APPENDIX C

SURFACE WATER DRAINAGE

C.1 Design Criteria

1. Design Rainfall Frequency

The design rainfall frequency for drains and structures for the initial drainage system and the major drainage system for various land uses shall be as shown in Table C.1.

Table C.1 Design Rainfall Frequency (years)

Land Use	Initial Storm	Major Storm
Residential	2	100
Commercial	5	100
Industrial	5	100

Source: D.I.D Planning and Design Procedure No. 1, 1975

In this planning of the storm water drainage system, a 5-year probability is adopted in the overall catchment area.

2. Storm Runoff Estimation

Storm Run off is estimated by the Rational Formula as follows:

$$Q = \frac{1}{360} CiA$$

where Q is the peak discharge in cubic meter per second of return period T years

i is the average intensity of rainfall in mm per hour for a duration equal to the time of concentration t_c, and a return period T years.

A is the catchment area in ha.

C is a runoff coefficient

(a) Time of Concentration (tc)

The time of concentration is the time required for the water to flow from the most remote point of the catchment to the point being investigated.

For urban stormwater drains, the time of concentration (t_c) consists of the time required for runoff to flow over the ground surface to the nearest drain (t_o), and the time of flow in the drain to the point under consideration (t_d).

$$t_c = t_o + t_d$$

i) Overland Flow Time (to) – The time for overland flow (t_o) shall be estimated from Figure C.1 using appropriate values of length, slope and runoff coefficient C.

ii) Drain Flow time (t_d) – The time of flow in drains shall be estimated from the hydraulic properties of the drain. In the case of streams where the hydraulic properties are difficult to determine the time of flow shall be estimated using the velocities shown in Table C.2.

The calculation of the flow time is by the following formula:

$$t_d = \frac{1}{60} \cdot \frac{L}{V}$$

Where: L = Length of water channel (m)

V = Average flow speed (m/sec)

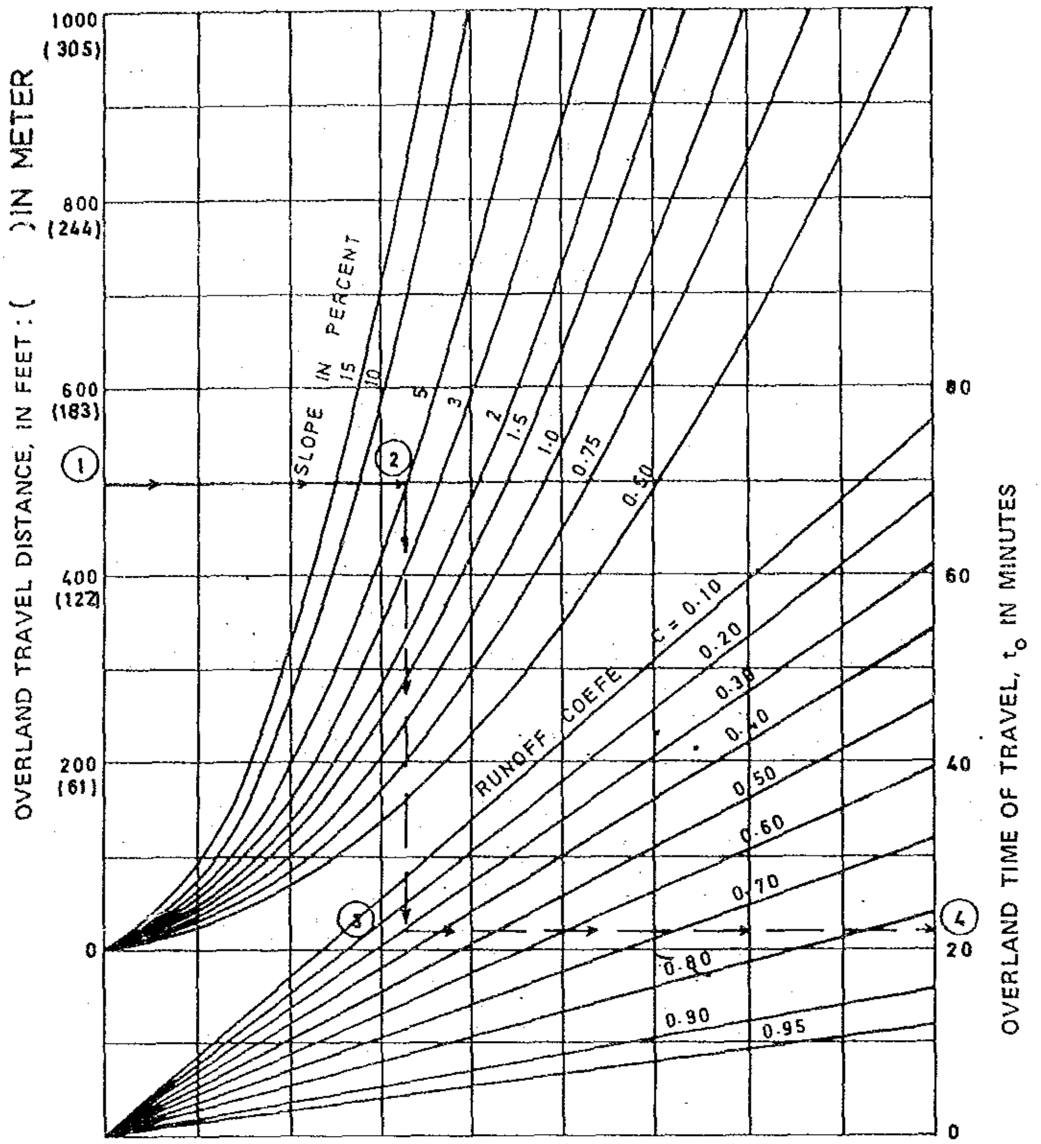


Figure Design Chart for Estimation of Overland Time of Flow

Source: D.I.D Planning and Design Procedure No. 1, 1975

Table C.2 Approximate Stream Velocities

Average Slope of Channel (percent)	Average Velocity (m./second)
1–2	0.6
2–4	0.9
4–6	1.2
6–10	1.5
10–15	1.8

Source: D.I.D Planning and Design Procedure No. 1, 1975

(b) Rainfall intensity-duration curve

The Rainfall intensity-duration curve of KUANTAN is adopted in this study.

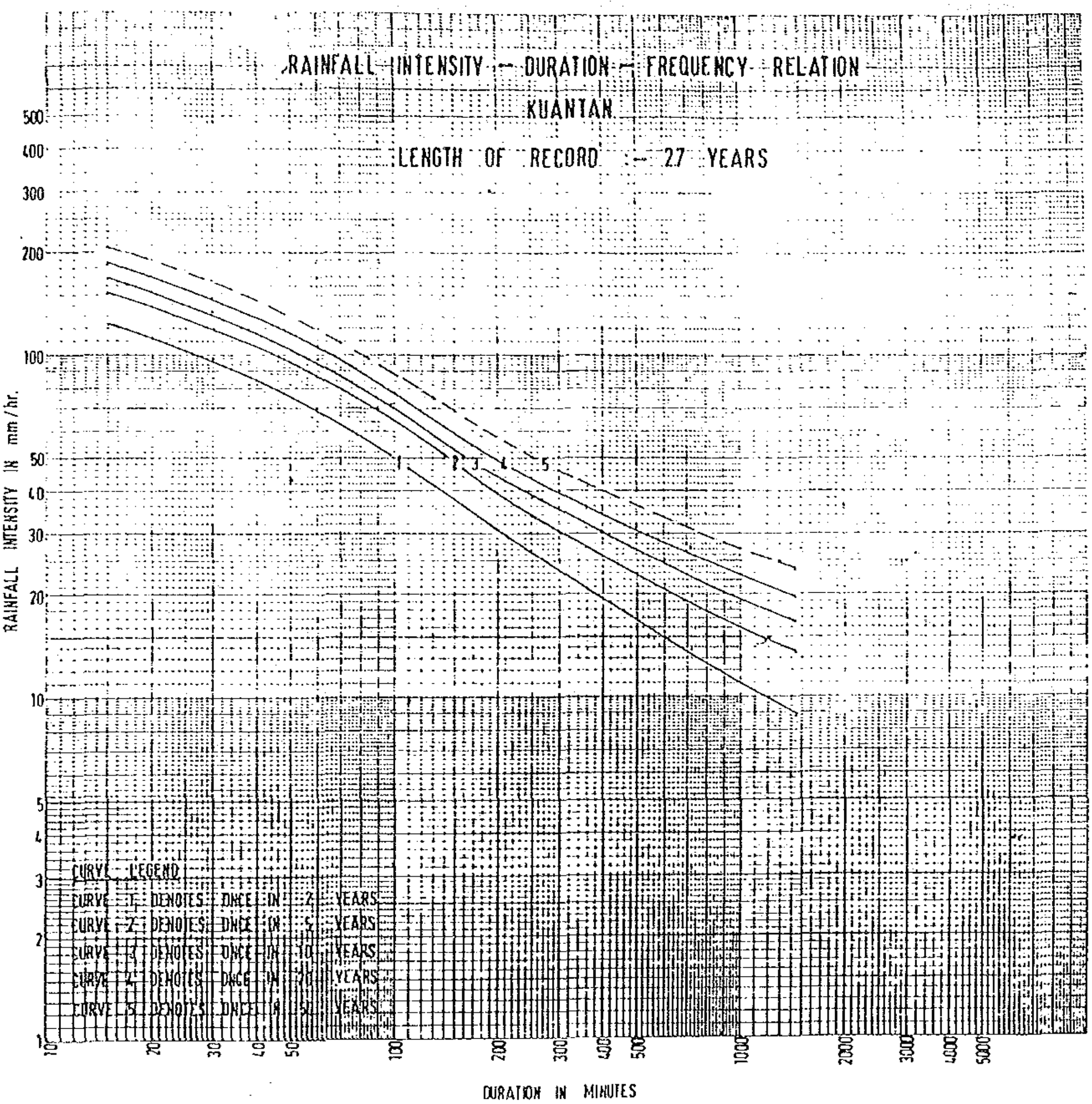


FIG:C.2 RAINFALL INTENSITY-DURATION CURVE

Source: D.I.D

(c) Runoff Coefficient (c)

The runoff coefficient, C, is the variable of the Rational Method least susceptible to precise determination. The values adopted in design are to be based on the ultimate expected development of the land. Table C.3 presents recommended values of runoff coefficients.

Table C.3 Rational Method Runoff Coefficients for Urban Centres

Land Use	Runoff Coefficient
Business: –	
City Areas Fully built-up and shophouses	0.90
Industrial: –	
Fully built-up	0.80
Residential: –	
(2 houses / acre)	0.55
(2 – 4 houses/acre)	0.65
(4 – 5 houses /acre)	0.75
(5 houses/ acre)	0.85
Pavement	0.95
Park (normally flat in urban areas)	0.30
Rubber	0.45
Jungle (nrmally steep in urban areas)	0.35
Mining Land	0.10
Bare Earth	0.75

Source: D.I.D. Planning and Design Procedure No.1, 1975

For catchments with composite land uses or surface characteristics, a weighted value of C are calculated from the formula:

$$C = \frac{A_1 C_1 + A_2 C_2 \ldots\ldots\ldots A_n C_n}{A}$$

Where C is the composite runoff coefficient A_1, A_2 etc. are n areas, each of relatively uniform land use or surface character, comprising the total area A.

and

C_1, C_2 etc. are the corresponding runoff coefficients obtained from Table C.4.

In this study, the following runoff coefficients are recommended for drainage system planning on the basis of the land usage pattern .

Table C.4 Recommended Runoff Coefficient

Land Use	Runoff Coefficient
Commercial/Business Area	0.90
Industrial Area	0.80
Residential Area	0.65
Mountain, Park Area/Open Space	0.35
Other Area	0.30

Source: D.I.D Planning and Design Procedure No.1, 1975

3. Flow Computation

Manning's formula shall be adopted for uniform flow computations. The formula is as follows:–

$$Q = A \cdot V \; ; V = \frac{1}{n} \cdot I^{1/2} \cdot R^{2/3}$$

Where

Q is Flow in m^3/S

n is Manning's roughness coefficient

A is Area in m^2

R is Hydraulic mean depth in meter

I is Slope in m/m.

Table C.5 Recommended Values of Manning's 'n'

Type of Channel and Description	Minimum	Normal	Maximum
1. Closed Conduits Flowing Partly Full			
Concrete culvert, straight and free of debris	.010	.011	.013
Concrete culvert with bends, connections with some debris,	.011	.013	.014
2. Lined or Built up Channels			
Precast invert sections and concrete lined channels	.013	.015	.017
Concrete bottom with cement rubble stone sides	.017	.020	.024
Channels with earth bottom, rubble sides	.020	.023	.026
3. Natural streams (1)			
Clean straight grassed banks	.025	.030	.035
Some weeds and stones	.030	.035	.040
4. Vegetal Lining	.030	.035	.05

Source: D.I.D. Planning and Design Procedure No. 1, 1975

The roughness coefficient adopted are Maximum values on Table C.5.

Table C.6 Adopted Values of Manning's 'n'

Type of Channel	n
Reinforced Concrete Channel	0.017
Wet Masonry Channel	0.026
Crassed Lined Channel	0.035

Source: D.I.D Planning and Design Procedure No. 1, 1975

4. Velocity of Flow

To prevent deposition of grit and sand in storm drains, the velocity of flow shall not be lower than 0.6 metre per second (2 ft/sec.) in any type of drain.

Care should also be given to maximum velocity of flow to prevent erosion of drains. The recommended minimum and maximum velocities for various types of drain are summarized on Table C.7.

Table C.7 Design Velocity

Type of Channel	Design Velocity (m/sec)	
	Minimum	Maximum
Reinforced Concrete Channel	0.6	3.0
Wet Masonry Channel	0.6	2.5
Grassed Lined Channel	0.6	2.2

Source: D.I.D Planning and Design Procedure No. 1, 1975

5. Freeboard

0.3m freeboard is adopted for Trunk Drain in this study.

