FINAL DRAFT REPORT
ON
MASTER PLAN
FOR
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH/BUKIT MERTAJAM METROPOLITAN AREA
MALAYSIA

VOLUME I
MASTER PLAN REPORT

NOVEMBER 1977

JAPAN INTERNATIONAL COOPERATION AGENCY

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ORDER OF PRESENTATION

VOLUME I MASTER PLAN REPORT

PART I	SUMMARY OF FINDINGS AND RECOMMENDATIONS----	I-1-21
PART II	BACKGROUND ----------	II-1-48
PART III	SEWERAGE MASTER PLAN ----------	III-1-68
PART IV	DRAINAGE MASTER PLAN ----------	IV-1-55
PART V	MANAGEMENT STUDIES----------	V-1-42

1) LIST OF ABBREVIATIONS
2) CONVERSION TABLES
3) GLOSSARY (DEFINITIONS OF TERMS)

VOLUME II APPENDICES

APPENDIX A	ECONOMY ----------	A-1-21
APPENDIX B	POPULATION & LAND USE DISTRIBUTION -------	B-1-14
APPENDIX C	WATER SUPPLY ----------	C-1- 9
APPENDIX D	WATER POLLUTION STUDIES ----------	D-1-20
APPENDIX E	DESIGN DATA ----------	E-1-59
APPENDIX F	WASTEWATER CHARACTERISTICS ----------	F-1-29
APPENDIX G	SEWERAGE SYSTEM CONSIDERATION ----------	G-1-37
APPENDIX H	STAGING OF SEWERAGE CONSTRUCTION ---------	H-1-36
APPENDIX I	STORMWATER QUANTITY ----------	I-1-13
APPENDIX J	DRAINAGE SYSTEM CONSIDERATION ----------	J-1-31
APPENDIX K	ALTERNATIVE ORGANIZATIONS ----------	K-1-4

PART - I

SUMMARY OF FINDINGS

AND RECOMMENDATIONS

Table of Contents

Section			Page
1.	INTRODUCTION	.....	I-1
2.	FINDINGS	.....	I-1
	2.1 Present Conditions of the Project Area	.....	I-1
	2.2 Conclusions and Result of Studies	.....	I-5
3.	RECOMMENDATIONS	.....	I-7
	3.1 Proposed Plans	.....	I-7
	Sewerage	.....	I-7
	Drainage	.....	I-8
	3.2 Proposed Staging of Construction	.....	I-8
	Sewerage	.....	I-8
	Drainage	.....	I-9
	3.3 Cost of Recommended Programme	.....	I-10
	3.4 Benefit of the Proposed Programme	.....	I-10
	3.5 Managerial Arrangements	.....	I-17
	3.6 Implications for Further Actions and Studies	.....	I-18

PART I

SUMMARY OF FINDINGS AND RECOMMENDATIONS

1. INTRODUCTION

The provision of an adequate sewerage and drainage systems for Butterworth/Bukit Mertajam Metropolitan Area for the year 2000 poses problems both technical and managerial. The task is of such magnitude as to require a formal long-range projected programme consisting of four staged undertakings sequenced over a period of 20 years. This Report submitted herewith contains the results of a comprehensive study of the problems and its practical solution in the form of a master plan for the proposed ultimate system. This comprises the overall scope of work within which individual stages may be scheduled and implemented with due effectiveness for the measured progress in orderly and reasonable manner towards an ultimate goal of the Project.

This Report includes and incorporates the results of field investigations, surveys, population forecasts, and interrelated technical and management studies, which broadly establish the basis of a multi-staged programme for the future development of the sewerage and drainage systems within the Project Area. The total programme is envisaged to give sufficient impact for improvement of environmental sanitation of the Area by providing adequate facilities for wastewater control programme inclusive of prevention of water pollution, which will undoubtedly contribute to enhance rapid development of the Area for commercial, industrial and residential purposes.

2. FINDINGS

2.1 Present Conditions of the Project Area

(a) In the Penang Master Plan prepared for the Penang Master Plan Committee in 1970, it was proposed to establish a metropolitan area in

Province Wellesley, which includes the two towns of Butterworth and Bukit Mertajam. According to the Plan, such metropolitan area would be well established by the year 1985. On the basis of this, the Project Area of the present report for Sewerage and Drainage Master Plan is defined basically as the Butterworth/Bukit Mertajam Metropolitan Area with total area of 11,600 ha (28,663 acres), excluding air-base. (Ref. Part II. Background). For the sewerage master planning purpose, the area excluding non-habitable areas such as, cemeteries, rivers, etc., with a total area of 10,854 ha (26,820 acres) is considered (Ref. Part III. Sewerage Master Plan). For drainage master planning purpose, due to topographical condition outside of the Project Area of 4,290 ha (10,600 acres) are taken into account, thus the total area considered for drainage system planning is 15,890 ha (39,260 acres). (Ref. Part IV. Drainage Master Plan).

(b) On the basis of 1970 National Census and by summation of ourselves for the Project Area, the population of the Project Area in 1970 is considered to be 172,230, based on which the population in 1976 is estimated to be 238,000, assuming 5.5% annual increase as in case of Penang Master Plan. (Ref. Part II. Background)

(c) Province Wellesley, in which the Project Area is situated, is essentially a flat alluvial plain, lying below RL+15m (+50 feet), being interrupted by patches of hilly land at its south-eastern border. The highest point of these hills is in the Bukit Mertajam, which is RL+536m (1,787 feet) and is located south-east end of the Project Area. These hills are formed in Mesozoic, Post Triassic Period and their formation is granite.

The Project Area is dominated by the Prai and Juru rivers, but is typified by natural river profiles meandering amongst tidal and fresh water swamps. With controlled drainage and irrigation, the Area is agriculturally productive and well suited to a variety of crops including rice, coconuts, pineapples, rubber and oil palms. (Ref. Part II. Background)

(d) Temperature is relatively constant throughout the year and the average monthly temperature varies by about 2°C (4°F). However, the daily temperatures show a greater variation of 5°C to 8°C (10°F to 15°F), with a mean day time maximum of 29°C(85°F) and a mean minimum of 22°C (71°F) at night. (Ref. Part II. Background)

(e) Heavy rain is recorded during the months of September, October and November. The total precipitation of 810 mm (31.9") was recorded through these months which was 37 percent of the annual rainfall of 2,172 mm (85.5"), on the basis of the record for five years from 1965 through 1970. (Ref. Part II. Background)

(f) The economy of whole Malaysia, inclusive of Project Area, has recently been remarkably improved by the vigorous government effort for the exploitation of affluent natural resources. In line with the economic development, the industrialization has been emerged as important economic sector to accommodate the increasing labor force.

The Third Malaysian Plan (1976 - 1980), has recently been launched and development expenditure of the government is expected to increase for the consecutive years reflecting the government emphasis on the improvement of infrastructural facilities.

(g) Penang is presently at a stage of its economic development as it is currently undergoing a process of economic restructuring, necessitate by its desire for economic growth and advancement. This economic restructuring has successfully been implemented by the strong support of both the State and the Federal Governments. Even in the Project Area, it is evident that industrial developments are significant and quite a number of factories are in operation in Mak Mandin and Prai industrial areas. With the implementation of these industrial development programmes, the State will attract more and more investors which will enable the State significant increase in Gross Regional Product and at the same time increase in population.

(h) Effect of pollution by domestic, industrial and other sources has been evident according to the results of our surveys on the water courses surrounded by commercial and residential areas and offshore marine waters facing the industrial zones, which suggest the need for implementation of the comprehensive sewerage system programme with due consideration on industrial waste control at the earliest possible date. (Ref. Part II. Backgound)

(i) Existing individual excreta disposal systems in the Project Area are mostly bucket system and septic tank with flush toilet. About 30 percent of population in the urbanized areas of the Project Area use flush toilet with septic tank, and from 60 to 70 percent of population use bucket system, while Kampongs generally use pit privies and others.

Sludge from septic tank is transported by vacuum lorries (desludgers) to trenching ground for burial. V-trenches of 1 m (3 ft) depth are dug and filled with sludge, and when full, they are covered with earth and levelled. Human excreta collected in bucket is dumped at the restricted site (Ref.Part II. Background)

(j) One general hospital, eight hospitals, 11 maternity hospitals, and 13 main health centers, excluding private clinics, are in Penang State. Generally, they are distributed adequately.

According to the record obtained from the Government District Hospitals/Clinics, the largest number of patients of water-borne diseases is of infectious hepatitis, followed by of dysentery and typhoid fever. (Ref. Part II. Background)

(k) Water supply conditions in Province Wellesley are satisfactory in terms of quantity and quality. The entire Province Wellesley is already covered by main pipe lines, and therefore, all of the population in the Province may soon be covered in the foreseeable future. (Ref. Part II. Background)

(l) About 80% of the Project Area is the tributary of the Prai and Juru rivers and the remaining parts discharge to the sea via existing numerous natural and piecemeal improved water course. Generally, the existing drains are with meandering alignment of varied widths and depths, which require need for improvements. The predominant topographical features of the area are low-lying and flat in which most of the existing drains are influenced by the tide, and these drains are commonly provided with tidal gates to prevent the flooding or damages to agricultural products due to the sea water. Average elevation in the Project Area is about RL+2.0 meters (+6.5 ft) while major areas lie below the RL+1.0 meter (3.0 ft). Mean high tide of the sea level is RL+1.1 meters (+3.6 ft) and the maximum is RL+1.68 meters (+5.5 ft). (Ref. Part II. Background)

(m) Due to the rapid development, numerous swamps which are now functioning as the reservoirs for controlling considerable flooding of the Area are demolishing. As a result, significant increase of the peak discharge of stormwater runoff is expected in the future. It is also observed during field surveys that even the existing drains have been or are to be overloaded by on-going development programme, especially in two urban areas, Butterworth and Bukit Mertajam. (Ref. Part II. Background)

2.2 Conclusions and Result of Studies

In pursuance of the ultimate objective of improving environmental sanitary conditions throughout the Project Area, investigations have been made into the adequacy of the existing waste disposal and drainage facilities, and methods whereby deficiencies can be eliminated.

On the basis of the results of the investigations, basic design bases for the system have been developed in relation to project implemetation, population estimates, wastewater productions, stormwater runoffs, characteristics of wastewaters, and design standards for the facilities. These basic aspects are summarized in the following:

(a) An anticipated population of the Project Area in 1985, based on the projection of Penang Master Plan, is 385,000, which will further increase, with reduced rate of 3.5% in accordance with the Assignment Report of WHO, to 545,000 in 1995. Taking the above data into account, the population in the year 2000 is projected as 648,000. (Ref. Part III. Sewerage Master Plan)

(b) Average per capita sewage flow rates, both at present and in the future, have been estimated at 170 1/cap/day (37 IG/cap/day) and 230 1/cap/day (50 IG/cap/day) respectively on the basis of the results of field surveys and studies. (Ref. Part III. Sewerage Mater Plan)

(c) On the basis of field surveys, both of the average BOD and SS of the domestic sewage in the year 2000 are estimated at the range of about 200 mg/1.

In view of the present conditions, the average strength of combined industrial waste water discharged to the public sewers in the year 2000 is estimated at around 150 mg/1 of BOD and SS.

(d) For the purpose of sewerage planning, after considering several alternatives, whole Project Area is divided into four sewerage districts, namely, Butterworth, Seberang Jaya, Prai, and Bukit Mertajam. Furthermore, for the detailed planning purpose, they are divided into 20 sewerage zones on the basis of geographical, topographical, demographical and other conditions,which enables to work out plan for overall system and to design individual facilties concerned. (Ref. Figure I-1 and Part III. Sewerage Master Plan)

(e) In line with the proposal in the Assignment Report of WHO and accounting existing watershed and general features of land use, the Project Area is divided into six drainage basins for the convenience of planning as described in Figure I-2. The individual drainage basin is further divided into 45 sub-basins on the basis of topographical conditions and is shown in the same figure. (Ref. Part IV. Drainage Master Plan)

3. RECOMMENDATIONS

3.1 Proposed Plans

Sewerage

(a) The sewerage sytem should be principally a separate system, but as an interim measure, combination of sanitary sewers, storm sewers and partially combined sewers be adopted in the areas where local drains are already provided, until such time when financing of the complete separate system is possible. (Ref. Part III. Sewerage Master Plan)

(b) The physical facilities recommended for sewerage system to be developed includes, (i) system of sanitary main, branch and lateral sewers, (ii) pumping stations, and (iii) sewage treatment facilities in the form of stabilization pond process. However, if the required land area for stabilization pond process is not available in some of built-up areas, the process will be easily modified to other processes such as aerated lagoon or oxidation ditch. (Ref. Part III. Sewerage Master Plan).

