

A new facility is being planned east of Soufrière which will be an acceptable alternative. Should this facility not be available, waste may be compacted and disposed on site in a suitably prepared location.

5.8.3 Operational Wastes

Operational wastes from the geothermal steam generation process will include initially steam condensate. Chemical characteristics of steam condensate vary widely, and actual characteristics and waste management alternatives will have to be evaluated once initial well information is available.

However, steam condensate samples collected by LANL from Sulphur Springs suggest that steam condensate may contain high levels of SO_4 and B. Other trace toxic contaminants may not be present.

Thermal wastes will be generated as part of the normal drilling and operation of the facility. These wastes can be managed in the short-term by discharging into a pond for cooling purposes. However, in the long-term, the optimal waste disposal scheme may be to reinject steam condensate to the geothermal resource through reinjection wells.

There is concern that reinjection of fluids might increase seismic activity in the project area. Although this is the case with deep well disposal of other liquids, reinjection experiments in producing geothermal areas in Italy and California indicate no increase in seismic

or micro-seismic effects. As such, no significant impact is anticipated in the project area.

Reinjection wells would probably have to be developed at a drilling site to minimize waste handling and attendant risks. Use of previously drilled wells in Sulphur Springs would not be suitable for wastes from Etangs and Belfond. In addition, these wells appear to be in poor structural condition and are very corroded.

After well development, operational wastes will include excess condensate, cooling tower basin water, sludge from the air pollution control equipment, and oily discharge and residues. These wastes are considered to be hazardous or extremely hazardous, depending on the chemical consistency and chemical concentrations. Waste management methods include segregation of wastes, collection and proper disposal of oil wastes, and reinjection of excess condensate and cooling tower water.

5.8.4 Sanitary Wastes

Sanitary wastes consist of those produced in sanitary facilities used by on-site workers. The concentrations of organic wastes are considered non-hazardous, if disposed of properly.

Wastes generated from the site can be piped to an on-site treatment facility or a lagoon, and the treated effluent discharged into a reinjection well. Injection of sewage liquid into the steam reservoir is an acceptable practice and any pathogens will likely be killed by the intense heat and pressure of the steam reservoir. This practice renders the liquid sewage impact insignificant.

5.8.5 Accidental Spills

Accidental spills can occur from various activities including failure of drilling equipment, failure of drill sumps, drill sump and condensate pond overflow, well blowouts or blowdowns, steam pipeline ruptures and valve leaks.

It is difficult to determine specific impacts of any accidental spill; however, based on accidental spills in other locations, general conclusions can be drawn: (1) Under alkaline conditions, the long-term pollution impact would be more significant than short-term impacts; since precipitation of metals would occur resulting in metal accumulation in the environment; (2) Under acid or neutral conditions, the short-term impact would be more significant than the long-term impact, since metals would tend to remain in solution

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and result in acute rather than chronic effects.

Mitigation measures recommended to minimize potential effects of accidental spills include the requirement of blowout prevention equipment to be used on all drilling. This equipment should be designed to control the well if adverse pressure conditions are encountered. Generally, hydraulic rams, which can be operated by remote control, should be installed. Additional blowout prevention equipment includes a valve on the rig floor to close the mud standpipe and a float valve in the drill pipe to prevent reversed flow.

In addition, a low 2 - 3 foot berm around the drilling site is recommended to contain accidental spills.

VI. RECOMMENDATIONS

Remedial measures to mitigate environmental impacts resulting from the Proposed Action were previously discussed. Additional recommendations are provided below to address environmental concerns regarding geothermal development on St. Lucia.

- Initial exploratory drilling at Etangs is recommended. This will minimize potential environmental impacts in the project area. Drilling in Belfond is also possible, since suitable mitigation measures are available to minimize impacts. However, impacts of drilling in Sulphur Springs will be more difficult to mitigate, and might result in potential environmental problems.

- Erosion control should be maintained throughout all phases of the project. In particular, permanent controls, such as stabilization with topsoil, mulch, seeding and planting of non-paved or graveled areas should be undertaken immediately following construction.

- Noise and air impacts on tourism should be mitigated by drilling and developing wells during the off-season (April - December).

- Surface and groundwater hydrology should be evaluated promptly to identify recharge areas, runoff patterns and aquifers of concern. This is critical for the proper siting of waste management facilities.

- Monitoring wells might be necessary for each drilling site, depending on groundwater hydrology. This will permit a direct assessment of groundwater contamination resulting from geothermal development.

- Consideration should be given to developing multiple wells from a single platform, if the geothermal resource is sufficient. This will minimize requirements for additional land.

- Contingency plans to develop alternate sources of water should be developed for potentially affected residents downstream from drilling sites.

PROVISIONAL MONITORING PROGRAM
GEOTHERMAL EXPLORATION DRILLING PROJECT
QUALIBOU CALDERA, ST. LUCIA

SUBMITTED TO

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

PREPARED BY

TIPPETTS-ABBETT-McCARTHY-STRATTON

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I. SUMMARY

A provisional monitoring program to identify significant changes in existing ambient quality and potential public health impacts resulting from the Geothermal Exploration Drilling Project on St. Lucia is described. The program follows a phased approach for data collection, data evaluation and long-term monitoring and focuses on potentially hazardous releases of toxic substances in and around each drilling area. Monitoring requirements for water/liquid effluents, soil/solid drilling wastes, and air are also described.

The monitoring program provides for the training of St. Lucian personnel in environmental and field investigations. This training and assistance will be of use both during the initial exploratory drilling program and during subsequent drilling efforts.

The proposed monitoring program is based on TAMS' knowledge of existing on-site environments. However, it will be updated and fine-tuned when additional site specific information is available.

II. INTRODUCTION

A monitoring program is provided below as an integral part of the Geothermal Exploration Drilling Project on St. Lucia. Its purpose is to identify significant changes in existing ambient quality resulting from the project and to evaluate the effects of these changes. Mitigation measures for potentially hazardous releases of toxic substances in and around the project area will be developed should these changes be significant.

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III. MONITORING PROGRAM

The monitoring program provides a phased approach to evaluate the physical and chemical characteristics of geothermal fluids and gasses in the project area, and to assess potential toxic effects on the human and physical environment. The program will be updated and fine-tuned once specific drilling sites are identified, drilling sequence is developed, and surface and groundwater hydrological information is provided.

One of the goals of the proposed monitoring program is to train St. Lucian personnel in environmental and field investigations. This will be of use should future geothermal drilling and development occur in the Qualibou Caldera.

Specific environmental media of concern to be included in the monitoring program include water/liquid effluents, soil/drilling wastes, and air. The monitoring program has been separated three distinct phases: (1) data collection; (2) data evaluation; and (3) long-term monitoring. A discussion of each of these phases is provided below.

3.1 Data Collection

As discussed previously, environmental monitoring data to be collected includes water/liquid effluents, soil/solid drilling wastes, and air.

3.3.1 Water/Liquid Effluents

3.3.1.1 Baseline Development

As determined during TAMS preliminary site work, water quality data for the project area is either extremely localized and limited to the Sulphur Springs area or nonexistent. Data from the immediate vicinity of Sulphur Springs, including most

of the thermal pools and several thermal outflows, cold springs, and the Migny River is available. Although this information is useful for background comparisons, it is insufficient for geothermal project monitoring and will need to be supplemented.

No water quality data are available for Belfond or Etangs. Thus, if these locations are chosen for drilling, a complete water quality baseline data base will have to be developed.

Permanent water quality stations will be selected to monitor each identified drilling site, and will be used throughout the life of the project. Stations will be sited such that data obtained will yield the greatest amount of useable information regarding surface and ground water outflows. In particular, specific potable water intakes will be identified for monitoring, such as the Delcer Filterworks, located downstream from Etangs.

Although most water quality sampling stations will be located downstream from a drilling site, stations will also be placed upstream from a site for control or ambient purposes. Eight to ten permanent sampling water quality monitoring stations will be established for each drilling site. Water samples will be collected and analyzed prior to drilling and site operations to establish baseline or background conditions for each site.

3.3.1.2 Monitoring Parameters

Table 1 provides recommended water quality monitoring parameters and effluent guidelines for the project. The proposed parameters selected will reflect water quality changes resulting from geothermal drilling and development in the vicinity of the Qualibou Caldera. The parameters selected are based on previous experience and potential water quality

TABLE 1

RECOMMENDED WATER QUALITY MONITORING PARAMETERS AND EFFLUENT GUIDELINES FOR GEOTHERMAL EXPLORATION DRILLING PROJECT, ST. LUCIA

Parameter (a)	Effluent Guideline (b)
Temperature (°C)	(c,d)
pH (units)	6.5-9.0 (d)
Dissolved Oxygen	≥5.0 (d)
Suspended Solids	(e)
Turbidity	(e)
Color	(e)
Conductivity (umhos/cm)	(e)
Alkalinity	≥20.0 (d)
Arsenic	0.05 (f,h)
Barium	1.0 (f)
Baron	0.75 (g)
Cadmium	0.01 (f,h)
Chloride	(e)
Chromium	0.05 (f,h)
Hydrogen Sulfide	20.0 (d)
Lead	0.05 (f,h)
Mercury	0.002 (f,h)
Nitrogen, NO_3	10.0 (f)
Selenium	0.01 (f,h)
Silver	0.05 (f,h)
Sulfate	(e)

Notes:

(a) Parameter units in mg/L, unless otherwise specified.

(b) Not to exceed numerical guideline, unless otherwise specified.

(c) Diluted effluent not to exceed by 3°C the receiving waters. However, if receiving waters are 28°C or less, diluted effluent not to exceed these waters by more than 5°C. (World Bank Environmental Guidelines, 1984).

(d) For protection of freshwater aquatic life (USEPA 1976).

(e) Diluted effluent not to signficantly exceed receiving waters.

(f) For protection of public heath from injection of potable water (U.S. EPA, 1976).

(g) For protection of sensitive crops form long-term irrigation (U.S. EPA, 1976).

(h) Trace element detection limit to be attained under special analytical laboratory service contract.

changes resulting from on-site operations. However, depending on site specific conditions, parameters may be added to or deleted from the table.

3.3.1.3 Data Collection

Water from each sampling station will be collected and analyzed bimonthly during drilling operations. However, should an unusual or a significant drilling event or spill occur on site, additional water samples may be collected and analyzed to identify potential contaminant releases.

Once steam from drilling is generated on site, condensate samples will be analyzed to determined the presence or non-presence of contaminants and their potential public health and environmental impact will be evaluated.

3.3.1.4 Monitoring Equipment and Laboratory Analyses

Table 2 provides proposed water quality monitoring equipment and the water quality monitoring parameters each instrument is designed to measure. It should be noted that the portable Hach DREL/5 Chemical Laboratory can provide duplicate measurements to the Hydrolab system for dissolved oxygen, conductivity, and pH. However, the Hydrolab system will provide much more reliable measurements for these parameters.

In addition to the parameters listed, the Hach DREL/5 Chemical Laboratory can provide a number of additional parameters that may potentially be used to better define water quality in the project area.

Most water samples will be analyzed on St. Lucia using these portable field monitoring instruments. Not only will this provide control of analyses and a rapid sample turn-around time, but it will also permit on-site training of St. Lucian personnel.

TABLE 2
WATER QUALITY SAMPLING EQUIPMENT AND CHEMICAL PARAMETERS (a)

Hydrolab in-situ Water Quality Analyzer

Parameter	Range
Dissolved Oxygen	0-20
Conductivity	0-20,000
pH (units)	0-14
Temperature (°C)	-50-150

Hach Model DREL/5

Parameter	Range	Test	Range
Acidity	0-250	Manganese, High Range	0-10
Alkalinity	0-250	Mercury	0.05
Arsenic	0-0.2	Nitrogen, Ammonia	0-2
Barium	0-250	Nitrogen, Nitrate	0-0.2
Boron	0-15	Nitrogen, Nitrate	0-30
Cadmium	0-0.07	Oxygen, Dissolved	0-20
Bromine	0-4	pH, Wide Range (units)	4-10
Calcium	0-1000	pH, Specific Range (units)	0-14
Carbon Dioxide	0-100	Phosphorus, Reactive	0-2
Chloride	0-125	Phosphorus, Acid Hydrolyzable	0-2
Chlorine, Total	0-2	Phosphorus, Organic and Acid Hydrolyable	0-2
Chromium, Hexavalent	0-0.5	Residue, Nonfilterable (Suspended Solids)	0-1
Color (units)	0-500	Selenium	0060
Conductivity (umhos/cm)	0-20,000	Sodium	0-1000
Copper	0-3	Sulfate	0-150
Fluoride	0-2	Sulfide, Hydrogen	0-5
Hardness	0-250	Turbidity (units)	0-400
Iodine	0-7		
Iron, total	0-2		
Lead	0-0.15		

Notes:
(a) Units in mg/L, unless otherwise noted.

It is also recommended that an analytical laboratory, which routinely analyzes water samples for trace elements, be selected to test approximately ten water and condensate samples per drilling site for toxic elements. This will help to verify results of the field sampling and analysis program. Recommended toxic elements for water quality analysis include arsenic, barium, cadmium, chromium, lead, mercury, selenium and silver.