TABLE C.8 KEMAMAN RIVER

ALTERNATIVE 1		ALTERNATIVE 2		ALTERNATIVE 3		ALTERNATIVE 4		PAST FLOOD LEVEL 1972	REMARKS
DISTANCE (km)	PROPOSED OUTSIDE WATER LEVEL (m)	DISTANCE (km)	PROPOSED OUTSIDE WATER LEVEL (m)	DISTANCE (km)	PROPOSED OUTSIDE WATER LEVEL (m)	DISTANCE (km)	PROPOSED OUTSIDE WATER LEVEL (m)	(m)	
- 0.6	+ 1.2					- 0.6	+ 1.2	- 0.5	
1	+ 1.5					1	+ 1.5	+ 2.0	
2	+ 1.7					2	+ 1.7	+ 2.2	
3	+ 1.9	(0)	+ 1.2	(0)	+ 1.2	3	+ 1.9	+ 2.4	
4	+ 2.1	(1)	+ 1.5	(1)	+ 1.5	4	+ 2.1	+ 2.6	
5	+ 2.3	(2)	+ 1.8	(2)	+ 1.8	5	+ 2.3	+ 2.9	
6	+ 2.6	2.7	+ 2.0	2.7	+ 2.2	6	+ 2.6	+ 3.2	
7	+ 2.9	3.7	+ 2.3	3.7	+ 2.3	7	+ 2.9	+ 3.4	
8	+ 3.2	4.7	+ 2.5	4.7	+ 2.5	8	+ 3.2	+ 3.7	
9	+ 3.4	5.7	+ 2.8	5.7	+ 2.8	9	+ 3.4	+ 4.0	
10	+ 3.7	6.7	+ 3.1	(7)	+ 3.2	(10)	+ 3.7	+ 4.3	
11	+ 4.0	7.7	+ 3.4	-	-	-	-	+ 4.6	
12	+ 4.3	8.7	+ 3.7	-	-	-	-	+ 4.9	
13	+ 4.6	9.7	+ 4.0	8.1	+ 3.5	11.4	+ 4.1	+ 5.1	
14	+ 5.0	10.7	+ 4.3	9.1	+ 3.8	12.4	+ 4.5	+ 5.4	
15	+ 5.2	11.7	+ 4.5	10.1	+ 4.1	13.4	+ 4.7	+ 5.7	
16	+ 5.4	12.7	+ 4.8	11.1	+ 4.4	14.4	+ 5.0	+ 6.0	

Source : Study Team, 1985

Note: 1. Water level is based on Mean Sea Level
2. Water level is flood level of 10 year frequency.

TABLE C.9 CUKAI RIVER

ALTERNATIVE 1, 4		ALTERNATIVE 2,3		PAST FLOOD LEVEL 1972	REMARKS
DISTANCE (km)	PROPOSED OUTSIDE WATER LEVEL (m)	DISTANCE (km)	PROPOSED OUTSIDE WATER LEVEL (m)	(m)	
- 2	+ 1.2	- 2	+ 1.2	-	
- 1	+ 1.4	- 1	+ 1.3	-	
0	+ 1.6	0	+ 1.4	+ 2.0	
1	+ 1.7	1	+ 1.5	+ 2.1	
2	+ 1.8	2	+ 1.7	+ 2.2	
3	+ 2.0	3	+ 1.8	+ 2.3	
4	+ 2.2	4	+ 2.0	+ 2.5	
5	+ 2.3	5	+ 2.1	+ 2.6	

Source: Study Team, 1985

Note : 1. Water level is based on Mean Sea Level.

2. Water level is flood level of 10 year frequency.

C.2 Storm Water Drainage System Design Data

PROJECT

Sheet C-2-1 .... of ....
Date ....
Designer ....

Table C.11 Storm Water Drainage System Design Data

$$Q = \frac{1}{360} \cdot C \cdot I \cdot A$$

LOCATION		AREA			SUB-AREA TIME OF CONCENTRATION			DRAIN DESIGN							DRAIN DETAILS								REMARKS
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)		(18)	(19)	(20)	(21)	(22)	
Drain Section	Sub-Area	Area (A)	Coefficient of Runoff (C)	Equivalent Area (C x A)	Overland Time	Drain Time	Sub-Area Time of Concentration	Design Return Period	Total Equiv. Area $\sum (C \times A)$	Critical Time of Concentration (t_c)	Total Time in Drain (t_d)	Storage Coefficient (C_s)	Rainfall Intensity (I)	Discharge $Q = \sum (C \times A) \times I \times C_s$	Grade	Type	Size	Capacity	Velocity	Length	Time of Flow in Section	[illegible]	
		ha		ha	Min	Min	Min	Years	ha	Min	Min		mm/hr	m^3/s	%			m^3/s	m/s	m	Min		
K-1	a	55	0.64	35.2	10	10	-	5	35.2	20	10	-	140	13.7	0.05	A	5.0X2.0	14.1	1.4	900	11	-	
K-1	b	22	0.73	16.1	10	5	-	5	16.1	15	5	-	150	6.7	0.1	A	3.0X1.5	6.9	1.5	400	5	-	Alternative 1,4
K-1	c	85	0.72	61.2	10	7	-	5	61.2	17	7	-	145	24.7	0.05	A	8.0X2.0	25.5	1.6	600	6	-	Alternative 1, 4
K-1	d	54	0.60	32.4	10	7	-	5	32.4	17	7	-	145	13.1	0.05	A	5.0X2.0	14.1	1.4	600	7	-	
K-2	a-1	124.0	0.65	80.6	10	12	-	5	80.6	22	12	-	135	30.2	0.05	A	8.0X2.3	31.2	1.7	1,100	11	-	
	a-2	54	0.65	35.1	-	6	22	5	115.7	28	18	-	125	40.2	0.05	A	10.0X2.3	41.0	1.8	500	5	-	
K-2	b-1	74.0	0.61	45.1	10	11	-	5	45.1	21	11	-	140	17.5	0.05	A	6.0X2.0	17.8	1.5	1,000	19	-	
	b-2	82.0	0.61	50.0	-	10	21	5	95.1	31	21	-	120	31.7	0.05	A	8.0X2.4	33.1	1.7	900	9	-	

Source: Study Team, 1985

PROJECT

Sheet C-2-2 of

Date

Designer

Table C.10 Storm Water Drainage System Design Data

$$Q = \frac{1}{360} \cdot C \cdot I \cdot A$$

LOCATION		AREA			SUB-AREA TIME OF CONCENTRATION			DRAIN DESIGN							DRAIN DETAILS								REMARKS
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)		(17)	(18)	(19)	(20)	(21)	(22)	
Drain Section	Sub-Area	Area (A)	Coefficient of Runoff (C)	Equivalent Area (C × A)	Overland Time	Drain Time	Sub-Area Time of Concentration	Design Return Period	Total Equiv. Area Σ (C × A)	Critical Time of Concentration (t_c)	Total Time in Drain (t_d)	Storage Coefficient (C_s)	Rainfall Intensity (I)	Discharge (Q = Σ (C × A) x I x C_s)	Grade	Type	Size	Capacity	Velocity	Length	Time of Flow in Section	Invert Level	
		ha		ha	Min	Min	Min	Years	ha	Min	Min		mm/hr	m^3/s	%			m^3/s	m/s	m	Min		
K-3	c-1	129	0.46	59.3	10	23	-	5	59.3	33	23	-	115	18.9	0.05	B	8.4 6.0X2.4	19.7	1.1	1400	21	-	Alternative 1,2
	c-2	89	0.46	40.9	-	13	33	5	100.2	46	36	-	100	27.8	0.05	B	10.5 8.0X2.5	28.4	1.2	800	11	-	Alternative 1,2
C-1	a	38	0.79	30.0	10	7	-	5	30.0	17	7	-	145	12.1	0.1	A	4.0X1.8	12.9	1.8	600	6	-	
C-1	b	112	0.56	62.7	10	20	-	5	62.7	30	20	-	120	20.9	0.05	A	6.0X2.4	23.0	1.6	1800	19	-	
C-1	c	64	0.57	36.5	10	20	-	5	36.5	30	20	-	120	12.2	0.1	A	4.0X1.8	12.9	1.8	1800	17	-	
C-1	d-1	63	0.62	39.1	10	9	-	5	39.1	19	9	-	140	15.2	0.1	A	4.0X2.2	16.9	1.9	1100	10	-	
C-1	d-2	38	0.62	23.6	-	9	19	5	62.7	28	18	-	125	21.8	0.05	A	6.0X2.4	23.0	1.6	800	8	-	
C-1	e	56	0.61	34.2	10	13	23	5	34.2	23	13	-	115	10.9	0.05	A	4.0X2.2	11.9	1.4	1200	14	-	

Source: Study Team, 1985

PROJECT

Sheet C-2-3 of ....
Date ....
Designer ....

Table C.12 Storm Water Drainage System Design Data

$$Q = \frac{1}{360} \cdot C \cdot I \cdot A$$

LOCATION		AREA			SUB-AREA TIME OF CONCENTRATION			DRAIN DESIGN							DRAIN DETAILS								REMARKS
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)		(18)	(19)	(20)	(21)	(22)	
Drain Section	Sub-Area	Area (A)	Coefficient of Runoff (C)	Equivalent Area (C × A)	Overland Time	Drain Time	Sub-Area Time of Concentration	Design Return Period	Total Equiv. Area Σ (C × A)	Critical Time of Concentration (t_c)	Total Time in Drain (t_d)	Storage Coefficient (C_s)	Rainfall Intensity (i)	Discharge $Q = \Sigma (C \times A) \times i \times C_s$	Grade	Type	Size	Capacity	Velocity	Length	Time of Flow in Section	Invert Level	
		ha		ha	Min	Min	Min	Years	ha	Min	Min		mm/hr	m³/s	%			m³/s	m/s	m	Min		
C-2	a-1	796	0.34	270.6	30	20	-	5	270.6	50	20	-	95	71.4	0.05	C	35.6 20.0X2.6	72.9	1.0	1200	20	-	
	a-2	604	0.34	205.4	-	30	50	5	476.0	80	50	-	75	99.2	0.05	C	38.0 20.0X3.0	107.1	1.1	1800	27	-	
	a-3	1073	0.34	364.8	-	33	80	5	840.8	113	83	-	60	140.1	0.05	C	45.4 25.0X3.4	143.6	1.2	2000	28	-	
C-3	a-1	177	0.41	72.6	10	17	-	5	72.6	27	17	-	125	25.2	0.05	B	10.4 8X2.4	26.5	1.2	1000	14	-	
	a-2	125	0.41	51.3	-	17	27	5	123.9	44	34	-	100	34.4	0.05	B	15 10X2.5	35.9	1.3	1000	13	-	
C-3	b	115	0.60	69.0	10	20	-	5	69.0	30	20	-	120	23.0	0.05	B	10.2 8.0X2.3	24.8	1.2	1200	17	-	
C-3	c	150	0.57	85.5	10	20	-	5	85.5	30	20	-	120	28.5	0.05	B	10.6 8.0X2.6	30.2	1.2	1200	17	-	

Source: Study Team, 1985

PROJECT

Sheet C-2-4 .... of ....
Date ....
Designer ....

Table C.13 Water Drainage System Design Data

$$Q = \frac{1}{360} \cdot C \cdot I \cdot A$$

LOCATION		AREA			SUB-AREA TIME OF CONCENTRATION			DRAIN DESIGN							DRAIN DETAILS								REMARKS
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)		(18)	(19)	(20)	(21)	(22)	
Drain Section	Sub-Area	Area (A)	Coefficient of Runoff (C)	Equivalent Area (C x A)	Overland Time	Drain Time	Sub-Area Time of Concentration	Design Return Period	Total Equiv. Area Σ (C x A)	Critical Time of Concentration (t_c)	Total Time in Drain (t_d)	Storage Coefficient (C_s)	Rainfall Intensity (I)	Discharge $Q = \Sigma (C \times A) \times i \times C_s$	Grade	Type	Size	Capacity	Velocity	Length	Time of Flow in Section	Invert Level	
		ha		ha	Min	Min	Min	Years	ha	Min	Min		mm/hr	m³/s	%			m³/s	m/s	m	Min		
K-1	b	31	0.78	24.2	10	5	-	5	24.2	15	5	-	150	10.1	0.1	A	4.0X1.6	11.0	1.7	400	4	-	Alternative 2,3
K-1	c	96	0.73	70.1	10	7	-	5	70.1	17	7	-	145	28.2	0.05	A	8.0X2.2	29.2	1.7	600	6	-	Alternative 2,3
K-3	C-1	129	0.57	73.5	10	23	-	5	73.5	33	23	-	115	23.5	0.05	B	10.3 8.0X2.3	24.8	1.2	1400		-	Alternative 3,4
	C-2	88	0.57	50.2	-	13	33	5	123.7	46	36	-	100	34.4	0.05	B	12.5 10.0X2.5	35.9	1.3	800		-	Alternative 3,4

Source: Study Team, 1985

C.3 Study of Landfill

TABLE C.14

FILL-UP HIGHT AND FILL-UP VOLUME
(WITHOUT PROJECT)

NAME OF DRAINAGE AREA	FILL-UP AREA ① (ha)	RIVER WATER LEVEL (m)	PRESENT M.G.E. ② (m)	FILL-UP M.G.E. ③ (m)	FILL-UP Hight ④=③-② (m)	AMOUNT OF FILL-UP ⑤=①×④ (m^3)	ACTUAL FILL-UP VOLUME ⑥=⑤× 0.8 (m^3)
K-1	164	3.0	1.2	3.5	2.3	3,772,000	(3,018,000)
K-2	254	3.6	2.2	4.0	1.8	4,572,000	(3,657,000)
K-3-a	24	4.0	1.5	4.5	3.0	720,000	(576,000)
K-3-b	132	4.6	1.0	5.0	4.0	5,280,000	(4,224,000)
K-3-c-1	124	5.0	2.5	5.5	3.0	3,720,000	(2,976,000)
K-3-c-2	71	5.0	2.5	5.5	3.0	2,130,000	(1,704,000)
K-3-d-1	173	5.1	2.0	6.0	4.0	6,920,000	5,536,000
K-3-d-2	231	5.1	2.5	5.5	3.0	6,930,000	5,544,000
K-4	200	3.2	1.2	3.5	2.3	4,600,000	3,680,000
K-5	104	2.4	2.5	3.0	0.5	520,000	416,000
C-1	103	2.5	1.6	3.0	1.4	1,442,000	(1,154,000)
C-2-a-1	270	2.5	2.4	4.5	2.1	5,670,000	4,536,000
C-2-a-2	197	2.5	2.0	4.0	2.0	3,940,000	3,152,000
C-2-a-3	255	2.5	1.6	3.0	1.4	3,570,000	2,856,000
C-3	247	2.4	2.5	3.0	0.5	1,235,000	(988,000)
TOTAL	2,549						44,017,000
							(18,297,000)

Source: Study Team, 1985

Note : M.G.E. is Mean Ground Elevation above Mean Sea Level.