(c) Industrial wastewater is also taken into account for sewerage planning. Factories in the Project Area may be classified into two forms, i.e. the one scattered within the Area and the other concentrated in group as industrial estates. Major polluters of the factories are of food, palm oil, rubber and textile industries generally discharging high BOD and SS which can be, in principle, treated by bological treatment methods. The joint treatment with domestic wastes using stabilization pond is recommended for current industrial wastes from the view point of economy and stability of effluent, although necessary counter measures will be taken in accordance with the future changes on characteristics of industrial wastes. (Ref. Part III. Sewerage Master Plan)

(d) Because of the resistance to corrosion from acids, alkalies, and virtually all corrosive substances, as well as resistance to erosion and scour, vitrified clay pipes are recommended for smaller sizes up to

300 mm (12 in.) in diameter. Sewers more than 300 mm (12 in.) in diameter should generally be of centrifugally-cast reinforced concrete pipes either coated or lined by suitable materials. (Ref. Part III. Sewerage Master Plan)

Drainage

(a) The drainage system is proposed to comprise open channels, and reservoirs together with land filling. Stormwater is collected road-side drains, then flows to main drains, which are to be improved using existing natural water courses in most of the areas, and discharges directly into the Prai river, Juru river or to the sea.

(b) In built-up area of Butterworth and Bukit Mertajam, open channels with enough capacity of conveying sotmwater runoff from the Initial Storm (caused by the rainfall intensity of 2 or 5-year return period) are proposed (Ref. Figure IV-2 and 3). In Butterworth area, construction of two reservoirs is also proposed as the preferable alternative system. For undeveloped areas, the storage system to prevent major damage from major storm (100 year return period) is proposed to reduce the peak flow rates of the stormwater runoff.

3.2 Proposed Staging of Construction

Sewerage

(a) Careful consideration has been given to establish the priority for implementation of construction programme by using rating procedure for evaluation of each of 20 zones with the following assessment elements: (Ref. Part III. Sewerage Master Plan)

i. Population density
ii. Waste load
iii. Availability of excreta dispoal system
iv. Flooding
v. Availabiltiy of water supply
vi. Incidence of water-borne diseases

The results of rating indicate that four sewerage zones, namely zones 1, 3 and 4 of Butterworth, and zone 3 of Bukit Mertajam sewerage districts,are among those to be given higher priority for the immediate implementation of construction. (Ref. Part III. Sewerage Master Plan)

(b) It is considered appropriate, on the basis of consideration on priorities referred above, to divide the total programme into four construction stages, namely, 1981-1985 (1st stage), 1986-1990 (2nd stage), 1991-1995 (3rd stage), and 1996-2000 (4th stage). For the 1st stage, zones, 1, 3 and 4 of Butterworth and zone 3 of Bukit Mertajam are recommended as stated above. (Ref. Part III. Sewerage Master Plan). According to government policy, however, the zones which are to be covered by new housing and industrial development programme will be given higher priority for implementation of sewerage programme.

(c) The First Stage programme comprises main sewers ranging from 225 mm (9 in.) to 1,050 mm (41 in.) dia. with the toal length of about 196 km (123 miles) to transport collected sewage to the treatment plant with four stabilization ponds which will discharge effluent into either Prai or Juru rivers directly through nearby waterways. One treatment plant is proposed for each of the four zones, each having the different capacity in accordance with the estimated volume of wasterwater. (Ref. Figure I-1, "Proposed Sewerage System")

Drainage

(a) In accordance with the urgency of the requirement, proposed drainage programme are divided into four construction stages to be implemented over 20 years. The First Stage programme is proposed in two urbanized areas, Butterworth and Bukit Mertajam.

(b) The First Stage programme includes the improvement and rehabilitation of the existing major drains to utilize them as the main drains in the proposed new drainage system. The sizes of these drains range between 2,200 x 1,300 mm (7 x 4 ft) and 25,000 x 3,000 mm (82 x 10 ft) with the total length of approximately 25 km (15.5 miles). (Ref. Part IV. Drainage Master Plan)

The construction of two reservoirs with the volume of 10,000 cu m and 17,000 cu m and a provision of the network of smaller drains in central portion of Butterworth area are also included in this stage.

3.3 Cost of Recommended Programme

The recommended plan for implementing sewerage and drainage systems calls for construction, operation and maintenance in four stages. Tables I-1 through I-5 show the construction costs for each completion period, including both local currency and foreign exchange. Operation and maintenance costs by stages are summarized in Table I-6. All the construction costs include contingency of 20% and engineering fee of 10%. All costs are estimated on the basis of 1976 price levels and no escalation is considered.

3.4 Benefits of the Proposed Programme

Significant benefits to public health and economy can be derived from the proposed programme, including both direct and indirect. All anticipated benefits have been evaluated on the basis of either quantifiable or non-quantifiable benefits. However, since these benefits are not fully quantifiable, non-quantifiable considerations have become important in the overall economic justification of the programme.

Evaluation of the major benefits include avoidance of productivity losses due to water-borne diseases and avoidance of the much higher cost of controlling water pollution by other means, but, it is not possible to quantify all the benefits expected in monetary terms, and cost-benefit ratio has not been estimated. Although no b/c analysis was made, it is believed that the benefits will overcome the costs, and the programme, as detailed in the report, is both economically and technically sound. If no sewerage and drainage systems were provided in the Area, sanitary conditions, which are already deplorable in many areas in the City, will become progressively worse.

TABLE I-1 Total Construction Cost by Stage at 1976 Price Level

(1,000 M$)

	Stage	1st Stage (1981-1985)	2nd Stage (1986-1990)	3rd Stage (1991-1995)	4th Stage (1996-2000)	Total
Government Contribution	Sewerage	63,250	116,850	85,300	86,200	351,600
	Drainage	68,330	8,410	38,550	111,940	227,230
	Total	131,580	125,260	123,850	198,140	578,830
Private Contribution	Sewerage	100,790	51,410	137,110	163,480	452,790
	Drainage	52,580	25,140	45,170	83,020	205,910
	Total	153,370	76,550	182,280	246,500	658,700
Grand Total		284,950	201,810	306,130	444,640	1,237,530

TABLE I - 2 Total Construction Cost of First Stage at 1976 Price

(1,000 M$)

Items	Government Contribution		Private Contribution		Total		Remarks
	Local Currency	Foreign Exchange	Local Currency	Foreign Exchange	Local Currency	Foreign Exchange	
Sewerage							
Main Sewers	32,480	-	-	-	32,480	-	
Branch & Lateral Sewers	-	-	59,410	-	59,410	-	
House Connections	-	-	16,950	-	16,950	-	
Pumping Stations	-	-	-	-	-	-	
Treatment Plants	7,890	1,970	-	-	7,890	1,970	
Land Aquisition	5,590	-	-	-	5,590	-	
(A) Sub-total	45,960	1,970	76,360	-	122,320	1,970	
Drainage							
Main Drains	46,940	-	-	-	46,940	-	
Networks of Smaller Drain	-	-	39,840	-	39,840	-	
Reservoirs for Intial Storm	350	-	-	-	350		
Reservoirs for Major Storm	-	-	-	-	-	-	
Land Acquisition	4,490	-	-	-	4,490	-	
(B) Sub-total	51,780	-	39,840	-	91,620	-	
(A) + (B)	97,740	1,970	116,200	-	213,940	1,970	
(C) Contingency	19,540	390	23,230	-	42,770	390	(A+B)x0.20
(D) Engineering Fee							
Design	4,820	1,150	6,970	-	11,790	1,150	(A+B+C)x0.05
Supervision	4,820	1,150	6,970	-	11,790	1,150	(A+B+C)x0.05
TOTAL	126,920 131,570	4,660	153,370 153,370	-	280,290 284,950	4,660	

TABLE I - 3 Total Construction Cost of Second Stage at 1976 Price

(1,000 M$)

Items	Government Contribution		Private Contribution		Total		Remarks
	Local Currency	Foreign Exchange	Local Currency	Foreign Exchange	Local Currency	Foreign Exchange	
Sewerage							
Main Sewers	34,510	-	-	-	34,510	-	
Branch & Lateral Sewers	-	-	25,670	-	25,670	-	
House Connections	-	-	13,290	-	13,290	-	
Pumping Stations	2,380	2,370	-	-	2,380	2,370	
Treatment Plants	17,180	4,290	-	-	17,180	4,290	
Land Aquisition	27,800	-	-	-	27,800	-	
(A) Sub-total	81,870	6,660	38,960	-	120,830	6,660	
Drainage							
Main Drains	5,050	-	-	-	5,050	-	
Networks of Smaller Drain	-	-	19,050	-	19,050	-	
Reservoirs for Intial Storm	-	-	-	-	-	-	
Reservoirs for Major Storm	1,000	-	-	-	1,000	-	
Land Acquisition	330	-	-	-	330	-	
(B) Sub-total	6,380	-	19,050	-	25,430	-	
(A) + (B)	88,250	6,660	58,010	-	146,260	6,660	
(C) Contingency	17,640	1,330	11,600		29,240	1,330	
(D) Engineering Fee							
Design	3,570	2,120	3,470		7,040	2,120	
Supervision	3,570	2,120	3,470		7,040	2,120	
TOTAL	113,030	12,230	76,550		189,580 201,810	12,230	

TABLE I - 4 Total Construction Cost of Third Stage at 1976 Price

(1,000 M$)

Items	Government Contribution		Private Contribution		Total		Remarks
	Local Currency	Foreign Exchange	Local Currency	Foreign Exchange	Local Currency	Foreign Exchange	
Sewerage							
Main Sewers	47,000	-	-	-	47,000	-	
Branch & Lateral Sewers	-	-	89,580	-	89,580	-	
House Connections	-	-	14,300	-	14,300	-	
Pumping Stations	120	110	-	-	120	110	
Treatment Plants	6,880	1,720	-	-	6,880	1,720	
Land Aquisition	8,810	-	-	-	8,810	-	
(A) Sub-total	62,810	1,830	103,880	-	166,690	1,830	
Drainage							
Main Drains	17,080	-	-	-	17,080	-	
Networks of Smaller Drain	-	-	34,230	-	34,230	-	
Reservoirs for Intial Storm	-	-	-	-	-	-	
Reservoirs for Major Storm	11,500	-	-	-	11,500	-	
Land Acquisition	630	-	-	-	630	-	
(B) Sub-total	29,210	-	34,230	-	63,440	-	
(A) + (B)	92,020	1,830	138,110	-	230,130		
(C) Contingency	18,400	360	27,610		46,010	360	
(D) Engineering Fee							
Design	4,070	1,550	8,280		12,350	1,550	
Supervision	4,070	1,550	8,280		12,350	1,550	
TOTAL	118,560	5,290	182,280		300,840 306,130	5,290	

TABLE I - 5 Total Construction Cost of Fourth Stage at 1976 Price

(1,000 M$)

Items	Government Contribution		Private Contribution		Total		Remarks
	Local Currency	Foreign Exchange	Local Currency	Foreign Exchange	Local Currency	Foreign Exchange	
Sewerage							
Main Sewers	51,900	-	-	-	51,900	-	
Branch & Lateral Sewers	-	-	106,540	-	106,540	-	
House Connections	-	-	17,310	-	17,310	-	
Pumping Stations	100	100	-	-	100	100	
Treatment Plants	8,020	2,000	-	-	8,020	2,000	
Land Aquisition	3,200		-	-	3,200	-	
(A) Sub-total	63,220	2,100	123,850	-	187,070	2,100	
Drainage							
Main Drains	39,220	-	-	-	39,220	-	
Networks of Smaller Drain	-	-	62,900	-	62,900	-	
Reservoirs for Intial Storm	-	-	-	-	-	-	
Reservoirs for Major Storm	45,600	-	-	-	45,600	-	
Land Acquisition	-	-	-	-	-	-	
(B) Sub-total	84,820	-	62,900	-	147,720		
(A) + (B)	148,040	2,100	186,750		334,790	2,100	
(C) Contingency	29,600	420	37,350		66,950	420	
(D) Engineering Fee							
Design	7,430	1,560	11,200		18,630	1,560	
Supervision	7,430	1,560	11,200		18,630	1,560	
TOTAL	192,500	5,640	246,500		439,000 444,640	5,640	

TABLE I-6 Operation and Maintenance Cost at 1976 Price Level

(1,000 M$/year)

	State		1st Stage (1981-1985)	2nd Stage (1986-1990)	3rd Stage (1991-1995)	4th Stage (1996-2000)
Government Contribution	Sewerage	Sewer (main)	330	680	1,150	1,710
		Sewer (small)	720	1,030	2,110	3,410
		Pumping Station	-	110	140	160
		Treatment Plant	250	560	820	1,090
	Drainage	Drain (main)	590	1,330	2,260	3,470
		Drain (small)	280	730	1,340	2,170
	Sub-total		2,170	4,440	7,820	12,010
Private Contribution*	Sewerage	House Connection	400	710	1,050	1,460
	Drainage	-	-	-	-	-
	Sub-total		400	710	1,050	1,460
Total			2,570	5,150	8,870	13,470

* Operation and maintenance cost of private contribution is for house connection only.

3.5 Managerial Arrangements

(a) The managerial arrangement with due consideration on organizational framework, legal support and financial planning are made in order to introduce a new institution to be responsible for the sewerage and drainage activities in the Project Area.

