JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF ENERGY AND ENERGY INDUSTRIES,
THE REPUBLIC OF TRINIDAD AND TOBAGO

THE STUDY
ON
POLLUTION PREVENTION AND CONTROL
WITHIN THE PETROLEUM SECTOR
IN
THE REPUBLIC OF TRINIDAD AND TOBAGO

JANUARY 1995

TECHNO CONSULTANTS, INC.
COSMO OIL CO., LTD.

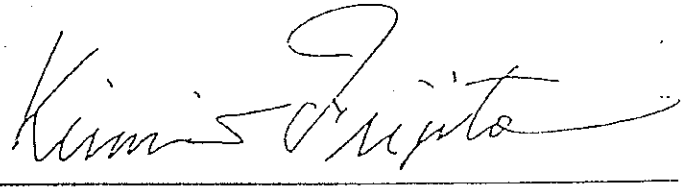
Preface

In response to a request from the Government of the Republic of Trinidad and Tobago, the Government of Japan decided to conduct a study on Pollution Prevention and Control within the Petroleum Sector in the Republic of Trinidad and Tobago and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Trinidad and Tobago a study team headed by Mr. Koji Tanaka, Techno Consultants, Inc. four times between September 1993 and December 1994.
The team held discussions with the officials concerned of the Government of the Republic of Trinidad and Tobago, and conducted field surveys in the study area. After the study team returned to Japan, further studies were conducted and the present report was prepared.

I hope that this report will contribute to the Pollution Prevention and Control within the Petroleum Sector in Trinidad and Tobago and to the enhancement of friendly relations between our two countries.
I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Trinidad and Tobago for their close cooperation extended to the study team.

January 1995



Kimio Fujita
President
Japan International Cooperation Agency

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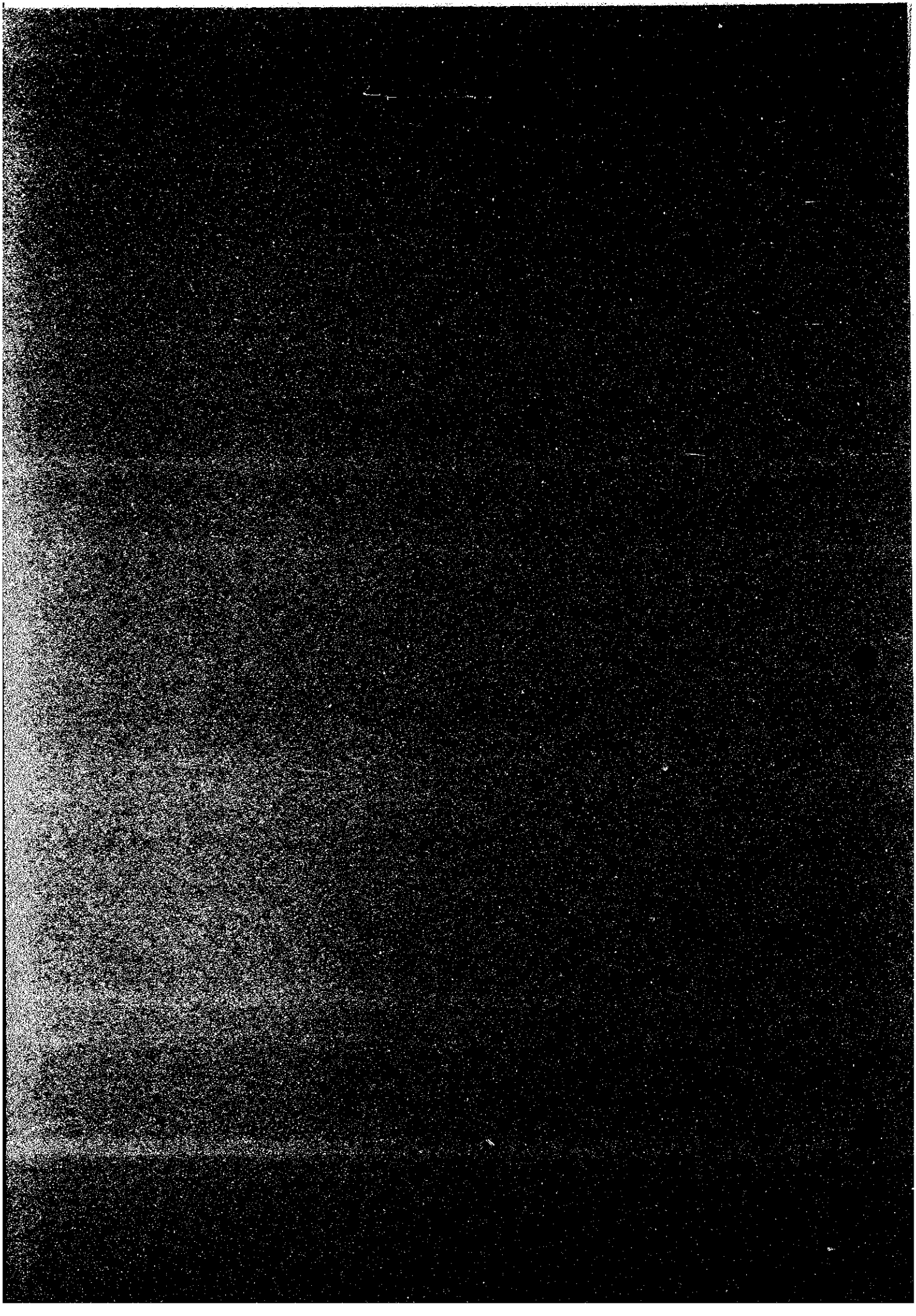
List of Abbreviations

ACA	Activated Carbon Adsorption
API	American Petroleum Institute
ATOC	AMOCO Trinidad Oil Company Limited
BBL	Barrel, a unit of volume equivalent to 159 liters
bbls	Barrels
BCF	Billion cubic feet
Bls	Barrels
BOD	Biological oxygen demand
BOPD	Barrels of oil per day, bpd
bpcd	Barrels per calendar day
BPD	Barrels per day
bpsd	Barrels per stream day
BM	Breakdown maintenance
CARICOM	Caribbean Community
CARIRI	The Caribbean Industrial Research Institute
CNG	Compressed natural gas
CODcr	Chemical oxygen demand by potassium bichomate method
CODmn	Chemical oxygen demand by potassium permanganate method
CPI	Corrugated plates interceptor
CTC	Carbon tetrachloride
DAF	Dissolved air flotation
DCF	Discounted cash flow
DCR	Dispersion by chemical reaction
DCS	Distributed digital control system
DEA	Diethanolamine
DRI	Direct reduction iron
EL	Elevation
EMA	Environmental Management Agency
EOR	Enhanced oil recovery
FRP	Fiber-reinforced plastics
GC	Gas chromatography
GC/MS	Gas chromatography/mass spectrometer
GDP	Gross Domestic Products

GIS	Geographical information system
hr	Hour
IADB	Inter-American Development Bank
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
kcal	Kilocalories
kl	Kiloliters
kWatts	KiloWatts
KWh	KiloWatt-hours
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
MBD	Thousand barrels per day
MMCFD	Million cubic feet per day
MMSCFD	Million standard cubic feet per day
MOEEI	Ministry of Energy and Energy Industries
MTBE	Methyl tertiary butyl ether
MTPY	Metric ton per year
NGC	Natural Gas Company of Trinidad and Tobago Limited
NGL	Natural gas liquids
NOx	Nitrogen oxides
NPMC	National Petroleum Marketing Company
NPV	Net present value
PAC	Poly aluminum chloride
OECD	Organization for Economic Cooperation and Development
PCOL	Premier Consolidated Oilfields Ltd.
PECOL	Same as PCOL
Petrotrin	Petroleum Company of Trinidad and Tobago Limited
pH	Measure of acidity with 7 indicating neutrality
PM	Preventive maintenance
PPGPL	Phoenix Park Gas Processors Limited
PPI	Parallel plates interceptor
ppm	Parts per million
psia	Pounds per square inch absolute, a unit of pressure
psig	Pounds per square inch gauge, a unit of pressure
SCFD	Standard cubic feet per day
SCF	Standard cubic feet

SIM	Selected ion monitoring method
SOx	Sulfur oxides
sq.	Square
SS	Suspended solids
TCL	Trinidad Cement Limited
TDS	Total dissolved solids in ppm
Trintoc	Trinidad and Tobago Oil Company, Limited
Trintopec	Trinidad and Tobago Petroleum Company, Limited
TSS	Total suspended solids in ppm
TT	Trinidad and Tobago
TOC	Total oxygen consumption
VGO	Vacuum gas oil

Chapter 1 Introduction



Chapter 1 Introduction

This is the Final Report for the STUDY ON POLLUTION PREVENTION AND CONTROL WITHIN THE PETROLEUM SECTOR IN THE REPUBLIC OF TRINIDAD AND TOBAGO conducted in accordance with the Scope of Work agreed upon in Port of Spain on February 8, 1993 by the representatives of the Ministry of Energy and Energy Industries of the Republic of Trinidad and Tobago and the Preparatory Study Team of the Japan International Cooperation Agency (JICA). A consortium of TECHNO CONSULTANTS, INC. and COSMO OIL CO., LTD. of Japan has executed this study under contract to JICA.

The study team, of which names and assignments of the members are given at the end of this chapter, commenced the study in September 1993 and completed it in January 1995. During this period the study team conducted three field surveys in the Republic each lasting about a month, from September to October 1993, from February to March 1994 and from July to August 1994, one draft report presentation and a seminar in December 1994.

The Scope of Work defines the objective of the study as quoted below, "The objective of this study is to review the present conditions of petroleum pollution and to formulate a program for minimizing the pollution within the petroleum sector in the Republic of Trinidad and Tobago, thereby contributing to the region's sound industrial development and environmental protection in the following refinery and facilities:

1. Refinery (Pointe-a-Pierre)
2. Onshore petroleum fields
3. Petroleum storage and pipeline."

The onshore petroleum fields, petroleum storage and pipeline are further defined by the Scope of Work and the Minutes of Meeting attached to it. Details of the scope of study are explained in Chapter 3, Scope of the Study. The scope of study consists mainly in developing a program to achieve the target oil content in effluent water streams from the onshore petroleum facilities. The target is defined as 50 ppm on a monthly average or 75 ppm on a daily maximum. It should be noted that the scope of study does not include assessment of impact on the environment of the effluent water.

The study team achieved the above objectives by accomplishing this study. The study

encompasses various aspects of petroleum pollution relating to the above three facilities. The study team encountered many difficulties, of which water produced in association with crude oil presented the most serious challenge. The effort made by the study team to discover its true nature and to develop a recommendable method for treating it led to the most important conclusions and recommendations of this study.

The water is found to be in the form of a very stable oil-in-water emulsion in which very fine oil particles, ranging in diameter from less than one micron to a maximum of ten microns, are thoroughly dispersed in the water phase. This emulsion is very stable by nature and does not separate into water and oil by conventional gravity-induced separators such as API separator, PPI, or CPI. After a series of experiments, the dissolved air flotation with coagulation has been selected for breaking the emulsion and eliminating oil particles from the water.

A hidden problem emerged when the dissolved air flotation with coagulation proved to be suited to the treatment of this water. The water after being rid of oil particles was found in many cases to contain more than 50 ppm of what may be recognized as "oil and grease" by the ASTM standard testing method. The two most extensively adopted processes for similar purposes, biological treatment and activated carbon adsorption, were tested as the most promising candidates for treating this water. On the basis of the results of the experiments, the study team recommends a combination of dissolved air flotation with coagulation and activated carbon adsorption for treating water for the onshore petroleum fields/main storage and dissolved air flotation with coagulation alone for Pointe-a-Pierre Refinery. By this the target level, 50 ppm on monthly average and 75 ppm on a daily maximum, may be achieved.

