MASTER PLAN
FOR
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH/BUKIT MERTAJAM METROPOLITAN AREA
MALAYSIA

VOLUME III

APPENDICES

MAY 1978

JAPAN INTERNATIONAL COOPERATION AGENCY

ORDER OF PRESENTATION

Table of Contents

Chapter	Page

Chapter		Page

Chapter | Page

Chapter | Page

LIST OF TABLES

LIST OF FIGURES

Figure No.		Page
G-10	Operation and maintenance cost of pumping station	G-41
G-11	Operation and maintenance cost for stabilization pond process	G-44
G-12	Operation and maintenance cost for aerated lagoon process	G-45
G-13	Operation and maintenance cost for oxidation ditch process	G-46
G-14	Required site area for pumping station	G-48
G-15	Required site area for treatment plant	G-50
G-16	Proposed sewerage system	G-57
H-1	Population density in 1976	H-7
H-2	Population density in 2000	H-8
H-3	Location of existing excreta disposal system	H-20
H-4	Flooding areas	H-23
H-5	No water supply areas	H-28
I-1	Representative area of land use	I-7
I-2	Ratio of stormwater qualities with different inlet time	I-12
J-1	Cumulative inflow and outflow curve for the reservoir in B.W.B.	J-8
J-2	Cumulative inflow and outflow curve for the reservoir in B.W.C.	J-9
J-3	Drainage system alternative - I in Butterworth area (B-IV)	J-12
J-4	Drainage System alternative - II in Butterworth area (B-IV)	J-13
J-5	Drainage system alternative - III in Butterworth area (B-IV)	J-14
J-6	Profile of Butterworth Drain A	J-15
J-7	Profile of Butterworth Drain B and D	J-16

Figure No.		Page

APPENDIX A

ECONOMY

The socio-economic characteristics of the whole Malaysia, and the State of Penang are presented in order to provide basic information as regards the infrastructural condition of the Butterworth and Bukit-Mertajam areas, where provision of sewerage and drainage system is proposed.

1. General

The Federal Government located at Kuala Lumpur is responsible for basic national policy directed by National Parliament consisting of two houses - the Senate and House of Representative; on such matters as foreign relations, security, education, defence, finance, transport, communications and immigration, while State Government is responsible for matters such as land, water, agriculture and forestry and recreation.

There are 13 States in Malaysia, i.e. two in the north of Borneo, namely, Sabah and Sarawak, and 11 in the Peninsular Malaysia, namely, Johore, Malacca, Negri Sembilan, Pahang, Selangor, Trengganu, Kelantan, Perlis, Kedah, Perak, and Penang, with each of the respective State Governments under the authorities delegated to them through their legislative bodies. There exist a number of different local government agencies, with due authorities assigned by the State Governments.

2. Whole Malaysia

Malaysian economy is in transition towards full-scale industrialization. Economic growth for the past few years are remarkable although they experienced a sluggish growth in 1975 due to the adverse effects of the worldwide recession of 1974-75. The recent economic climate in Malaysia has indicated marked improvement and real GNP for 1976 has grown by 11.3 percent amounting to M$26,914 million in 1976, as indicated in Table A-1.

The per capita GNP has correspondingly increased to M$2,184 in 1976.

TABLE A-1 Gross National Product at Current Prices, 1970-1976

(M$ Million)

	1970	1971	1972	1973	1974	1975	1976
Private Consumption	7,486	8,059	8,381	9,901	12,011	12,052	19,498
Public Consumption	1,997	2,243	2,777	3,122	3,811	4,745	5,220
Private Fixed Investment	1,459	1,675	1,779	2,243	3,223	3,320	3,589
Public Fixed Investment	693	852	1,308	1,552	2,157	2,518	2,777
Exports of Goods and Services	5,602	5,473	5,293	7,994	11,051	10,165	14,110
Change in Stock	+315	-136	-63	+228	+683	-667	-50
Less: Import of Goods and Services	5,397	5,665	5,832	7,597	11,702	10,386	11,200
Gross National Product	12,155	12,501	13,643	17,443	21,234	21,747	26,914

Source: Economic Report, 1976/77 Treasury Malaysia and the figures for 1976 only are excerpted from 1976 Annual Report of Bank Negara

The Malaysian economy is substantially dependent on the export of domestic products. Malaysia's favourable trade balance for the past several years has been contributing to the steady growth of the national economy. The balance of payments in 1976 has been significantly increased and gross international reserves, which comprise the reserve holdings of Bank Negara, stood at M$1,917 million at the end of September 1976. Export items of major significance are rubber, manufactured goods, petroleum (crude and partly refined), tin, palm oil, timber, and others, accounting for 25, 22, 14, 10, 7, and 5 percent respectively of total export value of M$12,030 million for 1976. Corresponding to increasing external demand and higher level of domestic economic activities reflecting increased income generated by an export boom, the domestic production have been increased particularly on key commodities such as petroleum, rubber, palm oil, sawlogs, sawn timber, tin and manufactured goods.

Agricultural sector has been the largest contributing sector for nation's economy accounting for 30 percent of total domestic products. The second largest and the fastest growing sector in nation's economy is the manufacturing sector.

The increased activities of the manufacturing sector is strongly emphasized by the Federal and State Governments and emerged as the main source of new job opportunities, through granting incentives to the selected industries by means of investment opportunities, tax credit, labour utilization relief, and locational incentive. Effort is being made for encouraging a more balanced industrial growth.

The Locational Incentive Scheme implemented since January 1975 has enabled the less developed areas to gain the benefits of industrialization with the gazetting of these areas as Locational Incentive Areas. Efforts are made for establishment of industrial estates, the provision of adequate infrastructure for industries. The Prai, Bayan Lepas, Sungai Way, Tanjung Keling and Bata Berendam areas are gazetted as free trade zone areas in 1976.

Federal Government's expenditure, which is the major component of the public sector, is expected to constitute 65 percent of the estimated total public spending in 1976, and State Governments' expenditures are expected to comprise about 21 percent of total public spending with the rest being shared by statutory bodies and municipalities. The public sector spending is estimated to reach M$9,210 million, stimulated by development investment which is expected to reach M$3,405 million in current price in 1976 with the intention of the Government to expedite the development projects during the early stages of Third Malaysia Plan (TMP) 1976-1980.

The development investment in 1977 is estimated to be M$4,494 million reflecting the objectives of the Third Malaysia Plan (TMP), which emphasize the eradication of poverty, restructure of society and national security. The expenditure on the services which will especially benefit the poor such as agriculture and rural development, social and community services and health activities are increased. The agriculture and rural development sectors will receive the largest allocations with emphasis on land development.

Net domestic borrowings by 1977 is estimated to reach M$2,000 million, comprising of M$1,700 million in Government Securities and M$300 million in Treasury bills.

Malaysia's high credit standing has permitted ready access to multilateral and bilateral lending agencies and international capital markets. The gross foreign loans are estimated to be M$733 million by 1976, comprising M$376 million in market loans and M$357 million in project loans, from the World Bank (M$100 million), the Asian Development Bank (M$90 million), United States (M$90 million), Japan (M$62 million), and other bilateral sources (M$15 million).

The number of project loan from these financing resources has been increasing in recent years and would continue to increase during the Third Malaysia Plan period when M$3.5 billion of the total loan of M$5.8 billion is expected to be obtained from multilateral and bilateral lending sources. Continued emphasis will be given to the raising of project related loans during the period of the Plan (TMP) as they are relatively with low-interest and are long-term in nature.

During the TMP, it is estimated that about 36 percent (M$5,040 million) of total Federal Government development expenditure of M$14,143 million would be disbursed as loans. Reflecting the continued emphasis on the improvement of infrastructural facilities, especially for the poorer states, the largest portion of loan allocations during the Plan (31 percent or M$1,640 million) would be made to public utilities including electricity, water supply, transport and communications.

The inflation has been stabilized in lower rate of 5 percent as reflected by the Consumer Price Index (CPI) which stood at 148 in 1976 based on 100 as of 1967, registering an annual increase of 3.3 percent.

The slower pace of increase in the CPI is mainly attributable to the declining rate of international inflation and to a large extent the improvement in food prices. The Government has been endeavouring the enforcement of the Control of Supplies Act 1961 to control the inflation by regularising and supervising the supply and distribution of essential commodities.

Malaysia has a well-established banking system. Bank Negara as the central bank of Malaysia is charged with supervising banking activities to maintain monetary stability together with controlling foreign exchange. Commercial banks well developed are the most important local sources of financing in Malaysia and they are closely supervised by Bank Negara. There are a total of 11 major country-wide commercial banks operating in Malaysia. These banks provide a wide range of specialized services of financial and management consulting.

The rate of interest charged by commercial banks for loans is maximum 10 percent per annum. Interest payable on one-year fixed deposit ranges from 7 percent to 9.1 percent.

Banking systems are well established in the State of Penang with 15 banking facilities including local branches of the major banks in operation at the end of October, 1974, which provide normal banking services, including acceptance of deposits, making loans and advances, discounting bills and provision of business investment advisory services.

The additional commercial banks are being set up reflecting recent economic reorientation with emphasis on industrialization. The average rate of interest charged by banks for loans and advances are in the range of 8 percent to 9.7 percent depending on borrowing sectors.

The economic recovery and corresponding pick-up in export-oriented and labour intensive industries have enhanced the employment. The agricultural, forestry and fishing sectors were in the past major sources of employment accounting for approximately 48 percent of total national employment which are now closely followed by the fast growing manufacturing sector. The unemployment rate decreased from 7 percent in 1975 to 6.8 percent in 1976 corresponding to over-all improvement of employment. The majority of registered unemployment falls in the 15-29 age group reflecting the degree of unemployment among youths. The unemployment level is higher in the urban than in rural areas presumably due to the drift of unemployed rural people. Labour organizations are active with increase of collective agreement entered for the purpose of improvement of employment conditions including higher wages. Significant improvement and stabilization of labour management relations in Malaysia are expected after passage of the amendments to the Industrial Relations Act of 1967, which aims to improve and broaden the effectiveness of the arbitration system. The basic salary and wage rates prevailed in 1975 are shown in Tables A-2(1) and (2).

Table A-3 indicates the progress of public utilities development in the past 10 years in whole Malaysia.

TABLE A-2(1) Basic Salary and Wage Rates in 1975

	MALAYSIA		
	High	Low	Average
I. TECHNICAL SCIENTIFIC, PROFESSIONAL			
1. Accountant	M$2,610	M$650	MS1,625
2. Architect	2,725	875	1,800
3. Auditor	2,610	650	1,625
4. Chemical Engineer	2,175	810	1,500
5. Chemist	1,960	810	1,390
6. Civil Engineer	3,800	810	2,310
7. Clinic Physician	3,260	1,960	2,610
8. Dentist	2,725	925	1,825
9. Economist	1,125	875	1,000
10. Electrical Engineer	2,710	810	1,775
11. Geodetic Engineer	1,960	760	1,360
12. Geologist	1,960	975	1,475
13. Industrial Engineer	2,725	810	1,760
14. Laboratory Technician	925	240	590
15. Legal Officer	2,725	925	1,825
16. Mechanical Engineer	2,175	810	1,500
17. Mining Engineer	3,990	975	2,490
18. Nurse	875	275	575
19. Personnel Officer	2,610	375	1,500
20. Pharmacist	2,175	550	1,360
21. Programmer	1,960	810	1,390
22. Purchaser/Buyer	1,300	550	925
23. Salesman	875	325	600
24. Statistician	1,960	810	1,390
25. Systems Analyst	1,625	760	1,200
26. Trial Lawyer	2,725	650	1,690
II. CLERICAL AND ADMINISTRATIVE			
1. Accounting Machine Operator	M$ 650	M$240	M$ 340
2. Bookeeper	975	210	600
3. Cashier	625	275	460
4. Clerk/Typist	375	160	275
5. Console Operator	810	490	650
6. Draftsman	1,090	225	650
7. Executive Secretary	1,460	760	1,110
8. Keypunch Operator/Verifier	650	240	450
9. Librarian	1,800	440	1,110
10. Messenger	160	90	125
11. Office Clerk	710	140	425
12. Secretary	875	325	600
13. Stenotypist	825	210	525
14. Storekeeper	540	125	340
15. Telegraph Operator	550	225	375
16. Telephone Operator	325	160	250

(to be continued)

(continued)

	MALAYSIA		
	High	Low	Average
III. LABOUR, TRADES, SKILLED CRAFTS			
1. Carpenter	21.75	6.50	14.10
2. Driver	21.75	3.25	12.50
3. Electrician	10.90	7.10	9.00
4. Janitor	10.90	2.75	6.75
5. Labourer (Unskilled)	16.25	2.75	9.50
6. Lathe Operator	18.10	7.25	12.75
7. Mechanic	30.75	4.75	17.75
8. Painter	9.75	3.75	6.75
9. Plumber	8.75	5.50	7.10
10. Radio Technician	14.60	7.50	11.10
11. Security Gurd/Watchman	12.50	2.75	7.60
12. Tool and Diemarker	18.10	7.25	12.75

I and II: Monthly rates

III : Daily rates

Source: Comparative Labour Costs, January, 1976, The SGV Group, management consultant, Philippine

TABLE A-2(2) Basic Salary and Wage Rates in 1975

Type of Labourer	M$/day
1. Common worker	8
2. Skilled worker	15
3. Carpenter	12
4. Stone masonry	12
5. Plumber	15
6. Foreman	20

Source: Public Works Department of State of Penang

TABLE A-3 Progress of Public Utilities Development

	1965	1975
Road (miles)		
Hard Surface	9,504	11,306
Earth Surface	488	597
Water Supply		
Served Population (million)	3.4	6.4
Public Stand Pipes (miles)	10,980	19,810
Telephone-subscribers' Lines (miles)	69,691	143,829
Electricity Consumption		
No. of Industrial Consummers (million KWH)	620	2,819
No. of Domestic Consumers (million KWH)	376	886
Health		
Beds per 1,000 population	1.87	1.66

Source: Economic Report 1976/77

3. State of Penang

State of Penang is divided into two local authorities, namely Municipal Council of Penang at the Penang Island and Municipal Council of Province Wellesley on the mainland. Municipal Councils are financially autonomous and retain certain degree of empowered authority, which is derived from the Municipal Ordinance and Local Government Act.

The Project Area of Butterworth and Bukit/Mertajam is administered by Municipal Council of Province Wellesley. Province Wellesley is separated from Penang Island by a water channel, two miles wide at the closest point of waterway and eight miles at the farthest point.

Province Wellesley is, however, linked to Penang Island by a well managed 24 hour ferry system. In contrast with Penang Island, which is typified by mountainous terrain, Province Wellesley is a flat, lowlying coastal plain and only interrupted by patches of hilly land at the south-eastern border of State.

During the early days after independence from 1957 to 1969, the economic structure were largely based on trade and agriculture sectors while manufacturing sector was given less attention for development.

The leading sectors in Penang's economic structure at the present stage are agriculture, trade and manufacturing, and the agriculture accounts for large percentage of the land use in Penang State. Out of 203 square miles of Province Wellesley, 80 percent mostly alienated land is devoted to agricultural use. Major crops are rubber, paddy, coconuts and oil/palms. Oil/palm is in the initial stage of development as a new crop with high economic return.

Penang has been an important trading center in the South East Asian region with its strategic location as the northern gate way to Malaysia, and well established port facilities and transportation.

Trading activities of Penang has been accelerated by the government encouragement with advantageous privilege in addition to the favorable location. Efforts have been made by the State to promote the port operation with provision of up to date port facilities to cope with the demand for recent cargo transfer and ship handling in the light of major technological changes. Newly constructed deep water wharves in Butterworth in the Project Area provides a vital contribution in handling cargo moving through the port.

It should be noted, however, that above mentioned agriculture and trade remained to be the main contributing factors for the economic growth of the State from 1957 up to 1969, when new economic re-structuring became necessary by significant increase of population and labour force which outstripped the growth of agriculture and trade sectors.

The limited capacities of the agriculture and trade sectors to absorb increasing labour force and corresponding imbalance in the labour market necessitated manufacturing sector to be the new growth generating sector. This manufacturing sector has been emphasized since 1970 with growing support of both the State and Federal Governments.

The transition in economic structure is illustrated by Tables A-4, 5, 6 and 7.