(b) After reviewing existing organizations, consideration on some alternatives are attempted and a new organization is suggested with due consideration on combination of the existing agencies with the standard generally accepted for the sewerage and drainage works.

(c) The Municipal Council, Province Wellesley (MPSP), which is presently administering the Project Area will be required to be responsible for the proposed sewerage and drainage system project.

The Engineering Department in the Council is suggested to expand its functions adding new functional units as appropriate. The existing functional units are proposed to be involved in the new organizational arrangement to the maximum extent possible.

(d) As to the existing regulations and by-laws pertinent to proposed Project, "The Municipal Ordinance enacted as Chapter 133 of old strait Settlement in 1913" and "The Street, Drainage and Builidng Act, 1974" are reviewed. The provisions of "The Municipal Ordinance" pertinent to the work proposed are studied and major items of them are presented. "The Street, Drainage and Building Act, 1974" is considered most appropriate to be applied for the relative sewerage and drainage works. The certain adjustment and addition of the provisions are also recommended particularly on the industrial effluent control.

(e) Preliminary financing plan up to the year 2000 with the objective of estimating the minimum requirements for the implementation of the planned Project was worked out, and the components of the recommended financial plan are presented with basic guideline. The details will be provided in feasibility report to be prepared consecutively.

3.6 Implications for Further Actions and Studies

Because of the limited time available to prepare the study programme and recommended plan for positive control of water qualities in waterways of the Project Area, several special actions and investigations are necessary and urgent to provide a sound basis for detailed planning and system design. Specifically, urgent studies and actions that should be undertaken for the continued protection and improvement of the environment of the Project Area are as follows:

(a) Within the Project Area, especially in the urbanized areas, water in the drains and rivers have already become polluted by domestic and industrial wastes. If no steps are taken to alleviate waste loads discharged to drains and rivers, these areas are expected to be further polluted and degraded in the immediate future. It is therefore recommended that the preliminary engineering and feasibility studies for the selected First Stage programme areas be commenced as soon as possible. It represents a solution to immediate problems as well as a logical basis for the best long-term solution.

(b) In the interim period, prior to the formation of the new organization for the sewerage and drainage programme, continuing advance planning will be required, and actions will be needed to begin the additional studies recommended and also to transfer technology to the staff of the organization. To perform these functions for continuity of the study activities of the Master Plan programme and to follow up the legislative requirements for additional information or clarification of materials presented in this report, it is recommended that Municipal Council Province Wellesley (MPSP) should take initiative on this matter in coordination with agencies concerned in Penang State Government and the Ministries of Local Government and Federal Teritory and of Health in the Federal Government.

(c) The object of study for the Juru River is limited to the reserve requirements estimation based on standard prepared by the Government of Malaysia in accordance with the scope of works for the programme. However the Government is concerned about the organic pollution of the River and realizes the necessity of the preparation of the study programmes and

recommended plan for positive control of water qualities and hydraulic and hydrological analyses of the Juru river, special actions and investigations under a separate project are necessary and urgent to establish water quality criteria and flood control programme for the river, coupled with appropriate surveillance programme for wastewaters and hydrologic data.

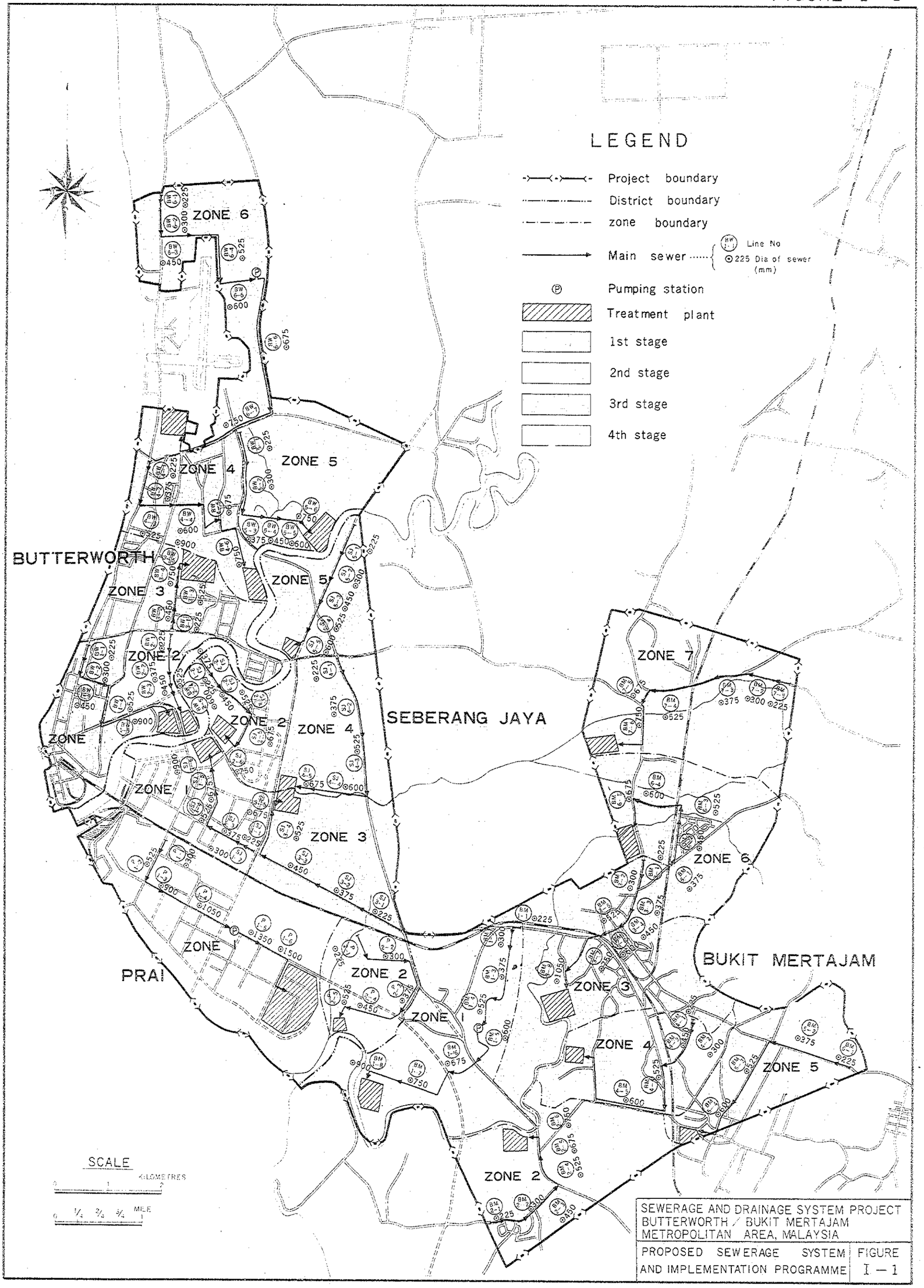
(d) Long-range industrial wastes control programme should be established at the earliest possible date for Prai Industrial Estate, to prevent the further water pollution in the nearby waterways of the estate, including monitoring of wastewaters produced in the factories and also establishing effluent standards for wastewater discharges.

(e) Prior to the preliminary engineering and feasibility studies for the First Stage programme, the following studies should be carried out:

i. Topographic surveys, including leveling, measuring cross sectional areas of the existing drains, and boring of the soils at the expected construction sites of major facilities.
ii. Study on waste loads estimation.
iii. Water quality survey in the waterways.
iv. Institutional and financial studies.

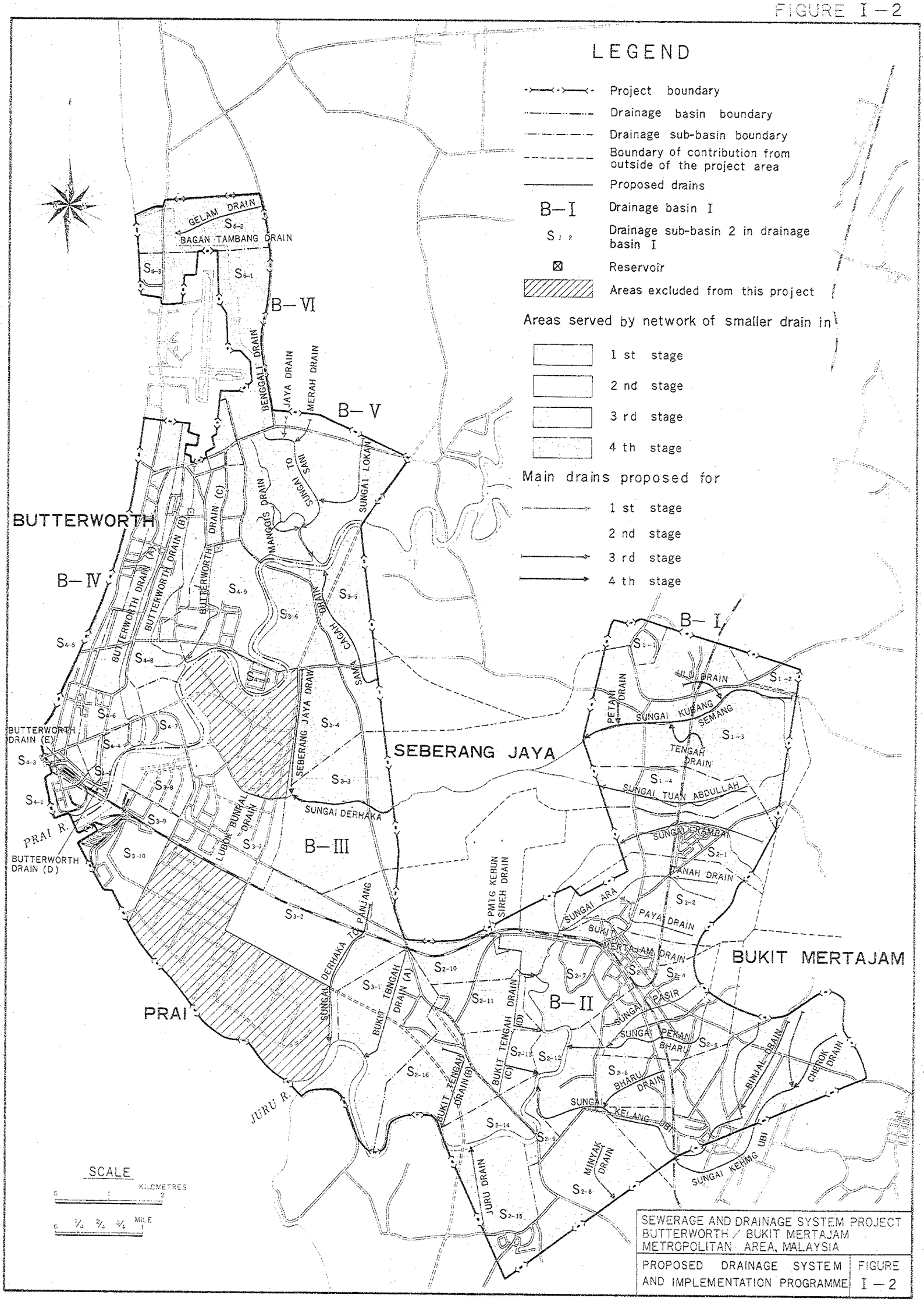
(f) It is recommended that regulations and laws to control the waste discharged from the real estate development areas to the public sewer system be established immediately, including guideline or criteria for wastewater qualities and methods for treatment.

(g) Necessary actions should be taken to acquire in advance the land spaces required for the sewerage facilities proposed in the Master Plan, so that the difficulties in obtaining enough areas for the system in the future can be avoided, since the Project Area is rapidly developing and vacant lots being occupied for housing and industrial development programmes.



SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA

PROPOSED SEWERAGE SYSTEM AND IMPLEMENTATION PROGRAMME	FIGURE I – 1



SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA

PROPOSED DRAINAGE SYSTEM AND IMPLEMENTATION PROGRAMME | FIGURE I – 2

PART II

B A C K G R O U N D

PART II

BACKGROUND

Table of Contents

Chapter		Page
1	PURPOSE AND SCOPE OF STUDY	II - 1
	1.1 Background of the Study	II - 1
	1.2 Purpose and Scope of the Study	II - 1
	1.3 Definition of Project Area	II - 2
	1.4 Problem and the Need for Study	II - 3
2	PHYSICAL CHARACTERISTICS OF PROJECT AREA	II - 5
	2.1 Location	II - 5
	2.2 Geology	II - 5
	2.3 Climate & Rainfall Characteristics	II - 6
	2.4 Present River System	II - 14
3	PUBLIC HEALTH CONDITIONS	II - 20
	3.1 Health and Medical Facilities	II - 20
	3.2 Incidence of Diseases	II - 20
4	POPULATION AND LAND USE	II - 22
	4.1 Present Population and Distribution	II - 22
	4.2 Present Land Use	II - 22
5	WATER SUPPLY SYSTEM	II - 27
	5.1 Existing Water Supply Systems	II - 27
	5.1.1 Water Agency	II - 27
	5.1.2 Areas and Population Served	II - 27
	5.1.3 Water Production and Use	II - 27
	5.1.4 Water Supply Conditions	II - 28
	5.1.5 Private Water Supply Systems	II - 28

Chapter

		Page
	5.2 Existing Water Supply Facilities	II - 28
	5.2.1 Outline of Existing Facilities	II - 28
	5.2.2 Water Sources	II - 29
	5.2.3 Pumping Stations	II - 30
	5.2.4 Treatment Plants	II - 32
	5.2.5 Water Quality	II - 33
	5.3 Management and Operation	II - 34
6	EXISTING EXCRETA DISPOSAL SYSTEMS	II - 35
	6.1 Existing Toilet and Excreta Disposal Systems	II - 35
	6.2 Sludge Collection and Disposal	II - 36
7	WASTEWATER PRODUCTION AND DISPOSAL	II - 38
	7.1 Domestic Wastes	II - 38
	7.1.1 Existing Domestic Wastewater Discharge	II - 38
	7.1.2 Sewage Flow & Strength	II - 38
	7.1.3 Septic Tank Effluent	II - 39
	7.2 Industrial Wastes	II - 40
	7.2.1 Industries in the Project Area	II - 40
	7.2.2 Industrial Wastewater Survey	II - 40
	7.2.3 Industrial Wastewater Quantity and Characteristics	II - 41
	7.2.4 Industrial Wastewater Treatment	II - 42
8	DRAINAGE SYSTEM	II - 43
	8.1 Existing Drainage System	II - 43
	8.2 Flooding in the Project Area	II - 44
9	EFFECTS OF PRESENT WASTE DISPOSAL SYSTEMS	II - 47
	9.1 Environmental Effects	II - 47
	9.1.1 Living Environment	II - 47
	9.1.2 Water Pollution	II - 47

CHAPTER 1

PURPOSE AND SCOPE OF STUDY

1.1 Background of the Study

The Penang Master Plan, 1970, was proposed to establish a metropolitan area on the mainland, which includes areas covered by two towns, Butterworth (BW) and Bukit Mertajam (BM). On the basis of this the Government of Malaysia requested Japanese Government to assist in developing a programme to establish comprehensive sewerage and drainage planning for the Butterworth/Bukit Mertajam Metropolitan Area.

1.2 Purpose and Scope of the Study

The main purpose of the study is to develop a master plan of sanitary sewerage and drainage systems for Butterworth/Bukit Mertajam Metropolitan Area:

(a) To develop comprehensive long-rang plans for the solution of existing sewerage and drainage problems in Butterworth/Bukit Mertajam Metropolitan Area.

(b) To achieve improvement in institutional arrangement in coordination of efforts in the technical areas.

To carry out the Project, Japan International Cooperation Agency (JICA) has identified the following specific study objectives, with major consideration to be given to the period from 1977 to 2000:

(a) Establish a master plan for the development of economically viable sewerage and drainage system in which the elements of work necessary are forecast and generally defined in successive stages to meet the present and future needs of the Project Area up to the year 2000, compatible with sound projections of population increase, housing development, water consumption and water system expansion, income growth, and other national and local socio-economic factors affecting the future of Province Wellesley.

(b) Undertake studies and formulate recommendations regarding the proper organization, an agency of department to carry out the planning, construction, operation, maintenance, management and administration of a sewerage and drainage system for the Project Area, together with proper legislative provision to provide sound legal basis for all the activities proposed.

(c) Submit project reports, including:
   1) Progress reports at the end of data collection at the project site
   2) Draft and final reports on the Master Plan for the Sewerage and Drainage System Project.

1.3 Definition of Project Area

For the purpose of Sewerage and Drainage Project for the Butterworth/Bukit Mertajam Metropolitan Area (BBMA), the Metropolitan Area of 11,600 ha is considered as the Project Area.

Among the entire BBMA, the area of airforce base, is excluded from the Project Area (Ref. Figure II-4).

Acreages of the Metropolitan Area, airforce base, and the Project Area measured by Survey Team is as follows:

- Butterworth/Bukit Mertajam Metropolitan Area ..... 12,020 ha (29,700 acres)
- Airforce Base (exclusive) ..... 420 ha (1,040 acres)
- Project Area ..... 11,600 ha (28,660 acres)

For master planning purpose, non-habitable areas such as cemeteries, rivers and others of 746 ha (1,840 acres) are excluded from the Project Area, and as regards the drainage master plan, catchment areas outside the Project Area are taken into account due to the topographical conditions. The additional areas cover the catchment area of 1,751 ha (4,327 acres). (Ref. PART IV, Drainage Master Plan)

1.4 Problem and the Need for Study

According to the estimates, some 238,000 people live in Butterworth/ Bukit Mertajam Metropolitan Area in 1976, comprising approximately 11,600 ha. During this century, the area has experienced a high growth rate in population, due to the increase of commercial and industrial activities, far out-stripping the national average. Because of its attractive settings, the area is expected to continue its growth, reaching a population of 648,000 by the year 2000 according to our projection.

Rising standards of living and increase of industries have caused and will continue to cause an increasing rate of consumption of water with the attendant increased burden of waste discharges to the natural waterways and open seas. The current wastewater discharge within the Project Area is estimated at approximately 110,000 cu m/day and is expected to increase at a rate exceeding that of population growth and to reach a level of over 340,000 cu m/day by the year 2000. At present, most of the wastewaters are discharged into the rivers and drains flowing into Penang Channel.

There is at present no sanitary sewerage system in the Project Area except limited small scale communal systems. Most of the domestic sewage and industrial wastes are discharged directly to drains and other available waterways, and in case of human excreta, from homes after passing through septic tanks into the open ditches or collected using bucket system. Approximately 30 percent of houses within the urban area and 7 percent of houses within the rural area have septic tank systems for excreta disposal.

The remainder of the houses dispose of their human wastes either by means of pit latrines or buckets.

The discharge of most of the municipal wastes without treatment, are causing increased pollution into existing rivers and drains while flowing through the two areas, particularly during the low flows in the dry seasons, and are eventually polluting the beaches and offshore marine waters. Such conditions have resulted in adverse biological effects, odours and nuisances. It is evident that the pollution will become more apparent by the year 2000 if no action is taken to alleviate the wastewater burden to the waterways.

For the past several years, public interest has become more sharply focussed on the need for clean water bodies to satisfy the need for rapidly increasing land development with better sanitation facilities for living condition, to provide the capability for water oriented recreation, and to conserve the natural qualities of the environment. Both the Government of Malaysia and the Penang State Government have commenced intensive programme to prevent and improve the deterioration of the environmental conditions in Penang State, including water pollution control on the waterways, sanitation improvement in Metropolitan Area, and flood control of major rivers and drains.

The magnitude of the problem of disposal of wastewater and the importance of maintaining a desirable minimum level of quality in the river and marine waters of Penang State, with due consideration on magnitude of expenditures needed for these purposes, requires careful long range planning and immediate implementation programme. The present report endeavours to cover the preliminary programme of long range outlook on the basis of sound consideration on technical and socio-economic factors.

CHAPTER 2

PHYSICAL CHARACTERISTICS OF PROJECT AREA

2.1 Location

Peninsular Malaysia forms the southern tip of the South-East Asia land mass; to the west and south are the islands of Indonesia and to the east the island of Kalimantan and East Malaysia. Peninsular Malaysia lies entirely within the tropics extending from latitude 1° to 7° north and from longitude 100° to 104° east. East coast of the peninsular faces to the South China Sea and west coast faces to the Straits of Malacca (See Figure II-I).

Penang State, the second smallest State among the thirteen States of Malaysia, is situated on the northwestern coast of Peninsular Malaysia between latitudes 5°7' to 5°35' north and longitudes 100°9' to 100°32' east. It is bounded on the North and East by Kedah State, to the South by Perak State, and to the West by the Straits of Malacca.

Geographically Penang State consists of two separate physical entities, Penang Island, a rectangular island 23 km (14 miles) long and 16 km (10 miles) wide, and Province Wellesley, a rectangular strip 48 km (30 miles) long and 17 km (11 miles) wide situated on the Peninsular Malaysia.

The Project Area for the Sewerage and Drainage Master Plan is situated in the midst of Province Wellesley. West end of the Project Area is the nearest point to the Penang Island from the Peninsular. From the north end to the south end of the hook-shaped Project Area is about 20 km (13 miles) long, and from the east end to the west end is about 15 km (9 miles) wide (See Figure II-2).

2.2 Geology

The topography of Peninsular Malaysia is characterized by a series of mountain ranges of igneous intrusions through older sedimentary rocks running parallel to the coast and flanked on both sides by wide alluvial plains which extend from the coast to the foothills. The mountains rise to heights of 2,150 m (7,000 ft) in the north and 900 m (3,000 ft) in the south of Peninsular.

Province Wellesley, in which the Project Area is situated, is essentially a very flat alluvial plain. Some of the areas are lying below 15 m (50 ft) contour being interrupted by patches of hilly land at its south-eastern border. The highest point of these hills is in the Bukit-Mertajam, which is 536 m (1,787 ft) above sea level and is located just south-east end of the Project Area. These hills are formed in Mesozoic, Post Triassic Period and their formation is granite.

The Project Area, is dominated by the Prai and Juru rivers, but is typified by natural river profiles meandering amongst tidal and fresh water swamps. With controlled drainage and irrigation, the Area is agriculturally productive and well suited to a variety of crops, including rice, coconuts, pineapples, rubber and oil palms.

Geological map in the Project Area and its vicinity is shown in Figure II-3.

2.3 Climate & Rainfall Characteristics

Proximity to the equator has given Peninsular Malaysia a climate of high humidity with uniformly high temperatures and rainfall. The equatorial climate is modified by the region's insularity and exposure to monsoonal wind system that originate in the Indian Ocean and the South China Sea. On the whole, the climate is pleasant and equable and the humidity is bearable though sometimes unpleasant.

Thunderstorms are frequent, and, although Malaysia is outside the typhoon and cyclon belts, the south-west monsoon is frequently accompanied by sudden squalls and violent gusty winds, especially along the Straits of Malacca where they are known as "Sumatras".

Temperature is relatively constant throughout the year and the average monthly temperature varies only by about 2°C (4°F). However, the daily temperatures show a greater variation of 5°C to 8°C (10°F to 15°F), with a mean daytime maximum of 29°C (85°F) and a mean minimum of 22°C (71°F) at night.

The climate in Penang State is applicable to west coast of Peninsular Malaysia including Project Area. Records of rainfall, temperature, relative humidity and daily sunshine are shown in Table II-1, II-2, II-3, and II-4.

For Penang State, rainfall has been recorded by Drainage and Irrigation Department (DID) and Penang Water Authority (PWA) respectively. Recorded data are available since 1933 in DID, from 1933 to 1969 with recording once a day, and from 1970, continuous recording with self-registering gauges. In PWA, rainfall data recorded continuously with automatical gauges since 1954 are available.

It is considered that five year length of record in DID is too short to expect a reliable result of statistical analysis. Thus data in PWA is used for deriving intensity-duration rainfall curve and the record most suitable among eight gauges in and around the Project Area as shown in Figure II-5, and described in Table II-5 is that of No. 6 gauge, because of its preciseness in details compared to others.

Although No. 6 station locates in the Penang Island the distance from the Project Area is not so large for rainfall characteristics changes because of topographic and climate conditions. This is confirmed and agreed by the government officials concerned.

TABLE II-1 Record of Rainfall (mm) at Bayan Lepas from 1946 to 1976

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Mean	125.7	95.0	195.6	245.6	227.8	159.5	160.5	193.0	261.6	329.7	303.3	149.4	2445.0
Max. 24 hrs.	94.5	95.0	177.0	97.5	111.5	126.2	119.9	119.9	139.2	164.8	157.5	114.3	177.0
Max. 48 hrs.	100.1	104.1	177.0	111.8	206.0	182.6	119.9	176.8	154.9	164.8	198.1	125.2	206.0
Max. 72 hrs.	154.4	104.1	177.0	113.3	222.3	225.3	123.4	181.6	207.0	189.5	233.2	188.0	233.2

TABLE II-2 Record of Temperature (°C) at Bayan Lepas from 1959 to 1972 14 years

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
24 hr Mean	26.8	27.2	27.4	27.6	27.6	27.2	26.9	26.7	26.5	26.3	26.4	26.6	26.9
Mean Daily Max.	31.1	31.7	31.7	31.8	31.7	31.3	31.0	30.8	30.7	30.3	30.3	30.5	
Mean Daily Min.	22.9	23.1	23.4	23.9	24.1	23.7	23.3	23.3	23.1	23.2	23.1	23.2	
Highest Max.	35.6	35.0	35.0	34.4	33.9	33.9	33.3	33.3	33.3	33.9	33.3	33.9	
Year		1959		1963		1959		1960				1970	
	1959	1965	sev.	1971	1963	1972	sev.	1972	sev.	1972	1972	1972	
Lowest Min.	18.9	20.6	20.6	21.7	21.7	21.1	20.6	20.6	20.6	21.7	21.1	20.6	
Year		1962			1968	1960			1964				
	1972	1968	sev.	sev.	1972	1961	1971	1964	1966	sev.	sev.	1959	

Note: sev. means several years

TABLE II-3 Record of Relative Humidity at Bayan Lepas

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
24 hr Mean	74.9	75.7	78.9	83.0	84.2	83.8	83.5	83.7	85.1	86.2	84.4	80.3	82.0
Mean Daily Max.	92.5	94.2	96.3	97.2	97.5	97.6	97.4	97.5	97.8	97.9	97.1	94.6	96.5
Mean Daily Min.	55.2	53.1	56.3	62.4	64.5	64.3	63.2	63.5	64.5	66.1	64.1	60.8	61.5
Lowest Min.	35	34	27	45	46	49	48	45	46	50	40	31	27
Year	1973	1973	1973	1972 1974	1972	1972	1974	1974	1973	1970	1968	1968	1973

Note: 24 hours mean, mean daily max., and mean daily min. are obtained from 1963-1974, 12 years records.
Lowest min. and year are obtained from 1968-1974, 7 years records.

