Table AP 4.29 Solid waste collection and transportation simulation result (1/8)

(Unit: Baht/d)

Type	Case No.	Type of facilities	No. of node	Selected node No. Node No. (Treatment volume: t/d)	Total	Collection and Transportation cost * 1st	2nd	Sub-total	Facilities related cost Depreciation	Maint. & Ope.	Land	Sub-total	Total cost
Type A Landfill only	1-(1)	Landfill	5	800 (2,040) 801 (2,891) 802 (552) 804 (57) 805 (0)	(5,540)	942,039	-	942,039	277,000	387,800	154,492	819,392	1,761,431
	1-(2)	Landfill	5	800 (3,000) 801 (2,260) 802 (255) 804 (15) 805 (10)	(5,540)	958,781	-	958,781	277,000	387,800	201,662	866,462	1,825,243
	2-(1)	Landfill	5	800 (2,040) 801 (2,891) 802 (552) 804 (57) 805 (0)	(5,540)			681,523	302,200	527,210	166,654	996,064	1,677,590
		(Transfer)	19		(3,098)								
	2-(2)	Landfill	5	800 (3,000) 801 (2,260) 802 (255) 804 (15) 805 (10)	(5,540)			685,747	302,200	527,210	213,724	1,043,134	1,728,881
		(Transfer)	19		(3,098)								
Type B Composting only	3-(1)	Composting	9	750 (540) 751 (270) 752 (765) 753 (765) 754 (765) 755 (765) 756 (765) 757 (765) 758 (140)	(5,540)	1,039,624	-	1,039,624	372,844	825,460	28,978	1,227,282	2,266,906
	3-(2)	Composting	5	750 (1,466) 751 (422) 755 (1,078) 757 (1,957) 758 (617)	(5,540)	873,037	-	873,037	367,180	825,460	63,568	1,256,208	2,129,245
	4-(1)	Composting	9	750 (540) 751 (270) 752 (765) 753 (765) 754 765) 755 (765(756 (765) 757 (765) 758 (140)	(5,540)			720,101	395,344	935,935	39,158	1,370,437	2,090,538
		(Transfer)	17		(2,455)								
	4-(2)	Composting	5	750 (827) 751 (600) 755 (1,484) 757 (2,212) 758 (417)	(5,540)			705,504	385,180	923,020	72,282	1,380,482	2,085,986
		(Transfer)	14		(2,169)								

* 1st ... Transportation cost from origin to the intermediate facilities.
2nd ... Transportation cost from intermediate facilities to the final disposal sites.

Table AP 4.29 Solid waste collection and transportation simulation result (2/8)

(Unit: Baht/d)

Type	Case No.	Type of facilities	No. of node	Selected node No. Node No. (Treatment volume: t/d)					Total	Collection and Transportation cost * 1st	2nd	Sub-total	Facilities related cost Depreciation	Maint. & Ope.	land	Sub-total	Total cost
Type C Incineration only	5	Incineration	5	701 (1,200)	705 (1,200)	708 (1,196)	710 (1,167)	712 (777)	(5,540)	671,760	30,670	701,830	1,057,104	808,840	148,520	2,014,464	2,716,294
	6	Incineration	5	701 (1,200)	705 (1,200)	708 (1,196)	710 (1,951)	712 (993)	(5,540)			681,285	1,061,604	820,505	157,750	2,039,859	2,721,144
		(Transfer)	3						(257)				(3,600	11,565	188	155,353)	
Type D Landfill & Composting	7	Composting (1,120 t)	3	750 (540)	751 (270)	758 (140)			(950)	181,746	-	181,746	65,998	141,550	17,184	224,732	406,478
		Landfill	5	800 (2,050)	801 (2,260)	802 (255)	804 (15)	805 (10)	(4,590)	778,327	-	778327	229,500	321,300	145,172	695,972	1,474,299
		Total							(5,540)	960,073	-	960,073	295,498	462,850	162,356	920,704	1,880,777
	8	Composting (1,120 t)	3	750 (540)	751 (270)	758 (140)			(950)			171,505	65,998	141,550	17,184	224,732	396,237
		Landfill	5	800 (2,050)	801 (2,260)	802 (255)	804 (15)	805 (10)	(4,590)			593,773	252,900	443,160	156,558	852,618	1,446,351
		Total							(5,540)			765,238	318,898	584,710	173,742	1,077,350	1,842,588
		(Transfer)							(2,708)				(23,400	121,860	11,386	156,646)	
	9	Composting (1,920 t)	5	750 (540)	751 (270)	755 (217)	757 (463)	758 (140)	(1,630)	265,742	-	265,742	113,030	242,870	14,490	370,390	636,132
		Landfill	5	800 (1,558)	801 (2,07@)	802 (255)	804 (15)	805 (10)	(3,910)	648,008	-	648,009	195,500	273,700	114,300	583,500	1,231,509
		Total								913,751	-	913,751	308,530	516,570	128,790	953,890	1,867,641

Table AP 4.29 Solid waste collection and transportation simulation result (3/8)

(Unit: Baht/d)

Type	Case No.	Type of facilities	No. of node	Selected node No. Node No. (Treatment volume: t/d)					Total	Collection and * Transportation cost 1st	2nd	Sub-total	Facilities related cost Depreciation	Maint. & Ope.	Land	Sub-total	Total cost
Type D(Cont'd) Landfill & Composting	10	Composting (1,920 t)	5	750 (540)	751 (270)	755 (217)	757 (463)	758 (140)	(1,630)			235,075	113,030	242,870	14,490	370,390	605,465
		Landfill		800 (1,558)	801 (2,702)	802 (255)	804 (15)	805 (10)	(3,910)			481,227	217,100	382,240	125,498	724,838	1,206,065
		Total										716,302	330,130	625,110	139,988	1,095,228	1,811,530
		(Transfer)	17						(2,412)				(21,600	108,540	11,198)	141,338)	
Type E Composting & Incineration	11	Composting (1,120 t)	3	750 (540)	751 (270)	758 (140)			950	168,891	-	168,891	65,998	141,550	17,184	224,732	393,623
		Incinera-tion	4	701 (1,200)	705 (1,200)	708 (1,138)	710 (1,052)		4,590	555,031	27,836	582,867	873,744	670,140	110,786	1,654,670	2,237,537
		Total								723,922	27,836	751,758	939,742	811,690	127,970	1,879,402	2,631,160
	12	Composting	3	750 (540)	751 (270)	758 (140)			950			165,238	65,998	141,550	17,184	224,732	389,970
		Incinera-tion	4	701 (1,200)	705 (1,200)	708 (1,200)	710 (990)		4,590			556,582	880,044	684,630	110,044	1,674,718	2,231,300
		Total										721,820	946,042	826,180	127,228	1,899,450	2,621,270
		(Transfer)	6						(322)				(6,300	14,490	258	21,048)	
	13	Composting (1,920 t)	5	750 (540)	751 (270)	755 (217)	757 (463)	758 (140)	(1,630)	232,999	-	232,999	113,030	242,870	15,306	371,206	640,205
		Incinera-tion	4	701 (1,200)	705 (1,016)	707 (864)	710 (830)		(3,910)	464,880	26,405	491,285	752,976	570,860	99,386	1,423,222	1,914,507
		Total								679,879	26,405	724,284	866,006	813,730	114,692	1,794,428	2,518,712

Table AP 4.29 Solid waste collection and transportation simulation result (4/8)

(Unit: Baht/d)

Type	Case No.	Type of facilities	No. of node	Selected node No. Node No. (Treatment volume: t/d)					Total	Collection and * Transportation cost 1st	2nd	Sub-total	Facilities related cost Depreciation	Maint. & Ope.	land	Sub total	Total cost
Type E (Cont'd) Composting & Incineration	14	Composting (1,920 t)	5	750 (540)	751 (270)	755 (217)	757 (463)	758 (140)	(1,630)			229,202	113,030	242,870	15,306	371,206	600,408
		Incineration (Incl. Transfer cost)	4	701 (1,200)	705 (911)	707 (902)	710 (897)		(3,910)			468,673	760,146	581,585	97,728	1,439,459	1,908,132
		Total										697,875	873,176	824,455	113,034	1,810,665	2,508,540
		(Transfer)	4	(Land-to-land) (Land-to-river)					(159) (357)				(3,600 3,570	7,155 3,570	120 272	10,935 7,412)	
Type F Incineration & Landfill	15	Incineration	1	701 (1,200)					(1,200)	137,520	9,965	147,485	227,720	175,200	56,832	459,752	607,237
		Landfill	5	800 (1,800)	801 (2,260)	802 (255)	804 (15)	805 (10)	(4,340)	710,478	-	710,478	217,000	303,800	130,296	651,096	1,361,574
		Total								847,998	9,965	857,963	444,720	479,000	187,128	1,110,848	1,968,811
	16	Incineration	1	701 (1,200)					(1,200)			136,681	227,720	175,200	56,832	459,752	596,433
		Landfill (Incl. Transfer cost)	5	800 (1,800)	801 (2,260)	802 (255)	804 (15)	805 (10)	(4,340)			536,904	234,100	403,160	137,864	75,124	1,312,028
		Total										673,585	461,820	578,360	194,696	1,234,876	1,908,461
		(Transfer)	16						(2,280)				(17,100	99,360	7,568	124,028)	

Table AP 4.29 Solid waste collection and transportation simulation result (5/8)

(Unit: Baht/d)

Type	Case No.	Type of facilities	No. of node	Selected node No. Node No. (Treatment volume: t/d)					Total	Collection and Transportation cost * 1st	2nd	Sub-total	Facilities related cost Depreciation	Maint. & Ope.	land	Sub-total	Total cost
Type C Landfill, Composting & Incineration	17-(1)	Incinera-tion	1	701 (1,200)					(1,200)	135,883	9,965	145,848	227,760	175,200	56,832	459,792	605,640
		Composting	3	750 (540)	751 (270)	758 (140)			(950)	170,106	-	170,106	65,998	141,500	17,184	224,732	394,838
		Landfill	5	800 (1,116)	801 (1,994)	802 (255)	804 (15)	805 (10)	(3,390)	554,505	-	554,505	169,500	237,300	87,338	494,138	1,048,643
		Total								860,494	9,965	870,459	463,258	554,050	161,354	1,178,662	2,049,121
	17-(2)	Incinera-tion	2	701 (1,200)	708 (1,200)					279,664	14,817	294,481	455,520	350,400	49,656	855,576	1,150,057
		Composting	3	750 (540)	751 (270)	758 (140)			(950)	172,969	-	172,969	65,998	141,550	17,184	244,732	397,701
		Landfill	5	800 (729)	801 (1,298)	802 (138)	804 (15)	805 (10)	(2,190)	336,672	-	336,672	109,500	153,300	56,604	319,404	656,076
		Total								789,305	14,817	804,122	631,018	645,250	123,444	1,399,712	2,203,834
	18-(1)	Incinera-tion	1	701 (1,200)					(1,200)			139,793	227,760	175,200	56,832	459,792	599,585
		Composting	3	750 (540)	751 (270)	758 (140)			(950)			170,k06	65,998	141,550	17,184	224,732	394,838
		Landfill	5	800 (1,252)	801 (1,858)	802 (255)	804 (15)	805 (10)	(3,190)			411,113	184,800	317,985	94,560	597,345	1,008,458
		Total										721,012	478,558	634,735	168,576	1,281,869	2,002,881
		(Transfer)	14						(1,973)				(15,300	80,685	7,222	103,207)	

Table AP 4.29 Solid waste collection and transportation simulation result (6/8)

(Unit: Baht/d)

Type	Case No.	Type of facilities	No. of node	Selected node No. Node No. (Treatment volume: t/d)					Total	Collection and Transportation cost * 1st	2nd	Sub-total	Facilities related cost Depreciation	Maint. & Ope.	land	Sub-total	Total cost
Type G Landfill, Composting & Incineration	18-(2)	Incineration	2	701 (1,200)	708 (1,200)				(2,400)			278,210	455,520	350,400	49,656	855,576	1,133,786
		Composting	3	750 (540)	751 (270)	758 (140)			(950)			172,006	65,998	141,550	17,184	224,732	396,738
		Landfill (Incl. Transfer cost)	5	800 (1,164)	801 (755)	802 (246)	804 (15)	805 (10)	(2,190)			280,171	117,600	187,995	81,080	386,675	666,846
		Total										730,387	639,945	679,945	147,920	1,466,983	2,197,370
		(Transfer)	8						(771)				(8,100	34,695	1,556	44,351)	
	19-(1)	Incineration	1	701						129,857	9,965	139,822	227,760	175,200	56,832	459,792	599,614
		Composting	5	750 (540)	751 (270)	755 (217)	757 (463)	758 (140)	(1,630)	243,292	-	242,292	113,030	242,870	15,306	371,206	614,498
		Landfill	5	800 (971)	801 (1,459)	802 (255)	804 (15)	805 (10)	(2,710)	444,448	-	444,448	135,500	189,700	74,112	399,312	843,760
		Total								817,597	9,965	827,562	476,290	607,770	146,250	1,230,310	2,057,872
	19-(2)	Incineration	2	701 (1,200)	703 (1,200)				(2,400)	275,841	20,995	296,836	455,520	350,400	127,776	930,696	1,227,532
		Composting	5	750 (540)	751 (270)	755 (217)	757 (463)	758 (140)	(1,630)	235,019	-	235,019	113,030	242,870	15,306	371,206	606,225
		Landfill	5	800 (473)	801 (882)	802 (130)	804 (15)	805 (10)	(1,510)	221,873	-	221,873	75,500	105,700	37,714	218,914	440,787
		Total								732,733	20,995	753,728	644,050	698,970	177,796	1,520,816	2,274,544

Table AP 4.29 Solid waste collection and transportation simulation result (7/8)

(Unit: Baht/d)

Type	Case No.	Type of facilities	No. of node	Selected node No. Node No. (Treatment volume: t/d)					Total	Collection and Transportation cost * 1st	2nd	Sub-total	Facilities related cost Depreciation	Maint. & Ope.	land	Sub-total	Total cost
Type C Landfill, Composting & Incineration	19-(3)	Incineration	2	701 (1,200)	703 (1,200)				(2,400)	282,431	20,995	303,426	455,520	350,400	124,776	930,696	1,234,122
		Composting	4	750 (540)	751 (270)	757 (475)	758 (345)		(1,630)	237,444	-	237,444	111,614	242,870	14,406	368,890	606,334
		Landfill	3	801 (847)	802 (154)	804 (509)			(1,510)	233,801	-	233,801	75,500	105,700	11,286	192,486	426,287
		Total								753,676	20,995	774,671	642,634	698,970	150,468	1,492,072	2,266,743
	19-(4)	Incineration	3	701 (1,200)	703 (1,194)	710 (952)			(3,346)	393,833	24,048	417,881	638,170	488,516	129,120	1,255,806	1,673,687
		Composting	4	750 (540)	751 (270)	757 (475)	758 (345)		(1,630)	229,516	-	229,516	111,614	242,870	14,406	368,890	598,406
		Landfill	3	800 (463)	802 (55)	804 (46)	801 (0)	803 (0)	(564)	84,636	-	84,636	28,200	39,480	28,546	96,226	180,862
		Total								707,985	24,048	732,033	777,984	770,866	172,072	1,720,922	2,452,955
	20-(1)	Incineration	1	701 (1,200)					(1,200)			138,583	227,760	175,200	56,832	459,792	598,375
		Composting	5	750 (540)	751 (270)	755 (217)	757 (463)	758 (140)	(1,630)			235,200	113,030	242,870	15,306	371,206	606,406
		Landfill	5	800 (1,049)	801 (1,381)	802 (255)	804 (15)	805 (10)	(2,710)			328,762	148,100	257,065	81,100	486,265	815,027
		Total (Incl. Transfer cost)										702,545	488,890	675,135	153,238	1,317,263	2,019,808
		(Transfer)	12										(12,600	67,365	6,988	86,935)	

Table AP 4.29 Solid waste collection and transportation simulation result (8/8)

(Unit: Baht/d)

Type	Case No.	Type of facilities	No. of node	Selected node No. Node No. (Treatment volume: t/d)					Total	Collection and Transportation cost * 1st	2nd	Sub-total	Facilities related cost Depreciation	Maint. & Ope.	land	Sub-total	Total cost
Type C Landfill, Composting & Incineration	20-(2)	Incineration	2	701 (1,200)	703 (1,200)				(2,400)			295,277	455,520	350,400	124,776	930,696	1,225,973
		Composting	5	750 (540)	751 (270)	755 (217)	757 (463)	758 (140)	(1,630)			233,828	113,030	242,870	15,306	371,206	605,034
		Landfill	5	800 (539)	801 (816)	802 (130)	804 (15)	805 (10)	(1,510)			202,134	79,100	119,065	42,692	240,857	442,991
		Total										731,239	647,650	712,335	182,774	1,542,759	2,273,998
		(Transfer)	4										(3,600	13,365	1,612	18,577)	

Appendix 4.14 Introduction to methods of evaluation

Methods of evaluation are broadly classified into four categories as follows:

- Deterministic evaluation method
- Economic evaluation method
- Operations research
- Compound evaluation method

(1) Deterministic evaluation method

Deterministic evaluation method is a method to establish some items of evaluation and criteria of judgment, and get ratings on the items according to the criteria by making an intuitive comparison to decide whether to employ a certain project or not, or to decide the order of priority of some subjects by comprehensive judgment.

Personal judgment or decision by discussion of a group such as a committee are often qualitative, while the deterministic evaluation method aims at an objective, universal and general judgment, representing the rating results qualitatively by means of digits, charts, etc. Items which are difficult to express numerically are shown digitally or diagrammatically.

This method has been used for a long time widely from basic studies in which many factors can only be evaluated qualitatively to industrialization which can be easily evaluated quantitatively.

i) Selection of evaluation items

Items for the evaluation of a project should be widely selected. The items range over from the level of the nation, politics, or economics to in-company level. Subdivision of items should be limited to the extent that a distinct difference of significance remains between items to maintain credibility in the final evaluation and facilitate the evaluation procedure.

ii) Establishment of evaluation criteria

The followings should be considered to establish evaluation criteria:

- Number of ratings to be provided
- Indication method of ratings

Generally, ratings of 2, 3, 4 or 5 grades are used. In some cases, the number of grades is increased or decreased depending on evaluation items and in the other cases, the same number of ratings are used for all items. The ratings are shown in marks and/or explanation. The

explanation includes symbolic, descriptive and numerical description.

iii) Conclusion of final evaluation

In the stage of final evaluation, the following points should be considered:

- Relative importance of evaluation items
- Appearance probability of ratings
- Weight by person in charge of ratings

There are various methods to conclude the final judgment from the evaluation results of each item.

a. Score method

Evaluation results of each item are expressed as the score obtained. This method is subdivided depending on the methods of calculation, weight by item and use of concept of probability.

- Addition method (addition of scores of each item)
- Continuous multiplication method (continuous multiplication of scores of each item)
- Addition/multiplication method (combination of addition and multiplication)
- Weight coefficient method (adjustment by importance of items)
- Probability method (adjustment of scores of each item by importance of items and appearance probability of ratings)

b. Profile method

Evaluation results are shown in diagrams and specific characters are judged from them.

This method is classified into the following four methods depending on the diagrams to be used.

- Chart method (ratings of each item are connected by a broken line and shown in a chart)
- Block method (ratings are shown in the form of checkers)
- Scale method (ratings are shown with a scale)
- Radial method (evaluation items are arranged radially)

c. Check list method

Evaluation items are arranged as a check list in the form of questions and anasers.

iv) Score method

a. Addition method

Scores of items are simply added and the priority order is decided by the total scores. Generally, maximum score of each item is different by item in case of providing different importance between items.

b. Continuous multiplication method

Scores of each item are multiplied by each and the results is used for a final evaluation.

The multiplied score is a very large number when there are many evaluation items. Therefore, it is almost impossible to prepare a large number of items. The score calculated varies from 1 at least to some tens of hundreds at the highest and therefore small difference of scores of each item can result in a large difference finally. Therefore, this is a very "sensitive" method.

c. Addition/multiplication method

Evaluation items are classified into some groups. The scores of the items in the same group are added and the results of each group are multiplied by each other.

d. Weight coefficient method

The maximum score of each items are the same. Each item has a weight coefficient respectively and the final score is obtained by adding all figures obtained by multiplying the score by the weight coefficient of each score.

By properly deciding the weight coefficient of each item, the final evaluation can be obtained in a proper way.

e. Probability method

All of the evaluation items have the weight coefficient and probability of each rating by presumption. The final evaluation can be obtained by multiplying these factors and the scores of items.

v) Profile method

a. Chart method

Ratings of each evaluation item are plotted on a chart, and the points are connected by straight lines to form a broken line graph. The pattern of the graph is examined for the final comprehensive evaluation.

b. Block method

Squares of checkers are painted out to show the positions of ratings and the pattern is examined.

c. Scale method

Rating positions are indicated by graduations of a numerically marked scale and the points are represented as a broken line graph or bar graph to examine the pattern.

This method can express the difference of importance between the items. The score method (addition method) can be used together.

d. Radial method

Evaluation items are arranged radially in a circle and the distance from the center shows ratings. The rating points are connected with straight lines and the pattern drawn by the lines is examined.

vi) Check list method

a. Questionnaire method

Evaluation items are established in the form of questions and answers. Reasons for the answers are also required.

b. Flow chart method

Relation between evaluation items, namely cause and effect, are expressed as a flow chart.

The flow advances ansering "Yes" or "No" and reaches "Yes" of total evaluation finally.

vii) Advantage and disadvantage of deterministic evaluation method

Table AP 4.30 Advantage and disadvantage of deterministic evaluation method

Method	Advantage	Disadvantage
Score method	(1) Qualitative factors shown digitally. (2) Definite ranking by score. (3) Easily input to a computer. (4) Easily handled mathematically.	(1) Unsuitable for scoring medium point between digits selected. (2) Final evaluation cannot be obtained only by scores. (3) Difficult to express digitally.
Addition method	(1) Maximum score of each item can be changed considering the difference between the items. (2) Easy calculation.	

Table AP 4.30 (cont'd)

Method	Advantage	Disadvantage
Continuous multiplication method	(1) Difference between the final scores of each project is large and distinction becomes clearly.	(1) Many evaluation items makes calculation exhausting.
Addition/ multiplication method	(1) High sensitivity.	(1) Classification of items into groups the items of which is to be added is important.
Weight coefficient method	(1) Convenient to decide importance.	(1) Complicated calculation.
Probability method	(1) High credibility. (2) Theoretical	(1) It is difficult to provide many evaluation items. (2) Complicated calculation.
Profile method	(1) Visual, and therefore problems can be traced. (2) Comparison of specific properties is easy.	(1) Undefinite order (2) Quantitatively undefinite.
Chart method	(1) Unevenness shown clearly.	(1) Large paper required.
Block method	(1) Understandable pattern.	(1) Large paper required.
Scale method	(1) Importance made clear	
Radial method	(1) Understandable degree of balance	
Check list method	(1) Factors offered as they are. (2) Factors can be added when problems occur.	(1) Unclear order (2) Undefinite quantitatively
Questionnaire method	(1) Facts can be clearly understood.	

(2) Economic evaluation method

Economic evaluation method is a method to evaluate a project in terms of expenses, expenditure and profits from economic standpoint. In this case of evaluation, the economic evaluation is limited to the static evaluation and dosen't include the OR.

The economic evaluation method basically finds indices of economical efficiency of a project. The economic indexes are found with the

following equations usually.

Economic index = output (achievement of a project)/
input (expense or expenditure of a project)

Economic index = output (achievement of a project) -
input (expense or expenditure a project)

Since the economic evaluation method is a quantitative evaluation, it is highly objective and is based on a relatively secure theory. Therefore, if proper parameters are selected and the evaluation indexes are calculated using proper data, this can be rational and of practical use.

It is almost impossible to apply this method of evaluation when the effect of a project is almost impossible to measure quantitatively (monetarily) such as solid waste disposal system.

(3) Operations research method

It is the most important subject to obtain the highest efficiency and the most brilliant achievement under restrictions of time, materials, money, personnel and technique.

The operations research method answers this problem with operations research. It represents various phenomena occurred in operation of a project with a mathematical model which can be used for the static and dynamic estimation of effects and cost of a project.

OR method have been developed in various fields in various forms. The following basic methods have been already put in practical use.

- Linear programming (LP)
- Non-linear programming (NLP)
- Dynamic programming (DP)
- Queuing theory
- Game theory
- Inventory control theory
- Optimum distribution theory
- Statistical intention decision theory
- Search theory
- Information theory
- Simulation

These methods are applied actually for an ideal system which is a model of a real system.

To prepare a model of this ideal system, following points should be considered generally.

