3. Construction Methods

The method of construction must be practical and feasible, taking into account the existing conditions of the high ground water level and weak sub-soil in the site.

3.1 Foundation Work for Structure

The foundations are the key works at the pumping station and gates. According to the proposed plans for the Phra Khanong Pumping Station, the foundation bed will be at least 6 to 8 metres below MSL.

For the construction of these deep sub-structures, it is necessary to install temporary cofferdams and dewatering facilities, the scale of which must be decided by the sub-soil conditions, outer water level and excavation depth. The piling works will be executed before or after excavation work depending on the site conditions. In case of piling work after excavation, it is necessary to provide stages for the piling equipment. The super-structure, mechanical and electrical works can be carried out by Thai Contractors using conventional methods.

3.2 Earth Works

The embankments will be of relatively low height and generally will not exceed two metres above ground even in 2000. Earth embankments will be placed and compacted to the required density layer by layer, near optimum moisture content. If the embankment material is saturated clay, construction of the embankment will not be permitted in rainy days in order that the material may be as dry as required. All side slopes should be provided with adequate protection against erosion by grass sod or turf, grouted stone, asphaltic concrete or portland cement concrete.

4. Selection of Type for Flood Protection/Drainage Facilities

Several types of flood protection and drainage facilities, either temporary or permanent, are constructed in Thailand, and the most satisfactory design amongst them should be selected and recommended for this project in order to meet the present situation such as materials, soil and constructability.

Methods of construction are largely affected by soil conditions. A very soft clay, the so-called "Bangkok Clay", constitutes a 20 m strata below the ground surface, and its value of cohesion ranges from 2.0 to 0.5 t/m^2. Under this Bangkok Clay strata, and approximately 30 m below the ground surface, a sand strata with an N-value of 30 to 45 is seen, and it is in this sand stratum that large scale structures, such as pumping stations and water gates, will be founded.

4.1 Flood Protection Barrier

The purpose of constructing a flood protection barrier is to protect an area from outside flood. Following three types are considered in this project.

- Raising of existing road
- Embankment construction
- Retaining Wall

(1) Raising the Existing Road

In general, land acquisition cost accounts for a large percent of total construction cost, so that the existing roads are adopted as much as possible where an embankment is necessary. The road is made up of subgrade, sub-base, base and surface asphalt (Fig. J.1), and sand and gravel shall be used for the material of sub-grade and sub-base respectively. Adjustment of the embankment height is made by the thickness of sand layer.

Slope gradient of the embankment shall be 1:2 (vertical:horizontal). As the materials of embankment are of high permeability, the slope face should be protected against erosion.

(2) Embankment Construction

Materials of embankment are obtained from local soil. The local soil, Bangkok Clay, has high water-content and is apt to settle due to consolidation. Also, the embankment and foundation will settle together. Therefore, operation and maintenance is important. The face of the embankment slope must be covered with turf, and roots of plants on the existing ground surface should be stripped out to prevent water infiltration beforehand.

(3) T-Shape Concrete Wall

This type consists of T-shaped concrete wall, with concrete sheet piles and foundation piles supporting a concrete wall. Amongst the three types of flood protection barriers proposed, this type is the safest but has the highest construction cost, and hence it is adopted only for significant flood protection facilities such as Chao Phraya River or the main klongs. A typical type is shown in Figs. J.2 and J.3.

4.2 Improvement of Klong

4.2.1 Type of Retaining Wall

To design the retaining wall, a stability analysis by the circular sliding method is conducted for each excavation depth based upon local soil conditions. According to the results of the calculation, and assuming a vertically face, the allowable height of the retaining is estimated 3.5 - 4.0 m by taking a safety factor of 1.2.

Following four types of retaining wall, based upon above results, are considered (Figs. J4 and J.5):

- Concrete Sheet Pile Wall (Type A)
- Anchored Sheet Pile Wall with Panels (Type B)
- Double Row of Pile Wall with Panels (Type C)
- Front-support Wall (Type D)

(1) Concrete Sheet Pile Wall (Type A)

This type consists of concrete sheet pile with the width of 0.5 m to 1.0 m and cast-in-situ concrete capping beam at the top of the wall. In order to support the earth pressure by the sheet pile only, depth of the klong should be less than 2.0 m or 2.5 m. Concrete sheet pile has the merit, such as low construction cost and no rust, though the strength is inferior to steel sheet pile. Although the depth of klong is limited to less than 2.0 m or 2.5 m, additional space for the structure is not required, so that it is preferred for retaining walls of middle to small scale klongs. A typical example is shown in Fig. J.4.

(2) Anchored Sheet Pile Wall with Panel (Type B)

The wall consists of a single row of piles at intervals of 1.50 m centre to centre, with panels between the piles. The wall is anchored against the horizontal soil pressure. Similar to the proposal of the CDM Master Plan, every second pile will be anchored and two piles connected to one anchor. Each anchor consists of three piles connected at the top.

A distance of 6.0 m between the row of anchor piles and retaining wall is adopted for safety. Panels, to be placed in the grooves of the piles, commence at a level of 0.06 m below klong bottom level to avoid heave of subsoil near the klong bottom due to vertical soil pressures.

Connections between panels, and between panel and piles have to be water tight to prevent migration of the soil.

This type of wall is adopted for large scale klongs and where there is sufficient area. A typical design is shown in Fig. J.5.

(3) Double Row of Pile Wall with Panel (Type C)
This type is similar to the previous, except that the anchor is replaced by a second sheet pile wall. This wall acts as an anchor and consists of a row of sheet piles at 1.05 m centre to centre. These are connected with be placed to 1.0 m below groundlevel.

The distance centre to centre of sheet piles on the second row is determined by the distance between the first row and second row. In this project, pitch of each pile in the second row is determined to be 1.5 m similar to the case in the first row. The distance between the first and second row comes to 1.5 m.

The construction cost of this type is more than the case of anchored sheet pile wall with panels, but less area is required. A typical design is shown in Fig. J.5.

4.2.2 Application of Retaining Wall

The type A concrete sheet pile wall is the cheapest and will be used for middle to small scale klong, depth of which is less than 2.0 to 2.5 m. For a large klong, depth of which is more than 2.0 to 2.5 m, types B, C or D will be used. Where klongs exist in low density areas the type B (anchored sheet pile wall with panel) is the second cheapest but a large-area is required for an anchored pile. Where klongs exist in a medium-high density area, type C (double row of piles and wall with panel) will be used, while where there is no space behind klongs type D (front support-anchored sheet pile wall with panel) will be used despites its hydrological disadvantage.

4.2.3 Cost Comparison of Klong Improvement

Sectional area of klong is designed from the unsteady flow analysis. In order to increase a sectional area, two shapes are considered; trapezoidal and rectangular shape (Fig. J.6). The former is usually constructed in low-density areas where required land for klong widening is easily acquired at low cost. The latter is constructed in high-density areas where land acquisition is difficult or the cost is high even if the land can be acquired.

Among the proposed klongs, where sectional areas are to be increased, are planned to be of rectangular shape with high-cost retaining walls within the right-of-way. The remaining are in medium to low density areas and land acquisition is considered to be possible based on the field reconnaissance and aerial photos (Fig. J.7).

For these klongs, cost comparison is made which type is cheaper. (See Appendix K about unit cost). Construction cost of a retaining wall is taken as 11,600 Baht per metre of double walls (Type A: concrete sheet pile wall and 18,200 Baht (Type B: anchored sheet pile wall). On the other hand, as unit land acquisition cost can vary from 500 to 3,000 Baht/m^2, for a cross sectional area of 30 m^2 klong, the cost will vary from 2,250 to 13,500 Baht/m. Thus, a trapezoidal shape is found to be cheaper.

In total, about 300 million Baht will be saved. Table J.1 shows the breakdown.

Table J.1 Cost Comparison for Klong Improvement

(Unit: million Baht)

Drainage Area	Rectangular Shape with Retaining Wall			Trapezoidal Shape without Retaining Wall		
	Construction Cost	Land Acquisition Cost	Total	Construction Cost	Land Acquisition Cost	Total
Bang Khen and Bang Sue	390.4	78.0	468.4	204.8	169.5	374.3
Klong Chan	87.0	-	87.0	25.1	17.4	42.5
Lat Phrao	231.2	9.8	241.0	203.2	19.4	222.6
Patterna Karn	78.6	-	78.6	12.9	19.5	32.4
Hua Mark	128.2	-	128.2	123.7	1.5	125.2
Huay Kwang	457.0	10.0	467.0	308.4	58.4	366.8
Bang Na	346.8	57.2	404.0	346.0	57.2	404.0
Total	1,719.2	155.0	1,874.2	1,224.9	342.9	1,567.8

(Refer to Fig. J.7)

4.3 Pumping Station

(1) Power Source of Pump

Two large pumping stations in Bangkok, Rama IV pumping station and Padung Krung Kasem pumping station, now in operation, are used for study purposes. The Rama IV pumping station, constructed by "caisson-method" is driven by diesel engine. Meanwhile, Padung Krung Kasem pumping station, the structure or which is supported by a pile foundation used an open cut method of construction is driven by electric-motor. Operation and maintenance cost as well as the construction cost of the electrically-driven Padung Krung Kasem pumping station was cheaper than that of the diesel-driven Rama IV pumping station as shown below (Table J.2).

Table J.2 Main Features of Existing Pumping Stations

	Rama IV P.S.	Padung Krung Kasem P.S.
Construction Year	1970 - 1972	1973 - 1975
Number of Pumps	4: Diesel engine (920 H.P.)	5
Type of Pumps	Mixed Flow	Axial Flow
Capacity of Pumps	5.5 m/sec each	5.0 m/sec each
Construction Cost	71 million Baht	38 million baht
Operation & Maintenance Cost	9.3 million Baht per year	2.7 million Baht per year

Unit cost of Rama IV pumping station and K. Kasem pumping station are 3.2×10^6 m^3 and 1.5×10^6 m^3 respectively. Moreover, O/M cost is 1.4×10^6 m^3 and 0.1×10^6 m^3 respectively.

In addition, according to the operating data of these two pumping stations, the Rama IV pumping station was not fully operational in rainy season and repairs were frequently required. On the other hand, the Padung Krung Kasem pumping station operated throughout the year, and the electric supply during the rainy season was sufficient. Therefore, electrically-driven pumps are recommended for this Project.

(2) Number of Pumps

Construction cost of a pumping station (including pump, pumphouse, land acquisition, etc.) is low when the number of pumps is small, and one pump in each pumping station provides the lowest construction cost.

Particularly, most of the klongs where new pumphouses have been proposed are of a limited width, and land acquisition along the klong is very difficult. Hence, a small number of pumphouses are better. Moreover, the pumps will work fairly constantly over one to two days against one rainfall, because the 6 hours duration discharge to the pumping station does not have a high peak but is of a flat-type, reflecting the gentle slope of the klong and rainwater retention in the flat areas.

Each pumping station will be equipped with at least two pumps in order:

1) to cope with the fluctuating demand of discharge due to differences between rainstorms: and
2) to allow down time for maintenance.

Considering these conditions, the number of pumps is proposed below.

Planned Discharge (m^3/sec)	Number of Pumps
- 30	2 - 4
31 - 100	3 - 5

(3) Type of Pump

Amongst the three main types; volute flow pump, axial flow pump and mixed flow pump, the mixed flow pump is not appropriate for this Project because the required lift will be 4 to 5 metres.

Lift of Pump (Unit: metre)

	Horizontal	Vertical
Axial Flow	0 - 4	0 - 7
Mixed Flow	3 - 7	5 - 50
Volute Flow	5 - 120	5 - 170

Axial flow and mixed flow pumps have in general comparable advantages and disadvantages. Notable differences are:

Item	Axial Flow	Mixed Flow
Cost	Low	High
Workability against change of lift	Bad	Good

For the Master Plan, a low cost, axial pump with adjustable vanes to get an improved workability is recommended. A typical example of pumping station is shown in Fig. J.8.

(4) Civil Works

All pumping stations must be supported by pile foundations due to the adequate bearing capacity of the subsoil. The piles have to be driven into the first sand layer, about 20 metres below ground surface level. Civil works will be executed in "open cut" method where the depth of excavation is less than 10 metres. For more than 10 metres, "caisson-method" or other methods, such "cast-in-situ concrete wall of underground method" are preferred.

4.4 Gate

Many wooden cofferdams and Reinforced concrete (R.C.) gates have been constructed in Bangkok City. The wooden Cofferdams do not have a long life, it is better to use permanent construction with R.C. There occurs sometimes, differential settlement, causing operation problems with the gate, therefore, a pile foundation design is adopted. Large gates will use a roller gate to decrease the operational load, so a sluice gate with roller is recommended. One gate 6 m wide will be installed as a control gate in the inland area, whilst the width of the gate will be the same as the width of the klong for the tidal gate along the Chao Phraya River as gravity discharge is expected.

5. Proposed Flood Protection/Drainage Facilities

Based on the selected type and drainage system planning, the facilities are proposed as shown in Table J.2.

Table J.2 Main Features of Flood Protection/Drainage Facilities

Embankwent	12.7 km
Gate and Cofferdam	65 places
Pumping Station	10 stations (218 m^3/sec)
Main-Klong	
Depening + Retaining Wall	10.5 km
Sub-Klong	
New Klong	7.3 km
Widening + Deepening + Retaining Wall	9.0 km
Deepening + Retaining Wall	63.5 km
Widening + Deepening	33.8 km
Main Pipe	350 km
Flood Forecasting and Worning System	1 set

The following Tables show the details which are:

Table J.3	Proposed Embankment
Table J.4	Proposed Gates and Cofferdams
Table J.5	Proposed Pumping Stations
Table J.6	Summary of Proposed Klong Improvement
Table J.7 to Table J.14	Work Category of Klong Improvement (Locations are shown in Figs. J.12 to J.15)
Table J.15 to Table J.22	Size of Klong Improvement (Locations are shown in Figs. J.12 to J.15, longitudinal profiles are in Figs. J.16 to J.20 and cross sections are in Figs. J.21 to J.27)

Table J.3 Proposed Embankment

Drainage Area	Section	Length (m)	Type	Remarks
Bang Na	I	2,000	Barrier (B)	from Phra Khanong P.S. to Chao Phraya River
	I	4,200	" (B)	along Chao Phraya River
Total		6,200		

Table J.4(1) Proposed Gates at Pumping Station

Name of Station	Klong width (m)	Gate		Number of Locetions	Remarks
		Width (m)	NO.		
Bang Khen (North)	15	4	3	1	Bang Khen Drainage Area
Bang Khen (South)	10	4	2	1	" "
Bang Sue	25	6	4	1	Bang Sue "
Kacha	12	4	2	1	Hua Mark "
Gig	12	4	2	1	" "
Bang Na Chine	10	4	2	1	Bang Na "
Jek	10	4	2	1	" "
Bang Oa	10	4	2	1	" "
Bang Na	15	6	3	1	" "
Phra Khanong	35	6	6	1	Trunk Drain
Total				10	

Table J.4(2) Porposed Gates in Inland Area

Barrier Section	Klong Width (m)	Gate		Number of Locations	Remarks
		Width (m)	NO.		
III	10	4	1	3	
IV	10	4	1	12	
IV	35	6	1	1	K. Saen Saep
V	10	4	1	12	
V	35	6	1	1	K. Phra Khanong
VI	10	4	1	10	
VII	10	4	1	9	
VIII	10	4	1	7	
Total				55	

Note: Section of barriers are shown in Fig

Table J.5 Proposed Pumping Station

Polder	Name	Capacity (m^3/sec)
A. Outlet Pump		
Bang Khen and Bang Sue	Bang Khen	15
	Bang Sue	50
Phra Khanong	Phra Khanong	90
Bang Na	Jek	6
	Bang Oa	18
	Bang Na	21
	Sub - Total	200
B. Inner Pump		
Phra Khanong	Gig	3
(Hua Mark)	Kacha	6
Bang Na	Bang Na Chine	9
	Sub - Total	18
Total		218

Table J.6 Summary of Proposed Klong Improvement

[Unit: km]

Polder	Drainage Area	Category *						Total
		I	II	III	IV-1	IV-2	V	
Main Klong		-	-	10.5	15.0	-	-	25.5
Bang Khen and Bang Sue	Bang Khen	-	-	-	3.9	10.0	6.5	20.4
	Bang Sue	-	2.0	6.0	-	12.7	-	20.7
	Sub-Total	-	2.0	6.0	3.9	22.7	6.5	41.1
Phra Khanog	Klong Chan	-	-	1.3	-	3.9	5.8	11.0
	Lat Phrao	-	4.9	8.1	-	4.2	2.7	19.9
	Huay Kwang	1.0	-	15.1	-	-	12.8	28.9
	Patterna Karn	-	-	-	-	3.0	5.5	8.5
	Hua Mark	-	-	9.3	-	-	0.5	9.8
	Sub-Total	1.0	4.9	33.8	-	11.1	27.3	78.1
Bang Na	Bang Na	5.8	2.1	13.2	1.0	5.0	-	27.1
Total		6.8	9.0	63.5	19.9	38.8	33.8	171.8

