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

VOLUME I

MASTER PLAN REPORT

APRIL 1977

JAPAN INTERNATIONAL COOPERATION AGENCY

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Forward

The present Report represents the work performed by Nihon Suido Consultants, Tokyo, Japan who has been retained for the purpose of establishing sewerage and drainage master plan for Butterworth and Bukit/ Mertajam Metropolitan Area, State of Penang, Malaysia, up to the year 2000.

In preparing the Report, approximately two calendar months were spent at the project site, during the months of November and December, 1976, for data collection and field surveys. Additional three months from January to March, 1977, were spent in Tokyo for review and evaluation of data collected and for formulation of the proposal on the master plan.

The Report is consisted of two volumes, namely, Volume I, Master Plan Report, including summary of the studies and Master Plan proposed for sewerage and drainage, and Volume II Appendices, with individual study reports on major items of work relevant for establishing proposed master plan.

ORDER OF PRESENTATION

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

1) LIST OF ABBREVIATIONS

ACP	-	Asbestos cement pipe
BBMA	-	Butterworth/Bukit Mertajam Metropolitan Area
BOD	-	Biochemical oxygen demand (5 day, 20 centigrade)
Ca	-	Calcium
Cl	-	Chlorides
CO_3	-	Carbonates
COD	-	Chemical oxygen demand
cu m	-	Cubic Metres
cu m/day	-	Cubic metres per day
cu m/cap/day	-	Cubic metres per capita per day
cu m/sec	-	Cubic metres per second
DID	-	Drainage and Irrigation Department
DO	-	Dissolved oxygen
DWF	-	Dry weather flow
ED	-	Engineering Department, Local Government of Penang Island
EPU	-	Economic Planning Unit, Prime Minister's Department Federal Government
Fe	-	Iron
g/cap	-	Grammes per capita
g/day	-	Grammes per day
ha	-	Hectares
HP	-	Hume pipe
Kg	-	Kilogrammes
Km	-	Kilometres
l/day	-	Litres per day
l/cap/day	-	Litres per second
LD	-	Labour Department, P.S.G.
m	-	Metres
mg/l	-	Milligrammes per litre
mm	-	Millimetres
MCPW	-	Municipal Council Province Wellesley
MHD	-	Medical and Health Department, P.S.G.

MPN	-	Most probable number
NSC	-	Nihon Suido Consultants Co., Ltd.
PDC	-	Penang Development Corporation
p/ha	-	Persons per hectare
PH	-	Hydrogen ion potential
ppm	-	Parts per million
PSG	-	Penang State Government
PVCP	-	Poly vinyl chloride pipe
PWA	-	Penang Water Authority
PWD	-	Public Works Department, P.S.G.
SEPU	-	State Economic Planning Unit, P.S.G.
sq m	-	Square metres
SS	-	Suspended solids
TCP	-	Town and Country Planning, P.S.G.
TOC	-	Total organic carbon
TOS	-	Total organic solids
TN	-	Total number
TS	-	Total solids
VCP	-	Vitrified clay pipe
WHO	-	World Health Organization
yr	-	Years

2) CONVERSION TABLES

TABLE - 1 Length (1)

m	cm	Yards	Feet	Inches
1	100	1.0936	3.2808	39.370
0.01	1	0.0109	0.0328	0.3927
0.9144	91.440	1	3	36
0.3048	30.480	0.3333	1	12
0.0254	2.540	0.0278	0.0833	1

TABLE - 2 Length (2)

km	Yards	Miles
1	1,093.61	0.62137
0.00091	1	-
1.60934	1,760	1

TABLE - 3 Area

ha	sq km	Acres	sq mile	sq m	sq ft
1	0.0100	2.471	0.00386	10,000	107.640
100	1	247.10	0.3861	-	-
0.4047	0.004047	1	0.00156	-	-
259	2.590	640	1	-	-
-	-	-	-	1	10.764
-	-	-	-	0.09290	1

1 sq ft = 144 sq in   1 sq in = 0.004946 sq ft

TABLE - 4 Volume

Litres	cu m	cu ft	Imp.gal.
1	0.001	0.03531	0.220
1,000	1	35.31	220
28.317	0.02832	1	

TABLE - 5 Weight

Kg	t	Ounces (OZ)	lb
1	0.001	35.27	2.2046
1,000	1	3.257×10^4	2,204.6
0.02835	2.835×10^{-5}	1	0.06250
0.4536	4.536×10^{-3}	16	1

TABLE 6 Velocity

m/sec	km/hr	ft/sec	mile/hr
1	3.600	3.2808	2.237
0.2778	1	0.9113	0.6214
0.3048	1.0973	1	0.6818
0.4470	1.6093	1.4667	1

TABLE - 7 Rate of Flow

l/sec	cu m/hr	cu m/sec	Imp.gal./min	cu ft/hr	cu ft/sec	Imp.MGD	cu m/day
1	3.6	0.001	13.198	127.13	0.03531	0.01901	86.4
0.2778	1	2.778×10^{-4}	3.666	35.31	9.810×10^{-3}	5.279×10^{-3}	24
1,000	3,600	1	1.3198×10^{4}	1.2713×10^{5}	35.31	19.01	86,400
0.07578	0.2728	7.577×10^{-5}	1	9.632	0.002676	1.440×10^{-3}	6.547
7.866×10^{-3}	0.02832	7.866×10^{-6}	0.10381	1	2.778×10^{-4}	1.495×10^{4}	0.6796
28.32	101.94	0.02832	373.7	3,600	1	0.5383	2,447
52.61	189.40	0.05261	694.3	6,688.3	1.858	1	4,546
0.01157	$4,167 \times 10^{-2}$	0.1157×10^{-4}	0.1528	1.471	4.087×10^{-4}	2.200×10^{-4}	1

3) GLOSSARY

(DEFINITIONS OF TERMS)

* Activated Sludge

Sludge floc produced in raw or settled wastewater by the growth of zoogleal bacteria and other organisms in the presence of dissolved oxygen and accumulated in sufficient concentration including return of floc previously formed.

* Activated Sludge Process

A process for achieving boilogical stabilization of sewage based on use of activated sludge generated under aerobic conditions maintained by included aeration in a reaction chamber, with the effluent subsequently settled and part of the sludge returned to the reaction chamber.

* Aeration

The bringing about of intimate contact between air and a liquid by one or more of the following methods: (a) spraying the liquid in the air, (b) bubbling air through the liquid, (c) agitating the liquid to promote surface absorption of air.

* Aerated Lagoon

A natural or artificial wastewater treatment pond in which mechanical or diffused-air aeration is used to supplement the oxyttgen supply.

* Aerobic

Requiring, or not destroyed by, the presence of free elemental oxygen.

* Aerobic Bacteria

Bacteria that require free elemental oxygen for their grwoth.

* Aerobic Digestion

Digestion of suspended organic matter by means of aeration.

* Amortization

The annual payments required to repay the principal amount of a loan in given number of years.

* Anaerobic Digestion

The degradation of organic matter brought about through the action of micro-organisms in the absence of elemental oxygen.

* Appurtenances

Auxiliary structures attached to a main structure to enable it to function, but not considered an integral part of it.

* Benefit-Cost Ratio

A theoretical economic concept, usually expressed by relating the present value of the stream of capital costs and annual expenses of the project.

* Biochemical Oxygen Demand (BOD)

Abbreviation for biochemical oxyenn demand. The quantity of oxygen used in the biochemical oxidation of organic matter in a specified time, at a specified temperature, and under specified conditions.

* Box Culvert

A culvert with a rectangular cross section.

* Branch Sewer

A sewer which receives wastewater from a relatively small area, and discharges into a main sewer serving more than one branch-sewer area.

* Coefficient

A numerical quantity, determined by experimental or analytical methods, interposed in a formula which express the relationship between two or more variables to include the effect of special conditions or to correct a theoretical relationship to one found by experiment or actual practice.

* Chlorination

The application of chlorine to water or wastewater, generally for the purpose of disinfection, but frequently for accomplishing other biological or chemical results.

* Coliforms

An important parameter for assessing the level of pollution in receiving waters, based on measuring the concentration of coliform bacteria, which is a rough index of the probable level of contamination by human excreta.

* Collecting System

A system of sewers and appurtenances for the collection, transportation, and pumping of sewage and industrial wastes.

* Cobined Sewer

A sewer receiving both surface runoff and sanitary and/or industrial wastewater.

* Concentration Time

The period of time required for storm runoff to flow from the most remote point of a catchment or drainage area to the outlet or point under consideration. It is not constant, but varies with depth of flow and condition of channel.

* Confluence

A junction or flowing together of streams; the place where streams

* Consumption Functions

A economics term expressing the patterns of expenditures of family incomes. Average amounts spent for each major category of service or material at each level of income are expressed as a percent of total family income. These patterns are usually further classified as to source of income or location, i.e. urban vs rural, working class vs. upper income levels, etc.

* Culvert

A closed conduit for the free passage of surface drainage water under a high-way, railroad, canal, or other embankment.

* Cumulative runoff

The total value of run-off over a specified period time. Successive summations are frequently plotted against time to produce a mass curve.

* Debt Service

The payments of interest and principal representing the annual costs of obtaining capital for the project.

* Demand Elasticity

A measure of the extent to which purchases of a given commodity or service are sensitive to price changes, expressed as a percentage change in quantities purchased resulting from a one percent change in the price of the item.

* Demographic Characteristics

The vital statistics of a population, such as births, deaths, marriages, rate of growth, age distribution, literacy and levels of education, skills and/or income.

