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PEOPLE'S DEMOCRATIC REPUBLIC OF YEMEN
STUDY
ON
THE IMPROVEMENT OF MA'ALLA AND TAWAHI SEWERAGE SYSTEM IN ADEN

FINAL REPORT

VOL. 1
SUMMARY

JANUARY, 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

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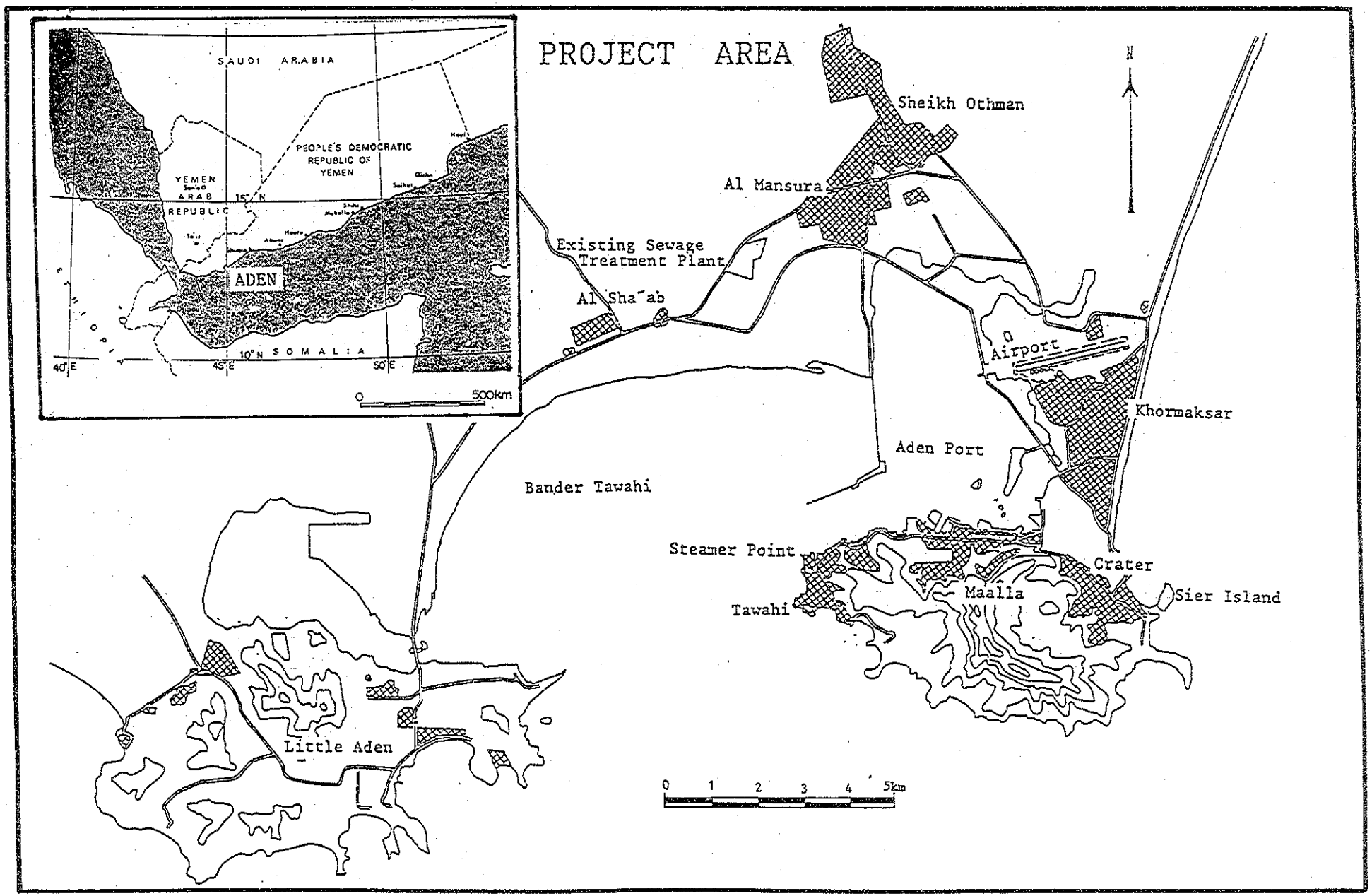
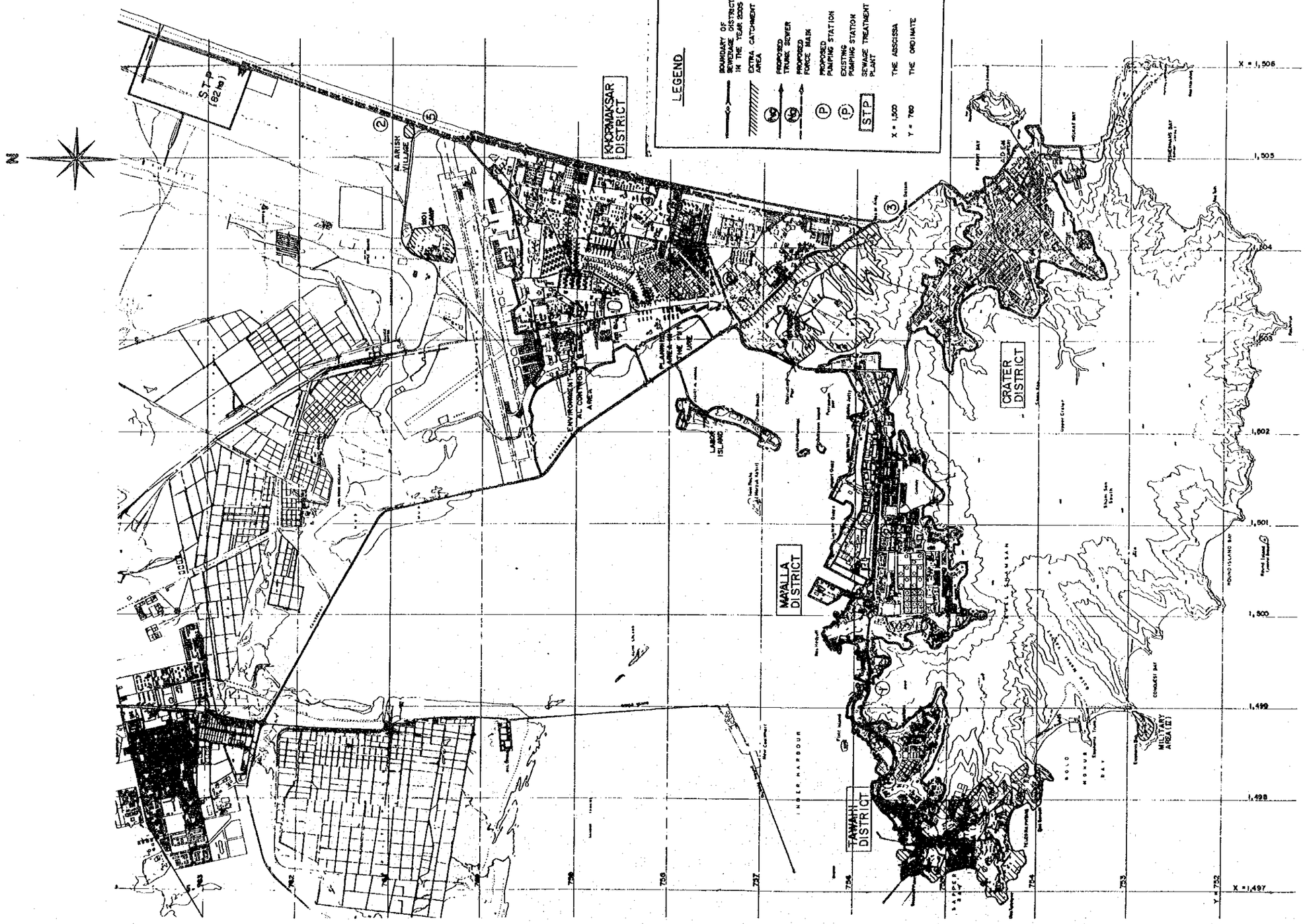

PROJECT AREA
SAUDI ARABIA
PEOPLE'S DEMOCRATIC REPUBLIC OF YEMEN
YEMEN ARAB REPUBLIC
ADEN
ETHIOPIA
SOMALIA
15°N
10°N
40°E
45°E
50°E
0 500km
N
Sheikh Othman
Al Mansura
Existing Sewage Treatment Plant
Al Sha'ab
Airport
Khormaksar
Aden Port
Bander Tawahi
Steamer Point
Crater
Maalla
Tawahi
Sier Island
Little Aden
0 1 2 3 4 5km



FEASIBILITY STUDY ON THE IMPROVEMENT OF MA'ALLA AND TAWAHI SEWERAGE SYSTEM	DATE: JAN. 1990	JICA
SEWERAGE GENERAL PLAN	SCALE: 1 : 20,000	DRAWING NO: 1

STUDY

ON

THE IMPROVEMENT OF MA'ALLA AND TAWAHI

SEWERAGE SYSTEM IN ADEN

IN

PEOPLE'S DEMOCRATIC REPUBLIC OF YEMEN

FINAL REPORT

CONSTITUENT VOLUMES

VOLUME ONE	SUMMARY REPORT
VOLUME TWO	MAIN REPORT
VOLUME THREE	APPEDICES
VOLUME FOUR	DRAWINGS

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ABBREVIATION

Agencies

ABC	Aden Bunkering Company
AFESD	Arab Fund for Economic and Social Development
ANA	Aden News Agency
ARC	Aquaculture Research Center
CSO	Central Statistical Organization
DANIDA	Danish International Development Agency
GDLG	The General Directorate for Local Government
HA	Highway Authority
IMF	International Monetary Fund
JICA	Japan International Cooperation Agency
JTS	John Taylor & Sons Consulting Civil Engineers
MOC	Ministry of Construction
MOF	Ministry of Finance
MOFA	Ministry of Foreign Affairs
MOFW	Ministry of Fish Wealth
MOP	Ministry of Planning
NCEP	National Council of Environmental Protection
PCEP	Public Corporation for Electric Power
PDRY	People's Democratic Republic of Yemen
PSF	Price Stabilization Fund
PWC	Public Water Corporation
UNDP	United Nations Development Program
UNICEF	United Nations International Children's Emergency Fund
WPCF	Water Pollution Control Federation
YPA	Yemen Port Authority
YTC	Yemen Telecommunication

