(3) Solid waste collection in the bungalow area

In this area, solid waste will not be generated in the same manner as the hotels. Therefore, it would be desirable to collect waste using an automatic loading system providing 200 lit.-drums instead of large-capacity containers.

(4) Solid waste collection from restaurants

Restaurants are located within residential areas, thus it is difficult to discriminate one restaurant from another, therefore, collection will be made by the auto-loading system.

(5) Solid waste collection at the beach

At present, 65 sets of 200-lit. drums (some are 100-lit. drums) are arranged, and hereafter, this system could be adopted.

However, these 100-lit. drums should be replaced with 200-lit. drums, and collection should be made by dump trucks and mechanical collection trucks.

Workers exclusively for cleaning up should be organized at the beach, and the number of them should be based on actual capacity, such as 2 workers/1.5 ha with reference to the current number of workers.

(6) Solid waste collection from parks

This should be done similarly as the solid waste collection at the beach.

3) Time chart of collecting cars

Fig. 5.4.31 shows the collecting time chart as a basis for obtaining the patterns of the collecting cars. This plan has been reviewed under the following conditions.

- The previously supposed number of vehicles in accordance with the generating quantity of the solid waste at each area subdivided in Fig. 5.4.32.
- The "trial and error" system, the most rational number of vehicles and collecting roots shall be decided by changing the roots or by adjusting the number of vehicles to balance the collecting and transporting time of all vehicles.

Fig. 5.4.31 and Table 5.4.23 shows only these results. Based on these, collecting patterns shall be established for 3 types of vehicles, namely, dump-trucks, drum-autoloading mechanical cars and container-autoloading mechanical collecting cars based on the pattern shown in Fig. 5.4.32 to Fig. 5.4.34.

FIG 5.4.30 SOLID WASTE COLLECTIO

LEGEND

RESIDENTIAL AREA

HOTEL

RESTAURANT AREA

LANDFILL SITE

FIG 5.4.30 SOLID WASTE COLLECTION ARERS

Fig. 5.4.31 Collecting Time Chart

X 30 km/H Ordinary running   C 15 km/H Collecting running

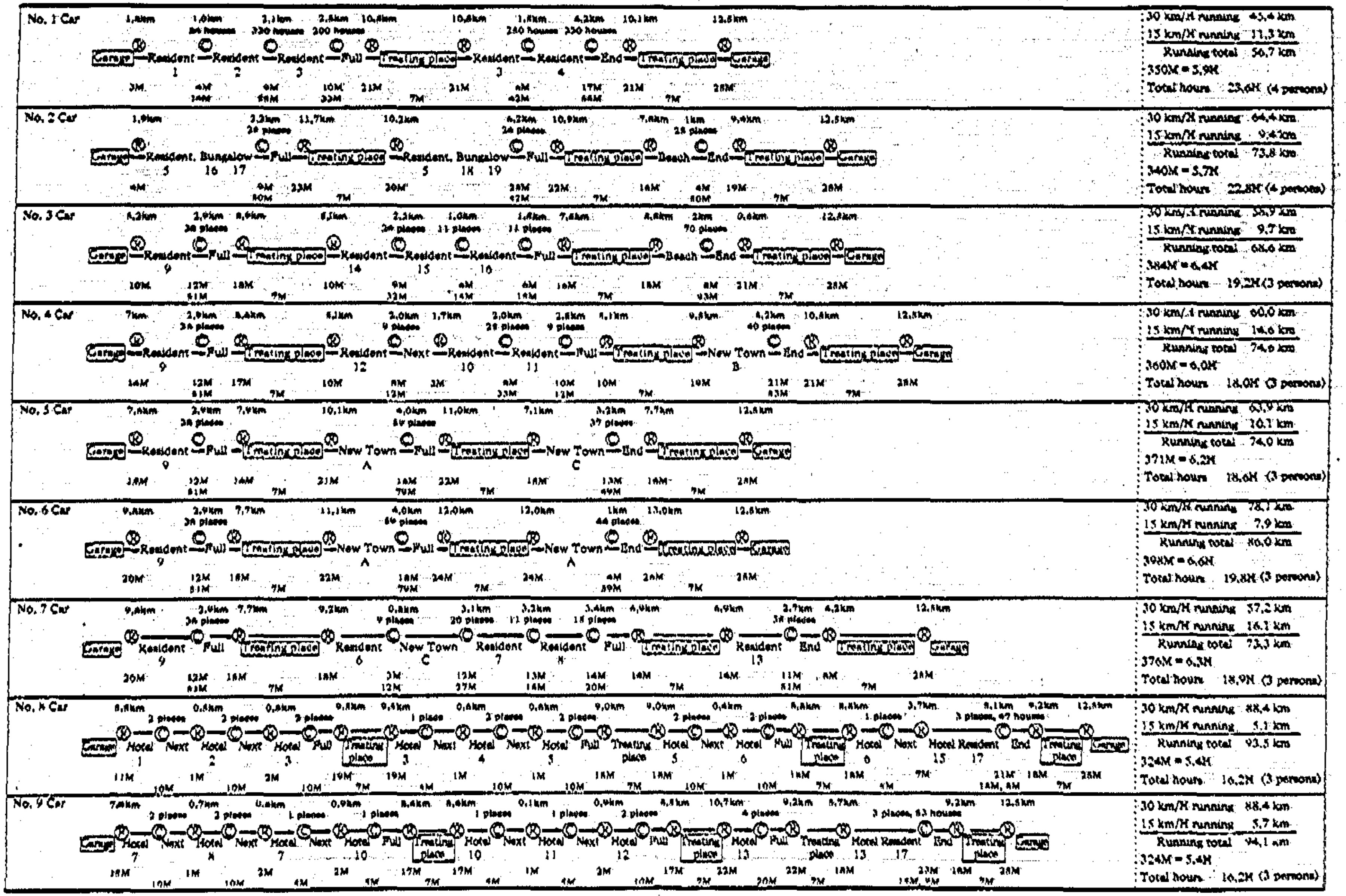


Table 5.4.23 Review of Solid Waste-Generating Quantity and Collection Schedule in 1981

PHASE 1981	Zone	Population (Room)	Volume m³/d Max.	Volume m³/d Av.	Weight t/d Max.	Weight t/d Av.	Car No.	1 10m³ Dump truck	2 43m³ Dump truck	3 Mechanical collecting car	4 Mechanical collecting car	5 Mechanical collecting car	6 Mechanical collecting car	7 Mechanical collecting car	8 Mechanical collecting car	9 Mechanical collecting car
Resident (0.3 t/m³)	1	500		1.4		0.42	Current collection	1 1.4m³								
	2	2,000		[illegible]		[illegible]	"	1 [illegible]m³								
	3	2,700		[illegible]		[illegible]	"	[illegible]								
	4	2,000		5.6		[illegible]	"	1 [illegible]m³								
	5	1,300		3.5		1.05	"		[illegible]							
	6	500		1.4		0.42								1 0.42		
	7	700		1.8		0.54								2 0.54		
	8	900		2.4		0.72								3 0.72		
	9	8,000		21.3		6.39				1 2.19	1 2.18	1 2.18	1 2.17	1 2.17		
	10	[illegible]		4.4		1.33					2 1.33					
	11	500		1.4		0.42					3 0.42					
	12	500		1.4		0.42					2 0.42					
	13	2,450		6.4		1.92								3 1.92		
	14	1,550				1.20				2 1.20						
	15	700		1.85		0.555				3 0.56						
	16	700		1.85		0.555				2 0.56						
	17	500		1.4		0.42									4 0.2	4 0.22
	A	10,300		27.5		8.25						2 3.0	[illegible] 2.25			
	B	2,500		6.7		2.01					3 2.01					
	C	3,650		9.6		2.85						3 1.25	3 1.0			
	Total	[illegible] 53,630		116.0		34.7										
Hotel (0.45 t/m³)	1	Room 170	2.6	1.3	1.2	0.6										
	2	100	1.6	0.8	0.7	0.4									2 1.3	
	3	220	3.4	1.7	1.5	0.8									1 0.7	
	4	110	1.7	0.9	0.8	0.4									[illegible]	
	5	370	5.8	2.9	2.6	1.3									2 0.8	
	6	250	4.0	2.2	2.0	1.0									[illegible]	
	7	150	2.5	1.2	1.0	0.5									[illegible]	
	8	110	1.1	0.5	0.8	0.4										1.10
	9	–	–	–	–	–										1 0.4
	9'	60	0.9	0.5	0.4	0.2										
	10	120	1.9	1.0	0.9	0.5										1 0.6
	11	80	1.2	0.6	0.5	0.3										[illegible]
	12	280	4.4	2.2	2.0	1.0										3 0.5
	13	450	10.1	3.5	4.5	2.3										2 2.0
	14	–	–	–	–	–										[illegible]
	15	270	4.2	2.2	1.9	1.0									4 1.0	
Bungalow	16	70	1.1	0.6	0.5	0.3	Current collection		1 1.1m³							
	17	70	1.1	0.6	0.5	0.3	"		1 1.1m³							
	18	70	1.1	0.6	0.5	0.3	"		1 1.1m³							
	19	90	1.4	0.7	0.6	0.3	"		2 1.4m³							
	Total	Room 3,270	50.9	26.0	23.0	11.7										
Restaurant (0.5 t/m³)	I		3.4	1.9	1.7	0.95	Simultaneous collection at Resident (9)									
	II		2.0	0.8	1.0	0.4										
	III		1.6	0.5	0.8	0.15										
	IV		–	–	–	–										
	Total		9.0	3.2	4.5	1.6										
Beach & Public Park (Beach [illegible] t/m³, Park [illegible] t/m³)	Beach		15.7	12.6	3.1	2.0			3 4.9m³	3 3.3						
	Park		–	–	–	–			(9.4t)							
	Total		15.7	12.6	3.1	2.0										
TOTAL			191.6 m³/d	157.8 m³/d	65.3 t/d	50.1 t/d		13.4m³/d	11.1m³/d	6.11t/d	6.15t/d	7.40t/d	7.47t/d	6.75t/d	10.9t/d	10.3t/d

Note: * Mechanical collecting car

Fig. 5.4.32 Collecting pattern with dump trucks

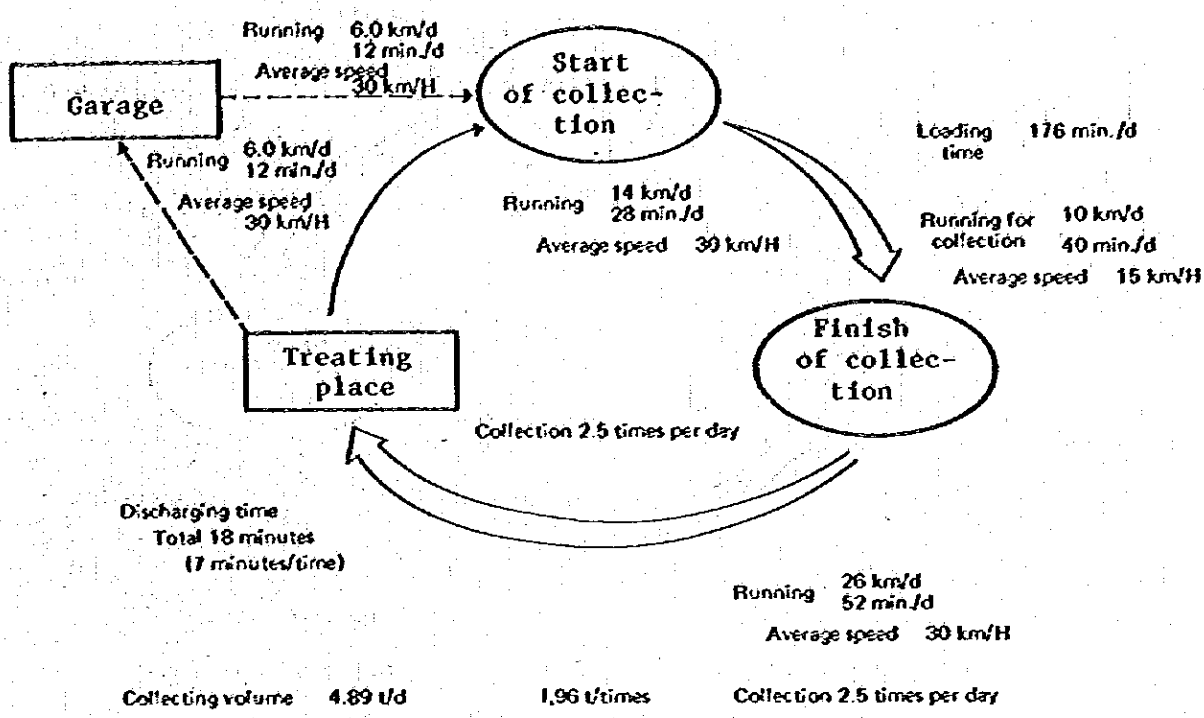


Fig. 5.4.33 Collecting pattern with mechanical collecting car mounted with 200 lit-drum auto-reversing device