- Propriety of a model depends on the boundary conditions of the system, propriety of variables selected and value of parameters.
- Parameters and structure of the model should correspond to parameters and structure of real system.
- The real system has "noise" or "factors" which cannot be explained in the model and are changing dynamically.
- "Noise" has a strong influence on the decision of real system conditions, and therefore the deviation from the target should be corrected by feedback system when deciding the target-oriented intention.
- Applicability of a model is affected by the magnitude of the noise and depends on the accuracy of the model.
- If the model has sufficient reality, the structure and boundary conditions of the system or details of the model should be reviewed.

(4) Compound evaluation method

Compound method is a combination of the deterministic evaluation method (D), economic evaluation method (E) and OR evaluation method (O).

Four combinations are considered as follows:

OD (combination of OR and deterministic approaches)

OE (combination of OR and economic approaches)

ED (combination of economic and deterministic approaches)

EDO (combination of economic, deterministic and OR approaches)

The above description was cited from "Evaluation and Decision for Study and Research (1972)" compiled by POEM Research Association, Japan Productivity Association.

Appendix 4.15 Evaluation criteria

Table AP 4.31 Evaluation criteria for evaluation items

Code	Evaluation elements	Rating methods	Ranks
V1	(V: Technology) Reliability of the system	Relative evaluation method. Utility and result in practical use of the system. Previous cases of practical application of the technology. Flexibility of treatment and disposal method.	a, b, c
V2	Ease of operation	Relative evaluation method. Technical level required for operation and maintenance of the system; etc.	a, b, c
V3	Practicability of the Plan	Relative evaluation method. Possibility of land acquisition. Appropriateness of the facilities location.	a, b, c
W1	(W: Economy) Unit treatment and disposal net cost per ton of solid waste	The cost is divided into 3 levels. (ref. Note 1.) a / b (310 Baht/t) / c (360 Baht/t)	a, b, c
X1	(X: Environmental protection) Adaptability to natural environmental cycles	Relative evaluation method. Reducibility of burden to environment. Grade of stabilization and volume reduction.	a, b, c
X2	Ease to satisfy environmental restrictions	Relative evaluation. In the case of application of standard pollution prevention equipment. (ref. Note 2.)	a, b, c
X3	Reliability of operation of pollution prevention equipment.	Relative evaluation. Ease of operation and maintenance when standard pollution prevention equipment is applied.	a, b, c
Y1	(Y: Resource recovery) Utility of recovered resources	Relative evaluation method. Ability to save virgin resource. Strength of social demand.	a, b, c
Y2	Marketability of recovered resources.	Relative evaluation method. Ease of sales and market development.	a, b, c
Y3	Stability of the resource supply to the market.	Relative evaluation method. Balance between demand and supply.	a, b, c
Z1	(Z: Administrative situation) Consistency with the existing system	Relative evaluation method. Grade of the system improvement. Utilization of the existing compost plants. (ref. Note 3.)	a, b, c
Z2	Reasonableness for budgeting	Overheads are divided into 2 levels. (ref. Note 3.) a / b (255 Baht/t)	a, b
Z3	Adaptability to the organization	Relative evaluation method. Necessity of reorganization and employment of competent personnel.	a, b, c
Z4	Adequacy of the system	Relative evaluation method. Appropriateness of the system to Bangkok in the year 2000.	a, b, c
Z5	Balance with the other urban institutions	Relative evaluation method. Availability of urban transportation system, sewer system, water supply, power supply, telecommunication system, etc.	a, b, c

* Note 1 ∿ 3 are shown in the next page.

Note 1. When treatment and disposal cost per ton of solid waste is 310 Baht or less, it is ranked in 'a'. This cost, calculated as of 1980, is securable amount in the year 2000 provided that a rate between the present GPP of Bangkok city and a total expense for sanitary utility enterprises paid from the GPP does not change in the future.

From socio-economic responsibility's viewpoint also, allocation of the above amount to the future sanitary utility enterprises shall be claimable with certainty. When the cost is over 310 Baht but less than 360 Baht, it falls in rank 'b'. The figure of 360 Baht is derived, in the same manner as above, from a rate between gross expenditure of metropolitan Tokyo and a total solid waste management cost paid for sanitary activities in Tokyo 23 wards as a part of the gross expenditure. The rate is applied to GPP of Bangkok city as it is. If the cost exceeds 360 Baht, it is regarded unreasonable amount and ranked in 'c'.

Note 2. Establishment of legal restrictions against issue of pollutant is common measure of environmental protection taken in many countries. The restrictions strictly order factories and effluent-discharging facilities to suppress their issuing flue gases and effluent including rank odour and noise within the specified limits. In our evaluation also, the restrictions stipulated in environmental standards and in the Factory Act are taken as the evaluation criteria and, for some toxic substance and noise to which no restrictions are placed, the following limitations are provisionally targeted. The further details of the restrictions against pollutant will be described in "Environmental assessment" in Phase II.

- Toxic substance in flue gas
  Nox; within 150 ppm (at 12% O_2 density in the flue gas)
  Sox; within 100 ppm (at 12% O_2 density in the flue gas)
  Fly ash; 0.18/Nm^3
  Noise; with 50 phon (A-characteristic range) at the facilities site.

Note 3. In the actual management of administrative activities, largeness of annual ordinary expenses should be taken as more serious obstruction for the sound management than an amount of the initial investment. Evaluation element Z_2 'Reasonability for budgeting' is to check adequacy of amount of ordinary expenses. The sums of collection & transportation cost per ton of solid waste and operation & maintenance cost of the related facilities were calculated from each of 15 cases of the typical Master Plan alternatives being selected at the 1st step, and an average of the sums was obtained 254 Baht per ton of solid waste. Applying this figure, the expenses per ton of solid waste less than 255 Baht is ranked 'a' and the same equivalent to 255 Baht or the higher is 'b'.

Appendix 4.16 Solid waste transport volume to the destinations

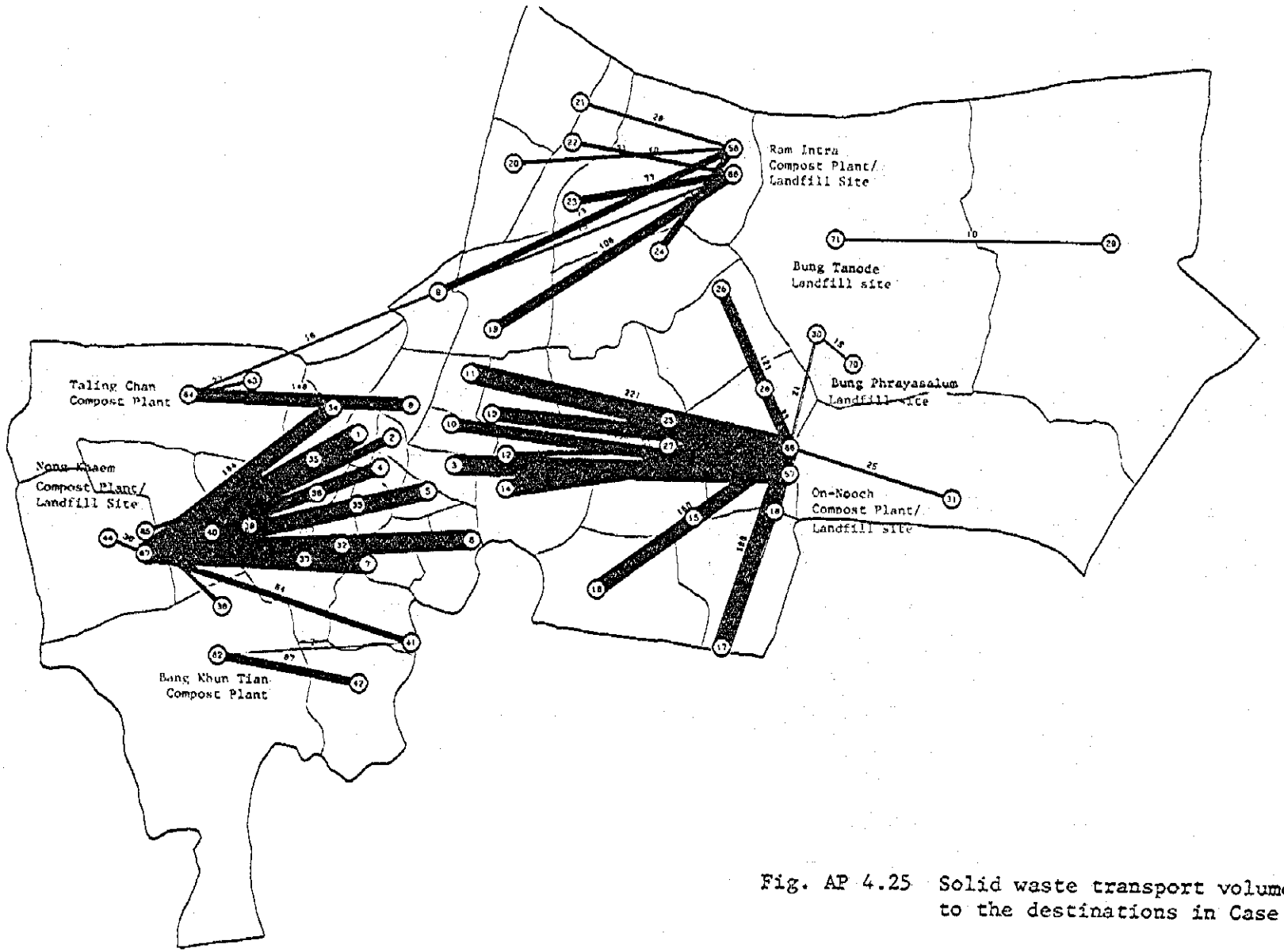


Fig. AP 4.25 Solid waste transport volume to the destinations in Case 9

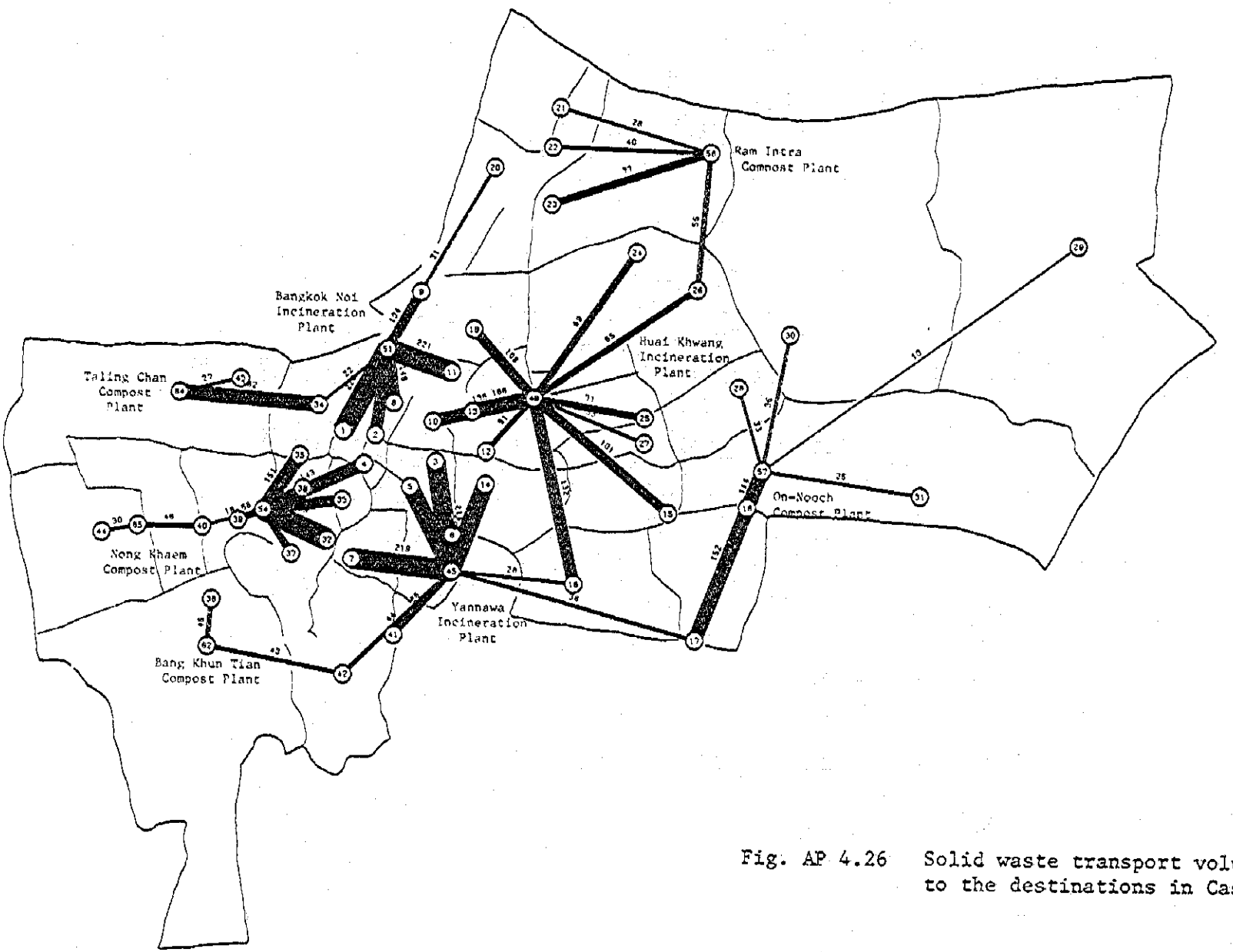


Fig. AP 4.26 Solid waste transport volume to the destinations in Case 13

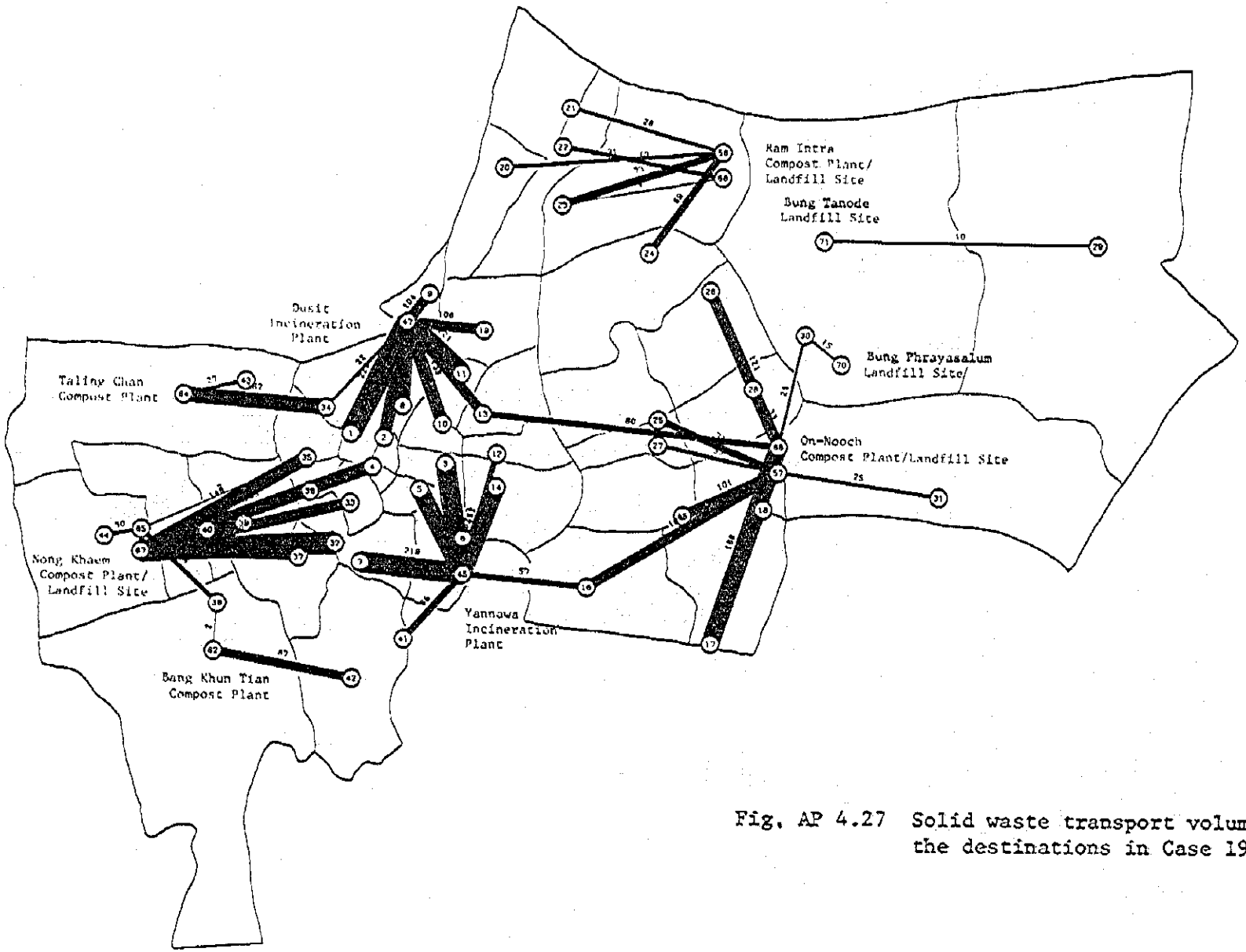


Fig. AP 4.27 Solid waste transport volume to the destinations in Case 19-(2)

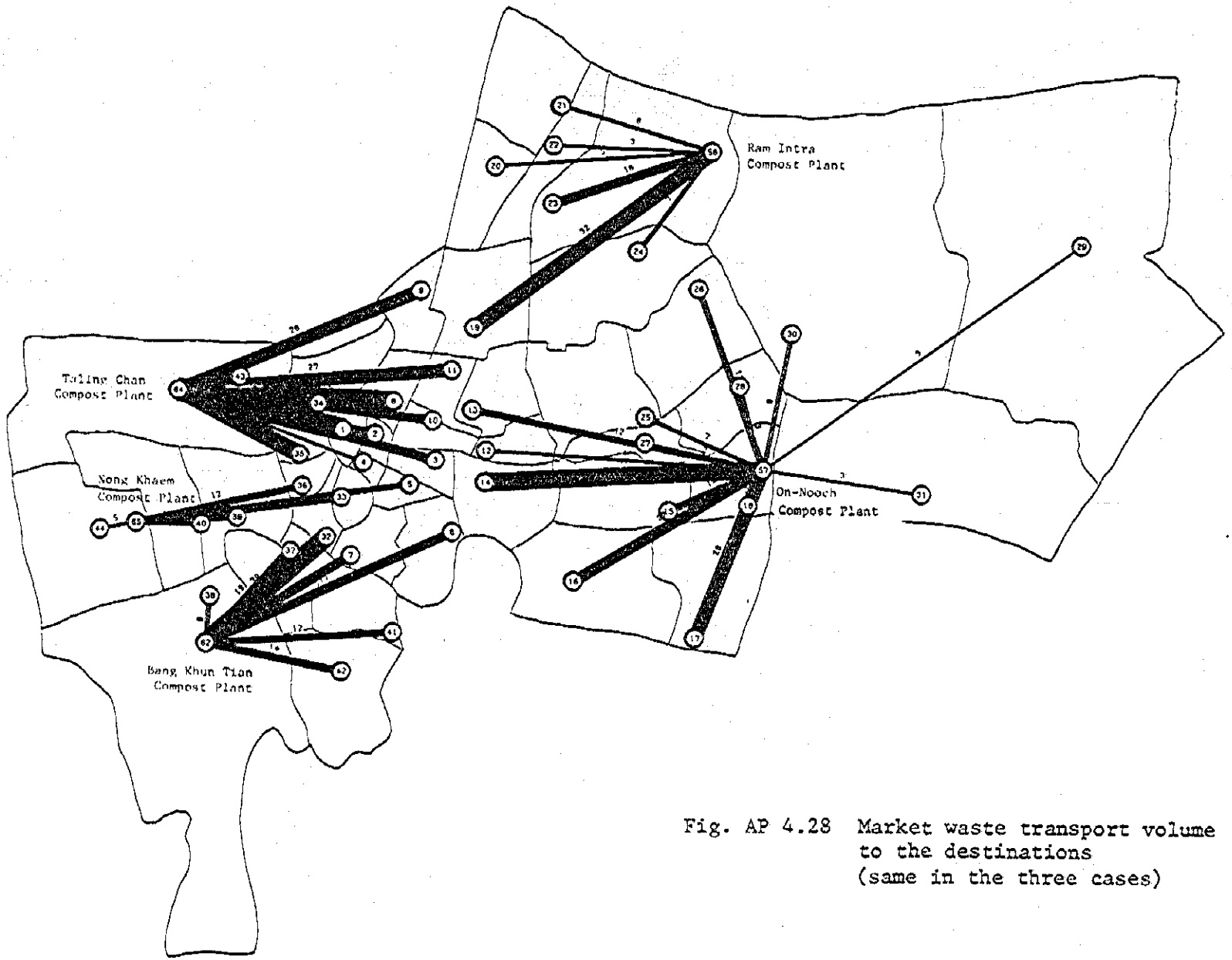


Fig. AP 4.28 Market waste transport volume to the destinations (same in the three cases)

Chapter 5 SOLID WASTE MANAGEMENT FACILITY PLAN AND THE COST ESTIMATION

Appendix 5.1 Design conditions of an incineration plant

(1) Properties of incoming solid waste (the year 2000)

Item / Solid waste	Lower heat value (Hu) [kcal/kg]	Combustible content [wt%]	Elemental composition of combustible content [wt%]						Moisture content [wt%]	Ash [wt%]
			C	H	O	N	S	Cl		
of maximum heat value	1,620	33.7	18.90	2.89	11.09	0.38	0.08	0.32	51.1	15.2
of minimum heat value	1,030	-	-	-	-	-	-	-	58.2	-
of average heat value	1,280	28.9	16.07	2.45	9.74	0.34	0.06	0.26	55.4	15.7

(2) Combustion temperature (at entrance of water-wall) — 750 - 900°C

(3) Type of gas cooling — water-wall

(4) Type of air and gas movement — forced-draft fan and induced-draft fan

(5) Type of refuse-charging — overhead crane

(6) Type of gas cleaning and emission standard — electrostatic precipitator (max. emission level 0.1 g/Nm^3)

(7) Ignition loss of residue — under 5 wt%

(8) Type of waste water processing — closed system by spraying into furnace (but, sewage is biochemically treated)

(9) Noise — 45 phon (at site boundary in midnight) (A characteristics)

(10) Vibration of ground — vertical: max. 60 dB (at site boundary in midnight); horizontal: max. 70 dB (at site boundary in midnight)

(11) Electricity — Single circuit, 3 phases, 69,000 V, 50 Hz

(12) Power generation — steam-turbine generator para-run with EGAT
surplus power will be sold to EGAT

(13) Emergency power generation — diesel engine generator

(14) Operation time in percent per annum — 80%

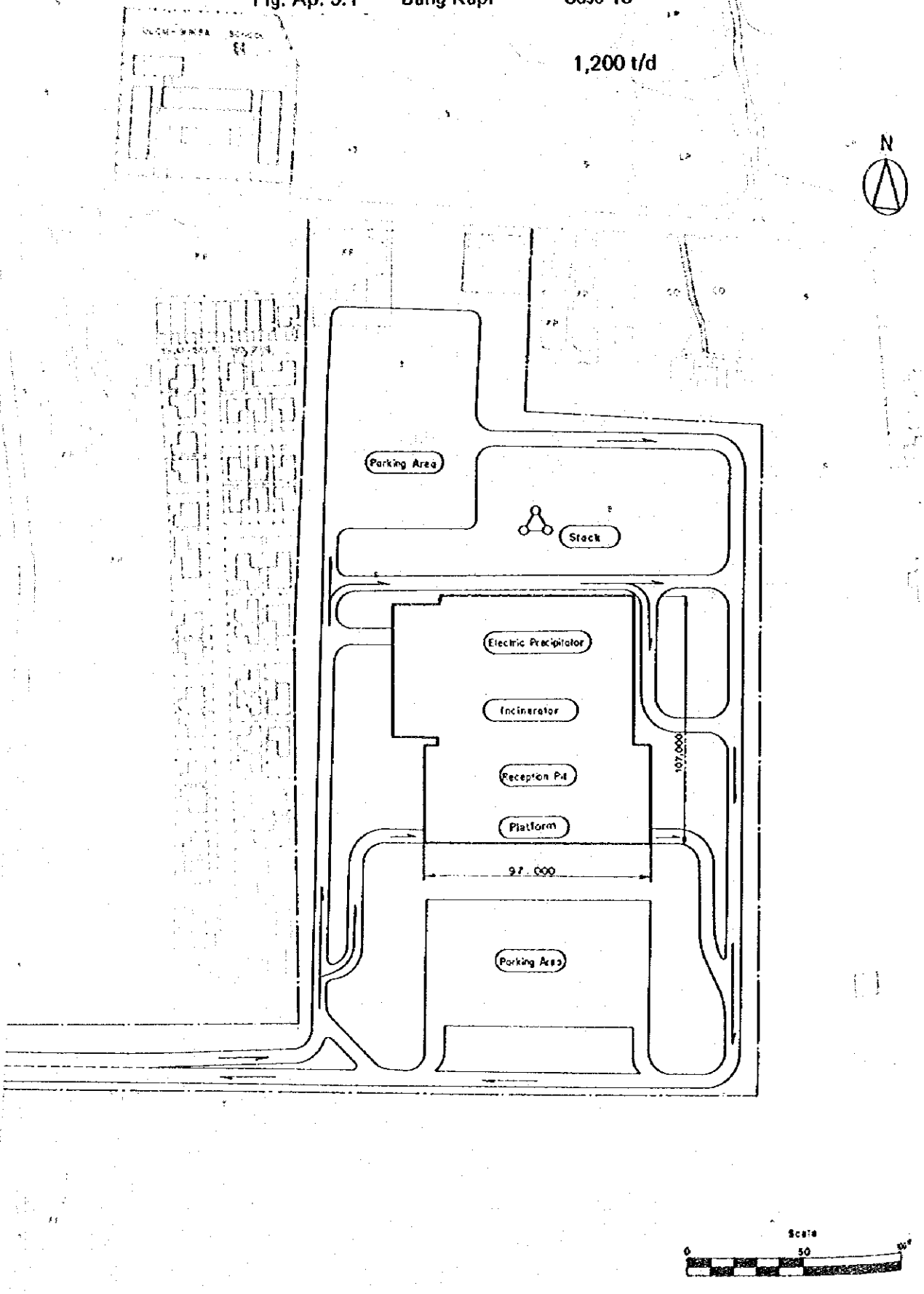
Appendix 5.2 Outline of principal components in the design of the incineration plants

(1)	Solid waste accepting and charging facilities	
	· weighbridge	1 unit for the capacity of 300 t/d
	· discharging gate	1 unit for the capacity of 100 t/d
	· reception pit	volume of 3 day storage, 1 unit
	· crane	3 units
(2)	Incinerator	3 units (starting oil-burner attached)
(3)	Residue treatment facilities	
	· residue cooling	water quenching and push-out discharger 1 unit per incinerator
	· residue crane	2 units
	· residue pit	1 unit, capacity with 2-day storage
	· residue weighbridge	1 unit
(4)	Waste water treatment	no-discharge type
(5)	Air supply equipment	
	· air duct	3 systems
	· forced-draft fan	3 units
	· cooling fan	3 units
	· steam-air heater	3 units
(6)	Dust collector	
	· electrostatic precipitator	3 units (max.emission level 0.1 g/Nm^3)
(7)	Gas discharging equipment	
	· flue	3 systems
	· induced-draft fan	3 units
(8)	Stack	steel made, concentration type (1 unit per incinerator), height 60 m
(9)	Boiler	
	· boiler	3 units
	· deaerator	3 units
	· attachment	1 unit of total
(10)	Power generation equipment	
	· steam turbine	1 unit
	· ground condenser	1 unit

	• generator	1 unit
	• emergency generator	1 unit
(11)	Recovered heat utilization equipment	
	• cooling equipment	1 assortment
(12)	Steam condenser	
	• steam condenser	3 units (water cooling type)
	• drain tank	2 units (1 unit is for a spare)
	• deaerator feed pump	5 units (2 units are for spares)
(13)	Piping	1 unit per incinerator
(14)	Pure water production equipment	2 units
(15)	Electric	1 assortment
(16)	Instrument	1 assortment
(17)	Water supply equipment	1 assortment
(18)	Electronic data processing system	1 assortment

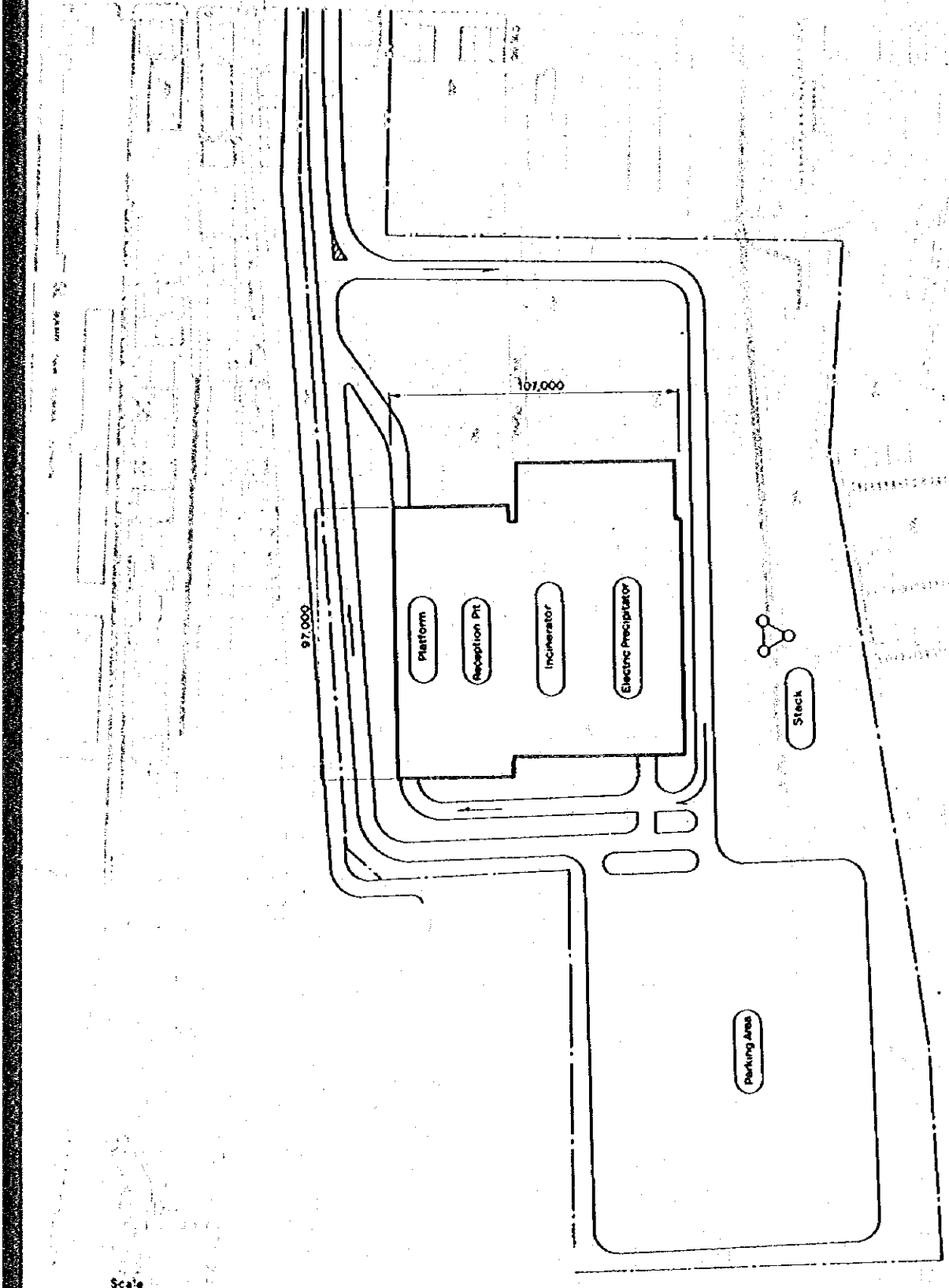
Appendix 5.3 Incineration Plants Layout (1)
Fig. Ap. 5.1 Bang Kapi Case 13

1,200 t/d



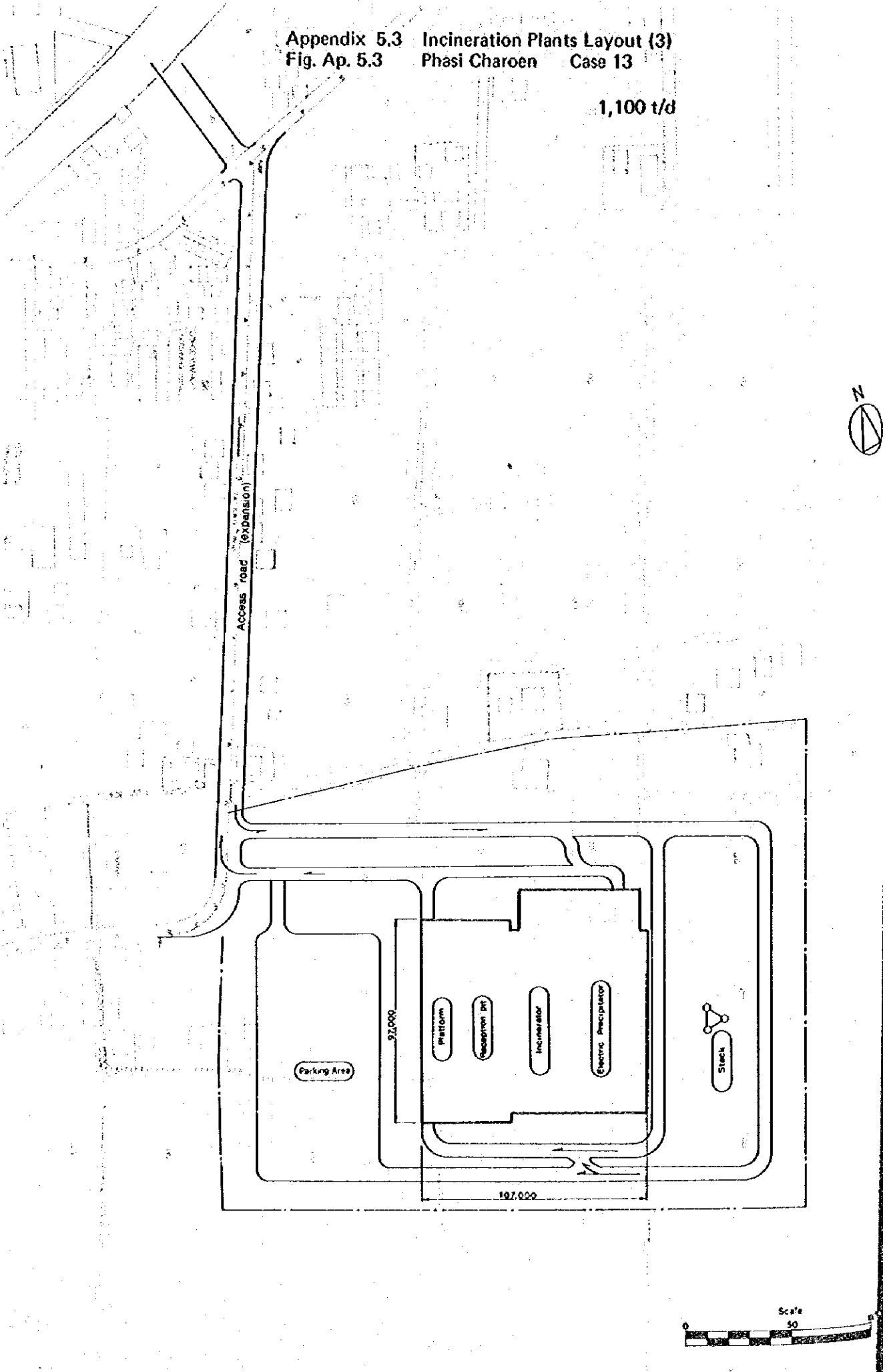
Appendix 5.3 Incineration Plants Layout (2)
Fig. Ap. 5.2 Bangkok Noi Case 13

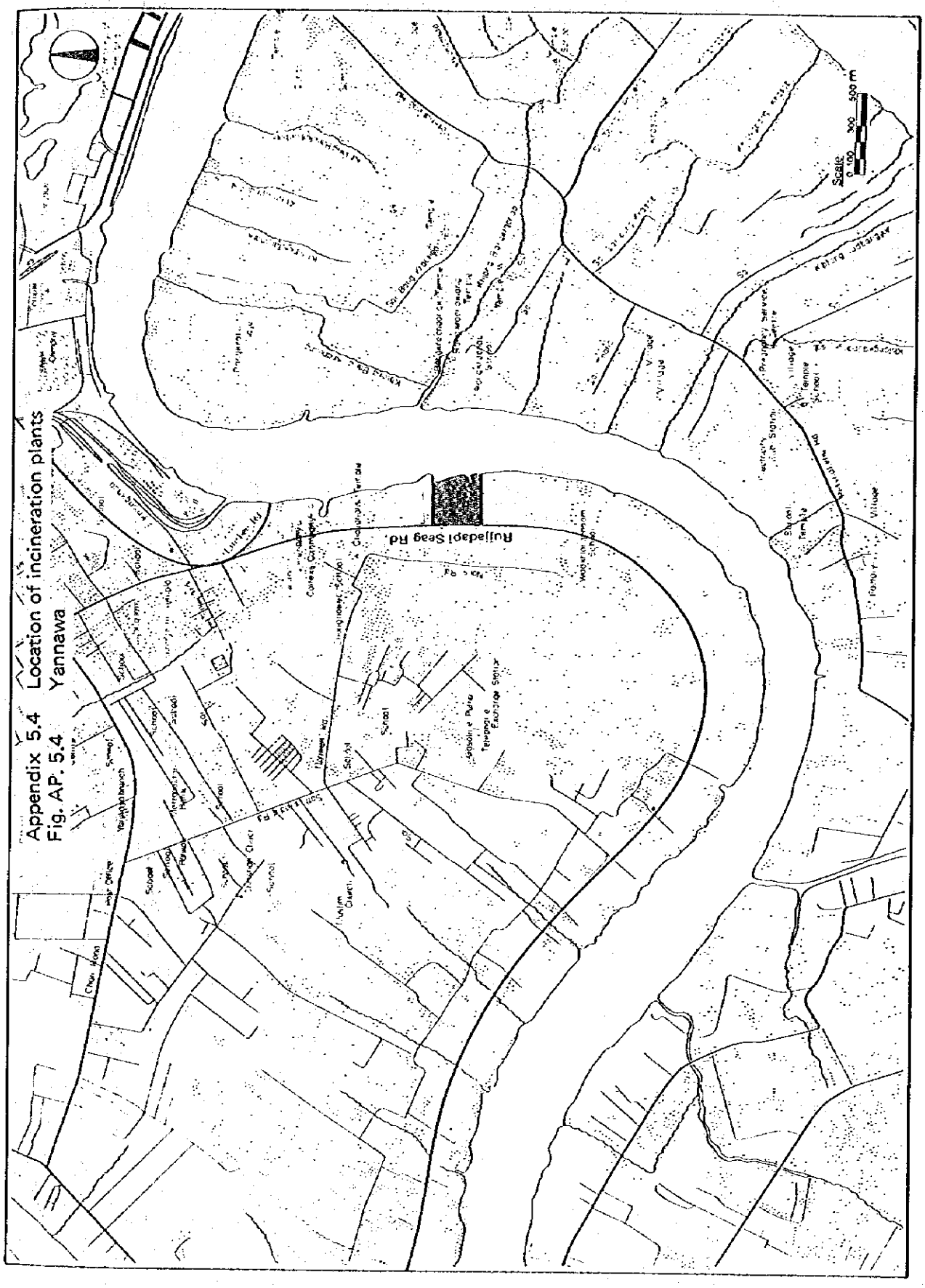
1,100 t/d



Appendix 5.3 Incineration Plants Layout (3)
Fig. Ap. 5.3 Phasi Charoen Case 13

1,100 t/d



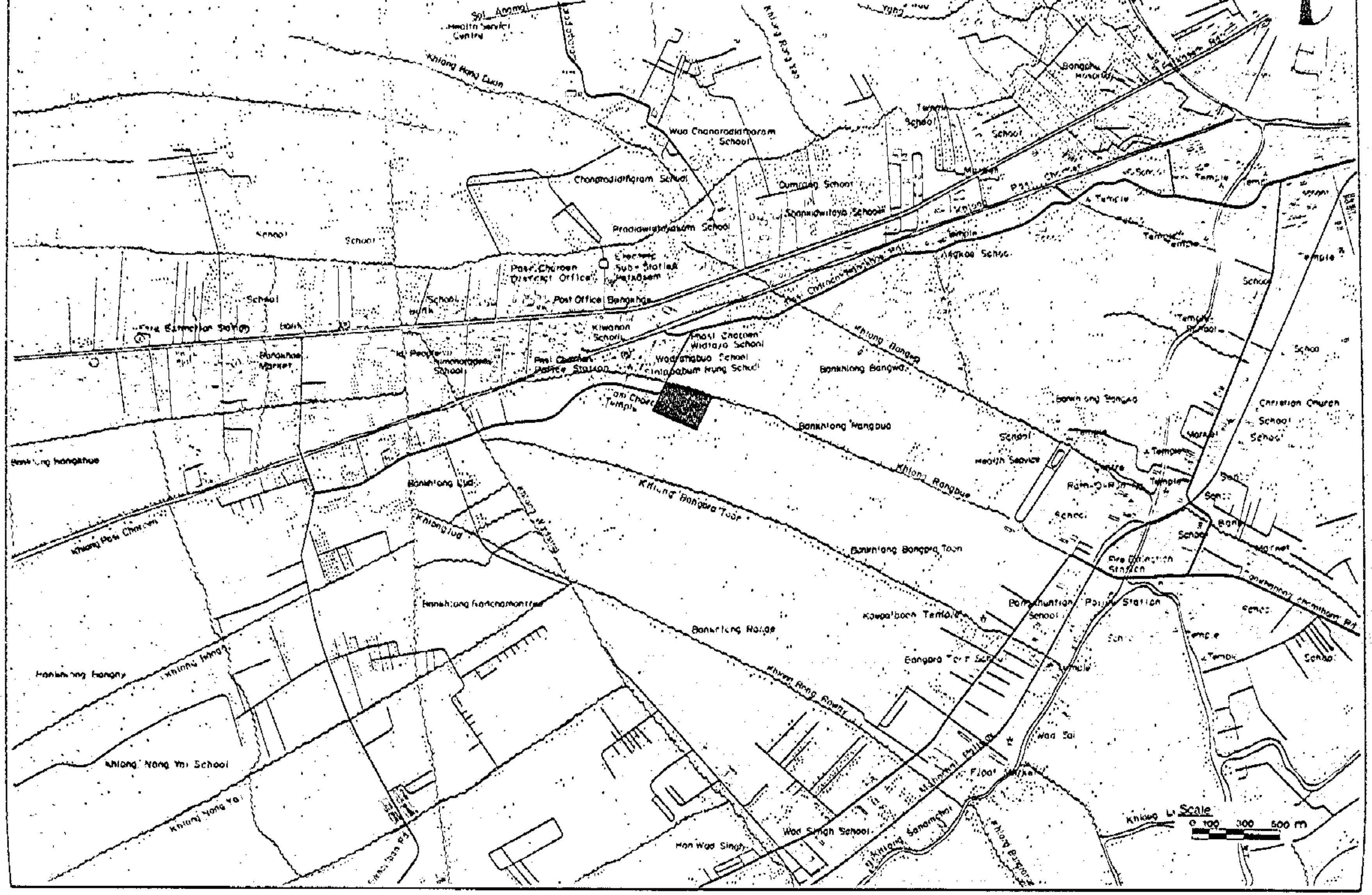

Appendix 5.4 Location of incineration plants
Fig. AP. 5.4 Yannawa
Rullada Seag Rd
Scale
0 100 300 500 m

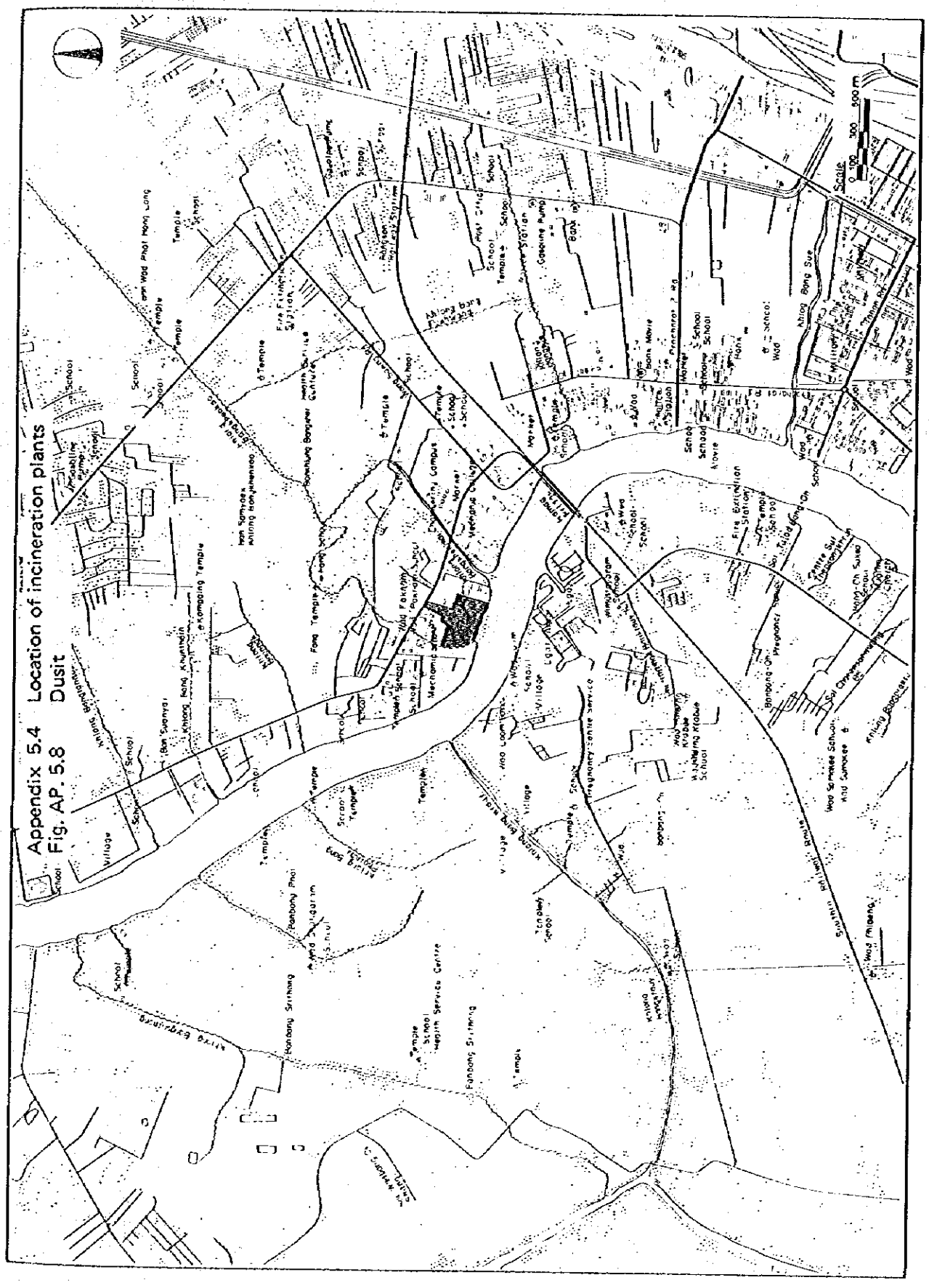
Appendix 5.4
Fig. AP. 5.5
Location of incineration plants
Bang Kapi
Scale
0
100
200
300 m

Appendix 5.4 Location of incineration plants
Fig. AP. 5.6 Bangkok Noi
Scale
0
100
300
500 m

