Engineering cost and physical contingency allowance are assumed at 8% and 10% of direct construction cost respectively. And administration cost is assumed at 2% of direct construction cost.

Break-down of project cost by cost item is shown below.

Project Cost		(Unit : Million Rp.)
(A)	Direct Construction Cost	211,309
	(1) Collection Sewer	174,502
	(2) Force Main	11,609
	(3) Treatment Plant	25,198
(B)	Administration Cost	4,226
(C)	Engineering Cost	16,905
(D)	Physical Contingency	21,160
	Total	253,600
(E)	House Connection Cost	20,751
	Grand Total	274,351

Further break-down of the direct construction cost and unit basic construction costs are shown in Table E.7.1 and Table E.7.2.

For break-down of the project cost by sewerage development area, see Table E.7.3.

7.2 Operation and Maintenance Cost

7.2.1 Sewerage System

Operation and maintenance (O/M) cost of sewerage system, consisting of collection system and treatment plant, amount to Rp. 2,670.1 million per annum at February, 1992 prices.

Break-down of annual O/M cost by cost item is shown in Table E.7.4.

For break-down of annual O/M cost by sewerage development area, see Table E.7.3.

Table E.1.1 Catchment Area and Population of Divided Sub-basin

Name of River Basin	No.of Sub-basin	Name of Sub-basin	Catchment Area (ha)	Population (person)		Population Density (per/ha)	
				Existing	Future	Existing	Future
Mati-Tega		Sub-Toatl	3,643	59,436	88,346	16.32	24.25
	1	Upper Mati	1,816	20,199	30,043	11.12	16.54
	2	Lower Mati	766	13,358	19,850	17.44	25.91
	3	Tega	1,061	25,880	38,453	24.39	36.24
Badung		Sub-Toatl	3,640	105,452	156,694	28.97	43.05
	4	Upper Badung	2,040	51,458	76,455	25.22	37.48
	5	Middle Badung	510	36,851	54,769	72.26	107.39
	6	Lower Badung	1,090	17,142	25,470	15.73	23.37
Yeh Ayung		Sub-Toatl	5,350	205,547	305,291	38.42	57.06
	7	Upper ayung	444	5,690	8,468	12.82	19.07
	8	Lower Ayung	275	6,165	9,149	22.42	33.27
	9	Upper Abian	161	5,510	8,190	34.22	50.87
	10	Abian-Loloan	499	16,072	23,808	32.21	47.71
	11	Lower Loloan	790	18,200	27,013	23.04	34.19
	12	Oongan	1,200	98,758	146,695	82.30	122.25
	13	Punggawa	575	19,174	28,520	33.35	49.60
	14	Rangda	913	30,681	45,599	33.60	49.94
	15	Pengegeh	493	5,298	7,849	10.75	15.92
Sama		Sub-Toatl	1,861	8,108	12,035	4.36	6.47
	16	Sama	1,861	8,108	12,035	4.36	6.47
Total			14,494	378,543	562,365	26.12	38.80

Table E.1.2 (1) Existing Wastewater Generation by Sub-Basin (1990)

(Unit : m3/day)

Name of River Basin	No.of Sub-basin	Name of Sub-basin	Domestic	Comm./Insti.	Tourism	Industry	Total
Mati-Tega		Sub-Total	9,702.0	1,209.0	128.0	171.3	11,210.3
	1	Upper Mati	3,039.7	159.1	0.0	41.9	3,240.7
	2	Lower Mati	2,089.0	664.3	62.6	45.8	2,861.7
	3	Tega	4,573.3	385.6	65.4	83.6	5,107.9
Badung		Sub-Total	16,350.7	3,815.7	295.8	221.4	20,683.6
	4	Upper Badung	7,910.0	2,351.2	117.1	77.0	10,455.3
	5	Middle Badung	5,834.2	938.0	164.4	69.6	7,006.2
	6	Lower Badung	2,606.5	526.5	14.3	74.8	3,222.1
Yeh Ayung		Sub-Total	32,477.8	8,982.8	903.6	217.3	42,581.5
	7	Upper ayung	826.6	24.6	0.0	5.9	857.1
	8	Lower Ayung	917.7	113.0	0.0	63.4	1,094.1
	9	Upper Abian	826.8	34.0	10.5	6.1	877.4
	10	Abian-Loloan	2,476.7	511.4	11.5	21.0	3,020.6
	11	Lower Loloan	2,771.5	548.2	60.3	27.5	3,407.5
	12	Oongan	16,217.9	5,956.2	690.8	47.6	22,912.5
	13	Punggawa	2,895.9	533.9	11.6	5.2	3,446.6
	14	Rangda	4,780.1	1,226.1	118.9	33.9	6,159.0
	15	Pengegeh	764.6	35.4	0.0	6.7	806.7
Sama		Sub-Total	1,230.8	215.9	3.7	0.0	1,450.4
	16	Sama	1,230.8	215.9	3.7	0.0	1,450.4
Total			59,761.3	14,223.4	1,331.1	610.0	75,925.8

Table E.1.2 (2) Future Wastewater Generation by Sub-Basin (2010)

(Unit : m3/day)

Name of River Basin	No.of Sub-basin	Name of Sub-basin	Domestic	Comm./Insti.	Tourism	Industry	Total
Mati-Tega		Sub-Total	17,398.5	2,115.1	521.8	1,065.8	21,101.2
	1	Upper Mati	5,443.3	264.7	34.7	260.2	6,002.9
	2	Lower Mati	3,469.5	1,126.6	121.2	284.3	5,001.6
	3	Tega	8,485.7	723.8	365.9	521.3	10,096.7
Badung		Sub-Total	26,909.2	6,259.4	543.0	1,392.7	35,104.3
	4	Upper Badung	12,055.0	3,651.0	210.0	480.9	16,396.9
	5	Middle Badung	9,916.4	1,643.7	282.6	433.9	12,276.6
	6	Lower Badung	4,937.8	964.7	50.4	477.9	6,430.8
Yeh Ayung		Sub-Total	54,781.9	14,520.8	3,153.4	1,558.0	74,014.1
	7	Upper ayung	1,316.7	32.6	0.0	37.2	1,386.5
	8	Lower Ayung	1,565.1	192.2	856.7	401.4	3,015.4
	9	Upper Abian	1,383.2	55.6	176.1	38.5	1,653.4
	10	Abian-Loloan	4,032.4	842.1	226.8	132.5	5,233.8
	11	Lower Loloan	4,510.0	921.6	175.3	177.9	5,784.8
	12	Oongan	27,013.7	9,207.4	1,403.7	479.0	38,103.8
	13	Punggawa	4,710.5	858.9	67.4	33.6	5,670.4
	14	Rangda	8,787.2	2,354.0	247.4	215.8	11,604.4
	15	Pengegeh	1,463.1	56.4	0.0	42.1	1,561.6
Sama		Sub-Total	2,097.0	370.9	76.8	0.0	2,544.7
	16	Sama	2,097.0	370.9	76.8	0.0	2,544.7
Total			101,186.6	23,266.2	4,295.0	4,016.5	132,764.3

Table E.1.3 (1) Existing Pollution Load Generation (BOD5) by Sub-Basin (1990)

(Unit : kg/day)

Name of River Basin	No.of Sub-basin	Name of Sub-basin	Domestic	Comm./Insti.	Tourism	Industry	Total
Mati-Tega		Sub-Total	1,160.1	261.2	20.4	191.3	1,633.0
	1	Upper Mati	362.9	34.4	0.0	46.7	444.0
	2	Lower Mati	250.2	143.5	16.0	51.0	460.7
	3	Tega	547.0	83.3	4.4	93.6	728.3
Badung		Sub-Total	1,957.8	824.1	28.6	259.3	3,069.8
	4	Upper Badung	946.1	507.8	11.0	86.4	1,551.3
	5	Middle Badung	700.3	202.6	14.0	86.4	1,003.3
	6	Lower Badung	311.4	113.7	3.6	86.5	515.2
Yeh Ayung		Sub-Total	3,896.5	1,940.4	73.2	281.6	6,191.7
	7	Upper ayung	98.3	5.3	0.0	6.7	110.3
	8	Lower Ayung	109.4	24.4	0.0	72.5	206.3
	9	Upper Abian	98.6	7.4	0.7	7.0	113.7
	10	Abian-Loloan	296.3	110.5	3.0	24.0	433.8
	11	Lower Loloan	331.0	118.4	12.3	32.3	494.0
	12	Oongan	1,953.5	1,286.6	48.5	86.4	3,375.0
	13	Punggawa	345.8	115.3	0.7	6.1	467.9
	14	Rangda	572.8	264.8	8.0	39.0	884.6
	15	Pengegeh	90.8	7.7	0.0	7.6	106.1
Sama		Sub-Total	147.0	46.7	0.9	0.0	194.6
	16	Sama	147.0	46.7	0.9	0.0	194.6
Total			7,161.4	3,072.4	123.1	732.2	11,089.1

Table E.1.3 (2) Future Pollution Load Generation (BOD5) by Sub-Basin (2010)

(Unit : kg/day)

Name of River Basin	No.of Sub-basin	Name of Sub-basin	Domestic	Comm./Insti.	Tourism	Industry	Total
Mati-Tega		Sub-Total	2,097.1	456.8	50.8	1,235.3	3,840.0
	1	Upper Mati	655.7	57.2	5.2	300.8	1,018.9
	2	Lower Mati	418.7	243.3	25.0	328.4	1,015.4
	3	Tega	1,022.7	156.3	20.6	606.1	1,805.7
Badung		Sub-Total	3,247.5	1,352.0	42.8	1,638.9	6,281.2
	4	Upper Badung	1,454.1	788.6	16.0	559.1	2,817.8
	5	Middle Badung	1,198.3	355.0	20.2	504.6	2,078.1
	6	Lower Badung	595.1	208.4	6.6	575.2	1,385.3
Yeh Ayung		Sub-Total	6,795.0	3,136.3	196.6	1,855.0	11,982.9
	7	Upper ayung	158.2	7.0	0.0	43.7	208.9
	8	Lower Ayung	188.4	41.5	46.2	477.4	753.5
	9	Upper Abian	166.5	12.1	9.7	45.8	234.1
	10	Abian-Loloan	663.7	181.9	15.0	157.8	1,018.4
	11	Lower Loloan	543.5	199.1	22.1	217.5	982.2
	12	Oongan	3,270.4	1,988.6	84.7	563.7	5,907.4
	13	Punggawa	567.5	185.5	3.7	40.5	797.2
	14	Rangda	1,061.0	508.4	15.2	258.6	1,843.2
	15	Pengegeh	175.8	12.2	0.0	50.0	238.0
Sama		Sub-Total	252.7	80.1	17.3	0.0	350.1
	16	Sama	252.7	80.1	17.3	0.0	350.1
Total			12,392.3	5,025.2	307.5	4,729.2	22,454.2

Table E.1.4 (1) Existing and Future River Water Quality in Dry Season

Out-put Station

(BOD5, mg/l)

River Name	Station No.	Existing		Future
		Observed	Calculated	Calculated
Mati River	1	7.8	6.4	8.3
Mati River	2	11.6	8.7	21.9
Tega River	3	13.5	11.9	29.5
Badung River	4	13.2	12.5	19.3
Badung River	5	29.8	26.7	50.2
Badung River	6	33.6	27.6	53.6
Yeh Ayung River	7-1	3.1	3.1	3.4
Oongan River	7-2	5.0	5.0	5.5
Yeh Ayung River	8	5.0	4.5	14.9
Abian Base River	9-1	7.2	6.5	12.8
Oongan River	9-2	22.3	20.0	29.9
Abian Base River	10-1	6.7	5.2	10.0
Loloan River	10-2	21.3	16.1	31.2
Loloan River	11	22.0	18.2	27.0
Punngawa River	12-1	29.2	29.5	59.2
Rangda River	12-2	35.2	35.4	71.2
Oongan River	12-3	51.4	51.7	103.9
Punngawa River	13	24.0	25.4	53.0
Rangda River	14	24.0	26.9	60.2
Pengegeh River	15	6.0	6.0	6.3
Sama River	16	4.1	5.9	5.9
Average		17.9	16.8	32.2

In-put Station

River Name	Station No.	Existing (BOD5, mg/l)
		Observed
Mati River	A	5.0
Tega River	B	3.1
Badung River	C	4.1
Yeh Ayung River	D	4.1
Average		4.1

Table E.1.4 (2) Existing and Future River Water Quality in Rainy Season

Out-put Station

(BOD5, mg/l)

River Name	Station No.	Existing		Future
		Observed	Calculated	Calculated
Mati River	1	11.9	9.5	17.1
Mati River	2	17.2	12.8	23.8
Tega River	3	14.2	14.0	27.3
Badung River	4	19.8	13.9	22.0
Badung River	5	32.1	28.7	47.6
Badung River	6	21.3	27.4	46.6
Yeh Ayung River	7-1	5.0	5.0	5.1
Oongan River	7-2	4.5	5.9	6.0
Yeh Ayung River	8	4.6	5.3	6.6
Abian Base River	9-1	6.2	4.3	5.2
Oongan River	9-2	16.0	14.2	13.4
Abian Base River	10-1	15.6	16.5	33.5
Loloan River	10-2	14.4	15.0	30.9
Loloan River	11	26.5	15.0	30.9
Punngawa River	12-1	23.1	24.1	39.0
Rangda River	12-2	39.0	40.3	131.8
Oongan River	12-3	50.5	52.4	85.3
Punngawa River	13	22.8	20.4	35.6
Rangda River	14	33.8	31.3	99.9
Pengegeh River	15	5.2	5.2	5.6
Sama River	16	2.7	2.7	6.4
Average		18.4	17.3	34.3

In-put Station

River Name	Station No.	Existing (BOD5, mg/l) Observed
Mati River	A	3.2
Tega River	B	6.2
Badung River	C	4.2
Yeh Ayung River	D	5.5
Average		4.8

Table E.2.1 Estimated Construction and Annual O&M Costs for Two (2) Alternatives

(Unit : million Rp.)

	Sewerage Only	Combination of Sewerage & On-site
Covered Area (Sewerage)	3,759 ha	1,560 ha
Covered Area (On-site)	-	5,687 ha
Total	3,759 ha	7,247 ha
Served Population (Sewerage)	368,600	232,400
Served Population (On-site)	-	223,800
Total	368,600	456,200
Construction Cost (Sewerage)		
(1) Collection Sewer	187,724	77,906
(2) House Connection	18,957	11,952
(3) Treatment Plant	20,462	15,309
Total	227,143	105,167
Construction Cost (On-site)		
Septic Tank with Up-flow filter	-	73,534
Grand Total	227,143	178,701
O&M Cost (Sewerage)		
(1) Collection Sewer & P.S.	140.0	58.1
(2) Treatment Plant	2,990.6	2,008.9
Total	3,130.6	2,067.0
O&M Cost (On-site)		
Desludging	-	294
Grand Total	3,130.6	2,361

Table E.2.2 Estimated Construction and O&M Costs for Sewerage and On-site Systems

(Unit : million Rp.)

	Sanur	Kuta	Nusa Dua
Covered Area (ha)	781	648	136
Served Population	27,140	21,580	1,540
Sewerage System			
Construction Cost			
(1) Collection Sewer	33,466.0	34,027.1	3,158.4
(2) House Connection	1,493.0	1,230.0	115.2
(3) Pump Station	3,429.0	8,117.5	1,102.0
(4) Treatment Plant	6,020.7	6,109.3	2,580.0
Total	44,408.7	49,543.9	6,955.6
O&M Cost per Year			
(1) Collection Sewer & P.S.	27.5	163.8	2.0
(2) Treatment Plant	560.3	571.6	511.1
Total	587.8	735.4	513.1
On-site System			
Construction Cost			
(1) Household Package Treatment Plant	45,318	49,071	11,440
(2) Sludge Treatment Plant	1,550	1,668	391
Total	46,868	50,739	11,831
O&M Cost per Year			
(1) Household Package T.P.	1,353	1,468	343
(2) Sludge T.P.	59	63	15
Total	1,412	1,531	358

Table E.4.1(1) Break-down of Construction Cost of Each Alternative

I. Individual Treatment System (Unit : Rp. milliom)

	Denpasar	Kuta	Sanur	Total
House connection	11,952	1,230	1,493	14,675
Collection sewer	78,993.8	30,243.7	33,466.0	142,706.5
Secondary & Tertiary	48,525.0	20,229.0	24,385.7	93,139.7
Main	18,020.0	8,102.5	7,324.7	33,447.2
Trunk	12,448.8	1,915.2	1,755.6	16,119.6
Force main system	-	6,615.9	-	6,615.9
Pipe	-	3,780.4	-	3,780.4
Booster pump	-	2,835.5	-	2,835.5
Treatment plant	15,309.0	6,109.3	6,020.7	27,439.0
Total	106,254.8	44,201.9	40,979.7	191,436.4

II. Partially Integrated Treatment System (Unit : Rp. million)

	Denpasar	Kuta	Sanur	Total
House connection	11,952	1,230	1,493	14,675
Collection sewer	78,993.8	30,246.7	33,466.0	142,706.5
Force main system	-	8,831.7	-	8,831.7
Pipe	-	5,616.5	-	5,616.5
Booster pump	-	3,215.2	-	3,215.2
Treatment plant	18,375.0	-	6,020.7	24,395.7
Total	109,320.8	40,308.4	40,979.7	190,608.9

Table E.4.1(2) Break-down of Construction Cost of Each Alternative

III. Integrated Treatment System (Unit : Rp. million)

	Denpasar	Kuta	Sanur	Total
House connection	11,952	1,230	1,493	14,675
Collection sewer	78,993.8	30,246.7	33,466.0	142,706.5
Force main system	-	8,831.7	7,157.0	15,988.7
Pipe	-	5,616.5	4,320.4	9,936.9
Booster pump	-	3,215.2	2,836.6	6,051.8
Treatment plant	21,205.8	-	-	21,205.8
Total	112,151.6	40,308.4	42,116.0	194,576.0

Table E.4.2(1) Break-down of O/M Cost of Each Alternative Plan

I. Individual Treatment System (Unit : Rp. milliom/year)

	Denpasar	Kuta	Sanur	Total
Collection sewer	58.0	23.8	27.5	109.3
Force main system	-	140.0	-	140.0
Pipe	-	5.3	-	5.3
Booster pump	-	134.7	-	134.7
Treatment plant	2,008.3	571.6	560.3	3,140.2
Electricity	1,803.3	513.4	503.2	2,819.9
Repair	70.1	19.9	19.5	109.5
Pesonnel	51.9	14.7	14.5	81.1
Chemicals	83.0	23.6	23.1	129.7
Total	2,066.3	735.4	587.8	3,389.5

II. Partially Integrated Treatment System (Unit : Rp. million/year)

	Denpasar	Kuta	Sanur	Total
Collection sewer	58.0	23.8	27.5	109.3
Force main system	-	172.2	-	172.2
Pipe	-	7.8	-	7.8
Booster pump	-	164.4	-	164.4
Treatment plant	2,578.8	-	560.3	3,139.1
Electricity	2,315.6		503.2	2,818.8
Repair	90.0	-	19.5	109.5
Personnel	66.6	-	14.5	81.1
Chemicals	106.6	-	23.1	129.7
Total	2,636.8	196.0	587.8	3,420.6

Table E.4.2(2) Break-down of O/M Cost of Each Alternative Plan

III. Integrated Treatment System (Unit : Rp. million/year)

	Denpasar	Kuta	Sanur	Total
Collection sewer	58.0	23.8	27.5	109.3
Force main system	-	172.2	149.8	322.0
Pipe	-	7.8	6.0	13.8
Booster pump	-	164.4	143.8	308.2
Treatment plant	3,138.1	-	-	3,138.1
Electricity	2,817.7	-	-	2,817.7
Repairing	109.5	-	-	109.5
Pesonnel	81.1	-	-	81.1
Chemicals	129.8	-	-	129.8
Total	3,196.1	196.0	177.3	3,569.4

Table E.5.1 Future Wastewater Generation by Kelurahan/Desa in Denpasar (2010)

Kelurahan & Desa		Sewerage Development Area (ha)	Wastewater Generation (m3/day)					
Code No.	Name		Domestic	Comm.& Insti.	Hotel	Restaurant	Industry	Total
101	Dauh Puri	60	2,230	1,050	228	21	101	3,630
102	Dauh Puri Kaja	95	2,743	1,621	55	0	0	4,419
103	Dauh Puri Kauh	125	3,334	250	14	11	83	3,692
104	Dauh Puri Kangin	59	1,597	466	92	9	0	2,164
105	Dauh Puri Kelod	188	5,584	2,183	350	10	138	8,265
106	Pemecutan	194	5,846	1,280	204	18	138	7,486
107	Pemecutan Kaja	175	2,289	394	19	10	92	2,804
108	Pemecutan Kelod	152	1,761	148	19	0	196	2,124
115	Ubung	14	221	69	5	1	33	329
117	Tegal Kerta	24	1,325	32	10	0	0	1,367
118	Tegal Harum	26	1,282	40	47	1	0	1,370
201	Dangin Puri	65	2,425	825	124	0	0	3,374
202	Dangin Puri Kauh	72	1,957	317	138	6	0	2,418
203	Dangin Puri Kaja	142	4,004	200	174	0	34	4,412
204	Dangin Puri Kangin	75	2,804	1,321	107	2	136	4,370
205	Dangin Puri Kelod	142	3,799	1,820	35	1	0	5,655
206	Sumerta	52	1,828	280	0	3	85	2,196
207	Sumerta Kauh	89	2,487	276	0	1	0	2,764
208	Sumerta Kaja	73	2,136	152	55	2	51	2,396
209	Sumerta Kelod	271	2,709	1,541	26	0	85	4,361
210	Kesiman	62	445	48	0	2	8	503
211	Kesiman Petilan	110	675	38	107	1	26	847
213	Tonja	86	976	33	0	0	0	1,009
305	Panjer	134	1,552	70	0	0	4	1,626
306	Sesetan	164	1,316	209	0	1	13	1,539
308	Pedungan	34	133	34	0	0	17	184
Total		2,683	57,458	14,697	1,809	100	1,240	75,304

Table E.7.1(1) Breakdown of Construction Cost for Sewerage Development

Item	Quantity	Unit Cost	Costruction Cost (million Rp)
(1) House Connection			
(1)-1 Denpasar Area	49,044	0.36 million Rp/unit	17,655.8
(1)-2 Kuta Area	3,420	"	1,231.2
(1)-3 Sanur Area	4,859	"	1,749.2
(1)-4 Tanjung Benoa Area	320	"	115.2
Sub - Total (1)	57,643	–	20,751.4
(2) Collection Sewer			
(2)-1 Denpasar Area			
1) Tertiary & Secondary	418,400 m	103,400~292,500Rp./m	56,545.0
2) Main Sewer	50,930 m	211,400~3,306,000Rp./m	41,176.0
3) Conveyance Sewer	4,390 m	1,854,200~4,434,600Rp./m	11,558.0
4) Lift Pump	2 stations		4,515.2
(2)-2 Kuta Area			
1) Tertiary & Secondary	65,700 m	103,400~292,500Rp./m	20,229.0
2) Main	13,700m	211,400~3,306,000Rp./m	8,102.5
3) Lift Pump	3 stations		5,342.0
(2)-3 Sanur Area			
1) Tertiary & Secondary	97,220 m	103,400~292,500Rp./m	13,200.0
2) Main	10,940 m	211,400~3,306,000Rp./m	9,400.0
3) Manhole Pump	3 stations		477.7
(2)-4 Tanjung Benoa Area			
1) Tertiary & Secondary	3,100 m	103,400~292,500Rp./m	651.0
2) Main	3,400 m	211,400~3,306,000Rp./m	2,203.9
3) Lift Pump	1 station		1,102.0
Sub - Total (2)			174,502.3
(3) Force Main			
(3)-1 Kuta Area			
1) Pipe (ø600)	5,200 m	416,000Rp./m	2,163.0
2) Booster Pump	Q=34 m3/min, H=45m		2,802.2
(3)-2 Sanur Area			
1) Pipe (ø500 x 2 lines)	5,160m x 2 lines	386,100Rp./m	3,984
2) Booster Pump	Q=31.6 m3/min, H=40m		2,660
Sub - Total (3)			11,609.2

Table E.7.1(2) Breakdown of Construction Cost for Sewerage Development

Item	Quantity	Unit Cost	Costruction Cost (million Rp)
(4) Treatment Plant			
(4)-(1) Integrated Treatment Plant (Capacity : 117,000 m3/day)			22,020.0
(A) Civil/Architect Works			12,564.0
1) Inflow Pump (152.5 m3/min)	1 ls		4,554.0
2) Aerated Lagoon	1 ls		7,290.0
3) Sludge Drying Bed	6,000 m2	50,000 Rp/m2	300.0
4) Administration Building	600 m2	300,000 Rp/m2	180.0
5) Micellaneous Works	1 ls		240.0
(B) Mechanical/Electrical Works			9,456.0
1) Inflow Pump (152.5 m3/min)	1 ls		6,546.0
2) Aerated Lagoon	1 ls		2,910.0
(4)-(2) Existing Treatment Plant Upgrading (Capacity : 18,800 m3/day)			3,178.4
(A) Civil/Architect Works			598.4
1) Aerated Lagoon	1 ls		372.2
2) Chlorination Tank	1 ls		46.2
3) Sludge Drying Bed	1,000 m2	50,000 Rp/m2	50.0
4) Administration Building	200 m2	300,000 Rp/m2	60.0
5) Miscellaneous Works	1 ls		70.0
(B) Mechanical/Electrical Works	1 ls		2,580.0
Sub - Total (4)			25,198.4
Total (2) + (3) + (4)			211,309.9
Total (1) + (2) + (3) + (4)			232,061.3

Table E.7.2 Unit Basic Construction Cost

1. Basic Construction Cost

No.	Works Item	Unit	Unit Price
1	Common Excavation	m 3	Rp. 2,575
2	Back fill	m 3	Rp. 867
3	a. Concrete Mix. 1:3:5	m 3	Rp. 91,281
	b. Concrete Mix. 1:2:3	m 3	Rp. 179,452
4	Reinforced Bar	kg	Rp. 1,500
5	Worker Form a) Wooden Material	m 2	Rp. 4,367
	b) Plywood Material	m 2	Rp. 5,039
6	Masonry 1:2	m 3	Rp. 92,076
7	Brick 1:2	m 3	Rp. 124,662
8	Mortar 1:2	m 2	Rp. 3,680
9	Sand fill	m 3	Rp. 18,787

2. Unit Construction Cost of Pipe Laying Work

Diameter (mm)	Unit Cost (1,000 Rp./m)	Remarks
150	201.8	include manhole cost
200	232.2	
250	260.8	
300	309.8	
350	315.7	
400	336.8	
450	368.1	
500	395.9	
600	486.4	
700	891.7	
800	918.5	
900	1,014.4	
1,000	1,104.8	
1,100	1,197.9	
1,200	1,290.1	
1,350	1,498.5	
1,500	1,734.8	

Table E.7.3 Break-down of Project Cost and O&M Cost by Sewerage Development Area

	Denpasar	Kuta	Sanur	Tanjung Benoa	Total
Project Cost (million Rp.)					
(A) Direct Const. Cost	129,335	41,640	33,199	7,135	211,309
(1) Collection Sewer	113,794	33,673	23,078	3,957	174,502
(2) Force Main	-	4,965	6,644	-	11,609
(3) Treatment Plant	15,541	3,002	3,477	3,178	25,198
(B) Administration Cost	2,869	554	642	161	4,226
(C) Engineering Cost	11,477	2,218	2,567	643	16,905
(D) Physical Contingency	14,366	2,776	3,214	804	21,160
Total	158,047	47,188	39,622	8,743	253,600
(E) House Connection Cost	17,656	1,231	1,749	115	20,751
Grand Total	175,703	48,419	41,371	8,858	274,351
O&M Cost (million Rp./yr.)					
(A) Collection Sewer	215	24	36	2	277
(B) Force Main	-	136	195	-	331
(C) Treatment Plant	1,366	264	306	126	2,062
Total	1,581	424	537	128	2,670

Note: The construction cost and O&M cost of the integrated treatment plant are allocated for Denpasar, Kuta and Sanur in proportion to the wastewater generation of each area.