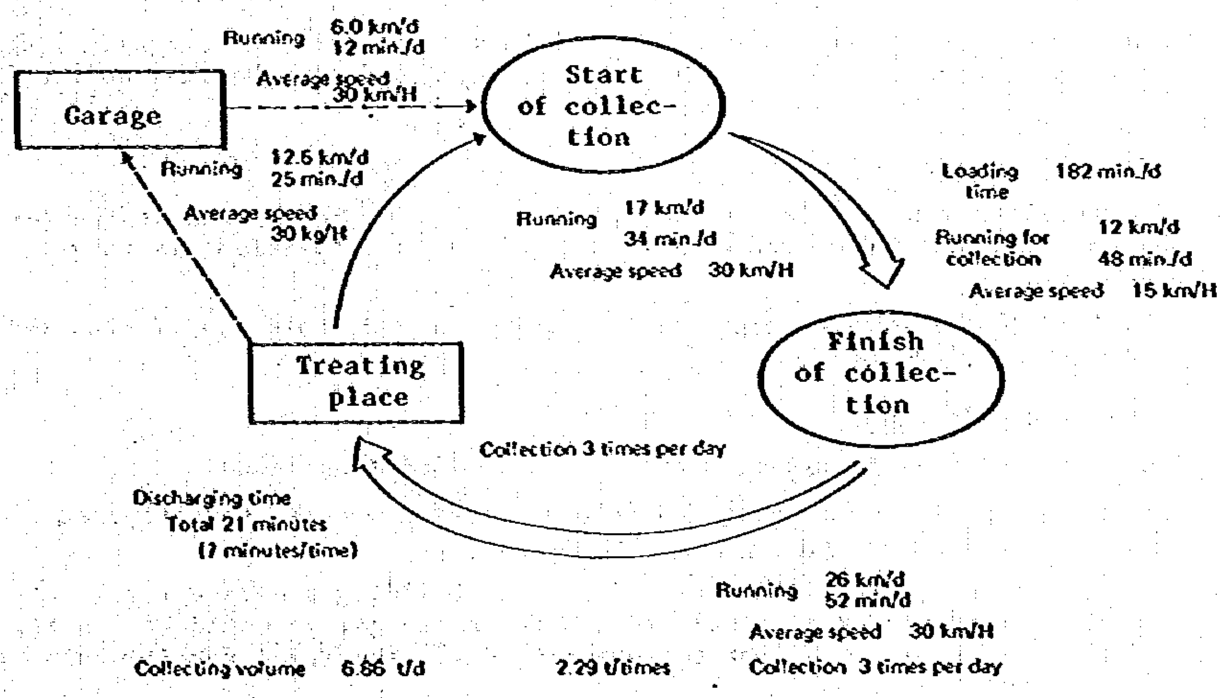
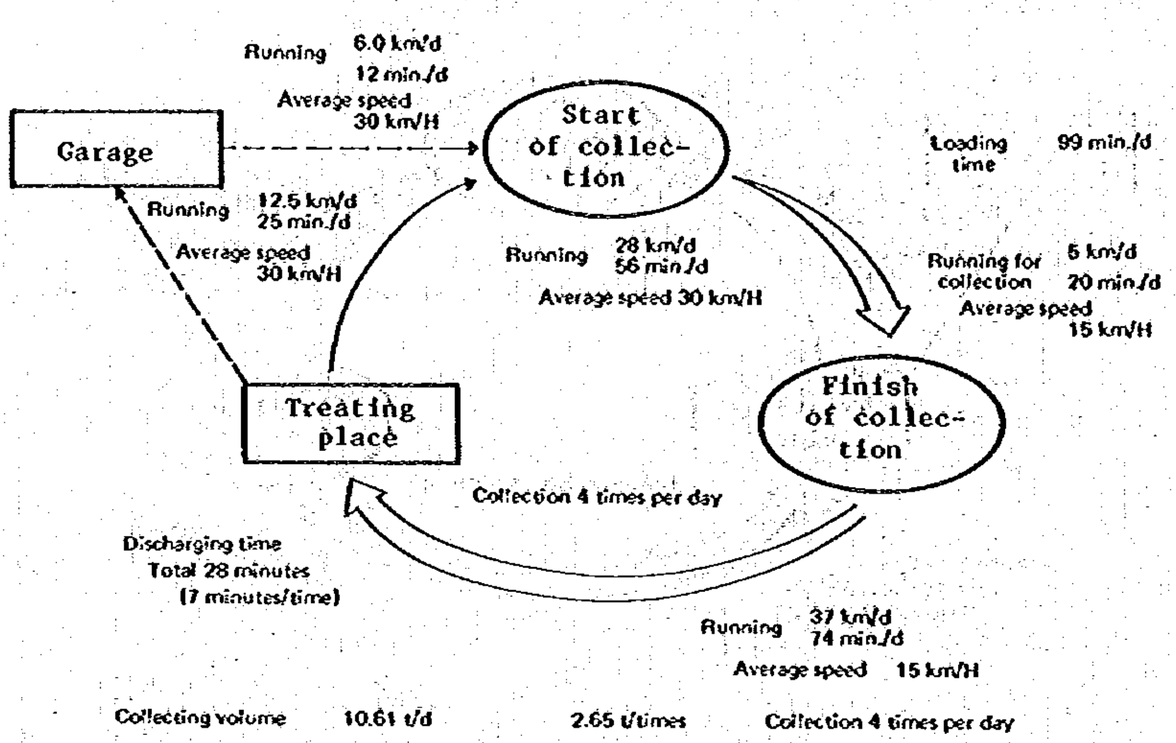


Fig. 5.4.34 Collecting pattern with mechanical collecting car mounted with 1.5 m^3 container reversing device



(f) Number of Vehicles Required

Calculation was made to estimate the number of vehicles (collecting cars) needed in the future by classifying the collecting volume of solid waste per day, in accordance with the collecting patterns of each type of vehicle in 1981, as shown on Table 5.4.24

The purchasing schedule for each vehicle was estimated as shown in Table 5.4.25 considering the duration time as 6 years for mechanical collecting cars and 7 years for dump trucks.

(g) Necessary Number of Containers

Calculation was made from the yearly necessary number of containers (each 1.5m^3) and drums proposed as containers by each classified discharging source.

Table 5.4.26 shows the above necessary number and Table 5.4.27 show the purchasing plan.

(h) Truck Terminal

A truck terminal for 14 collecting cars in 1986 is planned.

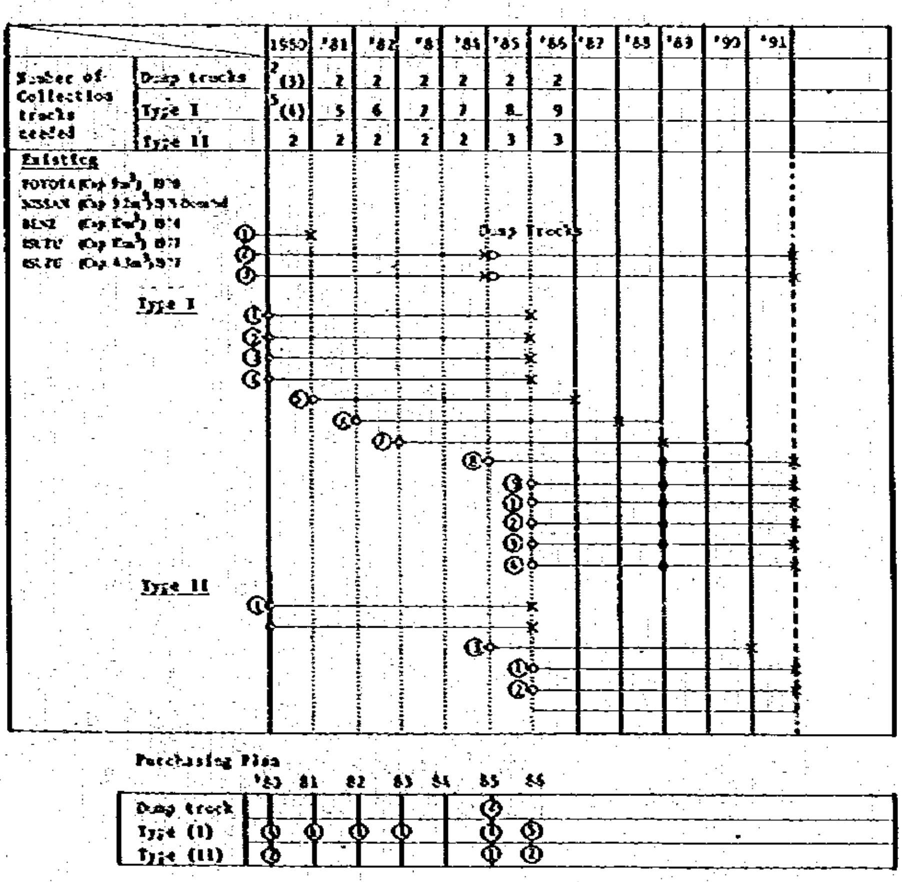
As there is already a garage capable of parking 4 cars, the proposed garage would accommodate the remaining 10 cars.

As for space, there is sufficient land for building a garage for 10 cars in the current truck terminal area, where a new garage would be constructed of the same type as that of the existing one. The space for it would be about 320m^2 (16 x 20m).