Appendix 5.4 Location of incineration plants

Fig. AP. 5.7 Phasi Charoen




Appendix 5.4 Location of incineration plants
Fig. AP. 5.8 Dusit

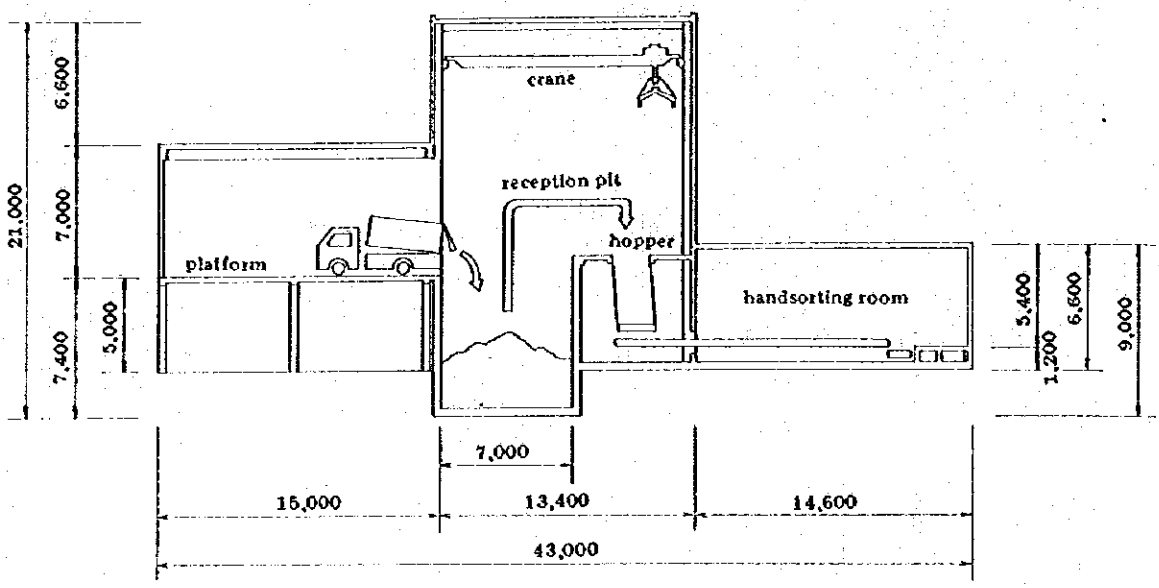
Appendix 5.5 Location of compost plants
Fig. AP. 5.9 Bang Khun Tian
Scale
0 300 500m

Appendix 5.5 Location of compost plants
Fig. AP. 5.10 Taling Chan
Scale
0 100 200 500 m

Appendix 5.6 Design drawing of the compost plant

Fig. Ap 5.11 Solid waste reception and separation house

(1) Section (Unit: mm)



(2) Plane (Unit: mm)

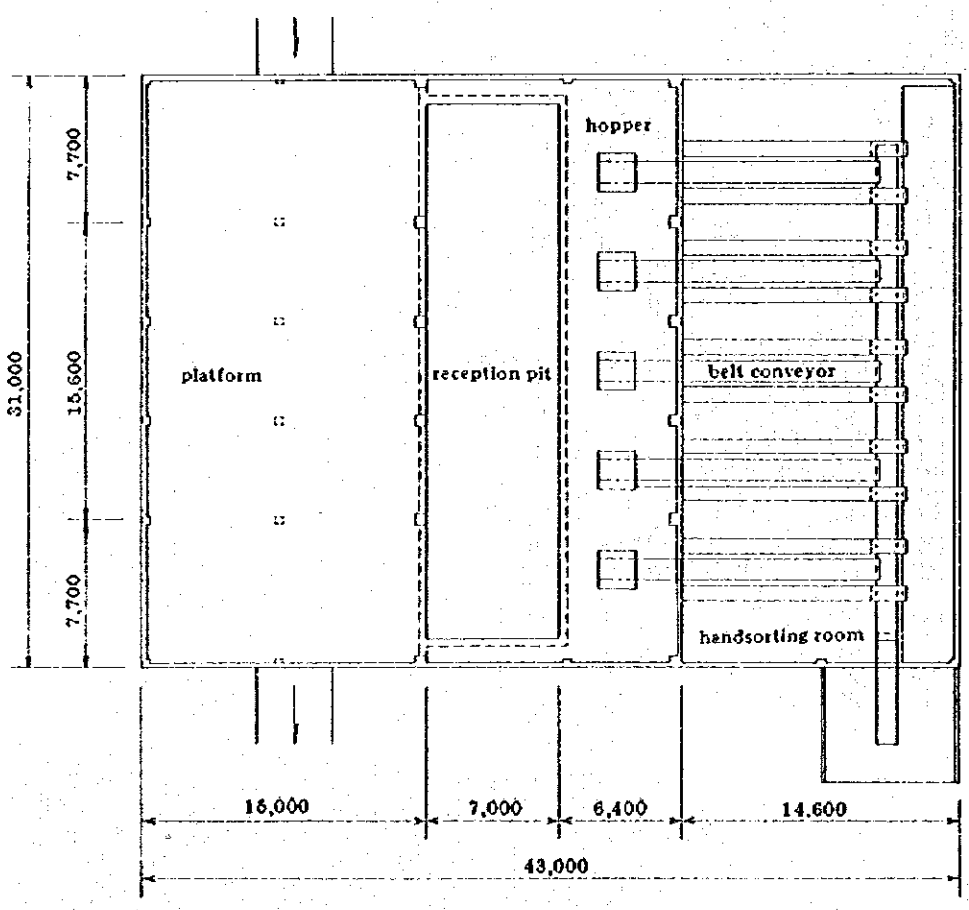


Fig. Ap 5.12 Fermentation house

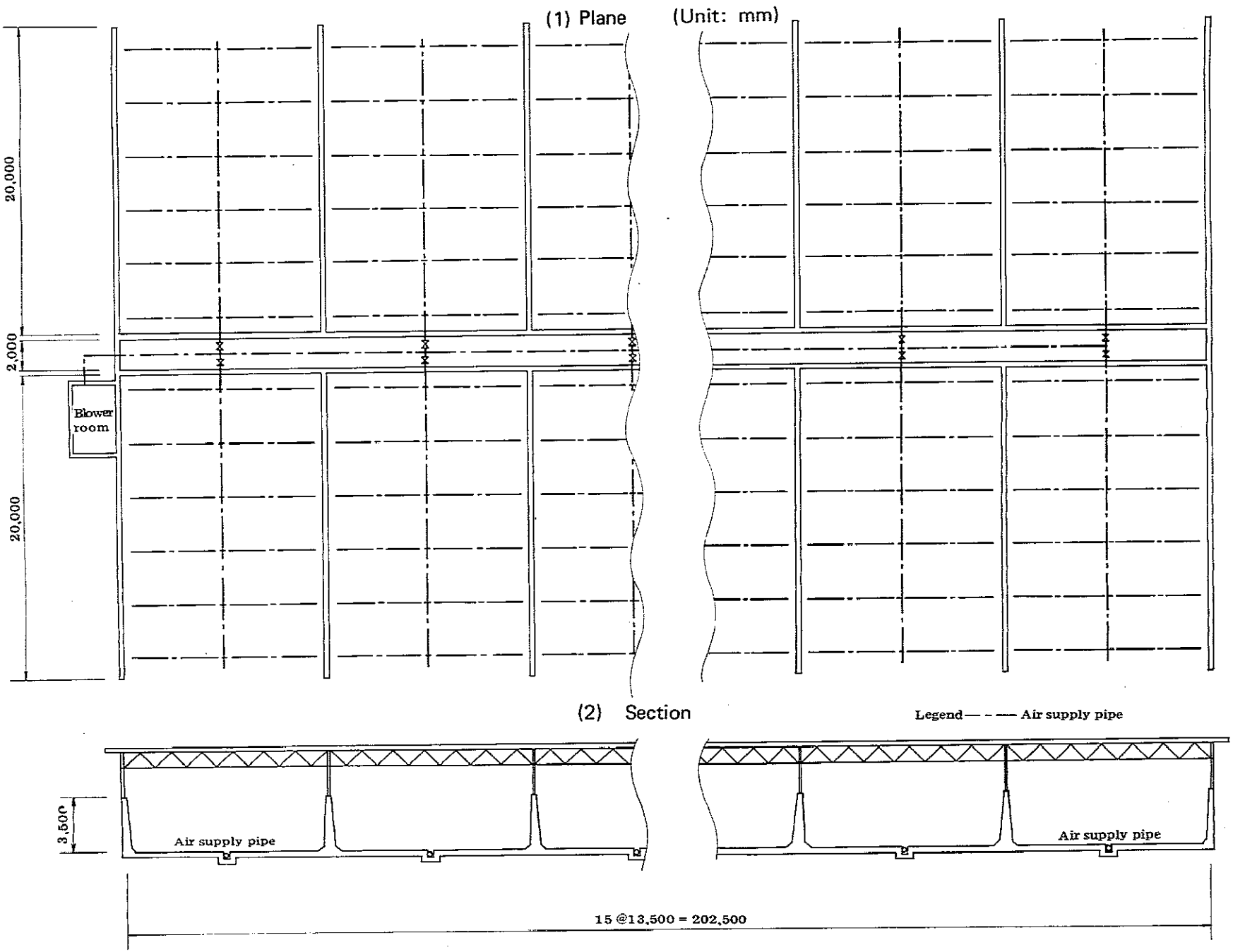
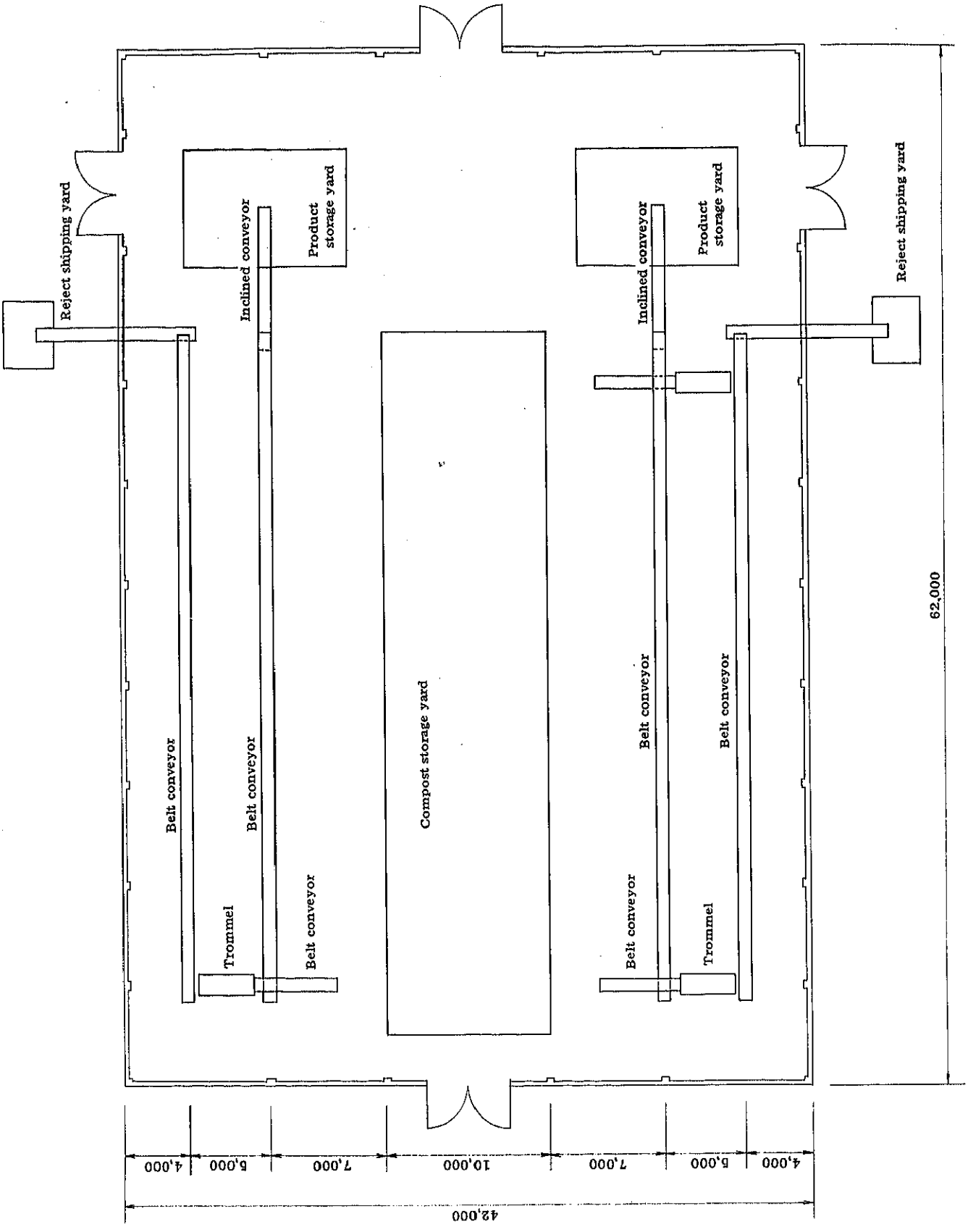


Fig. AP 5.13 Trommel screen house (Unit: mm)



Appendix 5.7 Planned landfill volume by year

Table AP 5.1 Planned landfill volume (Case No. 9)

(Unit: m^3)

Fiscal Year	Disposal volume					
	On-Nooch		Nong Khaem		Ram Intra	
	Gross (incl. rejects and residue)	Incoming waste	Gross (incl. rejects and residue)	Incoming waste	Gross (incl. rejects and residue)	Incoming waste
1983	170,755	105,283	247,712	225,193	32,736	0
4	187,924	122,452	257,991	234,537	"	0
5	192,784	143,184	270,068	245,516	"	0
6	202,871	169,143	285,100	259,182	"	0
7	230,640	196,912	301,032	273,665	16,864	0
8	198,602	164,874	236,149	214,681	152,796	135,932
9	217,991	184,263	251,342	228,493	176,389	159,525
1990	233,642	199,914	289,083	262,803	176,944	160,080
1	256,506	222,778	316,481	287,710	"	"
2	280,830	247,102	345,133	313,757	"	"
3	302,303	268,575	395,060	359,145	"	"
4	329,481	295,753	432,616	393,287	"	"
5	358,114	324,386	471,783	428,894	"	"
6	391,447	355,861	507,825	461,659	"	"
7	427,429	388,572	401,619	365,108	"	"
8	477,026	433,660	432,354	393,049	"	"
9	526,766	478,878	462,994	420,904	"	"
2000	582,575	529,614	496,984	451,804	"	"
1	639,855	581,686	525,303	477,548	152,198	135,334
2	669,203	608,366	549,397	499,452	158,406	141,542
3	701,663	637,875	574,281	522,074	162,864	146,000
4	740,251	672,955	599,983	545,439	"	"
5	779,089	708,263	623,997	567,270	"	"
6	813,142	739,220	646,610	587,827	"	"
7	845,876	768,978	668,346	607,587	"	"
8	879,440	799,491	690,635	627,850	"	"
9	913,858	830,780	713,490	648,627	"	"
2010	949,150	862,864	736,925	669,932	"	"
Total	13,499,213	12,041,682	12,730,293	11,572,993	4,036,893	3,501,213

Volume of rejects and residue is detailed in the table below.

(Period: fiscal 1983-2010)

(Unit: m^3)

Site	Rejected materials from compost	Residue from the incinerator attached to the existing compost plants	Residue from the incineration plants	*1 Covering soil
On-Nooch	690,432	333,312	0	433,787
Nong Khaem	152,768	83,328	0	921,204
Ram Intra	369,024	166,656	0	0

Note *1 Compost rejects and incineration residue will be utilized as covering material and the shortage of the material will be made up for by soil.

Table AP 5.2 Planned landfill volume (Case No. 13)

(Unit: m^3)

Fiscal Year	Disposal volume					
	On-Nooch		Nong Khaem		Ram Intra	
	Gross (incl. rejects and residue)	Incoming waste	Gross (incl. rejects and residue)	Incoming waste	Gross (incl. rejects and residue)	Incoming waste
1983	170,755	105,283	247,712	225,193	32,736	0
4	187,924	122,452	257,991	234,537	"	0
5	192,784	143,184	270,068	245,516	"	0
6	202,871	169,143	285,100	259,182	"	0
7	230,640	196,912	301,032	273,665	16,864	0
8	198,602	164,874	280,250	254,773	112,704	95,840
9	217,991	184,263	321,396	292,178	"	"
1990	239,833	206,105	352,937	320,852	"	"
1	105,688	71,960	170,612	155,102	109,971	93,107
2	112,585	78,857	217,327	197,570	110,975	94,111
3	119,447	85,719	353,175	321,068	111,956	95,092
4	127,074	93,346	411,415	374,014	112,704	95,840
5	135,092	101,364	473,260	430,236	"	95,840
6	83,245	49,517	144,883	131,712	36,755	19,891
7	85,850	52,122	163,424	148,567	59,344	42,480
8	93,331	59,603	203,258	184,780	69,944	53,080
9	105,061	71,333	193,843	176,221	75,310	58,446
2000	126,455	92,727	246,799	224,363	87,534	70,670
1	55,556	21,828	26,663	18,231	26,732	9,868
2	79,511	45,783	46,671	38,239	37,562	20,698
3	104,252	70,524	67,335	58,903	48,746	31,882
4	129,804	96,076	88,676	80,244	60,298	43,434
5	156,194	122,466	112,221	102,019	72,017	55,153
6	177,552	143,824	131,793	119,812	81,636	64,772
7	199,238	165,510	151,665	137,877	91,402	74,538
8	221,475	187,747	172,042	156,402	101,417	84,553
9	244,277	210,549	192,937	175,397	111,686	94,822
2010	267,658	233,930	214,361	194,874	122,215	105,351
Total	4,370,745	3,347,001	6,098,846	5,531,527	2,126,828	1,591,148

Volume of rejects and residue is detailed in the table below.

(Period: fiscal 1983-2010)

(Unit: m^3)

Site	Rejected materials from compost	Residue from the incinerator attached to the existing compost plants	Residue from the incineration plants	*1 Covering soil
On-Nooch	690,432	333,312	0	0
Nong Khaem	152,768	83,328	188,089	143,134
Ram Intra	369,024	166,656	0	0

Note *1 Compost rejects and incineration residue will be utilized as covering material and the shortage of the material will be made up for by soil.

Table AP 5.3 Planned landfill volume (Case No. 19-(2))

(Unit: m^3)

Fiscal Year	Disposal volume					
	On-Nooch		Nong Khaem		Ram Intra	
	Gross (incl. rejects and residue)	Incoming waste	Gross (incl. rejects and residue)	Incoming waste	Gross (incl. rejects and residue)	Incoming waste
1983	170,755	105,283	247,712	225,193	32,736	0
4	187,924	122,452	257,991	234,537	"	0
5	192,784	143,184	270,068	245,516	"	0
6	202,871	169,143	285,100	259,182	"	0
7	230,640	196,912	301,032	273,665	16,864	0
8	198,602	164,874	280,250	254,773	112,704	95,840
9	217,991	184,263	321,396	292,178	"	"
1990	239,833	206,105	352,937	320,852	"	"
1	105,688	71,960	170,612	155,102	109,971	93,107
2	112,585	78,857	217,327	197,570	110,975	94,111
3	119,447	85,719	353,175	321,068	111,956	95,092
4	127,074	93,346	411,415	374,014	112,704	95,840
5	135,092	101,364	473,260	430,236	"	"
6	133,884	100,156	226,667	206,061	51,927	35,063
7	147,789	114,061	280,674	255,158	59,005	42,141
8	162,342	128,614	326,304	296,640	76,000	59,136
9	189,024	155,296	283,098	257,362	96,878	80,014
2000	231,092	197,364	309,351	281,228	112,704	95,840
1	273,568	239,840	206,209	187,463	83,329	66,465
2	300,182	266,454	229,092	208,265	90,705	73,841
3	327,670	293,942	252,724	229,749	98,322	81,458
4	356,058	322,330	277,132	251,938	106,189	89,325
5	386,815	351,650	299,893	272,630	113,215	96,351
6	414,522	376,838	321,373	292,157	120,116	103,252
7	441,101	401,001	341,980	310,891	126,737	109,873
8	468,357	425,779	363,111	330,101	133,526	116,662
9	496,305	451,186	384,778	349,798	140,487	123,623
2010	524,962	477,238	406,996	369,996	147,624	130,761
Total	7,094,957	6,025,211	8,451,657	7,683,323	2,600,995	2,065,315

Volume of rejects and residue is detailed in the table below.

(Period: fiscal 1983-2010)

(Unit: m^3)

Site	Rejected materials from compost	Residue from the incinerator attached to the existing compost plants	Residue from the incineration plants	*1 Covering soil
On-Nooch	690,432	333,312	46,002	0
Nong Khaem	152,768	83,328	389,104	143,134
Ram Intra	369,024	166,656	0	0

Note *1 Compost rejects and incineration residue will be utilized as covering material and the shortage of the material will be made up for by soil.

Table AP 5.4 Planned landfill volume (without-project case)

(Unit: m^3)

Fiscal Year	Disposal volume					
	On-Nooch		Nong Khaem		Ram Intra	
	Gross (incl. rejects and residue)	Incoming waste	Gross (incl. rejects and residue)	Incoming waste	Gross (incl. rejects and residue)	Incoming waste
1983	170,755	705,283	233,625	225,193	32,736	0
4	187,924	122,452	242,969	234,537	"	0
5	192,784	143,184	253,948	245,516	"	0
6	202,871	169,143	267,614	259,182	"	0
7	230,640	196,912	282,097	273,665	16,864	0
8	198,602	164,874	223,113	214,681	152,796	135,932
9	217,991	184,263	236,925	228,493	176,389	159,525
1990	233,642	199,914	271,235	262,803	176,944	160,080
1	256,506	222,778	296,142	287,710	"	"
2	280,830	247,102	322,189	313,757	"	"
3	305,328	271,600	429,032	420,600	"	"
4	332,630	298,902	463,050	454,618	"	"
5	361,363	327,635	498,557	490,125	"	"
6	392,987	359,259	531,173	522,741	"	"
7	436,436	402,708	557,804	549,372	"	"
8	481,872	448,144	585,398	576,966	"	"
9	527,511	493,783	612,729	604,297	"	"
2000	578,640	544,912	643,360	634,928	"	"
1	641,754	608,026	654,998	646,566	155,254	138,390
2	665,670	631,942	680,430	671,998	160,698	143,834
3	693,827	660,099	706,696	698,264	162,864	146,000
4	725,144	691,416	733,824	725,392	"	"
5	756,664	722,936	759,428	750,996	"	"
6	784,305	750,577	783,316	774,884	"	"
7	810,866	777,138	806,273	797,841	"	"
8	838,103	804,375	829,812	821,380	"	"
9	866,031	832,303	853,950	845,518	"	"
2010	894,669	860,941	878,701	870,269	"	"
Total	13,266,345	12,242,601	14,638,388	14,402,292	4,042,241	3,506,561

Volume of rejects and residue is detailed in the table below.

(Period: fiscal 1983-2010)

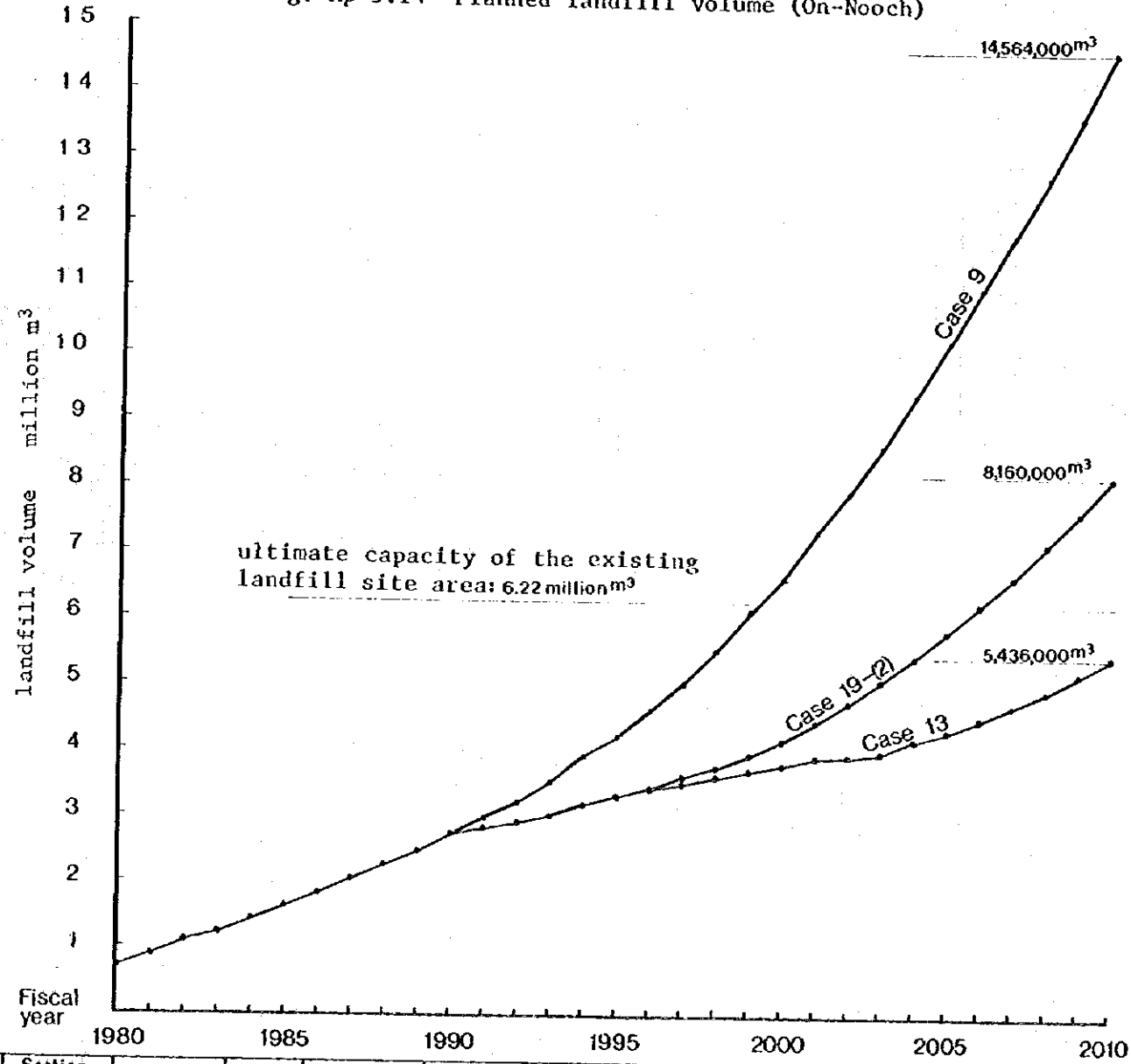
(Unit: m^3)

Site	Rejected materials from compost	Residue from the incinerator attached to the existing compost plants	Residue from the incineration plants	*1 Covering soil
On-Nooch	690,432	333,312	0	0
Nong Khaem	152,768	83,328	0	0
Ram Intra	369,024	166,656	0	0

Note *1 Compost rejects and incineration residue will be utilized as covering material and the shortage of the material will be made up for by soil.