TABLE C.15

FILL-UP HIGHT AND FILL-UP VOLUME
(ALTERNATIVE 1)

NAME OF DRAINAGE AREA	FILL-UP AREA ① (ha)	RIVER WATER LEVEL (m)	PRESENT M.G.E. ② (m)	FILL-UP M.G.E. ③ (m)	FILL-UP Hight ④=③-② (m)	AMOUNT OF FILL-UP ⑤=①×④ (m^3)	ACTUAL FILL-UP VOLUME ⑥=⑤× 0.8 (m^3)
K-1	120	2.3	1.2	3.0	1.8	2,160,000 - 900,000	(1,010,000)
K-2	254	3.0	2.2	2.5	Pumping	Station	1,000,000
K-3-a	24	3.4	1.5	2.5			
K-3-b	114	4.0	1.0	2.5			
K-3-c-1	124	4.6	2.5	2.5	Pumping	Station	1,000,000
K-3-c-2	71	4.6	2.5	2.5			
K-3-d-1	173	4.6	2.0	2.5			
K-3-d-2	231	4.6	2.5	2.5			
K-4	200	2.6	1.2	3.0	1.8	3,600,000	2,880,000
K-5	-	1.9	2.5	-	-	-	-
C-1	103	2.2	1.6	2.5	0.9	927,000	(742,000)
C-2-a-1	270	2.2	2.4	4.0	1.6	4,320,000	3,456,000
C-2-a-2	197	2.2	2.0	3.5	1.5	2,955,000	2,364,000
C-2-a-3	255	2.2	1.6	2.5	0.9	2,295,000	1,836,000
C-3	-	1.8	2.5	-	-	-	-
TOTAL	2,136						14,288,000
							(1,752,000)

Source: Study Team, 1985

Note : M.G.E. is Mean Ground Elevation above Mean Sea Level.

TABLE C.16

FILL-UP HIGHT AND FILL-UP VOLUME
(ALTERNATIVE 2)

NAME OF DRAINAGE AREA	FILL-UP AREA ① (ha)	RIVER WATER LEVEL (m)	PRESENT M.G.E. ② (m)	FILL-UP M.G.E. ③ (m)	FILL-UP Hight ④=③-② (m)	AMOUNT OF FILL-UP ⑤=①×④ (m^3)	ACTUAL FILL-UP VOLUME ⑥=⑤×0.8 (m^3)
K-1	132	1.8	1.2	2.5	1.3	1,716,000 - 400,000	(1,052,000)
K-2	254	2.4	2.2	3.0	0.8	2,032,000 - 200,000	(1,465,000)
K-3-a	24	2.9	1.5	3.5	2.0	480,000	(384,000)
K-3-b	114	3.5	1.0	4.0	3.0	3,420,000 - 1,350,000	(1,656,000)
K-3-c-1	124	4.1	2.5	4.5	2.0	2,480,000	(1,984,000)
K-3-c-2	71	4.1	2.5	4.5	2.0	1,420,000	(1,136,000)
K-3-d-1	173	4.1	2.0	5.0	3.0	5,190,000	4,152,000
K-3-d-2	231	4.1	2.5	4.5	2.0	4,620,000	3,696,000
K-4	200	2.1	1.2	2.5	1.3	2,600,000	2,080,000
K-5	-	1.5	2.5	-	-	-	-
C-1	103	2.0	1.6	2.5	0.9	927,000	(742,000)
C-2-a-1	270	2.0	2.4	4.0	1.6	4,320,000	3,456,000
C-2-a-2	197	2.0	2.0	3.5	1.5	2,955,000	2,364,000
C-2-a-3	255	2.0	1.6	2.5	0.9	2,295,000	1,836,000
C-3	-	1.7	2.5	-	-	-	-
TOTAL	2,148						26,003,000
							(8,419,000)

Source: Study Team, 1985

Note : M.G.E. is Mean Ground Elevation above Mean Sea Level.

TABLE C.17

FILL-UP HIGHT AND FILL-UP VOLUME
(ALTERNATIVE 3)

NAME OF DRAINAGE AREA	FILL-UP AREA ① (ha)	RIVER WATER LEVEL (m)	PRESENT M.G.E. ② (m)	FILL-UP M.G.E. ③ (m)	FILL-UP Hight ④=③-② (m)	AMOUNT OF FILL-UP ⑤=①×④ (m^3)	ACTUAL FILL-UP VOLUME ⑥=⑤× 0.8 (m^3)
K-1	132	1.8	1.2	2.5	1.3	1,716,000 - 400,000	(1,052,000)
K-2	254	2.4	2.2	3.0	0.8	2,032,000 - 200,000	(1,465,000)
K-3-a	24	2.9	1.5	3.5	2.0	480,000	-
K-3-b	24	3.2	1.0	3.5	2.5	600,000	-
K-3-c-1	124	3.6	2.5	4.0	1.5	1,860,000	(1,488,000)
K-3-c-2	71	3.6	2.5	4.0	1.5	1,060,000	(843,000)
K-3-d-1	173	3.6	2.0	4.5	2.5	4,325,000	3,460,000
K-3-d-2	231	3.6	2.5	4.0	1.5	3,465,000	2,772,000
K-4	200	2.1	1.2	2.5	1.3	2,600,000	2,080,000
K-5	-	1.5	2.5	-	-	-	-
C-1	103	2.0	1.6	2.5	0.9	927,000	(742,000)
C-2-a-1	270	2.0	2.4	4.0	1.6	4,320,000	3,456,000
C-2-a-2	197	2.0	2.0	3.5	1.5	2,955,000	2,364,000
C-2-a-3	255	2.0	1.6	2.5	0.9	2,295,000	1,836,000
C-3	-	1.7	2.5	-	-	-	-
TOTAL	2,058						21,558,000
							(5,590,000)

Source: Study Team, 1985

Note : M.G.E. is Mean Ground Elevation above Mean Sea Level.

TABLE C.18

FILL-UP HIGHT AND FILL-UP VOLUME (ALTERNATIVE 4)

NAME OF DRAINAGE AREA	FILL-UP AREA ① (ha)	RIVER WATER LEVEL (m)	PRESENT M.G.E. ② (m)	FILL-UP M.G.E. ③ (m)	FILL-UP Hight ④=③-② (m)	AMOUNT OF FILL-UP ⑤=①×④ (m^3)	ACTUAL FILL-UP VOLUME ⑥=⑤× 0.8 (m^3)
K-1	120	2.3	1.2	3.0	1.8	2,160,000 - 900,000	(1,010,000)
K-2	254	3.0	2.2	3.5	1.3	3,302,000 - 310,000	(2,392,000)
K-3-a	24	3.4	1.5	4.0	2.5	600,000	-
K-3-b	24	3.7	1.0	4.0	3.0	720,000	-
K-3-c-1	124	4.1	2.5	4.5	2.0	2,480,000	(1,984,000)
K-3-c-2	71	4.1	2.5	4.5	2.0	1,420,000	(1,136,000)
K-3-d-1	173	4.1	2.0	5.0	3.0	5,190,000	4,152,000
K-3-d-2	231	4.1	2.5	4.5	2.0	4,620,000	3,696,000
K-4	200	2.6	1.2	3.0	1.8	3,600,000	2,880,000
K-5	-	1.9	2.5	-	-	-	-
C-1	103	2.2	1.6	2.5	0.9	927,000	(742,000)
C-2-a-1	270	2.2	2.4	4.0	1.6	4,320,000	3,456,000
C-2-a-2	197	2.2	2.0	3.5	1.5	2,955,000	2,364,000
C-2-a-3	255	2.2	1.6	2.5	0.9	2,295,000	1,836,000
C-3	-	1.8	2.5	-	-	-	-
TOTAL	2,046						25,648,000
							(7,264,000)

Source: Study Team, 1985

Note : M.G.E. is Mean Ground Elevation above Mean Sea Level.

C.4 Study of Pumping Drainage

1. Design Rainfall

Frequency (%)	*1 Rainfall intensity for 1440 minutes duration (mm/hr)	Daily rainfall (mm)
50	8.9	214
20	13.6	327 *2
10	16.5	396
5	19.5	468
2	23.5	564

*1 Rainfall Intensity-Duration-Freuqency Relation, Kuantan, Length of Record – 27 years, DID

*2 Design daily rainfall

2. Pumping Capacity for the Drainage Area of 1 KM^2 Assuming,
   - Total volume of flood water shall be drained within 24 hours.
   - Volume of flood water during the time, which flood discharge is larger than pumping capacity, shall be storaged in the pond attached to the pumping station.
   - Runoff coefficient = 0.7
   - Design flood (rainfall) frequency = 5 years. We obtain pump capacity as follows.

1) Total volume of flood water : Vo

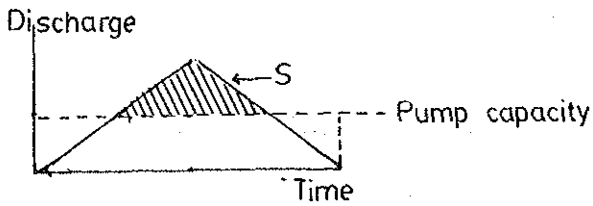
Vo = 327 mm X 1 Km^2 X 0.7 = 229.000 m^3

2) Pump capacity : P

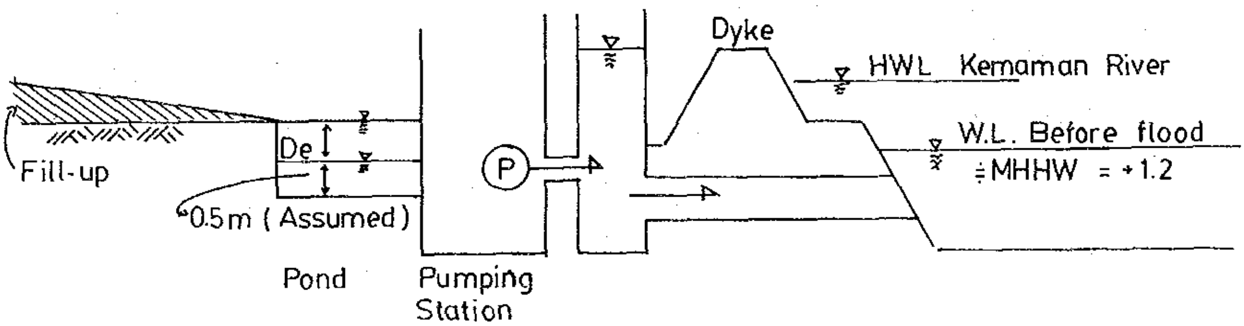
P = 229000m^3/86400 sec = 2.65 m^3/S

3) Required capacity of the pond : S

S = 1/4 X 229,000 = 57,300 m^3



4) Effective depth of the pond : De



De = 1m ~ 1.5m

5) Area necessary for pond : Ap

For De = 1m, A = 57,300 X 1/1.0 = 57,300 m^2

= 5.8 ha

Dredge volume = 57,300 X 1.5 = 86,000 m^3

For De = 1.5 m, a = 57,300 X 1/1.5 = 38,200 m^2

= 3.8 ha

Dredge volume = 38,200 X 2.0 = 76,400 m^3

6) Cost

De = 1m ; 2.65 m^3/S X 0.8
X 10^6 M$/$m^3$/s =M$ 2.12 X 10^6
86,000 m^3 X 5M$/$m^3$ =M$ 0.43 X 10^6
Total: M$ 2.55 X 10^6

De = 1.5m: 2.65X0.8X10^6 = M$ 2.12 X 10^6
76,400 X 5 = M$ 0.38 X 10^6
Total: M$ 2.50 X 10^6

3. Comparison of Pumping and Earth Filling Costs

1) For one meter fill-up of 1 Km^2,
Cost (by dredging) = 1X$10^6$$m^3$X5M$/m^3= M$ 5X10^6
Cost (by truck) = 1X$10^6$$m^3$X10M$/m^3= M$10X$10^6$

2) Pumping

Pumping station and pond	= M$ 2.55 X 10^6
Maintenance (Every 20 years life time of pump, 2.65 X 0.5 = 1.33)	= M$ 1.33 X 10^6 (every 20 years)
Running (0.5% X 2.12 = 0.011)	= M$ 0.011 X 10^6 (every year)
Total (20 years)	M$ 4.1 x 10^6

4. Costs

1) K-3 Area
Drainage area = 9.09 Km^2
Cost : (1) 2.55 X 9.09 = M$23.18 X 10^6 (construction)
(2) 1.33 X 9.09 = M$12.09 X 10^6 (every 20 years)
(3) 0.011X 9.09 = M$ 0.10 X 10^6 (every year)
(4) 2 Km^2 X 0.5m X 5M$/$m^3$
= M$ 5.00 X 10^6 (Fill for drainage)
(1) + (4) = M$28.18 X 10^6

2) K-2 Area

Drainage area = 3.34 Km^2

Cost : (1) 2.55 X 3.34 = M\$ 8.52 X 10^6

(2) 1.33 X 3.34 = M\$ 4.44 X 10^6

(3) 0.011X 3.34 = M\$ 0.04 X 10^6

(4) 2.00 Km^2 X 0.5m X 5M\$/m^3

=M\$5.00 X 10^6 (by river dredging)

APPENDIX D

CONSTRUCTION COST ESTIMATION

TABLE D.1

QUANTITIES - FLOOD CONTROL
KEMAMAN RIVER

ITEM	ALTERNATIVE 1	2	3	4
1 River mouth improvement				
Training dyke (Rubble mound)	$72x10^3 m^3$	$104x10^3 m^3$	$104x10^3 m^3$	$72x10 m^3$
2 Diversion channel				
Dredging		$1.77x10^6 m^3$	$1.77x10^6 m^3$	
Revetment (concrete block		$17.5x10^3 m^3$	$17.5x10^3 m^3$	
3 Separation levee				
Earth filling		$9600 m^3$	$9600 m^3$	
Gabion		$4000 m^3$	$4000 m^3$	
Steel sheet piling		$9600 m^2$	$9600 m^2$	
4 Dredging and dyke/ fill-up				
1) Downstream of div. chan.				
Dredging	$2.64x10^3 m^3$			$2.64x10^3 m^3$
Major-bed Arrangement	$0.8x10^6 m^3$			$0.8x10^6 m^3$
2) Upstream of diversion channel				
From 1.3km-5.8km	$2.25x10^6 m^3$	$2.25x10^6 m^3$	$2.25x10^6 m^3$	$2.25x10^6 m^3$
From 5.8km-8.8km		$1.35x10^6 m^3$		$1.35x10^6 m^3$
Major-bed Arrangement	$750x10^3 m^3$	$750x10^3 m^3$	$750x10^3 m^3$	$750x10^3 m^3$
3) Short-cut			$1300x10^3 m^3$	$1300x10^3 m^3$
5 Revetment				
1) Downstream (Gabion)	$26x10^3 m^3$			$26x10^3 m^3$
2) From 1.3km-11km	$39x10^3 m^3$	$39x10^3 m^3$	$39x10^3 m^3$	$39x10^3 m^3$
6 Kampung relocation	1 Lum.	1 Lum.	1 Lum.	1 Lum.
7 Land aquisition	93 ha	93 ha	81 ha	81 ha

Source: Study Team, 1985

TABLE D.2. QUANTITIES - FLOOD CONTROL
CUKAI RIVER

ITEM	ALTERNATIVE			
	1	2	3	4
1 River mouth improvement				
Training dyke		56×10^3 m^3	56×10^3 m^3	
2 Dredging and dyke/ fill-up	0.56×10^6 m^3	0.78×10^6 m^3	0.78×10^6 m^3	0.56×10^6 m^3
3 Revetment (Gabion)	21×10^3 m^3	30×10^3 m^3	30×10^3 m^3	21×10^3 m^3
4 Bush clearing (with trees)	20 ha	20 ha	20 ha	20 ha
Others				
1 Bridge reconstruction	1 Lum.	1 Lum.	1 Lum.	1 Lum.
2 Barrage	1 Lum.	1 Lum.	1 Lum.	1 Lum.