Table 5.4.24 Number of Collection Trucks Needed

	Unit	Amount/ Trucked	1980	1981	1982	1983	1984	1985	1986
Total amount of solid waste (Maximum)	t/d	-	62.4	65.2	69.7	74.3	79.1	85.6	93.3
	m^3/d	-	182.4	191.6	209.6	227.6	246.9	270.5	296.4
Dump trucks	t/d / unit	4.89	9.78 / 2	9.78 / 2	9.78 / 2	9.78 / 2	9.78 / 2	9.78 / 2	9.78 / 2
Collection trucks (Type I)	t/d / unit	6.86	31.44 / 4.6	34.22 / 5.0	38.70 / 5.6	43.28 / 6.3	48.06 / 7.0	53.14 / 7.7	58.52 / 8.5
Collection trucks (Type II)	t/d / unit	10.61	21.18 / 2.0	21.20 / 2.0	21.22 / 2.0	21.24 / 2.0	21.26 / 2.0	22.68 / 2.2	25.00 / 2.4
Num. of dump trucks needed			2	2	2	2	2	2	2
Num. of collection trucks I needed			5	5	6	7	7	8	9
Num. of collection trucks II needed			2	2	2	2	2	3	3
Total			9	9	10	11	11	13	14

Table 5.4.25 Purchasing Plan for Collection Trucks



The life of truck

Dump truck : 7 years

Collection truck: 6 years (I, II)

Table 5.4.26 Number of Containers Needed

Year			1980	1981	1982	1983	1984	1985	1986
Total amount of solid waste (Maximum)		m^3/d m^3/d	182.4 182.4	191.6 191.6	209.7 209.7	227.6 227.6	246.9 246.9	270.5 270.5	296.4 296.4
Residents (excluding district 17)	200ℓ drums (as Ave.170ℓ)	m^3/d / unit	105.7 / 622	114.7 / 675	125.6 / 739	136.5 / 803	148.4 / 873	161.4 / 950	174.3 / 1,026
Residents (only district 17)	30ℓ plastic buckets	m^3/d / unit	1.3 / 100	1.3 / 100	1.4 / 100	1.5 / 100	1.6 / 100	1.6 / 100	1.7 / 100
Bungalows	200ℓ drums (as Ave.170ℓ)	m^3/d / unit	4.7 / 30	4.7 / 30	4.7 / 30	4.7 / 30	4.7 / 30	4.7 / 30	4.7 / 30
Hotels	$1.5m^3$ containers	m^3/d / unit	46.2 / 35	46.2 / 35	46.2 / 35	46.2 / 35	46.2 / 35	49.3 / 37	54.4 / 38
Restaurants	200ℓ drums (as Ave.170ℓ)	m^3/d / unit	8.8 / 52	9.0 / 53	9.2 / 55	9.4 / 56	9.6 / 57	10.2 / 60	11.0 / 65
Beaches	"	m^3/d / unit	15.7 / 95	15.7 / 95	15.8 / 95	15.8 / 95	15.9 / 95	15.9 / 95	16.0 / 95
Parks	"	m^3/d / unit	0 / -	0 / -	6.8 / 40	13.5 / 80	20.5 / 120	27.4 / 160	34.3 / 200
Number of containers needed	200ℓ drums		799	867	959	1,064	1,175	1,295	1,424
	$1.5m^3$ containers		35	35	35	35	35	37	38
	30ℓ plastic buckets		100	100	100	100	100	100	100

Table 5.4.27 Purchasing Plan for Containers

No.of Container	Type of Container	1980	1981	1982	1983	1984	1985	1986
Number of containers needed	200ℓ drums	units 799	units 867	units 959	units 1,064	units 1,175	units 1,295	units 1,424
	$1.5m^3$ containers	35	35	35	35	35	37	38
	30ℓ plastic buckets	100	100	100	100	100	100	100
Number of containers subtracted	*1 200ℓ drums (existing)	350	350	350	350	350	350	350
	$1.5m^3$ containers for Hotels	35	35	35	35	35	37	38
	200ℓ drums for Restaurants & Bungalows	82	83	85	86	87	90	95
Net number of containers needed	200ℓ drums	367	434	524	628	738	855	979
	30ℓ plastic buckets	100	100	100	100	100	100	100
Purchasing plan	200ℓ drums	370 / 370	70 / 440	90 / 530	100 / 630	110 / 740	120 / 860	120 / 980
	30ℓ plastic buckets	100 / 100	0 / 100	0 / 100	0 / 100	0 / 100	0 / 100	0 / 100

*1. Existing drums: $(200^{\ell} \times 200^{units} + 100^{\ell} \times 300^{units})/200^{\ell} = 350^{units}$

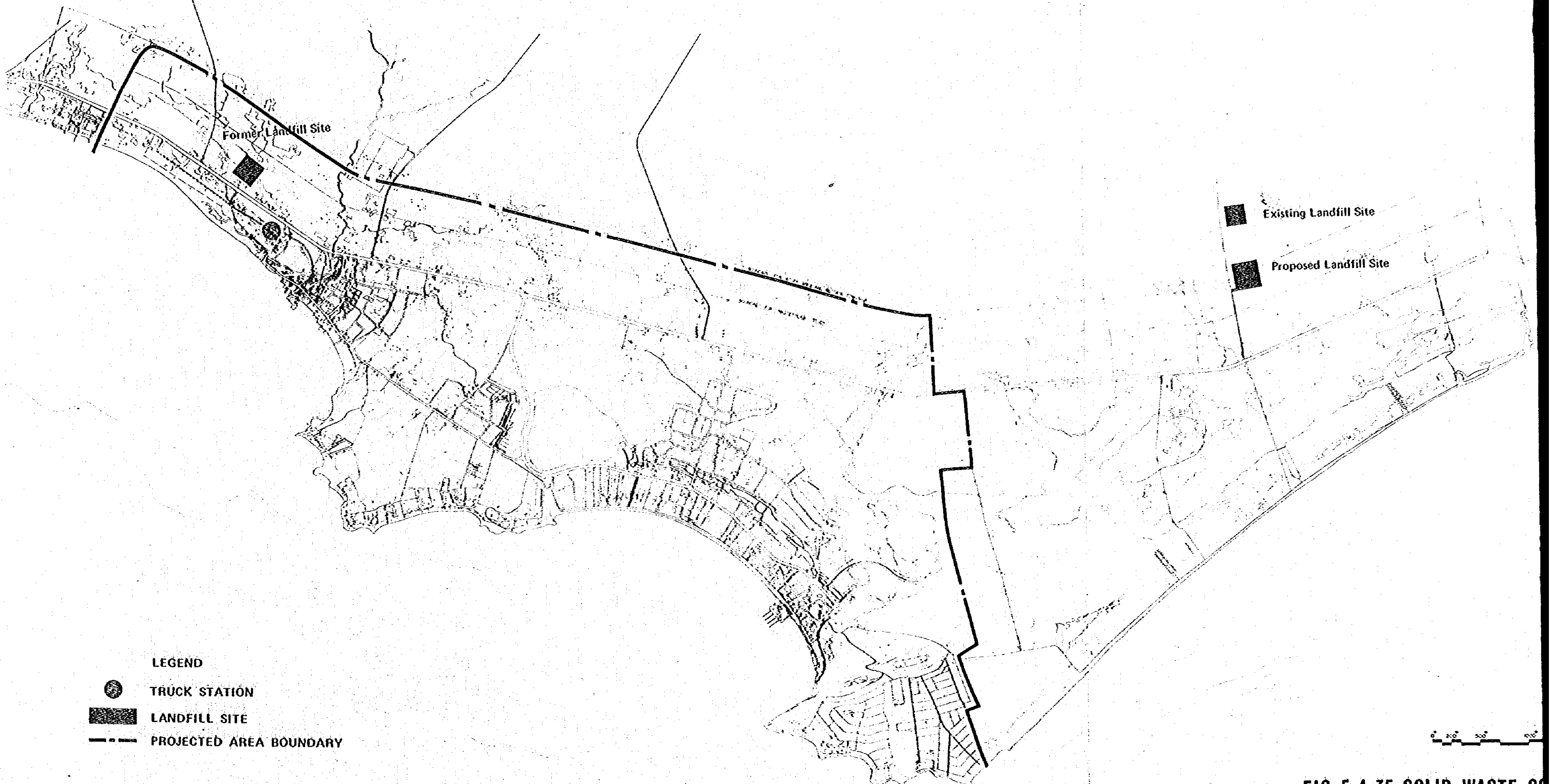


FIG 5.4.35 SOLID WASTE C
AND DISPOSAL P

FIG 5.4.35 SOLID WASTE COLLECTION AND DISPOSAL PLAN

5.5 System for Ko Lan Island

5.5.1 Project Area

As shown in Fig. 5.5.1, there are 4 sandy beaches and a small fishing village with a population of about 1,400 to the east. According to the Masterplan, arrangement are being considered for the 4 beaches and Ko Lan Village as the target area for tourism and regional development. The Ko Lan Vacation Co., is scheduled to conduct independent development operations as a private developer.

Therefore, a system needs to be provided to Ko Lan Village, Ta-van Beach, Tien Beach and Sa-mae Beach.

These areas or blocks are situated independently, thus it may not be feasible for a centralized plan in view of the topography of the island. Therefore, separate plans should be made by dividing the area into the following 3 blocks:

- Ko Lan Village
- Ta Van Beach
- Tien Beach & Sa-mae Beach

5.5.2 Project Duration

The initial planning year for Ko-Lan Island might be set for the main service roads from 1981 upto 1986, because the public piers and major road-arrangement at Ko Lan Village will be completed by 1980.

5.5.3 Estimated Quantity of Solid Waste

(a) Solid Waste in Ko Lan Village (Regional)

The estimated quantity of solid waste from Ko Lan Village was estimated on the basis of the forecast population in the Masterplan multiplied by the unit amount per capita per day.

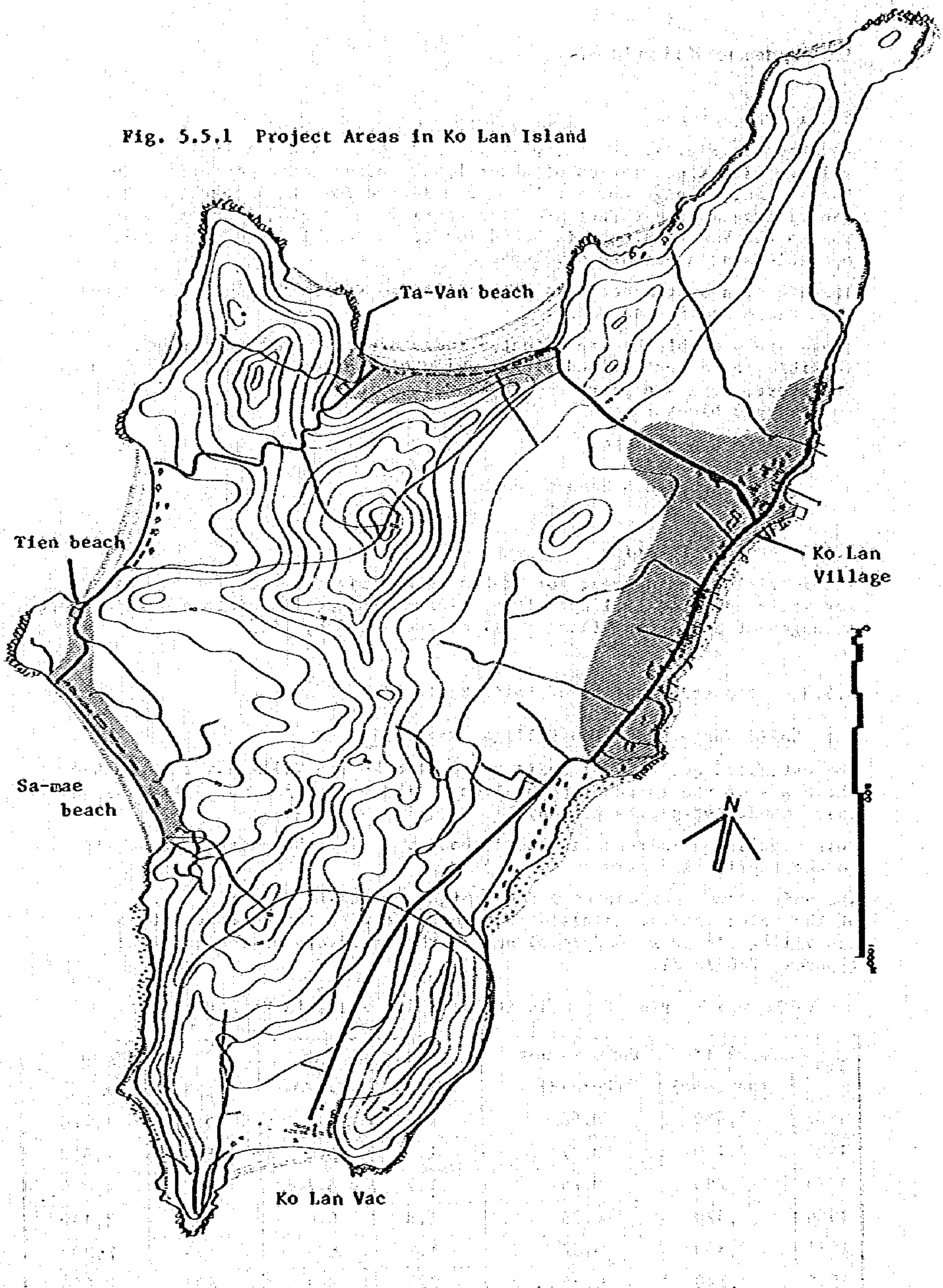
This population increase included those who might be engaged in services to the tourism industry.

