## 4.3 Present Condition and Problems of Storm Water Drainage Facilities

In Parallel to the field investigation mentioned in Sec. 4.2, the study team surveyed the present condition and problems of the storm water drainage facilities through field reconnaissance and interviews with the residents of the study area. The scope of the investigation and the present hydrographic conditions are as shown in Fig. 4.3.1.

### 4.3.1 Present Conditions

(a) Present Drainage Conditions

1) Central Pattaya Area (Proposed Drainage Area)

- The storm water on the area runs off through 3 tributaries. No. 1 Tributary passes to the north of the proposed Northern New Town and swamp areas parallel to the Back Road and then joins with No. 2 and No. 3 Tributaries, and runs down to the mouth of the Pattaya River. (Refer to Fig. 4.3.1)
- The rice field areas in No. 2 and No. 3 Tributaries geographically play a role as natural storm water regulating ponds.
- At times of heavy rainfall, there have been some floods in the environs of the swamp area which is located in the northeast side of the Back Road.

  It is considered that these floods were caused because some private land developers filled in the drainage channels with earth when they built the houses and roads.

2) Pattaya Hill and Northern Pattaya Areas

The storm water runs down along the western slope of these areas and runs off directly to the sea.

3) Pattaya Beach Area

At times of heavy rainfall, the storm water in the area is almost led to the sea, flowing over the paved surface of the Beach Road and through the drain pipes installed under the sidewalks, and the rest of the water is ponded in the low lands. However, big damage by floods has not occurred due to the geographical features of the area.

4) Southern Na Klua Area (Proposed Drainage Area)

- Storm water in the area between the Sukhumbit Highway and the Main Residential Road is first ponded in the swamp area, and then discharged into the sea through the box culverts and open channels. The existing drainage channel from the Main Residential Road to the coast has flow sections which can be utilized sufficiently even after the proposed Na Klua Towns are developed.
- At present, reclamation and land adjustment for the housing sites are rapidly progressing in the swamp areas in the northern part of the area.

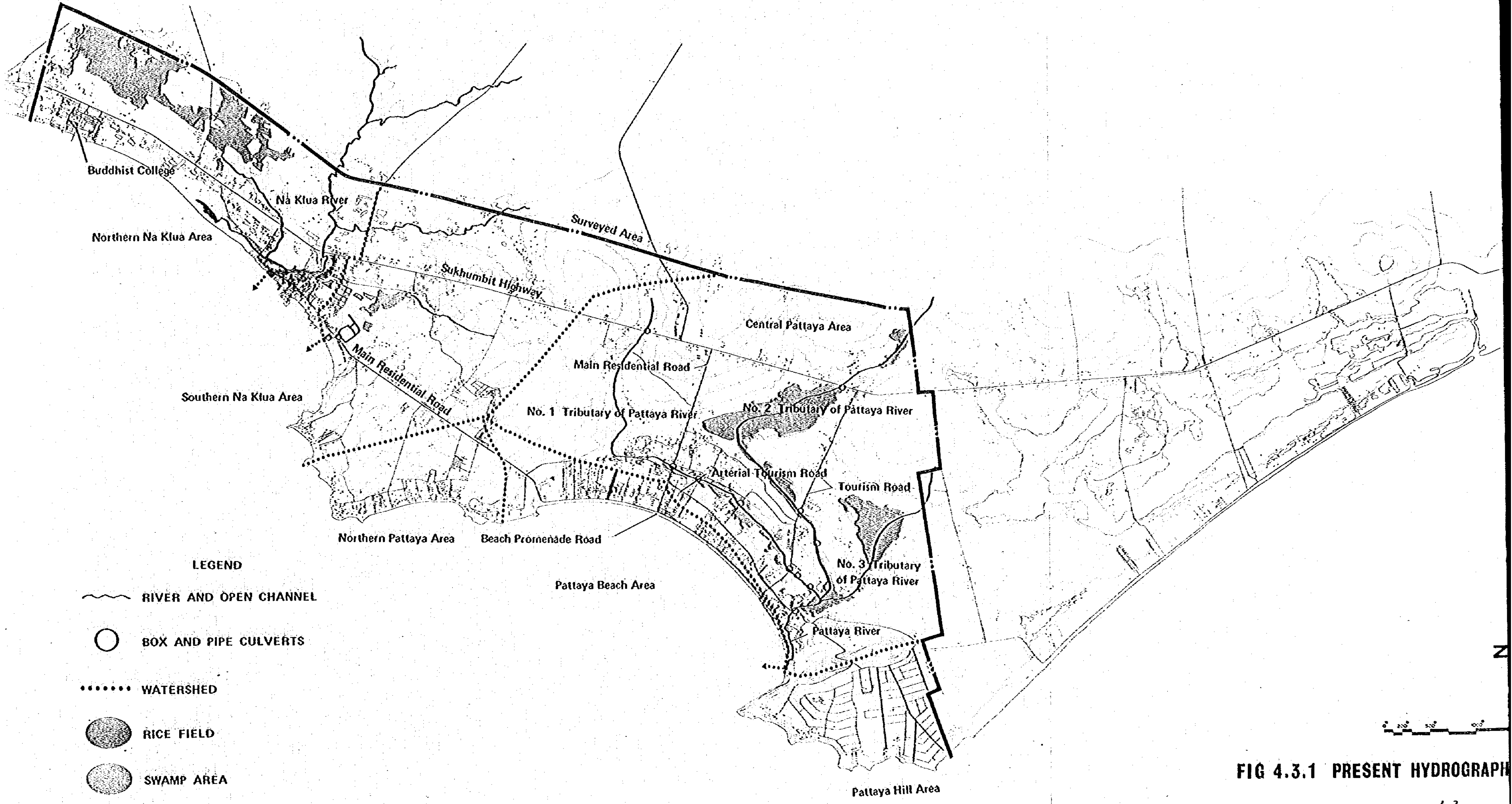



FIG 4.3.1 PRESENT HYDROGRAPH

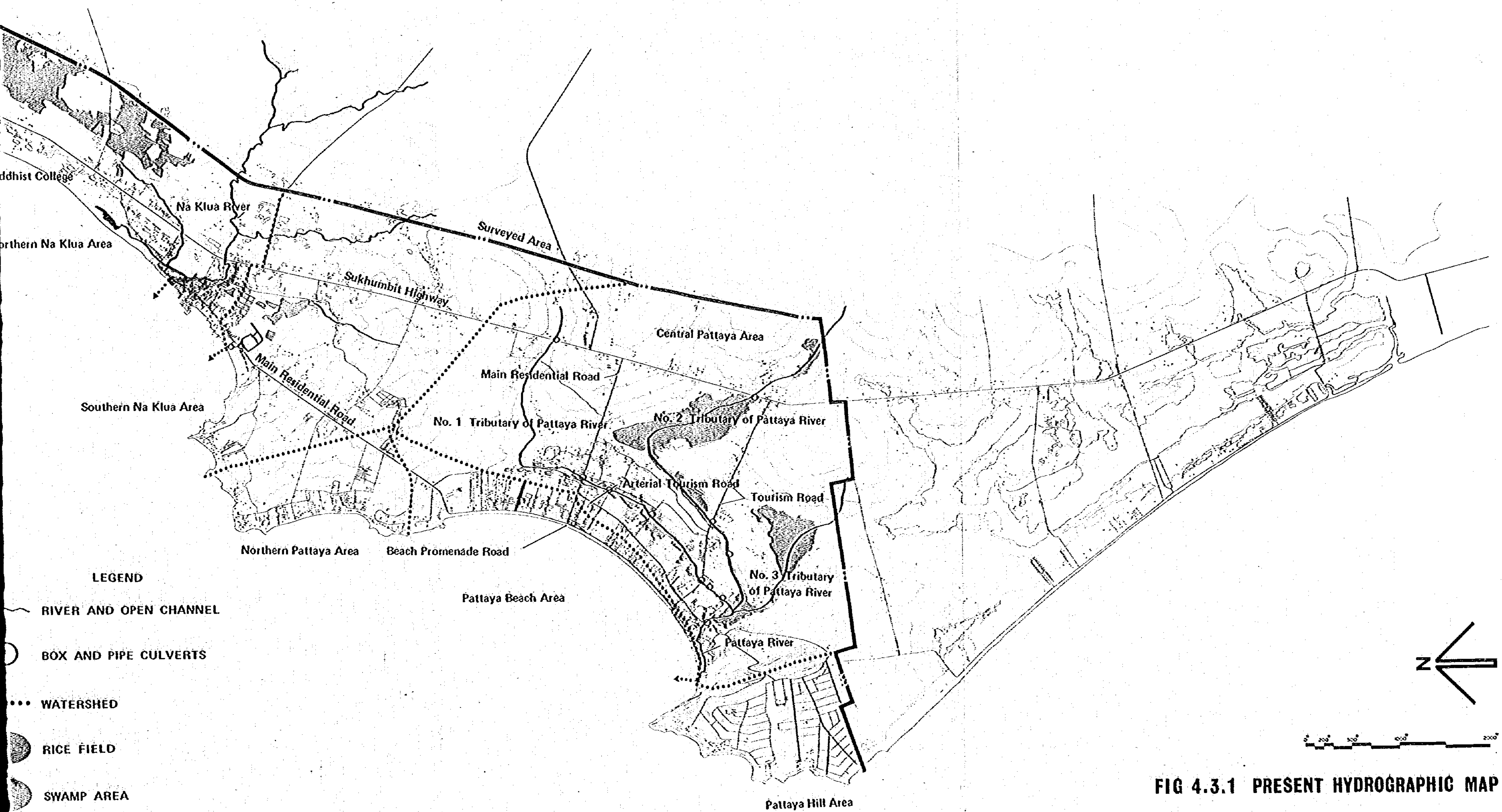



FIG 4.3.1 PRESENT HYDROGRAPHIC MAP

On these housing sites, however, a functional drainage system has not been planned at all.

5) Northern Na Klua Area

- At the shopping area located in the southern part of the area, roadside ditches are provided and the roads have not flooded before. These drainage facilities are under the jurisdiction of the Na Klua Sanitary District, however, it seems that satisfactory maintenance and control is not performed.
- Storm water in the area located in the western and eastern parts of the Sukhumbit Highway is directly discharged into the sea and the Na Klua River, respectively.

(b) Present Condition of Rivers

1) Pattaya River

The catchment area of the Pattaya River is widely distributed to the east side of the Back Road and the area is approximately 1,500 ha.

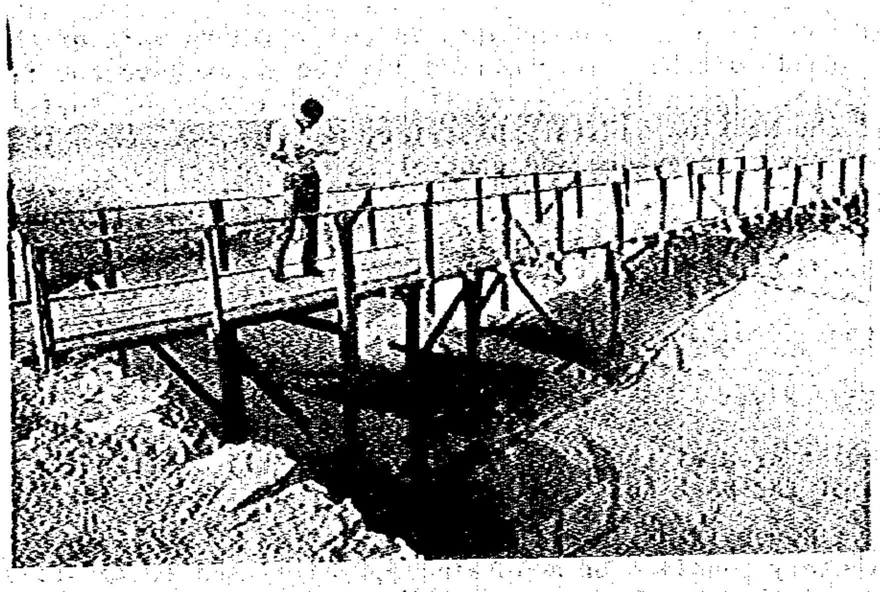
The Pattaya River is divided into 3 tributaries as shown in Fig. 4.3.1. No. 1 Tributary consists of mountainous, valley and swamp areas. The storm water is led to the swamp area behind the Back Road through the mountainous and valley areas. At present, unplanned reclamation and land adjustment for the housing sites are being carried out in the swamp area, greatly reducing the flow capacity of the river. It is estimated that the reason why the damage to the environs of the swamp area has been caused by floods is due to the aforementioned unplanned reclamation and land adjustment.

No. 2 and No. 3 Tributaries consist of mountainous, valley, rice field areas and natural waterways. The storm water is ponded in the rice field areas through the mountainous and valley areas. These rice field areas geographically play a role as natural stormwater regulating ponds, preventing a large amount of runoff toward the downstream area.

The channel from the junction of No. 2 and No. 3 Tributaries to the mouth of the river downtown meanders in a complicated manner with an effective width of less than 3 meters at some points, and the box culverts installed on its way are too small to cope with the peak runoff after development. The hotel near the mouth of the river provides a weir to use the channel for aesthetic appreciation.
This weir seems to be hydraulically undesirable but does not pose large problems according to the result of hydraulic calculations.

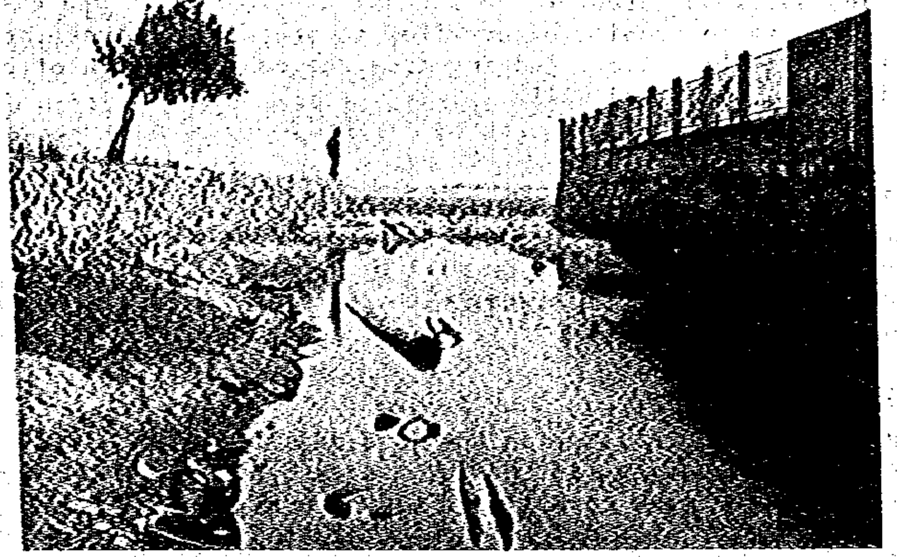
2) Na Klua River

The catchment area of the Na Klua River is widely distributed to the east side of Sukhumvit Highway and the area is approximately 9,600 ha. Improvement of the river is being made only at the crossing portion with the Sukhumvit Highway and other portions are left untouched. Documents recording the floods of the Na Klua River are not available. However, as a result of interviews of residents living for many years near the mouth of the river, it was learned that the river overflowed once in the past.

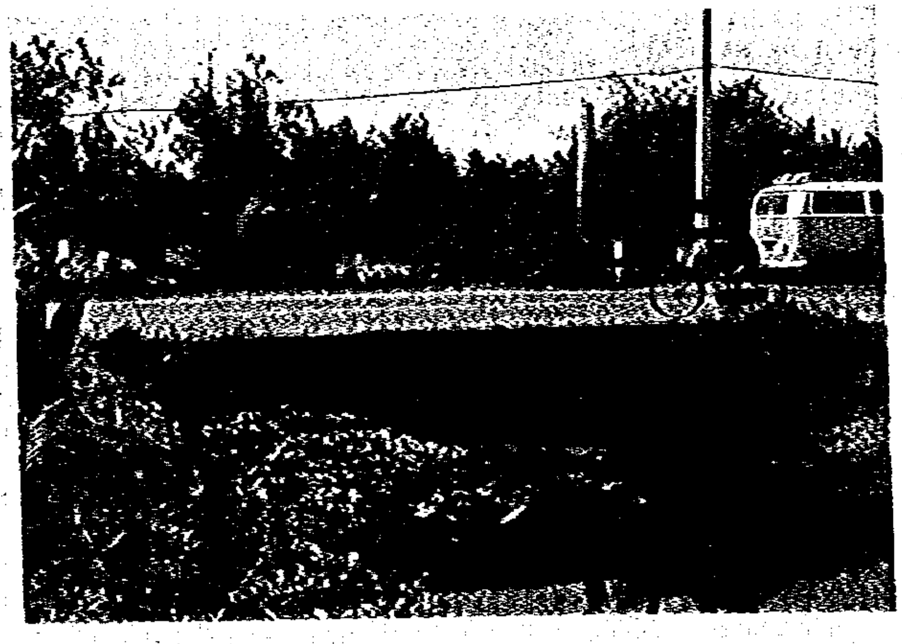


Present Condition of Pattaya River (Central Pattaya Area)

Existing Pipe Culverts (Central Pattaya Area)



Present Condition of Existing Drainage Channel
(Southern Na Klua Area)



Existing Box Culverts (Southern Na Klua Area)

It is assumed that this flood was caused because of the shortage of a flow sectional area of the channel at the wooden bridge at the mouth of the river. It is predicted that overflow in the future will be unlikely because the bridge was changed to a reinforced concrete one and the flow sectional area of the channel at the bridge was expanded. There is no problem of overflow in the middle stream and upstream of the Na Klua River, judging from the configuration of ground, if the river is controlled well.

