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JAPAN INTERNATIONAL COOPERATION AGENCY
DEPARTMENT OF NATIONAL PLANNING
AND IMPLEMENTATION
THE GOVERNMENT OF PAPUA NEW GUINEA

THE STUDY ON SEWERAGE SYSTEM OF PORT MORESBY IN PAPUA NEW GUINEA

SUMMARY REPORT

JUNE 1998

TOKYO ENGINEERING CONSULTANTS CO., LTD.
In Association with
NIPPON JOGESUIDO SEKKEI CO., LTD.

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In this report, project costs are estimated based on November 1997 prices with an exchange rate of 1 Kina = ¥ 81.3 (1US$ = ¥ 124.20)

PREFACE

In response to a request from the Government of Papua New Guinea, the Government of Japan decided to conduct a master plan and feasibility study on Sewerage System of Port Moresby in Papua New Guinea and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Papua New Guinea a study team headed by Mr. Kazufumi Momose, Tokyo Engineering Consultants Co., Ltd (TEC). and Nippon Jogesuido Sekkei Co., Ltd (NJS).four times between March 1997 and December 1997.

The team held discussions with the officials concerned of the Government of Papua New Guinea, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project 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 Papua New Guinea for their close cooperation extended to the team.

June 1998

Kimio Fujita
President
Japan International Cooperation Agency

THE STUDY ON SEWERAGE SYSTEM OF PORT MORESBY IN PAPUA NEW GUINEA

June 1998

Mr. Kimio Fujita
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir

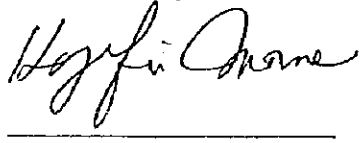
We are pleased to submit you the final report entitled "THE STUDY ON SEWERAGE SYSTEM OF PORT MORESBY IN PAPUA NEW GUINEA". This report has been prepared by the Study Team in accordance with the contracts signed on 14 March 1997, 11 November 1997 and 12 May 1998 between Japan International Cooperation Agency and Tokyo Engineering Consultants Co., Ltd. and Nippon Jogesuido Sekkei Co., Ltd.

The report examines the existing conditions concerning wastewater systems in Port Moresby, and presents a master plan for wastewater systems and results of a feasibility study on a priority project selected from the master plan.

The report consists of the Summary Report, Main Report and Appendix. The Summary Report summarizes the results of all studies. The Main Report presents the results of the whole study including background conditions, formulation of the master plan, selection of the priority project and the feasibility study on the priority project. The Appendix describes in detail the same contents in the Main Report.

All members of the Study Team wish to express grateful acknowledgement to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Construction, and Embassy of Japan in Papua New Guinea, and also to officials and individuals of the Government of Papua New Guinea for their assistance extended to the Study Team. The Study Team sincerely hopes that the results of the study contribute to the improvement of the wastewater systems and the social and economic development in Port Moresby.

Yours faithfully,



Kazufumi Momose
Team Leader

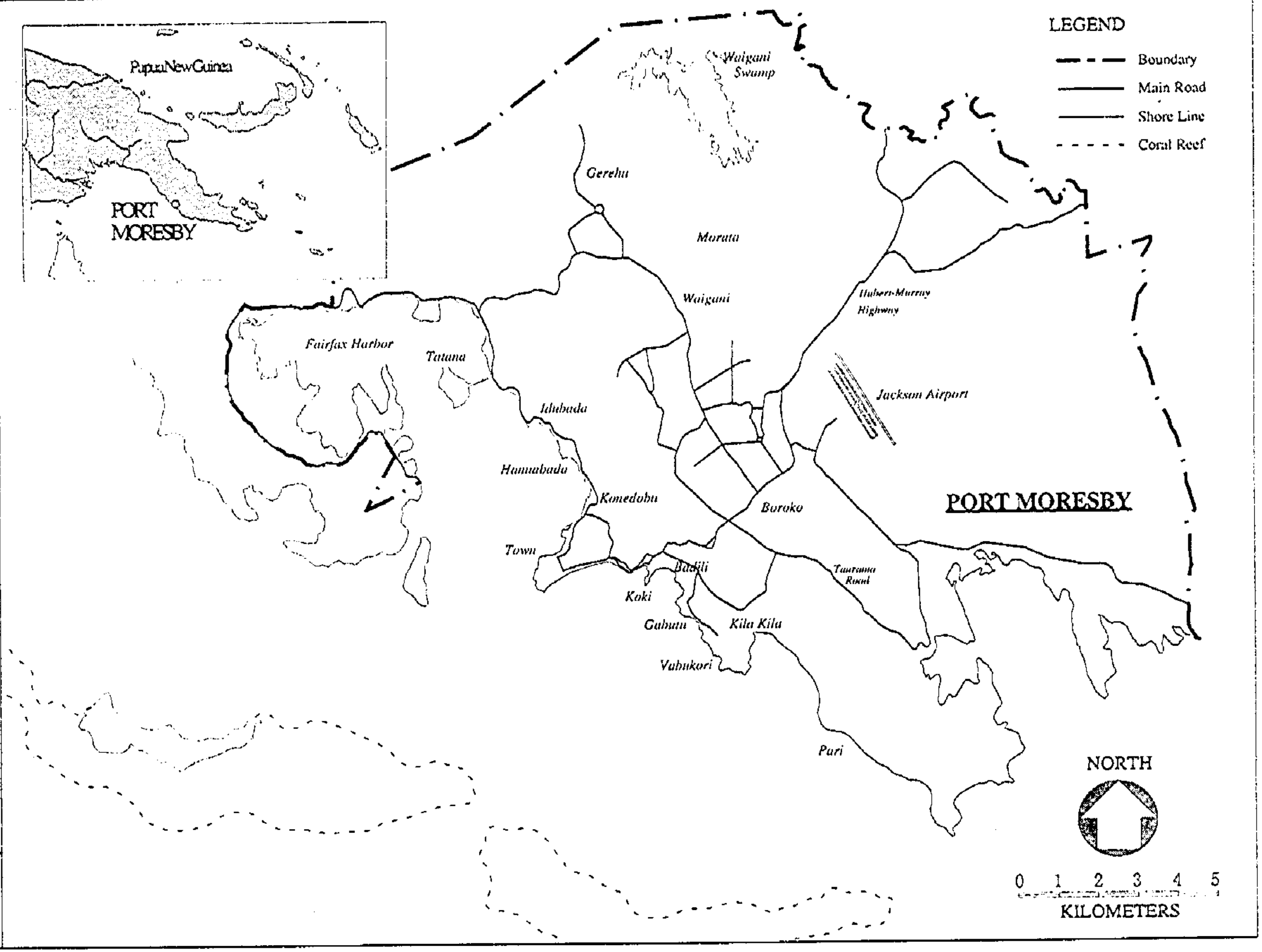
Date
May 1998

Title
Location Map of Study Area

Fig.
1.1

THE STUDY ON SEWERAGE SYSTEM OF PORT MORESBY IN PAPUA NEW GUINEA

TOKYO ENGINEERING CONSULTANTS in association with NIPPON JOGESUIDO SEKKEI



The Study on Sewerage System of Port Moresby

Study Outline

1. Target Annual Year 2015

2. Study Area / Population
   Area : 25,380 *ha*
   Population : 531,000

3. Composition of the Master Plan
   Construction of sewage main pipe: About 102 km
   Construction and improvement of pumping stations: New 23, Improvement 10
   Construction and improvement of sewage treatment plants: New 5, Improvement 3
   Construction of ocean discharge pipe: Diameter: 900 mm, Length: 3,650 m

4. Project Cost

Direct construction cost	72.47	million kina
Land acquisition cost	8.36	million kina
Engineering cost	7.25	million kina
Administration cost	1.09	million kina
Procurement cost	1.25	million kina
Physical contingency	7.25	million kina
TOTAL	97.66	million kina

5. Financial Analysis
   When management and operation of the sewerage system is dependent on the income derived from usage fees only, external financial support becomes indispensable. In this case, it is evident that taking loans at the high interest rate prevailing in the market will lead to financial failure. If low interest rate funds are available, a sound management in the long term is feasible.

6. Priority Project
   6.1 Target Annual Year 2005
   6.2 Study Area / Population
   Area : 649 ha (residential area)-Coastal Area (Paga, Kila Kila Area)
   Population : 93,000
   6.3 Facilities for Construction
   Construction of sewage main pipe: About 20 km
   Construction and improvement of pumping stations: New 15, Improvement 9
   Construction and improvement of sewerage treatment plants: New 2
   Construction of ocean outfall pipe: Diameter: 900 mm, Length: 3,650 m

6.4 Project Cost

Direct construction cost	21.17	million kina
Land acquisition cost	0.38	million kina
Engineering cost	2.72	million kina
Administration cost	0.41	million kina
Procurement cost	0.69	million kina
Physical contingency	2.72	million kina
TOTAL	34.07	million kina

CONTENTS

SUMMARY

Objectives of the Study

Previous studies made on the sewerage system of Port Moresby had pointed out the deterioration of the near shore seawater quality due to the discharge of untreated waste-water via short outfalls, pan latrines or direct to the sea as in stilt houses over the water. On the other hand, the fairly developed system for the inland area has maintained the quality of the receiving water bodies (Waigani Swamp and the rivers downstream) since the effluents are being treated at the 3 existing treatment plants before discharge.

However, improvements for the future are necessary to meet the increase in population, in addition to the sustainable development of Port Moresby and the improvement/conservation of the sanitary conditions of inhabitants and the environmental conditions of the receiving water bodies.

Therefore, with reference to the 1980 Sewerage Study Report and other related reports, a master plan has been formulated for the sewerage system of Port Moresby of which a feasibility study was conducted to give priority to the coastal areas.

Planning Basis

The target years for the Master Plan and the Feasibility Study are 2015 and 2005, respectively. According to the 1996 Urban Development and Services Study (UDSS) for the National Capital District (NCD), the population of NCD will increase from the estimated 251,000 in 1996 to 381,000 in 2005 and finally to 531,000 for the year 2015. The population including commerce and industry will generate a wastewater volume of 239,000 m^3/day in the year 2015. Out of the total volume, 160,000 m^3/day will be generated from the inland area whilst the coastal area will have 79,000 m^3/day.

Receiving Water Quality and Disposal Process

Wastewater is collected and disposed to rivers or sea in order to improve and conserve the sanitary conditions of the inhabitants. Wastewater has pollutant loads; therefore treatment is necessary to protect the quality of the receiving water bodies.

The degree of treatment or selection of treatment process is partly decided by the environmental values of the receiving water body be it for drinking, protection of aquatic life commercial application, recreation and aesthetic enjoyment. In the absence of legalized water quality standards, assumptions were made based on the environmental values of each watercourse and related legislative acts already enforced.

The Waigani Swamp will continue to receive the wastewater from the 3 existing treatment plants (Waigani, Gerehu and Morata) at an increased volume. The lagoon treatment process where BOD and SS are removed significantly, it is assumed that the environmental value of the swamp, e.g. "recreational and aesthetic uses" will be preserved. In as much as this process

is not capable of removing nutrients sufficiently enough to prevent eutrophication, the Waigani Swamp can continue as a natural wet land serving as tertiary treatment. Hence, the water quality downstream will be preserved to protect the aquatic ecosystem.

In the future, as population increases and the economy is developed, additional nutrient - removal facilities can be added to suit the beneficial usage of the Waigani Swamp.

The downstream end of the Laloki River will serve as the receiving water body for the proposed Bomana Sewage Treatment Plant (STP). Using a lagoon treatment process, it is assumed that the Bomana STP is adequate to preserve the environmental value of the river, e.g. "for the protection of the aquatic ecosystem in fresh water."

The western sector of the Papuan Coastal Lagoon (Walter Bay) will continue to receive waste-water from the Paga Point Outfall, whilst the eastern sector (Joyce Bay) is proposed to receive the waste-water from the Kila Kila zone extending from Koki to Pari. A long marine outfall similar to the Paga Point will be installed at Kila Kila. Additionally, primary treatment facilities to include sedimentation tanks with generated-sludge drying beds and a controlled dosage of disinfection will be provided to both outfalls before discharge.

The simulation made on the future water quality of the lagoon showed that the proposed treatment facilities could preserve the environmental value of the Papuan Lagoon, e.g. "for the protection of the aquatic ecosystem in marine waters." However, an environmental monitoring/estimation program shall be incorporated into the sewerage development plan. This monitoring program to include BOD, SS, nitrogen, phosphorous, chlorophyll, corals, tide, currents, etc., is necessary to monitor the nutrients that may lead to eutrophication.

Proposed Sewerage System

The inland sewerage system of the 3 existing zones (Waigani, Gerehu and Morata) has to be upgraded and improved to meet the increased wastewater volume. The proposed Bomana Zone will have a separate system with a STP located near the Laloki River. The sewage in all four zones will be gravitationally collected to their respective STP for treatment before discharge.

The existing smaller catchments along the coastal areas will be incorporated into two zones namely, the Paga Point which covers the western sector extending from Baruni, Tatana to Town area and Kila Kila which covers the eastern sector extending from Koki to Pari. Due to its topography, additional pumping stations will be installed. In addition, two separate zones are formulated for the planned urbanized areas of Vetorogo and Dogura Kohu.

The site of the existing Paga Point Pumping Station (PS) has to be expanded to cater for the proposed treatment plant and pumping station upgrading. However, with the proposed development plans of the National Capital District Commission (NCDC) in the nearby Sea Park, discussions were made between the parties concerned to settle the conflicts of zoning. It has been decided to proceed with the sewerage project partly due to the fact that the NCDC project is at a preliminary stage.