The unit amount per capita per day might be regarded as 85% of the volume on the mainland in accordance with the current data on Ko Lan Village (approx. 600g/c.d) and on the residents of the mainland (approx. 720g/c.d).

Table 5.5.1 Planning Quantity of Solid Waste in Ko Lan Village

Year	Population (persons)	Unit Amount (kg/c·d)	Daily Amount		Annual Amount	
			(t/d)	(m^3/d)	(t/Y)	(m^3/d)
1981	2,080	0.68	1.4	4.7	511	1,720
1982	2,140	0.71	1.5	5.0	548	1,830
1983	2,280	0.75	1.7	5.7	621	2,080
1984	2,320	0.78	1.8	6.0	657	2,190
1985	2,360	0.82	1.9	6.3	694	2,300
1986	2,520	0.85	2.2	7.3	803	2,660

Fig. 5.5.1 Project Areas in Ko Lan Island



(b) Solid Waste Volume at Each Beach (tourism)

Solid waste to be generated at each beach would consist of the following three categories:

- Beach solid waste from tourists
- Solid waste from restaurants, where 20% of tourists would visit.
- Solid waste from shops and the service area.

The estimated volume from restaurants and beaches was calculated based on that from restaurants and beaches on the mainland, including an allowance of 30%.

The above results are shown in Table 5.5.2, 5.5.3 and 5.5.4. Ta Van Beach and Tien Beach would be operated for tourism from March to September, and Sa-mae Beach might be used from October to February. The yearly discharge quantity of solid waste would be collected in the said period for tourism purposes.

Table 5.5.2 Solid Waste Generated on Ta Van Beach

In Season : Mar. ~ Sept.

Year	Beach				Restaurant			Sub-total	Others	Total			
	Visitor		Unit discharge	Daily Amount	Guest	Unit discharge	Daily Amount			Daily Amount		Annual Amount	
	(persons/d)	(persons/Y)	(kg/c)	(t/d)	(meals/d)	(kg/meal)	(t/d)	(t/d)	(t/d)	t/d	m^3/d	t/Y	m^3/Y
1981	900	192,600	0.2	0.18	180	0.5	0.09	0.27	0.08	0.35	1.00	56	160
1982	940	201,200	"	0.19	190	"	0.10	0.29	0.09	0.38	1.09	61	174
1983	990	211,900	"	0.20	200	"	0.10	0.30	0.09	0.39	1.11	63	180
1984	1,030	220,400	"	0.21	210	"	0.11	0.32	0.10	0.42	1.20	67	191
1985	1,080	231,100	"	0.22	220	"	0.11	0.33	0.10	0.43	1.23	69	197
1986	1,120	239,700	"	0.22	220	"	0.11	0.33	0.10	0.43	1.23	69	197

Table 5.5.3 Solid Waste Generated on Tien Beach

In Season : Mar. ~ Sept.

Year	Beach				Restaurant			Sub-total	Others	Total			
	Visitor		Unit discharge	Daily Amount	Guest	Unit discharge	Daily Amount			Daily Amount		Annual Amount	
	(persons/d)	(persons/Y)	(kg/c)	(t/d)	(meals/d)	(kg/meal)	(t/d)	(t/d)	(t/d)	t/d	m^3/d	t/Y	m^3/Y
1981	380	81,300	0.2	0.08	80	0.5	0.04	0.12	0.04	0.16	0.46	26	74
1982	400	85,600	"	0.08	80	"	0.04	0.12	0.04	0.16	0.46	26	74
1983	420	89,900	"	0.08	80	"	0.04	0.12	0.04	0.16	0.46	26	74
1984	440	94,200	"	0.09	90	"	0.05	0.14	0.04	0.18	0.51	29	83
1985	460	98,400	"	0.09	90	"	0.05	0.14	0.04	0.18	0.51	29	83
1986	480	102,700	"	0.10	100	"	0.05	0.15	0.05	0.20	0.57	32	91

Table 5.5.4 Solid Waste Generated on Sa Mae Beach

In Season : Oct. ∿ Feb.

Year	Beach				Restaurant			Sub-total	Others	Total			
	Visitor		Unit discharge	Daily Amount	Guest *1	Unit discharge	Daily Amount			Daily Amount		Annual Amount	
	(persons/d)	(persons/Y)	(kg/c)	(t/d)	(meals/d)	(kg/meal)	(t/d)	(t/d)	(t/d)	t/d	m^3/d	t/Y	m^3/Y
1981	1,260	190,300	0.2	0.25	250	0.5	0.13	0.38	0.11	0.49	1.40	55	157
1932	1,320	199,300	"	0.26	260	"	0.13	0.39	0.12	0.51	1.46	58	166
1983	1,380	208,400	"	0.28	280	"	0.14	0.42	0.13	0.55	1.57	62	177
1984	1,450	219,000	"	0.29	290	"	0.15	0.44	0.13	0.57	1.63	65	186
1985	1,510	228,000	"	0.30	300	"	0.15	0.45	0.14	0.59	1.69	67	191
1986	1,570	237,100	"	0.31	310	"	0.16	0.47	0.14	0.61	1.74	69	197

5.5.4 Planning of the Disposal System

(a) Comparison of Disposal Methods

The disposal method for the solid waste of the three zones on Ko Lan Island should be selected not only with a view to handling the waste in a sanitary and safe manner but also in view of the characteristics of the area, such as geological and hydrogeological conditions.

Bearing in mind these principal requirements, the following three methods might be listed for evaluation in selecting the best method.

- Sanitary landfill
- Transportation to the mainland by ship
- Incineration

The rough cost estimates in Table 5.5.5 show the initial and running costs for implementing the above three methods covering Ko Lan Village.

The transportation system listed under Item (2) above might not be recommended since the system requires high initial and running costs.

A further disadvantage of this system is that a stable and controlled waste disposal operation would be difficult to realize since the daily practical operations would be affected by the weather and the solid waste might not be transported under stormy weather.

Table 5.5.5 Rough Cost Estimates for Each Method

Method	Initial Cost (1,000 Bahts)	Running Cost (Bahts/ton)	Remarks
(1) Sanitary Landfill *1	420	70 - 80	
(2) Ship Transportation *2	2,700	450 - 500	Hardly Practicable under Stormy Weather
(3) Incineration *3	1,340	250 - 300	

Facilities *1 Facilities needed: Small Bulldozer, Garage
*2 Facilities needed: Transport Ship, Container
*3 Facilities needed: Incinerator, Shed

On the contrary, the sanitary landfill system would be the most inexpensive method and might be applicable for most of the waste materials. Accordingly, this system would be the most favorable one if an inexpensive and sufficiently large land area is available and the geological and hydrogeological conditions are satisfactory. However, Ko Lan Island is mainly made up of mountains and only narrow plain are open; and the main geological features of the island are that it is composed of granite and gronodiolite formed in the triassic period. It is assumed that the alluvial soil deposited in the valleys is mainly composed of sand originating from the weathered products of the granite and contains a relatively small amount of clay, and the thickness of the alluvial soil layer is thin. It is also assumed that the surface soil of the land is thin with dotted base rocks exposing thereon. On the other hand, the sandy beaches are characterized by heaps of beach deposits, including cracked coral pieces formed in the recent period(5-6).

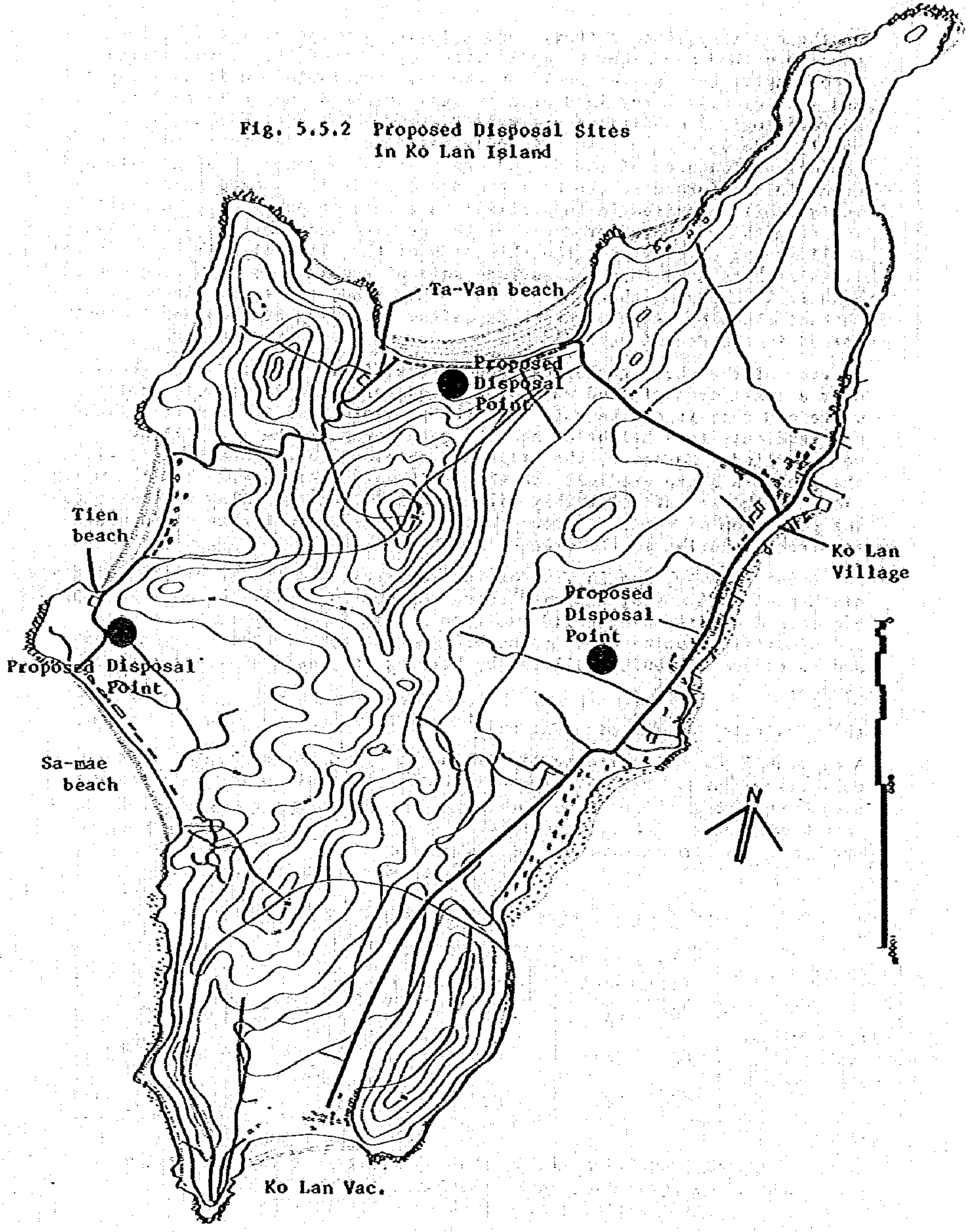
In view of the above geological conditions, it is expected that there is only a small area of land which is suited for being filled with solid waste and that it can be said that the possible land for landfill might be utilized only to a height of about 1 meter even if the landfill system were applied. Moreover, the hills are so close to the sea that it gives the slopes a steep gradient, so that rain-water which permeates the earth flows to the sea at relatively high speeds during the rainy weather causeing pollution of the underground water and the sea water if solid waste is directly buried in the ground.

For these reasons, and in view of the fact that the amount of the solid waste discharged from any of the said three regions is small, the most appropriate method of disposing solid waste on Ko Lan Island would be compact and simplified incinerators to stabilize the waste in the early stages and to reduce its bulk, followed by burying the residual ashes in the ground.