Source: Study Team, 1985

TABLE D.3 QUANTITIES - URBAN DRAINAGE

ITEM	ALTERNATIVE			
	1	2	3	4
Proposed Trunk Drain	17,900m	17,900m	17,900m	17,900m
Existing Trunk Drain	2,000m	2,000m	2,000m	2,000m
Proposed Secondary Drain	1,388ha	1,420ha	1,464ha	1,388ha
Land Filling	1,752x10³ m³	8,419x10³ m³	5,590x10³ m³	7,264x10³ m³
* Actual Land Filling	0	6,030x10³ m³	3,201x10³ m³	3,562x10³ m³
Pumping Station	2 Stations	-	-	-
Flood Gate	2 set	1 set	1 set	5 set
Bridge (W = 6.0 m)	1,560 m²	1,560 m²	1,620 m²	1,620 m²

Source: Study Team, 1985

Note : * V = (Land Filling Volume) - (Effective River Dredging Volume)
This volume is used for cost estimation

TABLE D.4 SCHEDULE OF UNIT CONSTRUCTION COSTS
(1984 PRICE LEVEL)

NO	DESCRIPTION	UNIT	UNIT COST M$	REMARKS
1	Excavation using dragline	m^3	3.20	
2	Compacted backfill	m^3	2.00	
3	Earthfill from borrow area and compaction	m^3	10.00	
4	Transport spoil over average distance of 1 km	m^3	1.00	
5	Reinforced concrete (including formwork and reinforcement) 1:2:4	m^3	500.00	
6	Plain concrete (including formwork) 1:3:6	m^3	300.00	
7	Wet Masonry Works t = 300 mm	m^2	52.00	
8	Reinforced concrete bridge			
	Heavy traffic	m^2	1,600.00	
	Medium traffic	m^2	1,200.00	
9	Dredging including earthfill by Suction Dredger	m^3	5.00	
10	Gabion	m^3	90.00	
11	Mattresses	m^3	150.00	
12	Rubble Mound	m^3	160.00	
13	Concrete Block	m^3	230.00	
14	Bush Clearing	ha	1,200.00	
15	Secondary Drain			
	Commercial and Industry area	ha	34,000.00	
	Residential area	ha	25,100.00	
16	Steel sheet piling	m^2	200.00	
17	Pumping Station	m^3/sec	0.8×10^6	
18	Flood Gate	set	0.5×10^6	
19	Barrage	Lump.sum	5.0×10^6	* cost of other countermeasure against salinity intrusion

Source: 1/ S.D.I.D.

2/ Drainage Master Plan For Kuala Kedah, March 1981, JICA

TABLE D.5 EXPENDITURE SCHEDULE (ALTERNATIVE 1)

M$ 10^6

	ITEM	1985-1990	1991-1995	1996-2000	GRAND TOTAL
	PREPARATION WORKS	5.00			5.00
FLOOD CONTROL COSTS	BARRAGE	5.00			5.00
	RIVER MOUTH IMPROVEMENT	11.52			11.52
	LAND AQUISITION/KG.RELOCATION	6.86			6.86
	DREDGING AND DYKE/LAND FILLING	25.05	21.00		46.05
	CUKAI RIVER IMPROVEMENT		3.00		4.73
	MAINTENANCE		0.74	1.85	2.59
URBAN DRAIN-AGE COSTS	TRUNK DRAIN	15.60	19.12		34.72
	SECONDARY DRAIN	10.40	13.00	12.18	35.58
	PUMPING STATION		36.70		36.70
	MAINTENANCE	0.24	1.32	2.70	4.26
	SUB TOTAL	81.40	94.88	16.73	193.01
	CONSULTANTS FEES	3.30	2.20		5.50
	TOTAL	84.70	97.08	16.73	198.51

Source: Study Team, 1985

TABLE D.6 EXPENDITURE SCHEDULE (ALTERNATIVE 2)

M$ 10^6

	ITEM	1985-1990	1991-1995	1996-2000	GRAND TOTAL
	PREPARATION WORKS	5.00			5.00
FLOOD CONTROL COSTS	BARRAGE	5.00			5.00
	DIVERSION CHANNEL/RIVER MOUTH IMPROVEMENT	24.52	8.00		32.52
	LAND AQUISITION/KG.RELOCATION	5.56			5.56
	DREDGING AND DYKE/LAND FILLING	18.26	15.00		33.26
	CUKAI RIVER IMPROVEMENT	6.59	9.00		15.59
	MAINTENANCE		0.92	2.30	3.22
URBAN DRAINAGE COSTS	TRUNK DRAIN	15.60	18.76		34.36
	SECONDARY DRAIN	10.80	13.50	12.42	36.72
	LAND FILLING	2.80	14.00	13.35	30.15
	MAINTENANCE	0.24	1.20	1.80	3.24
	SUB TOTAL	94.37	80.38	29.87	204.62
	CONSULTANTS FEES	3.70	2.60		6.30
	TOTAL	98.07	82.98	29.87	210.92

Source: Study Team, 1985

TABLE D.7 EXPENDITURE SCHEDULE (ALTERNATIVE 3)

M$ 10^6

	ITEM	1985-1990	1991-1995	1996-2000	GRAND TOTAL
	PREPARATION WORKS	5.00			5.00
FLOOD CONTROL COSTS	BARRAGE	5.00			5.00
	DIVERSION CHANNEL/RIVER MOUTH IMPROVEMENT	24.52	8.00		32.52
	LAND AQUISITION/KG.RELOCATION	6.10			6.10
	DREDGING AND DYKE/LAND FILLING	16.51	10.00		26.51
	SHORT CUT		6.50		6.50
	CUKAI RIVER IMPROVEMENT	6.59	9.00		15.59
	MAINTENANCE		0.92	2.30	3.22
URBAN DRAINAGE COSTS	TRUNK DRAIN	15.60	18.85		34.45
	SECONDARY DRAIN	10.80	13.50	13.52	37.82
	LAND FILLING	1.50	7.50	7.00	16.00
	MAINTENANCE	0.24	1.20	1.80	3.24
	SUB TOTAL	91.86	75.47	24.62	191.95
	CONSULTANTS FEES	3.70	2.60		6.30
	TOTAL	95.56	78.07	24.62	198.25

Source: Study Team, 1985

TABLE D.8 EXPENDITURE SCHEDULE (ALTERNATIVE 4)

M$ 10^6

	ITEM	1985-1990	1991-1995	1996-2000	GRAND TOTAL
	PREPARATION WORKS	5.00			5.00
FLOOD CONTROL COSTS	BARRAGE	5.00			5.00
	DIVERSION CHANNEL/RIVER MOUTH IMPROVEMENT	11.52			11.52
	LAND AQUISITION/KG.RELOCATION	7.40			7.40
	DREDGING AND DYKE/LAND FILLING	32.80	20.00		52.80
	SHORT CUT		6.50		6.50
	CUKAI RIVER IMPROVEMENT	1.73	3.00		4.73
	MAINTENANCE		0.88	2.20	3.08
URBAN DRAINAGE COSTS	TRUNK DRAIN	16.40	19.91		36.31
	SECONDARY DRAIN	9.58	13.00	13.00	35.58
	LAND FILLING	1.81	8.00	8.00	17.81
	MAINTENANCE	0.24	1.20	1.80	3.24
	SUB TOTAL	91.48	72.49	25.00	188.97
	CONSULTANTS FEES	3.60	2.60		6.20
	TOTAL	95.08	75.09	25.00	195.17

Source: Study Team, 1985

APPENDIX E

ECONOMIC EVALUATION

E.1. BASIC DATA ESTIMATION

As for the basic data,

a) Population in the Cukai town area

b) Numbers of living quarters

are prepared.

a) Secular change in population in the Cukai town area is drawn in Fig. E.1 and tabulated in Table E.1.

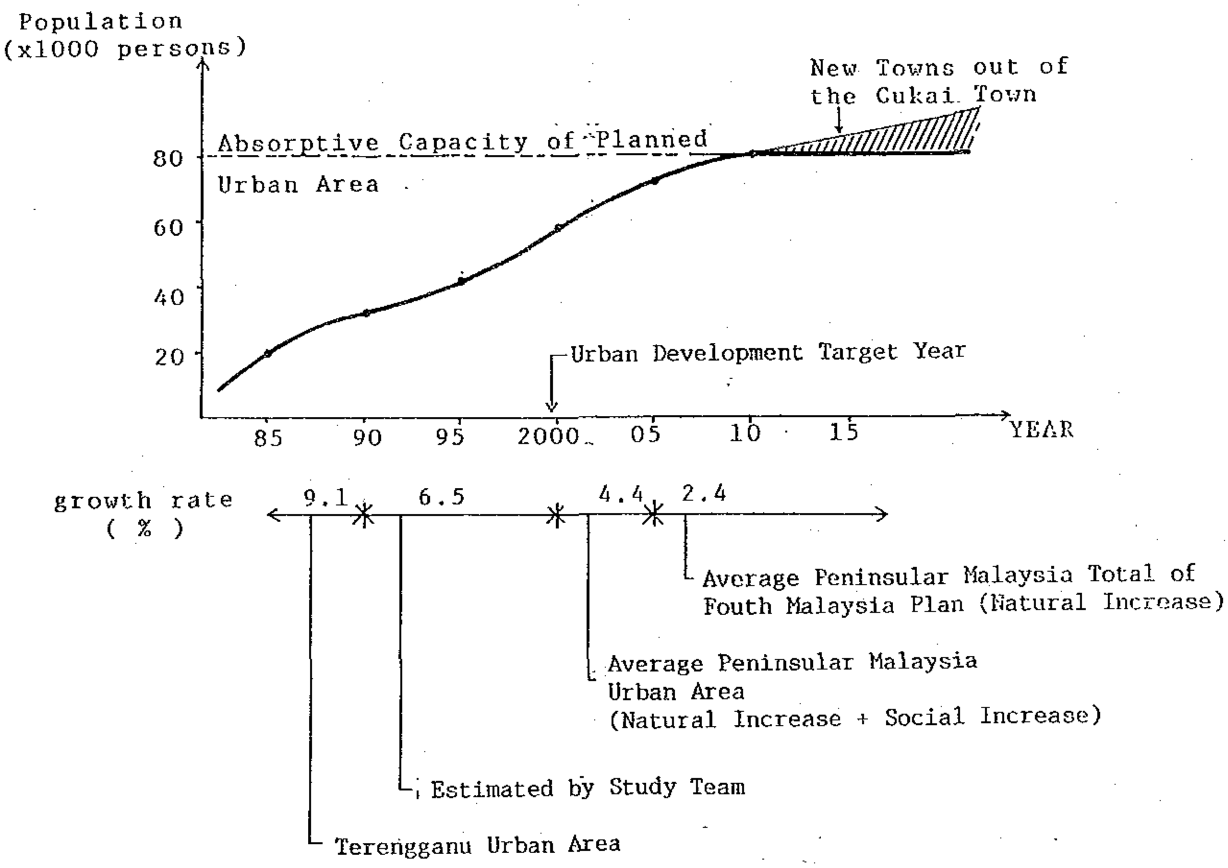


Fig. E.1 ESTIMATED POPULATION IN CUKAI TOWN AREA

Note: Figures of the year 1990 is affected by an increase in town area. Underdeveloping area is included in Cukau Towan Area in 1990.

TABLE E.1 ESTIMATED POPULATION IN CUKAI TOWN AREA

(x 1000 persons)

1985	1990	1995	2000	2005	2010
20	31	42	58	72	81

b) Number of living quarters in the Cukai town area are estimated with two steps.

(First Step)

Famili size = population in 1980 (Mukim Cukai) / total number of living Quarters in 1980 (Mukim Cukai)

= 25,384 (persons)/5,166 (living quarters)

= 4.91 (persons/living quarters)

Family size in the future is assumed to be 5 persons/living quarter and be constant.

(Second Step)

Estimated number of living quarters at each year (1985, 2000 and 2010)

= Population forecasted (1985, 2000, 2010)/family size

= 20,000/5 = 4,000 (1985)

= 58,000/5 = 11,600 (2000)

= 81,000/5 = 16,200 (2010)

Figures of living quarters at each year are readjusted according to the flood prone area.

E.2 FLOOD DAMAGE POTENTIAL ESTIMATION

a) Methods

The value of the flood damage potential estimated at the year 1985, 2000 and 2010, and is assumed to increase linearly from the year 1985 to 2010. It is constant after the year 2010 forth.

Town area is expected to grow outside the Cukai town area from the year 2010 as shown by the hatched part in Figure E.1.

b) Identification of Flood Damage

Flood damages identified are categorized into four items with various sub-items which are:–

1) General Property Damage Potential
2) Public Property Damage Potential
3) Agriculture Products Damage Potential
4) Income/Sales Loss Potentials

c) Estimation of Each Flood Damage Potential

Aggregated flood damage potentials are summarized in Table E.2.