### 4.3.2 Problems

As a result of the field investigation and studies, it can be said that improvement of the drainage system will be necessary in the Central Pattaya and Southern Na Klua Areas. The problems to be solved are presented as follows.

(a) Central Pattaya Area

At present, unplanned reclamation and land adjustment for the housing sites are being carried out in the swamp area behind the Back Road, greatly reducing the flow capacity of the natural waterways. If such unplanned reclamation and land adjustment are continued further without legal control, it is predicted that a lot of damage by flooding may be caused in the environs of the swamp areas at times of heavy rainfall.

In addition, the downstream of the Pattaya River meanders radically, the sectional areas of box culverts provided on the way are too small and there exist narrow parts of the channel at some points. Therefore, improvement of the existing channel will be necessary to cope with the peak runoff after future development.

(b) Southern Na Klua Area

The reclamation and land adjustment for the housing sites have been hastily carried out in the swamp area on the northern part of the area. A functional drainage system has not been considered at all in these sites. Therefore, there might occur local detention or flooding during heavy rainfall.

(c) Drainage System along the Existing Roads

The lack of roadside ditches can be mentioned as an overall problem for the study area. An implementation plan for a complete system of roadside ditches along existing roads should be carried out in alignment with the construction of proposed roads and channels, not only for the purpose of drainage but also for the purpose of harmonizing this tourism development project with the regional development of the study area. (Refer to Chapter 2, Section 2.4.3 (b) Drainage Plan)

## 4.4 Effect of Storm Water Drainage System

As mentioned before, the present storm water drainage system has various problems.

However, by building permanent storm water drainage facilities of some scale centering around the development areas, chronic flooding of roads, streets and buildings in the rainy season will be prevented, the areas with low utility value will be used more effectively and the social environment, such as productivity or the like, will be improved. Thereby, the public welfare of the residents of the study area will be further promoted.

Moreover, a proper drainage system will benefit residents of the area, which is a part of the important purpose of the infrastructure project for tourism and regional development.

## 4.5 Basic Plan and Policies

### 4.5.1 Proposed Drainage Area

At the master plan stage, the proposed drainage area was considered for the whole study area.

However, through the field investigation of present conditions and field interviews with the residents, it was suggested that the areas along Pattaya Beach and along the Na Klua River are free from danger of flood damage.

Accordingly, this feasibility study covers the storm water drainage system for the following areas.

- Central Pattaya Area (1,510 ha) mainly for the tourism industry.
- Southern Na Klua Area (262 ha) for residential areas.

However, roadside ditches is described separately as a part of the road and street system at Chapter 2, Section 2.4.3 (b).

### 4.5.2 Fundamental Policy

The following 6 items are set out as the fundamental policies of the storm water drainage system. Fig. 4.5.1 shows the flow chart of this feasibility study.

- To review the master plan.

  The study team began with a review of the master plan prior to the investigation. In the master plan, the storm water drainage system fundamentally aims at effective utilization of the whole usable area as the first consideration and treats the drainage in the development areas (city drainage) and the drainage in the rice field and swamp areas (farmland drainage) on the same level.

  Consequently, the system in the master plan expands the scale of drainage facilities. As a result the construction cost in the Phase 1 Project is estimated as 62 million Baht accounting for approximately 7% of the total infrastructure project cost.

- To plan the scale of the system to meet the basic requirements.

  It is thought that it would be very difficult to maintain a financial balance by the system itself, even if present and future land utilization and social capital conditions are taken into account. Therefore, the system should be reduced in scale as far as possible.

- Consideration of the present topographic condition and future development.

  Through the field reconnaissance made by the study team for the Central Pattaya Area, it was learned that the swamp area behind the Back Road and the rice field in the southern part of the area are always damp due to low level of the ground and play a role of natural regulating ponds at times of floods, which reduced the damage by flooding to the downstream area. The master plan proposes to use these areas as a central park with ponds and as general paddy-fields.

  If new main drainage channels are equipped in such areas, it would have the disadvantage of bringing about an increased peak discharge of the runoff resulting from the shortened time of concentration and it will require expansion of the scale of the drainage facilities.

  Therefore, the drainage plan in this feasibility study attaches importance to the present condition of these areas and utilize them as natural regulating ponds, and the plan does not provide main drainage channels for these areas.

  On the other hand, the Southern Na Klua Area is now equipped with a drainage channel only between the Main Residential Road and the coast and is locally provided with drainage channels in the upper stream area. Since the two Na Klua New Towns are proposed to be developed in this area, a plan for drainage channels will be made only for the development area.

  In case the landuse plan is changed as a result of social changes in the future, that is, the area being proposed as the green belt is developed as residential and/or hotel areas, a review of the proposed drainage system will obviously be needed.

- A short-cut plan (as an alternative for the Central Pattaya Area).

  As mentioned before, the swamp area behind the Back Road, especially the natural waterways in the northern area, are being reclaimed gradually for housing sites, which causes an overflow at times of flooding.

  Therefore, legal control is necessary to regulate such unplanned development at an early stage. Assuming that the reclamation and land adjustment for the housing sites are continued in this area, a short-cut plan in which the storm water in the Central Pattaya Area is drained by diverting it with the Main Residential Road will be studied as an alternative.

- To make the system harmonious with tourism.

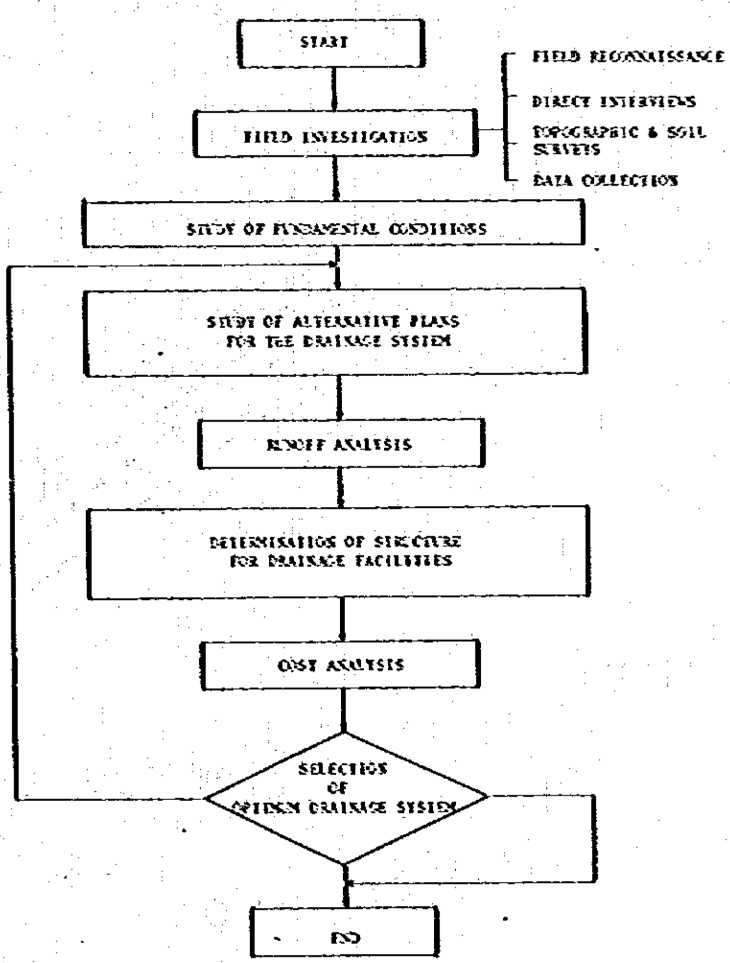
  Since the storm water drainage plan aims not only at enhancing the welfare of the residents but also at developing the infrastructure for tourism, the facility plan should be rational, and at the same time, special consideration should be given so as not to effect the natural environment and other facilities in the resort area.

- Correlation with the sewerage system. (Refer to Chapter 3)

  As is proposed in the sewerage system, the storm water and waste water will be treated separately.

  The storm water in the development area is to be led to the main open channels through the roadside ditches and branch open channels, while the treated water from the Pattaya Sewage Treatment Plant is discharged into one of the main storm water drainage channels through an independent discharge channel. The discharge rate of treated water is very low (0.17 $m^3$/sec.), and there will be little effect on the scale of storm water drainage facilities.

Fig. 4.5.1 Flow Chart of Feasibility Study for Storm Water Drainage System



## 4.6 Study of the Storm Water Drainage System

### 4.6.1 Design Criteria and Procedure

The design criteria and procedure for the rainfall analysis, runoff analysis and facility plan shall be set up based on the hydrometeorological data, topographical and geographical data in the study area and relevant technical documents, as follows.

(a) Rainfall Analysis

- Design Frequency of Rainfall: 5 years
- Rainfall Intensity:

The rainfall intensity is calculated from the following Talbot formula, using the rainfall intensity-duration curve collected in Chonburi Province at the time of the master plan. (Refer to Fig. 4.6.1 and Table 4.6.1)

$$i = \frac{8,000}{t + 34}$$

where

i = 5 year rainfall intensity in mm per hour
t = Duration of rainfall in minutes

Fig. 4.6.1 Rainfall Intensity-duration Curve in Chonburi Province

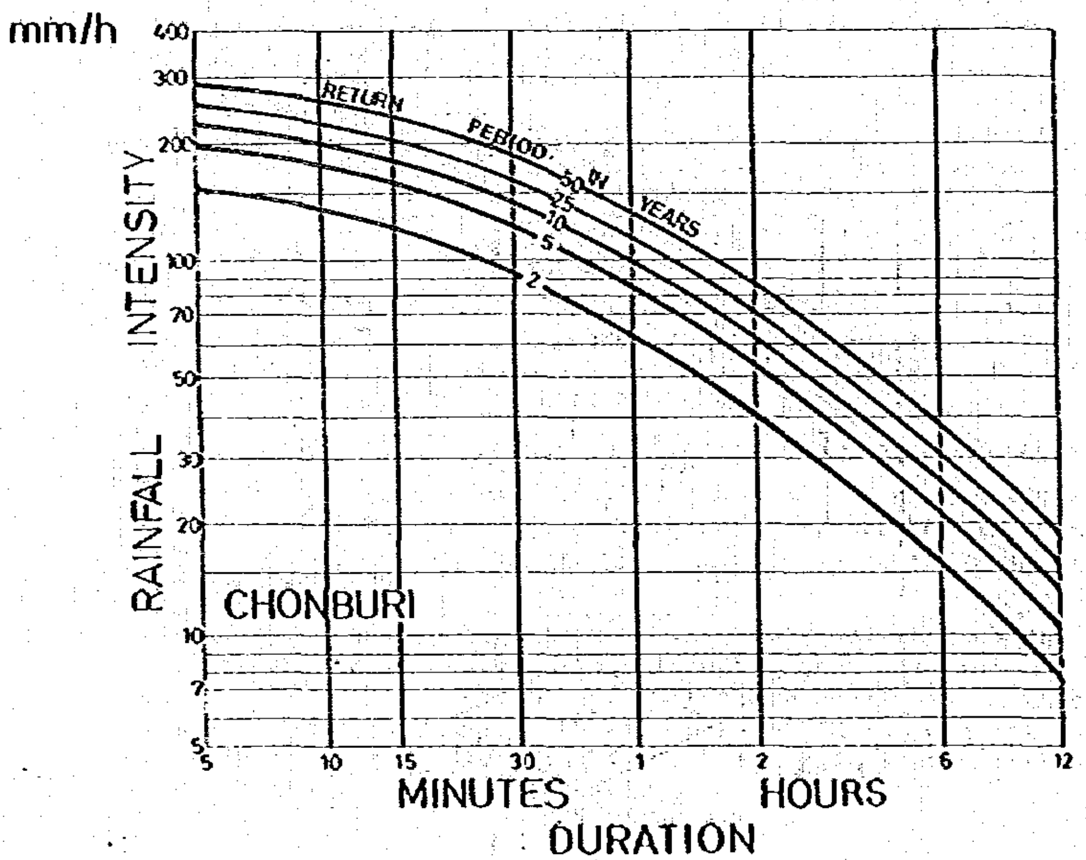


Table 4.6.1 Rainfall Intensity in Chonburi Province

| Duration of Rainfall (hr) | Rainfall Intensity (mm/h) |
|---|---|
| 1/6 | 181.8 |
| 1/2 | 125.0 |
| 1 | 85.1 |
| 2 | 51.9 |
| 3 | 37.4 |
| 4 | 29.2 |
| 5 | 24.0 |
| 6 | 20.3 |
| 7 | 17.6 |
| 8 | 15.6 |
| 9 | 13.9 |
| 10 | 12.6 |
| 11 | 11.5 |
| 12 | 10.6 |

(b) Runoff Analysis

- Runoff Analysis: Rational Method

$$Q = \frac{1}{360} \quad C \cdot i \cdot a$$

where

Q = Runoff in cubic meters per second
C = Runoff coefficient
i = Rainfall intensity in mm per hour
a = Drainage area in hectares

- Runoff Coefficient:

The coefficients are established as shown in Table 4.6.2.

Table 4.6.2 Runoff Coefficient

| Area | Runoff Coeffcient "C" |
|---|---|
| Residential areas | 0.50 |
| Hotel areas | 0.50 |
| Rice fields | 0.70 |
| Other areas | 0.20 |

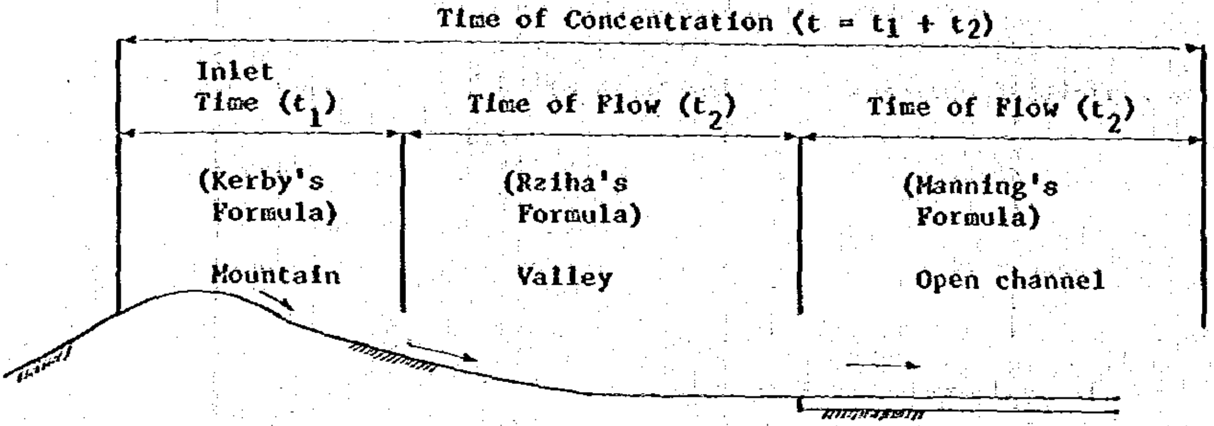
- Time of Concentration: Refer to Fig. 4.6.2.

$$t = t_1 + t_2$$

where

t = Time of concentration in minutes
$t_1$= Inlet time in minutes
$t_2$= Time of flow in minutes

Fig. 4.6.2 Calculation of the Time of Concentration




* Inlet Time: Kerby's formula

$$t_1 = [\frac{2}{3} \times 3.28\ \ell\ \frac{n}{s}]$$

where

$t_1$ = Inlet time in minutes

$\ell$ = Length from the most remote point in meters

s = Slope of ground surface

n = Coefficient determined by ground surface condition (0.02 ~ 0.80)

* Time of Flow:

Valley: Rziha's Formula

$$t_2 = \frac{\ell}{w} \qquad w = 20\ (\frac{h}{\ell})^{0.6}$$

where

$t_2$ = Time of flow in seconds

$\ell$ = Horizontal length from the inlet point in meters

w = Velocity of flow in meters per second

h = Head from the inlet point in meters

Open Channel: Manning's Formula

$$t_2 = \frac{\ell}{v} \qquad v = \frac{1}{n} \cdot R^{2/3} \cdot I^{1/2}$$

where

$t_2$ = Time of flow in seconds

$\ell$ = Length from the inlet point in meters

v = Velocity of flow in meters per second

n = Coefficient of roughness

R = Hydraulic radius in meters

$$= \left( \frac{\text{flow area of section}}{\text{wetted perimeter}} \right)$$

I = Hydraulic gradient

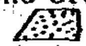
- Ponding Period:

The allowable ponding period of storm water in the regulating pond is generally in the range of 16 to 24 hours. In this feasibility study, 16 hours is utilized considering the future development of the upstream area of the ponds.

The calculation procedure and the example (rice field area in No.2 Tributary of the Pattaya River) of ponding are shown in Fig. 4.6.3 through Fig. 4.6.6 and Table 4.6.3, as follows.