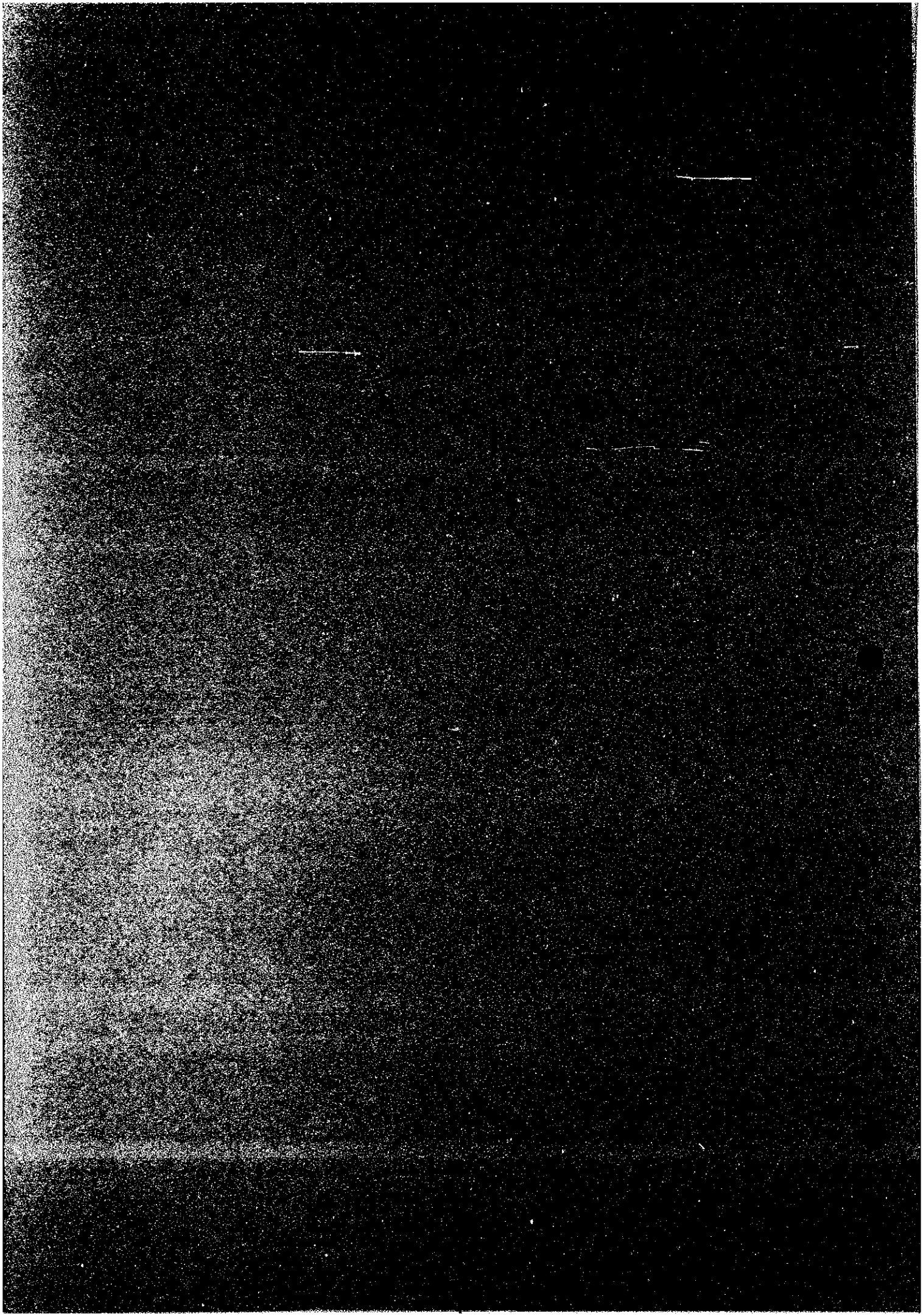
Other aspects of this study include review of the socio-economic background, effects of the climatic and geographical conditions on water pollution, treatment of oil-containing wastes, review of laws and regulations, air pollution by the refinery and service stations, recommendations for better maintenance, and measures to cope with accidental pollution.

This study has developed a comprehensive program for prevention and control of oil pollution, evaluates the program, and presents conclusions and recommendations. The core of the program is facilities recommended for Bernstein Main Storage and Pointe-a-Pierre Refinery, the dissolved air flotation with coagulation plus activated carbon adsorption for the former and the dissolved air flotation alone for the latter.

The study team consists of the following eleven members:

Name	Assignment and association
Koji TANAKA	Study team leader, TECHNO CONSULTANTS, INC. (TCI)
Yoshitaka IMAEDA	Industrial and environmental policies, TCI
Mahbub A. K. M. REZA	Climatic and hydrometric study, SANYU CONSULTANTS, INC.
Toshio SASAKI	Oil production, TCI
Muneteru YOSHIZAWA	Transportation and storage, TCI
Akira ISHIYAMA	Refining processes, COSMO OIL CO., LTD. (COC)
Tomoo UESUGI	Operation and maintenance, COC
Takeshi HIHARA	Oil water separation-1, TOHO CHEMICAL INDUSTRY CO., LTD.
Shinsuke SATOU	Oil water separation-2, TCI
Makoto NATORI	Effluent water treatment, TCI
Yoshikazu SATOU	Wastes disposal, COC.

Chapter 2 Summary



Chapter 2 Summary

This chapter summarizes the major conclusions and recommendations of the study.

1. Proposed Program

To achieve the 50 ppm target, a waste water treating system with dissolved air flotation with coagulation (DAF) plus activated carbon adsorption (ACA) is proposed for Bernstein Main Storage, and one with DAF alone for Pointe-a-Pierre Refinery.

Their cost is estimated at 16,300 and 3,377 thousand U.S. Dollars in 1994 Trinidad Tobago prices, respectively. The annual economic operation cost is estimated at 4,769 thousand U.S. Dollars, or 0.22 U.S. Dollars per barrel of crude oil. This report justifies this cost.

2. Dams and catches

Expansions of dams and catches installed on the rivers to prevent the accumulated oil from being washed away are not recommended.

3. Water Produced with Crude Oil, Oil-in-water Emulsion

Water produced with crude oil is in the form of very stable oil-in-water emulsion. This emulsion has been identified as the most serious cause of oil pollution. The conventional gravity-induced separators are ineffective to this emulsion. DAF was found to be effective and applicable to the actual waste water streams. By this method, the treated water becomes crystal clean.

4. Water after treatment by DAF

Water produced with crude oil needs to be further treated by ACA after DAF treatment because of the dissolved substances. Therefore, a system having both DAF and ACA is proposed for Bernstein Main Storage.

5. Project scheme

The following project schemes are proposed for Pointe-a-Pierre Refinery and Bernstein Main Storage.

	Bernstein Main Storage	Pointe-a-Pierre Refinery
Design conditions for DAF and ACA Units		
Flow rate, cubic meters per hour:	440/400	250
Oil content of water, mg/liter		
Inlet	1,000	400
Treated water	50	50
Waste treatment system,	to be included	to be included
Schedule, year		
Preparation	1	1
Construction	1	1

6. Evaluation

These facilities cost 4,769 thousand U.S. Dollars a year to operate, corresponding to 0.22 U.S. Dollars per barrel. This cost is justifiable in terms of comparison with some economic indicators, percentage on the earnings from petroleum exports, net economic value generation versus economic cost, importance of pollution control and expected socio-economic benefits.

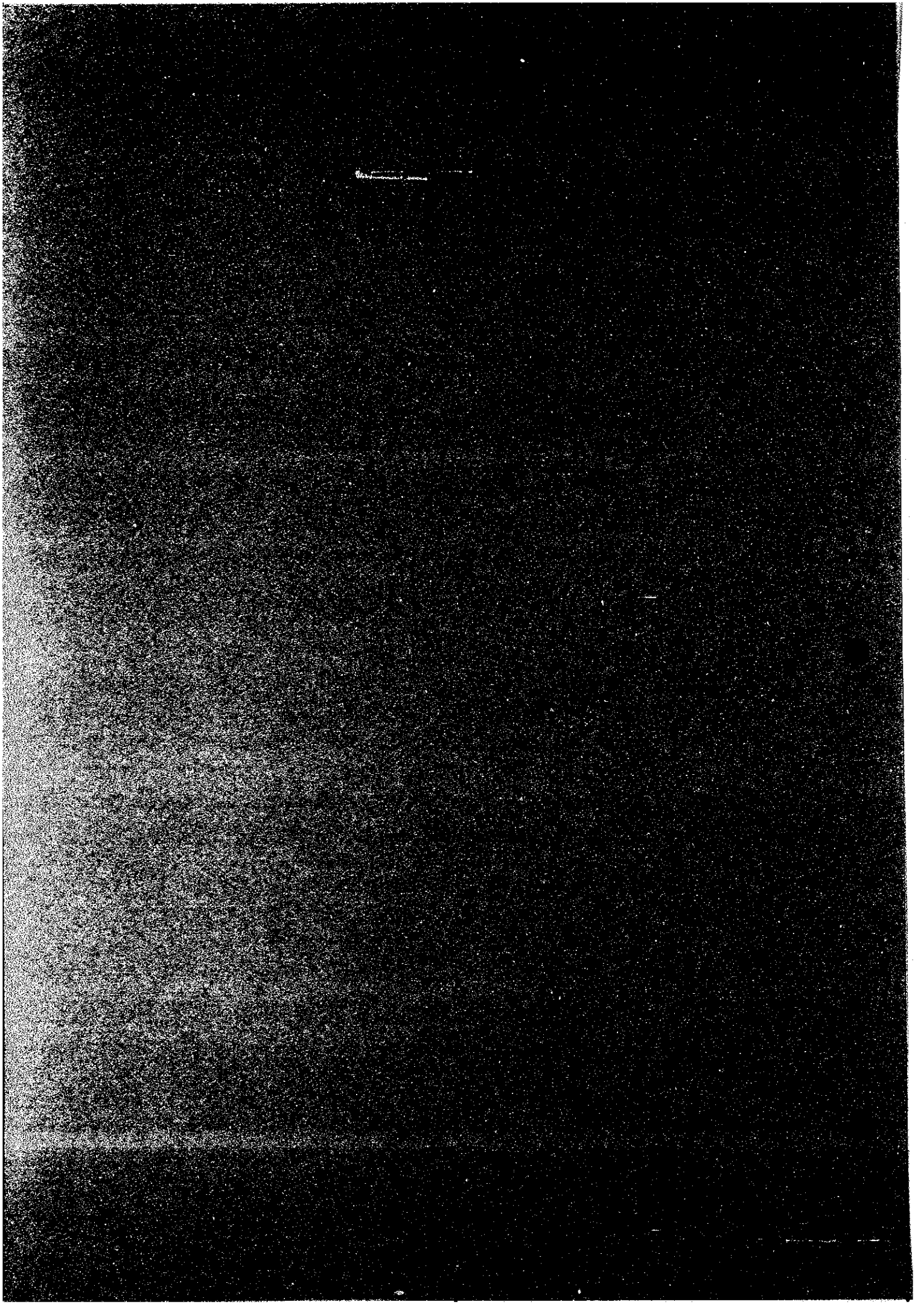
7. Recommendations

Execution of the program defined as project scheme is recommended to achieve the 50 ppm target. The inefficient oil wells that disproportionately produce large amounts of water per barrel of oil increase the total treating cost. A study similar to that done by the study team should be done on more comprehensive data. Suspension of operation of the inefficient wells should be studied to reduce the amount of foul water and to reduce the treating cost.