TABLE II-4 Records of Daily Sunshine (in hours) at Bayan Lepas
1968 - 1976 9 years

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean	8.0	8.2	7.8	7.5	6.5	6.3	6.4	6.3	5.2	5.2	5.6	6.0
Highest	11.4	11.2	11.1	11.3	11.3	11.3	11.5	11.2	10.9	10.5	11.2	11.3
Lowest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

The climate in the Area is governed by the monsoons. From November to March, it is dry season with monsoons of north-east, and wet season is from June to October with south-west monsoons. In September and October in which the south-west wind is predominant and in November when the monsoon changes its direction, there are heavy rain in the Area. The total rainfall depth of 810 mm (31.9") is recorded through these three months which is 37 percent of the total rainfall of one year of 2,172 mm (85.5"), both of which are averages of five years during 1965/1966 to 1969/1970. The most dry month is February with the rainfall of 65.5 mm (2.58") as an average of six years, 1965/1966 to 1969/1970. In Table II-6, the monthly rainfall records from 1965 to 1970 are shown.

TABLE II-5 Rainfall Gauge Station

No.	Name	Location	Responsible Organization	Records Available Since
1.	Ibu Bekalan Sungai Kulim	Province Wellesley	DID	1970 -
2.	Komplek Perai	"	DID	1970 -
3.	Station Located in Stream of SG. Ayer Terjun	Penang Island	PWA	1954 -
4.	Kolam Bersih Pulau Pinang	"	DID	1970 -
5.	Klinik Bukit Bendera	"	DID	1970 -
6.	Station Located in Ayer Itam Old Intake Catchment	"	PWA	1954-
7.	Kolam Takongan Ayer Itam	"	DID	1970 -
8.	Rumah Kebajikan Pulau Pinang	"	DID	1970 -

TABLE II-6 Rainfall Records at Ibu Bekalan Sungai Kulim (1965-1970)

Unit: mm

	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
1965/66	125	244	380	226	371	321	704	803	178	183	160	82
1966/67	315	207	182	277	182	269	254	22	117	255	278	173
1967/68	36	153	164	374	388	29	21	29	171	287	101	110
1968/69	231	374	111	290	260	292	208	22	180	33	220	88
1969/70	99	142	174	351	271	180	269	17	81	309	214	93

2.4 Present River System

The Project Area has two major rivers, namely Prai and Juru, with many branches and drains within their catchment areas, collecting storm-water runoff and finally discharging into the sea. The profile of these two major rivers are as follows:

(a) Prai river

Prai river is a wide fast flowing tidal river draining an area of about 16 sq km (4,000 acres) to discharge into the sea. Because it is tidal river, no water is used for water supply and irrigation within the Project Area. At present, this river is mainly utilized for navigation between Penang Harbour and inland industrial estates. Fishing and recreational activities are few.

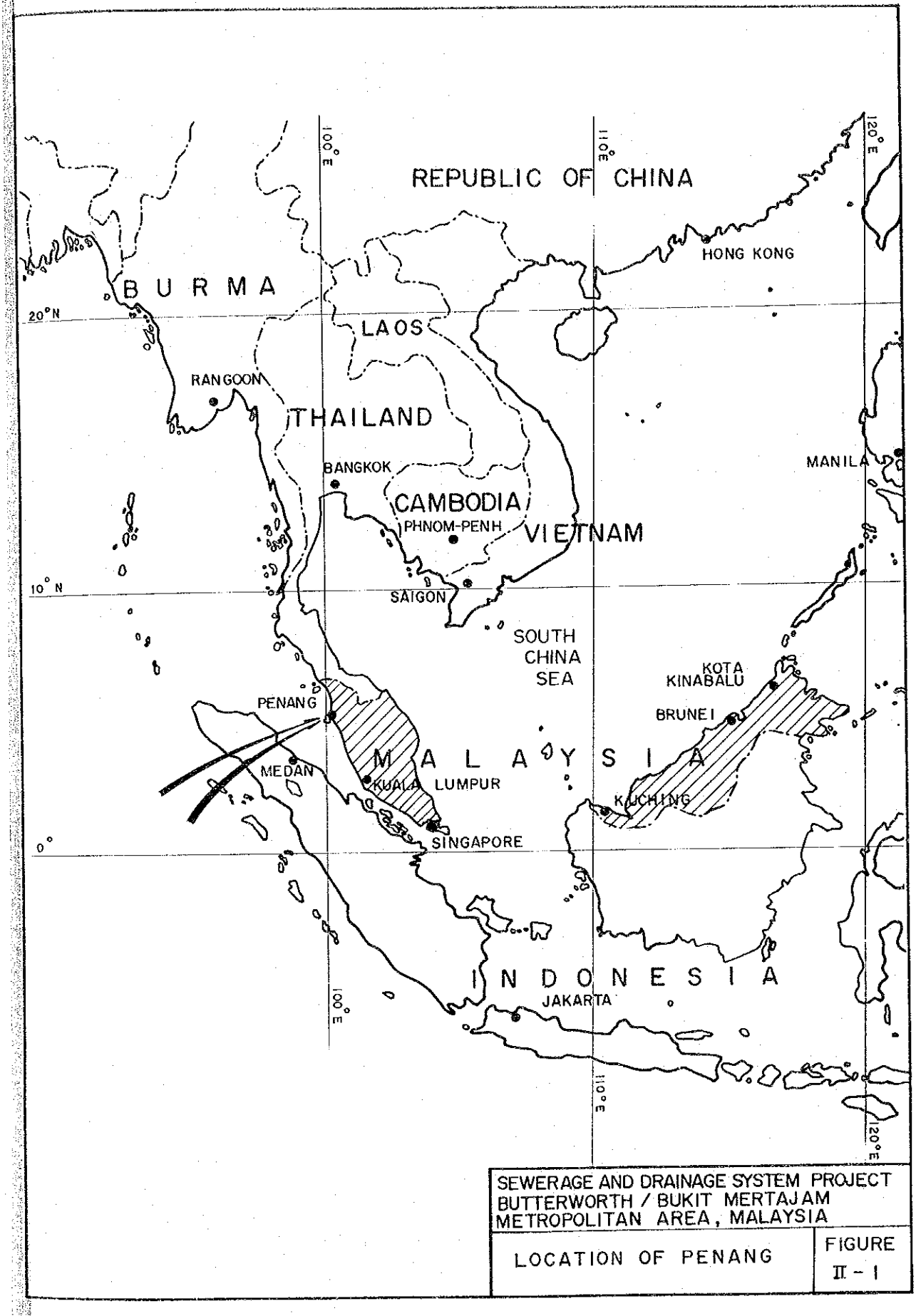
DID is now considering the construction of a barrage across the river near the Pontoon bridge at Permatang Pauh to facilitate the draining of swamp land which will be reclaimed in the catchment area. The fresh water produced by the barrage is planned for industrial water use.

Tributaries of Prai river, Jarak, Korok and Kulim are used for irrigation and water supply purposes. However, their intake points are located outside of the Project Area.

(b) Juru river

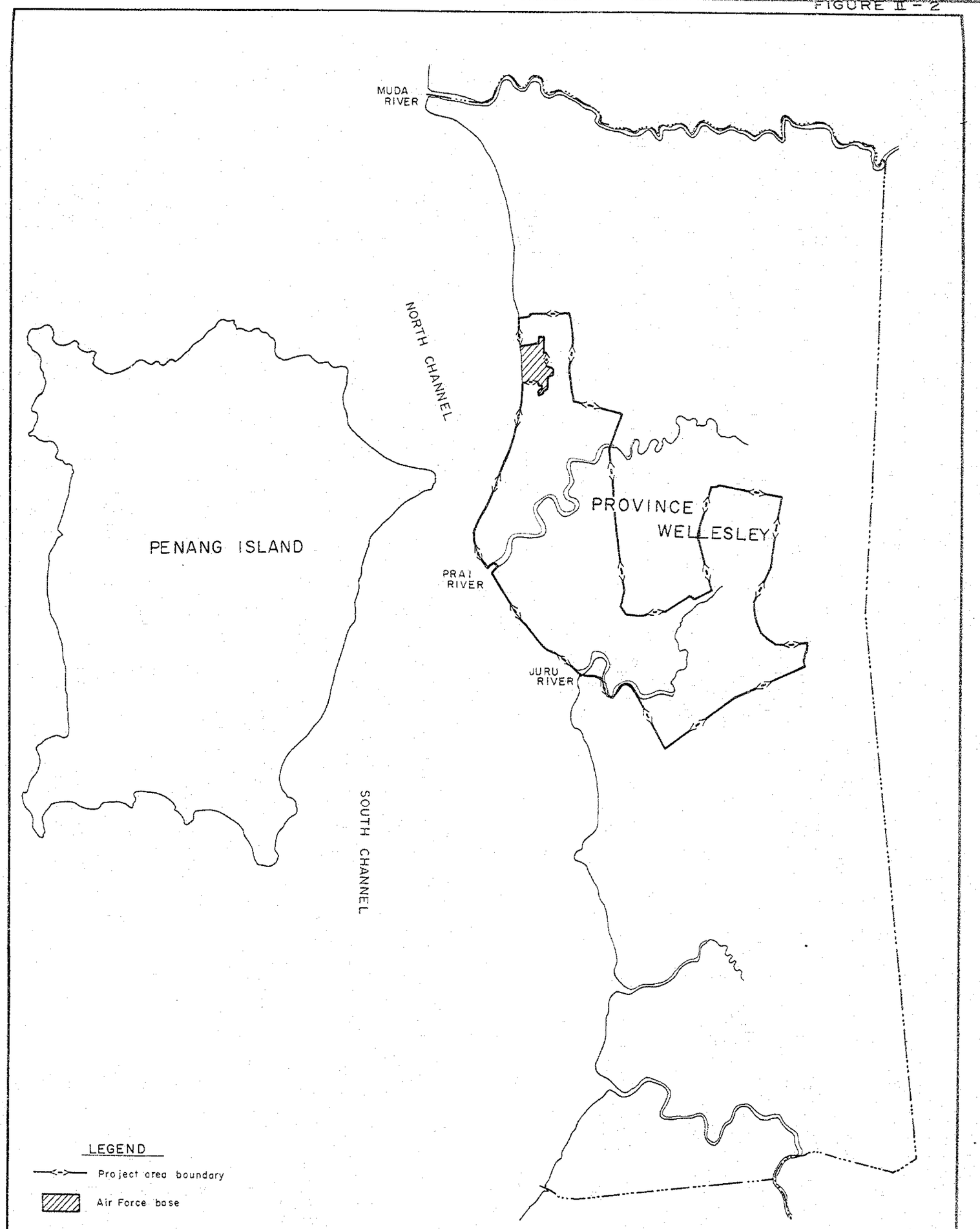
Juru river has a catchment area of about 2.6 sq km (630 acres) consisting of flat plain, swamp and paddy with the hill of Bukit Mertajam in its north-east corner. Water is heavily polluted by receiving discharge from the urbanized area and animal farms of Bukit Mertajam area. The water is not used for any purpose in the Project Area.