(i) H-V curve is obtained from the existing contour. (Refer to Fig. 4.6.4)

(ii) The allowable ponding level is to be within 30cm. above the normal ponding level. The allowable ponding volume, that is, the volume between the normal ponding level of 5.00 meters and the allowable ponding level of 5.30 meters, is estimated as 136,000 cu. meters. (Refer to Fig. 4.6.4)

(iii) The total inflow volume is calculated from the catchment area, mean runoff coefficient and time of concentration. For example, the inflow volume to the pond after 8 and 10 hours from the beginning of rainfall is given as  and  in Fig. 4.6.5, respectively. (Refer to Fig. 4.6.5 and Table 4.6.3)

(iv) The inflow curve shown in Fig. 4.6.6 is given by plotting the total inflow volume calculated in Table 4.6.3.

The proposed ponding period is 16 hours considering the life period of plants in the water (1-2 days) and the future development in the upstream area.

Assuming that the inflow volume to the pond is drained in 16 hours and the ponded water is constantly discharged, the planned max. ponding volume and discharge rate are estimated as 55,000 cu. meters and 3.0 cu. meters per second, respectively. As the spillway is planned to be installed at the discharge point of the pond in this feasibility study, the actual discharge rate of water at the spillway fluctuates drawing a curve, however, there is no problem in the design if the water is considered to be constantly discharged. (Refer to Fig. 4.6.6)

The ponding water level in case the planned max. volume of 55,000 cu. meters is ponded, is estimated as 5.13 meters from Fig. 4.6.4, satisfying the allowable ponding level of 5.30 meters.

Fig. 4.6.3 Calculation Procedure of Ponding

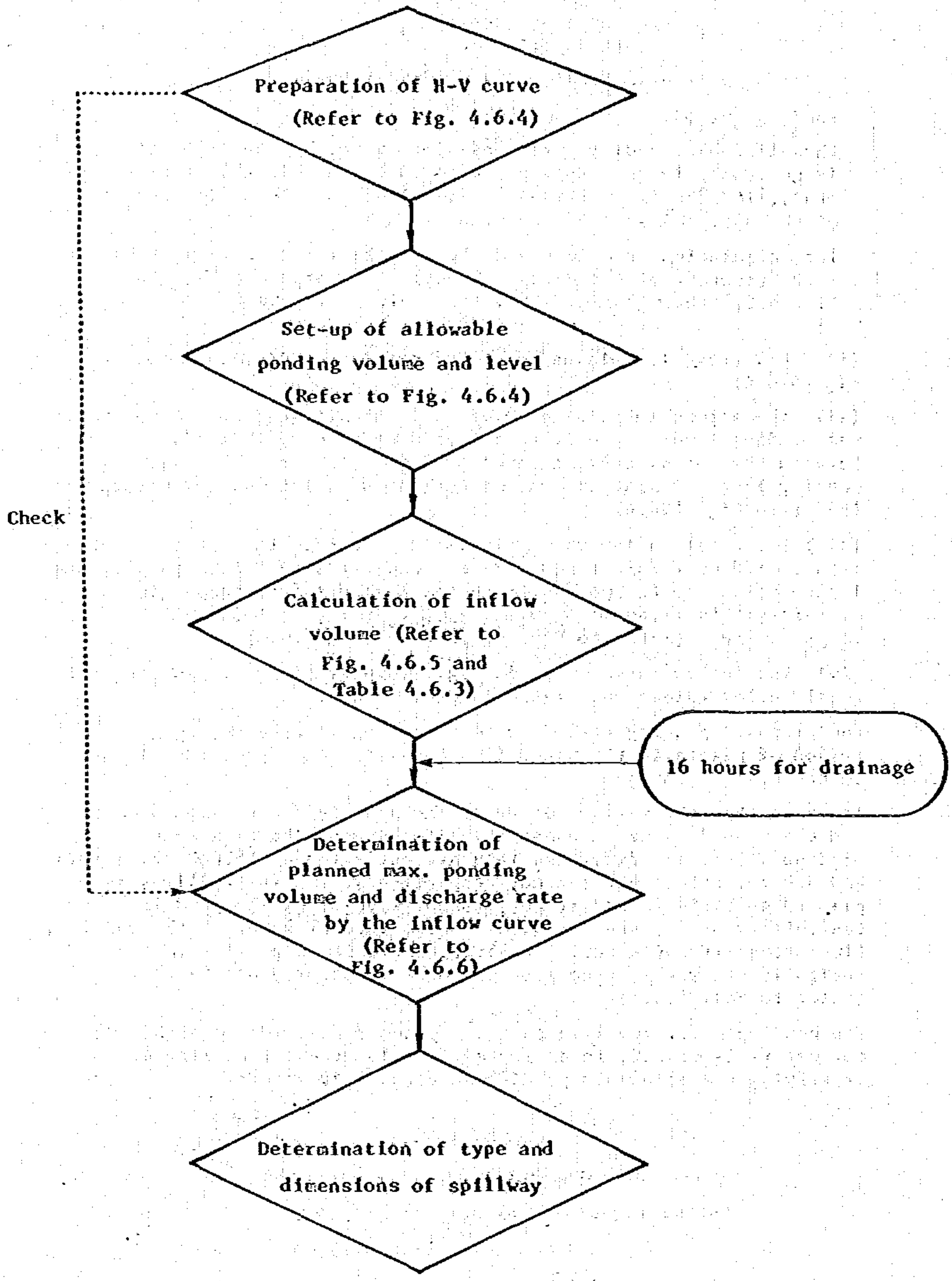


Fig. 4.6.4 Example of H-V Curve (Catchment area = 570ha, Mean runoff coefficient = 0.27)

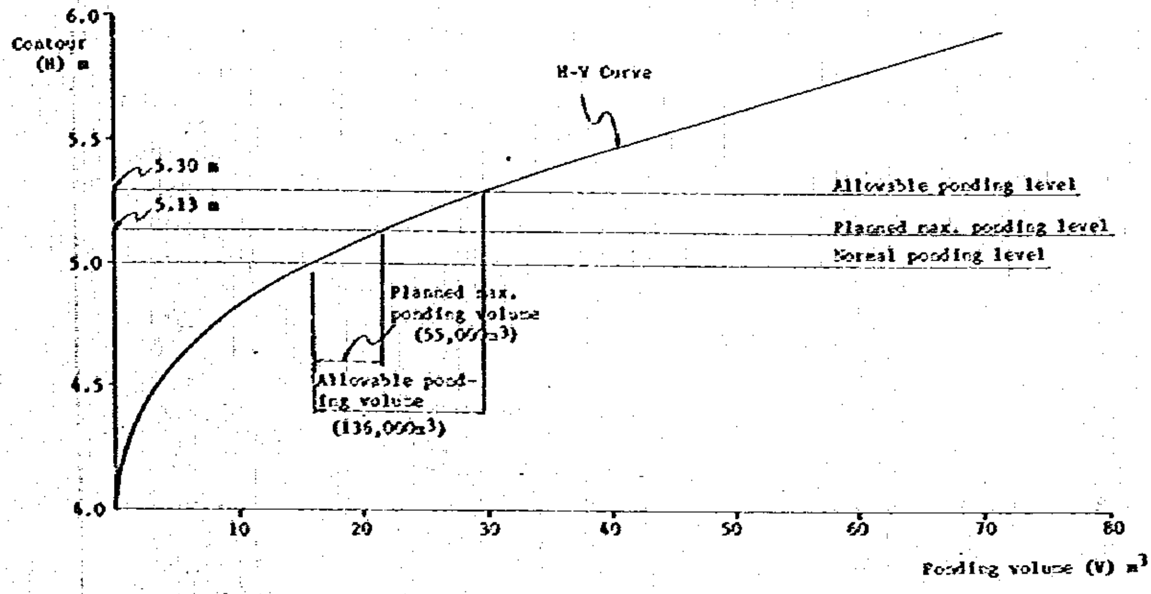



Fig. 4.6.5 Calculation Example of Inflow Volume (Catchment area = 570ha, Mean runoff coefficient = 0.27, Time of concentration = 4.4hr)

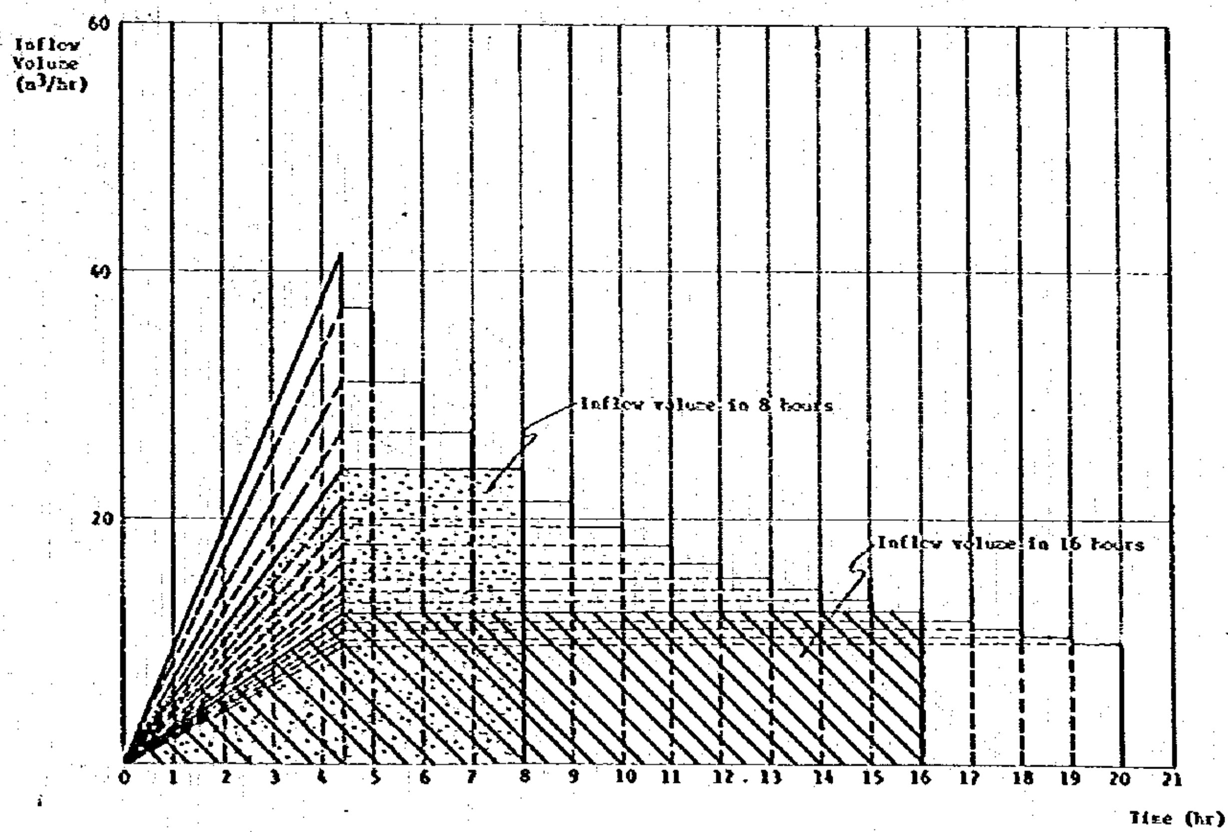
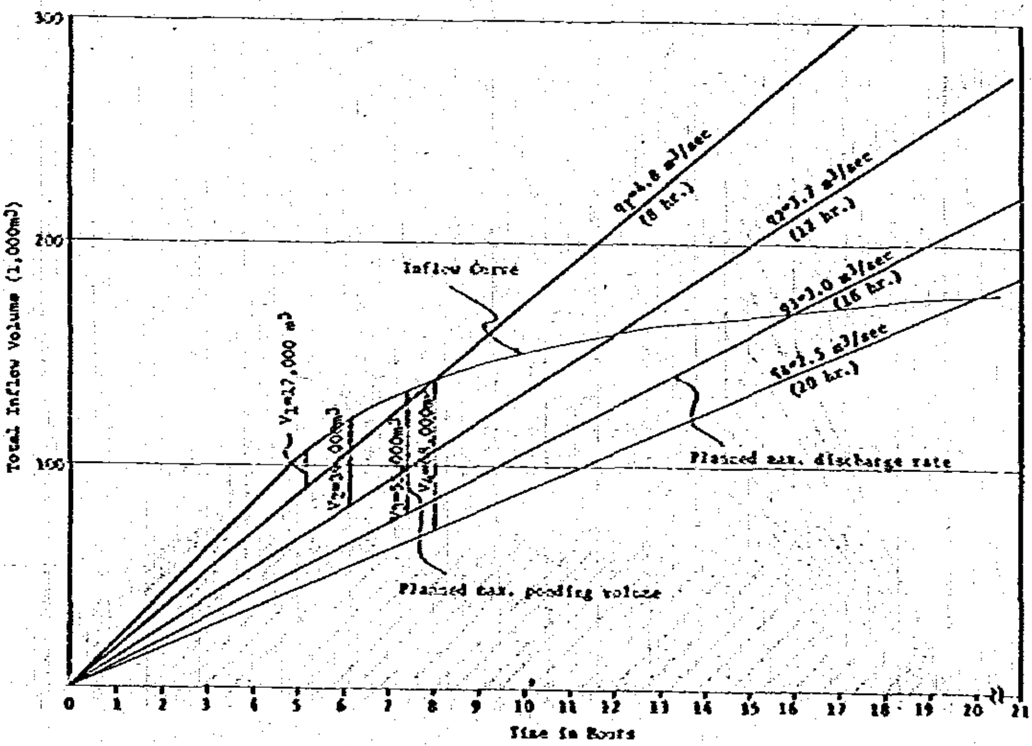


Table 4.6.3 Calculation Example of Inflow Volume (Catchment area = 570 ha, Mean runoff coefficient = 0.27, Time of concentration = 4.4 hr)

| Time (hr) | Average rainfall intensity ($i_r$ mm/hr) | Rate of inflow ($m^3$/sec) | Rate of inflow ($m^3$/hr) | Total inflow volume ($m^3$) |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 4.4 | 26.8 | 11.46 | 41,256 | 90,800 |
| 5 | 24.0 | 10.26 | 36.936 | 103,400 |
| 6 | 20.3 | 8.68 | 31,248 | 118,700 |
| 7 | 17.6 | 7.52 | 27,072 | 129,900 |
| 8 | 15.6 | 6.67 | 24,012 | 139,300 |
| 9 | 13.9 | 5.94 | 21,384 | 145,400 |
| 10 | 12.6 | 5.39 | 19,404 | 151,400 |
| 11 | 11.5 | 4.92 | 17,712 | 155,900 |
| 12 | 10.6 | 4.53 | 16,308 | 159,800 |
| 13 | 9.8 | 4.19 | 15,084 | 162,900 |
| 14 | 9.2 | 3.93 | 14,748 | 166,900 |
| 15 | 8.6 | 3.68 | 13,248 | 169,600 |
| 16 | 8.0 | 3.42 | 12,312 | 169,900 |
| 17 | 7.6 | 3.25 | 11,700 | 173,200 |
| 18 | 7.2 | 3.08 | 11,088 | 175,200 |
| 19 | 6.8 | 2.91 | 10,476 | 176,000 |
| 20 | 6.5 | 2.78 | 10,008 | 178,100 |

Fig. 4.6.6 Calculation Example of Planned Ponding Volume and Discharge Rate (Catchment area = 570ha, Mean runoff coefficient = 0.27 Time of concentration = 4.4hr)



(c) Facility Planning

- Study on scale of open channels and box culverts: Manning's Formula

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

where

Q = Discharge in cubic meters per second
A = Cross-sectional area of flow in square meters
V = Velocity of flow in meters per second
n,R,I : Refer to Sec. 4.6.1 (b)

- Coefficient of Roughness:

| Type of Structure | Coefficient of Roughness "n" |
| --- | --- |
| Concrete box culverts | 0.015 |
| Open channels with stone masonry | 0.030 |