(b) Selection of the Disposal Site

A desirable disposal site for incinerators would be the center of the collecting zones. Fig. 5.5.2 shows the proposed sites for each project area.

Fig. 5.5.2 Proposed Disposal Sites in Ko Lan Island



(c) Incinerator

1) Ko Lan Village

The following incinerator shown on Fig. 5.5.3 would be established in Ko Lan Village.

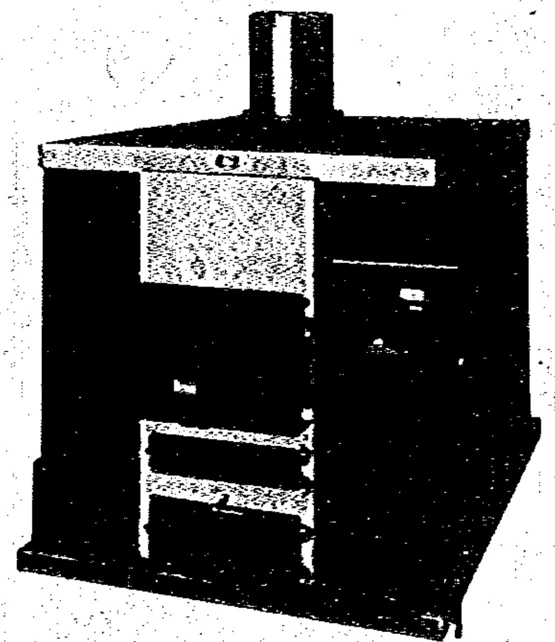


Fig. 5.5.3 Incinerator (Village)

Specifications (example)

Capacity	: 1.2t/5H x 2 Units
Equipment	: W 2.43m x D 2.88m x H 2.17m
Height of stack	: 7.79 (from the earth level)
Size of throwing port	: 0.58m x 0.72m
Area of fire-grate	: 1.76 m^2
Volume of burning room	: 6.33 m^3
Weight	: 13.9 ton
Accessories	: Blower, air blowing nozzle, oil-burner

2) Ta Van Beach

In this beach, an incinerator as shown in Fig. 5.5.4 might be set up.

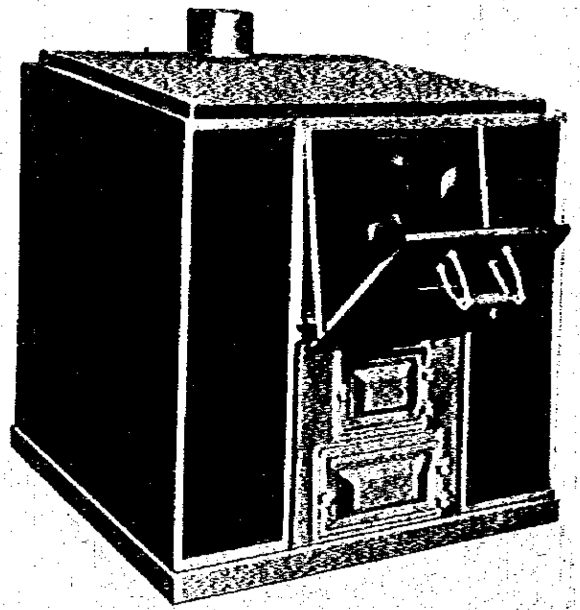


Fig. 5.5.4 Incinerator (Ta Van Beach)

Specifications (example)

Capacity	: 0.5t/5H x 1 Unit
Equipment	: W 1.65m x D 1.85m x H 1.38m
Height of stack	: 6.83 m (from the earth level)
Size of throwing port	: 0.40m x 0.55m
Area of fire-grate	: 0.89 m^2
Volume of burning room	: 1.47 m^3
Weight	: 4.0 ton
Accessories	: Oil-burner

3) Sa Mae Beach

In this beach, an incinerator as shown in Fig. 5.5.5 might be set up.

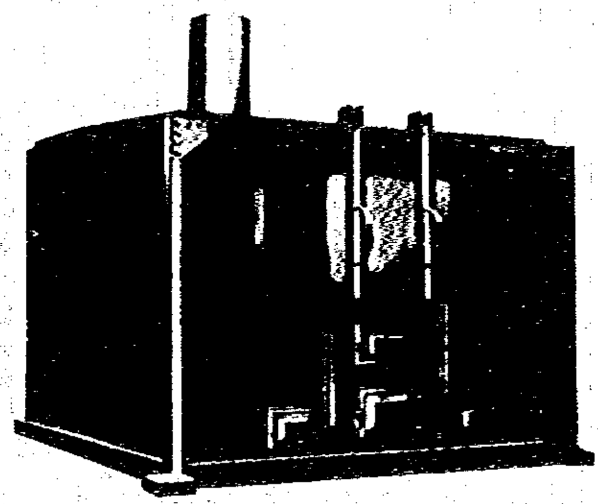


Fig. 5.5.5 Incinerator (Sa Mae Beach)

Specifications (example)

Capacity	: 0.7t/5H x 1 Unit
Equipment	: W 2.10m x D 2.25m x H 1.62m
Height of stack	: 7.07 m
Size of throwing port	: 0.54m x 0.72m
Area of fire-grate	: 1.25 m^2
Volume of burning room	: 2.79 m^3
Weight	: 7.2 ton
Accessories	: Oil-burner

5.5.5 Plan for Collecting System

As mentioned in the above, collection of solid waste would be conducted in the three blocks on the island on a separate basis. Although, the beach-utilizing periods are different on Tien Beach and Sa Mae Beach, the service areas are close to each other, thus the facility planned for Sa Mae Beach could also be used by Tien Beach.

(a) Review on Collecting Means

1) Ko Lan Village

The quantity of solid waste in Ko Lan Village would be as little as $4.7m^3$/day in 1981 and $7.3m^3$/day in 1986. Also, the planned road-width is as narrow as 3.5m. Accordingly, it is possible to employ the current pushcarts as collecting means, while smaller dump trucks with better mobility will be more favorably adopted in view of the higher collecting efficiency, reduction of collecting labor and economy.

Here, in this plan, it is proposed that a small dump truck with a loading capacity of $0.91m^3$ and a lower loading point could be provided. With this vehicle, operations will be conducted by one operator with one assistant.

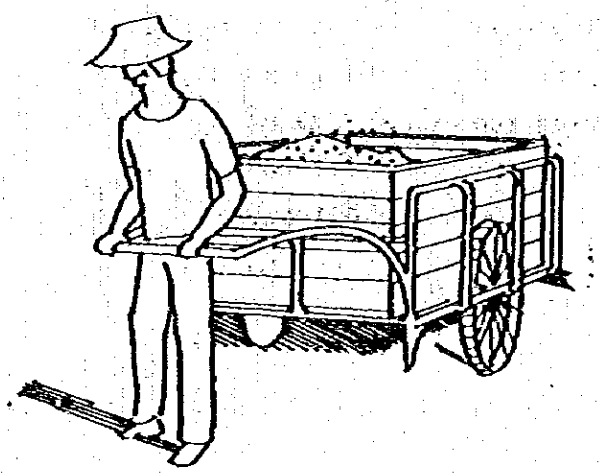
2) Ta Van Beach

On this beach, solid waste collection would be conducted along a simple beach-road (width 1.2m).

The collecting volume is as little as $1.2m^3$/d at the maximum, even in the final year of the plan, 1986. Thus, the best suitable means for collecting the solid waste in this block will be a push cart, because of the shorter collecting distance.

Fig. 5.5.6 shows a typical push cart just like the "rear car", whereby solid waste collection can be done by one worker.

Fig. 5.5.6 Reference Drawing for Push Cart



3) Tien Beach and Sa Mae Beach

In 1986, the solid waste-collection volume will be $0.6m^3/d$ and $1.8m^3/d$ on Tien Beach and Sa Mae Beach, respectively. The same system as that for Ta Van Beach shall be adopted because a simple local street will be constructed, collecting volume will be small, and the distance for collecting work will be short.

(b) Collecting Container

1) Ko Lan Village

In this village, a collecting system would be adopted which is the same as the station-system with drums the same as those used in the residential areas on the mainland. The drums would be 100 lit. for easier manual handling for loading.

2) Collecting containers at each beach

Because of the use of a "rear car" handled by one worker, the use of plastic buckets with a capacity of 60-70 liters might be easier to use than heavier drums.

For collecting operations, it is desirable that cleaned containers on the "rear car" be replaced with the containers filled with solid waste.

With such a collecting method, the beach road can be kept clean by preventing the spilling of garbage-juice, while the containers can be hygenic.

It is proposed that a 70 lit-container made of plastic be adopted.

(c) The number of Collecting Cars and Containers

1) Ko Lan Village

(1) Necessary number of drums (100 lit.)

In Ko Lan Village, the necessary number was estimated on the basis of 85 lit. of solid waste in each drum, as shown in Table 5.5.6.

Table 5.5.6 Necessary Number of Drums (100 lit.)

Year	Discharged volume of solid waste (m^3/d)	Drum capacity (t/unit)	Necessary number of drums (unit)
1981	4.7	85	55
1982	5.0	"	58
1983	5.7	"	67
1984	6.0	"	70
1985	6.3	"	74
1986	7.3	"	85

(2) The necessary number of collecting cars

This can be obtained on the basis of the time needed for one trip by the collecting car. The necessary time for one trip was estimated by establishing the following factors:

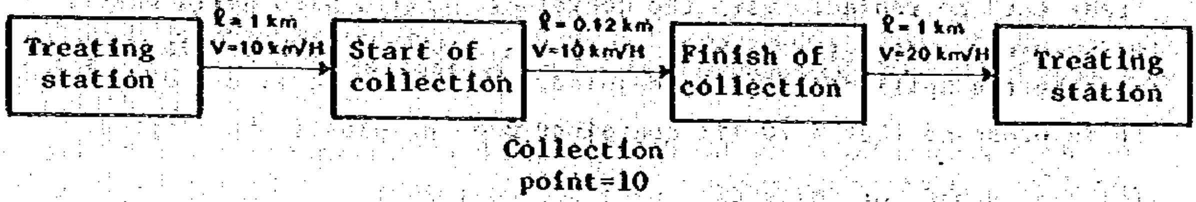
- Average distance from the treating stations to the collecting zone: 1 km
- Collection amount per trip: $0.91m^3$ (910 lit.)
- Number of drums collected per trip:

$$910 \text{ lit} \div 85 \text{ lit/drum} = 10.7 \text{ drums} \doteqdot 10 \text{ drums}$$

- Necessary time for loading per drum: 1 minute
- Average collecting distance per trip: 120 m
- Running speed: Collecting time .... 10 km per hour
  Ordinary time ...... 20 km per hour

Fig. 5.5.7 Time Chart Per Trip

Time chart per 1 trip



				Total
Running time	3 min.	1 min.	3 min.	7 min.
Collecting time	–	10 min.	–	10 min.
				17 min.

On the above time-chart, collection is made in twenty minutes per trip for $0.85m^3$ of solid waste. Two hours with 6 trips in 1981, and 3 hours with 9 trips in 1986, respectively, would be required based on the calculations made for collecting. Thus, one small dump truck will be enough during the project period in Ko Lan Village.

2) Ta Van Beach

(1) The necessary number of 70 lit-plastic buckets

In our estimation, 16 buckets and 20 buckets are sufficient for Ta Van Beach for 1981 and 1986 respectively, if the buckets can store 60 lit. of solid waste (85% of 70 lit.).

A total of 25 plastic buckets will be enough up to 1986, including 5 buckets for replacement.

(2) The necessary number of "rear cars"

The number of rear cars to be provided would be estimated as follows.

Item	Dimension
- Length of Beach	500m
- Average distance	500m
- Running speed	3 km per hour
- Replacing time	one minute per bucket
- Capacity of rear car	5 buckets

Twenty minutes would be sufficient for one trip.

In 1986, 20 plastic buckets would be needed, 4 trips might be necessary per day, and the needed time would be 80 min (1.3 hrs), thus one rear car is sufficient.