Table E.7.4 Breakdown of Operation and Maintenance Cost

Item	Quantity	Unit Cost	O/M Cost/Annum (million Rp.)
(1) Collection System			
Denpasar Area			
Sewer Line	473,720m	300Rp./m	142.1
Lift Pump	563,618kwh	130Rp./kwh	73.3
Kuta Area			
Sewer Line	79,400m	300Rp./m	23.8
Sanur Area			
Sewer Line	108,160m	300Rp./m	32.4
Lift Pump	27,594kwh	130Rp./kwh	3.6
Tanjung Benoa Area			
Sewer Line	6,500m	300Rp./m	2.0
Sub-total(1)			277.2
(2) Force Main			
Kuta Area			
Sewer Pipe	5,200m	300Rp./m	1.6
Booster Pump	1,036,154kwh	130Rp./kwh	134.7
Sanur Area			
Sewer Pipe	5,160m x 2	300Rp./m	3.1
Booster Pump	1,472,556kwh	130Rp./kwh	191.4
Sub-total (2)			330.8
(3) Integrated Treatment Plant			
Inflow Pump	1,176,950kwh	130Rp./kwh	153.0
Aerator	11,755,920kwh	130Rp./kwh	1,528.3
Other Electricity	73,000kwh	130Rp./kwh	9.5
Chemicals	42,705,000m3	3.2Rp./m3	136.7
Repairing	1 ls		84.9
Personnel	10person	2.4million	24.0
Sub-total (3)			1,936.4
(4) Treatment Plant of Tanjung Benoa			
Aerator	739,344kwh	130Rp./kwh	96.1
Other Electricity	10,600kwh	130Rp./kwh	1.4
Chemicals	1,540,300m3	3.2Rp./m3	4.9
Repairing	1 ls		18.5
Personnel	2 person	2.4million	4.8
Sub-total (4)			125.7
Total (1)+(2)+(3)+(4)			2,670.1

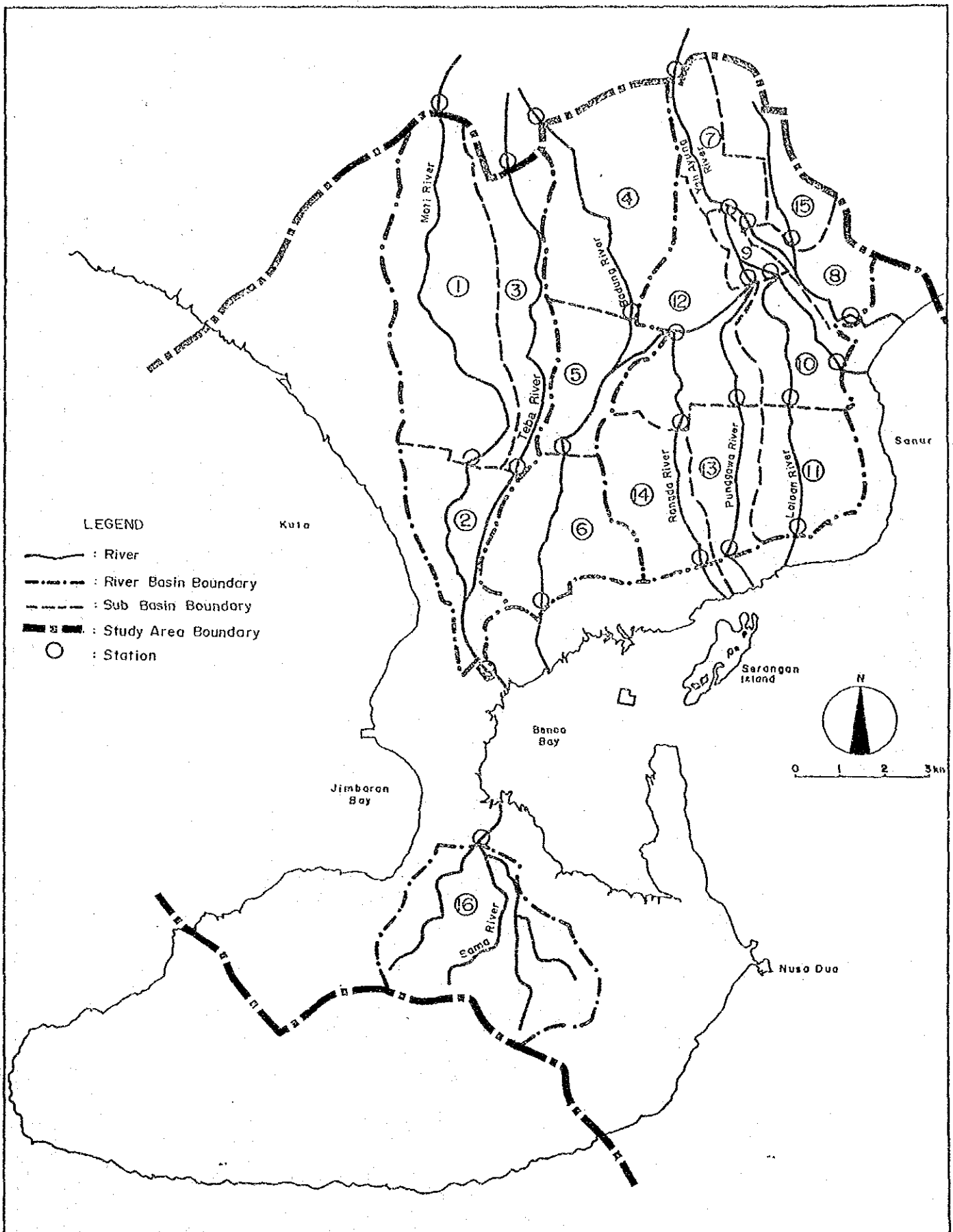

FIG. E.1.1 DIVISION OF OBJECTIVE RIVER BASIN

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

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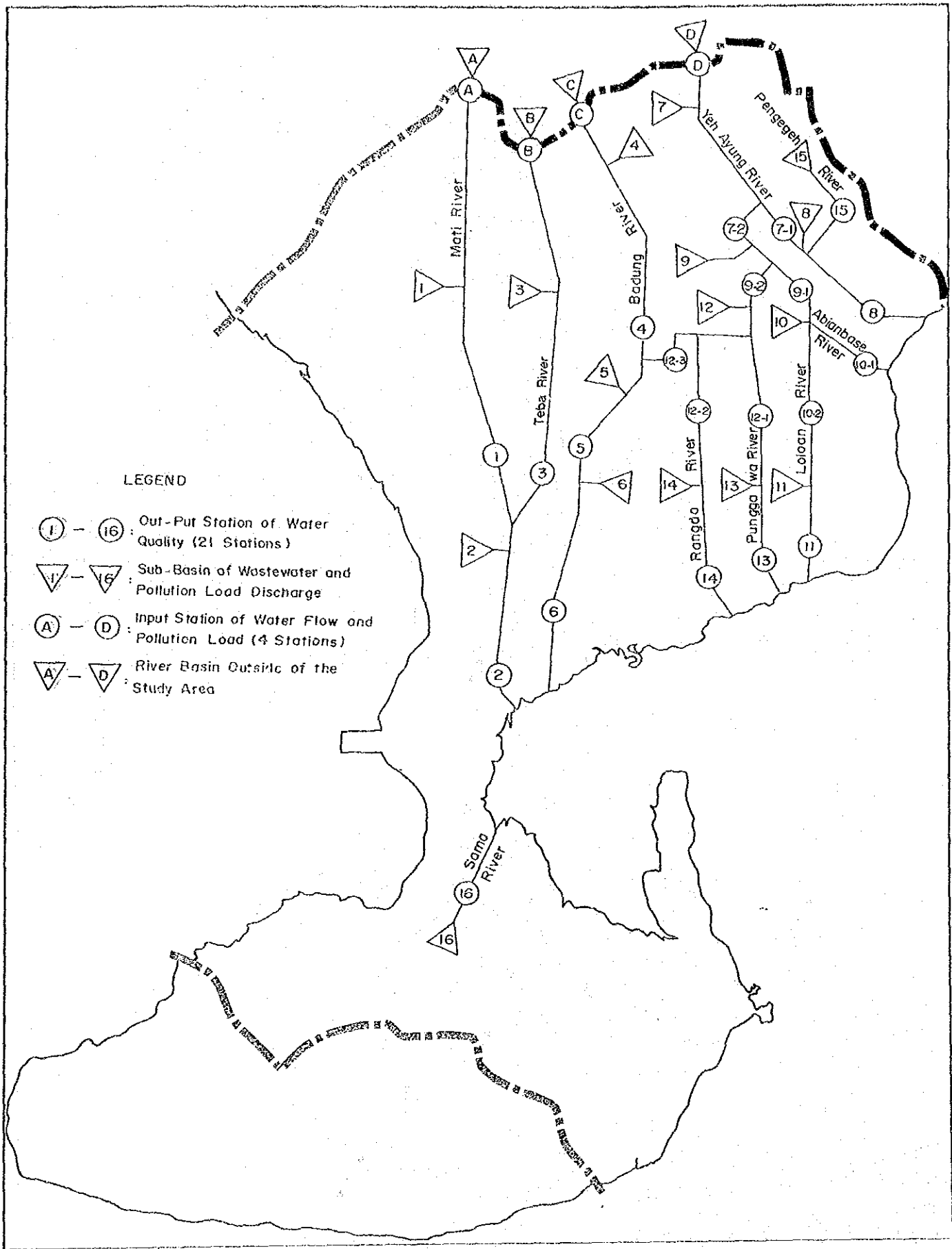

FIG. E.1.2 MODEL OF RIVER SYSTEM

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

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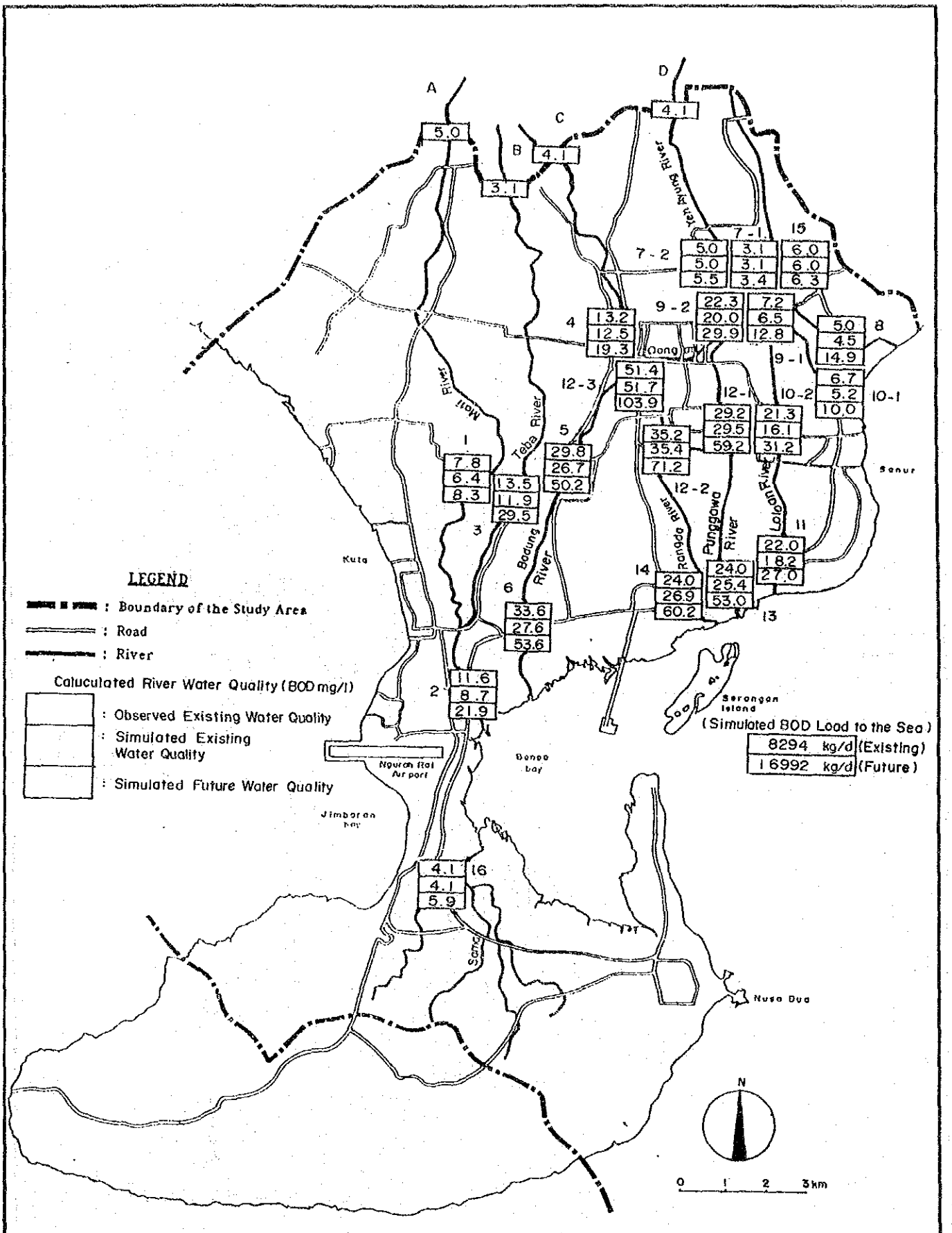


FIG. E.1.3(1) SIMULATED FUTURE RIVER WATER QUALITY (DRY SEASON)

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

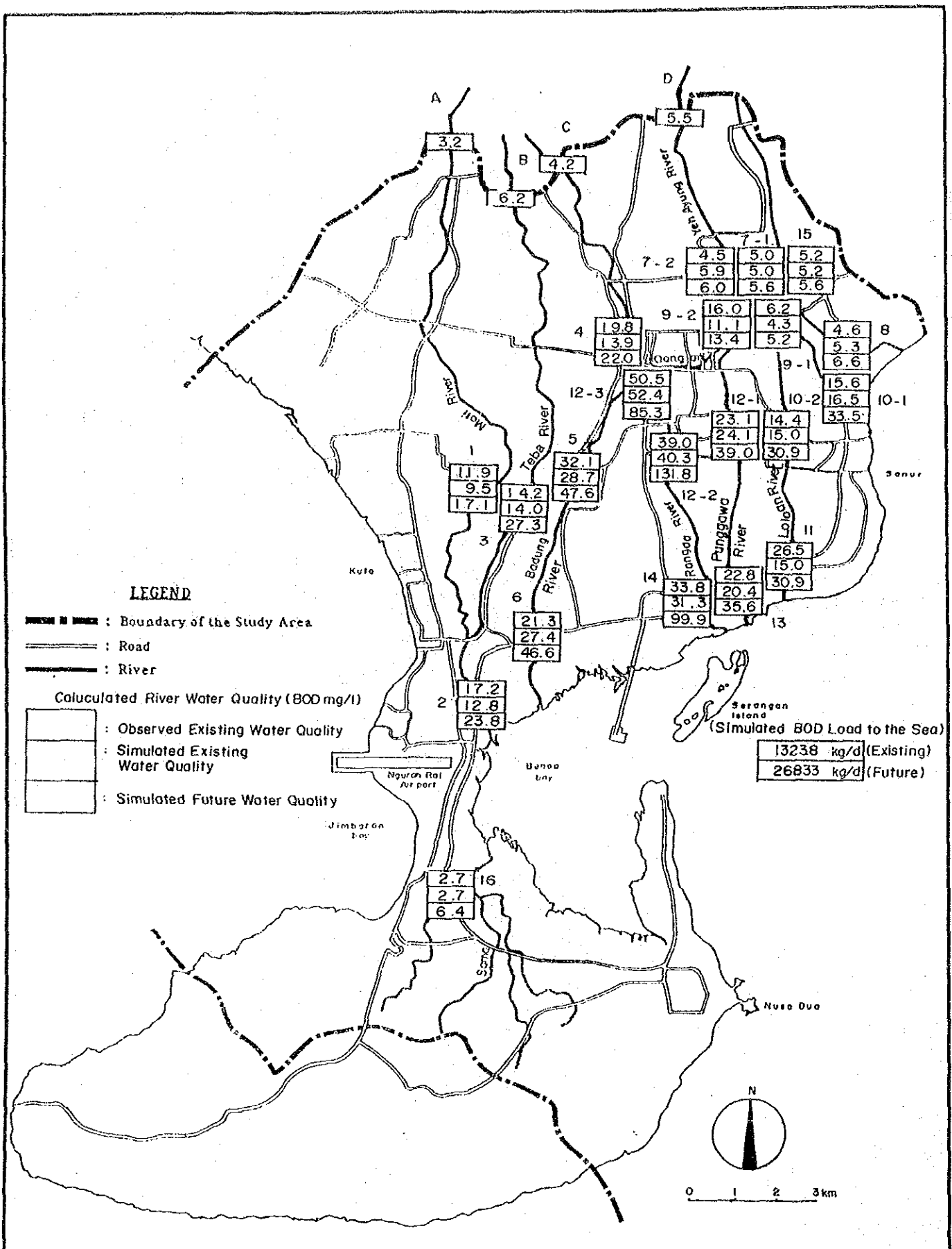
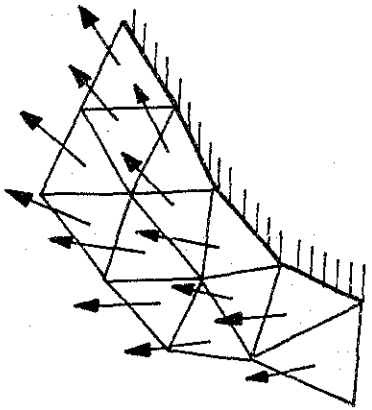
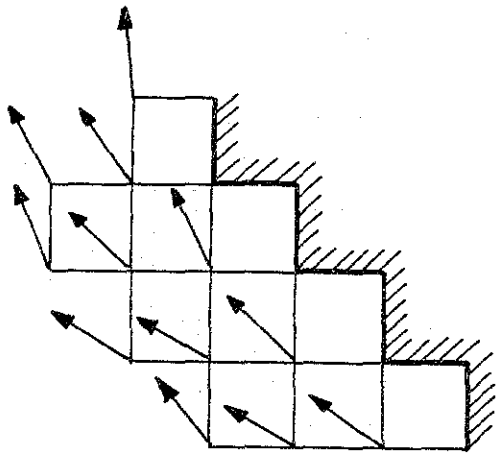


FIG. E.1.3(2) SIMULATED FUTURE RIVER WATER QUALITY (RAINY SEASON)

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR



(a) Finite Element Method (F E M)



(b) Finite Difference Method (F D M)

FIG. E.1.4	COMPARISON BETWEEN FINITE ELEMENT METHOD AND FINITE DIFFERENCE METHOD

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

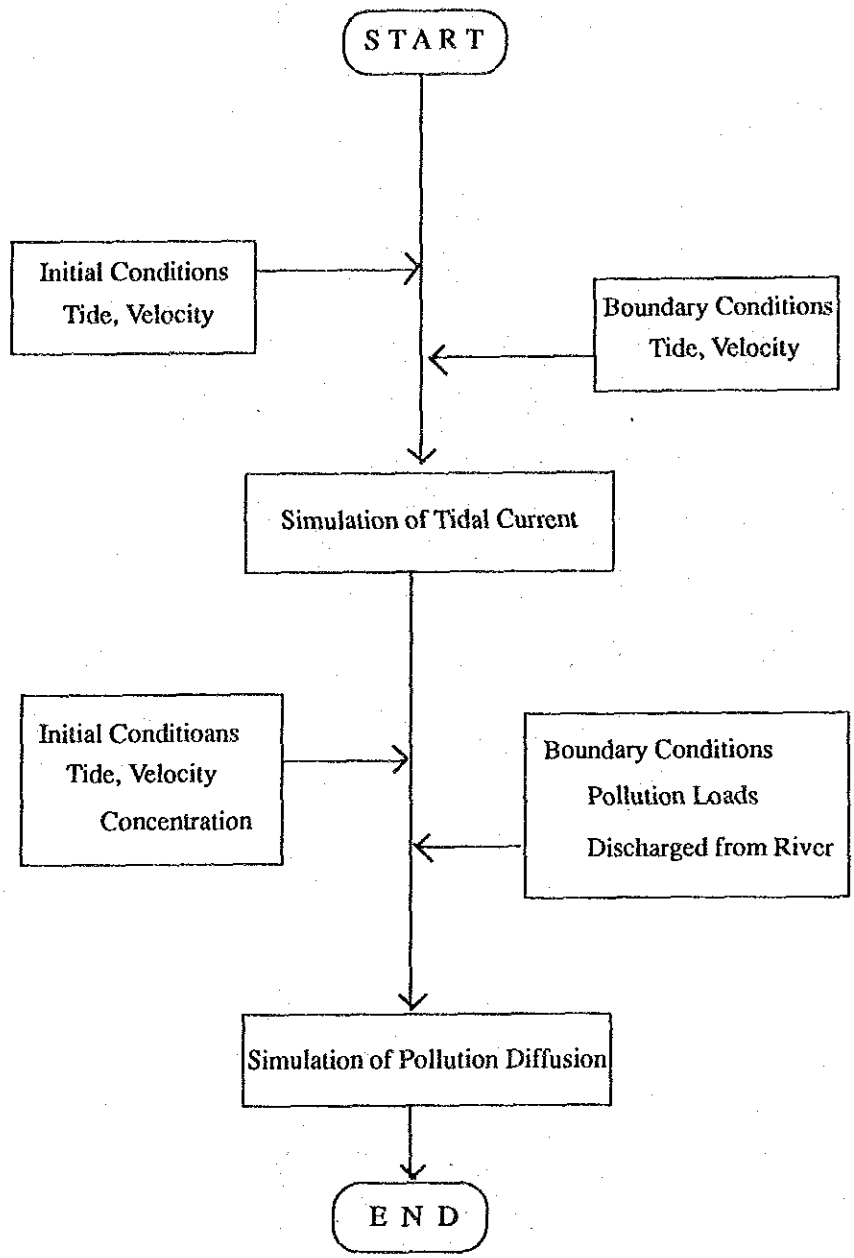
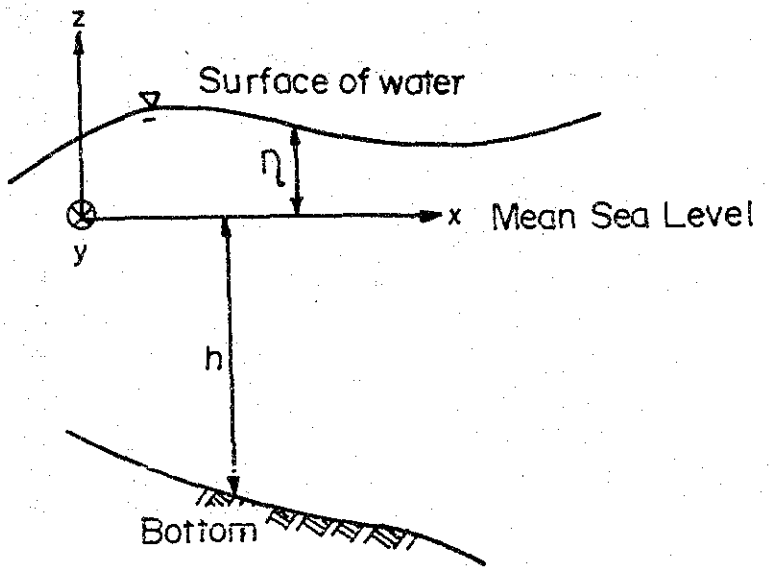


FIG. E.1.5 FLOW CHART OF SIMULATION OF SEA WATER QUALITY

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR



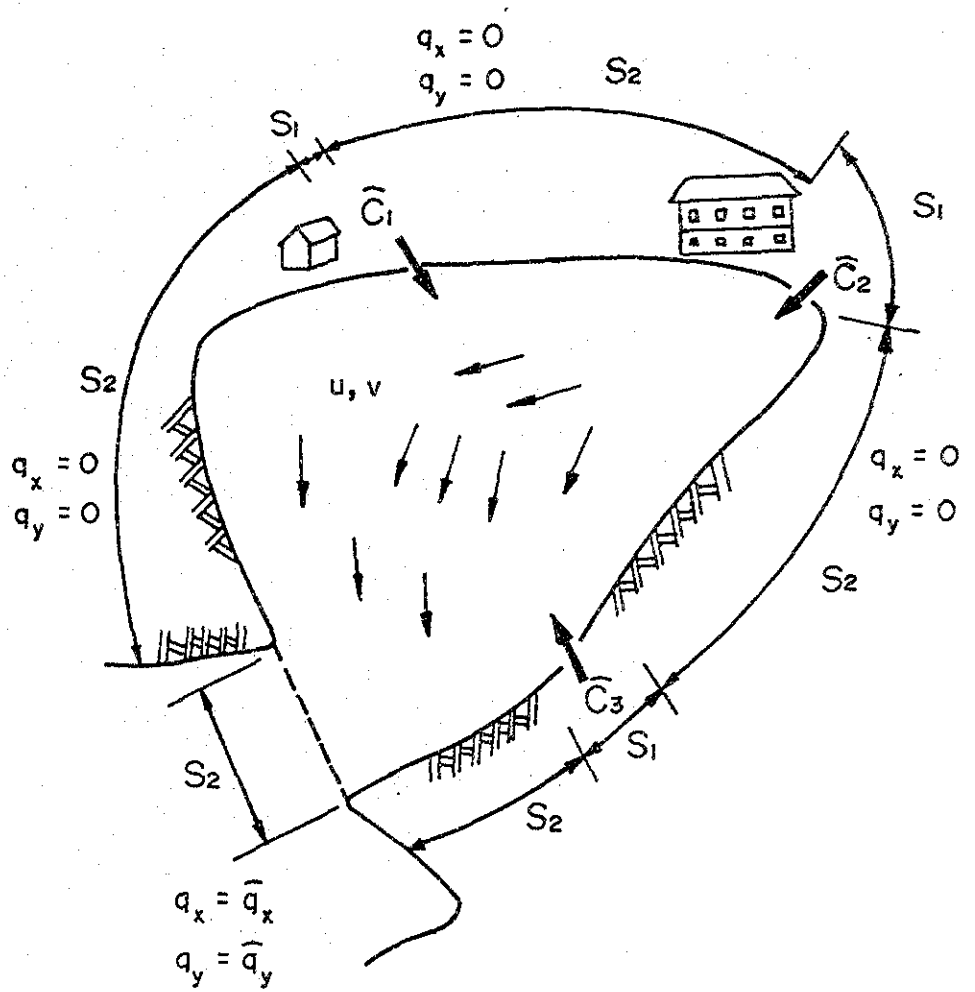
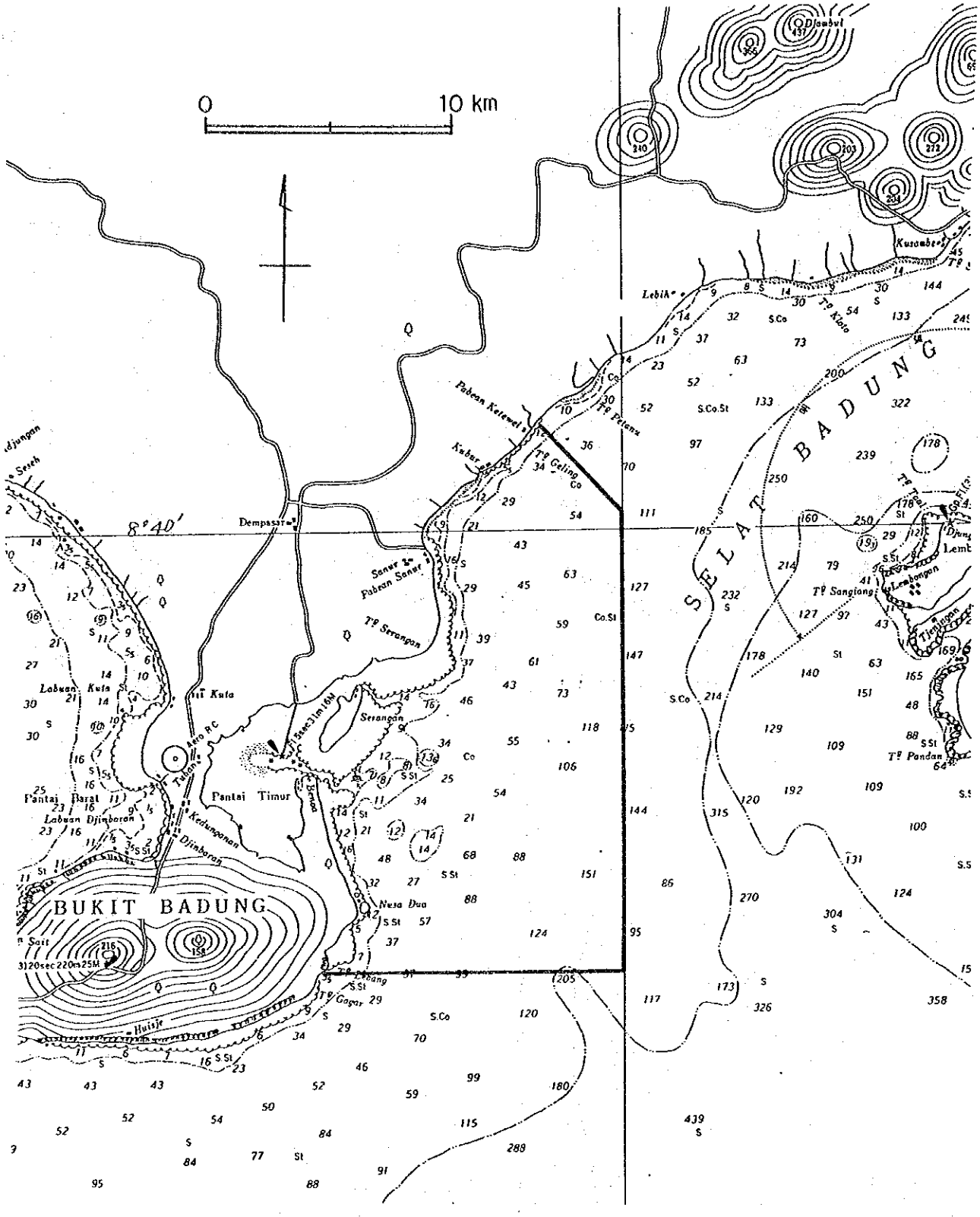


FIG. E.1.6	COORDINATE SYSTEM AND BOUNDARY CONDITIONS OF DIFFUSION MODEL

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR



Figures in the sea : water depth (m)