- Study on Discharge of Spillways:

$$Q = 1.8\,B\,h^{3/2}$$

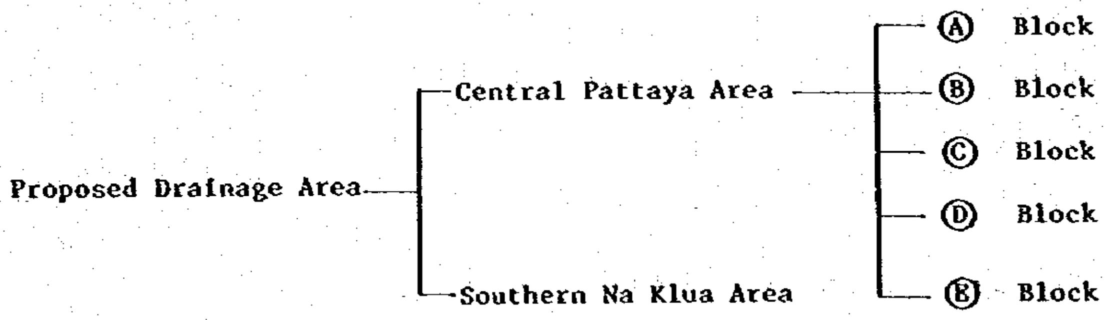
where

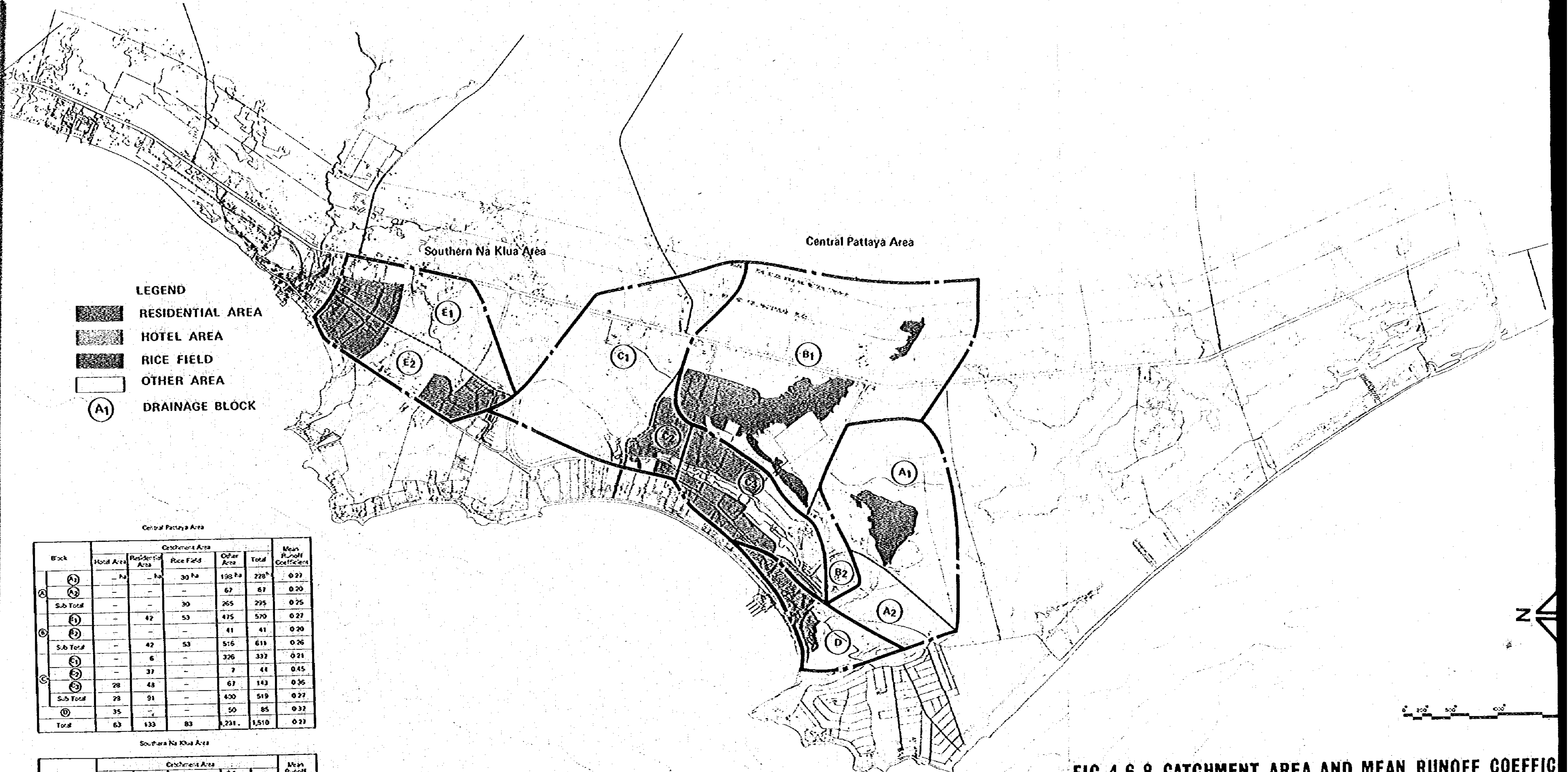
Q = Overflow discharge in cubic meters per second
B = Width of spillway in meters
h = Overflow depth in meters

### 4.6.2 Proposed Drainage Area

The proposed drainage areas are classified by topographic conditions and development plans, etc. as shown in Fig. 4.6.7. Fig. 4.6.8 shows the catchment area and mean runoff coefficient by drainage blocks.

Fig. 4.6.7 Proposed Drainage Area






Central Pattaya Area

| Block | | Catchment Area: Hotel Area | Residential Area | Rice Field | Other Area | Total | Mean Runoff Coefficient |
|---|---|---|---|---|---|---|---|
| A | A1 | – ha | – ha | 30 ha | 198 ha | 228 ha | 0.27 |
| | A2 | – | – | – | 67 | 67 | 0.20 |
| | Sub Total | – | – | 30 | 265 | 295 | 0.25 |
| B | B1 | – | 42 | 53 | 475 | 570 | 0.27 |
| | B2 | – | – | – | 41 | 41 | 0.20 |
| | Sub Total | – | 42 | 53 | 516 | 611 | 0.26 |
| C | C1 | – | 6 | – | 326 | 332 | 0.21 |
| | C2 | – | 37 | – | 7 | 44 | 0.45 |
| | C3 | 28 | 48 | – | 67 | 143 | 0.36 |
| | Sub Total | 28 | 91 | – | 400 | 519 | 0.27 |
| D | | 35 | – | – | 50 | 85 | 0.32 |
| Total | | 63 | 133 | 83 | 1,231 | 1,510 | 0.27 |

Southern Na Klua Area

| Block | | Catchment Area: Hotel Area | Residential Area | Rice Field | Other Area | Total | Mean Runoff Coefficient |
|---|---|---|---|---|---|---|---|
| E | E1 | – ha | 27 ha | – ha | 113 ha | 140 ha | 0.26 |
| | E2 | – | 61 | – | 61 | 122 | 0.35 |
| | Total | – | 88 | – | 174 | 262 | 0.30 |

FIG 4.6.8 CATCHMENT AREA AND MEAN RUNOFF COEFFIC
BY DRAINAGE BLOCKS

LEGEND

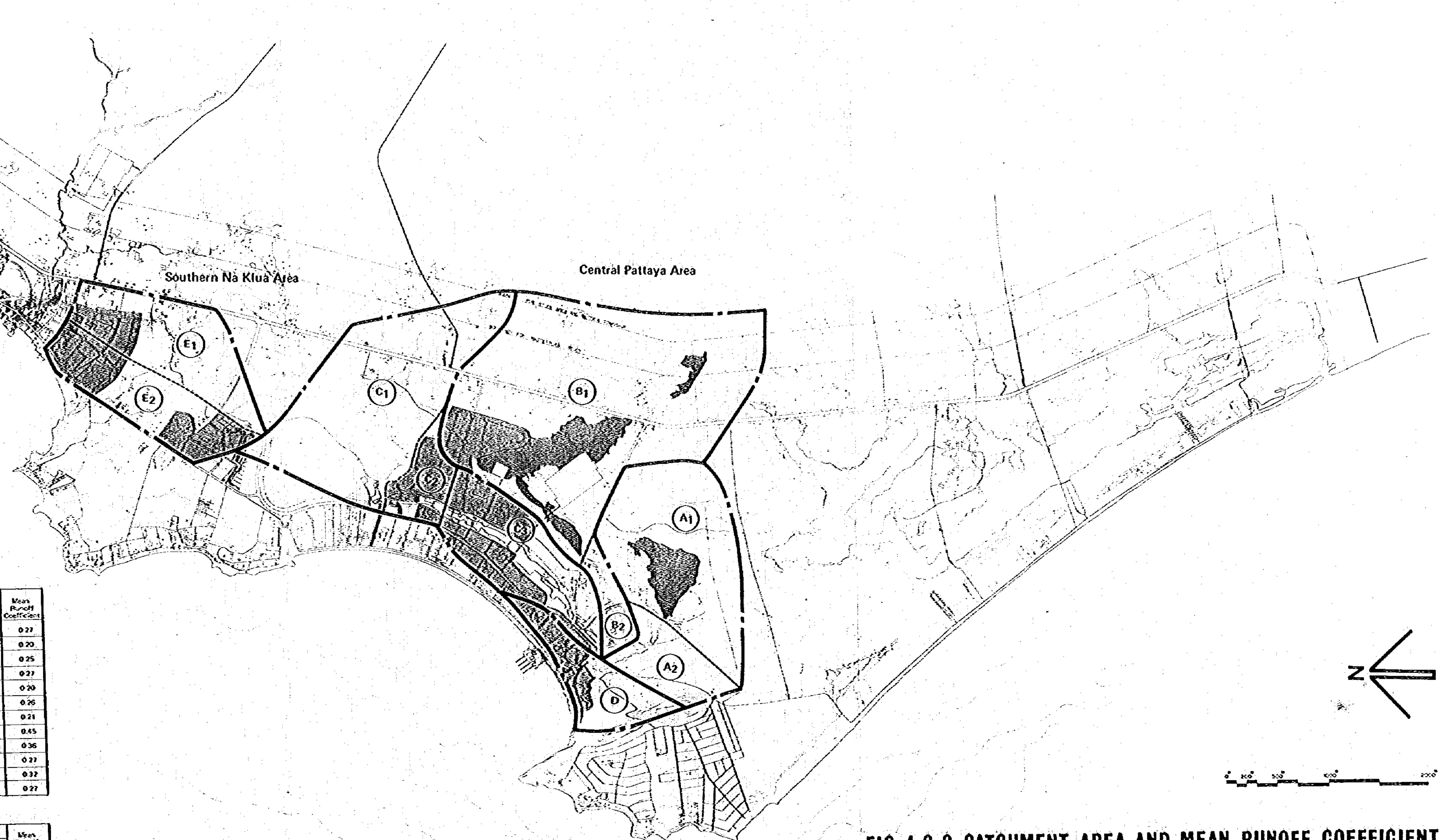
RESIDENTIAL AREA

HOTEL AREA

RICE FIELD

OTHER AREA

DRAINAGE BLOCK




Central Pattaya Area

| Catchment Area | | | | Mean Runoff Coefficient |
|---|---|---|---|---|
| Residential Area | Rice Field | Other Area | Total | |
| – ha | 30 ha | 198 ha | 228 ha | 0.27 |
| – | – | 67 | 67 | 0.20 |
| – | 30 | 265 | 295 | 0.25 |
| 42 | 53 | 475 | 570 | 0.27 |
| – | – | 41 | 41 | 0.20 |
| 42 | 53 | 516 | 611 | 0.26 |
| 6 | – | 326 | 332 | 0.21 |
| 37 | – | 7 | 44 | 0.45 |
| 43 | – | 67 | 143 | 0.36 |
| 91 | – | 430 | 519 | 0.27 |
| – | – | 50 | 85 | 0.32 |
| 133 | 83 | 1,231 | 1,510 | 0.27 |

Southern Na Klua Area

| Catchment Area | | | | Mean Runoff Coefficient |
|---|---|---|---|---|
| Residential Area | Rice Field | Other Area | Total | |
| 27 ha | – ha | 113 ha | 140 ha | 0.26 |
| 61 | – | 61 | 122 | 0.35 |
| 88 | – | 174 | 262 | 0.30 |

**FIG 4.6.8 CATCHMENT AREA AND MEAN RUNOFF COEFFICIENT BY DRAINAGE BLOCKS**

### 4.6.3 Alternative Plans for the System

(a) Central Pattaya Area

1) Alternative Plan 1 : Integrated Drainage Plan

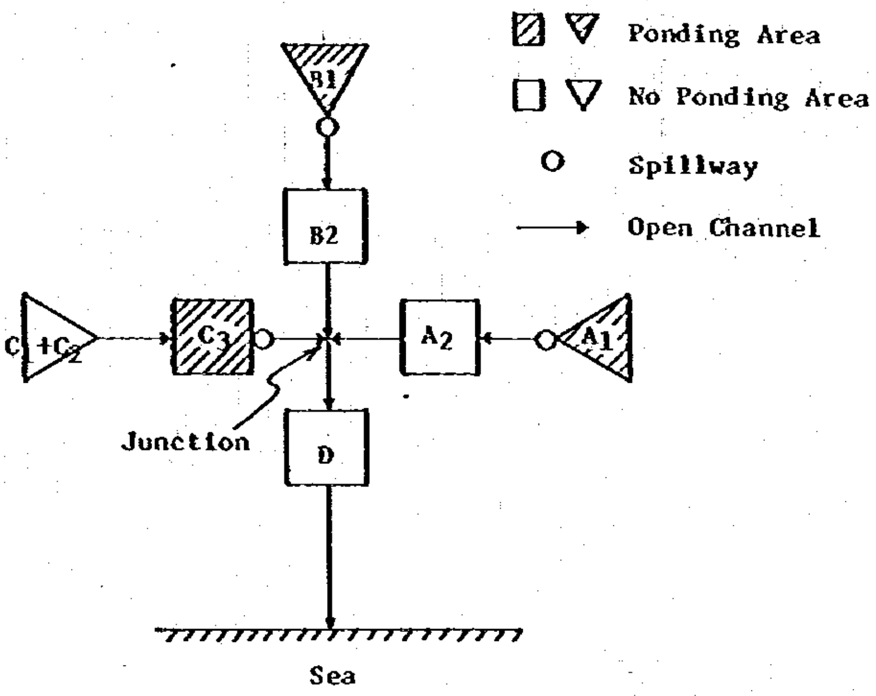
This plan is to lead the storm water in the Central Pattaya Area collectively into the Pattaya River. The storm water in $A_1$ and $B_1$ blocks is led to the rice field area, and the storm water in $C_1$, $C_2$ and $C_3$ blocks to the regulating pond in $C_3$ block for ponding. The ponded water passes through the spillways, box culverts and open channels, and joins with the storm water in $A_2$, $B_2$ and D blocks and then discharged into the sea.

The regulating pond in $C_3$ block is utilized mainly for the purpose of regulating the storm water, as well as a buffer for tourism and residential areas and also for aesthetic appreciation.

The existing river from the junction to the coast should be improved for the following reasons:

- The existing river meanders radically.
- The flow sectional area of box culverts on its way cannot sufficiently cope with the peak discharge of runoff after development.
- The channel is narrow in places.

Fig. 4.6.9 Alternative Plan 1

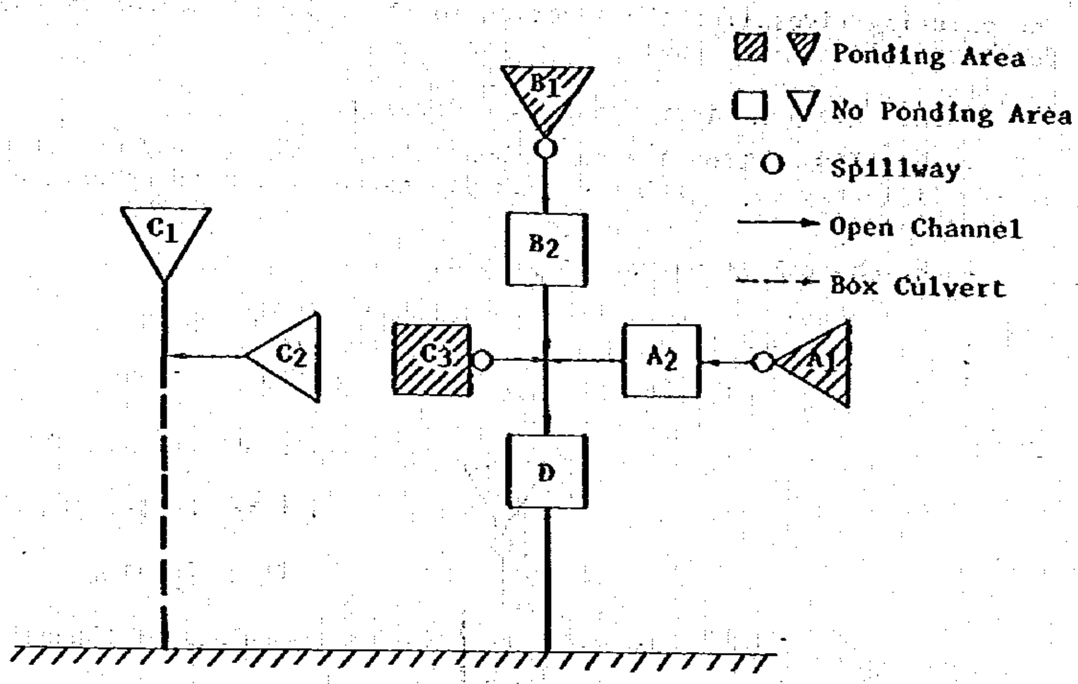


## 2) Alternative Plan 2.: Short-Cut Plan

This plan is for draining the storm water in the Central Pattaya Area by diverting it with the Main Residential Road. The storm water fallen on the south side of the road is discharged into the sea by the same way as in Alternative Plan 1, while the storm water fallen on the north side of the road, namely, the storm water in $C_1$ and $C_2$ blocks, is collected by open channels and discharged into the sea passing the short-cut box culvert from the Back Road to the Beach Road.

This box culvert is approximately 500 meters long. The box culvert is buried under the existing road because it is expected to be difficult to secure the right of way for an open channel because of the concentration of hotels and stores, etc. between the Back and Beach Roads.