3.3.1.5 Quality Assurance Objectives

The monitoring program for the geothermal project will meet specific quality assurance objectives. The field work will address the following:

- Precision - a measure of mutual agreement among individual measurements of the same property. This will be achieved in the field by taking duplicate measurements for one sample in ten. Precision will be determined by the identity between measurements for duplicate samples by the same instrument.

- Representativeness - expresses the degree to which data accurately and precisely represent the characteristics of a universe. Representativeness of the sampling scheme will be reflected in the variability among baseline samples taken. An initial low level of variability indicates a representative sampling scheme.

- Comparability - expresses the confidence with which one data set can be compared with another. One can fully expect that monitoring data collected with identical instruments will be fully comparable. In addition, data should be comparable, within instrumental limits of error, between instruments (such as Hach and Hydrolab) for identical stations.

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- Accuracy - the degree of agreement of a measurement with an accepted reference or "true" value. This quality assurance objective will be difficult to achieve for samples analysed in the field with a Hach or Hydrolab instrument, since field values are to be tied to absolute standards such as those developed by the U.S. National Bureau of Standards, or to U.S. Environmental Protection Agency Standards.

Although, field standards for monitoring work are not readily available for all parameters, it has been recommended that a limited number of samples be sent to an approved laboratory for confirmation. Samples analyzed by the approved laboratory for trace contaminants will meet all quality assurance requirements for accuracy, since the participating laboratory selected will participate in regular round-robin quality assurance testing programs.

The field monitoring program described provided all appropriate quality assurance objectives for the drilling [illegible], since our primary intent is to identify major changes in water quality resulting from drilling and geothermal development which might affect public health or the environment. These changes will be easily detected and quantified, should they occur during drilling.

3.1.2 Soil/Solid Drilling Waste

3.1.2.1 Baseline Development

There are apparently no data available regarding soil chemical analyses in the project area. As such, all baseline data will have to be developed.

It is recommended that for each selected drilling site, representative composite soil samples be collected to provide overall background soil trace contaminant concentrations. These composite samples should be a mixture of soil sub-samples

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collected from different locations in the immediate vicinity of a selected drilling site, and collected and homogenized from a depth of 0 to 3 inches below the leaf litter. These soil samples will provide background contaminant levels.

3.1.2.2 Monitoring Parameters

Extraction procedure (EP) toxicity tests are recommended for soil/solid drilling waste samples. The EP toxicity procedure provides a bench scale evaluation of the potential solubility of specific toxic elements in the environment. This test is particularly useful in evaluating potential public health and environmental effects, since it provides an estimate of biological availability of toxic elements in soil. Table 3 provides EP toxicity parameters and recommended guidelines.

3.1.2.3 Data Collection

Solid waste samples from drilling, including cuttings and drilling mud, will be collected to test for toxic elements, and to identify potential environmental compounds of concern entering the storage sump. These samples will also be composited from individual samples.

3.1.2.4 Laboratory Analysis

All testing for EP toxicity in soil and solid drilling wastes should be conducted in the United States, since analytical procedures and equipment, are specialized and will require substantial commitment of resources for development on St. Lucia.

3.1.2.5 Quality Assurance

The laboratory selected for EP toxicity testing of soil and drilling wastes will meet all project quality assurance requirements. In particular, the laboratory will participate

TABLE 3

RECOMMENDED EXTRACTION PROCEDURE (EP) TOXICITY PARAMETERS AND RECOMMENDED GUIDELINES FOR SOIL/SOLID DRILLING WASTES GENERATED BY THE GEOTHERMAL EXPLORATION DRILLING PROJECT, ST. LUCIA.

Parameter	Guideline (in mg/L)
Arsenic	5.0
Barium	100.0
Cadmium	1.0
Chromium	5.0
Lead	5.0
Mercury	0.2
Selenium	1.0
Silver	5.0

in regular inter-laboratory round-robin quality assurance testing programs.

3.1.3 Air

3.1.3.1 Baseline Development

Air quality data was collected in 1981 by Los Alamos National Laboratory (LANL) in Sulphur Springs. On the basis of this data and information on other geothermal systems, it appears that hydrogen sulfide, H_2S, will be the principal non-condensible gas effluent of concern. Baseline H_2S levels will be determined for Sulphur Springs, Etangs and Belfond.

3.1.3.2 Monitoring Parameters

Hydrogen sulfide will be the primary air contaminant monitored. However, other potential air contaminants including mercury will be evaluated.

3.1.3.3 Monitoring Equipment

Hydrogen sulfide concentrations will be recorded in the field with a portable meter, such as a Mine Safety Appliance (MSA) H_2S Model, at permanent sampling stations located different distances from the site. One station will be located upwind and three to six will be located downwind from the drilling site.

The presence or non-presence potential air contaminants will be determined with compound specific detector tubes, such as draeger tubes.

3.1.3.4 Quality Assurance

The H_2S meter will be calibrated in the field with pre-calibrated gas containing 10 ppm H_2S in Nitrogen. This will

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assure the quality of air monitoring data collected in the field.

Portable, compound-specific detector Draeger tubes will be pre-calibrated in the factory and will provide a quantitative but less precise indication of toxic substances, such as mercury in the ambient air.

3.2 Data Evaluation

Data evaluation will be an on-going activity throughout the project. As analytical data are received, data will be compared to baseline levels to note possible changes in ambient concentrations and their significance. These data will also be compared to previously collected data from permanent sampling stations to note potentially significant trends or changes over time. Finally, data will be compared to pertinent available environmental standards and criteria.

If comparisons suggest a significant risk to public health or to the environment, mitigation measures will be implemented to minimize impacts.

3.2.1 Water/Liquid Effluents

Ambient water quality changes will be evaluated by comparing baseline concentrations with those obtained downstream from a drilling site. Each of the water quality parameters has been selected to provide useful information regarding a potential source of pollution. For example, high turbidity and suspended solids levels downstream of the project site after site clearing would indicate erosion.

Trace contaminant concentrations will also be carefully evaluated to see if they pose a public health or environmental problems. The source of contamination will be identified, if

possibile, since there could be more than one source of contamination. For example, arsenic could be an environmental contaminant resulting from geothermal discharge, or it could result from use of arsenic based pesticides in the project area.

3.2.2 Soil/Solid Drilling Waste

Solid drilling waste, cuttings and drilling muds entering the sump will be evaluated to determine their toxicity and the potential for movement of toxic elements into groundwater.

Should this be a possibility, several courses of action are possible, depending on the nature of the threat. For example, if the waste shows marginal EP toxic levels for a certain metal, and pH is very low in the sump, neutralization with lime could mitigate the potential problem. If indicated, wells might be installed to monitor potential groundwater contamination.

3.2.3 Air

Ambient hydrogen sulfide concentrations will be evaluated with regard to air quality criteria and toxic or nuissance effects. Should certain air flow patterns lead to significant complaints or problems, mitigation methods will be identified and implemented.

3.3 Long-term Monitoring

One of the primary objectives of this monitoring program is to train St. Lucian personnel in environmental field methods that are applicable to geothermal systems. This training will be very helpful both during this exploratory drilling program and if additional wells are developed. To accomplish this training it is recommended that St. Lucian personnel actively participate in all stages of the monitoring program, from

initial site planning and baseline data collection, through data collection, evaluation and long-term monitoring.

In order to carry out as much monitoring work as possible in proximity to the project area, it was recommended that field testing instruments be purchased for use during the monitoring program and for training purposes. These instruments would be turned over to St. Lucian personnel to carry out the long-term monitoring program.

Economic Analysis

The economic analysis of the St. Lucia project is primarily a simple engineering/economic replacement analysis. This is a suitable approach because several diesel generators will soon be retired and can be replaced by geothermal units (see Table C.1). The analysis is further simplified by the fact that except for the intergrid connection and the initial powerhouse connection, the transmission, distribution, and administrative institutions are the same as for the diesel-fired option. Thus, while total system cost is the economic measure that would normally be employed, in the present comparative analysis the shared components net out so that attention needs to focus only on the relative costs of power generation alone.

The economic analysis consists of two parts. The first is a least-cost analysis of the two most viable methods of meeting anticipated future energy needs. Then a cost-benefit analysis of the project is undertaken as data on benefits permitted.

A standard methodology has been employed, which utilizes the following format. First, forecasts of future Peak Demands for power are made. Next, a forecast of Firm Capacity (or "Base Load") is made. The latter is done in stages: From Nominal, (or "Nameplate") Capacity, an allowance is subtracted for deterioration of equipment and another deduction is made for planned shutdown and repair time. This yields Available Capacity. Finally, to allow slack in the system for emergencies the capacity of the largest plant is subtracted, yielding the Firm Capacity. Given this information, New Firm Capacity Needed (or additional Base Load needed) is calculated as the difference between Peak Demand and Firm Capacity. An allowance of from 15 to 30 percent is normally added to allow for wasteage and use of its own power by the plant. In the case of geothermal, this latter allowance will of course be smaller than for other types of plants.

The central element of the economic analysis is to ascertain the least-cost means of obtaining the New Firm Capacity Needed. This involves pair-wise comparisons of discounted cost streams for each alternative system. In principle, this can involve comparisions of many combinations of systems. However, technical or other constraints remove many forms of energy production from the reasonable choice set for St. Lucia for the period under consideration. Intensive deforestation, low seasonal flows, high sedimentation and other factors make hydro generation uneconomic at this time. Solar and wind energy have potential for some small-scale uses that should be explored, but at present do not present alternatives for large-scale energy production. Coal may offer long-term potential as a substitute for petroleum. This needs further analysis. However, it was determined that the most relevant comparison for St. Lucia at this time is that between diesel and geothermal generation of the additional base load. The objective is to determine which of these two is the least-cost technique, including, where possible, allowance for exploration risk and negative externalities and spillovers.

The least-cost solution only identifies the most efficient way of obtaining a given benefit stream. It may be, however, that the benefits themselves are not sufficient to produce a reasonable rate of return to the

nation's resources. To the extent that available data permitted, the next step was therefore to test the least-cost solution by a cost/benefit analysis, in order to determine whether the activity represents an appropriate use of national resources. Consideration was also given to potential external benefits and positive spillover effects.

As with any new energy technology, the viability of the overall success of a geothermal power plant depends very much on the administrative and institutional peripherals of private/public utility management. Within the short-term, plans for the support of a private geothermal utility station will address legislative, administrative and institutional arrangements. This support, through technical assistance to the GOSL, will be illustrated in a long-term development plan early in the project implementation phase.

Scenario for the Geothermal Power Station.

The actual scenario for the introduction of geothermal electricity in St. Lucia will depend upon a number of factors, including funding schedules, and will be greatly influenced by actual well drilling costs, the geothermal-fluid conditions, and the well productivities that are encountered. In order to develop a cost system it was necessary to determine a schedule of expenditures for the construction period as well as for the operation period. The capital cost for a productive geothermal power plant was estimated by the World Bank to be approximately $30.6 million in 1983 prices. The operations and maintenance stream for the 20 year life of project are illustrated in Table C.2.

TABLE C.2

GEOTHERMAL PLANT CONSTRUCTION COSTS - 1987

Item	Cost (k$ US)
Generator Building	600
Site Staff & Training	700
Site Preparation	200
Injection Systems	900
Three Wells	6,000
Gas Removal	2,500
Steam/Water Separator	900
Four Generator Sets	12,000
Well Maintenance	100
Generator Maintenance	125
Sub-total	24,025
Contingency (25%)	6,000
TOTAL	30,025

GEOTHERMAL-PLANT OPERATING COSTS

Well Maintenance	=	10% of Initial Cost
Generator Maintenance	=	2% of Initial Cost
Site Staff	=	$200k per year
Well Drilling (as needed)		---
Generator Addition (as needed)		---
Contingency	=	25%

An obvious advantage of a geothermal plant is that the geothermal-power production units operate on a higher capacity factor (ratio of power produced to the maximum power that could be produced) than do diesel fired units. Preliminary calculations have shown the cost of geothermal electricity to be in the neighborhood of $0.17 EC/kWh, whereas electricity generated by diesel units is closer to $0.27 EC/kWh ($0.10 US/kWh) (see Figure C.1). This figure illustrates the comparative power costs over the level life cycle cost as calculated by the Los Alamos National Laboratory, and more closely reflects the average annual net expenditures of each alternative.

At present there are two independent electric power grids in St. Lucia. As stated earlier, St. Lucia Electric Services Ltd., LUCELEC, has projected an annual increase in electric-power demand of 4% in the southern grid and 5% in the northern grid. The use of this projection generates the electric-power demand shown in Figure C.2, containing the expected average and peak power demand curves until 2016. The uppermost smooth curve shows the projection of the total installed capacity. The reader will note the minimum power demand curve lies below the average power demand and the peak power demand is above the average power demand.

Firm capacity exceeds average power and is calculated as average power plus the largest single generator on-line which could be removed from operation without loss of average power. This analysis assumes that the useful economic life of a geothermal field is 20 years. This period is not the geothermal reservoir lifetime but rather is sufficient to cover the lifetime of the longest-lived equipment to be installed. This will result in a cost that reflects continuous operation past that time.

The Economic Cost Stream

The useful economic life of geothermal turbines used within this analysis conforms to the recent experience in the California geothermal fields as well as U.S. Navy experience on large steam turbine driven ships.

The economic estimates are based upon assumptions of production of geothermal energy with all borrowed funds, representing the estimated value of time and capital and funding mixes.