FIG. E.1.7 SIMULATION AREA FOR SEA WATER QUALITY

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

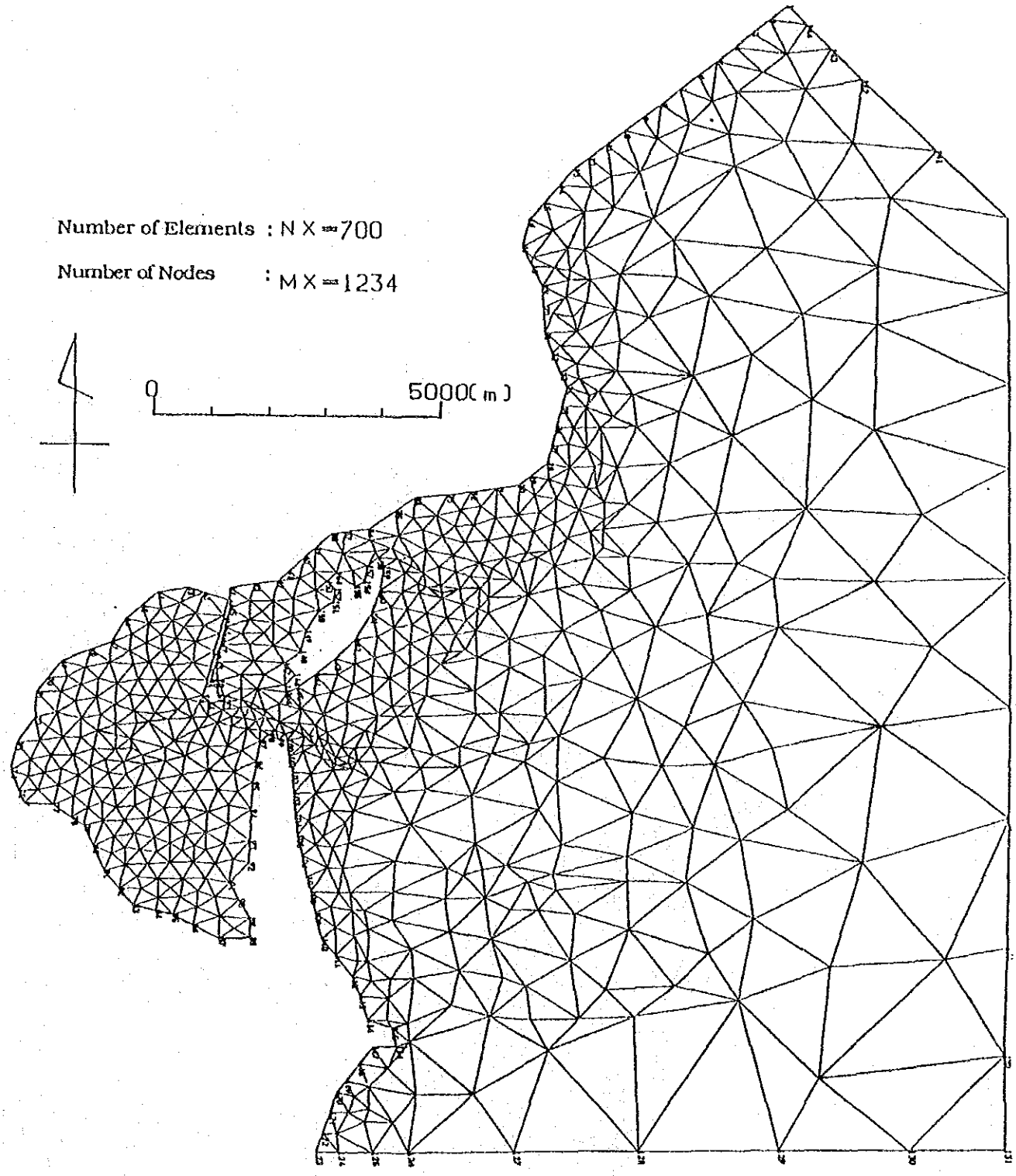


FIG. E.1.8 DISTRIBUTION OF FINITE ELEMENTS

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

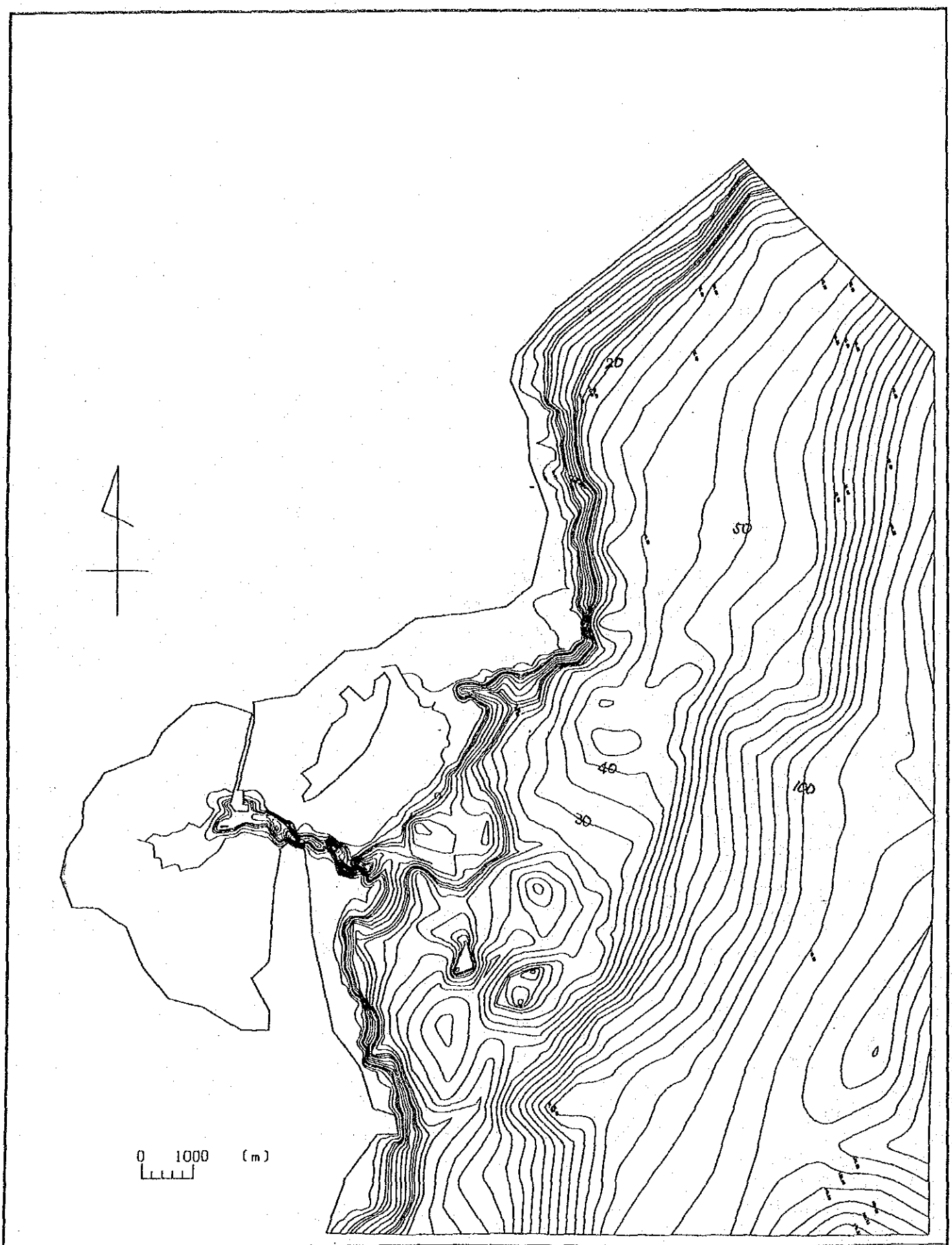


FIG. E.1.9 CONTOUR MAP OF DEPTH

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

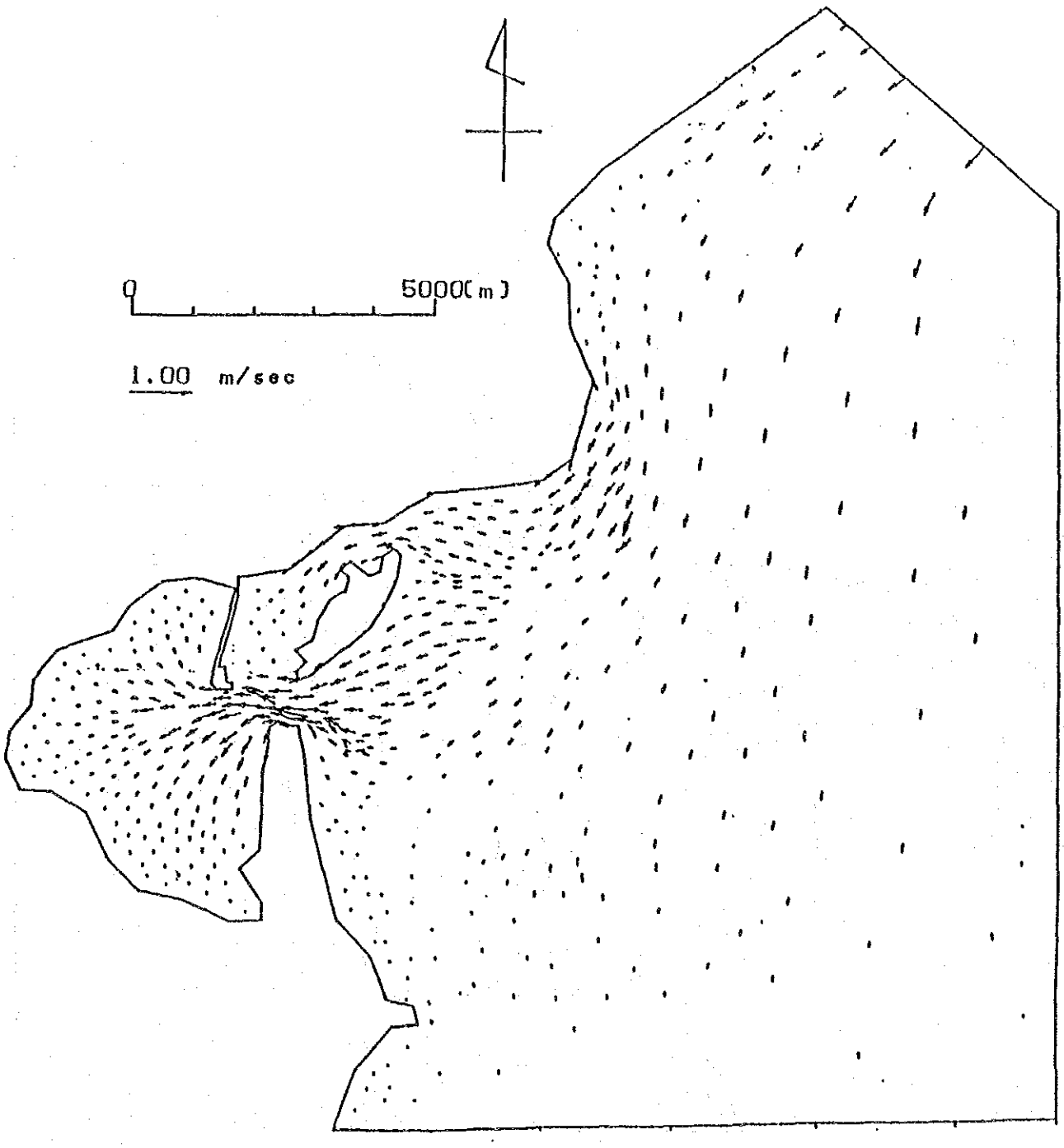


FIG. E.1.10 TIDAL VELOCITY IN FLOOD TIDE

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

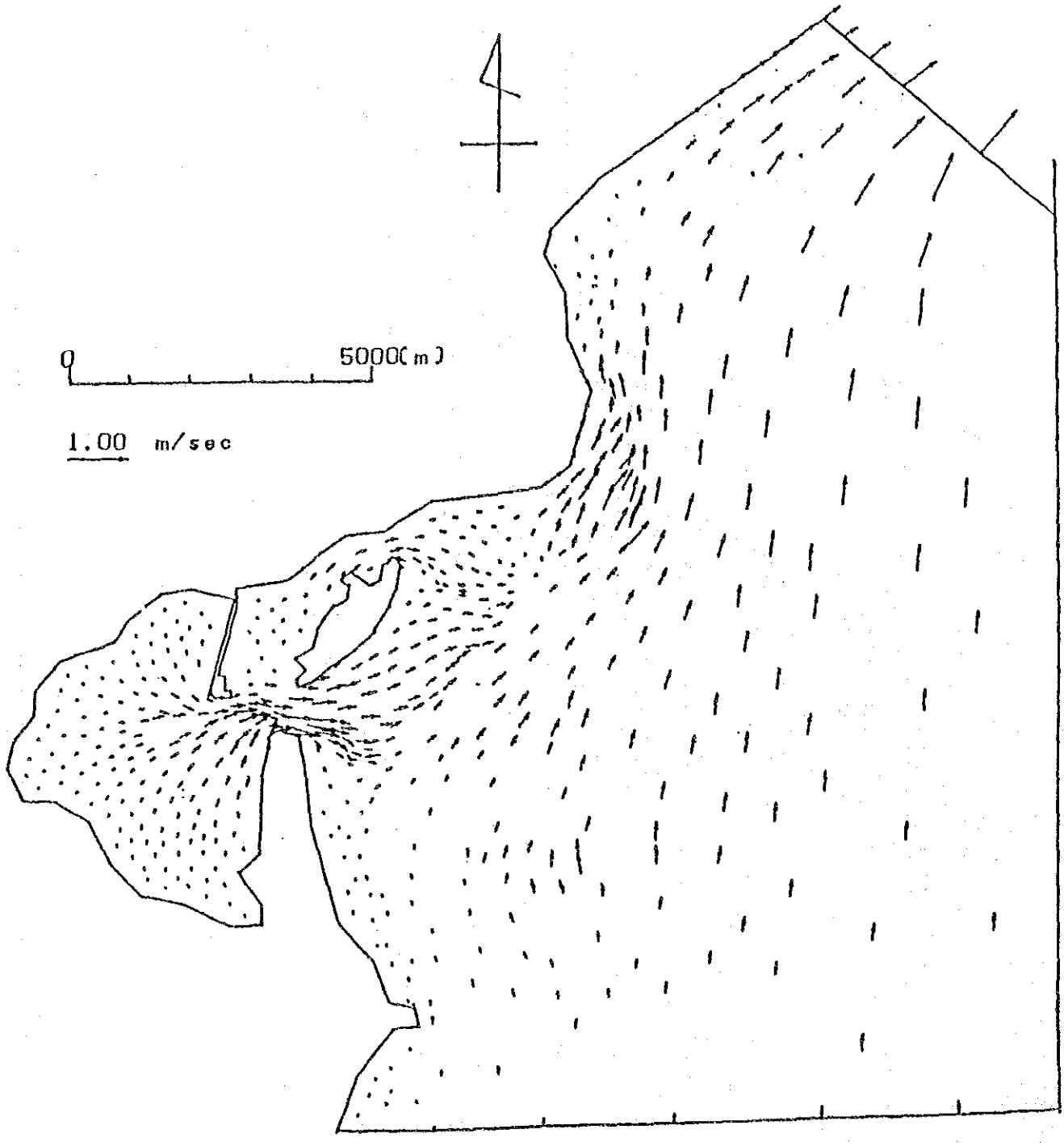


FIG. E.1.11 TIDAL VELOCITY IN EBB TIDE

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

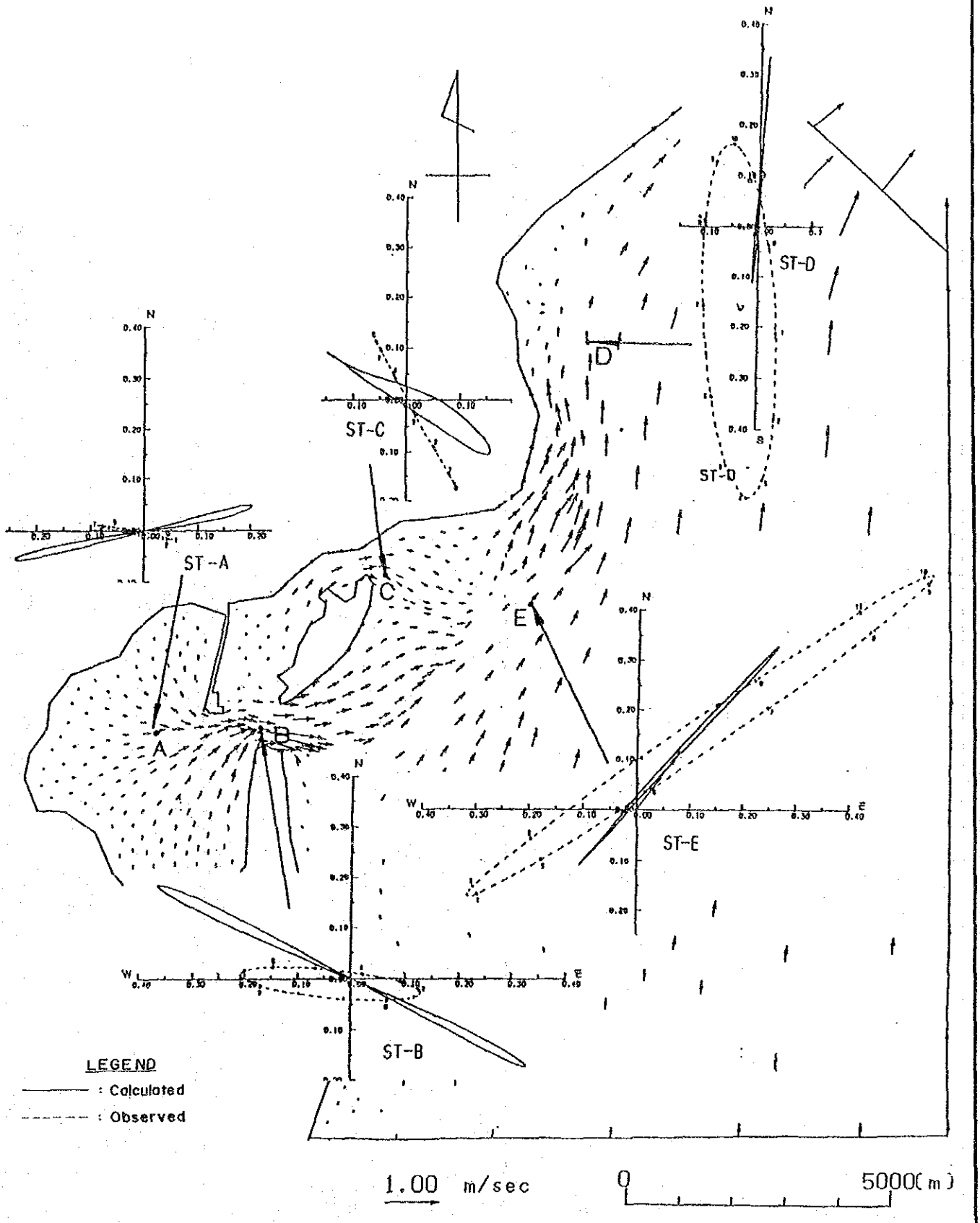


FIG. E.1.12 TIDAL ELLIPSES IN STUDY AREA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

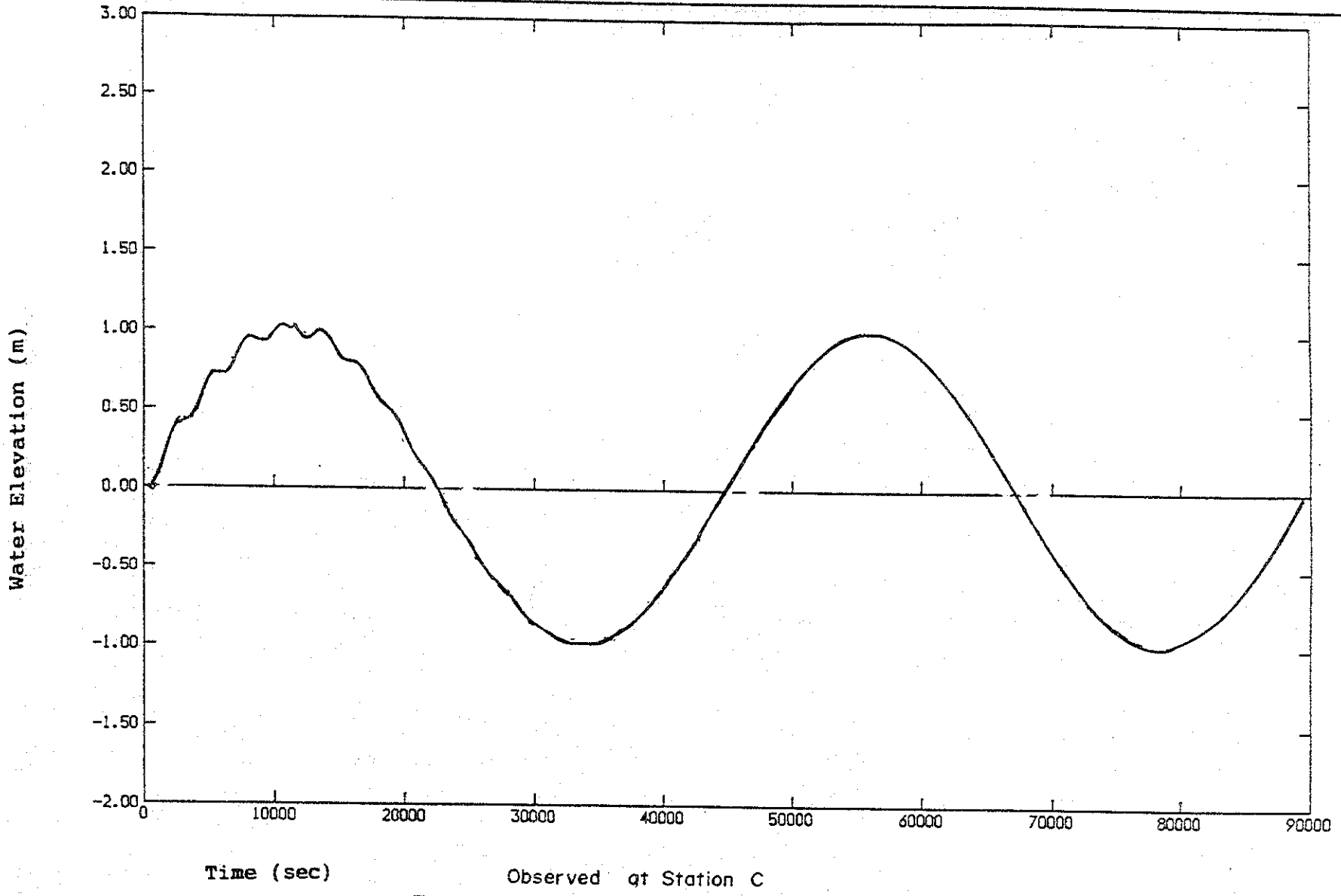


FIG. E.1.13 TIDAL ELEVATION CHANGES

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

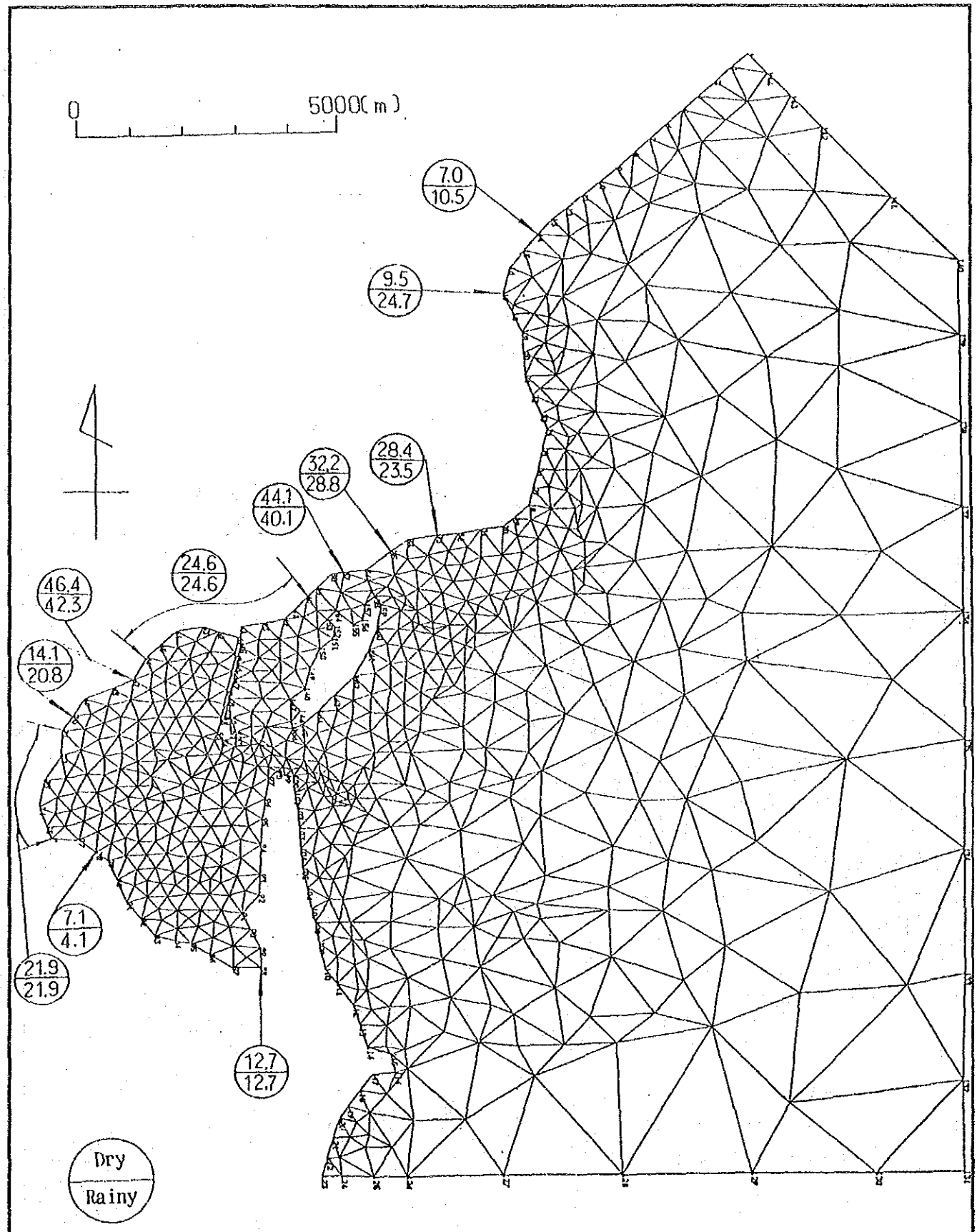


FIG. E.1.14 COD POLLUTION LOADS (EXISTING)

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

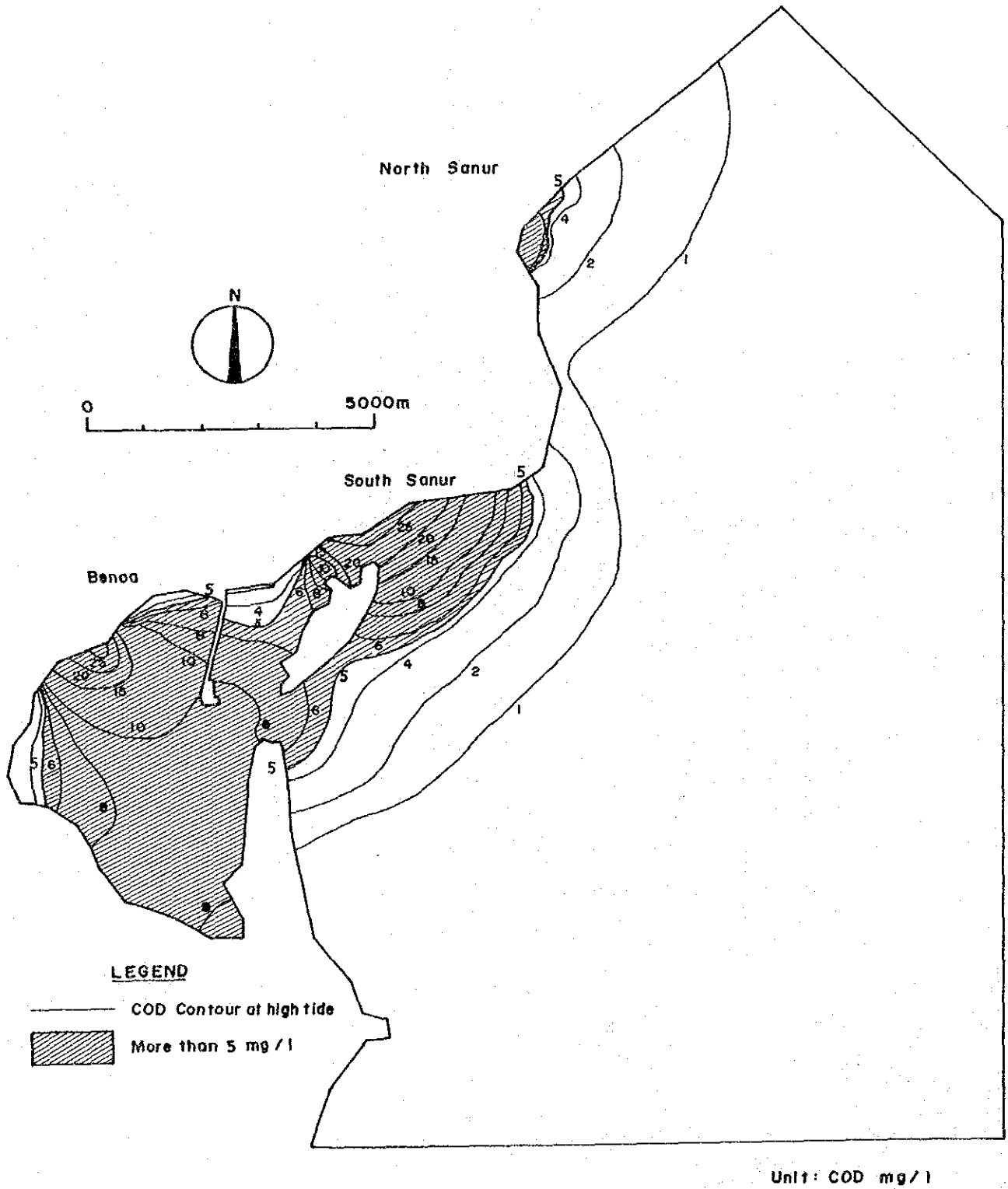


FIG. E.1.15 COD DISTRIBUTION IN DRY SEASON (EXISTING)