Fig. 4.6.10 Alternative Plan 2



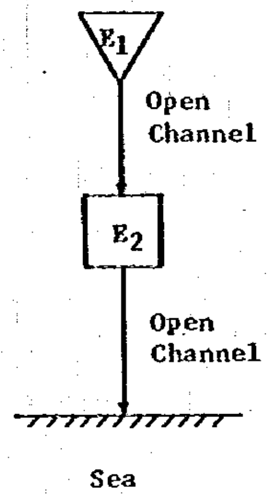
(b) Southern Na Klua Area

Only the system shown in Fig. 4.6.11 can be applicable for the drainage system in the Southern Na Klua Area.

The system plans to lead the storm water in the Area collectively into the sea.

The storm water in $E_1$ block is led into the open channel installed in Na Klua New Town A, and joins with the storm water in $E_2$ block and then discharged into the sea. The existing channel is used for drainage from the Main Residential Road to the coast because it can sufficiently cope with the peak discharge after development.

Fig. 4.6.11 Drainage System in the Southern Na Klua Area




### 4.6.4 Outline of the Drainage Facilities

An outline of storm water drainage facilities for the Central Pattaya and Southern Na Klua Areas is as shown in Fig. 4.6.12 through 4.6.14.

Fig. 4.6.12 Outline of Drainage Facilities (Central Pattaya Area, Alternative Plan 1)

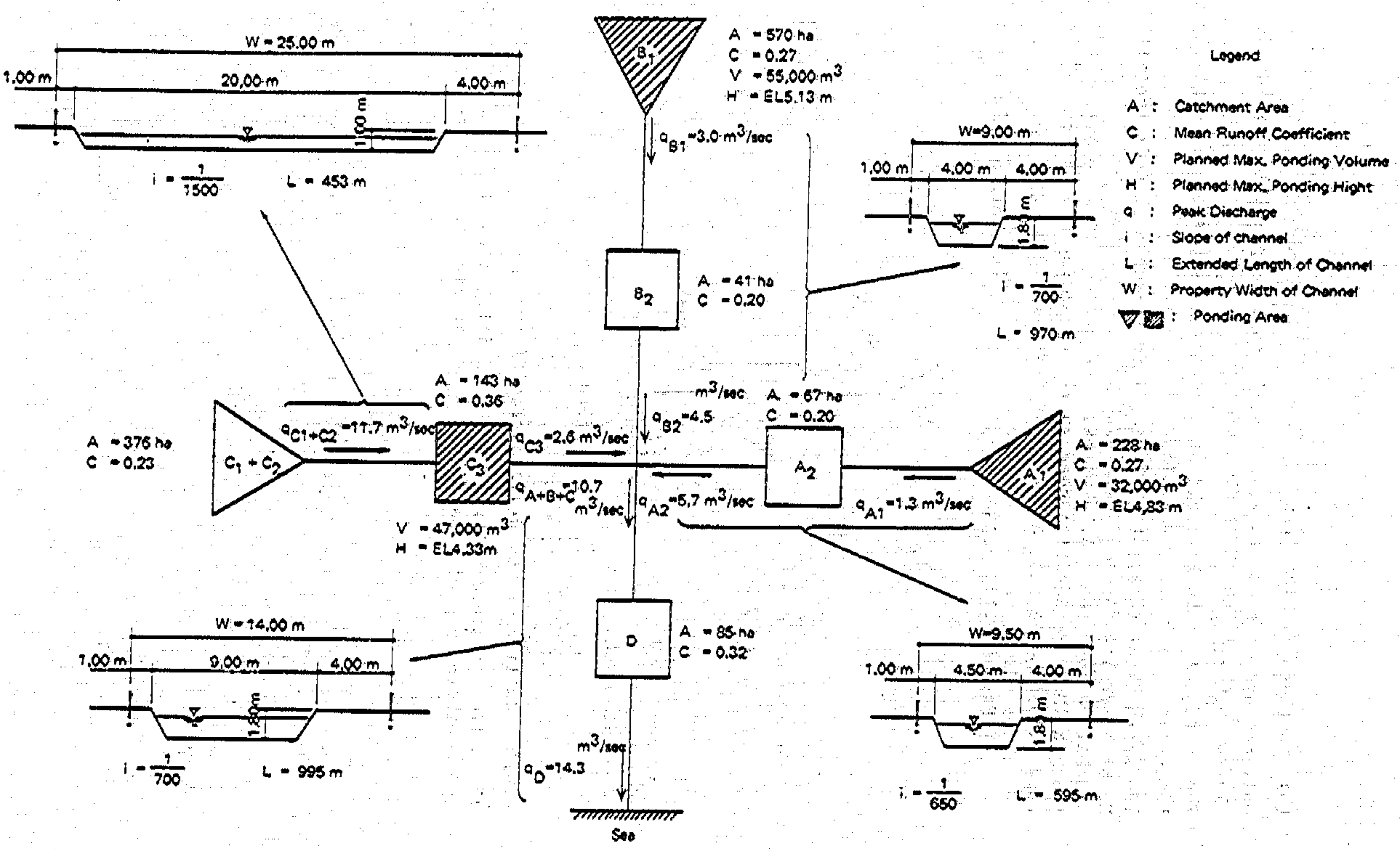


Fig. 4.6.13 Outline of Drainage Facilities (Central Pattaya Area, Alternative Plan 2)

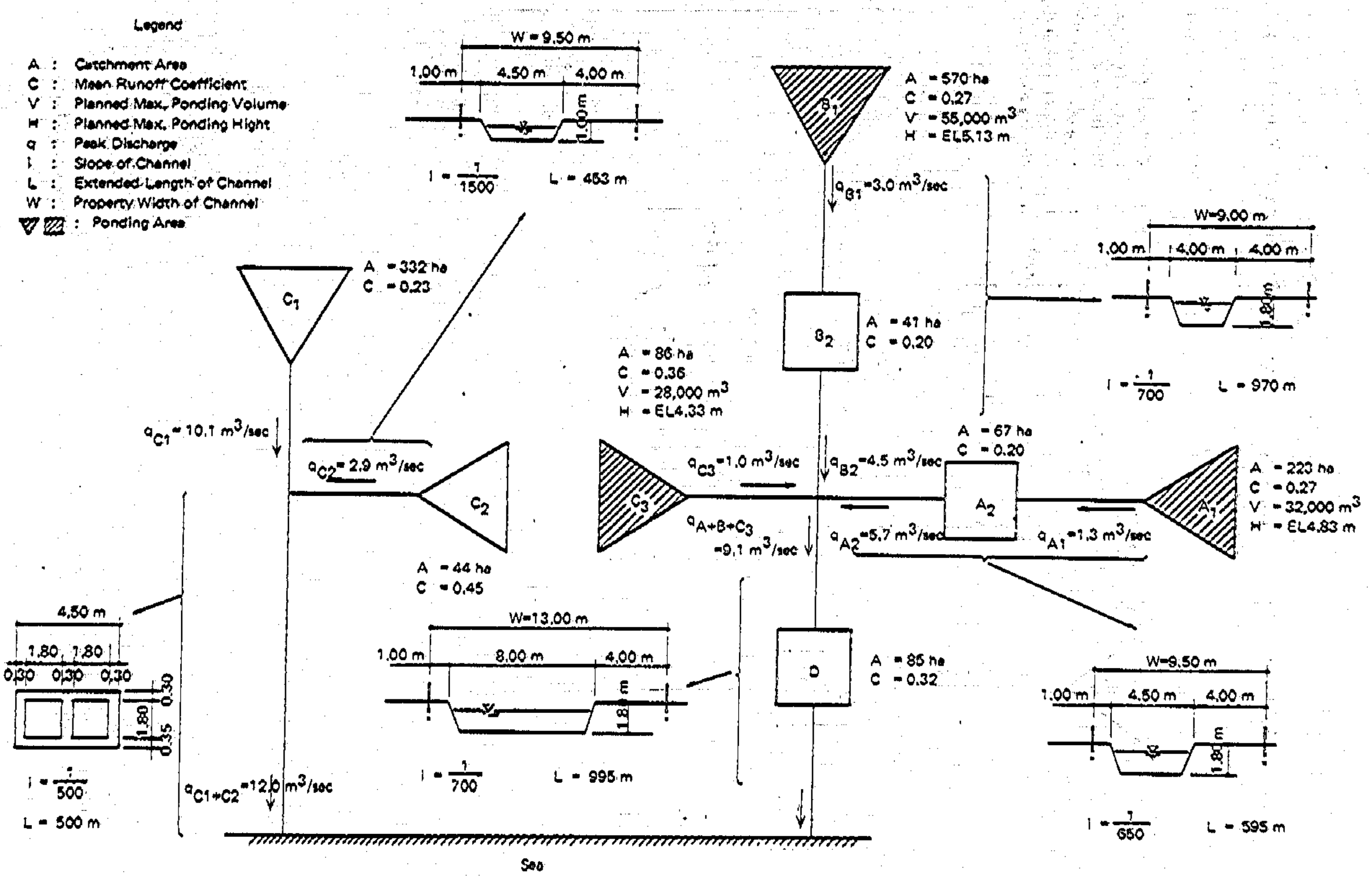
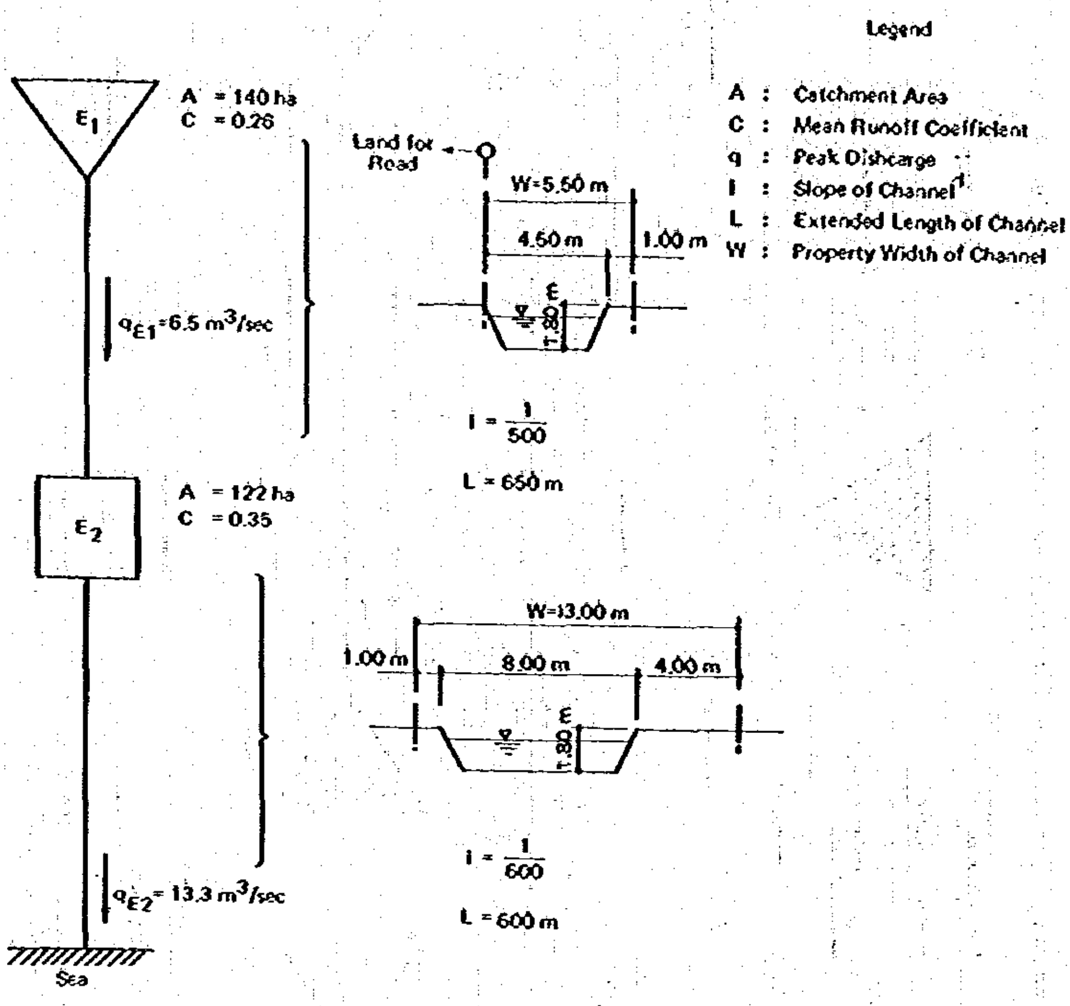


Fig. 4.6.14 Outline of Drainage Facilities (Southern Na Klua Area)



### 4.6.5 Selection of the Optimum System

Selection of the optimum storm water drainage system shall be made only for the Central Pattaya Area.

(a) Evaluation

1) Construction Costs

Total construction costs for Alternative Plans 1 and 2 are as shown in Table 4.6.4. The construction cost of Alternative Plan 2 is higher by approximately 25% than that of Alternative Plan 1 but there is no difference in total cost including the land costs between the two plans.

Table 4.6.4 Total Construction Costs of Alternative Plans

| Item | | Alternative Plan 1 (1,000 Baht) | Alternative Plan 2 (1,000 Baht) |
|---|---|---|---|
| Construction Costs | Main Open Channel | 12,190 | 12,110 |
| | Box Culvert | 4,250 | *1 9,980 |
| | Spillway | 700 | 660 |
| | Branch Open Channel | 4,270 | 4,270 |
| | Land Grading of Regulating Pond | 740 | 490 |
| | Sub-total | 22,150 (100) | 27,510 (124) |
| Land Costs | | 23,110 | *2 19,420 |
| Total | | 45,260 (100) | 46,930 (103) |

In the above table, there is a great difference in the construction cost of the culvert (*1) and the land cost (*2) between the two plans for the following reasons:

*1 Alternative Plan 2 requires a box culvert approximately 500 meters long between the Back and Beach Roads.

*2 Alternative Plan 2 requires a smaller regulating area than that of Alternative Plan 1 because the storm water in Alternative Plan 2 is drained by diversion.

2) Effect on the Sea Area

(1) Alternative Plan 1:

As the storm water in A, B and C blocks is ponded in the rice field area and the regulating pond, suspended solid in the water will be considerably deposited. Consequently, the effect of turbid water on the sea area would be smaller than Alternative Plan 2.

(2) Alternative Plan 2:

- The storm water on the south side of the Main Residential Road, that is, the storm water in A, B and $C_3$ blocks would pose less problem for the reason stated above.
- The storm water on the north side of the Main Residential Road, that is, the storm water in $C_1$ and $C_2$ blocks is directly discharged into the sea without ponding. Consequently, the effect of the turbid water would be large. Furthermore, as the discharge point is located in the sea-bathing area, it might effect the tourists and sea-bathers.

3) Maintenance and Operation:

(1) Alternative Plan 1:

- The maintenance and operation of the system will be conducted by patroling of the channels.
- The contents of which is scheduled below.
  * Removal of floodwood and obstacles, etc. in the open channels.
  * Removal of sediment in the culverts.
  * Repair of damaged parts of the channels.

(2) Alternative Plan 2:

- Maintenance and operation procedures are the same as in Alternative Plan 1.
- As the box culvert (for a short-cut) from the Back Road to the Beach Road is long, approximately 500 meters, maintenance and operation will require quite a lot of manpower and time.

(b) Selection:

As it is clear from the comparison above, Alternative Plan 1 is superior to Alternative Plan 2 in terms of economy, environmental conservation, and maintenance and operation. Consequently, Alternative Plan 1 is adopted as the best storm water drainage system in the Central Pattaya Area in this feasibility study.

However, if it is difficult to aquire the required land for the planned regulating pond, or if unplanned reclamation and land development for the housing sites continue without legal controls in the swamp area behind the Back Road, the Alternative Plan 2 may come into the picture, though there remain problems of environmental conservation and maintenance and operation.

In addition, if the required land for the proposed channel between the junction of No. 2 and No. 3 Tributaries of the Pattaya River to the mouth of it is not secured in future, the proposed drainage route would be changed to meet the future land requirements.

In the basic plan in this study, swamp area behind the Back Road (T-1) is designed as a series of storm water regulating ponds and as a park area. And this drainage system is planned to be the most feasible arrangements so as to minimize the earth works based on the existing topography and proposed landuse in the future.

If it is desirable to provide wider area to the park, that is, to narrow regulating ponds, it is possible technically by following measures:

- Lowering the top elevation of spillway
- Excavation of the earth and removing it on the bank

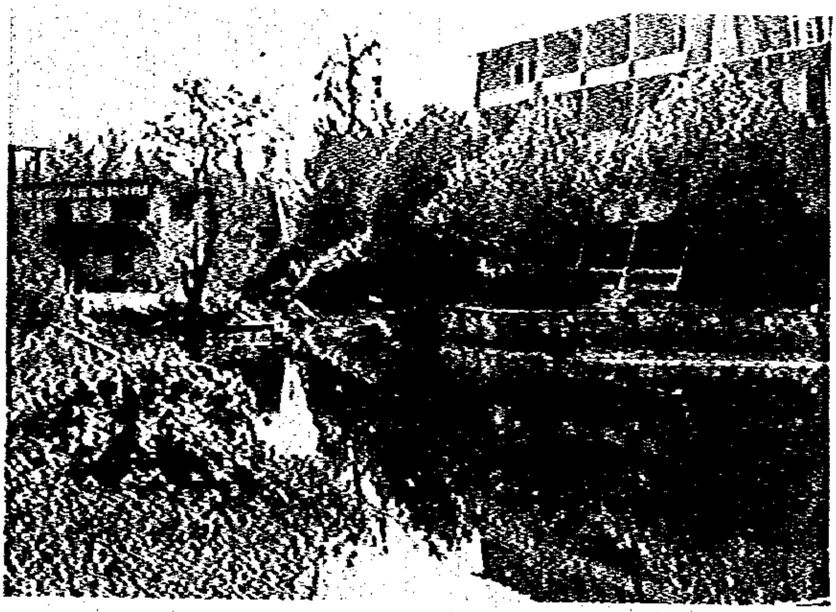
Table 4.6.5 shows relationship between the basic plan and three alternatives namely A, B and C. Other details are shown in drawings ST-003, -004, -005, -006 and -015.