It should also be noted that the electricity costs estimated herein include only the minor cost of the integration of the two distribution grids, but not the losses in the existing grid. Thus, the costs given are busbar costs.

In the Los Alamos Economic Study the geothermal electric-power system was assumed to produce a maximum of 30 MWH with the use of twelve 2.5 MW units. This is not to say that the twelve units would be placed to cover the base load, but were used as the minimum size unit which could illustrate a constant upgrading of firm power in small increments. Assuming the initiation of drilling in early 1986, a 120-day drilling period for each well, one of each two wells being capable of producing a net electrical output of 2.5 MW, and a period of 1 year for well testing and for the installation of the generation equipment, the first geothermal electricity can be expected to be on line in early 1987. These assumptions also lead to the expectation of 10 MW of geothermal electricity being available by the end of 1988. After that, a period of 5 years will elapse before another 2.5 MW geothermal unit will be

required. Subsequently, increasingly shorter intervals occur between successive additions of geothermal units, as the slope of the demand growth curve gradually increases.

The cost analysis shown in Figure C.1 assumes that all funds would be borrowed at a 10.5% interest rate and that inflation would remain constant throughout the course of the analysis. The outcome of the LANL analysis indicated that the UN repayment schedule of 5% of the sales price (presently $0.19 US/kWh) would be used for all geothermal electricity produced for the first 15 years of plant operation. An insurance charge of 2% of the investment was also included. Depreciation of equipment was not included in this analysis because at this juncture the entity is largely government owned. However, at the next stage of financial analysis, a course for the private sector analysis, depreciation of equipment must be included.

Diesel-Generated Electricity.

For estimating the cost of electricity generated by diesel engines, the following values were used: cost of a 2.5 MWe unit = $939,000 US (price given by LUCELEC, amounts to $US460/kW); cost of diesel oil = $EC3.39 per imperial gallon; a generation efficiency of 17.24 kWh/imperial gallon; and the same values as above were used for inflation, interest, and insurance.

For the generation of electricity by diesel engines, the recommended retirement of equipment as shown on Table C.3 was examined. The low speed of the diesels indicate that all are used as baseload generators. The 18-20 year useful lives of the equipment indicate replacement from 1984 through 1996, i.e., the immediate future. Common practice in the power industry is to retire equipment after 90,000-100,000 hours of running time.

Comparative Cost Analysis.

Comparative operation and capital costs for the diesel and geothermal options were calculated for the 20-year period, 1985 to 2005. The estimates are presented in Table c.3. The first columns of the table show the engineering requirements for diesel generation. The next two columns present the capital and O&M costs the fourth column, the total costs, for diesel generation. The fifth column contains the capital costs for geothermal power. Construction is assumed to be concentrated in the early years (before 1988). This assumed schedule may be unrealistic. However, because of the time value of money, the effect of this assumption is to bias geothermal cost estimates upward and this fact can be taken into consideration in evaluating the two alternatives. The next two columns of Table c.3 present maintenance and total costs for geothermal generation. The annual differences in cost between the two technologies are shown in the "Net Annual Savings" column. To simplify calculations, the rather minor salvage value for diesel generators was not included in the estimate for 2005.

The last column of the table repeats the same data, but clusters all capital cost differences at the date of commissioning. Cumulative capital costs are shown as a negative saving for geothermal during the first years (-$9.05), offset by the positive geothermal savings from 1989-2005 (again ignoring salvage value).

Table C.3 includes only direct costs. An additional external cost is imposed on St. Lucia in the form of land taken out of production for the new wells. It was assumed that the capitalized value of crop production on this land is reflected in the land price. Each well will remove 5 acres from production, for a total recution of 15 acres. With a land price of $3000 per acre, the cumulative loss to the economy is thus estimated at $45,000 to $50,000. This negligible amount was not included in the economic cost calculations.

Environmental damage also imposes an external cost on the economy. However, as noted in the environmental assessment, this cost is rather small and was not included in cost calculations for geothermal production.

The costs of a dry well are more significant. Mission time and resources did not permit a full and sophisticated analysis of the problem. Instead, a sensitivity analysis, explained below, was used as a proxy measure of the added costs imposed by hitting dry wells.

The cost streams for each alternative as shown in Table C.3 were discounted at 12 percent to determine their present values. As shown there, the results indicate that the discounted value of the diesel cost option is $37 million, and that for the geothermal $31 million, a total discounted net cost savings of $6 million.

The Equalizing Discount Rate (EDR) was calculated and the the present values of the cost streams were tested for sensitivity to the discount rate used. EDR is the discount rate which would make the present value of the Net Investment Cost Stream (or Net Annual Savings) equal zero. At this rate, cost were the decision criterion, one would be indifferent between the two options. As shown in Table C.3, EDR was estimated to be 34 percent.

The present values of each total cost stream were recalculated several times, using discount rates varying from 2 percent to more than 50 percent. The results are illustrated in the graph labeled Figure C.3. It can be seen that for all discount rates above 34 percent one would be indifferent between the two alternatives but for rates below 34%, geothermal exhibits a cost advantage. Calculations showed that even at rates of 75 percent there was no reversal (or "switchover") in favor of diesel.

Since the opportunity cost of capital in St. Lucia is very likely much lower than 34% (more on the order of 10 to 12 %), the analysis suggests that on a least-cost basis geothermal is the preferred alternative as a replacement source of energy, given the opportunity cost of capital.

Perhaps the greatest risk in geothermal power generation is that of drilling a dry hole. Developing a cost model that would fully reflect all of the complexities of this factor was too ambitious an undertaking for the time available. Instead, a rough sensitivity analysis was conducted. The results are shown in Table C.4. The procedure was to determine the effect on the discounted value of the geothermal cost stream of a hypothetical increase of 20 percent, of 30 percent, or of 67 percent, in initial capital costs, the latter being a proxy measure of the effects of hitting dry holes.

Not surprisingly, Table C.4 shows that the effect is to sharply reduce the Equalizing Discount Rate, but that even a 67 percent capital cost increase (to 15.1 million) leaves the EDR (18.5%) above the probable opportunity cost of capital. In short, the addition of a 67% cost factor to allow for the possibility of hitting dry wells leaves geothermal generation as the lower-cost choice, though obviously the magnitude of the advantage is sharply eroded.

Cost-Benefit Analysis.

The results of the Least-Cost analysis were tested by Benefit-Cost Analysis. The minimum benefit from the generation of electricity is reflected in the tariffs charged to customers. Revenues were used as the proxy measure of minimum benefits. Consideration of possible additional external benefits is noted below. Generation of the minimum benefit stream thus required estimates of future demand (in MWH) and of future tariffs. Sales were projected to increase at a compound rate of about 4.7 percent over this period. Estimates are shown in column one of Table C.5. It is anticipated that the proposed geothermal wells, or their diesel alternative, would supply approximately 36 percent of sales in each of the next 20 years, so these estimates constitute the second column in the table. Future Tariffs were inferred from forecast data on sales revenue and and MWH sales through 1994 provided in the October, 1984 Coopers & Lybrand Tariff Study. Estimates to 2005 were extrapolated from 1994. The Coopers & Lybrand study modelled different rates. Two were used in the estimates for this paper. C&L estimated the long-run marginal cost (MC) of power generation. Marginal Cost tariffs were then calculated. Overall Marginal Cost tariffs inferred from C&L projections are referred to as MC Tariffs in the third column of Table C.5. C&L determined that Marginal Cost Tariffs did not meet financial constraints set by its shareholders (CDC and GOSL) and by International Lending Agencies. C&L thus modelled another set of tariff rates which would satisfy "reasonable return" financial constraints. In particular, this included (a) a rate of return on average net revalued fixed assets of 6% and (b) 25% self-financing of future capital investment. Overall average rates can again be inferred from C&L projected tariff structures. These inferred average tariffs are labelled "FIN Tariff" (Financial Constraint Tariffs) in the fourth column of Table C.5. Revenues under each of these assumed tariffs are shown in the next two columns, followed by diesel costs. Net Benefits for each tariff structure under the diesel option are shown. The last three columns contain geothermal cost estimates, and the Net Benefits of the geothermal option under each of the two assumed tariff structures.

The Net Present Values of each alternative, for each Tariff scheme, were determined using a 12 percent discount rate. At this rate, both the Diesel and the Geothermal options show negative net benefits under the MC tariff structure. This is not surprising, since C&L projected falling Marginal Costs. Because of the well-known relationship between Marginal and Average costs, tariffs based on falling MC would be insufficient to cover Average Costs. This would generate net financial losses and, in the present case, it appears as negative net benefits. However, under the FIN tariff structure, both net benefit streams are positive. The geothermal option produces the largest net benefit and would be indicated as the preferred choice.

Since the choice of a single discount rate always contains a degree of arbitrary judgement, Net Benefits were recalculated over a range of discount rates. Figures C.4 and C.5 illustrate the net benefit streams over the range of discount rates. It can be seen from these that the Internal Rate of Return (the discount rate at which NPV is zero) is around 12 percent for the diesel alternative, and, depending upon the tariff structure, between 15 and 16 percent for the geothermal option. With an opportunity cost of capital of 10 to 12 percent, diesel generation produces negative, or only marginally positive, net benefits, while geothermal yields positive net returns. The geothermal results would be further improved by the addition of external benefits derived from the use of steam for other purposes. Since these external benefits are at present very difficult to quantify, they were not explicitly included in the calculations.

Import Substitution Effects.

As indicated in the LANL analysis, a savings of EC$209 million dollars over 30 years would be realized by substituting for the diesel fired generators. The net effects spread over the useful life of the geothermal power amounts to an average of US$4.69 million per year. Annual peak demand was projected at 20% from 1983 to 1990, ranging from 11.73 MW in 1983 to 15.5 MW in 1990. This amounts to an average annual increase of 3%. When added to the reduced power losses (estimated by IBRD) the annual growth rate will approach 4.7% p.a. The same Bank study indicated a petroleum import bill in 1978 of US$5.4 million and of $13.8 million in 1982. This increase reflects large c.i.f. price inceases as well as consumption patterns.

At this juncture, given that geothermal energy will reduce 36% of the petroleum import bill, annual maintenance savings of geothermal power to diesel will approach $4.69 million per year. This figure, derived from separate sources is consistent with the average annual expenditure over the 30 year useful life (above).

In conclusion, the comparative return on investment of geothermal over diesel represents a savings of over $209 million over the life of the project.

ANNEX

Financial Table for St. Lucia Geothermal Project, Soufriere, St. Lucia

	TOTAL	PROJECT SHARES PART I USAID	PART II UNREPRE	GOSL
	$U.S.	$U.S.	$U.S.	$U.S.
1.000 PERSONNEL & TRAVEL				
1.100 INTERNATIONAL PERSONNEL				
1.100 Consultants	84000			
1.199 Sub-Total	84000			
1.900 COMPONENT TOTAL	84000		84000	
2.000 CONTRACTS				
2.100 INTERNATIONAL CONTRACTS				
2.101 Civil Works (Harbour, Roads, Bridges) for Rig Delivery	170000	170000		
2.102 Relocat. of Util., Pad Preparation, Storage Ponds	40000			40000
2.103 Water Supply and Obtaining Lands	40000			40000
2.104 Project Supervision & Management				
including: Principal Consultant & Back-up	136000			
Drilling Engineering Services	6[illegible]000			
Geological Services	31000			
Drilling Superintendence	120000			
Geophysical Services	16000			
Geochemical Services	30000			
Test/Reservoir Engineering	60000			
Accounting & Purchases	40000			
Secretarial & Office	16000			
Drafting	9000			
Sundries:	105000			
Including: Telephone				
Telex				
Travel				
Reproduction				
2.104 Total	625000		625000	
2.105 Drilling, including:				
Mobilization/Moving	290000	290000		
Conductor Mouse, Rat Holes	12000	12000		
Fuel & Oil	75000	75000		
Contractor Charges (Rig & Crew, Fuel)	1320000	1320000		
Materials (Bits & Reamers, Hole Openers)	201000		201000	
(Expendable Tools)	60000		60000	
(Other Rental Tools, TODCO Gas)	120000		120000	
(Casing & Liners)	470070	470070		
(Muds & Chemicals)	255000		255000	
Cementation & Cement	210000		210000	
2.105 Total	3013070	2167070	846000	
All-inclusive Cost per m:	$669.57			
2.106 Drilling Contingency Fund	572130	402930	169200	
2.107 Wellsite Mud Logging Services	65000		65000	
2.108 Electric Formation/Production Logging	100000		100000	
2.109 Well Completion, Supplies & Services	292500		292500	

ANNEX K

2.110 Production Testing & Reservoir Evaluation	100000		100000	
2.111 Chemical Analysis	15000		15000	
2.112 Environmental Impact Study and Monitoring	75000	75000		
2.900 COMPONENT TOTAL	5107700	2815000	2212700	80000
4.000 EQUIPMENT, PREMISES, FREIGHT & INSURANCE				
4.200 NON-EXPENDABLE EQUIPMENT				
4.210 INTERNATIONAL				
4.211 Vehicle	10000			
4.289 TOTAL NON-EXPENDABLE	10000			
4.900 COMPONENT TOTAL	10000		10000	
5.000 MISCELLANEOUS				
5.101 Vehicle Maintenance & Fuel	4000		4000	
5.201 Reporting Costs	10000		10000	
5.301 Technical Support, H.Q. Administration, Proj. Mgt.	65000	65000		
5.401 Technical Assistance & Training	90000	90000		
5.501 Repairs and Safety Measures to Pre-existing Wells	30000	30000		
5.900 COMPONENT TOTAL	199000	185000	14000	
9.100 GROSS TOTAL EXPENDITURE	5400700	3000000	2320700	
80000				
9.200 CREDIT PROCEEDS OF EQUIPMENT				
9.300 CREDIT RESIDUAL VALUE OF EQUIPMENT	5600		5600	
9.400 PRE-PROJECT EXPENDITURE	65000		65000	
9.900 NET TOTAL EXPENDITURE	5460100	3000000	2380100	80000
	TOTAL	USAID	UNRFRNE	GOSL