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

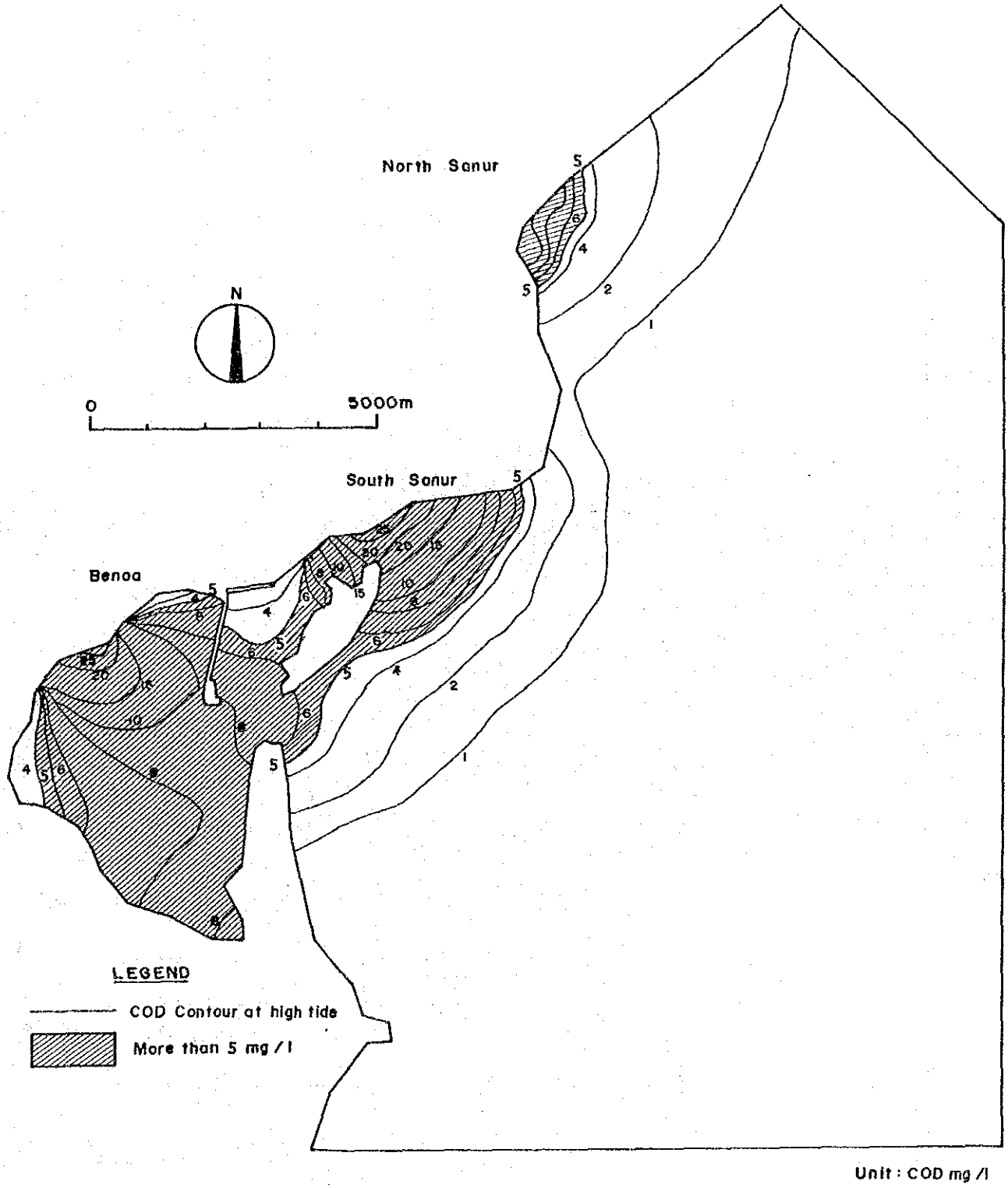


FIG. E.1.16 COD DISTRIBUTION IN RAINY SEASON (EXISTING)

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

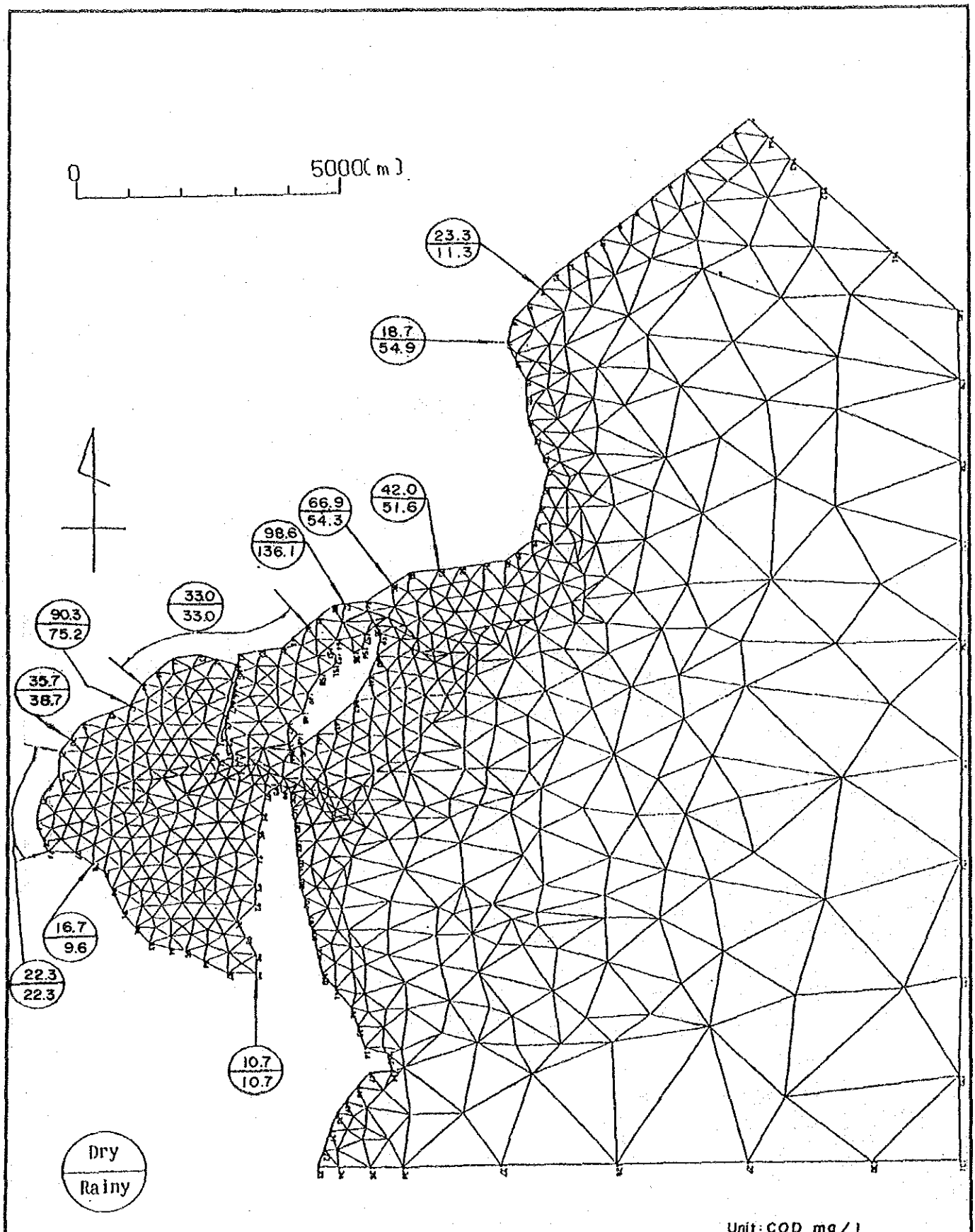


FIG. E.1.17 COD POLLUTION LOADS (FUTURE) - WITHOUT PROJECT

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

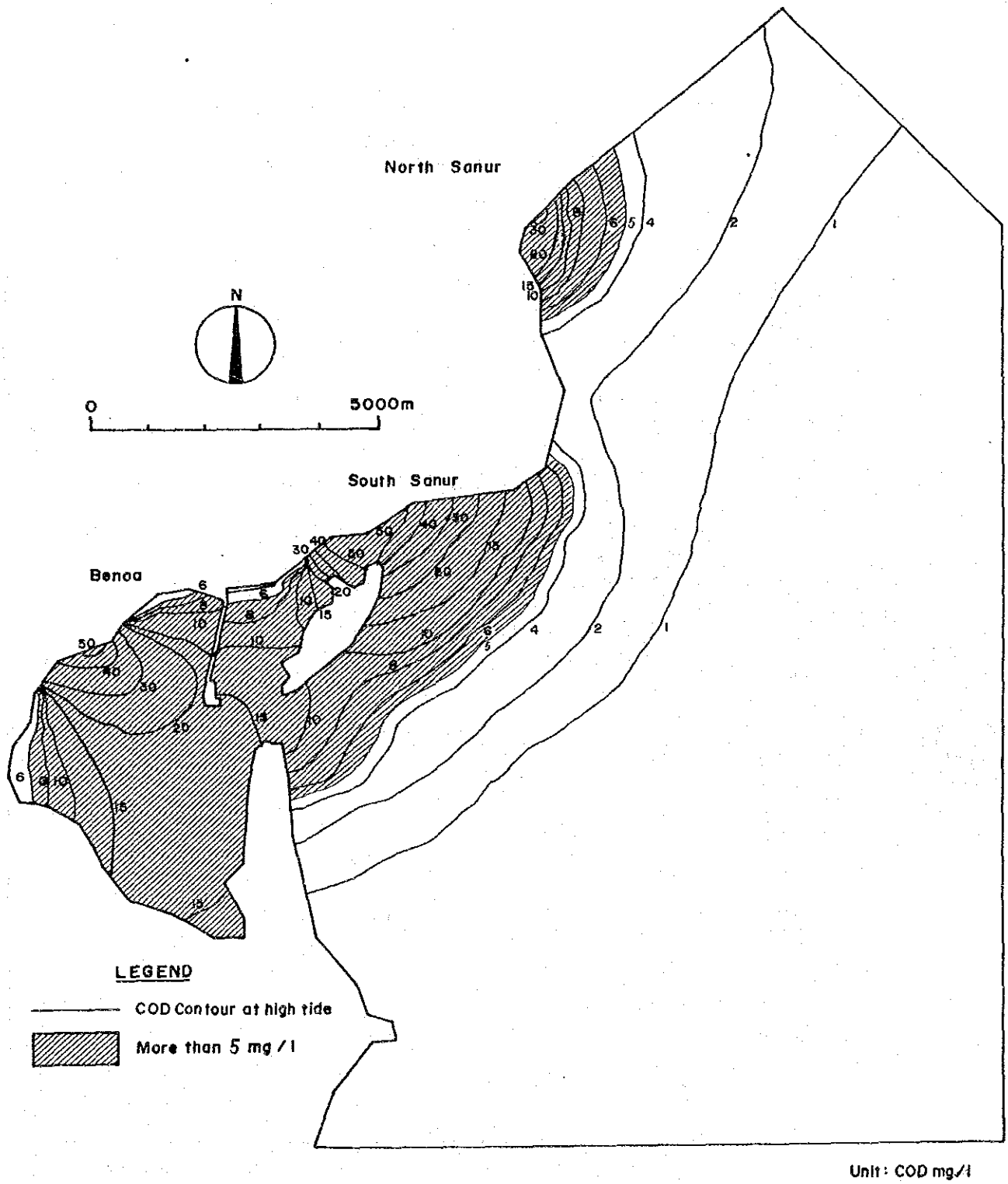


FIG. E.1.18 COD DISTRIBUTION IN DRY SEASON (FUTURE) - WITHOUT PROJECT

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

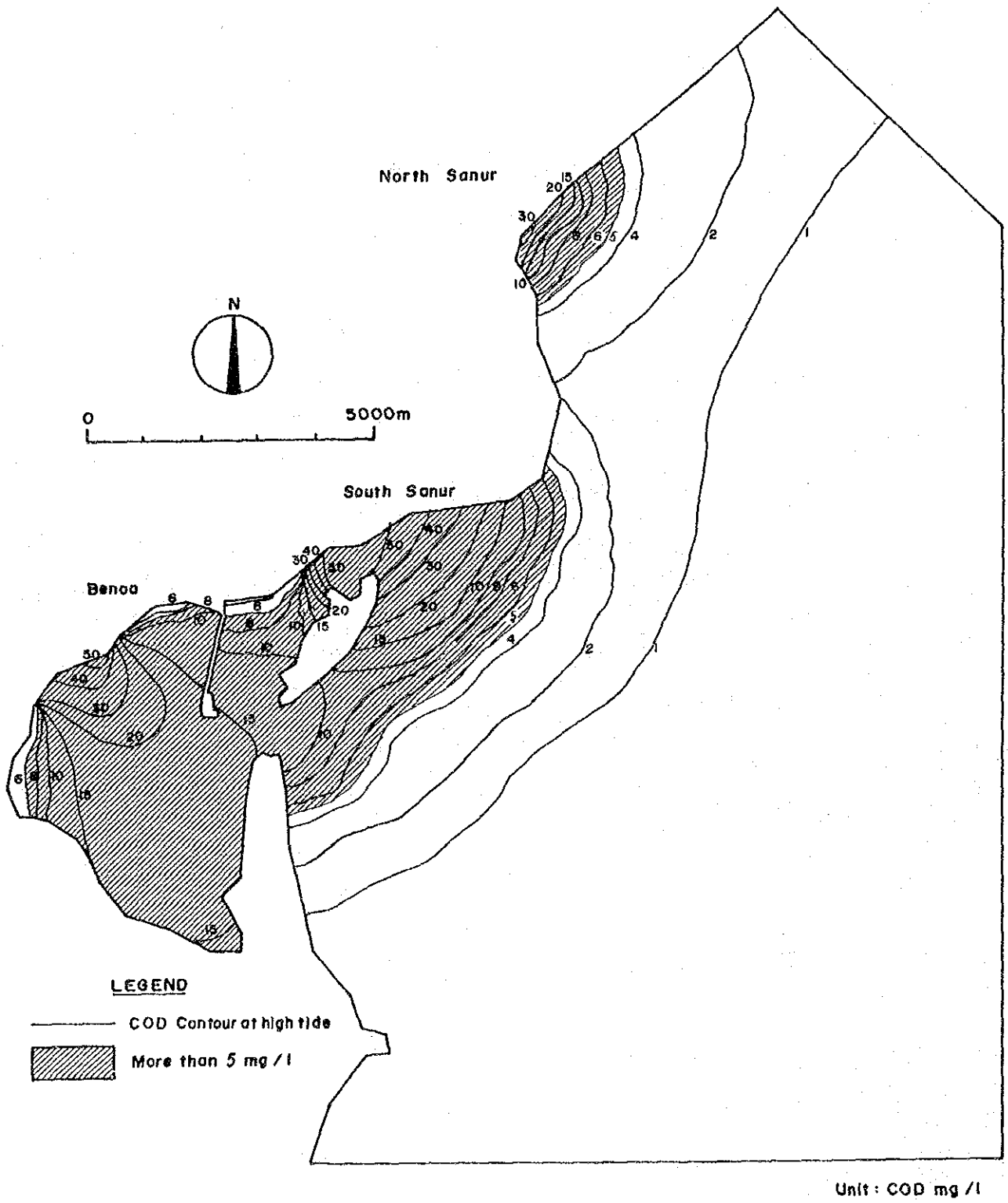


FIG. E.1.19 COD DISTRIBUTION IN RAINY SEASON (FUTURE) - WITHOUT PROJECT

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

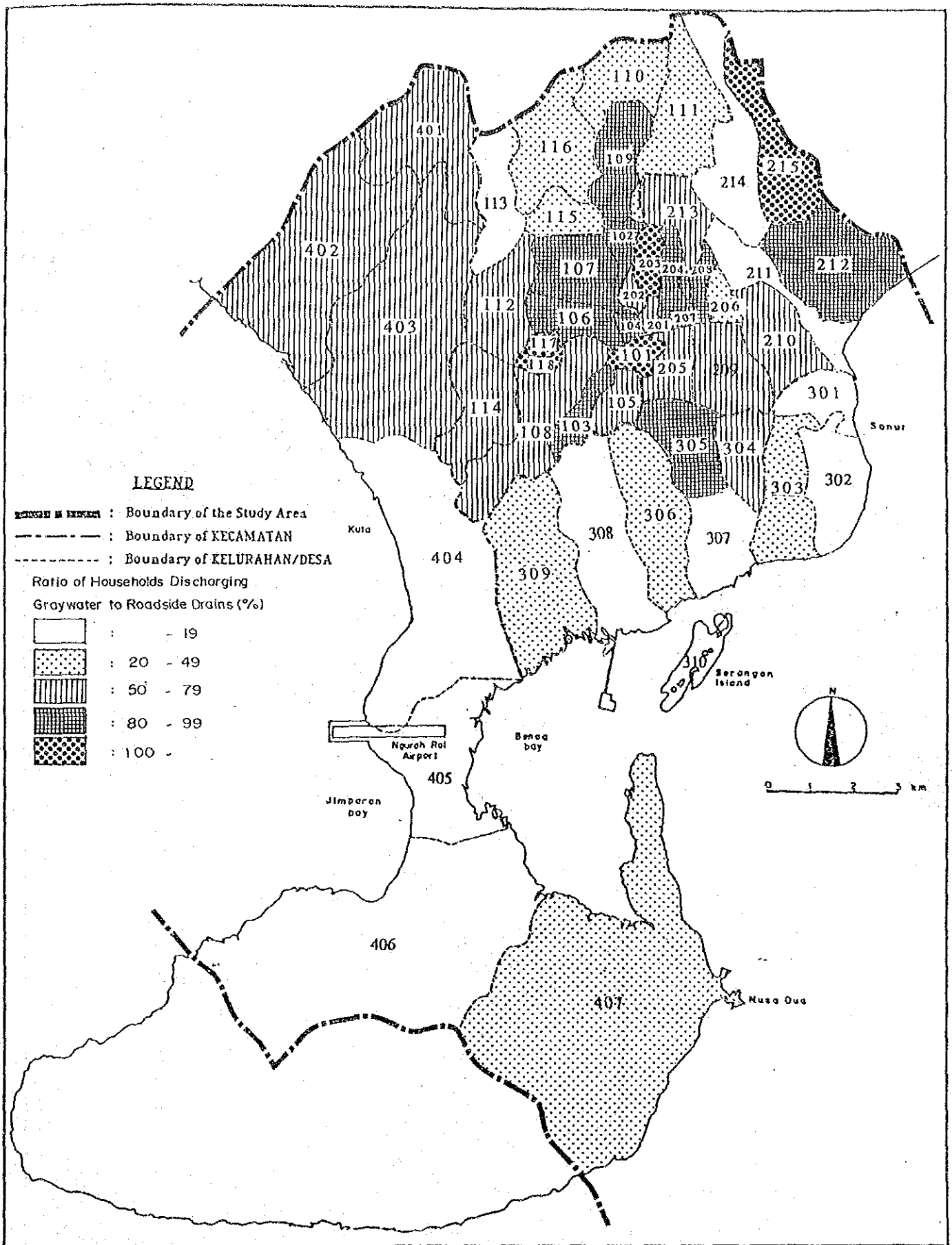


FIG. E.2.1 EXISTING STATUS OF GRAYWATER MANAGEMENT

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

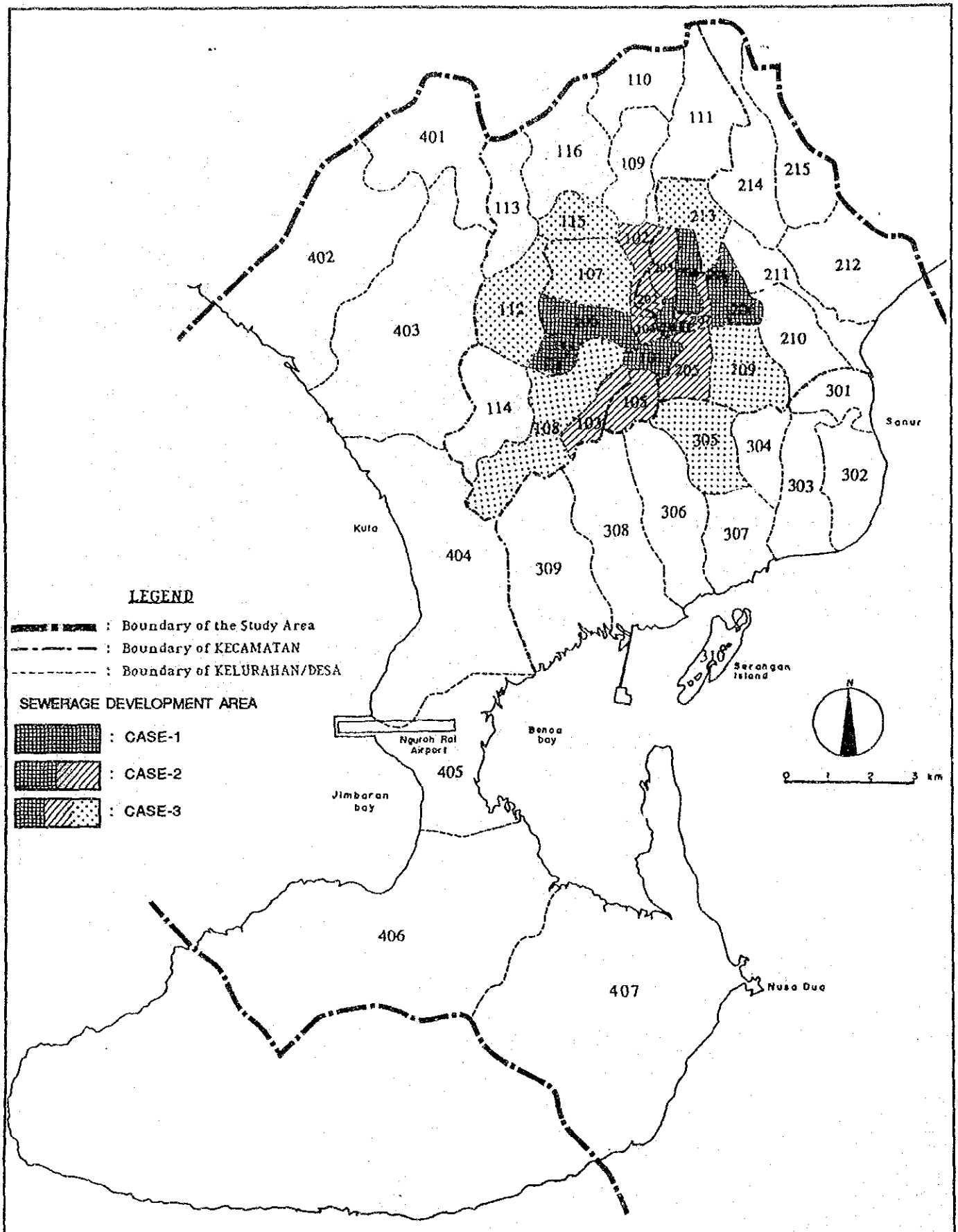


FIG. E.2.2 SEWERAGE DEVELOPMENT AREA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

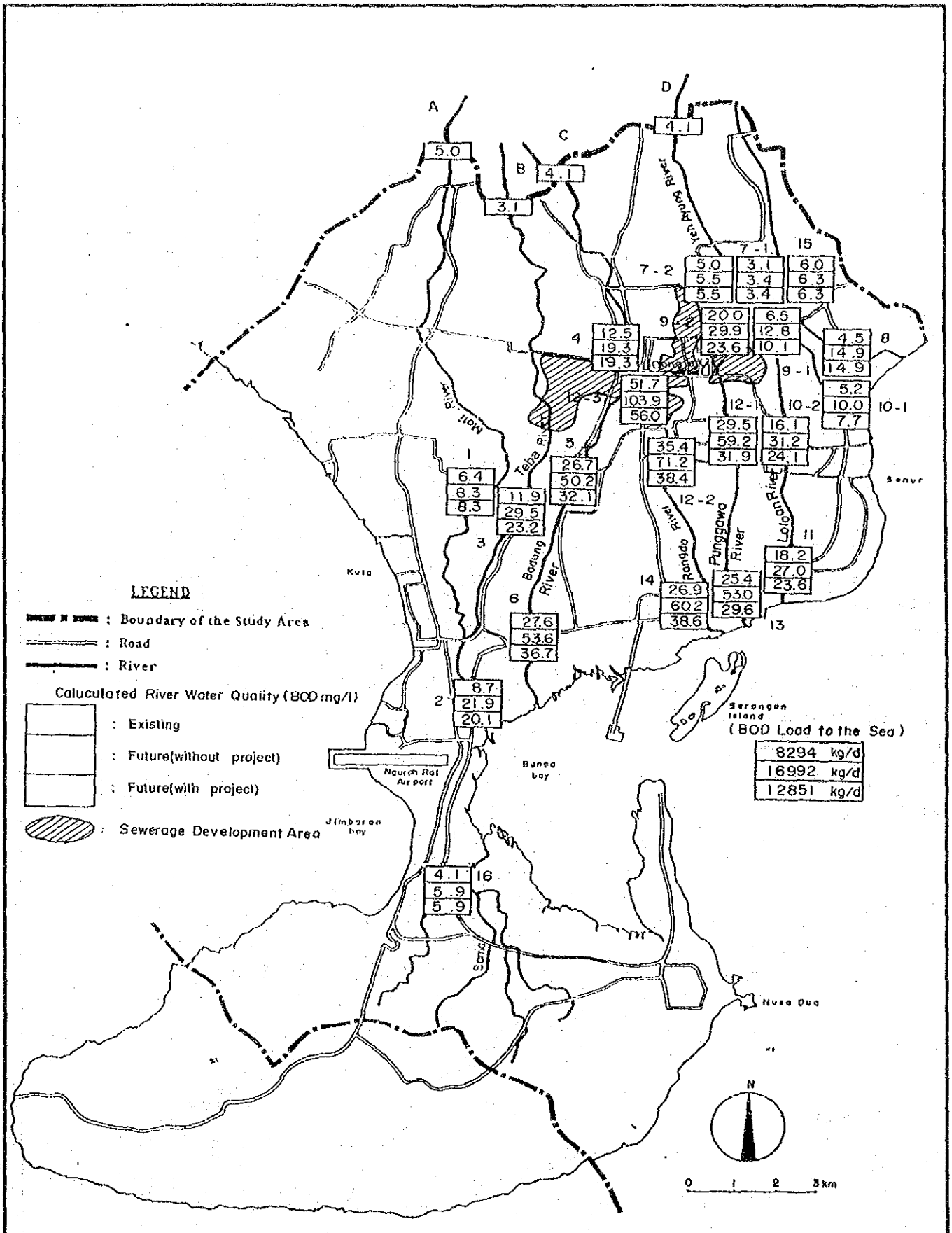


FIG. E.2.3(1) SIMULATED RIVER WATER QUALITY BY SEWERAGE SYSTEM ONLY OF CASE - I (DRY SEASON)

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

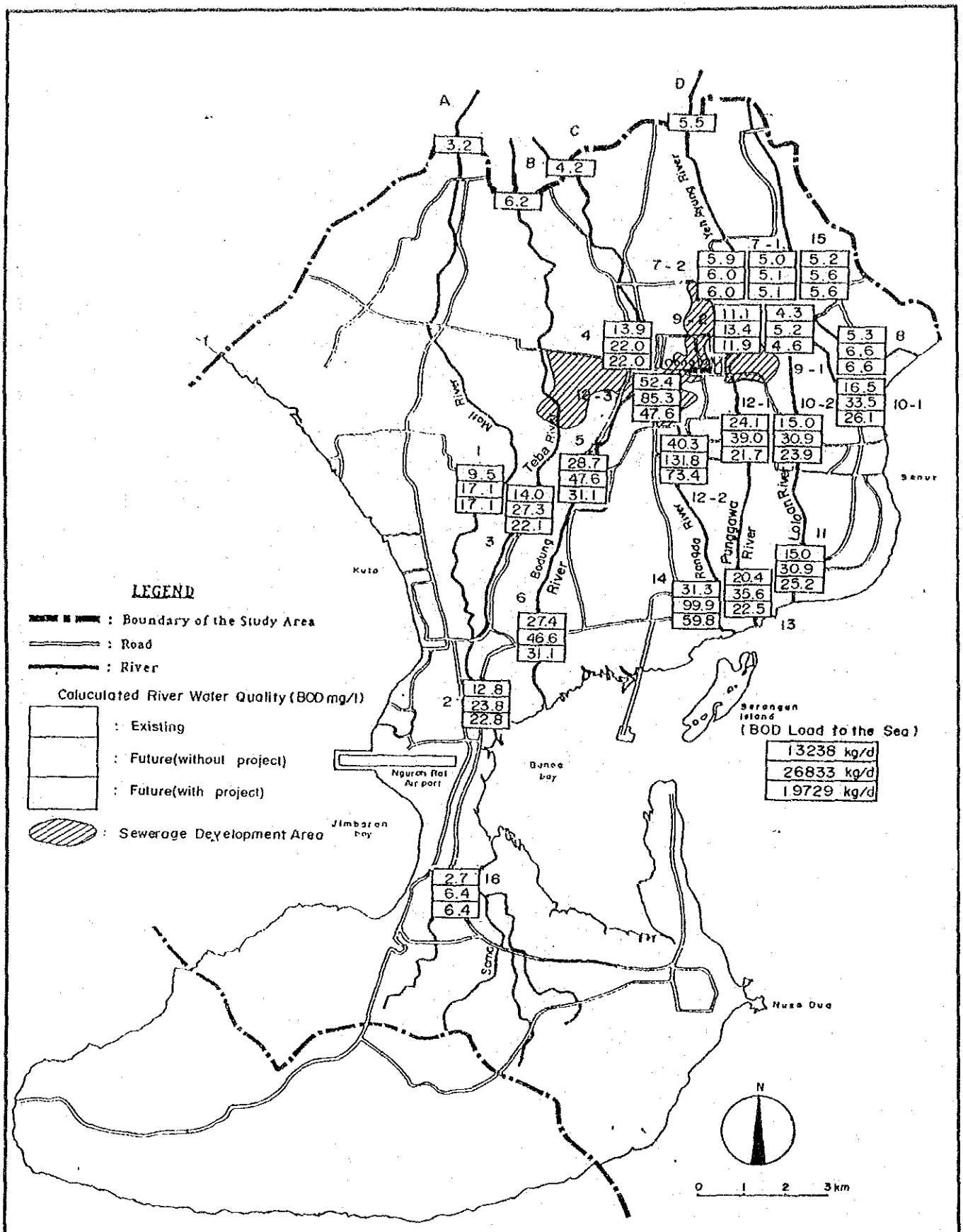


FIG. E.2.3(2) SIMULATED RIVER WATER QUALITY BY SEWERAGE SYSTEM ONLY OF CASE - I (RAINY SEASON)