The collected sewage from the Paga Point and Kila Kila Zones will pass through a primary treatment process before discharge through an outfall into the Papuan Lagoon. The collected sewage from the Vetorogo and Dogura Kohu Zones will pass through secondary treatment process before discharge into the nearby coast.

Project Cost and Implementation Schedule

The total project cost estimated at 98 million Kina is divided into 63 M Kina and 35 M Kina for the coastal and inland areas, respectively. The development of the coastal area sewerage system has been given top priority to improve significantly the degraded water quality along the coast.

Organization and Management

EDA RANU succeeded the responsibility of operating the water and sewerage system of Port Moresby from NCDC on 1 November 1996. In order to strengthen EDA RANU's management and administrative capacities as an autonomous company the following are recommended.

- Public authorities hold a minimum of 51% shares.
- Management policy and a corporate plan are formulated.
- Long-term development policy and planning are made.
- Works Programme detailing estimates, schedule and volume of work to be contracted out be identified.
- Operation and maintenance manual to be created.
- Training Programme to be strengthened.
- Industrial effluents, communal and domestic septic tanks to be monitored periodically.

Financial Analysis

The proposed project is feasible (with a 3.01% FIRR) if the financial source is through a long-term loan having a low interest rate (about 2% to 3% level). An interest rate of 8.5% will give a disastrous output.

Feasibility Study

As a result of the study on the Master Plan, the Feasibility Study of the Coastal Region was given priority mainly due to the degradation of the water quality along the coast.

Sewerage System of the Coastal Region

The sewerage collected from the Paga Point Zone will be successively pumped (possibly 8 stations) towards Paga Point STP intercepting locally gravitated load. Similarly, the sewage collected from the Kila Kila Zone will be successively pumped towards the Kila Kila STP.

Management of the Sewerage Operation

The proposed sewerage system in the coastal area requires proper operation and maintenance to function efficiently. Operation of the series of pumping stations and STP need special skills different from the gravitationally existing system.

An organizational structure is proposed based on the existing structure. The total manpower requirement to include additional staff for the new STPs and pumping stations is 42. The works to be strengthened are the following:

- Keeping records.
- Formulating job procedural manual, and
- Providing staff training.

These indirect activities are easily neglected because their resultant effects are not seen.

Financial Plan

The financial analysis for the upgrading/development of the sewerage system in the Coastal Region shows a better FIRR.

Conclusion and Recommendation

In conclusion, the proposed sewerage system has to be implemented as early as possible for reasons and recommendations as follows:

- To improved the environmental condition of the receiving water bodies.
- The financial analysis indicated a viable result.
- Findings of the Inhabitants Behavior Survey reveal that the residents show high interest in the provision of the sewerage system and their willingness to pay the charges is encouraging.
- Consultations with the Department of Environment and Conservation is required.
- The water supply system should be improved since efficient operation of the sewerage system requires adequate water volume.
- A confirmation study on future water quality of the Papuan Lagoon is necessary to confirm the simulated model that has been developed.
- Effort to increase sewerage revenue to be enhanced.

1. INTRODUCTION

The population of Port Moresby, the capital city of Papua New Guinea (PNG) was about 77,000 in the early 1970s. It increased to about 250,000 in 1995, and the population even now, is increasing at a rapid pace.

Port Moresby comprises a rocky coastal strip and inland valley areas. There are three sewage treatment plants (STP) in the inland area, but no treatment plant exists in the coastal area. As a result, untreated sewage, which causes severe pollution of water and destruction of the environment, is being directly discharged into the ocean. The Government of Australia developed the existing sewerage system during the 1960s and 1970s, when the country was a colony of Australia. Since 1980s, sewerage studies have been carried out by the Government of Papua New Guinea. However, no new sewerage project has been implemented because no budget was earmarked for it.

In June 1992, the Japan International Cooperation Agency (JICA) carried out "The Study on Water Supply System of Port Moresby in Papua New Guinea." According to the results of this study, it was found that the existing sewerage system in its present state, cannot cope up with the increase in the volume of sewage that is being generated.

In view of these circumstances, the Government of PNG requested the Government of Japan to conduct a master plan and feasibility study on the Port Moresby sewerage system for the purpose of protecting the urban environment protection and improving sanitation.

Responding to the Government of PNG's request, JICA dispatched a mission to conduct "The Study of the Sewerage system of Port Moresby in Papua New Guinea" from March, 1997 to May, 1998, in cooperation with National Planning Agency and EDA RANU.

2. OBJECTIVES OF THE STUDY

The objectives of the study based on the concluded S/W with JICA by the Government of PNG are as follows:

(1) To formulate a master plan for improvement of wastewater management that contributes to the upgrading of sanitary and environmental conditions and operation and maintenance in Port Moresby;
(2) To conduct a feasibility study on the priority project(s) selected from the Master Plan; and
(3) To transfer technology on planning methods and skills to counterpart personnel during the Study.

3. PRESENT CONDITION OF THE SEWERAGE SYSTEM

3. 1 Facilities

(1) Pipeline

The Government of Australia laid most existing pipes during the first half of the sixties. Subsequently, the pipeline network was extended by the Government of PNG, National Capital District Commission (NCDC) and private housing developers. Due to the rapid population growth, the inadequacy of flow capacity in the sewer became a serious problem. The implementation status of the main projects after the eighties undertaken by NCDC, which has been gradually improving trunk systems and replacing old pipelines before the eighties, are as follows:

a) Coastal Area
- Reinforcement of construction of the ocean discharge pipe at Paga Point in 1982.
- Installation of pumping station and laying the pressure and gravity pipes in Koki area.
- Conversion of superannuated asbestos pipe to PVC pipe in each area.

b) Inland Area
- Installation of reinforced pipes in Boroko, Gordon and Hohola.
- Installation of additional trunk pipes of diameter ranging from 900 up to 1350 over a distance of 3 km from the Moitaka area to Waigani Sewage Treatment Plant in 1986.

(2) Pumping Stations

A total of 10 pumping stations (one in the inland area and the rest in the coastal area) are working satisfactorily and maintained in good working condition by proper maintenance carried out by staff exclusively retained for this purpose. Although, there are no operating records, responses to questionnaires given to the staff, showed no serious problems such as overflow of sewage.

(3) Treatment Plants

The three lagoons including Waigani, which is the largest, Morata and Gerehu, are anaerobic and facultative ponds. Although the capacity of each facility is adequate for the influent quantity handled, because of the accumulated sludge remaining untouched for a long period, there is concern that the capacity of the facility will deteriorate.

3. 2 Operation and Management

(1) Status of the Organization

The responsibility for water supply and sewage treatment in the National Capital District of PNG was transferred to EDA RANU in February 1996. However, the duties of EDA RANU relate only to water supply, construction, operation and maintenance of sewerage facilities. The rest of the jobs are being subcontracted to the private sector. Although a

Planning Committee was established, the guidelines, the policy for investment and the financial plan have not yet been decided. The problem of shortage of human resources in the waterworks departments, such as engineers and supervisors, staff for accounting work and financial planning work needs to be addressed immediately.

(1) Financial Status of Organization

In spite of low tariff collection rate (60-70%) in the last decade by NCDC, it was generally felt that the water supply business was in the black and the sewerage business was a little in the red. It is not clear as of this time whether the amount of about six million kina provided by the government for establishing EDA RANU is part of an investment or a financial subsidy; moreover, the assessment of facilities that were taken over from NCDC and the balance sheet are also unsettled. Whereas JC-KRTA carries out sewerage tariff collection and issues invoices annually, the collection rate is not very good.

4. PLANNING CONDITIONS

4. 1 Population and Land Use

(1) Population

1) Present Population

Papua New Guinea carried out a census of the population once in ten years. In this study, the population of NCD (divided into 9 blocks: urban area - 7 blocks, semi-urban area – 2 blocks) in 1995 was estimated using the data of last four censuses in 1966, 1971, 1980 and 1990.

1966	41,848
1971	76,507
1972	123,624
1973	195,579
1974	251,000

2) Future Population

The World Bank formulated a land use plan for NCDC in 1995 (target year: 2015) called "Urban Development and Services Study." According to this plan, the area under consideration was divided into 14 blocks and the following population cases were proposed according to high, middle and low-growth development taking into account the rate of increase from the past censuses. The plan makes use of a low-growth population value of 531,000.

High-growth – 640,000, Middle-growth – 590,000, and Low-growth – 531,000

However, the plan also pointed out that NCD could reach a population of 675,000 by 2015 if the PNG government does not adopt measures to restrict the increase in the population growth rate. In order to harmonize this study's objectives with those of the World Bank's plan, this study has decided the planned target year as 2015, and the anticipated population in target year as 531,000 persons.

(2)Land Use

The land use plan considers that the increase in population can be absorbed by newly developed residential area of about 2,200 ha. Besides, the plan accounts for development of about 400 ha as commercial area, and development of about 500 ha as industrial area as part of employment measures. The gross area planned for new developments for other purposes and including the areas mentioned above, works out to about 6,700 ha.

4. 2 Sewered and Unsewered Area

About 60% of households are already connected to the public sewerage system. The percentage of households connected to public sewerage system in comparatively high-income residential areas as Boroko, Hohola, and Gordon amounts to more than 90. The "Survey of Residents' Consciousness" carried out as part of this study, shows that even residents with low income in unconnected areas are willing to pay the usage fees if their households are connected to the sewerage system.

On the other hand, a feature of drainage in unconnected areas, such as communities dwelling in houses built on platforms above water in Hanuabada, is the discharge of wastewater directly into the ocean. Pit latrines are also used in many households. As a result, sea water pollution, mainly caused by leaching, is widespread. Considering the above, the projected treatment area would be 15,000 ha, taking into account the designated urban area at present and in the future.

4.3 Wastewater Quantity and Quality

(1) Unit per capita wastewater consumption

The Study on the Port Moresby Water Supply Development Plan (1994) implemented by JICA gave the per capita water consumptions listed below, using NCDC's actual water supply records. There are slight differences in the values for various types of housing. Basic domestic water consumption ranges from a minimum of 300 liter per capita per day (Lcd) to a maximum of 380 Lcd. The average value is 350 Lcd.

The basic domestic water consumption adopted was 350 Lcd, referring to three reports of sewage surveys undertaken in the past.
-Report on the Sewerage of Port Moresby, (1974)
-Port Moresby Sewerage Study, (1980)
-Environmental Plan -- Joyce Bay Outfall Study, (1988)

Meanwhile, the first phase on-site survey (dry season – April) and second phase on-site survey (rainy season – December) were conducted as a part of this Study, to analyze water quality for both domestic drainage and industrial wastewater. The results indicated that the domestic water consumption of the survey was close to the values obtained by other surveys. The commercial water consumption was 100 Lcd. For this study, 450 Lcd (350 Lcd + 100 Lcd) was accepted as the unit per capita wastewater consumption.

(2) Unit Pollutant Loads

Referring to the recommended values by Japan and other countries, unit BOD (Biochemical Oxygen Demand) pollution load was taken as 45 g-BOD/capita/day. Water quality surveys for domestic sewage, industrial wastewater and also influent and effluent originating from the three STPs in the inland area were carried out twice in each dry and rainy season as a part of this study. Quality of influent of the STP was determined as follows: BOD=170mg/l, SS=200mg/l.

5. RECEIVING ENVIRONMENT AND SEWAGE TREATMENT OPTIONS

5. 1 Status of Regulations and Laws related to Water Environment

Regulations/laws related to water environment in PNG are as follows:

(1) Water Resources Act (1982)

The Water Resources Act confers power to the enforcing authority to restrict discharge of wastewater into a public water body. The Act specifies the concept of environmental protection affecting water utilization in a broad sense.

(2) Environmental Planning Act (1978)

The Environmental Planning Act provides for government control of projects likely to have significant impact on the environment. It is a fundamental law for environmental protection to be considered in case of ocean outfalls.

(3) Recommended Water Quality Standards for Papua New Guinea (Draft).

Recommended Water Quality Standards give the outline of desired water quality according to the type of water use. The following are specified: 1) raw water standard for drinking, 2) standards for ecological preservation of fresh water and sea water areas, and 3) recreational and visual estimation standards for water bodies.

Although it is essential to observe the above-mentioned related laws/guidelines in the study on sewage treatment systems, presently, water bodies have not been designated establishing its specific use and the quality desired considering environmental conservation. Accordingly, this study will conform to the existing status of water use, and investigations shall be restricted to the level of desired quality of effluent and sewage treatment.

5. 2 Applicable Sewage Treatment Processes

Sewage treatment processes and methods considered for the study include the Sedimentation Method as a simplified treatment method, and the Stabilization Pond Method, which has given satisfactory results over a long term in PNG. A Nutrient Removal Process is also proposed as a form of advanced treatment method for reference. Each treatment process, in

general, can be expected to remove pollutants with the percentages mentioned in Table 5.1.