Technical Terms

STP	Sewage Treatment Plant
P/S	Pumping Station
B.M.	Bench Mark
T.B.M.	Temporary Bench Mark
BOD	Biochemical Oxygen Demand

COD	Chemical Oxygen Demand
T-P	Total Phosphorus
T-N	Total Nitrogen
NH_4-N	Ammonia Nitrogen
K-N	Kjeldahl Nitrogen
pH	The reciprocal of the logarithm of the hydrogen-ion concentration
DO	Dissolved Oxygen
SS	Suspended Solids
TS	Total Solids
MPN	Most Provable Number
ACP	Asbestos Cement Pipe
DCIP	Ductile Cast Iron Pipe
PVC	Polyvinyl Chloride Pipe
RCP	Reinforced Concrete Pipe
VCP	Vitrified Clay Pipe

Units

km	Kilometer
m	Meter
cm	Centimeter
mm	Millimeter
ft	Foot, Feet
in or "	Inch
km^2	Square Kilometer
ha	Hectare
m^2	Square Meter
cm^2	Square Centimeter
m^3	Cubic Meter
l	Liter
ml	Milliliter
cm^3	Cubic Centimeter
g	Gram
mg	Milligram

lcd	Liter per Capita per Day
gcd	Gram per Capita per Day
mg/l	Milligram per Liter
ppm	Part per Million
y	Year
d	Day
hr	Hour
min	Minute
sec	Second
a.m.	Ante Meridiem
p.m.	Post Meridiem
V	Volt
kV	Kilovolt
W	Watt
kW	Kilowatt
kWh	Kilowatt Hour
US$	US Dollar
YD	Yemen Dinar
Fils	1/1,000 Dinar
JY	Japanese Yen
DM	Deutsche Mark

Others

C&A	Civil and Architectual
M&E	Mechanical and Electrical
DPS 2010	Development Pricipal Scheme for the Year 2010

1. INTRODUCTION

1.1 PROJECT BACKGROUND

In 1988 the Government of the People's Democratic Republic of Yemen (PDRY) requested the Government of Japan to conduct a study on the improvement of Ma'alla and Tawahi sewerage systems in Aden (the Study) in order to improve the aging system in the area.

In response to the official request of the Government of PDRY, the Government of Japan decided to carry out the Study, and Japan International Cooperation Agency (JICA), an agency responsible for implementation of technical cooperation programs of the Government of Japan, undertook the Study in close coordination with the PDRY government authorities concerned, according to the Scope of Work signed on 17th July, 1988.

The General Directorate for Local Government (GDLG) acts as the counterpart agency to the Japanese study team organized by JICA and also as a coordination body in relation to other relevant organizations for smooth implementation of the Study.

1.2 OBJECTIVES OF THE STUDY

The objectives of the Study are to formulate a master plan of a sewerage system in the Ma'alla, Tawahi, Crater and Khormaksar districts in Aden and to carry out a feasibility study for the improvement of Ma'alla and Tawahi sewerage systems.

1.3 SCOPE OF THE STUDY

The scope of the study will cover the following.

(1) Study Area: The Study area covers the four districts, viz. Ma'alla, Tawahi, Crater and Khormaksar.

(2) Target Years: The target year for the long term program is the year 2010, and that for the first phase program is 2000.

(3) Contents of the Study: The Study comprises field surveys and data collection in PDRY and analysis work in PDRY and in Japan. More specifically it includes; i) data collection and analysis, ii) formation of the basic concept, iii) survey, and iv) a feasibility study.

1.4 UNDERTAKING OF THE STUDY

The Government of Japan, through JICA, has taken necessary measures to dispatch the study team to PDRY and effect technology transfer to the PDRY counterpart personnel in the course of the Study. The study team commenced the work on 22nd November, 1988 and from the beginning of December, undertook surveys, discussions with PDRY authorities concerned, field investigations, and analyses of data collected in Aden until 12th March, 1989. The results of the activities are presented in the Interim Report, which was submitted to GDLG in June, 1989.

The second on-site survey was conducted from June to September, 1989. The Draft Final Report, which contains all the study items, was submitted to GDLG in November, and discussions on the Report were held in Aden in December, 1989. The Final Report was completed in January, 1990 reflecting conclusions for the discussions.

1.5 REPORTS AND DOCUMENTS PREPARED

A number of reports have been prepared and submitted to GDLG during the period of the Study, either in the form of draft or interim, covering all the work performed under the Study. All reports culminate in the Final Report which is composed of the following four volumes.

(1) Volume One SUMMARY REPORT
(2) Volume Two MAIN REPORT
(3) Volume Three APPENDICES
(4) Volume Four DRAWINGS

2. PRESENT CONDITION OF THE STUDY AREA

2.1 PHYSICAL CHARACTERISTICS OF THE AREA

(1) Greater Aden, the capital of PDRY and the mainland part of the Aden Governorate, occupies the south-western corner of the Arabian Peninsula. It faces Africa through the Bab-al-Mandab Strait, south of the Red Sea. The city lies at longitude 45° 02" east and at latitude 12° 50" north, at Khormaksar.

(2) The most important topographic component is Tawahi Bay. To the north and northeast of Greater Aden, are major areas of flat sand dunes. In the west and the south of Greater Aden there are mountainous areas. The study area, consisting of the four districts, viz. Ma'alla, Tawahi, Crater and Khormaksar, occupies the eastern and southern part of Greater Aden. Crater is the oldest district and is built on the rocky remains of a former crater. Ma'alla and Tawahi have developed on a littoral road with ground level from +10.3 m to 4.5 m above mean sea level. Most of the available land in the above districts have already been used up. Khormaksar is built on the tongue of sand linking the former island to the continent, and the ground level varies from +2.7 m to 3.7 m above mean sea level.

(3) The Aden Trap series is part of an extensive elongated outcrop of volcanic rocks associated with the Red Sea and Abyssinian rifts. The association of volcanicity with the east African rift system, with the west Arabian (Red Sea) and Levantine rifts, and with rifting in other regions is well known. The geology of PDRY is broadly divisible into three parts, and Greater Aden is included in the southwest part which is a structurally depressed area, mainly covered by volcanic rocks of the Aden Trap Series.

(4) Greater Aden area is situated within the seashore strip of Afro-Asian climatic region of the tropical-zone of northern hemisphere. General climatic conditions in Aden are summarized below.

a. High temperatures throughout the year with small seasonal differences, with maximum and minimum mean daily temperatures of 36.4° C in June and

22.8° C in November respectively.

b. High relative humidity, with the lowest mean of 66 % in July and the highest mean of 75 % in April.

c. Scarcity of rainfall with average annual rainfall of 68 mm.

d. Relatively stable seasonal wind, with the prevailing wind directions in winter being eastward and southward to westward in summer, with transition periods in October/November and April/May.

2.2 SOCIO-ECONOMIC CONDITION

(1) PDRY is one of the least developed countries (LLDC) in the world, with per capita GNP of US$ 480 in 1986. The economy of PDRY is dualistic in nature, with a modern sector, i.e. refinery, port and industries, centered around Aden, and a traditional subsistence sector, i.e. agriculture and fishing along the coastal areas.

The gross domestic product (GDP), both at factor and 1985 constant prices, in five recent years are as shown in Table 2.1 below.

Table 2.1 Change in Gross Domestic Product

(unit: YD million)

	1983	1984	1985	1986	1987
GDP (factor cost)	289.6	320.9	320.3	291.6	308.1
increase (%)	10.5	10.8	-0.2	-9.0	5.7
GDP (constant price)	308.5	316.2	313.0	282.5	290.2
increase (%)	3.5	2.5	-1.0	-9.7	2.7

(2) Development planning for PDRY was first initiated in the three-year development plan which covered April 1971 to March 1974. It was then

followed by successive five-year plans extending from April 1974 to December 1978, 1981 to 85 and 1986 to 1990. The last two five-year plans placed priority on productive sectors such as agriculture, fisheries and industries. Sectoral allocations of development expenditures on actual basis are shown in Table 2.2 below.

Table 2.2 Sectoral Allocation of Development Expenditures

(Unit: YD million)

	1974-80		1981-85	
	Actual	%	Actual	%
Agriculture	72.7	23.0	84.4	12.4
Fisheries	35.9	11.3	37.4	5.5
Industry	24.3	7.6	20.6	3.0
Power	13.0	4.1	102.0	15.0
Oil/Mineral	15.7	5.0	63.1	9.2
Construction	11.0	3.5	13.2	1.9
Trans/Communication	76.0	24.0	152.4	22.3
Trade	3.5	1.1	33.6	4.9
Water Supply	2.2	0.7	28.5	4.2
Social Services	62.3	19.7	147.5	21.6
Total	316.6	100.0	682.7	100.0

Source: Statistical Year Book 1985-1986,
Central Statistical Organization

(3) For the third five-year plan which is now underway, priority is given to the geological and mineral resource survey sector so as to further tap natural resources, particularly oil exploration and to earn necessary foreign exchange. Sectoral allocations under the current five-year plan are shown in Table 2.3.

Table 2.3 Third Five-Year Plan, 1986-90

(Unit: YD million)

	1986	1987	1988	1989	1990
Agr/Fish	19.5	19.7	18.8	16.4	15.5
Ind/Pow/Oil	42.3	43.1	35.3	24.5	19.0
Geol/Min	14.4	20.1	22.9	21.3	24.3
Com/Cons	34.0	33.1	26.7	23.9	20.3
Social	36.8	31.8	19.3	17.5	11.8
Total	147.0	147.8	123.0	103.6	90.9

Source: Ministry of Planning

(4) Because of the scarcity of the domestic resources, the country is highly dependent on external resources for development expenditures. Foreign resources cover nearly one half of the total development expenditures from 1983 to 1987 as shown in Table 2.4 below. As a result of considerable borrowing, the long term external debt has increased from US$ 945 million in 1983 to US$ 1,658 million in mid 1988. Bilateral aid constitutes more than 70 % of the long term debt, of which the main donors are U.S.S.R. (more than 50 % of the external debt) and China (8 %), whilst the rest is from international organizations, viz. the World Bank and Arab Fund for Economic and Social Development. The debt service ratio rose to 15.8 % in 1987. Nevertheless, according to the Bank of Yemen, the external loans have been made available with an average interest rate of just 2 %. Therefore, the debt service obligations have still remained manageable.