Table E.2 AGGREGATED FLOOD DAMAGE POTENTIAL CORRESPONDING TO FLOOD FREQUENCY

(Unit: x10^6 M$)

Alternative	Year	Flood Frequency (%)				
		20	10	5	2	1
Without	1985	7.4	9.1	11.3	13.8	14.6
	2000	23.6	37.8	54.1	70.3	77.7
	2010	44.5	118.9	112.1	148.4	166.0
Alternative–1	1985	0.3	0.9	7.0	7.7	12.0
	2000	3.8	8.6	25.3	32.7	57.8
	2010	9.4	22.9	50.7	66.5	131.6
Alternative–2	1985	0.3	0.6	6.3	7.4	9.6
	2000	2.6	5.1	21.5	27.5	43.3
	2010	6.0	13.6	39.4	56.3	92.0
Alternative–3	1985	0.0	0.6	6.3	7.4	9.6
	2000	0.0	5.1	21.6	27.5	43.2
	2010	0.0	13.6	39.4	55.2	92.0
Alternative–4	1985	0.3	0.6	6.9	7.7	9.9
	2000	3.7	7.6	24.5	33.2	47.8
	2010	9.4	21.1	48.6	67.7	106.0

Source: Study Team, 1985

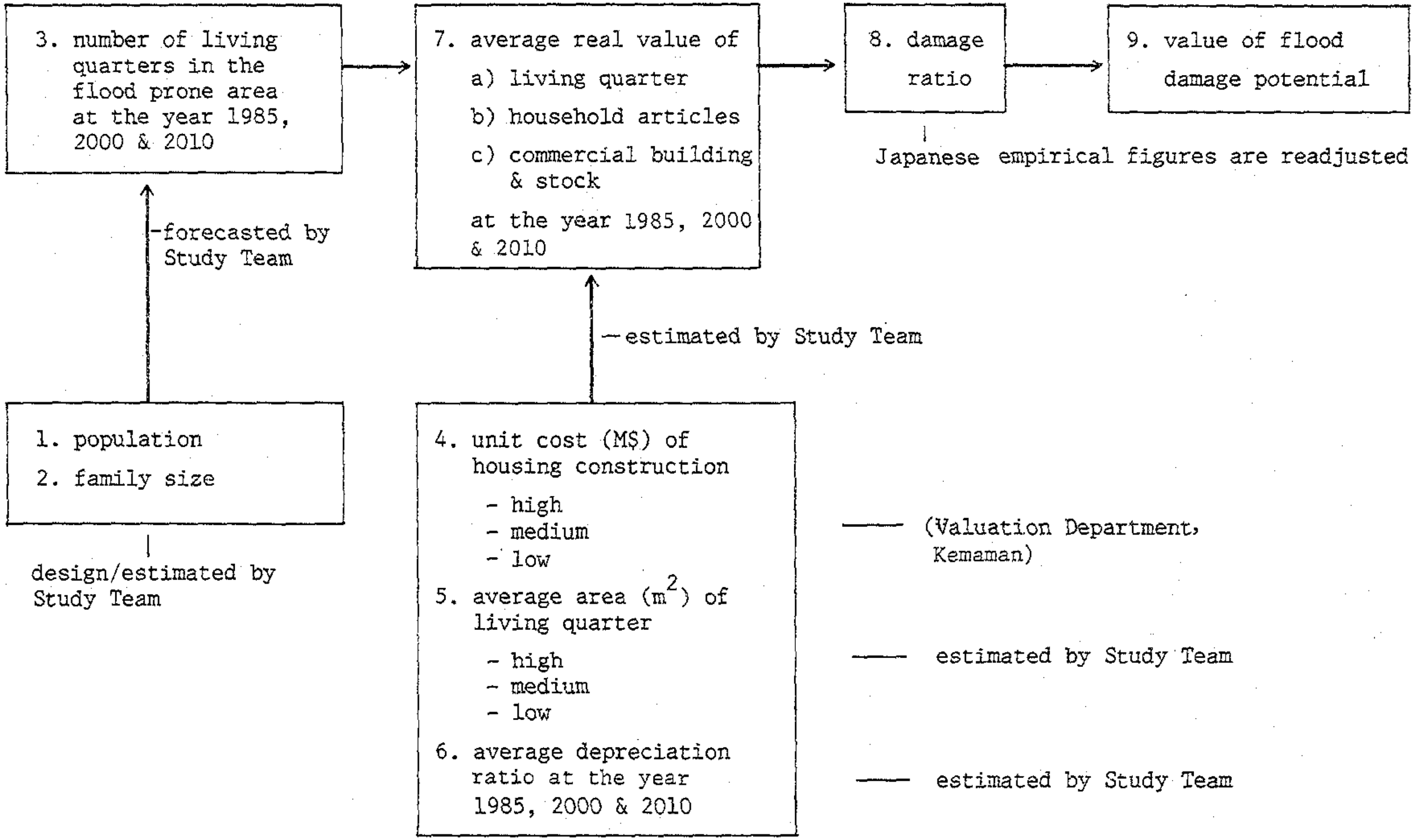


FIG. E.2 FLOW CHART OF GENERAL PROPERTY DAMAGE POTENTIAL ESTIMATION c-1) General Property Damage Potential

This item of damage potential consists of three sub-items, which are:–

- House
- Household articles
- Commercial building and stock

c-1-1) Unit cost of housing construction and average area of living quarter are shown with the average construction cost of living quarters in Table E.3.

Overall Estimation flow is shown in Fig. E.2.

TABLE E.3 HOUSING CONSTRUCTION DATA

		Average Floor Area (m^2) 1/	Unit Cost ($M\$/m^2$) 2/	Standard Construction Cost ($\times 10^2$ M\$)
WOODEN	HIGH	165	215	360
	MEDIUM	120		260
	LOW	60		130
PERMANENT	HIGH	130	460	600
	MEDIUM	90		410
	LOW	60		280
COMMERCIAL		245	410	1,000

Note: 1/ Figures were estimated based on the standard of SEDC's housing project and the findings of field survey conducted by the Study Team.

2/ Source: Valuation Department, Kemaman
Figures were confirmed by private construction company.

c-1-2) Depreciated values of houses at the year 1985, 2000 and 2010 are calculated based upon the estimated figures concerning:–

a) Number of houses by wood/permanent,

b) Weighted average rate of depreciation for houses.

a) and b) are summarized in Tables E.4 and E.5 with notes.

TABLE E.4 NUMBER OF HOUSES BY WOOD/PERMANENT

	1985		2000		2010	
	WOOD	PERMANENT	WOOD	PERMANENT	WOOD	PERMANENT
HIGH	47	186	140	1020	244	2384
MEDIUM	1878	1878	2857	5796	4490	12330
LOW	2080	231	1608	179	1714	191
COMMERCIAL	76		173		337	

Source: Study Team, 1985

Note : - 90% of high class houses constructed after 1985 is expected to be permanent.

-80% of medium class houses constructed after 1985 is expected to be permanent.

-10% of low class house constructed after 1985 is expected to be permanent.

TABLE E.5 WEIGHTED AVERAGE RATE OF DEPRECIATION (%)

	1985		2000		2010	
	WOOD	PERMANENT	WOOD	PERMANENT	WOOD	PERMANENT
HIGH	40	3	24	10	8	11
MEDIUM	40	3	32	20	28	13
LOW	40	3	40	20	39	25
COMMERCIAL	20		20		19	

Source: Study Team, 1985

Note : - Depreciation rates for wooden, permanent house and shophouse are 2%, 1% and 1.5% of construction cost per year respectively (Source: Valuation Department in Kemaman).

- Average rates of depreciation are calculated with a weight of number of houses by the years after construction.

With Tables E.4 and E.5, we finally arrive at depreciated value of house at the year 1985, 2000 and 2010. Table 6 presents the results.

TABLE E.6 DEPRECIATED VALUE OF HOUSE ($x10^2$M$,1985 price)

	1985		2000		2010	
	WOOD	PERMANENT	WOOD	PERMANENT	WOOD	PERMANENT
HIGH	216	582	274	540	331	534
MEDIUM	156	398	176	328	187	357
LOW	78	272	78	224	79	210
COMMERCIAL (+ equipment)	730		836		846	

Source: Study Team, 1985

c-1-3) Household Article

Quantity of household articles is expected to increase at the same rate as the growth rate of GRDP. Value of this sub-item, therefore, increases year by year.

Estimated function is given below:

$$\begin{pmatrix}\text{household} \\ \text{articles' value} \\ \text{at the year t}\end{pmatrix} = \begin{pmatrix}\text{value at the} \\ \text{year, 1985}\end{pmatrix} \times \left(1 + \frac{r}{100}\right)^{t-1985}$$

Where, t ; year

r ; growth rate of GRDP

Results are shown in Table E.7.

TABLE E.7 VALUE OF HOUSEHOLD ARTICLES DAMAGE POTENTIAL PER HOUSEHOLD

($\times 10^2$ M$)

	1985		2000		2010	
	WOODEN	PERMANENT	WOODEN	PERMANENT	WOODEN	PERMANENT
HIGH	116	200	197	340	230	484
MEDIUM	40	76	68	129	76	184
LOW	10	37	17	63	37	90

c-1-4) Commercial Building

This sub-item consists of two componentns:–

– Commercial building (shophouse)
– Stock

First item is explained together with the house. Second sub-item is estimated based upon the figures in 1985.

Estimated value of stock for each shophouse is 28,000 Malaysian dollars per commercial unit, which is the average of stock per commercial unit in the Cukai town area in 1985. Original data are collected during the asset survey by the Study Team.

c-2) Public Property Damage Potential

This item contains six sub-items. Actual values of flood damage in case of 1983 flood are expanded at the growth rate of population in the Cukai town area, and arrived at the value of damage potentials at the year 1985, 2000 and 2010. Those are shown in Table E.8.

TABLE E.8 PUBLIC PROPERTY DAMAGE POTENTIAL (IN CASE OF THE SAME FLOOD DISCHARGE AS THE 1983 FLOOD)

($X10^3 M\$$)

	1985	2000	2010
1)School Damage	38	107	175
2)Electricity Facilities	126	353	580
3)Telecommunication Facilities	0	0	0
4)Water Supply Facilities	0	0	0
5)Road	22	62	101
6)Bridge	0	0	0

Source: Kemaman District Office

All the figures are converted into the value weighted by the flood frequency.

c-3) Agriculture Products' Damage Potential

Estimation of this damage is not conducted because:--

- no commercial agricultural activity exists, and all agricultural products are consumed within producers' houses.

- each unit of cultivated area is small.

Impact of estimation error attributable to this exclusion is examinated in a sensitivity analysis.

c-4) Income/Sales Loss Potential

This item consists of four sub-items; which are:–

- workers' income loss
- shop sales loss
- electricity consumption loss
- transportation charge loss

General estimation function is given below:–

Income/Sales Loss Potential = (Loss per day) x (Duration day) x (Number of person/shophouse)

Brief explanations on each sub-item are given below.

a) Workers' income loss

Those who live in the low class and wooden houses are assumed to be diem workers, engaging in fishing, mining and so on.

Their average diem is assumed 22 Malaysian dollars per day, lower than the national opportunity cost of labour. Data are collected during the asset survey by the Study Team.

b) Shop salesloss

Average sales performance is assumed to be 650 Malaysian dollars per day, based upon the asset survey data compiled by the Study Team.

c) Electricity consumption loss

Actual value of damage in case of the 1983 damage is expanded at the growth rate of population and arrives at the damage potential at the year 1985, 2000 and 2010.

Those are converted into the value weighted by the flood frequency.

d) Transportation charges loss

Concerning the bus charge and taxi charge, no actual loss attributable to the 1983 flood is apparent in the Cukai town area.

As for beca charge loss, it accounts for negligible part of flood damage as a whole. This is, therefore, excluded in the flood damage calculation.

E.3 ECONOMIC EVALUATION

Besides the assumptions described in Chapter 9, the followings are set.

(Economic price)

Economic prices of cost items are calculated based upon the conversion factors, which are:–

– opportunity cost of labour = 0.77

– opportunity cost of construction matterial = 0.77

– opportunity cost of capital = 8%

(Source: National Parameter for Economic Evaluation, EPU, 1979.)

Benefits and costs of the project are tabulated in Tables E.9 to E.13.

Table E.9 BENEFIT OF THE PROJECT

(Unit (Unit: x10^6 M$)

		Flood Frequency (%)				
		20	10	5	2	1
Alternative–1	1985	7.0	8.2	4.3	6.2	2.6
	2000	19.8	29.3	28.8	37.6	19.9
	2010	35.1	96.0	61.4	82.0	34.4
Alternative–2	1985	7.0	8.5	5.0	6.4	5.0
	2000	21.0	32.7	32.6	42.8	34.4
	2010	38.5	105.4	72.7	92.1	74.0
Alternative–3	1985	7.4	8.5	5.0	6.4	5.0
	2000	23.6	32.7	32.6	42.8	34.5
	2010	44.5	105.4	72.7	93.2	74.0
Alternative–4	1985	7.0	8.5	4.4	6.1	4.7
	2000	19.8	30.3	29.6	37.2	29.9
	2010	35.2	97.9	63.5	80.7	60.0

Source: Table E.2.

TABLE E.10

EXPENDITURE SCHEDULE (ALTERNATIVE 1)

Unit : M$ 10^6

	ITEM	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	GRAND TOTAL
	PREPARATION WORKS	3.00	2.00															5.00
FLOOD CONTROL COSTS	BARRAGE				1.00	2.00	2.00											5.00
	RIVER MOUTH IMPROVEMENT				4.00	4.00	3.52											11.52
	LAND AQUISITION/ KG. RELOCATION		0.86	2.00	2.00	2.00												6.86
	DREDGING AND DYKE/ LAND FILLING				9.05	9.00	7.00	7.00	7.00	7.00								46.05
	CUKAI RIVER IMPROVEMENT						1.73	1.00	1.00	1.00								4.73
	MAINTENANCE (*1)										0.37	0.37	0.37	0.37	0.37	0.37	0.37	2.59
URBAN DRAIN-AGE COSTS	TRUNK DRAIN			3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.52						34.72
	SECONDARY DRAIN			2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	1.78	35.58
	PUMPING STATION							4.52	4.00	9.40	9.40	9.38						36.70
	MAINTENANCE (*2)				0.04	0.08	0.12	0.16	0.20	0.28	0.32	0.36	0.54	0.54	0.54	0.54	0.54	4.26
	SUBTOTAL	1.00	2.86	8.50	22.59	23.58	20.87	19.18	18.70	24.18	16.59	16.23	3.51	3.51	3.51	3.51	2.69	193.01
	CONSULTANTS FEES (*3)			0.30	1.00	1.00	1.00	0.60	0.60	0.60	0.20	0.20						5.50
	TOTAL	3.00	2.86	8.80	23.59	24.58	21.87	19.78	19.30	24.78	16.79	16.43	3.51	3.51	3.51	3.51	2.69	198.51

Source: Study Team, 1985

Note : 1. *1 0.5% of FLOOD CONTROL COSTS every year
2. *2 1% of TRUNK DRAIN COST every year and M$ 0.04 x 10^6 every year for K-2 P.S and M$ 0.10 x 10^6 every year for K-2 P.S
3. Other maintenance cost is M$ 4.44 x 10^6 every 20 years for K-2 P.S and M$ 12.09x 10^6 every 20 years for K-3 P.S
4. *3 Consultants Fees are 5% of Flood Control Cost and Trunk Drain Cost.