* Note: Category I : new drain with retaining wall
Category II : widening + deepening + construction of retaining wall
Category III : deepening + construction of retaining wall
Category IV : no improvement (IV-2) or deepening (IV-1)
Category V : widening + deepening

Table J.7 Drainage Works of Trunk Drainage System

	Category I	Category II	Category III	Category IV	Category V
. Phra Khanong	-	-	Sections 1, 2, 4, 5	Sections 3, 6, 7, 8, 9, 10	-
. Tan	-	-	Sections 11, 12, 14	Sections 13, 15	-
. Saen Saep	-	-	Sections 20, 21, 24	Sections 16, 17, 18, 19, 22, 23, 25, 26	-

Note: Category I = new drain
Category II = deepening and widening + construction of retaining walls
Category III = deepening + construction of retaining walls
Category IV = no improvemetn(IV-2) or deepening(IV-1)
Category V = deepeing + widenig

Table J.8 Drainage Works in Bang Khen and Bang Sue drainage areas

	Category I	Category II	Category III	Category IV	Category V
. Lat Phrao	-	-	-	Sections 1 to 8 (16.5 km)	-
. Bang Sue	-	section 11	Sections 9, 10, 12		-
. Bang Khen	-	-	-	Section 14 to 15 (3.9 km)	Sections 16, 17, 18

Note: Category I = new drain
Category II = deepening and widening + construction of retaining walls
Category III = deepening + construction of retaining walls
Category IV = no improvement(IV-2) or deepening(IV-1)
Category V = deepening + widening

Table J.9 Drainage Works in Klong Chan Drainage Area

	Category I	Category II	Category III	Category IV	Category V
. NN	-	-	-	-	Sections 1, 2, 3
. Bang Toei	-	-	-	Section 4 to 5 (3.9 km)	-
. Bang Chala	-	-	Section 7		-
. Phlu	-	-	-	-	Section 8

Note: Category I = new drain
Category II = deepening and widening + construction of retaining walls
Category III = deepening + construciton of retaining walls
Category IV = no improvement(IV-2) or deepening(IV-1)
Category V = deepening

Table J.10 Drainage Works in Lat Phrao Drainage Area

	Category I	Category II	Category III	Category IV	Category V
. NN	-	-	Section 1	-	-
. Lat Plakao	-	-	-	-	Section 2
. NN	-	-	-	-	Section 3
. Chan	-	Sections 4, 6, 7	Sections 10, 11	-	-
. Sua Noi	-	-	Section 5	-	-
. Song Kla Tiam	-	-	Sections 8, 9	-	-
. Ta Nang	-	-	Section 15	Section 13 to 14 (4.2 km)	-

Note: Category I = new drain
Category II = deepening and widening + construction of retaining walls
Category III = deepening + construction of retaining walls
Category IV = no improvement(IV-2) or deepening(IV-1)
Category V = deepenig

Table J.11 Drainage Works in Patterna Karn Drainage Area

	Category I	Category II	Category III	Category IV	Category V
. NN	-	-	-	-	Sections 1, 2
. NN	-	-	-	-	Section 3
. NN	-	-	-	-	Section 4
. NN	-	-	-	Section 6 to 7 (3 km)	

Note : Category I = new drain
Category II = deepening and widening + construction of retaining walls
Category III = deepening + construction of retaining walls
Category IV = no improvement(IV-2) or deepening(IV-1)
Category V = deepening + widening

Table J.12 Drainage Works in Hua Mark Drainage Area

	Category I	Category II	Category III	Category IV	Category V
North					
. Gig	-	-	Section 1	-	-
. Kacha	-	-	Sections 2, 3	-	-
South					
. NN	-	-	-	-	Section 1
. Sakae	-	-	Sections 2, 4	-	-
. NN	-	-	Section 3	-	-
. Hua Mark	-	-	Section 6	-	-

Note: Category I = new drain
Category II = deepening and widening + construction of retaining walls
Category III = deepening + construction of retaining walls
Category IV = no improvemetn(IV-2) or deepening(IV-1)
Category V = deepening + widening

Table J.13 Drainage Works in Huay Kwang Drainage Area

	Category I	Category II	Category III	Category IV	Category V
East					
. Wat Iuk	-	-	Section 1	-	Sections 2, 3
. NN	Section 5	-	-	-	-
. Plab Pla	-	-	-	-	Section 6
West					
. Lat Phrao	-	-	Sections 1, 2	-	Sections 3, 4
. Huay Kwang	-	-	Section 6	-	Sections 7, 10
. NN	-	-	-	-	Section 8
. NN	-	-	-	-	Section 9
. NN	-	-	Section 11	-	-
. Sam Saen	-	-	Sections 12, 13, 14	-	-

Note: Category I = new drain
Category II = deepening and sidening+ construction of retaining walls
Category III = deepening + construction of retaining walls
Category IV = no improvement(IV-2) or deepening(IV-1)
Category V = deepening + widenig

Table J.14 Drainage Works in Bang Na Draiange Area

	Category I	Category II	Category III	Category IV	Category V
. NN	Section 1	-	-	-	-
. Bang Oa	-	-	Sections 2, 3	-	-
. Bang Jek	-	-	Sections 5, 6, 7	-	-
. NN	-	-	Section 9	-	-
. Bang Na Jen	-	-	Section 10	-	-
. NN	Section 11	Section 12	-	-	-
. Bang Lai	-	Section 13	-	-	-
. NN	Section 14	-	-	-	-
. Kelet	-	-	-	Sections 15, 16, 17 18, 19(partly) (5 km)	-
. NN	Section 19(partly)	-	-		-
. Bang Na	-	-	Sections 20, 21, 22, 23	Section 24 (1 km)	-
. NN	Section 25	-	-	-	-

Note: Category I = new drain

Category II = deepening and widening + construction of retaining walls

Category III = deepening + construction of retaining walls

Category IV = no improvement(IV-2) or deepening(IV-1)

Category V = deepening + widening

Table J.15(1) Proposed Retaining Walls and Excavations for Trunk Klong Improvement (1/2)
(K. Phra Khanong, K. Tan, K. Saen Saep)

Klong	Section No.	Distance from the mouth (km)	Length (m)	Category	Shape	Width (m)	Depth (m)	Retaining Wall		Excavation ($1,000 m^3$)	Land Required (m^2)
								Type	Length (m)		
Phra Khanong	1	2.5 - 3.5	1,000	III	R	35	4.5	B	2,000	35	-
	2	3.5 - 4.5	1,000	III	R	28	4.5	B	1,000	64	-
	3	4.5 - 5.5	1,000	IV	T	40	4.0	-	-	48	-
	4	5.5 - 6.5	1,000	III	R	28	4.0	B	1,000	20	-
	5	6.5 - 7.5	1,000	III	R	24	4.0	B	1,000	22	-
	6	7.5 - 8.5	1,000	IV	T	37	4.0	-	-	90	-
	7	8.5 - 9.5	1,000	IV	T	42	4.0	-	-	36	-
	8	9.5 - 10.5	1,000	IV	R	26	4.0	-	-	30	-
	9	10.5 - 11.5	1,000	IV	T	37	4.0	-	-	32	-
	10	11.5 - 12	500	IV	T	38	4.0	-	-	16	-
Tan	11	4 - 5.5	1,500	III	R	21	4.5	B	1,500	45	-
	12	5.5 - 6.5	1,000	III	R	22	4.5	B	1,000	26	-
	13	6.5 - 7.5	1,000	IV	R	28	4.5	-	-	46	-
	14	7.5 - 8.5	1,000	III	R	22	4.5	B	1,000	16	-
	15	8.5 - 9.5	1,000	IV	R	27	4.0	-	-	50	-
K. Saen Saep	16	9.5 - 10.5	1,000	IV	T	37	4.0	-	-	60	-
	17	10.5 - 11.5	1,000	IV	R	28	4.0	-	-	24	-
	18	11.5 - 12.5	1,000	IV	R	28	4.0	-	-	24	-
	19	12.5 - 13.5	1,000	IV	T	47	4.0	-	-	52	-

Table J.15(2) Proposed Retaining Walls and Excavations for Trunk Klong Improvement (2/2)
(K. Phra Khanong, K. Tan, K. Saen Saep)

Klong	Section No.	Distance from the mouth (km)	Length (m)	Category	Shape	Width (m)	Depth (m)	Retaining Wall		Excavation ($1,000\ m^3$)	Land Required (m^2)
								Type	Length (m)		
K. Saen Saep	20	13.5 - 14.5	1,000	III	R	18	4.0	B	1,000	26	-
	21	14.5 - 15.5	1,000	III	R	20	4.0	B	1,000	32	-
	22	15.5 - 16.5	1,000	IV	T	30	4.0	-	-	40	-
	23	16.5 - 17.5	1,000	IV	R	27	4.0	-	-	40	-
	24	17.5 - 18.5	1,000	III	R	25	4.0	B	1,000	24	-
	25	18.5 - 19.5	1,000	IV	T	39	4.0	-	-	40	-
	26	19.5 - 20	500	IV	T	35	4.0	-	-	20	-
Total			25,5000	-		-	-	-	11,500	958	-

Note: Category I = new drain
Category II = widening + deepening + construction of retaining walls
Category III = deepening + construction of retaining walls
Category IV = deepening or no improvement
Category V = deepening + widening
R = Rectangular channel
T = Trapezoidal channel

A = Concrete sheet pile wall
B = Anchored sheet pile wall

Table J.16 Proposed Retaining Walls and Excavations for Trunk Klong Improvement

(Bang Khen and Bang Sue Drainage Areas)

Klong	Section No.	Length (m)	Category	Shape	Width (m)	Depth (m)	Retaining Wall Type	Retaining Wall Length (m)	Excavation (1,000 m^3)	Land Required (m^2)
Lat Phrao	1 to 8	16,500	IV	T	30-40	3	-	-	-	-
Bang Sue	9	2,000	III	R	15	3	B	4,000	16	-
	10	2,000	III	R	16	3.2	B	4,000	16	-
	11	2,000	II	R	20	3.5	B	4,000	32	4,000
	12	2,000	III	R	25	4.5	B	4,000	26	-
	20,21	6,200	IV	T	20	3.0	-	-	-	-
Bang Khen	14	2,000	IV	T	23	2.6	-	-	24	-
	15	1,900	IV	T	22	2.7	-	-	21	-
	16	2;000	V	T	24	2.7	-	-	77	24,000
	17	2,000	V	T	30	2.9	-	-	68	16,000
	18	2,500	V	T	30	3.0	-	-	56	12,5000
Total		41,100	-		-	-	-	16,000	336	56,5000

Note: Category I = new drain
Category II = widening + deepening + construction of retaining walls
Category III = deepening + construction of retaining walls
Category IV = deepening or no improvement
Category V = deepening + widening
R = Rectangular channel
T = Trapezoidal channel
A = Concrete sheet pile wall
B = Anchored sheet pile wall

Table J.17 Proposed Retaining Walls and Excavations for Trunk Klong Improvement

(Klong Chan Drainage Area)

Klong	Section No.	Length (m)	Category	Shape	Width (m)	Depth (m)	Retaining Wall		Excavation ($1,000\ m^3$)	Land Required (m^2)
							Type	Length (m)		
N.N	1 to 3	4,800	V	T	11	1.8	-	-	45.0	14.400
Bank Toei	4, 5	3,900	IV	T	12	2.0	-	-	-	-
Bang Chala	7	1,300	III	R	5	1.9	A	2,600	3.9	-
Phlu	8	1,000	V	T	8	1.9	-	-	8.2	3.000
Total		11,000	-	-	-	-	-	2,600	57.1	17.400

Note: Category I = new drain
Category II = widening + deepening + construction of retaining walls
Category III = deepening + construction of retaining walls
Category IV = deepening or no improvement
Caregory V = deepening + widening
R = Rectangular channel
T = Trapezoidal channel

A = Concrete sheet pile wall
B = Anchored sheet pile wall

Table J.18 Proposed Retaining Walls and Excavations for Trunk Klong Improvement

(Lat Phrao Drainage Area)

Klong	Section No.	Length (m)	Category	Shape	Width (m)	Depth (m)	Retaining Wall		Excavation ($1,000 m^3$)	Land Required (m^2)
							Type	Length (m)		
N.N	1	1,200	III	R	10	2.2	A	2,400	6	-
Lat Plakao	2	1,200	V	T	15	2.0	-	-	12.6	3,600
N.N	3	1,500	V	T	12	1.5	-	-	19.8	6,000
Chan	4	2,400	II	R	10	2.8	B	4,800	24	4,800
	6, 7	2,500	II	R	10	2.5	A	5,000	22.5	5,000
	10, 11	2,200	III	R	13	1.8	A	4,400	15.4	-
Sua Noi	5	1,000	III	R	9	2.8	B	2,000	5	-
Song Kla Tiam	8, 9	2,500	III	R	8	1.8	A	5,000	10	-
Ta Nang	13, 14	4,200	IV	T	8	2.8	-	-	-	-
	15	1,200	III	R	16	2.8	B	2,400	9.6	-
Total		19,900	-		-	-	-	26,000	124.9	19,400

Note: Category I = new drain
Category II = widening + deepening + construction of retaining walls
Category III = deepening + construction of retaining walls
Category IV = deepening or no improvement
Category V = deepening + widening
R = Rectangular channel
T = Trapezoidal channel

A = Concrete sheet pile wall
B = Anchored sheet pile wall

Table J.19 Proposed Retaining Walls and Excavations for Trunk Klong Improvement
(Paterna Karn Drainage Area)

Klong	Section No.	Length (m)	Category	Shape	Width (m)	Depth (m)	Retaining Wall		Excavation ($1,000 m^3$)	Land Required (m^2)
							Type	Length (m)		
N.N	1, 2	2,800	V	T	13	2.0	-	-	30.8	8,400
N.N	3	1,200	V	T	13	1.8	-	-	12.5	3,600
N.N	4	1,500	V	T	15	3.0	-	-	30.0	7,500
N.N	6, 7	3,000	IV	T	14	2.0	-	-	-	-
Total		8,500	-	-	-	-	-	-	73.3	19,500

Note: Category I = new drain
Category II = widening + deepening + construction of retaining walls
Category III = deepening + construction of retaining walls
Category IV = deepening or no improvement
Category V = deepening + widening
R = Rectangular channel
T = Trapezoidal channel

A = Concrete sheet pile wall
B = Anchored sheet pile wall

Table J.20 Proposed Retaining Walls and Excavations for Trunk Klong Improvement

(Hua Mark Drainage Area)

Klong	Section No.	Length (m)	Category	Shape	Width (m)	Depth (m)	Retaining Wall		Excavation (1,000 m^3)	Land Required (m^2)
							Type	Length (m)		
North										
Gig	1	1,200	III	R	12	1.8	A	2,400	4.8	-
Kacha	2, 3	2,700	III	R	12	1.9	A	5,400	10.8	
Sub-total		3,900	-	-	-	-	-	7,800	15.6	-
South										
N.N	1	500	V	T	11	1.8	-	-	9.9	1500
Sakae	2	1,700	III	R	8	1.8	A	3,400	6.8	-
	4	1,100	III	R	9	1.9	A	2,200	5.5	-
N.N	3	1,600	III	R	12	1.6	A	3,200	9.6	-
Hua Mark	6	1,000	III	R	10	2.7	B	2,000	5	-
Sub-total		5,900	-	-	-	-	-	10.800	36.8	1500
Total		9,800	-	-	-	-	-	18.600	52.4	1500

Note: Category I = new drain
Category II = widening + deepening + construction of retaining walls
Category III = deepening + construction of retaining walls
Category IV = deepening or no improvement
Category V = deepnig + widening

R = Rectangular channel
T = Trapezoidal channel

A = Concrete sheet pile wall
B = Anchored sheet pile wall

Table J.21 Proposed Retaining Walls and Excavations for Trunk Klong Improvement
(Huay Kwang Drainage Area)