3) Tien Beach & Sa Mae Beach

In this area, planning will be made with the object of Sa Mae Beach generating the higher volume of solid waste.

(1) The necessary number of 70 lit-plastic buckets

This will be 23 in 1981 and 29 in 1986, respectively, by estimation similar to that of Ta Van Beach.

A total of 34 buckets would be enough up to 1986 with an allowance of 5 buckets for replacements.

(2) The necessary number of "rear cars"

Both Tien and Sa Mae Beaches are about 500m long nearly the same as Ta Van Beach. The collecting system for solid waste would be the same as on Ta Van Beach, thus the necessary time for one rear can trip is estimated to be about 20 minutes.

Therefore, the necessary time for collecting 29 plastic buckets (6 trips) in 1986 will be about 120 minutes (2 hrs), and one rear car will be enough for the planning period.

(d) Other Considerations

The space for treating stations might be used as the station for collecting cars in Ko Lan Village and rear cars on each beach.

Also, collecting workers may clean each beach because of the smaller area of cleaning and the shorter collecting time.

5.6 Estimation of Construction Cost and Maintenance and Operation Cost

(1) Construction Cost

Unit : x 10^3 bahts

Year	Items	Pattaya Main Land			Ko Lan Island			TOTAL		
		Collection	Disposal	Sub-Total	Collection	Disposal	Sub-Total	Collection	Disposal	Total
1980	Local	1,565	2,655	4,220	-	-	-	1,565	2,655	4,220
	Foreign	2,486	4,121	6,607	-	-	-	2,486	4,121	6,607
	Sub-Total	4,051	6,776	10,827	-	-	-	4,051	6,776	10,827
1981	Local	144	0	144	54	329	383	198	329	527
	Foreign	415	0	415	82	1,652	1,734	497	1,652	2,149
	Sub-Total	559	0	559	136	1,981	2,117	695	1,981	2,676
1982	Local	148	7	155	0	0	0	148	7	155
	Foreign	412	2	414	0	0	0	412	2	414
	Sub-Total	560	9	569	0	0	0	560	9	569
1983	Local	151	7	158	2	0	2	153	7	160
	Foreign	415	2	417	0	0	0	415	2	417
	Sub-Total	566	9	575	2	0	2	568	9	577
1984	Local	29	7	36	0	0	0	29	7	36
	Foreign	0	2	2	0	0	0	0	2	2
	Sub-Total	29	9	38	0	0	0	29	9	38
1985	Local	432	7	439	1	0	1	433	7	440
	Foreign	1,330	2	1,332	0	0	0	1,330	2	1,332
	Sub-Total	1,762	9	1,771	1	0	1	1,763	9	1,772
1986	Local	904	7	911	2	0	2	906	7	913
	Foreign	2,901	2	2,903	0	0	0	2,901	2	2,903
	Sub-Total	3,805	9	3,814	2	0	2	3,807	9	3,816
Total	Local	3,373	2,690	6,063	59	329	388	3,432	3,019	6,451
	Foreign	7,959	4,131	12,090	82	1,652	1,734	8,041	5,783	13,824
	Total	11,332	6,821	18,153	141	1,981	2,122	11,473	8,802	20,275

(2) Maintenance Operation & Cost

Unit : x 10^3 Bahts

Year	Items	Pattaya Main Land			Ko Lan Island			TOTAL		
		Collection	Disposal	Sub-Total	Collection	Disposal	Sub-Total	Collection	Disposal	Total
1980	Local	1,152	525	1,677	-	-	-	1,152	525	1,677
	Foreign	0	14	14	-	-	-	0	14	14
	Sub-Total	1,152	539	1,691	-	-	-	1,152	539	1,691
1981	Local	1,166	527	1,693	77	234	311	1,243	761	2,004
	Foreign	0	14	14	0	0	0	0	14	14
	Sub-Total	1,166	541	1,707	77	234	311	1,243	775	2,018
1982	Local	1,342	615	1,957	78	240	318	1,420	855	2,275
	Foreign	0	14	14	0	0	0	0	14	14
	Sub-Total	1,342	629	1,971	78	240	318	1,420	869	2,289
1983	Local	1,545	668	2,213	78	253	331	1,623	921	2,544
	Foreign	0	14	14	0	0	0	0	14	14
	Sub-Total	1,545	682	2,227	78	253	331	1,623	935	2,558
1984	Local	1,651	719	2,370	78	261	339	1,729	980	2,709
	Foreign	0	14	14	0	0	0	0	14	14
	Sub-Total	1,651	733	2,384	78	261	339	1,729	994	2,723
1985	Local	1,977	746	2,723	79	267	346	2,056	1,013	3,069
	Foreign	0	14	14	0	0	0	0	14	14
	Sub-Total	1,977	760	2,737	79	267	346	2,056	1,027	3,083
1986	Local	2,183	608	2,796	80	285	365	2,268	893	3,161
	Foreign	0	14	14	0	0	0	0	14	14
	Sub-Total	2,188	622	2,810	80	285	365	2,268	907	3,175
Total	Local	11,021	4,408	15,429	470	1,540	2,010	11,491	5,948	17,439
	Foreign	0	98	98	0	0	0	0	98	98
	Sub-Total	11,021	4,506	15,527	470	1,540	2,010	11,491	6,046	17,537

References

5-1 Examples:

(1) Toshiriro Adachi, Eiko Muraoka, Yasuhito Kawai. "Solid Waste Treatment for Building," Construction Engineering Center.

(2) The Society of Heating, Air-Conditioning and Sanitary Engineers of Japan. "Heating, Air-Conditioning and Sanitary Engineering," Vol. 52, No. 7, 1978.

5-2 Examples:

(1) National Federation of Sanitation Adjustment Co-operation (in Japan). "Study to Make Guide-Line for Solid Waste Treatment & Disposal in Recreational Areas," 1978.

(2) Japan Tourist Association. "Report for Solid Waste Problem in Recreational Areas," 1973.

5-3 Japan Environmental Sanitation Center (Association). "Guide Line of Industrial Solid Waste Treatment," 1974.

5-4 Dr. H. Hanajima. "Landfill Disposal of Solid Waste," Journal of Solid Waste, Vol. 3, No. 7, 1973.

5-5 The American Public Works Association. "Municipal Refuse Disposal," Public Administration Service.

5-6 "Geological Map of Thailand" Dept. of Mineral Resources of Bangkok, Thailand, 1969.

CHAPTER 6
PORT FACILITIES


LAS

C O N T E N T S

Chapter 6 PORT FACILITIES

Tables

Figures

CHAPTER 6 PORT FACILITIES

6.1 Introduction

Some ten years ago, Pattaya was no more than a small fishing village. Since then, however, by virtue of its beautiful scenic resources and the convenience of transportation from Bangkok, the village has grown up to be one of the leading seaside resorts in Southeast Asia and it attracts a number of foreign tourists.

The Chonburi Coast, including Pattaya, is located near Bangkok, the gigantic capital of the country, and enjoys a very high incidence of recreational utilization. Bang Saen Beach, some 40km north of Pattaya, is also quite popular for domestic tourists. The area along the coast between Bangkok and Sattahip is favored with a number of conditions suitable for industrial development as well as for recreational activities. All in all, the area has the potential for playing the principal role in the national development expected in the future.

In particular, the area has easy access by sea in addition to the advantage of being close to Bangkok: the seaway starting off Sattahip and coursing between Ko Phai and Ko Lan to Ko Si Chang attains a depth above 20m providing passage for big ships. In fact, Ko Si Chang has been serving as the transit port for ships bound for Bangkok Port and a number of port facilities along the coast from Laem Chabang to Sri Racha are fully active. The facilities include an oil refinery complex with accompanying piers for loading and unloading tankers, and a pier for shipping tapioca which is one of the major export items of this country.

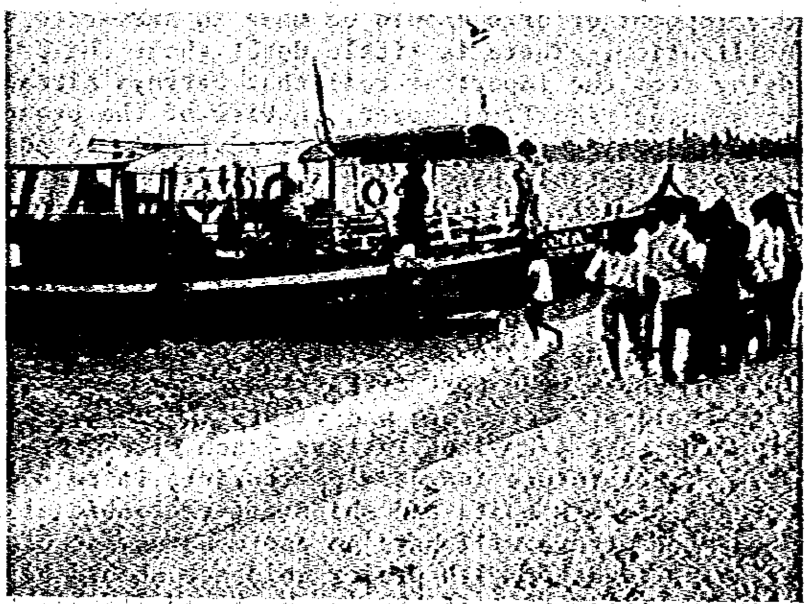
Future plans for this area which are considered now include installing an integrated industial complex around Laem Chabang with a deep sea port to be constructed as its core, and construction of a nuclear power plant.

As mentioned above, it can safely be said that the Chonburi Coast, in addition to its traditional fisheries, has enormous potential for various recreational and industrial developments on the basis of the favorable land and water transportation conditions. It is to be desired that harmonious development efforts should be made in answer to such demands for varied utilization. There is little doubt about the priority of tourism, judging from the important role that Pattaya already has as an international seaside resort. However, in view of the present utilization of the sea area around Pattaya, it would be advisable to push forward various measures for establishing orderly operations by all sorts of boats, organizing rescue and salvage systems, and protecting the marine environment in general with the aim of reconciling sightseeing and recreational activities with the other activities.

At present, the sea area around Pattaya has a wide range of shipping, such as commercial sightseeing boats, personal boats for recreational purposes, fishing boats with their home port at Pattaya, etc. They total about 500 in number, with small size scooters and yachts included, most of them centering along the some 4-km-long Pattaya beach with a rather high rate of congestion. If the future increase of tourists is to accompany a proportional increase of such boats and ships for recreational and sightseeing purposes, the waters will have an enormous number of them. Regulatory measures together with proper guidance should be provided to promote an orderly utilization of the sea area and its coastline. The present situation of the utilization of the area poses several problems as listed below:

- Unlawful occupation of the beach and illegal buildings; (Photo. 1)
- Confusion in utilization of the water surface;
- Lack of safe embarkation and disembarkation facilities; (Photo. 2)
- Lack of rescue systems;
- Lag in marine environment conservation measures;

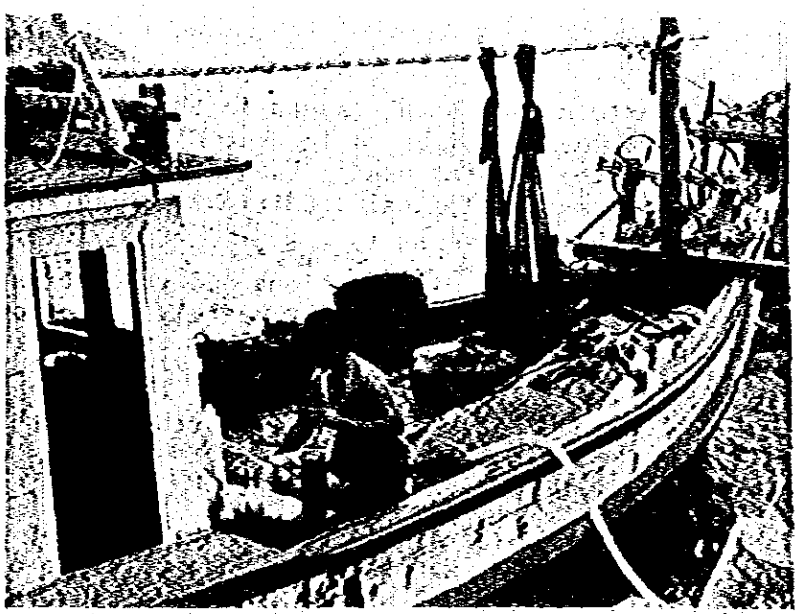
(Photo. 1)



(Photo. 2)

In order to solve the above problems and to seek a new direction for the preferred future development, the present feasibility study of marine facilities was conducted. The study was based on the 1977 Master Plan prepared by JICA and on the data collected through on-the-spot surveys of natural conditions, of the actual status of utilization and of construction-related facts.