TABLE E.11

EXPENDITURE SCHEDULE (ALTERNATIVE 2)

Unit : M$ 10^6

ITEM	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	GRAND TOTAL
PREPARATION WORKS	3.00	2.00															5.00
BARRAGE				1.00	2.00	2.00											5.00
DIVERSION CHANNEL/ RIVER MOUTH IMP.				8.52	8.00	8.00	8.00										32.52
LAND AQUISITION/ KG. RELOCATION		0.56	1.00	2.00	2.00												5.56
DREDGING AND DYKE/ LAND FILLING				6.26	7.00	5.00	5.00	5.00	5.00								33.26
CUKAI RIVER IMPROVEMENT				0.59	3.00	3.00	3.00	3.00	3.00								15.59
MAINTENANCE (*1)										0.46	0.46	0.46	0.46	0.46	0.46	0.46	3.22
TRUNK DRAIN			3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.16						34.36
SECONDARY DRAIN			2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	1.62	36.72
LAND FILLING						2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.15	30.15
MAINTENANCE (*2)				0.04	0.08	0.12	0.16	0.20	0.24	0.28	0.32	0.36	0.36	0.36	0.36	0.36	3.24
SUBTOTAL	1.00	2.56	7.60	25.01	28.68	27.52	25.56	17.60	17.64	10.14	9.44	6.32	6.32	6.32	6.32	4.59	204.62
CONSULTANTS FEES (*3)			0.30	1.20	1.20	1.00	1.00	0.60	0.60	0.20	0.20						6.30
TOTAL	3.00	2.56	7.90	26.21	29.88	28.52	26.56	18.20	18.24	10.34	9.64	6.32	6.32	6.32	6.32	4.59	210.92

Source: Study Team. 1985

Note : 1. *1 0.5% of FLOOD CONTROL COSTS every year
2. *2 1% of TRUNK DRAIN COST every year
3. *3 Consultants Fees are 5% of Flood Control Costs and Trunk Drain Cost.

TABLE E.12

EXPENDITURE SCHEDULE (ALTERNATIVE 3)

Unit : M$ 10^6

	ITEM	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	GRAND TOTAL
	PREPARATION WORKS	3.00	2.00															5.00
FLOOD CONTROL COSTS	BARRAGE				1.00	2.00	2.00											5.00
	DIVERSION CHANNEL/ RIVER MOUTH IMP.				8.52	8.00	8.00	8.00										32.52
	LAND AQUISITION/ KG. RELOCATION		1.00	1.10	2.00	2.00												6.10
	DREDGING AND DYKE/ LAND FILLING				4.51	7.00	5.00	5.00		5.00								26.51
	SHORT CUT								6.50									6.50
	CUKAI RIVER IMPROVEMENT				0.59	3.00	3.00	3.00	3.00	3.00								15.59
	MAINTENANCE (*1)										0.46	0.46	0.46	0.46	0.46	0.46	0.46	3.22
URBAN DRAIN-AGE COSTS	TRUNK DRAIN			3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.25						34.45
	SECONDARY DRAIN			2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.72	37.82
	LAND FILLING						1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.00	16.00
	MAINTENANCE (*2)				0.04	0.08	0.12	0.16	0.20	0.24	0.28	0.32	0.36	0.36	0.36	0.36	0.36	3.24
	SUBTOTAL	1.00	3.00	7.70	23.26	28.68	26.22	24.26	17.80	16.34	8.84	8.23	5.02	5.02	5.02	5.02	4.54	191.95
	CONSULTANTS FEES (*3)			0.30	1.20	1.20	1.00	1.00	0.60	0.60	0.20	0.20						6.30
	TOTAL	3.00	3.00	8.00	24.46	29.88	27.22	25.26	18.40	16.94	9.04	8.43	5.02	5.02	5.02	5.02	4.54	198.25

Source : Study Team, 1985

Note : 1. *1 0.5% of FLOOD CONTROL COSTS every year
2. *2 1% of TRUNK DRAIN COST every year
3. *3 Consultants Fees are 5% of Flood Control Costs and Trunk Drain Cost.

TABLE E.13

EXPENDITURE SCHEDULE (ALTERNATIVE 4)

Unit : M$ 10^6

	ITEM	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	GRAND TOTAL
	PREPARATION WORKS	3.00	2.00															5.00
FLOOD CONTROL COSTS	BARRAGE				1.00	2.00	2.00											5.00
	RIVER MOUTH IMPROVEMENT				4.00	4.00	3.52											11.52
	LAND AQUISITION/ KG. RELOCATION		1.40	2.00	2.00	2.00												7.40
	DREDGING AND DYKE/ LAND FILLING				10.80	12.00	10.00	10.00		10.00								52.80
	SHORT CUT								6.50									6.50
	CUKAI RIVER IMPROVEMENT						1.73	1.00	1.00	1.00								4.73
	MAINTENANCE (*1)										0.44	0.44	0.44	0.44	0.44	0.44	0.44	3.08
URBAN DRAIN-AGE COSTS	TRUNK DRAIN			4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	3.51						36.31
	SECONDARY DRAIN			1.78	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	35.58
	LAND FILLING						1.81	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	17.81
	MAINTENANCE (*2)				0.04	0.08	0.12	0.16	0.20	0.24	0.28	0.32	0.36	0.36	0.36	0.36	0.36	3.24
	SUBTOTAL	3.00	3.40	7.88	24.54	26.78	25.88	19.46	16.00	19.54	9.02	8.47	5.00	5.00	5.00	5.00	5.00	188.97
	CONSULTANTS FEES (*3)			0.30	1.10	1.20	1.00	1.00	0.60	0.60	0.20	0.20						6.20
	TOTAL	3.00	3.40	8.18	25.64	27.98	26.88	20.46	16.60	20.14	9.22	8.67	5.00	5.00	5.00	5.00	5.00	195.17

Source : Study Team, 1985

Note :
1. *1 0.5% of FLOOD CONTROL COSTS every year
2. *2 1% of TRUNK DRAIN COST every year
3. *3 Consultants Fees are 5% of Flood Control Costs and Trunk Drain Cost.

E.4 SENSITIVITY ANALYSIS

(CONDITIONS)

The alternative with the highest cost efficiency and favourable non-tangible effects is Alternative 3, and this is examined in vairous aspects.

Cost is further devided into labour cost and construction material/maintenance cost. Labour cost accounted for 21.8% of the total cost, while construction material/maintenance for 78.2%.

(CONCLUSIONS)

EIRR shows slightly elastic changes, corresponding to the fuctuation of benefits rather than that of costs.

EIRR ranges from 4.8% to 9.9% corresponding to the change in benefits and costs (-30% to +30%).

TABLE E.14 SENSITIVITY ANALYSIS
(ALTERNATIVE-3, EVALUATION PERIOD; 30 YEAR)

	Changes in Cost and Benefit (%)						
	-30	-20	-10	0	+10	+20	+30
Total Cost	9.9	8.9	8.0		6.6	6.0	5.5
Labour Cost	7.4	7.2	7.0	7.2	6.7	6.6	6.4
Construction Material Cost	8.9	8.1	7.5		6.4	5.9	5.4
Total Benefit	4.8	5.7	6.5	7.5	7.9	8.5	9.2

TABLE E.15 SENSITIVITY ANALYSIS
(EVALUATION PERIOD; 50 YEARS)

(Unit: %)

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
EIRR	7.1	7.5	8.2	7.3

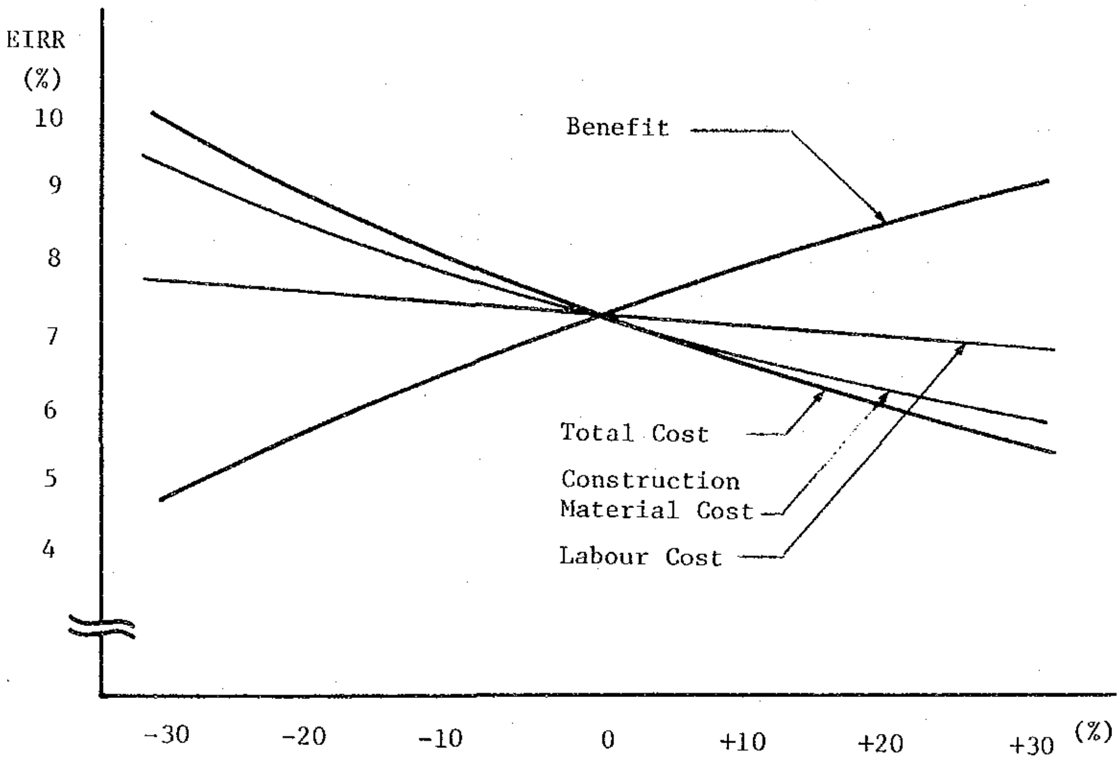


FIG. E.3. SENSITIVITY ANALYSIS

E.5 DEVELOPMENT POTENTIAL

E.5.1 New Town Centre Development Potential

In case of ALTERNATIVE 2 and 3, the drainage area K-5 which located North of planned diversion channel has high development potential because of direct connection with existing commercial centre of Cukai town.

a) Land value in case of without project, ALT. 1 and ALT. 4 is as followsings :

– Additional Residential Area 45 ha
(Newly developed residential area)

– Development Cost (filling + inflastructure) 15 M$/$m^2$

$45 \times 10^4 \times 15 = 6.75 \times 10^6$ (M$)

– Land Value 35 M$/$m^2$

$45 \times 10^4 \times 35 = 15.75 \times 10^6$ (M$)

– Present Land Value 9 M$/$m^2$

$45 \times 10^4 \times 9 = 4.05 \times 10^6$ (M$)

TABLE E.16 LANDUSE IN POTENTIAL LAND

Unit: hectar

LANDUSE	AREA	REMARKS
Water Surface	20	Canal, Marina, Yacht harbour, Swamp area, etc.
Road and Public Facility Area	11	Road, Side walk, Lighting, Public building (Fire station, Police etc.)
Park and Recreational Area (Public)	14	Include Private & Public Marina and Yacht club, Gardent etc.
Commercial & Bussiness Area	15	(to be sold or rent)
Residential Area (High Class)	12	(to be sold or rent)
(Medium Class)	10	(to be sold or rent)
TOTAL	82	

Incremental value by development is

$15.75 - 6.75 - 4.05 = 4.95 \fallingdotseq 5.0$ (million M$)

(without project)

b) Land value in case of New Town Centre Infrastructure project carried out.

- Assumed landuse for Town Centre is as following.

- Infrastructure Cost is assumed as followings: -

Filling the land

$62 \times 10^4 \times @\, 5\ M\$/m^2 = 4.6 \times 10^6$ (M$)

Inflastructure & Environmental development
(Road, water supply, sewer, electricity, landscaping etc.)

25 million (M$)

Present land value (State land : 9 M$/m²) 82ha

7.38 million (M$)

Total Development Cost	Approx 37 Million (M$)

- Selling price of land

	Million M$	Million M$
Commercial area	(15 ha @ 500 M$/m²)	75
High Cost Residential	(12 ha @ 300 M$/m²)	36
Medium Cost Residential	(10 ha @ 200 M$/m²)	20
	Total	131

- Total Land Value increasement after Town Centre infrastructure project.

131 - 37 = 94 (Million M$)

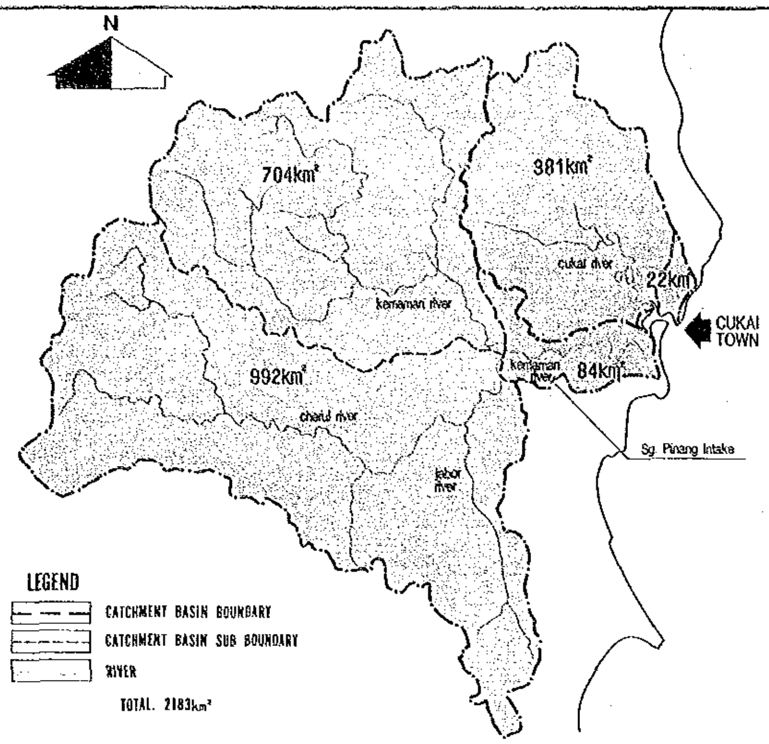
with project (ALT. 2 & 3)

c) Differnece between with Town Centre Development (ALT. 2, ALT. 3) and normal residential development (ALT 1, 4 and without project) is calculated as follows.

94 - 5 = 89 (Million M$)

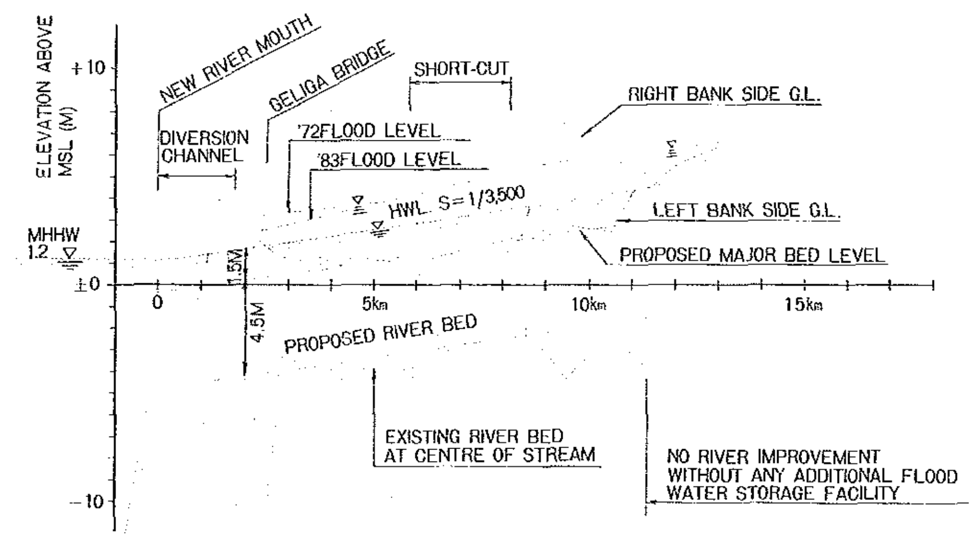
Then this amount can be considered potential development benefit for the case of ALT - 2 and ALT - 3.