Table 5.1 Pollutants Removal Rate of Sewage Treatment

Pollutants	Primary Treatment	Secondary Treatment	Nutrient Removal
BOD (%)	30 – 50	85 – 95	90 – 95
COD (%)	30 – 50	70 – 85	85 – 95
T-SS (%)	40 – 60	85 – 95	90 – 95
T-N (%)	10 – 30	20 – 40	60 – 70
T-P (%)	20 – 40	30 – 50	70 – 80

5. 3 Investigations related to Inland Area

5. 3. 1 Status of Waigani Swamp

Presently, the functions of Waigani swamp can be classified into the following: 1) final receiving pond for the wastewater generated from the three sewage treatment lagoon facilities; 2) a bathing spot for the neighborhood residents; and 3) a fishing ground for residents in the neighborhood. In particular, several full-time fishermen make a living by selling tirapia and carp in the downtown market, and also use the catch as sustenance.

Based on aerial photographs and spot surveys, the Study Team has determined the various characteristics of Waigani Swamp in dry season as given below.

1) Total catchment area : 88.3 km^2
2) Surface water area of the swamp: 2.6 km^2
3) Mean depth of the swamp : 0.7 m
4) Swamp Volume : 1,820,000 m^3

The results of on-site water quality analyses are as given in Table 5.2.

Table 5.2 Water Quality Survey Result (mg/L)

Month	Location	pH	SS	BOD	COD	S-COD	DO	T-N	T-P
July '97	Waigani Swamp	7.8	81	12	124	-	14.0	6.4	0.38
Dec. '97	Jackson Creek	7.2	134	9	91	58	1.3	2.8	0.54
	Waigani Swamp	8.2	58	9	80	66	6.1	4.6	1.87
	Zooland Creek	7.0	8	37	53	72	2.0	5.8	3.95
	Laloki River	7.4	28	5	54	61	3.9	3.5	0.25

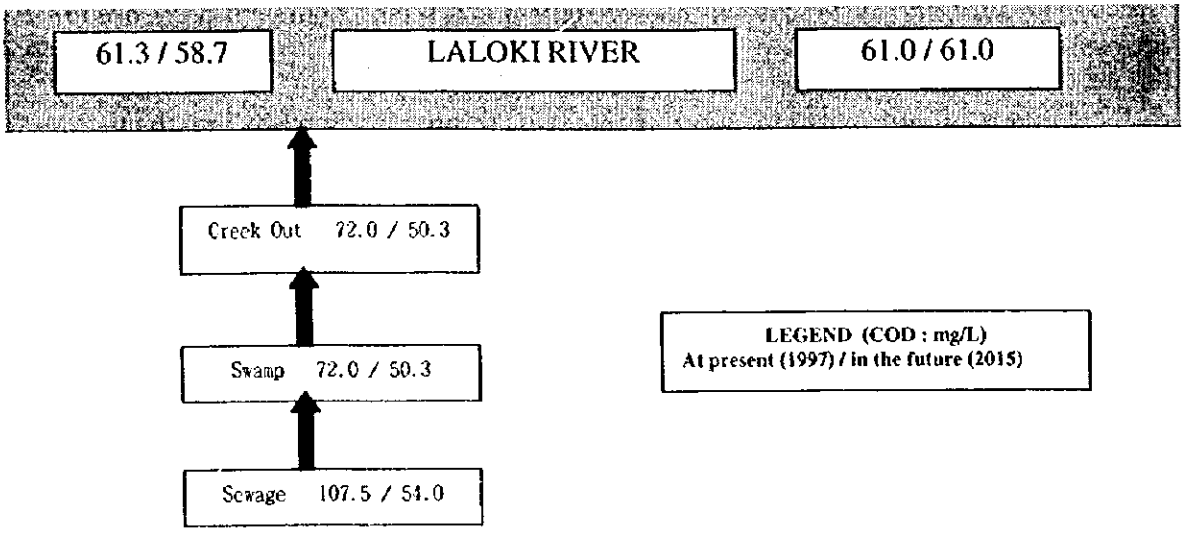
The swamp exhibits eutrophication, as indicated by the high concentration of T-N (Total Nitrogen) and T-P (Total Phosphorous), but adverse effects such as mass perishing of fishes has not occurred.

5. 3. 2 Pollutant Load Analysis of the Waigani Swamp and Lower Laloki River Basin

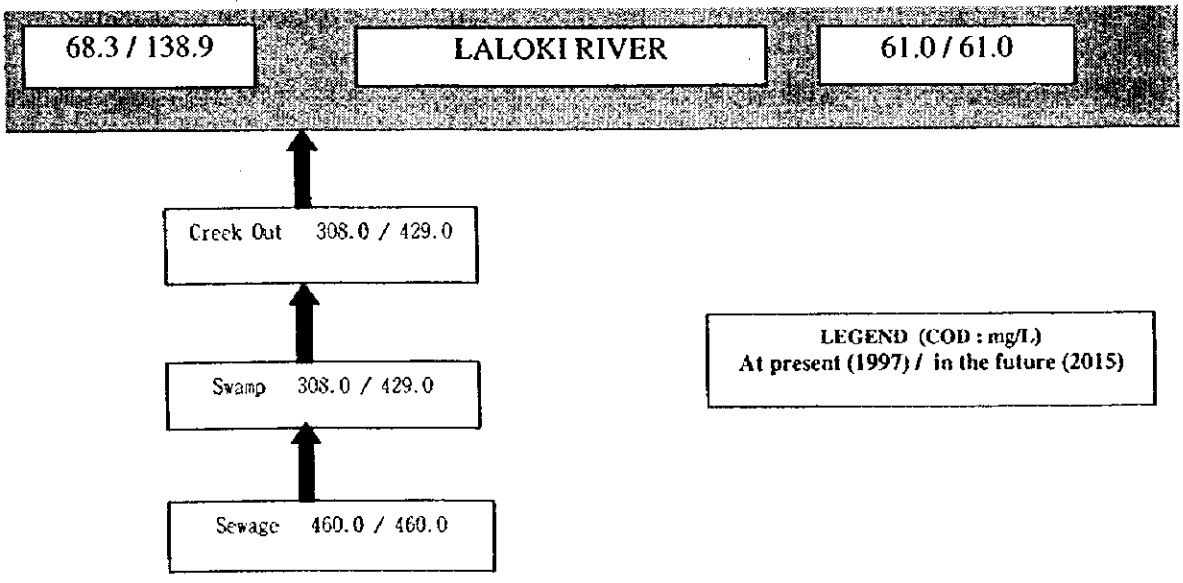
Analysis of the existing and predicted (2015) pollutant load balance of Waigani swamp and Laloki river using a water quality simulation model was undertaken by the Study Team. For the present, the data of water quality surveys is being used for determining the quality of effluent from STP; and the recommended effluent quality is being used for future predictions.

In order to verify the effects of sewage treatment, the same simulation is also being carried out at locations with sewage treatment (raw sewage inflows directly into the Waigani swamp.) Mentioned-below figures show the results of simulation analysis in the dry season.

(1) Scenario 1: With sewage treatment



(2) Scenario 2: Without sewage treatment



Conclusions from the analysis are summarized below.

- The outflow of the Waigani swamp in dry season has no effect on the water quality of Lower Laloki River Basin (after the confluence).
- Adequate expansion/improvement of the STPs will contribute to improvement in the water quality of the Laloki River (behind junction) in the future.
- If sewage is left untreated, the quality of water in the Waigani Swamp will deteriorate by 4 to 8 times, and that in the Laloki river will deteriorate by 1.1 to 2 times.

5. 3. 3 Selection of Sewage Treatment Method

The existing stabilization pond is considered to satisfy the necessary conditions. In the years ahead, when eutrophication of the Waigani swamp becomes serious, suitable measures will be required to eliminate the nutrition salts. In this case, investigations not only from technical aspects but also from aqua-environmental ecosystem and socioeconomic aspects need to be carried out.

5. 3. 4 Assessment of Environmental Impacts that Accompany Sewage Treatment

(1) Anticipated improvements
- Stabilization of the fishing industry because of improvements in the quality of water of the Waigani swamp
- Promotion of use of Waigani swamp as a recreational site (bird watching) by virtue of the diversification of living species (mainly birds)
- Improvement in aesthetic aspects and elimination of foul odors in the Waigani swamp and the Laloki River

(2) Apprehensions of deteriorating situations
- Unexpected advance of eutrophication caused by increasing wastewater quantity in the future
- Adverse effects on health due to behavior of colon bacillus in the Waigani swamp
- Inflow and accumulation of harmful substances originating in industrial wastewater

5. 4 Investigations for Coastal Area

The coastal waters around Port Moresby can be classified firstly into harbors and bays (the seashore) such as the Joyce Bay, then into islands, and lagoons encircled by coral reefs (offshore), and finally the coral sea located on the outside of the coral reefs (the open sea). If these waters are classified by environmental standards (draft) of PNG, the harbors and lagoons are grouped together as resort and scenic waters, and the open sea can be considered to conform to natural conservation waters.

The Study Team conducted water-related investigations such as (1) Water Quality Survey, (2) Preliminary Water Quality Prediction and (3) Coral Reef Assessment. The outline of each investigation is given below.

(1) Water Quality Survey

A water quality survey was carried out and the results of the survey in the Papuan Lagoon and the outside the lagoon are as given in Table 5.3.

Table 5.3 Water Quality in the Sea in 1997

(unit :mg/L)

Location	COD-Mn	T - N	T – P
Paga discharge	1.3	0.13	0.009
Kila Kila discharge	1.4	0.25	0.009
Coral Sea	1.3	0.09	0.008

(2) Preliminary Water Quality Prediction

Considering that the project is implemented based on this plan, changes in water quality of the effluent discharged were analyzed using a forecast model in the lagoon after primary treatment from Paga Point and Kila Kila (COD-Mn:51mg/L, T-N:37.44mg/L, T-P:3.64mg/L and Total Coliform:2.4• ~10^8MPN/100mL). For analyzing the results, Japan's "Environmental Standards for Conservation of the Living Environment, " for Sea Area -- Category A and for Bathing: Type II (COD-Mn:2mg/L, Total Coliform:1,000MPN/100mL, T-N:0.3mg/L, and T-P:0.03mg/L) were used as judgement criteria. Firstly, Table 5.4 indicates the quality of water that has risen vertically from the outfall point of Paga (depth: 24m) and Kila Kila (depth:35m) to the surface of the sea.

Table 5.4 Water Quality in Coastal Area in 1997

Item		Paga	Kila Kila
Floating point (down stream)m		25	30
Dilution ratio		299	290
CODMn	Mg/L	1.6	1.6
T-N	Mg/L	0.32	0.32
T-P	Mg/L	0.021	0.022
Coliform	MPN/100mL	8.0×10^5	8.3×10^5

The results of analysis considering dilution shows that the value of COD-Mn is within the allowable standards, but T-N and T-P are higher than the standard values. The total coliform at Paga at a discharge rate of 3.5km/0.41day, and at Kila Kila at a discharge rate of about 4km/0.46day is less than 1,000MPN/100mL, because of dilution due to horizontal flow and the reduction in coliform level due to the effect of brine and ultraviolet rays. This value satisfies the above-mentioned standard.

Next, a complete mixing box model that takes account the effect of sea water exchange was used to predict T-N and T-P. The Papuan Lagoon was divided into three boxes (Harbor, Paga and Kila Kila). The sea water exchange rate was assumed as 0.1 in Kila Kila, and 0.05 between the other two boxes. Table 5.5 shows the water quality (T-N and T-P) in the year 2015.

Table 5.5 Water Quality in Coastal Area in 2015

	Harbour	Paga	Kila Kila
T-N (mg/L)	0.220	0.22	0.18
T-P (mg/L)	0.020	0.021	0.016

The above mentioned results show that the water quality standards (T-N:0.3mg/L, T-P:0.03mg/L) are adequately satisfied.

(3) Coral Reef Assessment

As a part of this Study, a coral reef assessment was carried out by University of Papua New Guinea to provide information on the distribution, occurrence and general status of coral reefs. According to the report, the Walter Bay (Era Beach and Koki) and the Joyce Bay are extremely polluted, as a result of wastewater and solid wastes generated from human and industrial activities. Destruction of the coral reef is unavoidable, regardless of the route selected for construction of the ocean outfall pipeline. The report states that the effect on the environment can be minimized by first treating the sewage and then discharging it into the ocean.

Raw wastewater discharge reduces the quantity of dissolved oxygen and increases nutritive salts in the waters, thereby leading to destructive phenomena such as extinction of fishes, proliferation of planktons, and destruction of coral reefs. The report points out that the occurrence of damage by raw sewage depends on the permissible capacity of discharged water, sea water exchange rate, and so on. If the sewage flow in the future increases tremendously, the necessity of considering an ocean outfall could be acknowledged, but for this Study, even if the effluent is discharged into the lagoon after primary treatment in the year 2015, no excessive deterioration in water quality is likely to occur because the lagoon has adequate receptivity for the effluent.

In accordance with above-mentioned investigations, sewage treatment processes and various issues for the three divisions of sea water are listed below:

The Coastal Treatment Method : Stabilization Pond + Chlorination
Problems : (1) Eutrophication
: (2) Residual Chlorine

The Offshore Treatment Method : Sedimentation + Chlorination
Problems : (1) Land and construction expenses for construction of sedimentation facility
: (2) Residual Chlorine

The Open Sea Treatment Method : Dust Prevention + Sand Prevention
Problems : (1) Residual Sediment

If the Project is implemented based on this Study, the environmental effects mentioned below may be predicted.
(Advantages) :(1) Improvement in the quality of treated water
:(2) Improvement in aesthetic aspects
(Disadvantage) :(1) Increase in the quantity of nutritive salts

5. 5 Related Organizations in Papua New Guinea

The environmental organizations related to the Project are listed in Table 5.6.

Table 5.6 Related Organization to the Project

−Dept. of Environment and Conservation (DEC)	General Environment Preservation
−Bureau of Water Resources, DEC and Water Resources Guard	Effluent Quantity Control
−Dept. of Health (DOH)	General Sanitation
−National Capital District Commission (NCDC)	Sanitation in NCD
−Eda Ranu	Water Supply and Sewerage Operation and Maintenance

5. 6 Monitoring Plan

It is necessary to implement the sewerage system project and at the same time perform continuous monitoring in order to improve the water environment in Port Moresby. For implementing the monitoring plan, cooperation of EDA RANU, DEC and DOH is necessary.

The objectives of the aqua-environment monitoring plan are as follows:

(1) Discharge water quality
Confirm that the quality of industrial water (discharged directly, discharged into the sewerage system) is examined and the standards are adhered to by the sewage treatment plants.

(2) Public water bodies
Confirm that quality of water in the public water bodies and changes in the coral reef are continuously surveyed, and the surveyed data is used as the basis for adopting environmental conservation measures for the public water bodies.

6. SEWERAGE MASTER PLAN

6.1 Sewerage System

(1) Area under the sewerage plan
From the study area of 25,000 ha, the area considered under the sewerage plan including urban areas in the future is 15,000 ha based on the land use plan of 2015. This area is broadly divided into inland area and coastal area according to topographical conditions.

(2) Guidelines for provision of facilities in the inland area
In the early part of the 1970s, stabilization ponds were provided in the three districts of Waigani, Geruhu and Morata. The relation between the existing treatment capacity and future planned inflow rate of each treatment plant confirmed during the Study is as given in Table 6.1. The data given below shows that the capacity of all the plants will be inadequate in the future.

Table 6.1 Design Flow in Inland Area

Name of Zone	Flow (m^3/day)	Design Flow (m^3/day)
Waigani	57,157	86,741
Morata	5,400	15,225
Gerehu	7,325	18,018

No comprehensive development plan exists as of this stage for Bomana district, which is expected to be developed in the future. Therefore, the topographical conditions of the relevant area were considered, and treatment facilities (stabilization ponds) were planned in the vicinity of the Laloki river. In addition, the size of each facility was estimated referring to the existing treatment areas, and the following figures were obtained.

Planned sewage capacity: 39,887 m^3/day
Surface sewer pipeline to be provided: 515,200 m
Trunk sewer pipeline: 26,700 m

(3) Guidelines for provision of facilities in the coastal area

The Town district was urbanized first, therefore, aging of facilities and discharge of untreated sewage in the sea from this district have led to the major problem of marine pollution. In addition, two other districts - Dogura Kohu zone to the south east and Vetorogo zone to the north west are planned for development, hence three areas in all are to be considered.

1) Currently urbanized areas

A large number of small-diameter sewer pipes are provided mainly in the Town district. These pipes meet at Paga Point and discharge the sewage into the sea. Eight alternative proposals were made making maximum use of existing facilities and comparisons were made with respect to "construction cost," "maintenance and operation cost," "impact on the environment," "applicability to future plans," and "ease of land acquisition." The results of the comparisons showed that installation of treatment facilities at Paga district and Kila Kila district, and discharge of sewage 3 km ahead of each facilities into the sea, was the most feasible proposal (refer to Table 6.2).

Table 6.2 Design Flow in Coastal Area

Name of Zone	Population in 2015	Design Flow (m^3/day)
Paga Point	36,000	20,700
Kila Kila	70,100	41,000

2) Areas planned for development

No detailed development plan exist as of this stage for Dogura Kohu zone and Vetorogo zone, which are planned for development in the future. Similar to the Bomana district in the inland area, the topographical conditions were considered, and treatment facilities (stabilization ponds) in areas bordering the coast line have been planned. In addition, the scale and size of various facilities were estimated as shown below, referring to the current areas where sewage is treated.

Dogura Kohu zone

- Planned sewage capacity: 18,209 m^3/day

- Surface sewer pipeline to be provided: 169,400 m
- Trunk sewer pipeline: 8,800 m

Vetorogo zone
- Planned sewage capacity: 13,115 m^3/day
- Surface sewer pipeline to be provided: 235,200 m
- Trunk sewer pipeline: 12,200 m

6.2 Construction cost

The total amount for the complete project required for providing facilities as proposed in the Master Plan is estimated as 97,657,000 kina. The share of priority project areas in the coastal area is estimated as 340,071,000 kina or 35% of the total amount, and the share of other areas mainly in the inland area is about 63,586,000 kina or 65% of the total amount.

6.3 Implementation plan

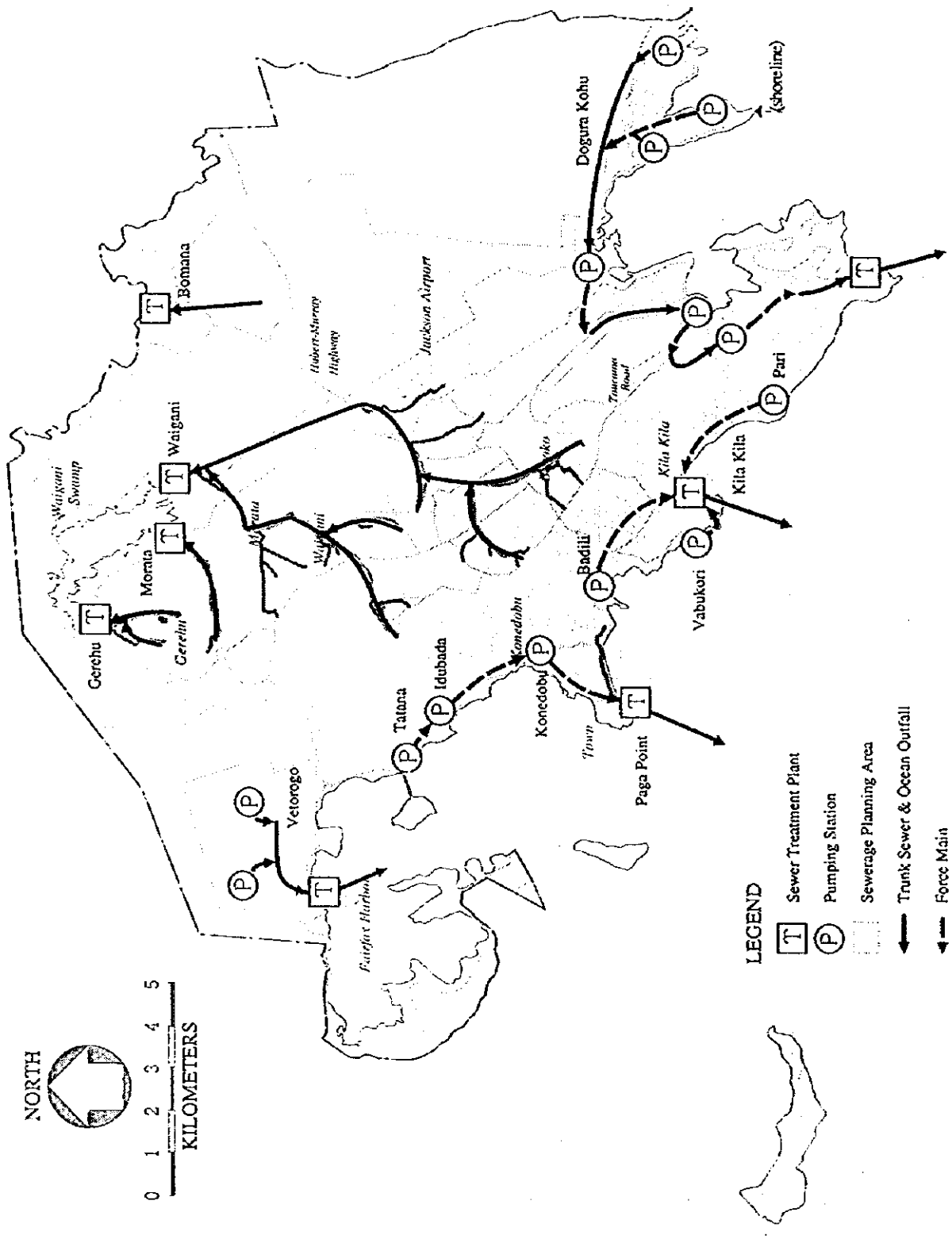
Considering the entire Study area and deciding the coastal area as requiring urgent rehabilitation for resolving problems such as aging of facilities and marine pollution, the plan for the entire Study area was divided into four phases.

1) Phase 1 (2000 to 2002)
The zone in the coastal area under this phase are Kila Kila, Koki, Badili, Gabusu, Vabukori and Pari, whose total inhabitable area works out to 317 ha. The total project amount for this phase is 21,755,000 kina.

2) Phase 2 (2003 to 2005)
The zone in the coastal area under this phase are Baruni, Tatana, Idubada, Hanuabada, Konedobu and Town, whose total inhabitable area works out to 332 ha. The total project amount for this phase is 12,316,000 kina.

3) Phase 3 (2006 to 2010)
The zone in the inland area under this phase, which presently have treatment facilities, are Waigani, Geruhu and Morata. As already mentioned earlier, the treatment capacity of all three treatment plants is inadequate. New treatment facilities and improvements at locations where flow capacity of trunk sewer pipelines is inadequate, are important issues to be addressed. The total project amount for this phase is 12,235,000 kina.

4) Phase 4 (2010 to 2015)
The zone planned for development under this phase in the inland area is Bomana zone (area: 3,680 ha) and in the coastal area are Vetorogo zone and Dogura Kohu zone. The main facilities to be provided are treatment plants (stabilization ponds) at three locations, pumping stations, and trunk sewer pipelines. The total project amount for this phase is 51,261,000 kina.



Date	Title	Fig.
May 1998	Proposed Sewerage System	6.1

THE STUDY ON SEWERAGE SYSTEM OF PORT MORESBY IN PAPUA NEW GUINEA

TOKYO ENGINEERING CONSULTANTS in association with NIPPON JOGESUIDO SEKKEI

Table 6.1 Proposed Trunk Sewers and Force Mains

	Inland Area				Coastal Area			Total
	Waigani	Morata	Gerehu	Bomana	F/S Area	Vetorogo	Dogura Kohu	
1.Sewer Network (m)	4,900ha	720ha	810ha	3,680ha	649ha	1,210ha	1,680ha	13,649ha
	12,600	63,000	56,000	515,200	77,700	235,200	169,400	1,129,100
2.Trunk Sewer (m)								
200mm	0	0	0	0	10,161	0	0	10,161
250mm	0	0	0	0	303	0	0	303
300mm	463	0	949	8,800	3,490	5,000	2,900	21,602
350mm	2,320	0	0	7,700	270	4,400	2,600	17,290
400mm	2,212	1,712	1,362	2,900	310	1,600	1,000	11,096
450mm	0	912	0	1,900	640	1,200	700	5,352
500mm	3,337	712	0	4,500	1,233	0	1,600	11,382
600mm	0	0	0	900	2,216	0	0	3,116
S-Total	8,332	3,336	2,311	26,700	18,623	12,200	8,800	80,302
3.Force Main (m)								
150mm	0	0	0	0	2,120	0	0	2,120
200mm	0	0	0	0	3,500	0	1,700	5,200
250mm	0	0	0	0	0	500	0	500
300mm	0	0	0	0	2,086	500	1,500	4,086
350mm	0	0	0	0	220	0	2,000	2,220
400mm	0	0	0	0	0	0	0	0
450mm	0	0	0	0	3,640	0	1,200	4,840
500mm	0	0	0	0	303	0	0	303
600mm	0	0	0	0	0	0	2,000	2,000
700mm	0	0	0	0	0	0	0	0
800mm	0	0	0	0	360	0	0	360
S-Total	0	0	0	0	12,229	1,000	8,400	21,629
4.Ocean Outfall (m)								
					3,650			3,650
S-Total	0	0	0	0	3,650	0	0	3,650

Table 6.2 Project Cost for Seven Planning Sewerage Zones

(Unit:1000Kina)

	Inland Area				Coastal Area			Total
	Waigani	Morata	Gerehu	Bomana	F/S Area	Vetorogo	Dogura Kohu	
1.Sewer Network (m)	4,900ha	720ha	810ha	3,680ha	649ha	1,210ha	1,680ha	13,649ha
	12,600	63,000	56,000	515,200	77,700	235,200	169,400	1,129,100
2.Trunk Sewer (m)								
200mm	0	0	0	0	2,368	0	0	2,368
250mm	0	0	0	0	86	0	0	86
300mm	162	0	332	3,080	1,222	1,750	1,015	7,561
350mm	865	0	0	2,872	101	1,641	970	6,449
400mm	860	666	530	1,128	121	622	389	4,316
450mm	0	412	0	859	289	542	316	2,419
500mm	1,735	370	0	2,340	641	0	832	5,919
600mm	0	0	0	529	1,303	0	0	1,832
S-Total	3,623	1,448	862	10,808	6,130	4,556	3,522	30,951
3.Force Main (m)								
150mm	0	0	0	0	413	0	0	413
200mm	0	0	0	0	781	0	379	1,160
250mm	0	0	0	0	0	127	0	127
300mm	0	0	0	0	605	145	435	1,185
350mm	0	0	0	0	80	0	730	810
400mm	0	0	0	0	0	0	0	0
450mm	0	0	0	0	1,627	0	536	2,163
500mm	0	0	0	0	153	0	0	153
600mm	0	0	0	0	0	0	1,226	1,226
700mm	0	0	0	0	0	0	0	0
800mm	0	0	0	0	356	0	0	356
S-Total	0	0	0	0	4,015	272	3,307	7,594
4.Pumping Station								
Newly	0	125	0	0	4,014	250	1,291	5,680
Improvement	0	0	0	0	372	0	0	372
S-Total	0	125	0	0	4,386	250	1,291	6,052
5.Treatment Plant								
Newly				5,375	7,745	2,921	3,315	19,356
Improvement	1,363	1,074	1,187					3,624
S-Total	1,363	1,074	1,187	5,375	7,745	2,921	3,315	22,980
6.Ocean Outfall								
					4,893			4,893
S-Total	0	0	0	0	4893	0	0	4,893
G-Total	4,986	2,647	2,049	16,183	27,169	7,999	11,435	72,470

Fig.6.2 Project Implementation and Disbursement Schedule

(Unit:1000Kina)

		Phase-1				Phase-2			Phase-3					Phase-4				
		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Implementation Schedule																		
1. Preparation of Project																		
2. Pre-Construction Stage																		
2-1. Detailed Design																		
2-2. Bidding																		
3. Construction																		
3-1. Collection System																		
Trunk Sewer																		
Force Main																		
3-2. Pumping Station																		
3-3. Sewage Treatment Plant																		
3-4. Ocean Outfall																		
4. Procurement Equipment																		
Disbursement Schedule	**Total Cost**													7,986				
1. Land Acquisition	8,360	297	27			50									114	114	153	153
2. Administration	1,086		14	60	190	5	37	101		22	40	40	42		7,623	7,623	10,183	10,190
3. Construction Work	72,470		938	4,012	12,688	342	2,437	6,752		1,483	2,691	2,691	2,817					
4. Procurement Equipment	1,247							687					560					
5. Engineering Service	7,247		94	401	1,269	34	244	675		148	269	269	282		762	762	1,018	1,019
6. Contingency	7,247		94	401	1,269	34	244	675		148	269	269	282		762	762	1,018	1,019
Sub-Total of Annual Disbursement	97,657	297	1,167	4,875	15,416	466	2,961	8,889		1,802	3,270	3,270	3,983	7,986	9,262	9,262	12,372	12,381
7. O/M Cost	17,544					793	793	793	1,490	1,490	1,490	1,490	1,490	1,543	1,543	1,543	1,543	1,543
Total of Annual Disbursement	115,201	297	1,167	4,875	15,416	1,259	3,754	9,682	1,490	3,292	4,760	4,760	5,473	9,529	10,805	10,805	13,915	13,924

6.4 Organization and systems

(1) Start of water supply and sewerage projects by EDA RANU

The provision, maintenance and operation of water supply and sewerage systems in the Papua New Guinea were carried out by the execution department, a department within the National Capital District Commission (NCDC), which was directly responsible for this work. However, the NCD Water and Sewerage Pty. Ltd., commonly known as "EDA RANU," and owned 100% by the government was established because of the need for an independent corporate body with clearly defined responsibilities, capable of good accomplishments in work for which improved efficiency was demanded, and capable of responding aptly to the increase in population of the capital district. In November 1996, all responsibilities related to provision, management, maintenance and operation of water supply and sewerage systems of the capital district were handed over to EDA RANU. For transfer of management, maintenance and operation of water supply and sewerage from NCDC to EDA RANU, two laws were established (law related to transfer of water supply and sewerage facilities called the "NCDC Transfer of Assets, etc. Act", and the law related to EDA RANU's water supply and sewerage called the "NCD Water and Sewerage Act.")

(2) Management of EDA RANU

EDA RANU has been incorporated as a "Pty. Ltd." This "Pty. Ltd." is a "closely-held corporation" or a "closed corporation." The standing rules of the corporation include (1) restriction in the number of stockholders to less than 50, (2) issue of stocks and company debentures and receiving loans from an unspecified large number of people are prohibited. The laws state that as long as the government owns more than 51% of the stocks (currently the government holds 100%), the Minister of Finance has the authority to: 1) issue and order new stocks; 2) approve appointments/ dismissals of directors; 3) approve contracts (including contracts for employing directors) valued at 100,000 kina and above. Accordingly, this corporation is a national corporation under the jurisdiction of the government.

All assets of water supply and sewerage systems of the NCDC have reverted to EDA RANU, but since the estimation work for assessing the amount is still incomplete, it is not yet clear whether the book value of about 55,000,000 kina is a correct estimate or not, and EDA RANU's capital is still "2 kina, 2 stocks." These two stocks are owned (one each) by the Department of Energy and Petroleum and the Department of National Planning & Implementation (in the name of the Minister of the respective departments). The government is supposed to compensate NCDC for the transferred assets. As a totally self-sustaining body, EDA RANU makes use of loans from government financial institutions (5,000,000 kina) and the income derived by way of water supply and sewerage tariff collection, as the operating capital for managing and operating the systems.

EDA RANU is managed by the Executive Chairman (full time, with a term of two years) who is also the Director, and seven non-full-time directors. The Executive Chairman is appointed by the Prime Minister, while the other directors are appointed by the ministers owning stocks in the corporation. Consequently, the entire amount of salaries to the directors are being paid from EDA RANU's account, but the government holds the

personnel rights of all the directors. The highest decision-making organization for management is the Board, which consists of the Executive Chairman and other directors, but day-to-day management is being carried out by the staff members (total 140 persons as of November 1997) under the General Manager reporting to the Board.

(3) Organization of EDA RANU

EDA RANU's organization consists of the Operation and Maintenance Department (consisting of Water Supply Department, Sewerage Department, Engineering Support Department), and the Administration Department. However, since service contracts have been concluded with private companies for management and maintenance of purification plants (concessive contract for a period of 22 years) and invoicing, collection of water supply and sewerage tariffs, EDA RANU's duties only include management and maintenance of water distribution and supply facilities (refer to Fig.6.3).

A part of the work of managing and maintaining sewerage facilities, such as cleaning the lagoon and replacing sewer pipes, has been entrusted to private companies, but basically, the Sewerage Operation Department has been operating, managing, cleaning and carrying out minor repairs of all the sewerage facilities (refer to Fig.6.4). The work of responding to applications for sewer connections from users is being done not by the Sewerage Operation Department, but by the Planning and Engineering Department.

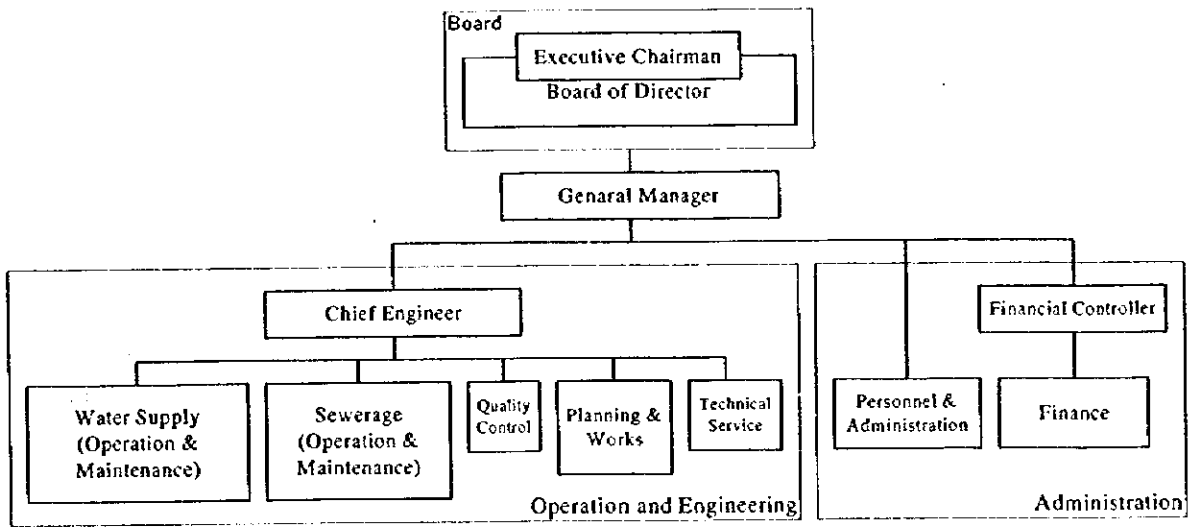


Fig.6.3 Organization of EDA RANU (as of December 1997)

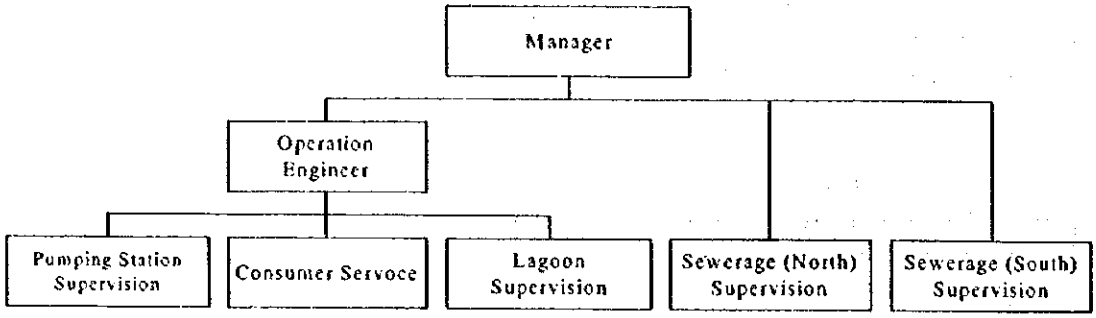


Fig.6.4 Organization of the Sewerage Operation Department (total 31 persons as of December 1997)

6.5 Financial analysis

EDA RANU was privatized in November 1996, and at the same time the work of collecting sewerage tariffs was entrusted to a consultant, JC-KRTA (PNG). During the NCDC management era, there were problems in the overall system, including the tariff system, tariff collection frequency, and tariff recovery percentage, but improvements to the management system became apparent one year after privatization.

JC-KRTA (PNG) made all out efforts after it was entrusted with the service contract in November 1996 and established a water supply tariff collection system that accounted for a collection rate of 86%. A year later this water supply tariff collection became established.

The financial base of the sewerage system is tariff collection. We proposed a plan to link the sewerage tariff collection system with the water supply tariff collection system, and EDA RANU has been planning to carry out full-fledged revision of tariffs to be collected from June 1998, along similar lines of thought as our proposed plan. In other words, EDA RANU's plan includes the adoption of meter-rate system as the basis of sewerage tariff based on the quantity of water used, collection of higher tariff from wealthy users whose consumption is larger, distinguishing between tariffs on residential users and industrial users, increasing the income from the latter, and increasing the frequency of tariff payments in a year to facilitate its payment.

The budget for 1997 has been increased substantially to account for maintenance expenditure. This expenditure also includes contingency expenditure, but since the income is inadequate, there are items with excessively small amounts allocated to them in the initial budget. In any case, the amount for operating wages currently is nearly zero, and the maintenance expenditure needs to be restricted within the range of the derived income. This necessitates proportional distribution by arbitrary method, but the introduction of an accounting management system is also under consideration. Improvements are anticipated in the future, and these are some of the effects attributed to privatization.

Financial analysis was carried out not only with regard to investments in the Master Plan, but also for the entire sewerage operation department, including current sewerage operations. All financial statements (money flow table, profit and loss statement and lease comparison table)

for the period in the Master Plan have been estimated and shown in Table 6.3. The revenue derived from the sewerage business is not very high, and the investment plan needs to be justified considering commonality and effects of environmental improvements also. If favorably-received capital can be used, sound management is possible over the long term even considering the financial aspects, but trial calculations clearly show that investing capital through commercial financing leads to financial collapse.

The FIRR is 3.01%, as shown in Table 6.4. However, if grants are made available in the first phase of work, the FIRR can be further improved. External assistance in this way, can contribute significantly to strengthening the financial base of EDA RANU, which has just been privatized.

Table 6.3 The Financial Statesments of Sewerage Division of Eda Ranu : M/P
(Collection Rate 80 %(first five years), 85 % (after that), Interest Rate 2.7 %)

Phase	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	4
Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Fund Flow Table																	
Cash Collection 80%-85%	5,426	5,709	5,969	6,240	6,523	7,246	7,575	7,879	8,195	8,254	8,865	9,221	9,591	9,975	10,375	10,791	11,228
Loan (2.7%)	297	1,167	4,874	15,416	465	2,963	8,889	0	1,801	3,269	3,269	3,983	7,986	9,261	9,261	12,372	12,381
Investment	297	1,167	4,874	15,416	465	2,963	8,889	0	1,801	3,269	3,269	3,983	7,986	9,261	9,261	12,372	12,381
Interest Payment (2.7%)	8	40	171	587	600	680	920	920	969	1,057	1,145	1,250	1,457	1,678	1,898	2,198	2,486
Loan Repayment	0	0	0	0	0	0	0	0	0	0	15	73	317	1,088	1,111	1,259	1,704
O/M	3,502	3,684	3,851	4,026	4,209	4,676	4,887	5,084	5,288	5,501	5,721	5,949	6,188	6,437	6,694	6,964	7,249
Net Cash Inflow	1,916	1,985	1,947	1,627	1,714	1,890	1,768	1,875	1,939	1,697	1,984	1,949	1,628	772	672	370	-211
Income Statement																	
Cash Collection 80%-85%	5,426	5,709	5,969	6,240	6,523	7,246	7,575	7,879	8,195	8,254	8,865	9,221	9,591	9,975	10,375	10,791	11,228
O/M	3,502	3,684	3,851	4,026	4,209	4,676	4,887	5,084	5,288	5,501	5,721	5,949	6,188	6,437	6,694	6,964	7,249
Depreciation	0	23	164	606	614	684	1,003	1,003	1,039	1,106	1,174	1,284	1,284	1,476	1,669	1,940	2,211
Interest Payment (2.7%)	8	40	171	587	600	680	920	920	969	1,057	1,145	1,250	1,457	1,678	1,898	2,198	2,486
Balance	1,916	1,962	1,783	1,021	1,100	1,206	765	872	900	591	825	738	661	384	114	-311	-718
Balance sheet																	
Cash	1,916	3,902	5,848	7,475	9,189	11,079	12,847	14,722	16,661	18,357	20,342	22,291	23,919	24,691	25,363	25,734	25,523
Investment	0	1,140	6,014	21,430	21,845	24,808	33,697	33,697	35,498	38,767	42,036	46,019	46,019	55,280	64,541	76,913	89,294
Less Accum.Depreciation	0	23	187	793	1,407	2,091	3,094	4,097	5,203	6,377	7,661	8,945	10,421	12,090	14,030	16,241	16,241
Land	297	324	324	324	374	374	374	374	374	374	374	374	8,360	8,360	8,360	8,360	8,360
Total Assets	2,213	5,343	11,999	28,436	30,001	34,170	43,824	44,696	47,330	51,121	55,091	59,739	67,877	76,241	84,234	94,766	106,936
Loan (balance)	297	1,464	6,338	21,754	22,219	25,182	34,071	34,071	35,872	39,141	42,395	46,305	53,974	62,147	70,297	81,410	92,087
Reserved Fund	1,916	3,879	5,661	6,682	7,782	8,988	9,753	10,625	11,458	11,980	12,696	13,434	13,903	14,094	13,937	13,356	14,849
Total Liabil.&Capital	2,213	5,343	11,999	28,436	30,001	34,170	43,824	44,696	47,330	51,121	55,091	59,739	67,877	76,241	84,234	94,766	106,936

Table 6.4 FIRR of the Eda Ranu Sewerage Service (Master Plan)

(1000 Kina:1997 Price)

Year	Cash Collection	Investment (All	O&M	Total Cash Outflow	Net Cash Flow	FIRR
1999	5,426	297	3,502	3,799	1,627	
2000	5,709	1,167	3,684	4,851	858	
2001	5,969	4,874	3,851	8,725	-2,756	
2002	6,240	15,416	4,026	19,442	-13,202	
2003	6,523	465	4,209	4,674	1,849	
2004	7,246	2,963	4,676	7,639	-393	
2005	7,575	8,889	4,887	13,776	-6,201	
2006	7,879	0	5,084	5,084	2,795	
2007	8,195	1,801	5,288	7,089	1,106	
2008	8,254	3,269	5,501	8,770	-516	
2009	8,865	3,269	5,721	8,990	-125	
2010	9,221	3,983	5,949	9,932	-711	
2011	9,591	7,986	6,188	14,174	-4,583	
2012	9,975	9,261	6,437	15,698	-5,723	
2013	10,375	9,261	6,694	15,955	-5,580	
2014	10,791	12,372	6,964	19,336	-8,545	
2015	11,228	12,381	7,245	19,626	-8,398	
2016	11,228	931	7,245	8,176	3,052	
2017	11,228	2,861	7,245	10,106	1,122	
2018	11,228	0	7,245	7,245	3,983	
2019	11,228	233	7,245	7,478	3,750	
2020	11,228	3,026	7,245	10,271	957	
2021	11,228	0	7,245	7,245	3,983	
2022	11,228	0	7,245	7,245	3,983	
2023	11,228	40	7,245	7,285	3,943	
2024	11,228	40	7,245	7,285	3,943	
2025	11,228	668	7,245	7,913	3,315	
2026	11,228	0	7,245	7,245	3,983	
2027	11,228	148	7,245	7,393	3,835	
2028	11,228	148	7,245	7,393	3,835	
2029	11,228	505	7,245	7,750	3,478	
2030	11,228	514	7,245	7,759	3,469	
2031	11,228	931	7,245	8,176	3,052	
2032	11,228	2,861	7,245	10,106	1,122	
2033	11,228	0	7,245	7,245	3,983	
2034	11,228	233	7,245	7,478	3,750	
2035	11,228	3,026	7,245	10,271	957	
2036	11,228	0	7,245	7,245	3,983	
2037	11,228	0	7,245	7,245	3,983	
2038	11,228	40	7,245	7,285	3,943	
2039	11,228	40	7,245	7,285	3,943	
2040	11,228	668	7,245	7,913	3,315	*3.01%*
2041	11,228	0	7,245	7,245	3,983	3.19%
2042	11,228	148	7,245	7,393	3,835	3.35%
2043	11,228	148	7,245	7,393	3,835	3.49%
2044	11,228	505	7,245	7,750	3,478	3.61%
2045	11,228	514	7,245	7,759	3,469	3.72%

7. FEASIBILITY STUDY FOR PRIORITY PROJECTS

The capacity of existing sewerage facilities has been verified to be adequate for the inland area from among the areas mentioned in the Master Plan. However, the problem of marine pollution is very serious in the coastal area, and it has been confirmed that urgent measures for improvement are necessary. Based on these facts, the existing urbanized areas centered around Town district and Kila Kila District were selected as priority project areas.

7.1 Sewerage system

(1) Paga zone

Sewage will be collected from the new zone of Baruni, Tatana, Idubada and Hanuabada, while making effective use of existing facilities in the Town zone. After connecting these zone to the existing facilities of Town zone, the sewage will be treated by simplified methods at Paga point and discharged into the sea. The outline of the planned population, planned sewage volume and various facilities is as given below.

- Planned population: 31,162 persons (in the year 2005); 36,000 persons (in the year 2015)
- Planned sewage volume: 18,900 m^3/day (in the year 2005); 20,700 m^3/day (in the year 2015)
- New pumping stations: At seven locations (Tatana 1, 2, 3, 4; Hanuabada 1, 2; Konedobu 1)
- Rehabilitation of existing pumping stations: At six locations (Yacht Club, Konedobu 2, Stanley, Rose, Dabara, Paga)
- Trunk sewer pipelines (Gravity flow pipe: Concrete pipe, PVC pipe): Approx. 5,500 m
- Trunk sewer pipelines (Conveying pipe: Ductile cast iron): Approx. 4,300 m
- Sub-trunk sewer pipelines (Gravity flow pipes: Concrete pipe. PVC pipe): Approx. 3,400 m
- Treatment plants: Primary sedimentation ponds and sludge thickening tanks

(2) Kila Kila zone

Currently, approximately 50% of the surface-laid pipes have been installed in the Koki, Badili and Kila Kila zone. While making use of these pipes, the new zone of Gabutu, Vabukori and Pari will be connected, treatment plants will be installed at locations facing the Joyce Bay in the Kila Kila zone, and the sewage collected will be discharged into the Papuan Lagoon. The outline of planned population, planned sewage volume and other facilities is as given below.

- Planned population: 61,400 persons (in the year 2005); 70,100 persons (in the year 2015)
- Planned sewage volume: 35,900 m^3/day (in the year 2005); 41,000 m^3/day (in the year 2015)
- New pumping stations: At eight locations (Kila Kila; Gabutu 1, 2, 3; Vabukori 1, 2, 3; Pari)
- Rehabilitation of existing pumping stations: At three locations (Koki, Badili, Kaugere)

- Trunk sewer pipelines (Gravity flow pipe: Concrete pipe, PVC pipe): Approx. 3,100 m
- Trunk sewer pipelines (Conveying pipe: Ductile cast iron): Approx. 7,900 m
- Sub-trunk sewer pipelines (Gravity flow pipes: Concrete pipe, PVC pipe): Approx. 6,600 m
- Ocean discharge pipelines (High density polyethylene pipe: 900 mm): 3,650 m
- Treatment plants: Primary sedimentation ponds and sludge thickening tanks

7.2 Construction cost

The total project cost required for providing facilities in the priority project area is 34,071,000 kina. From this cost, Kila Kila zone accounts for 21,755,000 kina or approximately 65% of the total cost, and Paga zone accounts for 12,316,000 kina or approximately 35% of the total cost.

7.3 Implementation plan

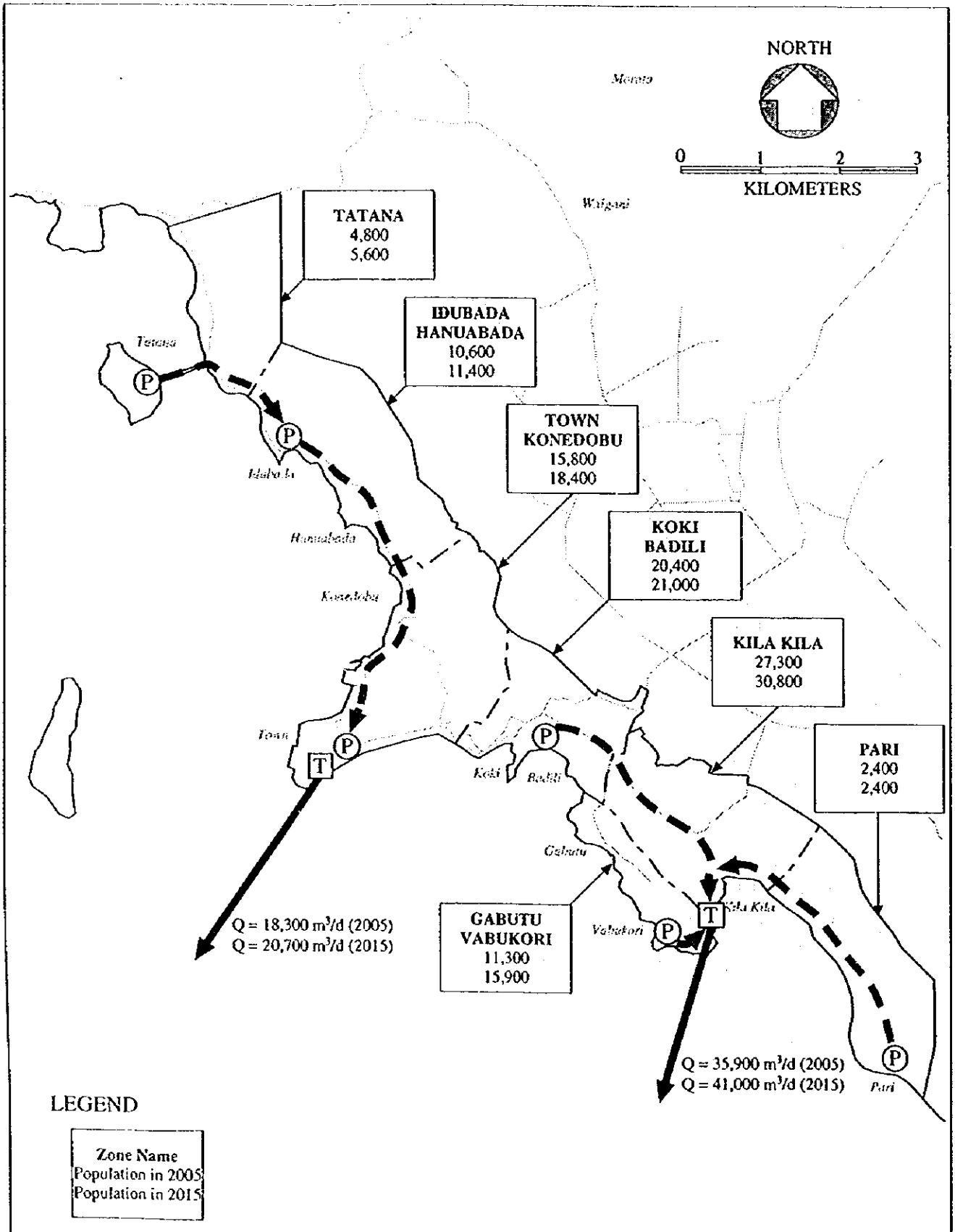
A review of the current state of marine pollution shows that this problem is serious in Joyce Bay, and urgent measures for improvement are required. On the other hand, the effect of pipelines discharging sewage into the sea at Paga Point in the Paga zone is considerably large. This effect could also be verified through contamination analysis performed during the Study. From the above, it was decided to implement the plan by dividing it into two phases, taking Phase 1 for Kila Kila zone and Phase 2 for Paga zone.

(1) Phase 1 (Year 2000 to 2002)

In the year 2000, construction of sewer pipelines will start from the downstream end of Kila Kila zone. From the following year onward, construction of sewer pipelines of other districts and construction of the Kila Kila treatment plant will start. By the year 2003, the construction of pipes discharging into the sea and pumping stations attached to the Kila Kila treatment plant will be completed.

2) Phase 2 (Year 2003 to 2005)

Construction of trunk lines of Konedobu and Town districts will start from the year 2003. In the following year, that is 2004, construction of the sewer pipelines and pumping stations in other districts will be completed. In the year 2005, after completing treatment facilities and other remaining work at Paga Point, all the work for the priority project area will be completed.



Date	Title	Fig.
May 1998	Proposed Sewerage System in F/S Area	7.1

THE STUDY ON SEWERAGE SYSTEM OF PORT MORESBY IN PAPUA NEW GUINEA

TOKYO ENGINEERING CONSULTANTS in association with NIPPON JOGESUIDO SEKKEI

Table 7.1 Proposed for Each Sewage Facilities

Zone / Item	Paga			Kila Kila				Total
	Haruni/Tatana	Idohada/Hanuabada	Konedobu/Town	Koki/Badili	Gabutu/Vabukori	Kila Kila	Pari	
	70ha	168ha	94ha	134ha	14ha	160ha	9ha	649ha
1.Sewer Network (m)	9,800	23,520	-	18,760	1,960	22,400	1,260	67,900
2.Sub-Trunk Sewer (m)								
200mm	550	2,460	160	3,049	0	2,302	520	9,041
250mm	0	130	116	57	0	0	0	303
300mm	0	0	0	0	0	430	0	430
400mm	0	0	0	0	0	200	0	200
S-Total	550	2,590	276	3,106	0	2,932	520	9,974
3.Trunk Sewer (m)								
200mm	760	0	0	0	360	0	0	1,120
250mm	0	0	0	0	0	0	0	0
300mm	2,580	0	0	0	480	0	0	3,060
350mm	0	270	0	0	0	0	0	270
400mm	0	110	0	0	0	0	0	110
450mm	0	640	0	0	0	0	0	640
500mm	0	0	1,181	0	0	52	0	1,233
600mm	0	0	0	373	0	1,843	0	2,216
S-Total	3,340	1,020	1,181	373	840	1,895	0	8,649
4.Force Main (m)								
150mm	960	0	0	0	1,160	0	0	2,120
200mm	0	0	0	0	300	0	3,200	3,500
250mm	0	0	0	0	0	0	0	0
300mm	220	130	0	336	1,400	0	0	2,086
350mm	0	0	220	0	0	0	0	220
400mm	0	0	0	0	0	0	0	0
450mm	0	1,480	1,000	1,160	0	0	0	3,640
500mm	0	0	303	0	0	0	0	303
600mm	0	0	0	0	0	0	0	0
700mm	0	0	0	0	0	0	0	0
800mm	0	0	0	0	0	360	0	360
S-Total	1,180	1,610	1,523	1,496	2,860	360	3,200	12,229
5.Pumping Station	Tatana-1	Hanuabada-1	Konedobu-1, 2	Koki	Gabutu-1, 2, 3	Kila Kila	Pari	
	Tatana-2	Hanuabada-2	Yacht	Badili	Vabukori-1, 2, 3			
	Tatana-3		Stanley	Knugere				
	Tatana-4		Paga					
			Lawes, Davara					
6.Treatment Plant			Paga			Kila Kila		
7.Ocean Outfall (m)			Diameter in 560 mm			Diameter in 900 mm		
			Length in 3,000m			Length in 3,650		
			(Existing)					

Table 7.2 Project Cost

(Unit:1000Kina)

Item \ Zone	Paga			Kila Kila				Total
	Baruni/Tatana	Idubada/Hanuabada	Konedobu/Town	Koki/Badili	Gabutu/Vabukori	Kila Kila	Pari	
1.Sewer Network (m)	70ha	168ha	94ha	134ha	14ha	160ha	9ha	649ha
	9,800	23,520	-	18,760	1,960	22,400	1,260	67,900
2.Sub-Trunk Sewer (m)								
200mm	128	573	37	710	0	536	121	2,107
250mm	0	37	33	16	0	0	0	86
300mm	0	0	0	0	0	151	0	151
400mm	0	0	0	0	0	78	0	78
S-Total	128	610	70	727	0	765	121	2,421
3.Trunk Sewer (m)								
200mm	177	0	0	0	84	0	0	261
250mm	0	0	0	0	0	0	0	0
300mm	903	0	0	0	168	0	0	1,071
350mm	0	101	0	0	0	0	0	101
400mm	0	43	0	0	0	0	0	43
450mm	0	289	0	0	0	0	0	289
500mm	0	0	614	0	0	27	0	641
600mm	0	0	0	219	0	1,084	0	1,303
S-Total	1,080	433	614	219	252	1,111	0	3,709
4.Force Main (m)								
150mm	187	0	0	0	226	0	0	413
200mm	0	0	0	0	67	0	714	781
250mm	0	0	0	0	0	0	0	0
300mm	64	38	0	97	406	0	0	605
350mm	0	0	80	0	0	0	0	80
400mm	0	0	0	0	0	0	0	0
450mm	0	662	447	519	0	0	0	1,627
500mm	0	0	153	0	0	0	0	153
600mm	0	0	0	0	0	0	0	0
700mm	0	0	0	0	0	0	0	0
800mm	0	0	0	0	0	356	0	356
S-Total	251	699	680	616	699	356	714	4,015
5.Pumping Station								
Newly	494	394	1,192	592	818	399	125	4,014
Improvement			249	123				372
S-Total	494	394	1,441	715	818	399	125	4,386
6.Treatment Plant								
			2,636			5,109		7,745
S-Total	0	0	2636	0	0	5,109	0	7,745
7.Ocean Outfall								
						4,893		4,893
S-Total	0	0	0	0	0	4,893	0	4,893
G-Total	1,953	2,135	5,441	2,276	1,769	12,633	960	27,169

Fig.7.2 Project Implementation and Disbursement Schedule

(Unit: 1000Kina)

		Phase-1				Phase-2		
		1999	2000	2001	2002	2003	2004	2005
Implementation Schedule								
1. Preparation of Project								
2. Pre-Construction Stage								
2-1. Detailed Design								
2-2. Bidding								
3. Construction								
3-1. Collection System								
Trunk Sewer								
Force Main								
3-2. Pumping Station								
3-3. Sewage Treatment Plant								
3-4. Ocean Outfall								
4. Procurement Equipment								
Disbursement Schedule	**Total Cost**							
1. Land Acquisition	374	297	27			50		
2. Administration	407		14	60	190	5	37	101
3. Construction Work	27,169		938	4,012	12,688	342	2,437	6,752
4. Procurement Equipment	687							687
5. Engineering Service	2,717		94	401	1,269	34	244	675
6. Contingency	2,717		94	401	1,269	34	244	675
Sub-Total of Annual Disbursement	34,070	297	1,167	4,875	15,416	466	2,961	8,889
7. O/M Cost	2,379					793	793	793
Total of Annual Disbursement	36,449	297	1,167	4,875	15,416	1,259	3,754	9,682

7.4 Financial analysis

The period for feasibility study is from 2000 to 2005, that is eight years out of the period for the Master Plan, covering the first phase (3 years from 2000 to 2002) and the second phase (3 years from 2003 to 2005). The year 2006 is the period for making preparations for the following third phase. Population estimates and other assumptions are the same as in the Master Plan. The investment plan is exactly the same as the investment plan for the first eight years in the Master Plan. An amount equivalent to 34 million kina is being planned as investment up to the year 2005. O&M cost not only includes the O&M cost related to these investments, but also includes the O&M cost for the entire sewerage operation department including the existing department.

The total amount for tariff billed in 1997 was 2,774,000 kina but according to the new tariff system, the annual tariff bill is estimated as 6,782,000 kina. This revised proposal has almost the same contents as our proposal. To ensure sound management of EDA RANU, the new system should be implemented by all means. Our financial analysis presupposes the implementation of this tariff system. The tariff collection rate is predicted as 80% for the first five years, and 85% subsequently. Income is expected to increase significantly compared to the estimated income of the previous World Bank Study, indicating the large impact of privatization.

The calculations for financial statements (money flow table, , profit and loss statement and lease comparison table) are shown in Table 7.3. Assuming that the investment capital can be obtained as a loan at an interest of 2.7% for a period of 30 years (term of deferment 10 years), the depreciation period is calculated with construction items taken as 50 years, machinery and electrical equipment as 15 years, and straight-line depreciation (residual amount zero). Investment on equipment is assumed to be zero at the end of the feasibility study period, the equipment at the point of completion of the feasibility study period is assumed to be retained, and the financial statement until the year 2015 has been estimated. If such conditions are satisfied, the financial status of the sewerage department can be maintained in a sound condition until 2015.

It was verified from trial calculations that if commercial finance is obtained, the project was not at all feasible even if conditions that are very much more generous than the actual financial conditions are assumed in the trial calculations. Accordingly, investments through commercial financing are not possible for an unprofitable sewerage business, and it is essential that funds or grants are requested from international aid organizations.

The FIRR of investment plan of this feasibility study period is shown in Table 7.4. Considering the period until 2015, the FIRR is 6.21%; if a longer period is considered, the FIRR improves. This indicates that the scale of the investment plan should not be very large, and the increase in income from tariff and the O&M cost should be restricted within the range of the income derived from tariffs. In this way, the key to success of this investment plan lies in the implementation of the new tariff system, the establishment of a tariff collection system based on the water tariff, and restriction of the O&M cost within the range of the income. If these items are realized, the investment plan of this feasibility study is feasible and is preferred.

Table 7.3 The Financial Statesments of Sewerage Division of Eda Ranu : F/S

(Collection Rate 80% (first five year), 85% (after that), Interest Rate 2.7 %)

Unit: 1000 Kina 1997 Price

Phase	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	4
Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Fund Flow Table																	
Cash Collection 80%-85%	5,426	5,709	5,969	6,240	6,523	7,246	7,575	7,879	7,879	7,879	7,879	7,879	7,879	7,879	7,879	7,879	7,879
Loan (2.7%)	297	1,167	4,874	15,416	465	2,963	8,889	0	0	0	0	0	0	0	0	0	0
Investment	297	1,167	4,874	15,416	465	2,963	8,889	0	0	0	0	0	0	0	0	0	0
Interest Payment (2.7%)	8	40	171	587	600	680	920	920	920	920	920	918	909	880	850	816	770
Loan Repayment	0	0	0	0	0	0	0	0	0	0	0	15	73	317	1,088	1,111	1,259
O/M	3,502	3,684	3,851	4,026	4,209	4,676	4,887	5,084	5,084	5,084	5,084	5,084	5,084	5,084	5,084	5,084	5,084
Net Cash Inflow	1,916	1,985	1,947	1,627	1,714	1,890	1,768	1,875	1,875	1,875	1,860	1,804	1,569	827	834	720	321
Income Statement																	
Cash Collection 80%-85%	5,426	5,709	5,969	6,240	6,523	7,246	7,575	7,879	7,879	7,879	7,879	7,879	7,879	7,879	7,879	7,879	7,879
O/M	3,502	3,684	3,851	4,026	4,209	4,676	4,887	5,084	5,084	5,084	5,084	5,084	5,084	5,084	5,084	5,084	5,084
Depreciation	0	23	164	606	614	684	1,003	1,003	1,003	1,003	1,003	1,003	1,003	1,003	1,003	1,003	1,003
Interest Payment (2.7%)	8	40	171	587	600	680	920	920	920	920	920	918	909	880	850	816	770
Balance	1,916	1,962	1,783	1,021	1,100	1,206	765	872	872	872	872	874	883	912	942	976	1,022
Balance sheet																	
Cash	1,916	3,902	5,848	7,475	9,189	11,079	12,847	14,722	16,597	18,471	20,331	22,136	23,704	24,531	25,365	26,085	26,406
Investment	0	1,140	6,014	21,430	21,845	24,808	33,697	33,697	33,697	33,697	33,697	33,697	33,697	33,697	33,697	33,697	33,697
Less Accum.Depreciation	0	23	187	793	1,407	2,091	3,094	4,097	5,100	6,103	7,106	8,109	9,112	10,115	11,118	12,121	12,121
Land	297	324	324	324	374	374	374	374	374	374	374	374	374	374	374	374	374
Total Assets	2,213	5,343	11,999	28,436	30,001	34,170	43,824	44,696	45,568	46,439	47,296	48,098	48,663	48,487	48,318	48,035	48,356
Loan (balance)	297	1,464	6,338	21,754	22,219	25,182	34,071	34,071	34,071	34,071	34,056	33,983	33,666	32,578	31,467	30,208	28,504
Reserved Fund	1,916	3,879	5,661	6,682	7,782	8,988	9,753	10,625	11,497	12,368	13,240	14,115	14,997	15,909	16,851	17,827	19,852
Total Liabil.&Capital	2,213	5,343	11,999	28,436	30,001	34,170	43,824	44,696	45,568	46,439	47,296	48,098	48,663	48,487	48,318	48,035	48,356

Table 7.4 FIRR of the Eda Ranu Sewerage Service (F/S)

(1000 Kina:1997 Price)

Year	Cash Collection	Investment (All)	O&M	Total Cash Outflow	Net Cash Flow	FIRR
1999	5,426	297	3,502	3,799	1,627	
2000	5,709	1,167	3,684	4,851	858	
2001	5,969	4,874	3,851	8,725	-2,756	
2002	6,240	15,416	4,026	19,442	-13,202	
2003	6,523	465	4,209	4,674	1,849	
2004	7,246	2,963	4,676	7,639	-393	
2005	7,575	8,889	4,887	13,776	-6,201	
2006	7,879	0	5,084	5,084	2,795	
2007	7,879	0	5,084	5,084	2,795	
2008	7,879	0	5,084	5,084	2,795	
2009	7,879	0	5,084	5,084	2,795	
2010	7,879	0	5,084	5,084	2,795	
2011	7,879	0	5,084	5,084	2,795	
2012	7,879	0	5,084	5,084	2,795	
2013	7,879	0	5,084	5,084	2,795	
2014	7,879	0	5,084	5,084	2,795	
2015	7,879	0	5,084	5,084	2,795	*6.21%*
2016	7,879	931	5,084	6,015	1,864	6.90%
2017	7,879	2,861	5,084	7,945	-66	6.88%
2018	7,879	0	5,084	5,084	2,795	7.68%
2019	7,879	233	5,084	5,317	2,562	8.28%
2020	7,879	3,026	5,084	8,110	-231	8.23%
2021	7,879	0	5,084	5,084	2,795	8.73%
2022	7,879	0	5,084	5,084	2,795	9.14%
2023	7,879	0	5,084	5,084	2,795	9.48%
2024	7,879	0	5,084	5,084	2,795	9.77%
2025	7,879	0	5,084	5,084	2,795	10.02%
2026	7,879	0	5,084	5,084	2,795	10.23%
2027	7,879	0	5,084	5,084	2,795	10.40%
2028	7,879	0	5,084	5,084	2,795	10.56%
2029	7,879	0	5,084	5,084	2,795	10.69%
2030	7,879	0	5,084	5,084	2,795	10.80%
2031	7,879	931	5,084	6,015	1,864	10.87%
2032	7,879	2,861	5,084	7,945	-66	10.87%
2033	7,879	0	5,084	5,084	2,795	10.95%
2034	7,879	233	5,084	5,317	2,562	11.01%
2035	7,879	3,026	5,084	8,110	-231	11.01%
2036	7,879	0	5,084	5,084	2,795	11.06%
2037	7,879	0	5,084	5,084	2,795	11.11%
2038	7,879	0	5,084	5,084	2,795	11.15%
2039	7,879	0	5,084	5,084	2,795	11.19%
2040	7,879	0	5,084	5,084	2,795	11.22%
2041	7,879	0	5,084	5,084	2,795	11.25%
2042	7,879	0	5,084	5,084	2,795	11.28%
2043	7,879	0	5,084	5,084	2,795	11.30%
2044	7,879	0	5,084	5,084	2,795	11.32%
2045	7,879	0	5,084	5,084	2,795	11.34%

7. 5 Project Evaluation and Recommendation

The coastal area, which has been selected as a priority project area, has old and outmoded facilities, but the sewerage collection system is accessible to nearly 50% of the population. However, in most locations, the sewage collected is discharged into the sea, and this has become the prime cause of marine pollution. In this section, the effects of implementing this project and the evaluations considering future developments are mentioned, as below.

The outline of facilities required for the project are as follows:

- **Installation of sub-trunk sewer pipelines:** Pipelines connected to the ends of existing sewer system and connecting new trunk sewers
- **Installation of trunk sewers:** Pipelines that connect sub-trunk sewer pipes and reach up to the treatment plant via pumping stations
- **Pumping stations:** Based on geographical and terrain conditions, new pumping stations are required at 16 locations along the trunk sewer route. The capacity of eight existing pumping stations is to be enhanced by extensive improvements in order to cope with the increase in capacity in the future.
- **Treatment plants:** Installation of primary sedimentation facilities and sludge thickening facilities at the treatment plants at two locations - Paga and Kila Kila
- **Ocean outfall pipeline:** Existing facilities at Paga shall be used; installation of new outfall pipeline with diameter 900 mm and length 3,650 m at Kila Kila

(1) Water quality conservation effect for receiving water bodies

Results of simple pollution analysis show that COD and coliform levels are below the strict standard levels of Japan. It was also found that accumulation of T-N and T-P, which are difficult to decompose, will not be a problem in the year 2015. From the above, the following effects are anticipated to accompany the purification of receiving water bodies:

- The natural environment will be conserved by protecting animal and plant species in and surrounding the water
- Aquatic resources will be protected
- Environment around water will be conserved through allocation of areas for recreation activities
- Scenic spots around water bodies in cities will create a cool, pleasant and peaceful feeling

(2) Recommendation for conserving water quality of receiving water bodies over a very long term

The levels of COD, T-N, T-P and total coliform in public water bodies up to the year 2015 are as mentioned above. However, the purifying functions of nature cannot bring about decomposition of T-N and T-P, which gradually accumulate in the Papuan Lagoon, bring about an increase in the nutritive salts due to eutrophication, and reduce the dissolved oxygen. There are apprehensions that the above-mentioned factors may lead to extinction of fish and destruction of coral reefs.

As a part of this Study, a baseline study was implemented for constructing a monitoring system over the long term in order to study the effects of implementation of this project on coral reefs found at a large number of locations surrounding sea areas. It is felt that the discharge outlet into the sea should be extended to the outer reef, and direct discharge offshore should also be considered.

For this case, the two instances mentioned below for the two locations at Paga Point and Kila Kila were visualized, and the approximate project costs for installing treatment plants were compared. Comparing to the current plan, the cost would increase by 3.4 million Kina in the case of Paga Point, and by 6.5 million in the case of Kila Kila with the least cost plan A (refer to Table 7.5 and 7.6). It is required to reconsider before implementation whether this extension plan should be executed or not.

For Paga Point

The existing ocean outfall pipe (diameter 600 mm) is extended to the outer reef over a distance of 4.5 km.

- Total Extension: 7.5 km
- Extension of the existing pipe: 3.0 km
- Additional extension: 4.5 km
- Extension of inner reef excavation: None
- Extension of outer reef excavation: 2.0 km
- Construction cost: Approximately 5.418 million kina.

Table 7.5 Comparison of Ocean Outfall Option (1) (Unit : Thousand Kina)

	STP Installation Plan	Outfall Pipe Extension (No Treatment)
1. Land Acquisition	50	-
2. Administration	143	185
3. Construction Work	9,531	(9,531-2,636)+5,418=12,313
4. Procurement Equipment	687	687
5. Engineering Service	953	1,231
6. Contingency	953	1,231
7. Total	12,217(1.00)	15,647(1.28)

For Kila Kila

The following three cases may be contemplated considering the effects of pipe excavations on coral reefs:

Case A: Extension of the pipeline in the present plan to the outer reef (no treatment plant)

- Total Extension: 7.65 km
- Extension of the planning: 3.65 km
- Additional extension: 4.0 km
- Extension of inner reef excavation: 1.5 km

- Extension of outer reef excavation: 1.0 km
- Construction cost: Approximately 10.560 million kina

Case B: Shift of pipeline under present plan to the tip of the peninsula and extension to the outer reef (no treatment plant)

- Total Extension: 9.15 km
- Extension over land: 1.65 km
- Extension of the sea floor: 7.5 km
- Extension of inner reef excavation: None
- Extension of outer reef excavation: 1.5 km
- Construction cost: Approximately 12.260 million kina

Case C: Over land up to Taurama Beach and extension to the outer reef (no treatment plant)

- Total Extension: 10.0 km
- Extension over land: 6.5 km
- Extension of the sea floor: 3.5 km
- Extension of inner reef excavation: None
- Extension of outer reef excavation: 1.0 km
- Construction cost: Approximately 14.270 million kina

Table 7.6 Comparison of Ocean Outfall Option (2) (Unit : Thousand Kina)

	STP	Ocean outfall Pipe Extension (No Treatment)		
	Installation Plan	Case A	Case B	Case C
1. Land Acquisition	324	-	-	-
2. Administration	264	346	372	402
3. Construction Work	17,638	23,089	24,780	26,799
4. Procurement Equipment	-	-	-	-
5. Engineering Service	1764	2,309	2,479	2,680
6. Contingency	1,764	2,309	2,479	2,680
7. Total	21,754(1.00)	28,053(1.29)	30,119(1.38)	32,561(1.50)

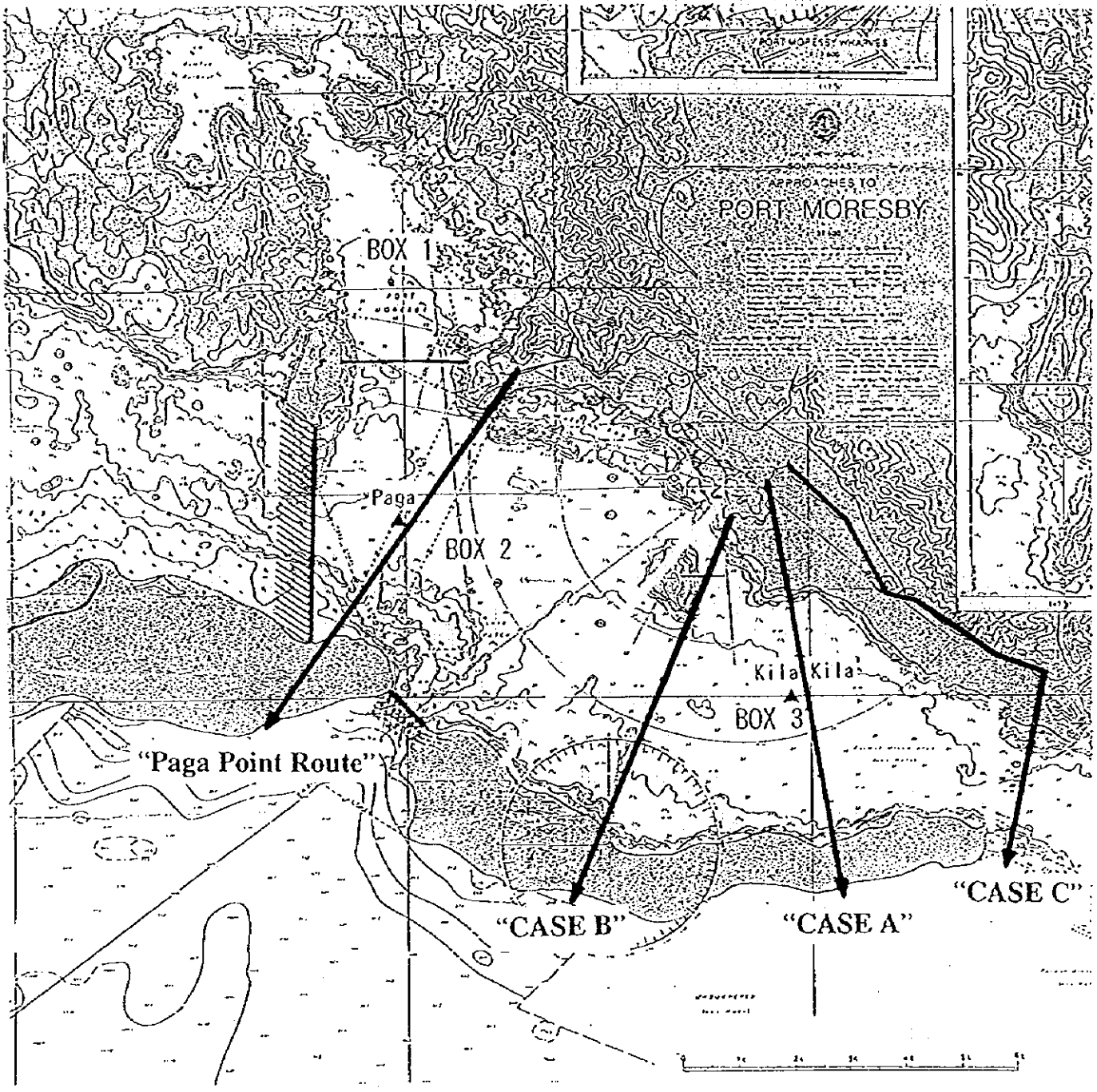


Fig 7.2 The Concept of Ocean Outfall Route

(3) Recommendation for management of sewerage project

1) Views on financial status in the future

The FIRR for this project considering the period until 2015 is 6.21%. The key to success of this investment plan lies in implementing a new tariff system and establishing the tariff collection system based on the water tariff. If the O&M costs are restricted to fall within the range proportional to the income, this investment plan is feasible and may be said to be desirable.

2) Review of organization to cope with the expansion of sewerage facilities

The construction and scale of organization of the departments responsible for sewerage work of EDA RANU is considered to be generally adequate for maintaining and operating the existing sewerage facilities. However, with the expansion of sewerage facilities and reinforcement of maintenance and operations to be proposed by the Study Team, a review of the organization and business plans is necessary so that the ability to implement operation and maintenance plans of sewerage facilities to be expanded in the future, can be enhanced.

Given below are the construction of organization and duties of every responsible department for operation and maintenance of sewerage facilities in the future. The planning and design departments, material procurement and work subcontracting departments, and workshop (stores, machinery repairs) departments are not organized separately for the water supply system and the sewerage system, but integrated. Persons responsible for sewerage and persons responsible for water supply shall be stationed in each department.

Organization	Charged Tasks
Sewage Operation and Maintenance Section	Periodic inspection and cleaning of sewers and manholes. Fixing broken pipes and superannuated pipes. Connecting to households. And yet, the work groups are divided into Coastal Area and Inland Area
Pumping Station Operation and Maintenance Section	Periodic inspection. Fixing troubles and cleaning. And yet, the outside charges except simple repairs.
Treatment Plant Operation and Maintenance Section	Inspection of STP. Removal of sludge. Accumulated sludge moving to the farming land. The external charges except daily routine works such as grass mowing within the premises.
Water Analysis Control	Water quality analysis for influent and effluent of STP. Monitoring and analyzing of industrial wastewater and toxic substances. The external charges for detailed water analysis asking to the reliable laboratory and institute.

＜Below listed sections hold the charges in common with the water supply section＞

Planning and Design Section	Maintaining and keeping the sewerage ledger. Negotiating with and instructing developers. Developing an annual plan. Basic design and cost estimation. Supervising works.
Procurement Section	Materials and equipment procurement. Construction ordering.
Workshop Section	Periodic inspection and repair for materials and equipment. Stock management. Maintenance of machine-tool and tools

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