An important point to be noted with regard to this facilities plan is how to bring about systematic order in the operation of sightseeing and recreation-purpose shipping for providing tourists with safer and more comfortable services, as against the current situation where all kinds of craft are randomly using the sea and the beach. The study points out that an area in which people are allowed to enjoy safe and pleasant swimming should be secured first of all, while bringing together those sightseeing boats that are usually scattered along the beach at random by furnishing them with safe embarkation and disembarkation facilities as well as with anchoring berths. The on-site detailed investigation conducted recently revealed a need for modification of the master plan for completion of the north and main ports within Phase I (1986). Re-examination of various factors, such as coastline utilization, port management, mooring methods and berthing areas, construction costs, etc., led to the conclusion that the construction of the north port should be delayed until necessary while the main port should be completed within Phase I, i.e. by 1986. The need for the north port will be discussed after the data on utilization of and the port operations of the then completed main port becomes available. Further, the master plan maintained that Pattaya-based fishing boats might continue their present operations. More detailed study revealed that they are operated seasonally, and that most of the people are living aboard their boats; making it rather difficult to control the water area utilization and consequent contamination. (Photo. 3) The feasibility study here suggests that efforts should be directed to gradually moving them out to neighboring fishing ports and organizing the fishing ports.



(Photo. 3)

6.2 Natural Conditions

Little data is available with regard to the meteorology of the sea area near Pattaya.[10] However, surveys are under way in Leam Chabang and Ao Phai, both about 20km to the north of Pattaya, to provide basic information on natural conditions for two projects: one for a proposed deep sea port and the other for constructing an atomic power plant. These surveys are undertaken by the Electricity Generating Authority of Thailand,[8] the Asian Institute of Technology,[1] and NEDECO[4] together with some other consulting firms. Other sources of usuful information are the NEB[2,3] and AIT[11] reports dealing with environmental problems in Chonburi Province. From these reports, the general information of the natural conditions in the province can be readily grasped.

Further data on the oceanography of the Gulf of Thailand in general can be obtained from the report by the National Marine Science Committee[12] on pollution as well as the NAGA[4,13] report.

All in all, such information is limited as far as Pattaya Beach and the sea area it faces are concerned. For this reason, the following survey and other research activities were performed for the study;

- The collection of data on meteorological conditions, 1965 through 1974;[6]
- Deep sea boring in Pattaya and Ko Lan;
- Sounding in the sea area off Pattaya;
- A profile survey along Pattaya Beach;
- Topographic and land-use surveys along Pattaya Beach, for both northern and southern parts.

The appendix gives the details of the data thus collected. Further, it should be noted that the references as to Pattaya's natural conditions are enumerated at the end of this chapter.

6.2.1 Winds

The Meteorological Department has been engaged in the observation of winds at Chonburi, Ko Si Chang, and Sattahip, but not in the vicinity of Pattaya. For the use of the present study, the data at Sattahip was selected to represent the meteorological conditions around Pattaya in determining the state of winds there.

Table 6.2.1 gives the frequencies of directions and velocities of winds at Sattahip, while Fig. 6.2.1 illustrates the monthly variation of frequencies of wind directions.

According to Fig. 6.2.1 the prevailing direction of the winds in the area is southwest from May through September, and is north or northeast from October through January. These phenomena are due to the monsoons in the respective directions of southwest and northeast.

According to Table 6.2.1, winds of a velocity in the range of 2.5 to 7m/sec represent 80% of the whole and the frequency of winds of higher velocities than 15.0m/sec is as small as 0.1%. Such circumstances with moderate winds and a low frequency of strong winds favours marine recreational activities such as yachting and others.

6.2.2 Waves

(a) Wave Frequency

There is no available data covering wave observations for Pattaya Beach. Accordingly, the wave heights and wave periods were forecasted using Sattahip's records of wind direction and velocity measured at intervals of three hours.

Fig. 6.2.2 shows the directional wave height frequency off Pattaya thus estimated. In the order of directional frequency, southwestern and southern waves are the highest, representing 44% of the whole. Next come western and west-southwestern waves at 16%, and then northern waves at 12%. North-northwestern to west-northwestern winds advancing directly toward Pattaya Beach account for 10%.

Fig. 6.2.3 gives the wave frequency by height estimated for the area off Pattaya beach. Waves with a height from 0.3 to 0.5m appear most frequently, representing 30%. Next come waves 0.5 to 0.75m in height, representing 20%. The area ordinarily has such waves, i.e. with a height in the region of from 0.3 to 0.75m.

According to Fig. 6.2.4, 35% of all the waves have a 3.0 second period and few waves have a period longer than 5.0 seconds.

Further, Figs. 6.2.5 and 6.2.6 show the calculated frequency by wave height at the point (Station 2) where the construction of the main Pattaya port is proposed. Actually, the given values are the wave frequencies at the area off Pattaya Beach after correction using directional refraction coefficient determined (see Figs. 6.2.7 through 6.2.12). According to these figures, 88% of the waves have a height of less than 0.3m and the wave height of 95% frequency is about 0.5m.

(b) Probable Wave Height

The expected value of deep water wave height was calculated on the basis of wave data for a period from 1965 through 1974, and the results are given in Figs. 6.2.13 and 6.2.14. The wave height at the return periods of 20 years and 30 years is as follows.

Wave direction \ Return period	20 years	30 years
N - NW	1.70 m	1.84 m
S - SW	2.51 m	2.70 m

6.2.3 Sea Level

The sea level characteristics at Ko Si Chang close to Pattaya are as shown in Fig. 6.2.15.

6.2.4 Sea Bottom Topography

Fig. 6.2.16 is a sounding map for Pattaya Beach prepared as a result of a survey. The map shows that Pattaya Beach has a shoal with an increasing length as it gets north so that the width of the shoal is 200 to 300m in the northern area close to Laem Kalomphom. This is due to a reef, and such a topography makes it difficult to construct a port here. The southern half of the beach, where the existing wooden pier is located, has a sufficient depth and is adequate for port construction.

6.2.5 Beach Profile

Fig. 6.2.17 gives a typical profile of Pattaya Beach. The foreshore has a steep slope of about 1/10 with the changing point of the gradient lower than the mean sea level by 1 to 1.5m. Following this point, the slope is as gentle as 1/100 to 1/200. When the tide is high, Pattaya Beach gets narrow to a width of only 20 to 30m, which leaves rather a small space for recreational purposes.

6.2.6 Soil

Deep boring was conducted at five points along Pattaya Beach and at one point on Ko Lan. Table 6.2.2 gives the results obtained along the beach, and Fig. 6.2.18 shows the soil profile where the construction of the Main Port is planned. Pattaya Beach in general has a soil profile comprizing sand and hard clay layers appearing alternately, with high N-values in the region from 30 to 50.

Fig. 6.2.19 shows the grain size distribution of the foreshore materials at Pattaya Beach. The median diameter (d_{50}) is 1.0mm-2.0mm, which is fairly coarse.

6.2.7 Current

Fig. 6.2.20 shows the current velocity at the ebb tide. The tidal current off Pattaya Beach has a velocity of about 1 knot, which is comparatively swift, but the constant current is as slow as about 0.04m/sec.

Table 6.2.1 Frequencies of the Direction and the Velocity of the Wind at Sattahip

(Source : Meteorological Department.)

Sattahip Station (period 1965 - 1974)

Speed m/sec \ Direction	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Calm	Total (%)
< 2.5	77	12	2	2	3	2	8	7	43	32	36	16	13	6	4	12	3	278 (7.6)
2.5 ~ 5.0	179	49	32	5	16	13	40	54	306	172	205	106	89	25	38	74		1,403 (38.4)
5.0 ~ 7.0	136	53	44	6	27	10	92	68	171	120	170	91	107	26	59	42		1,222 (33.4)
7.0 ~ 9.0	30	13	13	4	7	8	29	20	44	57	100	59	50	17	17	7		475 (13.0)
9.0 ~ 11.0	6	1	2		1	2	10	6	13	25	42	22	22	4	1	3		160 (4.4)
11.0 ~ 13.0	2	1	1				6	2	9	16	33	13	12	2		1		93 (2.6)
13.0 ~ 15.0					1		3		1	2	3	2	4	1				17 (0.5)
15.0 ~ 17.0								1		1	1							3
17.0 ~ 19.0							1											1
19.0 ~ 21.0																		
Total	430	129	94	17	55	35	159	158	587	425	585	309	297	81	119	139	3	3,652 (100.0)