Table 2.4 Source of Development Expenditures: 1983-1987

(Unit: YD Thousand)

	1983	1984	1985	1986	1987
Total Exp.	149,400	158,800	131,900	102,900	114,900
Domestic:	79,900	92,200	70,600	45,300	45,400
Govt Resources	60,900	64,500	48,300	38,400	38,400
Banking System	8,600	19,400	17,000	3,200	2,600
Self-financing	10,400	8,300	5,300	3,700	4,400
Foreign:	69,500	66,600	61,300	57,600	69,500
(% of Total)	(46.5)	(41.9)	(46.5)	(56.0)	(60.5)

Source: Ministry of Planning

(5) Development outlay for fiscal 1986 decreased to YD 102.8 million from YD 132.1 million for 1985. It then recovered slightly to YD 114.9 million in 1987. As for sectoral allocation of development expenditures for fiscal 1987, power development received the largest portion, with more than 20 %, followed by mineral survey (17 %), social service (15.2 %), transport (14.8 %) and agriculture sector (13.0 %). Over the last three years, mineral survey and power sector expenditures have increased rapidly while transport/communication and social service sectors, in which sewerage and water supply are included, have declined substantially. Development expenditures by economic activities are given in Table 2.5.

Table 2. 5 Investment Expenditures

(Unit: YD Thousand)

	1985	1986	1987
Agriculture	14,000	11,300	14,900
Fishery	2,000	2,300	5,800
Industry	2,600	2,300	3,600
Mineral Survey	12,600	11,300	19,500
Power	23,500	33,100	27,100
Water Supply	6,500	4,900	7,600
Oil refinement	10,400	600	0
Construction	2,400	200	100
Trade/Hotel	4,600	1,400	1,800
Transport/Com	24,800	14,200	17,000
Social Service *1	28,700	21,200	17,500
Total	132,100	102,800	114,900

Note: *1) Sewerage sector investments are included.

Source: Ministry of Planning

2.3 POPULATION AND LAND USE

(1) The last population census was carried out in 1988, 15 years after the previous census in 1973. Population in the four districts, Greater Aden, Aden Governorate and PDRY as a whole from the last two census is shown in Table 2.6. As shown in the table, the total Aden Governorate population increased from 291,376 in 1973 to 418,755 in 1988. On the other hand, in the four districts, population increased from 132,517 in 1973 to 151,602 in 1988. Annual growth rates for Aden Governorate and the four districts over the 15 year period are 2.4 % and 0.9 % on an average, respectively. Because of lower growth rates in the four districts, the ratio of the population in the four district in the entire governorate population decreased from 45 % to 36 % over the same period.

Table 2. 6 Census Records

District	Population 1973	Population 1988	Annual Growth Rate (%)
Ma'alla	47,044	53,404	0.85
Tawahi	16,444	18,815	0.90
Crater	54,261	59,725	0.64
Khormaksar	14,768	19,658	1.93
Sub-total	132,517	151,602	0.90
Greater Aden	240,370	-	
Aden Governorate	291,376	418,755	2.4
PDRY Total	1,590,275	2,345,266	2.6

(2) The total area of Greater Aden is 49,088 ha, of which built-up areas account for 5,032 ha in 1980. The rest of the land consists mostly of noninhabitable areas such as sand dunes and mountains. Agricultural area and various kinds of military facilities are included in the rest. According to a study for Development Principal Scheme for 2010 (DPS 2010) by the Ministry of Construction, the four districts are already fully

developed, and there is little land for further development. This is mainly because of the topographic condition of the districts. Therefore, spatial expansion of the four districts is not envisaged except for limited land reclamation in Khormaksar. Future urbanization will extend to other districts outside the four districts.

2.4 PUBLIC HEALTH CONDITION

Incidence of infectious diseases in Greater Aden is still at a high level, suggesting unsatisfactory sanitary conditions in the area. The ratio of reported number of water borne infectious diseases per 1,000 population in 1987 in Greater Aden are as follows.

Dysentery	479
Typhoid and Paratyphoid	2
Infectious Hepatitis	25
Enteritis and Others Diarrhoeal Diseases	23
Bilharzia	13

2.5 WATER SUPPLY

(1) The water supply system in Greater Aden has a long history, and is well developed. Water supply systems developed individually in the past have been combined and linked to each other, and now form an integrated Greater Aden water supply system. At present, all the residents in Greater Aden are supplied with piped water. Water supply facilities are maintained satisfactorily by Public Water Corporation (PWC).

(2) The source of the water supply in Aden is limited to groundwater which is taken from aquifer of wadis. Scarcity and limitation of available groundwater resources will be the most serious problem in the future. The latest Water Supply Master Plan prepared by a British Consultant estimated overall per capita water consumption in 1978 and 1984 to be 125 lcd and 132

lcd, respectively, while in the four districts, average water consumption in 1984 was 163 lcd.

(3) The Master Plan projected the per capita water demand in Greater Aden in 1995 and 2010 to be 267 lcd and 281 lcd, respectively. Based on the water demand projection, development of new water resources by exploitation of groundwater and desalination of sea water is recommended. Improvement of transmission mains, distribution networks and related facilities are also recommended by the Master Plan. At present, Stage 2 Project, upto 1995, is underway.

2.6 SEWERAGE SYSTEM AND WASTEWATER DISPOSAL

(1) The General Directorate for Local Government (GDLG), one of the member bodies of the Council of Ministries under direct control of the Prime Minister's office, is responsible for sewerage projects in PDRY at the national level. Sewerage and public health projects were under the purview of the Municipal Department, which is one of the five departments in GDLG. Planning and implementation of the sewerage projects in major urban areas in PDRY are executed directly by GDLG.

In each of the six Governorates in PDRY, People's Local Councils (PLC) have been established. PLC administers local affairs through its execution office, i.e. the Governorate Office. The Aden Capital Municipality, one of the three organizations under executive control of PLC, is responsible for operation and maintenance of the sewerage system in Greater Aden.

(2) In Aden, the Sewerage and Drainage Works Ordinance of the Aden Municipality, which was enacted in 1955 before independence, is still effective at present. The fact that the British Army had to complete the modern sewerage system in Aden during their colonial rule was reflected in the character of this Ordinance. However, the contents of this Ordinance cover all the necessary regulations to execute all sewerage works. Collection of sewerage service charge is also prescribed in the Ordinance.

At present, there is a wide recognition among the authorities concerned to

enact a new sewerage law and to review the Ordinance. A draft of a new the sewerage act was prepared in 1982, and discussion is continuing. It is proposed in the draft that local governments be made responsible for construction, operation and maintenance of sewerage systems. Collection of sewerage charge is also to be considered. A socio-economic study for the improvement of the institutional and legal arrangements is currently under way by GDLG. Meanwhile, Resolution 59/81 of the Council of Ministers directed PLC to establish a water and sewerage department in its Governorate Office. However, this resolution has not yet been fully realized.

(3) Aden is provided with water-borne sewerage system, which had been the only one modern sewerage system in the major urban areas in PDRY until a sewerage system in Mukalla was completed in 1988. The oldest sewerage system was constructed in Crater in the 1940s. In 1957, sewerage systems in Ma'alla and Tawahi were constructed. In 1963, overall improvement work was carried out in Crater and a new sewerage system was constructed in Khormaksar. The existing sewerage facilities in the four districts were shaped in the present form in the 1960s. At present, most of the residents in the four districts, except for those living in limited unsewered areas, are provided with sewerage service. Sewerage facilities in the four districts are summarized in Table 2.7.

Table 2.7 Outline of Existing Sewerage Facilities

Disrtict	Planning Area (ha)	Sewer Dia. (mm)	Length (m)	Material	Pumping Station	Sweeper Passage	Length(m)	Ocean Outfall
Ma'alla	279	150-400	19,780	ACP CIP VCP CP	4	53	2,704	1
Tawahi	87	150-225	6,988	ACP CIP VCP	7	78	2,511	5
Crater	235	100-750	6,770	ACP	2	-	-	1
Khormaksar	418	100-400	17,822	ACP	17	-	-	1

(4) According to the observations made by Aden Municipality and field investigations made by the study team, the per capita quantity and characteristics of the sewage in the four districts were estimated as follows.

Per capita sewage flow:	118	lcd
BOD concentration:	324	mg/l
Per capita BOD loading:	38.2	gcd
SS concentration:	263	mg

Based on the average sewage flow and the present population, total sewage flow in the four districts is calculated to be approximately 17,900 m3/d on a daily average basis.

(5) Collected sewage is disposed of by means of sea outfall without any treatment, resulting in water pollution of the receiving waters. The Inner Harbor of Tawahi Bay, into which raw sewage from Ma'alla and Tawahi districts are discharged, is particularly polluted. The nuisance caused by the deficiencies in the existing system has produced complaints from the harbor and other authorities and shortcomings in the system are detrimental to the development of tourism and trade and thus affect the potential for earning foreign currency.

(6) Many of existing pumping stations in the four districts are in very bad condition because of deteriorating mechanical equipment and structures. These pumping stations need to be rehabilitated. In addition, high temperature, sediments in sewer pipes and various unfavorable local conditions are the causes of hydrogen sulphide gas generation resulting in damage to concrete and steel structures. Sewer pipes and manholes at many locations that are subject to hydrogen sulphide build up are badly damaged. Some of them need immediate replacement.

3. PLANNING CONSIDERATIONS

3.1 STUDY AREA

As defined under the Scope of Work for the Study, the study area for the long term program up to 2010 encompasses the four districts in Greater Aden, viz. Ma'alla, Tawahi, Crater and Khormaksar. The study area for the feasibility study was initially limited to Ma'alla and Tawahi districts when the study commenced. However, Khormaksar was added later in the course of the study by an amendment to the Scope of Work.

The areas to be served by the sewerage system by 2010 are essentially the same as the urbanized areas envisaged in DPS 2010, prepared by the Town Planning Section of the Ministry of Construction. Most of the urban areas in the study area have already been developed. A sizable area that is presently seashore in Khormaksar, east of the causeway up to the airport is reserved for future residential area and environmental control zone. Future residential area is to be reclaimed and developed at a later stage. This area is included in the planning area. A part of the environmental control zone will not be developed by 2010.