Klong	Section No.	Length (m)	Category	Shape	Width (m)	Depth (m)	Retaining Wall Type	Retaining Wall Length (m)	Excavation (1,000 m^3)	Land Required (m^2)
East										
Wat Tuk	1	1,800	III	R	10	2.0	A	3,600	9.0	-
Wat Tuk	2, 3	1,700	V	T	13	2.0	-	-	18.7	5,100
N.N	5	1,000	I	R	10	1.8	A	2,000	18	10,000
Plab Pla	6	1,500	V	T	15	1.8	-	-	17.1	4,500
Sub-total		6,000	-		-	-	-	5,600	62.8	19,600
Lat Phrao	1, 2	3,200	III	R	13	3.6	B	6,400	22.4	-
	3, 4	2,200	V	T	21	3.3	-	-	53.9	11,000
Hyat Kwang	6	2,000	III	R	12	2.1	A	4.000	12.0	-
Huay Kwang	7, 10	4,000	V	T	16	2.1	-	-	57.6	16,000
N.N	8	1,800	V	T	11	2.0	-	-	18.0	5,400
N.N	9	1,600	V	T	19	2.2	-	-	26.1	6,400
N.N	11	2,000	III	R	9	2.7	B	4,000	10	-
Sam Sen	12, 13,	4,100	III	R	10	2.7	B	8,200	20.5	-
	14	2,000	III	R	13	2.8	B	4,000	14	-
Sub-total		22,900	-		-	-	-	26,600	234.5	38,800
Total		28,900	-		-	-	-	32,200	297.3	58,400

Note: Category I = new drain
Category II = widening + deepening + construction of retaining walls
Category III = deepening + construction of retaining walls
Category IV = deepening or no improvement
Category V = deepening + widening
R = Rectangular channel
T = Trapezoidal channel

A = Concrete sheet pile wall
B = Anchored sheet pile wall

Table J.22 Proposed Retaining Walls and Excavations for Trunk Klong Improvement (Bang Na Drainage Area) (1/2)

Klong	Section No.	Length (m)	Category	Shape	Width (m)	Depth (m)	Retaining Wall Type	Retaining Wall Length (m)	Excavation (1,000 m^3)	Land Required (m^2)
N.N	1	700	I	R	10	3	B	1,400	21	7,000
Bang Oa	2, 3	1,400	III	R	10	2.9	B	2,800	7.0	-
Bang Jek	5	1,300	III	R	10	2.2	A	2,600	6.5	-
	6	1,500	III	R	10	2.8	B	3,000	7.5	-
	7	700	III	R	10	2.8	B	1,400	3.5	-
N.N	9	1,000	III	R	8	2.0	A	2,000	4.0	-
Bang Na Jen	10	2,000	III	R	10	2.2	A	4,000	10.0	-
N.N	11	1,400	I	R	8	2.3	A	2,800	26.6	11,200
	12	1,100	II	R	8	2.2	A	2,200	4.4	-
Bang Lai	13	1,000	II	R	10	2.3	A	2,000	9	2,000
N.N	14	1.500	I	R	10	2.2	A	3,000	33.0	15,000
Kelet	15 to 18	4,000	IV	T	10	2.1	-	-	-	-
	19	1,000	IV	T	10	2.2	-	-	-	-
N.N	19	1,200	I	R	10	2.2	A	2,400	26.4	12,000
Bang Na	20	2,300	III	R	10	2.8	B	4,600	11.5	-
	21	1,000	III	R	12	2.6	B	2,000	6.0	-
	22, 23	2,000	III	R	15	2.6	B	4,000	15.0	-
	24	1,000	IV	R	15	2.8	-	- -	7.5	-
	25	1,000	I	R	10	2.2	A	2,000	22.0	10,000
Total		27,100	-		-	-	-	42,200	220.9	57,200

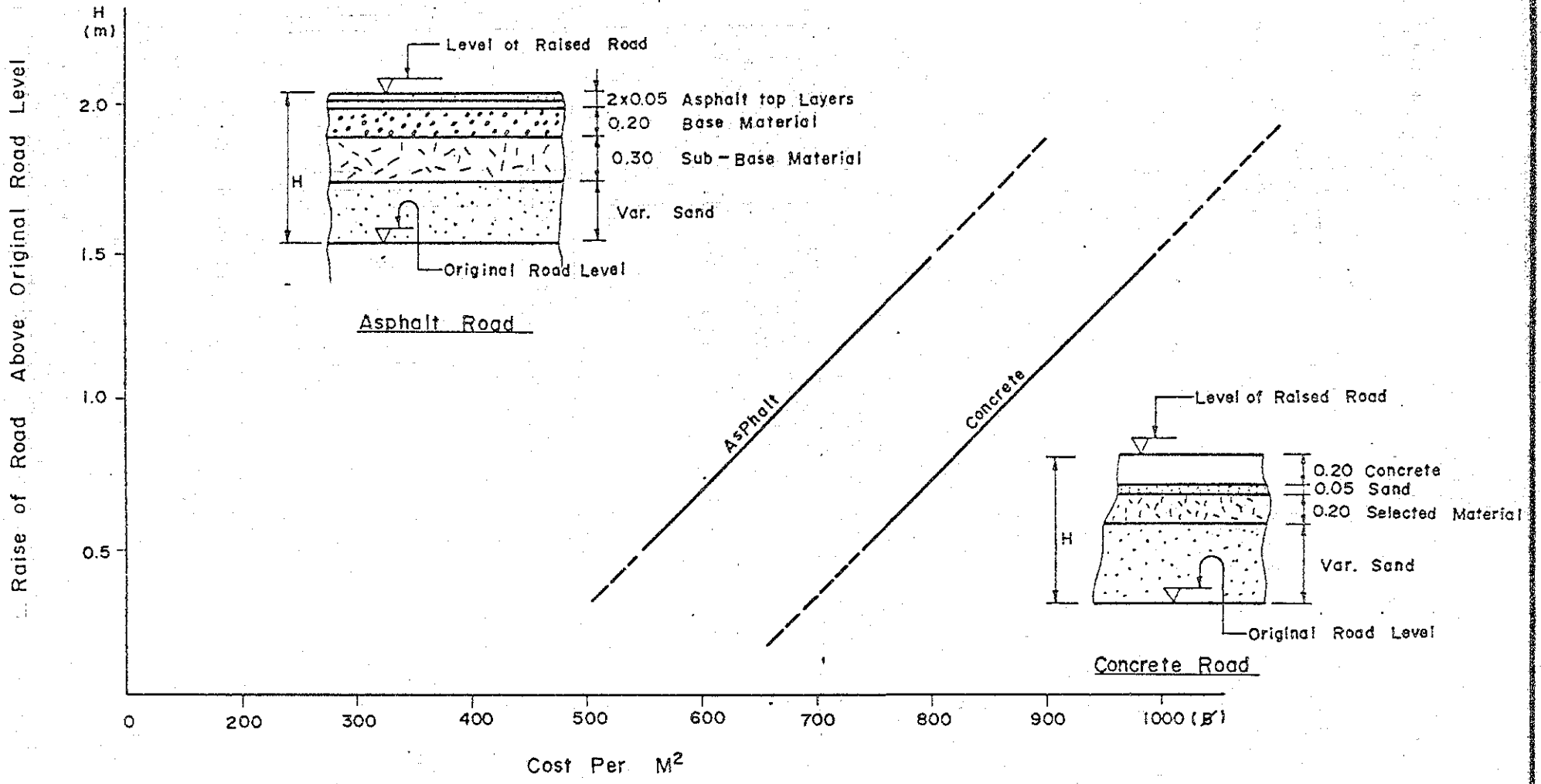
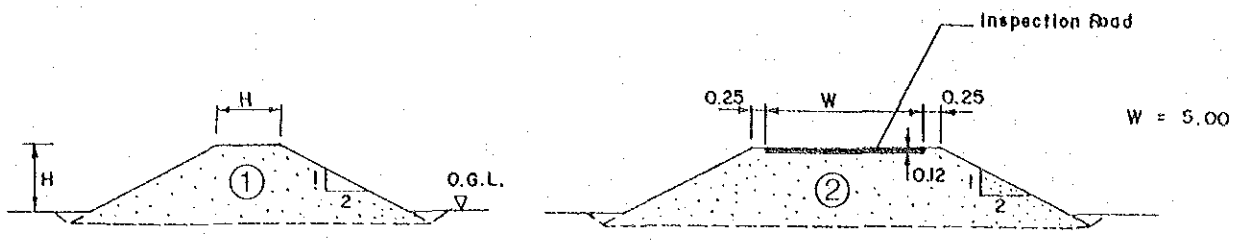
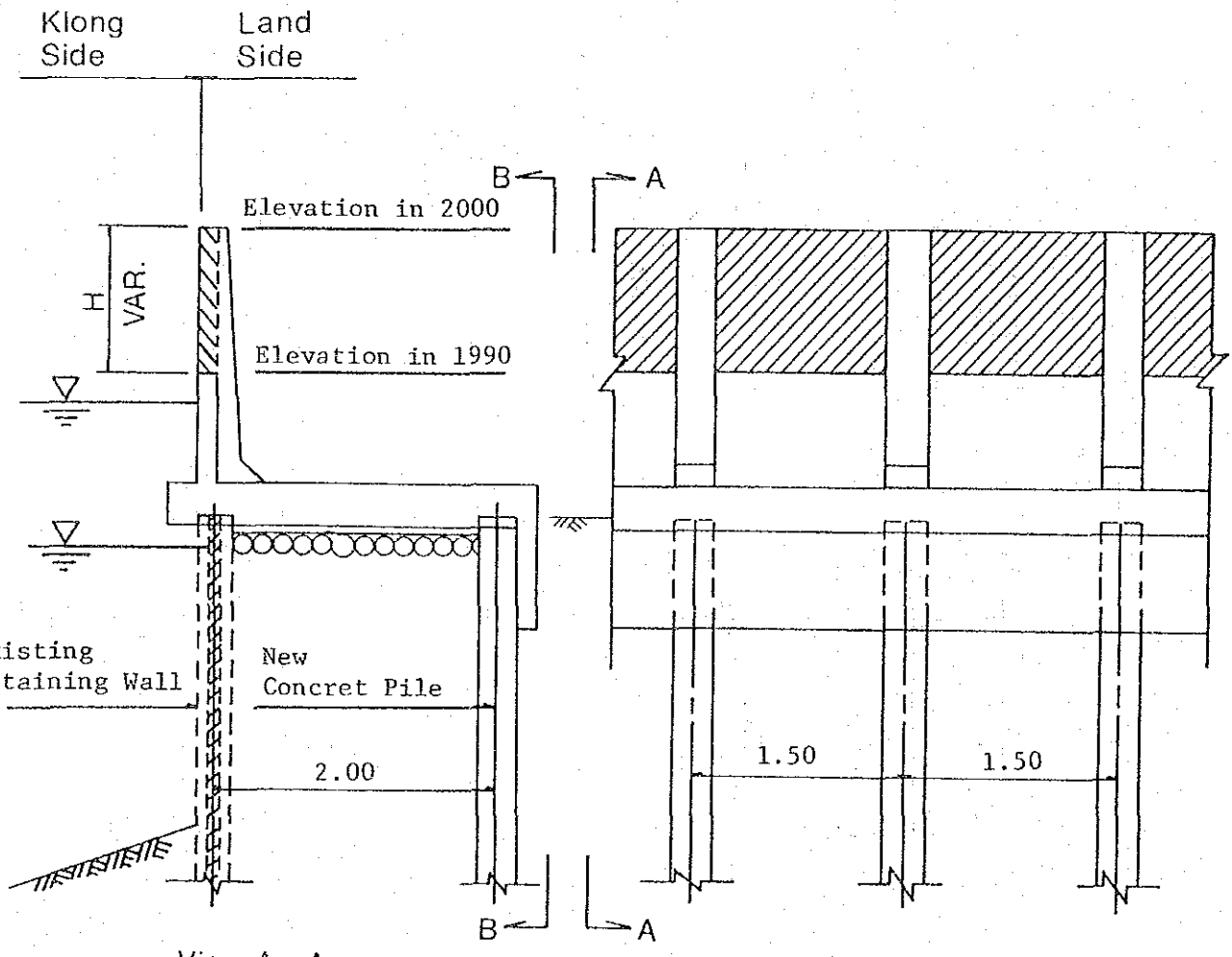


Fig. J.1	COST CURVES FOR RAISE OF ROADS

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



TYPE A (Embankment)

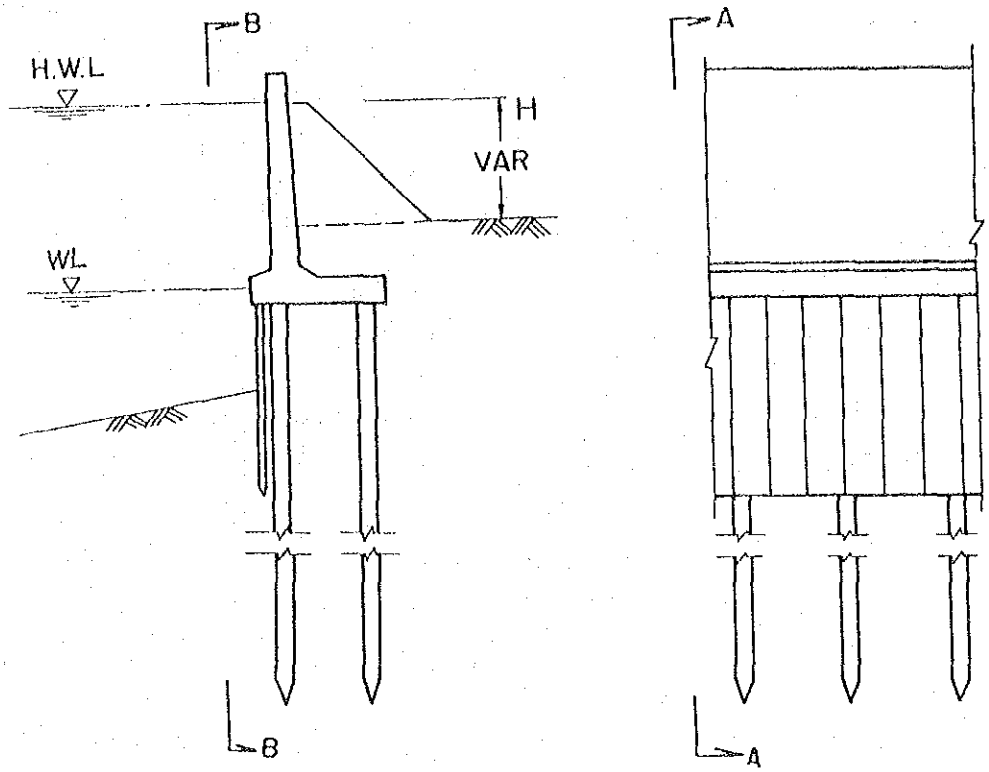


TYPE B

Fig. J.2	WATER PROTECTION BARRIER STRUCTURE (TYPE A, B)