FIGURE II - 1



SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA

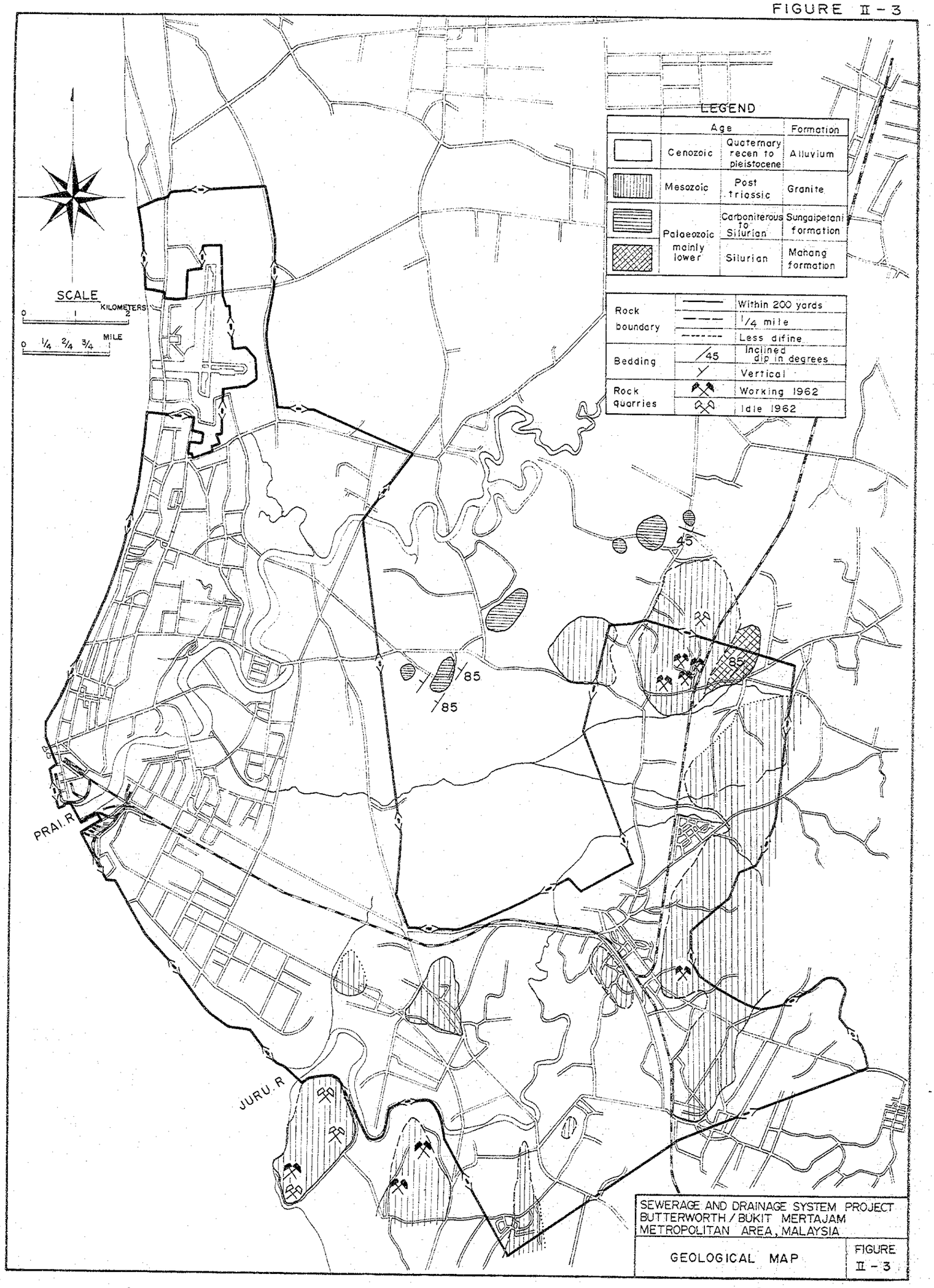
LOCATION OF PENANG | FIGURE II - 1



SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA

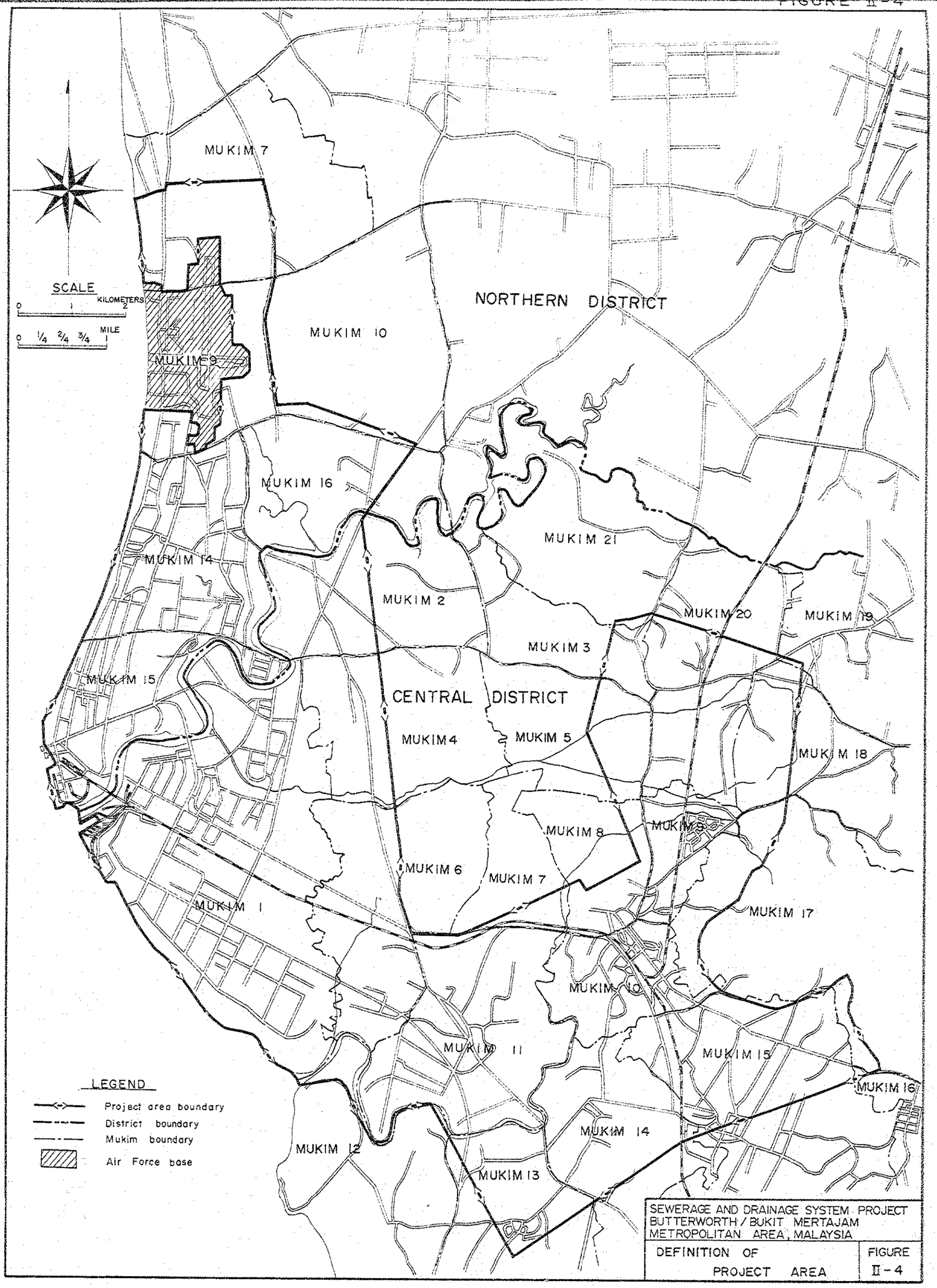
LOCATION OF METROPOLITAN AREA — FIGURE II-2

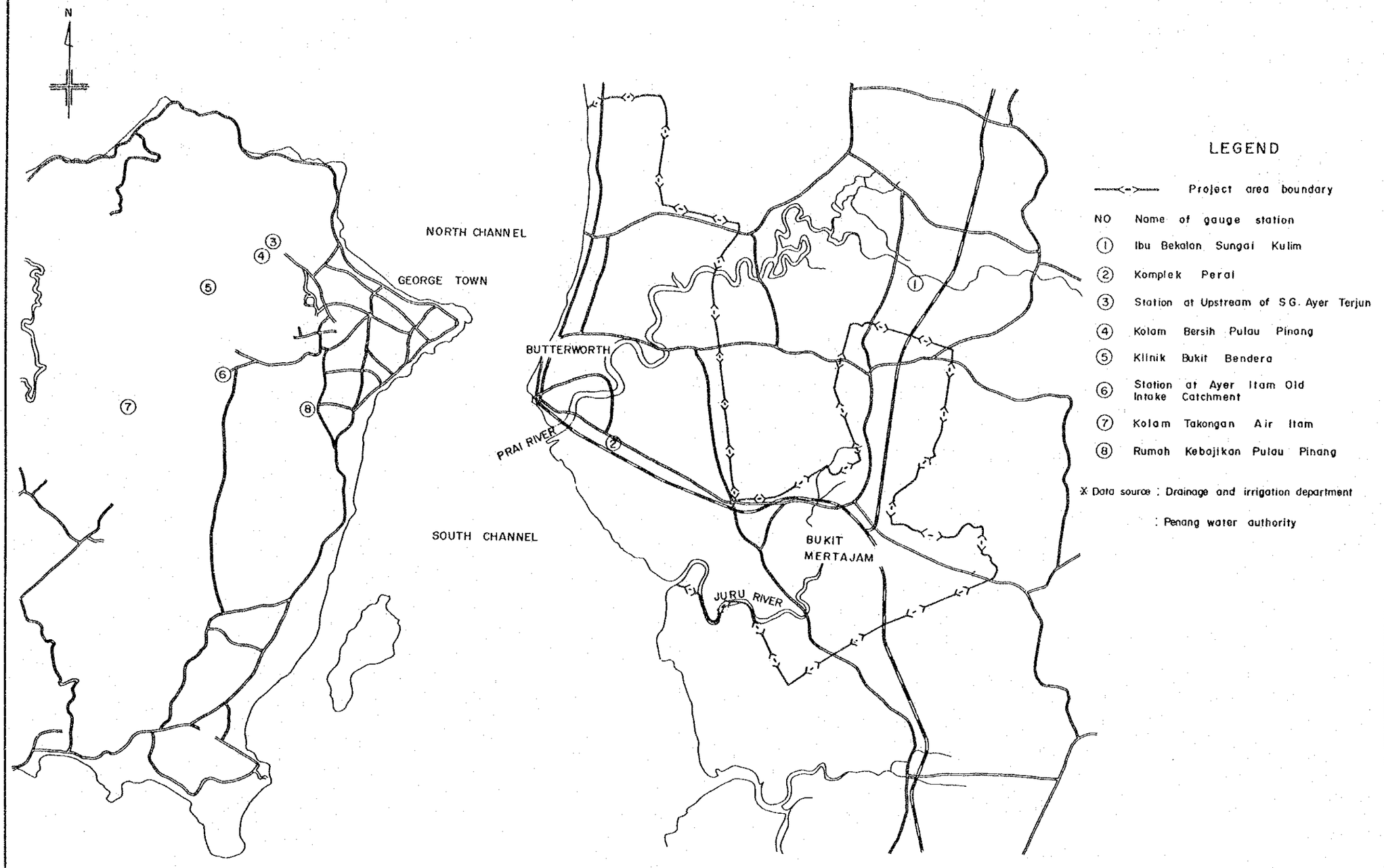
FIGURE II - 3



SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA

GEOLOGICAL MAP — FIGURE II - 3


MUKIM 7
NORTHERN DISTRICT
SCALE
KILOMETERS
0 1 2
0 1/4 2/4 3/4 1 MILE
MUKIM 9
MUKIM 10
MUKIM 16
MUKIM 21
MUKIM 14
MUKIM 2
MUKIM 20
MUKIM 19
MUKIM 3
MUKIM 15
CENTRAL DISTRICT
MUKIM 4
MUKIM 5
MUKIM 18
MUKIM 8
MUKIM 6
MUKIM 7
MUKIM 1
MUKIM 17
MUKIM 11
MUKIM 15
MUKIM 16
MUKIM 14
MUKIM 12
MUKIM 13
LEGEND
Project area boundary
District boundary
Mukim boundary
Air Force base
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
DEFINITION OF PROJECT AREA
FIGURE II-4



Scale 1 :126,720

SEWERAGE AND DRAINAGE SYSTEM PROJECT BUTTERWORTH / BUKIT MERTAJAM METROPOLITAN AREA, MACAYSIA

LOCATION OF RAIN GAUGE | FIGURE II - 5

CHAPTER 3

PUBLIC HEALTH CONDITIONS

3.1 Health and Medical Facilities

The distribution of the health and medical facilities in the Penang State has been generally adequate. There are one general hospital, 8 hospitals, 11 maternity hospitals, and 13 main health centers excluding private clinics in the Penang State.

Among these facilities, two hospitals are located in the Project Area. They are district hospitals in Butterworth and Bukit Mertajam. Total number of bed in each hospital is 134 and 206 respectively in 1975, and number of admissions in 1975 are 8,679 and 14,505, with average length of stay as 5.65 days and 5.18 days respectively. Bed occupancy rate, calculated from number of bed and average daily number of patients, is 85.07 percent in Butterworth district hospital and 120.39 percent in Bukit Mertajam district hospital.

The site for new hospital complex, serving for the Butterworth and Bukit Mertajam areas is planned at Seberang Jaya in the Project Area. This site covers an area of 30 ha (74 acres).

3.2 Incidence of Diseases

Number of patients of water-borne communicable diseases for both of the North and Central Districts in Province Wellesley, including adjacent areas of the Project Area. It is pointed out that these figures are reported cases only which are considered to be approximately 75% of the total incidence actually occurred.