Various areas outside of the planning area which will discharge sewage into the planning area are defined as extra catchment areas. Design of a sewerage system in the extra catchment area is out of scope of the study. However, sewage flow from these areas are included in the design of sewerage systems in the planning area.

The total planning area in the four districts is 1,105 ha, of which 86 ha is undeveloped area in Khormaksar. Extra catchment areas total 421 ha. Planning areas and extra catchment areas in the four districts are shown in Table 3.1.

Table 3.1 Planning Areas for the Study

District	Planning Area (ha) Sewerage System	Future Land Reclamation	Extra Catchment Area Military or Police Camp	Others
Ma'alla	279	-	-	-
Tawahi	87	-	119 *1	-
Crater	235	-	-	-
Khormaksar	418	86	181 *2	121 *3
Total	1,019	86	300	121

Note *1: Military camps are located outside the sewerage planning area.
*2: Components of the area are;
Badr Camp 102 ha (inside the sewerage planning area)
Tareq Camp 62 ha (inside the sewerage planning area)
Police Camp 17 ha (outside the sewerage planning area)
*3: Components of the area are;
Isthmus Camp 118 ha (outside the sewerage planning area)
Al Arish Village 3 ha (outside the sewerage planning area)

3.2 POPULATION PROJECTION

From a study on population projections made by various studies, it is considered appropriate that population projection for sewerage project be based on the projection made by DPS 2010. Population expected in new housing developments approved after establishment of DPS 2010 is added as an increment.

Review of land use plan by DPS 2010 revealed that relatively large areas are earmarked for institutional purposes where various kinds of public organizations will be established in the study area, particularly in Khormaksar. For the sewerage plan, population equivalence for these public

organizations has been considered in order to estimate sewage flow from them.

Population and population equivalence for the sewerage plan are shown in Table 3.2 below.

Table 3.2 Population Projection for Sewerage Planning

District	Firt Phase Program (2000)			Long Term Program (2010)		
	Residential Population		Population Equivalence for Public Organization	Residential Population		Population Equivalence for Public Organization
	DPS 2010	New Development		DPS 2010	New Development	
Ma'alla	57,300	6,000	6,700	58,000	10,000	6,800
Tawahi	19,700	-	13,200	20,000	-	13,400
Crater	73,100	-	4,200	77,000	-	4,300
Khormaksar	20,000	-	20,600	21,000	-	20,800
Total	170,100	6,000	44,700	176,000	10,000	45,300

3.3 SEWAGE QUANTITIES AND CHARACTERISTICS

Sewage quantities for the plan have been estimated, based on the latest water supply master plan and information obtained from PWC. The sources of sewage is classified into three categories, viz. domestic, public organizations and others. Domestic sewage includes sewage from households and community facilities, such as schools, small shops and etc. Sewage from public organizations is calculated separately, based on population equivalence. Others include sewage from various extra catchment areas. In addition to these sewage flows, groundwater infiltration is considered in the specific area taking into account groundwater levels. Total sewage flow in the four districts by category is summarized in the following Table 3.3.

Sewage characteristics are based on the results of the water quality analysis conducted by the study team and recommendations made by WHO. Taking in to account a reasonable increment of waste loading resulting from increase of water consumption, sewage characteristics for the plan are determined as shown in Table 3.4.

Table 3.3 Total Sewage Flow

(unit: m3/d)

District	Category	First Phase Program (2000)			Long Term Program (2010)		
		Daily Average	Daily Maximum	Peak Flow	Daily Average	Daily Maximum	Peak Flow
Ma'alla	Domestic	9,495	10,445	18,990	12,240	13,464	24,480
	Public Org.	1,005	1,106	2,010	1,224	1,346	2,448
	Others	-	-	-	-	-	-
	Infiltration	-	-	-	-	-	-
	Total	10,500	11,551	21,000	13,464	14,810	26,928
Tawahi	Domestic	2,955	3,251	5,910	3,600	3,960	7,200
	Public Org.	1,980	2,178	3,960	2,412	2,653	4,824
	Others	900	990	1,800	900	990	1,800
	Infiltration	-	-	-	-	-	-
	Total	5,835	6,419	11,670	6,912	7,603	13,824
Crater	Domestic	10,965	12,062	21,930	13,860	15,246	27,720
	Public Org.	630	693	1,260	774	851	1,548
	Others	-	-	-	-	-	-
	Infiltration	-	-	-	-	-	-
	Total	11,595	12,755	23,190	14,634	16,097	29,268
Khormaksar	Domestic	3,000	3,300	6,000	3,780	4,158	7,560
	Public Org.	3,090	3,399	6,180	3,744	4,118	7,488
	Others	3,090	3,399	6,180	3,090	3,399	6,180
	Infiltration	3,145	3,145	3,145	3,145	3,145	3,145
	Total	12,325	13,243	21,505	13,759	14,820	24,373
Total	Domestic	26,415	29,058	52,830	33,480	36,828	66,960
	Public Org.	6,705	7,376	13,410	8,154	8,968	16,308
	Others	3,990	4,389	7,980	3,990	4,389	7,980
	Infiltration	3,145	3,145	3,145	3,145	3,145	3,145
	Total	40,255	43,968	77,365	48,769	53,330	94,393

Table 3. 4 Sewage Characteristics

(unit: mg/l)

BOD5	CODcr	CODmn	SS	NH4-N	T-P
250	550	110	200	46	10

3.4 ENGINEERING CONSIDERATIONS FOR SYSTEM PLANNING

Various kinds of feasible sewerage systems inclusive of conventional, vacuum, pressurized and small bore systems have been analyzed from technical and economic view points. The conventional system is recommended considering its high convenience level expected and present condition of the study area where the system has been operated and maintained for a few decades without any serious problems.

Consideration was given to modify the existing system to combined sewerage system. Although chances of rainfall is scarce and rainfall intensity is low, the capacity of most existing sewers is found to be insufficient to accomodate stormwater runoff. Existing sewer networks should, therefore, be utilized as sanitary sewers as they are at present, with necessary improvements, and storm water runoff should be treated separately.

Taking into account the water pollution in the Inner Harbor caused by raw sewage disposal from Ma'alla and Tawahi districts and opposition from public authorities concerned, sewage treatment is strongly recommended. Other benefits derivable from sewage treatment is reuse of the effluent for the green belt project. Reuse of the treated effluent will greatly contribute to preserve water resources which are very limited and scarce in Aden.

Stabilization pond process is recommended for the sewage treatment for the project considering the favorable climatic conditions and minimum requirements of mechanical and electrical equipment and electric power for operation.

4. LONG TERM PROGRAM

4.1 ALTERNATIVE SEWERAGE SYSTEMS

In order to select the most appropriate sewerage system for the the four district on long term basis, the following four alternatives have been considered. Four alternatives are shown in Figure 4.1, and a brief description is given below.

Alternative 1A Sewage collected from Ma'alla and Tawahi districts are disposed of by an ocean outfall from Steamer Point without treatment. Sewage collected from Crater and Khormaksar districts are treated at a stabilization pond treatment plant proposed to be constructed north of the airport.

Alternative 1B Sewage collected from Ma'alla and Tawahi districts are treated in an oxidation ditch treatment plant proposed to be constructed on a reclaimed area in front of the existing Hedjuff pumping station. Sewage collected from Crater and Khormaksar are treated as in Alternative 1A.

Alternative 2 Sewage collected from Ma'alla and Tawahi are sent to the site adjacent to the existing Al Shaab treatment plant. Treatment is by stabilization pond. Sewage collected from Crater and Khormaksar are treated in the same way as for Alternative 1A.

Alternative 3 Sewage collected from the four districts are sent to a treatment plant located at the same site for a treatment plant for Crater and Khormaksar districts in the above Alternatives. Stabilization pond process is recommended.

Direct construction costs for the four alternatives are estimated as shown below.

Construction Cost for Alternatives

(unit: YD 1,000)

Alternatives	1A	1B	2	3
Construction Cost	11,059	13,626	12,881	9,769

Alternative 3 is found to be the least cost sewerage system for the four districts. Consideration on other aspects such as effects on water pollution control and reuse of treated effluent enhances the advantages of Alternative 3. Thus, Alternative 3 is recommended for the long term program.