Table 4.6.5 Area of Storm Water Regulating Pond and Specification of Spillway

| Plan | Top Elevation of Spillway | Area of Regulating Pond | Width of Spillway | Earth Volume of Excavation | Remarks |
|---|---|---|---|---|---|
| Basic | EL. 4.00 | 140,000 | 7.50 | 2,000 | Proposed System |
| Alt.A | EL. 3.90 | 110,000 | 5.00 | 6,000 | |
| Alt.BB | EL. 3.80 | 90,000 | 4.00 | 9,000 | |
| Alt.C | EL. 3.70 | 70,000 | 3.00 | 11,000 | |

The area of pond and the specification of spillway will be determined in the detail design stage after detailed topografic survey.

Fig. 4.6.15 shows the proposed drainage network in the Central Pattaya and Southern Na Klua Areas.



Present Pattaya River

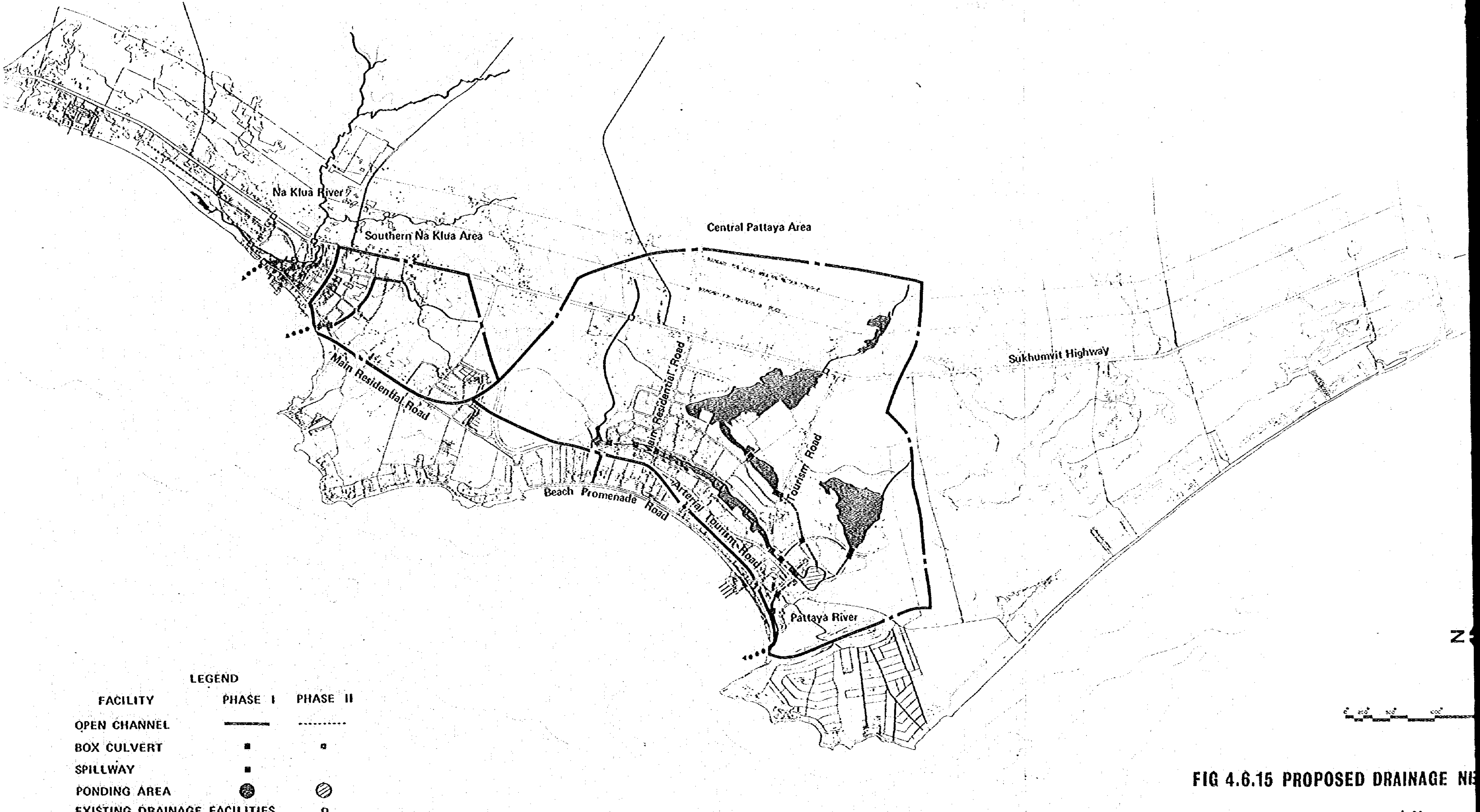



FIG 4.6.15 PROPOSED DRAINAGE NE


LEGEND

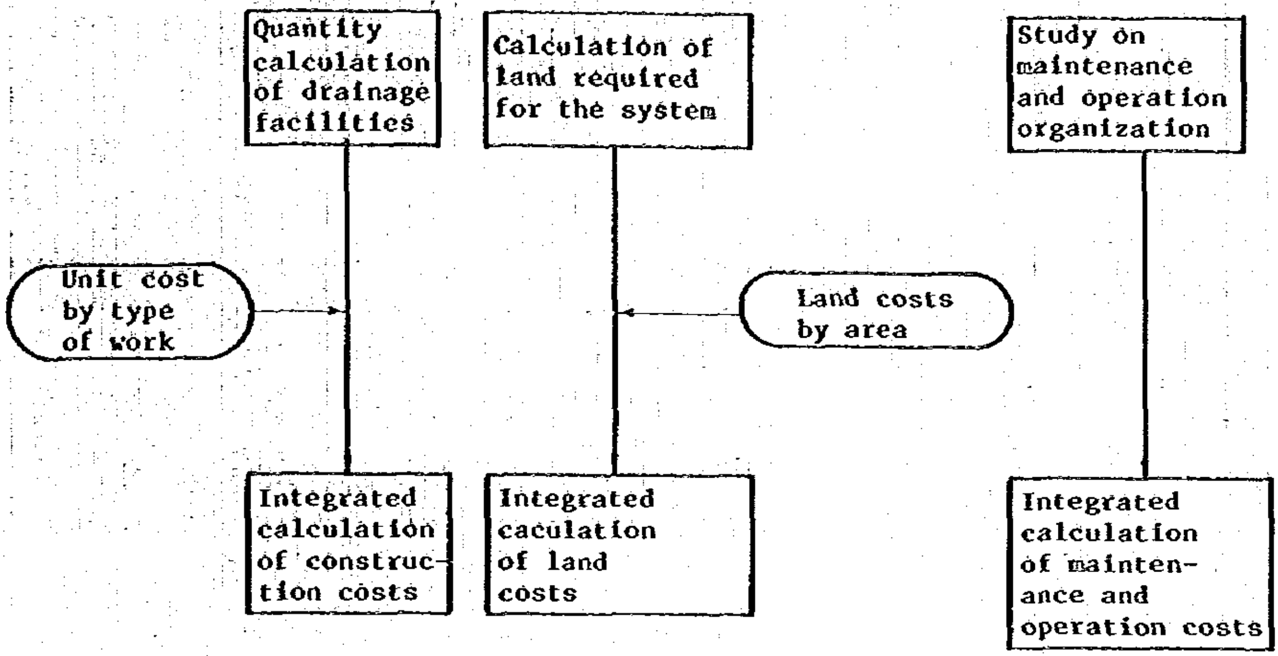
| ...ITY | PHASE I | PHASE II |
|---|---|---|
| ...ANNEL | ▬▬▬ | --------- |
| ...VERT | ▪ | ▪ |
|  | ▪ |  |
| ...AREA | ● | ⊘ |
| ...DRAINAGE FACILITIES |  | o |

FIG 4.6.15 PROPOSED DRAINAGE NETWORK

## 4.7 Cost Estimation

The integrated calculation of construction costs, land costs and maintenance and operation costs was made according to the flow chart illustrated below.

Fig. 4.7.1 Flow Chart of Cost Estimation




### 4.7.1 Construction and Land Costs

The construction and land costs for the storm water drainage system for Phase 1 (1981 to 1986) are as shown in Tables 4.7.1 and 4.7.2. Refer to Tables 4.7.3, 4.7.4 and Fig. 4.7.2 concerning the quantity of drainage facilities, unit cost by type of work and land costs by area.

Table 4.7.1 Phase 1 Construction and Land Costs for Storm Water Drainage System (Central Pattaya Area)

(Unit: 1,000 Baht)

| WORKS | | TOTAL COST WITHOUT TAX | TOTAL TAX | TOTAL COST WITH TAX | TOTAL U.L | 1981 COST WITHOUT TAX | 1981 TAX | 1981 COST WITH TAX | 1981 U.L | 1982 COST WITHOUT TAX | 1982 TAX | 1982 COST WITH TAX | 1982 U.L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Main Open Channel | LOCAL | 6,073 | 260 | 6,333 | 291 | 3,573 | 127 | 3,700 | 158 | 2,500 | 133 | 2,633 | 133 |
| | FOREIGN | 531 | - | 531 | - | 201 | - | 201 | - | 330 | - | 330 | - |
| | TOTAL | 6,604 | 260 | 6,864 | 291 | 3,774 | 127 | 3,901 | 158 | 2,830 | 133 | 2,963 | 133 |
| 2. Box Culvert | LOCAL | 2,627 | 73 | 2,700 | 79 | 1,849 | 52 | 1,901 | 56 | 778 | 21 | 799 | 23 |
| | FOREIGN | 53 | - | 53 | - | 39 | - | 39 | - | 14 | - | 14 | - |
| | TOTAL | 2,680 | 73 | 2,753 | 79 | 1,888 | 52 | 1,940 | 56 | 792 | 21 | 813 | 23 |
| 3. Spillway | LOCAL | 675 | 21 | 696 | 21 | 100 | 3 | 103 | 3 | 575 | 18 | 593 | 18 |
| | FOREIGN | 24 | - | 24 | - | 2 | - | 2 | - | 22 | - | 22 | - |
| | TOTAL | 699 | 21 | 720 | 21 | 102 | 3 | 105 | 3 | 597 | 18 | 615 | 18 |
| 4. Branch Open Channel | LOCAL | 4,136 | 129 | 4,265 | 155 | 1,034 | 32 | 1,066 | 39 | 3,102 | 97 | 3,199 | 116 |
| | FOREIGN | 135 | - | 135 | - | 34 | - | 34 | - | 101 | - | 101 | - |
| | TOTAL | 4,271 | 129 | 4,400 | 155 | 1,068 | 32 | 1,100 | 39 | 3,203 | 97 | 3,300 | 116 |
| 5. Land Grading of Regulating Pond | LOCAL | 426 | 33 | 459 | - | - | - | - | - | 426 | 33 | 459 | - |
| | FOREIGN | 197 | - | 197 | - | - | - | - | - | 197 | - | 197 | - |
| | TOTAL | 623 | 33 | 656 | - | - | - | - | - | 623 | 33 | 656 | - |
| Sub-total | LOCAL | 13,937 | 516 | 14,453 | 546 | 6,556 | 214 | 6,770 | 256 | 7,381 | 302 | 7,683 | 290 |
| | FOREIGN | 940 | - | 940 | - | 276 | - | 276 | - | 664 | - | 664 | - |
| | TOTAL | 14,877 | 516 | 15,393 | 546 | 6,832 | 214 | 7,046 | 256 | 8,045 | 302 | 8,347 | 290 |
| 6. Land Costs | LOCAL | 17,137 | - | 17,137 | - | 10,915 | - | 10,915 | - | 6,222 | - | 6,222 | - |
| | FOREIGN | - | - | - | - | - | - | - | - | - | - | - | - |
| | TOTAL | 17,137 | - | 17,137 | - | 10,915 | - | 10,915 | - | 6,222 | - | 6,222 | - |
| Total | LOCAL | 31,074 | 516 | 31,590 | 546 | 17,471 | 214 | 17,685 | 256 | 13,603 | 302 | 13,905 | 290 |
| | FOREIGN | 940 | - | 940 | - | 276 | - | 276 | - | 664 | - | 664 | - |
| | TOTAL | 32,014 | 516 | 32,530 | 546 | 17,747 | 214 | 17,961 | 256 | 14,267 | 302 | 14,569 | 290 |

*U.L: Unskilled labor

Table 4.7.2 Phase 1 Construction and Land Costs for Storm Water Drainage System (Southern Na Klua Area)

(Unit: 1,000 Baht)

| WORKS | | TOTAL COST WITHOUT TAX | TOTAL TAX | TOTAL COST WITH TAX | TOTAL U.L | 1981 COST WITHOUT TAX | 1981 TAX | 1981 COST WITH TAX | 1981 U.L | 1982 COST WITHOUT TAX | 1982 TAX | 1982 COST WITH TAX | 1982 U.L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Main Open Channel | LOCAL | 4,304 | 158 | 4,462 | 182 | 1,233 | 51 | 1,284 | 62 | 3,071 | 107 | 3,178 | 120 |
| | FOREIGN | 258 | - | 258 | - | 105 | - | 105 | - | 153 | - | 153 | - |
| | TOTAL | 4,562 | 158 | 4,720 | 182 | 1,338 | 51 | 1,389 | 62 | 3,224 | 107 | 3,331 | 120 |
| 2. Box Culvert | LOCAL | 598 | 17 | 615 | 18 | 598 | 17 | 615 | 18 | - | - | - | - |
| | FOREIGN | 12 | - | 12 | - | 12 | - | 12 | - | - | - | - | - |
| | TOTAL | 610 | 17 | 627 | 18 | 610 | 17 | 627 | 18 | - | - | - | - |
| 3. Branch Open Channel | LOCAL | 2,068 | 64 | 2,132 | 78 | 1,034 | 32 | 1,066 | 39 | 1,034 | 32 | 1,066 | 39 |
| | FOREIGN | 68 | - | 68 | - | 34 | - | 34 | - | 34 | - | 34 | - |
| | TOTAL | 2,136 | 64 | 2,200 | 78 | 1,068 | 32 | 1,100 | 39 | 1,068 | 32 | 1,100 | 39 |
| Sub-total | LOCAL | 6,970 | 239 | 7,209 | 278 | 2,865 | 100 | 2,965 | 119 | 4,105 | 139 | 4,244 | 159 |
| | FOREIGN | 338 | - | 338 | - | 151 | - | 151 | - | 187 | - | 187 | - |
| | TOTAL | 7,308 | 239 | 7,547 | 278 | 3,016 | 100 | 3,116 | 119 | 4,292 | 139 | 4,431 | 159 |
| 4. Land Costs | LOCAL | 1,306 | - | 1,306 | - | 1,136 | - | 1,136 | - | 170 | - | 170 | - |
| | FOREIGN | - | - | - | - | - | - | - | - | - | - | - | - |
| | TOTAL | 1,306 | - | 1,306 | - | 1,136 | - | 1,136 | - | 170 | - | 170 | - |
| Total | LOCAL | 8,276 | 239 | 8,515 | 278 | 4,001 | 100 | 4,101 | 119 | 4,275 | 139 | 4,414 | 159 |
| | FOREIGN | 338 | - | 338 | - | 151 | - | 151 | - | 187 | - | 187 | - |
| | TOTAL | 8,614 | 239 | 8,853 | 278 | 4,152 | 100 | 4,252 | 119 | 4,462 | 139 | 4,601 | 159 |
| Grand Total | LOCAL | 39,350 | 755 | 40,105 | 824 | 21,472 | 314 | 21,786 | 375 | 17,878 | 441 | 18,319 | 449 |
| | FOREIGN | 1,278 | - | 1,278 | - | 427 | - | 427 | - | 851 | - | 851 | - |
| | TOTAL | 40,628 | 755 | 41,383 | 824 | 21,899 | 314 | 22,213 | 375 | 18,729 | 441 | 19,170 | 449 |