TABLE A-4 Penang Economy, 1969

Economic Sector	Employment Distribution		Gross Regional Product	
	Number ('000)	Percentage (%)	Amount (M$ Million)	Percentage (%)
Agriculture, Forestry and Fishery	65.5	31.2	110.0	16.2
Mining and Quarrying	0.5	0.2	1.0	0.1
Manufacturing	21.0	10.0	81.0	11.9
Construction	8.0	3.8	45.0	6.6
Electricity, Water and Sanitary Services	2.0	1.0	16.0	2.4
Transportation, Storage and Communication	13.0	6.2	36.0	5.3
Trade, Government and Services	100.0	47.6	391.0	57.5
All Sectors	210.0	100.0	680.0	100.0

Service: Penang Development Corporation (PDC)

TABLE A-5 Penang Economy, 1975

	Employment Distribution		Gross Regional Product	
	Number ('000)	Percentage (%)	Amount (M$ Million)	Percentage (%)
Agriculture, Forestry and Fishery	65.5	22.6	140.0	11.8
Mining and Quarrying	0.6	0.2	1.4	0.1
Manufacturing	51.4	17.7	258.0	21.7
Construction	14.1	4.9	95.0	8.0
Electricity, Water and Sanitary Services	3.2	1.1	32.0	2.7
Transportation, Storage and Communication	19.7	6.8	65.0	5.5
Trade, Government and Services	135.5	46.7	596.6	50.2
All Sectors	290.0	100.0	1,188.0	100.0

Source: Penang Development Corporation (PDC)

TABLE A-6 Employment, Unemployment and Labour Force, 1969

	Number ('000)	Percentage (%)
Employment	230.0	85.5
Full	210.0	78.1
Partial (Underemployed)	20.0	7.4
Unemployment	39.0	14.5
Labour Force	269.0	100.0

Source: Penang Development Corporation (PDC)

TABLE A-7 Employment, Unemployment and Labour Force, 1975

	Number ('000)	Percentage (%)
Employment	305.0	93.1
Full	290.0	88.5
Partial (Underemployed)	15.0	4.6
Unemployment	22.5	6.9
Labour Force	327.5	100.0

Source: Penang Development Corporation (PDC)

The projected sectorial growth pattern in Penang is in sharp contrast to that in most of West Malaysia where expansion in land cultivation is expected to provide a major source of new development.

The import-substituting industries in Penang have already been started at strategic locations and a new phase of export oriented industrialization, with the provision of free trade zones, is in progress in consistent with national goal of diversification of export.

The major industries are concentrated in Project Area on Mainland due to the land availability and development of the Butterworth wharves, mainly in the Butterworth/Prai urbanized area and Bukit/Mertajam, mostly in the Mak Mandin and Prai Industrial Estates. The continuous effort has been made for further successful economic expansion and reduction of unemployment by encouraging new growth-generating sectors as tourism, fisheries and construction.

Penang has well-developed infrastructure advantageous for economic development. The port of Penang administered by the Penang Port Commission is presently well equipped with advanced facilities to handle increasing cargoes. The further expansion and improvement are contemplated. The Bayan Lepas Airport on Penang Island is one of the two international airports in Malaysia with wider coverage of service to domestic and international routes. The expansion programme is in progress to cope with increasing passengers and enlarged aircrafts.

Malayan Railway provides both freight and passenger service between Butterworth, Kedah, Southern Thailand, Bangkok and Kuala Lumpur. The branch line extends through Butterworth and Bukit/Mertajam into the Port area and industrial zones to facilitate direct transport of raw materials and goods.

The bus services are provided by public and private companies. The urban services are provided for factory, office and other workers, school children and general public. Rural services are provided to primarily agricultural population. The taxis are easily available especially in George Town at Penang Island and in lesser degree in Butterworth area on the mainland. However, the new improvements and expansions of bus services are required to provide for more frequent and broader service to labour forces anticipated to increase in the developing industrial areas. Telecommunications and postal services including telex and telephone services are presently adequate in general with highly developed system through extensive domestic and international circuit. Data in 1974 from Telecommunications Department indicates that 15 telephone exchanges are provided in Penang Island, Butterworth and Bukit Mertajam area with 15,000 subscribers in Penang Island, 3,000 in Butterworth and 1,000 in Bukit/Mertajam.

Further expansion has been programmed in Butterworth area reflecting the developments in industrial areas. The electricity supply in Province Wellesley is provided by National Electricity Board (NEB) while Municipal Council of Penang Island is responsible for electricity supply in Penang Island. NEB's thermal generating plant located at the Prai Industrial Estate has a capacity of 90 megawatts with planned capacity of 270 megawatts. Water supply in Province Wellesley is administered by the Penang Water Authority which has four separate sources of water supply having a combined minimum yield of 45 MIGED.

Other facilities for education, medical and health and recreation are well developed. However, they are, in general, concentrated in Island area and requires to be developed in the Project Area.

As regards public sanitation facilities they are by far inadequate in contrast with other infrastructural system. The lack of sewerage disposal system is the one most serious in the Project Area, where only available systems are limited to a number of septic tanks, night soil collection, pit latrines or open drains mostly without any treatment plant. The trenching for night soil has exhausting the readily available sites and the soils in many areas are approaching to saturation.

State of Penang is characterized as the most densely populated area with the significantly high annual increase rate of population attributable to relative high rate of birth, reduced death rate and balanced distribution between male and female.

The population composition is also characterized by its various ethnic groups of Malays, Chinese, Indians and others. The Chinese make a majority group accounting for about 56 percent of total State population and are mainly distributed in Penang Island and predominantly concentrated in urban area accounting for 67 percent of Chinese in the State. The Malays accounting for about 30 percent of total State population are concentrated in Province Wellesley and mainly in rural areas. Indian/Pakistani are largely residents of Penang Island and predominantly in urban areas.

Geographically the population is less distributed in Province Wellesley compared with Penang Island. About 44 percent of total population is in Province Wellesley against 56 percent in Island. Province Wellesley is presently not only less populous but also less urbanized than Penang Island, but significant increase in population in North and Central Districts of Province Wellesley is expected in the light of the projected development. In addition to natural growth of population there is likelihood that there might be an influx of migration in Province Wellesley with increased development and expanded economic activities.

TABLE A-8 Project Population by Five Year Age-Group in Penang: 1970 - 1980

Age-Group / Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
All Ages	776,124	789,922	807,275	825,506	844,650	864,771	883,654	903,406	924,057	945,640	968,220
0 - 4	105,051	105,124	108,200	111,379	114,665	118,060	121,208	124,437	127,749	131,143	134,625
5 - 9	110,221	108,480	106,801	105,155	103,543	101,966	104,941	108,022	111,207	114,501	117,903
10 - 14	103,482	104,855	106,316	107,795	109,301	110,832	109,102	107,406	105,743	104,114	102,520
15 - 19	89,790	92,576	95,522	98,562	101,698	104,932	106,372	107,835	109,318	110,823	112,356
20 - 24	69,524	72,795	76,312	80,025	83,933	88,035	90,846	93,746	96,736	99,822	103,004
25 - 29	50,866	53,803	56,916	60,219	63,728	67,466	70,709	74,136	77,754	81,562	85,562
30 - 34	47,031	47,531	48,069	48,619	49,184	49,769	52,604	55,611	58,802	62,188	65,792
35 - 39	38,840	40,162	41,531	42,946	44,411	45,930	46,429	46,939	47,462	47,999	48,556
40 - 44	36,725	36,888	37,059	37,241	37,437	37,647	38,919	40,230	41,586	42,989	44,443
45 - 49	30,044	31,024	32,013	33,033	34,084	35,172	35,323	35,482	35,652	35,834	36,032
50 - 54	27,075	27,342	27,576	27,815	28,057	28,037	29,209	30,138	31,097	32,085	33,107
55 - 59	21,694	22,262	22,815	23,406	24,034	24,709	24,920	25,135	25,353	25,576	25,804
60 - 64	18,471	18,614	18,692	18,770	18,850	18,928	19,375	19,852	20,361	20,904	21,486
65 - 69	11,985	12,586	13,150	13,749	14,381	15,053	15,118	15,184	15,251	15,318	15,386
70 - 74	7,815	8,075	8,279	8,497	8,723	8,962	9,361	9,784	10,231	10,706	11,209
75 -	7,510	7,805	8,024	8,295	8,621	9,003	9,218	9,469	9,755	10,076	10,435

Source: Department of Statistics

The age group under 15 years of age accounts for 41 percent of total population indicating lower rate as compared with 44 percent of whole West Malaysia while the working age group in the range from 15 to 54 years bracket accounts for higher rate of 51 percent as compared with about 46 percent of whole West Malaysia.

The accelerated population growth coupled by increased labour force is an impetus for development, but it requires corresponding social and economic improvement to accommodate them. The labour force in Penang State is considered to be 290,000 in 1975 with competitive priced labour, but unemployment rate is relatively high with about 6.9 percent of the labour force as indicated in Table A-7.

The labour force in Penang State is competitive in quantity and quality. About 60 percent of labour force have completed their lower secondary education and only a very small fraction is not educated. The wages rates vary depending on the qualifications and skills of labourers. The wage rates for top management range from M$2,000 to M$4,500 per month. The daily wages for unskilled workers range from M$3 to 5. For skilled workers the daily wage rates are ranged from M$8 to 10, averaging about M$250/month.

There is no published data of individual household income for the Project Area, which directly contributes to the revenue strategies in financial evaluation of the Project. The field sample survey is, therefore, performed in an attempt to estimate those incomes of households among potential consumers of the sewerage services, representing various levels of income status in the Project Area. The average household income including those of higher level management shows M$500 as indicated by Table A-9.

TABLE A-9 Monthly Income by Housing Type

Income M$/month	Number of Households by Housing Type							
	Total	A	B	C	D	E	F	G
Less than 201	12	11	1					
201 - 400	24	7	12	2	3			
401 - 600	16	1	5	4	6			
601 - 800	7			3	2			2
801 - 1000	6		3				2	1
1001 - 2000	3			1			1	1
more than 2000	2		1				1	
Total	70	19	22	10	11		4	4
Average	500	200	500	600	500		1300	900

Note: A -- Kampong house
B -- One-storied attached terrace house
C -- Two-storied attached terrace house
D -- Flat house
E -- Commercial house
F -- Semi-detached house
G -- Isolated house

4. National Development Plan

An essential component of each economic development order in Malaysia is based on the New Economic Policy (NEP) designed to achieve national unity through the two-pronged objectives of eradicating poverty irrespective of race and restructuring society to eliminate the imbalance between racial groups in participation in social functions.

(1) Second Malaysia Plan (1971-1975)

Under the NEP the Second Malaysia Plan (1971-1975) has been completed recently and favorable progress has been attained in respect of eradication of poverty, reduction of economic imbalances and overall economic development despite the uncertainties of the international economic situation. The manufacturing sector contributed significantly to enhance a rate of employment growth which was recorded at 3.3 percent annum. The agricultural development was also accelerated by various government efforts as land development, stabilization of rubber prices, encouragement of double cropping system, improvement of socio-economic condition of estates workers. The provision of housing and other social amenities to enhance the well-being or urban poor was also achieved under the Second Malaysia Plan. The government policy was also directed towards assisting the Malays and other indigenous people to participate fully in the growth of commerce and industry including training programme to upgrade their capabilities.

(2) Third Malaysia Plan (1976-1980)

The Third Malaysia Plan is a logical extension of the Second Malaysia Plan (SMP) and represents a continuation of all efforts previously made to implement the primary objectives of NEP. The forecasted expansion of world economic activity following the worldwide recession of 1974/75 encouraged the Government to permit an enlarged commitment to the task for this five year's plan with sufficient investible resources to be generated by inflows of foreign capital in addition to further boost to external earnings by export of petroleum products. The total investment target under the TMP is therefore sizable, amounting to M$44.2 billion in current prices which indicates the increase of 49.3 percent over the cumulative amount expended during the period of SMP.

The major enlarged tasks to be undertaken during TMP include.

i) to ensure equal opportunities for the poor to improve their income and quality of life

ii) to reduce economic imbalances between racial groups and regions

iii) to promote further utilization of countries human resources through education and training in the sciences, technology and business management

iv) to develop agriculture and industries for further increase of employment

v) to promote the balanced distributions of racial groups in various aspects of economy as employment, ownership of wealth.

vi) to reduce the urban poor by expanding employment opportunities in manufacturing and construction with provision of low-cost housing and other amenities.

vii) to safeguard the nation's security from antinational elements seeking subversive destructive actions, and

viii) to direct appropriate attention to safeguard the environment from any progress of degradation before it can not be dealt with low cost.

APPENDIX B

POPULATION AND LAND USE DISTRIBUTION

CHAPTER 1

THE POPULATION

1.1 Demographic Data Obtained

The basic source of information on population used in this study is the demographic data of the following four reports including those referred in them from National Census and other statistical data by the different government agencies:

i) Penang State Water Supply Project Report, 1965 - 2000 by Binnie & Partners Consultants Co., Ltd. for Public Works Dept. Penang, 1967.

ii) Penang Master Plan, 1969 - 1985 by Robert Nathan Associates Inc. for the Penang Master Plan Committee, 1970.

iii) WHO assignment Report, 1975 - 1995 by WHO, 1973.

iv) Population Projection for the State of Peninsular Malaysia, 1970 - 1980 by Dept. of Statistics, 1976.

(1) Penang State Water Supply Project, 1967

The data used in population projection in this study were obtained from 1957 Census and population projections for the period of 1957 - 1982 given by the Statistic Department. For the purpose of the study, the populations of the Penang Island and the Province Wellesley were estimated separately for the period from 1965 to 2000. Among the data referred above, this is the only report that estimated the population up to the year 2000, with the projection by the year 1970 to be between 839,200 (lower growth rate) and 889,600 (upper growth rate). However, according to the 1970 Census the population of Penang State was 776,124, which indicated that the population projection in this study should be considered as over estimates.

(2) Penang Master Plan, 1970

Source of the data for the population projection in this report was the 1957 Census and the population projection by the Statistic Department. In this report, the population of the Project Area, according to our analysis, was projected as 166,000, 250,000 and 385,000 for the years 1970, 1975 and 1985 respectively, with average growth rate of 5.5 percent. The demographic data in the report are very useful as they have separate estimates for Island Penang and Province Wellesley on different periods with delineation on Mukims, which gives us sound basis for detailed projection of population growth and its distribution.

(3) WHO Assignment Report, 1973

Study area of this Report is Butterworth and Bukit Mertajam Metropolitan Area, and estimated population in the year 1985 is that of Penang Master Plan, namely, 385,000, based on which the population in 1995 is projected as 545,000 with annual growth rate of 3.5 percent.

(4) Population Projection for the State of Peninsular Malaysia, 1976

In this projection the Statistic Department used the fertility and mortality of each five-year groups for future population estimation. The fertility and mortality used in this projection are medium scale in the Department's assumption scales. This population projection also includes the internal immigration between States in Peninsular Malaysia. However, since the projection was made at the State level, no detailed breakdown of the areas in the State is obtainable from this projection, which does not serve well for the purpose of our study.

1.2 The Population Estimates for the Project Area, 1970 and 1976

As the data referred above do not specifically indicate the population and its distribution according to the land use, either in terms of the Project Area or for the year 1976, the time of the present study, the undertaking was done to estimate these two factors. The 1970 Census which has the breakdown of all the Mukims in the State, was used as the basis of the estimate, out of which total of 27 Mukims were involved with the Project Area. The total population of these Mukims are 209,380 for the area of 28,891 ha, but some of the Mukims are only partially included in the Project Area. These are therefore identified accordingly in order to determine the total population of the Area, and its distribution in 1970, and is shown in Table B-1, which shows total population of 172,230 in the total Project Area of 11,600 ha.

Thus defining the population of the Project Area in 1970 to be 172,230 for the area of 11,600 ha, the projection for the year 1976 was then undertaken. As the average annual growth rate of 5.5 percent employed in case of Penang Master Plan during the period 1970 - 1985 is considered adequate and reasonable, this same rate was applied to the population of each of the 27 Mukims involved with the Project Area in order to obtain 1976 estimate, which is also indicated in Table B-1 and Figure B-1, showing the total population as 238,000.