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2528B.E 1985A.D



View A - A

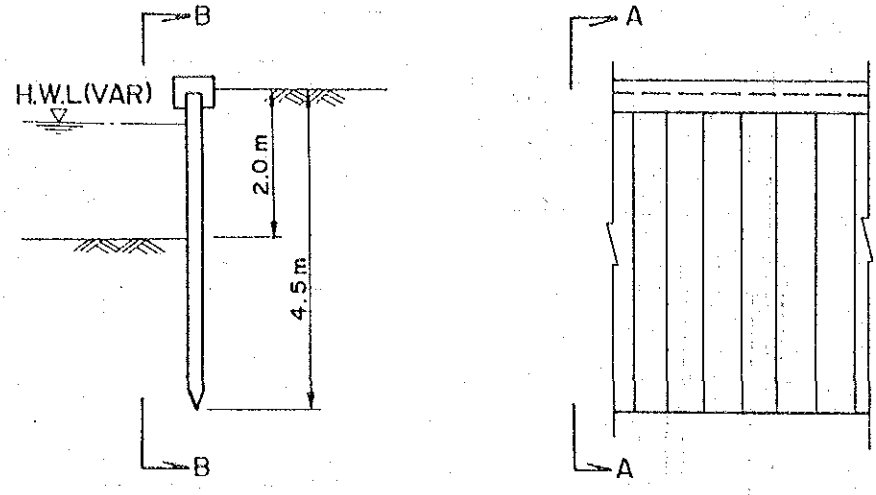
View B - B

TYPE C

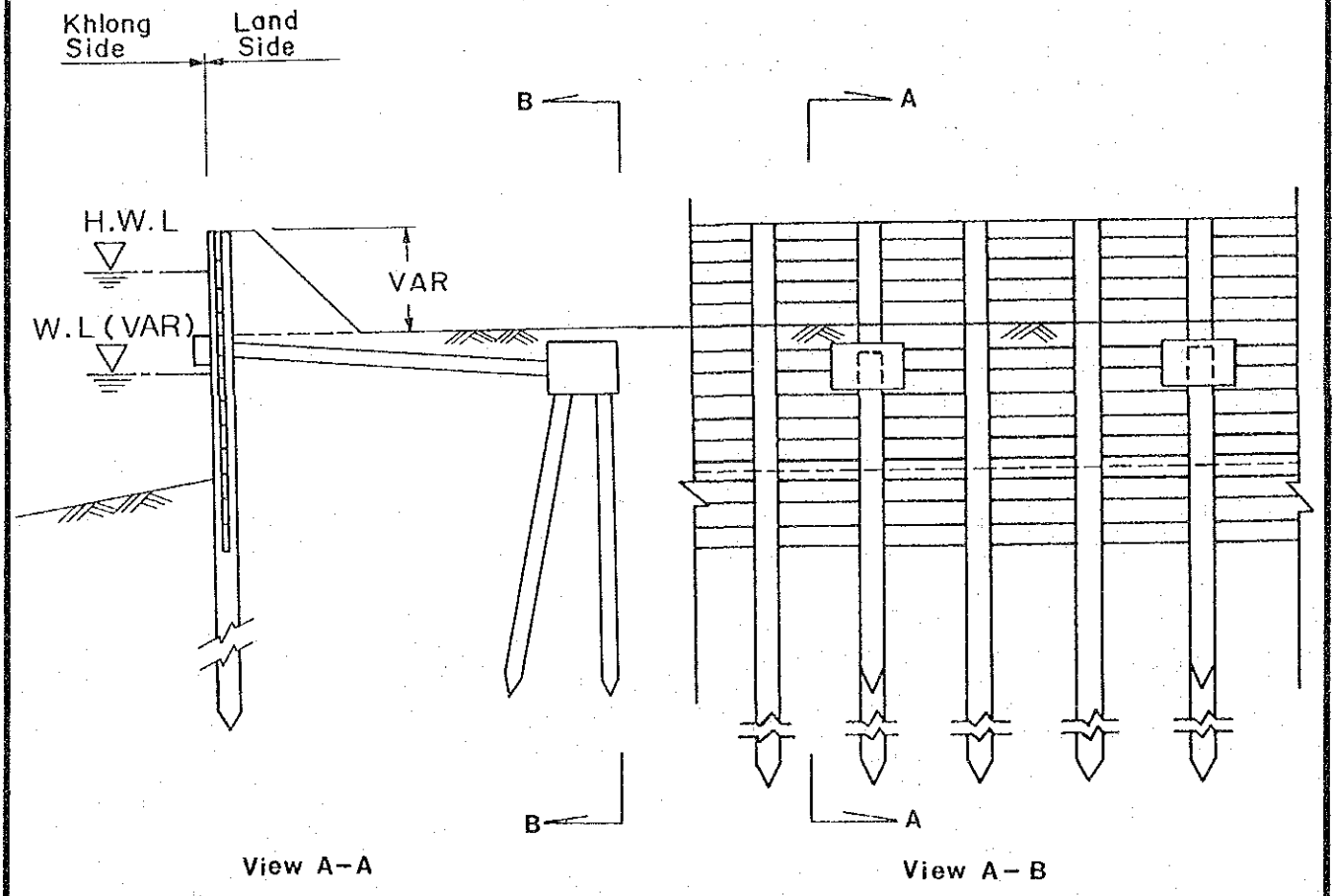
Fig. J.3	WATER PROTECTION BARRIER STRUCTURE (TYPE C)

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2528B.E 1985A.D



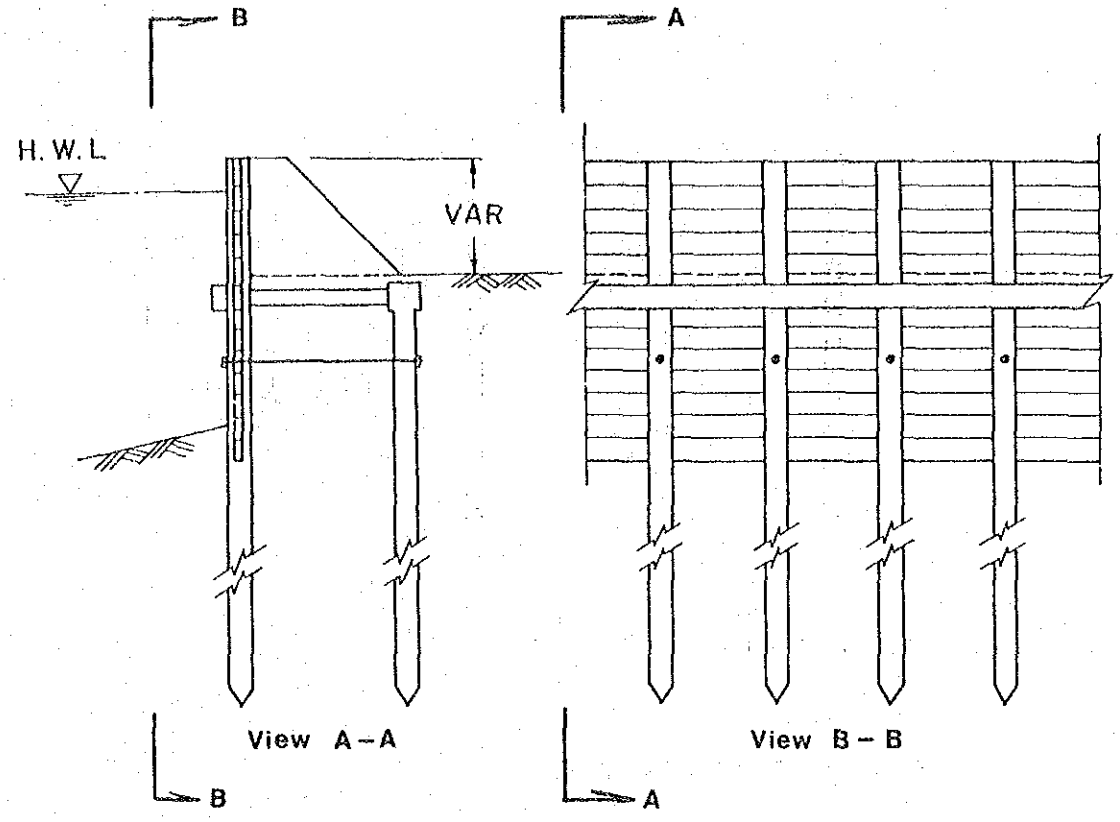
TYPE A



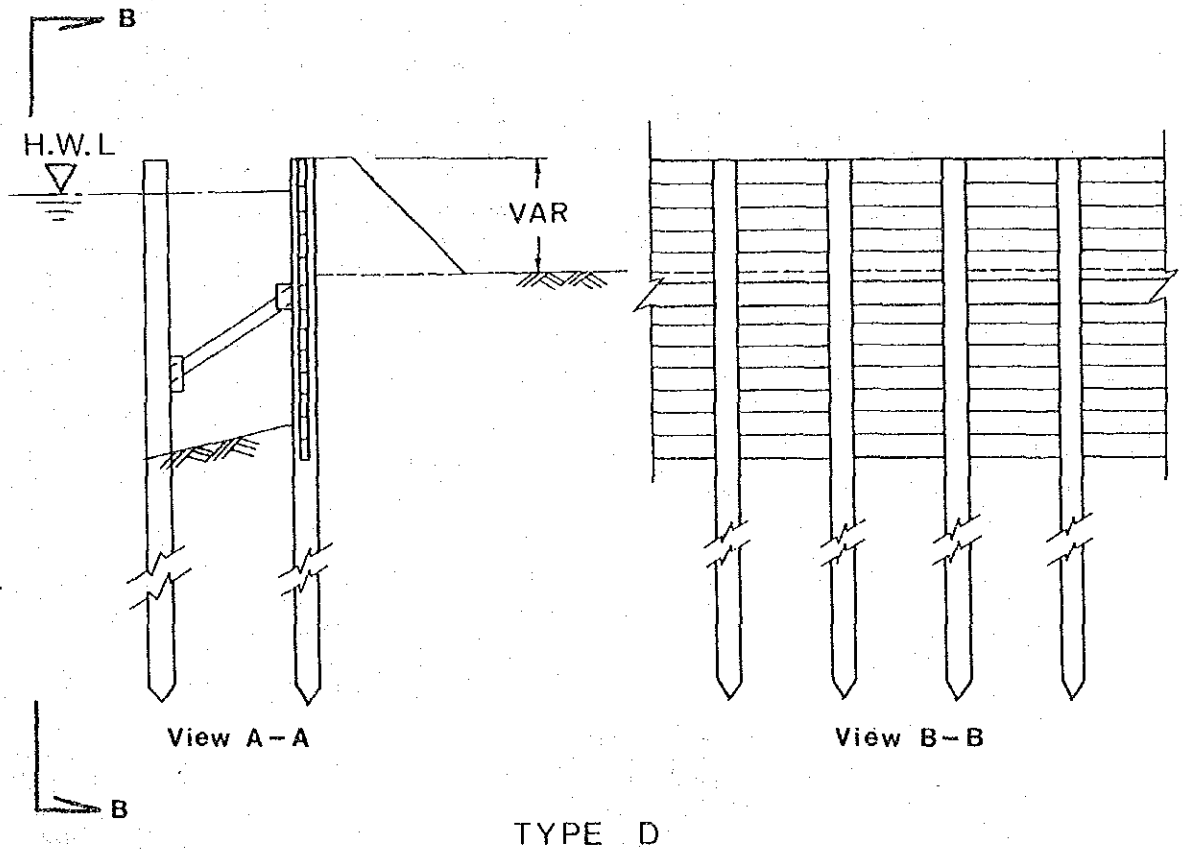
TYPE B

Fig. J.4	RETAINING WALL STRUCTURE (TYPE A, B)

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



TYPE C

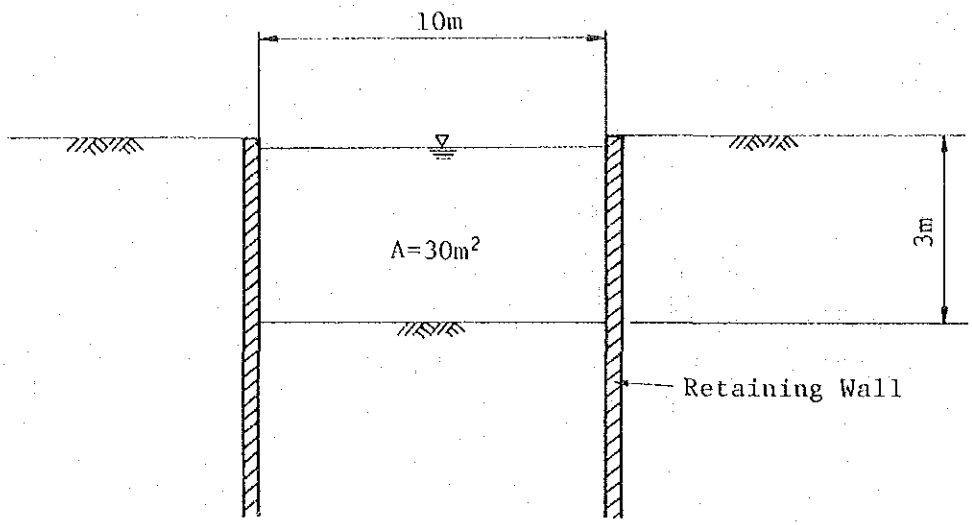


TYPE D

Fig. J.5 RETAINING WALL STRUCTURE (TYPE C, D)

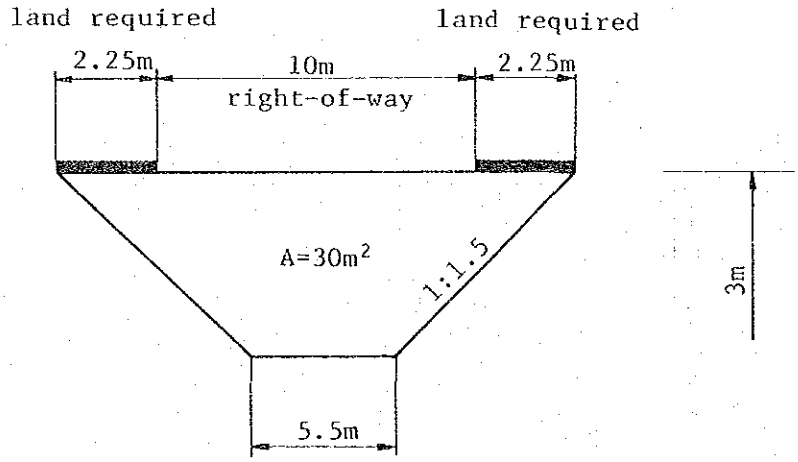
MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2528B.E 1985A.D



Construction Cost	:	10,200~18,200	Baht/m
Land Acquisition Cost	:	0	
Total Cost	:	10,200~18,200	Baht/m

(A) Rectangular Shape



Construction Cost	:	0	
Land Acquisition Cost	:	2,250~13,500	Baht/m
Total Cost	:	2,250~13,500	Baht/m

(B) Trapezoidal Shape

Fig. J.6 TWO TYPES FOR KLONG IMPROVEMENT

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

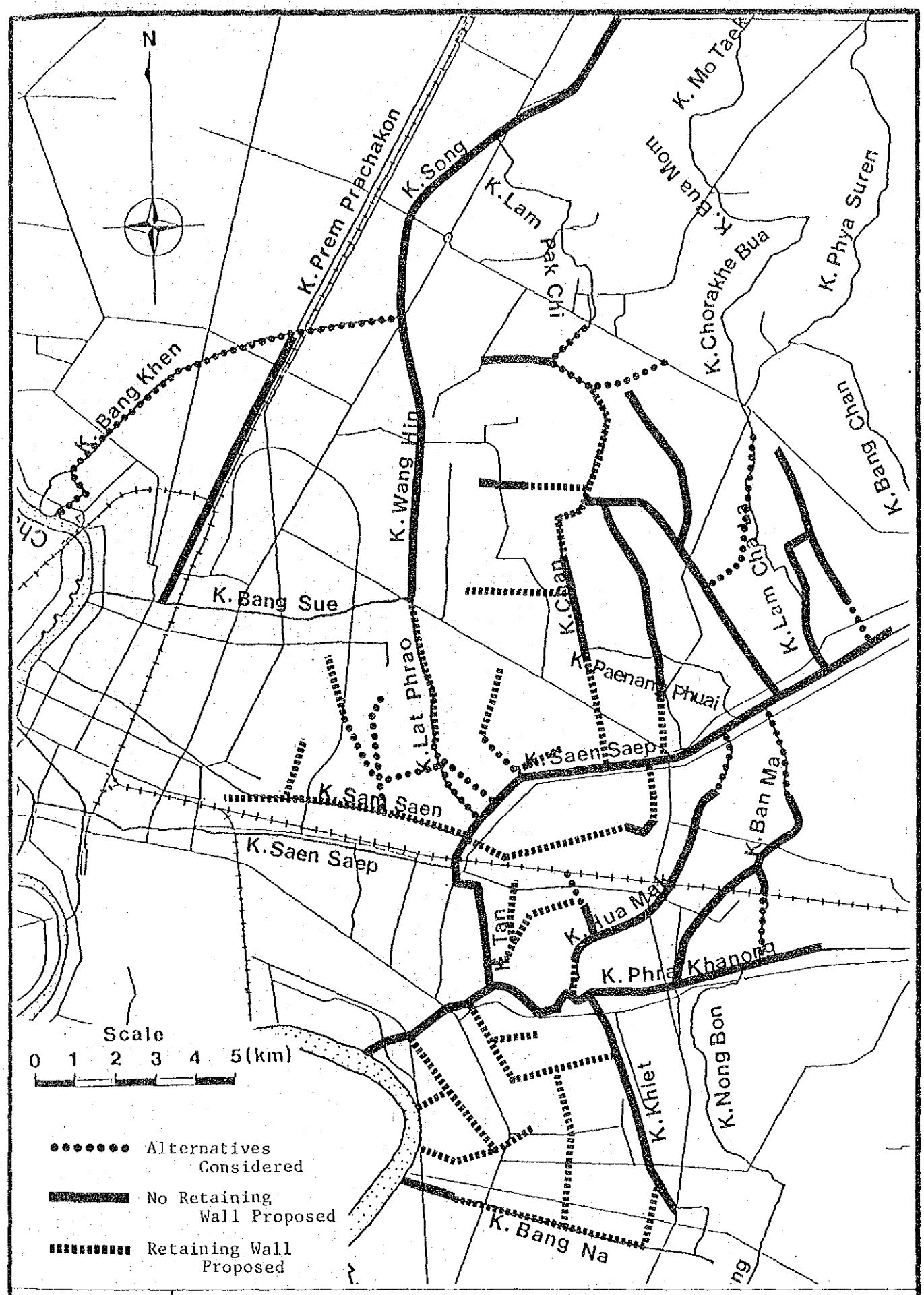


Fig. J.7 KLONGS USED FOR ALTERNATIVE STUDY

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

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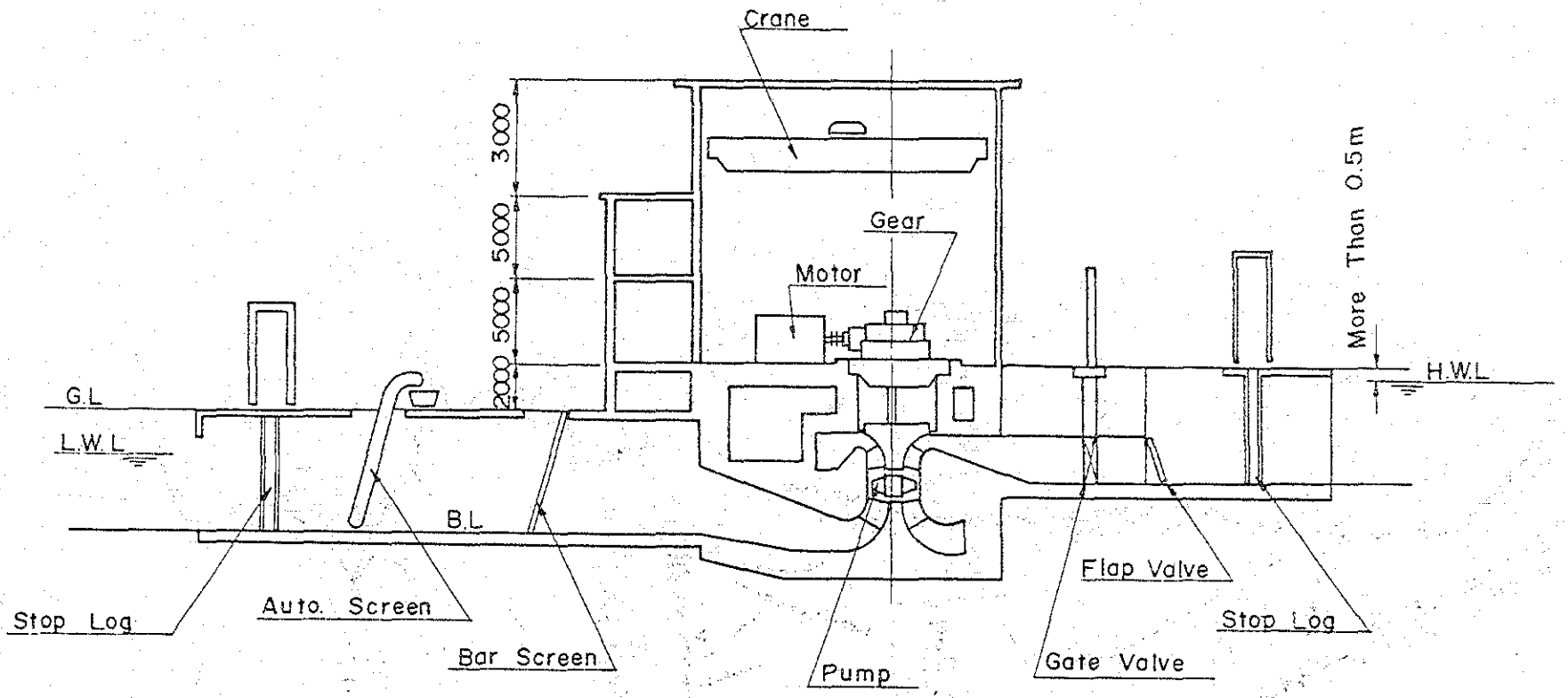

Fig. J.8 EXAMPLE OF PUMPING STATION

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

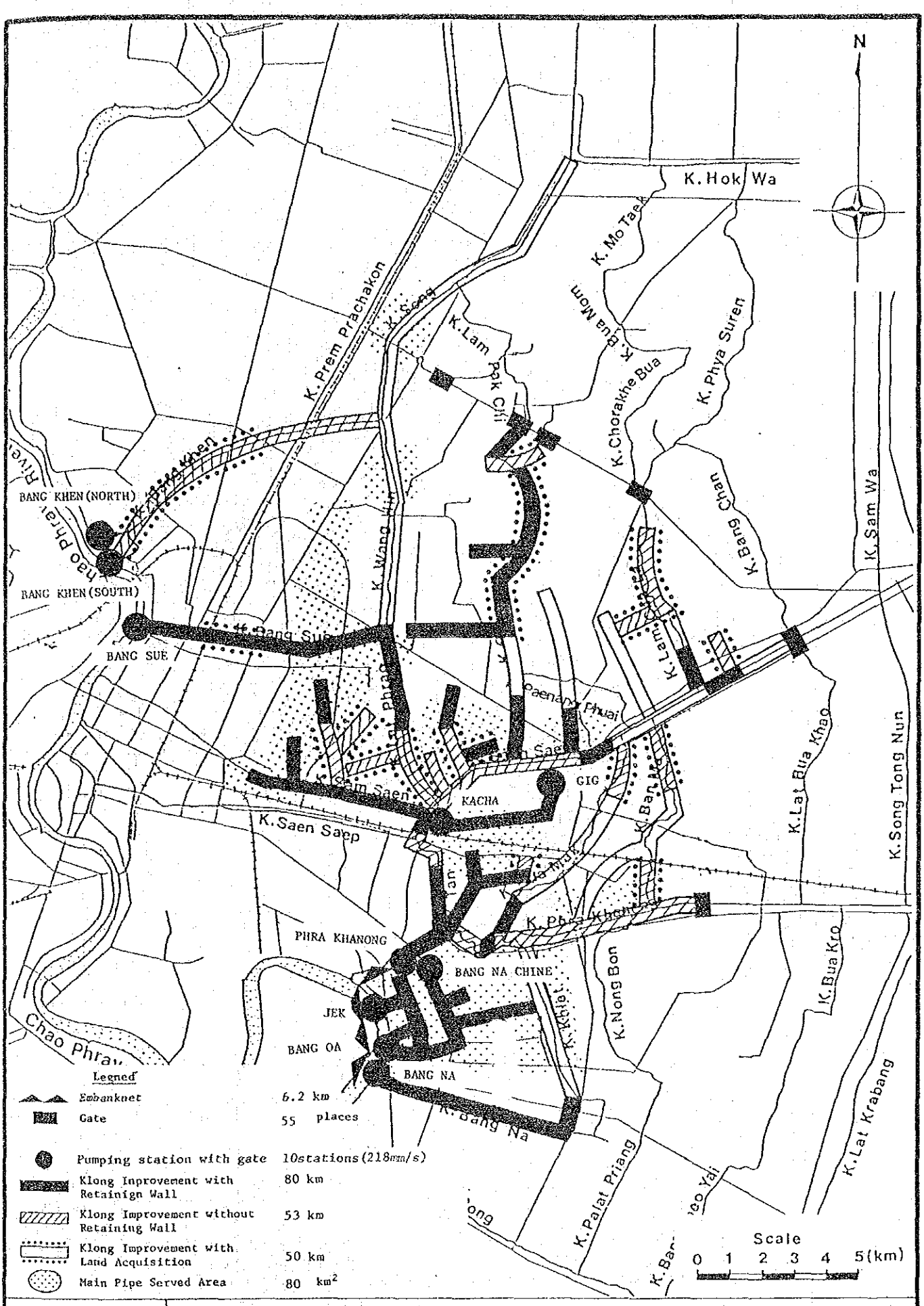

Fig. J.9 PROPOSED FLOOD PROTECTION/DRAINAGE FACILITIES

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

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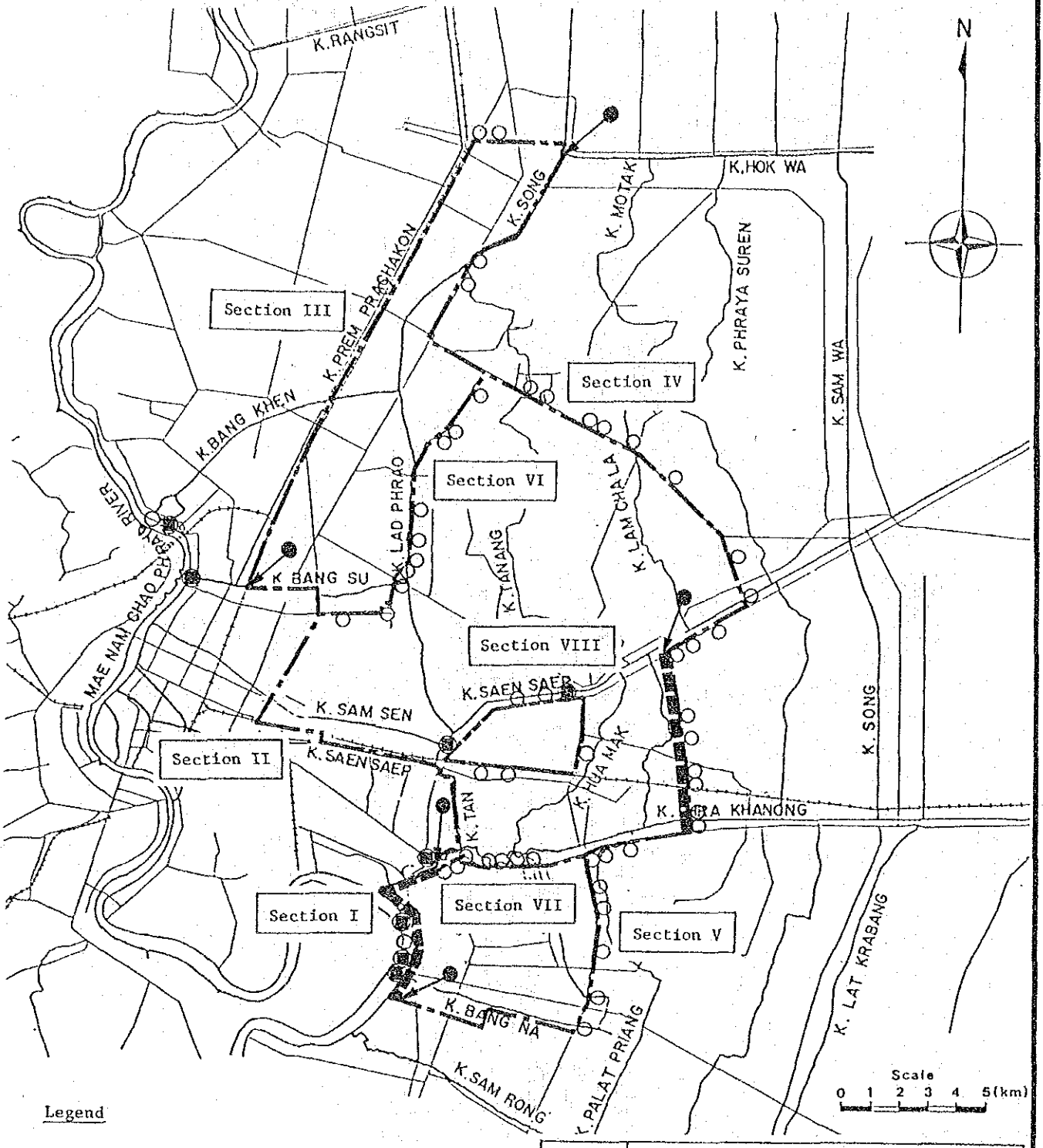

Legend

- Barrier to be newly constructed (Section A & B)
- Section III — Barrier utilizing existing road & railway
- ○ Control Gate
- ⊗ Pumping Station w/Ancillaty Gate

Note: Based on the klong network indicated in the topographic map(Scale 1:20,000) which was established in 1978, location of gates along the battier are proposed.

Section	Barrier		
	Exist. Road/ Railway	To be Con- structed	Total Length
I	- km	6.2 km	6.2 km
II	19.4	-	19.4
III	20.9	-	20.9
IV	26.4	-	26.4
V	17.1	6.5	23.6
VI	12.1	-	12.1
VII	5.6	-	5.6
VIII	13.0	-	13.0
Total	114.5 km	12.7 km	127.2 km

Fig. J.10 PROPOSED BARRIER AND CONTROL GATE

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

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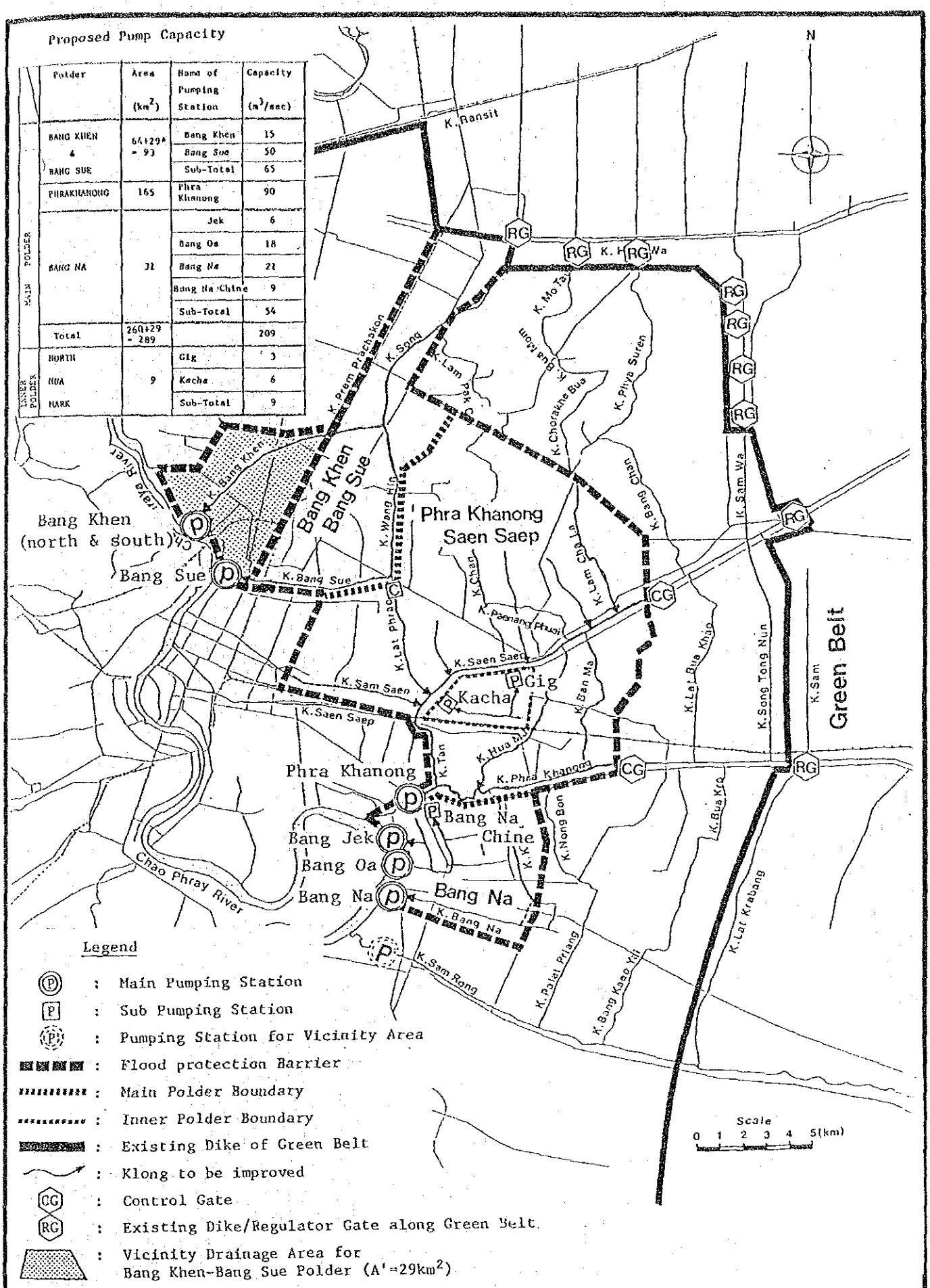
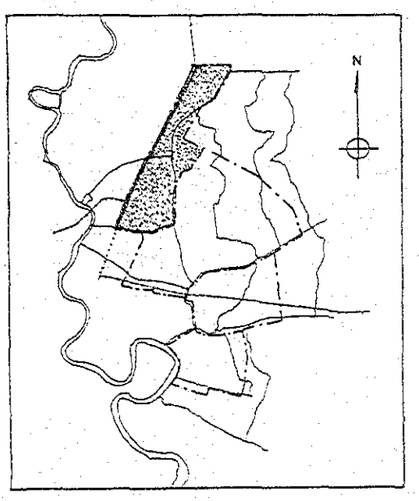