*U.L: Unskilled labor

## Table 4.7.3 Quantity of Work (Phase 1 up to 1986)

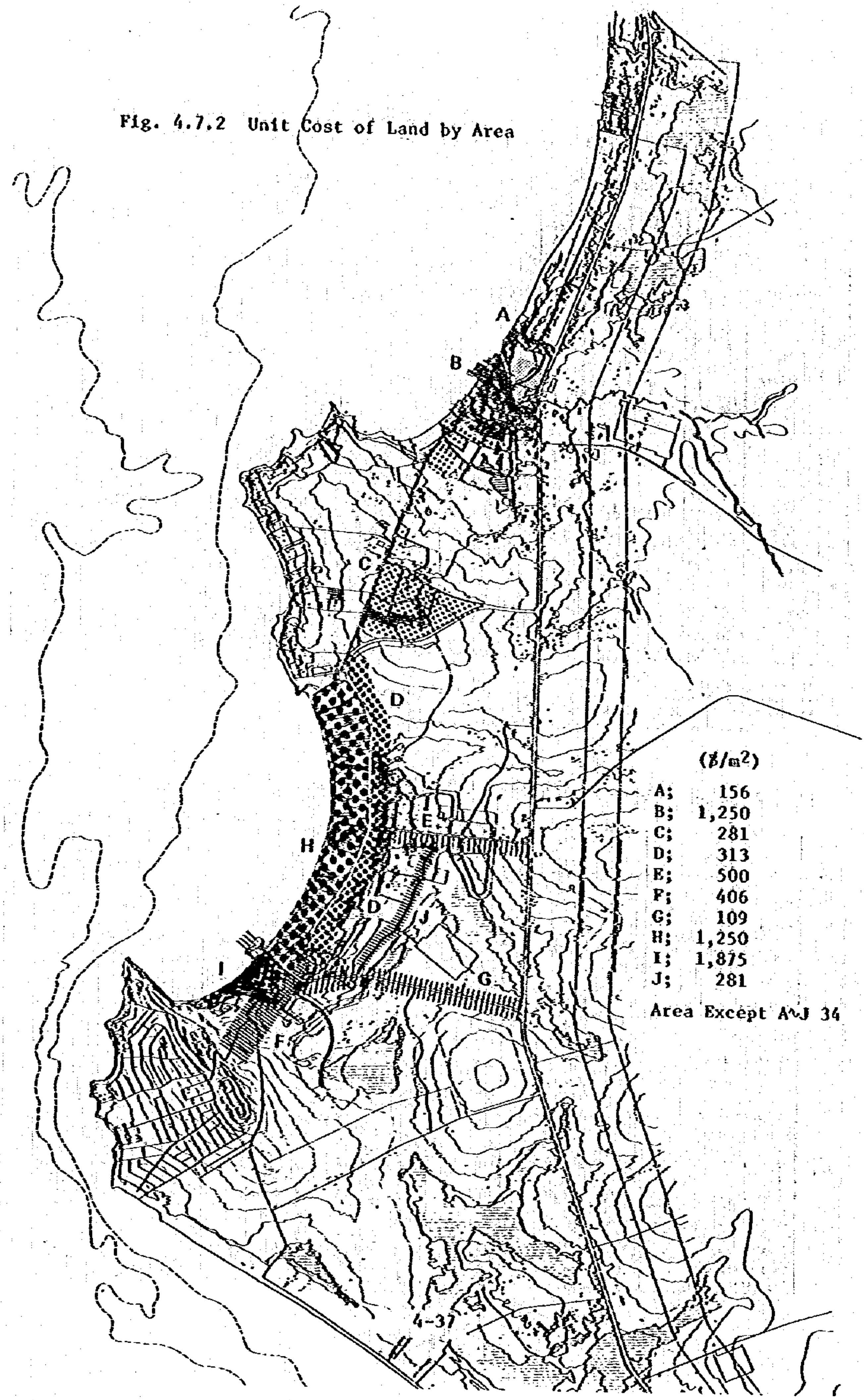
| Area | Item | *1 Excavation ($m^3$) | Redidual Soil ($m^3$) | Concrete ($m^3$) | Formwork ($m^3$) | Reinforcement (t) | Cobble Stones ($m^3$) | Leveling Concrete ($m^3$) | Banking ($m^3$) | *2 Masonry ($m^2$) | Pavement ($m^2$) | Timbering ($m^3$) | Staging ($m^3$) | Grading ($m^2$) | *3 Land ($m^2$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Central Pattaya Area | Main Open Channel | Δ22,050<br>∇ 2,450 | 22,080 | - | - | - | - | - | 2,420 | 5,630 | 4,764 | - | - | - | 24,900 |
| | Box Culvert | Δ1,845<br>∇ 205 | 2,050 | 1,128 | 2,327 | 90.36 | 253 | 127 | - | - | - | 1,434 | 785 | - | - |
| | Spillway | Δ830<br>∇ 92 | 922 | 341 | 335 | 20.60 | 125 | 63 | - | - | - | - | - | - | - |
| | Branch Open Channel | Δ6,300<br>∇ 700 | 7,000 | - | - | - | - | - | - | 9,600 | - | - | - | - | 6,800 |
| | Land Grading of Regulating Pond | - | - | - | - | - | - | - | - | - | - | - | - | 164,000 | 164,000 |
| | Total | Δ31,025<br>∇ 3,447 | 32,052 | 1,469 | 2,712 | 110.95 | 378 | 190 | 2,420 | 15,230 | 4,764 | 1,434 | 785 | 164,000 | 195,700 |
| Southern Na Klua Area | Main Open Channel | Δ11,180<br>∇ 1,240 | 11,390 | - | - | - | - | - | 1,030 | 4,500 | 1,455 | - | - | - | 9,508 |
| | Box Culvert | Δ423<br>∇ 47 | 470 | 258 | 528 | 20.67 | 56 | 28 | - | - | - | 169 | 147 | - | - |
| | Branch Open Channel | Δ3,150<br>∇ 350 | 3,500 | - | - | - | - | - | - | 4,600 | - | - | - | - | 3,400 |
| | Total | Δ14,753<br>∇ 1,637 | 15,360 | 258 | 528 | 20.67 | 56 | 28 | 1,030 | 9,300 | 1,455 | 169 | 147 | - | 12,908 |

*1 Δ: Mechanical excavation, ∇: Manual excavation
*2 Main open channel: t = 70cm, Branch open channel: t = 35cm
*3 The land required for the box culverts and spillways is included in the land for the road system and main open channel work, respectively.

## Table 4.7.4 Unit Cost by Work

| Work | Unit | Machine and Material Cost | | Operation Cost | | Labor Cost | Tax |
|---|---|---|---|---|---|---|---|
| | | Local Currency (B) | Foreign Currency (B) | Local Currency (B) | Foreign Currency (B) | Local Currency (B) | Local Currency (B) |
| Mechanical Excavation | $m^3$ | 2.58 | - | 17.35 | 11.07 | - | 1.99 |
| Manual Excavation | $m^3$ | - | - | - | - | 39.95 | 0.95 |
| Residual soil | $m^3$ | 11.05 | - | 28.60 | 9.33 | - | 4.02 |
| Banking | $m^3$ | - | - | 36.14 | 12.49 | - | 3.37 |
| Concrete | $m^3$ | 478.34 | - | 165.65 | - | - | 15.81 |
| Form work | $m^2$ | 161.33 | - | 58.62 | - | 16.02 | 6.03 |
| Reinforcement | t | 9,459.40 | - | 993.50 | - | 249.10 | 253.00 |
| Cobblestones | $m^3$ | 149.97 | - | 42.41 | 52.75 | 46.90 | 14.97 |
| Leveling concrete | $m^3$ | 478.34 | - | 165.65 | - | - | 15.81 |
| Masonry (main open channel) | $m^2$ | 570.00 | - | 175.40 | - | 26.49 | 18.20 |
| Masonry (branch open channel) | $m^2$ | 265.00 | - | 87.70 | - | 13.20 | 9.10 |
| Pavement | $m^2$ | 29.99 | - | 8.44 | - | 9.38 | 2.99 |
| Timbering | $m^3$ | 11.49 | - | 4.04 | - | - | 0.37 |
| Staging | $m^3$ | 15.79 | - | 5.47 | - | - | 0.50 |
| Land Grading of Regulating Pond | $m^2$ | 0.20 | - | 2.40 | - | - | 0.20 |

Fig. 4.7.2 Unit Cost of Land by Area



### 4.7.2 Maintenance and Operation

The organization for maintenance and operation of the storm water drainage system should be established taking into consideration the scale of facilities and length of channels, etc., of the proposed drainage system, as shown in Fig. 4.7.3.

Fig. 4.7.3 Organization for Maintenance and Operation of the Storm Water Drainage System

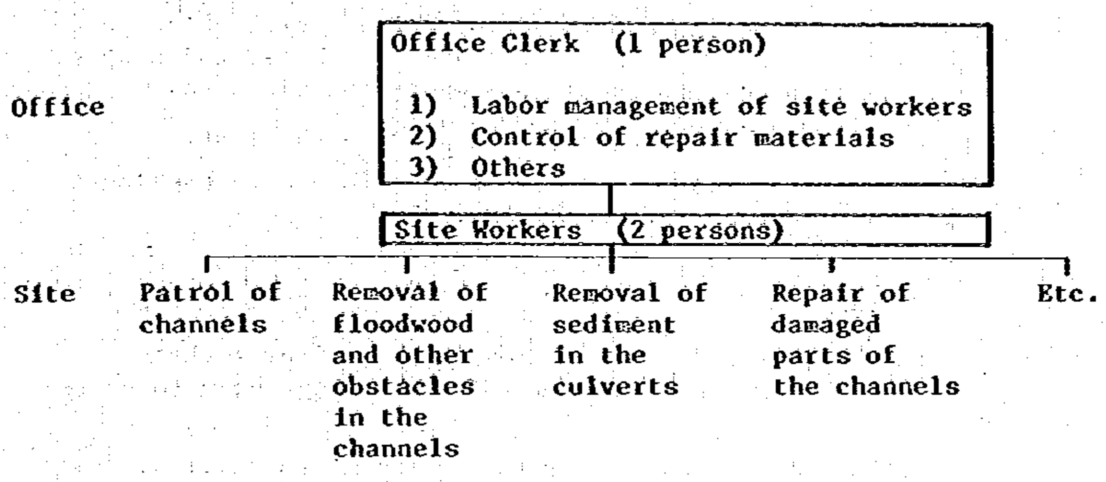



Table 4.7.5 shows the yearly maintenance and operation costs for the storm water drainage system in the Central Pattaya and Southern Na Klua Areas based on the aforementioned maintenance and operation organization.

Table 4.7.5 Maintenance and Operation Costs for Storm Water Drainage System

| Item | | Number of Persons | Unit Cost (B/year) | Maintenance and Operation Costs (B/year) |
|---|---|---|---|---|
| Central Pattaya Area | Office Clerk | 1 | 14,400 | 14,400 |
| | Site workers | 2 | 9,000 | 18,000 |
| | Repair work expenses and others | Construction Cost x 0.8% | | 123,100 |
| | Sub-total | – | | 155,500 |
| Southern Na Klua Area | Office Clerk | 1 | 14,400 | 14,400 |
| | Site workers | 2 | 9,000 | 18,000 |
| | Repair work expenses and others | Construction Cost x 0.8% | | 60,400 |
| Sub-total | | – | | 92,800 |
| Total | | | | 248,300 |

## 4.8 Emergency Action to the Flood Area near Wat Chaimonkon

### 4.8.1 Present Condition

According to the field investigation and interviews to the residents, it is known that this area is flooded very often in wider area of approximately 15 ha, as shown in Fig. 4.8.1. Magnitude of the floods are reported as follows:

- In light rain, flooding remains for 2 or 3 days.
- In heavy rain, flooding continued for a few weeks. Storm water depth reaches about 0.5 m above the ground. Water comes up to 0.1 m above floor of houses at some spots in this area.
- Storm water comes from the north and goes to the east.
- Flood in this area was not serious before the earth banking in the swamp was made on the downstream.

### 4.8.2 Causes of Flood

Though we can confirm the real cause of floods only after technical analysis by detailed topographic surveys, the followings seem to be the major causes.

- Wat Chaimonkon area does not have adequate storm water drainage system.
- Earth banking in the swamp on the downstream without any consideration to the effect on storm water to the Pattaya river.

### 4.8.3 Emergency Drainage Plan

The following two alternatives are proposed as an emergency drainage plan for Wat Chaimonkon area. (Refer to Fig. 4.8.1.)

(A) Alternative 1:

This plan intends to provide enough capacity of flow to the downstream area.

Action: 1 ....... Replace pipe culverts at Ⓐ , Ⓑ and Ⓒ by larger pipes and reset lower than the existing level.

Action: 2 ....... Enlarge channels at the specified location as follows.
- from point Ⓒ to point Ⓐ.
- from point Ⓐ to point Ⓑ.
- from point Ⓑ to the rice field.

Action: 3 ....... Open channels along the south tourism access road (T-2)

(b) <u>Alternative 2:</u>

This plan will drain flood water to the beach using a short-cut pipe culvert crossing sand dune.

Action: ............ Embed pipe culvert under the ground between point Ⓓ, and point Ⓔ.

(c) <u>Recommendations:</u>

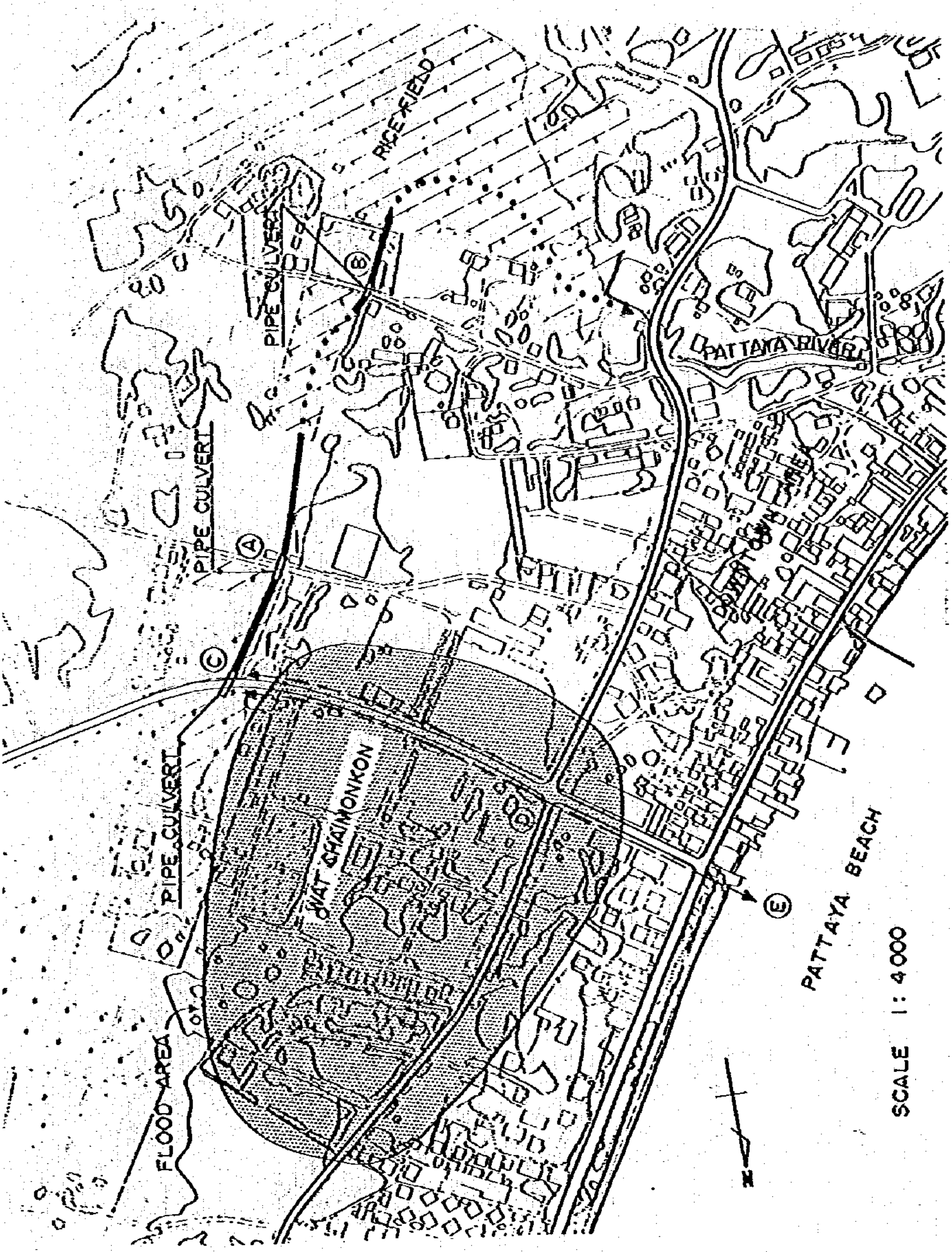
Alternative 1 is recommendable for an emergency countermeasure to the flood area near Wat Chaimonkon by following reasons.

- Embedded pipe in Alternative 2 is not desirable from technical point of view because it will be difficult to have a sufficient hydraulic gradient due to limitation from tidal level and earth cover for pipes.
- Pipe laying work in Alternative 2 may require a long time and trouble because the site have been developed with residents houses, shops and restaurants with heaviest traffic volume.

Section of pipes and open channels will be determined after the detailed topographic survey and hydraulic calculations of the area.

Present Condition of Existing Pipe Culverts (at point Ⓑ in Fig. 4.8.1)

Fig. 4.8.1 Flood area Near Wat Chaimonkon and Emergency Drainage Plan



## REFERENCE


1) ASCE-Manuals and Reports on Engineering Practice-No. 37 (WPCF Manual of Practice No. 9), Design and Construction of Sanitary and Storm Sewers, Headquarters of the Society, New York, 1974.