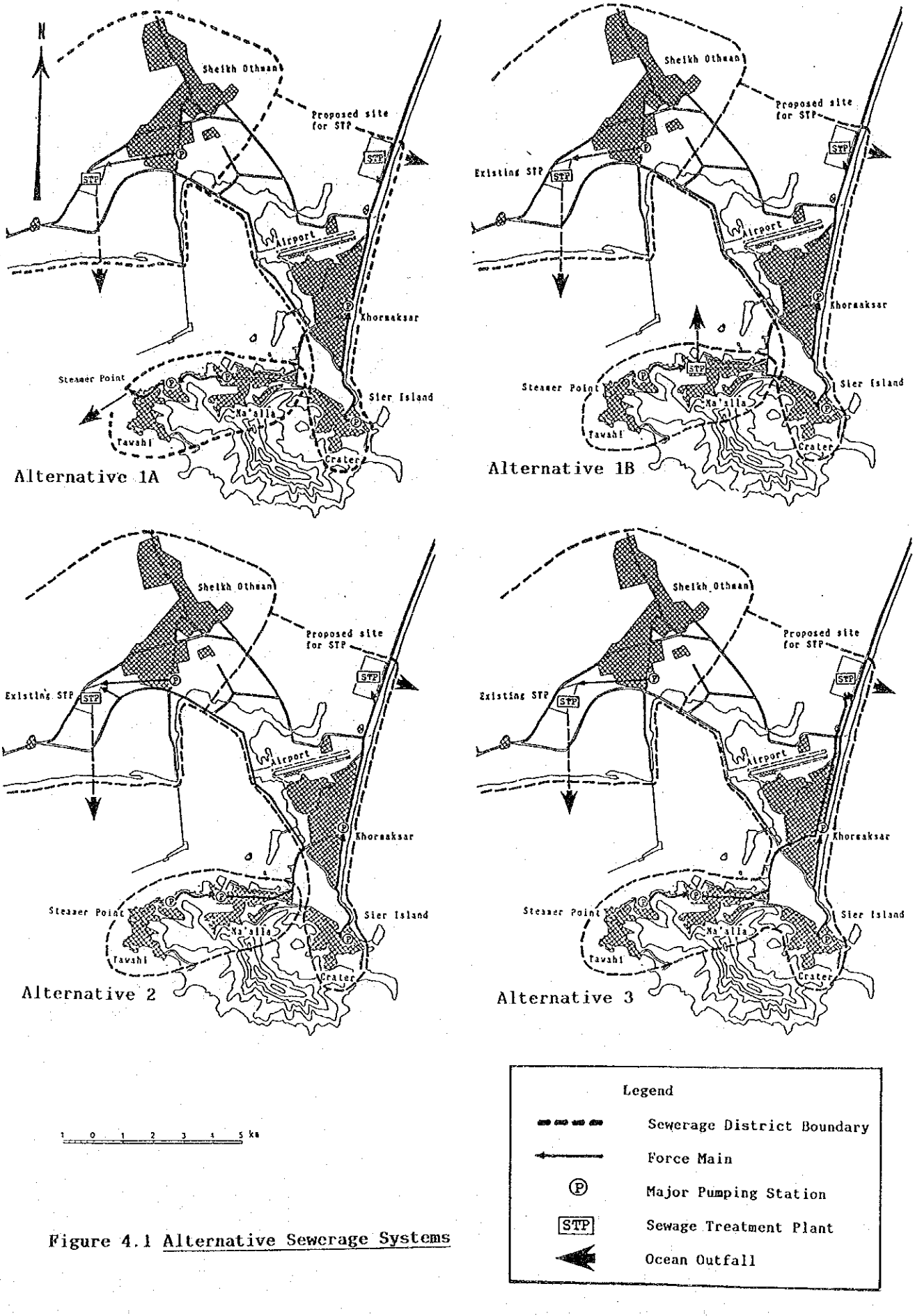


Figure 4.1 Alternative Sewerage Systems

4.2 PUMPING AND FORCE MAIN SYSTEM

A study on the alternative pumping and force main systems was conducted to select the least cost solution, since these two facilities are major components of the system and those costs account for more than half the total construction cost. Four possible systems mentioned below and illustrated in Figure 4.2 are considered.

Case 1 Multi-continuous Transfer System, Single Line

Case 2 Intermediate Transfer System, Single Line

Case 3 Multi-continuous Transfer System, Double Lines

Case 4 Intermediate Transfer System, Double Lines

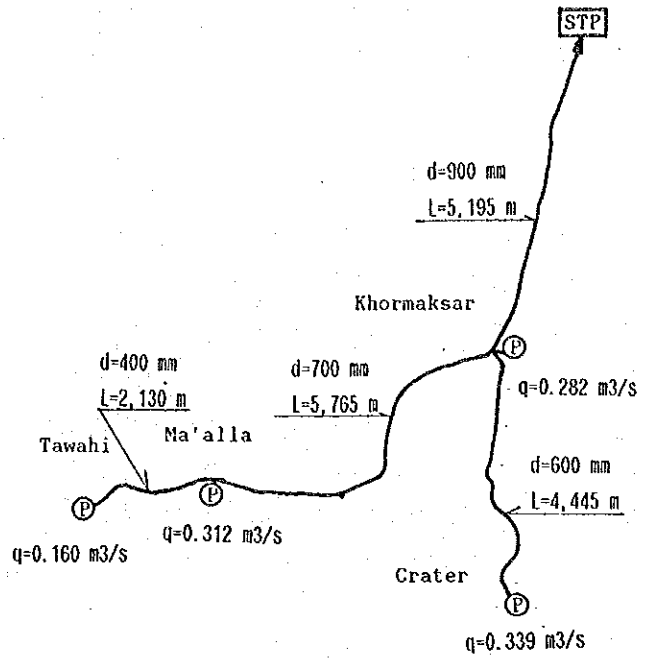
Direct construction costs for the four cases are estimated as shown below.

Construction Cost for Four Cases

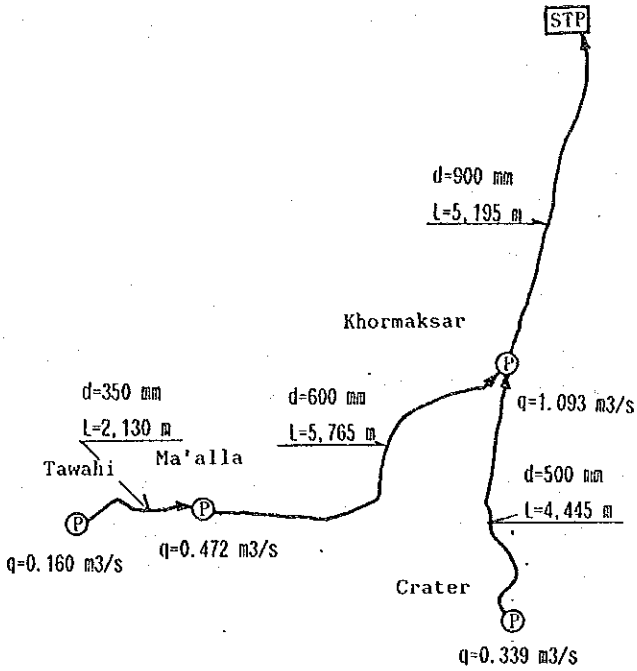
(unit: YD 1,000)

Cases	1	2	3	4
Long Term Cost	6,349	6,075	6,817	7,387
First Phase Cost	4,354	5,276	3,721	3,954

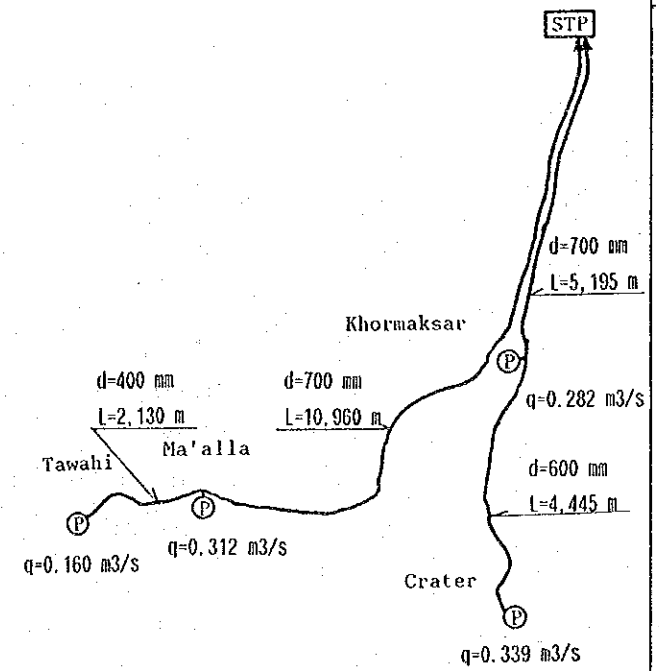
Considering the first phase construction cost, Case 3 or 4 is recommended for the project, and selection is left for the next stage of the project, although cost estimation is based on Case 3.



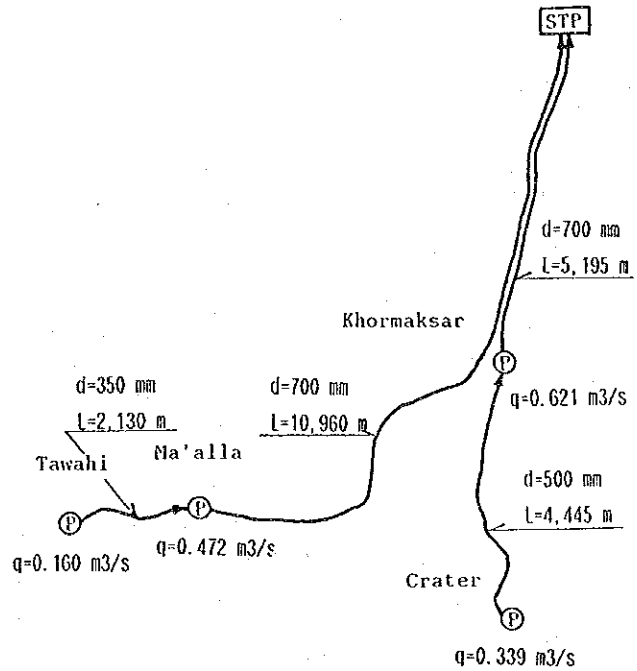
Case-1 Multi-continuous Transfer System, Single Line



Case-2 Intermediate Puming System Single Line



Case-3 Multi-continuous Transfer System, Double Lines



Case-4 Intermediate Puming System, Double Lines

Figure 4.2 Alternative Pumping and Force Main Systems

4.3 SEWERAGE FACILITIES TO BE PROVIDED UNDER LONG TERM PROGRAM

Based on the proposed sewerage system selected and studies on the existing sewerage systems, all the sewerage works to be provided under the long term program to satisfy conditions in the study area are identified as shown in Figure 4.3.

All the works under the long term program are classified into two categories, viz. major works and district works. Major works are defined as those for which it is necessary to pump and deliver sewage from the four districts to the proposed treatment plant. These are composed of four pumping stations, one in each district, a treatment plant and force mains to connect pumping stations and treatment plant. District works are defined as those which involve district networks. These works include replacement or new construction of gravity sewers, rehabilitation of existing pumping stations and improvement of sweeper passages. An outline of the sewerage facilities proposed is summarized below.

(1) Major Works

a. Sewage Treatment Plant

Process: Stabilization pond system with an anaerobic pond, a facultative pond and two stages of maturation ponds in series.