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

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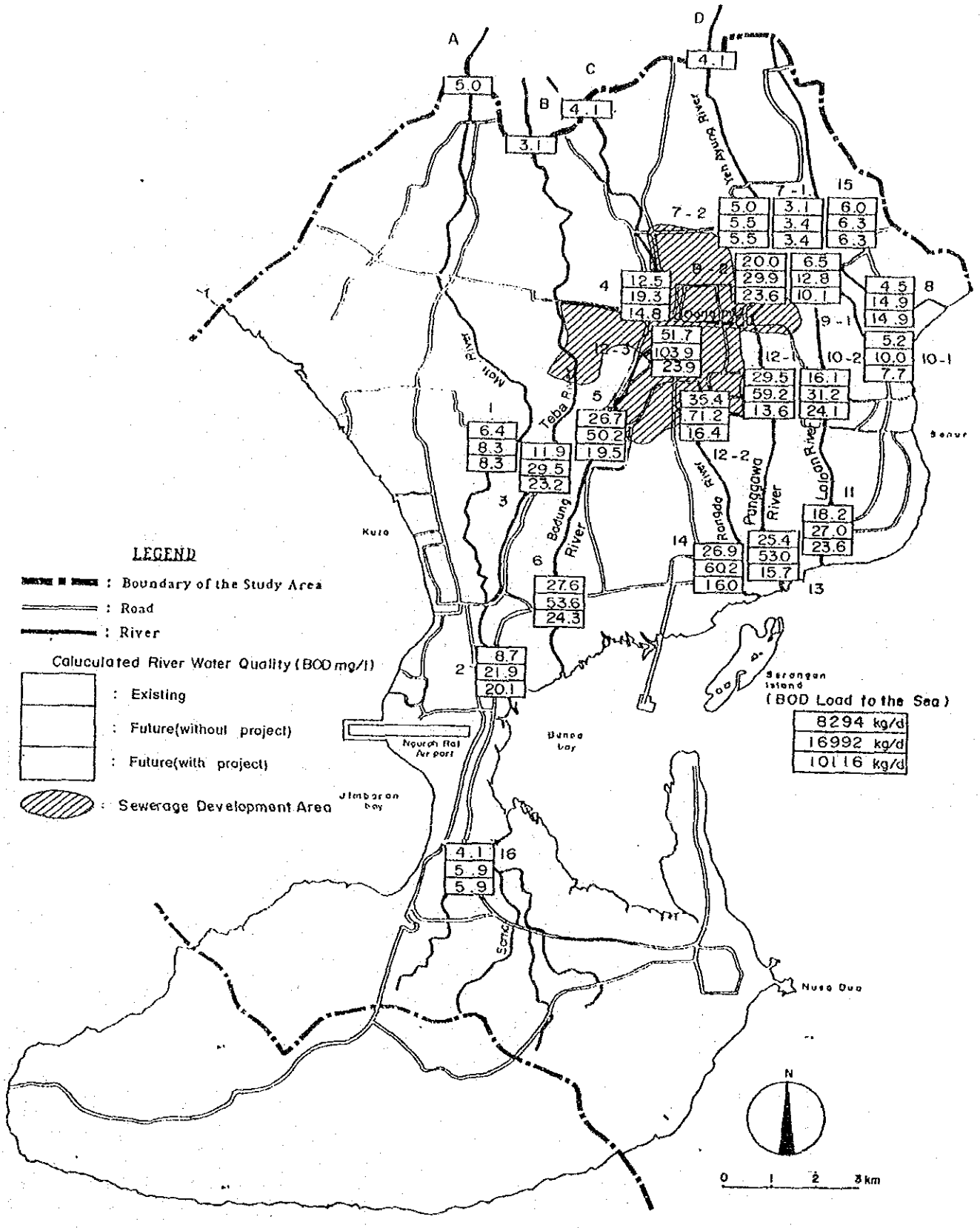

FIG. E.2.4(1) SIMULATED RIVER WATER QUALITY BY SEWERAGE SYSTEM ONLY OF CASE - II (DRY SEASON)

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

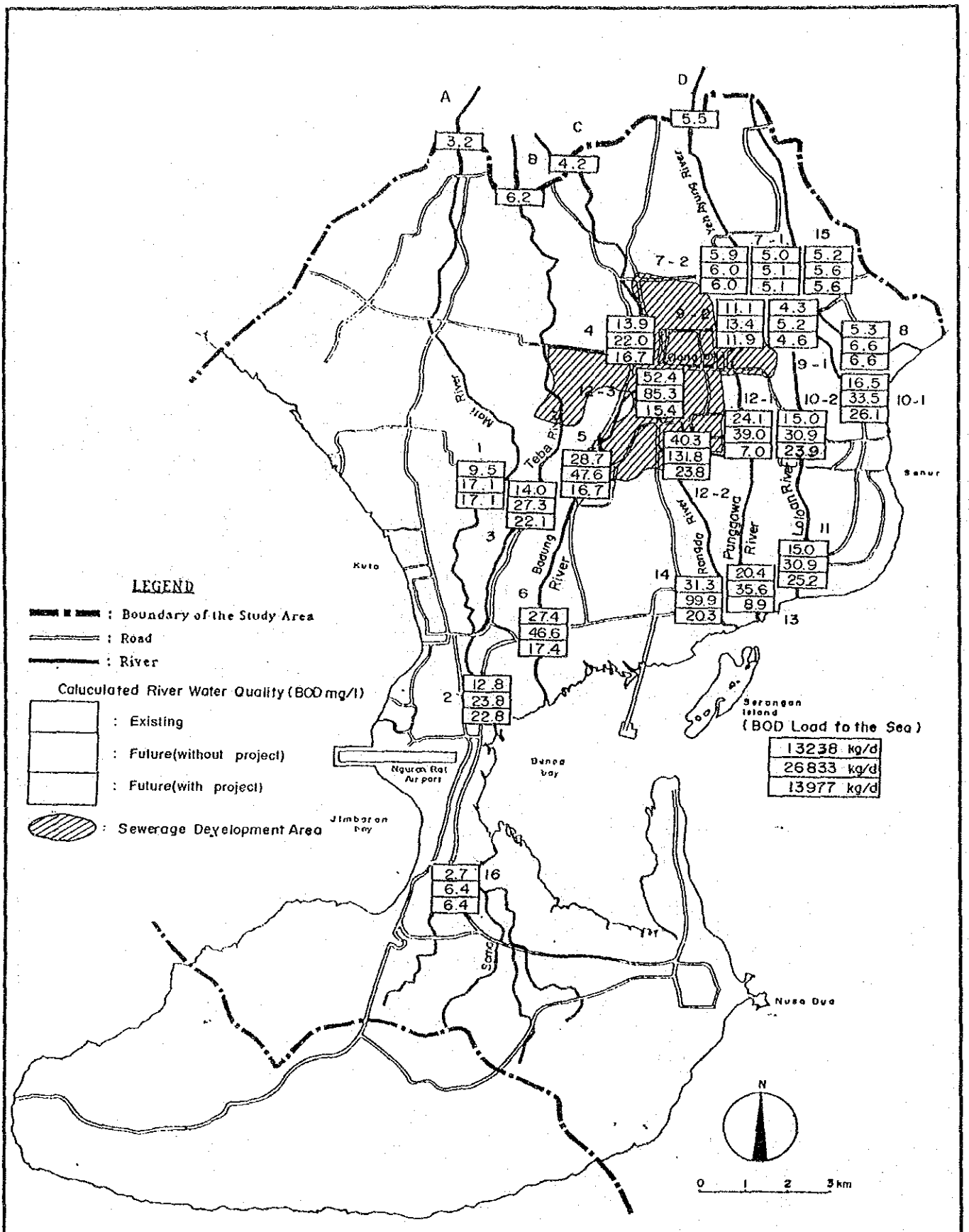

FIG. E.2.4(2) SIMULATED RIVER WATER QUALITY BY SEWERAGE SYSTEM ONLY OF CASE - II (RAINY SEASON)

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

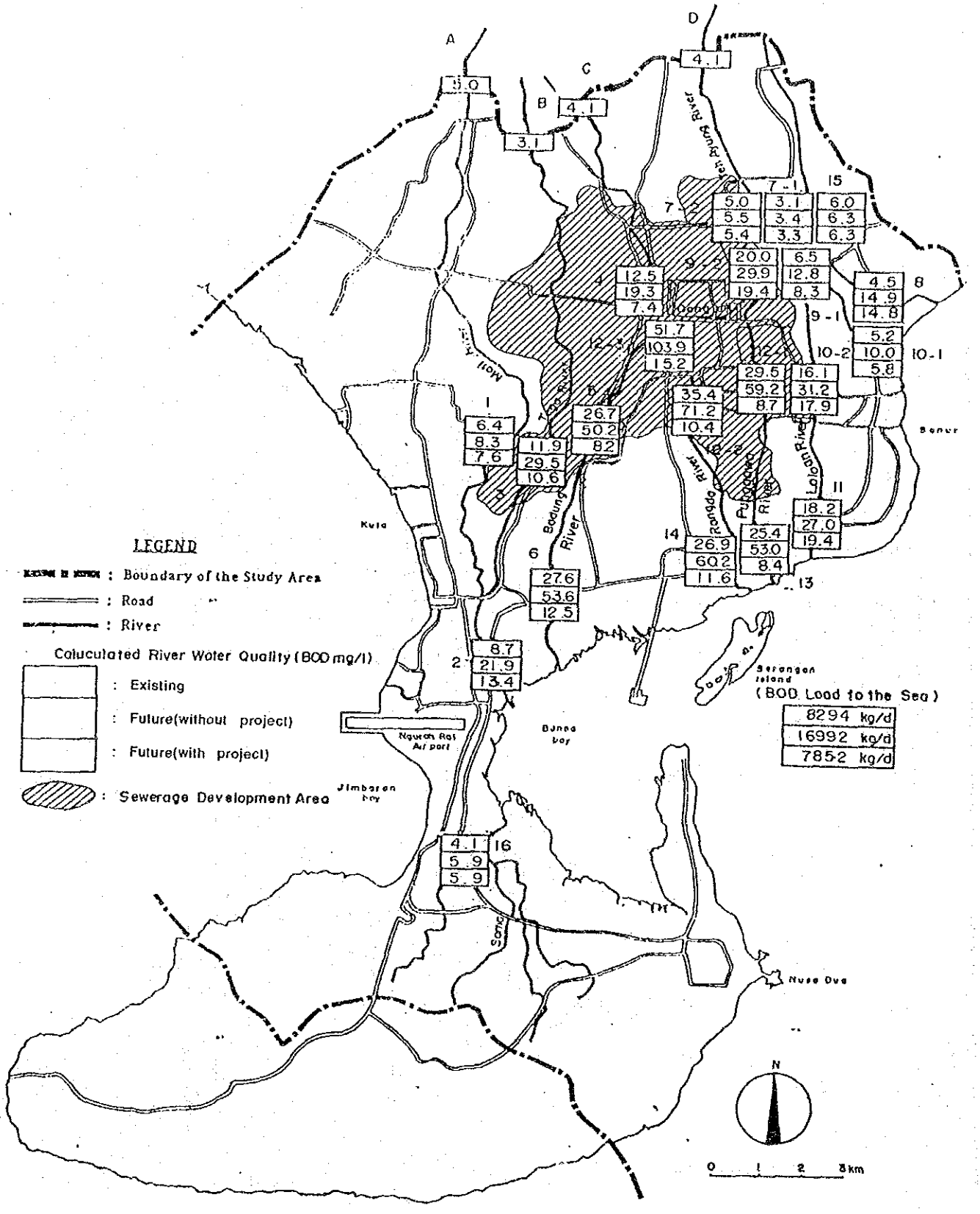

FIG. E.2.5(1) SIMULATED RIVER WATER QUALITY BY SEWERAGE SYSTEM ONLY OF CASE - III (DRY SEASON)

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

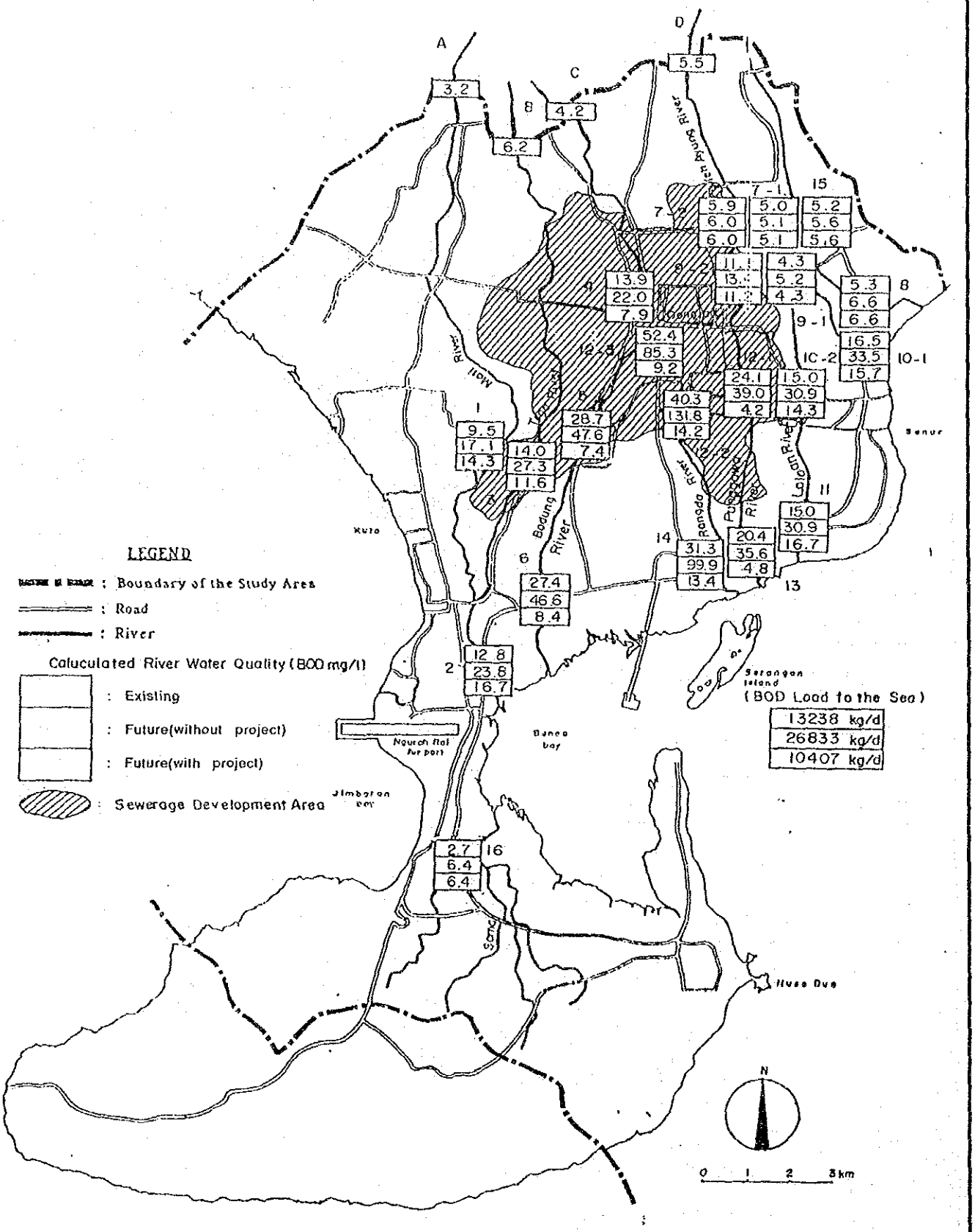

FIG. E.2.5(2) SIMULATED RIVER WATER QUALITY BY SEWERAGE SYSTEM ONLY OF CASE - III (RAINY SEASON)

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

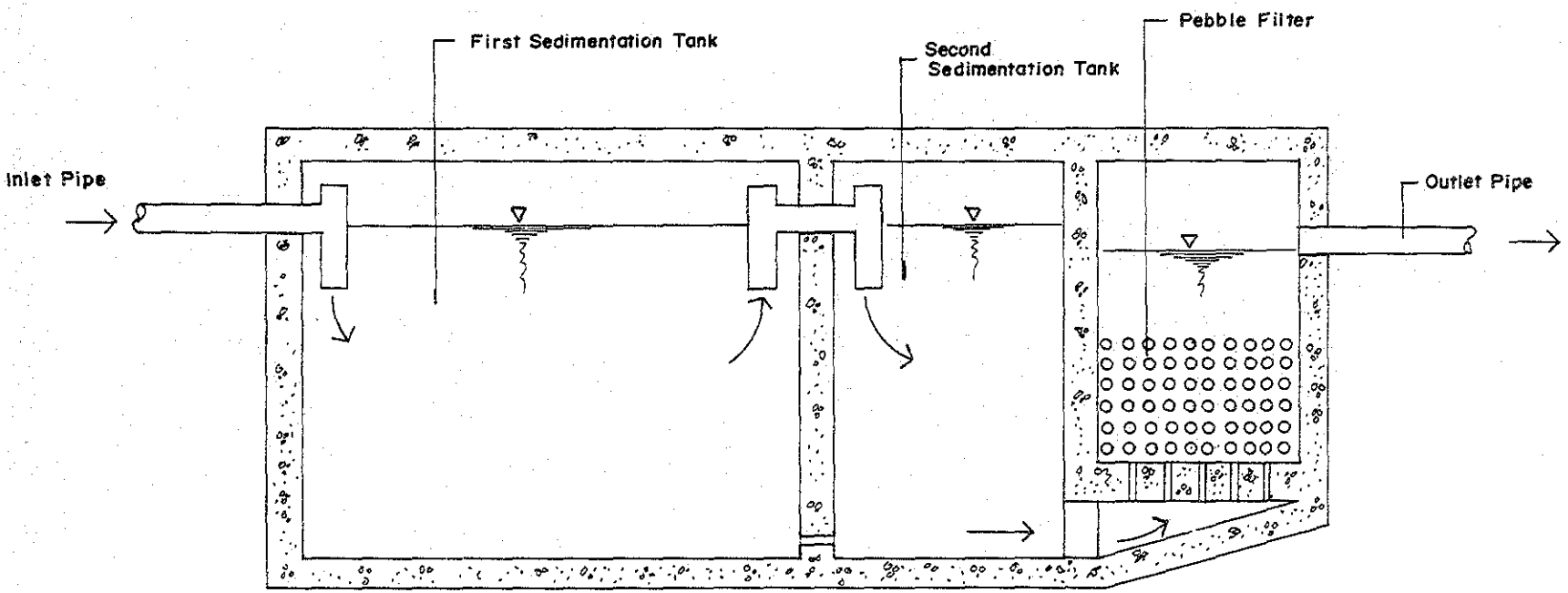

FIG. E.2.6 SEPTIC TANK WITH UP-FLOW FILTER

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

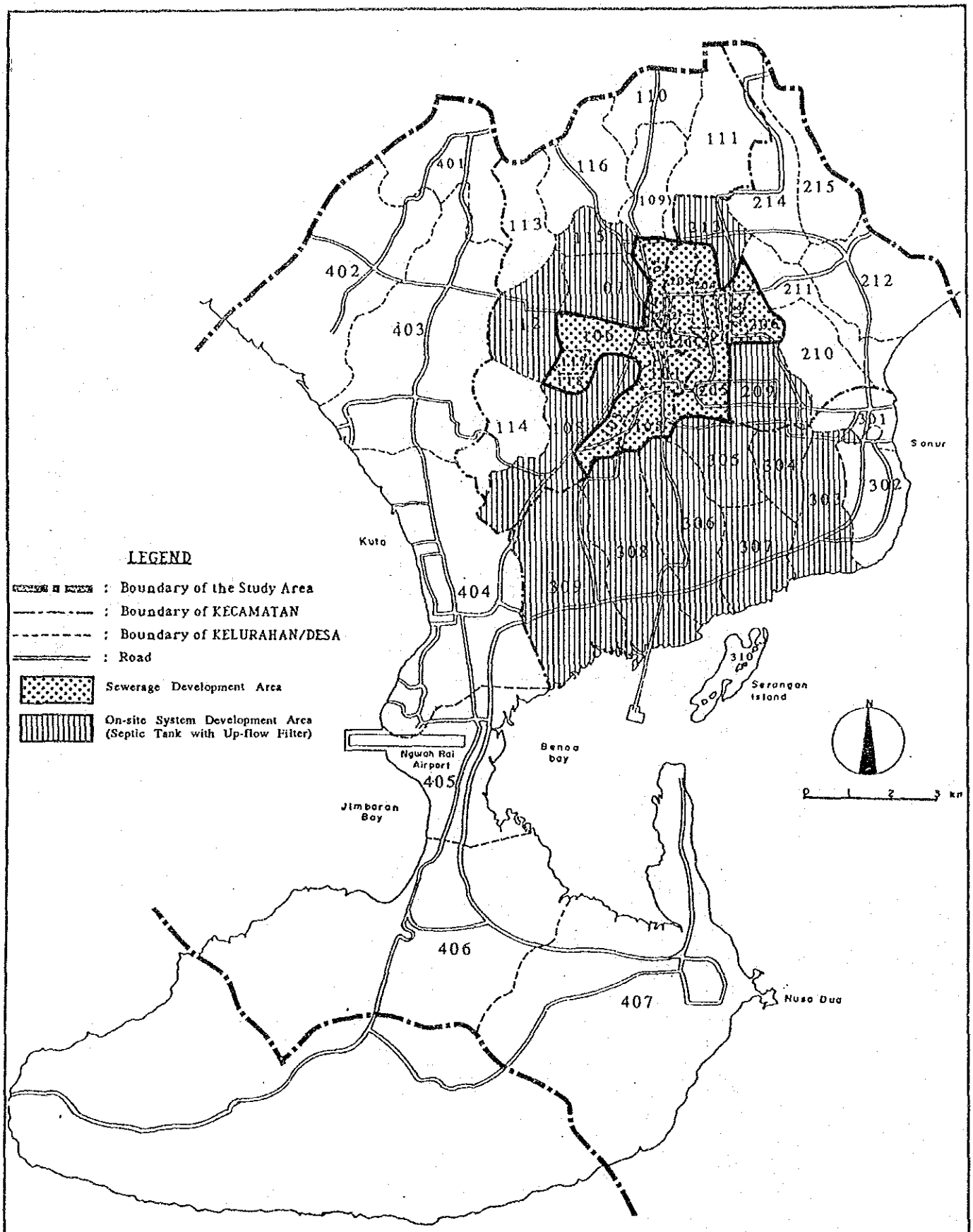

FIG. E.2.7 COMBINATION OF SEWERAGE AND ON-SITE SYSTEM

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

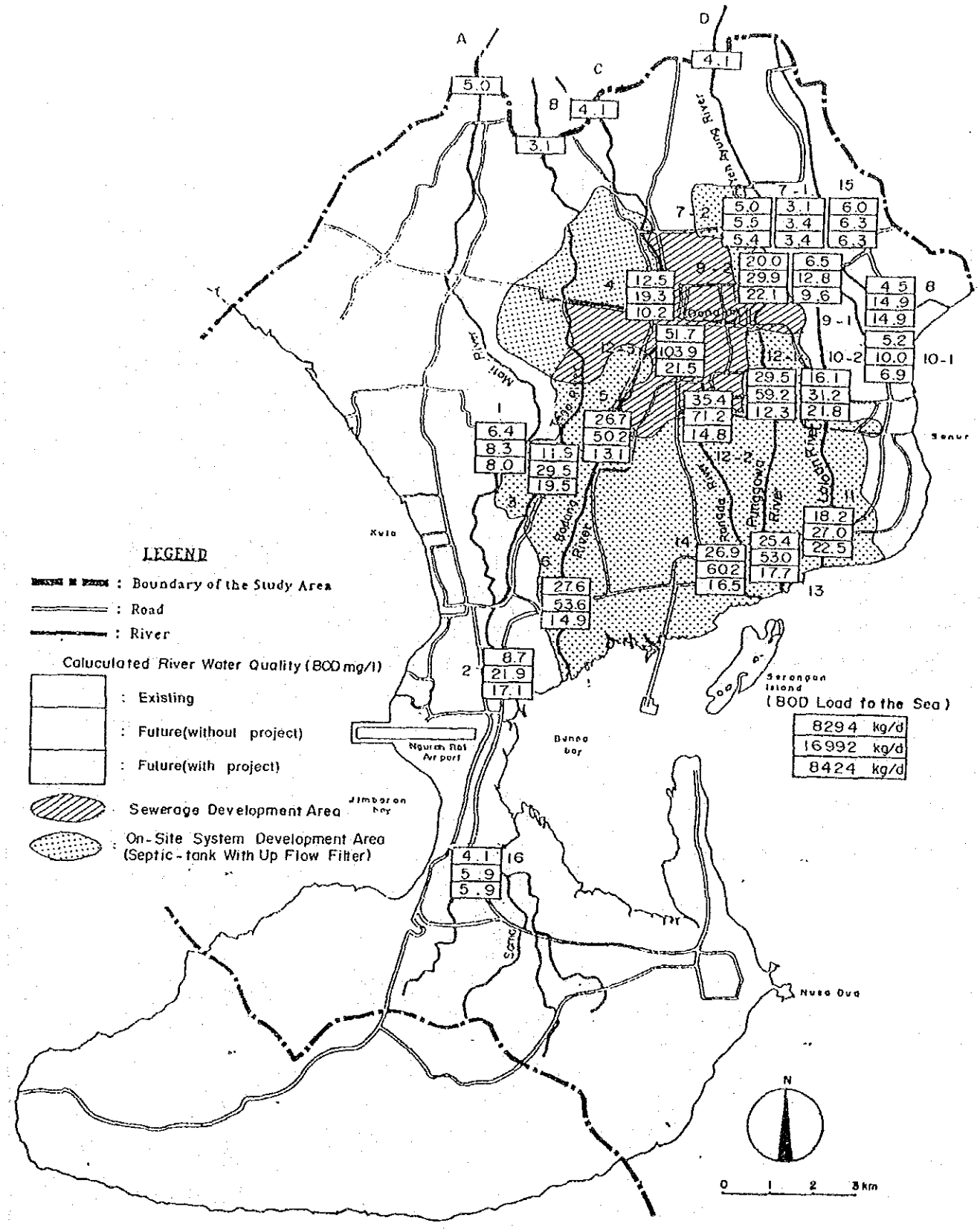

FIG. E.2.8(1) SIMULATED RIVER WATER QUALITY BY COMBINATION OF SEWERAGE AND ON-SITE SYSTEM (DRY SEASON)

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

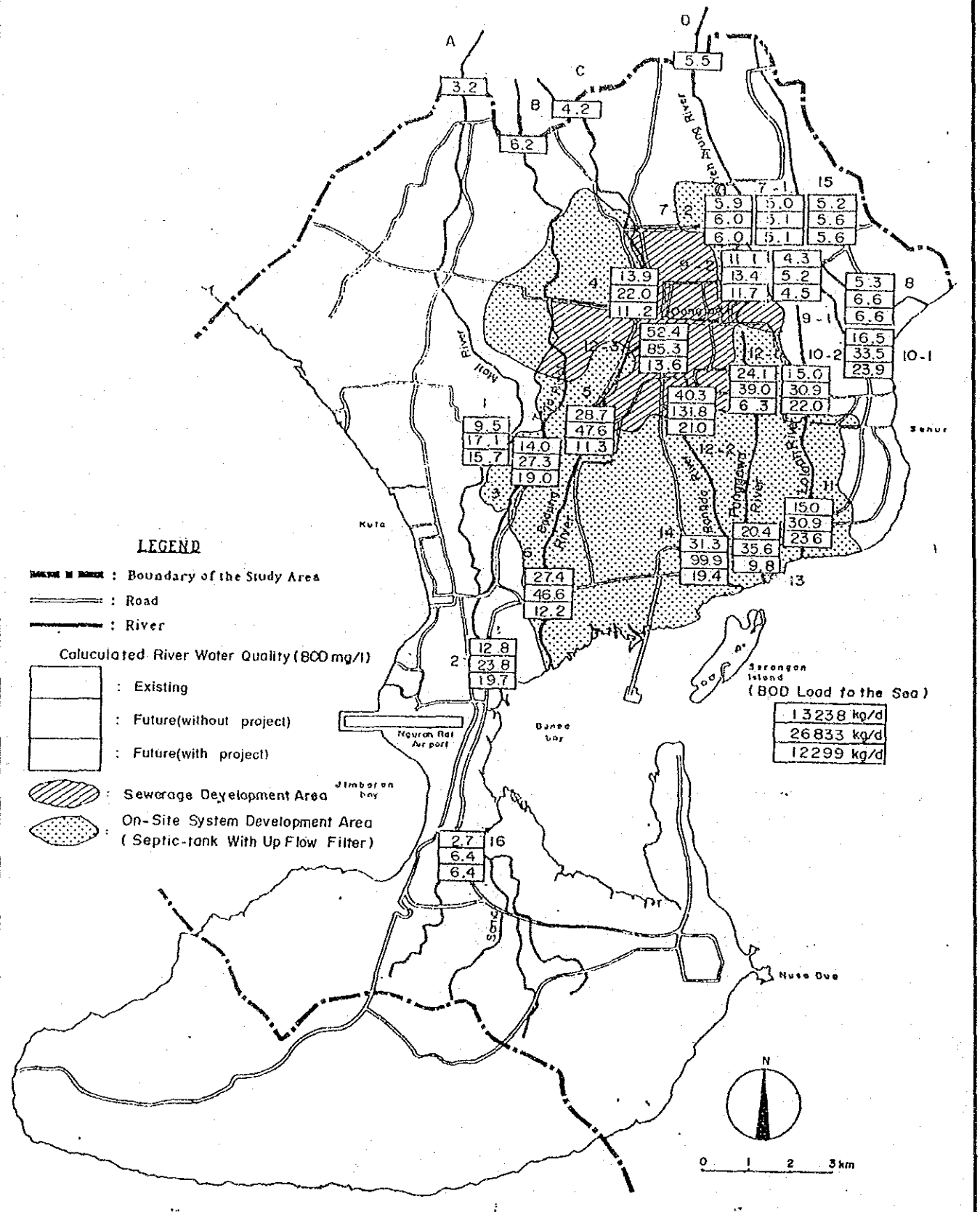

FIG. E.2.8(2) SIMULATED RIVER WATER QUALITY BY COMBINATION OF SEWERAGE AND ON-SITE SYSTEM (RAINY SEASON)