NOTES: (1) DRILLING CONTRACT AS PCT OF TOTAL PROJECT COSTS: 55%
(2) RELATIVE PROJECT COSTS FOR VARIOUS DRILLING COSTS:

Drilling Cost per metre	Project Cost	Project Cost
$600.00	2003444	5147036
$650.00	2078444	5372036
$700.00	2153444	5597036
$750.00	2228444	5822036
$800.00	2303444	6047036
$850.00	2378444	6272036
$900.00	2453444	6497036
$950.00	2528444	6722036
$1,000.00	2603444	6947036
$1,050.00	2678444	7172036
$1,100.00	2753444	7397036
$1,150.00	2828444	7622036
$1,200.00	2903444	7847036

NON-EXPENDABLE EQUIPMENT LIST AND DEPRECIATION SCHEDULE

Vehicle
Cost 10000
Depreciation Rate 0.33
Residual Value after 18 months 5595

	DIAMETER	COST/M	LENGTH	TOTAL
Conductor				
	20 inch	$213.00	30	6390
	13 3/8	$103.00	300	30900
	9 5/8	$80.00	900	72000
	7 inch	$49.00	600	29400
Sub-Total:				138690
Perforation:				18000
TOTAL				156690

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The Basic Geothermal Model

Geothermal reservoirs consist of permeable and porous rock in which ground water, percolating down to depths of several miles, is heated directly or indirectly by the underlying magma. The resultant steam or effluent expands and rises to the surface. Regions of extremely high heat flow usually display hot springs, geysers, and fumaroles (steam vents) at the surface. Geothermal energy is also available in "hot rocks" and volcanos directly, rather than in reservoirs of heated water.

The basic features of a geothermal steam field, wet or dry, are a source of natural heat of great output; an adequate water supply; an "aquifer", or permeable reservoir; and a cap rock.

The source of heat is a magmatic intrusion into the earth's crust, having a temperature of 600 to 900°C, often at depths of the order of 7 to 15 km. This view is supported by various facts and reasons, notably that all the known "commercial" fields are in regions where volcanic activity has occurred during recent Miocene-Quaternary times, or is still occurring. Some fields are actually situated on, or close to volcanos whereas others are not directly linked with a center of recent volcanic activity.

In an active volcano, a magmatic intrusion reaches the surface through a large fault system. In compact, hard rock faulting may provide a channel for the upward flow of magma, while plastic rocks such as clay may flow by gravity into the fault space and seal it from above. The energy of a magmatic intrusion may be sufficient to penetrate the fault system in hard rocks but insufficient to prevail against the overburden of the plastic rocks. In such cases the magma may intrude to the boundary between the hard and plastic rocks. This cryptovolcanism may occur in areas devoid of recent volcanic activity, and is more likely to be found in geological areas of thick plastic formations. This is similar to the St. Lucian fields at Soufriere.

Magmatic intrusions without present eruption are common in acidic volcanoes and can also occur in basic volcanoes. Such intrusions provide the heat source for the Japanese and Central Mexican fields located on or around volcanoes.

Early hypotheses about geothermal fluids suggested that they were of "magmatic" or "juvenile" origin, that is, wtaer vapour and gases released from solution in the magma when the pressure is reduced. While this may still be partially true it is now believed that at least 90% of the water in a geothermal reservoir is "meteoric", originating from rain water. It would appear tht most of the water in the aquifer is of meteoric origin and that it is

heated conductively through a largely impermeable base rock, even though some relatively small quantity of magmatic steam may penetrate this base rock through faults and fissures.

As hot fluid is withdrawn from bores or from surface vents, the hydrological balance of the system is restored, or partially restored, by the inflow of new water. There are often clearly visible "recharge areas", where the permeable reservoir terrain outcrops, permitting the ingress of rainwater.

Drilling into the earth, through the "cap rock" the steam is extracted, cleaned and introduced into a steam turbine. These steam turbines have been in use for many years with only one difference. The source of steam. On the old World War II destroyers, steam was produced via oil fired boilers diverted into the steam turbine which was connected to an electrical generator.

The produced electricity was used as the basic motive power (electric motor drive) or as the basic electrical supply for these large ships.

In the geothermal system, the steam is delivered free, and subsequently put to work to produce electricity.

Figure __ illustrates the common approach to a geothermal field development and the required elements to deliver electricity.

A four-phased program is needed to develop the administrative, financial and technical aspects of the Soufriere geothermal field. The major activity of the proposed project will provide and coordinate a financing package for an appropriate exploration program involving three 1,500 meter wells. This phase could be started even after the receipt of the evaluation report by Los Alamos Laboratory which was financed by USAID. Mike, HUH? The work on this report was completed in May 1984 and the results support the earlier findings on the expected high reservoir temperature. The LANL report outlines a development program which may lead to installation of 2.5 MW of well-head generator capacity by 1987. The Mission does not consider that the Government should install non-condensing well-head units to produce power at an earlier date. The well-head units may be appropriate for demonstration purposes, as temporary installation. The cost of drilling three exploratory wells (4,500 m), including mobilization and demobilization of drilling equipment is estimated to be US$5.0 million. A consulting organization needs to be selected to supervise the work of the drilling contractor and implementation of the technical surveys, i.e., production tests, reservoir studies, preliminary design of the power plant and the feasibility study for that plant. The preparatory activities should be completed by mid-1985.

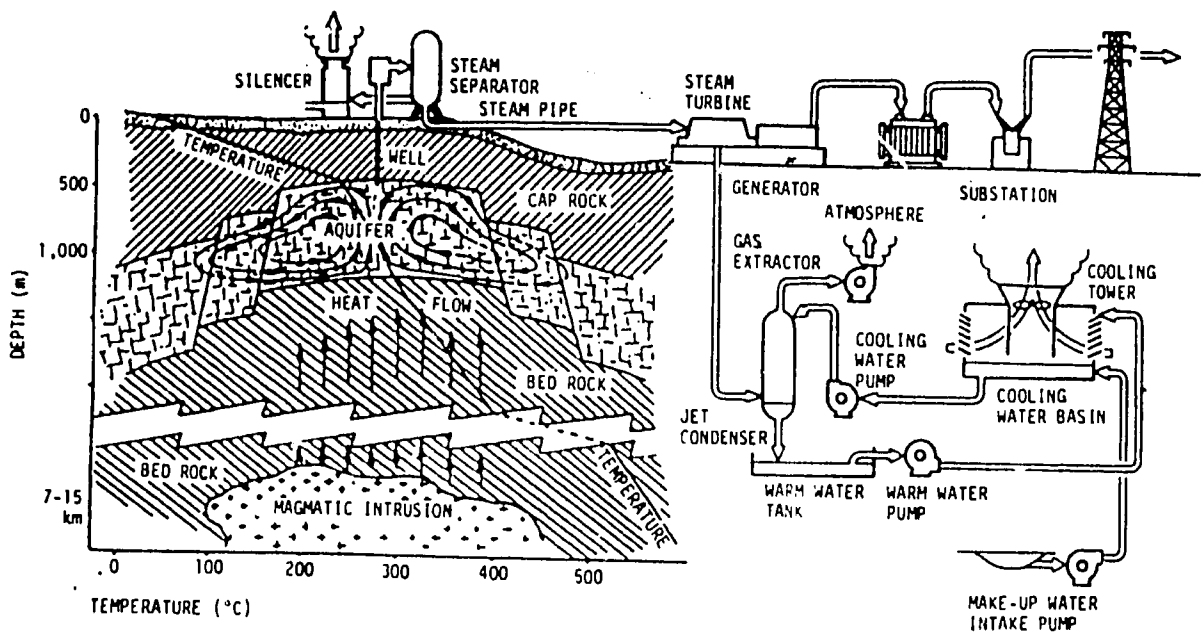

Fig. Basic Model of a Steam Field

ST. LUCIA GEOTHERMAL PROJECT

MEMORANDUM OF UNDERSTANDING

1. Representatives of the Government of St. Lucia (GOSL), the United States Agency for International Development (AID), and the United Nations Revolving Fund for Natural Resources Exploration (FUND) met in New York on March 28 and 29, 1985 to discuss plans for exploring St. Lucia's geothermal energy production potential. This Memorandum of Understanding (MOU) incorporates both the agreements and the concerns that were expressed during the two days of tripartite meetings in March.

2. Project design and management. Subject to the resolution of technical, legal and other issues and acceptance and ratification of all agreements by their governing bodies, GOSL, AID and the FUND have agreed that:

- a. based upon initial studies of the potential for geothermal power generation, AID and the FUND shall join the GOSL to implement a project to drill three (3) exploration wells for the purpose of determining the economic feasibility of geothermal power generation in St. Lucia.

- b. The project, is estimated to cost five and one half million US dollars (DOLS 5,500,000). Subject to the availability of funding, a grant of up to three million (DOLS 3,000,000) US dollars will be provided by AID. Up to two and one half million (DOLS 2,500,000) US dollars will be provided by the FUND.

- c. AID and the FUND shall enter into a joint financing agreement to determine their respective contributions; management of funds; project management and implementation responsibilities; and all other matters necessary to proceed expeditiously with the project.

- d. The FUND and the GOSL will enter into an agreement whereby the GOSL will retain the FUND to manage the project on behalf of the GOSL and will further agree to repay the FUND for participating in this project, if the geothermal field is determined to have commercial potential and that potential is actually realized. Replenishment shall be at the rate of 5 percent per annum of the fair market value of the electrical energy produced for a period of fifteen years, the total not to exceed three times the full amount of the FUND's project expenditure at constant prices.

- e. AID and the GOSL, subject to AID's appropriation and obligation processes, will enter into an agreement whereby the GOSL will use AID funds to carry out the project as administered by the FUND.

/...

- f. Funds provided by AID and expended on behalf of the GOSL by the FUND shall not be subject to repayment by the GOSL to the FUND or AID.

- g. All major decisions concerning this project, including, but not limited to, amendments to the work program for the project, selection of the technical consultants to manage the project and the selection of the drilling contractor will be submitted to the Project Committee (COMMITTEE) composed of one representative of the GOSL, AID and the FUND for its concurrence.

- h. All major decisions regarding the project, including material changes to the work program, that the FUND, its technical consultants or the Drilling Contractor propose will be made only after full consultation with the COMMITTEE.

- i. While the GOSL will retain the FUND to act as Project Manager, both the GOSL and AID will have the right to have one or more representatives on-site at all times. Said representative shall not have authority over project management; however, advice shall be provided by representatives to management.

- j. The FUND shall be responsible for the selection of the technical consultants who shall manage the project on a daily basis and AID shall be responsible for the selection of the Drilling Contractors who shall perform exploration related services, procurement and drill the holes.

- k. A tripartite technical consultancy mission will visit St. Lucia to review all technical data from prior work in order to make recommendations to GOSL, AID and the FUND for a work program for the project.

- l. An overall project recommendation which will define the project, including the work program and budget, will be prepared after the technical consultancy mission submits its recommendations.

- m. The recommendations and the agreements mentioned above in 2 (c) (d) and (e) will not become effective until they are acceptable to three parties and where appropriate, specific agreements approved by the GOSL, AID and the FUND in accordance with their respective procedures. Details to be worked out at 8 July meeting.

- n. Funds will not be allocated to the project by either AID or the FUND unless allocation of funds is concurrently approved by both parties.

/...

- o. The GOSL reaffirms its total commitment to seek the maximum possible participation of the private sector during the initial drilling phase and in any subsequent commercial exploitation of its geothermal resources.

- p. The parties agreed in principal that the value of the energy produced for FUND replenishment purposes will not be less than the average or weighted price at which electrical energy is sold to the consumer.

3. The GOSL, AID and the FUND further agree to the following timetable: (it is understood that the authorization and obligation by AID of any funds are subject to all AID obligation and allotment processes).

- a. Mid-April submission of MOU concerning the March 28-April 3, 1985 meeting by all three parties for joint approval.

- b. April 30 - Tripartite technical consultancy mission will visit St. Lucia to make recommendations for a project work plan. AID will be jointly responsible with the FUND for preparing a report summarizing their recommendations and will submit that report to the other parties by May 15.

- c. June 14 - Representatives of GOSL, AID and the FUND will meet in New York to discuss the technical recommendations and agree upon final project recommendations, including a work program and budget.

- d. June 28 - The project recommendation as approved by the GOSL, AID and the FUND will be submitted to the FUND's advisory body (JOG).

- e. July 8 - Meeting in St. Lucia to agree on the final form of all legal documents between GOSL, AID and the FUND.