Capacity: 48,800 m3/d

Area: 816,000 m2

b. Pumping Stations

Name	Design Flow (m3/min.)	Pump Unit (number)	Total Head (m)	Pump Dia. (mm)	Motor Power (kW)
Tawahi	9.6	3	52	200	90
Ma'alla	18.7	3	40	250	120
Crater	20.3	3	43	250	140
Khormaksar	16.3	3	33	250	90

c. Force Main

Section	Pipe Dia. (mm)	Length (m)	Material
Tawahi P/S to Ma'alla P/S	400	2,130	DCIP
Ma'alla P/S to STP	700	10,960	DCIP
Crater P/S to Khormaksar	600	4,445	DCIP
Khormaksar P/S delivery	450	105	DCIP
Khormaksar to STP	700	5,195	DCIP
	(Total 22,835 m)		

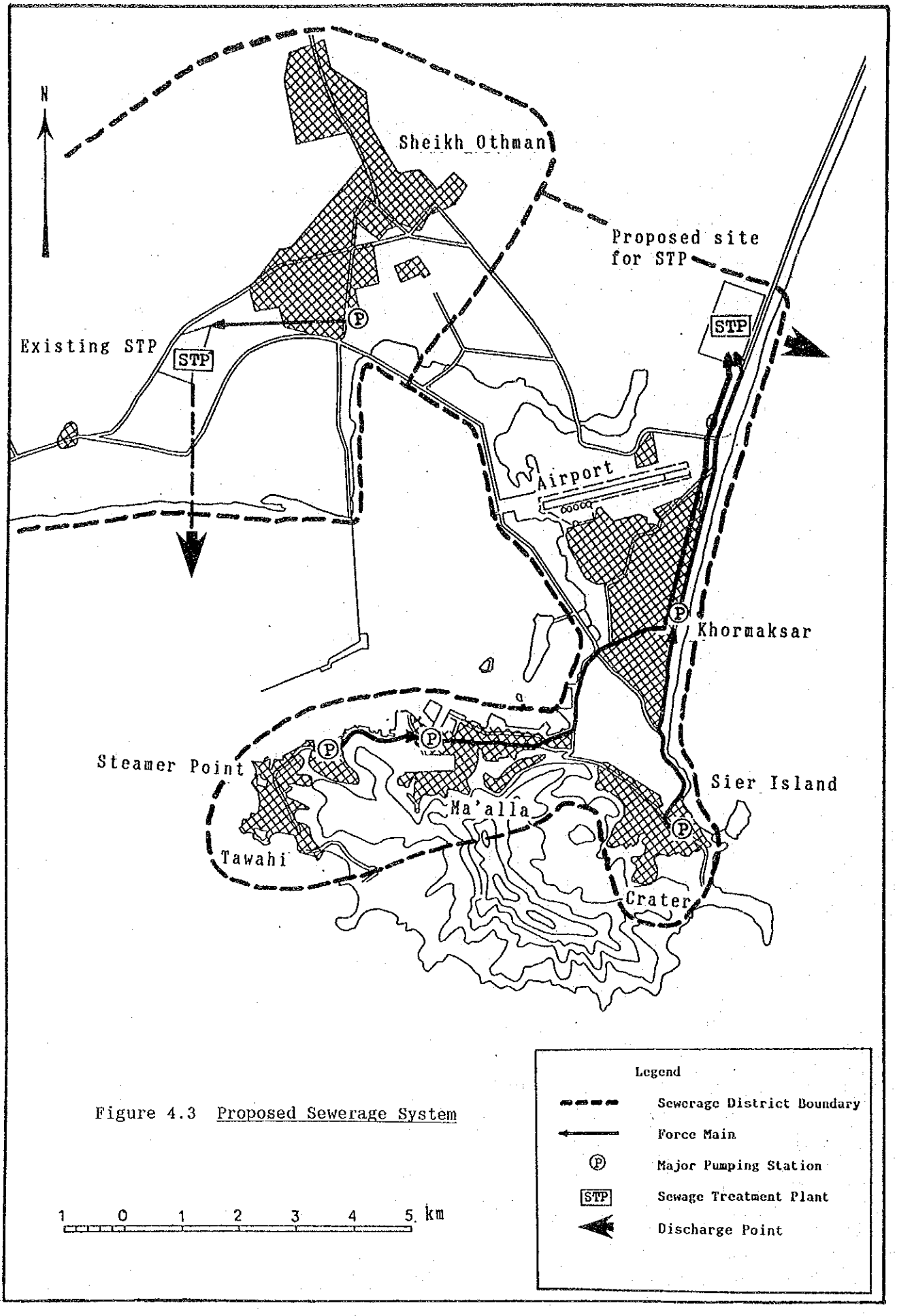


Figure 4.3 Proposed Sewerage System

(2) District Works

	Ma'alla	Tawahi	Crater	Khormaksar
Gravity Sewer				
Total length (m)	1,497	1,255	-	5,470
Diameter (mm)	200 - 600	200 - 400	-	200 - 250
Material	VCP	VCP	-	VCP
Rehabilitation of P/S				
Number of stations	3	1	1	15
Improvement of Sweeper Passage				
Number of locations	53	78	-	-
Total length (m)	2,704	2,511	-	-

4.4 PROJECT COST

Construction cost for all sewerage facilities proposed for the long term program up to 2010 was estimated taking into account the present condition in the study area. All costs are divided into foreign and local currency portions, based on the local availability of materials and services. Total project cost inclusive of indirect cost, such as provisional sums, physical contingency and engineering cost was estimated to be approximately YD 24.1 million at December 1988 prices, of which YD 20.7 million (86.0%) is foreign currency and YD 3.4 million (14.0%) is local currency. Breakdown of project cost is shown in Table 4.1

Annual operation and maintenance costs of approximately YD 0.4 million at 1988 prices will be required when the project is completed. Breakdown of operation and maintenance cost is shown in Table 4.2.

Table 4.1 Project Cost

(unit: YD 1,000)

Classification and Work Item	Cost		
	F.C.	L.C.	Total
Direct Cost			
1. Sewage Treatment Plant	1,951	1,531	3,482
2. Major Pumping Stations	2,077	40	2,117
3. Force Main	4,669	279	4,948
4. Gravity Sewers	1,781	331	2,112
5. Rehabilitation of Pumping Stations	629	23	652
6. Improvement of Sweepers' Passages	518	51	569
7. Sub-total Direct Construction Cost	11,625	2,255	13,880
Indirect Cost			
8. Provisional Sums	6,545	694	7,239
9. Sub-total	18,170	2,949	21,119
10. Physical Cotingency 5 % of 9	909	147	1,056
11. Sub-total	19,079	3,096	22,175
12. Engineering Cost 9 % of 11	1,634	262	1,896
13. Total Project Cost	20,713	3,358	24,071

Table 4.2 Operation and Maintenance Cost

Facility	Cost (YD 1,000/anum)			
	Labor	Power	Repair	Total
Sewers	80	-	20	100
Pumping Stations	94	125	30	249
Sewage Treatment Plant	26	11	20	57
Total	200	136	70	406

4.5 IMPLEMENTATION SCHEDULE

The implementation schedule for the long term program has been developed to complete all work by 2010. A two phase implementation schedule is recommended taking into account the total project cost and urgency of the works. As shown in Figure 4.4, it is proposed that the first phase program commence in 1990, and the second phase in 2001. However, it is desirable to advance the initiation of the second phase program, if funds are available.

Work to be implementated under each phase are as follows.

(1) First Phase Program

a. Construction of two sections of force main, from Tawahi P/S to Ma'alla P/S and Ma'alla P/S to STP.
b. Construction of two main pumping stations, Ma'alla P/S and Tawahi P/S.
c. Construction of STP, the first one of the three process trains.
d. Construction and replacement of gravity sewers in Ma'alla and Tawahi districts.
e. Improvement of sweeper passages in Ma'alla and Tawahi districts.
f. Rehabilitation of pumping stations in Ma'alla and Tawahi districts.

(2) Second Phase Program

a. Construction of three sections of force main, from Crater P/S to Khormaksar junction, from Khormaksar P/S to the junction and from the junction to STP.
b. Construction of two main pumping stations, Crater P/S and Khormaksar P/S.
c. Construction of STP, two remaining process trains.
d. Replacement of sewers in Khormaksar.
e. Rehabilitation of pumping stations in Crater and Khormaksar districts.

Figure 4.4 Implementation Schedule

Work Item	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
I First Phase Program																					
1. Engineering Service	(14)		(31)																		
2. Preparatory Work			(21)																		
3. Major Works																					
- Force Main			(20)																		
- Pumping Station			(16)																		
- Sewage Treatment Plant			(16)																		
4. District Works																					
- Gravity Sewer			(10)																		
- Improvement of Sweepers' Passage				(15)																	
- Rehabilitation of Pumping Station				(14)																	
II Second Phase Program																					
1. Engineering Service												(14)		(31)							
2. Preparatory Work													(22)								
3. Major Works																					
- Force Main														(27)							
- Pumping Station														(16)							
- Sewage Treatment Plant														(27)							
4. District Works																					
- Gravity Sewer														(27)							
- Rehabilitation of Pumping Station															(19)						

Note: Figures in parentheses are periods in month.

5. FIRST PHASE PROGRAM

5.1 FIELD SURVEY

In order to carry out preliminary engineering design for all facilities to be constructed under the first phase program, various field surveys were conducted on site in Aden. These includes the following.

a. Topographic or leveling survey of force main route, existing sewers and manholes and sites for proposed pumping stations and treatment plant

b. Collection of information regarding underground cables and pipes

c. Soil test to find out suitable soils for embankment

5.2 CONSTRUCTION MATERIALS AND METHODS

Presently, most construction materials, mechanical and electrical equipment for sewerage facilities are not locally available, and have to be imported from foreign countries. Skilled and non-skilled laborers for construction work are in short supply in Aden. Natural conditions in Aden are not favorable for construction of sewerage facilities. High temperatures and high organic concentration sewage tend to cause hydrogen sulphide build up, which causes corrosion of structures.

Considering the factors mentioned above, all the materials and equipment necessary for the project have been identified and several alternatives have been studied to select the most suitable ones for the study area. As a result, the most economical but durable and easy to maintain materials and methods are proposed.

5.3 IMPLEMENTATION SCHEDULE

Detailed implementation schedule for the first phase program was worked out based on the implementation schedule for the long term program. The project is assumed to start from the second quarter of 1990 and to be completed by mid 1994, as shown in Figure 5.1.

5.4 PROJECT COST

Based on the detailed implementation schedule, disbursement schedule was developed and the first phase project cost was estimated. Annual price escalation rates of 5% for foreign currency portion and 2 % for local currency portion are included in the estimation. Total project cost for the first phase program was estimated to be approximately YD 13.6 million, of which YD 12.0 million (88 %) is foreign currency and YD 1.6 million (12 %) is local currency. Breakdown of the first phase project cost is shown in Table 5.1. Annual operation and maintenance cost for facilities to be completed under the first phase program was estimated to be approximately YD 0.2 million as shown in Table 5.2.

Figure 5.1 First Phase Implementation Schedule

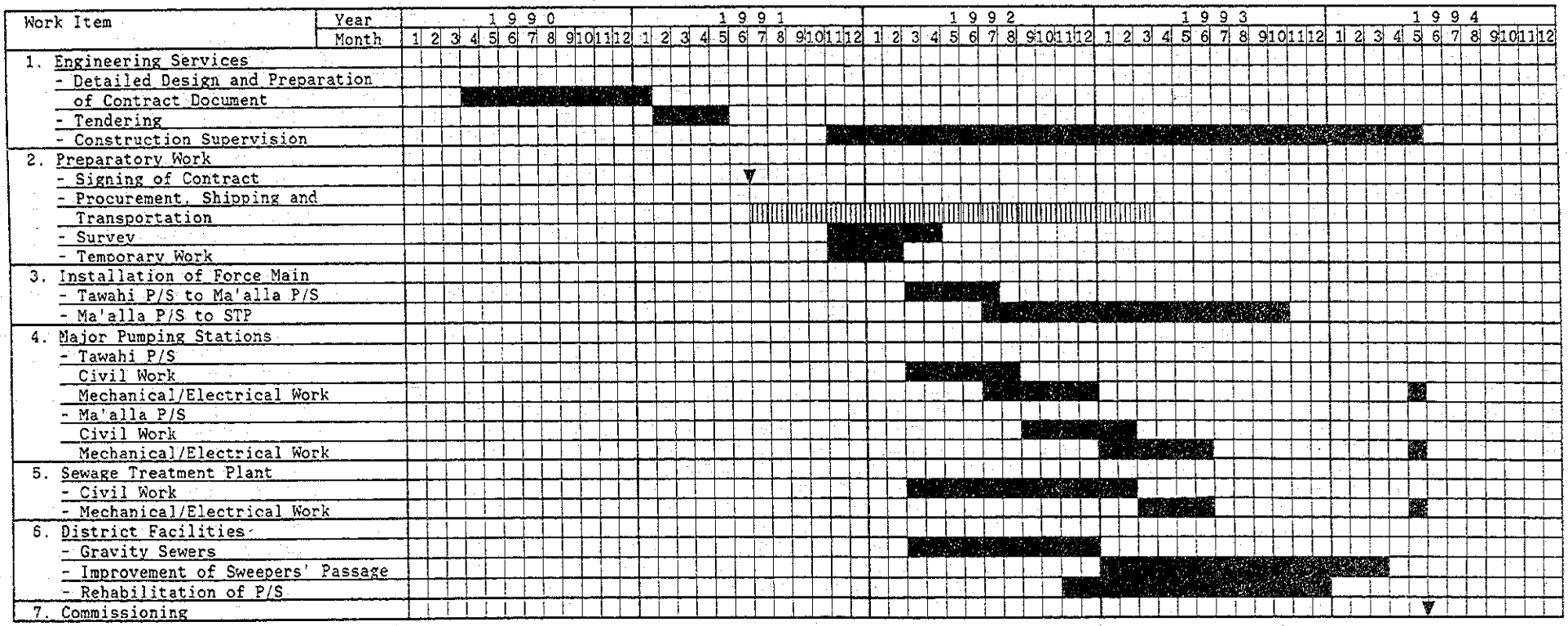


Table 5.1 Project Cost for the First Phase Program

(unit: YD 1,000)

Classification and Work Item	F.C.	L.C.	Total
Direct Cost			
Direct Cost			
1. Sewage Treatment Plant	843	621	1,464
2. Major Pumping Stations	1,015	20	1,035
3. Force Main	2,741	164	2,905
4. Gravity Sewers	557	76	633
5. Rehabilitation of P/S	198	7	205
6. Improvement of S. Passage	518	51	569
7. Total Direct Cost	5,872	939	6,811
Indirect Cost			
8. Provisional Sums	3,158	370	3,528
9. Sub-total (7+8)	9,030	1,309	10,339
10. Physical Contingency (5 % of 9)	452	65	517
11. Engineering Cost	813	114	927
12. Sub-total (9+10+11)	10,295	1,488	11,783
13. Price Escalation	1,746	104	1,850
14. Total Project Cost	12,041	1,592	13,633

Note 1. Construction cost is estimated at December 1988 price.

2. Engineering cost does not include price escalation.

Table 5.2 Operation and Maintenance Cost for the First Phase Program

(unit: YD 1,000)

Facility	Operation and Maintenance Cost			
	Labor	Power	Repair	Total
Sewers	40	-	10	50
Pumping Stations	47	53	10	110
Sewage Treatment Plant	13	11	10	34
Total	100	64	30	194

6. INSTITUTIONAL ARRANGEMENTS

6.1 PROPOSED ORGANIZATIONAL STRUCTURE

The institutional and legal arrangements and current practices are somewhat confusing in PDRY. The study team considers that firstly, a legal framework on the national level is to be provided. However, the two following possible alternative organizational arrangements limited to Greater Aden only, is examined for the long term program.

Alternative 1 Aden Municipality assumes all responsibility for the sewerage project, in addition to present responsibility for operation and maintenance.

Alternative 2 Establishment of a public corporation for sewerage services

In each case, GDLG will act as a central government agency and assume responsibility for policy making,planning, budgeting central government subsidy and providing training at the national level.

Alternative 1 is recommended for the long term, taking into account advantages and disadvantages of the two alternatives and the current situation in Aden.

For the first phase program, a more practical arrangement is recommended because of difficulties to modify present organizations to cope with the urgent necessity of the project. The study team's proposal for organizational arrangements for the first phase program is as follows.

a. GDLG will assume the responsibility for the implementation of the project, including planning, design, and construction.

b. Budgetary provision for the project will be made by GDLG. This includes coordination with other government authorities and negotiation with foreign agencies to seek internal and external funds.

c. As for engineering, maximum utilization of engineering consultants is recommended.

d. Cooperation with Aden Municipality in engineering should be sought. A technical committee is recommended to be established with representatives from GDLG, Aden Municipality and other government agencies.

e. On-the-job training for both GDLG and Aden Municipality staff throughout the duration of the project should be provided to the maximum extent possible.

6.2 STAFFING REQUIREMENTS

Based on the proposal for organizational arrangements, the necessary staff at various levels was estimated and compared to the present staff levels. Shortages in specific positions such as engineers, skilled craftmen and drivers/technical clerk are recognized, as shown in Table 6.1. In particular, all staff for the sewage treatment plant should be recruited or shifted from other positions before commissioning of the treatment plant.

Tablele 6.1 Estimated Staff for Operation and Maintenance for the Long Term Program

Job Classification	Proposed Number				Present Number	Surplus/ Deficit
	Sewer	P/S	STP	Total		
Profesional Engineers	3	1	2	6	4	-2
Assistant Engineers	1	1	-	2	-	-2
Supervisors	2	2	2	6	17	+11
Skilled Craftmen	4	8	2	14	13	-1
Semi-skilled operators and Craftmen's mates	-	14	2	16	28	+12
Drivers	2	8	1	11	9	-2
Technical Cerk	-	-	1	1	-	-1
Non-skilled	40	13	4	57	121	+64
Total	48	45	12	113	192	+79

7. PROJECT EVALUATION

7.1 Financial Analysis

(1) Financial Aspects Relating to the Sewerage Sector

Due to limited financial resources, adequate investment has not been allocated in the sewerage sector under the present development plan. With regard to the development budget, there have only been three sewerage projects in recent years in the country i.e. (1) Sheik Othman project, (2) Mukalla (phase I) project and (3) Mukalla (phase II) project. Mukalla phase II (Sherij) project was financed by grant aid from DANIDA (Danish International Development Agency). The development outlay for the sewerage sector for the period 1982-1988 are shown below:

Table 7.1 Development Budget for Sewerage Sector:1982-1988

(Unit: YD)

	Aden	Mukalla	Sherij
1982	3,958,000	-	-
1983	4,560,000	-	-
1984	3,213,800	2,000,000	-
1985	1,164,000	2,245,300	-
1986	-	2,431,335	1,500,000
1987	-	2,818,000	1,830,000
1988	-	400,000	605,000
Total	12,895,800	9,894,635	3,935,000

(2) Financial Position of Aden Municipality

There are two main sources of revenues for the Municipality i.e. (1) Municipal revenues and (2) central government contribution (subsidy). The major items of the former are property tax (22%), commercial license fees (9%), qat sale fees (13%), while the latter is composed primarily of beer tax (16%) and Housing Ministry compensation (9%).

For expenditure, there are three categories grouped under each department, namely (1) emoluments (wages and salaries), (2) administrative expenses, (3) transfer expenses. Personnel emoluments account for 63.7% of the total in 1988. The overall balance between revenue and expenditure shows an improvement in recent years. Nevertheless the revenues for 1986-1988 have been far below the 1985 revenue level.

Likewise, recent recurrent expenditures for sewerage services have been confined only to maintenance works, whereas new capital outlay for procurement of pumping and other equipment facilities has been nil.

Table 7.2 Expenditures for Sewerage Sector, Aden

(Unit: YD)

	1987	1988	1989
Maintenance			
- Sewer Network	12,960	17,549	19,935
- Pumping Station	19,995	17,505	19,008
Equip./Facilities	-	-	-
Total	32,955	35,054	38,943

Source: Aden Municipality

(3) First Phase Investment Plan

The total estimated project cost including price escalation contingency is YD 13.6 million with a foreign exchange component of YD 12.0 million. It is projected that the first phase of the long term investment plan will be disbursed on a yearly basis as follows.

Table 7.3 First Phase Investment Plan

(Unit:YD1,000)

Item		1990	1991	1992	1993	1994	Total
1. Installation of Force Main	F/C	-	542	1,574	481	144	2,741
	L/C	-	32	95	28	9	164
	Total	-	574	1,669	509	153	2,905
2. Major Pumping Station	F/C	-	503	263	249	-	1,015
	L/C	-	10	5	5	-	20
	Total	-	513	268	254	-	1,035
3. Sewage Treatment Plant	F/C	-	85	303	303	152	843
	L/C	-	62	223	223	113	621
	Total	-	147	526	526	265	1,464
4. District Facilities	F/C	-	127	734	245	167	1,273
	L/C	-	13	77	26	18	134
	Total	-	140	811	271	185	1,407
5. Indirect Costs	F/C	-	737	983	983	455	3,158
	L/C	-	87	115	115	53	370
	Total	-	824	1,098	1,098	508	3,528
6. Physical Contingency (5%)	F/C	-	100	193	113	46	452
	L/C	-	10	26	20	9	65
	Total	-	110	219	133	55	517
7. Engineering Services	F/C	231	164	161	161	96	813
	L/C	32	23	23	23	13	114
	Total	263	187	184	184	109	927
8. Total	F/C	231	2,258	4,211	2,535	1,060	10,295
	L/C	32	237	564	440	215	1,488
	Total	263	2,495	4,775	2,975	1,275	11,783
9. Price Escalation (F/C:5%, L/C:2%)	F/C	12	231	664	546	293	1,746
	L/C	1	10	35	36	22	104
	Total	13	241	699	582	315	1,850
10.Grand Total	F/C	243	2,489	4,875	3,081	1,353	12,041
	L/C	33	247	599	476	237	1,592
	Total	276	2,736	5,474	3,557	1,590	13,633

Note F/C:Foreign Currency
L/C:Local Currency

(4) Tariff and Affordability

a. Sewerage Tariff

Presently no user charges are levied in the country and sewerage operations are totally dependent on central government and municipality funds. In particular, the absence of a cost recovery system in the sewerage sector has been placing a heavy burden on municipal finances, resulting in slow and tardy expansion and the services. It is recommended that introduction of a sewerage tariff should be seriously considered in the form of surcharge on water charges, in order to cover at least recurrent operation and maintenance costs.

b. Sewerage Surcharge Rate and O & M Cost

According to the PWC financial report, water sales revenues were YD3.6 million, YD 4.16 million and YD 4.46 million in 1986, 1987 and 1988 respectively. Of this total, the revenues from the proposed project area reached YD 678,000, YD 789,000 and YD 771,000 in 1986, 1987 and 1988 respectively. If a 10 percent surcharge rate was applied, it is estimated that sewerage revenues would have amounted to YD 68,000, YD 79,000 and YD 77,000 in 1986, 1987 and 1988 respectively, which, in fact, surpasses the O & M costs incurred during this period.

Table 7.4 Water Revenues and Accrued Sewerage Revenues

(Unit: YD Thousand)

	1986	1987	1988
O & M Cost	33	35	39
Water Revenues			
: Greater Aden	3,110	3,740	3,690
: Project Area	678	789	771
10% Surcharge	68	79	77

Source: PWC, IBRD Report, and Mission estimate

Note: Water revenues from the Project area have proportionally decreased in the total revenues of Greater Aden, in accordance with changes in population distribution.

For the proposed project, O & M expenses are estimated to amount to YD 193,000 in 1995 and YD 268,000 in 2000. It is suggested that if an appropriate surcharge rate (e.g.30%) is set as sewerage tariff, necessary revenues for O & M costs would be generated.

Table 7.5 Sewerage Surcharge Rates and O & M Cost

(Unit: YD Thousand)

	1995	1996	1997	1998	1999	2000
O & M Costs	193	203	221	233	252	268
Water Revenues						
: Greater Aden	4,037	4,092	4,141	4,197	4,247	4,304
: Project Area	787	798	787	776	764	753
10% Surcharge	79	80	79	78	76	75
20% Surcharge	157	160	157	155	153	151
30% Surcharge	236	239	236	233	229	226

Source: PWC, IBRD report, and Mission estimate

Note: 1) Water revenues are expected to increase by 2.0% per annum.
2) O & M costs are assumed to increase by 3% per annum.
3) The share of Project area in total revenue is expected to decrease proportionally over the years to come.
4) The present water tariff is assumed to remain unchanged.

c. Affordability

The average wage in ministries and public corporations, compiled by the Central Statistical Office (CSO), is YD 82.4. On the other hand, the Public Water Corporation (PWC) estimated a household income at the time of tariff change in 1986. The average family income was in the range YD 50 and YD 100 and a value of YD 73 was used as a mean family income in Aden. In view of the current water bill of YD 1.6 (24.2m3) per month, the proportion of the water charges against monthly income

is around 1.6-3.2 %. If the household water consumption increases by 2.0% per annum, and if family incomes grow by 2.5% per annum, and if a 30.0% sewerage surcharge rate is levied on monthly water charges, the combined water and sewerage charges as a percentage of the projected household income per month in 1995 and 2000 would be as indicated in the following table.

Table 7.6 Average Monthly Water and Sewerage Charges per Household

(YD in 1988 prices)

Year	Family Income	Water Charge	Sewerage Charge	Total Combined	Percent of Average Income
1988	YD 76	1.6	0.48(0.32)	2.08(1.92)	2.7%(2.5%)
1995	YD 90.4	3.4	1.02(0.68)	4.42(4.08)	4.8%(4.5%)
2000	YD 101.8	3.8	1.14(0.76)	4.94(4.54)	4.9%(4.5%)

Note: A parenthesis shows the case of 20% of surcharge rate.

The international affordable limit for combined water and sewerage tariff is estimated to be 3.0 to 5.0 % of the monthly income. The table shows that 30% surcharge rate would be within the 5.0 % limit of the internationally accepted standard of the affordability and willingness to pay limit of urban consumers.

(5) Financial Evaluation

Due to Government regulations, financial information of Municipality treasury such as balance sheets and income statements had not been released to the JICA Team. And there is no tariff policy for sewerage services. Thus, ordinary financial analysis has become difficult. Nevertheless, based on the following assumptions, the financial internal rate of return has been estimated.

a. Benefits

The benefits are assumed to be sewerage revenues resulting from proposed surcharge rate on water tariff.

b. Costs

The costs comprises investment cost and O & M cost including contingencies. The calculations of financial internal rate of return by different surcharge rates have been tested. The results show that in case of surcharge rates between 10% and 50% a financial rate of return is incomputable and negative. The higher surcharge rates would surpass the limit of affordability discussed before. It is recommended that in view of above computation, external financing sources such as grant assistance would be essential to reduce the financial burden on the Government.

7.2 Economic Analysis

(1) Economic Analysis

Traditionally economic benefits of the sewerage project are considered to be derived from (1) increase in land value adjacent to the project area,(2) economic savings in sewerage service expenditures,(3) possible effect on industrial development and (4) possible impact on tourism development. In case of the proposed project quantification of these benefits would be extremely difficult, if not impossible. Instead, the average incremental cost (AIC) approach has been tried. The AIC is computed by dividing the sum of the net present value (NPV) of the project cost by the sum of the net present value (NPV) of wastewater flow. Thus the AIC has been calculated as follows

Table 7.7 Average Incremental Costs (AIC)

Discount Rates	3%	5%	10%
NPV Cost (YD Thousand)	17,332	14,938	11,346
NPV Flow (m3 thousand)	108,728	75,543	34,538
AIC (YD/m3)	0.159	0.198	0.329

It is necessary that the AIC estimated above must be compared with the sewerage tariff, which is the proposed sewerage tariff.

Table 7.8 Proposed Sewerage Tariffs

Surcharge Rates	10%	20%	30%
Domestic Consumer (YD/m3)	0.012	0.025	0.037
Commercial Consumer (YD/m3)	0.035	0.07	0.105
Industrial Consumer (YD/m3)	0.023	0.046	0.069

The evaluation shows that the presently proposed tariff for sewerage service appears to be below the computed AIC and is consequently justified from economic analysis.

(2) Socio-Economic Benefits and Justification

As said above, the quantification of the economic benefits appear to be difficult. Nevertheless the proposed project will be justified qualitatively on the basis of the following socio-economic benefits to the country.

a. Urban Environmental Impact

The existing sanitary situation will further deteriorate due to low precipitation and due to the obsolete distribution network in Aden. In older districts in Ma'alla and Tawahi, where low-income people live, only "Sweeper Passage" system is installed and is not, as yet, provided with modern sewerage systems.

Uncontroled discharge of untreated effluent into the Tawahi Bay has been a source of complaints, due to the possibility of contamination of the Bay. If no appropriate remedial measure is taken, water pollution would be further aggravated with adverse effects on the natural environment in the Bay and on the human population residing nearby. The new treatment facilities to be constructed under the proposed Project will treat all the effluent from domestic and

industrial factories before discharge. The Project will contribute to improvement in the urban sanitation environment.

b. Least-Cost Considerations

The Project presents a least cost solution to the long-term sewerage development plan for the Aden Municipality, which is derived from a comparative analysis on possible alternatives, based on acceptable demand projections and design parameters, method of treatment, route of force main, and so forth. The recommended alternative selected will benefit the people in Aden in a cost-effective manner.

c. Beneficiaries

The proposed Project will benefit the present and future population of Aden. It will provide treatment to sewage from an estimated 152,000 inhabitants living in the Project area and from public buildings, commercial shops and industrial factories. Improvements, as a result of the network rehabilitation and sewage treatment, will provide a better environment for the estimated 661,000 urban population as a whole in Greater Aden in 2010.

d. Institutional Sustainability

Under the proposed project it is expected that the government would take the first step towards establishment of financial viability by introduction of a sewerage tariff which would reflect the real cost of providing sewerage services in Aden. With expected revenues accrued, it is also expected that the municipality will be able to carry out more effectively rehabilitation and maintenance activities. In addition, the project will provide the technical staff of the GDLG and the municipality with an excellent opportunities to gain experience and technology transfer for such large-scale civil works.

Thus, the proposed project will contribute to institutional strengthening in terms of financial capability and technical improvement.

e. Economic Impacts

The country is presently undergoing an economic slump, and construction work and network rehabilitation will provide numerous business opportunities. It will not have only direct effect on the construction and engineering industry but also indirect impacts on commercial and manufacturing industry development. The contribution to the macro-economic development of the country would be substantial.

f. Reuse of Treated Effluent

The Greater Aden is presently supplied with water from boreholes in the Wadi Tuban Aquifer. The rate of water extraction has largely exceeded the aquifer recharge and as a result, the water level in the boreholes has steadily declined. Consequently, as the hydraulic gradient of aquifer has lowered, sea water has intruded and some boreholes had to be abandoned because of high water salinity levels.

Increasing the country's water resources will be an important development priority. The treated sewage effluent is a supplementary water resource for "the green belt project" (first phase: 180 ha, second phase: 300 ha, third phase: 300 ha) in the city and agricultural development in the suburban area. The proposed treatment plant, therefore, will make an important contribution to mitigation of water scarcity in the country.

system in Aden. Final report. Vol. 1. Summary.

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