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

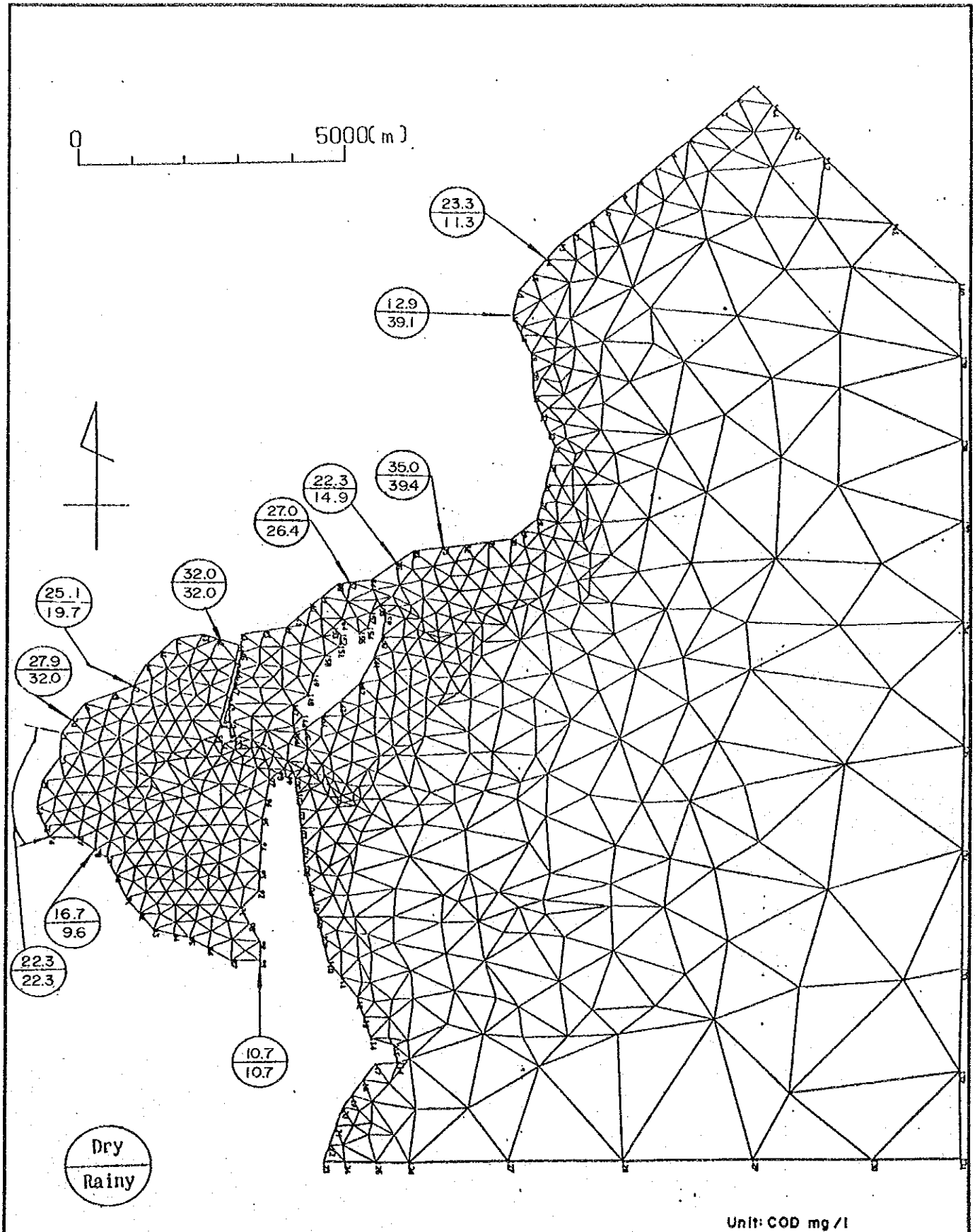

FIG. E.2.9 COD POLLUTION LOADS (FUTURE) - WITH PROJECT

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

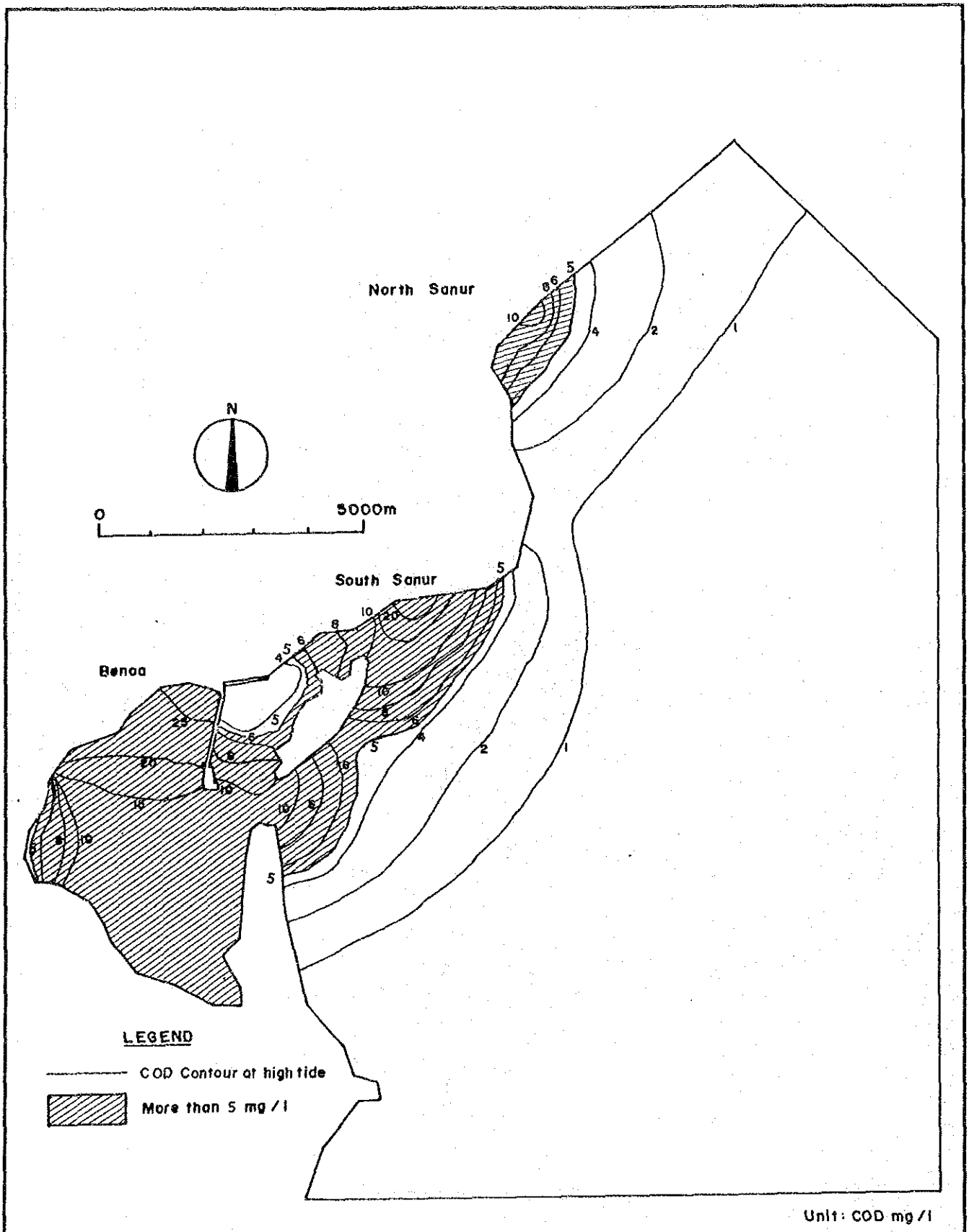

FIG. E.2.10 COD DISTRIBUTION IN DRY SEASON (FUTURE) - WITH PROJECT

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

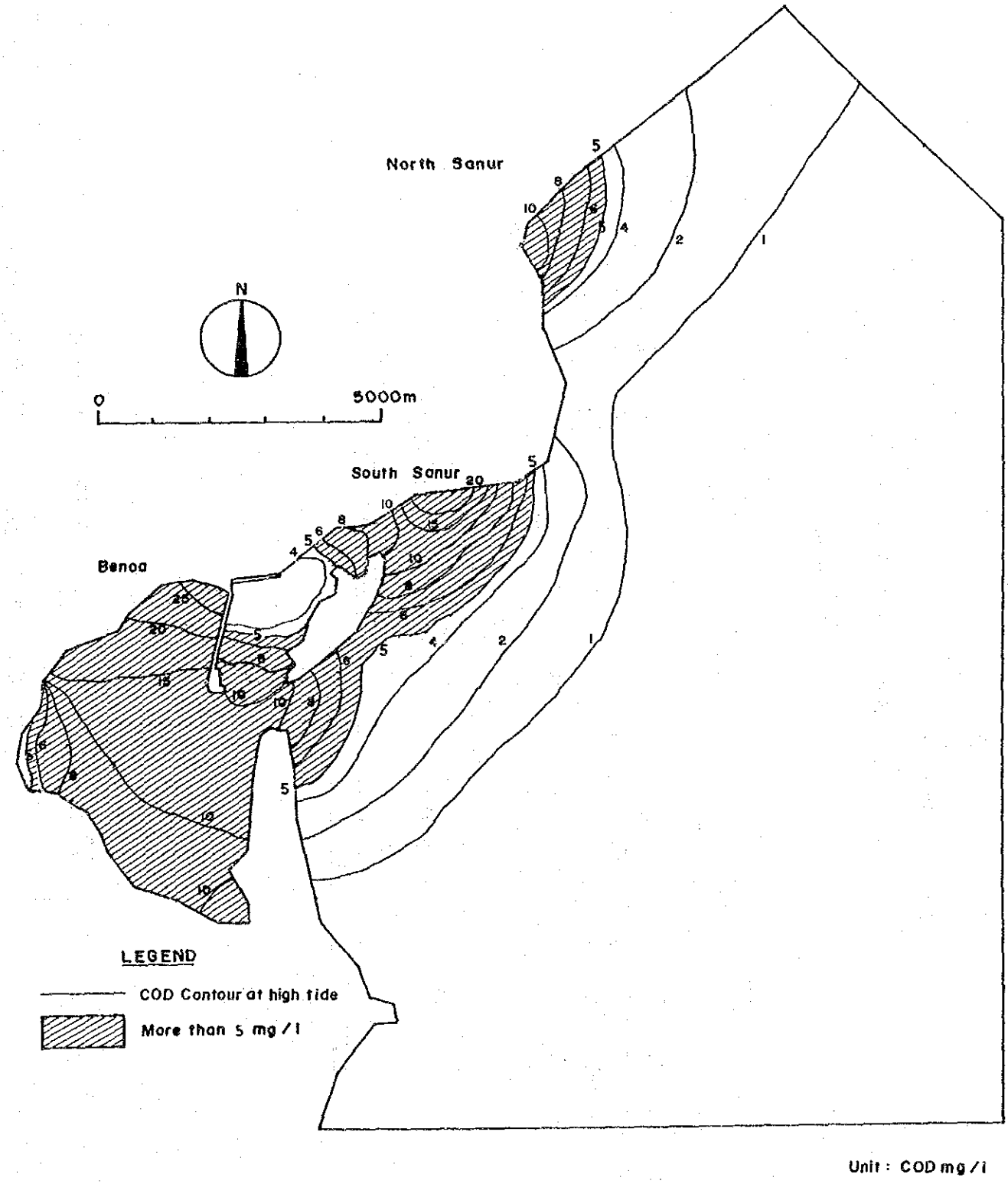

FIG. E.2.11 COD DISTRIBUTION IN RAINY SEASON (FUTURE) - WITH PROJECT

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

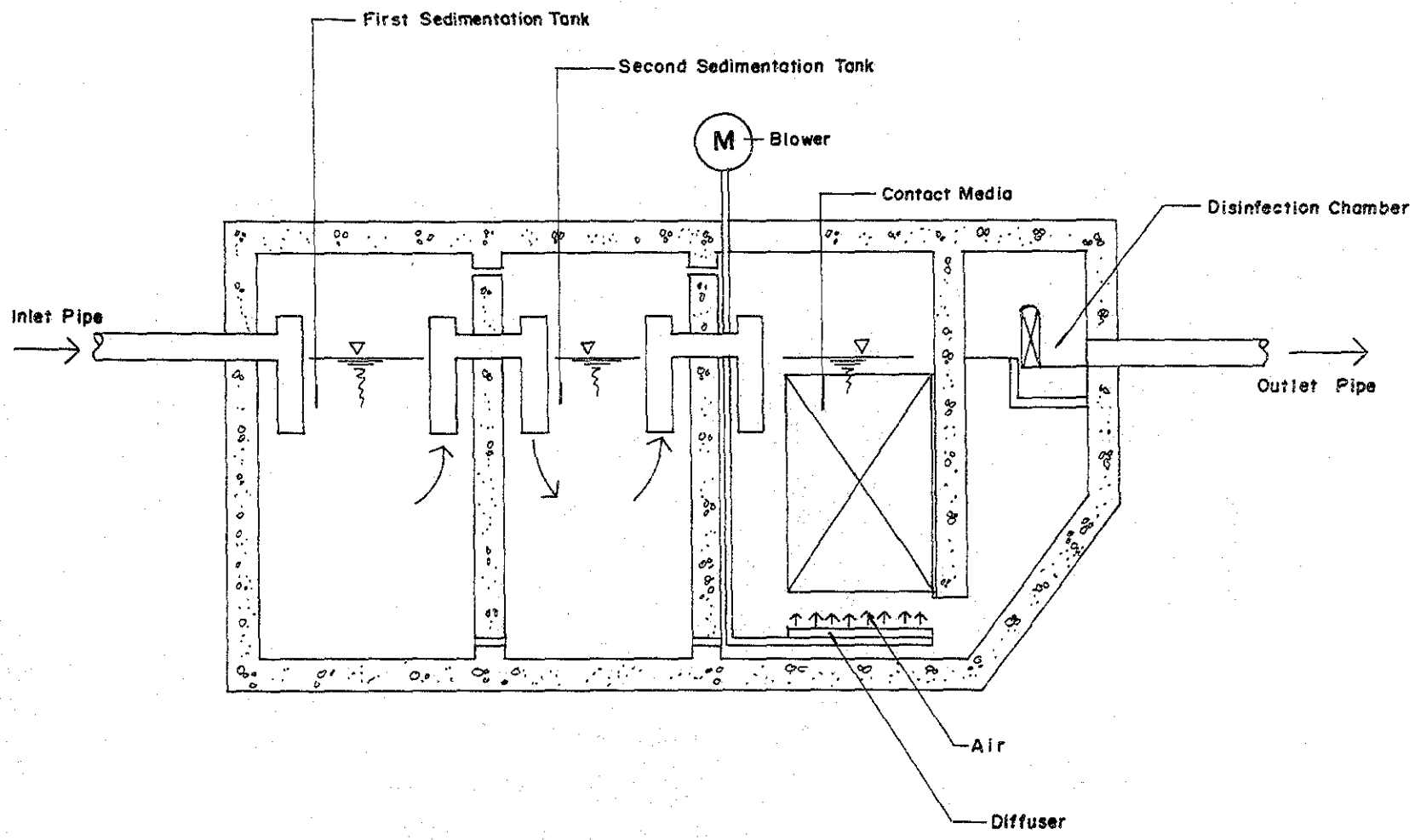

FIG. E.2.12 HOUSEHOLD PACKAGE TREATMENT PLANT

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

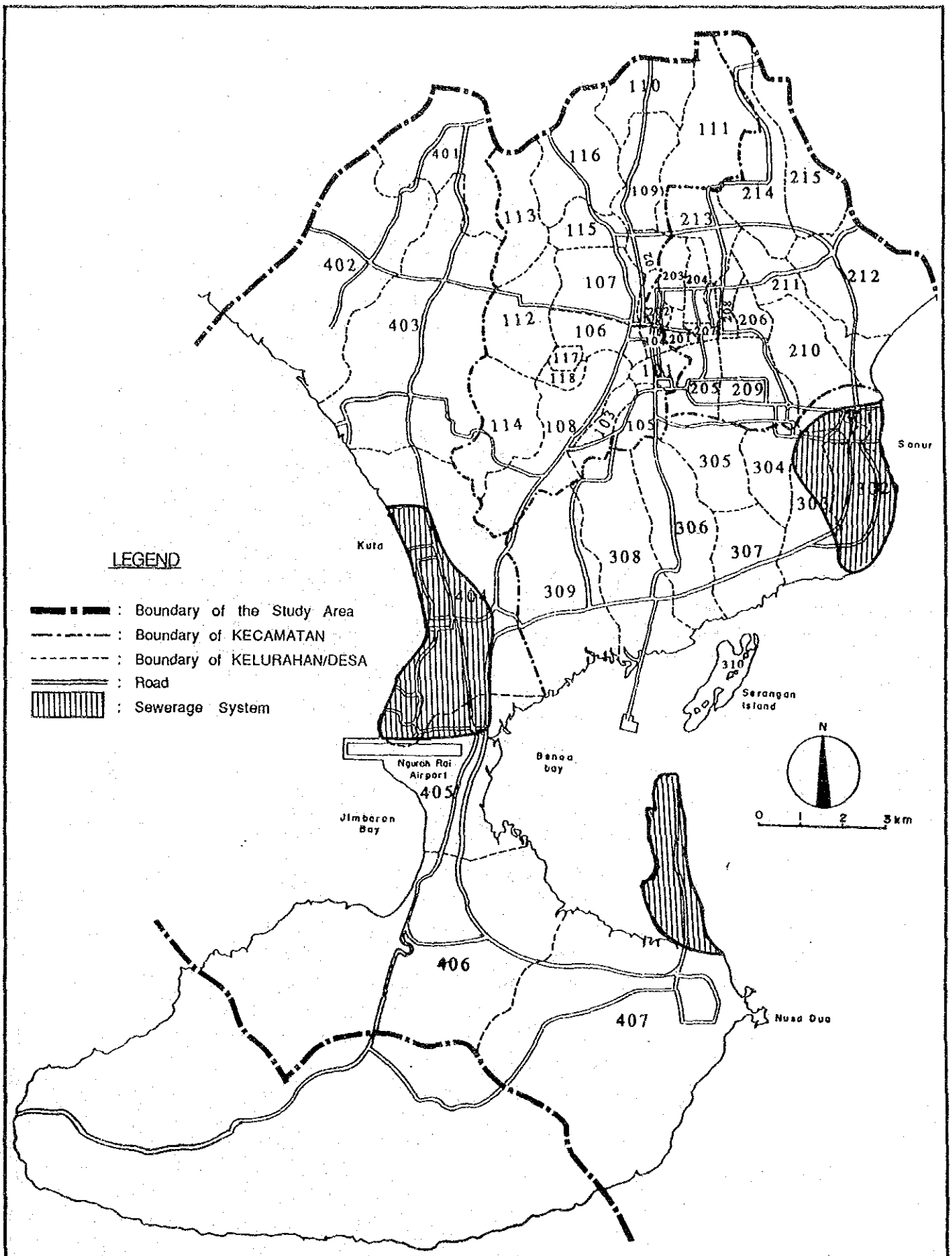

FIG. E.2.13 SEWERAGE SYSTEM DEVELOPMENT AREA (RESORT AREA)

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

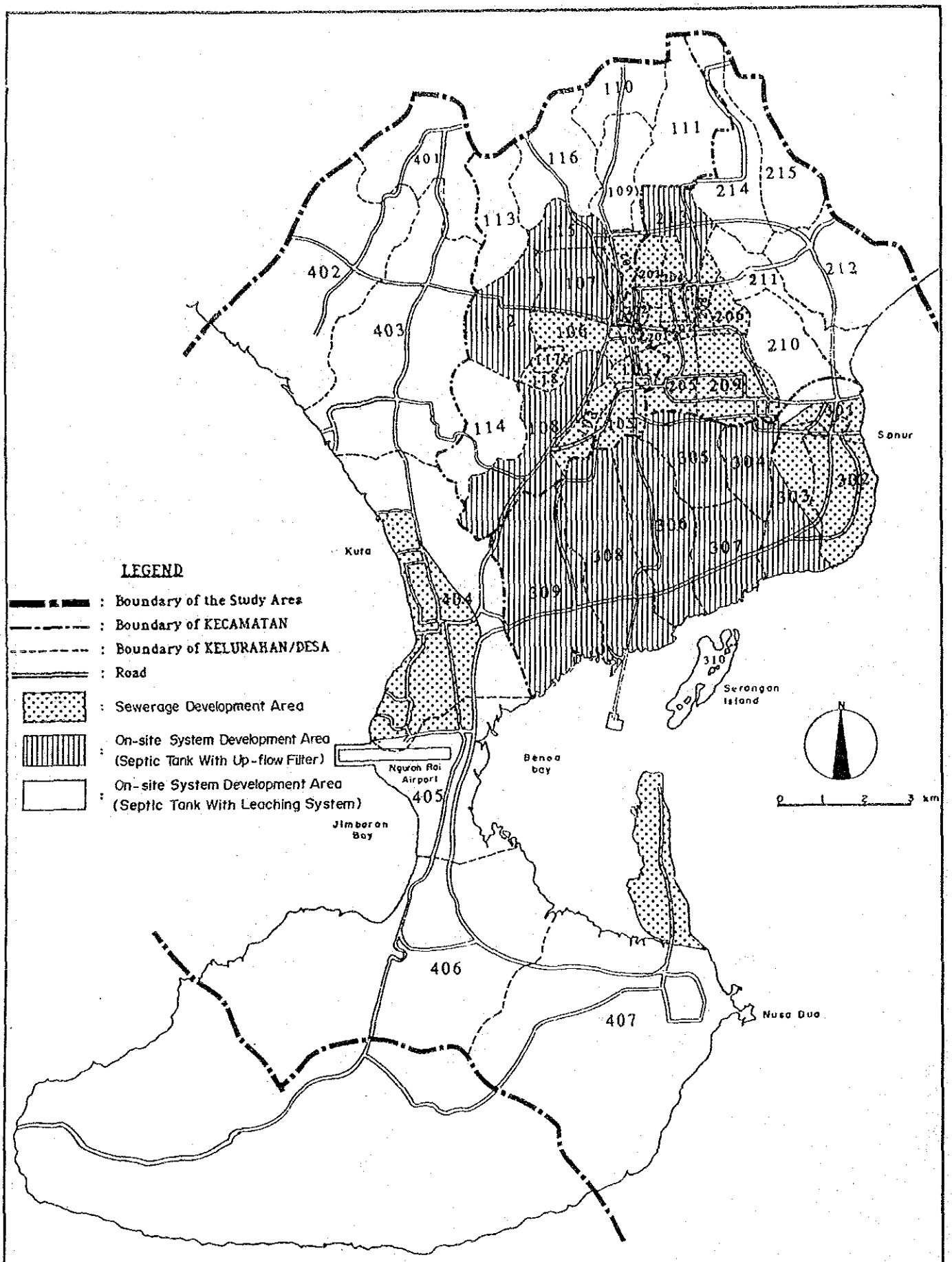

FIG. E.2.14 ZONING OF WASTEWATER DISPOSAL SYSTEM DEVELOPMENT

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

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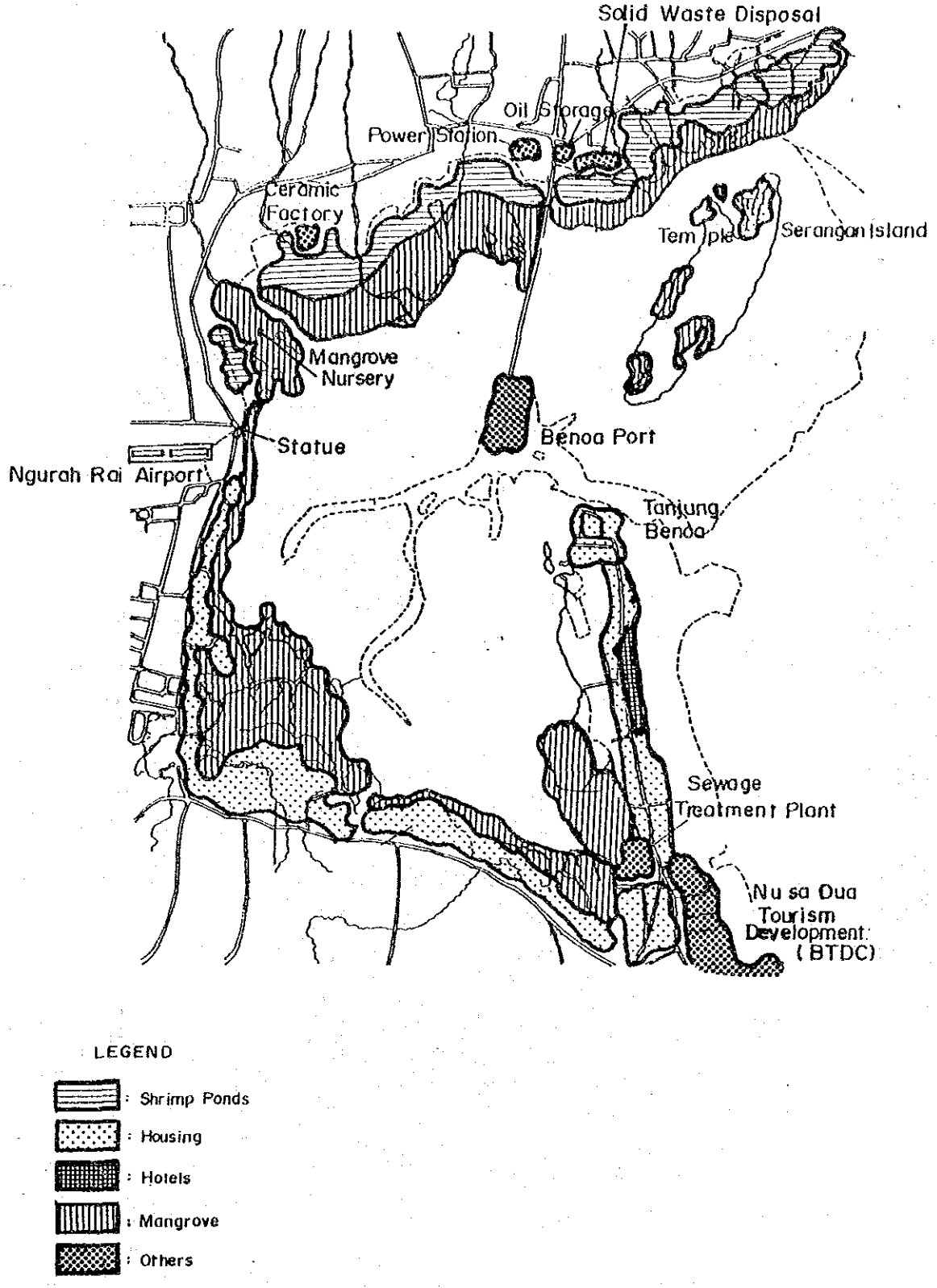