1.3 The Population Projection up to 2000

Since the population for the years 1970 and 1976 was established for the Project Area as described in the preceding chapters, the population projection in the years 1980, 1985, 1990, 1995 and 2000 were undertaken. As stated earlier the average annual growth rate of 5.5 percent employed in the Penang Master Plan up to the year 1985 was considered reasonable, and therefore the same rate was applied for annual growth for the period of 1976 - 1985. From 1985 to 2000, 3.5 percent annual growth rate employed by WHO report up to the year 1995 was considered appropriate and was used. Table B-2 below shows the result of the projection stated above.

TABLE B-1 Population and Population Distribution for Mukim in 1970, with 1976 Projection

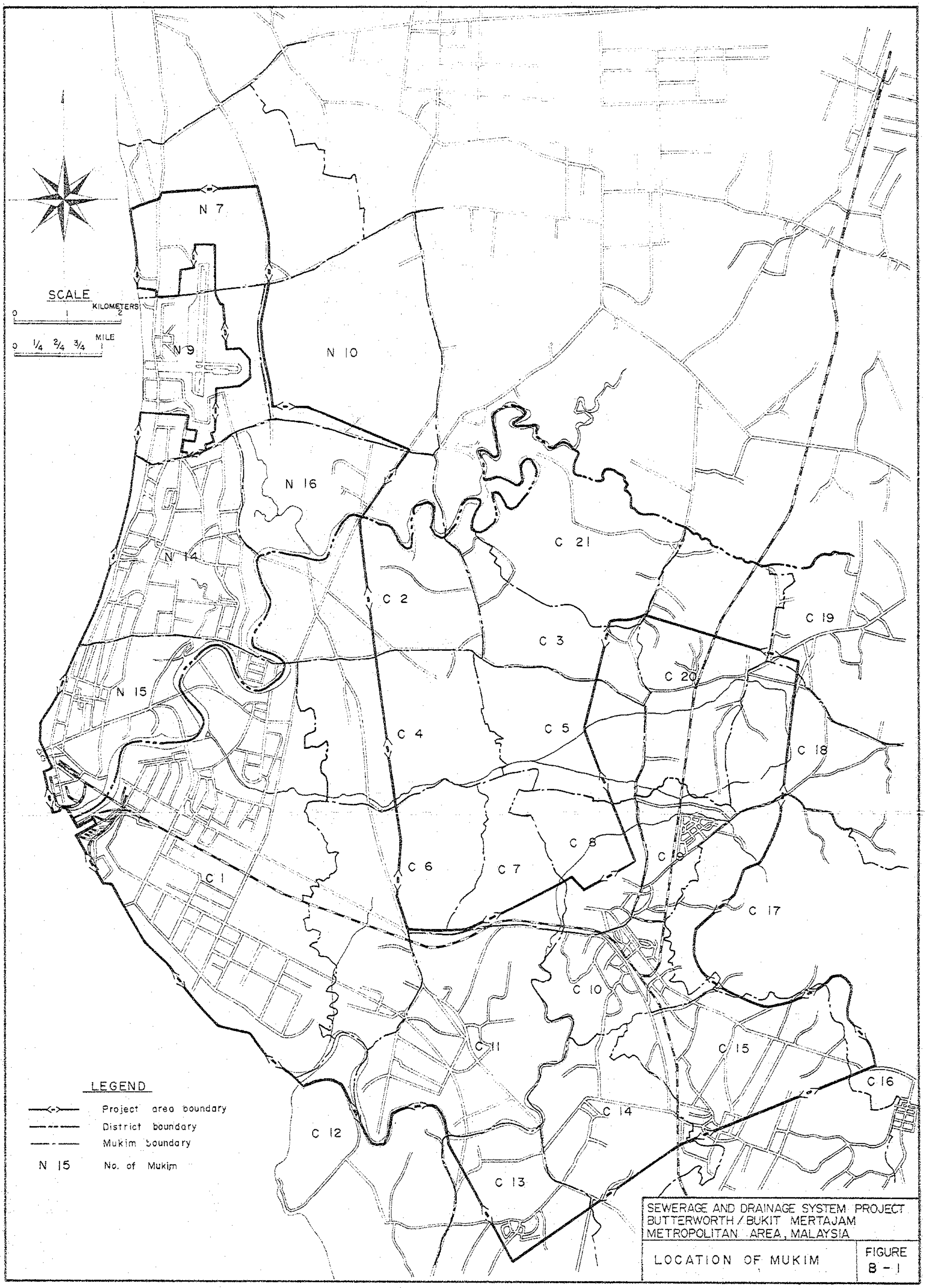
No. of Mukim	Mukim Total* Area (ha)	Mukim Total* 1970 Population	Mukim Total* 1970 Population Density (Persons/ha)	Project Area** Area (ha)	Project Area** 1970 Population	Project Area** 1976 Population	Project Area** 1976 Population Density (Persons/ha)
N 7	1,152	8,485	7.4	389	3,751	5,183	13.3
N 9	650	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	46.4	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
**: Calculated by Survey team

TABLE B-2 Future Population of the Project Area

Year	Population	Annual Growth Rate (%)
1970	172,230	
		5.5
1976	238,000	
		5.5
1980	294,400	
		5.5
1985	385,000	
		3.5
1990	458,000	
		3.5
1995	545,000	
		3.5
2000	648,000	

Figure B-1



SCALE
KILOMETERS
0 1 2
MILE
0 1/4 2/4 3/4 1
N 7
N 9
N 10
N 16
N 14
N 15
C 1
C 2
C 3
C 4
C 5
C 6
C 7
C 8
C 9
C 10
C 11
C 12
C 13
C 14
C 15
C 16
C 17
C 18
C 19
C 20
C 21
LEGEND
Project area boundary
District boundary
Mukim boundary
N 15 No. of Mukim
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
LOCATION OF MUKIM
FIGURE
B - 1

CHAPTER 2

LAND USE DISTRIBUTION

2.1 The Population Distribution according to Land Use, 1976

After the total population in the Project Area is properly estimated for the present and projected up to the year 2000, it was necessary to identify the state of distribution according to the condition of land use. The categories of land use employed for such purpose are defined as follows:

(1) Industrial Area

The areas where factories are established or to be established under control of the State Government for industrial activity.

(2) Social and Commercial Area

The area occupied mainly by social and public administrative buildings and stores and shops. Isolated public premises such as schools are not included in this category, but small industries and workshops, such as motor vehicles repairing workshops, are included.

(3) Residential Area

The housing areas which have relatively high population density. The difference between residential area and rural area is the difference in their population density. New housing schemes are included in this category.

(4) Rural Area

The areas where scattered houses are situated. The rural villages or "kampong" are included in this category.

(5) Agricultural Area

The areas consist of rice fields (paddy), coconut plantations, and rubber plantations.

(6) Others

Non-habitable open spaces, such as rivers, swamps, mountains, cemeteries, etc., are included in this category.

Table B-5, "Population and Land Use of Mukim in 1976" shows the state of distribution of total population of 238,000 according to the land use, on the basis of field surveys and technical assumption.

TABLE B-3 Population Density in 1976

Land Use	Population Density	
Social and Commercial area	0, 120 or 160	persons/ha
Residential area	80 - 160	"
Industrial area	0	"
Agricultural area	0	"
Others	0	"

2.2 The Population Distribution according to Land Use, 2000

On the basis of Table B-5 as stated in the preceding chapter, further assumption was made for the year 2000 with the assumed total population of 648,000, which is shown in Table B-6. Assumption is made in this table that rural and agricultural areas would be converted to the other categories of land use, mostly residential and industrial, by the year 2000, and therefore Mukims of residential areas are given higher increase of population distribution.

Low density residential area which has population density of 52 persons/ha in the following table, will be remainded as the mixed area of high density new developed residential and agricultural. However since it is difficult to define the boundary of being developed area at present, as the average population density 52 person/ha is used. Population density by land use in 2000 is as follows:

TABLE B-4 Population Density in 2000

Land Use	Population Density
Social and Commercial area	0, 120 or 160 persons/ha
Residential area (High density area)	120 or 160 "
" " (Low density area)	52 "
Industrial area	0 "

2.3 The Population Distribution for Sewerage Districts and Zones

For the purpose of developing Sewerage Master Plan, sewerage districts and zones are considered on the basis of geological, topographical, demographical and other factors, which are enumerated in details in Appendix G, "Sewerage System Consideration". An attempt was therefore made to identify the areas involved and to specify population concerned and its distribution in terms of land use. These are shown in Tables B-7, B-8 and B-9. These will be referred again in the study reports and in the Master Plan particularly in case of staging consideration of construction programme.

TABLE B-5 Population and Land Use of Mukim in 1976 (in the Project Area)

No. of Mukim	Area (ha)							Population Density (Persons/ha)			Population			
	Social & Commercial	Residen-tial	Indust-rial	Rural	Agricul-tural	Others	Total	Social & Commercial	Residen-tial	Rural	Social & Commercial	Residen-tial	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.

TABLE B-6 Population and Land Use of Mukim in 2000 (in the Project Area)

No. of Mukim	Area (ha)						Population Density (Persons/ha)			Population			
	Social & Commercial	Residential (High)	Residential (Low)	Industrial	Others	Total	Social & Commercial	Residential (High)	Residential (Low)	Social & Commercial	Residential (High)	Residential (Low)	Total
N 7		36	353			389		120	52.0		4,320	18,372	22,692
N 9			281			281			52.0			14,626	14,626
N10			47			47			52.0			2,446	2,446
N14	2	462	305	95*	21*	885	120	120	52.0	240	55,440	15,874	71,554
N15	16*	207					0	120		0	24,840		
	47	237		79*	59*	645	160	160		7,520	37,920		70,280
N16		74	430		19*	523		120	52.0		8,880	22,379	31,259
C 1	46*						0			0			
	35	508	297	1,024*	264*	2,174	120	120	52.0	4,200	60,960	15,457	80,617
C 2			368		52*	420			52.0			19,152	19,152
C 3			88			88			52.0			4,580	4,580
C 4	2*						0			0			
			352			354			52.0			18,320	18,320
C 5			187			187			52.0			9,732	9,732
C 6			659	91*	12*	762			52.0			34,298	34,298
C 7			54			54			52.0			2,810	2,810
C 8	1	86	106			193	120	120	52.0	120	10,320	5,517	15,957
C 9		57	213			270		120	52.0		6,840	11,086	17,926
C10	19	108	315		3*	445	120	120	52.0	2,280	12,960	16,394	31,634
C11		162	850		48*	1,060		120	52.0		19,440	44,239	63,679
C12			46		14*	60			52.0			2,394	2,394
C13		38	318		10*	366		120	52.0		4,560	16,550	21,110
C14			610		8*	618			52.0			31,747	31,747
C15		13	668			681		120	52.0		1,560	34,765	36,325
C16			5			5			52.0			260	260
C17			165		144*	309			52.0			8,587	8,587
C18			195		20*	215			52.0			10,149	10,149
C19			5			5			52.0			260	260
C20			485		72*	557			52.0			25,242	25,242
C21			7			7			52.0			364	364
Total	64* 104	1,988	7,409	1,289	746*	11,600	0 130.1	124.8	52.0	14,360	248,040	285,600	648,000

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

TABLE B-7 Correlation between Mukims and Sewerage Districts in the Metropolitan Area

(Unit: ha)

District	Butterworth						Seberang Jaya					Prai		Bukit Mertajam							
Zone	1	2	3	4	5	6	1	2	3	4	5	1	2	1	2	3	4	5	6	7	Total
N 7						389															389
N 9						281															281
N10					47																47
N14			435	450																	885
N15	390	200	55																		645
N16					523																523
C 1							480	360	119	76		1,139									2,174
C 2											420										420
C 3																				88	88
C 4										354											354
C 5																			55	132	187
C 6									391			91	280								762
C 7														10		44					54
C 8																153			40		193
C 9																53			217		270
C10																445					445
C11														870		190					1,060
C12														60							60
C13															366						366
C14															364		235	19			618
C15																32	235	414			681
C16																		5			5
C17																63		52	194		309
C18																			32	183	215
C19																				5	5
C20																			122	435	557
C21																				7	7
Total	390	200	490	450	570	670	480	360	510	430	420	1,230	280	940	730	980	470	490	660	850	11,600

TABLE B-8 Land Use and Population of Zone in 1976

Name of Sewerage Zone		Area (ha)							Population Density (Persons/ha)			Population			
		Social & Commercial	Residential	Industrial	Rural	Agricultural	Others	Total	Social & Commercial	Residential	Rural	Social & Commercial	Residential	Rural	Total
Butterworth	1	16* 47	190	67*			70*	390	0 160	160		0 7,520	30,400		37,920
"	2		33				167*	200		108.6			3,585		3,585
"	3	2	176	107*	119		86*	490	120	120	57.9	240	21,120	6,895	28,255
"	4		21		411		18*	450		120	57.9		2,520	23,812	26,332
"	5				231	75*	264*	570			17.1			3,961	3,961
"	6		18		316	336*		670		120	21.3		2,160	6,742	8,902
Seberang Jaya	1		157	2*	48	159*	114*	480		80	22.9		12,560	1,097	13,657
"	2			29*	3	229*	99*	360			23.0			69	69
"	3				155	300*	55*	510			19.3			2,991	2,991
"	4				143	264*	23*	430			52.6			7,518	7,518
"	5				138	115*	167*	420			31.7			4,369	4,369
Prai	1			639*	94	93*	404*	1,230			19.8			1,860	1,860
"	2				106	138*	36*	280			18.6			1,974	1,974
Bukit	1		16		299	450*	175*	940		80	21.0		1,280	6,279	7,559
Mertajam	2		38		144	509*	39*	730		80	23.2		3,040	3,347	6,387
"	3	20	209		376	87*	288*	980	120	119.2	48.5	2,400	24,920	18,220	45,540
"	4		9		193	248*	20*	470		80	27.8		720	5,357	6,077
"	5				235	224*	31*	490			30.9			7,257	7,257
"	6		46		208	319*	87*	660		120	40.0		5,520	8,320	13,840
"	7				265	503*	82*	850			37.5			9,947	9,947
Total		16* 69	913	844*	3,484	4,049*	2,225*	11,600	0 147.2	118.1	34.4	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.

TABLE B-9 Land Use and Population of Zone in 2000

Name of Sewerage Zone		Area (ha)						Population Density (Persons/ha)			Population			
		Social & Commer-cial	Residen-tial (High)	Residen-tial (Low)	Indus-trial	Others	Total	Social & Commer-cial	Residen-tial (High)	Residen-tial (Low)	Social & Commer-cial	Residen-tial (High)	Residen-tial (Low)	Total
Butterworth	1	16* 47	237		67*	23*	390	0 160	160		0 7,520	37,920		45,440
	2		182			18*	200		120			21,840		21,840
	3	2	275	73	107*	33*	490	120	120	52.0	240	33,000	3,799	37,039
	4		212	232		6*	450		120	52.0		25,440	12,074	37,514
	5		74	477		19*	570		120	52.0		8,880	24,825	33,705
	6		36	634			670		120	52.0		4,320	32,996	37,316
Sub-Total		16* 49	1,016	1,416	174*	99*	2,770				7,760	131,400	73,694	212,854
Seberang Jaya	1		354	82	2*	42*	480		120	52.0		42,480	4,268	46,748
	2	18* 35	154	48	50*	55*	360	0 120	120	52.0	4,200	18,480	2,498	25,178
	3			510			510			52.0			26,543	26,543
	4	30*		400			430			52.0			20,818	20,818
	5			368		52*	420			52.0			19,152	19,152
Sub-Total		48* 35	508	1,408	52*	149*	2,200				4,200	60,960	73,279	138,439
Prai	1				1,063*	167*	1,230							
	2			268		12*	280			52.0			13,948	13,948
Sub-Total		-	-	268	1,063*	179*	1,510				-	-	13,948	13,948
Bukit Mertajam	1		16	876		48*	940		120	52.0		1,920	45,592	47,512
	2		38	677		15*	730		120	52.0		4,560	35,234	39,794
	3	20	355	552		53*	980	120	120	52.0	2,400	42,600	28,729	73,729
	4		9	458		3*	470		120	52.0		1,080	23,837	24,917
	5			459		31*	490			52.0			23,889	23,889
	6		46	527		87*	660		120	52.0		5,520	27,428	32,948
	7			768		82*	850			52.0			39,970	39,970
Sub-Total		20	464	4,317	-	319*	5,120				2,400	55,680	224,679	282,759
T O T A L		64* 104	1,988	7,409	1,289*	746*	11,600				14,360	248,040	385,600	648,000

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

APPENDIX C

WATER SUPPLY SYSTEM

CHAPTER 1

EXISTING WATER SUPPLY SYSTEM

1.1 Water Agency

The water supply system of the State of Penang is operated by the Penang Water Authority (PWA), which was established on the 1st of January 1973, in accordance with the Penang Water Authority Enactment, 1972.