- f. July 30 - Funding allocation approval for DOLS 2,500,000 by the FUND and DOLS 3,000,000 by AID and the signing of the USAID Project Agreement.

- g. August 30 - Signing of all project agreements and letters of agreement by GOSL, AID and the FUND.

- h. Earliest ratification of all project agreements by GOSL to allow implementation of project by November 1, 1985.

12 June 1985
New York

R/STL/GT.

SAINT LUCIA PERMANENT MISSION
TO THE UNITED NATIONS
41 EAST 42ND STREET
SUITE 315
NEW YORK, N. Y. 10017
(212) 697-9360 - 1

UNRF

'85 JUN 14 P3:17

June 14, 1985

Mr. Shigeaki Tomita
Director
United Nations Revolving Fund
for Natural Resources
Exploration
304 East 45th Street
New York, NY 10017

Dear Sir,

Subject: Project Recommendation
STL/GT/83/001 - Geothermal
Development Project in St. Lucia

Further to my letter dated June 13, 1985, I wish to confirm that the Government of St. Lucia accepts the Project Recommendation STL/GT/83/001 as amended following our discussions on June 13 and agrees to its presentation to the Joint Operations Group (JOG) for approval.

Yours Sincerely,

Ausbert d'Auvergne
Deputy Director of Finance &
Planning

UNITED NATIONS REVOLVING FUND FOR NATURAL RESOURCES EXPLORATION

GEOTHERMAL EXPLORATORY DRILLING IN THE QUALIBOU CALDERA, SOUFRIERE, ST. LUCIA

PROJECT RECOMMENDATION

STL/NR/83/001

Conditional on the availability of funding[1/], approval is sought from the Joint Operations Group (JOG) for this project in St. Lucia in accordance with the attached work plan and expenditure schedule.

1/ This project includes an input of up to US$3,000,000 from a US/AID Grant to the Government of St. Lucia to be administered by the Fund under a Management Services Agreement between the Government of St. Lucia and the Fund.

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UNITED NATIONS REVOLVING FUND FOR NATURAL RESOURCES EXPLORATION

GEOTHERMAL EXPLORATORY DRILLING IN THE QUALIBOU CALDERA, SOUFRIERE, ST. LUCIA (STL/GT/84/001)

I. BACKGROUND

1. St. Lucia, with a population of 124,000 and a land area of 616 sq. kms., is a small island nation in the central part of the Lesser Antilles. The economy is based primarily on two industries: agriculture and tourism.

2. The national electric utility, St. Lucia Electricity Services (LUCELEC), operates two physically separate grids, a 14.805 MW grid serving the northern end of the island and a 4.12 MW system supplying the south. Both systems are entirely diesel-based and jointly supply approximately 16000 customers. An additional 1 MW diesel unit is planned for the Southern Grid in 1985 and a 5-MW bunker oil unit for the Northern Grid in 1987. It is planned to connect the two grids by 1990.

3. The hydropower potential of the island totals only 600 KW and is insignificant. The only viable domestic alternative to imported diesel or bunker oil for electricity generation is the geothermal resource in the Qualibou Caldera near Soufrière in the west-central part of the island.

4. This prospect has been investigated since 1974 and is now ready for deep exploratory drilling. The British Government financed a study by I.G.S. between 1974 and 1977 terminating in the drilling of 7 shallow, large-diameter holes in the Sulphur Springs area, 2 of which produced in sum approximately 1 MW of steam. Subsequently, further pre-feasibility work was carried out by Aquater of Italy in 1982, financed by the European Investment Bank (E.I.B.), and most recently by the Los Alamos National Laboratory (LANL) (1983-84) financed by the U.S. Trade Development Program. The consensus is that the caldera offers excellent prospects for the discovery of producible high-enthalpy fluids at depths between 1 and 2 kms.

5 If the exploratory drilling in the Qualibou Caldera were successful, the St. Lucia Government intends to energetically pursue commercial electrical power production, initially by two 5 MW mobile turbine-generator units, or by a single 10 MW unit, depending on the results of the drilling. Such a development would also make available large quantities of process heat which could find immediate application in the copra plant at Soufrière for coconut oil production, thereby replacing 100,000 gallons of imported bunker fuel per annum. A particularly interesting new possibility in St. Lucia for excess hot geothermal fluids is dry ice production for domestic use and export, while other possible uses include timber processing, concrete block production beer brewing, alcohol production from sugar cane, banana chip processing, and hot water service to hotels. In the event of the discovery of a very large resource it might be possible to eventually consider a plant to convert bauxite from Brazil, Guyana, Jamaica or Suriname to alumina, thus establishing the first heavy industry in the country.

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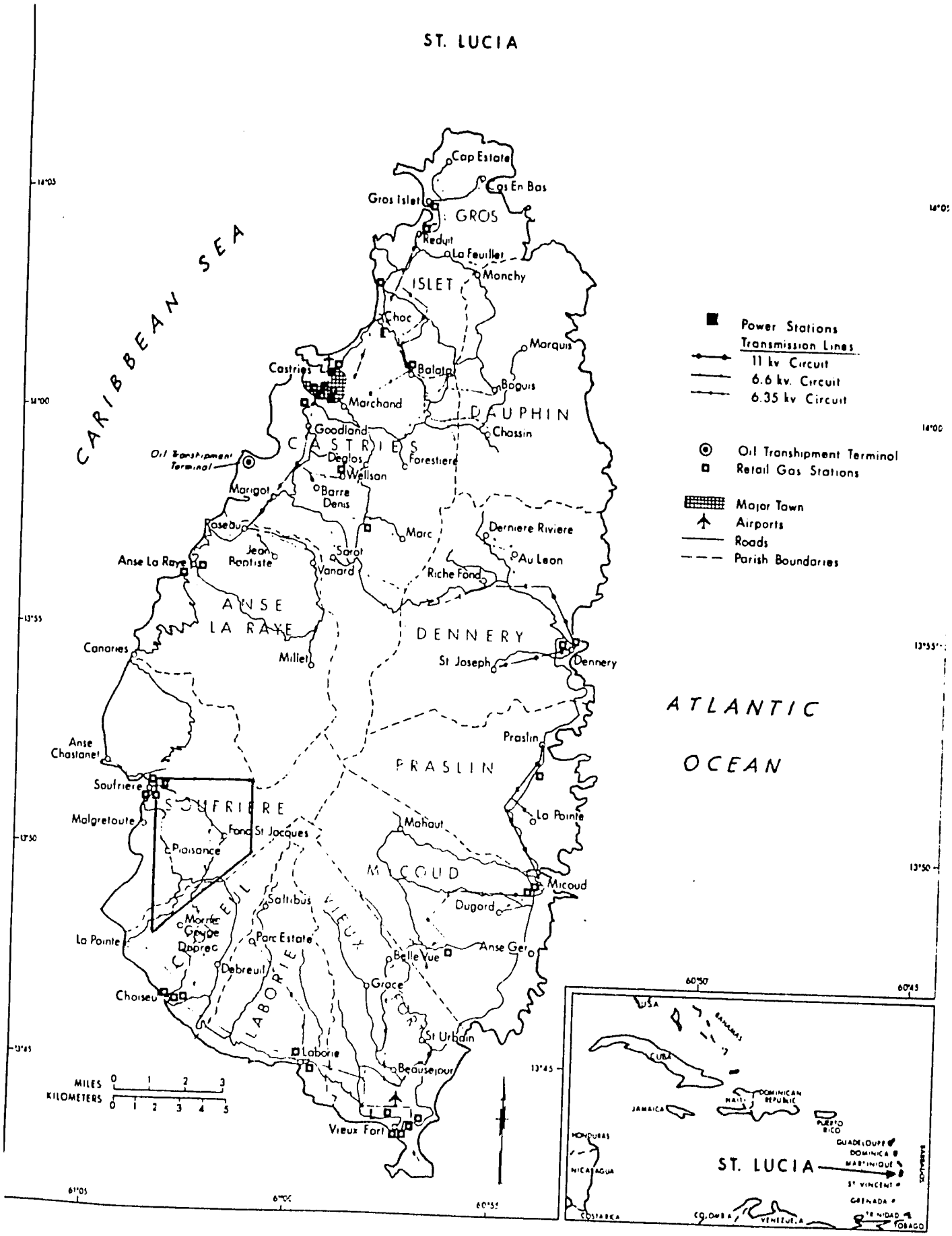

Fig. 1. Map of St. Lucia showing Project Exploration Area and existing power grids.

II. THE PROJECT

6. The objective of the project is the discovery within the Qualibou Caldera near Soufrière, the second largest town in St. Lucia, of a high enthalpy geothermal reservoir suitable for production of electricity for the national grid.

7. The Project Exploration Area comprises approximately 25 sq. kms. as shown in Annex A. The coordinates are given in Annex B.

8. In carrying out the project, consisting of drilling three production-size exploratory wells to an approximate depth of 1500 m each and the testing thereof (Annex C), the Fund will expend not more than $2,500,000, while US/AID will provide up to $3,000,000 to co-finance this project through a Management Services Agreement between the Fund and the Government of St. Lucia. The expected duration of the project is approximately 18 months.

9. It is considered that this three hole programme will be sufficient to discover a geothermal reservoir within the caldera, and if such exists, to carry out well testing, and to produce a preliminary reservoir assessment.

10. Should the project meet with exploration success, and if the St. Lucia Government so requests, the Fund will provide advisory assistance aimed at obtaining investment for developing the geothermal resource.

11. The Government of St. Lucia has agreed to the co-financing of this project between the Fund and USAID as outlined above.

III. TECHNICAL AND ECONOMIC ASSESSMENT

12. The caldera area is excellently located for exploitation, any producing well being less than 2 kms. from the 11 kv transmission lines of the Southern Grid (See Fig.1).

13. If the project were successful it is assumed that the Northern and Southern grids would be immediately connected. The gap between the Northern and Southern grids is approximately 5 kms on both the western and eastern sides of the island. At present this connection is scheduled for completion between 1987 and 1990.

14. The proposed Exploration Area covers the Qualibou Caldera, approximately 6 kms. in diameter, which formed between 32,000 and 39,000 years B.P. and which hosts acid volcanic domes dated between 20,000 and 32,000 years B.P.. A phreatic eruption is known to have occurred within the caldera during historic times (1766).

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(a) The Craters of Belfond, where caldera-related faulting and recent phreatomagmatic volcanism indicate fracture permeability, and low resistivity suggests that geothermal brines might occur at a depth of less than 1 km.

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24. A normal transportable 10 MW condensing plant, including turbine, generator, condensing equipment, pump, demister, radial blower, cooling tower, instrumental control, separator and collecting tank is available for US$3.8 million complete. Adding 20% for construction (using Mexican figures) the total cost could be less than US$5.0 million.

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DRAFT EXPENDITURE SCHEDULE
STL/GT/83/001

PROJECT	m/m	TOTAL US$	PART I UNRFNRE	PART II US/AID	GOSL
1.000 PERSONNEL AND TRAVEL					
1.100 INTERNATIONAL PERSONNEL					
1.190 Consultants	4	84,000			
1.199 Sub-total		84,000			
1.900 COMPONENT TOTAL		84,000	84,000		
2.000 CONTRACTS					
2.100 INTERNATIONAL CONTRACTS					
2.101 Civil Works (Harbour, Roads, Bridges) for Rig Delivery		170,000		170,000	
2.102 Site Access, Pad Preparation, Ponds		40,000			40,000
2.103 Water Supply		40,000			40,000
2.104 Project Supervision & Management including:					
Principal Consultant & Back-up.					
Drilling Engineering Services.					
Geological Services.					
Drilling Superintendence.					
Geophysical Services.					
Geochemical Services.					
Test/Reservoir Engineering.					
Accounting & Purchases.					
Secretarial & Office.					
Drafting.					
Local Accommodation, Board and Office Facilities.					
Sundries Including: Telephone, Telex Travel, Reproduction					
2.104 Total		625,000	625,000		
2.105 Drilling including:					
Mobilization/Moving		290,000		290,000	
Conductor Mouse, Rat Holes		12,000		12,000	
Fuel & Oil		75,000		75,000	
Contractor Charges (Rig & Crew, Fuel)		1,320,000		1,320,000	
Materials (Bits & Reamers, Hole Oreners)		201,000	201,000		
(Expendable Tools)		60,000	60,000		
(Other Rental Tools, TODCO Guages)		120,000	120,000		
(Casing & Liners)		470,070		470,070	
(Muds & Chemicals)		255,000	255,000		
Cementation & Cement		210,000	210,000		
2.105 Total		3,013,070	846,000	2,167,070	