FIG. E.3.1 EXISTING LAND USE OF BENOA BAY

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

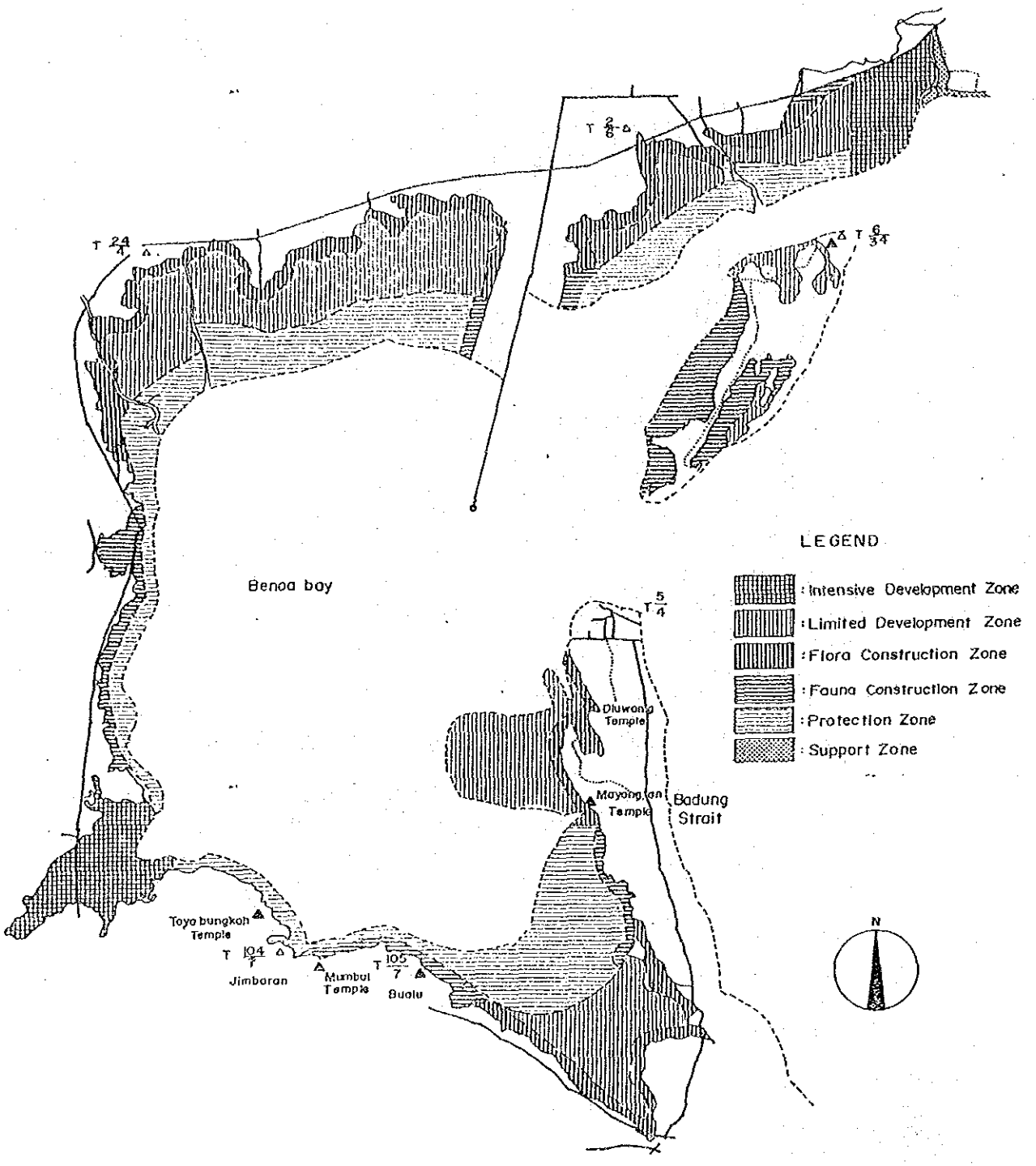

FIG. E.3.2 PROPOSED ZONING OF BENOA BAY BY MINISTRY OF FORESTRY

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

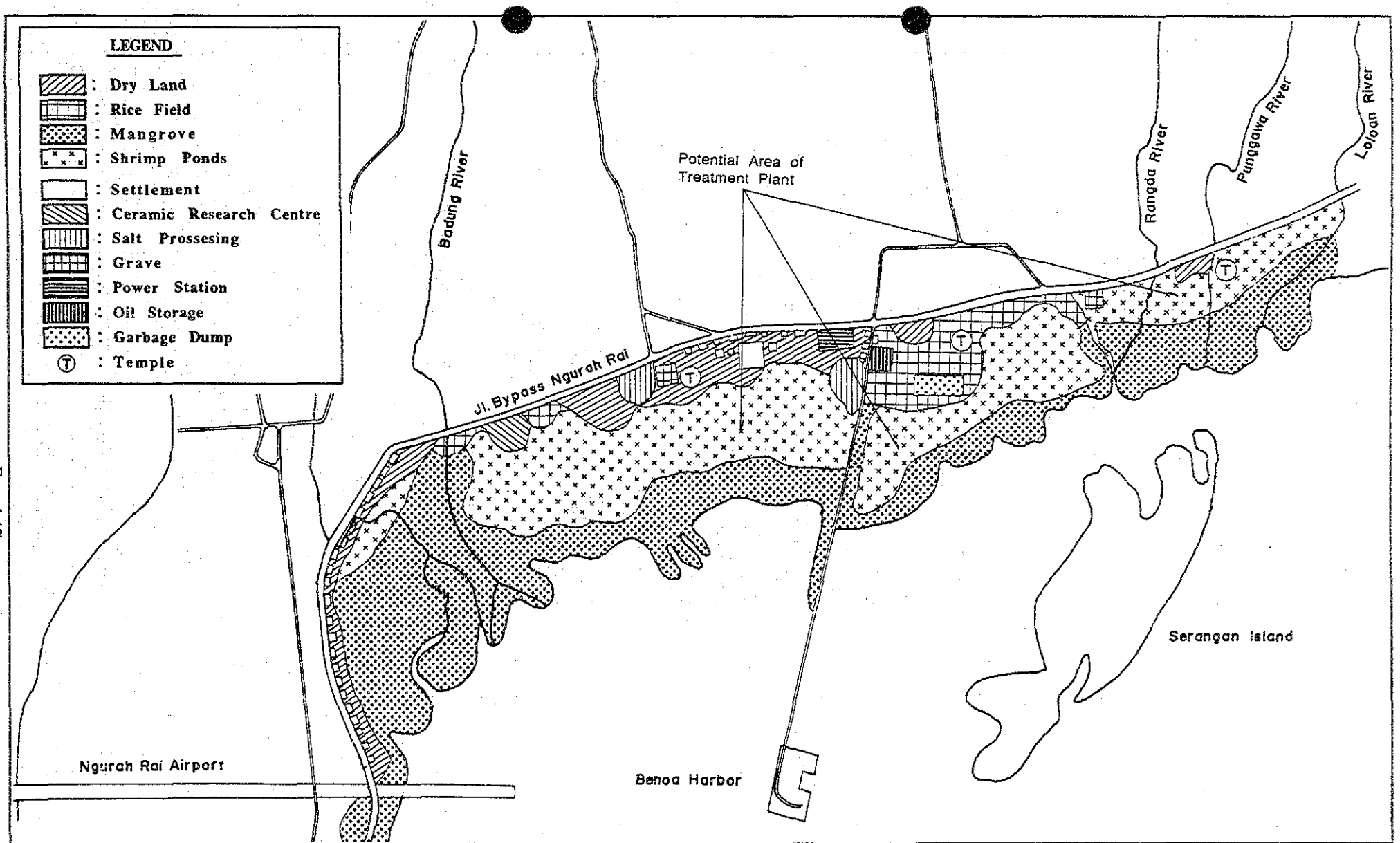

FIG. E.3.3 POTENTIAL AREA OF TREATMENT PLANT

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

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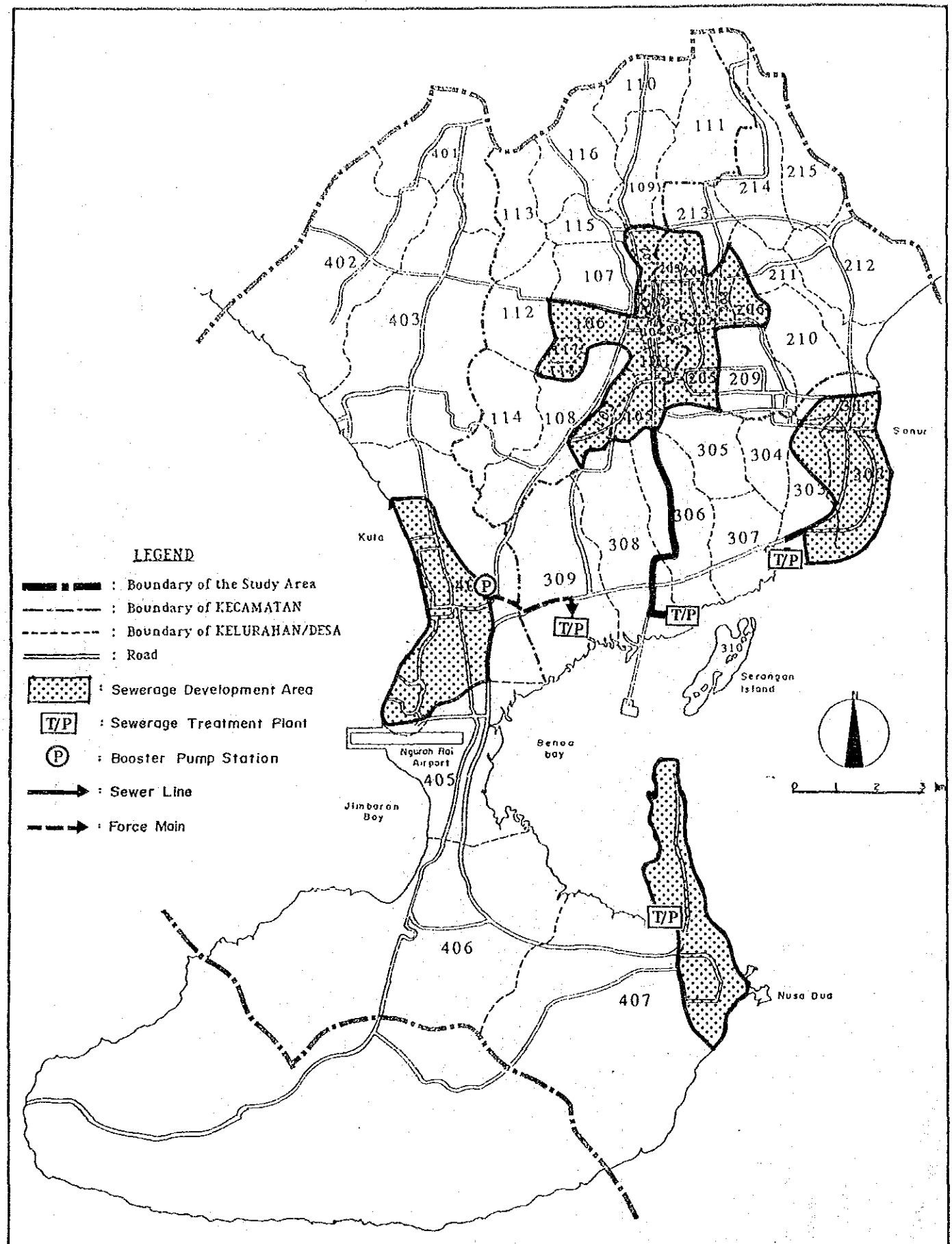

FIG. E.4.1 INDIVIDUAL TREATMENT SYSTEM

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

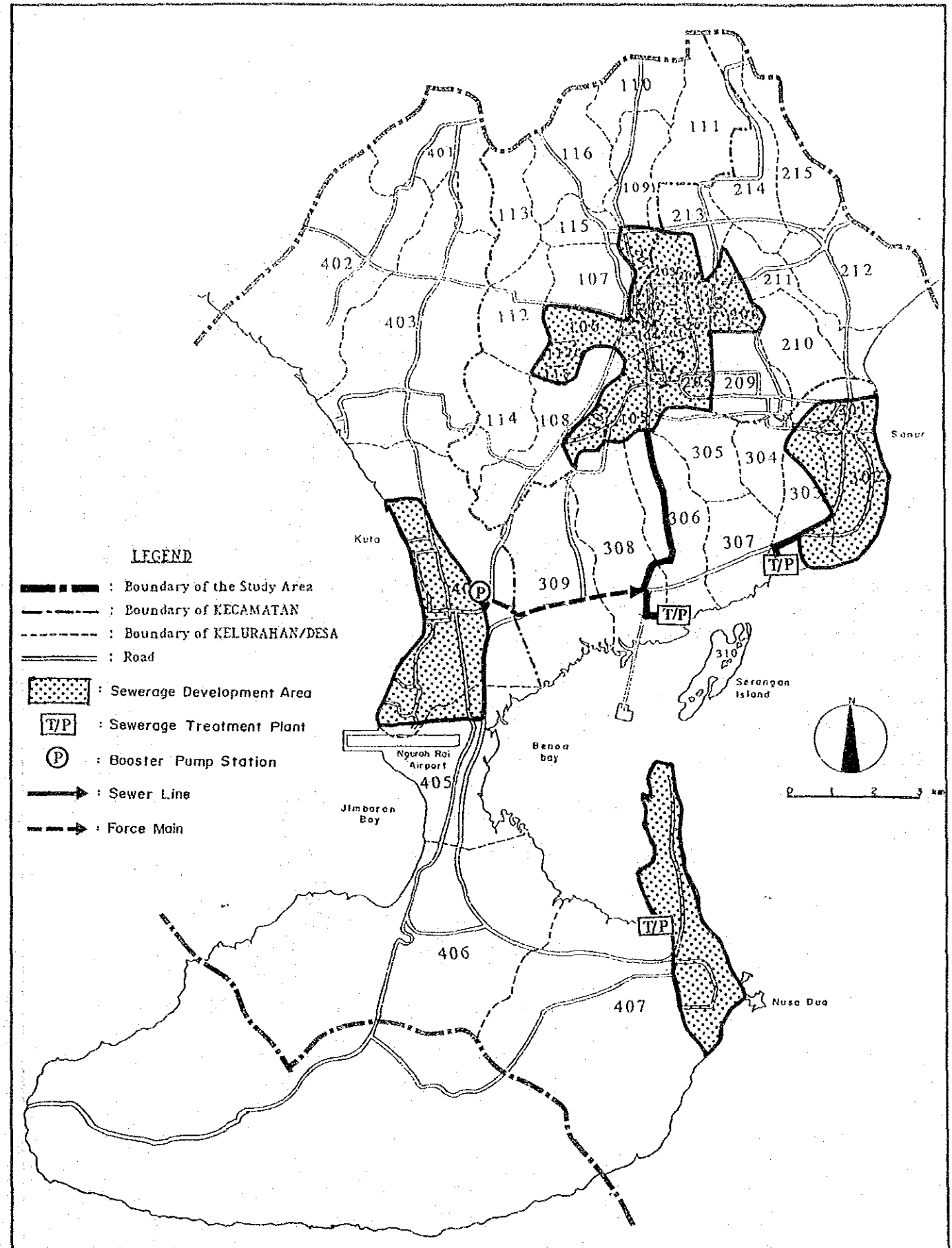

FIG. E.4.2 PARTIALLY INTEGRATED TREATMENT SYSTEM

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

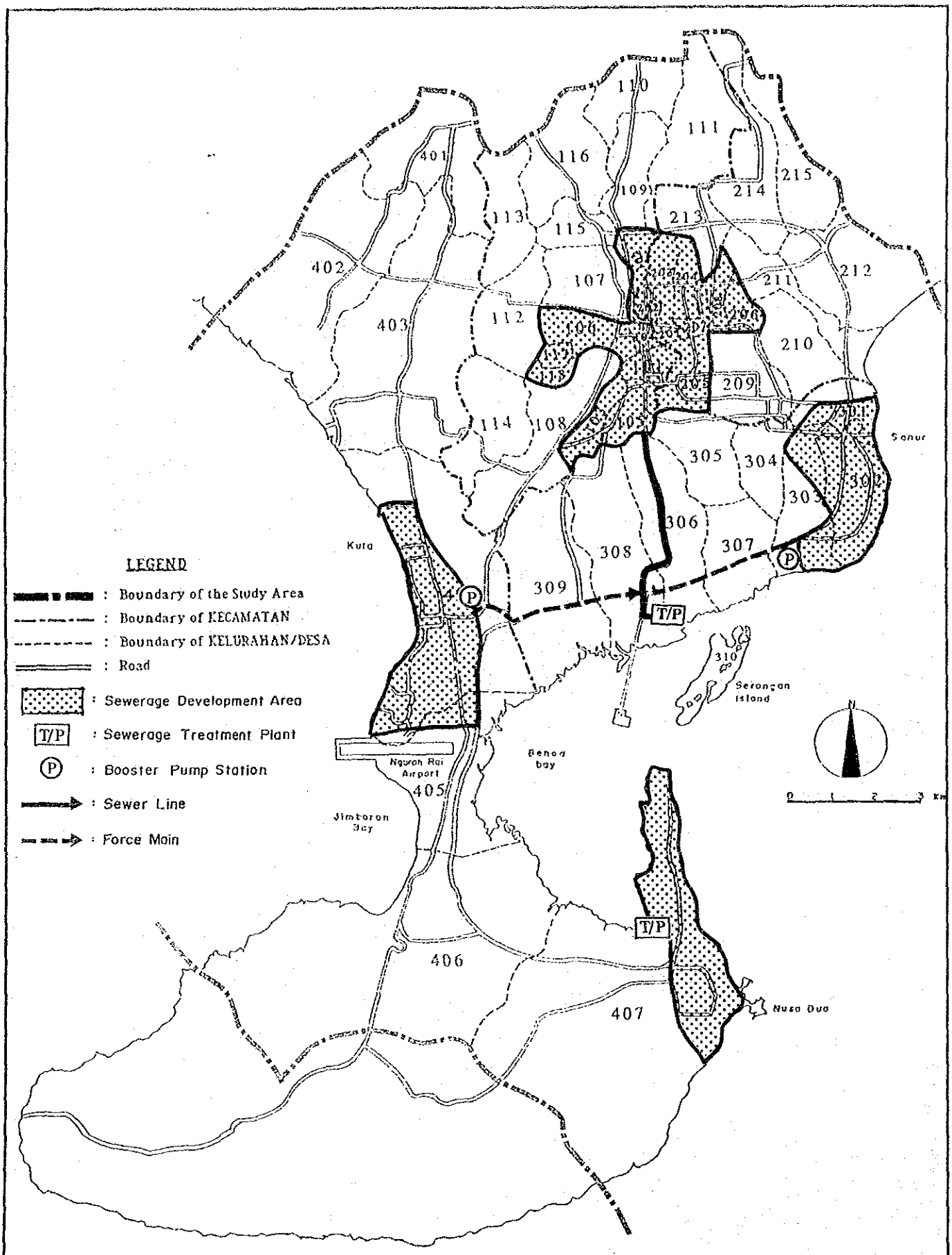

FIG. E.4.3 INTEGRATED TREATMENT SYSTEM

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

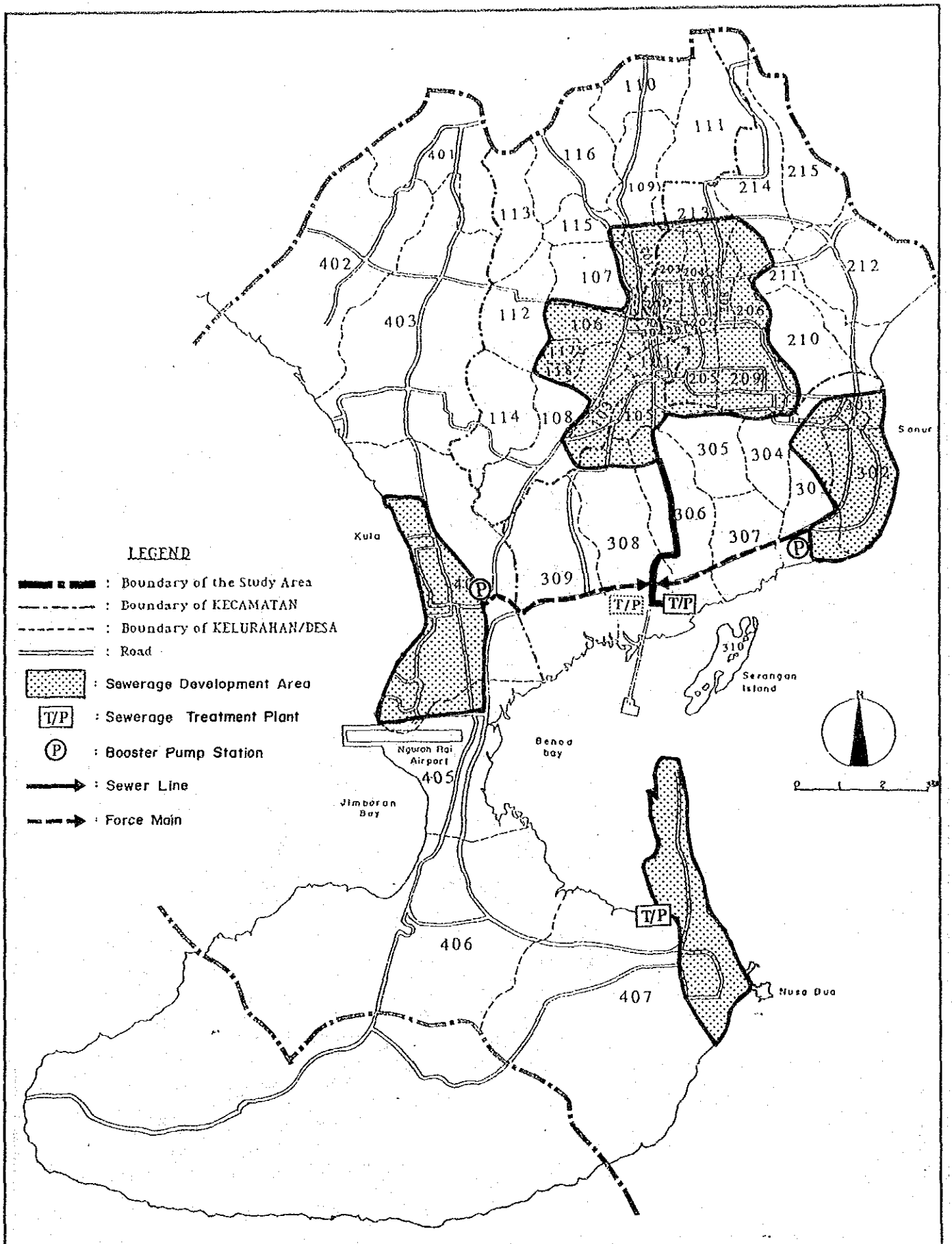

FIG. E.5.1 PROPOSED SEWERAGE DEVELOPMENT PLAN

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

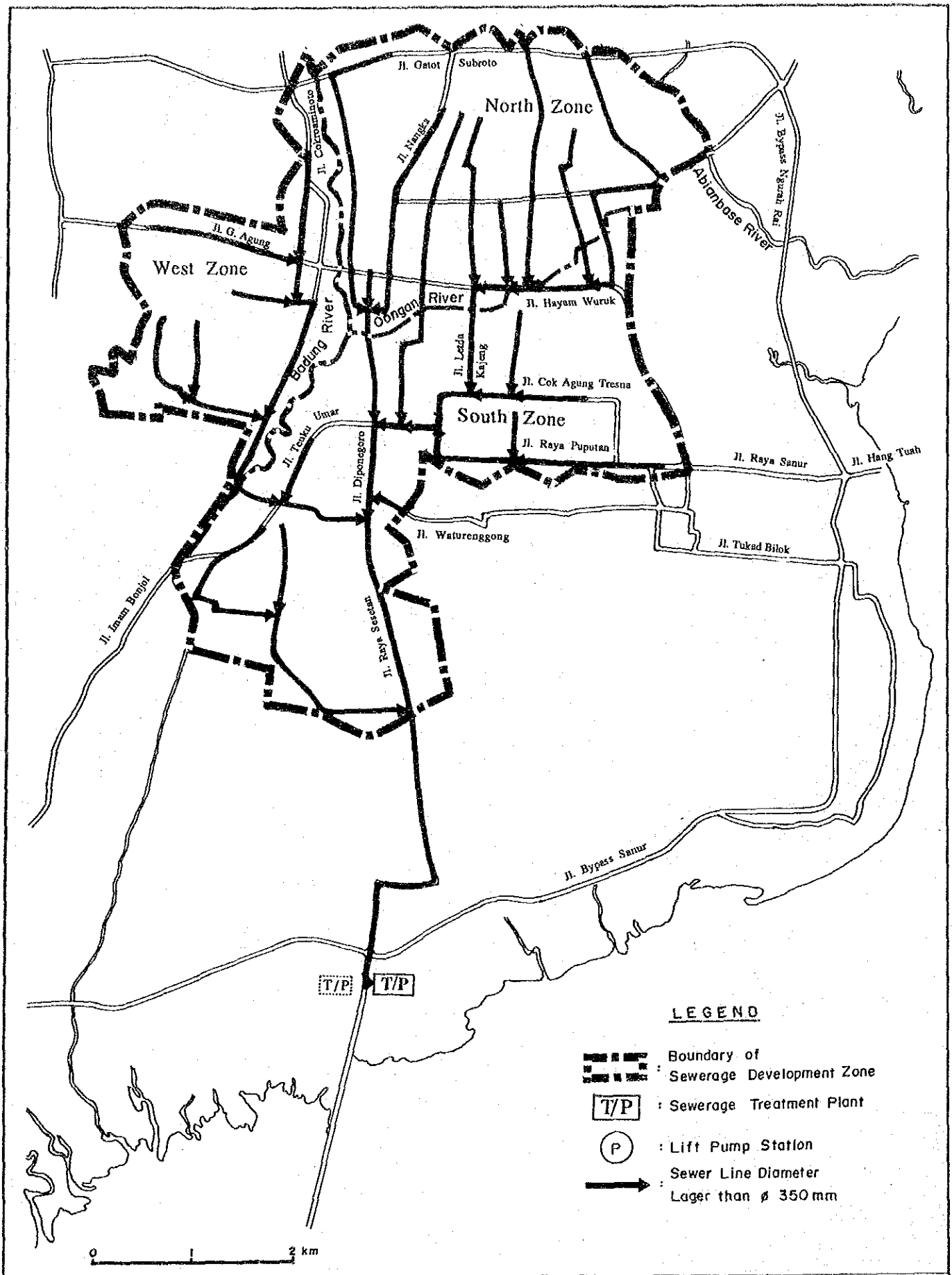

FIG. E.5.2 SEWERAGE DEVELOPMENT PLAN IN DENPASAR

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

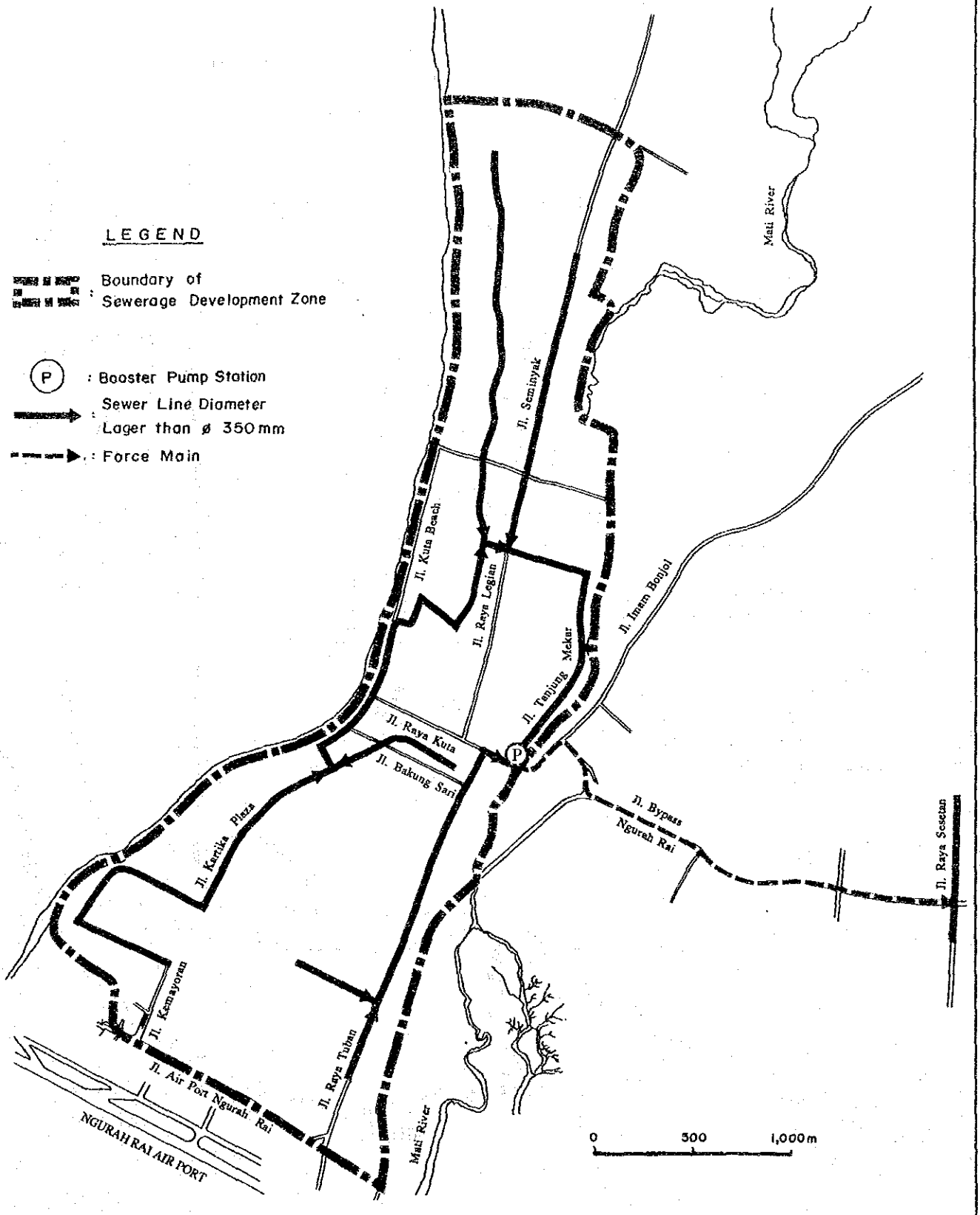

FIG. E.5.3 SEWERAGE DEVELOPMENT PLAN IN KUTA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