TABLE II-7 Number of Patient of Water-Borne Disease

	1970		1971		1972		1973		1974		1975	
	PWN	PWC	PWN	PWC	PWN	PWC	PWN	PWC	PWN	PWC	PWN	PWC
Cholera	(7.4) 12	(42.5) 50	-	-	-	(5.7) 7	-	-	(5.1) 9	(0.8) 1	-	-
Dysentery	-	(0,8) 1	(1.2) 2	(3.3) 4	(4.7) 8	(2.4) 3	(17.9) 31	(3.2) 4	(5.1) 9	(7.8) 10	(2.2) 4	(5.3) 7
Infectious Hepatitis	-	-	-	-	-	-	(35.3) 61	(4.8) 6	(26.6) 47	(1.6) 2	(25.4) 46	(5.3) 7
Typhoid fever	(0.6) 1	(1.7) 2	(4.2) 7	(9.2) 11	(26.6) 45	(4.9) 6	(26.6) 46	(9.5) 12	(2.3) 4	(5.4) 7	(2.8) 5	(6.1) 8
Leptospiral Infections	-	-	-	-	-	-	(0.6) 1	-	-	-	-	-

Note: PWN: Province Wellesley North District

PWC: Province Wellesley Central District

Figures in ( ) = incidence rate per 100,000 population in the district

These figures were obtained from Government District Hospitals/Clinics only

CHAPTER 4

POPULATION AND LAND USE

4.1 Present Population and Distribution

As the population and its distribution in the Project Area at the time of the present study is not readily available, assumption is undertaken by using 1970 National Census and other study data. Out of 1970 Census which includes the breakdown in mukims, 27 mukims are identified as included in the Project Area, wholly or partially. Determining the population in each of these mukims within the Project Area from the data of the Census, the total population within the Area in 1970 at the time of National Census is estimated to be 172,230, as shown in Table II-8. (Ref. Appendix B. Polulation & Land Use Distribution)

The population data provided in the Penang Master Plan Report 1970, which includes the population projection for 1970, 1975 and 1985, is found to be useful source of information for projection of the year 1976, the time of the present study. Assuming its projection of 5.5% annual growth rate up to the year 1985 as reasonable and realistic assumption with a few percent of plus and minus deviation which is normal for this type of projection, it is considered appropriate to apply the same average of 5.5% annual growth rate to each of the 1970 population of mukims within the Project Area as referred above up to the year 1976, which leads to the conclusion that the total population of the Area in 1976 to be 238,000, as indicated in Table II-8.

4.2 Present Land Use

It is considered that Province Wellesley is the State's major agricultural area. At present, agricultural area of 4,049 ha (10,000 acres) which consists of paddy field, rubber farm, and coconut farm is still located in the total Project Area of 11,600 ha.

The built-up areas are in the Project Area. They are Butterworth and Bukit Mertajam town areas covering area of 649 ha (1,600 acres).

Three large scale industrial development programmes by Penans State Government are now underway, and fastly being established. In 1976, total industrial area including areas of large scale factories cover 844 ha (2,090 acres).

Entire Project Area is classified into 6 land use categories: a) industrial, b) social and commercial, c) residential, d) rural, e) agricultural, and f) others. Present land use is illustrated in Figure II-6, and acreage of each category is as shown in Table II-9.

TABLE II-8 Population & Distribution in Mukim in 1970, with 1976 projection

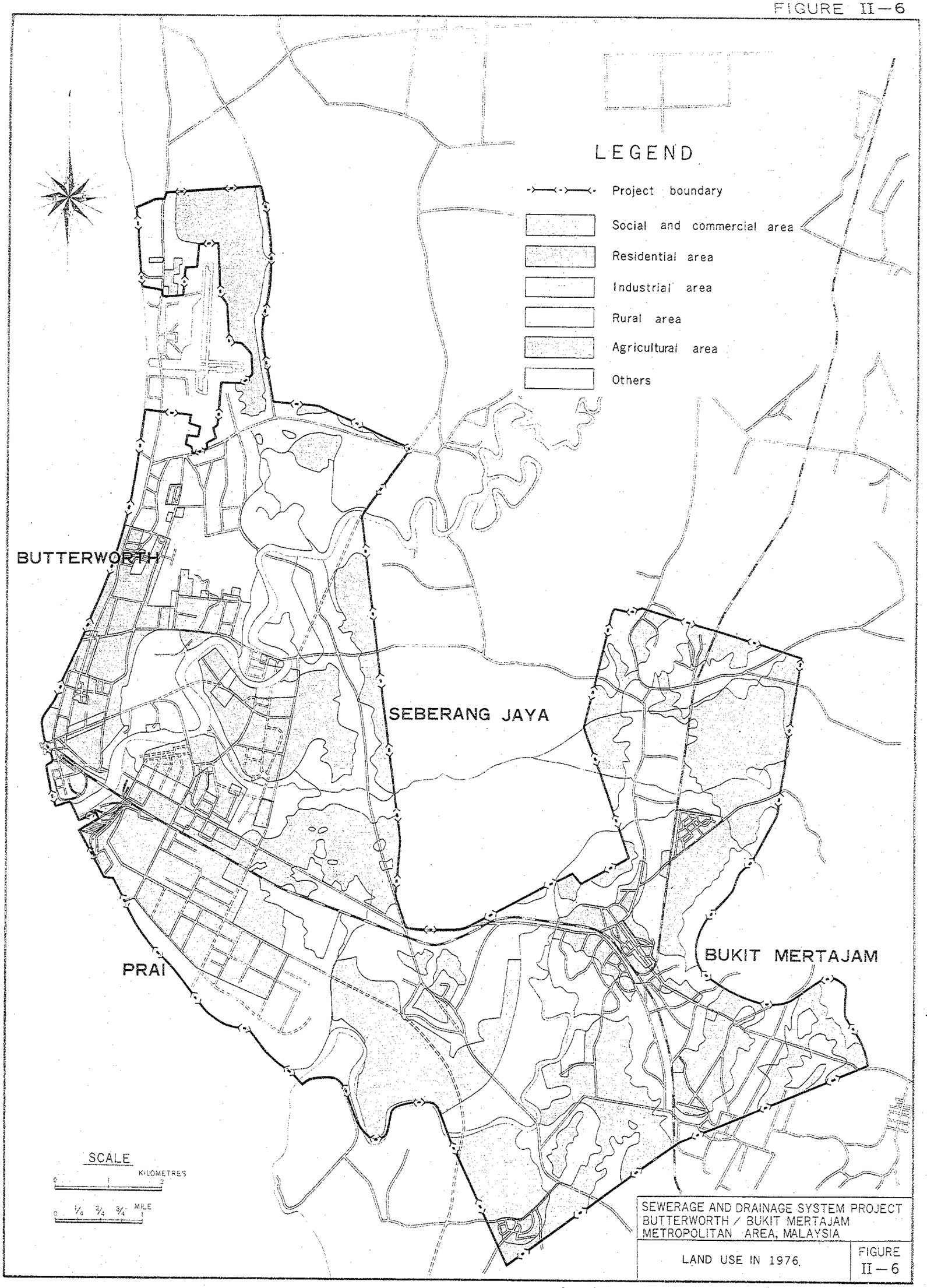
No. of Mukim	Mukim Total*			Project Area**			
	Area	1970		Area	1970	1976	
	(ha)	Population	Population Density Persons/ha	(ha)	Population	Population	Population Density Persons/ha
N 7	1,152	8,485	7.4	389	3,751	5,183	13.3
N 9	650	6,917	10.6	281	2,691	3,719	13.2
N10	1,059	3,286	3.1	47	146	202	4.3
N14	885	39,502	44.6	885	39,502	54,587	61.7
N15	645	30,035	46.6	645	30,035	41,505	64.3
N16	668	3,441	5.2	523	2,720	3,759	7.2
C 1	2,174	10,875	5.0	2,174	10,875	15,028	6.9
C 2	848	3,952	4.7	420	3,162	4,369	10.4
C 3	457	3,381	7.4	88	2,029	2,804	31.9
C 4	781	5,934	7.6	354	5,341	7,381	20.9
C 5	625	2,816	4.5	187	2,253	3,113	16.6
C 6	1,035	4,096	4.0	762	4,096	5,660	7.4
C 7	1,176	1,665	1.4	54	1,665	2,301	42.6
C 8	406	10,116	24.9	193	10,116	13,979	72.4
C 9	270	9,131	33.8	270	9,131	12,617	46.7
C10	445	19,641	44.1	445	19,641	27,141	61.0
C11	1,060	5,116	4.8	1,060	5,116	7,070	6.7
C12	1,480	2,740	1.9	60	114	158	2.6
C13	1,328	2,776	2.1	366	2,776	3,836	10.5
C14	1,813	6,645	3.7	618	3,323	4,592	7.4
C15	1,535	9,706	6.3	681	8,735	12,071	17.7
C16	1,688	5,567	3.3	5	17	23	4.6
C17	2,195	1,100	0.5	309	155	214	0.7
C18	1,055	1,405	1.3	215	280	387	1.8
C19	1,551	2,137	1.4	5	7	10	2.0
C20	1,008	6,477	6.4	557	4,534	6,265	11.2
C21	902	2,438	2.7	7	19	26	3.7
Total	28,891	209,380	7.2	11,600	172,230	238,000	20.5

Note: *: from 1970 Census
**: Culculated by Survey team

TABLE II-9 Population and Land Use of Mukim in 1976 (in Project Area)

No. of Mukim	Area (ha)							Population Density			Population			
	Social Commercial	Residential	Industrial	Rural	Agricultural	Others	Total	Social Commercial	Residential	Rural	Social Commercial	Residential	Rural	Total
N 7		18		141	230*		389		120	21.4		2,160	3,023	5,183
N 9				175	106*		281			21.3			3,719	3,719
N10				30	17*		47			6.7			202	202
N14	2	197	95*	530		61*	885	120	120	57.9	240	23,640	30,707	54,587
N15	16*	133						0	108.6		0	3,585		
	47	190	79*			280*	645	160	160		7,520	30,400		41,505
N16				201	58*	246*	523			18.7			3,759	3,759
C 1		157	670*	108	593*	646*	2,174		80	22.9		12,560	2,468	15,028
C 2				138	115*	167*	420			31.7			4,369	4,369
C 3				67	21*		88			41.9			2,804	2,804
C 4				137	208*	9*	354			53.9			7,381	7,381
C 5				61	126*		187			51.0			3,113	3,113
C 6				304	382*	76*	762			18.6			5,660	5,660
C 7				49	5*		54			47.0			2,301	2,301
C 8	1	86		72	34*		193	120	120	49.2	120	10,320	3,539	13,979
C 9		57		148	65*		270		120	39.0		6,480	5,777	12,617
C10	19	108		221	28*	69*	445	120	120	53.9	2,280	12,960	11,901	27,141
C11		16		292	450*	302*	1,060		80	19.8		1,280	5,790	7,070
C12				4		56*	60			39.5			158	158
C13		38		24	288*	16*	366		80	33.2		3,040	796	3,836
C14				216	359*	43*	618			21.2			4,592	4,592
C15		13		344	324*		681		80	32.1		1,040	11,031	12,071
C16				3	2*		5			7.7			23	23
C17				11	154*	144*	309			19.5			214	214
C18				10	185*	20*	215			38.7			387	387
C19				2	3*		5			5.0			10	10
C20				189	296*	72*	557			33.1			6,265	6,265
C21				7			7			3.7			26	26
Total	16* 69	913	844*	3,484	4,049*	2,225*	11,600	0 147.2	118.1		10,160	107,825	120,015	238,000

Note: * is non-habitable area, e.g. government office zone, water courses, cemeteries, mountainous areas, parks, industrial areas, agricultural areas.



SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA

LAND USE IN 1976.

FIGURE II—6

CHAPTER 5

WATER SUPPLY SYSTEM

5.1 Existing Water Supply System

5.1.1 Water Agency

The water supply system of the State of Penang is operated by the Penang Water Authority (PWA) which was established by amalgamation of the former City Water Department of the City Council of George Town and the former Water Supply Section of the State Public Works Department on 1st January 1973.

5.1.2 Areas and Population Served

Approximately 280,000 persons or about 80 percent of the total population in Province Wellesley is served by the water supply system.

The water supply area is illustrated in Figure II-7.

5.1.3 Water Production and Use

Water production by year for the last 6 years for Province Wellesley is shown in Table II-10.

TABLE II -10 Total Annual Water Production
(1969 - 1974)

Unit: 1000 cu m

Year	NORTH	CENTRAL	SOUTH	TOTAL
1969	12,029	1,500	1,786	15,315
1970	13,438	1,772	1,723	16,933
1971	17,770	1,587	1,987	21,344
1972	19,116	1,623	1,627	22,366

- to be continued -

Year	NORTH	CENTRAL	SOUTH	TOTAL
1973	21,230	1,623	2,223	25,076
1974	24,430	1,714	1,623	26,767

Data Source: 1969 - 1974 Water Supply Record of the Penang Water Authority

5.1.4 Water Supply Conditions

Water supply conditions in Province Wellesley are satisfactory on both aspect of quantity and quality. The entire Province Wellesley is already covered by main pipe lines, and therefore, all of the population in the Province may soon be covered in the foreseeable future.