Fig. J.11 PROPOSED PUMPING STATION

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2528B.E 1985A.D

Key Map



Legend

- Boundary of Drainage Area
- New Drain
- Improvement Drain (with Retaining Wall)
- Improvement Drain (without Retaining Wall)
- (1) Section Number
- (3) " (Trunk Drain)
- (P7) Pumping Station
- (P1) " (main)
- Retention Area

1 2 3 4
III. R 16 × 2
1000
5

where

1 : Category
- I = New Drain
- II = Widening + Deeping + Construction of Retaining Wall
- III = Deeping + Construction of Retaining Wall
- IV = Dridging or No-improvement
- V = IV + Widening

2 : Shape
- R = Rectangular Channel
- T = Trapezoidal Channel

3 : Top Width fo Channel

4 : Depth of Channel

5 : Length

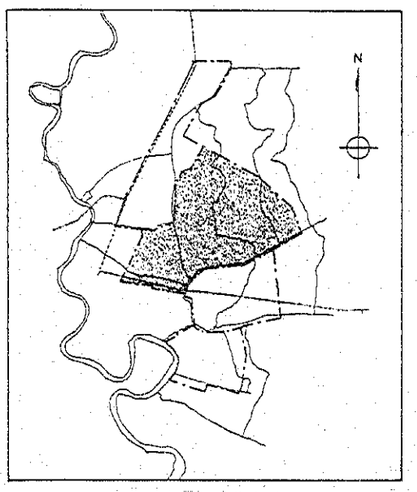
Bang Khen, Bang Sue Drainage Area

Section No	Cross Section (m)	Section No	Cross Section (m)
(1) to (8)	IV.T 35 × 3 16500	(15)	IV.T 22 × 2.7 1900
(9)	III.R 15 × 3 2000	(16)	V.T 24 × 2.7 2000
(10)	III.R 16 × 3.2 2000	(17)	V.T 30 × 2.9 2000
(11)	II.R 20 × 3.5 2000	(18)	V.T 30 × 3 2500
(12)	III.R 25 × 4.5 2000	(20) (21)	IV.T 20 × 3 6200
(14)	IV.T 23 × 2.6 2000		
(P1)	Q = 15 m³/s	K.Bang Khen	
(P2)	Q = 50 m³/s	K.Bang Sue	

Fig. J.12 PROPOSED DRAINAGE FACILITIES (BANG KHEN AND BANG SUE DRAINAGE AREA)

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

Key Map



Klong Chan Drainage Area			
Section No	Cross Section (m)	Section No	Cross Section (m)
①	V.T 11 × 1.8 1800	⑤	IV.T 12 × 2 2500
②	V.T 11 × 1.8 1000	⑦	III.R 5 × 1.9 1300
③	V.T 11 × 1.8 2000	⑧	V.T 8 × 1.9 1000
④	IV.T 12 × 2 1400		

Lat Phrao Drainage Area			
Section No	Cross Section (m)	Section No	Cross Section (m)
①	III.R 10 × 2.2 1200	⑧	III.R 8 × 1.8 1000
②	V.T 15 × 2 1200	⑨	III.R 8 × 1.8 1500
③	V.T 12 × 1.5 1500	⑩	III.R 13 × 1.8 1100
④	II.R 10 × 2.8 2400	⑪	III.R 13 × 1.8 1100
⑤	III.R 9 × 2.8 1000	⑬	IV.T 8 × 2.8 1000
⑥	II.R 10 × 2.5 1000	⑭	IV.T 8 × 2.8 3200
⑦	II.R 10 × 2.5 1500	⑮	III.R 16 × 2.8 1200

Huay Kwang Drainage Area			
Section No	Cross Section (m)	Section No	Cross Section (m)
East		④	V.T 21 × 3.3 1100
①	III.R 10 × 2 1800	⑥	III.R 12 × 2.1 2000
②	V.T 13 × 2 1600	⑦	V.T 16 × 2.1 1800
③	V.T 13 × 2 1100	⑧	V.T 11 × 2 1800
⑤	I.R 10 × 1.8 1000	⑨	V.T 19 × 2.2 1600
⑥	V.T 15 × 1.8 1500	⑩	V.T 16 × 2.1 1200
West		⑪	III.R 9 × 2.7 2000
①	III.R 13 × 3.6 1200	⑫	III.R 10 × 2.7 2100
②	III.R 13 × 3.6 2000	⑬	III.R 10 × 2.7 2000
③	V.T 21 × 3.3 1100	⑭	III.R 13 × 2.8 2000

Legend

- Boundary of Drainage Area
- New Drain
- Improvement Drain (with Retaining Wall)
- Improvement Drain (without Retaining Wall)
- ① Section Number
- ③ " (Trunk Drain)
- P7 Pumping Station
- P1 " (main)

1 2 3 4 where

III. R 10 × 2

1000

5

1 : Category
- I = New Drain
- II = Widening + Deeping + Construction of Retaining Wall
- III = Deeping + Construction of Retaining Wall
- IV = Dridging or No-improvement
- V = IV + Widening

2 : Shape
- R = Rectangular Channel
- T = Trapezoidal Channel

3 : Top Width fo Channel

4 : Depth of Channel

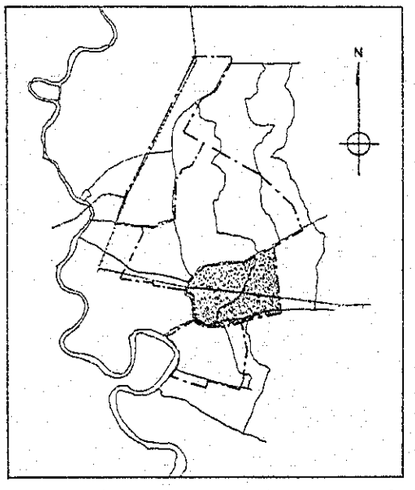
5 : Length

Retention Area

Fig. J.13 PROPOSED DRAINAGE FACILITIES (HUAY KWANG, LAT PHRAO, KLONG CHAN DRAINAGE AREA)

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK.

Key Map



Legend

- Boundary of Drainage Area
- New Drain
- Improvement Drain (with Retaining Wall)
- Improvement Drain (without Retaining Wall)
- (1) Section Number
- (3) " (Trunk Drain)
- (P7) Pumping Station
- (P1) " (main)

1 2 3 4 where

III. R 10 × 2 (1000, 5)

1 : Category
- I = New Drain
- II = Widening + Deeping + Construction of Retaining Wall
- III = Deeping + Construction of Retaining Wall
- IV = Dridging or No-improvement
- V = IV + Widening

2 : Shape
- R = Rectangular Channel
- T = Trapezoidal Channel

3 : Top Width fo Channel

4 : Depth of Channel

5 : Length

Retention Area

Hua Mark Drainage Area

Section No	Cross Section (m)	Section No	Cross Section (m)
North		South	
(1)	III.R 12 × 1.8 1200	(1)	V.T 11 × 1.8 500
(2)	III.R 12 × 1.9 2000	(2)	III.R 8 × 1.8 1700
(3)	III.R 12 × 1.9 700	(3)	III.R 12 × 1.6 1600
		(4)	III.R 9 × 1.9 1100
		(6)	III.R 10 × 2.7 1000
(P7)	Q = 3.0 m³/s K.Gig		
(P8)	Q = 6.0 m³/s K.Khacha		

Paterna Karn Drainage Area

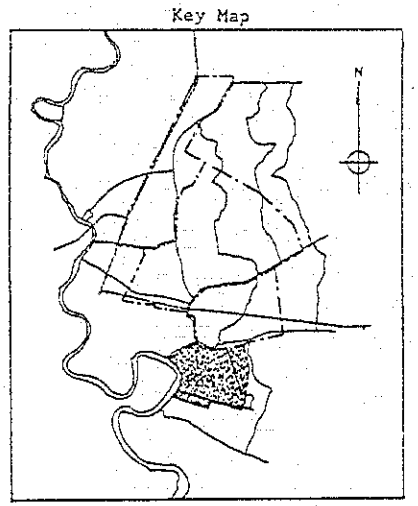
Seaction No	Cross Section (m)	Section No	Cross Section (m)
(1)	V.T 13 × 2 1400	(4)	V.T 15 × 3
(2)	V.T 13 × 2 1400	(6)	IV.T 14 × 2 1500
(3)	V.T 13 × 1.8 1200	(7)	IV.T 14 × 2 1500

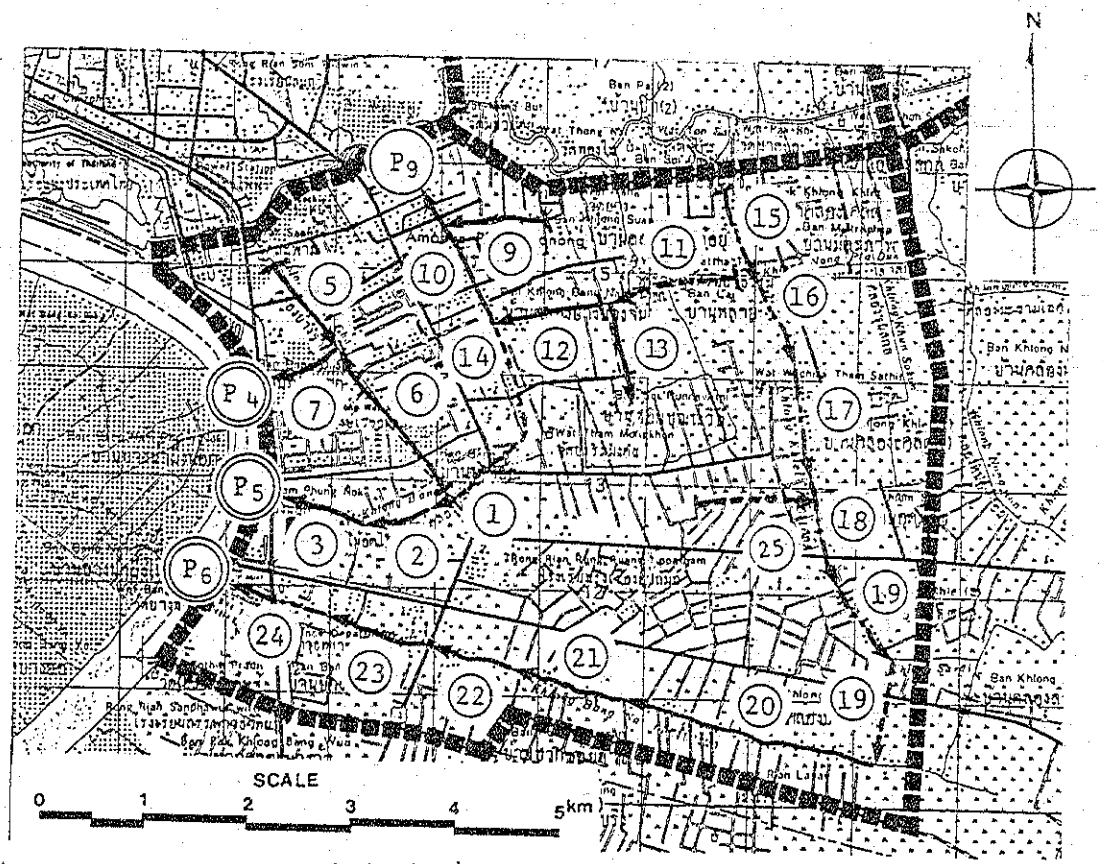
Trunk Drainage Facilities

Section No	Cross Section (m)	Section No	Cross Section (m)
(1)	III.R 35 × 4.5 1000	(14)	III.R 22 × 4.5 1000
(2)	III.R 28 × 4.5 1000	(15)	IV.R 27 × 4 1000
(3)	IV.T 40 × 4 1000	(16)	IV.T 37 × 4 1000
(4)	III.R 28 × 4 1000	(17)	IV.R 28 × 4 1000
(5)	III.R 24 × 4 1000	(18)	IV.R 28 × 4 1000
(6)	IV.T 37 × 4 1000	(19)	IV.T 47 × 4 1000
(7)	IV.T 42 × 4 1000	(20)	III.R 18 × 4 1000
(8)	IV.R 26 × 4 1000	(21)	III.R 20 × 4 1000
(9)	IV.T 37 × 4 1000	(22)	IV.T 30 × 4 1000
(10)	IV.T 38 × 4 500	(23)	IV.R 27 × 4 1000
(11)	III.R 21 × 4.5 1500	(24)	III.R 25 × 4 1000
(12)	III.R 22 × 4.5 1000	(25)	IV.T 39 × 4 1000
(13)	IV.R 28 × 4.5 1000	(26)	IV.T 35 × 4 500
(P1)	Q = 90 m³/s K.Phra Khanong		

Fig. J.14 PROPOSED DRAINAGE FACILITIES (HUA MARK AND PATERNA KARN DRAINAGE AREA, TRUNK DRAIN)

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK





Bang Na Drainage Area			
Section No	Cross Section (m)	Section No	Cross Section (m)
①	I.R 10 × 3 700	⑮	IV.T 10 × 2.1 1000
②	III.R 10 × 2.9 700	⑯	IV.T 10 × 2.1 1000
③	III.R 10 × 2.9 700	⑰	IV.T 10 × 2.1 1000
⑤	III.R 10 × 2.2 1300	⑱	IV.T 10 × 2.1 1000
⑥	III.R 10 × 2.8 1500	⑱	IV.T 10 × 2.2 1000
⑦	III.R 10 × 2.8 700	⑲	I.R 10 × 2.2 1200
⑨	III.R 8 × 2 1000	⑳	III.R 10 × 2.8 2300
⑩	III.R 10 × 2.2 2000	㉑	III.R 12 × 2.6 1000
⑪	I.R 8 × 2.3 1400	㉒	III.R 12 × 2.6 1000
⑫	II.R 8 × 2.2 1100	㉓	III.R 12 × 2.6 1000
⑬	II.R 10 × 2.3 1000	㉔	IV.R 12 × 2.8 1000
⑭	I.R 10 × 2.2 1500	㉕	I.R 10×2.7 1400
P4	Q = 6 m³/s K.JEK		
P5	Q = 18 m³/s K.Bang Os		
P6	Q = 21 m³/s K.Bang Na		
P9	Q = 9 m³/s K.Bang Na Cline		

Legend

- Boundary of Drainage Area
- New Drain
- Improvement Drain (with Retaining Wall)
- Improvement Drain (without Retaining Wall)
- ① Section Number
- ③ " (Trunk Drain)
- P7 Pumping Station
- P2 " (main)
- Retention Area

1 2 3 4 where

III. R 10 × 2

1000

5

1 : Category
- I = New Drain
- II = Widening + Deeping + Construction of Retaining Wall
- III = Deeping + Construction of Retaining Wall
- IV = Dridging or No-improvement
- V = IV + Widening