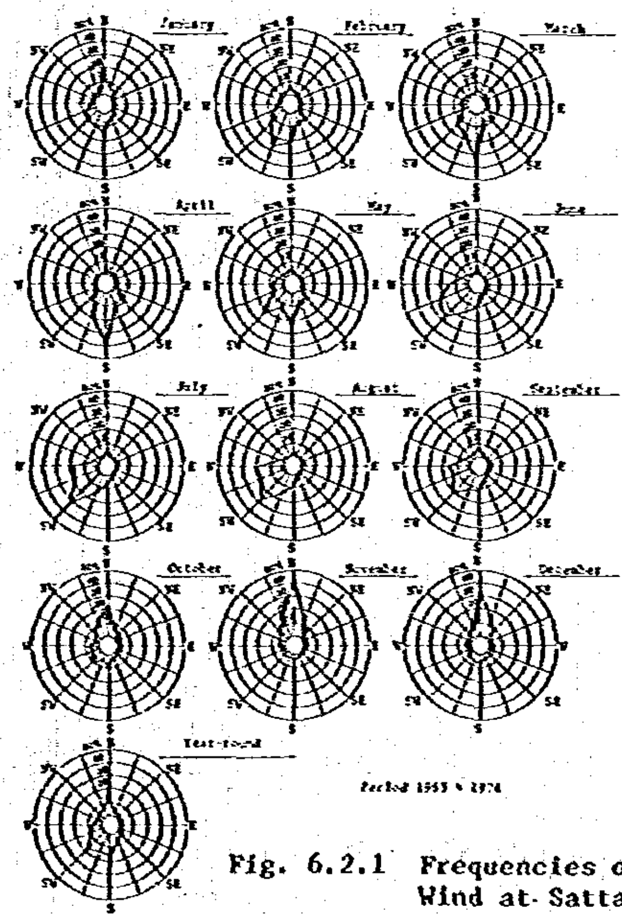


Fig. 6.2.1 Frequencies of the Direction of the Wind at Sattahip

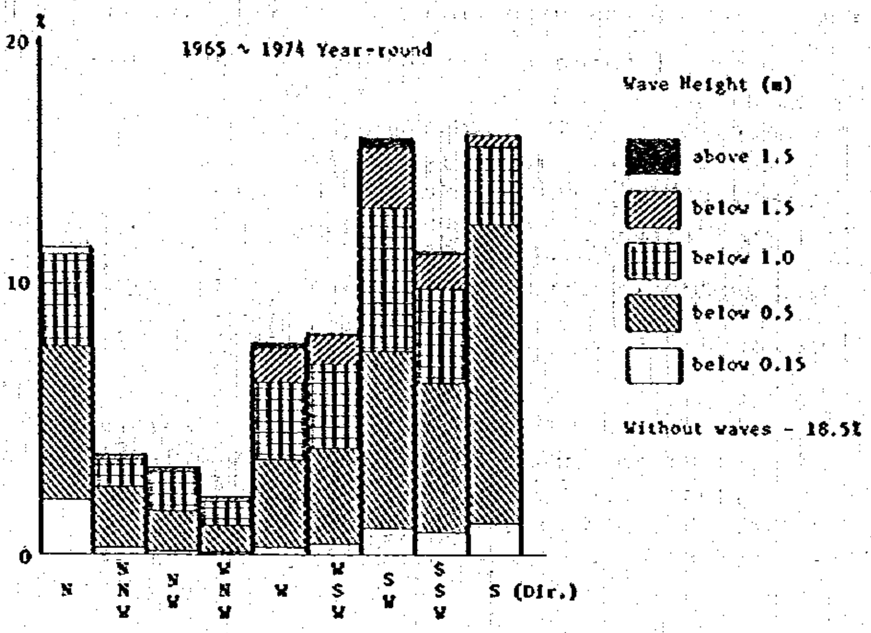


Fig. 6.2.2 Directional Wave Height Frequency, off Pattaya Beach

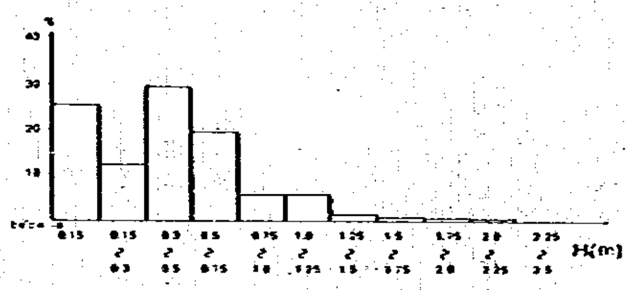


Fig. 6.2.3 Wave Height Frequency Off Pattaya

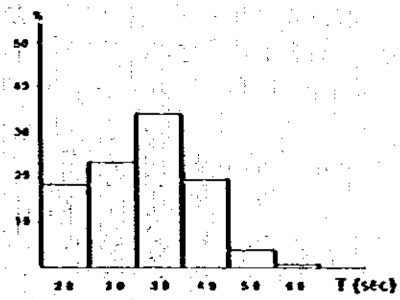


Fig. 6.2.4 Wave Period Frequency Off Pattaya

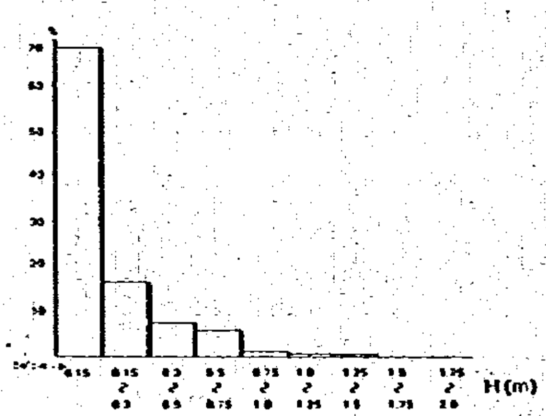


Fig. 6.2.5 Wave Height Frequency at Pattaya (Station 2)

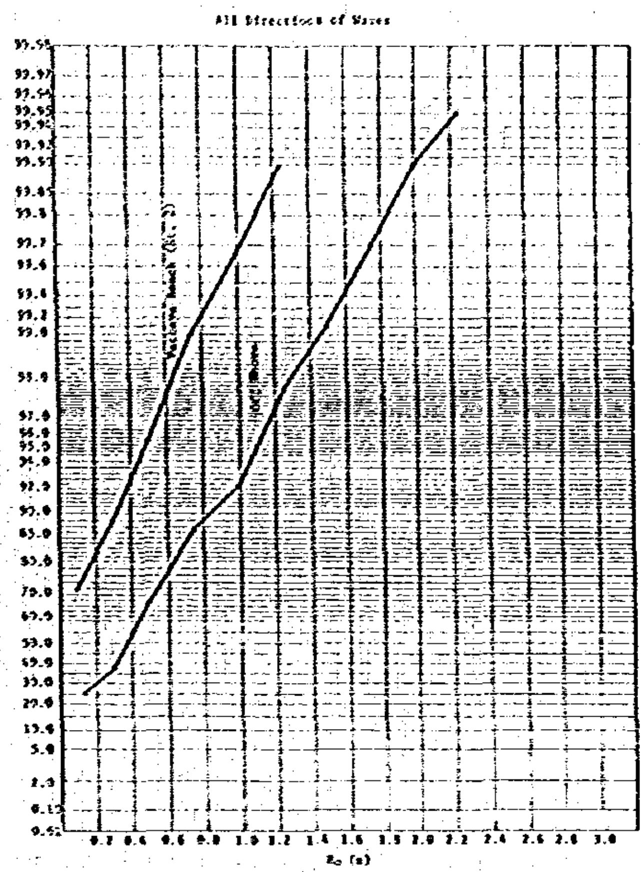


Fig. 6.2.6 Wave Height Frequency

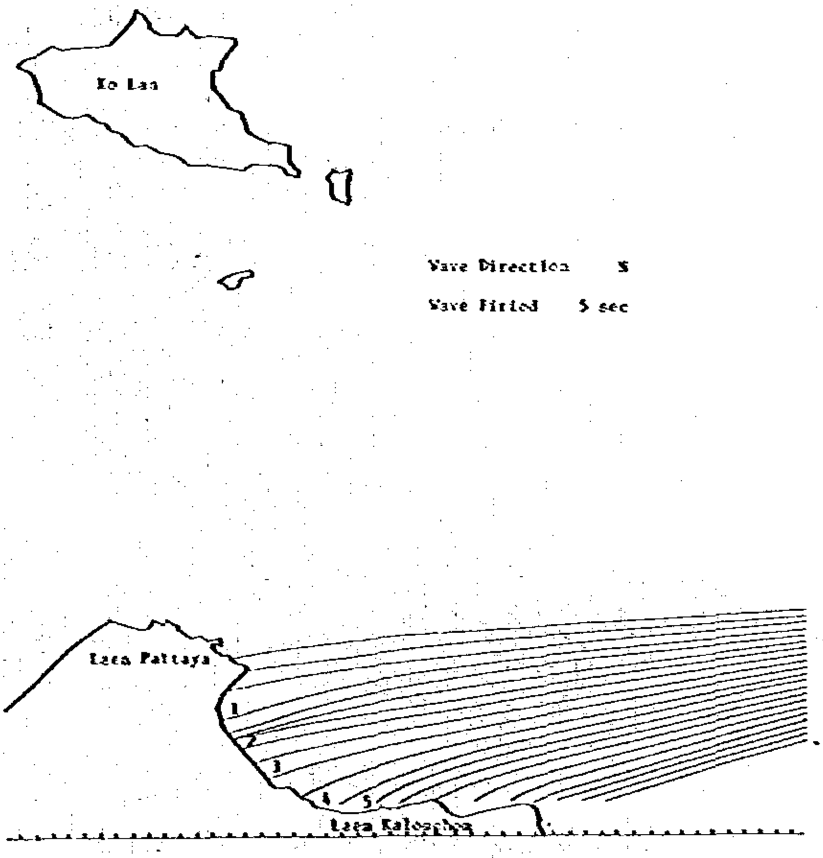


Fig. 6.2.7 Wave Refraction Diagram

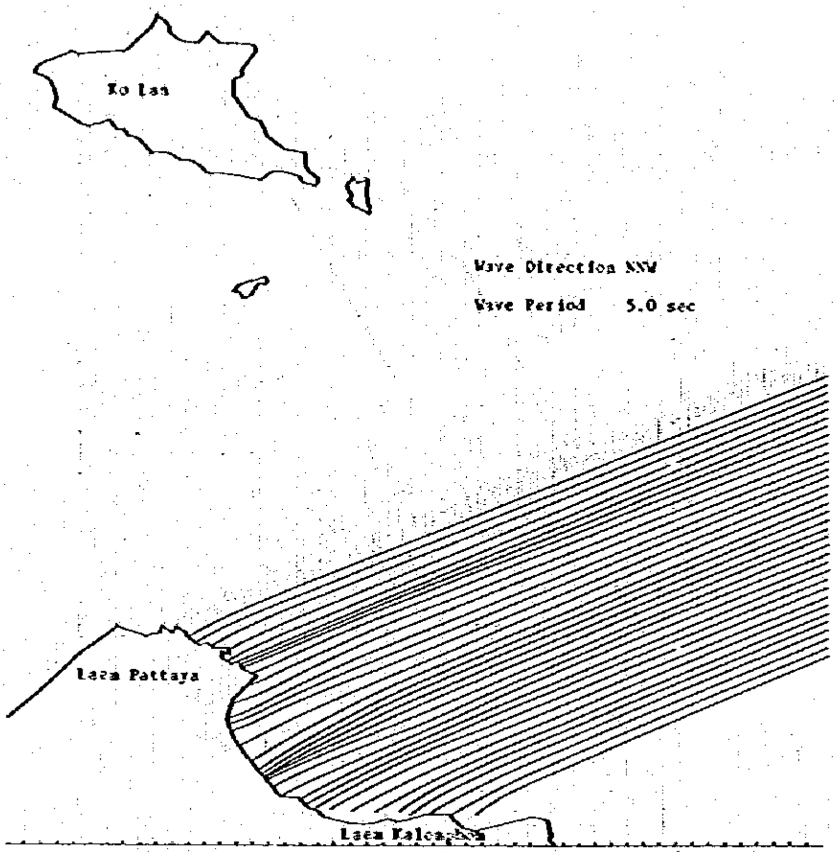


Fig. 6.2.8 Wave Refraction Diagram

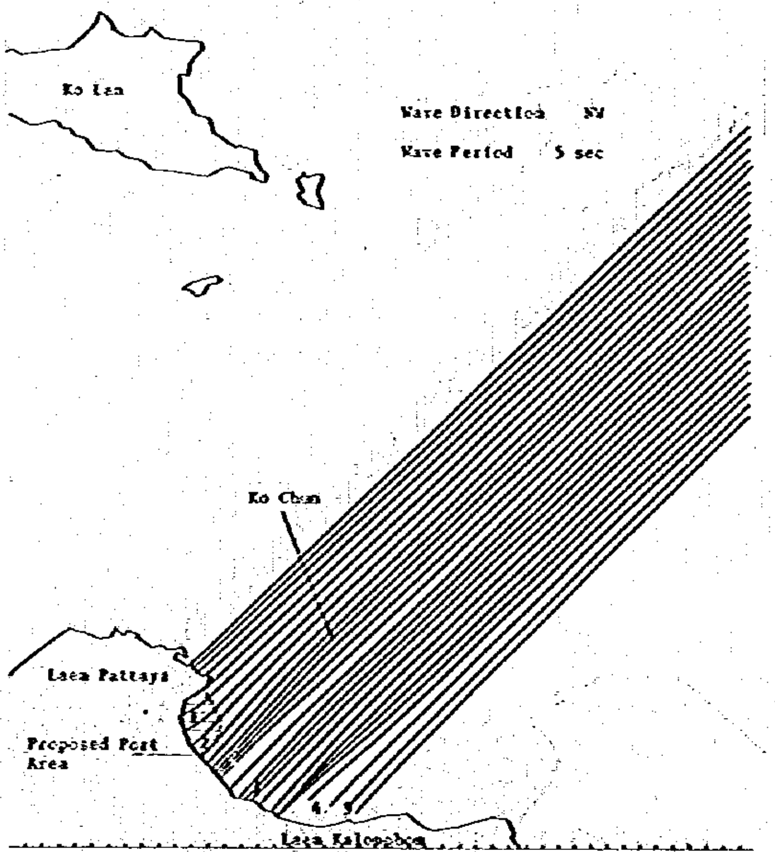


Fig. 6.2.9 Wave Refraction Diagram