On the date of commencement, the former City Water Department of the City Council of George Town and the former Water Supply Section of the State Public Works Department were amalgamated into one Authority to supply a portable water supply to the State of Penang.

1.2 Water Service Area, Water Production and Use

The existing supplies in Province Wellesley is administratively divided into three zones - North, Central, South.

The data of the water service area, the water service population and the quantity of water supplied are shown in Tables C-1 and C-2. Monthly analysis of water consumption in Province Wellesley is shown in Table C-3.

TABLE C-1 Distribution Data in Province Wellesley

Item	1969	1970	1971	1972	1973	1974	1975
Area Served (ha)	27,213	27,516	27,658	27,956	28,184	28,434	
Population Served	232,470	238,170	244,010	249,990	263,180	273,470	
Water Supplied (cu m/day)	41,958	46,393	58,474	61,118	68,698	83,218	
Water Sold (cu m/day)	37,555	36,485	40,634	43,379	49,991	62,927	64,490
Unaccounted (percent)	10.5	21.4	30.5	29.0	27.2	24.4	
Consumption (l/day/cap)	162	153	167	174	190	230	

Data Source: PWA

TABLE C-2 Distribution Data by Water Supply Zone in Province Wellesley

	Item	1969	1970	1971	1972	1973	1974
NORTH	Area Served (ha)	12,290	12,380	12,414	12,473	12,590	12,717
	Population Served	125,510	128,590	131,740	134,970	141,200	145,880
	Water Supplied (cu m/day)	32,950	36,816	48,685	52,234	58,163	64,125
	Water Sold (cu m/day)	24,025	23,333	26,406	27,374	31,383	44,020
CENTRAL	Area Served (ha)	8,109	8,311	8,412	8,599	8,684	8,752
	Population Served	69,120	70,810	72,550	74,330	78,850	83,380
	Water Supplied (cu m/day)	4,112	4,855	4,350	4,441	4,443	4,615
	Water Sold (cu m/day)	8,767	8,837	9,423	10,624	12,435	12,078
SOUTH	Area Served (ha)	6,814	6,825	6,832	6,884	6,910	6,965
	Population Served	37,840	38,770	39,720	40,630	43,130	44,210
	Water Supplied (cu m/day)	4,896	4,722	5,440	4,443	6,092	4,478
	Water Sold (cu m/day)	4,763	4,315	4,805	5,381	6,173	6,829

TABLE C-3 Monthly Analyses of Water Consumption in Province Wellesley

Unit: 1,000 cu m/month

	1974			1975			1976		
	Domestic	Trade	Total	Domestic	Trade	Total	Domestic	Trade	Total
Jan.				1,190	591	1,781	1,333	920	2,253
Feb.				1,186	663	1,849	1,293	799	2,092
Mar.				1,124	615	1,739	1,224	768	1,992
Apr.				1,219	732	1,951	1,313	838	2,151
May				1,287	763	2,050	1,292	814	2,106
Jun.	1,165	479	1,644	1,206	750	1,956	1,266	841	2,107
Jul.	1,115	523	1,638	1,200	787	1,987	1,274	904	2,178
Aug.	1,136	504	1,640	1,256	883	2,139	1,289	925	2,214
Sept.	1,130	535	1,665	1,240	849	2,089	1,328	967	2,295
Oct.	1,122	572	1,694	1,292	874	2,166			
Nov.	1,108	610	1,718	1,138	865	2,003			
Dec.	1,097	610	1,707	1,149	844	1,993			
Total	7,873	3,833	11,706	14,487	9,216	23,703	11,612	7,776	19,388
Percent	67.3	32.7	100.0	61.1	38.9	100.0	59.9	40.1	100.0

Data Source: PWA

1.3 Outline of the Existing Water Supply Facilities

The existing supplies in Province Wellesley is divided into three zones - North, Central, South.

The north zone supplies rural areas in the north of Province Wellesley and the town of Butterworth. Water is derived from a lowland catchment area of about 12,950 hectare (32,000 acres) above an intake on the Sungai Kulim and flows along a channel to the Bukit Toh Allang treatment plant. The works and the existing mains to Butterworth and Bukit Mertajam have a capacity of 40,914 cu m/day (9 MIGD), but when the new scheme is brought into operation the pressure at Butterworth will be raised. The mains will then have sufficient capacity to supply peak demand corresponding to a yield of 30,913 cu m/day (6.8 MIGD). The excess output will be available for supply to Lunas and Kulim in State of Kedah.

The central zone supplies the town of Bukit Mertajam and Prai. The water is obtained from three small streams on the slope of Bukit Mertajam hill with a combined catchment area of about 243 hectare (600 acres). There is a storage reservoir on each stream, their combined capacity being 218,210 cu m (48 MIG) and reliable yield 4,546 cu m/day (1.0 MIGD). The sources can not be expanded and the water requirements for the zone are being supplemented from an 450 mm (18 in.) diameter pipeline from the Bukit Toh Allang treatment works in the north zone.

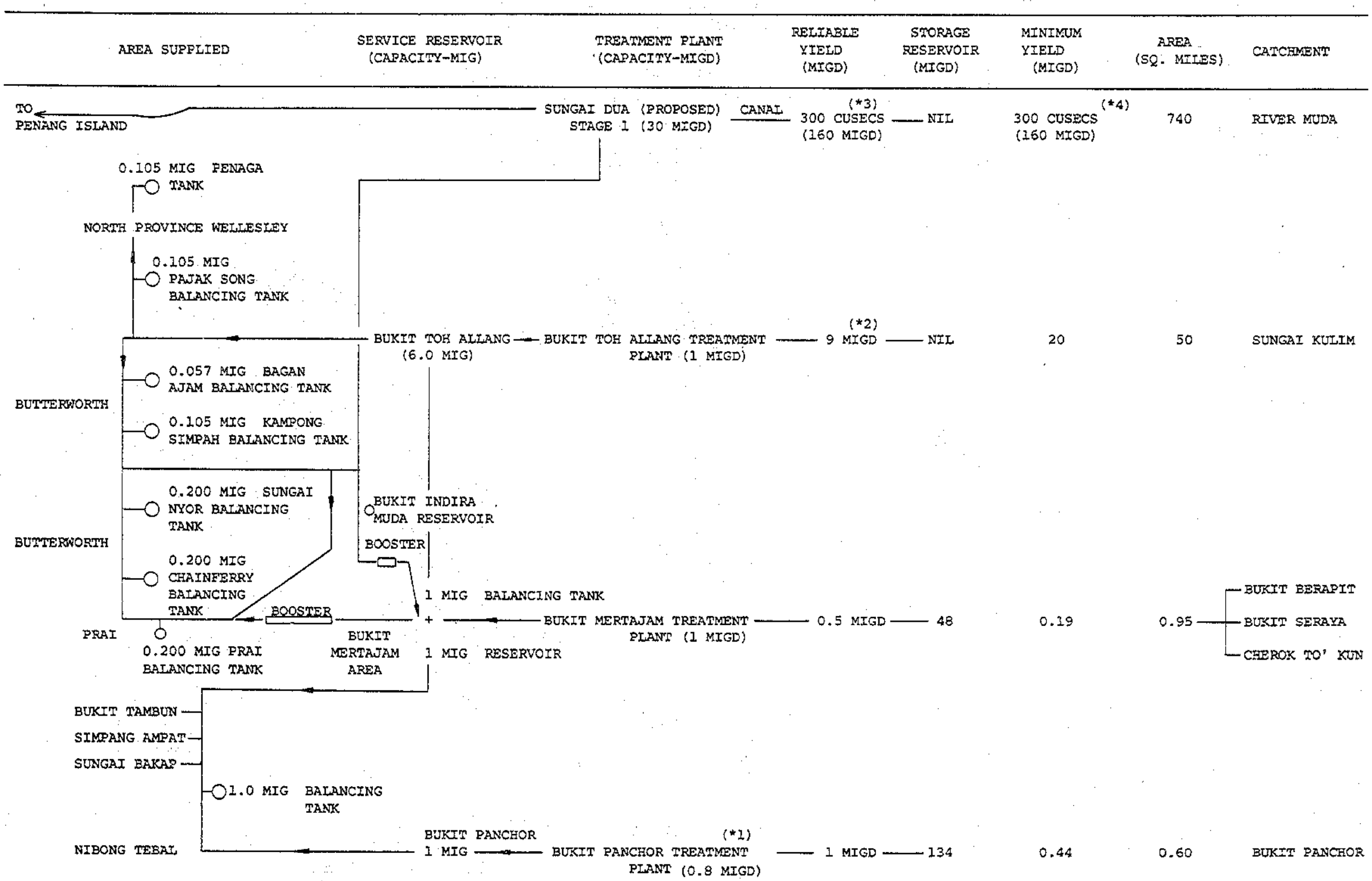
In the south zone the principal areas supplied are Nibong Tebal and Sungai Bakap. Water is obtained from a 609,164 cu m (134 MIG) capacity impounding reservoir and is treated in the 3,637 cu m (0.8 MIGD) treatment works at Bukit Panchor. The reliable yield of the reservoir is estimated to be 4,546 cu m/d (1.0 MIGD) and there are plants to modify the filters to increase the output of the works to this amount. In the meantime the supply is being supplemented by drawing water from the Bukit Toh Allang treatment works through Bukit Mertajam.

The Muda River Waterworks Project was completed partially and enabled extra water to be distributed into the water supply system through improvised measures at the work site.

The Muda River is the largest single source of water in the Penang State and flows into the sea about 19 km (12 miles) north of Butterworth. The river flows into the State from Kedah, and its northern bank forms the State boundary.

The outline of the existing water supply facilities described above is illustrated in Figure C-1.

FIGURE C-1 Existing and Proposed Water Supply System in Province Wellesley



(*1) TO BE INCREASED TO 1 MIGD

(*2) AFTER ABSTRACTION FOR IRRIGATION

(*3) WHEN TIDAL BARRAGE IS BUILT

(*4) 300 CUSECS-FLOW TO BE MAINTAINED BY IRRIGATION DAM IF NECESSARY.

CHAPTER 2

WATER SUPPLY PROJECT FOR THE PROJECT AREA

2.1 Outline of the Water Supply Projection

The report "Penang State Water Supply," prepared by Binnie & Partners (MALAYSIA), and submitted to the Government of Penang in September 1967, presents a long-term projection for water supply system of the State of Penang up to the year 2000. The PWA reviews the water demand curves for Province Wellesley and compares present figures and projections with the curves derived in Volume 1 Appendix 3 of Binnie's Report of 1967 in 1976.

The existing and proposed water supply system in Province Wellesley is shown in Figure C-1.

2.2 Water Requirements

In Province Wellesley the PWA operates installations with a combined yield of 50,000 cu m/day (11 MIGD). Existing mains will be able to distribute 40,000 cu m/day (8.8 MIGD) in the State leaving 10,000 cu m/day (2.2 MIGD) available for distribution to towns in Kedah if required. It is estimated that demand, including the requirements of industry, will have increased to 305,000 cu m/day (67.1 MIGD) in maximum by the year 2000 leaving a deficit of 264,000 cu m/day (58.1 MIGD).

Therefore, the River Muda Water Works should be capable of development in Province Wellesley to yield 264,000 cu m/day (58.1 MIGD) to meet the maximum predicted demand.

The further details of future water requirements referred in paragraph 2-1 is shown in Table C-4.

TABLE C-4 Water Requirements in Province Wellesley

	Year	Domestic							Industrial		Total	Maximum	Existing	River Muda
		Popula-tion-urban	Demand (l/d/c)	Quantity (cu m/d)	Popula-tion-rural	Demand (l/d/c)	Quantity (cu m/d)	Total (cu m/d)	Rate (l/d/c)	Quantity (cu m/d)	Quantity (cu m/d)	Quantity (cu m/d)	Quantity (cu m/d)	Quantity (cu m/d)
	1965	96,300	182	17,700	202,200	91	13,200	30,900	14	1,400	32,300	35,500	40,000	-
Upper growth limit	1975	151,000	200	30,000	258,900	100	25,900	(51,800) 55,900	23	(30,000) 3,600	(81,800) 59,500	(96,800) 65,000	40,000	(56,700) 25,000
	1980	189,100	209	39,500	292,900	105	30,500	(65,900) 70,000	27	(45,500) 5,000	(111,400) 75,000	(122,700) 81,800	40,000	(82,700) 41,800
	1990	296,400	223	65,900	374,900	114	42,700	(103,200) 108,500	41	(80,000) 12,300	(183,200) 120,800	(201,400) 131,800	40,000	(161,400) 91,800
	2000	464,800	227	105,500	479,800	123	54,500	(150,900) 160,000	45	(126,400) 20,900	(277,300) 180,900	(305,000) 196,800	40,000	(265,000) 156,800
Lower growth limit	1965	88,400	182	15,900	194,600	91	12,300	28,200	14	1,400	29,600			
	1975	124,800	200	25,000	237,200	100	23,600	48,600	18	2,300	50,900			
	1980	148,200	209	30,900	261,900	105	27,300	58,200	20	3,200	61,400			
	1990	209,000	223	46,400	319,200	114	36,400	82,800	25	5,000	87,800			
	2000	294,800	227	66,800	389,100	123	47,700	114,500	27	8,200	122,700			

Note: Maximum quantity includes 10 percent addition to average domestic consumption. ( ) is the figure reviewed by P W A in 1976.

Data Source: "Penang State Water Supply" by Binnie & Partners of 1967 and P W A study of 1976.

APPENDIX D

WATER POLLUTION STUDIES

1. General

The Project Area extends over the alluvial plain of the Prai river and the hill of Bukit Mertajam. A half of the area is located in the flat area of the former, and the rest is included in the Juru river basin which originates from the latter (see Figure D-1).

Both rivers are affected by tidal movements of sea water level, and wide swamps also exist in tidal area, some of which are being reclaimed for the purpose of developing the Project Area. The rivers receive waters of their tributaries and drains, which are discharging rain water, irrigation water, sewage, effluent of septic tank, and industrial wastewater.

Rainfall in the area is approximately 2,700 mm annual(*1), and its seasonal variation between rainy and dry seasons is small.

Temperature is very stable throughout the year in this State, with average of 26.8°C, and annual difference is within 9°C.

The Malacca Strait has strong tidal streams ranging from 26 to 100 cm/sec in daily maximum(*2). The tidal stream of the Penang Channel itself is also strong, and its annual maximum velocity is roughly estimated at 80 to 100 cm/sec.

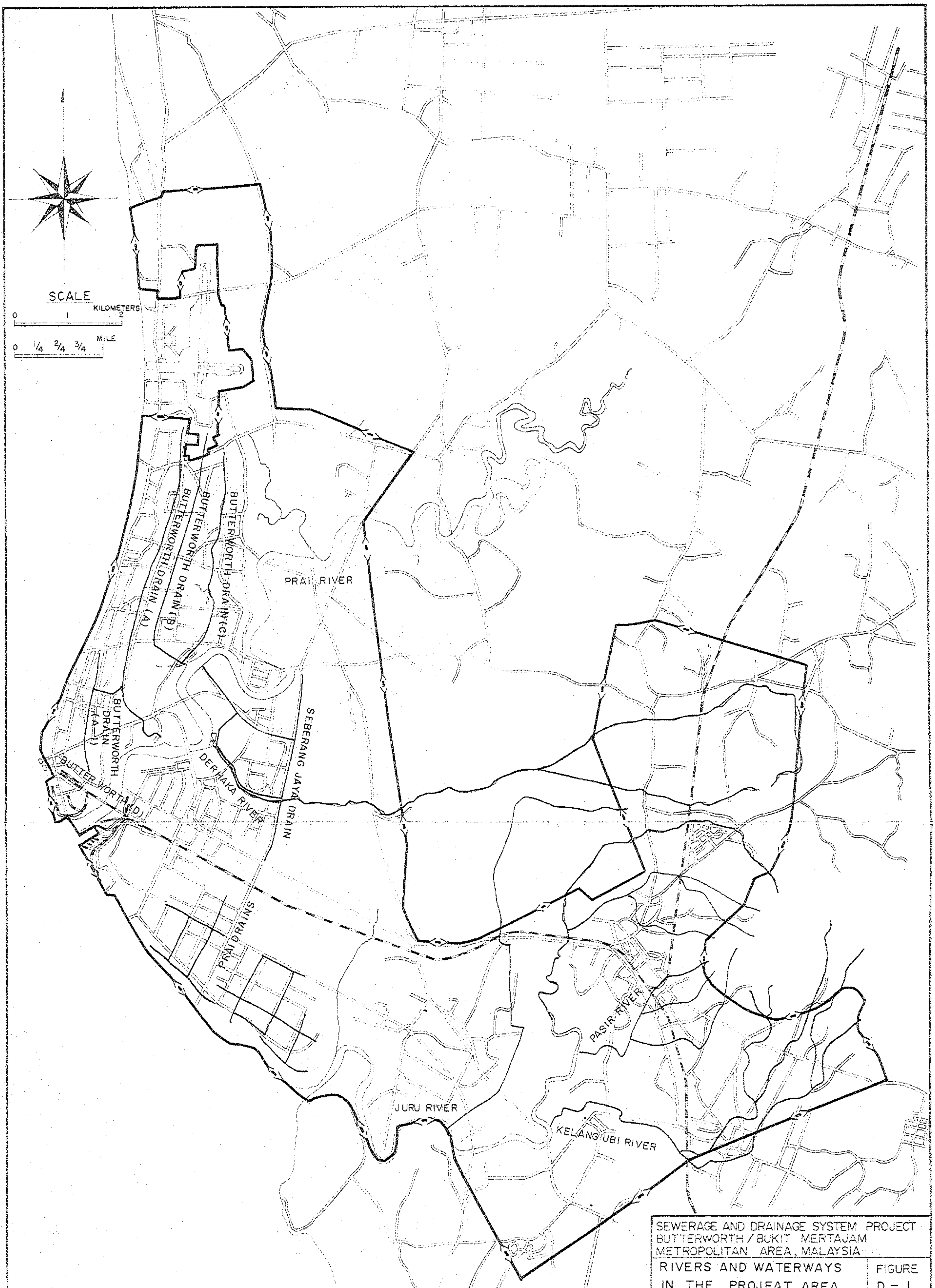
The mean tidal range is approximately 1.5 m at Penang Port(*3).

As the whole area of the Penang Channel is designated as a port area, fishing activity is negligible in the Channel. The Penang Port is one of the most important trading ports in Malaysia, and is under expansion and improvement of its facilities at George Town and Butterworth Wharves areas.

Although there is no particular recreational area along the Butterworth-Prai beach, the Butterworth beach is often used for bathing and fishing by the people living along the beach, and the areas along the Juru river-mouth and the airport are used for fishing by fixed nets. (see Figure D-1).

(*1) "Feasibility Report on Drainage and Reclamation of Sg. Prai Basin in Malaysia", JICA (1968)

(*2),(*3) "Tide Table", Habour Master. (1976)



SEWERAGE AND DRAINAGE SYSTEM PROJECT BUTTERWORTH / BUKIT MERTAJAM METROPOLITAN AREA, MALAYSIA	
RIVERS AND WATERWAYS IN THE PROJEAT AREA	FIGURE D - I

2. Survey on Rivers and Waterways

(1) Sampling and Analysis

Water quality of rivers and waterways in the Project Area were surveyed by the project team in December, 1976. Sampling points are shown in Figure D-2.

Most of the samples were collected at surface, and water temperature, pH, dissolved oxygen, and electric conductivity were measured at the site by portable "water quality checker". The samples collected from the Prai were analyzed on suspended solids, chemical oxygen demand, faecal coliforms, and chlorides at the laboratory.

The analytical methods used were as follows:

Permanganate Value (PV)	:	Oxygen absorbed from Acid Permanganate, 27°C 4 hours
SS	:	Glass Fiber Filter Method
Faecal Coliforms	:	Silver Nitrate Titration Method
Hydrogen Sulfide	:	Filter Colorimetry by Zink Acetate

These methods are based on "Standard Methods", 14th edition, 1975, APHA-AWWA-WPCF.

(2) Findings of the Survey

The results of water quality analyses are shown in Table D-1.

a. Water Temperature

As shown in Table D-1, water temperatures of rivers and drains vary according to their flow condition, higher in slack waters, lower in rapid streams.

The highest temperature of 34.4°C was recorded at the Butterworth A-1, (Ref. Figure D-2), during the survey on December, 1976. The hottest season of the State is from February to May, and the annual highest temperature of drains may be more than 37°C, and while the average water temperature of the Prai river was 28.4°C.

In general, water temperature of natural waters in the Project Area is suitable for bacterial activity to decompose organic load in all seasons.

b. Electric Conductivity

Electric conductivity, which is an indicator of tidal water penetration to the streams, indicates that, at flood tide, tidal water comes up to the point No. P-7, which is located at about 10 km of upstream from the river mouth. Further, tidal variation of water level is observed at the point No. P-10 which is located at more than 20 km upstream the river mouth. (Ref. Figure D-2).

Since the tidal gate has been constructed at the Tuan Abdul Rahaman Bridge near the sampling point No. J-2, tide water is stopped at the gate, so that electric conductivity of the upstream water from the point No. J-2 are low. (see Table D-1).

c. DO

The level of dissolved oxygen is shown in Figure D-3. Zero (less than 1 mg/l) DO concentrations are recorded in the drains of the Butterworth A-1, A, C, and D, the Derhaka river, and the Prai drains, and the tidal gate area of the Juru. This remarkable decrease of DO is due to organic loads included in domestic, industrial, and animal farm wastewaters. The colour of the lower stream of the drains is changed to blackish one, and black ooze is accumulated in the area referred above. This is the results of successional reactions, namely, organic loads, oxygen consumption, sulfate reduction, sulfide formation, and then ferous sulfide (black) accumulation. Additional formation of sulfide leads to bad smell, releasing hydrogen sulfide.

After wastewaters discharged into the rivers, the conditions are rapidly recovered by the flushing-out effects of tidal movements. However, tidal gate of the Juru is interfering the flushing-out of the upper streams, so that accumulation of the upper stream pollution of Juru is accelerated.

The water temperature of the Seberang Jaya drains, averaged about 30°C during the survey, gives a DO saturation value of 7.5 mg/l. The DO content of the waters at the sampling points S-1, 2, 3 and 11 were higher than the saturation value (see Table D-1). This is due to photosynthesis of aquatic plants in the slack waters of the drains, and due to scarce organic loads. If organic loads discharged into the slack waters, the DO content may be greatly decreased as in case of the points S-7 to 9. This is a shortcoming of slack water in the drains.

d. BOD and PV

According to the findings of the Juru river pollution survey, the BOD and PV values are comparatively low in spite of the heavily polluted waters at the upper tributaries from the tidal gate. This may be explained by tidal flushing. The same effect can be expected at the Prai river because of comparatively low PV contents although the data are very limited (Table D-1).

Figure D-2

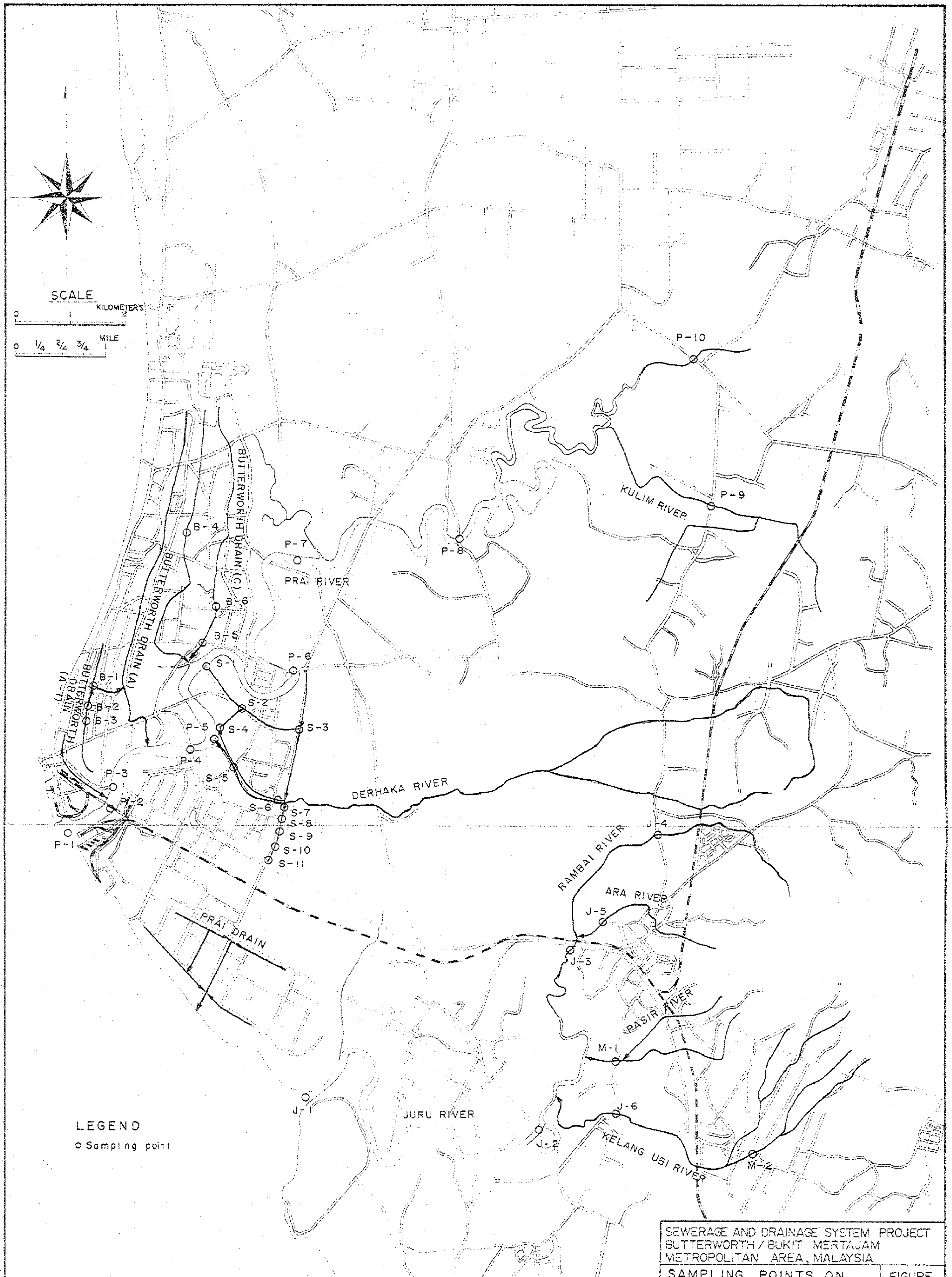

SCALE
KILOMETERS
0 1 2
MILE
0 1/4 2/4 3/4 1
P-10
P-9
KULIM RIVER
P-8
P-7
PRAI RIVER
P-6
B-4
B-6
B-5
BUTTERWORTH DRAIN (C)
BUTTERWORTH DRAIN (A)
BUTTERWORTH DRAIN (A-1)
B-1
B-2
B-3
S-1
S-2
S-3
S-4
S-5
S-6
S-7
S-8
S-9
S-10
S-11
P-5
P-4
P-3
P-2
P-1
DERHAKA RIVER
J-4
RAMBAI RIVER
ARA RIVER
J-5
J-3
PASIR RIVER
M-1
J-6
J-2
J-1
JURU RIVER
KELANG UBI RIVER
M-2
PRAI DRAIN
LEGEND
o Sampling point
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
SAMPLING POINTS ON
WATERWAYS SURVEY
FIGURE
D - 2

Figure D-3

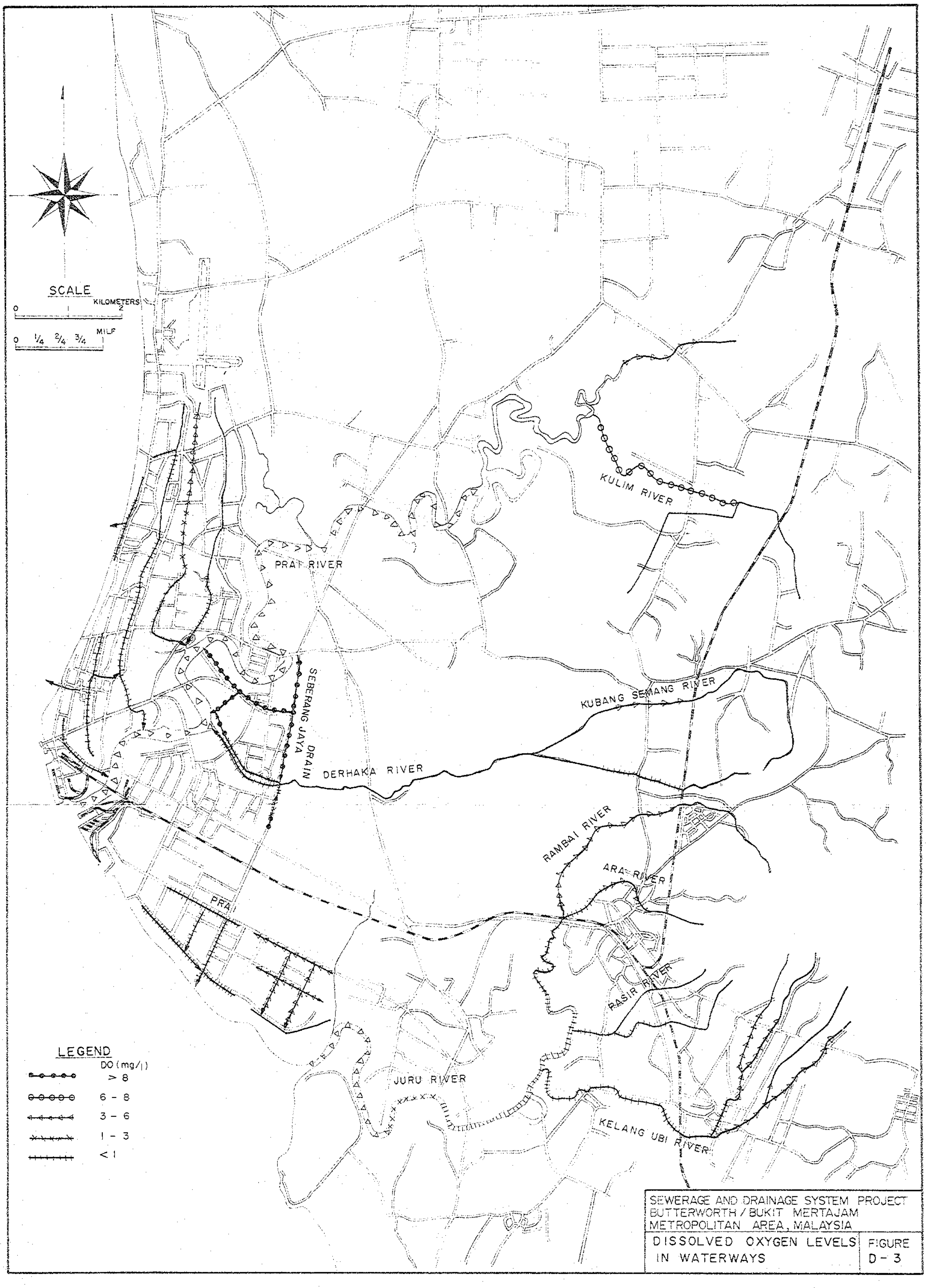

SCALE
KILOMETERS
0
1
2
MILE
0
1/4
2/4
3/4
KULIM RIVER
PRAI RIVER
SEBERANG JAYA DRAIN
KUBANG SEMANG RIVER
DERHAKA RIVER
RAMBAI RIVER
ARA RIVER
PRAI
PASIR RIVER
JURU RIVER
KELANG UBI RIVER
LEGEND
DO (mg/l)
> 8
6 - 8
3 - 6
1 - 3
< 1
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
DISSOLVED OXYGEN LEVELS
IN WATERWAYS
FIGURE
D - 3

TABLE D-1 Water Quality of Rivers and Drains in the Project Area

No. of Station	Date/Time	T °C	pH	EC m℧/cm	DO mg/l	PV mg/l	SS mg/l	Cl^- mg/l	Coli-forms N/ml
P-1*	16 Dec.13:00	28.6	7.3	32.5	5.2	3.4	15	9,500	-
P-1**	17 Dec. 7:45	27.1	7.0	41.9	6.0	1.8	8	14,700	-
P-2**	9 Dec.16:20	28.9	8.3	47.2	8.4	-	-	-	-
P-3*	3 Dec.14:20	32.2	6.0	41.3	5.3	8	303	12,190	138
P-4**	9 Dec.15:55	29.3	8.2	45.1	8.7	-	-	-	-
P-5**	4 Dec. 9:57	27.7	6.9	28.2	4.2	-	-	-	-
P-6**	4 Dec.10:10	27.7	6.7	22.6	3.9	3	15	7,160	561
P-6**	9 Dec.14:00	28.4	7.6	32.2	4.4	-	-	-	-
P-7**	9 Dec.15:00	29.2	7.7	27.1	5.2	-	-	-	-
P-8**	4 Dec.11:00	27.2	6.8	0.1	3.8	2	20	222	25
P-9**	4 Dec.11:40	25.8	7.2	0.4	7.5	1	21	9	110
P-10**	4 Dec.11:45	28.2	6.7	0.4	4.3	1	11	8	43
J-1*	5 Dec. 9:20	27.4	6.6	37.2	3.6	-	-	-	-
J-1**	17 Dec. 8:44	26.7	7.8	43.6	6.9	3.3	62	15,600	15
J-2*	5 Dec. 8:50	27.9	6.2	3.8	0.5	-	-	-	-
J-3**	5 Dec.12:30	28.4	6.5	0.1	0.9	-	-	-	-
J-4**	5 Dec.12:55	26.6	6.6	0.2	2.0	-	-	-	-
J-5**	5 Dec.11:35	30.1	5.8	0.5	0.3	-	-	-	-
J-6**	5 Dec.12:40	27.7	6.5	0.2	0.7	-	-	-	-

(to be continued)

Note: * low tide

** high tide

TABLE D-1 Water Quality of Rivers and Drains in the Project Area

(continued)

No. of Station	Date/Time	T	pH	EC	DO	PV	SS	Cl⁻	Coli-forms
		°C		m℧/cm	mg/l	mg/l	mg/l	mg/l	N/ml
B-1	7 Dec.14:30	33.4	5.8	0.6	0.9	-	-	-	-
B-2	7 Dec.14:45	34.4	6.6	0.6	0.7	-	-	-	-
B-3	7 Dec.15:00	33.4	6.7	0.6	0.7	-	-	-	-
B-4	14 Dec.18:30	28.8	7.0	0.5	1.1	-	-	-	-
B-5	3 Dec.15:00	31.3	6.2	4.8	0.1	-	-	-	-
B-6	3 Dec.15:10	33.7	6.2	0.5	0.5	-	-	-	-
S-1	3 Dec.15:50	30.7	6.4	8.1	11.5	-	-	-	-
S-2	3 Dec.15:45	30.7	6.4	2.6	12.9	-	-	-	-
S-3	3 Dec.14:40	31.8	6.6	0.2	11.7	-	-	-	-
S-4	3 Dec.15:58	28.5	6.6	0.2	0.2	-	-	-	-
S-5	3 Dec.16:10	28.2	6.2	0.7	0.5	-	-	-	-
S-6	3 Dec.16:15	31.4	6.1	0.1	0.5	-	-	-	-
S-7	3 Dec.16:40	30.5	7.8	0.6	0.9	-	-	-	-
S-8	3 Dec.16:35	27.7	7.8	0.1	2.3	-	-	-	-
S-9	3 Dec.16:30	32.0	7.9	0.4	0.7	-	-	-	-
S-10	3 Dec.16:32	32.3	7.9	0.3	1.8	-	-	-	-
S-11	3 Dec.16:25	33.5	8.5	0.6	21.9	-	-	-	-
M-1	5 Dec.11:40	28.4	6.5	0.3	0.7	-	-	-	-
M-2	5 Dec.10:00	24.7	7.3	0.3	2.3	-	-	-	-

-: not measured

3. Survey on Sea Water Quality

(1) Sampling and Analysis

Sea survey was carried out in December, 1976, along the east coast of the Penang Channel extending from the river mouth of the Prai to about 13 km south and north respectively (Ref. Figure D-4). The sea water samples were taken from the surface at 26 points as shown in Figure D-4, and analyzed for;

a. Water Temperature (T)
b. pH
c. Electric Conductivity (EC)
d. Dissolved Oxygen (DO)
e. Permanganate Value (PV)
f. Chloride (Cl^-)
g. Suspended Solids (SS)
h. Faecal Coliform (Coliform)

T, pH, EC and DO were tested by portable "Water Quality Checker" at the sites immediately after samples were taken. The other components were analyzed at the laboratory as soon as after they were brought there from the sites.

Analytical methods used were the same as those mentioned in Section 2, (1).

(2) Findings of the Survey

The results of water quality analyses are described in the following and also summarized in Table D-2.

a. Water Temperature

The surface water temperatures obtained during the survey were 26.5 to 28.6°C, which rose in the morning as the sun rises. The diurnal variation of the surface water temperature might be more than 2.5°C. This diurnal temperature variation and strong tidal currents accelerate vertical mixing of the sea water.

b. Electric Conductivity and Chloride

Electric conductivity and chloride are indices of penetration of fresh water into the sea. The distribution of electric conductivity (Figure D-5) shows the fresh water feather of the Prai river run-off at ebb tide. The low values at the sampling points 8, 13, 15, 16, 22, KP, and KJ, as shown in Table D-2, are attributable to the dilution of the sea water by the river waters.

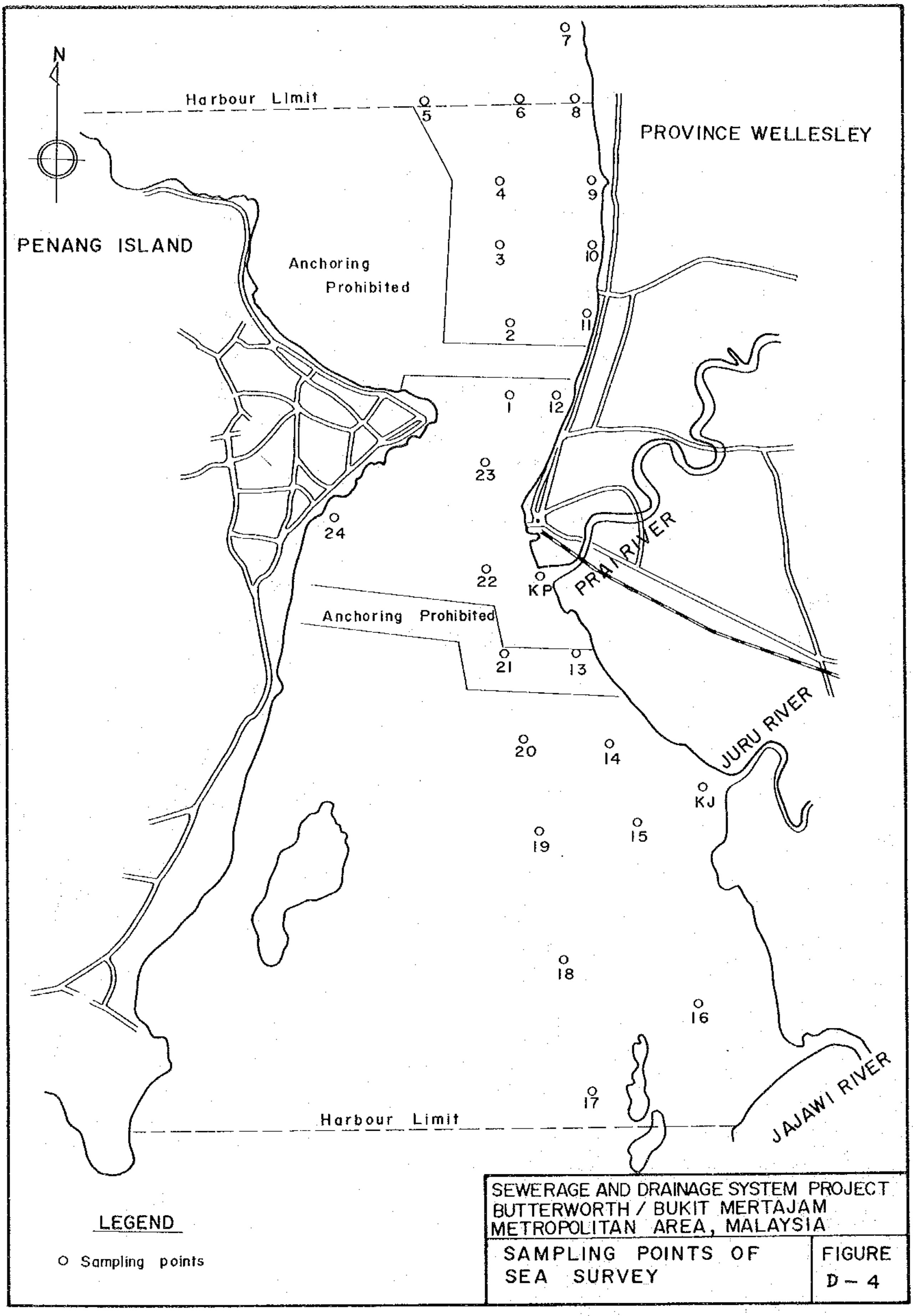
c. DO and PV

The values of DO and PV, as shown in Table D-2, indicate that the water of the Penang Channel has not yet been heavily polluted by organic pollutants, but, near the river mouths, the water qualities are slightly degraded.

d. Suspended Solids and Floating Matter

The results of analysis show that the concentration of SS is lower at the offshore than the near shore. This may be due to vertical mixing of shallow bottom material by strong tidal currents and waves. The sub-surface waters at the river mouths of the Prai and the Juru, have the higher SS concentration than the surface waters. This may also be due to turbulence of tidal movements.

Since the whole surveyed area is within the Penang Port Area, many floating matters were found, including plastics, wood fragments, and other floatables, which were disposed of from the ships, or discharged from rivers and drains from George Town, Butterworth, and other town areas. These floatables were found up to the sampling points 5, 18 and further along the current lines.



SEWERAGE AND DRAINAGE SYSTEM PROJECT BUTTERWORTH / BUKIT MERTAJAM METROPOLITAN AREA, MALAYSIA	
SAMPLING POINTS OF SEA SURVEY	FIGURE D – 4

TABLE D-2 The Results of Seawater Analysis (in the Penang Channel)

No. of Station	T	pH	EC	Chloride (Cl^-)	DO	PV	SS	Coli-forms
	°C		m℧/cm	o/oo	mg/l	mg/l	mg/l	N/ml
1	27.1	7.7	47.7	18.4	6.8	1.6	3	5
2	27.3	7.9	46.7	18.4	6.8	1.3	14	18
3	27.6	8.0	47.9	17.0	6.8	1.2	9	2
4	27.5	8.0	47.8	17.3	6.8	1.1	5	0
5	27.4	8.0	48.0	17.2	7.0	1.4	12	0
6	27.6	8.0	47.8	17.3	7.5	1.3	3	2
7	27.7	7.9	48.3	17.2	7.3	2.0	20	0
8	27.9	7.8	43.9	14.6	6.9	2.7	21	0
9	28.3	8.0	49.2	17.3	6.9	1.4	14	0
10	28.6	8.0	49.1	17.2	7.1	1.8	27	1
11	28.6	8.0	49.0	17.2	7.3	1.8	55	0
12	28.2	7.9	48.8	-	6.3	-	-	-
13	26.5	7.9	46.8	17.3	6.8	1.5	14	1
14	26.7	8.0	47.7	17.3	7.3	1.5	11	4
15	27.1	7.5	46.3	17.1	7.5	1.5	24	0
16	26.4	8.1	46.1	17.1	7.2	1.6	12	0
17	27.0	8.0	48.0	17.3	7.5	1.0	5	0
18	27.3	8.0	47.7	17.3	7.7	1.3	16	0
19	27.3	7.9	47.7	17.2	7.2	1.3	3	1
20	27.5	7.9	47.7	17.4	6.8	1.0	8	4
21	27.6	7.9	47.5	17.2	7.9	1.1	5	7
22	28.6	8.3	47.7	17.8	7.3	0.8	6	0
23	28.2	8.3	47.8	17.4	7.5	1.2	3	2
24	28.2	8.3	48.2	17.3	7.3	1.4	12	365

(to be continued)

TABLE D-2 The Results of Seawater Analyses (in the Penang Channel)

(continued)

No. of Station	T	pH	EC	Chloride (Cl^-)	DO	PV	SS	Coli-forms
	°C		m℧/cm	o/oo	mg/l	mg/l	mg/l	N/ml
KP	28.6	7.3	32.5	9.5	5.2	3.4	15	125
22	28.4	7.7	38.2	12.5	5.5	3.2	8	145
KP	27.1	7.0	41.9	14.7	6.0	1.8	8	20
KP*	26.2	7.5	43.1	17.0	6.8	2.4	114	305
KJ	26.7	7.8	43.6	15.6	6.9	3.3	19	15
KJ**	25.7	7.8	41.2	16.5	6.1	2.3	62	30

Note: (*) : 2.7 m deep, (**) : 5.0 m deep

T : Water Temperature, EC: Electric Conductivity,

DO: Dissolved Oxygen, PV: Oxygen Absorbed from Acid Manganate,

SS: Suspended Solids

The Surveys were carried out on 16th and 17th December, 1976.

All samples were collected at the surface except marked ones.

e. Coliforms

In spite of discharged wastewaters from George Town, Butterworth, and other town area, the concentration of coliforms was comparatively low in the sea water except near the river mouth of the Prai and at the outfall point of the sewage from George Town. The results of the coastal water survey on coliforms also show that the coliform contamination is only in the water near the sewer outfall as shown in Figure D-6.

Because the coastal area in Butterworth is used for bathing, the coliform contamination has to be alleviated to the level permissible for bathing and other recreational purposes.

The WHO criteria(*1) on faecal coliforms suggest a limit of 0.5 cells/ml is satisfactory for marine bathing water, and also consider that faecal coliform concentrations between 0.5 to 2 cells/ml as slightly polluted, 10 to 20 cells/ml as distinctively polluted, and more than 20 cells/ml as heavily polluted.

California standard (10 to 100 total cells/ml), while effective, seems to be too conservative, and that the Brazil standard of 100 total cells/ml may be realistic to use in developing countries, including Malaysia, with limited financial resources.(*2)

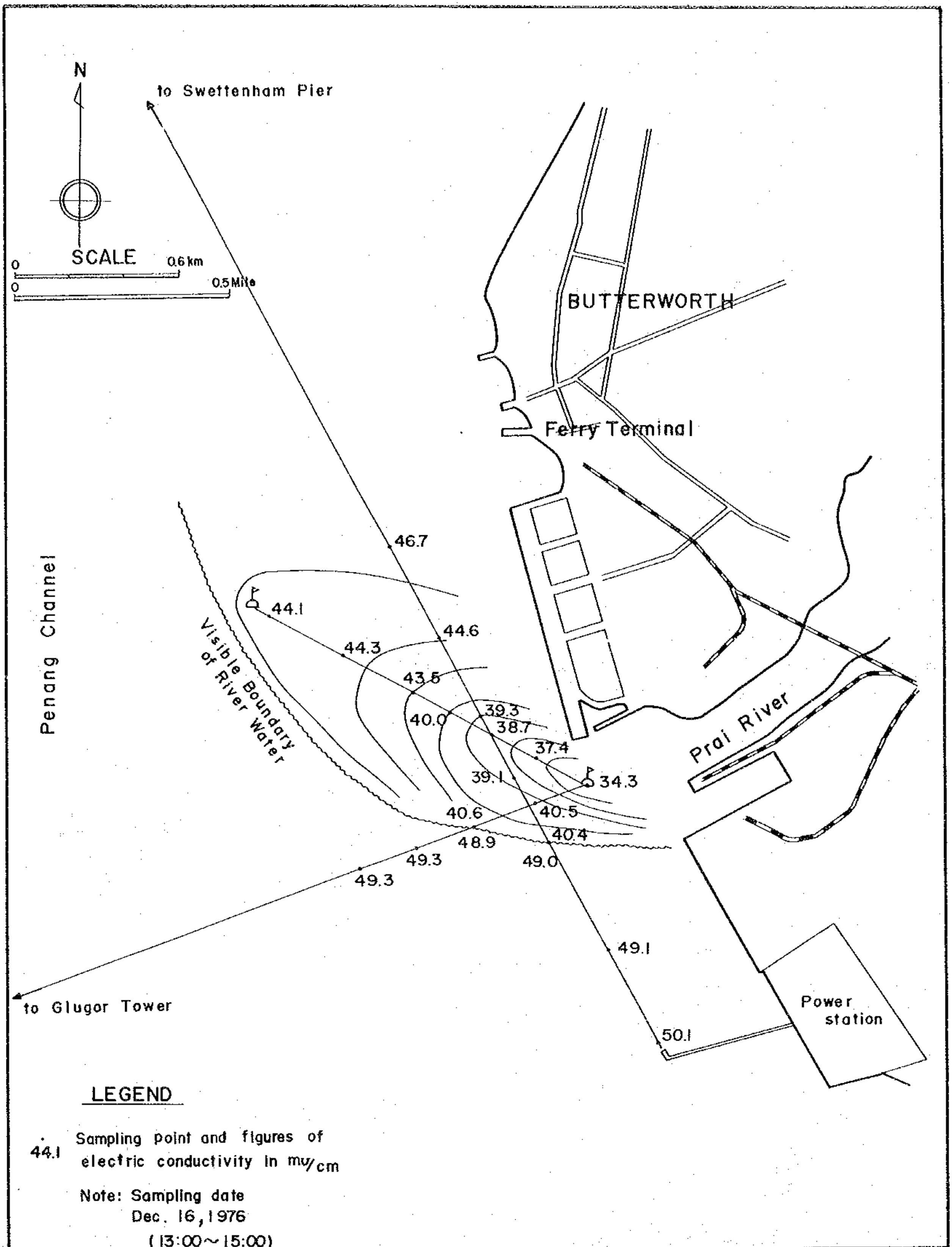
f. Miscellaneous

Plankton: Planktonic blooming often appears along the shore in the Penang Channel. Redish motile type plankton is dominant in the bloom, and gathers in the surface thin layer. The patch of the bloom are comparatively small, approximately 1 to 2 km long and 0.5 to 1 km wide, and the chlorophyll content, which is a good index of the standing crop of phytoplankton of the water, was not so high ranging at around 0.4 mg/cu m at the time of survey in December 1976.

Bottom Sediment: The bottom sediments of the Penang Channel were also observed at the same time when the water quality survey was carried out. The bottom sediment in front of the Prai Industrial Complex were silty mud, which might have been accumulated by the tidal currents for years. The silty mud is grayish, and does not include black organic ooze and/or coalblack mud, but has slight smell of hydrogen sulfide.

(*1) Document EVRO 3125/(1), 1974, by WHO working group.
(*2) "Criteria for Marine Waste Disposal in Southeast Asia", by H.F. Ludwig (1973)

The sediments of the river mouths of the Prai and the Juru were also grayish silty clay, and were not highly polluted although they receive coalblack waters and muds from their tributatries. This may be due to the effects of tidal washing out. The most part of the Butterworth beach is sandy.



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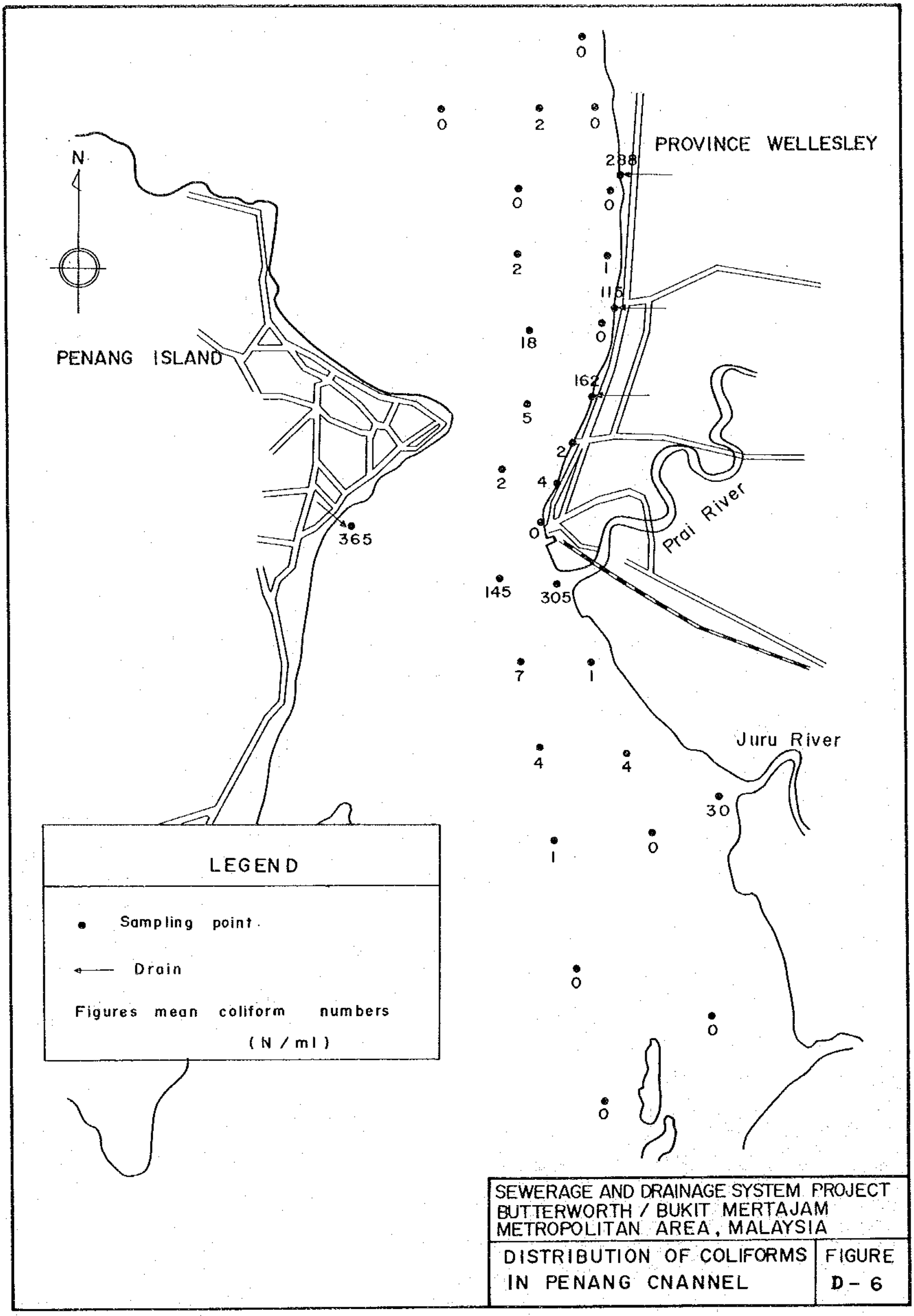
METROPOLITAN AREA, MALAYSIA

FRESH WATER RUNOFF FROM PRAI RIVER AT EBB TIDE

FIGURE D-5



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

DISTRIBUTION OF COLIFORMS IN PENANG CNANNEL	FIGURE D-6

APPENDIX E

DESIGN DATA

CHAPTER 1

SUMMARY

In this Chapter, the design bases necessary to design sanitary and storm water conduits have been studied, covering flow friction formulae, sizes of structures of facilities, hydraulics of sewers, materials of facilities, and measures needed for control of sulfides, and criteria have been developed for this Project as summarized below:

(1) The Manning formula should be used for design of pipes and channels.

(2) No public sanitary sewer shall be less than 225 mm (9 in.) in diameter.

(3) Earth covering of public sewers should not be less than one meter unless special protection measures against the expected load are provided.

(4) All sanitary sewers shall be so designed and constructed to give mean velocities, when flowing full or half-full, of not less than 60 cm/sec for VCP, based on the Manning formula with an 'n' value of 0.013. For RCP or any cement-bonded pipe materials, using an 'n' value of 0.013, the minimum flow velocity should be 75 cm/sec (2.5 ft/sec).

(5) For storm sewers the velocity of flow should be not less than 80 cm/sec (2.6 ft/sec).

(6) For sanitary sewers, full pipe capacity of the design peak flow rate should be provided.

(7) Minimum sewer slopes for different sewer pipe sizes are recommended, so that in no case, the velocity of flow will be less than 75 cm/sec for concrete pipe, and 60 cm/sec for VCP.

(8) Sewers should generally be laid with straight alignment between manholes. Exceptions should be allowed only when there is assurance that available cleaning methods will be workable in the curved section.

(9) When a smaller sewer joins a larger sewer, the crown of both sewers should be placed at the same elevation.

(10) Sanitary sewers of smaller size up to 300 mm (12 in.) in diameter should normally be of vitrified clay. For larger size sewers up to 1,800 mm (70 in.) in diameter, centrifugally-cast reinforced concrete pipes, conforming to internationally accepted standards, should be used.

(11) Joints of concrete pipe should be the rubber-gasket type, and factory

applied 'push-fit' resilient type joints should be used for vitrified clay pipes.

(12) Manhole spacing should not be more than 200 meters (656 ft).

CHAPTER 2

DESIGN FACTOR

In determing the required capacities of sanitary and storm sewers the following factors should be considered:

(1) Sanitary Sewers

a. Peak flow rate of domestic sewage

b. Additional maximum sewage or waste flow from industrial plants

c. Ground water infiltration

d. Depth of excavation

e. Location of treatment plant

f. Pumping requirements

g. Design velocities needed to assure self-cleansing and prevention of sulfide buildup

(2) Storm Sewers

a. Peak storm water runoff for the designed return period of rainfall

b. Topography of area

c. Condition of rivers

d. Pumping requirements

CHAPTER 3

FLOW FRICTION FORMULAE

For determining sewer capacities, a wide variety of equations have been developed. Among the equations widely used are:

a. The Chezy and Darcy-Weisbach equations

b. The Manning equation

c. The Kutter equation, and

d. The Hazen-Williams equation

The Kutter and the Manning equations are most widely used for pipes and conduits of all shapes, flowing either full or partly full. Although the use of the Kutter equation has been extensive and the graphs and tables for the equation are available, its popularity is declining because of its empirical and cumbersome nature. The Manning equation tends to be used very extensively, because of its simplicity and because the "n" value is essentially the same as used in Kutter's equation.

A comparison was made between the velocities of circular pipes calculated by means of three different equations namely; Kutter, Manning, and Hazen-Williams. The velocities for full flow in sewer pipes from 225 mm to 1,800 mm in diameter were calculated using a friction coefficient 'n' value of 0.013 for the Kutter and Manning equations, and a 'C' value of 110 for Hazen-Williams which corresponds to 'n' value of 0.013.

As shown in Table E-1, the results of the calculations indicate that the velocities given by the three equations are essentially the same, but with some minor variations. In smaller sewers the Kutter's equation gives the lowest values, but the values become practically the same as the sewer size increases, and the order is then reversed for the larger sewer pipes. It is not possible to judge the adaptability of the equations by such calculations; however, it is clear that Manning's equation gives intermediate values, hence appears to be the best choice for general application and has been adopted for use on this project.

TABLE E-1 Comparison of Flow Velocities in Pipes Calculated by Different Formula (meter/second)

Pipe dia. and slope (*)		Kutter (n=0.013)	Manning (n=0.013)	Hazen-Williams (C=110)
225 mm	0.0045	0.700	0.758	0.824
300	0.0035	0.770	0.809	0.862
375	0.0026	0.784	0.809	0.845
450	0.0022	0.825	0.841	0.866
525	0.0018	0.835	0.843	0.857
600	0.0016	0.866	0.869	0.874
675	0.0014	0.881	0.879	0.876
750	0.0013	0.914	0.909	0.899
900	0.0011	0.955	0.944	0.922
1,050	0.0009	0.960	0.946	0.912
1,200	0.0008	0.991	0.975	0.931
1,350	0.0007	1.004	0.987	0.932
1,500	0.0007	1.078	1.058	0.996
1,800	0.0007	1.218	1.195	1.118

Note: (*) Recommended minimum slopes for sanitary sewers

In view of these facts the Manning equation is recommended for the design of sewers and channels. The equation is expressed as;

$$V = \frac{1}{n} R^{2/3} S^{1/2}$$

where: n = coefficient of roughness

R = hydraulic radius, m

S = slope

Care must be taken in selecting the friction coefficient. In general, 'n' values from 0.013 to 0.015 are used in sewer design, depending upon the type of joint and the pipe material. Table E-2 is a summary of friction coefficients for different sewer materials for use with the Manning formula.

TABLE E-2 Values of 'n' to be used with the Manning Equation

Conduit Materials	Manning 'n' value
1) Closed Conduits	
Asbestos-cement pipe	0.010 - 0.015
Brick	0.013 - 0.017
Cast iron pipe	
Uncoated (new)	
Cement-lined and seal coated	0.011 - 0.015
Concrete (monolithic)	
Smooth forms	0.012 - 0.014
Rough forms	0.015 - 0.017
Concrete pipe	0.011 - 0.015
Plastic pipe (smooth)	0.011 - 0.015
Vitrified clay pipes	0.011 - 0.015
2) Open Channels	
Lined channels	
Brick	0.012 - 0.018
Concrete	0.011 - 0.020
Vegetal	0.030 - 0.040
Excavated or dredged	
Earth, straight and uniform	0.020 - 0.030
Earth, winding, fairly uniform	0.025 - 0.040
Rock	0.030 - 0.045
Unmaintained	0.050 - 0.140
Natural channels (minor streams, top width at flood stage 100 ft)	
Fairly regular section	0.030 - 0.070
Irregular section with pools	0.040 - 0.100

Data Source: WPCF Design Manual of Practice No. 9 (1970)

Factors which affect the choice of a coefficient are conduit material, Reynolds number, size and shape of conduit, and depth of flow. In addition to these interrelated factors the following should be considered:

(a) Rough, opened, or offset joints.

(b) Poor alignment and grade due to settlement or lateral soil movement.

(c) Deposits in sewers.

(d) Amount and size of solids being transported.

(e) Coatings of grease or other matter on interior of sewer.

(f) Tree roots, joint compounds, and mortar dams resulting from poor or deteriorated jointing and other protrusions.

(g) Flow from laterals disruption flow in the sewer.

The values are commonly used for sewer design and hence are higher than the values obtained in laboratory tests with clear water and clean conduits. The range in coefficient for a given pipe material is explained partially by the disturbing influences mentioned previously in the general discussion of coefficients.

It is recommended the Manning's 'n' of 0.013 be used for all proposed and future sewer and 0.015 be used for all existing sewers. Higher values of 'n' should be used for existing sewers if available data indicate deterioration, deposits, or inferior workmanship.

The 'n' value of 0.013 for both proposed and future sewers is based on the use of pipe units having not less than 1.5 m (5 ft) laying lengths, with true and smooth inside surfaces, and on the assumption that only first-class construction procedures will be followed.

CHAPTER 4

SEWER DESIGN AND CONSTRUCTION

4.1 Minimum Size of Sewer

The adoption of a minimum size of sewer is necessary, because experience has shown that comparatively large objects, such as scrub bushes, and also tree roots, sometimes get into sewers and that stoppage resulting from them as much less likely if sewers are not smaller than 225 mm (9 in.). Smaller pipes experience more frequent troubles in cleaning of settled debris, roots, etc., especially where slopes are flat.

Another factor determining the minimum size of pipe is construction cost, which may be greatly affected by topographical conditions. Where the ground surface slope in the area is flat, ranging between 0.1 and 0.3 meters per thousand meters, sewer must be deeper. Consequently, the construction cost will also be increased. For example, to keep the velocity of flow higher than 75 cm/sec in a 225 mm pipe, the slope must be 0.0045, but for a 150 mm pipe the slope would be 0.0076 for the same velocity of flow, and the difference of depth will be 3.1 meters per one km of sewer length. Hence, the construction cost for 150 mm (6 in.) pipes would hardly be cheaper than 225 mm (9 in.) pipes, because the increased cost of excavation will overcome the reduced cost to be gained by the use of smaller pipes. This deeper level of sewers not only increases the cost of excavation as the trenchs are wider and deeper for main and submain sewers, but also adds to the power cost as it involves lifting of the sewage from a greater depth. For these reasons, the minimum size of sanitary sewers for this project, except house connection, should be 225 mm (9 in.) in diameter.

For house connections, smaller sizes may be used; however, house connection pipes should be larger than the building sewers, so that articles which pass through the building sewers may readily pass through the building connection pipes. Experience shows that a diameter greater than 150 mm is usually satisfactory for house connection pipes, except for large buildings which have terminal pipes of more than 150 mm in diameter.

4.2 Minimum Depth of Sewer

Enough earth covering should be left between the top of the sewer and paved surfaces to protect the sewers from traffic loads and to avoid undue interference with other underground facilities. The minimum allowable cover may depend on the size of pipe, soil conditions, pavement and traffic loads.

The calculation indicates that for one meter of earth covering under a 20 ton truck load, pipes laid on continuous concrete cradle bedding will be capable of supporting the load. It was concluded that it is reasonable to use at least one meter of earth covering for sewer pipe in the Project Area.

Another factor to be considered in deciding the required earth covering for public sewer pipes, is the length and slope of private sewers to be connected. Where the private sewers are deep, it may be more economical to pump from the buildings than to lower the public sewers to such depths. Deeper house sewers may be caused either because of low ground elevation or because the houses are located far from the street.

An estimation was made for new developed housing area, to check the depth of private sewer pipes. At the representative house, with a plot of 30 meters of frontage and depth, assuming an average slope of pipe at 2 percent and minimum earth covering at the starting point of the sewer at 30 cm, the minimum earth covering of the public sewer would be one meter to receive the sewage from the house by gravity.

In view of the above mentioned results, it is recommended that the earth covering of public sewers be not less than one meter except for specific situations where studies show that shallower depths are feasible.

4.3 Velocity of Flow

(1) Minimum Velocity

Sewage should flow at all times, with sufficient velocity to prevent settlement of solid matter and consequent loss of sewer capacity. This is particularly important in the Project Area because of the flat slopes. The most significant factors to be considered are discussed below:

a. The commonly accepted minimum velocity for self-cleansing of sanitary sewers is 60 cm/sec. A velocity of 60 cm/sec can prevent most deposits of solids in sewers.

b. Ground surface slopes in the area, except in one part of Bukit Mertajam District, generally range between 0.01 and 0.03 percent. Sewer slopes are generally steeper than the ground surface slopes and sewers will become deeper, and costs for construction will be significantly increased if higher minimum velocities are used. A minimum slope for 225 mm (9 in.) sewer pipe to give a flow velocity of 60 cm/sec is 0.30 percent, based on an 'n' value of 0.013, but for 75 cm/sec, 0.45 percent is necessary. In case of a ground surface slope of 0.03 percent, the difference of construction cost between two different velocities may be M$40,000/km of pipe length.

c. An important consideration in selecting the design flow velocities for sanitary sewers in regions of hot climate, including tropical areas like Malaysia, is the problem of sulfide generation because of the high temperatures. This is especially important where concrete or other cement-bonded pipe is used as the sewer material, because unless controlled the sulfides will attack and dissolve the cement which binds the pipes material together, so that sooner or later the pipe may suffer structural failure. Experience with this problem in other countries has shown that the most effective method of sulfide control is to use a design velocity at average flow not less than 75 cm/sec, and preferably higher (Refer Annex). At velocities of 75 cm/sec or higher sulfide generation will be avoided in the sewer. For purposes of final design more precise methods should be used for evaluating the sulfide hazard (which is a function of BOD and temperature as well as flow velocity) on a case by case basis, but the general rule noted above should be sufficient for master planning. Another solution to the sulfide problem, where concrete or other corrodable materials are used, is to protect the pipe with suitable lining or coating.

d. For storm water, a higher velocity is preferable, because stormwater generally contains heavier solids such as larger sand, and soil for which a higher cleansing velocity is necessary. For open channels, a flatter slope may be allowed where necessary, because it is comparatively inexpensive to remove silt deposits from open channels.

In view of the above mentioned comments, the following criteria are recommended:

(a) All sanitary sewers shall be so designed and constructed to give mean velocities, when flowing full or half-full, of not less than 60 cm/sec for VCP, based on the Manning formula using an 'n' value of 0.013. For RCP or any cement-bonded pipe materials, using an 'n' value of 0.013, the minimum design flow velocity should be 75 cm/sec, and it found necessary suitable lining or coating for pipes should be used.

(b) In storm sewers, the velocity shall not be less than 80 cm/sec. For open channels, where ground surface slopes are comparatively flat, a velocity of 30 cm/sec may be allowed if removal of deposits is easy and inexpensive.

(2) Maximum Velocity

The maximum velocity should not exceed 3.0 m/sec, to protect sewer erosion. Where the ground surface slope is steep and velocities of more than 3.0 m/sec may result, special provision should be made to protect against displacement by erosion and shock.

4.4 Design Depth of Flow

Temperature in Penang State is relatively high with the average of around 27°C, accordingly the sewage temperature will also be high, hence fresh sewage tends to rapidly become anaerobic and to generate sulfides. As noted in the previous discussions, among the measures available for solving sulfide problems, it is believed the effective method for use in the Project Area is to use flow velocities to prevent sulfide buildup or to use suitable lining or coating pipes.

The field survey on sewage flow fluctuation in selected representative districts indicated (Ref. Appendix F) that peak flows usually occur at around 8:00 a.m. and 5:00 p.m., each lasting about one hour. The rest of the day, the sewage flow rate is less than the peak rate, therefore, if the sewer pipe is designed on the basis of 100 percent of the design peak flow, there will be some space above the water surface elevation in the pipe in most of the day.

Considering the above mentioned conditions, all circular pipes are recommended to be designed on the basis of full capacity.

4.5 Peak Flow Rate

Peak flow is the instantaneous maximum flow rate that can be expected in a sewer, which is generally obtained by multiplying factor to average flows. Small contributing populations give large factors while large populations give smaller factors.

For sewerage system in George Town, a formula to estimate the peaking factor for sewer was developed and used for years indicating good agreement with the local conditions. The formula is given by the expression;

$$M = \frac{5}{P^{1/7}}$$

where

M : peak to average ratio (peaking factor)

P : design population, thousand

In view of the fact that the condition in the Project Area is quite similar to those in George Town, it is recommended that the equation adopted to George Town be used for designing sewers in the Project Area.

Sewer design flow rate at any given point in the sewer can be calculated by the following formula:

$$Q = P' \times q \times M$$

where,

Q : sanitary sewer design flow rate, cu m/day

P': Population contributed

q : daily average flow rate, cu m/day/cap

M : the peak to average ratio (peaking factor), expressed by the formula;

$$M = \frac{5}{P^{1/7}}$$

This formula is shown in graphical form in Figure E-1.

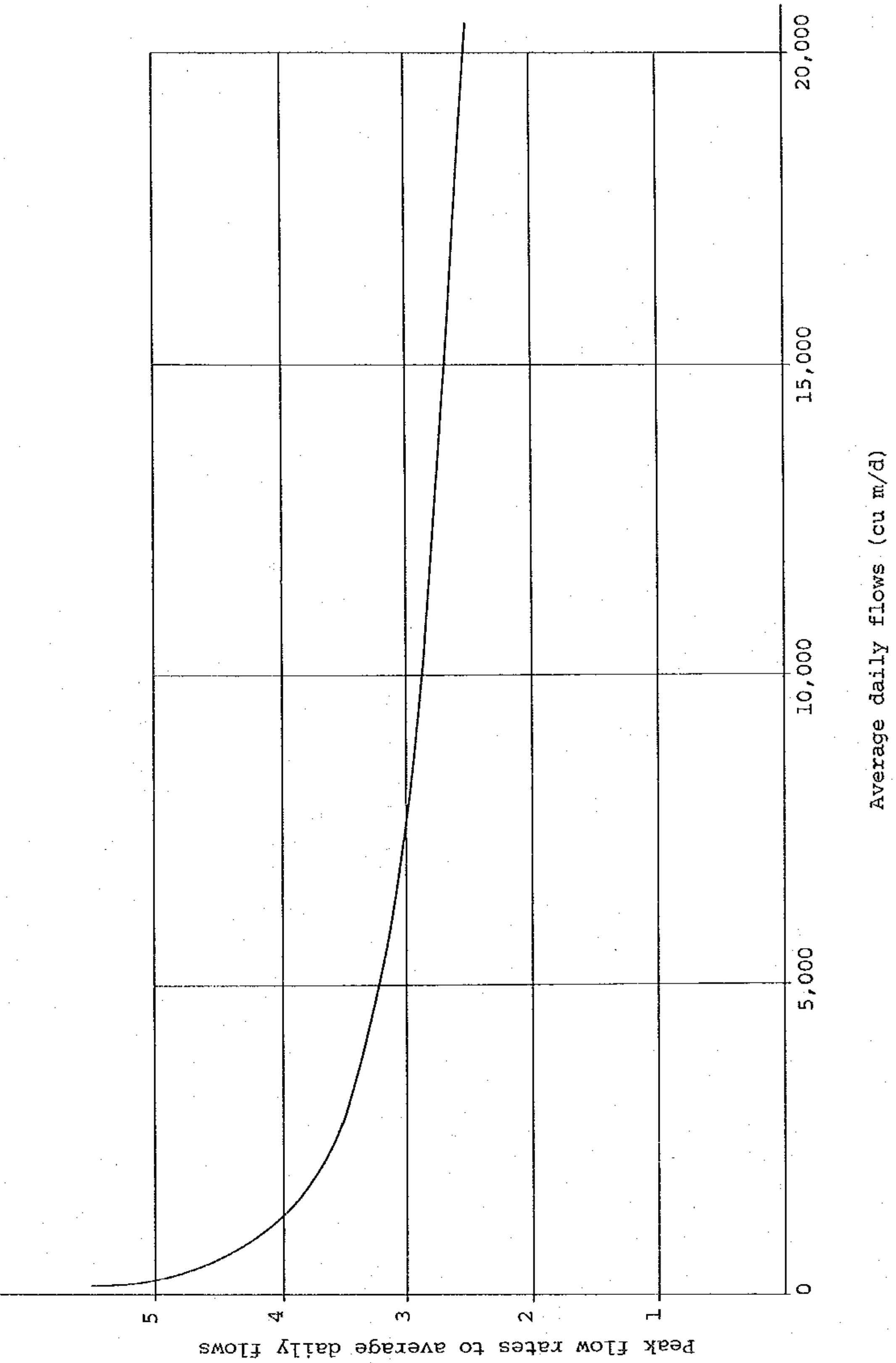


FIGURE E-1 Peak flow rates to average daily flows

4.6 Slope

Sewer sections and slopes should be designed so that the velocity of flow shall not be less than 60 cm/sec for clay pipes and 75 cm/sec for cement-bonded pipes. Each pipe section will be separately evaluated to determine the minimum design velocity necessary to control sulfide. Minimum slopes which should generally be provided for the different pipe materials are shown in Table E-3, however, slopes greater than these are desirable.

TABLE E-3 Minimum Slope for Sanitary Sewers

Sewer Size (mm dia)	Minimum Slope m/1,000 m		Velocity m/sec	
	VCP	RCP	VCP	RCP
225	3.0	4.5	0.619	0.758
300	2.2	3.5	0.642	0.809
375	1.7	2.6	0.655	0.809
450	1.4	2.2	0.671	0.841
525	1.2	1.8	0.688	0.843
600	1.1	1.6	0.720	0.869
675	1.0	1.4	0.743	0.879
750	0.9	1.3	0.756	0.909
900	0.8	1.1	0.805	0.944
1,050 and larger	0.7 or less	0.9 or less	0.834 and more	0.946 and more

Note: Manning formula using an 'n' value of 0.013.

4.7 Alignments

Sewers should generally be laid with straight alignment between manholes. Laying curved sewers should be avoided, unless the available sewer cleaning equipment can handle curvilinear alignments. Curvilinear alignments are acceptable only for large trunks where physical access inside the sewers is readily accomplished.

4.8 Increasing Size

When a smaller sewer joins a larger one, the invert of the larger sewer should be at a sufficiently lower elevation to maintain the same energy gradient. There are four methods which may be used:

(a) To place the crown of both sewers at the same elevation.

(b) To place the water surface of both sewers at the same elevation.

(c) To place the center of both sewers at the same elevation.

(d) To place the invert of both sewers at the same elevation.

For the hydraulical reason method (b) is the most desirable; however, it is impossible to construct both sewers at the same water surface elevation to meet hourly flow rate variation.

Since the sewer depth is the smallest by method (d), this will show the lowest construction cost, and method (c) will be the second lowest, although the difference will not be significant in the area of average topographic condition. It is therefore recommended to adopt method (a) which has hydraulic advantages and small extra cost.

4.9 Type and Material of Conduit

Sewer pipes are most commonly made of clay or of concrete. Asbestos-cement, and other materials are also suitable for sewer pipes, but may not be available locally at competitive price.

Pipes currently available in Malaysia are limited both in sizes and materials. The following pipes are produced and available on markets:

(a) Clay pipe up to 300 mm in diameter

(b) Centrifugally cast reinforced concrete pipe up to 1,800 mm in diameter.

(c) Asbestos-cement pipe up to 600 mm in diameter

(d) Pitch-fibre pipe 100 and 150 mm in diameter

For selection of sewer materials for the Project, careful considerations should be given to the problem of corrosion of pipes by sulfide buildup in sewers. Even though the sewer system should be designed and operated to be sulfide-free, such corrosion might not be completely prevented in all sewers. Preference should therefore be given to corrosion-resistant materials, such as vitrified clay pipe or lining or coating pipe.

The resistance of vitrified clay pipe to corrosion from acids, alkalies, and virtually all corrosive substances gives it a distinct advantage over other materials as well as excellent resistance to erosion and scour. Disadvantages of vitrified clay pipe are the limited range of sizes and strengths and the fact that it is more brittle than other pipe.

Centrifugally-cast reinforced-concrete pipe is available in the market in sizes up to 1,800 mm in Malaysia. The advantages of concrete pipe are the relative ease with which the required strength may be provided and wide range of sizes and laying lengths available. A disadvantage is that all cement-bonded pipes are subject to corrosion, hence a higher design flow velocities must be used to prevent sulfide corrosion problem. Higher velocities require more slope, hence greater excavation and pumping cost.

TABLE E-4 Price of Sewer Pipe
(M$/m in 1976)

Diameter (mm)	Pipe Material: Centrifugally Cast Reinforced Concrete	Pipe Material: Centrifugally Cast Reinforced Concrete with High Alumina Cement Mortar Lining of 1/2 in.	Pipe Material: Vitrified Clay
150	11.47	18.85	12.99
225	17.05	28.36	21.65
300	20.98	35.25	32.50
375	30.33	49.34	
450	35.25	57.87	
525	42.46	68.69	
600	47.57	76.88	
675	63.44	97.21	
750	70.82	107.70	
900	92.95	137.54	
1,050	122.95	174.75	
1,200	136.23	192.79	
1,350	179.84	246.07	
1,500	208.85	283.77	
1,800	281.47	369.67	

Note: exclusive of joint material

Pitch fibre pipes are also available in Malaysia in sizes 100 and 150 mm diameter. The pipes are generally of good quality and to meet internationally accepted standards.

In view of the above mentioned conditions, the following considerations should be taken into account in selecting sewer materials:

(a) Sanitary sewers of smaller sizes up to 300 mm in diameter should normally be virtrified clay pipes which are available locally at competitive price.

(b) Sanitary sewers of 375 mm or more in diameter should be of centrifugally-cast-reinforced-concrete pipes conforming to