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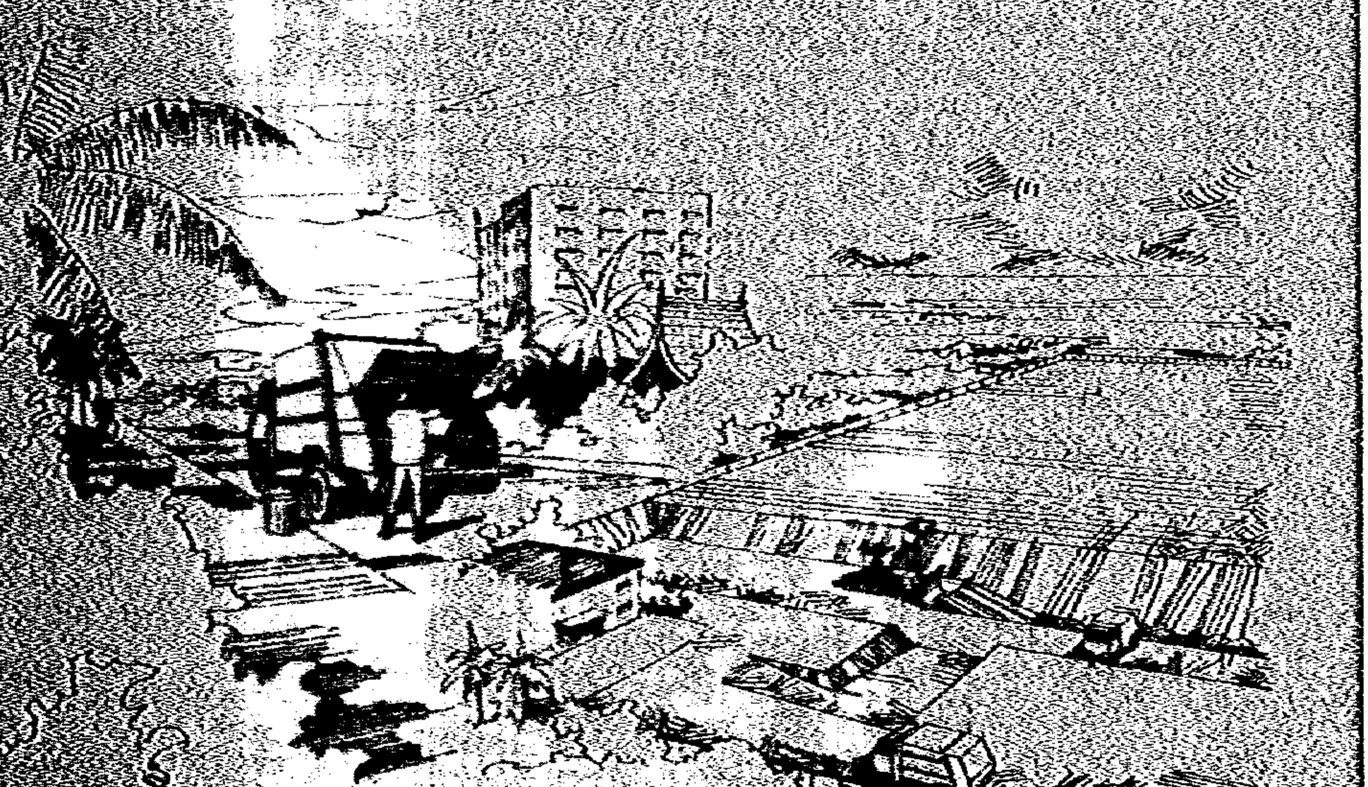
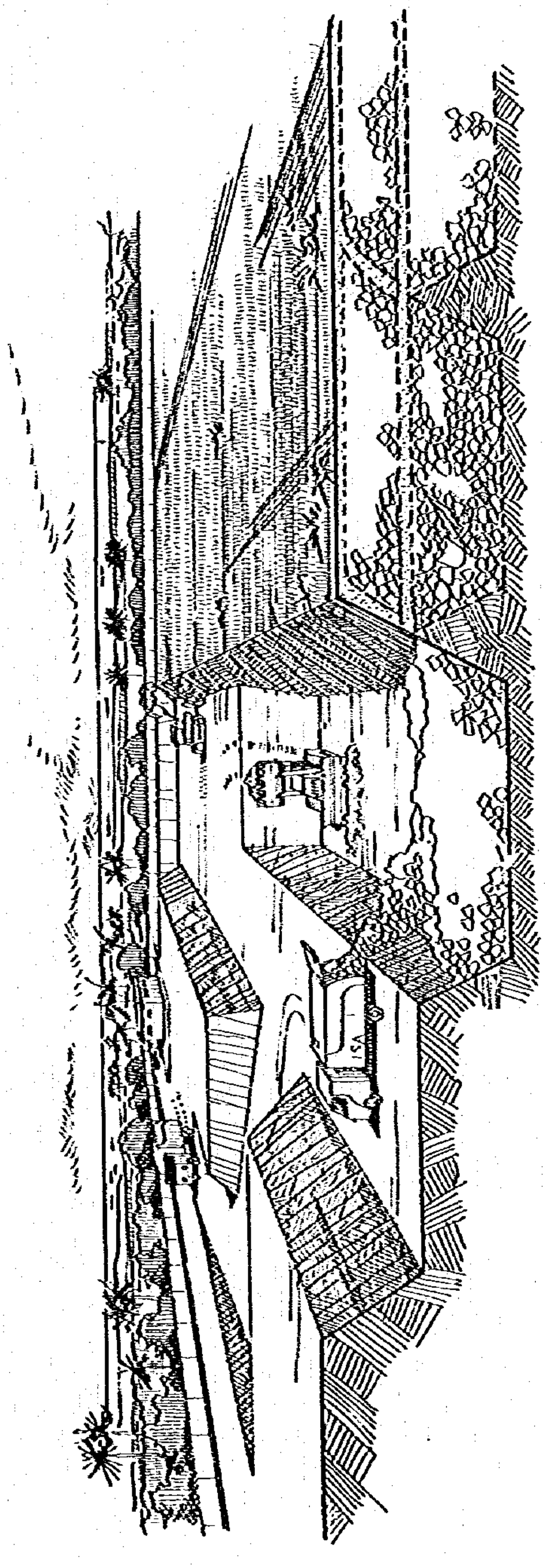
# CHAPTER 5
# SOLID WASTE DISPOSAL SYSTEM







C O N T E N T S

## Chapter 5 SOLID WASTE COLLECTION AND DISPOSAL SYSTEM

Solid Waste Collection and Disposal System

Tables

Solid Waste Collection and Disposal System

Figures

# CHAPTER 5 SOLID WASTE COLLECTION AND DISPOSAL SYSTEM

## 5.1 Introduction

In conjunction with the tourism development plan of Pattaya (the beautiful international beach resort in Thailand), it is deemed urgent to eatablish environmental infrastructures such as water supply system, sewerage system, storm water drainage network, and waste collection and disposal systems.

This chapter deals with the results of the Feasibility Study Part II concerning collection and disposal of solid waste from the study area.

This report is compiled from various materials collected in the course of a field survey conducted about 50 days starting from early May, 1978.

As the range and area of the study is wide, there might be points where further investigation is still needed. It is expected that these points will be given full consideration and thoroughgoing examination during the detailed design stage.

## 5.2 Collection of Data

In Thailand, data were collected mainly on the following items, with the co-operation of Thai counterparts, the Office of Sanitary District, and the Pattaya Branch of the Tourist Organization of Thailand.

General

- Service area
- Percentage of service
- Basic number to be given service (num. of residents, num. of hotel rooms, etc.)
- Unit amount (residents, hotels, restaurants, beaches, etc.)
- Composition analysis of solid waste

Collection

- Collection trucks (num. of trucks, type, capacity, etc.)
- Collection frequency
- Study of collection times by following the collection trucks
- Location of truck terminals
- Type of containers (residents, hotels, restaurants, etc.)
- Charging rate for collection
- Running unit costs
- Amount of labor for solid-waste collection and disposal

Disposal

- Dumping site-area-distance
- Water quality test of ground water around the former dumping site and the existing dumping site
- Topographic survey of the proposed dumping area
- Land costs at the proposed dumping sites
- Survey of the surroundings of the proposed dumping sites

## 5.3 Present Situation of the Collection and Disposal of Solid Waste in the Project Area

### 5.3.1 Summary

The collection and disposal of solid waste in the project area (Fig. 5.3.1) is implemented by the Sanitary District Office of Na Klua.

A summary of the data collected about solid waste collection and disposal in this area is shown in Table 5.3.1.

As a characteristic of this area, a considerable amount of waste is disposed from hotels, restaurants, and beaches in addition to the waste from residents. The ratio of waste coming from residents is estimated to be approximately 30 - 40% of the total waste at present.

Table 5.3.1 Data Summarized

| Item | Unit | Amount and Explanation |
|---|---|---|
| 1) Area | $km^3$ | 22.2 |
| 2) Population-approx | persons | 26,000 |
| 3) Population collected from - approx | % | 100 |
| 4) Collection charge | ฿ month/house<br>฿ month/room | 6 ( for house)<br>4 ( for hotel) |
| 5) Container barrels | unit | 200 (200 l barrel)<br>300 (100 l barrel) |
| 6) Collection workers | persons | 22 ( for truck)<br>9 ( for beach) |
| 7) Trucks | unit | 3 of $10m^3$ capacity<br>1 of 3.2 capacity<br>1 of 4.3 capacity |
| 8) Collection frequency | times/day | 1-2 for house, 1 for hotel |
| 9) Truck trips | trips/day | 2 - 3 |
| 10) Land available | ha | 2.4 |
| 11) Treatment after dumping | -- | open burning |
| 12) Volume collected | $m^3$/day | 80 - 120 |
| 13) Per capital amount | l/c/day | 3.1-4.6 (including hotel) |

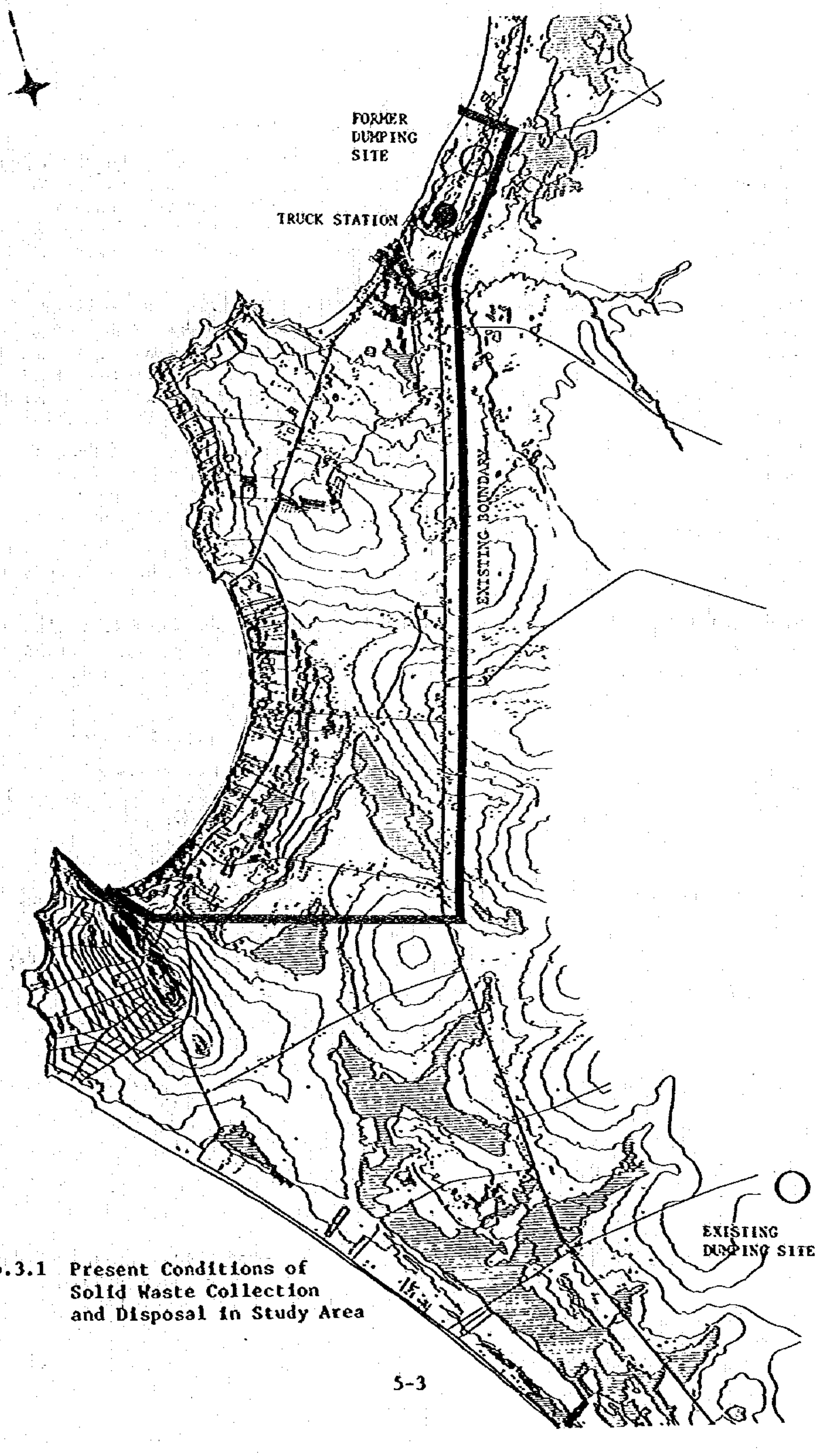



Fig. 5.3.1 Present Conditions of Solid Waste Collection and Disposal in Study Area

### 5.3.2 Tracing Survey for Unit Amount of Solid Waste

The amount of waste per resident per day is estimated to be in the range of 600 - 750 g at present, judging from the volume of waste in the Na Klua district, and from the results of the questionnaire. Regarding hotels, questionnaire sheets were distributed and a tracing survey of solid waste collector trucks was conducted, and from these survey findings, it was estimated to be 6 - 8 kg per room, per day.

The same tracing survey of solid waste collection trucks, as well as the questionnaire survey on the beach sweepers were undertaken concerning the amount of waste from the beach, and a waste volume of 2 - 3 $m^3$ per day per hectare of the beach area was obtained. However, this volume includes a considerable amount of waste from residents, and therefore it is necessary to reduce the figure when considering the waste from the beach alone.

As regards restaurants, satisfactory results were not obtained from this survey.

### 5.3.3 Quality of Solid Waste

Concerning the state of waste, a survey was conducted on the bulk density and composition of waste through on-the-spot investigation.

In calculating bulk density, waste collected in one solid waste collection truck was weighed by large tapioca-truck weighing machine, and divided by volume of wastes. Results of this survey are shown on Table 5.3.2.

Table 5.3.2 Bulk Density of Waste

| Type of truck | Capacity | Bulk Density | Collection Area |
|---|---|---|---|
| 1) Toyota | V = $9m^3$ | 1) 0.41 $t/m^3$<br>2) 0.41 | Northern Pattaya (including 7 major hotels) |
| 2) Benz | V = $10m^3$ | 1) 0.29<br>2) 0.27 | Na Klua |
| 3) Nissan (small) | V = $3.2m^3$ | 1) 0.26<br>2) 0.18 | Narrow road only |
| 4) Isuzu | V = $10m^3$ | 1) 0.35<br>2) 0.32 | Southern Pattaya (including 4 major hotels) |
| 5) Open Dump | V = $4.3m^3$ | 1) 0.34<br>2) 0.27 | Beach and residential area |

Composition Analysis of waste, on the other hand, was conducted by a local consultant in Bangkok. The results are shown in Table 5.3.3.

These data on the quality of solid waste were the outcome of only one day in the year, therefore, we could not estimate all the characters of the quality, only from these data. But it might be enough to guess from the figures of bulk density and composition analysis that comparatively wet waste garbage was disposed predominantly.

Table 5.3.3 Analysis of Solid Waste Quality

| Item | No.1 | No.2 | No.3 | No.4 |
|---|---|---|---|---|
| A. Results in average | | | | |
| 1. Composition (weight %, as wet) | | | | |
| (1) Food waste | 40.1 | 38.8 | 56.5 | 59.4 |
| (2) Paper | 12.2 | 20.3 | 1.9 | 6.6 |
| (3) Yard waste & wood | 5.8 | 13.0 | 11.6 | 3.7 |
| (4) Plastic, rubber & leather | 5.8 | 7.3 | 3.3 | 6.7 |
| (5) Metal & glass | 5.2 | 1.8 | 8.2 | 2.8 |
| (6) Textiles | 0.5 | 4.9 | 0.3 | 1.4 |
| (7) Miscellaneous | 30.4 | 13.9 | 18.2 | 19.4 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 |
| 2. Moisture (weight %) | 51.0 | 52.5 | 49.1 | 65.1 |
| B. Remarks | | | | |
| 1. Date of sampling | July 10, 1978 | July 10, 1978 | July 10, 1978 | July 10, 1978 |
| 2. Place of sampling | Existing site (Inland) | Existing site (Inland) | Existing site (Inland) | Existing site (Ko-Lan Village) |
| 3. Number of sampling | 3 | 3 | 3 | 1 |
| 4. Name of collection truck | Truck #5 (Isuzu) | Truck #2 (Benz) | Truck #1 (Toyota) | Cart |
| 5. Collection area | Beach mainly | Na Klua | Hotel mainly | Ko-Lan Village |