Appendix 5.8 Landfill volume for each section and landfill schedule

Fig. Ap 5.14 Planned landfill volume (On-Nooch)



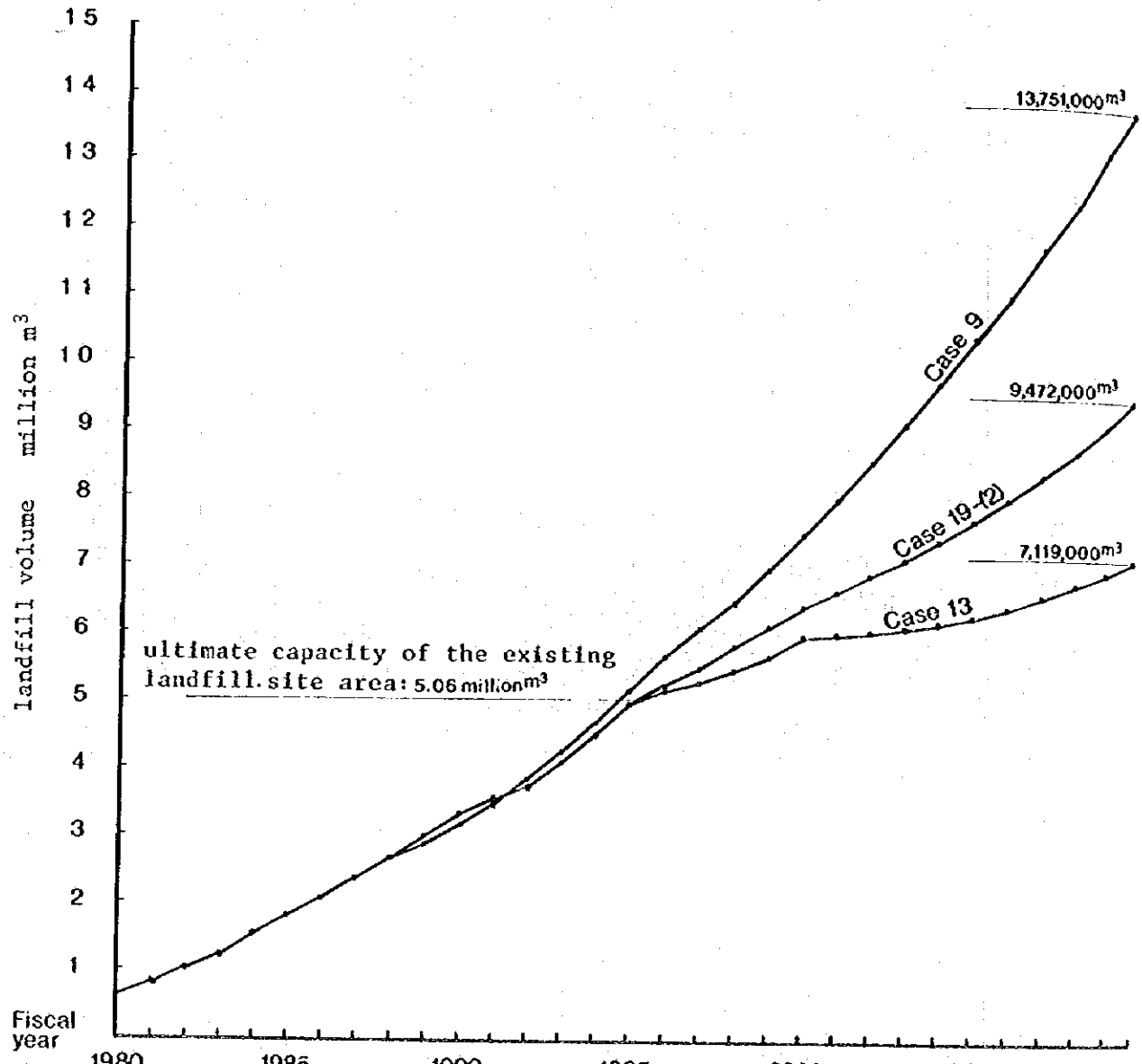
Case No.19-(2)	Section No	1	2	3	4	5	6	7	8	9 10 11
	Capacity (1,000m³)	1,322	453	801	371	965	856	1,433	1,400	696
	Area (1,000m²)	119	48	78	40	92	65	106	85	86

Case No.13	Section No	1	2	3	4	5	6	7.8.9
	Capacity (1,000m³)	1,322	453	801	371	965	856	1,454
	Area (1,000m²)	119	48	78	40	92	65	136

Case No.9	Section No	1	2	3	4	5	6	7	8	9.10
	Capacity (1,000m³)	1,322	453	801	371	1,820	2,292	2507	1,952	3,154
	Area (1,000m²)	119	48	78	40	158	189	203	42	269

Note : 1. Capacity means ultimate capacity of the section. Capacity of the final section is planned to enable to accept the disposed-of volume with a room.
2. Area means botton area of the landfill.

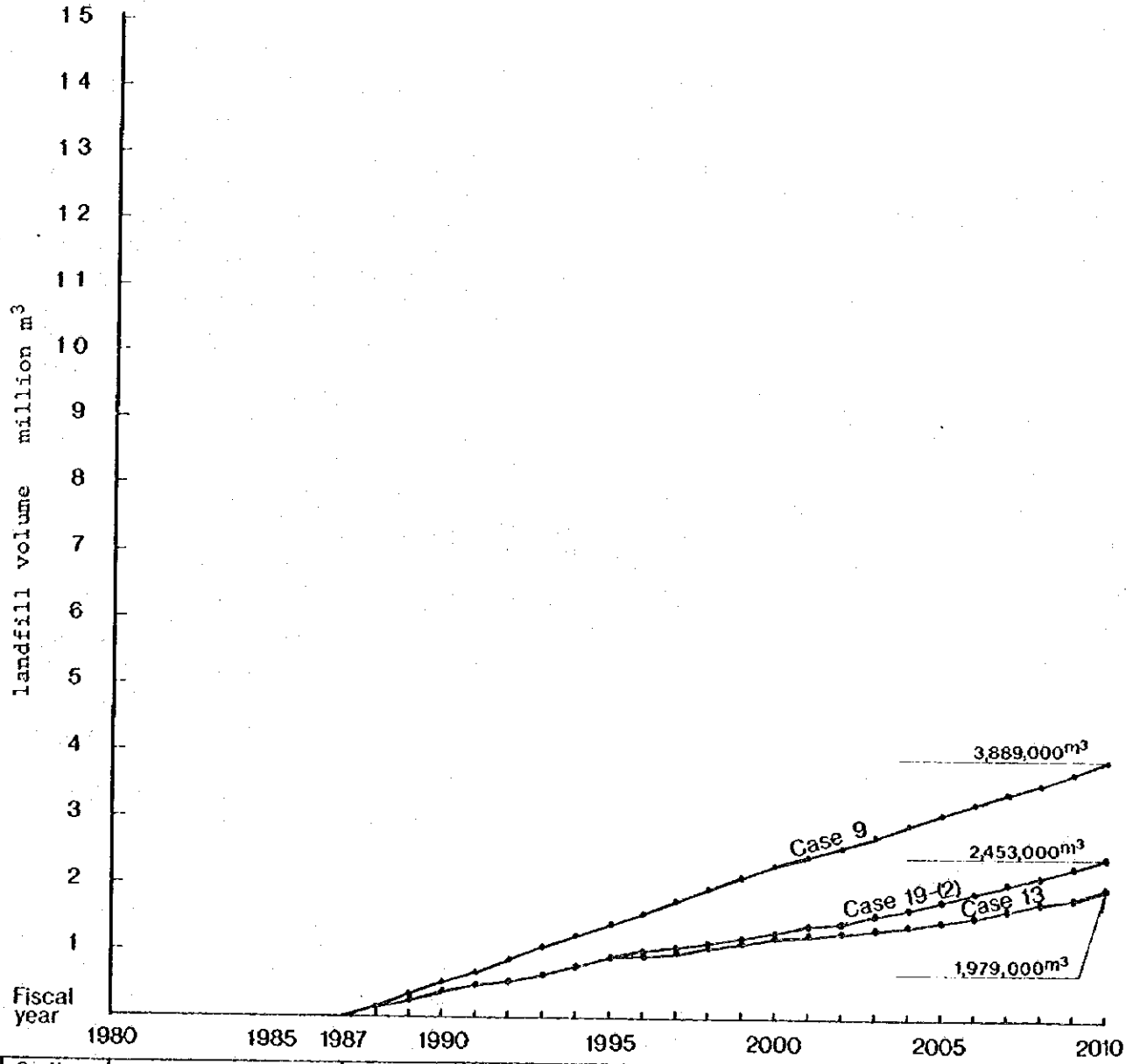
Fig. AP 5.15 Planned landfill volume (Nong Khaem)



Case No.9-(2)	Section No	1	2	3	4	5		6.7.8
	Capacity (1,000m³)	1,770	1,823	1,419	1,390	2,309		768
	Area (1,000m²)	136	154	111	127	163		44
Case No.13	Section No	1	2	3	4	5 . 6 . 7		
	Capacity (1,000m³)	1,770	1,823	1,419	1,145	1,012		
	Area (1,000m²)	136	154	111	118	53		
Case No.9	Section No	1	2	3	4	5	6	789
	Capacity (1,000m³)	1,770	1,823	2,523	2,309	1,784	2,675	942
	Area (1,000m²)	136	154	227	163	131	179	43

Note : 1. Capacity means ultimate capacity of the section. Capacity of the final section is planned to enable to accept the disposed-of volume and a little more.
2. Area means bottom area of a fill.

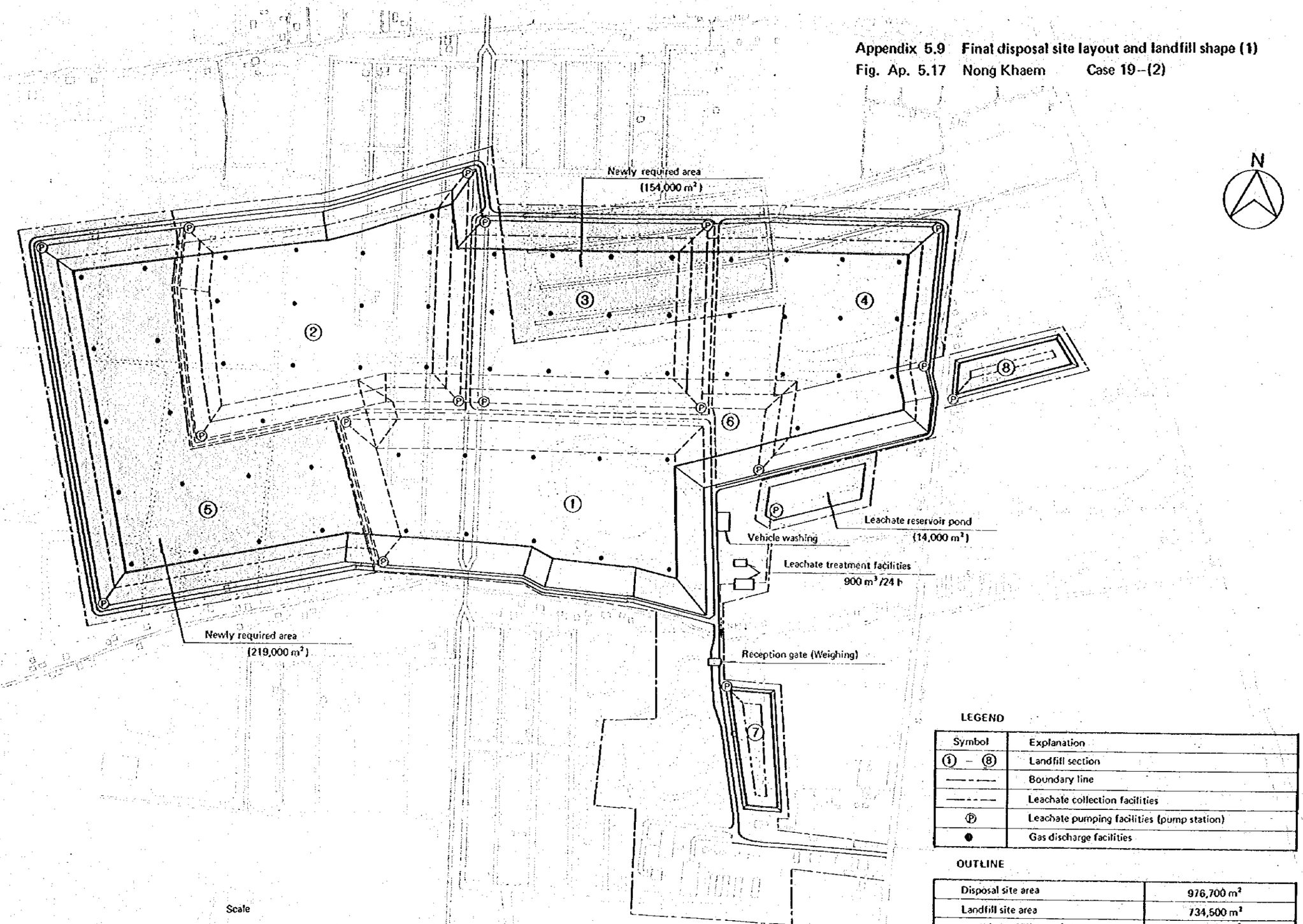
Fig. Ap 5.16 Planned landfill volume (Ram Intra)



Case No.19-(2)	Section No		1	2	3	4	5
	Capacity (1000m³)		605	593	513	543	212
	Area (1000m²)		58	59	42	38	7
Case No.13	Section No		1	2	3		4
	Capacity (1000m³)		669	567	515		242
	Area (1000m²)		64	47	51		11
Case No.9	Section No		1	2	3	4	5
	Capacity (1000m³)		882	835	922	312	960
	Area (1000m²)		82	78	69	14	87

Note : 1. Capacity means ultimate capacity of the section. Capacity of the final section is planned to enable to accept the disposed-of volume and a little more.
2. Area means bottom area of a fill.

Appendix 5.9 Final disposal site layout and landfill shape (1)
Fig. Ap. 5.17 Nong Khaem Case 19–(2)



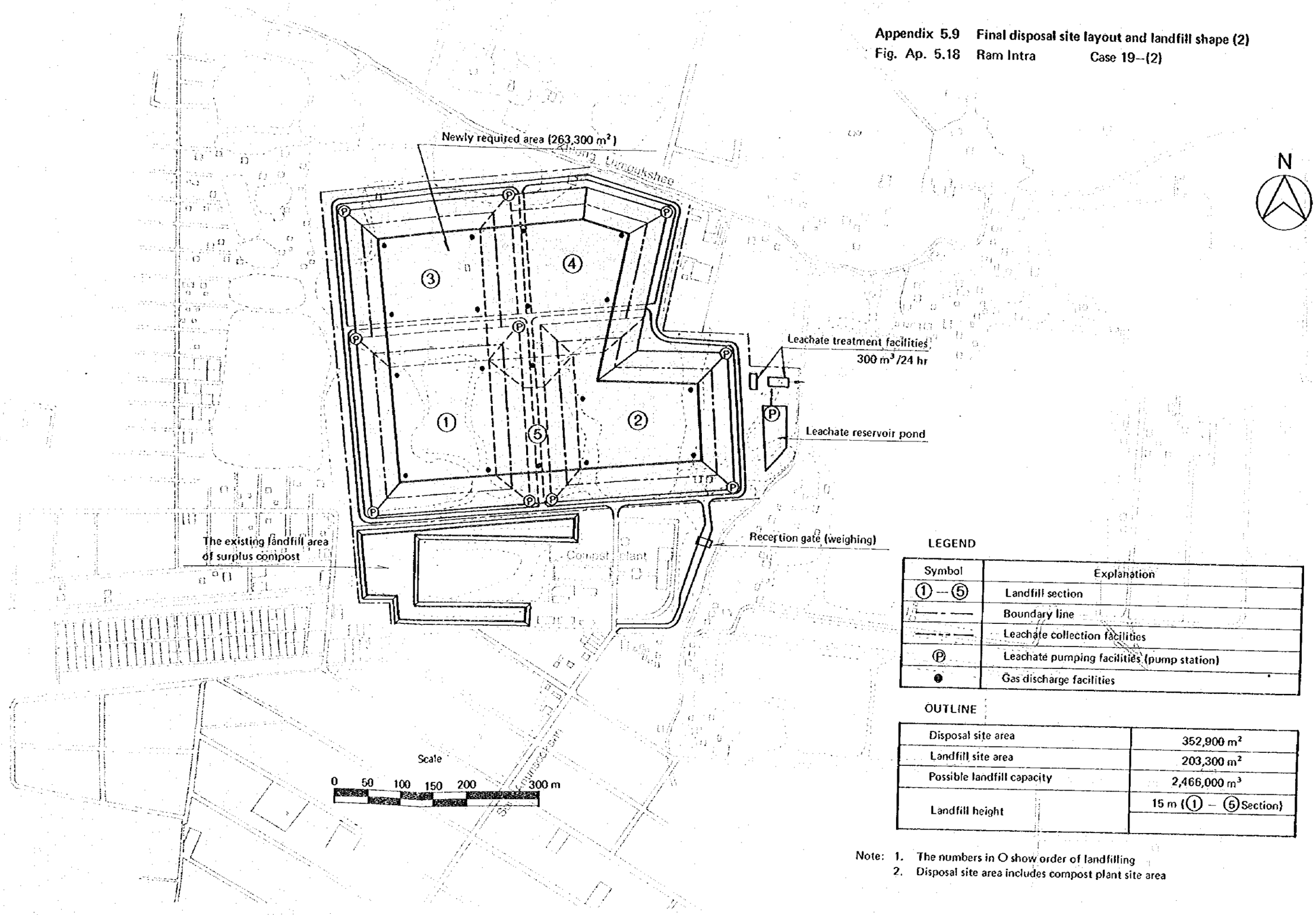
LEGEND

Symbol	Explanation
① – ⑧	Landfill section
———	Boundary line
———	Leachate collection facilities
Ⓟ	Leachate pumping facilities (pump station)
●	Gas discharge facilities

OUTLINE

Disposal site area	976,700 m²
Landfill site area	734,500 m²
Possible landfill capacity	9,478,000 m³
Landfill height	15 m (①–⑥ Section)
	3 m (⑦, ⑧ Section)

Note: 1. The numbers in O show order of landfilling.
2. Disposal site area includes compost plant site area.



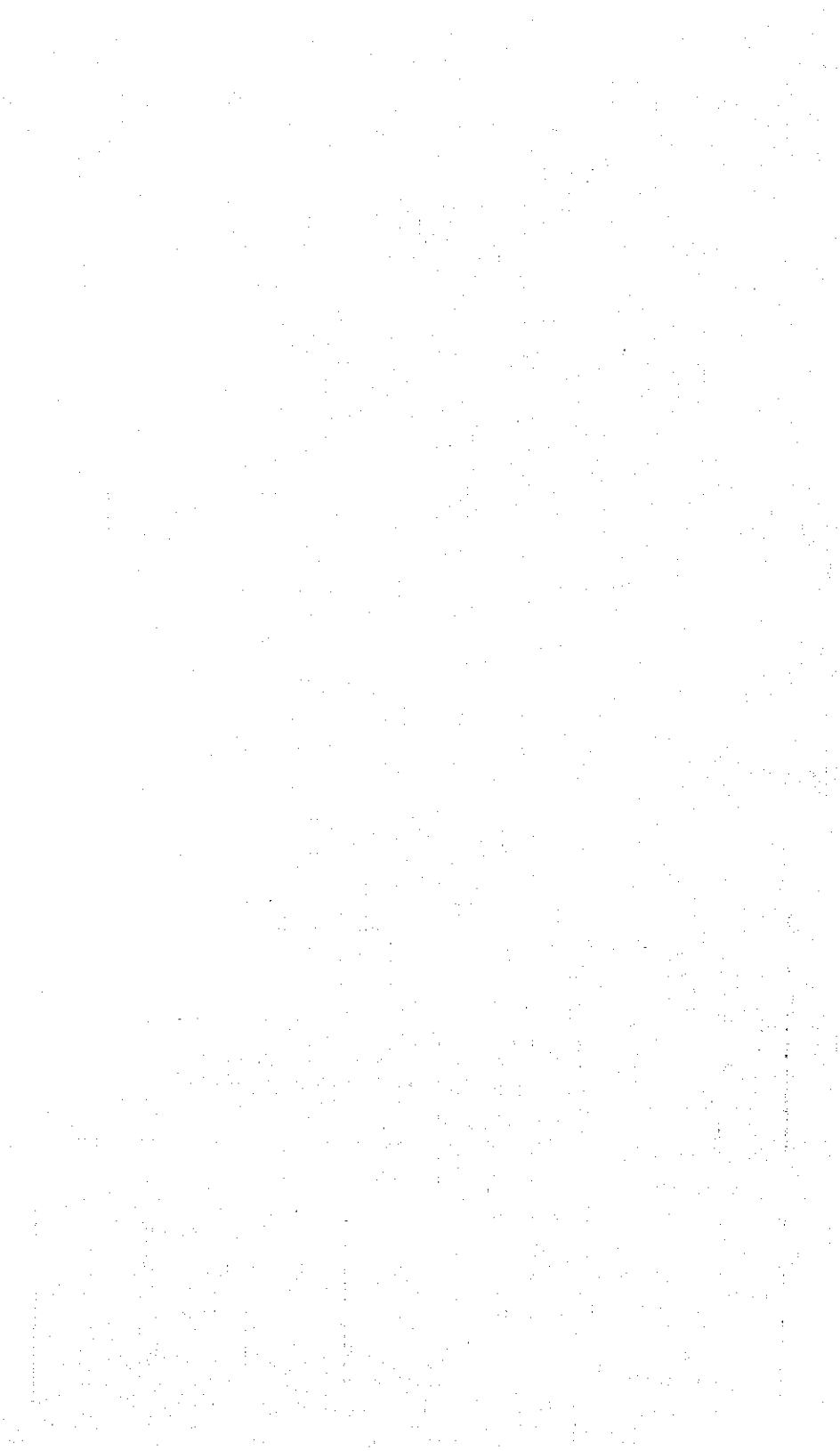
LEGEND

Symbol	Explanation
① – ⑤	Landfill section
	Boundary line
	Leachate collection facilities
Ⓟ	Leachate pumping facilities (pump station)
●	Gas discharge facilities

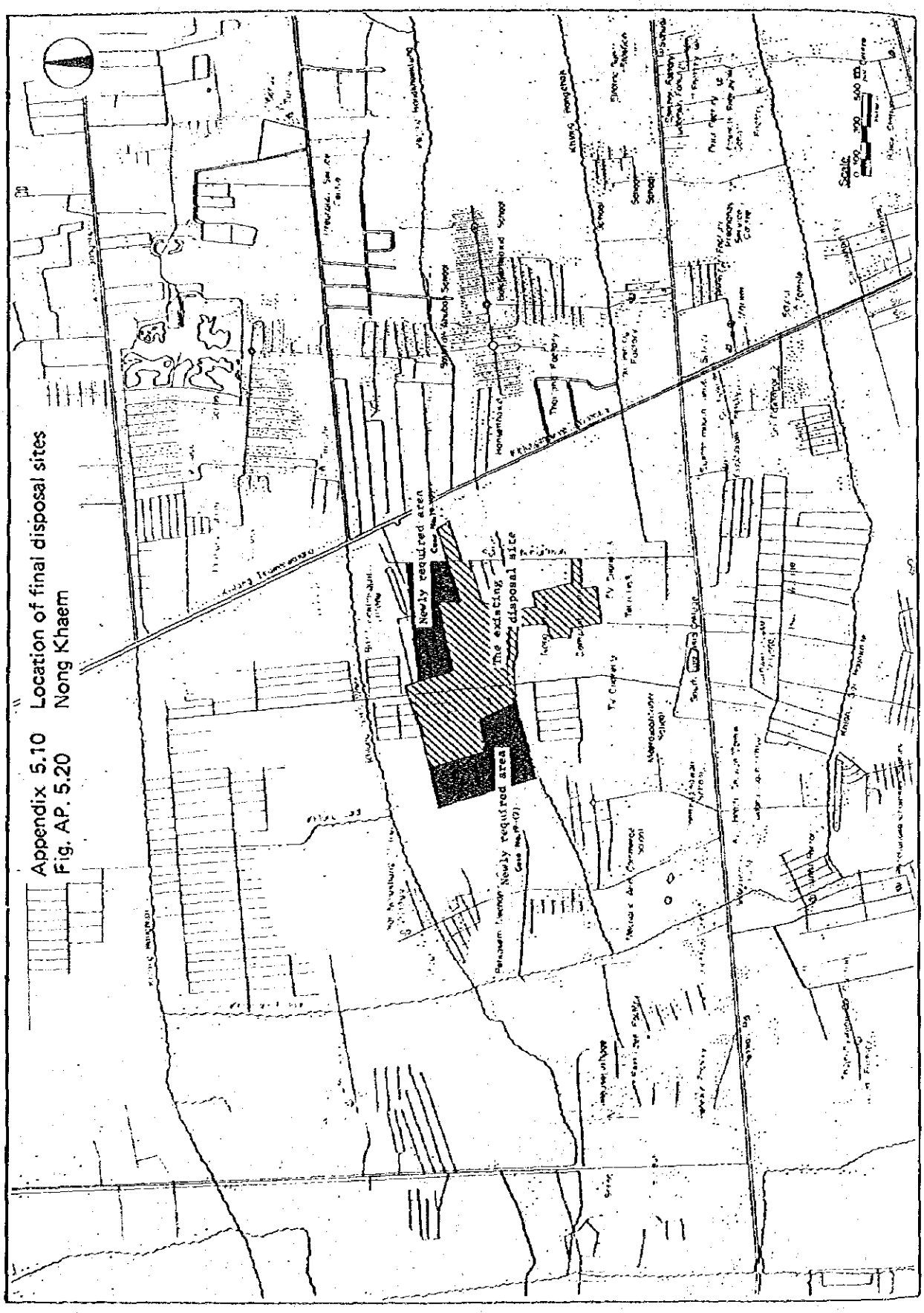
OUTLINE

Disposal site area	352,900 m²
Landfill site area	203,300 m²
Possible landfill capacity	2,466,000 m³
Landfill height	15 m (① – ⑤ Section)

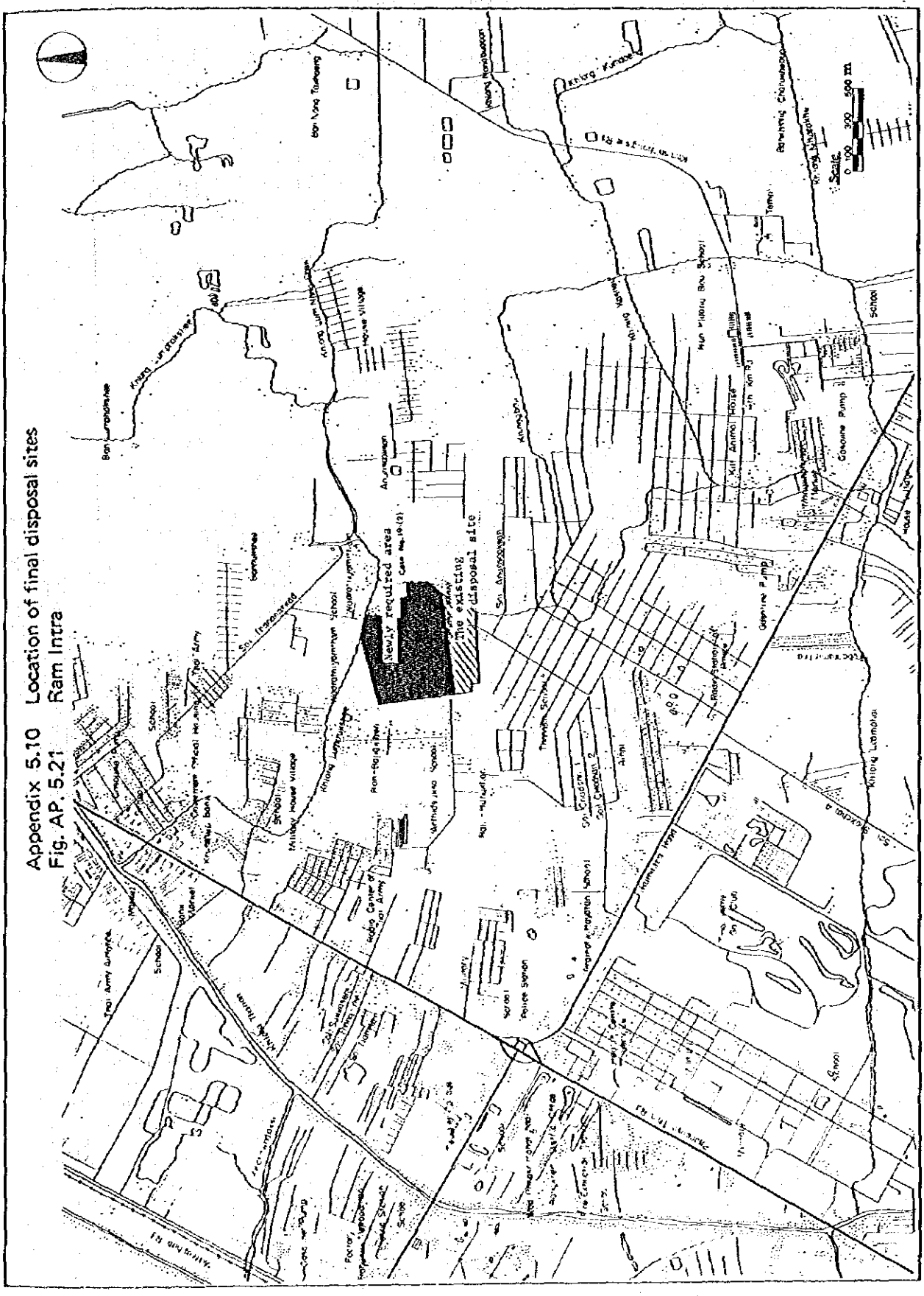
Note: 1. The numbers in O show order of landfilling
2. Disposal site area includes compost plant site area



Appendix 5.10 Location of final disposal sites
Fig. AP. 5.19 On-Nooch
The existing disposal site
Newly required area


Appendix 5.10
Fig. AP. 5.20
Location of final disposal sites
Nong Khaem
Newly required area
The existing disposal site
Newly required area
Scale

Appendix 5.10 Location of final disposal sites
Fig. AP. 5.21 Ram Intra



Appendix 5.11 Outline of leachate treatment facilities

Table AP 5.5 Capacity of leachate treatment facilities

Site	Case No.	Capacity (m^3/d)	Remark
On-Nooch	9	400	to be constructed by 1987
		600	to be constructed in 1992
		500	to be constructed in 2003
	13	500	to be constructed by 1987
	19-(2)	500	to be constructed by 1987
		200	to be constructed in 2000
Nong Khaem	9	800	to be constructed by 1986
		500	to be constructed in 2002
	13	800	to be constructed by 1987
	19-(2)	900	to be constructed by 1987
Ram Intra	9	450	to be constructed by 1988
	13	300	- ditto -
	19-(2)	300	- ditto -

Note: The total of the capacities are planned to increase as the completed landfill increases. The quantity of leachate is determined by the following equation.

$$Q = \frac{1}{1,000}(C_1A_1 + C_2A_2)P$$

where, Q = leachate discharge volume per year (m^3/year)

C_1 = coefficient of seepage in a working section (assumed to be 1.0)

C_2 = coefficient of seepage in a completed section (assumed to be 0.4)

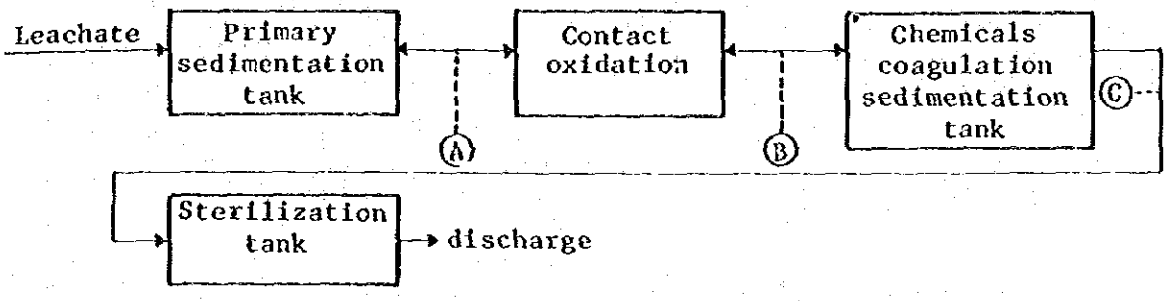
A_1 = area of a working section (m^2)

A_2 = area of a completed section (m^2)

P = precipitation (assumed 912 mm/year)

Capacity is determined to treat Q on a 80% operation rate and 20% surplus rate bases.

Table AP 5.6 Process flow and pollutant concentration



(Unit: mg/L*1)

Leachate (incoming and after treatment)				
Consti-tuent	Position			
	Incoming	Ⓐ	Ⓑ	Ⓒ
pH	7 - 9			5 - 9
BOD	200	200	20(90%)*2	20
COD	700	700	700	350(50%)*2
SS	200	120(40%)*2	120	30(75%)*2

Note: *1 Except pH

*2 Figures in parentheses show the removed quantity of constituent in percent.

Table AP 5.7 Design criteria

Item	Criteria
1. Primary sedimentation tank Surface loading Retention time Weir loading	 $\leq$20 $m^3/m^2 \cdot d$ $\geq$3 h $\leq$100 $m^3/m \cdot d$
2. Contact oxidation tank BOD loading	0.6 $kg/m^3 \cdot d$ (for fillers)
3. Chemicals mixing tank Retention time	 $\geq$10 min
4. Chemicals coagulation tank Retention time	 $\geq$10 min
5. Coagulation sedimentation tank Surface loading Retention time Weir loading	 $\leq$20 $m^3/m^2 \cdot d$ $\geq$3 h $\leq$100 $m^3/m \cdot d$

Table AP 5.8 Reservoir pond capacity

(Unit: m^3)

Case No.	On-Nooch	Nong Khaem	Ram Intra
9	26,000	22,000	8,000
13	9,000	14,000	5,000
19-(2)	11,000	16,000	5,000

Note: Capacity was determined by the following equation:

$$Q = \frac{1}{1,000} (Cm\ P\ A_1 + Cm'\ P'\ A_2)$$

$$Cm = \frac{1}{100} (0.002\ P^2 + 0.16\ P + 21)$$

$$Cm' = \frac{1}{100} (0.002\ P'^2 + 0.16\ P + 21)$$

where, Q = Reservoir pond capacity (m^3)

P = Annually probable maximum precipitation per day (assumed to be 89.3 mm/d)

P' = Absorbed portion of P by fill (P-run-off quantity) (assumed to be 0.6 P)

A_1 = Working section (m^2)

A_2 = Completed section (m^2)

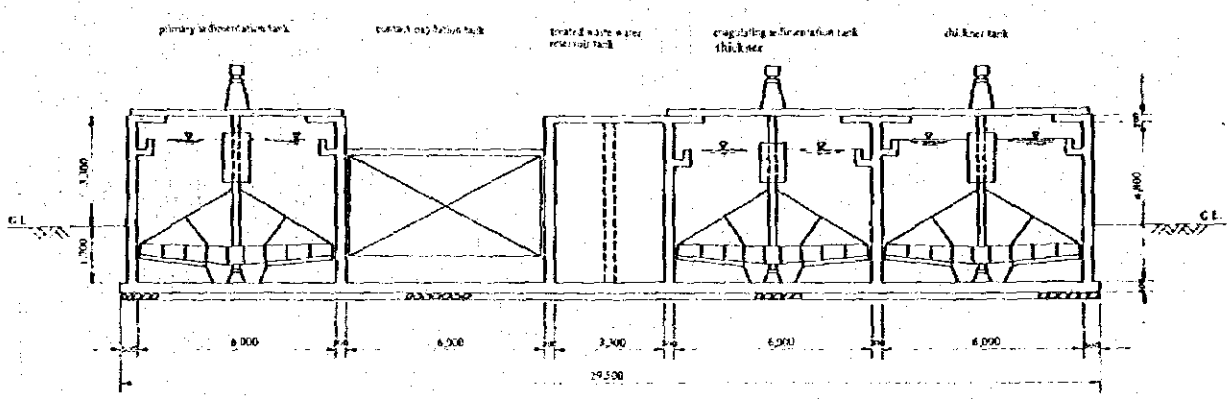
Cm = Percolation coefficient of landfill-working section

Cm' = Percolation coefficient of completed section

Fig. Ap 5.22 Design drawing of leachate treatment facilities

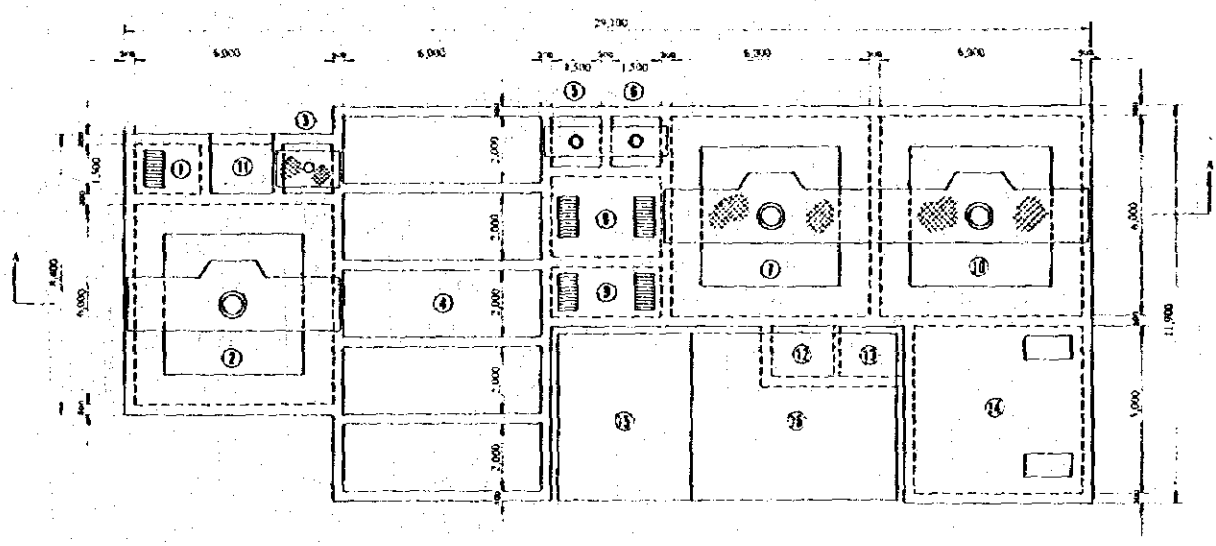
(1) Section (A-A section)

(Unit: mm)



(2) Plane

(Unit: mm)



Symbol	Name of equipment	Symbol	Name of equipment	Symbol	Name of equipment
①	reception tank (fitted with screen)	⑦	coagulating sedimentation tank	⑬	sludge discharge pump sump
②	primary sedimentation tank	⑧	treated waste water reservoir tank	⑭	sludge storage tank
③	pH adjustment tank	⑨	sterilizing tank	⑮	blower and pump room
④	contact oxidation tank	⑩	thickener tank	⑯	chemicals pumps and tanks room
⑤	chemical reaction tank	⑪	sludge discharge pump sump		
⑥	coagulation tank	⑫	sludge discharge pump sump		

Note In addition to the above equipment, a control house (including operation room, instrument room and analysing room), an electric house and a workroom are necessary.

Appendix 5.12 Purchase schedule of trucks and other equipment

Table AP 5.9 Collection

(Unit: vehicle)

Case No.	Equipment	Period (fiscal year) 1983 to 1985	1986 to 1990	1991 to 1995	1996 to 2000	2001 to 2005	2006 to 2010	Total
9	Compactor	90	238	515	600	570	790	2,803
	Container loader	0	0	20	5	14	20	59
	Dump truck	52	17	0	55	23	10	157
	Total	142	255	535	660	607	820	3,019
13	Compactor	90	206	428	490	435	610	2,259
	Container loader	0	0	21	6	12	21	60
	Dump truck	52	17	0	45	18	6	138
	Total	142	223	449	541	465	637	2,457
19-(2)	Compactor	90	206	428	515	495	640	2,374
	Container loader	0	0	21	6	12	21	60
	Dump truck	52	17	0	0	45	23	137
	Total	142	223	449	521	552	684	2,571
W/O	Compactor	90	238	515	630	580	810	2,863
	Container loader	0	0	21	6	16	21	64
	Dump truck	52	17	0	57	23	10	159
	Total	142	255	536	693	619	841	3,086

Table AP 5.10 Road sweeping

(Unit: vehicle)

Equipment	Period (fiscal year) 1983 to 1985	1986 to 1990	1991 to 1995	1996 to 2000	2001 to 2005	2006 to 2010	Total
Dump truck	0	8	8	7	12	11	46
Mech. road sweeper	2	2	9	11	5	17	46
Road washer	0	0	11	10	2	23	46
Compactor with a crane	0	7	10	10	9	10	46
Total	2	17	38	38	28	61	184

Note: Equipment plan is the same in all cases (9, 13, 19-(2), W/O).

Table AP 5.11 River and canal cleaning

(Unit: unit)

Equipment	Period (fiscal year)						Total
	1983 to 1985	1986 to 1990	1991 to 1995	1996 to 2000	2001 to 2005	2006 to 2010	
Mechanical working boat	1	1	1	2	1	1	7
Small boat	4	10	55	40	10	55	174
Dump truck	0	1	17	7	6	17	48
Total	5	12	73	49	17	73	229

Note: Equipment plan is the same in all cases (9, 13, 19-(2), W/O).

Table AP 5.12 Incineration residue hauling

(Unit: vehicle)

Case No.	Equipment	Period (fiscal year)						Total
		1983 to 1985	1986 to 1990	1991 to 1995	1996 to 2000	2001 to 2005	2006 to 2010	
13	Residue truck	0	13	19	10	13	19	74
19-(2)		0	13	13	0	13	13	52

Table AP 5.13 Compost plant

(Unit: vehicle)

Case No.	Equipment	Period (fiscal year)						Total
		1983 to 1985	1986 to 1990	1991 to 1995	1996 to 2000	2001 to 2005	2006 to 2010	
9	Front-end loader	0	11	3	7	7	0	28
	Crawler dozer	0	8	2	2	7	0	19
	Backhoe	0	2	2	0	4	0	8
	Dump truck	1	9	5	4	9	1	29
	Other vehicle		2	2	1	2	3	10
	Total	1	32	14	14	29	4	94
13 & 19-(2)	Front-end loader	0	9	2	10	2	5	28
	Crawler dozer	0	5	2	4	3	4	18
	Backhoe	0	0	2	2	0	4	8
	Dump truck	1	7	4	9	4	7	32
	Other vehicle	0	0	2	2	1	3	8
	Total	1	21	12	27	10	23	94
W/O	Front-end loader	0	9	0	7	2	0	18
	Crawler dozer	0	5	0	2	3	0	10
	Dump truck	1	7	2	5	4	1	20
	Total	1	21	2	14	9	1	48

Note: Other vehicles include station wagons for general use.

Table AP 5.14 Final disposal

(Unit: vehicle)

Case No.	Equipment	Period (fiscal year)						Total
		1983 to 1985	1986 to 1990	1991 to 1995	1996 to 2000	2001 to 2006	2007 to 2010	
9	Front-end loader		7	5	5	10	3	30
	Crawler dozer		3		3			6
	Backhoe		3		2	1		6
	Dump truck		3		3	2		8
	Other vehicle	2	13	2	13	2	10	42
	Total	2	29	7	26	15	13	92
13	Front-end loader		6	4	2	5	2	19
	Crawler dozer		3		3			6
	Backhoe		3		2	1		6
	Dump truck		3		2	1		6
	Other vehicle	2	13	2	13	2	10	42
	Total	2	28	6	22	9	12	79
19-(2)	Front-end loader		7	3	3	9	1	23
	Crawler dozer		3		3			6
	Backhoe		3		2	1		6
	Dump truck		3		2	1		6
	Other vehicle	2	13	2	13	2	10	42
	Total	2	29	5	23	13	11	83
W/O	Crawler dozer		2	4	2	7		15
	Other vehicle		6		6			12
	Total		8	4	8	7		27

Note: Other vehicles include jeeps, disinfecting trucks, water trucks, fire engines, etc.

Appendix 5.13 Additional labor requirements

Table AP 5.15 Collection

(Unit: person)

Case No.	Kind of worker	Period (fiscal year) 1983 to 1985	1986 to 1990	1991 to 1995	1996 to 2000	2001 to 2005	2006 to 2010	Total
9	Driver	129	153	280	430	263	233	1,488
	Collector	272	353	601	1,015	777	687	3,705
	Total	401	506	881	1,445	1,040	920	5,193
13	Driver	129	153	203	253	157	184	1,079
	Collector	272	353	338	511	464	543	2,481
	Total	401	506	541	764	621	727	3,560
19-(2)	Driver	129	153	203	282	231	194	1,192
	Collector	272	353	338	598	684	574	2,819
	Total	401	506	541	880	915	768	4,011
W/O	Driver	129	153	288	466	271	240	1,547
	Collector	272	353	625	1,118	798	709	3,875
	Total	401	506	913	1,584	1,069	949	5,422

Table AP 5.16 Road sweeping

(Unit: person)

Kind of worker	Period (fiscal year) 1983 to 1985	1986 to 1990	1991 to 1995	1996 to 2000	2001 to 2005	2006 to 2010	Total
Sweeper	72	170	330	460	150	150	1,332
Driver	0	19	26	22	7	14	88
Assistant	Δ 39	9	11	9	5	9	4
Total	33	198	367	491	162	173	1,424

Note: Excess labor (refer to as Δ) is to be redistributed to other positions.
Manpower requirements are the same in all cases (9, 13, 19-(2), W/O).

Table AP 5.17 River cleaning

(Unit: person)

Kind of worker	Period (fiscal year) 1983 to 1985	1986 to 1990	1991 to 1995	1996 to 2000	2001 to 2005	2006 to 2010	Total
Boat crew member	29	66	75	112	0	0	282
Driver, Worker	0	0	26	30	0	0	56
Total	29	66	101	142	0	0	338

Note: Manpower requirements are the same in all cases (9, 13, 19-(2), W/O).

Table AP 5.18 Incineration residue hauling

(Unit: person)

Case No.	Kind of worker	Period (fiscal year) 1983 to 1985	1986 to 1990	1991 to 1995	1996 to 2000	2001 to 2005	2006 to 2010	Total
13	Driver	0	14	22	10	0	0	46
19-(2)	Driver	0	14	14	0	0	0	28

Table AP 5.19 Incineration plant

(Unit: person)

Plant capacity	Officer	Driver	Worker	Skilled worker	Engineer	Total
1,500 ton per day plant	8	3	30	47	10	98
1,100-1,200 ton per day plant	7	3	28	36	10	84

Table AP 5.20 Compost plant

(Unit: person)

Name of plant	Skilled worker	Hand-sorting workman	Officer	Landfill operation worker	Engineer	Total
Bang Khun Tian	19	60	5	10	2	96
Taling Chan	29	120	7	12	3	171
Total	48	180	12	22	5	267

Table AP 5.21 Final disposal site

(Unit person)

Case No.	Period (fiscal year) 1983 to 1985	1986 to 1990	1991 to 1995	1996 to 2000	2001 to 2005	2006 to 2010	Total
9	20	42	25	28	35	30	180
13	20	35	1	Δ 18	Δ 3	13	48
19-(2)	20	36	1	Δ 9	15	24	87
W/O	9	10	29	26	23	30	127

Note: Figures in the table show the total number of officers, engineers, drivers, landfill operation workers and skilled workers.