Safety of substances dissolved in water to aquatic organisms is not established. The government and Petrotrin should therefore monitor on a long-term basis accumulation of such substances in the bodies of aquatic organisms that live in the contaminated areas and their effects.

It is also recommended that good practices of operation and maintenance should be implemented to the extent the budget of Petrotrin permits. Use of earthen pits should be abandoned. Preventive maintenance should be done on facilities that can cause a major accidental pollution.

Chapter 3 Scope of the Study



Chapter 3 Scope of the Study

3-1 Subjects for the Study

The subjects for this study have been agreed upon between the government of the Republic and the Preparatory Study Team of JICA as exemplified in the Scope of Work signed on February 8, 1993 by the representatives of both parties. Specifically, the scope of work is defined as follows:

1. Review of General Conditions for the Study

   1.1 Present social and economic conditions of Trinidad and Tobago
   1.2 National, regional and industrial development policies
   1.3 Production and trade of crude oil and petroleum products
   1.4 Present status of environmental protection of Trinidad and Tobago
   1.5 Present industrial situation and future projection
   1.6 Petroleum sector policy, projects and programs
   1.7 Laws, regulations and incentives relevant to environmental protection
   1.8 Institution and organization for pollution prevention and control

2. Physical Distribution of Crude Oil and Petroleum Products

   2.1 Physical distribution study
   2.2 Availability of crude oil, condensate, LPG and natural gas

3. Identification and Characterization of Sources of Petroleum Pollution

   3.1 Climatic and hydrometric study
   3.2 Oil wells, oil field tank farms and pipelines
   3.3 Water separation facilities
   3.4 Other refinery facilities

4. Analytical Survey of Selected Sources with respect to the Following Items

   4.1 Test on emulsion breaking with field sample
   4.2 Evaluation of emulsion breaking technology for waste water from oil field tank farms and refinery

4.3 Environmental measurement and monitoring of waste water, exhaust gas and solid wastes from oil field tank farms, refinery and gas stations

4.4 Review and study of crude oil production with special attention to the enhanced oil recovery

4.5 Review of ongoing "Upgrading Project" in view of pollution prevention and control

4.6 Review and diagnosis on operation and maintenance technologies at oil field tank farms and refinery

4.7 Study on overall optimization for waste water separation at oil field tank farms and refinery as integrated system

4.8 Countermeasures for incidental pollution

5. Formulation of a Master Plan for Pollution Prevention and Control

5.1 Governmental support system for pollution prevention and control

5.2 Monitoring system for petroleum pollution

5.3 Conceptual design for water separation and waste water disposal at oil field tank farms

5.4 Conceptual design for water separation from crude oil at refinery

5.5 Conceptual design for waste water treatment with recycling at refinery

5.6 Improvement of operation and maintenance technologies

5.7 Environmental prevention measures for exhaust gas and solid wastes

5.8 Cost estimation

5.9 Implementation schedule

5.10 Impacts of petroleum pollution reduction

6. Conclusion and Recommendation

3-2 Target Oil Content

The above scope is supplemented by the Minutes of Meeting signed by the same representatives on February 9, 1993. The Minutes of Meeting further specify in detail the scope of work. Its "Study Basis of Oil and Grease Limits" says, "The following draft instructions from the Ministry of Energy and Energy Industries to the oil companies will be employed as the basis of the study, conceptual design/engineering necessary for the study. 'Oil and grease discharges from refineries and land based petroleum facilities shall not normally exceed 50 ppm on monthly average or 75

ppm on a daily maximum.'" Thus, the oil content at 50 ppm in the effluent water streams has become the target of this study.

3-3 Selected Sites and Facilities for the Study

In the Minutes of Meeting both parties have agreed that the sites and facilities selected to be studied are as follows:

(1) Pointe-a-Pierre Refinery

(2) Point Ligoure Main Storage of TRINMAR

(3) Onshore oil fields shown on the Attachment I to the Minutes but not including those operated by the Premier Consolidated Oilfields Ltd. (PCOL).

It is also mentioned that the site selection will be made based on the following criteria:

1. Effluents from Trintopec/Trintoc
2. The site for the study shall be so selected as to represent the different types of oil pollution problems in the effluents

(4) Earthen catchment pit at Penal.

Referring to (3) above, the Minutes of Meeting specifies the following facilities:

1. Oil fields, main storage and effluent water treating facilities at Fyzabad formerly operated by the Trinidad and Tobago Petroleum Co., Ltd. (Trintopec) and now by the Petroleum Company of Trinidad and Tobago Limited (Petrotrin),
2. Oil fields, gathering stations, main storages, and effluent water treating facilities at Forest Reserve and Bernstein operated formerly by the Trinidad and Tobago Oil Co., Ltd. (Trintoc), and now by Petrotrin,
3. Oil fields, associated facilities and effluent water treating facilities at Guapo operated formerly by Trintopec, and now by Petrotrin,
4. Oil fields, associated facilities and effluent water treating facilities at Central Los Bajos operated formerly by Trintopec, and now by Petrotrin,
5. Oil fields, associated facilities and effluent water treating facilities at McKenzie operated formerly by Trintopec, and now by Petrotrin,

6. Oil fields, associated facilities, main storage and effluent water treating facilities at Point Fortin operated formerly by Trintoc, and now by Petrotrin,
7. Oil fields, associated facilities and effluent water treating facilities at Parrylands operated formerly by Trintoc, and now by Petrotrin.

The petroleum storage facilities include, in addition to those mentioned above, the main storage at Point Ligoure.

3-4 Other Items Agreed in the Minutes

The Minutes also record the following items as having been agreed between both parties.

3-4-1 Review of Ongoing "Upgrading Project"

JICA's study will be carried out independently from the ongoing "Upgrading Project," and JICA's review and study of the environmental issues of the ongoing "Upgrading Project" will be to the extent and in the manner necessary for the Study.

3-4-2 Counterpart Training

(1) Counterpart Training in Japan

The Ministry of Energy and Energy Industries has requested that their counterpart officials be invited to Japan for the purpose of learning the current environmental protection practices within the petroleum sector in Japan, and that transfer of technology be facilitated in connection with the Study.

For this purpose, JICA has already invited to Japan Mr. Oswald Adams of the Ministry from November to December of 1993 and Dr. Ahmad Khan of Petrotrin in August to September 1994.

(2) Seminars in Trinidad

The Minutes states "In connection with the Study, the Ministry requested JICA to hold seminars in Trinidad at appropriate times during the study period, so that the persons who may be concerned with environmental issues within the petroleum sector could be enlightened."

Initially, the seminars were planned during the third field survey. However, it was agreed between the Ministry of Energy and Energy Industries and the study team and recorded in the

Minutes of Meeting for the second field survey that the seminar be held after the draft presentation meeting instead of during the third field survey as originally planned. This is because the seminar will be more fruitful if it is held after all the results have been obtained. Accordingly, a seminar was held on Tuesday, December 13, 1994, after the draft report had been presented to the Ministry of Energy and Energy Industries and Petrotrin.

3-5 Strategy and Approach to the Study

The strategy to the Study was initially formulated as explained in Chapter 4, Framework of the Study, of the Inception Report presented in August 1993. There has been a major modification in the strategy and approach since it was found during the first home-office work that the major problem is the tight oil-in-water emulsion that is produced in association with crude oil. Intensive experiments on the dissolved air flotation that had not been originally planned were done during the first home office work period, the second field survey, and the second home office period. Along with such experiments, another series of experiments was done during the same span of time to seek demulsifiers that can break emulsions, thereby enabling an appropriate combination of the gravity-induced conventional separators to achieve the 50 ppm target.

Contrary to the expectation that has been harbored since the beginning of this study, the use of demulsifiers proved either ineffective or only partially effective and is therefore not recommended. In addition, there is a controversy about possible adverse side effects of these demulsifiers discharged with treated water on the ecological environment. One may wish to argue that the study team has not tested all the demulsifiers, or that there will be new demulsifiers that are more effective and more benign to the environment. The study team does not deny such a possibility. However, the study team can only recommend proven measures that can achieve the 50 ppm target. Therefore, the proposal to use demulsifiers should be abandoned. The Inception Report supposed that experiments on the effects of demulsifiers would provide a basis for conceptual design for facilities to treat waste water but the experiments actually provided negative information that demulsifiers cannot be counted on. This result prompted the study team to decide to use dissolved air flotation plus activated carbon adsorption.

Figure 3-1 illustrates the basic approach to this study. Of all aspects of the study, the major areas for which technological solutions to the problems must be recommended can be broadly classified into (1) Oil wells, main storages, tank farms, (2) Dams and catches, (3) Pointe-a-Pierre Refinery, and (4) Wastes, contaminated soils, earthen pits. Figure 3-1 presents major problems, issues, alternatives and recommendations for solving the problems in a manner that will facilitate

understanding of the entire scope of the study at a glance. The legal and administrative measures are no less important than the technical measures but not shown in this figure.