* Depreciation

The amount which must be charged against profits each year in a series which will equal the original purchase price of a given asset at the end of its useful life expectancy.

* Discount Rate

The compound rate of interest which measures the difference between two values separated by one or more successive periods of time. The rate is applied to the ultimate value to determine the present value of the series at any prior point in time.

* Design Rainfall

he rainfall estimate corresponding to an enveloping depth - duration curve for the selected frequency, often referred to as the "Design Storm"/

* Discharge

As applied to a stream or conduit, the rate of flow, or volume of water flowing in the stream or conduit at a given place and within a given period of time.

* Dissolved Oxygen

The oxygen dissolved in water, wastewater, or other liquid, usually expressed in milligrams per liter, parts per million, or percent of saturation. Abbreviated - DO.

* Domestic Wastewater

Wastewater derived principally from dwellings, business buildings, institutions and the like. It may or may not contain ground water, surface water or storm water. Also called sanitary sewage

* Drainage Basin

An area from which surface runoff is carried away by a single drainage system. Also called catchment area, watershed, drainage area.

* Feasibility Study

A compilation of the economic benefits of a proposed project for comparison with engineering and other estimates of total costs to determine the relative merits of the project vis-a-vis other potential social investments.

* Financial Rate of Return

A pressure pipe joining the pump discharge at a water or wastewater pumping station with a point of gravity flow.

* Gradient

The rate of change of any characteristic per unit of length or scope. The terms is usually applied to such terms as elevation, velocity, pressure.

* Grease/Oils/Floatables

An important characteristic of wastewaters influencing design of treatment systems, which includes all grease, oils, and other materials tending to float under conditions of quiescence.

* Head

The height of the free surface of fluid above any point in a hydraulic system; a measure of the pressure or force exerted by the fluid.

* House Connection

The pipe carrying sewage from the building to a common sewer. Also called Building Sewer and House Sewer.

* Hydraulic Gradient

The slope of the hydraulic grade line; the rate of change of pressure head; the ratio of the loss in the sum of the pressure head and position head to the flow distance. For open channels, it is the slope of the water surface and is frequently considered barallel to the invert. For closed conduits under pressure, it is the slope of the line jointing the elevations to which water would rise in pipes freely vented and under atmospheric pressure. A positive slope is usually one which drops in the direction of flow.

* Industrial Wastes

The liquid wastes from industrial processes, as distinct from domistic or sanitary wastes.

* Infiltration

(1) The flow or movement of water through the iterstices or pores of a soil or other porous medium. (2) The quantity of groundwater that leaks into a pipe through joints, porous walls, or breaks. (3) The entrance of water from the ground into a gallery. (4) The absorption of liquid by the soil, either as it falls as precipitation or from a stream flowing over the surface.

* Infrastructure

The basic structures and facilities upon which the economic activities of a community or region are dependent, such as roads, railways, school systems, water and power supply and other public utilities. Sometimes referred to as Social Overhead Capital.

* Inlet

(1) A surface connection to a drain pipe. (2) A structure at the diversion end of a conduit. (3) The upstream end of any structure through which water may flow. (4) A form of connection between the surface of the ground and a drain or sewer for the admission of surface or storm water. (5) An intake.

* Intercepting Sewer

A sewer that receives dry-weather flow from a number of connecting sewers or outlets and, if in combined system, quantities of storm water, and conducts such waters to a point for treatment or disposal.

* Internal Rate of Return

An economic measurement expressed as the rate of interest which equates the present value of the stream of benefits of a project with the present value of the stream of project costs.

* Interpolation

The process of supplying intermediate terms in a series of values by mathematical calculation.

* Invert

The floor, bottom, or lowest portion of the internal cross section of a closed conduit. Used particularly with reference to aqueducts, sewers, tunnels, and drains. Originally, it referred to the inverted arch which was used to from the bottom of a masonry-lined sewer.

* Inverted Siphon (same as Depressed Sewer)

A section of a sewer constructed lower than adjacent sections, to pass beneath a watercourse or other obstruction. It runs at full or a greater than atmospheric pressure because its crown is depressed below the hydraulic grade line.

* Land Use

The culture of the land surface, which affects the social and economic conditions of a region and which determines the amount and character of the runoff and erosion. Existing or zoned economic use of land, such as residential, industrial, farm, commercial.

* Lift Station

A small wastewater pumping station that lifts the wastewater to a higher elevation when the continuance of the sewer at reasonable slope would involve excessove de°tjs pf tremcj. pr that raises wastewater from areas too low to drain into available sewers. These stations may be equipped with pnumatic ejectors, centrifugal pumps, or other pumps.

* Main Sewer

A sewer that receives many tributary branches and serves a large teritory. Also called Trunk Sewer.

* Manhole

An opening in a sewer provided for the purpose of permitting a man to enter or leave the sewer.

* Micro and Macro Drainage

Storm water systems are commonly considered as divided into local/ smaller conduit systems (micro-drainage), which discharge into larger conduits or systems(macro-drainage).

* Multiple Project

A capital investment project in which one or more of the assets acquired are used jointly to obtain two or more categories or economic benefits to the community.

* Municipality

The officials governing such a community as city, town, etc.

* Outfall Sewer

A sewer which receives the sewage from a collecting system and carries it to a point of final discharge. See Pipe Outle.

* Open Channel

Any natural or artificial waterway or conduit in which water flows with its surface exposed to the outside atmosphere.

* Outlet

Downstream opening or discharge end of pipe, culvert or canal.

* Overland Flow

The flow of water over the ground before it enters some defined channel.

* Oxdation Pond

A basin used for retention of wastewater before final disposal, in which biological oxydation of organic material is effected by natural or artificially accelerated transfer of oxygen to the water from air.

* pH

The reciprocal of the logarithm of the hydrogen-ion concentration in grams per liter of solution. Neutral water, for example, has a pH value of 7 and a hydrogen-ion concentration of 10^{-7}.

* Pipe Outlet

A pipeline which conveys the effluent from a reservoir, sewage treatment plant, or other structure to its point of discharge.

* Present Value

The economic method which recognizes and quantifies the values of differences in time. Benefits or costs which are expected to be received or incurred at a future date are worth less than those which can be enjoyed or must be paid currently. Present value at any point in time is determined by applying a given discount rate to the ultimate value for the appropriate number of years.

* Primary Treatment

(1) The first major (some times the only) treatment in a wastewater treatment works, usually sedimentation. (2) The removal of a substantial amount of suspended matter but little colloidal and no dissolved matter.

* Rainfall Intensity

Amount of rainfall occuring in a unit of time, converted to its equivalent in millimeters per hour at the same rate.

* Rainfall-Intensity Curve

A curve that expresses the relation on rate of rainfall and their duration. Each curve is generally for a period of years during which time the intensities shown will not, on the average, be exceeded more than once.

* Rational Method

A method of estimating the runoff in a drainage basin at a specific point and time by means of the rational runoff formula. For each drainage area, the rainfall rate under a stated intensity-duration relationship, the fraction that will appear as runoff, and the basin area above the specific point are estimated. Their products is the flow. This method is used to estimate storm runoff in urban areas and flood flows in streams.

* Regression Analysis

A statistical technique used to quantify the relationship of related variables. A simple regression equation mathematically states the probable effect on a dependent variable of a given change in an independent variable. A multiple regression analysis classifies and quantifies the relationship of a single dependent variable to two or more independent variables. If a causes and effect relationship exist among the variables, it is possible by further statistical analysis to determine what proportion of an observed change in the dependent variable could have occured by chance and what proportion of the change may have been caused by the change in each of the independent variables.

* Roughness Coefficient

A factor in the Chezy, Darcy-Weisbach, Hazen-Williams, Kutter, Manning, and other formulas for computing the average velocity of flow of water in the conduit or channel, which represent the effect of roughness of the confining material on the energy losses in the flowing water.

* Runoff

(1) That portion of the earth's available water supply that is transmitted through natural surface channels. (2) That part of the precipitation which runs off the surface of a drainage area and reaches a stream or other body of water or a drain or sewer.

* Runoff Coefficient

The ratio of the maximum rate of the runoff to the uniform rate of rainfall with a duration equaling or exceeding the time of concentration which produced this rate of runoff.

* Sanitary Sewer

A sewer which carries liquid and water-carried wastes from sanitary conveniences of residences, commercial buildings, industrial plants, and institutions, together with quantities of ground, storm and surface water which are not admitted intentionally.

* Sanitary Wastewater

(1) Domestic wastewater with storm and surface water excluded. (2) Wastewater discharging from the sanitary conveniences of dwellings (including apartment houses and hotels), office buildings, industrial plants, or institutions. (3) The water supply of a community after it has been used and discharge into a sewer. Also called sanitary sewage.

* Sea-Level Datum

A determination of Mean Sea Level that has been adopted as a standard detum for elevations. The sea level is subject to some variations from year to year but, as the permanency of any datum, is of prime importance in engineering work. After adoption of a sea-level datum it should, in general, be maintained indenfinitely even though differing slightly from later determinations of Mean Sea Level based on longer series of observations.

* Secondary Treatment

The treatment of wastewater by biological or chemical methods after primary treatment by sedimentation.

* Separable Costs-Remaining Benefits

A method of allocating the cost of jointly used assets in a multiple purpose project among the categories of benefits obtained for the purpose of calculating the benefit-cost ratio for each increment of capital expense.

* Separate System

A system of sewers and drains in which sanitary wastewater and storm water are carried in separate conduits.

* Septic Tank

A settling tank in which settled sludge is in immediate contact with the wastewater flowing through the tank and the organic solids are decomposed by anaerobic bacterial action.

* Settleable Solids

(1) That matter in wastewater which will not stay in suspension during a preselected settling period, such as an hour, but settles to the bottom. (2) In the Imhoff cone test, the volume of matter that settles to the bottom of the cone in one hour.

* Sewage

The spent water of a community. Term now being replaced in technical usage by the preferable term wastewater.

* Sewage Works

All-inclusive term for wastewater collection, pumping, treatment, and disposal facilities. Term declining in use.

* Sewer

A pipe or conduit that carries wastewater or storm water drainage.

* Sewerage

System of piping, with appurtenances, for collecting and conveying wastewater from source to discharge. Term declining in use.

* Stabilization Lagoon

A shallow pond for storage of wastewater before discharge. Such lagoons may serve only to detain and equalized wastewater composition before regulated discharge to a stream, but often they are used for biological oxidation.

* Stabilization pond

A type of oxidation pond in which biological oxidation of organic matter is effected by natural or artificially accelerated transfer of oxygen to the water from air.

* Storm Sewer

A sewer that carries storm water and surface water, street wash and other wash waters, or drainage but excludes domestic wastewater and industrial wastes. Also called storm drain.

* Storm Water

The excess water running off from the surface of a drainage area during or immediately after a period of rain. It is that portion of the rainfall and resulting surface flow that is excess of that which can be absorbed through the infiltration capacity of the surface of the area.

* Storm-water System

System of drains and appurtenances for conveying the runoff from street surfaces.

* Sub-main Sewer

A arbitary term used for relatively large branch sewers.

* Submarine Outfall

An outfall extending from shore to a considerable distance into marine receiving waters, used for final disposal of works.

* Submerged Outlet

An outlet entirely covered by water.

* Term

The period of time stated in the loan contract by the end of which the loan must be fully repaid.

* Tidal River

A river in which flow and water surface elevation are affected by the tides. Such effect usually occurs in the lower stretch near the mouth, where the gradient is very flat. In some streams, the effect may extend a hundred or more kilometers upstream from the mouth.

* Time Lag

(1) referring to discharge or water level, the time elapsing between the occurrence of corresponding changes in discharge or water level at two points in a river. (2) Referring to runoff of rainfall, the time between the center of mass, or beginning, or rainfall to the peak, or center of mass, of runoff.

* Useful Life Expectancy

The period of time during which a piece of equipment a building or other physical asset is expected to render the service or perform the function for which it is intended, at an acceptable level of efficiency, with ordinary maintenance and under operating conditions expected in the given situation. Technical and financial planning assumes that the asset will have to be replaced at the end of its expected useful life.

* Wastewater Solids
(Sewage Solids)

The solid content of sewage consists of those in the settleable, suspended and dissolved usually expressed as total solids and suspended solids. The total solids and suspended solids are further divided into volatile and non-volatile for the purpose of differentiating between the organic and inorganic content. Settleable solids are those readily amenable to settling irrespective of their size.

* Wastewater

The spent water of a communicty. From the standpoint of source, it may be a combination of the liquid and watercarried wastes from residences, commercial buildings, industrial plants, and institutions, together with any groundwater, surface water, and storm water that may be present. In recent years, the word wastewater has taken precedence over the word sewage.

* Yard Piping

That portion of the house connection sewer extending from the house to the property line. The yard piping plus the service connection make up the total house connection.

PART - I

SUMMARY

PART I

SUMMARY

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

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

The summary of findings and recommendations of the study are as follows:

GENERAL

(1) In the Penang Master Plan prepared for the Penang Master Plan Committee in 1970, it was proposed to establish a metropolitan area in Province Wellesley, which includes the two towns Butterworth and Bukit Mertajam.

According to the definition, the metropolitan area will be urbanized by the year 1985. On the basis of this, the Project Area of the present Report for Sewerage and Drainage Master Plan is defined basically as the Butterworth/Bukit Mertajam Metropolitan Area with total area of 11,600 ha. (Ref. Master Plan Report Part II Background)

(2) On the basis of 1970 National Census and by summation of ourselves, the population of the whole Project Area is estimated to be 172,230 in 1970 and 238,000 in 1976. An anticipated increased population in 1985, based on the projection of Penang Master Plan, is 385,000, which will further increase, according to the Assignment Report of WHO, to 545,000 in 1995. Taking the above data into account, the population in the year 2000 is projected as 648,000. (Ref. Master Plan Report Part II Background)

SEWERAGE

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

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

The field survey shows that the septic tanks are not necessarily working well, and effluents discharged into the drains sometimes show high degree of pollution, together with domestic waste water also discharged in the drains untreated.

In new housing development areas, communal septic tanks with sedimentation basin and filter bed are installed. All collected sludge from septic tanks are transported by vacuum trucks for land fill at present. It is considered that, until sewerage system is completed, the septic tanks should remain functioning with effluent preferrably connected to sanitary sewers. (Ref. Master Plan Report Part II. Background)

(5) For the purpose of sewerage planning, whole Project Area is divided, after considering several alternatives, into 4 sewerage districts, namely, Butterworth, Seberang Jaya, Prai, and Bukit Mertajam. Furthermore, for the detailed planning purpose, they are divided into 20 sewerage zones on the basis of geographical, topographical, demographical and other conditions, which enables to work out plan for overall system and to design individual facilities concerned. (Ref. Master Plan Report Part III. Sewerage Master Plan)

(6) Careful consideration has been done in establishing priorities of locations for implementation of construction programme by stages mentioned above by the rating procedures for evaluation for each of 20 zones with the following assessment elements: (Ref. Master Plan Report Part III. Sewerage Master Plan)

a. Population density
b. Waste load production aspect
c. Excreta disposal system
d. Flooding
e. Housing and industrial development programme
f. Availability of water supply
g. Incidence of water-borne diseases

The result of rating indicates that four sewerage zones, namely zones 1, 3 and 4 of Butterworth, and zone 3 of Bukit Mertajam Sewerage districts, are to be given priority for the first stage programme. (Ref. Master Plan Report Part III. Sewerage Master Plan)

(7) It is considered appropriate to divide the total programme into 4 construction stages, namely, 1981 - 1985 (1st stage), 1986 - 1990 (2nd stage), 1991 - 1995 (3rd stage), and 1996 - 2000 (4th stage). (Ref.

(8) The physical facilities recommended for sewerage system developed includes (a) system of sanitary trunk mains, submains, branches and house connexions, (b) pumping stations, and (c) sewage treatment facilities in the form of stabilization pond/oxidation ditch processes. (Ref. Master Plan Report Part III. Sewerage Master Plan)

The first stage programme comprises of house connexions, a network of interceptors, branch and lateral sewers and trunk mains to transport collected sewage, to the treatment plant, which will be discharged into either Prai or Juru rivers. For the treatment facilities, identical facilities are proposed for all 4 zones except zone 1, where aerator is proposed due to the limited land available (Ref. Master Plan Report Part III. Sewerage Master Plan)

(9) The estimated magnitude of investment for implementation of sewerage system construction by stages is shown in the following table. In estimating the costs, effort has been exercised to use the locally produced materials and equipment as much as possible in order to encourage local industries and to reduce foreign borrowings. (Ref. Master Plan Report Part III. Sewerage Master Plan)

TABLE I-1 Proposed Sewerage System and Construction Cost of 1st Stage

(Cost unit: 1000 M$)

Name of Sewerage Zone	Butterworth Zone - 1	Butterworth Zone - 3	Butterworth Zone - 4	Bukit-Mestajan Zone - 3	Remarks
(1) Public Sewer					
Diam. (mm)	225- 900	225- 1050	225- 750	225- 1050	
Length (m)	92200	116800	133200	278100	
Construction Cost					
(a) Local Currency	21420	26720	29240	55530	
(b) Foreign Exchange	-	-	-	-	
(2) House Connexion					
Diam. (mm)	150	150	150	150	
Length (m)	110800	125700	111100	217800	
Construction Cost					
(a) Local Currency	4680	5310	4700	9200	
(b) Foreing Exchange	-	-	-	-	
(3) Pumping Station					
Peak Flow (cum/s)	-	-	-	-	
(4) Treatment Plant					
Ave.Daily Flow(cum/d)	15800	21500	13000	25900	
Treatment Process	Oxidation ditch	Stabilization pond	Stabilization pond	Stabilization pond	
Construction Cost (including land cos-)					
(a) Local Currency	11250	12340	6190	12780	
(b) Foreing Exchange	15470	3620	1600	4550	
Sub-Total	52820	47990	41730	82060	
(a) Local Currency	37350	44370	40130	77510	
(b) Foreing Exchange	15470	3620	1600	4550	
Currency	10560	9600	8350	16410	
Engineering Fee					
Design	3170	2880	2500	4930	
Supervision	3170	2880	2500	4930	
	69720	63350	55080	108330	

Note: Assuming escalation of 5 percent/year, the costs were claculated for the year 1983 which is middle year of the proposed 1st stage.

DRAINAGE

(10) Area concerned to the drainage planning is defined as follows:

° Area covered by proposed drainage system	9,874 ha	(24,398 acres)
° Prai and Seberang Jaya area excl. from this Project	980 "	(2,422 ")
° Non-inhabitable area (river & mountain)	746 "	(1,843 ")
Sub-Total	11,600 "	(28,663 ")
° Contribution area from outside the Project Area	1,851 "	(4,327 ")
Total	13,351 ha	(32,990 acres)

In association with the proposal in the assignment report of WHO and accounting existing watershed and general features of land use, the Project Area has been divided into six drainage basins for the conveniences of drainage planning. They are named B-I - B-VI and the individual drainage basin has further been divided into sub-basin on the basis of topographical conditions and shown in Fig.IV-1.

(11) About 80 % of the Project Area is the tributary of the Prai and Juru river and remaining parts discharge to the sea. Data on Prai river is available, which enables to proceed to design profiles of drains discharging into it. However, the Juru river has not been studied yet and our recommendation is limited to the preliminary consideration for the required drainage facilities to the extent to clarify the routes and space needed for them in the future. When the area is developed, the space for drainage systems should be allocated on the basis of the proposal of this Report . (Ref. Section 3.2)

(12) Flooding in urban areas is reported to be rather minor problem at the present stage. However, rapid development will cause serious flood, and according to a result of field survey it was found that existing drains have been used up by on-going development projects. Land acquisition according to the drainage system proposed in this Report would be the matter for serious consideration and immediate action.

(13) Existing main drains are heavily silted in their major portions. The capacities of them have been checked and it was found that those in populated area such as southern half of Butterworth and Bukit Mertajam core portion, haye capacity to cope with 2-year and 5-year frequency rainfall respectively at present. And it was also found that some minor improvements of main drains including desilting and lining will contribute to alleviation of flooding for some time. However, rapid urbanization will increase runoff coefficients and demolish swampy areas which contribute largely to alleviation of flooding now, and piecemeal improvement will not be warranted as menas to cope with expected stormwater runoff to be increased rapidly in the near future.

It is recommended, therefore, that drainage project for Butterworth area be set forth as early as possible. In Bukit Melitajam area existing drains can be used for time being by minor improvement.

(14) Although the Project Area is generally flat and low-lying no pumping station is recommended. In lieu of construction of pumping stations, land filling is recommended to cope with the highest recorded sea level + 1.68 m (+ 5.5 ft) and drainage systems, within which least head loss is required, for the mean high sea level of spring tide (which will occure once a year). Reservoirs are set in the proposed system.

(15) The total construction cost for the proposed system is million$ 318. (in 1976 price). It also includes 20 % contingencies and 10 % engineering fees.

(16) Staging of construction is planned to coincide with that of the sewerage plan. The first stage area is considered to be B-IV (Butterworth area) and a part of B-II (Bukit Mertajam area), because of its high population density and rapid urbanization experienced now. The first stage programme would include the construction of main drains of size from 2,200 x 1,320 mm to 7,800 x 4,680 mm with the total length of about 19,000 meters (1.18 miles).

The construction of two reservoirs with the volume of 10,500 cu m and 12,000 cu m respectively and a furnishment of network of smaller drains in central portion of Butterworth are also included. The construction costs of first stage is shown in Table 1-2.

TABLE 1-2 Drainage Construction Cost of 1st Stage

(1000 M$)

Description	1st Stage (1981-1985)
a. Main Drains	63,102
b. Network of Smaller Drains	58,089
c. Reservoir	654
d. Land Acquisition	3,226
(A) Sub Total	125,071
(B) Contingency	25,014
(C) Engineering Fee	
Design	7,504
Supervision	7,504
Total	165,093

Note: Escalation Rate is estimated at 5 % per year (base 1976).

(17) Capital costs of the construction programme may be met by the borrowing from a combination of sources, international and local. Foreign exchange funds may be financed with a long-term loan from the multilateral and/or bilateral sources, and local costs may be met by funds from local sources inclusive of government loan and/or subsidies.

PART II

BACKGROUND

PART II

BACKGROUND

Table of Contents

CHAPTER 1

PURPOSE AND SCOPE OF STUDY

1.1 Background of the Study

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

Nihon Suido Consultants Co., Ltd. (NSC), as the Sub-contractor, was assigned to undertake the work required.

1.2 Purpose and Scope of the Study

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

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

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

To carry out the project, the JICA has identified the following specific study objectives, with major consideration to be given to the 23 year period from 1977 to 2000:

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

(b) Undertake studies and formulate recommendations regarding the proper organization, agency or department to carry out the planning, construction, operation, maintenance, management and administration of a sewerage system for the Project Area.

(c) Submit Project reports, including:
* Progress reports at the end of data collection at the project site.
* Draft and final reports on the Master plan for the sewerage and drainage system project.

1.3 Definition of Project Area

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

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

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

o Butterworth/Bukit Mertajam Metropolitan Area
. . . . 12,020 ha (92,700 acres)
o Airforce Base . . . . 420 ha (1,040 acres)
o Project Area . . . . 11,600 ha (28,600 acres)

As regards to the drainage system, some areas outside the Project Area are taken into account due to the topographical conditions. The additional areas cover the catchment area of main drain or natural waterway flowing through the Project Area. (Ref. PART IV)

1.4 Problem and the Need for Study

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

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

There is at present no sanitary sewerage system in the Project Area. Most of the domestic sewage and industrial wastes are discharged directly to drains and other available waterways, and in case of human excrete, from homes after passing through septic tanks into the open ditches or collected using bucket system. 30 percent of houses within the urban area and 7 parcent of houses within the rural area have septic tank systems for excreta disposal. The remainder of the houses dispose of their human wastes either by means of pit latrines or bucket. The result of the discharge of most of the City's wastes without treatment, is gross pollution, which produces septicity in the drains and rivers particularly during low flows in the dry seasons and pollutes the beaches and offshore marine waters.

The existing rivers and drains gradually become grossly polluted while flowing through the Town Area. These rivers and drains will become more polluted by the year 2000, if no action is taken to alleviate the wastewater burden to the waterways. Such conditions have resulted in adverse biological effects, odours and nuisances.

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

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

CHAPTER 2

PHYSICAL CHARACTERISTICS OF PROJECT AREA

2.1 Location

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

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

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

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

2.2 Geology

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

Province Wellesley, in which the Project Area is situated, is essentially a very flat alluvium plains. This plain is lying below the 15 m (500 feet) contour being interruped by patches of hilly land at its south-eastern border. The highest point of these hills is in the Bukit-Mertajam, which is 536 m (1,787 feet) above sea level and is located just south-east end of the Project Area. These hills were formed in Mesozoic, Post Triassic Period and their formation is granite.

The Project Area, which is composed mainly of flat plains, is dominated by the Prai and Juru rivers, are predominant. These plains are typified by nature river profiles meandering amongst tidal and fresh water swamps. With controlled drainage and irrigation, these alluvium plains can be agriculturally productive and well suited to a variety of crops, rice paddies, coconut, pineapple, rubber and oil palms.

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

2.3 Climate & Rainfall Characteristics

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

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

Temperature is relatively constant throughout the year and the average monthly temperature varies only by about 2°C (4°F). However, the daily temperatures show a greater variation, at coastal locations being 5°C to 8°C (10°F to 15°F), with a mean daytime maximum of 29°C to 33°C (85°F to 92°F) and a mean minimum of 22°C (71°F) at night.

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

For Penang State, rainfall has been recorded by DID and PWA respectively. Recorded data are available since 1933 in DID, from 1933 to 1969 with recording once a day, and from 1970, continuous recording with self-resistering gauges was indicated. In PWA, rainfall data recorded continuously with automatical gauges since 1954 are available.

There are eight gauges in and around the Project Area as shown in Figure II-5, and described in Table II-5.

It is considered that five year length of record in DID is too short to expect a reliable result of statistical analysis. Thus data in PWA is used for deriving intersity-duration rainfall curve and the record most suitable is that of No. 6 gauge, because in of its preciseness in details compared to others.

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

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

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Mean	(4.95) 125.7	(3.74) 95.0	(7.70) 195.6	(9.67) 245.6	(8.97) 227.8	(6.28) 159.5	(6.32) 160.5	(7.60) 193.0	(10.30) 261.6	(12.98) 329.7	(11.94) 303.3	(5.88) 149.4	(96.26) 2445.0
Max. 24 hrs.	(3.72) 94.5	(3.74) 95.0	(6.97) 177.0	(3.84) 97.5	(4.37) 111.5	(4.97) 126.2	(4.72) 119.9	(4.72) 119.9	(5.48) 139.2	(6.49) 164.8	(6.20) 157.5	(4.50) 114.3	(6.97) 177.0
Max. 48 hrs.	(3.94) 100.1	(4.10) 104.1	(6.97) 177.0	(4.40) 111.8	(8.11) 206.0	(7.19) 182.6	(4.72) 119.9	(6.96) 176.8	(6.10) 154.9	(6.49) 164.8	(7.80) 198.1	(4.93) 125.2	(8.11) 206.0
Max. 72 hrs.	(6.08) 154.4	(4.10) 104.1	(6.97) 177.0	(4.46) 113.3	(8.75) 222.3	(8.87) 225.3	(4.86) 123.4	(7.15) 181.6	(8.15) 207.0	(7.46) 189.5	(9.18) 233.2	(7.40) 188.0	(9.18) 233.2

Note: Figures in ( ) = inch

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

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
24 hr Mean	26.8	27.2	27.4	27.6	27.6	27.2	26.9	26.7	26.5	26.3	26.4	26.6	26.9
Mean Daily Max.	31.1	31.7	31.7	31.8	31.7	31.3	31.0	30.8	30.7	30.3	30.3	30.5	
Mean Daily Min.	22.9	23.1	23.4	23.9	24.1	23.7	23.3	23.3	23.1	23.2	23.1	23.2	
Highest Max,	35.6	35.0	35.0	34.4	33.9	33.9	33.3	33.3	33.3	33.9	33.3	33.9	
Year	1959	1959 1965	sev.	1963 1971	1963	1959 1972	sev.	1960 972	sev.	1972	1972	1970 1972	
Lowest Min.	18.9	20.6	20.6	21.7	21.7	21.1	20.6	20.6	20.6	21.7	21.1	20.6	
Year	1972	1962 1968	sev.	sev.	1968 1972	1960 1961	1971	1964	1964 1966	sev.	sev.	1959	

Note; sev. means several years

TABLE II-3 Record Relative Humidity at Bayan Lepas

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

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

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

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

TABLE II-5 Rainfall Gauge Station

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

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

2.4 Water Resources

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

(1) Prai river

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

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

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

(2) Juru river

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

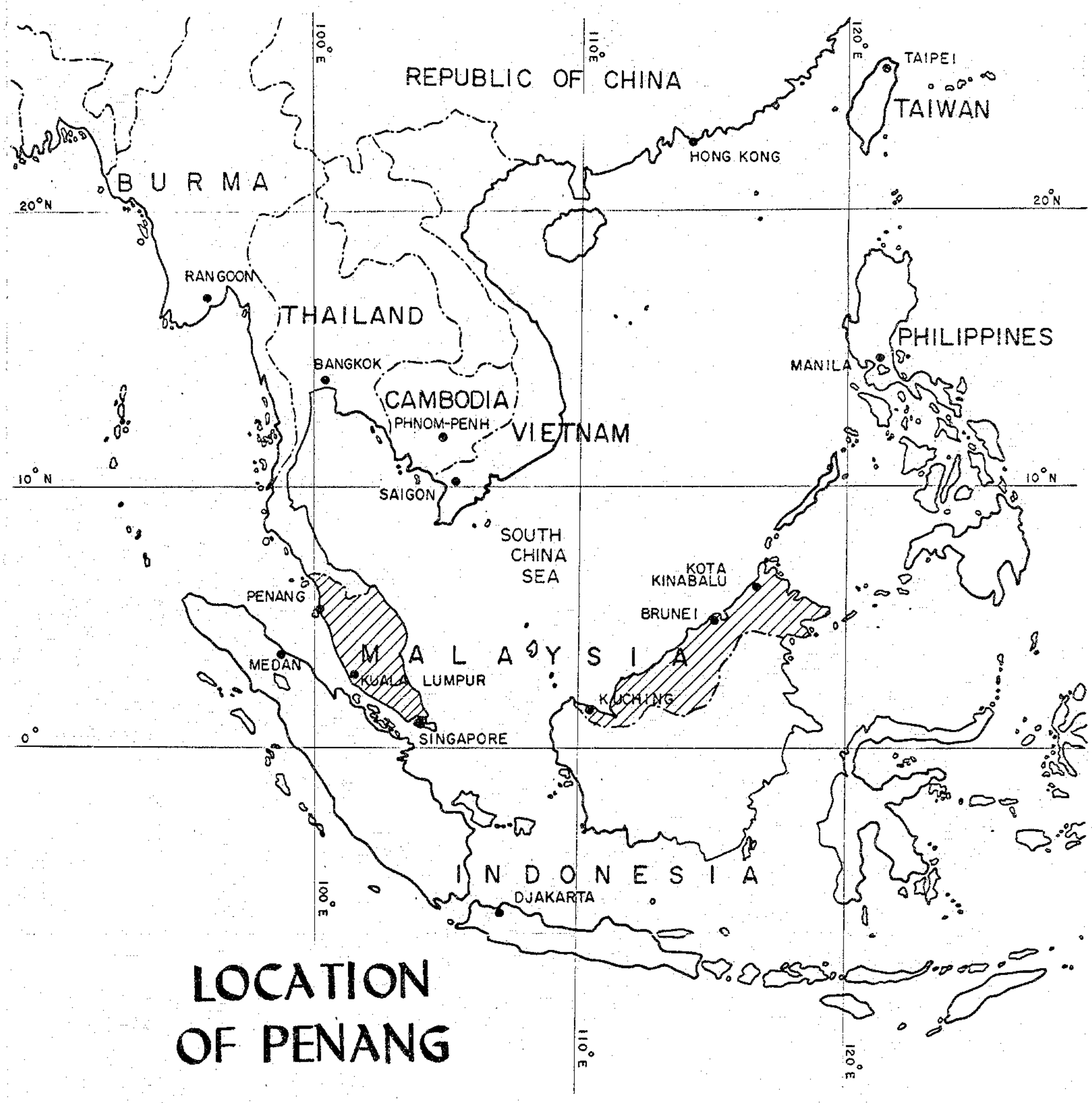
TABLE II-6 Rainfall Records (1965-1970)

(Ibu Bekalan Sngai Kulin)

Unit mm

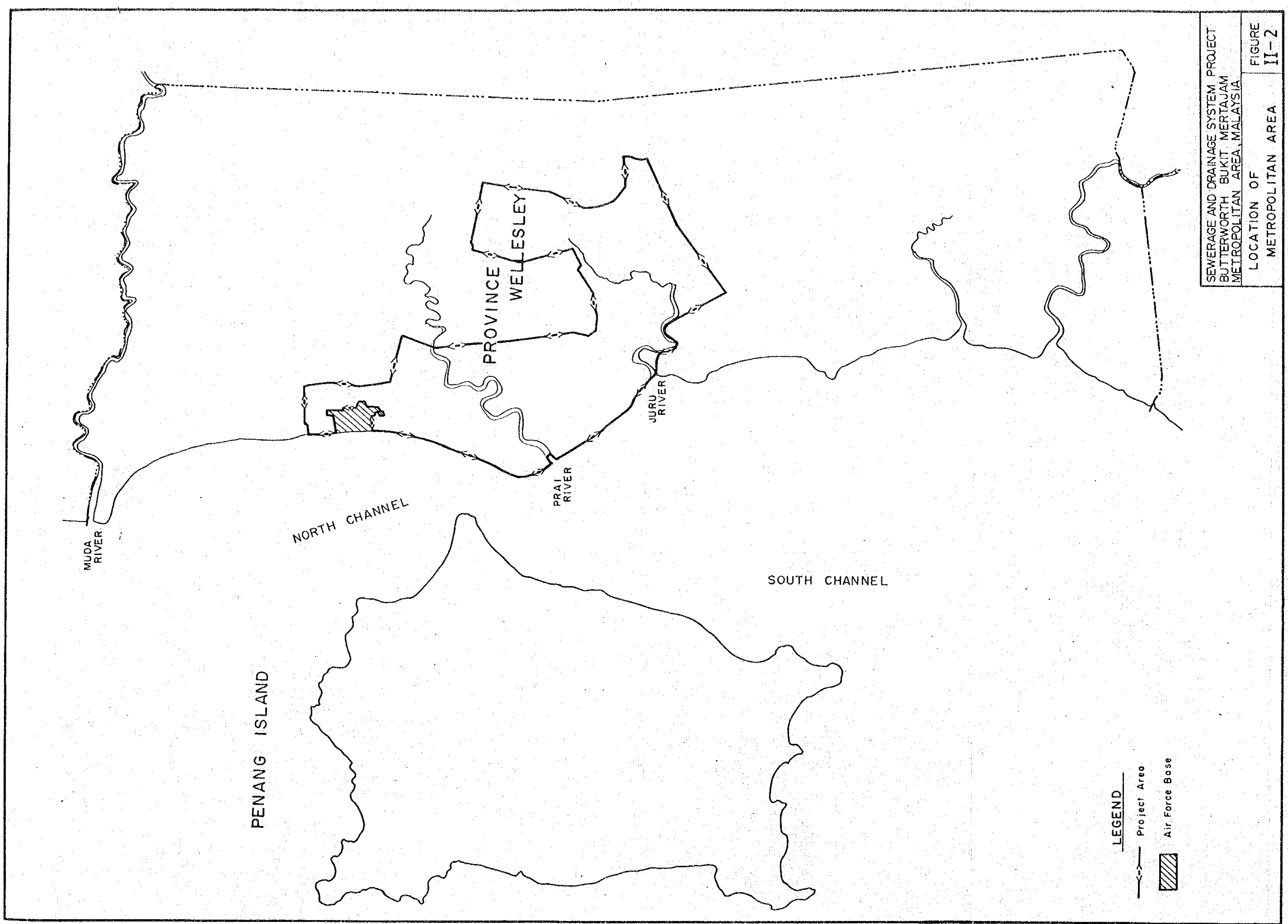
YEAR	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR	APRIL	MAY	JUNE
1965166	(4.94) 125	(9.60) 244	(14.95) 380	(8.91) 226	(14.60) 371	(18.62) 321	(2.77) 704	(3.16) 803	(7.02) 178	(7.20) 183	(6.28) 160	(3.23) 82
1966167	(12.48) 315	(8.14) 207	(7.17) 182	(10.91) 277	(7.17) 182	(10.60) 269	(9.99) 254	(0.87) 22	(4.60) 117	(10.02) 255	(10.94) 278	(6.83) 173
1967168	(1.43) 36	(6.00) 153	(6.44) 164	(14.73) 374	(15.26) 388	(1.15) 29	(0.83) 21	(1.14) 29	(6.74) 171	(11.28) 287	(3.98) 101	(4.34) 110
1968169	(9.10) 231	(14.73) 374	(4.38) 111	(11.40) 290	(10.25) 260	(11.51) 292	(8.20) 208	(0.85) 22	(7.08) 180	(1.28) 33	(8.65) 220	(3.46) 88
1969170	(3.91) 99	(5.59) 142	(6.86) 174	(13.83) 351	(10.68) 271	(7.07) 180	(10.60) 269	(0.68) 17	(3.18) 81	(12.15) 309	(8.43) 214	(3.65) 93

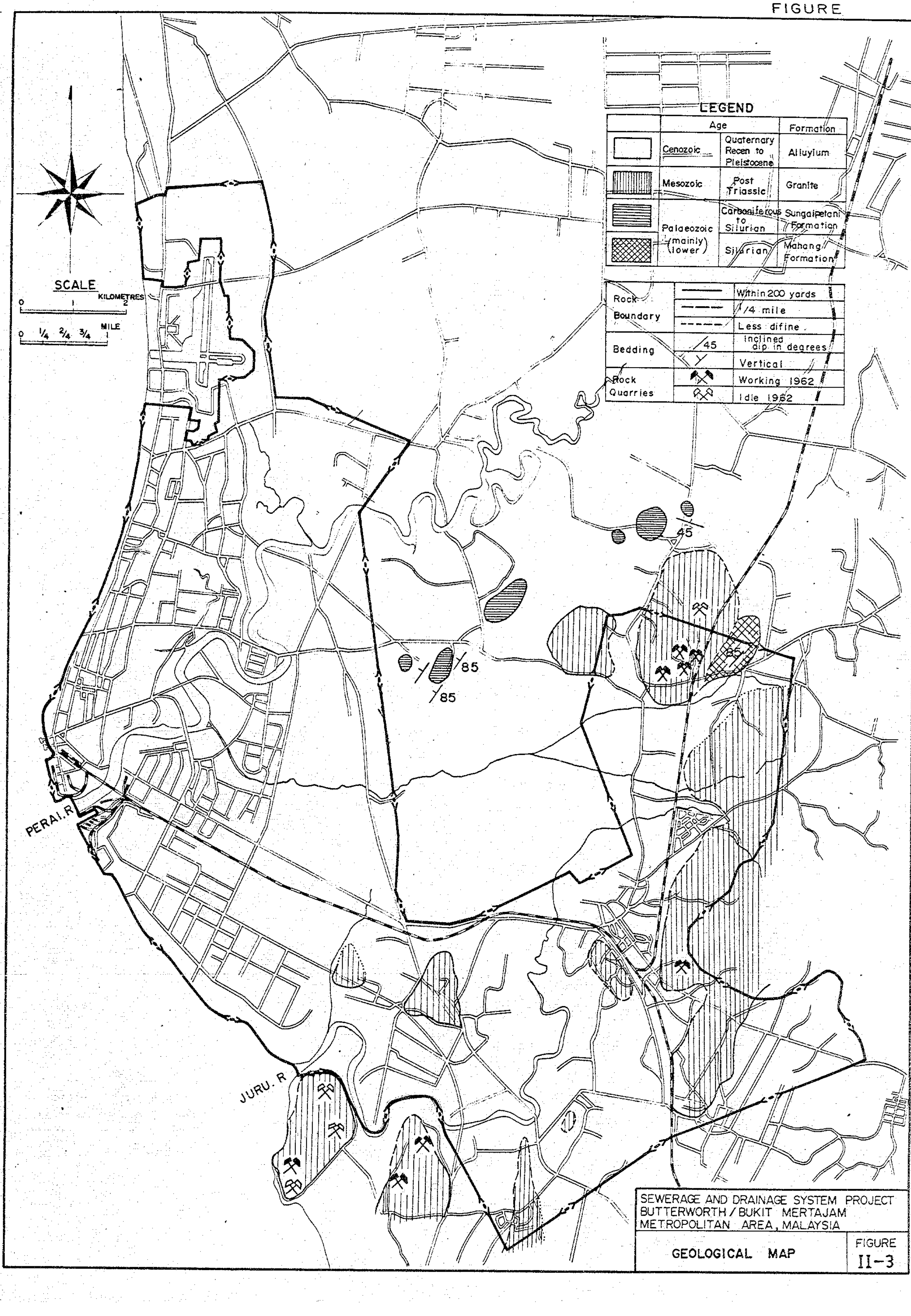
Note : Figures in ( ) : Inch



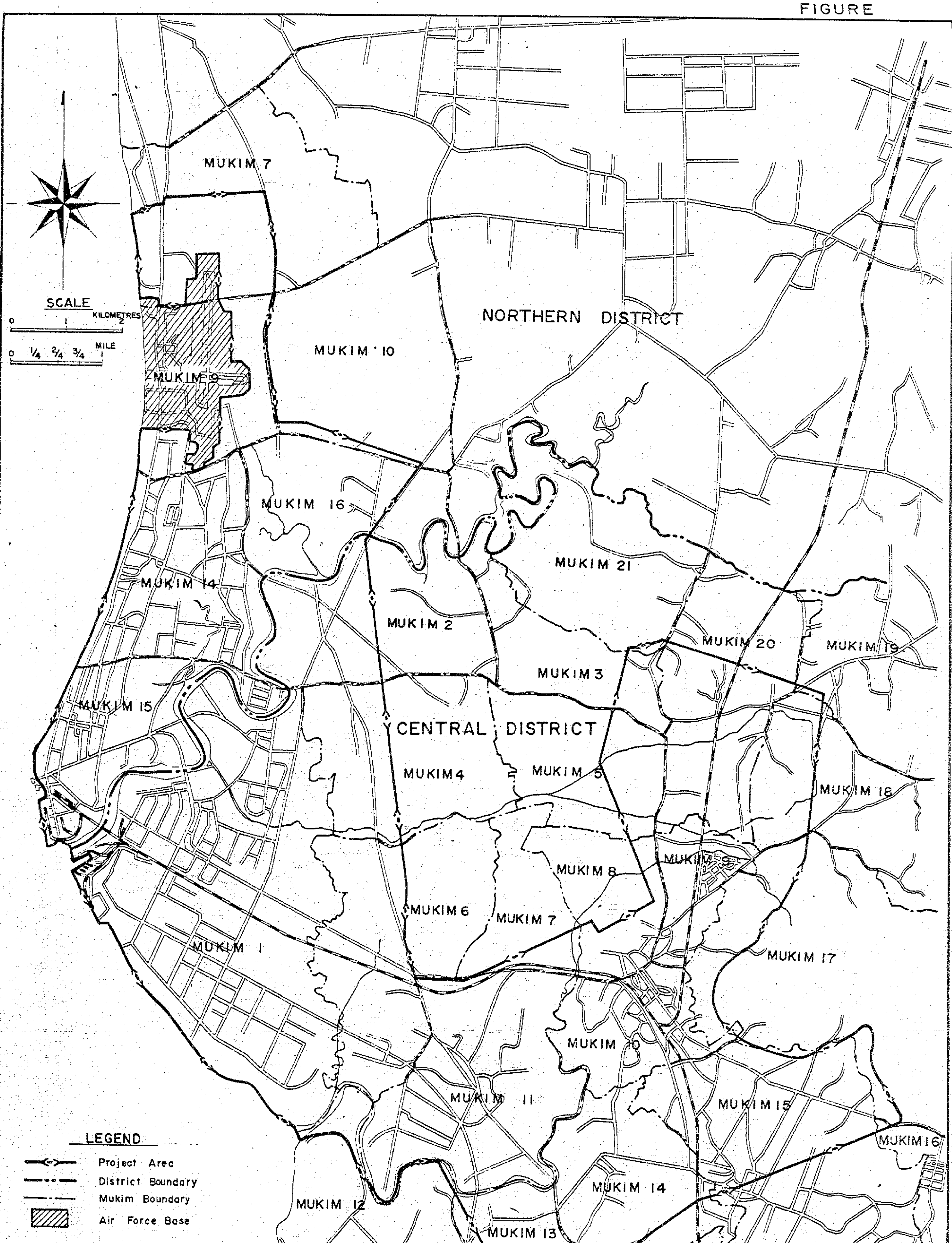
LOCATION OF PENANG

FIGURE II-1


SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
LOCATION OF
METROPOLITAN AREA
FIGURE
II-2
PROVINCE
WELLESLEY
MUDA RIVER
PRAI RIVER
JURU RIVER
NORTH CHANNEL
SOUTH CHANNEL
PENANG ISLAND
LEGEND
Project Area
Air Force Base


LEGEND
Age
Formation
Cenozoic
Quaternary Recen to Pleistocene
Alluvium
Mesozoic
Post Triassic
Granite
Palaeozoic (mainly lower)
Carboniferous to Silurian
Sungaipetani Formation
Silurian
Mahang Formation
Rock Boundary
Within 200 yards
1/4 mile
Less difine.
Bedding
45
Inclined dip in degrees
Vertical
Rock Quarries
Working 1962
Idle 1962
SCALE
KILOMETRES
0 1 2
MILE
0 1/4 2/4 3/4 1
45
85
85
85
PERAI. R
JURU. R
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
GEOLOGICAL MAP
FIGURE
II-3

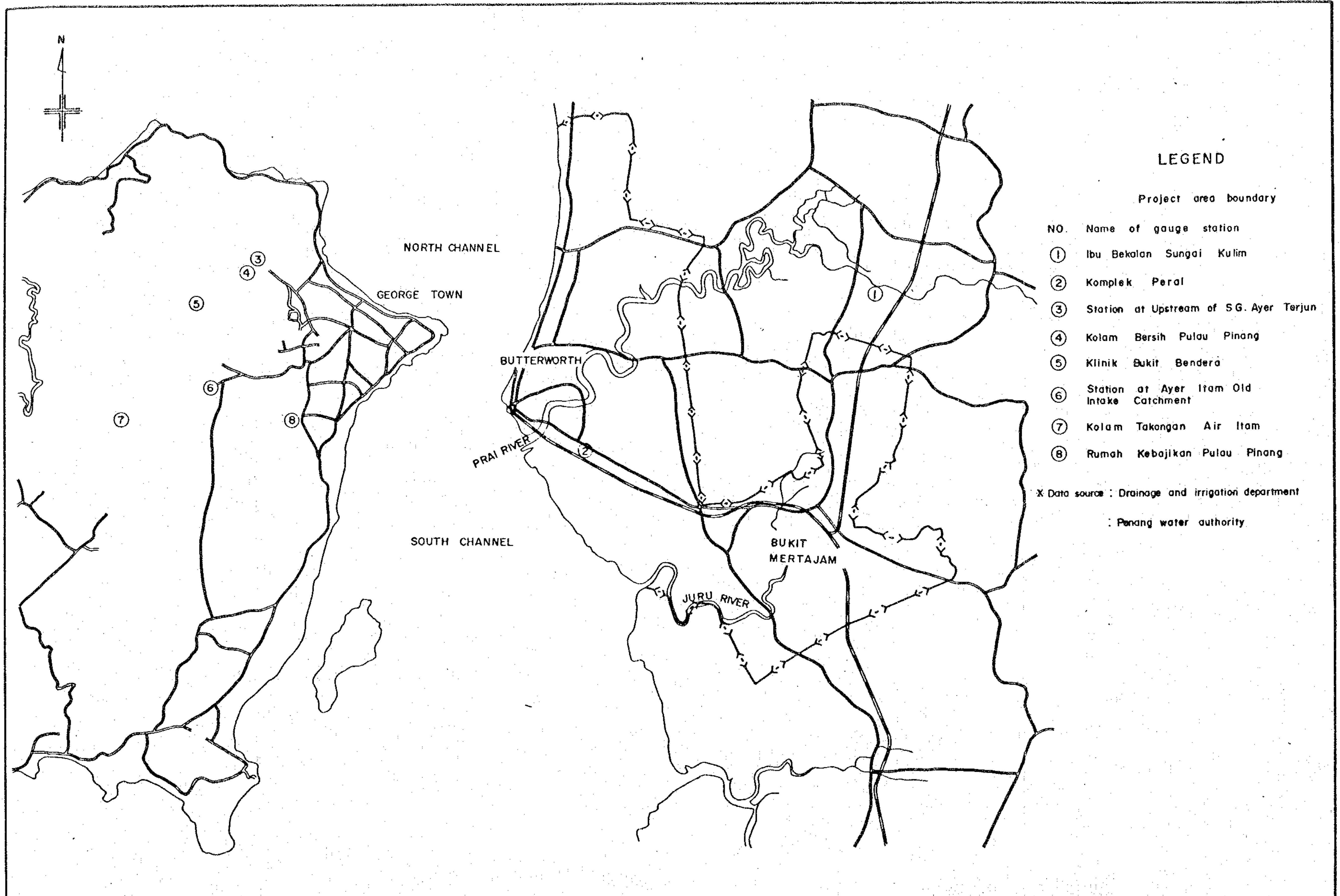
FIGURE



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

DEFINITION OF PROJECT AREA

FIGURE II-4



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

LOCATION OF RAIN GAUGE

FIGURE II - 5

CHPATER 3

PUBLIC HEALTH CONDITIONS

3.1 Health and Medical Facilities

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

Among these facilities, two hospitals are located in the Project Area. They are district hospitals in Butterworth and in Bukit Mertajam. Total bed number of each hospital is 134 and 206 respectively in 1975. And numbers of admissions in 1975 are 8,679 and 14,505, average length of stay is 5.63 days and 5.18 days respectively. Bed occupancy rate, calculated from bed numbers and average daily numbers of patients, are 85.07 percent in Butterworth District Hospital and 120.39 percent in Bukit Mertajam District Hospital.

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

3.2 Incidence of Diseases

Number of patients of water-borne communicable diseases are shown in Table II-7. These figures are for North District and of Central District in Province Wellesley, including outside areas of the Project Area. However, Medical and Health Officer of Penang State indicates that the incidence rates per 100,000 population would be more indicative of the real situation in the Project Area. It is also pointed out that these figures did not necessarily cover the whole incidents in the Districts and unreported patients were not included. It is considered that the reported incidence will cover approximately 75% only of the total incidents actually occurred.

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

	1970		1971		1972		1973		1974		1975	
	PWN	PWC	PWN	PWC	PWN	PWC	PWN	PWC	PWN	PWC	PWN	PWC
Cholera	(7.4) 12	(42.5) 50	-	-	-	(5.7) 7	-	-	(5.1) 9	(0.8) 1	-	-
Dysentery	-	(0.8) 1	(1.2) 2	(3.3) 4	(4.7) 8	(2.4) 3	(17.9) 31	(3.2) 4	(5.1) 9	(7.8) 10	(2.2) 4	(5.3) 7
Food Poisoning	-	-	-	-	-	-	(1.2) 2	-	(2.8) 5	-	(7.2) 13	(2.3) 3
Infectious Hepatitis	-	-	-	-	-	-	(35.3) 61	(4.8) 6	(26.6) 47	(1.6) 2	(25.4) 46	(5.3) 7
Typhoid fever	(0.6) 1	(1.7) 2	(4.2) 7	(9.2) 11	(26.6) 45	(4.9) 6	(26.6) 46	(9.5) 12	(2.3) 4	(5.4) 7	(2.8) 5	(6.1) 8
Leptospiral Infections	-	-	-	-	-	-	(0.6) 1	-	-	-	-	-

Note: PWN: Province Wellesley North District

PWC: Province Wellesley Central District

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

CHAPTER 4

POPULATION AND LAND USE

4.1 Present Population and Distribution

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

The population data provided in the Penang Master Plan, 1970, which includes the population projection for 1970, 1975 and 1985, is found to be useful source of information for projection up to the year 1976, the time of the present study. Assuming its projection of 385,000 for the year 1985 as reasonable and realistic assumption with a few percent of plus and minus deviation which is normal for this type of projection, it is considered appropriate to apply average of 5.5% annual growth rate used for 1985 projection to 1970 population of each of the mukims within the Project Area up to the year 1976, which leads to the conclusion that the total population of the Area in 1976 to be 238,000, as indicated in Table II-8 referred above.

4.2 Present Land Use

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

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

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

Entire Project Area is classified into 7 land use categories: a) industrial, b) social and commercial, c) residential, d) rural, e) agricultural, and f) others. Present land use is illustrated in Figure II-6, and acreage of each category is as shown in Table II-9.

TABLE II-8 Population & Distribution by Mukims in 1970, with 1976 Projection

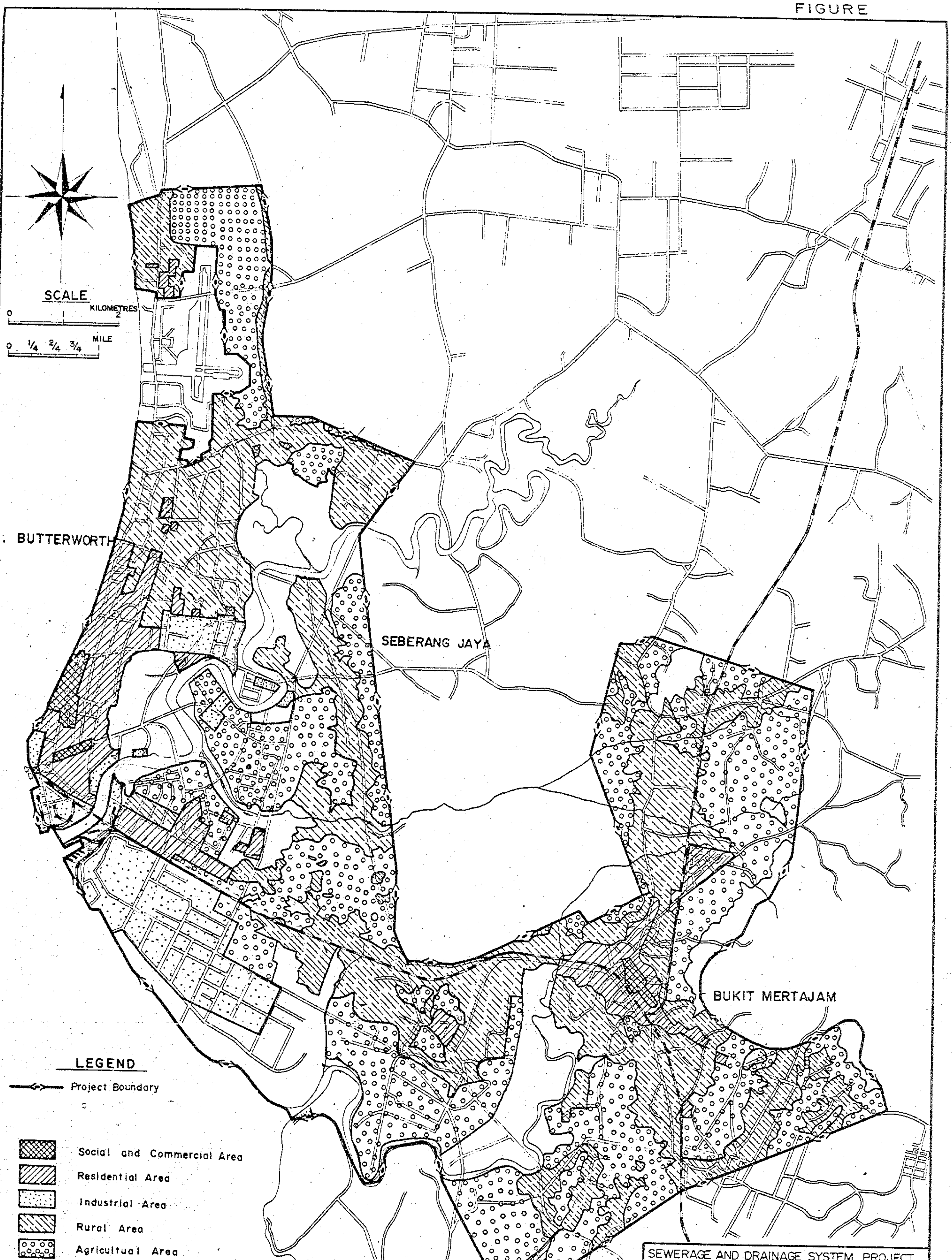
No. of Mukim Involved	Mukim Total (by 1970 Census)			Project Area (by NSC)			Population
	Population (1970)	Area (ha)	Population Density	Area (ha)	Population (1970)	Population Density	(1976)
N 7	8,485	1,152	7.4	389	3,751	9.6	5,183
N 9	6,917	650	10.6	281	2,691	9.6	3,719
N10	3,286	1,059	3.1	47	146	3.1	202
N14	39,502	885	44.6	885	39,502	44.6	54,587
N15	30,035	645	46.6	645	30,035	46.6	41,505
N16	3,441	668	5.2	523	2,720	5.2	3,759
C 1	10,875	2,174	5.0	2,174	10,875	5.0	15,028
C 2	3,952	848	4.7	420	3,162	7.5	4,369
C 3	3,381	457	7.4	88	2,029	23.1	2,804
C 4	5,934	781	7.6	354	5,341	15.1	7,381
C 5	2,861	625	4.5	187	2,253	12.0	3,113
C 6	4,096	1,035	4.0	762	4,096	5.4	5,660
C 7	1,665	1,176	1.4	54	1,665	30.8	2,301
C 8	10,116	406	24.9	193	10,116	52.4	13,979
C 9	9,131	270	33.8	270	9,131	33.8	12,617
C10	19,641	445	44.1	445	19,641	44.1	27,141
C11	5,116	1,060	4.8	1,060	5,116	4.8	7,070
C12	2,740	1,480	1.9	60	114	1.9	158
C13	2,776	1,328	2.1	366	2,776	7.6	3,836
C14	6,645	1,813	3.7	618	3,323	5.4	4,592
C15	9,706	1,535	6.3	681	8,735	12.8	12,071
C16	5,567	1,688	3.3	5	17	3.3	23
C17	1,100	2,195	0.5	309	155	0.5	214
C18	1,405	1,055	1.3	215	280	1.3	387
C19	2,137	1,551	1.4	5	7	1.4	10
C20	6,477	1,008	6.4	557	4,534	8.1	6,265
C21	2,438	902	2.7	7	19	2.7	26
Total	209,380	28,891		11,600	172,230		238,000

TABLE II-9 Population and Land Use by Mukim in 1976

No. of Mukim	Area (ha)							Population Density			Population			Total
	Social Commercial	Residen-tial	Indust-rial	Rural	Agricul-tural	Others	Total	Social Commercial	Residen-tial	Rural	Social Commercial	Residen-tial	Rural	
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 not inhabited area, e.g. government office etc.

FIGURE



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

LAND USE IN 1976

FIGURE II - 6

CHAPTER 5

WATER SUPPLY SYSTEM

5.1 Existing Water Supply System

5.1.1 Water Agency

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

5.1.2 Areas and Population Served

Approximately 280,000 people or about 70 percen of the total population in Province Wellesley is served by the water supply system.

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

5.1.3 Water Production and Use

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

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

Unit: 1000 cu m

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

- to be continued -

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

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

5.1.4 Water Supply Conditions

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

5.1.5 Private Water Supply Systems

There are at present privately owned water supply systems in Province Wellesley. Some of them use wells and irrigation water, but the areas presently covered by them may be included in the water service area in the near future for supply from the municipal water system.

5.2 Existing Water Supply Facilities

5.2.1 Outline of Existing Facilities

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

(a) North Zone

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

(b) Central Zone

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

(c) South Zone

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

The total rated output of all existing Water works in Province Wellesley is 49,870 cu m/day (11 m.g.d.).

Storage tanks have the following Capacities:

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

5.2.2 Water Sources

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

TABLE II - 11 Water Source

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

5.2.3 Pumping Stations

There are five pumping stations of the water supply system in Province Wellesley. The quantities of water pumped from low level intakes to supplement yields of high level intakes were followings in 1973.

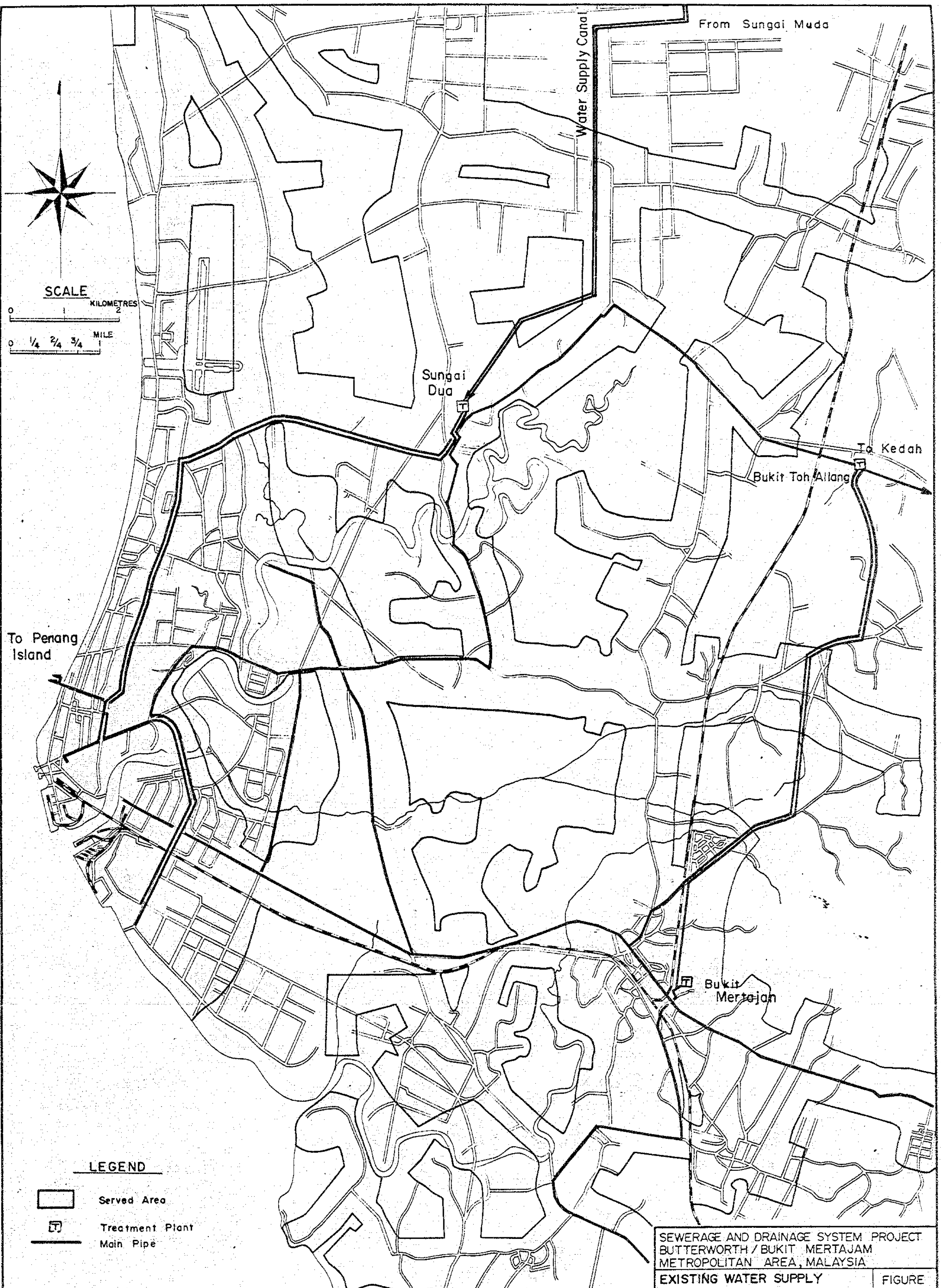
TABLE II - 12 Total Annual Quantities of Pumping Station (1973)

Unit: 1000 cu m

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

Note: * Commenced operation with effect from April 1973.
Data Source: 1973 Annual Report of Penang Water Authority.

FIGURE



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

EXISTING WATER SUPPLY SYSTEM ON 1976

FIGURE II-7

5.2.4 Purification Plants

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

TABLE II - 13 The Treatment Process of Plant

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

5.2.5 Water Quality

Analyses of the raw water at several points are shown in Tables II-14.

TABLE II - 14 Results of Water Analyses

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

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

Data Source: PWA

5.3 Management and Operation

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

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

FIGURE II-8 The Organization of the Penang Water Authority