Appendix 5.14 Personnel for an incineration plant

Table AP 5.22 Personnel for an incineration plant

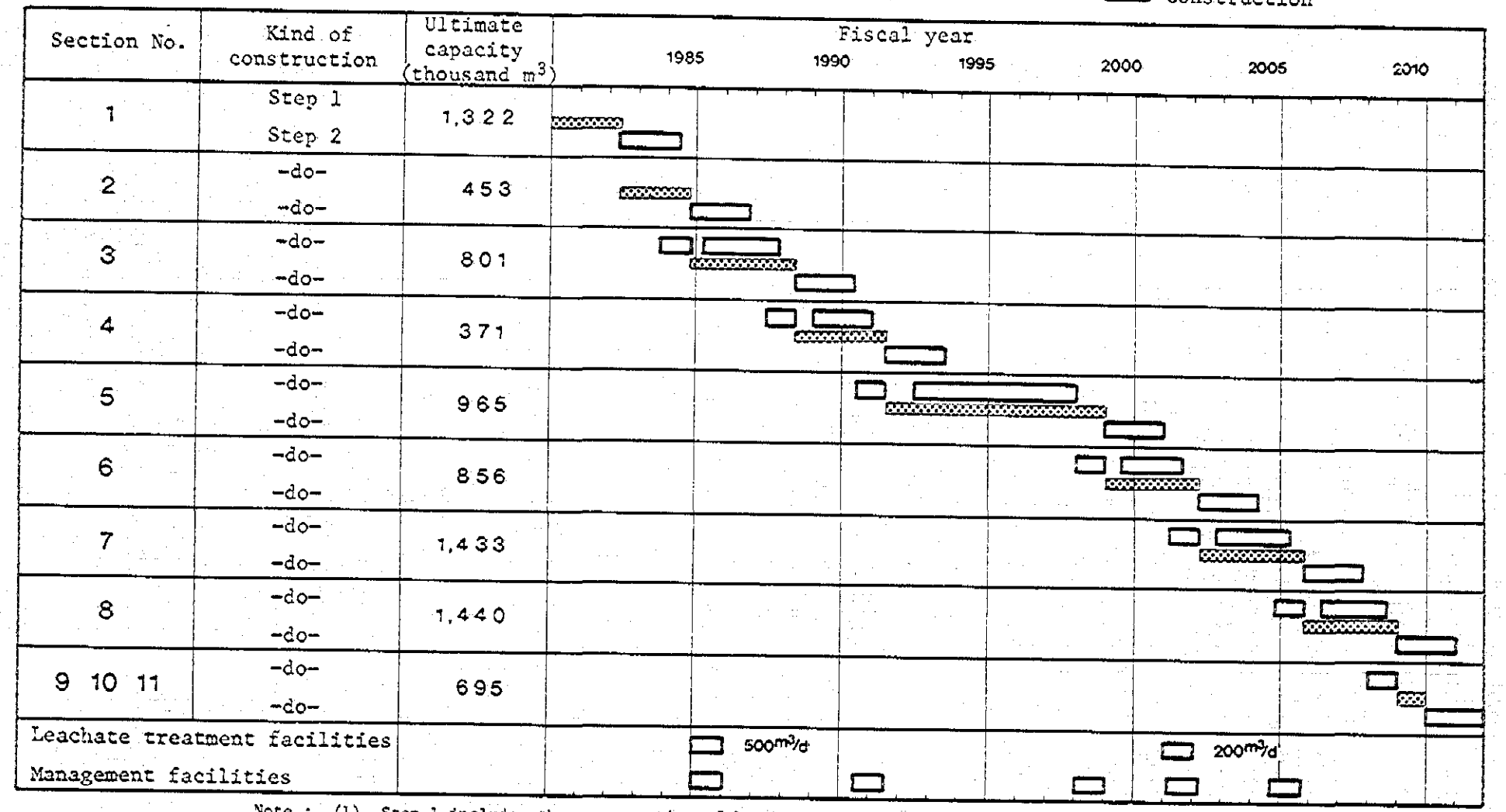
Duty	Content	Number of workers (person)				
		W	S	D	O	E
Concerning scaling	reception, scaling, data processing	2 1	1 1		1 1	
Concerning platform	control and indication of incoming trucks, sweeping	4 3	1 1			
Control center	control and operation of equipment	4 4	4 4			
Concerning furnace	operation and routine maintenance of furnace	4 4	12 8			
Crane operation	operation and routine maintenance of cranes	7 7				
Technical management	operation and maintenance planning, pollution control		3 3			1 1
Material management	acquisition of items necessary for daily operation and routine maintenance	1 1	1 1			
Power generation management	power generation management, safety management		1 1			1 1
Boiler-turbine	operation and maintenance of boiler and turbine	4 4	8 4			
Special maintenance	planning and management of overhaul, special maintenance		11 8			1 1
Shredder	operation and routine maintenance of shredder		1 1			
Water treatment	operation and maintenance of waste water treatment and pure water production equipment	4 4	4 4			
Driver	driving of a commuters' car and a messenger car			3 3		
General management	general management, personnel management, contract, accounting				6 5	
Manager	top and middle managers				1 1	7 7
Total		30 28	47 36	3 3	8 7	10 10

Legend: Upper figures in the column "No. of workers" are for a 1,500 ton per day plant and lower figures for a 1,100 or 1,200 ton per day plant.

W: Worker
S: Skilled worker
D: Driver
O: Officer
E: Engineer

Appendix 5.15 Construction and landfill implementation schedule at final disposal site

Fig. AP 5.23 On-Nooch Case No. 19-(2)

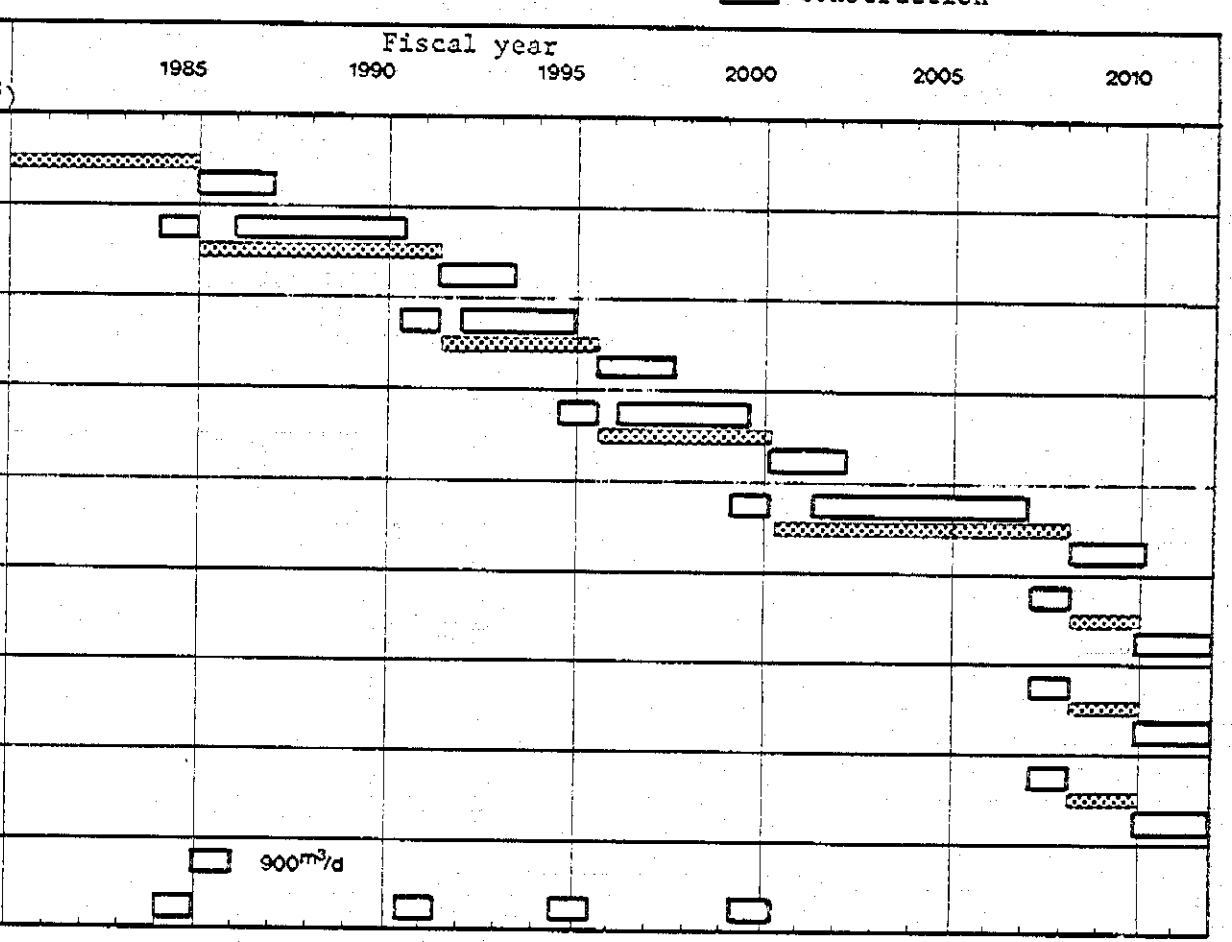


Note : (1) Step 1 includes the construction of leachate collection and discharge facilities embankment, etc.
(2) Step 2 includes the final soil covering, construction of rainwater drain and gas discharge facilities, etc.
(3) Construction during landfill work includes construction of embankment from the second to fifth stories.

Fig. AP 5.24 Nong Khaem Case No. 19-(2)

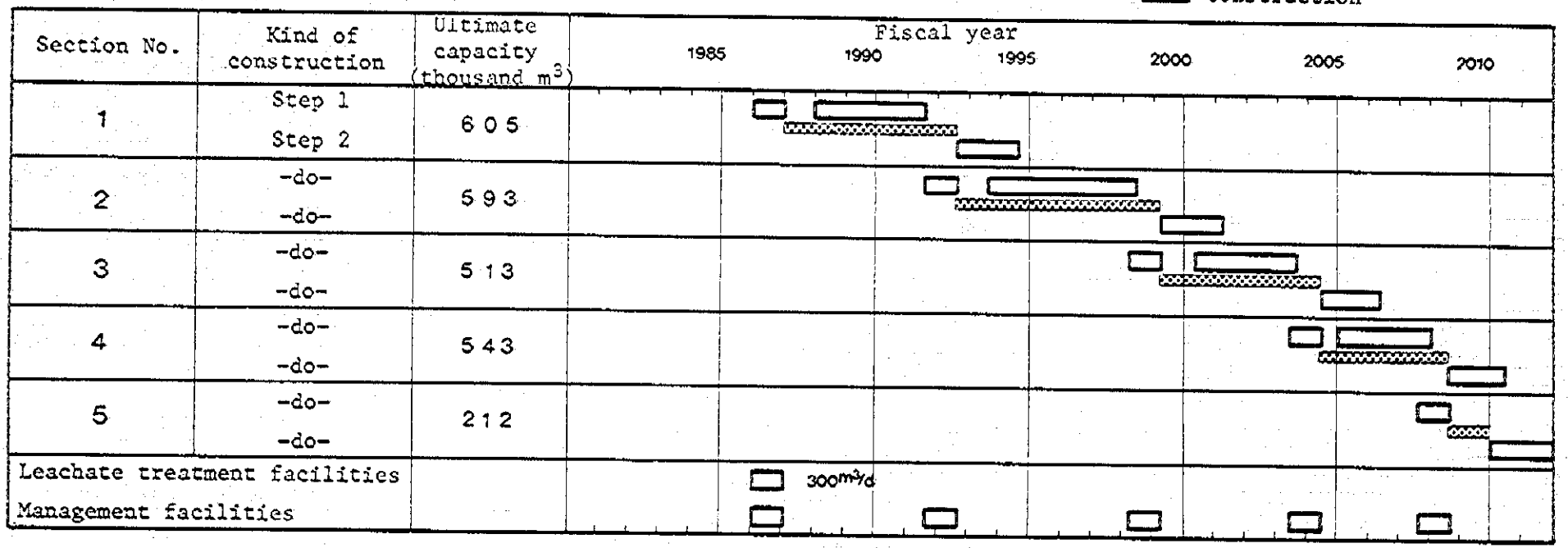
Legend : Landfill work
construction

Section No.	Kind of construction	Ultimate capacity (thousand m^3)
1	Step 1 Step 2	1,770
2	-do- -do-	1,823
3	-do- -do-	1,419
4	-do- -do-	1,390
5	-do- -do-	2,309
6	-do- -do-	706
7	-do- -do-	35
8	-do- -do-	27
Leachate treatment facilities		
Management facilities		



Note : (1) Step 1 includes the construction of leachate collection and discharge facilities embankment, etc.
(2) Step 2 includes the final soil covering, construction of rainwater drain and gas discharge facilities, etc.
(3) Construction during landfill work includes construction of embankment from the second to fifth stories.

Fig. AP 5.25 Ram Intra Case No. 19-(2)



Note : (1) Step 1 includes the construction of leachate collection and discharge facilities embankment, etc.
(2) Step 2 includes the final soil covering, construction of rainwater drain and gas discharge facilities, etc.
(3) Construction during landfill work includes construction of embankment from the second to fifth stories.

Appendix 5.16 Construction cost items of incineration plants

Table AP 5.23 Cost for architectural and civil work (incineration plant)

(Unit: thousand Baht)

Construction item	Construction work	Plant									
		Yannawa		Dusit		Bang Kapi		Bangkok Noi		Phasi Charoen	
		Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local
Superstructure	Concrete work	0	70,201	0	70,201	0	56,160	0	51,480	0	51,480
	Steel work	41,664	66,893	41,664	66,893	33,332	53,514	30,554	87,555	30,554	87,555
	Others	0	60,849	0	60,849	0	48,827	0	6,258	0	6,258
	Total	41,664	197,943	41,664	197,943	33,332	158,501	30,554	145,293	30,554	145,293
Substructure	Pile and foundation	104	28,943	104	28,943	81	22,633	75	20,783	75	20,783
Miscellaneous	Clearance & reclamation	0	29,888	0	15,054	0	20,100	0	14,265	0	17,640
	Access road	0	0	0	502	0	505	0	257	0	8,615
	In-site road	2	2,964	2	2,118	2	2,896	2	2,287	2	2,553
	Parking yard	0	3,694	0	5,540	0	0	0	4,925	0	0
	Electricity and water supply	207	393	240	527	281	538	190	395	182	968
	Others	4	5,684	4	6,103	0	6,455	4	4,810	0	6,119
	Total	213	42,623	246	29,844	283	30,494	196	26,939	184	35,895

Table AP 5.24 Purchase and installation cost for equipment of the incineration plant
(1,500 ton per day)

(Unit: thousand Baht)

Name of equipment	Equipment Cost						Installation work cost	
	CIF	Duty	Standard profit	Business tax	Financial cost	Economic cost	Foreign labor	Local labor
Reception and charging equipment	40,842	4,084.2	7,188.2	1,886.5	54,000.9	48,030.2	3,726.8	555.2
Incinerator	133,064	13,306.4	23,419.3	5,093.7	174,883.3	156,483.2	19,059.6	2,839.6
Boiler	114,328	11,432.8	20,121.8	4,376.6	150,259.2	134,449.8	11,365.2	1,693.1
Steam condenser	3,026	302.6	532.6	115.8	3,977.0	3,558.6	142.8	31.6
Pure water production	8,117	811.7	1,428.6	310.7	10,668.0	9,545.6	943.6	140.7
Particulate emission control	125,594	12,559.4	22,104.5	4,807.7	165,065.6	147,698.5	12,807.2	1,908.1
Water supply	4,055	405.5	713.7	155.2	5,329.4	4,768.7	245.0	36.6
Waste water treatment	37,631	3,763.1	6,623.1	1,440.5	49,457.7	44,254.1	3,740.8	557.3
Recovered heat utilization	34,660	3,466.0	6,100.2	1,326.8	45,553.0	40,760.2	432.6	64.3
Power generation	36,720	10,795.6	5,287.4	3,639.9	56,442.9	42,007.4	3,956.4	589.4
Air supply	10,752	1,075.2	1,892.3	411.5	14,131.0	12,644.3	1,068.2	159.3
Flue and others	18,715	3,406.1	3,040.6	1,197.7	26,359.4	21,755.6	1,412.6	210.5
Stack	14,820	1,482.0	2,608.3	567.3	19,477.6	17,428.3	3,017.0	449.4
Residue crane	10,690	1,069.0	1,881.4	409.2	14,049.6	12,571.4	1,950.2	290.6
Electric equipment	79,992	23,997.6	11,438.9	8,080.0	123,508.5	91,430.9	7,298.2	1,087.4
Instrumentation	79,239	23,771.7	11,331.2	8,003.9	122,345.8	90,570.2	5,376.0	800.9
Piping	28,129	8,438.7	4,022.4	2,841.3	43,431.4	32,151.4	7,099.4	1,057.7

Table AP 5.25 Purchase and installation cost for equipment of the incineration plant
(1,200 ton per day)

(Unit; thousand Baht)

Name of equipment	Equipment Cost						Installation work cost	
	CIF	Duty	Standard profit	Business tax	Financial cost	Economic cost	Foreign labor	Local labor
Reception and charging equipment	35,884	3,588.4	6,315.5	1,657.5	47,445.4	42,199.5	3,274.6	487.9
Incinerator	116,431	11,643.1	20,491.8	4,457.1	153,023	136,922.8	16,676.8	2,484.6
Boiler	100,037	10,003.7	17,606.6	3,829.5	131,476.8	117,643.6	9,944.2	1,481.4
Steam condenser	2,659	265.9	468.0	101.8	3,494.7	3,127.0	186.2	13.9
Pure water production	6,757	675.7	1,189.2	258.7	8,880.6	7,946.2	830.2	123.6
Particulate emission control	109,895	10,989.5	19,341.5	4,206.8	144,432.8	129,236.5	10,026.8	1,493.8
Water supply	19,479	1,947.9	3,428.3	745.7	25,600.9	22,907.3	229.6	34.1
Waste water treatment	33,063	3,306.3	5,819.1	1,265.7	43,454.1	38,882.1	3,287.2	489.6
Recovered heat utilization	30,453	3,045.3	5,359.7	1,165.7	40,023.7	35,812.7	379.4	56.5
Power generation	32,475	9,547.7	4,676.2	3,219.2	49,918.1	37,151.2	3,500.0	521.3
Air supply	9,408	940.8	2,003.8	370.6	12,723.2	11,411.8	935.2	139.3
Flue and others	16,375	2,980.3	2,660.4	1,048.0	23,063.7	19,035.4	1,236.2	184.2
Stack	13,021	1,302.1	2,291.7	498.4	17,113.2	15,312.7	2,650.2	394.8
Residue crane	9,393	939.3	1,653.2	359.6	12,345.1	11,046.2	1,713.6	255.3
Electric equipment	70,282	21,084.6	10,050.3	7,099.2	108,516.1	80,332.3	6,413.4	955.4
Instrumentation	69,620	20,886.0	9,955.7	7,032.3	107,494.0	79,575.7	4,723.6	703.7
Piping	23,836	7,150.8	3,408.5	2,407.7	36,803.0	27,244.5	6,238.4	929.3

Fig. AP 5.26 Unit construction cost (financial)

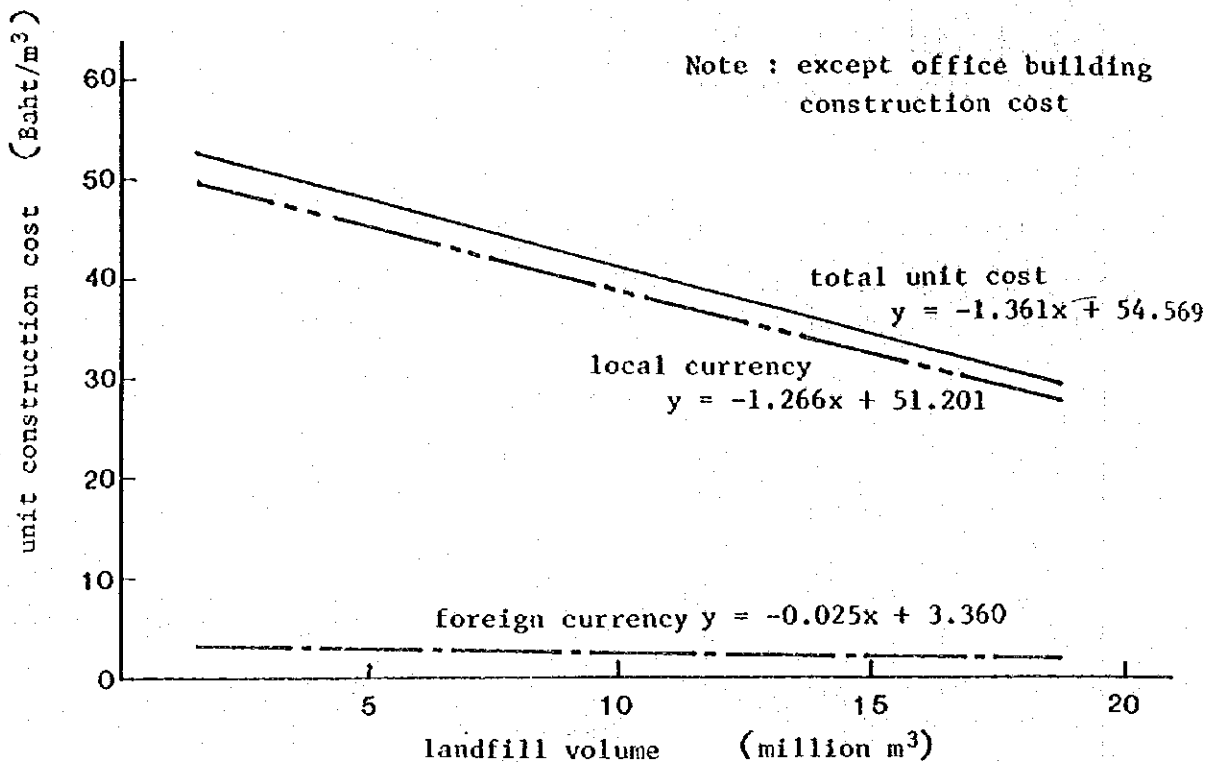


Fig. AP 5.27 Unit construction cost (economic)

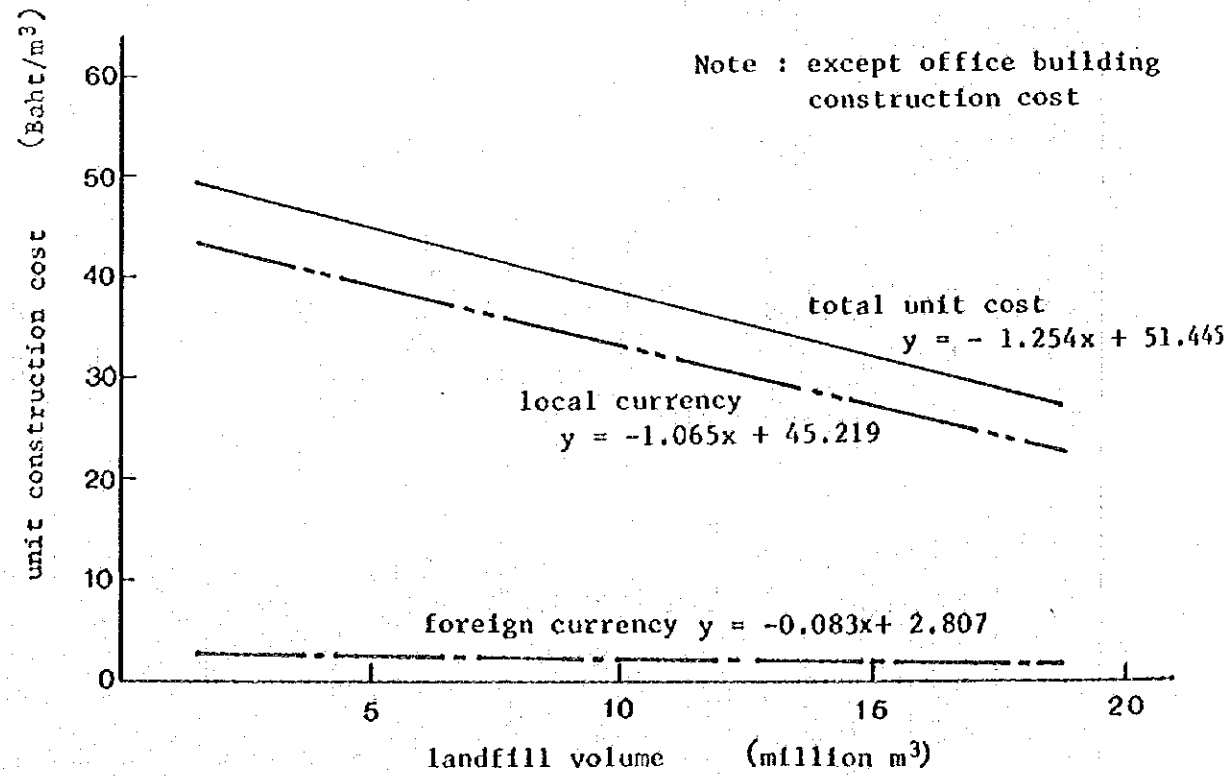


Table AP 5.26 Construction cost items (On-Nooch) (Financial cost)

(Unit: 1,000 Baht)

Name of equipment	Number & Size	Material and equipment		Labor		Total	
		Foreign	Local	Foreign	Local	Foreign	Local
Case 13 (per 4,899,900 m)							
Leachate collection and discharge facilities	1 unit	1,581	11,684	0	3,987	1,581	15,671
Embankment	5,800 m	0	20,534	0	5,887	0	26,421
Final soil covering	53 ha	0	72,034	0	12,773	0	84,807
Gas discharge facilities	47 unit	0	2,325	0	873	0	3,198
Rainwater drain facilities	14,800 m	0	4,134	0	5,262	0	9,396
On-site road	1 unit	0	8,572	0	6,700	0	15,272
Leachate treatment facilities	500 m^3/d	8,110	3,200	230	480	8,340	1,680
On-site building*1	1 unit	1,474	4,427	0	2,356	1,474	6,783
Others*2	1 unit	3,901	1,578	212	400	4,113	1,978
Subtotal		15,066	126,488	442	38,718	15,508	165,206
Miscellaneous expense	30%						54,214
Business tax	3.3%	15,066	126,488	422	38,718		7,753
Total						15,508	227,173
Unit cost per landfill volume (m^3)*3 (Baht)						2.9	45.0
Case 9 (per 13,350,400 m^3)							
Leachate collection and discharge facilities	1 unit	2,428	20,559	0	4,596	2,428	25,155
Embankment	10,400 m	0	36,461	0	10,453	0	46,914
Final soil covering	126 ha	0	172,350	0	27,281	0	199,631
Gas discharge facilities	107 unit	0	5,463	0	2,005	0	7,468
Rainwater drain facilities	26,200 m	0	7,200	0	9,165	0	16,365
On-site road	1 unit	0	15,757	0	12,717	0	28,474
Leachate treatment facilities	1,500 m^3/d	16,372	2,889	460	1,037	16,832	3,926
On-site building*1	1 unit	1,474	4,427	0	2,356	1,474	6,783
Others*2	1 unit	7,800	2,990	424	794	8,224	3,784
Subtotal		28,074	268,076	884	70,404	28,958	338,480
Miscellaneous expense	30%						110,231
Business tax	3.3%						15,763
Total		28,074	268,076	884	70,404	28,958	464,474
Unit cost per landfill volume (m^3)*3 (Baht)						2.1	34.3

Note: *1 including office building, warehouse, repairing house, rest house, etc.

*2 including truck scale, truck washing, electric equipment, illumination, vegetation, etc.

*3 except on-site building construction cost.

Table AP 5.27 Parking lot construction cost (Case No. 9)

(1) Cost items

(Unit: million Baht)

Location	Cost items	Financial cost			Economic cost		
		Foreign	Local	Total	Foreign	Local	Total
Yannawa	Main construction	2.7	42.7	45.4	1.9	42.6	44.5
	Scafolding, temporary construction and miscellaneous expenditure	-	9.1	9.1	-	9.1	9.1
	Business tax	-	1.8	1.8	-	-	-
	Total	2.7	53.6	56.3	1.9	51.7	53.6
Bangkok Noi	Main construction	2.7	40.3	43.0	1.9	40.2	42.1
	Scafolding, temporary construction and miscellaneous expenditure	-	8.6	8.6	-	8.6	8.6
	Business tax	-	1.7	1.7	-	-	-
	Total	2.7	50.6	53.3	1.9	48.8	50.7
Total		5.4	104.2	109.6	3.8	100.5	104.3

(2) Main construction cost items

(Unit: thousand Baht)

Location	Cost items	Size	Financial cost		Economic cost		
			Foreign	Local	Foreign	Local	Unskilled
Yannawa	Pavement	14,600m^2	-	28,382.4	-	19,710.0	8,672.4
	Building	560m^2	2,738.4	8,086.4	1,892.8	7,414.4	672.0
	Clearance & reclamation	40,000m^3	-	6,000.0	-	5,440.0	560.0
	Fence	600m	-	183.6	-	177.0	6.6
	Total		2,738.4	42,652.4	1,892.8	32,741.4	9,911.0
Bangkok Noi	Pavement	14,600m^2		28,382.4	-	19,710.0	8,672.4
	Building	560m^2	2,738.4	8,086.4	1,892.8	7,414.4	672.0
	Clearance & reclamation	24,000m^3	-	3,600.0	-	3,264.0	336.0
	Fence	600m	-	183.6	-	177.0	6.6
	Total		2.738.4	40,252.4	1,892.8	30,565.4	9,687.0

Chapter 6 ECONMIC AND FINANCIAL ANALYSES

Appendix 6.1 Economic evaluation of solid waste management project

Comparison the total benefit and cost for solid waste management enterprise in the economic analysis is summarized as follows:

1. Benefit from the proposed solid waste management project can be expressed by 3,574 t/d which is the additional solid waste treatment volume resulted by increase of the solid waste collection volume from 1,966 t/d (1980) to 5,540 t/d (2000).

2. Cost against the above benefit is expressed as follows: (refer to a figure in the next page.)

   1) Cost required for the existing solid waste management system:

      Solid waste treatment cost for 1,966 t/d: (a + b)

      Solid waste treatment cost for 3,574 t/d: (c + d)

      (c + d) was calculated by subtracting the treatment cost for 1,966 t/d which is required for maintainance of the existing solid waste treatment system in the future, from the treatment cost of 5,540 t/d.

   2) Cost required for the proposed solid waste management system:

      Solid waste treatment cost for 5,540 t/d treated by the proposed solid waste management system

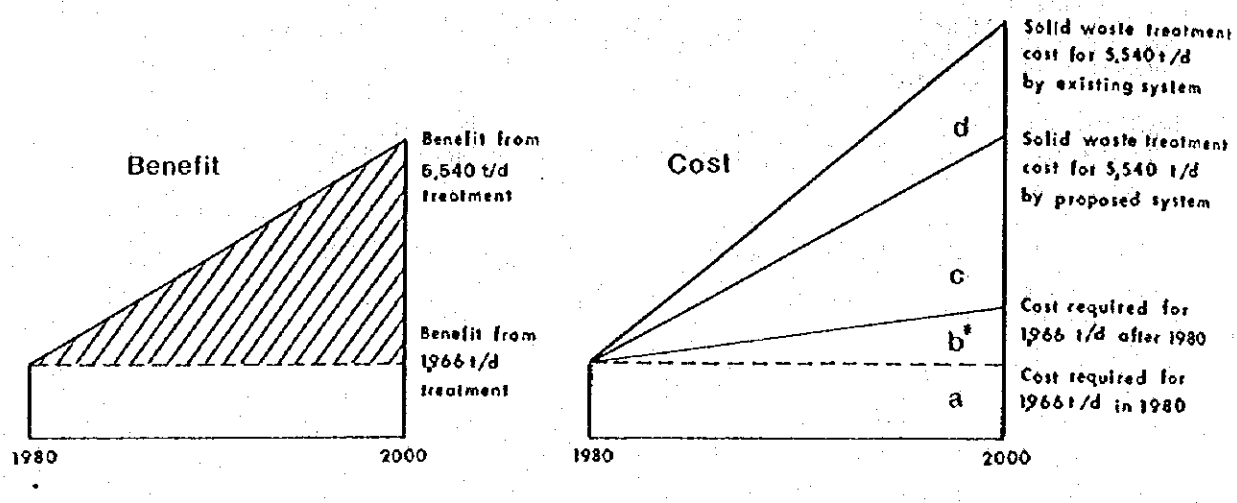
      When the proposed solid waste management system is established, treatment cost of the existing system will be influenced to some extent and the required cost for 1,966 t/d will not be the same as (a + b) described above.
      Suppose the cost of (a + b) does not change after the establishment of the proposed system, the cost reflecting the 3,574 t/d can be expressed as "c"; however, the total cost under the proposed system includes the effect of construction of the proposed system not only in the total cost but also in the treatment cost of 1,966 t/d.

      Therefore, the value "c" does not accurately reflect the additional benefit.

      To avoid such inaccuracy, the solid waste treatment cost for 1,966 t/d should be calculated with the existing system and with only 3,574 t/d of the proposed system.

      It is difficult, however, to determine what part of the future solid waste collection volume shall be treated by existing system and what part by proposed system. (If the assumption is made that the existing collection volume should be treated by the existing system, the solid waste flow will become unreasonable because of the limitation of treatment capacity of the proposed solid waste facilities).

Considering these facts, it seems difficult to simply compare the additional cost with benefit of the solid waste management project as usually done with a normal construction project. To avoid an unbalanced result, total cost has been compared with the total benefit in this sanitation project.



b* : Due to the increase of the accummulated incoming solid waste volume, existing solid waste treatment cost for 1,966 t/d in 1980 will increase even if the treatment volume of 1,966 t/d is maintained in the future.

Appendix 6.2 Direct benefit flow

Table Ap 6.1(A) Benefit flow (Case No. 9)

(Unit: million Baht)

Year	Primary Direct Benefit		Secondary Direct Benefit				Total Direct Benefit	
	15 m height of solid waste	3 m height of solid waste	Ash for reclamation land	Electric power generation	Compost product	Retrieved ferrous metal	15 m height	3 m height
1983	80.0	397.5	-	-	13.0	1.3	94.3	411.8
1984	83.2	413.7	-	-	13.0	1.3	97.5	428.0
1985	87.1	433.0	-	-	13.0	1.3	101.4	447.3
1986	92.0	457.2	-	-	13.0	1.3	106.3	471.5
1987	97.1	482.8	-	-	13.0	1.3	111.4	497.1
1988	102.6	509.8	-	-	13.0	1.3	116.9	524.1
1989	108.0	536.8	-	-	13.0	1.3	122.3	551.1
1990	114.0	566.7	-	-	13.0	1.3	128.3	581.0
1991	119.7	594.9	-	-	13.0	1.3	134.0	609.2
1992	125.6	624.5	-	-	13.0	1.3	139.9	638.8
1993	131.6	654.0	-	-	16.0	1.4	149.0	671.4
1994	138.1	686.4	-	-	16.0	1.4	155.5	703.8
1995	144.9	720.2	-	-	16.0	1.4	162.3	737.6
1996	151.7	753.8	-	-	16.0	1.4	169.1	771.2
1997	159.0	790.3	-	-	22.3	2.0	183.3	814.6
1998	166.6	828.1	-	-	22.3	2.0	190.9	852.4
1999	174.2	865.6	-	-	22.3	2.0	198.5	889.9
2000	182.6	907.6	-	-	22.3	2.0	206.9	931.9
2001	188.7	937.7	-	-	22.3	2.0	213.0	962.0
2002	194.8	968.1	-	-	22.3	2.0	219.1	992.4
2003	201.1	999.6	-	-	22.3	2.0	225.4	1,023.9
2004	207.8	1,032.8	-	-	22.3	2.0	232.1	1,057.1
2005	214.6	1,066.6	-	-	22.3	2.0	238.9	1,090.9
2006	219.9	1,093.1	-	-	22.3	2.0	244.2	1,117.4
2007	225.6	1,121.5	-	-	22.3	2.0	249.9	1,145.8
2008	231.3	1,149.5	-	-	22.3	2.0	255.6	1,173.8
2009	237.1	1,178.7	-	-	22.3	2.0	261.4	1,203.0
2010	243.4	1,209.5	-	-	22.3	2.0	267.7	1,233.8
Total	4,422.3	21,980.0	-	-	506.2	46.6	4,975.1	22,532.8

Table Ap 6.1(B) Benefit flow (Case No. 13)

(Unit: million Baht)

Year	Primary Direct Benefit		Secondary Direct Benefit				Total Direct Benefit	
	15 m height of solid waste	3 m height of solid waste	Ash for reclamation land	Electric power generation	Compost product	Retrieved ferrous metal	15 m height	3 m height
1983	80.0	397.5	-	-	13.0	1.3	94.3	411.8
1984	83.2	413.7	-	-	13.0	1.3	97.5	428.0
1985	87.1	433.0	-	-	13.0	1.3	101.4	447.3
1986	92.0	457.2	-	-	13.0	1.3	106.3	471.5
1987	97.1	482.8	-	-	13.0	1.3	111.4	497.1
1988	102.6	509.8	-	-	13.0	1.3	116.9	524.1
1989	108.0	536.8	-	-	13.0	1.3	122.3	551.1
1990	114.0	566.7	-	-	13.0	1.3	128.3	581.0
1991	119.7	594.9	8.9	35.9	13.0	1.3	178.8	654.0
1992	125.6	624.5	8.4	35.9	13.0	1.3	184.2	683.1
1993	131.6	654.0	7.0	35.9	13.0	1.3	188.8	711.2
1994	138.1	686.4	6.4	35.9	13.0	1.3	194.7	743.0
1995	144.9	720.2	5.8	35.9	13.0	1.3	200.9	776.2
1996	151.7	753.8	23.9	89.2	13.0	1.3	279.1	881.2
1997	159.0	790.3	23.7	89.2	13.0	1.3	286.2	917.5
1998	166.6	828.1	23.3	89.2	13.0	1.3	293.4	954.9
1999	174.2	865.6	23.4	89.2	16.0	1.4	304.2	995.6
2000	182.6	907.6	22.9	89.2	16.0	1.4	312.1	1,037.1
2001	188.7	937.7	31.5	113.8	22.3	2.0	358.3	1,107.3
2002	194.8	968.1	31.5	113.8	22.3	2.0	364.4	1,137.7
2003	201.1	999.6	31.5	113.8	22.3	2.0	370.7	1,169.2
2004	207.8	1,032.8	31.5	113.8	22.3	2.0	377.4	1,202.4
2005	214.6	1,066.6	31.3	113.8	22.3	2.0	384.0	1,236.0
2006	219.9	1,093.1	31.1	113.8	22.3	2.0	389.1	1,262.3
2007	225.6	1,121.5	30.9	113.8	22.3	2.0	394.6	1,290.5
2008	231.3	1,149.5	30.7	113.8	22.3	2.0	400.1	1,318.3
2009	237.1	1,178.7	30.5	113.8	22.3	2.0	405.7	1,347.3
2010	243.4	1,209.5	30.3	113.8	22.3	2.0	411.8	1,377.9
Total	4,422.3	21,980.0	464.5	1,763.5	463.0	43.6	7,156.9	24,714.6

Table Ap 6.1(C) Benefit flow (Case No. 19-(2))

(Unit: million Baht)

Year	Primary Direct Benefit		Secondary Direct Benefit				Total Direct Benefit	
	15 m height of solid waste	3 m height of solid waste	Ash for reclamation land	Electric power generation	Compost product	Retrieved ferrous metal	15 m height	3 m height
1983	80.0	397.5	-	-	13.0	1.3	94.3	411.8
1984	83.2	413.7	-	-	13.0	1.3	97.5	428.0
1985	87.1	433.0	-	-	13.0	1.3	101.4	447.3
1986	92.0	457.2	-	-	13.0	1.3	106.5	471.5
1987	97.1	482.8	-	-	13.0	1.3	111.4	497.1
1988	102.6	509.8	-	-	13.0	1.3	116.9	524.1
1989	108.0	536.8	-	-	13.0	1.3	122.3	551.1
1990	114.0	566.7	-	-	13.0	1.3	128.3	581.0
1991	119.7	594.9	8.9	35.9	13.0	1.3	178.8	654.0
1992	125.6	624.5	8.4	35.9	13.0	1.3	184.2	683.1
1993	131.6	654.0	7.0	35.9	13.0	1.3	188.8	711.2
1994	138.1	686.4	6.4	35.9	13.0	1.3	194.7	743.0
1995	144.9	720.2	5.8	35.9	13.0	1.3	200.9	776.2
1996	151.7	753.8	17.9	71.8	13.0	1.3	255.7	857.8
1997	159.0	790.3	17.4	71.8	13.0	1.3	262.5	893.8
1998	166.6	828.1	16.9	71.8	13.0	1.3	269.6	931.1
1999	174.2	865.6	17.4	71.8	16.0	1.4	280.8	972.2
2000	182.6	907.6	17.1	71.8	16.0	1.4	288.9	1,013.9
2001	188.7	937.7	18.1	71.8	22.3	2.0	302.9	1,051.9
2002	194.8	968.1	17.9	71.8	22.3	2.0	308.8	1,082.1
2003	201.1	999.6	17.7	71.8	22.3	2.0	314.9	1,113.4
2004	207.8	1,032.8	17.4	71.8	22.3	2.0	321.3	1,146.3
2005	214.6	1,066.6	17.0	71.8	22.3	2.0	327.7	1,179.7
2006	219.9	1,093.1	16.6	71.8	22.3	2.0	332.6	1,205.8
2007	225.6	1,121.5	16.1	71.8	22.3	2.0	337.8	1,233.7
2008	231.3	1,149.5	15.6	71.8	22.3	2.0	343.0	1,261.2
2009	237.1	1,178.7	15.1	71.8	22.3	2.0	348.3	1,289.9
2010	243.4	1,209.5	14.6	71.8	22.3	2.0	354.1	1,320.2
Total	4,422.3	21,980.0	289.3	1,256.5	463.0	43.6	6,474.7	24,032.4

Appendix 6.3 Development of electricity generation in Thailand

Annual electricity generation in Thailand 1980 is 14,753 million kW.h. 80 percent of this power was generated using expensive imported fuel oil. A rate of electrification of households is not large but, considering the progress of electrification especially in the rural area and the promotion of the development of industry, demand of electricity is thought increase greatly in the future.

In the Power Development Plan established by EGAT, the future demand of electricity is estimated to increase 7 - 13% per annum. The imported fuel oil for electricity generation will decrease due to the substitution of Thai natural resources such as gas, lignite and hydropower.

Under these circumstances, electricity generation utilizing the surplus heat from the incineration plant will reduce the high construction cost of an electrical generation plant and imported crude oil. Generated electricity from the proposed incineration plant will contribute to the improvement of the national standard of living and the national economy.

Table Ap 6.2 Energy generation in Thailand

Energy Generation from	1980		1979	
	Million kW·h	percent	Million kW·h	percent
Hydro	1,653.31	11.20	3,099.07	22.19
Thermal	11,998.71	81.33	9,899.45	70.89
Gas Turbine	284.35	1.93	241.06	1.73
Diesel	64.43	0.44	66.08	0.47
Purchased from Laos	752.93	5.10	658.89	4.72
Total	14,753.73	100.00	13,964.55	100.00

Source: Annual Report 1980, EGAT

Table Ap 6.3 EGAT power development plan

Fiscal Year	Peak (MW)	Energy (GW·h)
1981	2,663.0	16,221.0
1982	3,001.0	18,386.0
1983	3,433.0	20,570.0
1984	3,817.0	22,894.0
1985	4,195.0	25,252.0
1986	4,604.0	27,725.0
1987	4,968.0	29,944.0
1988	5,346.0	32,273.0
1989	5,742.0	34,693.0
1990	6,150.0	37,211.0

Source: EGAT Power Development Plan (Planned in 1981)

Appendix 6.4 Costs of a hydro-type electric power station

Table Ap 6.4 Percentage of annual expenses in the case of hydro-type electric power station

(Unit: percent)

Year	Book value	Rate of interest + Depreci-ation	Repair expenses	Personnel expenses	General management cost + Others	Total expenses
1	100.00	6.07	0.78	0.04	1.41	8.30
2	97.43	5.98	0.88	0.05	1.50	8.41
3	94.86	5.89	0.98	0.05	1.59	8.51
4	92.29	5.80	1.09	0.05	1.68	8.62
5	89.72	5.71	1.22	0.05	1.78	8.76
6	87.15	5.62	1.35	0.06	1.89	8.91
7	84.58	5.53	1.50	0.06	2.00	9.09
8	82.01	5.44	1.66	0.07	2.12	9.29
9	79.44	5.35	1.83	0.07	2.25	9.50
10	76.87	5.26	2.02	0.07	2.39	9.74
11	74.30	5.17	2.22	0.08	2.53	10.00
12	71.73	5.08	2.44	0.08	2.69	10.29
13	69.16	4.99	2.68	0.09	2.85	10.61
14	66.59	4.90	2.94	0.09	3.01	10.95
15	64.02	4.81	3.22	0.10	3.20	11.33
16	61.45	4.71	3.52	0.10	3.40	11.74
17	58.88	4.63	3.82	0.11	3.58	12.14
18	56.31	4.54	4.12	0.11	3.73	12.50
19	53.74	4.45	4.44	0.12	3.91	12.92
20	51.17	4.36	4.78	0.12	4.09	13.35
21	48.60	4.27	5.16	0.12	4.28	13.83
22	46.03	4.18	5.50	0.13	4.48	14.29
23	43.46	4.09	5.80	0.13	4.67	14.69
24	40.89	4.00	6.18	0.14	4.86	15.18
25	38.32	3.91	6.54	0.14	5.06	15.65

Appendix 6.5 Effect on rice yield by use of city compost

Table Ap 6.5 Comparison of effect of city compost, farm manure, and chemical fertilizer on rice yield

(Suwanawong, S. and Suthdhani, S. 1968)

Treatment	Yield (kg/ha)
No treatment	1,944
City compost, 2 t/ha	2,181
City compost, 6 t/ha	2,396
Farm manure, 2 t/ha	2,198
Farm manure, 6 t/ha	2,349
City compost (2 t/ha) + Fertilizer	2,350
City compost (6 t/ha) + Fertilizer	2,504
Farm manure (2 t/ha) + Fertilizer	2,271
Farm manure (6 t/ha) + Fertilizer	2,398
Chemical fertilizer	2,274

Table Ap 6.6 Effect on rice yield using compost in successive years (Unhulled rice)

(Unit : kg/1,000 m²)

Treatment	Year									
	1976		1977		1978		1979		1980	
City compost 250 kg (dry weight)	591 kg	(113)	607 kg	(100)	676 kg	(104)	682 kg	(104)	577 kg	(106)
- do - 550 (- do -)	594	(113)	682	(104)	682	(105)	702	(107)	559	(102)
- do - 1,000 (- do -)	574	(109)	619	(102)	698	(108)	665	(102)	586	(107)
Farm compost 250 kg (dry weight)	603	(115)	618	(102)	694	(107)	662	(101)	554	(101)
- do - 500 (- do -)	572	(109)	598	(99)	634	(99)	660	(101)	549	(101)
- do - 1,000 (- do -)	598	(114)	597	(99)	680	(105)	667	(102)	553	(101)
No supply of organic fertilizer	525	(100)	605	(100)	647	(100)	655	(100)	546	(100)
Much supply of organic fertilizer	537	(102)	584	(97)	669	(103)	654	(100)	532	(97)

Notes : Number in ( ) indicates yield index.

Source: TAKAHASHI, Urban waste disposal and agriculture utilization, Agriculture and Horticulture, Vol. 57 No. 1

Table Ap 6.7 The ingredients of compost and the market price

Component	Unit price of the ingredient (yen/kg)		Compost component (%)		Market price of the component			
					Japan (yen/kg)		Thailand (Baht/kg)	
			On-Nooch compost	Nong Khaem compost*	On-Nooch compost	Nong-* Khaem compost*	On-Nooch	Nong Khaem compost*
N	1.41 ← Ammonium Sulfate Urea	T-N : 21% T-N : 46%	1.00	0.92	1.41	1.30	0.26 (average)	0.30 (average)
P	2.39 ← Super Phosphate Fused Phosphate	$T-P_2O_5$: 17% $T-P_2O_5$: 20%	0.72	1.04	1.72	2.49		
K	0.92 ← Potassium Sulfate Potassium Chloride	$T-K_2O$: 50% $T-K_2O$: 60%	1.12	1.06	1.03	0.98		
Ca	0.43 ← Slaked Lime Calcium Silicate	Alkali : 60% Alkali : 35%	5.80	7.74	2.49	3.33	0.08	0.11
	Total				6.65	8.10	0.34	0.41

Note : * After trommel processing

Table Ap 6.8 Price comparison of chemical fertilizer between Thailand and Japan

Sort of fertilizer	Thailand	Japan
High-analysis compound fertilizer (15-15-15)	4,800 Baht/t	77,000 yen/t
Lime	600 Baht/t	18,000 yen/t