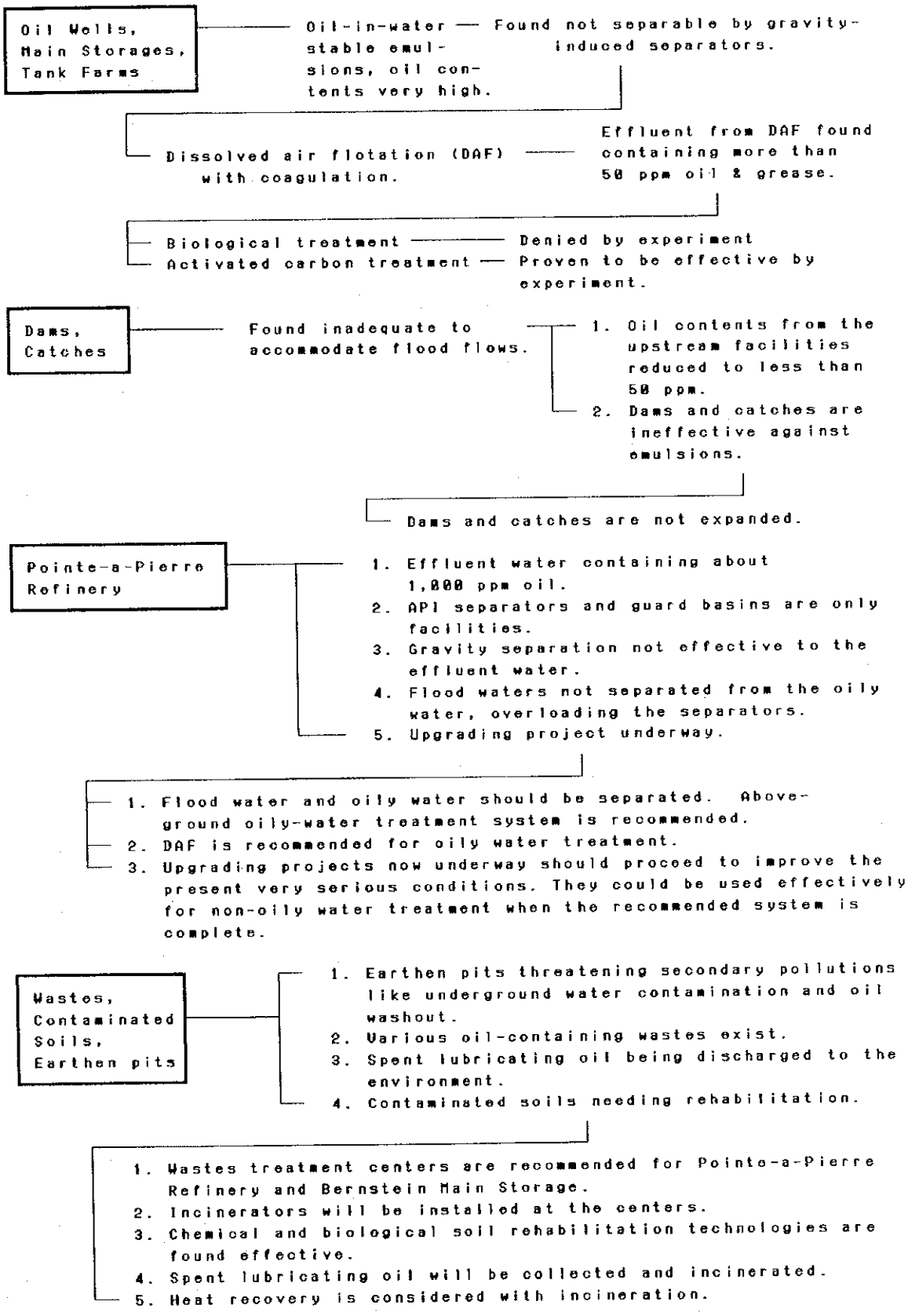
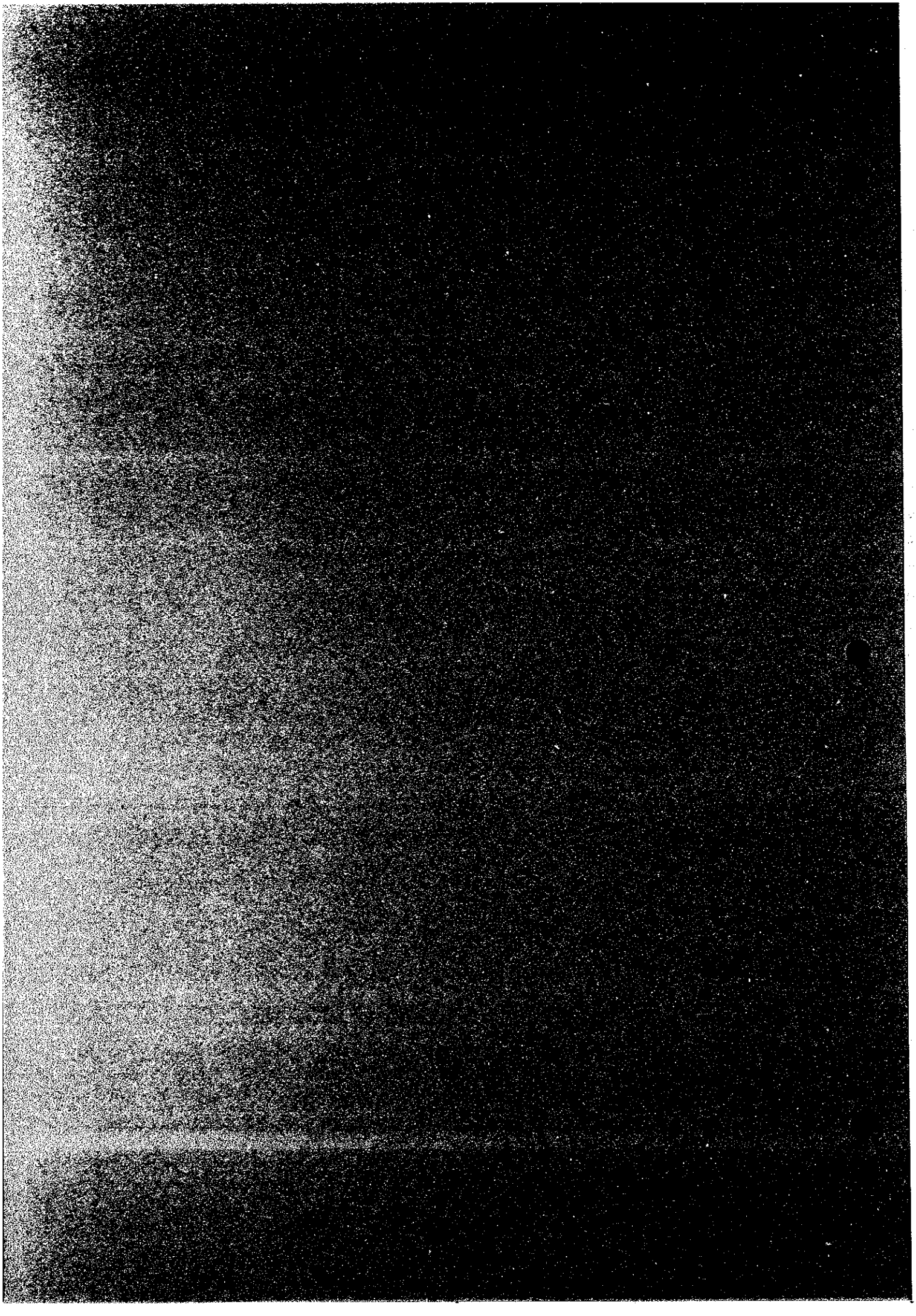


Figure 3-1 Approach to the Study

Chapter 4 Background of the Study



Chapter 4 Background of the Study

4-1 History and Environment of the Study

4-1-1 Background of Environmental Pollution by Petroleum

In Trinidad and Tobago, oil production on a commercial scale started in 1907 at Point Ligoure, to the south of Pitch Lake. Output thereafter increased steadily, and Trinidad and Tobago became in the late 1930s the largest oil producer in the British Commonwealth. The growth of the refining industry followed growth of oil production. Four refining/topping facilities were built during the 1910s. Over the years a number of expansions took place at the refineries, most noticeably at the refineries at Point Fortin and at Pointe-a-Pierre, the former built in 1912 and the latter in 1916. In the 1950s, their capacities were expanded to 100 MBD and to 365 MBD, respectively. With such large capacities, Trinidad and Tobago became an established exporter of petroleum products. While the growing production and export of petroleum and its products contributed greatly to economic development, the operations without sufficient measures to protect the environment have caused serious oil pollution in various parts of the country.

Many of the onshore wells are superannuated. Enhanced oil recovery by steam injection is extensively practiced to squeeze out the remaining oil. With steam injection, crude oil being produced is accompanied by water which contains emulsified oil. The amount of water could be very large. The ratio of associated water to water plus crude oil can exceed 90 percent in certain extreme cases. This water, or an oil-in-water emulsion to be exact, can contain oil at concentrations exceeding 10,000 ppm. Such emulsified oil in the water cannot be separated by the commonly used gravity-induced oil separators. Consequently, such water containing oil at very high concentrations is discharged to the rivers. In view of the fact that the ratio of the proven reserve to production is less than 10 years, naturally there is a tendency to resort even more to enhanced oil recovery by steam injection. This could in turn cause more serious oil pollution unless appropriate measures are taken to forestall further pollution.

No substantial measure has been taken to regulate environmental damage by oil, although the Petroleum Act established in 1969 contains regulations on the prevention of oil pollution. In 1989, a guideline was issued for the control of oil and grease in the effluent water from the petroleum sector. However, the guideline has not been rigorously enforced, because of technical and economical difficulties associated with enforcement. Obviously, the de-facto absence of

regulations on environmental protection has allowed the oil pollution to become worse.

4-1-2 Significance of Pollution Prevention and Control

Diversification of the economy is one of the basic policies of the nation, aiming at reducing dependence on petroleum. Ironically however, the nation has to promote the petroleum industry, because its expansion appears to be the only effective means at hand to resolve the problems of chronic fiscal deficits and foreign currency shortage. Considering the present situation in which environmental conservation is becoming a matter of global concern, pollution prevention is an indispensable step impossible to circumvent, both in terms of internal and international politics, before the nation can further develop its petroleum industry. Trinidad and Tobago plans to modernize and expand Pointe-a-Pierre Refinery, for example, by using funds from an international financing institution. A condition attached to the finance requires that Trinidad and Tobago take appropriate measures to prevent and control oil pollution on its own territory and on the surrounding Caribbean Sea, in which area there are countries depending on tourism. Domestically, for the development and diversification of economy, it is important to prevent the oil pollution from damaging the tourism and agricultural sectors; both sectors are promising candidates for foreign currency earners.

4-1-3 Significance of This Study

This study concerns oil pollution of large scale and varied in nature. In formulating a strategy for countermeasures, a systematic approach, comprising measures appropriate to individual problems, must be worked out. The entire system must be effective and efficient, just as the measures to deal with each source of pollution. The study team has kept this principle in mind and accordingly developed the conclusions and recommendations. As a unique feature of this study, there are emulsions produced with crude oil, noticeably under steam enhancement, which have been found not amenable either to chemicals (emulsion breakers) or to gravity-induced oil-water separators. As a result of extensive scrutiny of the technologies for oil-water separation and intensive experiments on actual samples, the study team recommends technologies which are new to Trinidad and Tobago. The total system as recommended along with the introduction of these new technologies to Trinidad and Tobago are expected to be helpful in the formulation of its petroleum policies.

In order for the government to effectively implement environmental protection measures, which do not by nature generate prompt profits, proper guidance by the government by means of right

legal and administrative measures is very important. The government emphasizes environmental conservation in the Medium Term Policy Framework. The Environmental Management Agency (EMA) will be established soon as a concrete step toward better environmental management. With the assistance of the World Bank and in association with other concerned organizations, the EMA will draft environmental regulations and standards. Establishment of the monitoring system and development of human resources are also important missions of the government.

Under such a circumstance, recommendations by this study could contribute to betterment of the nation's environment.

4-2 Natural, Social and Economic Conditions of the Nation

4-2-1 Natural Conditions

(1) Geography

Trinidad and Tobago is an island country with an area of 5,128 km^2, comprising the Islands of Trinidad and Tobago and several small islands. The island of Trinidad is about 105 kilometers long and 77 kilometers wide, with an area of 4,828 km^2. It is located about 10 kilometers north of the Venezuelan coast from which it is separated by the Gulf of Paria and by the Channels of Dragon's Mouth and Serpent's Mouth. Geologically, it is marked by three mountain ranges extending from east to west, with the highest peak named Aripo rising to 940 meters in the north range. The Island of Tobago is a small one, 51 kilometers long and 18 kilometers wide, having an area of 300 km^2, and lying about 33 kilometers to the northeast of the Island of Trinidad. The Island of Tobago has a mountainous spine rising to 500 meters.

(2) Climate

The climate of the country is tropical with a small seasonal variation. The trade wind moderates the heat, and the daily temperature variation is between 21 and 31°C throughout the year. Rain falls in all seasons, but the wettest season is from June to December. The precipitation varies with the region, ranging from 1,500 to 3,000 millimeters.

4-2-2 Social Conditions

(1) Population, Ethnic Composition and Religion

The population of the country was about 1.24 million according to the May 1990 census, with an average population density of 242 people per square kilometer. The average annual population

growth rate from 1980 to 1990 was approximately 1.3 percent. The ethnic composition is: African descent 40.8 percent, East Indians 40.7 percent, mixed 16.3 percent, Europeans 0.9 percent, Chinese 0.5 percent, others 0.8 percent. The Africans and the mixed are mainly Roman Catholic (33 percent), although some are Anglicans (15 percent). Most East Indians are Hindu (25 percent) and Muslim (6 percent).