	TOTAL PROJECT			
	TOTAL US$	PART I UNRFNRE	PART II US/AID	GOSL
2.106 Drilling Contingency Fund	602,614	169,200	433,414	
2.107 Wellsite Mud Logging Services	65,000	65,000		
2.108 Electric Formation/Production Logging	100,000	100,000		
2.109 Well Completion, Supplies & Services	292,500	292,500		
2.110 Production Testing & Reservoir Evaluation	100,000	100,000		
2.111 Chemical Analysis	15,000	15,000		
2.112 Environmental Impact Study & Monitoring	90,000		90,000	
2.900 COMPONENT TOTAL	5,153,184	2,212,700	2,860,484	80,000
4.000 EQUIPMENT, PREMISES, FREIGHT & INSURANCE				
4.200 NON-EXPENDABLE EQUIPMENT				
4.210 INTERNATIONAL				
4.211 Vehicle	10,000			
4.289 TOTAL NON-EXPENDABLE	10,000			
4.900 COMPONENT TOTAL	10,000	10,000		
5.000 MISCELLANEOUS				
5.101 Vehicle Maintenance and Fuel	4,000	4,000		
5.201 Reporting Costs	10,000	10,000		
5.301 Tech. Support, H.Q. Admin.,Proj.Mgt.	65,000		65,000	
5.401 Technical Assistance and Training	60,000		60,000	
5.900 COMPONENT TOTAL	139,000	14,000	125,000	
9.100 GROSS TOTAL EXPENDITURE	5,386,184	2,320,700	2,985,484	80,000
9.200 CREDIT PROCEEDS OF EQUIPMENT				
9.300 CREDIT RESIDUAL VALUE OF EQUIPMENT	5,595	5,595		
9.400 PRE-PROJECT EXPENDITURE	65,000	65,000		
9.900 NET TOTAL EXPENDITURE	5,445,590	2,380,106	2,985,484	80,000

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PROJECT ACTIVITILS

	RESPONS.	1985 N	D	1986J	F	M	A	M	J	J	A	S	O	N	D1987J
		1	2	3	4	5	6	7	8	9	10	11	12	13	14 15
1 Preparatory to Drilling SL-1															
1.1 Award Management/Supervisory Contract															
1.2 Award Contract for Civil Works	IUNRFNRE	-													
1.3 Project Committee Organizational Meeting	IUS/AID	-													
1.4 Civil Works for Rig Deliver/	ITripart.	-													
1.5 Repair, Extend Access Road	IUS/AID	--													
1.6 Road Maintenance	IGOSL	----													
1.7 Review of all Pre-feasibility Studies	IGOSL	----------													
1.8 Prepare Hydrology Report	IUNRFNRE	--													
1.9 Selection of Drillsite SL-1	IUNRFNRE	--													
1.10 Design Well SL-1	IUNRFNRE	X													
1.11 Award Drilling Contract	IUNRFNRE	-													
1.12 Arrange Cementation Contract	IUS/AID	--													
1.13 Arrange Mud Engineering Contract	IUNRFNRE	--													
1.14 Arrange Well-site Contract	IUNRFNRE	--													
1.15 Arrange Analytical Contracts	IUNRFNRE	--													
1.16 Delivery of Supplies for SL-1	IUNRFNRE	--													
1.17 Field Supervision by Management Consultants	IUNRFNRE	---													
1.18 Arrange Water Supply, SL-1	IUNRFNRE	----------													
1.19 Prepare Drillpad for SL-1	IGOSL	--													
1.20 Award Cementation Contract	IGOSL	--													
1.21 Award Mud Engineering Contract	IUNRFNRE		-												
1.22 Award Well-site Contract	IUNRFNRE		-												
1.23 Award Analytical Contracts	IUNRFNRE		-												
1.24 Construct Water Storage Pond	IUNRFNRE		-												
1.25 Rig Mobilization & Delivery	IGOSL		--												
1.26 Environmental Monitoring	IUS/AID		---												
1.27 Technical Assistance & Training	IUS/AID	----------													
	IUS/AID	----------													
2 Exploratory Drilling															
2.1 Well-site Contract	IUNRFNRE		----------												
2.2 Well-logging	IUNRFNRE		----------												
2.3 Drill SL-1	IUNRFNRE			0000000000000											
2.4 Three Optional Drill Pads for SL-2	IUNRFNRE				--------										
2.5 Complete Well SL-1	IUNRFNRE					--									
2.6 Environmental Analysis	IUS/AID					--			--				--		
2.7 Project Committee Meeting	ITripart.														
2.8 Selection of Drillsite SL-2	IUNRFNRE					--									
2.9 Well, Flow and Production Tests	IUNRFNRE						----------								
2.10 Drill SL-2	IUNRFNRE						0000000000								
2.11 Three Optional Drill Pads for SL-3	IUNRFNRE							--------							
2.12 Complete Well SL-2	IUNRFNRE								--						
2.13 Project Committee Meeting	ITripart.									--					
2.14 Selection of Drillsite SL-3	IUNRFNRE									--					
2.15 Drill SL-3	IUNRFNRE										0000000000000				
2.16 Complete Well SL-3	IUNRFNRE											--			
2.17 Well Completion Report	IUNRFNRE													X	
2.18 Reservoir Study	IUNRFNRE														--------
2.19 Final Report	IUNRFNRE														X

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SLCWPN2

WORK PLAN AND SCHEDULE FOR STL/GT/83/001

	RESPONS.	PRE-PROJECT M-8	A-7	M-6	J-5	J-4	A-3	S-2	O-1	PROJECT N-1	D/J/F/M/A/J-2	F-3	M-4	A-5	M-6	7
0 TRIPARTITE ORGANIZATION																
0.1 First Organizational Meeting, N.Y.	Tripart.	##														
0.2 Second Technical Meeting, S.L.	Tripart.		###													
0.3 Third Project Recommendation Approval Meeting, N.Y.	Tripart.				#											
0.4 Legal Issues Meeting (US/AID & UNFRNRE)	AID/FUND				#											
0.5 JOG Meeting	UNRFNRE				-											
0.6 Fourth Project Agreements Meeting	Tripart.															
0.7 Submission to Administrator UNDP for Approval	UNRFNRE						-									
0.8 Funding Approval US/AID	US/AID						x									
0.9 Project Signature Meetings	Tripart.															
0.10 Project Ratification	GOSL															
0.11 PROJECT BECOMES OPERATIONAL										x						
A-C PRE-PROJECT ORGANIZATION																
A REVOLVING FUND HEADQUARTERS																
A.1 Arrange Management Contract	UNRFNRE															
A.2 Arrange DOE Geophysical Interpretation	UNRFNRE															
A.3 Requisition Vehicle	UNRFNRE															
A.4 Liaison with GOSL, US/AID, & UNDP	UNRFNRE															
Management Contractors Headquarters	UNRFNRE															
A.5 Preparation of Drilling and Supply Specifications	UNRFNRE															
B US/AID BARBADOS																
B.1 Environmental Impact Study	US/AID															
B.2 Pre-selection of Drilling Contractors	US/AID															
B.3 Arrange Consultant/Contractor for Civil Works	US/AID															
C GOVERNMENT OF ST. LUCIA																
C.1 Land Title Search	GOSL															
C.2 Acquisition of Rights of Way	GOSL															

EXPLANATORY NOTES

1. Under overall supervision by the UNRFNRE a consultant project management group with the requisite range of specializations and experience (geology, geophysics, geochemistry, drilling superintendence and reservoir engineering) will ensure that all possible technical and scientific data are collected during the project, whilst at the same time maintaining an efficient and economic drilling operation.

2 The consulting group awarded the management contract will produce a synthesis of all the pre-feasibility data in the Qualibou Caldera, including hydrology, to assist in selection of the exact drilling location of the first hole (SL-1) in the area south and south-east of the Sulphur Springs and the manner in which this hole is drilled. This work should preferably be completed three weeks before the drill pad for SL-1 is scheduled to be prepared.

3. Local contractors are capable of preparing roads, drilling pads and water ponds, which work will be funded by the Government of St. Lucia. Provision of water for the drilling will also be the responsibility and at the cost of the Government.

4. Drilling will be contracted, and the rig will be shipped to St. Lucia for the contract. US/AID will ~~take~~ fund ~~of~~ the civil works (harbour, roads, bridges) required for ensuring delivery of the rig to the drill site.

5. It is proposed to use a rig capable of handling depths of 2500 m. It is anticipated that a 1500 m hole will require approximately 60 - 90 days to drill.

6. The rainy season, from June to September, is not expected to affect the progress of the drilling.

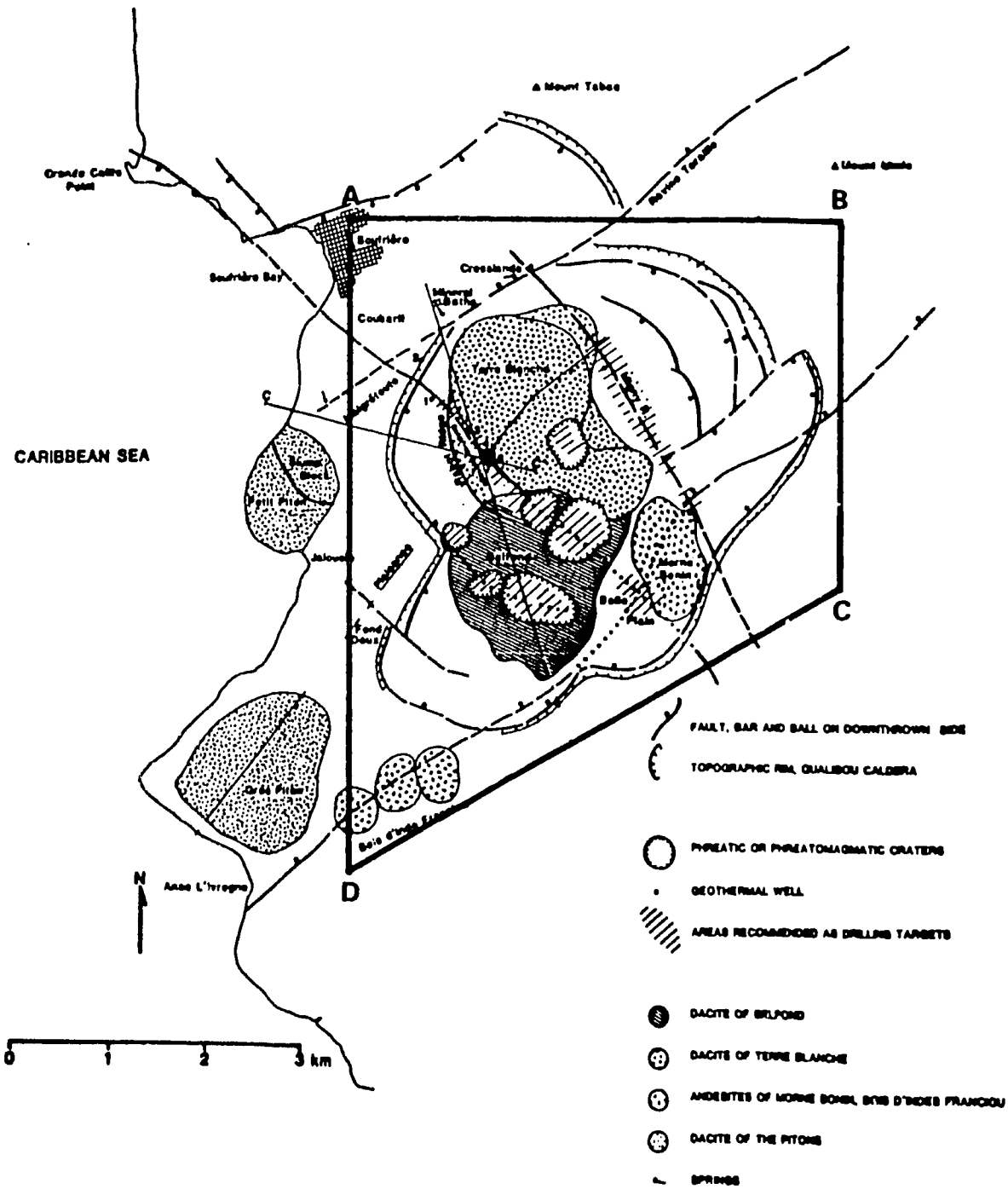
7. The environmental impact study and monitoring, required under US/AID regulations, will be administered and financed by US/AID.

8. A contingency of 20 percent has been allowed under Line 2.106 for the drilling activity costs under Line 2.105, apportioned between the Fund and US/AID.

9. A technical assistance and training component, to be financed by US/AID, has been provided for under Line 5.401.

ANNEX A

Map of Exploration Area



ANNEX B

Description of Exploration Area and Excluded Areas

A. Exploration Area

The area is a quadrangle, covering approximately 25 sq. kms. with the following coordinates, proceeding clockwise from the NW corner:

A.	13° 51' 30"N	61° 03' 30"W
B.	13° 51' 30"N	61° 00' 45"W
C.	13° 49' 30"N	61° 00' 45"W
D.	13° 48' 00"N	61° 03' 30"W

B. Excluded Areas

None

UNITED NATIONS REVOLVING FUND FOR NATURAL RESOURCES EXPLORATION

GEOTHERMAL EXPLORATORY DRILLING IN THE QUALIBOU CALDERA, SOUFRIERE, ST. LUCIA

PROJECT RECOMMENDATION

STL/GT/83/001

Conditional on the availability of funding[1/], approval is sought from the Joint Operations Group (JOG) for this project in St. Lucia in accordance with the attached work plan and expenditure schedule.

1/ This project includes an input of up to US$3,000,000 from a US/AID Grant to the Government of St. Lucia to be administered by the Fund under a Management Services Agreement between the Government of St. Lucia and the Fund.

UNITED NATIONS REVOLVING FUND FOR NATURAL RESOURCES EXPLORATION

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I. BACKGROUND

1. St. Lucia, with a population of 124,000 and a land area of 616 sq. kms., is a small island nation in the central part of the Lesser Antilles. The economy is based primarily on two industries: agriculture and tourism.