2 : Shape
- R = Rectangular Channel
- T = Trapezoidal Channel

3 : Top Width fo Channel

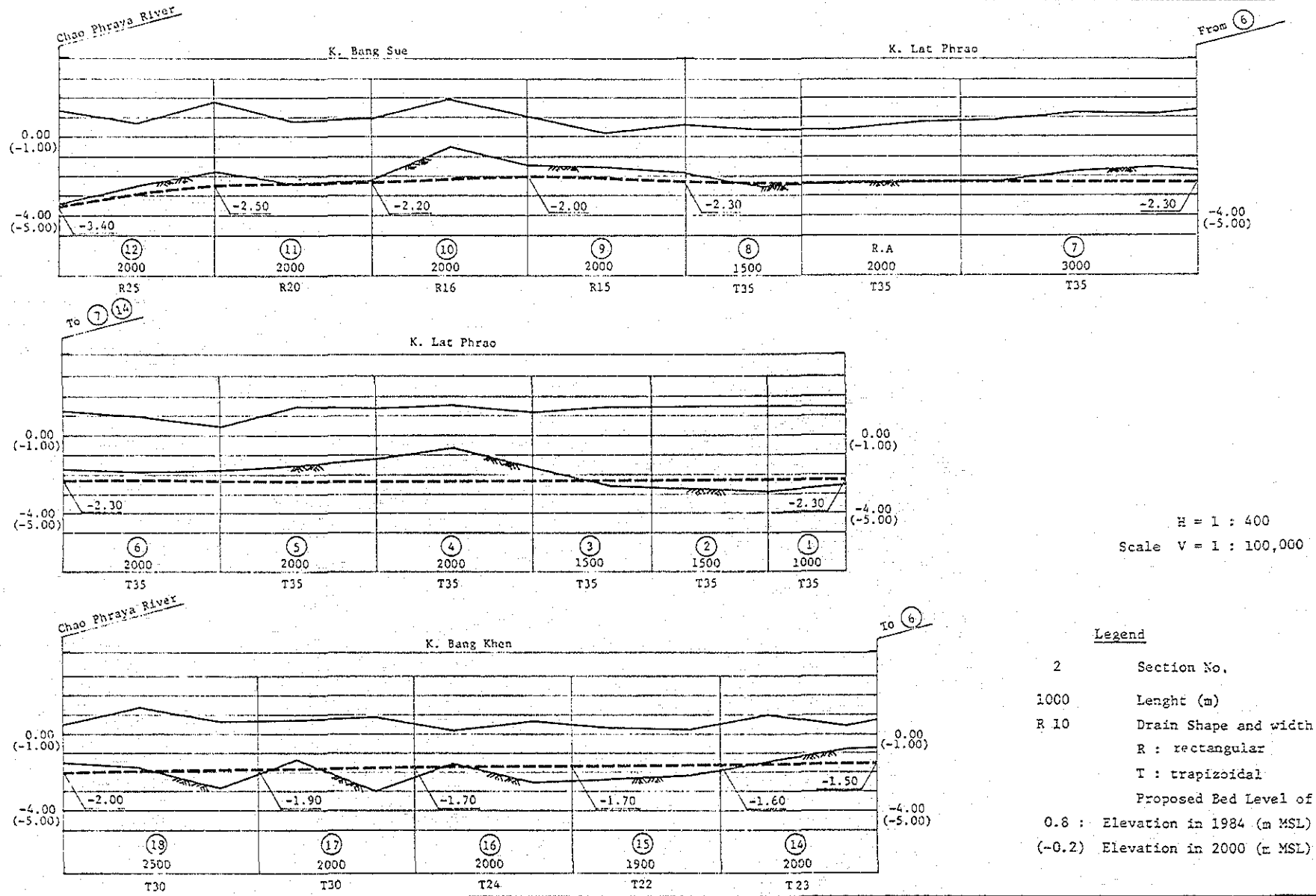
4 : Depth of Channel

5 : Length

Fig. J.15 PROPOSED DRAINAGE FACILITIES (BANG NA DRAINAGE AREA)

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2528B.E 1985A.D



H = 1 : 400
Scale V = 1 : 100,000

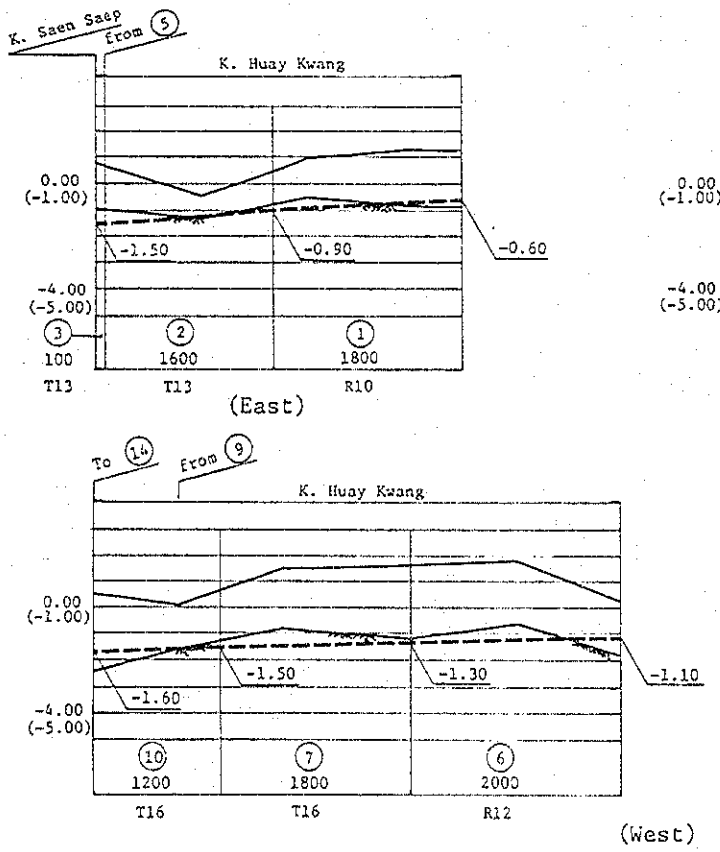
Legend

2	Section No.
1000	Lenght (m)
R 10	Drain Shape and width (m)
	R : rectangular
	T : trapizoidal
	Proposed Bed Level of Drain
0.8 :	Elevation in 1984 (m MSL)
(-0.2)	Elevation in 2000 (m MSL)

Fig. J.16 PROFILE OF DRAIN (BNAG KHEN, BANG SUE DRAINAGE AREA)

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2528(1985)A(1)



Legend

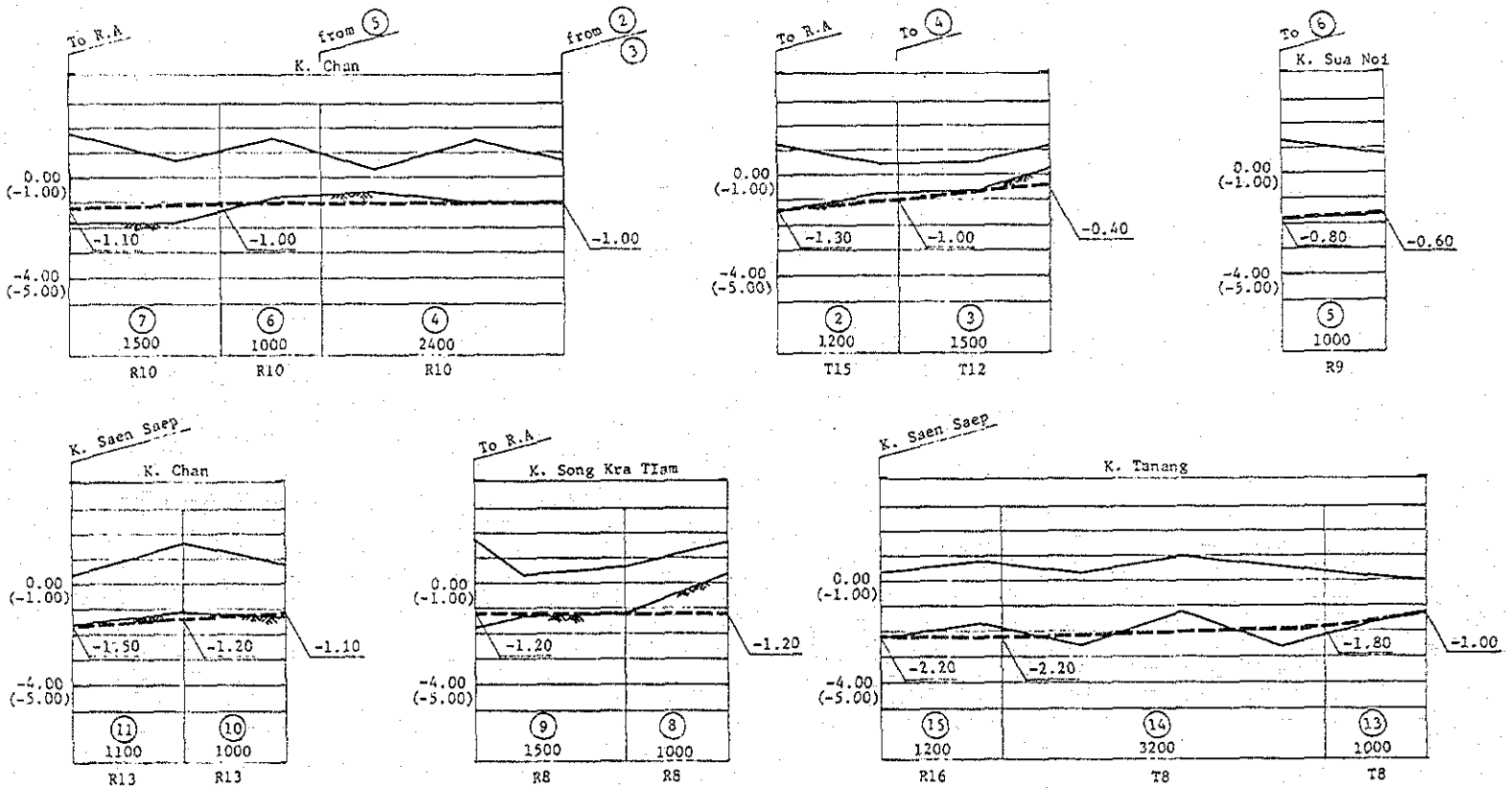
2	Section No.
1000	Lenght (m)
R 10	Drain Shape & h (m)
	R : rectangula
	T : trapizoidal
	Proposed Bed Level of Drain
0.8 :	Elevation in 1984 (m MSL)
(-0.2)	Elevation in 2000 (m MSL)

H = 1 : 400
Scale V = 1 : 100,000

Fig. J.17 PROFILE OF DRAIN (HUAY KWANG DRIANAGE AREA)

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2528B.E 1985A.D



Legend

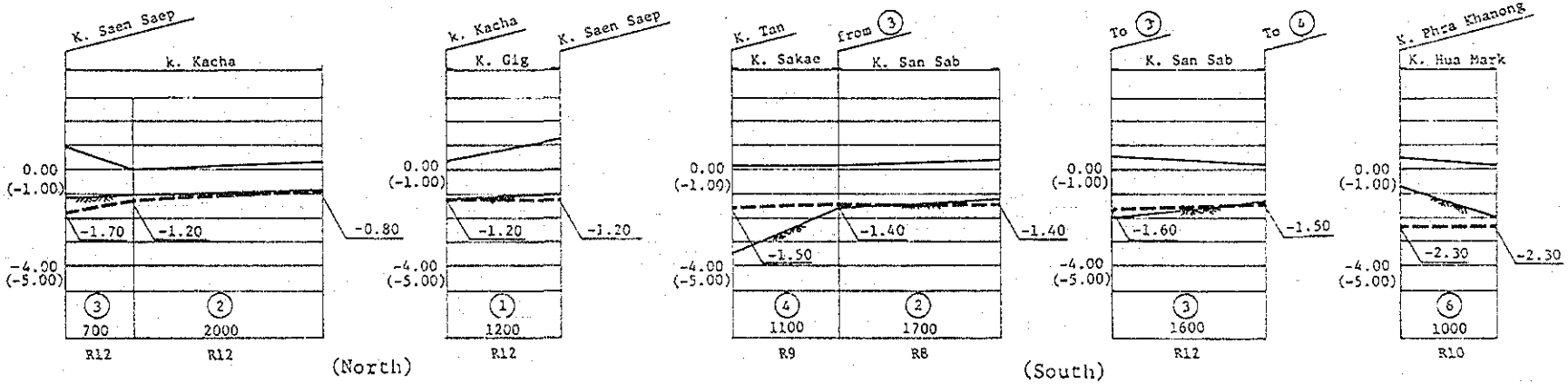
2	Section No.
1000	Lenght (m)
R 10	Drain Shape and width (m)
	R : rectangular
	T : trapizoidal
	Proposed Bed Level of Drain
0.8 :	Elevation in 1984 (m MSL)
(-0.2)	Elevation in 2000 (m MSL)

H = 1 : 400
Scale V = 1 : 100,000

Fig. J.18 PROFILE OF DRAIN (LAT PHRAO DRAINAGE AREA)

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2528 B.E. 1985 A.D.



Legend

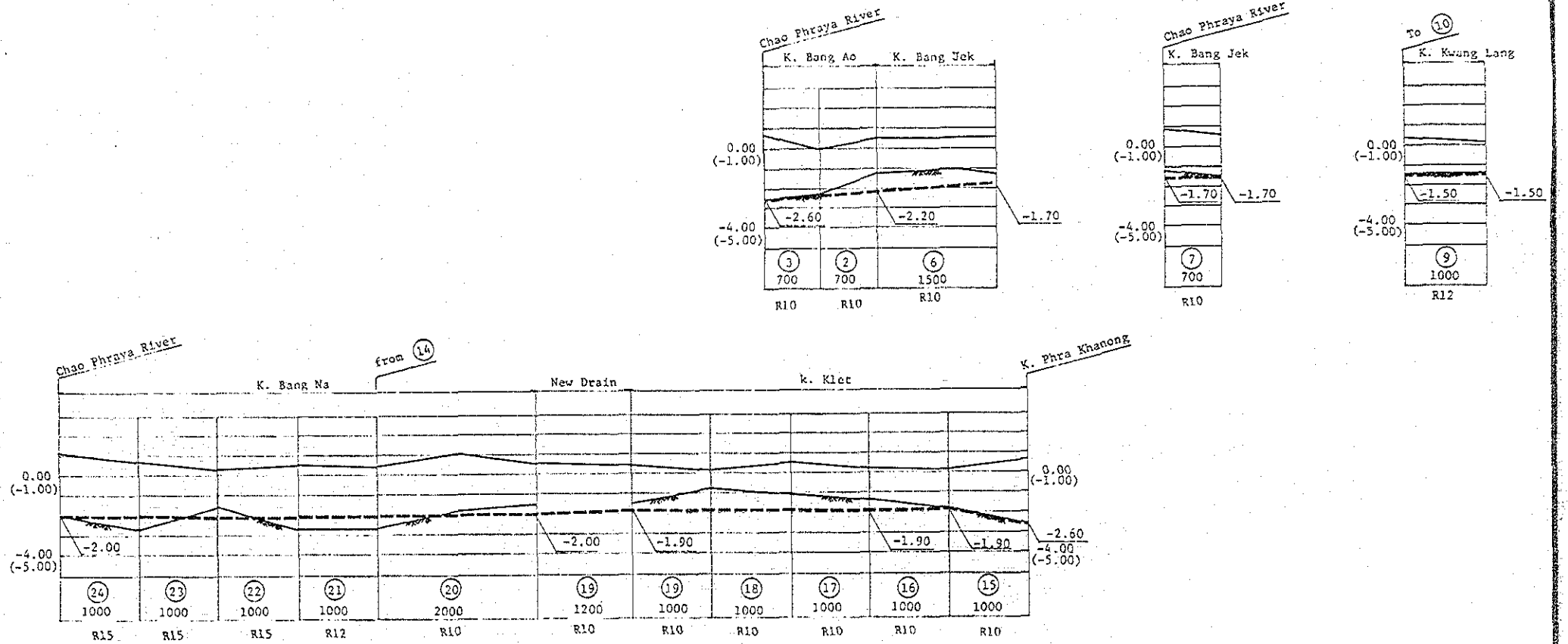
2	Section No.
1000	Lenght (m)
R 10	Drain Shape and width (m)
	R : rectangular
	T : trapizoidal
	Proposed Bed Level of Drain
0.8 :	Elevation in 1984 (m MSL)
(-0.2)	Elevation in 2000 (m MSL)

H = 1 : 400
Scale V = 1 : 100,000

Fig. J.19 PROFILE OF DRAIN (HUA MARK DRAINAGE AREA)

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2528B.E 1985A.D



Legend

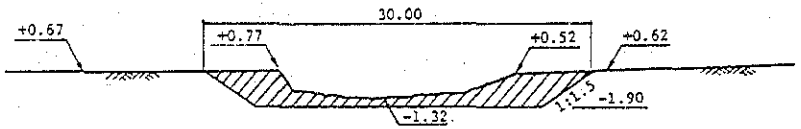
2	Section No.
1000	Lenght (m)
R 10	Drain Shape and width (m)
	R : rectangular
	T : trapizoidal
	Proposed Bed Level of Drain
0.8 :	Elevation in 1984 (m MSL)
(-0.2)	Elevation in 2000 (m MSL)

H = 1 : 400
Scale V = 1 : 100,000

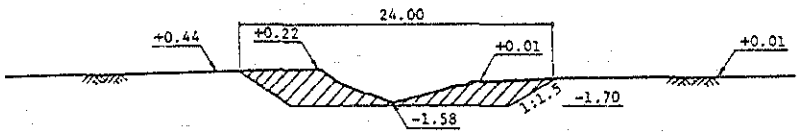
Fig. J.20 PROFILE OF DRAIN (BANG NA DRIANAGE AREA)

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

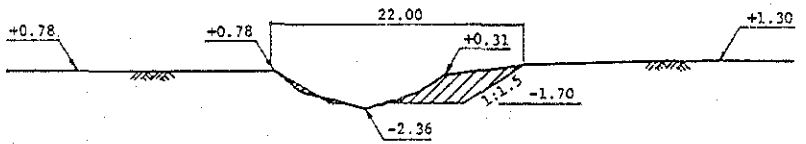
JICA 2528 B.E. 1985 A.D.



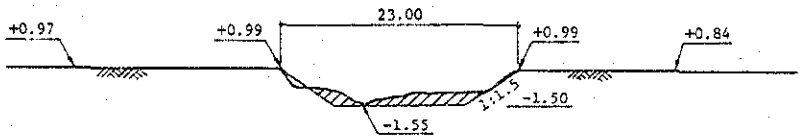
⑰ K. Bang Khen



⑯ K. Bang Khen



⑮ K. Bang Khen



⑭ K. Bang Khen

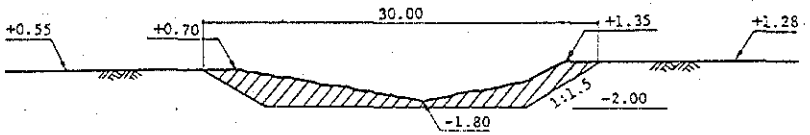
Legend

20 : Section No.

▨ : Excavation Required

+0.37 : Ground Elevation in 1984 (m)

Scale 1 : 800



⑱ K. Bang Khen

Fig. J.21 CROSS SECTION OF DRAIN (BANG KHEN, BANG SUE DRAINAGE AREA)

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

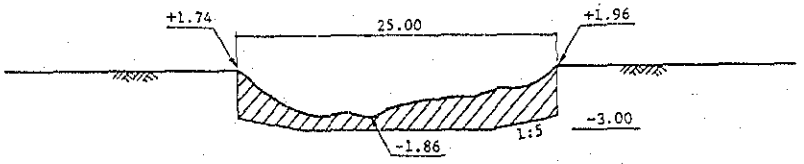
Legend

20 : Section No.

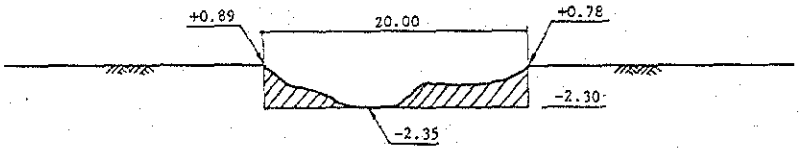
: Excavation Required

+0.37 : Ground Elevation in 1984 (m)

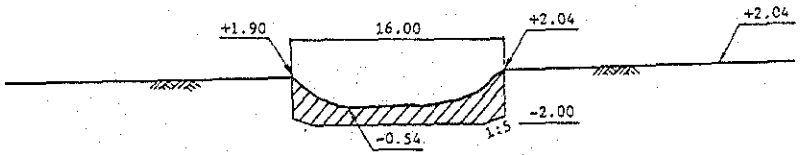
Scale 1 : 800



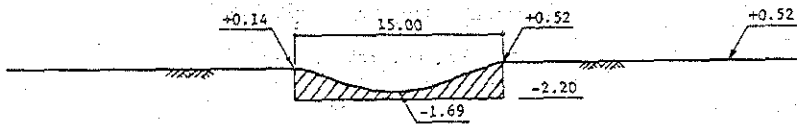
(12) K. Bang Sue



(11) K. Bang Sue



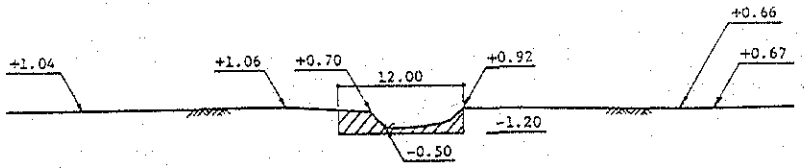
(10) K. Bang Sue



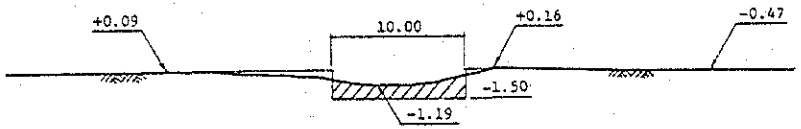
(9) K. Bang Sue

Fig. J.22	CROSS SECTION OF DRAIN(BANG KHEN, BANG SUE DRAINAGE AREA)
MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK	

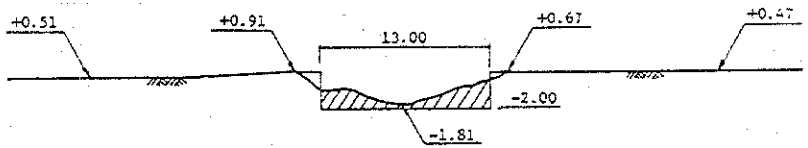
JICA 25283.E 1985A.D



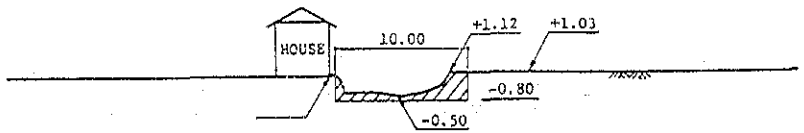
⑥ (West)



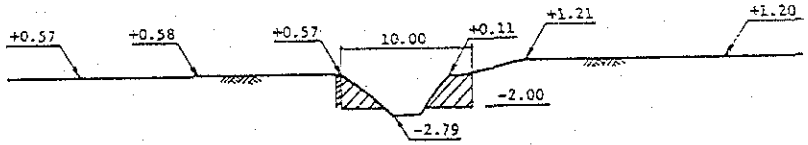
② (East)



⑭ (West)



① (East)



⑬ (West)

Legend

20 : Section No.

▨ : Excavation Required

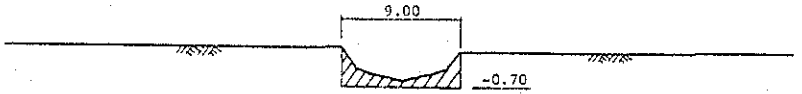
+0.37 : Ground Elevation in 1984 (m)

Scale 1 : 800

Fig. J.23	CROSS SECTION OF DRAIN (HUAY KWANG DRAINAGE AREA)

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

JICA 2538 B.E. 1995 A.D.



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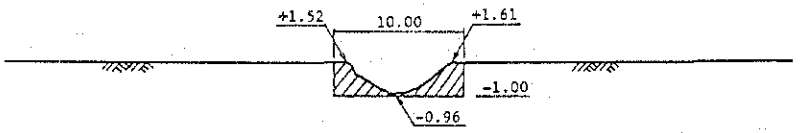

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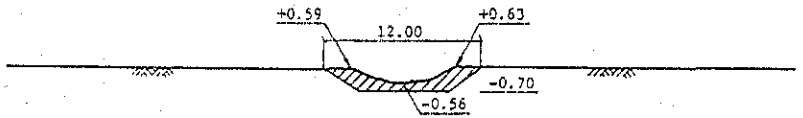
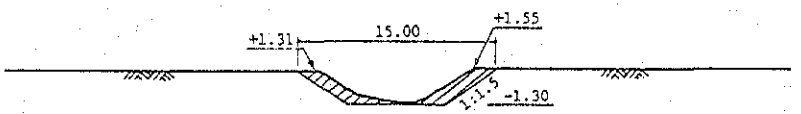
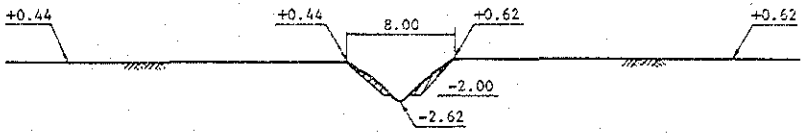


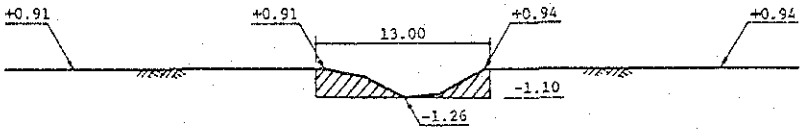
③



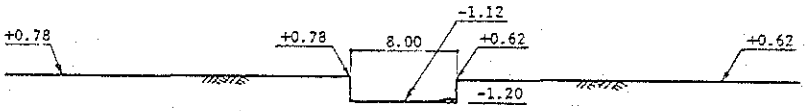
②



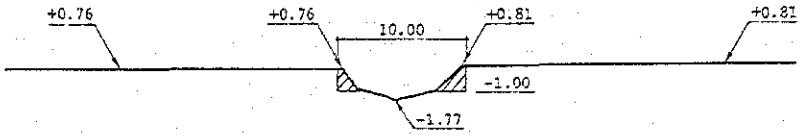
⑭



⑩



⑧



⑦

Legend

20 : Section No.

▨ : Excavation Required

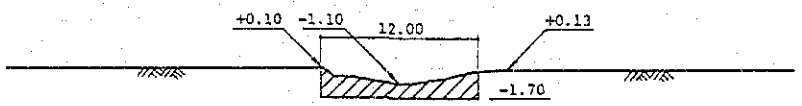
+0.37 : Ground Elevation in 1984 (m)

Scale 1 : 800

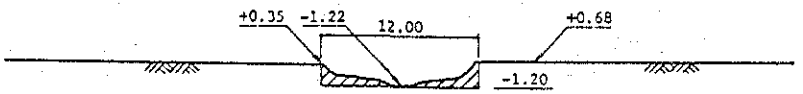
Fig. J.24 CROSS SECTION OF DRAIN (LAT PHRAO DRAINAGE AREA)

MASTER PLAN ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

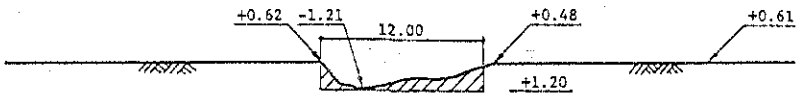
JICA 2528 B.E. 1985 A.D.



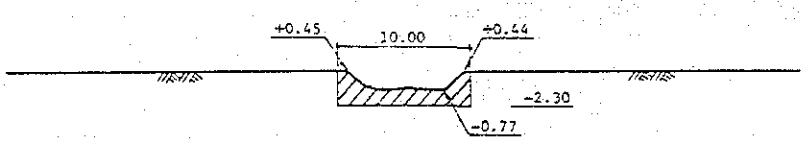
(3) (North)



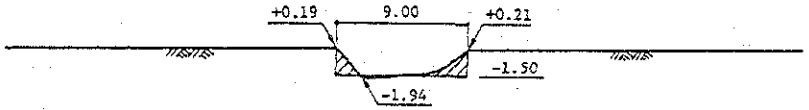
(2) (North)



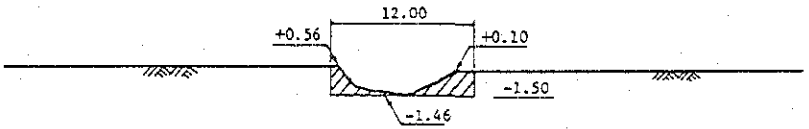
(1) (North)



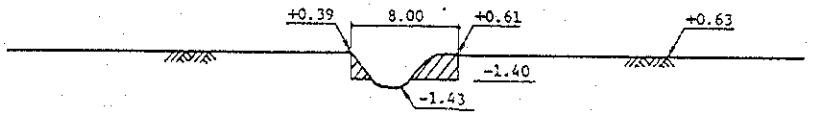
(6) (South)



(4) (South)



(3) (South)



(2) (South)

Legend

20 : Section No.

: Excavation Required

+0.37 : Ground Elevation in 1984 (m)

Scale 1 : 800

Fig. J.25 CROSS SECTION OF DRAIN (HUA MARK DRIANAGE AREA)

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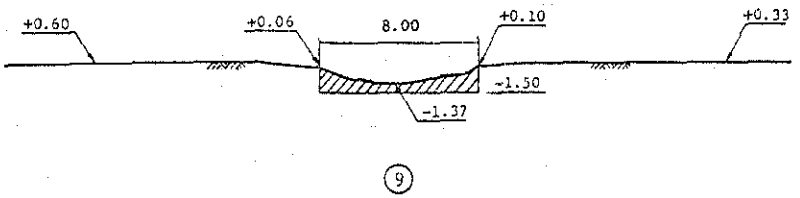
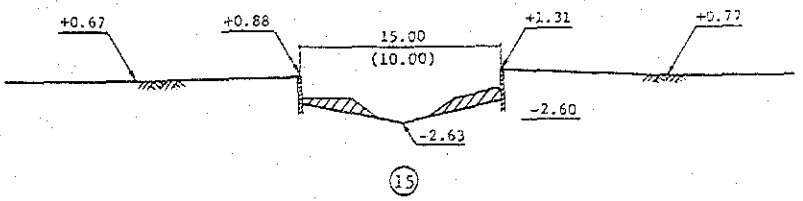
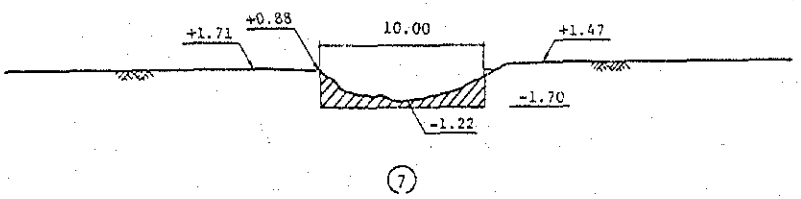


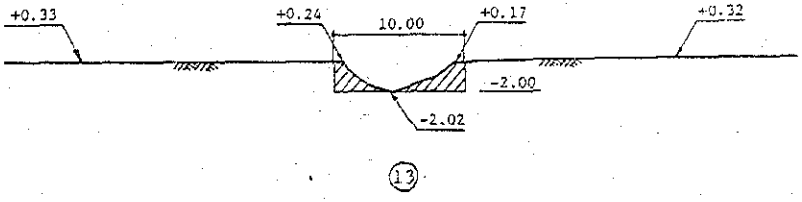
⑨



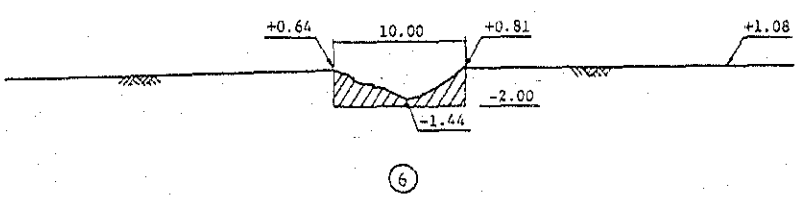
⑮



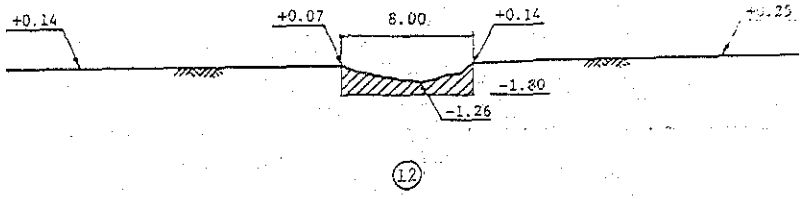
⑦



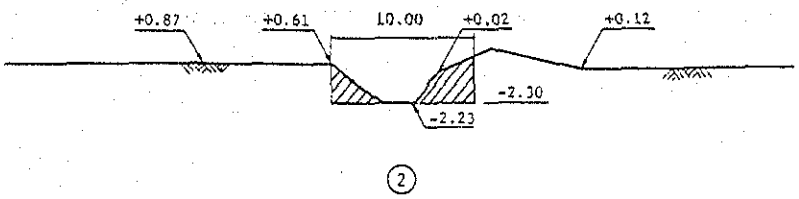
⑬



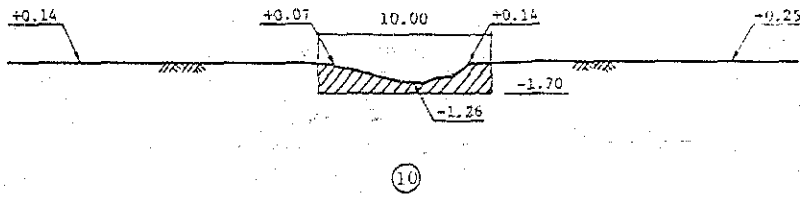
⑥



⑫



②



⑩

Legend

20 : Section No.

▨ : Excavation Required

+0.37 : Ground Elevation in 1984 (m)

Scale 1 : 800

Fig. J.26 CROSS SECTION OF DRAIN (BANG NA DRIANAGE AREA : 1)

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