"AN EXAMPLE OF NEW TOWN CENTRE DEVELOPMENT PLAN", which is used to calculate the potential of development described above, is shown on Fig. A. 5.

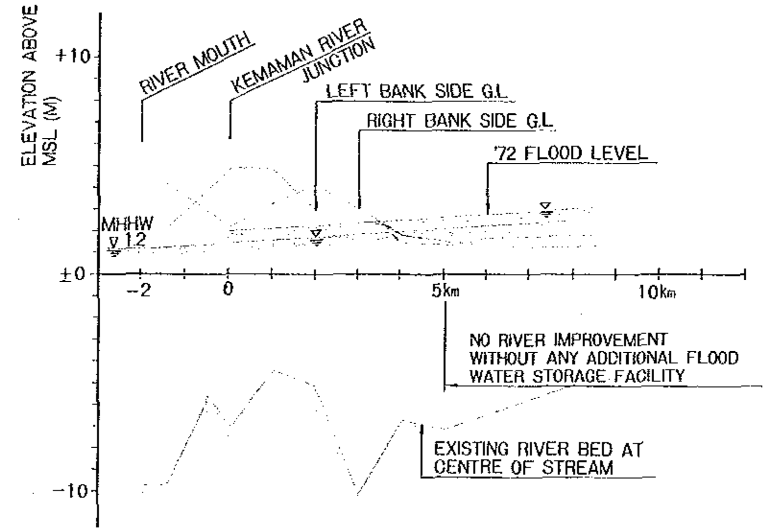


KEMAMAN RIVER CATCHMENT

KEMAMAN RIVER

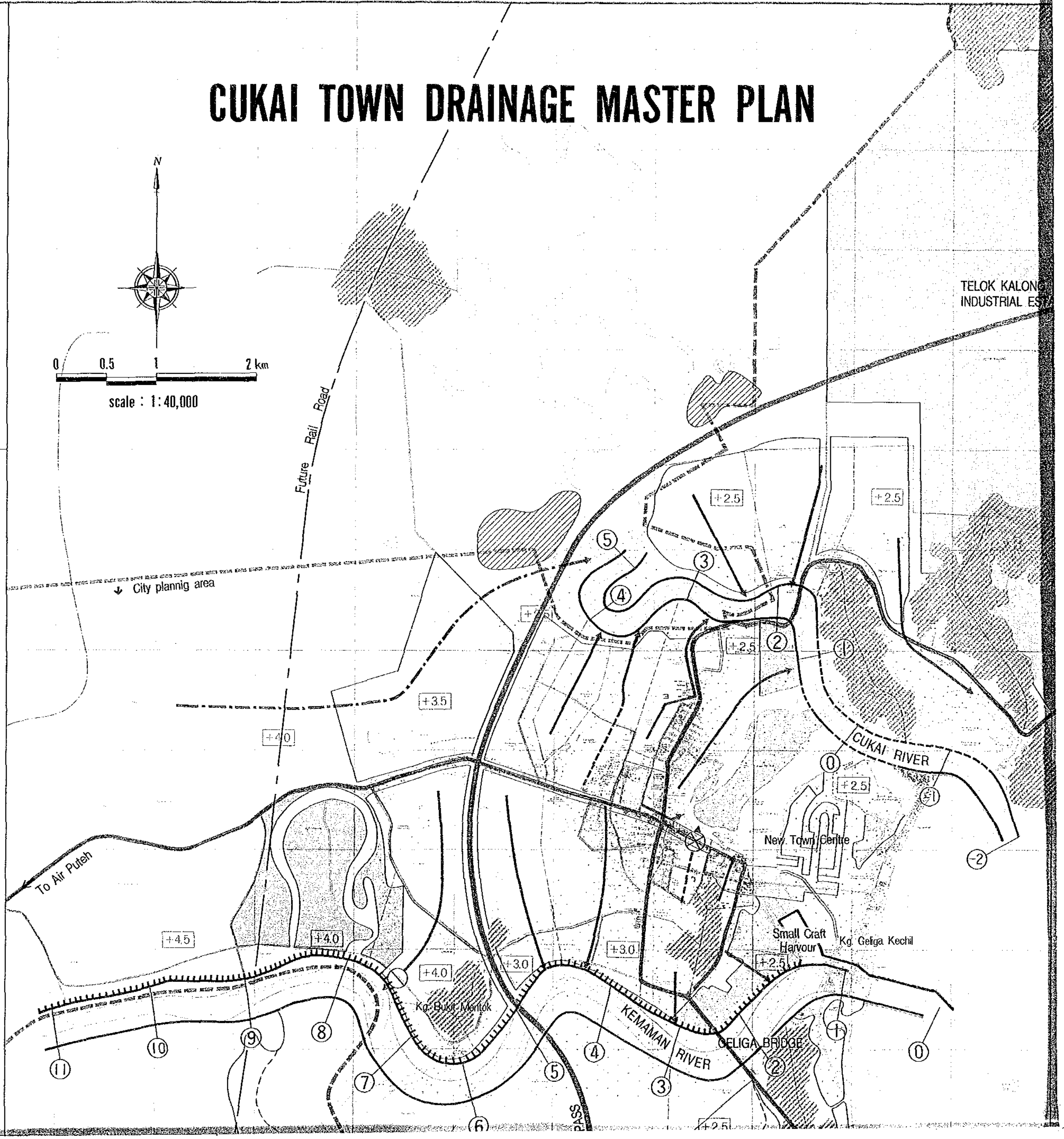


CUKAI RIVER

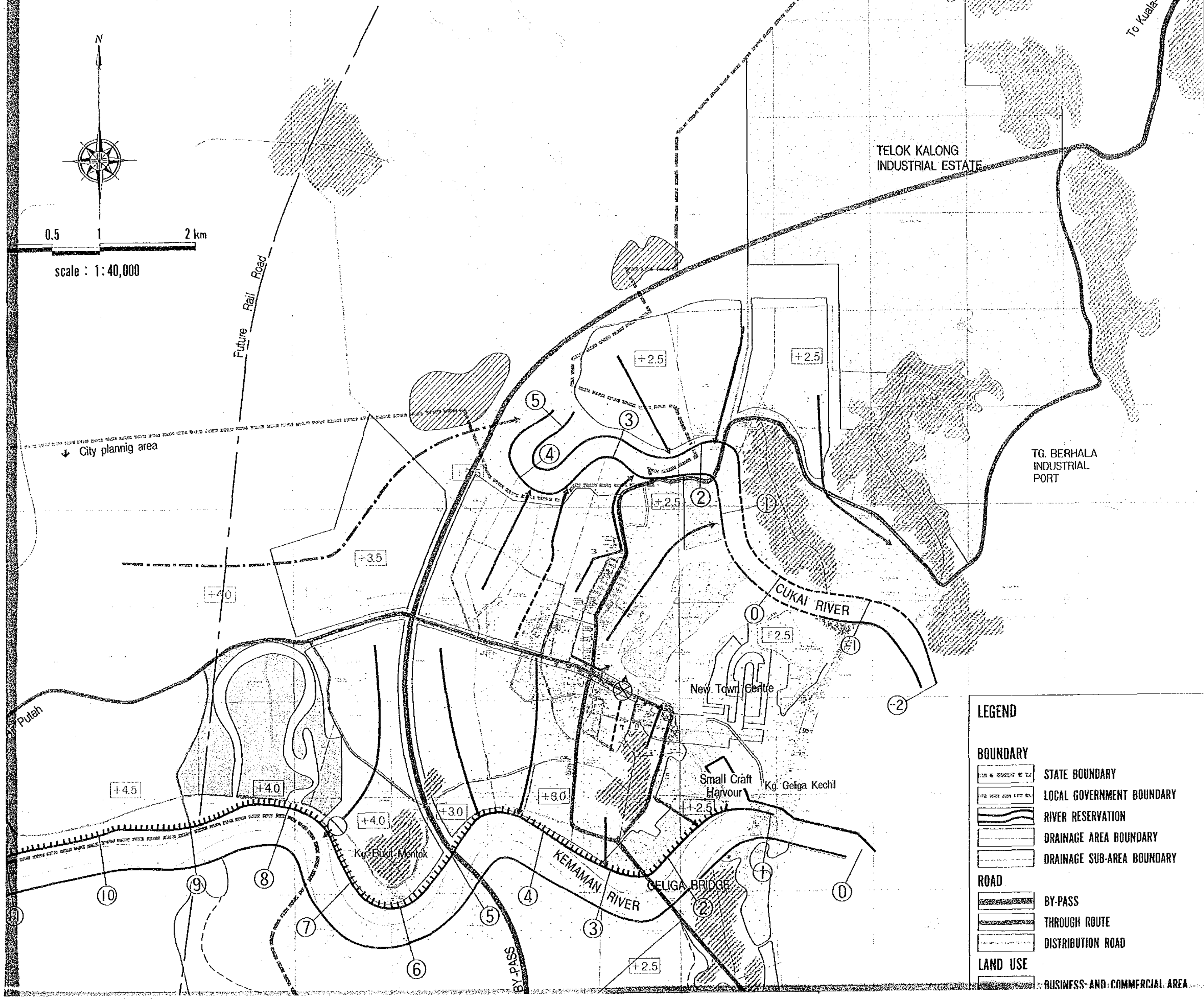


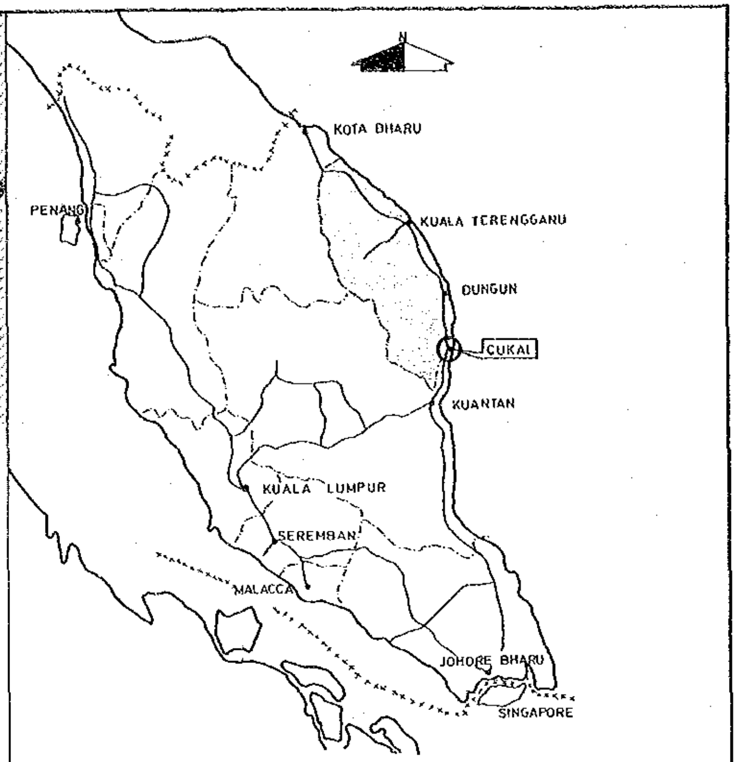
LONGITUDINAL PROFILE

CUKAI TOWN DRAINAGE MASTER PLAN

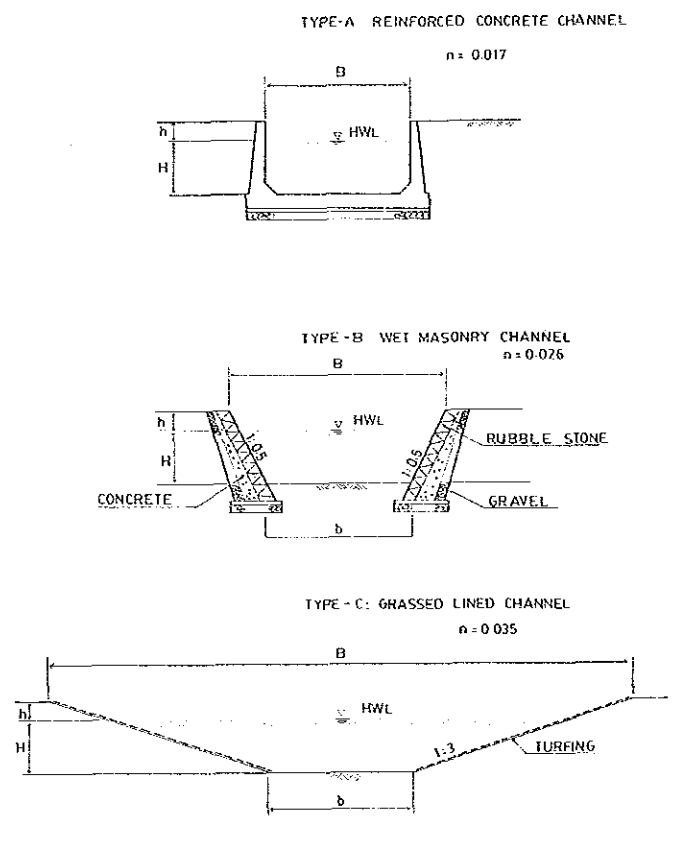


CUKAI TOWN DRAINAGE MASTER PLAN





LOCATION MAP



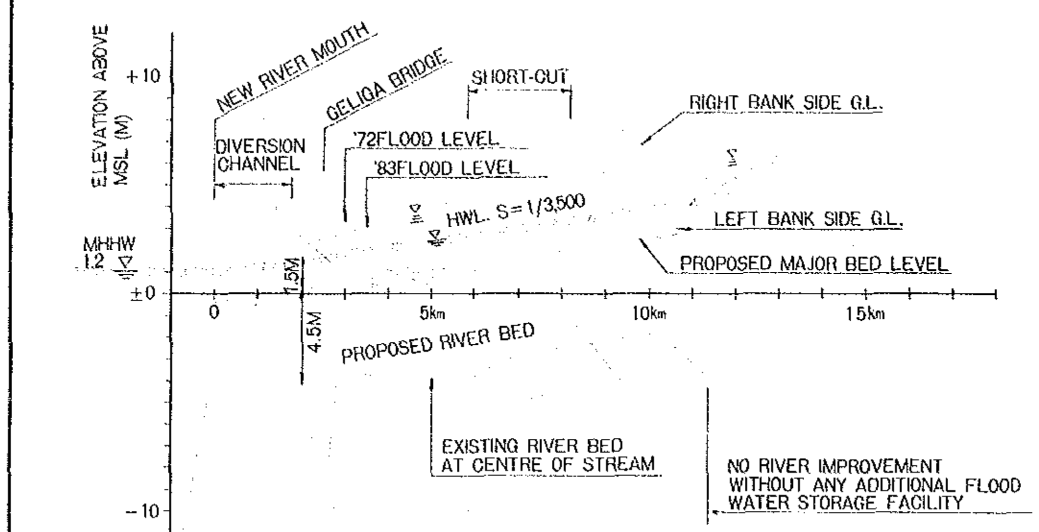
TYPICAL CROSS SECTION OF TRUNK DRAIN

POLICIES;

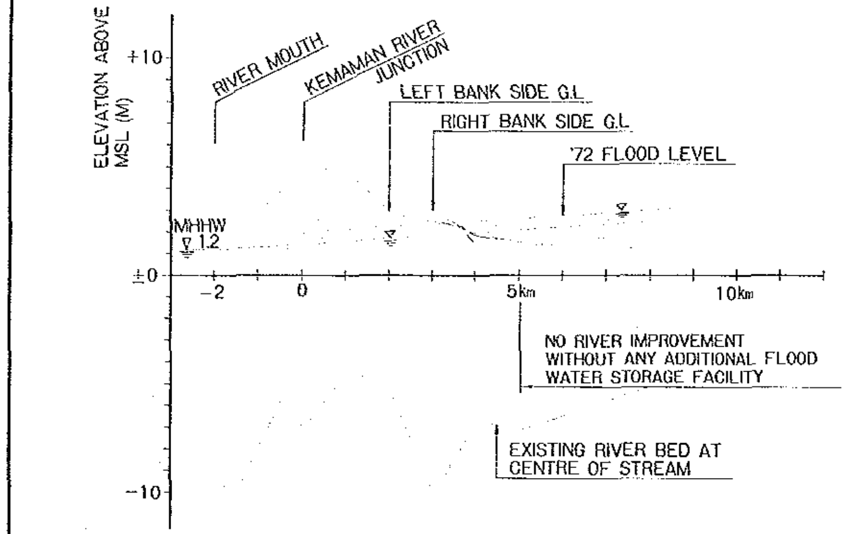
1. River improvement or development of upstream areas should have additional flood control facilities to hold increased flood discharge and sediment run-off.

2. Trunk drain discharges from Telok Kalong area

KEMAMAN RIVER

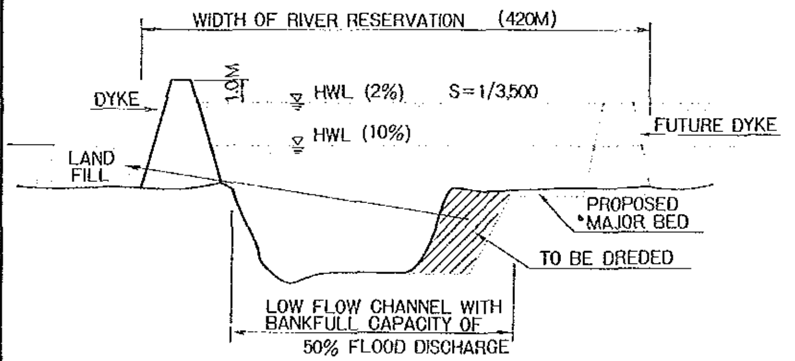


CUKAI RIVER



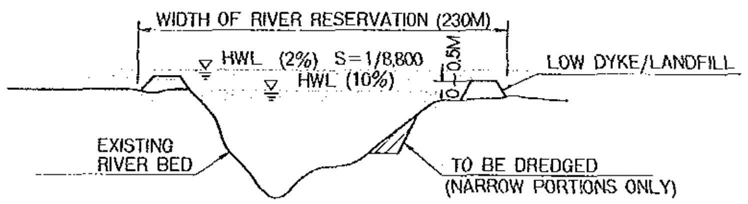
LONGITUDINAL PROFILE

KEMAMAN RIVER



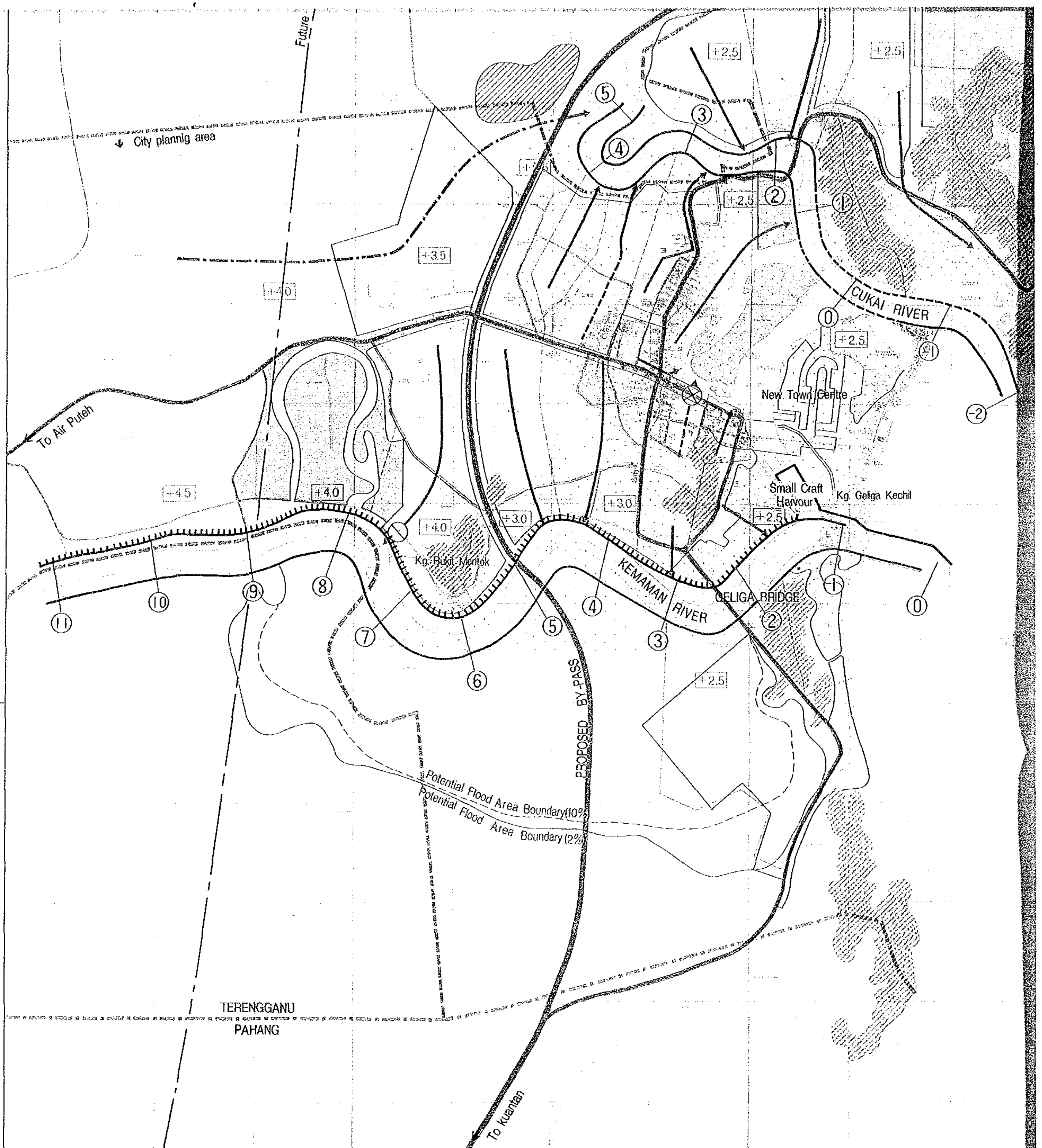
Kemaman River
Design Flood Discharge
10%(10-Year) flood
Q=2,400 m^3/S
2%(50-Year) flood
Q=3,400 m^3/S

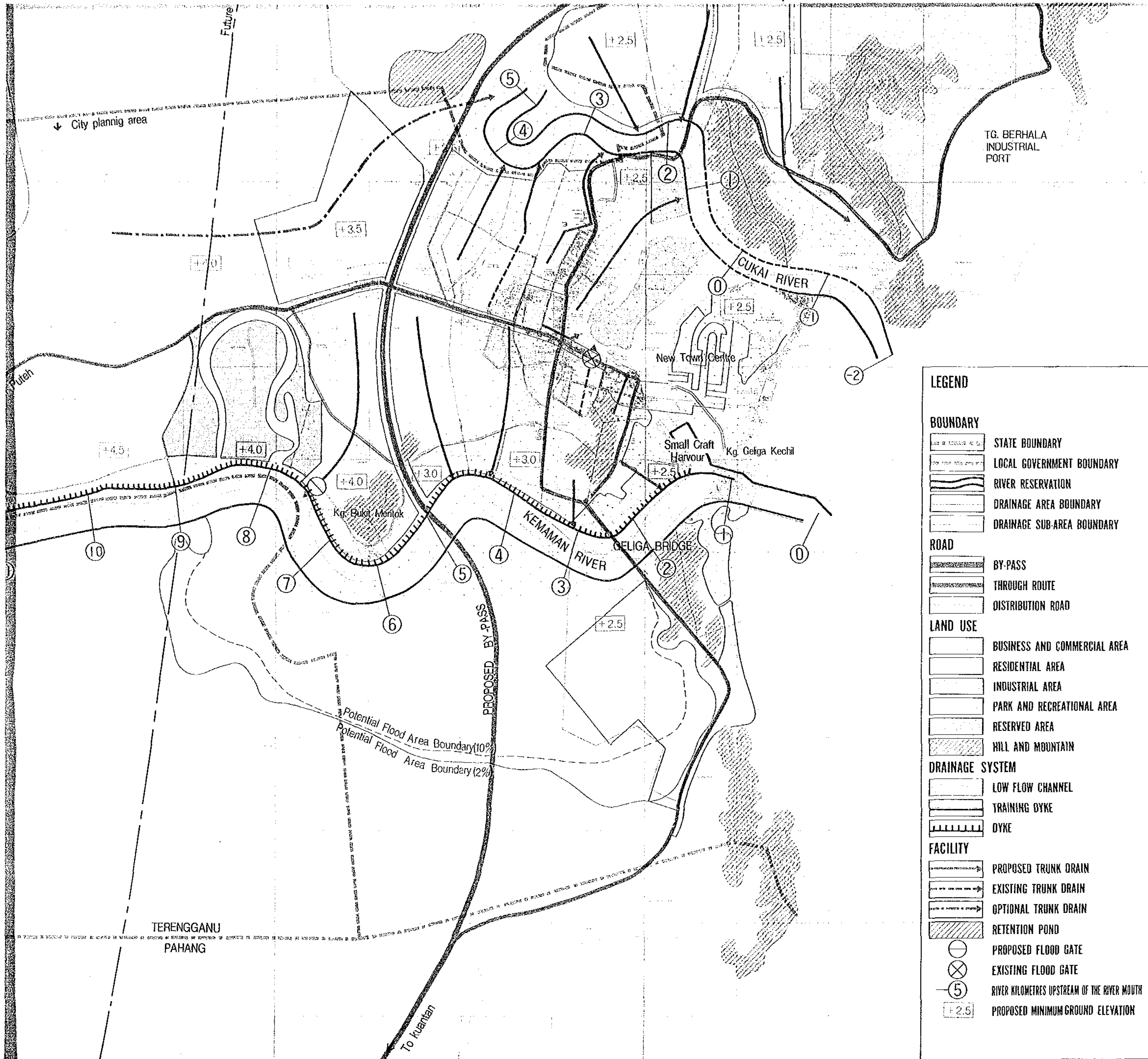
CUKAI RIVER

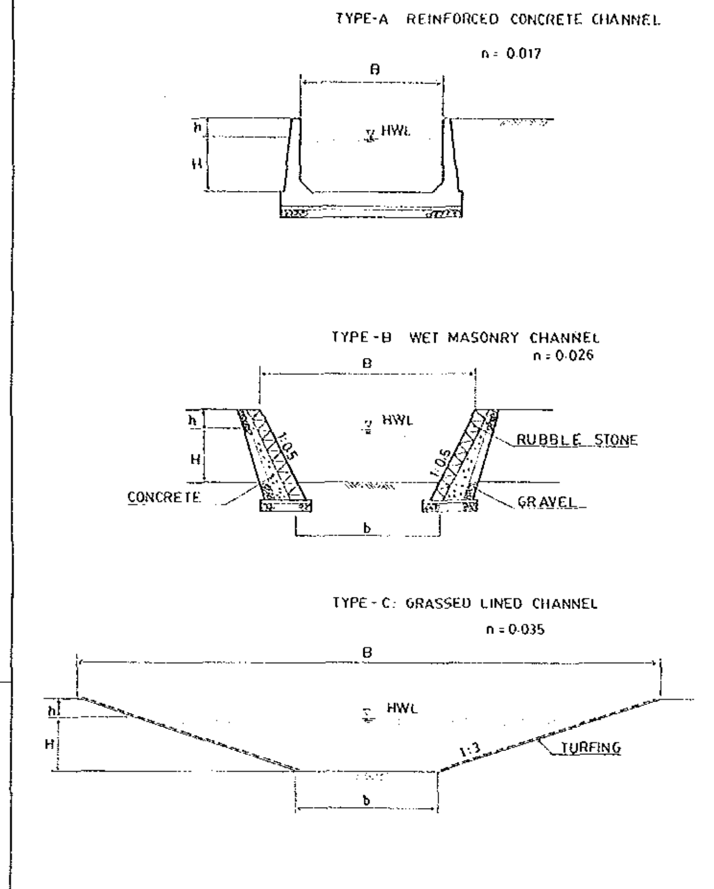


Cukai River
Design Flood Discharge
10%(10-Year) flood
Q=607 m^3/S
2%(50-Year) flood
Q=884 m^3/S

CONCEPT OF RIVER PROFILE DESIGN







TYPICAL CROSS SECTION OF TRUNK DRAIN

POLICIES;

1. River improvement or development of upstream areas should have additional flood control facilities to hold increased flood discharge and sediment run-off.

2. Trunk drain discharges from Telok Kalong area should be into the nearest to mouth of Cukai River or otherwise must be held in retention ponds.

THE GOVERNMENT OF MALAYSIA

REGIONAL STUDY ON THE INTEGRATED DEVELOPMENT OF SOUTH TERENGGANU

PREFEASIBILITY STUDY

FOR

THE DRAINAGE OF CUKAI TOWN AREA

JAPAN INTERNATIONAL COOPERATION AGENCY

August 1985

JICA

JICA