2. The national electric utility, St. Lucia Electricity Services (LUCELEC), operates two physically separate grids, a 14.805 MW grid serving the northern end of the island and a 4.12 MW system supplying the south. Both systems are entirely diesel-based and jointly supply approximately 16000 customers. An additional 1 MW diesel unit is planned for the Southern Grid in 1985 and a 5-MW bunker oil unit for the Northern Grid in 1987. It is planned to connect the two grids by 1990.

3. The hydropower potential of the island totals only 600 KW and is insignificant. The only viable domestic alternative to imported diesel or bunker oil for electricity generation is the geothermal resource in the Qualibou Caldera near Soufrière in the west-central part of the island.

4. This prospect has been investigated since 1974 and is now ready for deep exploratory drilling. The British Government financed a study by I.G.S. between 1974 and 1977 terminating in the drilling of 7 shallow, large-diameter holes in the Sulphur Springs area, 2 of which produced in sum approximately 1 MW of steam. Subsequently, further pre-feasibility work was carried out by Aquater of Italy in 1982, financed by the European Investment Bank (E.I.B.), and most recently by the Los Alamos National Laboratory (LANL) (1983-84) financed by the U.S. Trade Development Program. The consensus is that the caldera offers excellent prospects for the discovery of producible high-enthalpy fluids at depths between 1 and 2 kms.

5 If the exploratory drilling in the Qualibou Caldera were successful, the St. Lucia Government intends to energetically pursue commercial electrical power production, initially by two 5 MW mobile turbine-generator units, or by a single 10 MW unit, depending on the results of the drilling. Such a development would also make available large quantities of process heat which could find immediate application in the copra plant at Soufrière for coconut oil production, thereby replacing 100,000 gallons of imported bunker fuel per annum. A particularly interesting new possibility in St. Lucia for excess hot geothermal fluids is dry ice production for domestic use and export, while other possible uses include timber processing, concrete block production beer brewing, alcohol production from sugar cane, banana chip processing, and hot water service to hotels. In the event of the discovery of a very large resource it might be possible to eventually consider a plant to convert bauxite from Brazil, Guyana, Jamaica or Suriname to alumina, thus establishing the first heavy industry in the country.

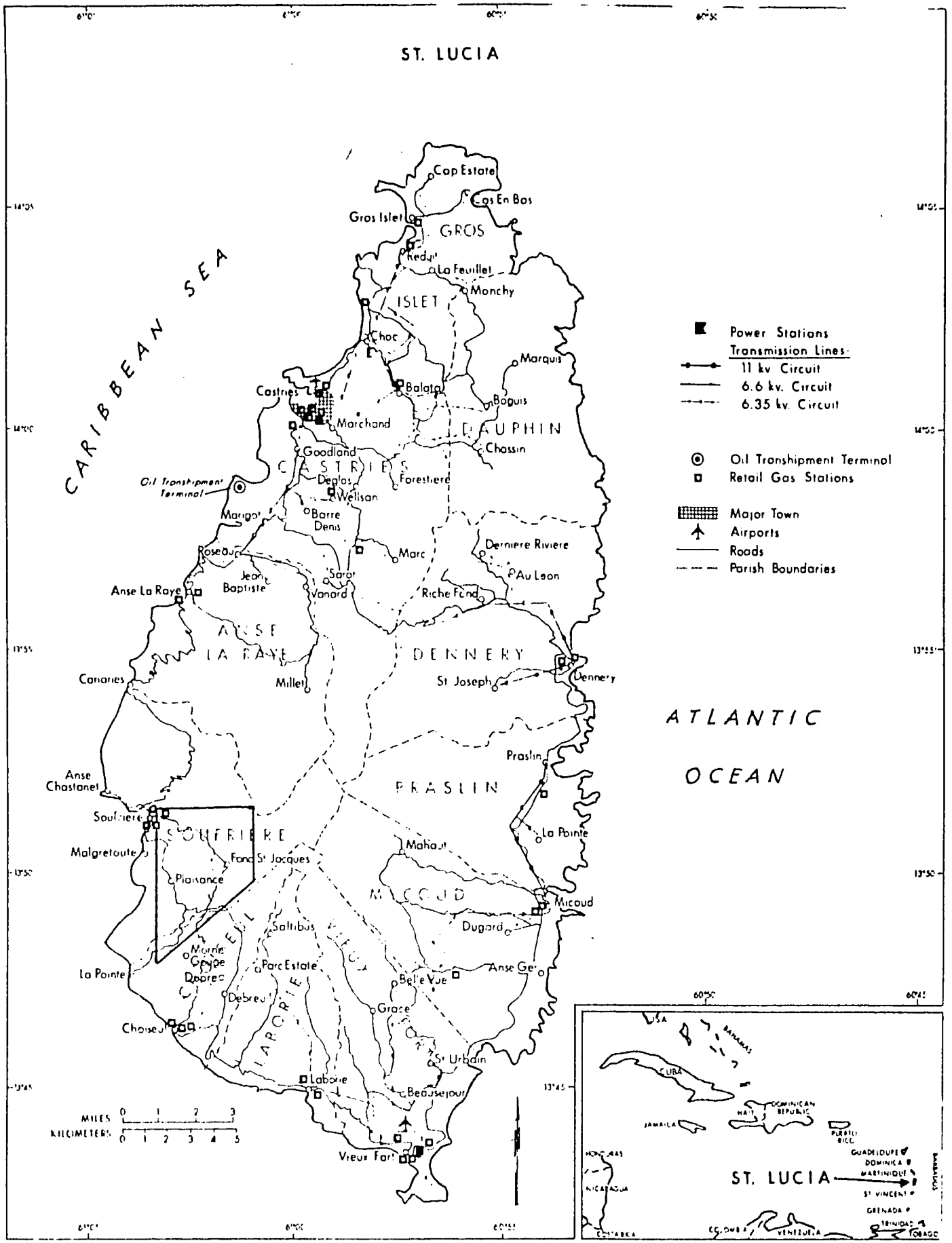

Fig. 1. Map of St. Lucia showing Project Exploration Area and existing power grids.

II. THE PROJECT

6. The objective of the project is the discovery within the Qualibou Caldera near Soufrière, the second largest town in St. Lucia, of a high enthalpy geothermal reservoir suitable for production of electricity for the national grid.

7. The Project Exploration Area comprises approximately 25 sq. kms. as shown in Annex A. The coordinates are given in Annex B.

8. In carrying out the project, consisting of drilling three production-size exploratory wells to an approximate depth of 1500 m each and the testing thereof (Annex C), the Fund will expend not more than $2,500,000, while US/AID will provide up to $3,000,000 to co-finance this project through a Management Services Agreement between the Fund and the Government of St. Lucia. The expected duration of the project is approximately 18 months.

9. It is considered that this three hole programme will be sufficient to discover a geothermal reservoir within the caldera, and if such exists, to carry out well testing, and to produce a preliminary reservoir assessment.

10. Should the project meet with exploration success, and if the St. Lucia Government so requests, the Fund will provide advisory assistance aimed at obtaining investment for developing the geothermal resource.

11. The Government of St. Lucia has agreed to the co-financing of this project between the Fund and USAID as outlined above.

III. TECHNICAL AND ECONOMIC ASSESSMENT

12. The caldera area is excellently located for exploitation, any producing well being less than 2 kms. from the 11 kv transmission lines of the Southern Grid (See Fig.1).

13. If the project were successful it is assumed that the Northern and Southern grids would be immediately connected. The gap between the Northern and Southern grids is approximately 5 kms on both the western and eastern sides of the island. At present this connection is scheduled for completion between 1987 and 1990.

14. The proposed Exploration Area covers the Qualibou Caldera, approximately 6 kms. in diameter, which formed between 32,000 and 39,000 years B.P. and which hosts acid volcanic domes dated between 20,000 and 32,000 years B.P.. A phreatic eruption is known to have occurred within the caldera during historic times (1766).

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Geophysical Services.					
Geochemical Services.					
Test/Reservoir Engineering.					
Accounting & Purchases.					
Secretarial & Office.					
Drafting.					
Local Accommodation, Board and Office Facilities.					
Sundries Including: Telephone, Telex Travel, Reproduction					
2.104 Total		625,000	625,000		
2.105 Drilling including:					
Mobilization/Moving		290,000		290,000	
Conductor Mouse, Rat Holes		12,000		12,000	
Fuel & Oil		75,000		75,000	
Contractor Charges (Rig & Crew, Fuel)		1,320,000		1,320,000	
Materials (Bits & Reamers, Hole Openers)		201,000	201,000		
(Expendable Tools)		60,000	60,000		
(Other Rental Tools, TODCO Guages)		120,000	120,000		
(Casing & Liners)		470,070		470,070	
(Muds & Chemicals)		255,000	255,000		
Cementation & Cement		210,000	210,000		
2.105 Total		3,013,070	846,000	2,167,070	

	TOTAL PROJECT			
	TOTAL US$	PART I UNRFNRE	PART II US/AID	GOSL
2.106 Drilling Contingency Fund	602,614		602,614	
2.107 Wellsite Mud Logging Services	65,000	65,000		
2.108 Electric Formation/Production Logging	100,000	100,000		
2.109 Well Completion, Supplies & Services	292,500	292,500		
2.110 Production Testing & Reservoir Evaluation	100,000	100,000		
2.111 Chemical Analysis	15,000	15,000		
2.112 Environmental Impact Study	20,000		20,000	
2.900 COMPONENT TOTAL	4,923,184	2,043,500	2,799,684	80,000
4.000 EQUIPMENT, PREMISES, FREIGHT & INSURANCE				
4.200 NON-EXPENDABLE EQUIPMENT				
4.210 INTERNATIONAL				
4.211 Vehicle	10,000			
4.289 TOTAL NON-EXPENDABLE	10,000			
4.900 COMPONENT TOTAL	10,000	10,000		
5.000 MISCELLANEOUS				
5.101 Vehicle Maintenance and Fuel	4,000	4,000		
5.201 Reporting Costs	10,000	10,000		
5.301 Tech. Support, H.Q. Admin.,Proj.Mgt.	65,000		65,000	
5.900 COMPONENT TOTAL	79,000	14,000	65,000	
9.100 GROSS TOTAL EXPENDITURE	5,096,184	2,151,500	2,864,684	80,000
9.200 CREDIT PROCEEDS OF EQUIPMENT	5,595	5,595		
9.300 CREDIT RESIDUAL VALUE OF EQUIPMENT	65,000	65,000		
9.400 PRE-PROJECT EXPENDITURE				
9.900 NET TOTAL EXPENDITURE	5,155,590	2,210,906	2,864,684	80,000

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Date 06-Jun-85

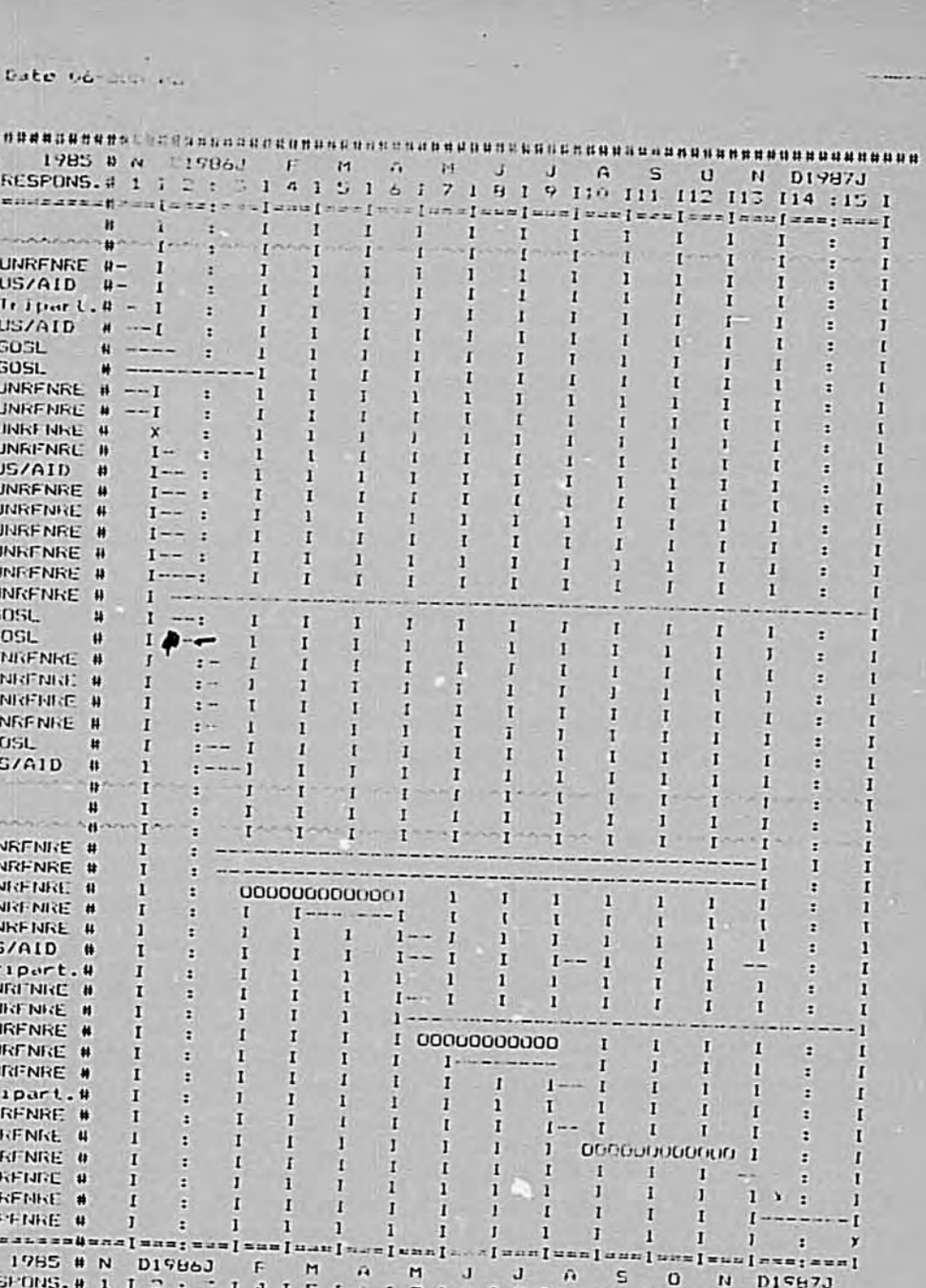
SLCWPN2

WORK PLAN AND SCHEDULE FOR STL/GT/85/001:

		PRE-PROJECT								PROJECT											
	1985	M	A	M	J	J	A	S	O	N	D	1986	J	F	M	A	M
	RESPONS.	-8	-7	-6	-5	-4	-3	-2	-1	#	1	2	:	3	4	5	6	7
B HEADQUARTERS ORGANIZATION																		
0.1 First Organizational Meeting, N.Y.	Tripart.	##																
0.2 Second Technical Meeting, S.L.	Tripart.		###															
0.3 Third Project Recommendation Approval Meeting, N.Y.	Tripart.				#													
0.4 Legal Issues Meeting (US/AID & UNRFNRE)	AID/FUND					#												
0.5 JOG Meeting	UNRFNRE																	
0.6 Fourth Project Agreements Meeting	Tripart.																	
0.7 Submission to Administrator UNDP for Approval	UNRFNRE																	
0.8 Funding Approval US/AID	US/AID																	
0.9 Project Signature Meetings	Tripart.																	
0.10 Project Ratification	GOSL																	
0.11 PROJECT BECOMES OPERATIONAL										X								
A-C PRE-PROJECT ORGANIZATION																		
A REVOLVING FUND HEADQUARTERS																		
A.1 Arrange Management Contract	UNRFNRE																	
A.2 Requisition Vehicle	UNRFNRE																	
A.3 Liaison with GOSL, US/AID, & UNDP	UNRFNRE																	
Management Contractors Headquarters	UNRFNRE																	
A.4 Preparation of Drilling and Supply Specifications	UNRFNRE																	
B US/AID BARBADOS																		
B.1 Environmental Impact Study	US/AID																	
B.2 Pre-selection of Drilling Contractors	US/AID																	
B.3 Arrange Consultant/Contractor for Civil Works	US/AID																	
C GOVERNMENT OF ST. LUCIA																		
C.1 Land Title Search	GOSL																	
C.2 Acquisition of Rights of Way	GOSL																	

Date 06-

	PROJECT ACTIVITIES	RESPONS.
1	Preparatory to Drilling SL-1	
1.1	Award Management/Supervisory Contract	IUNRFNRE
1.2	Award Contract for Civil Works	IUS/AID
1.3	Project Committee Organizational Meeting	ITripart.
1.4	Civil Works for Rig Delivery	IUS/AID
1.5	Repair, Extend Access Road	IGOSL
1.6	Road Maintenance	IGOSL
1.7	Review of all Pre-feasibility Studies	IUNRFNRE
1.8	Prepare Hydrology Report	IUNRFNRE
1.9	Selection of Drillsite SL-1	IUNRFNRE
1.10	Design Well SL-1	IUNRFNRE
1.11	Award Drilling Contract	IUS/AID
1.12	Arrange Cementation Contract	IUNRFNRE
1.13	Arrange Mud Engineering Contract	IUNRFNRE
1.14	Arrange Well-site Contract	IUNRFNRE
1.15	Arrange Analytical Contracts	IUNRFNRE
1.16	Delivery of Supplies for SL-1	IUNRFNRE
1.17	Field Supervision by Management Consultants	IUNRFNRE
1.18	Arrange Water Supply, SL-1	IGOSL
1.19	Construct Drillpad for SL-1	IGOSL
1.20	Award Cementation Contract	IUNRFNRE
1.21	Award Mud Engineering Contract	IUNRFNRE
1.22	Award Well-site Contract	IUNRFNRE
1.23	Award Analytical Contracts	IUNRFNRE
1.24	Construct Water Storage Pond	IGOSL
1.25	Rig Mobilization & Delivery	IUS/AID
2	Exploratory Drilling	
2.1	Well-site Contract	IUNRFNRE
2.2	Well-logging	IUNRFNRE
2.3	Drill SL-1	IUNRFNRE
2.4	Three Optional Drill Pads for SL-2	IUNRFNRE
2.5	Complete Well SL-1	IUNRFNRE
2.6	Environmental Analysis	IUS/AID
2.7	Project Committee Meeting	ITripart.
2.8	Selection of Drillsite SL-2	IUNRFNRE
2.9	Well, Flow and Production Tests	IUNRFNRE
2.10	Drill SL-2	IUNRFNRE
2.11	Three Optional Drill Pads for SL-3	IUNRFNRE
2.12	Complete Well SL-2	IUNRFNRE
2.13	Project Committee Meeting	ITripart.
2.14	Selection of Drillsite SL-3	IUNRFNRE
2.15	Drill SL-3	IUNRFNRE
2.16	Complete Well SL-3	IUNRFNRE
2.17	Well Completion Report	IUNRFNRE
2.18	Reservoir Study	IUNRFNRE
2.19	Final Report	IUNRFNRE



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EXPLANATORY NOTES

1. Under overall supervision by the UNRFNRE a consultant project management group with the requisite range of specializations and experience (geology, geophysics, geochemistry, drilling superintendence and reservoir engineering) will ensure that all possible technical and scientific data are collected during the project, whilst at the same time maintaining an efficient and economic drilling operation.

2 The consulting group awarded the management contract will produce a synthesis of all the pre-feasibility data in the Qualibou Caldera, including hydrology, to assist in selection of the exact drilling location of the first hole (SL-1) in the Belfond target area and the manner in which this hole is drilled. This work should preferably be completed three weeks before the drill pad for SL-1 is scheduled to be prepared.

3. Local contractors are capable of preparing roads, drilling pads and water ponds, which work will be funded by the Government of St. Lucia. Provision of water for the drilling will also be the responsibility and at the cost of the Government.

4. Drilling will be contracted, and the rig will be shipped to St. Lucia for the contract. US/AID will take fund of the civil works (harbour, roads, bridges) required for ensuring delivery of the rig to the drill site.

5. It is proposed to use a rig capable of handling depths of 2500 m. It is anticipated that a 1500 m hole will require approximately 60 - 90 days to drill.

6. The rainy season, from June to September, is not expected to affect the progress of the drilling.

7. The environmental impact study, required under US/AID regulations, will be administered and financed by US/AID as a pre-project activity.

8. As US/AID funds will specifically pay for the drilling contractor charges under Line 2.105, a contingency of 20 percent has been allowed under Line 2.106. This figure, however, is based on the total figure for Line 2.105, not US/AID's contribution.

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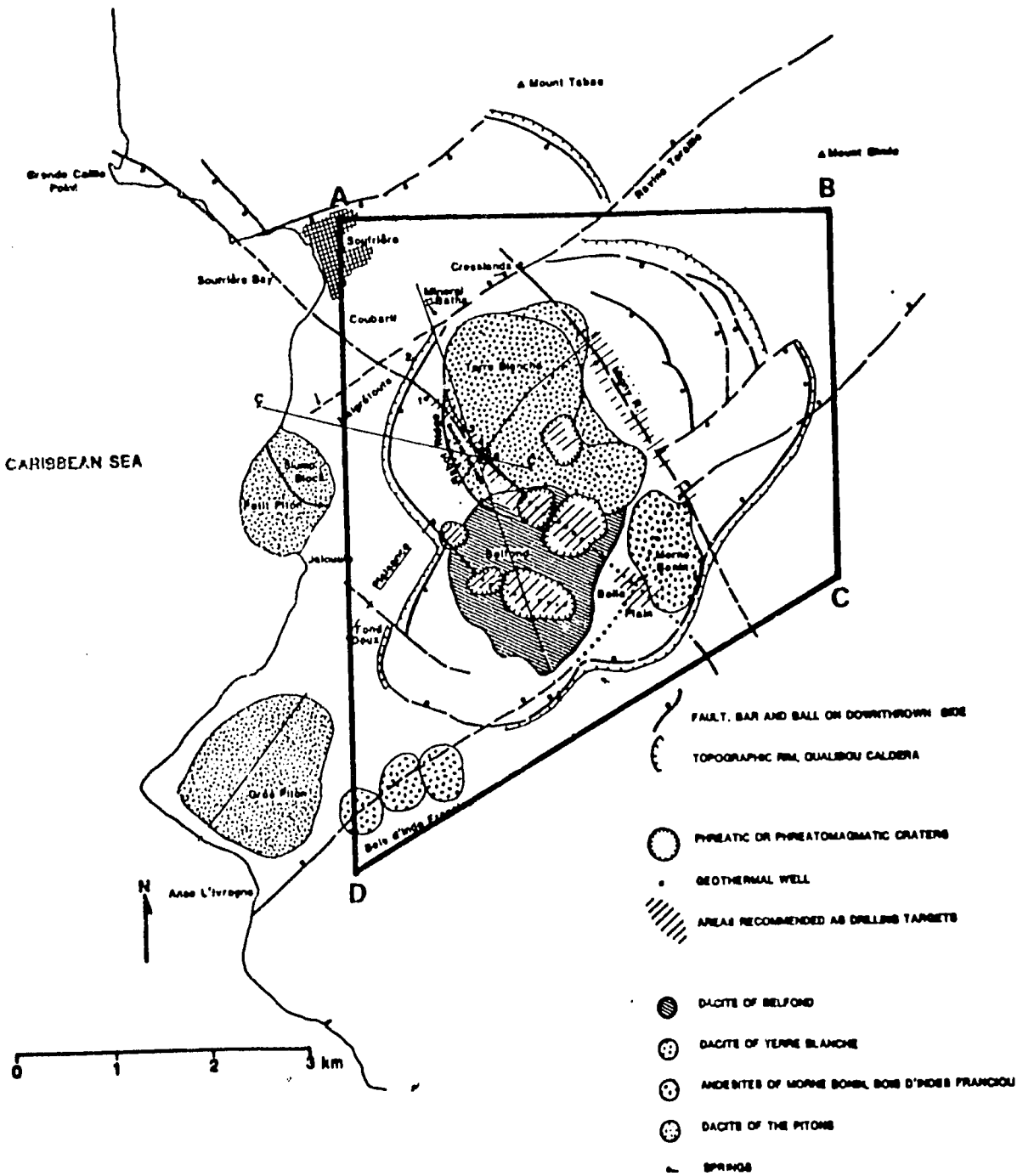
ANNEX A

Map of Exploration Area



ANNEX B

Description of Exploration Area and Excluded Areas

A. Exploration Area

The area is a quadrangle, covering approximately 25 sq. kms. with the following coordinates, proceeding clockwise from the NW corner:

A.	13° 51' 30"N	61° 03' 30"W
B.	13° 51' 30"N	61° 00' 45"W
C.	13° 49' 30"N	61° 00' 45"W
D.	13° 48' 00"N	61° 03' 30"W

B. Excluded Areas

None

ANNEX C

Work Plan

1. Objective

The objective of the Project is to determine the presence of a high enthalpy geothermal reservoir in the Exploration Area (The Qualibou Caldera).

2. Part I of the Project

Part I of the Project will consist of:

(a) Overall supervision and co-ordination of all project activities for Parts I and II of the Project.

(b) Pre-drilling geo-scientific and engineering review of all available data and a hydrological study, to assist in the precise siting of the initial well. Continual review of data for siting of subsequent wells.

(c) Provision of technical consultancy group who will be responsible for the implementation and execution of the following activities:
   (i) geological, geophysical and geochemical inputs;
   (ii) drilling engineering and superintendence;
   (iii) reservoir engineering and testing.

(d) Provision of the following sub-contracts:
   Cementation
   Mud engineering
   Mud logging
   Chemical analyses
   Formation and production logging
   Wireline logging and testing
   Well completion

(e) Provision of various supplies, including bits, reamers, hole openers, expendable tools, rental tools, Todco gauges, and vehicle.

3. Part II of the Project

(a) Project management services for Parts I and II of the Project to be carried out by the Fund and to include technical backup, general administration, legal and accounting services;

(b) Environmental assessment and monitoring;

(c) Preparation of road and other access requirements;

(d) Preparation of drilling pads and water supply (responsibility of GOSL);

(e) Provision of all drilling services required to effectively carry out a three-hole programme with an approximate aggregate total depth of 4,500 m;

(f) Provision of drilling supplies consisting of hole casings, liners and other related equipment and supplies necessary to compl[illegible] drilling programme and not pre[illegible]

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