5.1.5 Private Water Supply Systems

There are at present privately owned water supply systems in Province Wellesley. Some of them use wells and irrigation water, but the areas presently covered by them will not doubt be included in the water service area in the near future for supply from the municipal water system.

5.2 Existing Water Supply Facilities

5.2.1 Outline of Existing Facilities

The served area in Province Wellesley is divided into three zones, namely North, Central, and South.

(a) North Zone

This system covers rural areas in the north of Province Wellesley and the town of Butterworth. The water is derived from the Sungai Kulim and flows along a channel to the Bukit Toh Allang treatment plant. The plant and the existing mains to Butterworth and Bukit Mertajam have a capacity of 40,914 cu m/day (9 MIGD).

(b) Central Zone

This system supplies water to the towns of Bukit Mertajam and Prai. The water is obtained from three streams on the slopes of Bukit Mertajam hill where storage reservoirs exist, and supplemental water is from the Bukit Toh Allang treatment works in the north.

(c) South Zone

The principal areas supplied in this zone are Nibong Tebal and Sungai Bakap. Water is obtained from a impounding reservoir and is treated in the treatment plant at Bukit Panchor.

The total rated output of existing treatment plants in Province Wellesley is 49,870 cu m/day (11 MIGD).

Storage tanks have the following capacities:

Bukit Toh Allang	27,276	cu m/day	(6.0 m.g.d.)	
Bukit Mertajam	9,092	"	(2.0 ")	(2 reservoirs)
Sungai Bakap	4,546	"	(1.0 ")	
Bukit Panchor	4,546	"	(1.0 ")	
Butterworth	2,546	"	(0.56 ")	(4 reservoirs elevated)
North Province Wellesley	955	"	(0.21 ")	(2 reservoirs elevated)
Prai	909	"	(0.2 ")	(elevated)
Total	49,870	cu m/day	(10.97 MIGD)	

5.2.2 Water Sources

Water Sources of the water supply system in Province Wellesley are as described in Table II-11.

TABLE II - 11 Water Source

Name of Treatment Plant	Water Source
Bukit Toh Allang	Sungai Kulim
Bukit Mertajam	Streams on the hill
Bukit Panchor	Impounding reservoir
Sungai Dua	Sungai Muda

5.2.3 Pumping Stations

There are five pumping stations for the water supply system in Province Wellesley. The quantities of water pumped from low level intakes to supplement yields of high level intakes are as follows.

TABLE II - 12 Total Annual Quantities of Pumping Station

(1973)

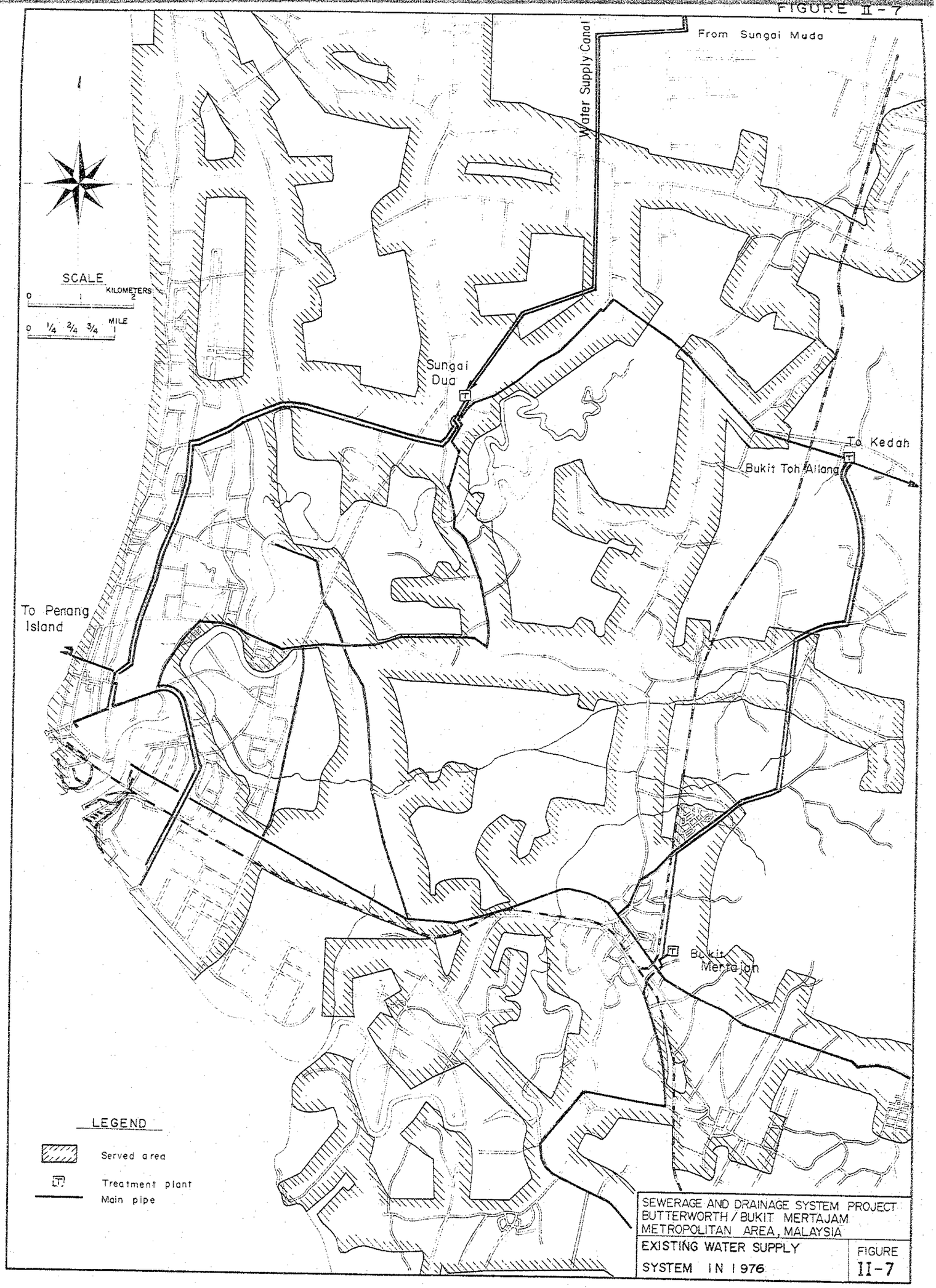
Unit: 1000 cu m/year

Name of Pumping Station	Quantities
Bukit Toh Allang Pumping Station	37,446
Bukit Mertajam Pumping Station	728
Bukit Panchor Pumping Station	412
Sungai Buaya Pumping Station	138
*Sungai Dua Pumping Station	1,467
Total	40,191

Note: * Commenced operation with effect from April 1973.

Data Source: 1973 Annual Report of Penang Water Authority.

FIGURE II-7



SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA

EXISTING WATER SUPPLY SYSTEM IN 1976

FIGURE II-7

5.2.4 Treatment Plants

The treatment processes of plants are shown in Table II-13.

TABLE II - 13 Treatment Process of Plant

Treatment Plant	System	Chemicals for Pre-Sedimentation	Sedimentation	Filtration	Sterilization	Conditioning
Bukit Toh Allang	Pumped	Chlorine Soda Ash Alum	Lovo Type	Rapid Gravity	Chlorine	Lime Dry Feed
Bukit Mertajam	Gravity w/Pumped Auxiliary Supply	Alum Lime Chlorine	Horizontal Type	Rapid Gravity	Chlorine	Lime Slurry Feed
Bukit Panchor	Gravity w/Pumped Auxiliary Supply	Alum Lime Sodium Aluminate	Horizontal Type	Rapid Gravity	Chlorine	Lime Dry Feed
Sungai Dua	Pumped	Lime Alum Soda Ash	Horizontal Type	Rapid Gravity	Chlorine	Lime Dry Feed

Source: PWA

5.2.5 Water Quality

The result of the water quality analysis at several points is shown in Tables II-14.

TABLE II - 14 Results of Water Analysis

Location: (1) Bukit Toh Allang Service Reservoir (Treated water)
(2) Sungai Kulim (Raw water)
(3) Prai Post Office (Treated water)
(4) Kg. Selamat Sekolah (Treated water)

Sample taken on: Month (1976) Day Time	(1) 8:50	(2) 10:15	(3) 8:00	(4) 10:25
CHEMICAL ANALYSIS (mg/l)				
Salinity	0.1	-	0.1	0.1
Chlorides as Cl	6	3	5	6
Total solids dried at 105° - 100°C	75	160	55	75
Oxygen absorbed from $KMnO_4$, 4 hrs., 27°C	0.25	1.65	0.20	0.25
Ammonical Nitrogen	0.01	0.09	0.01	0.01
Albuminoid "	0.02	0.10	0.01	0.01
Oxidized "	0.30	0.15	0.15	0.35
Nitrite "	-	0.001	-	-
Iron expressed as Fe	0.15	0.25	0.15	0.10
Total Hardness as $CaCO_3$	35	10	20	30
Fluoride as F	0.08	0.04	0.02	0.04
Turbidity	Clear with slight sedimentation	Turbid	Clear	Clear
Odour	Nil	Nil	Nil	Nil
Colour	-	-	-	-
pH	6.7	7.8	8.3	8.4

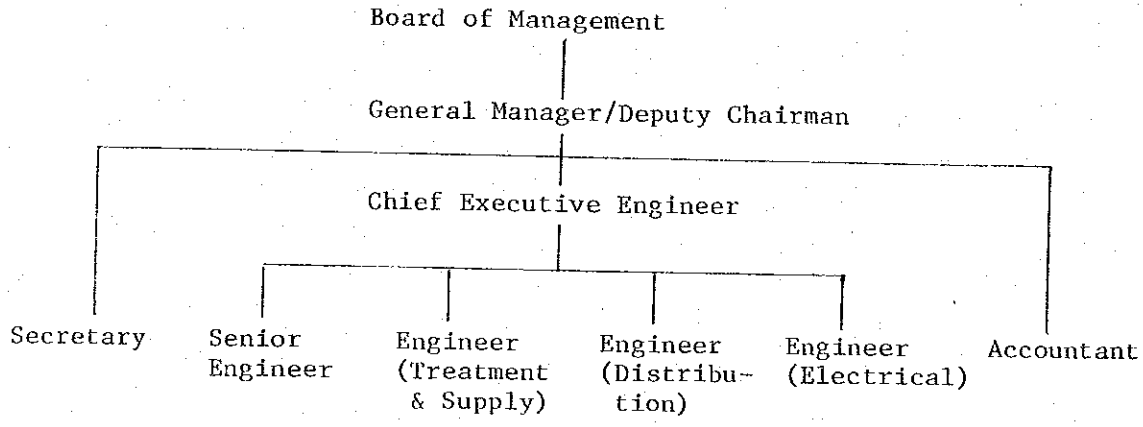
Data Source: PWA

5.3 Management and Operation

The Penang Water Authority was established in 1973 in accordance with the Penang Water Authority Enactment 1972.

The present organization is as shown in Figure II-8.

FIGURE II-8 The Organization of the Penang Water Authority



CHAPTER 6

EXISTING EXCRETA DISPOSAL SYSTEMS

6.1 Existing Toilet and Excreta Disposal System

Existing toilet facilities in the houses are classified into three categories, flush toilet with septic tank or Imhoff tank, bucket toilet, and pit privy.

Data obtained from "Population and Housing Census of Malaysia 1970" shows distribution of these facilities in the town areas and in the rural area. Number of houses classified according to the toilet facilities in the town and the rural areas are shown in Table II - 15 .

It should be noted that in the town areas, more than 90 percent of the houses are covered by flush or bucket toilets, but pit privy is predominant in the rural area. Toilets over the waterways or no toilet houses are mostly located in the rural areas outside of the Project Area.

TABLE II - 15 Toilet facilities in North and Central Districts in 1970

		Flush toilet	Bucket toilet	Pit privy	Toilet water-way	No toilet	Total
Central District	Bukit Mertajam	993 (28.5)	2,396 (68.9)	54 (1.6)	2 (0.)	34 (1.0)	3,479 (100)
	Rural	1,355 (8.7)	3,485 (22.4)	6,955 (44.7)	1,182 (7.6)	2,593 (16.7)	15,570 (100)
North District	Butterworth	2,620 (30.6)	5,177 (60.4)	501 (5.8)	55 (0.6)	218 (2.5)	8,571 (100)
	Rural	2,548 (7.5)	5,898 (17.5)	14,150 (41.9)	1,800 (5.3)	9,354 (27.7)	33,750 (100)

Note: North and Central Districts includes the outside areas of the Project Area. Rural means the remainder of Butterworth and Bukit Mertajam Town Areas in the North and Central Districts respectively.