(2) Politics and Administration

Trinidad and Tobago is a republic headed by the President. Executive power rests with the Prime Minister and the Cabinet. The parliament is bicameral, consisting of a Senate and House of Representatives. The senators are appointed and members of House are elected every five years. Administration is executed through provinces and districts. The Island of Trinidad is divided into eight provinces and 29 districts; the Island of Tobago is counted as one province. The whole country is therefore divided into nine provinces and 30 districts. There are also ten local self-governing bodies; three of them are special municipalities of Port of Spain, San Fernando and Arima.

4-2-3 Economic Condition

(1) General

Like other Caribbean countries, the economy of the Republic used to be dependent on such agricultural products as sugar and cocoa. In the 1940s, the economic structure of the country shifted to one in which the petroleum sector led the economy. Since then, the country has been dependent chiefly on exports of petroleum and petroleum products. During the 1970s in particular, the petroleum sector grew rapidly thanks greatly to the sudden rises in oil price which occurred twice; increases in oil production mainly from offshore fields followed the price hikes. In 1980 the petroleum sector including refining accounted for 40 percent of the GDP, 90 percent of the total export and over 50 percent of the central government revenue, as a result of rapid development of the petroleum sector. Since the mid 1980s, the importance of the petroleum sector has been gradually fading as prices and production declined. To offset such a trend to some extent, natural gas has been making an increasing contribution to the national economy, as the development and utilization of this resource were accelerated. The economic structure depending on export of energy-based commodities has remained unchanged. (Refer to Table 4-1.)

Since the economy of Trinidad and Tobago has been heavily dependent on the petroleum industry, the economy of the country has been affected by variation in production and international price of crude oil. From the mid 1970s to the beginning of the 1980s, the country achieved rapid

economic growth favored by the substantial increases in international oil prices and domestic crude oil production. From 1974 to 1976, in particular, the country recorded an incredibly high economic growth rate, an average of 36 percent in GDP. From 1979 to 1980, the country achieved an economic growth exceeding 20 percent, while the economic growth rate from 1977 to 1978 was 11 percent. During the more recent period from 1982 to 1989, however, the reduced domestic oil production and the decline in the price of oil in the early 1980s worsened the economy as shown below.

- Real Gross Domestic Product fell to two thirds.
- The nominal GNP per capita, measured in United States dollars, fell by more than half, from US$ 7,226 to US$ 3,246.
- Petroleum export earnings fell sharply, and net foreign currency reserves turned negative in 1988.
- Government revenue from the petroleum sector declined sharply, and the resulting fiscal deficits obliged public expenditure to be tightened.
- The unemployment rate doubled from 10 percent to 20 percent.

Table 4-1 Economic Significance of the Energy Sector

(Unit: Current Million TT $)

	1970	1975	1980	1985	1990	1991
GDP	1,656.7	5,392.3	15,892.2	17,999.1	19,690.2	19,491.5
Petroleum %[1)]	21.5	41.3	42.1	26.8	31.8	24.7
Government Revenue	313.2	1,808.5	6,202.4	6,361.2	5,662.8	6,704.2
Petroleum %[1)]	23.1	69.4	58.9	42.1	40.9	40.5
Foreign Exchange		2,198.7	6,536.5	5,247.1	8,842.0	7,443.1
Petroleum %		77.2	90.6	79.2	82.5[2)]	82.4[2)]

Note: 1) Excluding gas based petrochemical industry.
2) Including gas based chemicals such as ammonia, urea and methanol.
Source: Draft Policy Paper on Energy, November 1992

The economic situation of the country in recent years is summarized in Table 4-2. As shown in the table, the real GDP growth rate turned positive once in the 1990s. This growth was attributable largely to substantial rises in oil price, not to any change in the economic structure of

the country.

Table 4-2 Major Economic Indicators

(Unit: Million TT$)

	1986	1987	1988	1989	1990	1991	1992
GDP at 1985 Price	17,500	16,678	16,027	15,895	16,134	16,531	16,268
Real GDP Growth Rate (%)	-2.8	-4.7	-3.9	-0.8	1.5	2.5	-1.6
Per Capita GDP at 1985 Price (TT$)	14,627	13,764	13,229	13,102	13,144	13,360	12,992
Export	4,888	5,029	5,586	6,522	8,225	7,443	7,943
Foreign Currency Reserves (US$ Million)	329	79	-6	102	188	24	-25
Unemployment Rate (%)	17.2	22.3	22.0	22.0	20.0	18.5	19.6
Inflation Rate (%)	7.7	10.8	7.8	11.4	11.1	3.8	6.5

Source: Annual Statistical Digest 1991, Central Statistical Office
Review of the Economy 1993, Central Statistical Office

The petroleum sector provides about 25 percent of the GDP as shown in Table 4-3. This figure is not large if it is compared with those of the oil producing countries in the Middle East. However, other industries of this country are heavily dependent on the petroleum sector, and therefore the real contribution by the petroleum sector to the national economy is larger than it may appear from the above figure.

Table 4-3 Configuration of GDP by Sector at Current Market Price

(Unit: Percent)

	1986	1987	1988	1989	1990	1991	1992
Petroleum	22.7	25.2	24.1	27.2	30.3	25.4	21.9
Agriculture	2.8	2.8	2.7	2.5	2.5	2.5	2.5
Manufacturing	8.2	8.3	8.7	9.6	8.5	8.8	9.3
Construction and Quarrying	9.5	9.0	9.3	8.9	8.0	8.3	8.6
Distribution and Restaurant	14.0	13.9	14.8	14.7	12.5	14.4	15.2
Transport, Storage and Communication	10.0	9.8	9.9	9.3	8.1	8.8	9.0
Finance, Insurance, Real Estate, etc.	12.5	11.9	11.3	11.3	10.6	11.3	12.4
Government	16.4	14.8	14.1	11.9	10.6	11.1	11.9
Others	4.3	4.4	5.1	4.6	8.9	9.4	9.2

Source: Annual Statistical Digest 1991, Central Statistical Office
Review of the Economy 1993, Central Statistical Office

As for employment, farming activities account for about 50 percent of the total employment. Other major sectors in terms of employment are the construction sector at 20 percent, the agriculture sector including sugar refining at 13 percent, and the manufacturing sector excluding sugar refining and petroleum-related industries at 11 percent. The petroleum sector employs only 6 percent.

Table 4-4 shows the international balance of payments. The trade balance has been substantially in surplus by virtue of the export of petroleum, petroleum products and petrochemical products. However, the service account has been continuously recording heavy deficits due to the repatriated dividends of foreign petroleum companies, and both current and total accounts have been continuously negative. The continuously negative balances rapidly reduced the foreign currency reserves of the country, and principal repayments were deferred from 1988 in accordance with the rescheduling agreements with foreign countries.

Table 4-4 Balance of Payments

(Unit: Million TT$)

		1986	1987	1988	1989	1990	1991	1992
1.	Merchandise (Net)	-387	801	1,079	1,411	3,512	1,449	2,100
	Exports	4,888	5,029	5,586	6,522	8,225	7,443	--
	Imports	5,274	4,228	4,508	5,111	4,712	5,994	--
2.	Services	-1,751	-1,559	-1,417	-1,590	-1,577	-1,479	-1,540
3.	Unrequited Transfer	-137	-132	-114	-106	-108	-58	-68
4.	Current Account (1+2+3)	-2,275	-891	-452	-284	1,828	-88	491
5.	Capital Account (incl. errors & omissions)	-138	-9	-182	-427	-2,636	-988	-1,024
6.	Overall Surplus (4+5)	-2,414	-900	-634	-661	-808	-1,326	-532
7.	Valuation Change in Reserves	0	0	-45	83	0	0	0
8.	Exceptional Financing	0	0	370	1,036	1,170	631	326
9.	Change in Reserves (6+7+8)	-2,414	-900	-309	458	362	-696	-206
10.	Foreign Currency Reserve	1,185	285	-24	434	797	101	-105

Source: Annual Statistical Digest 1991, Central Statistical Office
Review of the Economy 1993, Central Statistical Office

As shown in Table 4-5, crude oil, petroleum products, ammonia, urea and methanol, and direct reduction iron, all derived from the country's hydrocarbon resources, have been the major export products. In 1991, for example, the export earning of crude oil and petroleum products amounted to 64.5 percent of total exports. If the chemical products made from natural gas are

included, the share of the energy sector in the total export exceeded 85 percent. On the other hand, the share of agricultural products such as sugar and cacao, which had been the major export commodities, was only 2 percent. As for imports, crude oil for refining, cereals such as maize, rice and wheat, machinery, electric appliances and vehicles had large shares. Regarding the trade balance by group, all groups excluding "Beverages and Tobacco", "Mineral Fuels" and "Chemicals and Related Products" were negative.

The U.S.A. has been predominantly the largest trading partner with the largest shares in both exports and imports, 41 percent and 47 percent in 1992, respectively. The trades with CARICOM (Caribbean Community) countries such as Jamaica, Barbados and Guyana is also thriving. The trade balance between the Republic and the CARICOM countries has been continuously in surplus on the side of the Republic since 1987. As for trade with Japan, the balance has been constantly in surplus to Japan. The major commodities imported from Japan are automobiles and auto parts. The major commodities exported to Japan are wires and rods made from direct reduction iron (DRI), an energy intensive product. In 1992, about 93 percent of total exports to Japan was DRI; cocoa accounted for two percent, pitch one percent, and others (meat products and beer) less than one percent. The country's major export products, namely natural-gas-based chemicals such as ammonia, urea and methanol, have not been exported to Japan due to the high cost of transportation.

Table 4-5 Export and Import by Commodity

(Unit: %)

	1986	1987	1988	1989	1990	1991
Export						
Crude Petroleum	40.7	36.1	30.2	32.3	37.3	31.1
Petroleum Products	31.2	35.8	30.8	29.0	31.1	33.5
Ammonia	9.2	7.2	10.8	11.0	8.4	9.2
Iron and Steel Bars/Rods	4.9	5.0	5.4	6.0	5.2	5.6
Urea	3.5	2.9	5.0	3.6	2.9	3.4
Methanol	2.3	2.9	4.3	2.6	2.0	3.1
Sugar Refined/Unrefined	1.7	1.5	1.7	1.9	1.5	1.6
Cocoa	0.2	0.2	0.2	0.2	0.3	0.2
Others	6.3	8.4	11.6	13.4	11.3	12.3
Import						
Crude Oil including Partly Refined Petroleum	0.0	2.4	7.4	3.3	9.8	14.6
Machinery	13.7	11.3	8.2	10.3	11.6	10.6

Food	7.1	8.9	7.9	8.6	8.0	5.7
Electrical Appliances	5.6	5.6	4.3	4.8	5.2	5.1
Motor Vehicles & Parts	7.4	3.5	3.6	1.2	1.9	5.0
Paper Products	3.4	4.0	3.8	4.9	4.0	3.3
Iron and Steel Products	2.6	1.9	3.1	3.3	2.2	2.3
Others	55.9	58.0	56.6	59.0	57.3	53.4

Source: Annual Statistical Digest 1991, Central Statistical Office

4-3 Industrial Development Policy

4-3-1 History of the Economy and Policy

The economy of Trinidad and Tobago achieved rapid growth by taking advantage of the sudden rises in oil price. The country recorded an annual average GDP growth rate of 36 percent from 1974 to 1976, and maintained high economic growth of 10 to 20 percent every year until the beginning of the 1980s. During this period, much of the abundant revenue from the petroleum sector was directed toward establishment and expansion of energy intensive industries, development of infrastructure and improvements of social welfare.

In and after 1982, as mentioned previously, the decline in petroleum prices and the reduced domestic oil production rapidly worsened the economy. Under such a situation, the government initiated the following measures to rectify the imbalance of economy.

- Reduction of governmental deficit through tighter control of public expenditure
- Consolidation and reduction of personal and corporate income tax rates, and implementation of a 15 percent Value Added Tax
- Devaluation of TT$ in 1985 and further devaluation in 1988
- Restructuring, privatization and liquidation of a number of state enterprises
- Increase in public utility price
- Relaxation of foreign exchange control
- Liberalization of the trade regime
- Partial rescheduling of external debts (principals only)

4-3-2 Economic Development Policy

The petroleum sector has been playing a critical role in the economy and it will be a mainstay of the economy for many years to come. However, at the same time, excessive dependence on the

petroleum sector is a structural weakness of the country's economy. In recognition of this, the government has been implementing several policy measures to diversify the economy as well as to revitalize the petroleum sector. The basic strategy for implementing the above policy is to encourage investment by the private sector, especially by foreign companies. In this context, the government endeavors to enhance the country's attractiveness to foreign and local investors. In April 1993, foreign exchange controls were abolished completely. Trade restrictions are also being liberalized. The highest tariff on imported goods, 100 percent in the past, will be 20 percent in a few years. The quota restriction, an administrative barrier to import, has already been abandoned.

The country is playing an increasing role as an export base of manufactured goods to the United States and as an offshore banking center. The major foreign companies that have invested in the non-oil sector of the country are as follows:

Banking
- Bank of Nova Scotia (Canada)
- Canadian Imperial Bank of Commerce (Canada)
- Citibank (USA)

Communication
- Cable and Wireless (UK)
- IBM (USA)
- ICL (UK)

Iron and Steel
- P.T. Ispat Indonesia (Indonesia)
- Nucor (USA)

Consumer products
- Johnson and Johnson (USA)
- Nestle (Switzerland)
- Unilever (Holland)

Insurance
- American International Group (USA)

On the other hand, the country is actively promoting privatization of many government-owned

businesses to solve the fiscal deficit problem and to increase operational efficiency. The principal companies that have been privatized are as follows:

- Telephone Company (49 percent of stock was sold to the Cable and Wireless of the UK)
- Steel Company (leased to Ispat of Indonesia)
- National Urea Co. (100 percent privatized)
- Fertilizer of T&T (100 percent privatized)

Further, about 20 companies including BWIA International, the Methanol Company, Petrotrin and Trinidad and Tobago Electric Commission are scheduled to be auctioned partly or entirely.

4-3-3 Key Industries

The key industries considered important for diversification of the economy are manufacturing, agriculture and fishery, tourism and service. The most important of the basic policies for these industries may be briefly summarized as follows.

(1) Manufacturing

Industries using natural gas as feedstock and/or fuel are emphasized as candidates for promotion. For other industries the key issue is strengthening international competitiveness. The abolition of foreign exchange control in 1993 depreciated the exchange rate of the TT dollar to US dollar by about 35 percent; this devaluation improved the competitiveness of the export industries. Further, to cope with the reduction of import tariffs, many manufacturers are making efforts to improve competitiveness by, for example, reduction of cost.

(2) Agriculture and Fishery

The government is committed to the development of this sector. The government regards this sector as a major generator of economic value and foreign currency and also as a prime instrument for diversification of the economy. The basic strategies for the development of this sector are directed toward increasing cultivation and export of crops other than sugar, reducing dependence on imported foods by increasing production of food crops, and enhancing productivity and efficiency of the traditional crops represented by sugar. The basic policy for the forestry sector is sustainable development, or expansion of timber production within the context of environmental protection and forest resources conservation. Further, the government has a policy to promote development and utilization of the undeveloped marine resources to feed the population, and to increase employment opportunities and foreign currency earnings.

(3) Tourism

Development of tourism promises to have a prompt effect on the generation of employment opportunities. The government, therefore, is eagerly promoting untapped tourism resources. Development of infrastructure, including modernization of the existing airports and construction of hotels, constitutes an important element of the government's tourism development program. Human resource development is also a critical element to the success of the tourism sector. The government plans to increase opportunities for training those working and wishing to work in this sector. Specifically, the existing hotel school will be upgraded to accommodate more students and to provide more extensive courses.

(4) Services

The government has a policy to develop the nation into an international business center for providing banking, insurance, legal, accounting, computer, brokerage, translation, engineering and telecommunication services by exploiting the country's locational advantage being situated between North and South America.

4-4 Production and Trade of Petroleum and Petroleum Products

4-4-1 Crude Oil

(1) Production

Since the commencement of commercial oil production in 1907, output increased steadily. Especially from the mid 1960s, oil production increased rapidly by the development of offshore oil fields; production peaked in 1978 at 83.87 million barrels, or 230,000 BPD. Production has been declining steadily ever since. In 1992 production was only 50.2 million barrels, equivalent to about 60 percent of the peak production. The cumulative onshore, offshore and total oil productions to the end of 1992 are 1,436, 1,210 and 2,657 million barrels, respectively. Figure 4-1 shows the change of oil production.

The country's proven crude oil reserves in 1992 are about 494 million barrels, and the reserve-to-production ratio is less than 10 years. If the potential reserves, supposed to exist mainly in the younger offshore fields and estimated to amount to 850 million barrels, are added, this ratio increases to about 25 years.

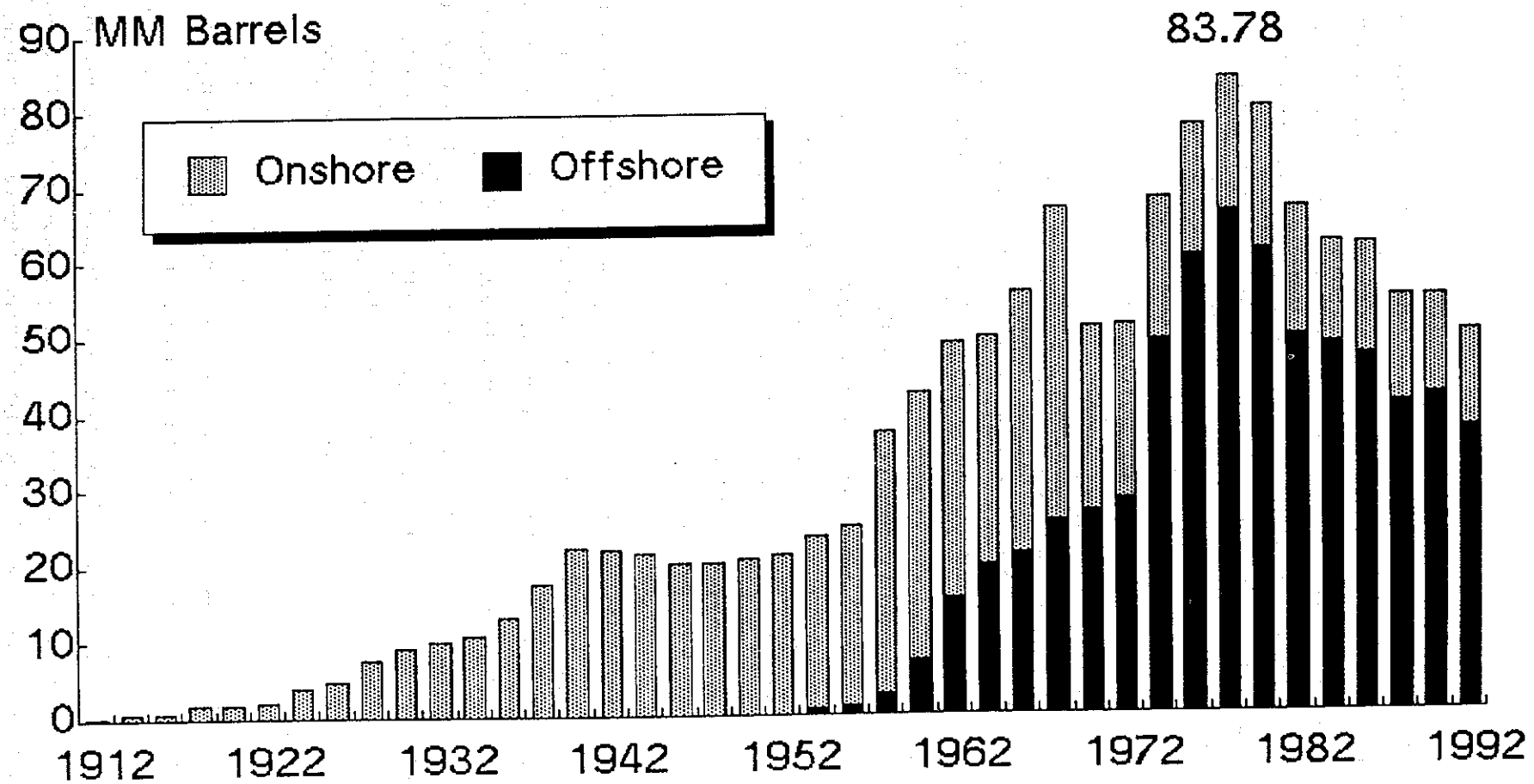


Figure 4-1 Historical Production of Crude Oil

Currently, oil is produced mainly by the following five companies. Enron of United States origin started oil production in 1993. In addition, 12 small independent companies are producing oil from several idle wells of Petrotrin under the Lease Operatorship and Farmout programs. The Lease Operatorship is restricted to local companies and the work is restricted to wells already drilled. In the Farmout, local companies are allowed to form joint ventures with foreign firms, and work including drilling is permitted.

- AMOCO Trinidad Oil Company Ltd. (ATOC):
  Foreign Company (USA),
  The biggest oil and gas producer in the country
- Petroleum Company of Trinidad and Tobago Ltd. (Petrotrin):
  State owned oil company established in 1993 by a merger of Trintoc and Trintopec
- Trinidad Northern Areas Ltd. (TRINMAR):
  Joint venture company of Petrotrin and Texaco Trinidad Inc.
- Trinidad and Tobago Marine Petroleum Co. Ltd. (Trintomar):
  Joint Venture company of Petrotrin and National Gas Company
- Premier Consolidated Oilfields Ltd. (PCOL):
  Branch of a British Firm

ATOC, the biggest oil producer in the country, has been operating in the East Cost Marine area, and its entire production is exported to the USA. The company produces about 50 percent of the total production of the country. Next to ATOC in production is Petrotrin. In 1992 Petrotrin produced 34,295 BPD, equivalent to about 25 percent of the total production. Petrotrin virtually monopolizes onshore oil production. Petrotrin's onshore crude is sent entirely to the two domestic refineries while its offshore crude is exported. TRINMAR is producing oil in the Gulf of Paria. TRINMAR's production in 1992 was 32,000 BPD, equivalent to 23 percent of the total production. TRINMAR's crude oil is sold entirely to Petrotrin, and dividends are paid to Texaco, the shareholder of the company.

The mode of production in the country may be widely divided into gas lift, flowing, and pumping. Of these the gas lift produces about 50 percent (refer to Figure 4-2).

Table 4-6 summarizes numbers of wells and production by year and by mode of production. As may be seen from the table, average oil production per well is no more than 120 BPD even in case of a gas lift system which is applied only to large reservoirs. In the case of a pumping system

which is applied to superannuated wells, production is only 14 BPD.

Table 4-6 Number of Wells and Average Production per Well

	Flowing	Plunger	Pumping	Gas/Lift	Total
Number of Wells					
1982	392	9	2,420	552	3,373
1983	344	7	2,292	496	3,139
1984	319	7	2,351	464	3,141
1985	325	5	2,371	463	3,164
1986	352	1	2,357	485	3,195
1987	320	1	2,392	529	3,238
1988	331	-	2,364	547	3,242
1989	364	-	2,266	554	3,184
1990	371	2	2,216	567	3,156
1991	368	2	2,229	614	3,213
Production (bpd/well)					
1982	149.2	0.9	15.7	145.8	(52.6)
1983	121.4	0.8	15.5	166.4	(51.0)
1984	140.0	0.8	15.9	189.0	(54.4)
1985	139.7	2.2	16.0	200.2	(55.6)
1986	139.7	19.2	15.4	172.0	(52.6)
1987	114.5	8.2	15.1	156.0	(47.7)
1988	115.5	-	14.9	142.2	(46.4)
1989	108.8	-	14.3	139.6	(46.7)
1990	129.9	43.8	14.1	125.5	(47.5)
1991	103.7	31.5	14.1	120.4	(44.4)

Note:Figures in parenthesis are weighted averages.
Source:Annual Statistical Digest 1991, Central Statistical Office

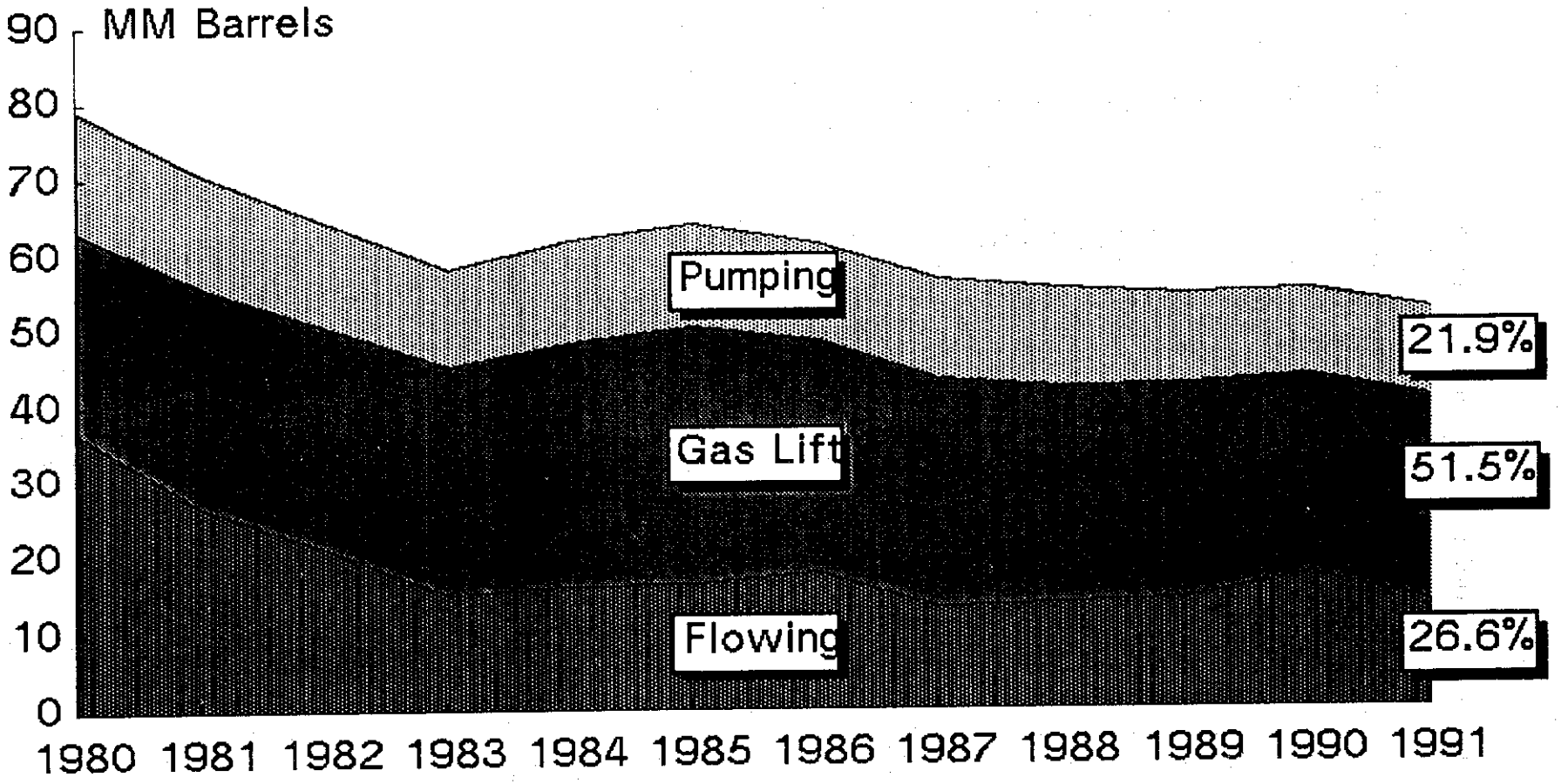


Figure 4–2 Crude Oil Production by Method

(2) Local Consumption and Trade

Roughly half the crude oil produced locally is exported; the balance is refined. In 1982, 31.72 million barrels of crude oil, equivalent to 49 percent of the total production, was exported. In 1992, 26.89 million barrels of oil, equivalent to 51 percent of the total production, was refined and the 49 percent balance was exported. It should be noted, however, that about 90 percent of the country's oil is exported, because local consumption of petroleum products is around 5 million barrels, or 10 percent of the total oil production. On the other hands, a large amount of crude oil had been imported for processing. Since the end of the 1970s, import of crude oil decreased remarkably, keeping pace with the decrease in capacity utilization of the refineries. However, in recent years, import of foreign crude is gradually increasing. In 1991, import of crude oil increased to 14.55 million barrels, or 2.27 times that of the previous year, by a processing agreement with Maraven, a national oil company of Venezuela. (Refer to Table 4-8.)

4-4-2 Petroleum Products

The refining industry of Trinidad and Tobago has a long history. The first topping still was constructed in 1910. This was a small facility intended to produce gasoline; all products were consumed in the local market. In 1912, Point Fortin Refinery was constructed, and oil products were exported to Britain for the first time. In 1914, a small topping still was built at Tabaquite to supply gasoline for local consumption. In 1916, Pointe-a-Pierre Refinery was constructed. Since then, a number of expansions were carried out, particularly at Pointe-a-Pierre Refinery and at Point Fortin Refinery, to process the increasing production of domestic crude oil. In 1933, two topping units were installed at Pointe-a-Pierre Refinery, and subsequently importation of foreign crude oil for processing began. During the 1950s, the peak period of the country's refining industry, the capacity reached a maximum of 465,000 BPD and this capacity was full utilized. However, since 1974 when the Refinery Throughput Tax was introduced at a very high rate, the refinery throughput has dropped drastically. Tables 4-7 and 4-8 summarize changes of refinery throughput and production of petroleum products.

Table 4-7 Refinery Throughput

(Unit: Thousand BPD)

	Point Fortin	Point-a-Pierre	Total
1965	70,000	365,000	435,000
1970	69,870	364,368	434,238
1975	46,782	187,666	234,448
1980	50,325	163,703	214,028
1985	25,450	56,010	81,400
1986	17,889	63,955	81,844
1987	23,887	62,338	86,225
1988	20,613	65,081	85,694
1989	21,600	65,000	86,600
1990	40,000	110,000	150,000
1991	29,400	84,000	113,400

Source: The Petroleum Encyclopedia of Trinidad and Tobago (1993 Edition), Krishna Persad and Associates Ltd.

The domestic consumption of petroleum products has been hovering around five million barrels per year. The National Petroleum Marketing Company monopolizes distribution of petroleum products excepting lubrication oil. The domestic market has characteristics of a high share of gasoline and a low share of fuel oil. The reason for the low share of fuel oil is extensive utilization of natural gas as fuel by power stations and heavy industries such as steel mills. The major reason for the high share of gasoline is the extensive use of private cars and minibuses as the only means of transportation in the absence of railways. The low shares of other products increase the share of gasoline in relative terms.

The annual consumption and export ratio of major petroleum products in 1992 are as follows:

	BBL	Percent	
LPG	600,000	25	(Excluding LPG from PPGPL)
Gasoline	2,700,000	60	
Aviation Fuels	700,000	80	
Gas Oil	900,000	85	
Fuel Oil	5,000	99	

Table 4-8 Refinery Throughput and Output

(Unit: Thousand Barrels)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Throughput										
Locally Produced	31,717	27,178	27,434	29,678	28,082	27,901	28,537	26,895	27,173	26,890
Imported	23,389	0	709	243	1,560	3,412	2,670	1,039	6,416	14,547
Total	55,106	27,178	28,143	29,921	29,942	31,313	31,207	27,854	33,589	41,438
Output										
LPG	768	662	585	746	739	671	479	708	768	479
Motor Gasoline	11,169	8,386	5,971	7,089	8,621	8,511	6,337	4,831	6,128	6,076
Aviation Gasoline	314	157	78	43	58	65	18	4	90	33
Aviation Turbine Fuel	2,506	2,014	1,907	2,258	2,470	2,295	2,657	2,055	1,832	1,788
White Spirit	13	10	5	8	-2,054	-1,332	-1,991	13	9	16
Kerosene	1,491	1,078	1,172	887	606	887	917	722	1,436	2,516
Gas/Diesel Oil	9,500	4,520	4,243	4,220	4,011	4,608	4,796	4,290	4,886	5,411
Fuel Oil	27,381	14,540	14,625	17,853	18,001	19,234	19,012	14,442	16,412	21,492
Lubricants	480	130	41	1	39	77	14	0	0	250
Asphalt Products	385	193	172	194	140	125	148	246	138	167
Petro-Chemicals	750	398	337	121	39	13	20	136	71	-4
Others	723	-3,552	-2703	-3,405	-4,562	-4,598	-2,208	-370	927	2,206
Total	55,482	28,536	26,435	29,999	28,109	30,558	30,208	27,070	32,696	40,431

Source: Annual Statistical Digest 1991, Central Statistical Office

4-4-3 Natural Gas

(1) Production

Since the start of commercial oil production in 1907, the gas produced in association with oil has been recovered and used. In and after 1969, gas/condensate fields were discovered on the east cost and gas fields on the north coast of Trinidad Island. Small gas fields were also discovered in the Gulf of Paria. However, the sufficient availability of associated gas had discouraged the development of these gas fields. In was toward the late 1970s that a gas pool in the Teak Field located on the East Coast was developed to supplement associated gas, the supply of which was becoming insufficient then. In 1983, AMOCO started commercial production of gas at Cassia Field on the East Coast, and it ensured a dependable supply to large consumers including fertilizer factories and power plants. Further, Trintomar, a state owned company, started gas production in 1991. The current production of natural gas in the country is about 260 billion standard cubic feet per year, or 710 million SCFD. The proven reserves of natural gas in the country are about 8,400 billion standard cubic feet or about 1,500 million barrels oil equivalent. At the 1991 production rate, the proven reserves are expected to sustain production for more than 30 years. Approximately, 62 percent of the proven reserves is located in the East Coast Marine area, 36 percent is in the North Coast Marine area. The gas fields on the East Coast were leased to AMOCO, Texaco/British Gas and South East Coast Consortium (SECC). Those on the North Coast areas were leased to Petrotrin and the group of British Gas, Deminex, Agip and Occidental.

Table 4-9 Natural Gas Production

(Unit: BCF)

	1986	1987	1988	1989	1990	1991
AMOCO Trinidad	228.3	230.7	222.1	217.5	180.5	203.5
Trintomar	0.0	0.0	0.0	0.0	18.6	22.2
Others	39.5	40.5	42.6	38.3	35.6	35.8
Total	267.9	271.2	262.7	255.8	234.7	261.5

Source: A Draft Energy Policy for Trinidad and Tobago, November 1992

(2) Consumption

Until the late 1950s, gas was used almost exclusively within the producing companies as fuel for the company-owned and -operated refineries, power stations and compressors for gas lift, oil production and reservoir pressure maintenance, and only a negligible amount was sold. However, since 1959 when gas began to be used as feed for ammonia production, the

consumption of gas has been rapidly increasing in diverse uses. At present, the largest consumer of natural gas in the country is the gas-based petrochemical industry, which now consumes more than 300 million SCFD as feed and fuel for producing ammonia, urea and methanol. More than 90 percent of these chemicals are exported. The domestic consumption is very small. The utilization of gas for power generation comes next to the petrochemical industry. All three power stations on the Island of Trinidad use natural gas as fuel, together consuming 140 MMSCFD. Gas is also extensively used as fuel by industries such as steel mills. About 20 percent of gas produced in the country is consumed by the producing companies themselves, and the rest is sold to National Gas Company (NGC). NGC is responsible for transmission and distribution of gas to local consumers. Table 4-10 summarizes natural gas consumption through the distribution channel of NGC.

Gas containing such heavier hydrocarbons as ethane, propane and butane was used until 1991 when a natural gas processing plant was constructed. Now propane, butane and NGL are separately recovered. The recovered propane and butane are mostly exported as LPG. More than 60 percent of recovered NGL is exported. The natural gas processing plant has a provision to add an ethane recovery unit.

Table 4-10 Gas Sales by the National Gas Company

(Unit: MMCFD)

	1985	1986	1987	1988	1989	1990	1991	1992	1993
Power Generation	98	104	108	116	116	119	130	137	148
Petrochemicals									
Fertilizers of T&T	89	90	90	95	91	92	95	91	104
Hydro Agri Trinidad	27	27	27	29	22	27	31	31	33
Trinidad Nitrogen Co.	42	47	47	78	90	91	96	99	86
Methanol Co. of T&T	32	29	37	35	36	36	42	46	46
Caribbean Methanol Co.	0	0	0	0	0	0	0	0	42
T&T Urea Company	8	8	9	10	10	10	11	10	12
Sub-total	198	201	210	247	249	256	275	277	323
Iron & Steel (ISPAT)	9	14	18	22	25	26	27	29	31
Petrotrin	0	0	27	21	25	29	33	29	34
TCL	5	6	7	7	8	9	9	10	11
LPG Extraction (PPGPL)	0	0	0	0	0	0	10	21	18
Small Consumers	8	8	8	9	8	9	9	10	7
TOTAL	318	333	379	422	431	447	490	512	572

Note: Figures on 1993 are those of December
Source: Ministry of Energy and Energy Industry

4-5 Present Situation of Environmental protection

4-5-1 Present Situation of Petroleum Pollution

This section portrays characteristics of the petroleum pollution in the country; Chapter 7 will provide an overview. Petroleum pollution on the Island of Trinidad is evident mainly in rivers, sea and soils. Rivers located near the sources of pollution are most seriously affected. Black oil is seen floating on rivers running through the oil producing areas. The banks are smeared black with oil. Besides, the color of those rivers, to which the water produced in association with crude oil is discharged, is a light brown. This phenomenon seems particularly noticeable if the effluent water comes from wells operated under steam enhancement. What makes water light brown is not suspended silt particles as is the case with many rivers but oil-in-water emulsions that come from underground with crude oil. The oil contents of river water were from 20 to more than 1,000 ppm according to the analysis done as part of this study, varying greatly with the condition of sampling, location and season. Many of the observed oil contents far exceed the solubilities of oils in water, indicative of the existence of such emulsions.

On the sea, pollution in the Gulf of Paria is most serious, even more serious than in oil producing areas of the Middle East. In the southern part of the gulf near the oil producing area, sea water is light brown like polluted rivers as far as hundreds of meters from the coast. Evidently, such emulsions flow into the sea without being separated or decomposed. The causes of the serious pollution in the Gulf of Paria are as follows:

- Many rivers running through the oil producing area flow into the gulf.
- Two refineries are located in this area.
- Ports for loading and unloading crude oil and petroleum products are located in this area.
- The gulf is a semi-closed system.

Currently, soil pollution by oil is not regarded as very serious, because the effects are rather confined. However, the risk of secondary environmental pollution such as ground water contamination is pointed out.

The major sources of petroleum pollution are the onshore oil fields, tank farms and refineries. Particularly, the emulsions separated from the crude oil produced with steam injection cause the most serious pollution. According to a study done by the Ministry of Energy and Energy Industries, the amount of oil discharged to the rivers and/or sea in 1988 is estimated at 210 bpd, or

equivalent to 0.14 percent of the oil production of that year, though this figure must be accepted with some reserve because such quantification is admittedly difficult. The study team estimated it to be 284 bpd on the basis of analyses of the oil content of river water and hydrometric data. This figure must also be accepted with reserve.

The petroleum pollution affects the country's natural bio-diversity. Mangrove forests are reportedly at risk at certain locations along the coast of the Gulf of Paria and other coasts. The mangrove forests must be valuable resources for the tourism and fishery industries, both being promising industries for achieving diversification of the economy. The coral reef of Tobago Island and the mangrove forest at Caroni Swamp, to the south of Port of Spain, are two important tourism resources that must be preserved. Oil pollution also adversely affects yields of certain agricultural crops. More fertilizers and pesticides are reportedly needed to maintain the standard yields in the affected areas. The loss suffered by agriculture is compensated for by cash payments. This is a band-aid approach in view of the fact that the nation wishes to promote self-sufficiency of food supply and export of agricultural products other than sugar, and of the fact that the farmers are demanding higher compensation.

4-5-2 Environmental Protection Policy

Besides petroleum pollution, Trinidad and Tobago has been facing serious environmental problems: hazardous liquid and solid wastes, air pollution in urban areas, forest destruction that occurs especially in the Northern Range. The environmental administration is carried out by 28 institutions backed by 40 pieces of legislation. The central organization is the Environmental Division of the Ministry of Planning and Development. In addition, the Town and Country Planning Division of the same ministry has authority to evaluate and to approve plans for constructing factories, roads and buildings. For some specified industries, submission of an environmental assessment report is mandatory at the time of application for approval. Although an administrative and legal framework is being formed, the nation's environmental administration is short of fulfilling its valid functions, because of the absence of regulations that can be enforced on the activities that cause pollution, and shortage of staff equipped with sufficient knowledge in environmental protection.

The government emphasizes the conservation and safeguarding of the environment in the Medium Term Policy Framework. As the first step of the government's principal strategy for environmental conservation, the Environmental Management Agency (EMA) responsible for overall environmental administration will soon be established. The establishment of the EMA

will improve the current complicated environmental management system.

Presently, in Trinidad and Tobago, there is no regulation for air pollution, water pollution, no definition of hazardous wastes. In the petroleum sector, the Ministry of Energy and Energy Industries prepared draft regulations on oil and grease in 1989, which specifies a monthly average of 50 ppm for effluent water from oil fields and refineries. The proposed standard of 50 ppm maximum oil and grease was prepared under the assistance of the Environmental Protection Agency of the United States and with reference to the standards of neighboring oil producing countries. The proposed standard was scheduled to be enforced in 1990. However, it has not been rigorously enforced yet, because Trintoc and Trintopec, now merged into Petrotrin, the state-owned oil companies, did not agree with the 50 ppm standard on the ground of technical difficulties. AMOCO and TRINMAR reportedly said that they would be able to comply with the standard, because the crude oils they produced were relatively easy to separate from water.

Formulation of environmental regulations and standards will be a priority mission of the EMA. This work will start this year under the World Bank's financial assistance (Business Expansion and Industrial Restructuring Loan). The establishment of a monitoring system is also an important task of the EMA. The monitoring system will be a cooperative undertaking led by the EMA, but involving other governmental organizations and the industrial sector due to limitation of the budget and manpower of the EMA, while its details are yet to be disclosed. In establishing the monitoring system, those which are being carried out at the three pilot areas of the Point Lisas Industrial Estate, in the southwestern part of Tobago Island and Chaguaramas in the northwestern highland, will be referred to.

The government fully recognizes the importance of global partnership, and intends to obtain proper assistance from more advanced countries. The government also wishes to cooperate with its regional partners in proceeding with environmental protection measures.

4-6 Petroleum Sector Policy, Projects and Programs

Petroleum and natural gas have been critically important in the economy of the nation and will be so for many years to come. The basic policies for the petroleum and natural gas sector are to revitalize the exploration and production activities and to promote utilization of the natural gas resources. The basic strategy for implementation of the above policies is to encourage foreign investment and to reduce the country's direct investments in high-risk capital intensive activities such as off-shore exploration and petrochemicals production. In this context, several important

reforms including a new petroleum taxation regime have been introduced.

The existing state-owned enterprises are undergoing rationalization to enhance efficiency. The biggest event in this direction was the establishment of Petrotrin at the end of 1993 by a merger of Trintoc and Trintopec. The country intends to revitalize idle wells (mainly shallow ones) by transferring mining concessions from Petrotrin to small companies whose administration costs are low. This should contribute to increasing oil production and employment opportunities.

In the area of exploration and production, many projects are being promoted by foreign companies. Major projects and foreign partners are as follows:

- Southern Basin Consortium (Exxon/Chevron/Total)
- Caroni Basin Consortium (Anderman Smith/Shell)
- E&P Licenses for Block 89/3 (Unocal)
- South-East Offshore (Mobil)
- Deep Samaan (AMOCO)
- Dolphin Field (British Gas/Texaco)
- TRINMAR Waterflood Project (Texaco)
- Petrotrin Heavy Oil Project

Completion of a 500,000 metric-ton-per-year methanol plant at Point Lisas in 1993 represents a major development in the natural gas downstream sector. The owner of this plant, the Caribbean Methanol Co., is a joint venture comprising a local insurance company, CLICO (Colonial Life Insurance Company), Ferrostaal and Helm, and Metallgesellshaft. Construction of another methanol plant by the investment of Ferrostaal and Helm of Germany is projected; the completion of this plant will make Trinidad and Tobago the world's largest methanol exporter. The country will also become the world's first exporter of iron carbide, which liberally uses natural gas in the production process, on completion of Nucor Plant now under construction at Point Lisas.

The biggest project in the energy sector is the proposed construction of a 400-million-cubic-feet-per-day (MMCFD) liquefied natural gas (LNG) plant, intended to export gas to the Northeastern United States. It is still in a preliminary feasibility study stage. The principal gas source for this project will be the reservoirs in the east coast marine area. The investment cost is estimated to be US$ one billion. This project will contribute not only to securing stable foreign currency earnings but also to increasing employment opportunities. The government expects that this project could provide 3,000 jobs in construction at peak, and 300 direct permanent jobs on

completion.

In the transportation sector, replacement of gasoline by compressed natural gas (CNG) has been investigated. Right now, a small amount of CNG is used as automobile fuel, because only 10 CNG filling stations have been set up. However, there is a tremendous opportunity for foreign currency earning by exporting replaced gasoline if the majority of vehicles are switched to CNG. Further, CNG has an advantage in that it is by far the cleaner and environmentally more desirable fuel.

In addition to the above, there is a plan to produce MTBE from methanol and iso-butylene. However, at present, it is questioned whether this project is realistic due to supply limitation of iso-butylene.

As for the environmental protection, the government has a plan to phase down the lead content of gasoline.