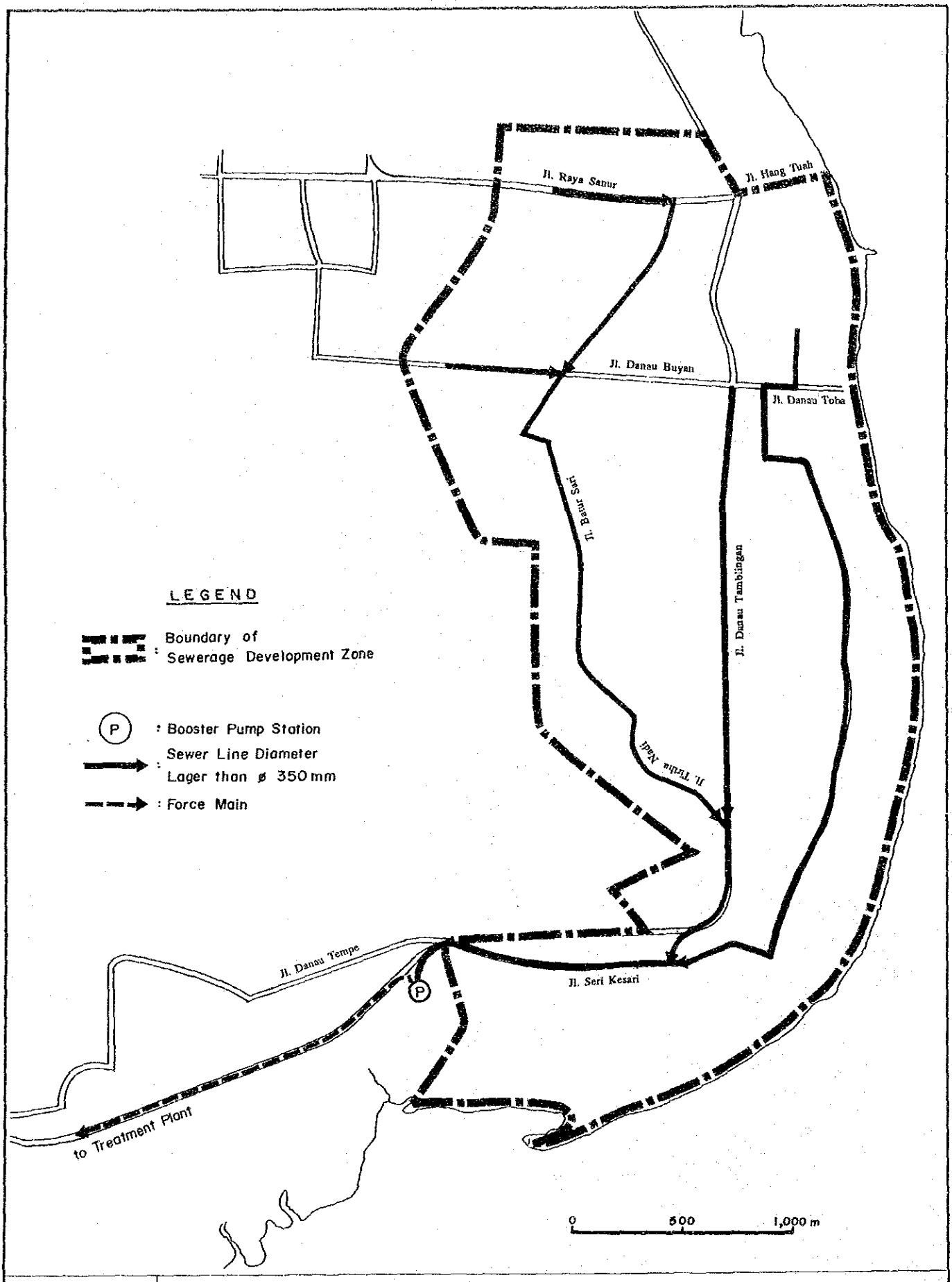

FIG. E.5.4 SEWERAGE DEVELOPMENT PLAN IN SANUR

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

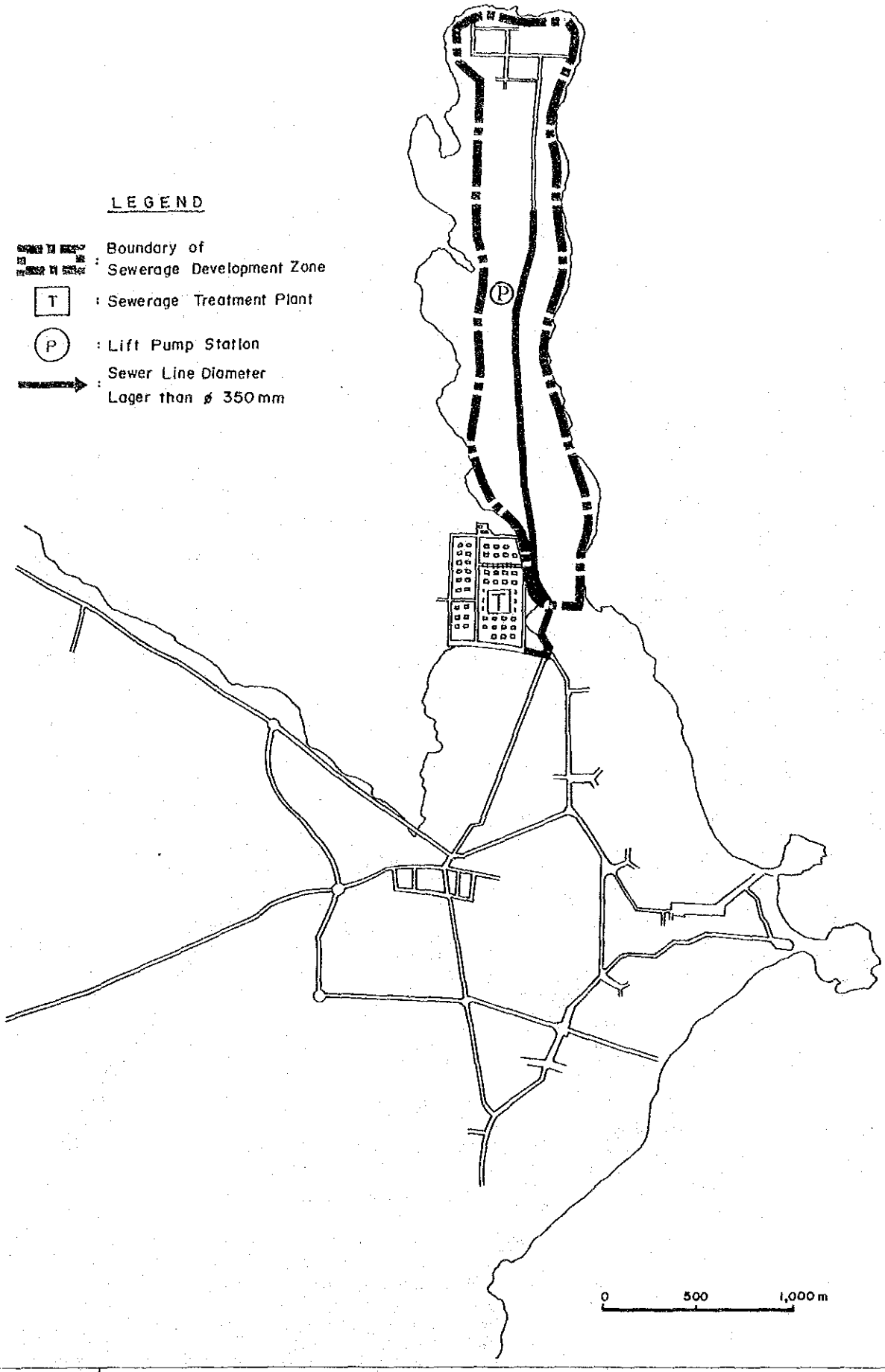

FIG. E.5.5 SEWERAGE DEVELOPMENT PLAN IN TANJUNG BENOA

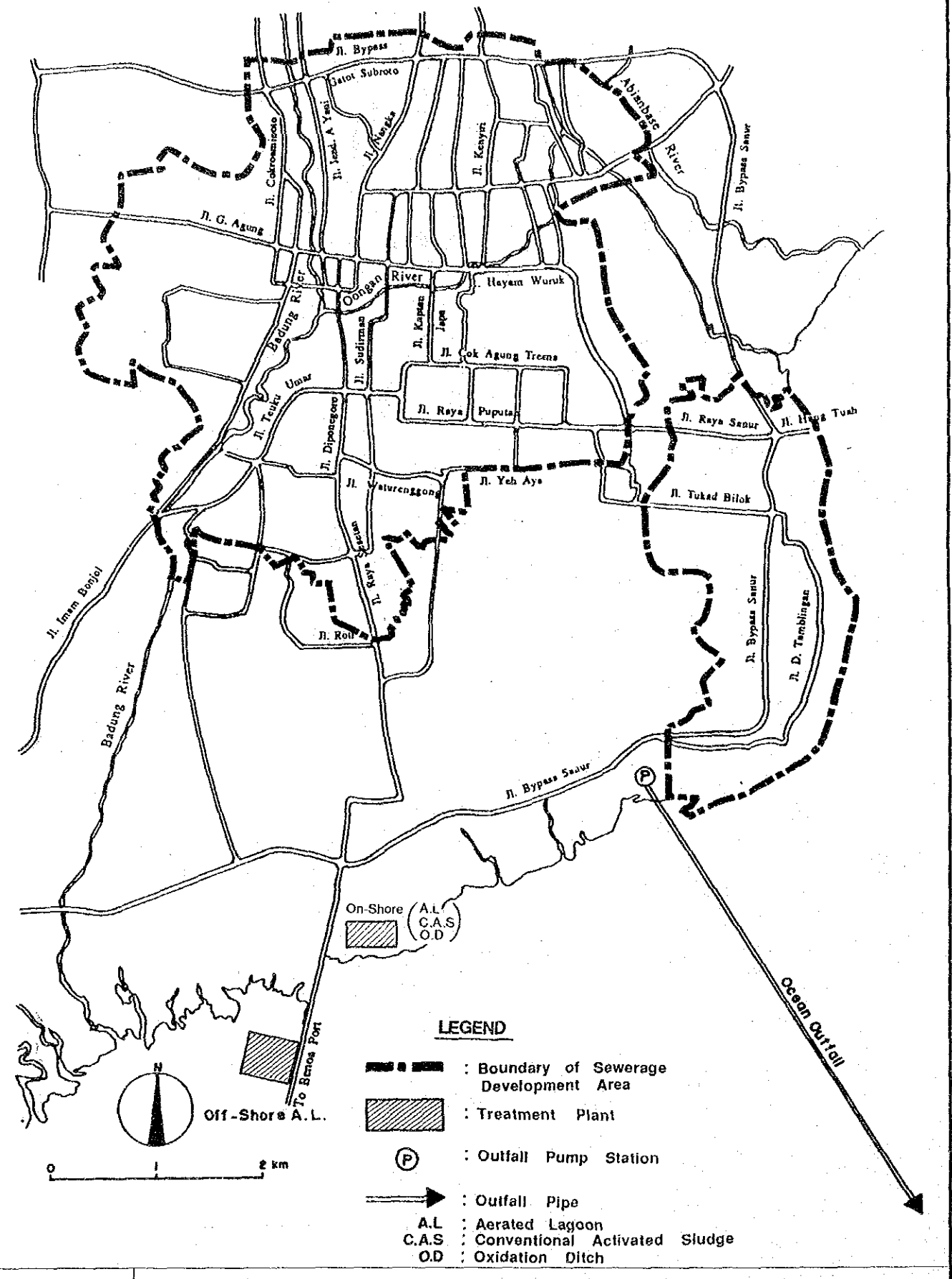

FIG. E.5.6 LOCATION OF ALTERNATIVE TREATMENT PLANTS

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

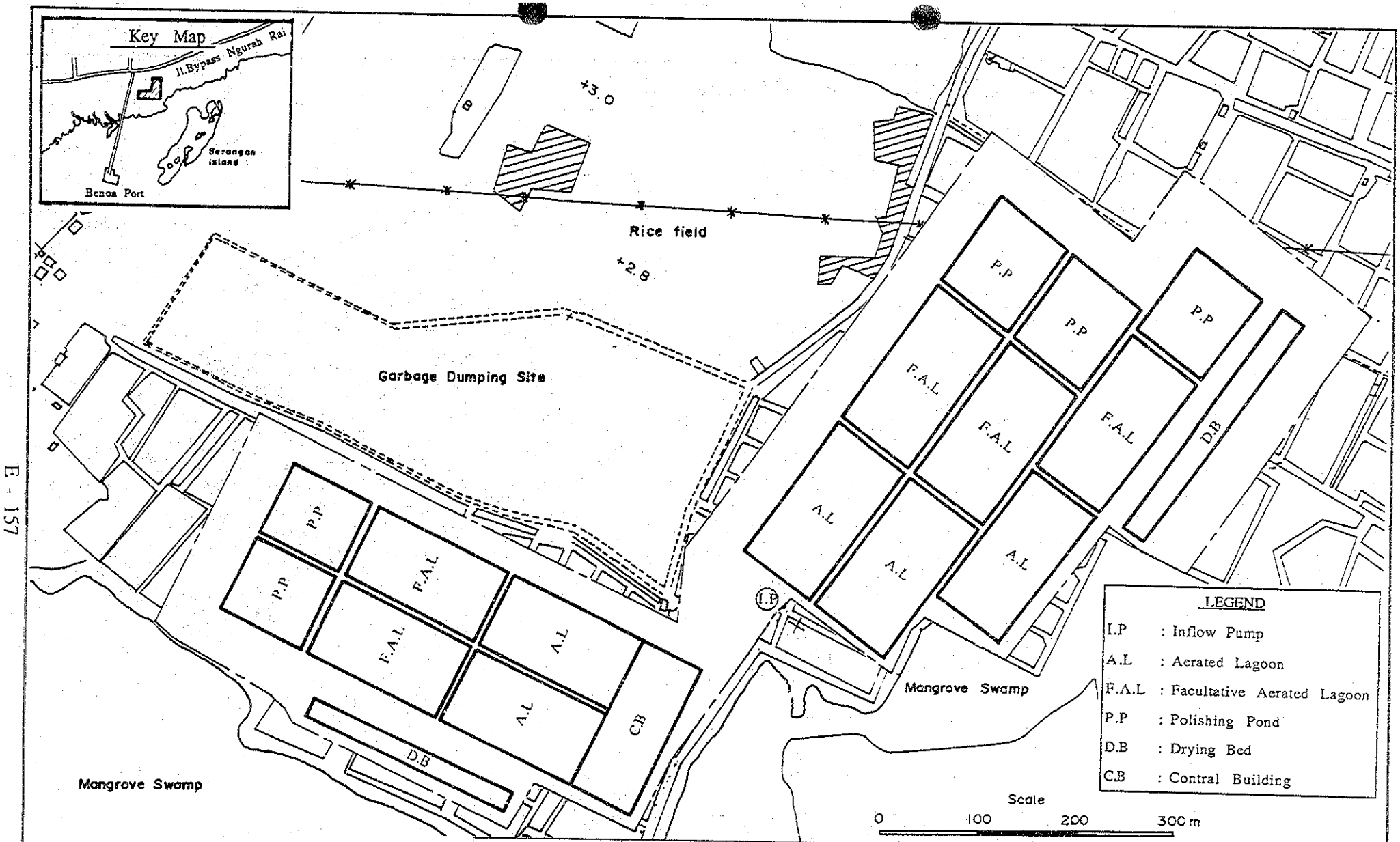

FIG. E.5.7 LAYOUT OF ALTERNATIVE TREATMENT PLANT (AERATED LAGOON)

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

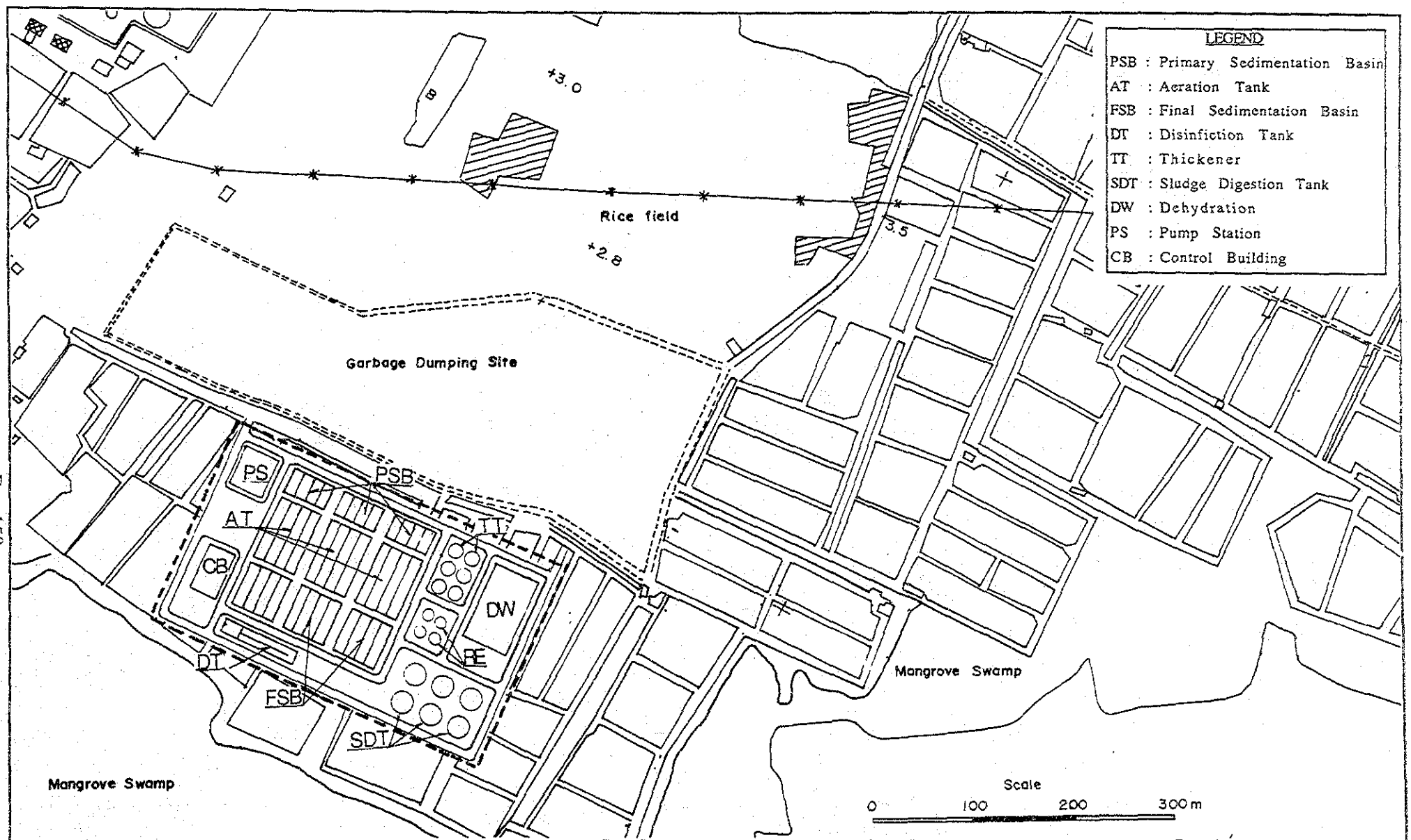

FIG. E.5.8 LAYOUT OF ALTERNATIVE TREATMENT PLANT (CONVENTIONAL ACTIVATED SLUDGE)

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

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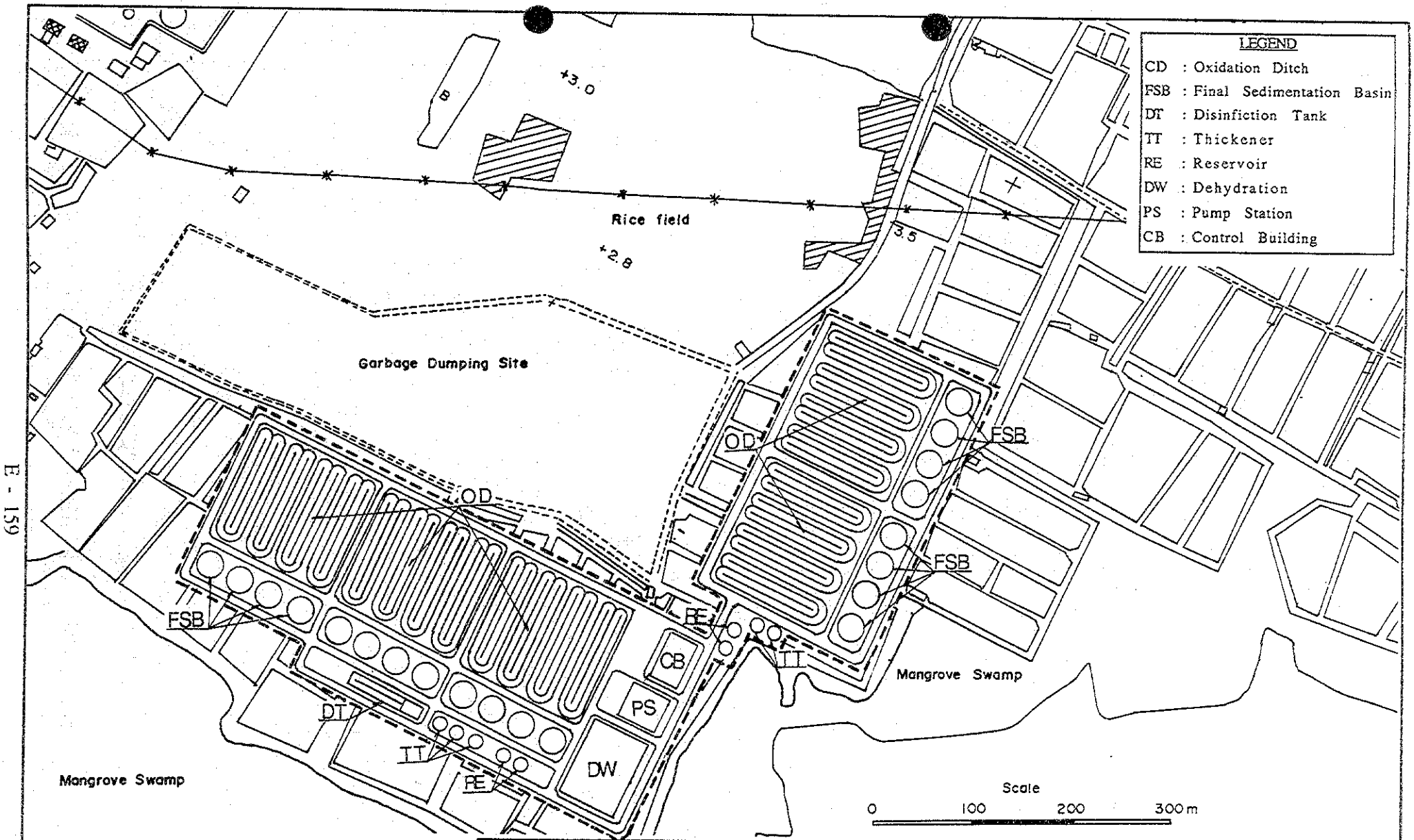


FIG. E.5.9 LAYOUT OF ALTERNATIVE TREATMENT PLANT (OXIDATION DITCH)

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

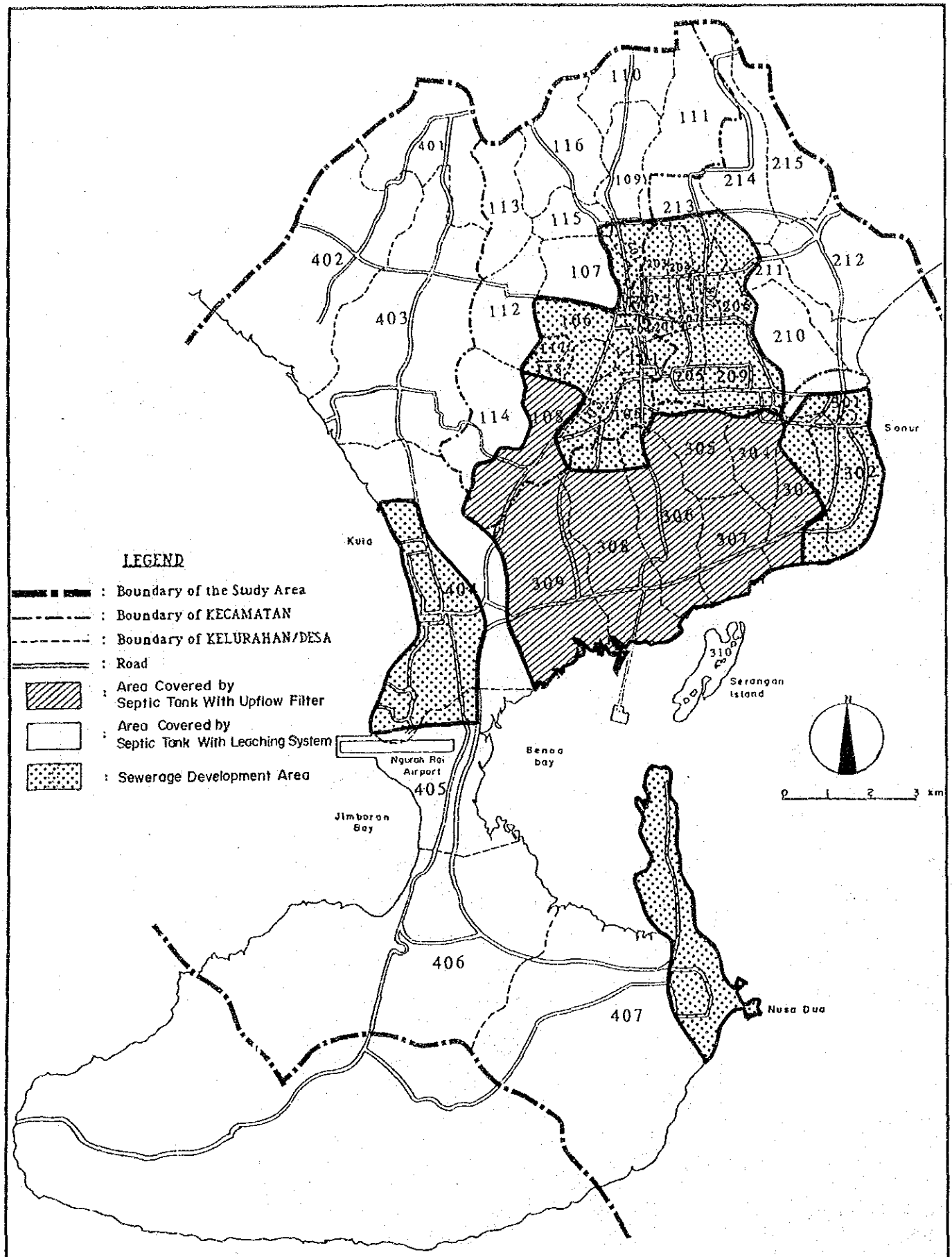
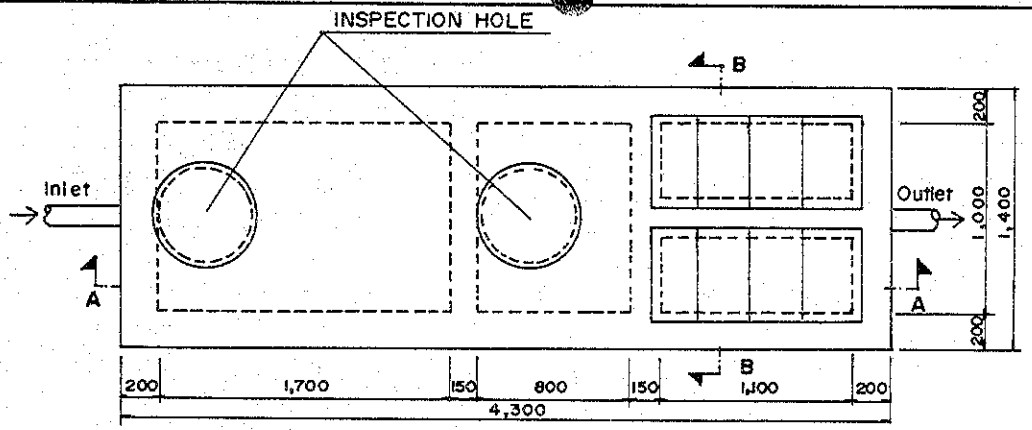
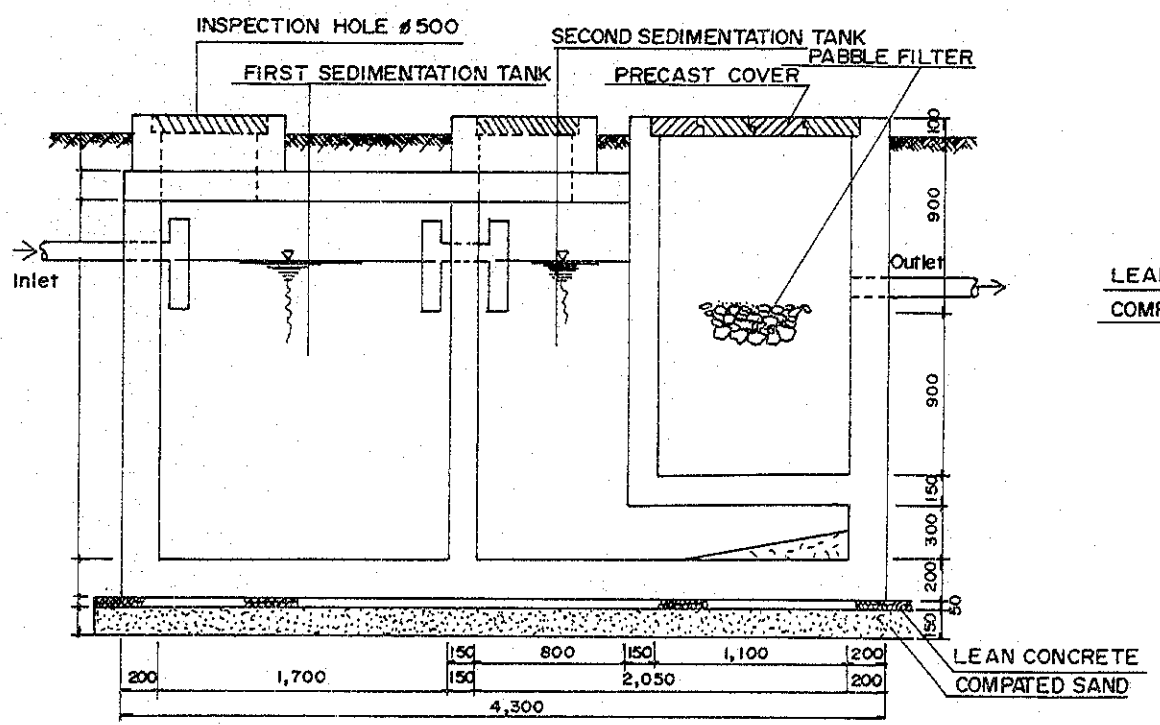


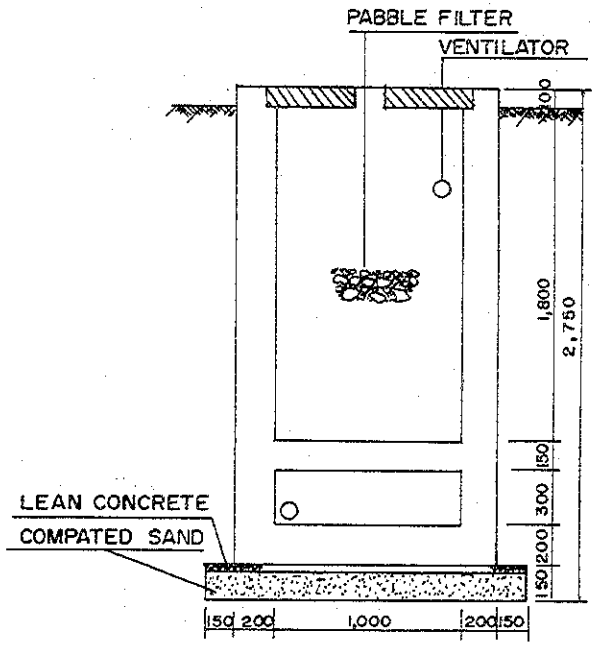
FIG. E.6.1 PROPOSED ON-SITE DEVELOPMENT AREA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR





SECTION A – A



SECTION B – B

FIG. E.6.2 SEPTIC TANK WITH UP-FLOW FILTER

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR