3.3.3 Comparison of Alternative Plans

Project efficiency of the three (3) alternative plans of dilution water introduction are compared in terms of water quality improvement in dry season, construction cost and pump operation cost. The improved water quality of the target klongs is shown in terms of average and maximum BOD for the divided klong groups. The comparison is shown in Table E.5.

As evident from Table E.5, Plan B is obviously the most economically efficient. Hence Plan B is recommended.

4. Proposed Plan of Klong Water Purification

The Plan B of dilution water introduction improves the existing water quality of the target klongs to a considerable extent in dry season. The estimated daily average water quality in terms of BOD is not more than 15 mg/l in all the target klongs except for K. Toey. (Refer to Table E.1) In rainy season, however, no beneficial effects of klong water quality improvement is attained. In fact the water quality in some klongs of Ratanakosin Area becomes worser. Daily average water quality in terms of BOD is worse than 40 mg/l, for Plan B, in the klongs: Mahanak, Bang Lam Phu, Ong Ang, Lod, Wat Tep Tida and Wat Rajabopit (Refer to Table E.2).

The final proposal of klong water purification is summarized below.

4.1 Planning Conditions for Dilution Water Introduction

Introduction of the dilution water from the Chao Phraya River in dry season is planned with the following conditions.

(1) Pollution load run-offs into the klongs: Existing ones

(2) Rainfall : 1.1 mm/day

(3) Evapo-transpiration : 1.8 mm/day

(4) Expected dilution water from the eastern outer areas : 10 m^3/s

(5) Maintenance klong water level : +0.77 m M.S.L. for dry season

(6) Suction water level of Drainage P.S. : 0 m M.S.L. for Phra Khanong
+0.3 m M.S.L. for Krung Kasem

(7) Water stage of the Chao Phraya River : See Fig. E.6.

4.2 Proposed Structural Measures

Four (4) pump stations will be reconstructed for the introduction of dilution water from the Chao Phraya River. Three (3) shallow klongs will be dredged to increase their discharge capacities.

(1) Pump Station

Bang Sue P.S. : Four (4) pumps among the existing 17 pumps will be remodelled into reversible type by the reconstruction of the existing gate structures. The reversible pumps have a discharge capacity of 3 m^3/s each.

Sam Sen P.S. : Four (4) pumps among the existing 15 pumps will be modified into reversible type by the reconstruction of the existing gate structures. The reversible pumps have a discharge capacity of 3 m^3/s each.

Tavate P.S. : Two (2) additional pumps with a capacity of 3 m^3/s each will be installed.

Sathorn P.S. : Two (2) additional pumps with a capacity of 3 m^3/s each will be constructed.

(2) Dredging

The klongs of Wat Tep Tida, Wat Rajabopit and Chong Non Sri will be dredged according to the following plan.

	Length (m)	Width (m)	Volume (m^3)	Bed El. (MSL, m)
K. Wat Tep Tida	745	7.0	4,000	-1.5
K. Wat Rajabopit	1,122	6.8	8,000	-1.5
K. Chong Non Sri	3,600	6.0 ~ 10.0	77,000	-1.5 ~ -2.0
Total	5,467		89,000	

4.3 Effects of Proposed Plan

The improved klong water quality in dry season by the proposed plan of dilution water introduction is shown below, in comparison to the water quality under the existing conditions.

Improved Water Quality (BOD: mg/l)

	Existing	Proposed plan
Ratanakosin Area		
K. Wat Tep Tida & K. Wat Rajabopit	17 (56)	12 (24)
Other klongs/1	12 (22)	10 (18)
Klongs in Surrounding Area/2	20 (33)	12 (16)
K. Tocy	23 (30)	25 (31)
K. Sathorn & K. Chong Non Sri	47 (52)	12 (15)

Note: 1) /1; Lod, Bang Lum Phu, Ong Ang, Phadung Krung Kasem, Mahanak
2) /2; Bang Sue, Sam Sen, Prem Prachakorn, Saen Saep, Bang Kapi, Huai Khwang, Tan, Phra Khanong
3) Figure in parenthesis is maximum value
4) Figure with no parenthesis is average value

Table E.1 Comparison of Calculated Average and Maximum BOD by Alternative Plans of Dilution Water Introduction in Dry Season

Unit : mg/l

	Recorded	A	B	C
K. Bang Sue	11 - 13 (16 - 18)	8 - 10 (9 - 10)	8 - 10 (9 - 11)	7 (8 - 9)
K. Sam sen	16 - 25 (26 - 28)	6 - 16 (7 - 16)	6 - 15 (7 - 16)	5 - 10 (5 - 10)
K. Prem Prachakorn	24 - 25 (29 - 32)	9 - 13 (10 - 15)	9 - 13 (11 - 15)	10 (12)
K. Huai Khwang	31 (33)	15 (15)	15 (15)	10 (10)
K. Mahanak - K. Saen Saep	14 - 25 (21 - 28)	12 - 15 (13 - 16)	11 - 14 (13 - 15)	10 - 12 (12 - 13)
K. Bang Kapi	24 (26)	14 (15)	14 (15)	9 (9)
K. Phadung Krungkasem	14 - 16 (20 - 22)	9 - 13 (10 - 14)	9 - 13 (10 - 13)	8 - 11 (10 - 12)
K. Bang Lamphu	8 (18)	11 (18)	11 (18)	10 (16)
K. Ong Ang	9 (15)	9 (15)	9 (13)	8 (11)
K. Lod	8 - 10 (17 - 19)	8 - 9 (13 - 14)	8 (12 - 13)	6 - 7 (11 - 12)
K. Wat Teptida	18 (56)	15 (26)	10 (16)	9 (14)
K. Wat Ratchabopit	15 (30)	16 (27)	14 (24)	12 (24)
K. Tan	16 (17)	14 (14)	14 (14)	10 (10)
K. Phra Khanong	12 (13)	12 (13)	12 (13)	10 (10)
K. Toey	23 (30)	25 (31)	25 (31)	24 (30)
K. Sathorn	44 (45)	35 (36)	9 (13)	9 (13)
K. Chong Non Sri	50 (52)	50 (52)	14 (15)	14 (15)

cf.) Figure in parenthesis indicates maximum BOD.

Table E.2 Comparison of Calculated Average and Maximum BOD by Alternative Plans of Dilution Water Introduction in Rainy Season

Unit : mg/l

	Recorded	A	B	C
K. Bang Sue	8 - 14 (9 - 15)	8 - 17 (8 - 17)	8 - 17 (8 - 17)	7 - 13 (7 - 13)
K. Sam sen	11 - 29 (15 - 30)	8 - 22 (8 - 24)	8 - 22 (8 - 23)	7 - 20 (7 - 21)
K. Prem Prachakorn	26 - 35 (27 - 39)	28 - 39 (28 - 41)	28 - 39 (28 - 41)	26 - 38 (37 - 41)
K. Huai Khwang	11 (11)	9 (9)	9 (9)	9 (9)
K. Mahansk - K. Saen Saep	20 - 22 (22 - 24)	15 - 47 (15 - 48)	15 - 45 (15 - 47)	16 - 46 (16 - 47)
K. Bang Kapi	16 (20)	8 (9)	8 (9)	8 (8)
K. Phadung Krungkasem	30 - 37 (30 - 38)	31 - 34 (31 - 34)	30 - 33 (31 - 34)	33 - 36 (33 - 36)
K. Bang Lamphu	18 (23)	48 (49)	48 (49)	51 (52)
K. Ong Ang	16 (22)	46 (46)	45 (46)	45 (46)
K. Lod	14 - 22 (18 - 24)	45 (46)	44 - 45 (45 - 46)	44 - 45 (46)
K. Wat Teptida	44 (55)	55 (55)	47 (47)	46 (47)
K. Wat Ratchabopit	28 (33)	49 (51)	50 (50)	50 (50)
K. Tan	5 (5)	5 (5)	5 (5)	5 (5)
K. Phra Khanong	5 (6)	5 (5)	5 (5)	5 (5)
K. Toey	19 (26)	18 (23)	18 (23)	18 (23)
K. Sathorn	37 (37)	37 (37)	35 (35)	35 (35)
K. Chong Non Sri	32 (33)	32 (33)	30 (30)	30 (30)

cf.) Figures in parenthesis indicates maximum BOD.

Table E.3 Comparison of Construction Cost

(Unit: Baht)

	Plan A	Plan B	Plan C
Pump Station			
Bang Suc P.S.	9,280,000	9,280,000	18,770,000
Sam Sen P.S.	7,910,000	7,910,000	13,170,000
Tavatc P.S.	10,350,000	10,350,000	14,590,000
Sathorn P.S.	10,430,000	10,430,000	10,430,000
Sub Total	37,970,000	37,970,000	56,960,000
Dredging			
K. Chong Non Sri	0	8,470,000	8,470,000
K. Bang Sue	0	0	21,340,000
K. Sam Sen	0	0	11,000,000
K. Huai Khwang	0	0	2,200,000
K. Lad Phrao	0	0	29,810,000
K. Tan	0	0	1,540,000
Sub Total	0	8,470,000	74,360,000
Retaining Wall			
K. Bang Sue	0	0	234,000,000
K. Sam Sen	0	0	299,000,000
K. Huai Khwang	0	0	23,400,000
K. Lad Phrao	0	0	330,200,000
K. Tan	0	0	62,400,000
Sub Total	0	0	949,000,000
Total	37,970,000	46,440,000	1,080,320,000

Table E.4 Comparison of Alternative Pump Operation Cost

(Unit: Baht/day)

	Plan A	Plan B	Plan C
Introduction			
Bang Sue P.S.	22,200	22,200	24,400
Sam Sen P.S.	15,900	15,900	20,200
Tavate P.S.	6,700	6,700	8,600
Sathorn P.S.	800	7,000	7,000
Sub Total	45,600	51,800	60,200
Discharge			
Krung Kasem P.S.	9,500	10,100	14,500
Phra Khanong P.S.	76,700	76,800	161,500
Chong Non Sri P.S.	200	6,000	6,000
Sub Total	86,400	92,900	182,000
Total	132,000	145,100	242,600

Table E.5 Comparison of Alternative Plans

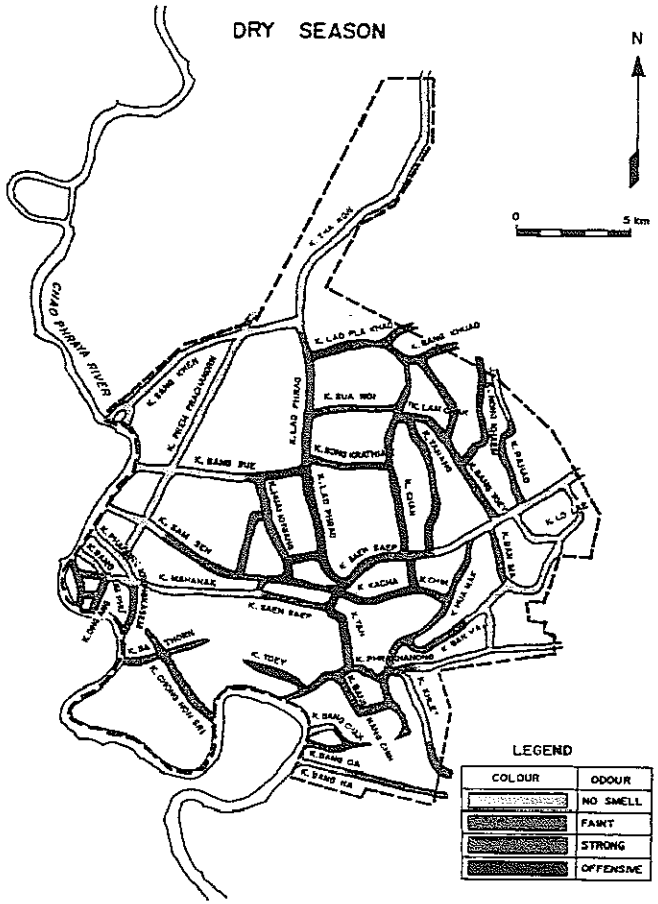
			Existing	Plan A	Plan B	Plan C
Improved Water Quality in Dry Season (BOD: mg/l)	Ratanakosin Area	K. Wat Tep Tida & K. Wat Rajabopit	17 (56)	16 (27)	12 (24)	11 (24)
		Other Klongs /1	12 (22)	11 (18)	10 (18)	9 (16)
	Klongs in Surrounding Area /2		20 (33)	12 (16)	12 (16)	9 (13)
	K. Toey		23 (30)	25 (31)	25 (31)	24 (30)
	K. Sathorn & K. Chong Non Sri		47 (52)	43 (52)	12 (15)	12 (15)
Construction Cost (million Baht)			0	38.0	46.4	1,080.3
Pump Operation Cost (million Baht/year)			12.8	31.7	34.8	58.2

Note: 1) /1 ; Lod, Bang Lum Phu, Ong Ang, Phadung Krung Kasem, Mahanak

2) /2 ; Bang Sue, Sam Sen, Prem Prachakorn, Saen Saep, Bang Kapi, Huai Khwang, Tan, Phra Khanong

3) Figure in parenthesis is maximum value.

4) Figure outside parenthesis is average value.



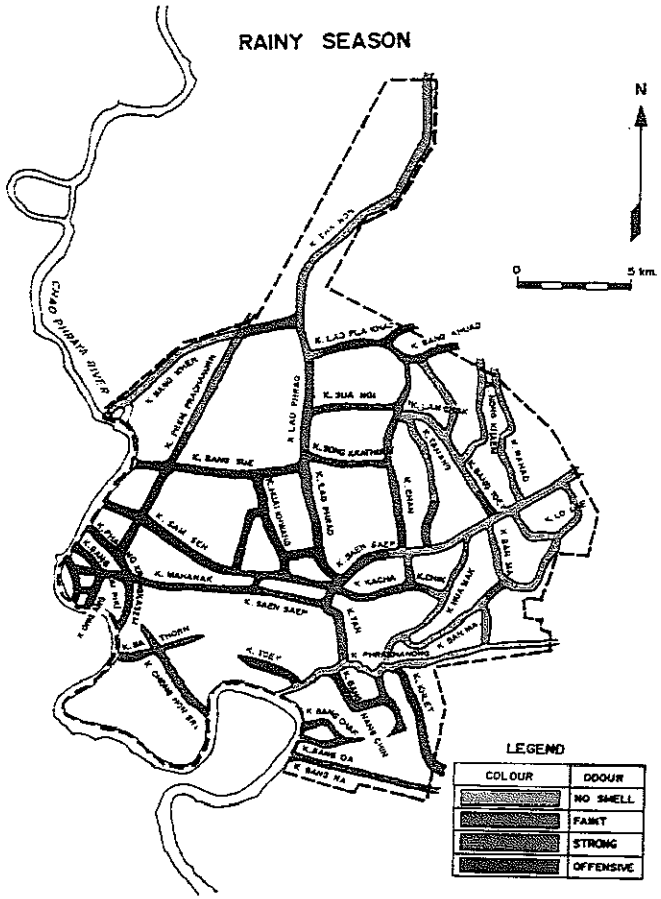


FIG. E.1 OBSERVED COLOUR AND ODOUR

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

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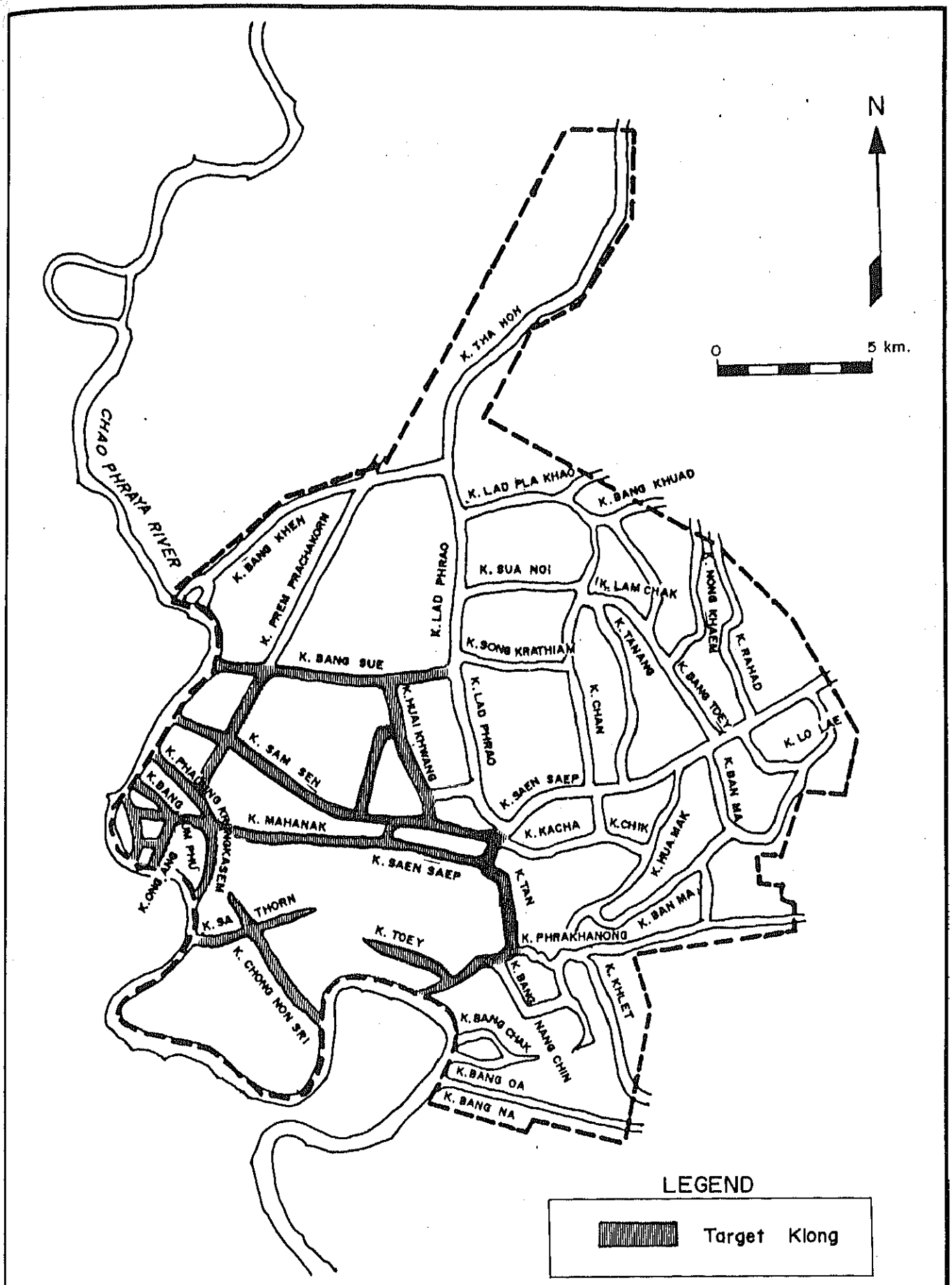

FIG. E . 2 LOCATION OF TARGET KLONGS

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

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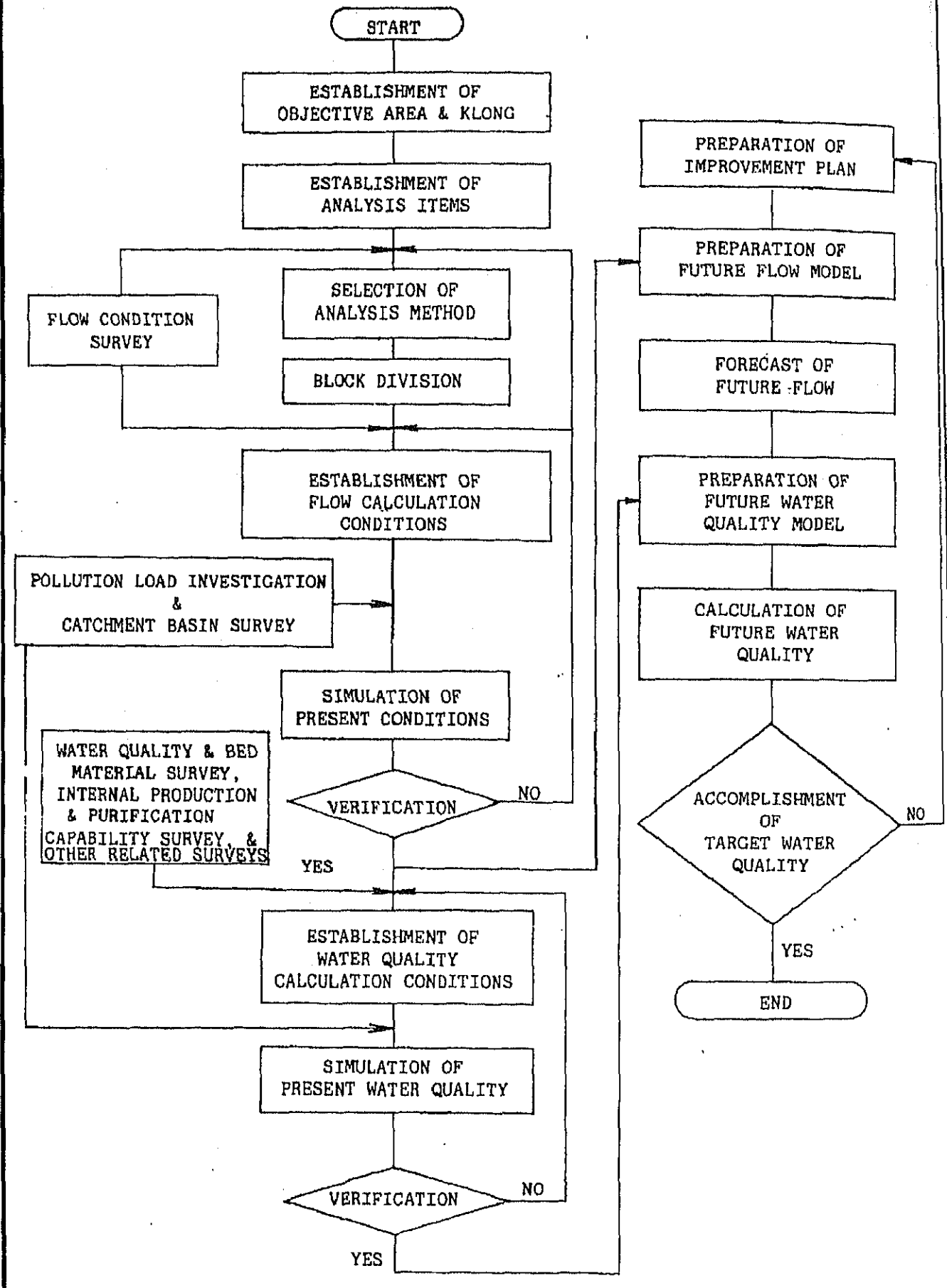

FIG. E.3 FLOW CHART OF SIMULATION

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

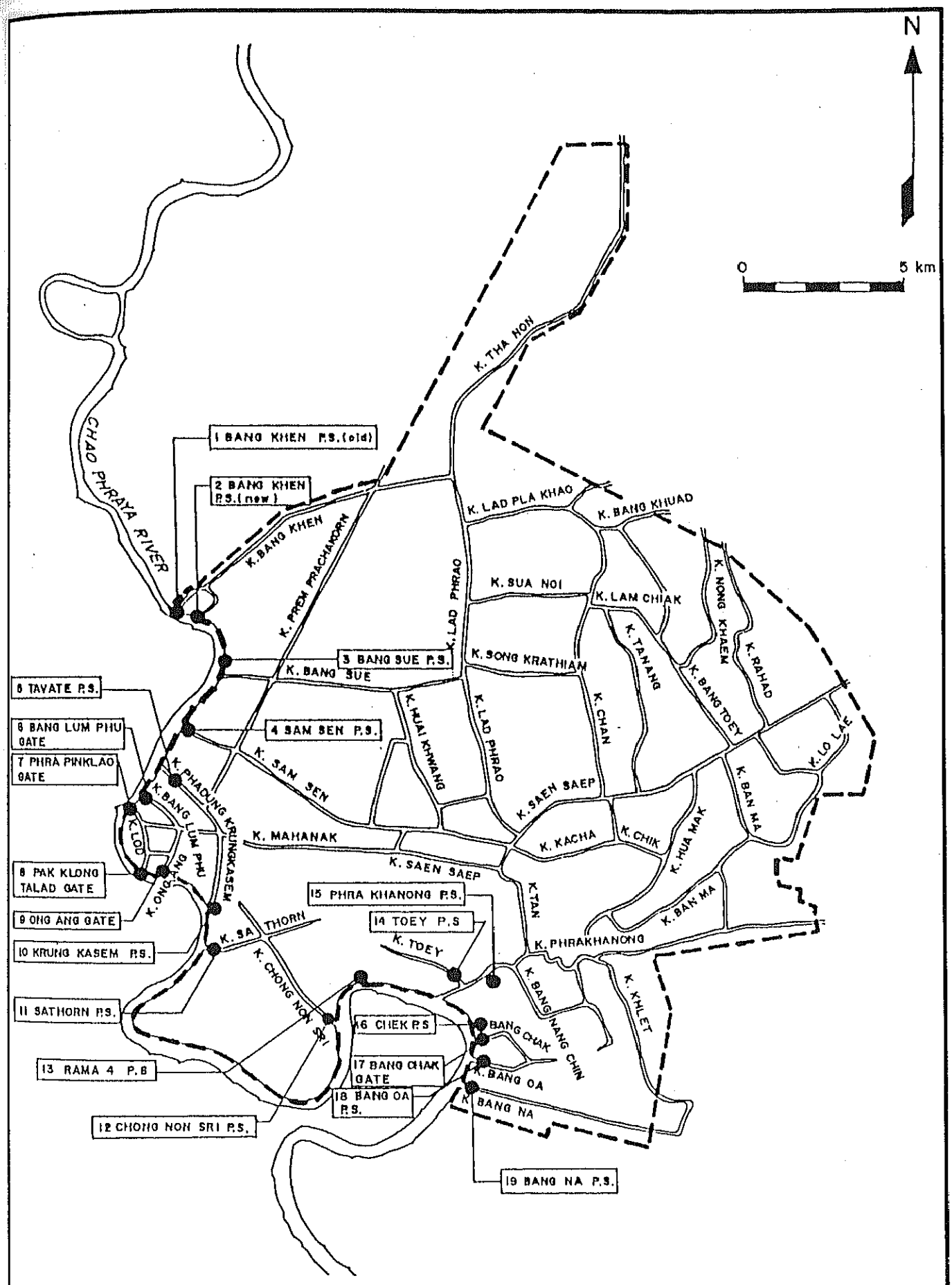

FIG. E.4 OBJECTIVE KLONG FOR WATER QUALITY SIMULATION

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

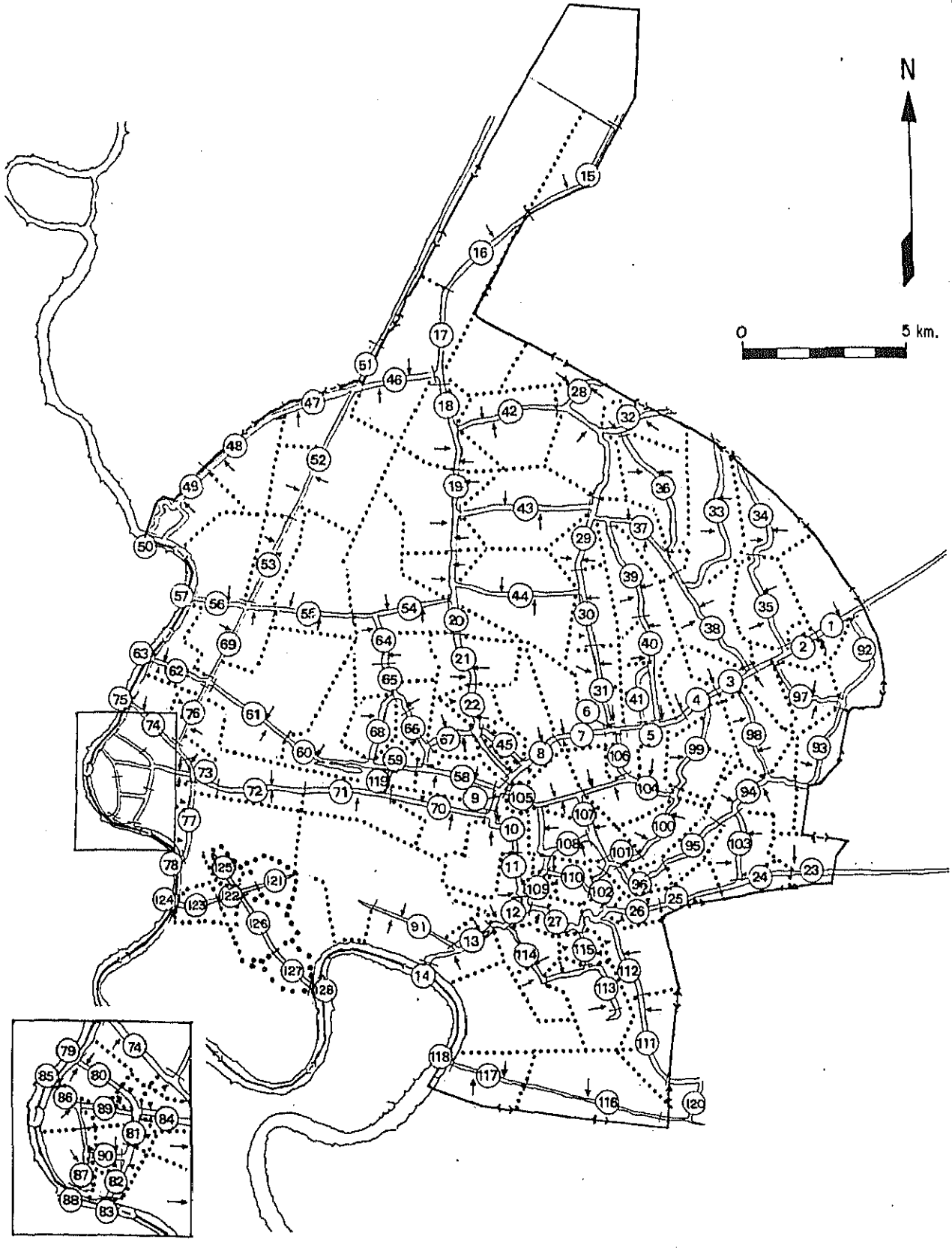

FIG. E. 5 PROPOSED KLONG NETWORK MODEL

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

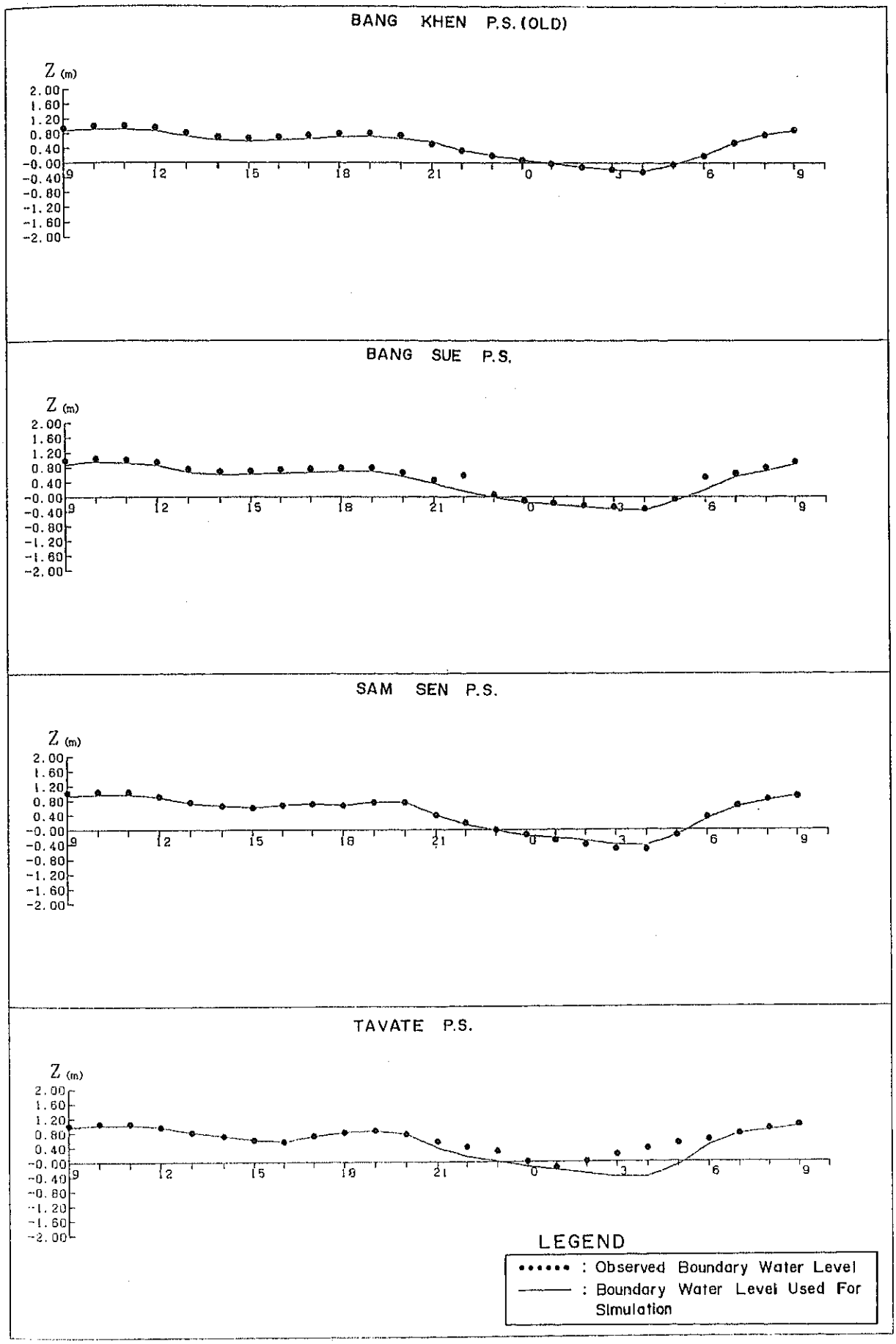

FIG. E.6 (1) BOUNDARY WATER LEVEL FOR SIMULATION IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

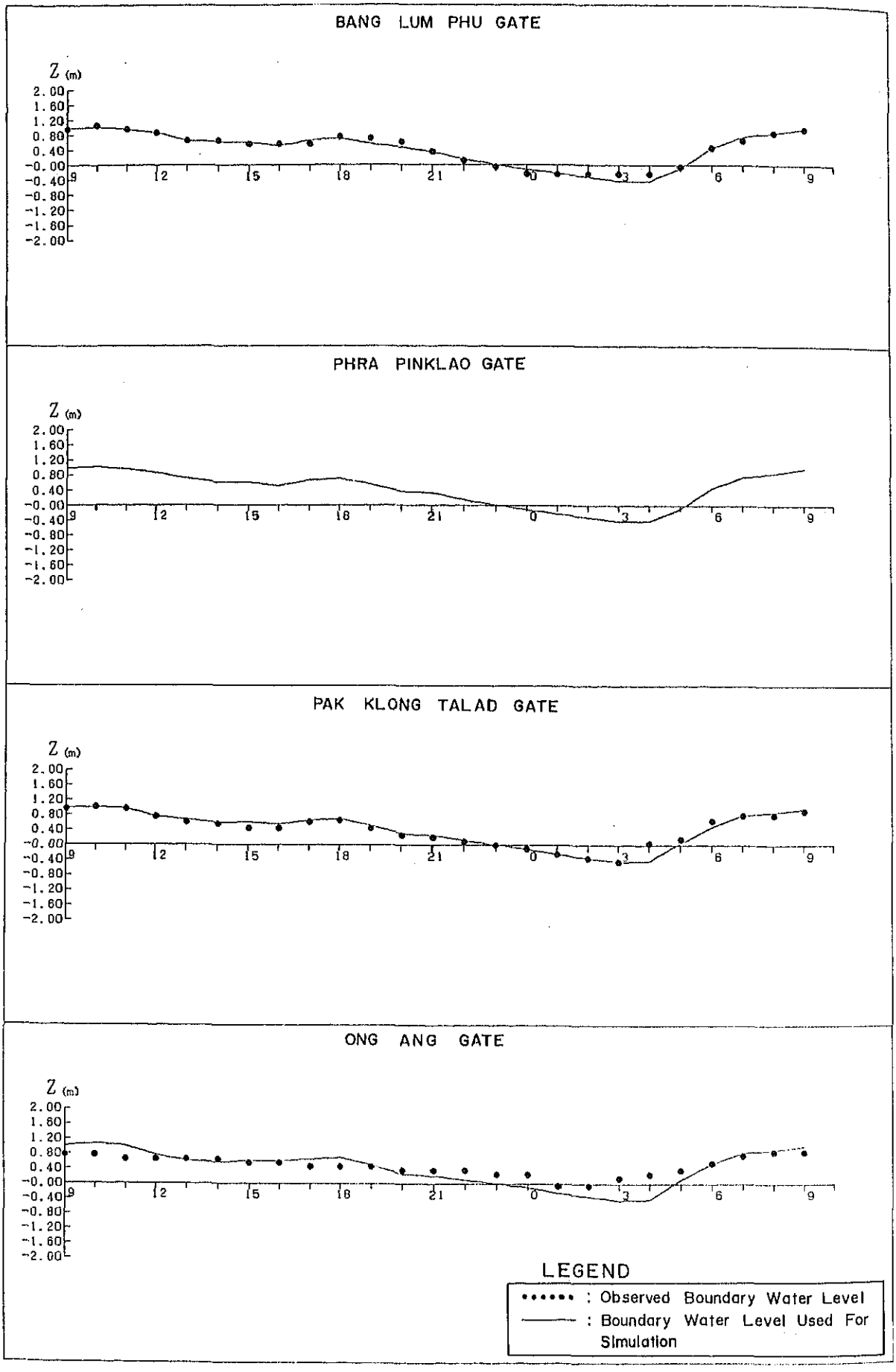

FIG. E.6 (2) BOUNDARY WATER LEVEL FOR SIMULATION IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

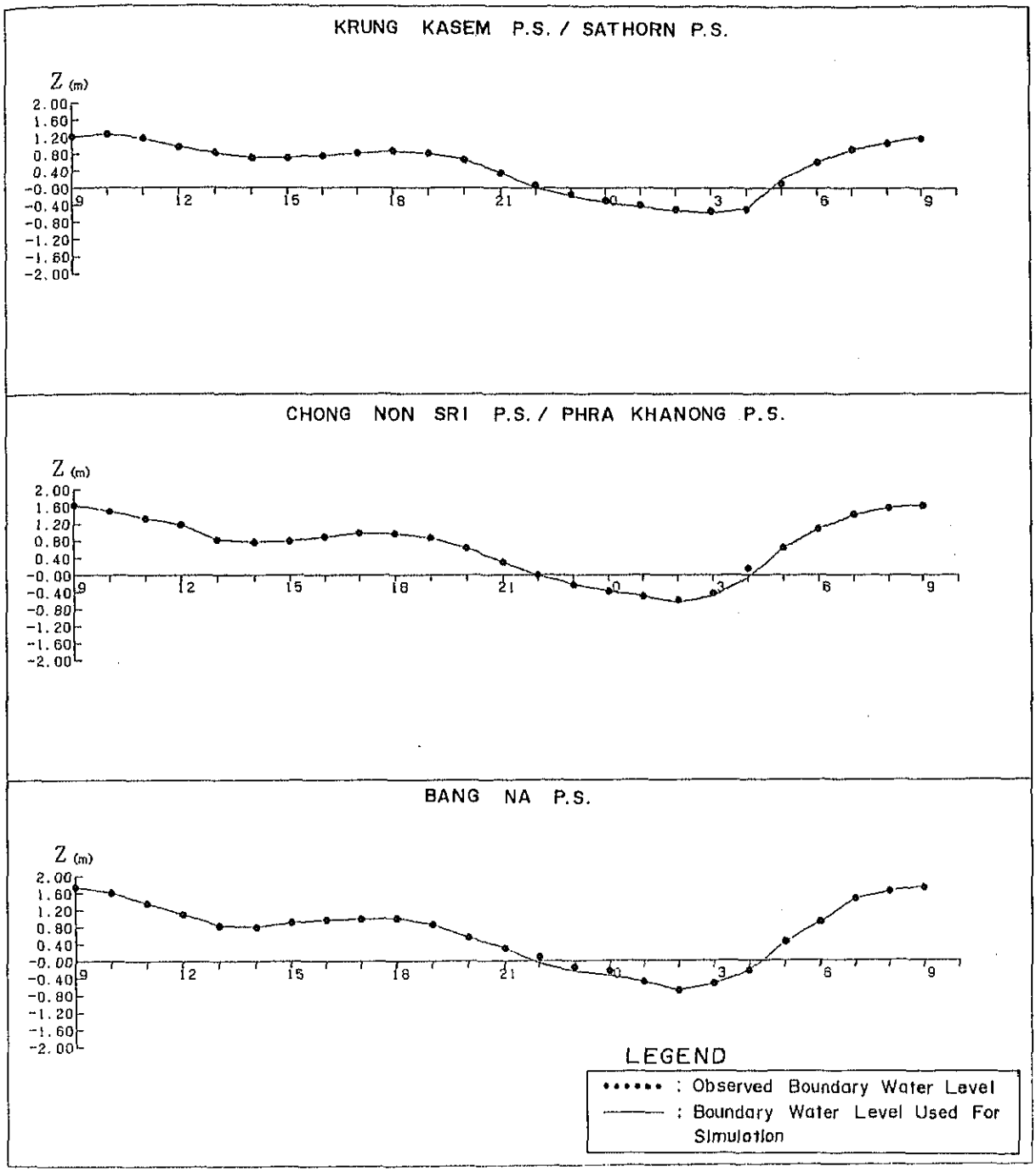

FIG. E.6 (3) BOUNDARY WATER LEVEL FOR SIMULATION IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

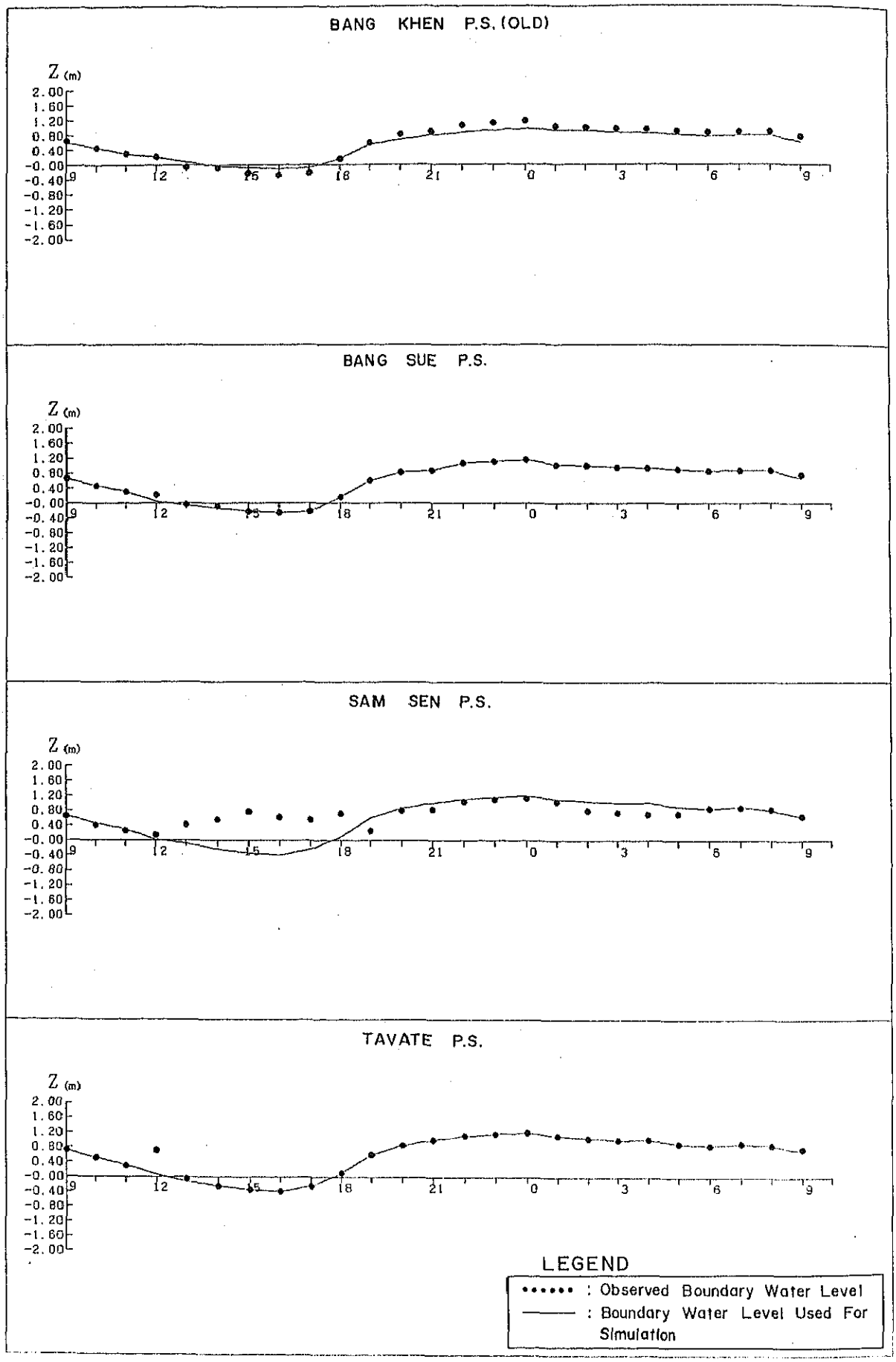

FIG. E .7 (1) BOUNDARY WATER LEVEL FOR SIMULATION IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

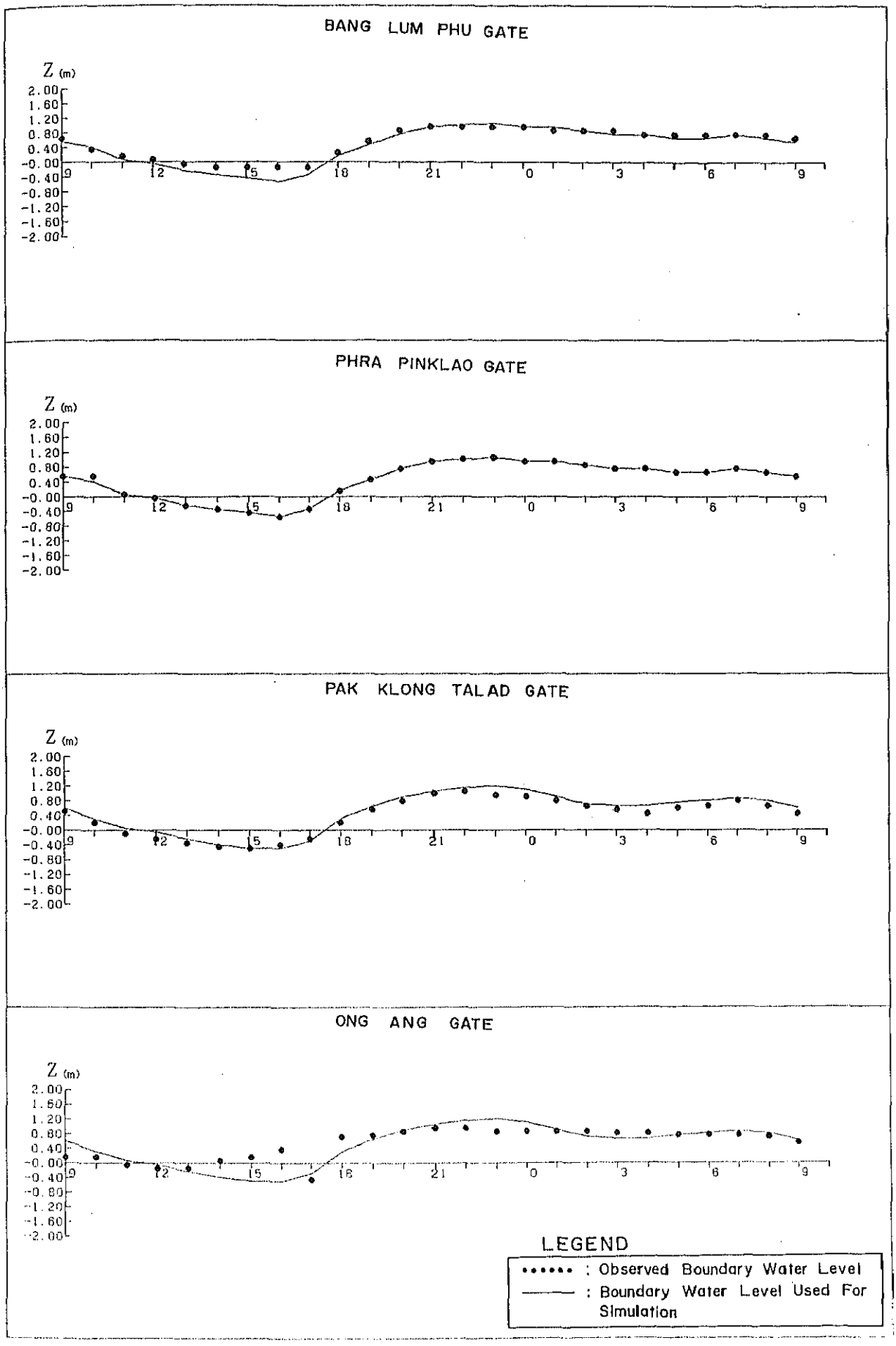

FIG. E.7(2) BOUNDARY WATER LEVEL FOR SIMULATION IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

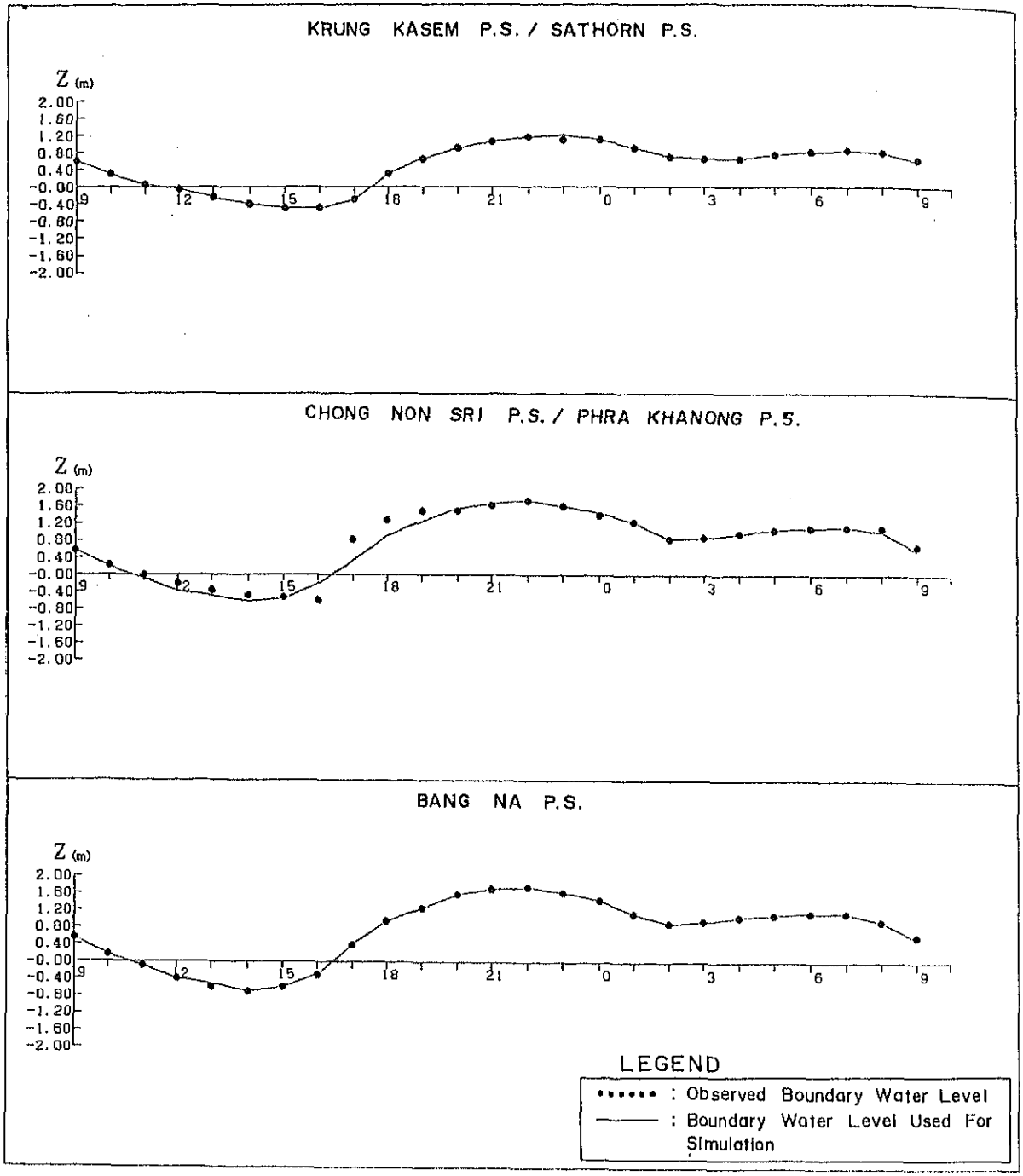

FIG. E.7 (3) BOUNDARY WATER LEVEL FOR SIMULATION IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

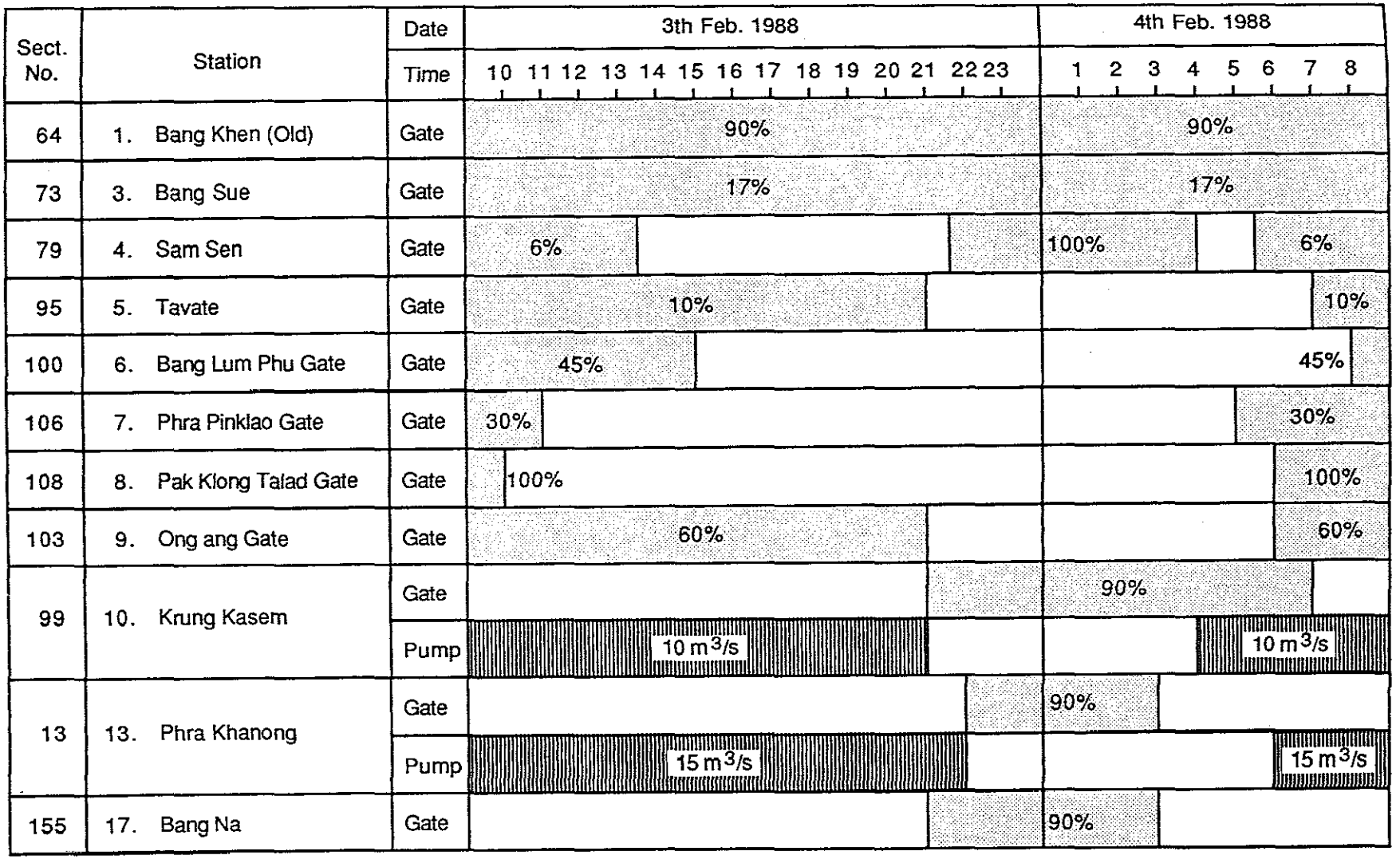

FIG. E.8 PUMP AND GATE OPERATION FOR SIMULATION IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

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Sect. No.	Station	Date	16th July 1988	17th July 1988
		Time	10 11 12 13 14 15 16 17 18 19 20 21 22 23	1 2 3 4 5 6 7 8
64	1. Bang Khen (Old)	Gate	90%	90%
73	3. Bang Sue	Gate	100%	
		Pump	12 m^3/s	12 m^3/s
79	4. Sam Sen	Gate	100%	
95	5. Tavate	Gate	Closed	Closed
100	6. Bang Lum Phu Gate	Gate	Closed	Closed
106	7. Phra Pinklao Gate	Gate	2%	2%
108	8. Pak Klong Talad Gate	Gate	Closed	Closed
103	9. Ong ang Gate	Gate	3%	3%
99	10. Krung Kasem	Gate	Closed	Closed
		Pump	10 m^3/s	6 m^3/s
13	13. Phra Khanong	Gate	100%	
		Pump	54 m^3/s	54 m^3/s
155	17. Bang Na	Gate	100%	

FIG. E.9 PUMP AND GATE OPERATION FOR SIMULATION IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532 B.E. 1989 A.D.

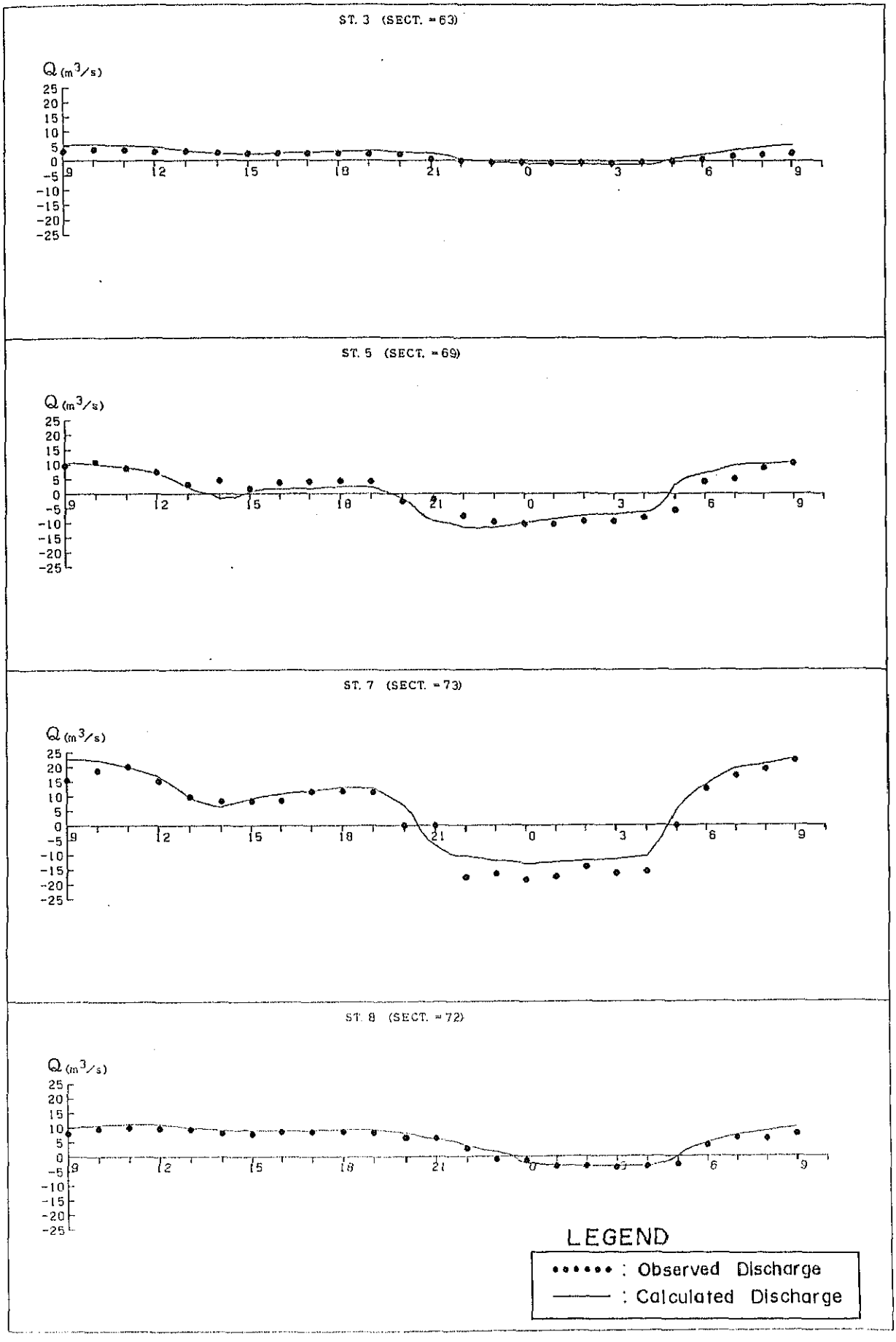

FIG. E.10(1) OBSERVED AND CALCULATED DISCHARGES IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

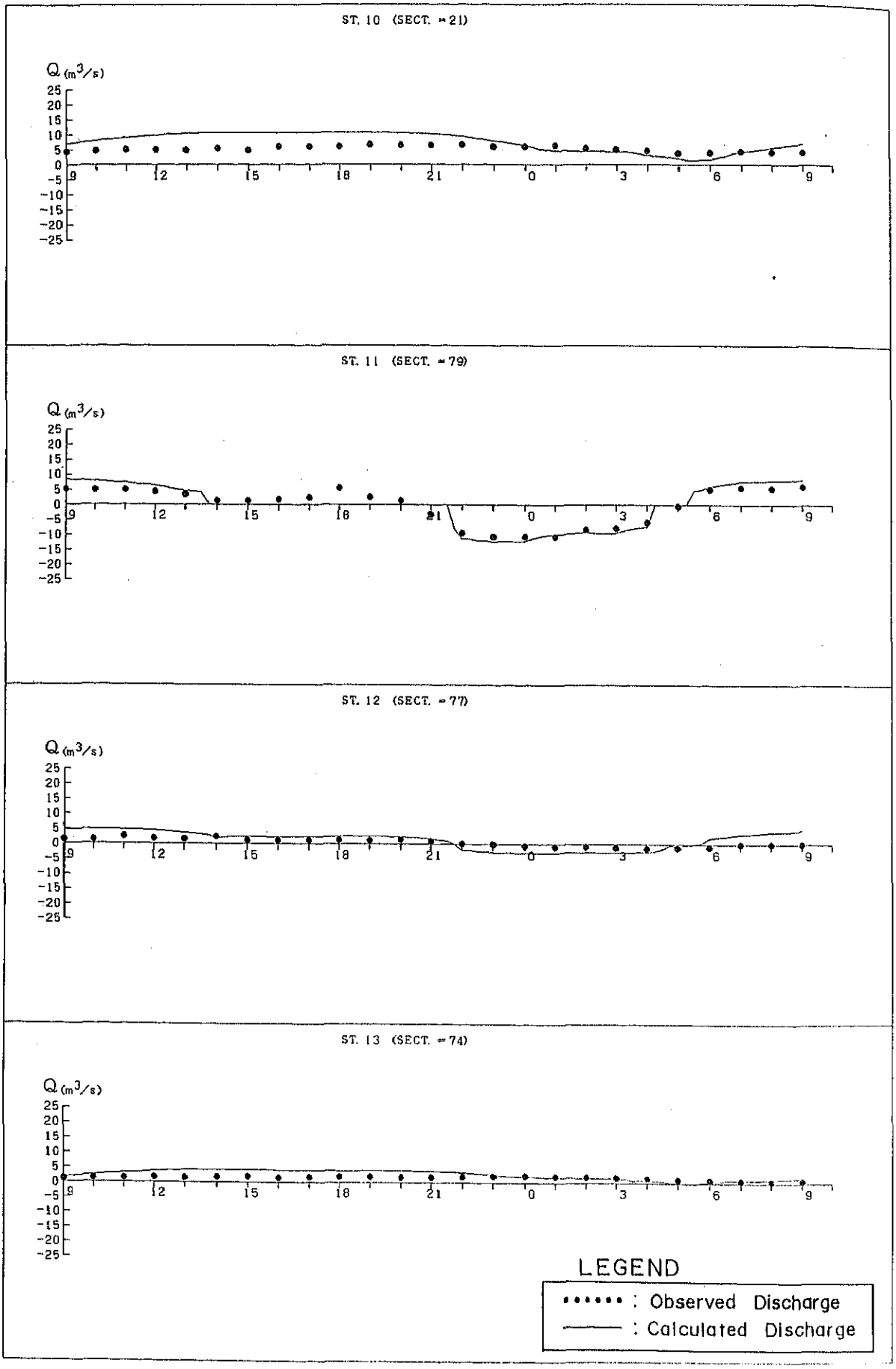

FIG. E.10(2) OBSERVED AND CALCULATED DISCHARGES IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

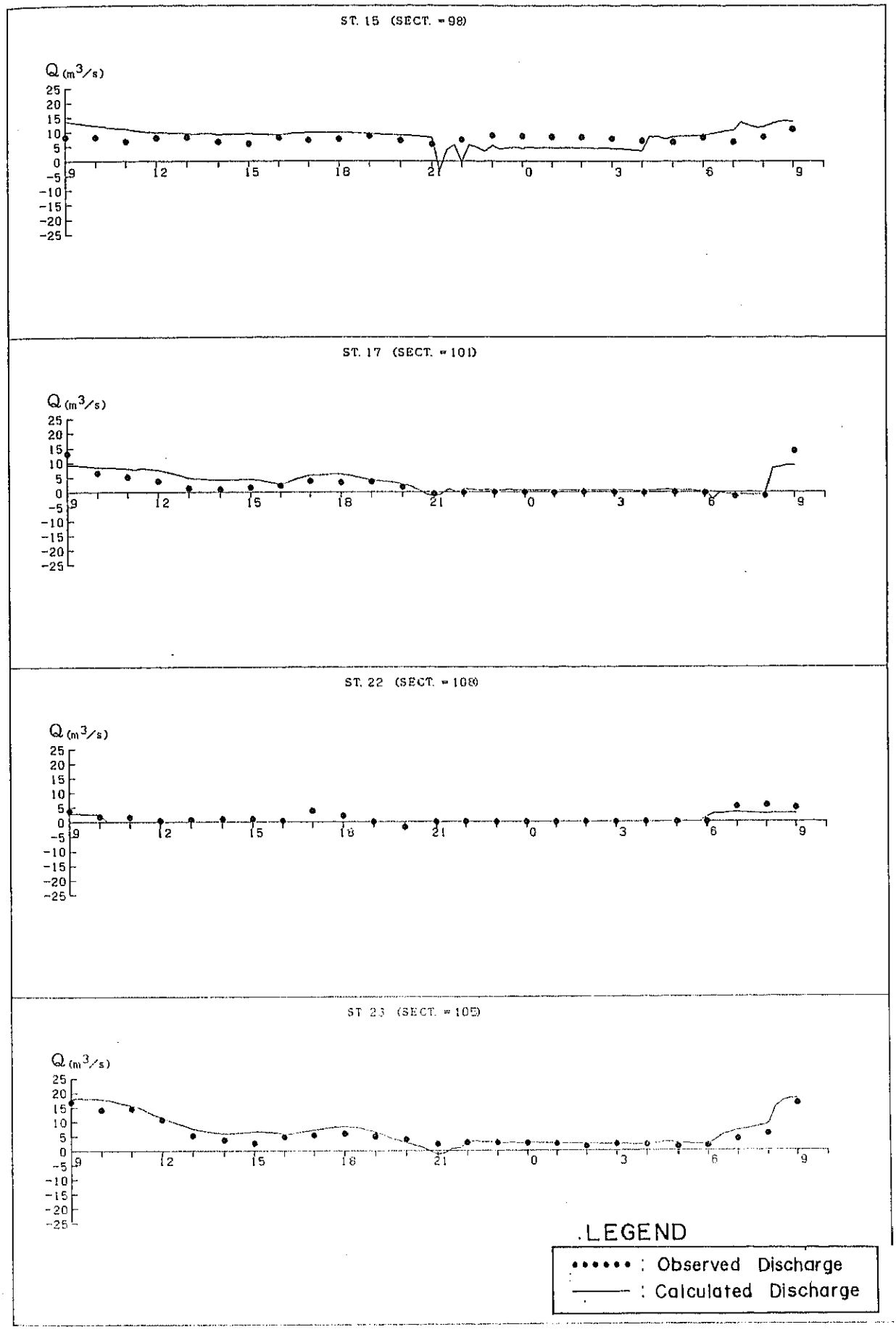

FIG. E.10(3) OBSERVED AND CALCULATED DISCHARGES IN DRY SEASON

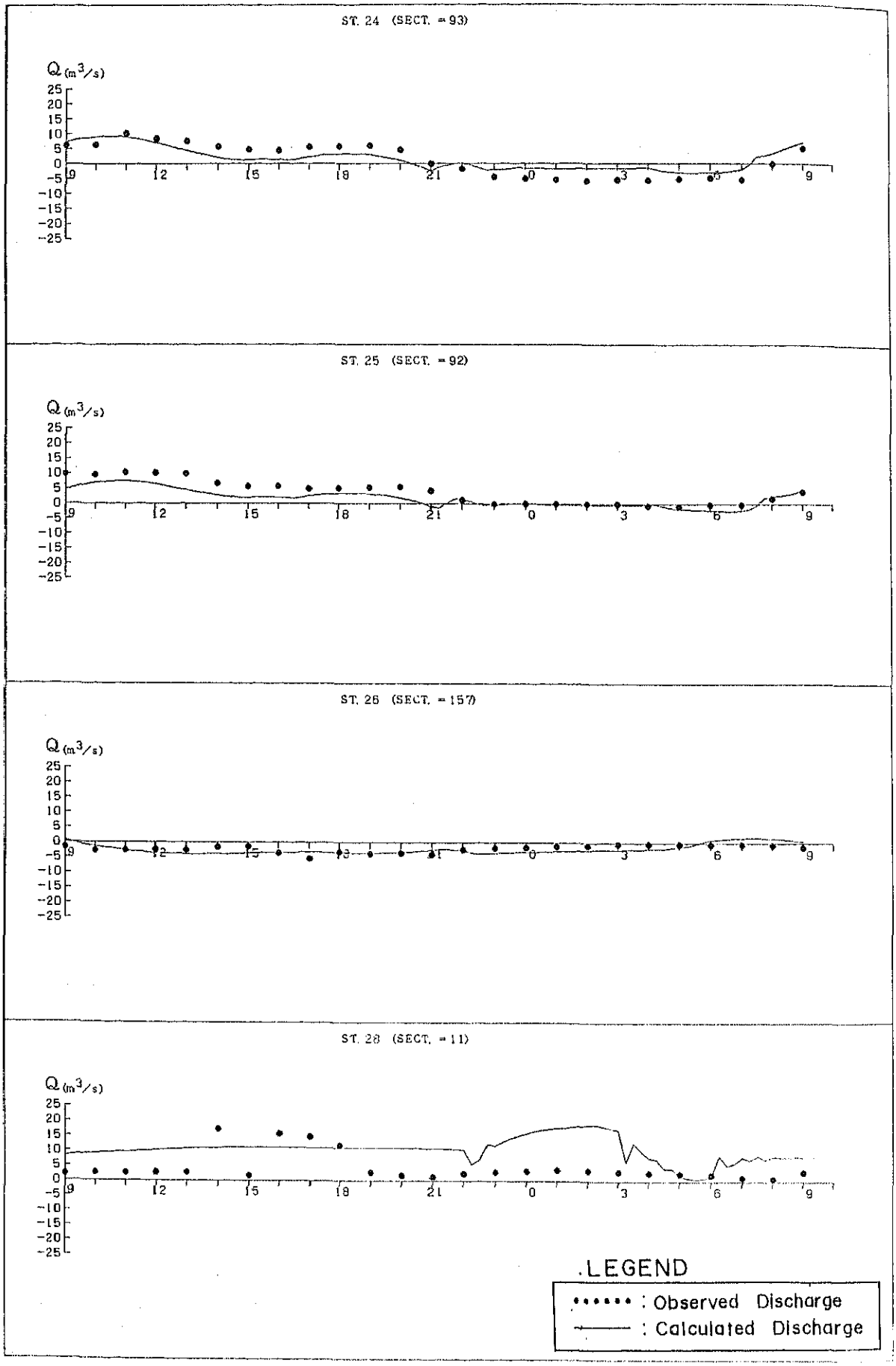

FIG. E.10(4) OBSERVED AND CALCULATED DISCHARGES IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

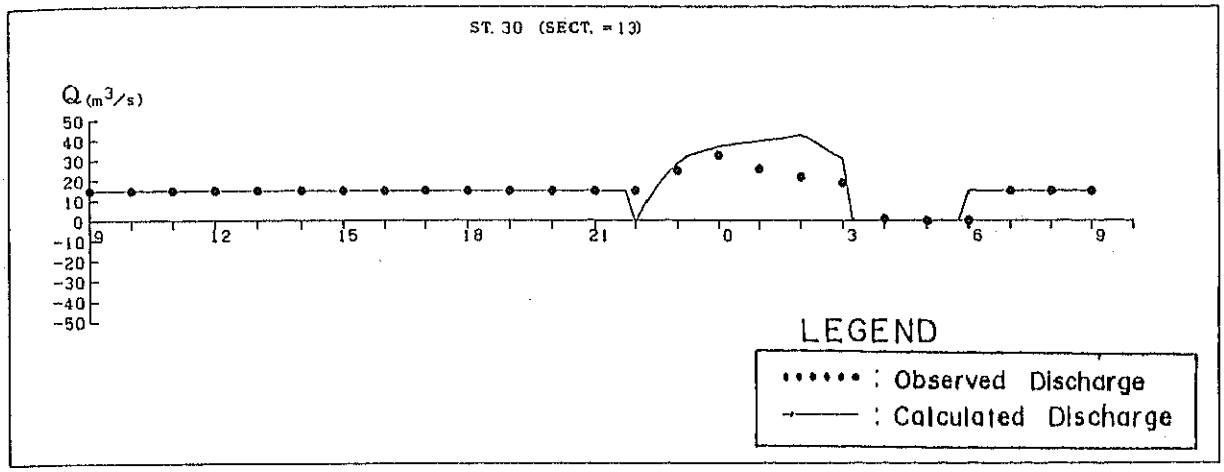

FIG. E.10(5) OBSERVED AND CALCULATED DISCHARGES IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

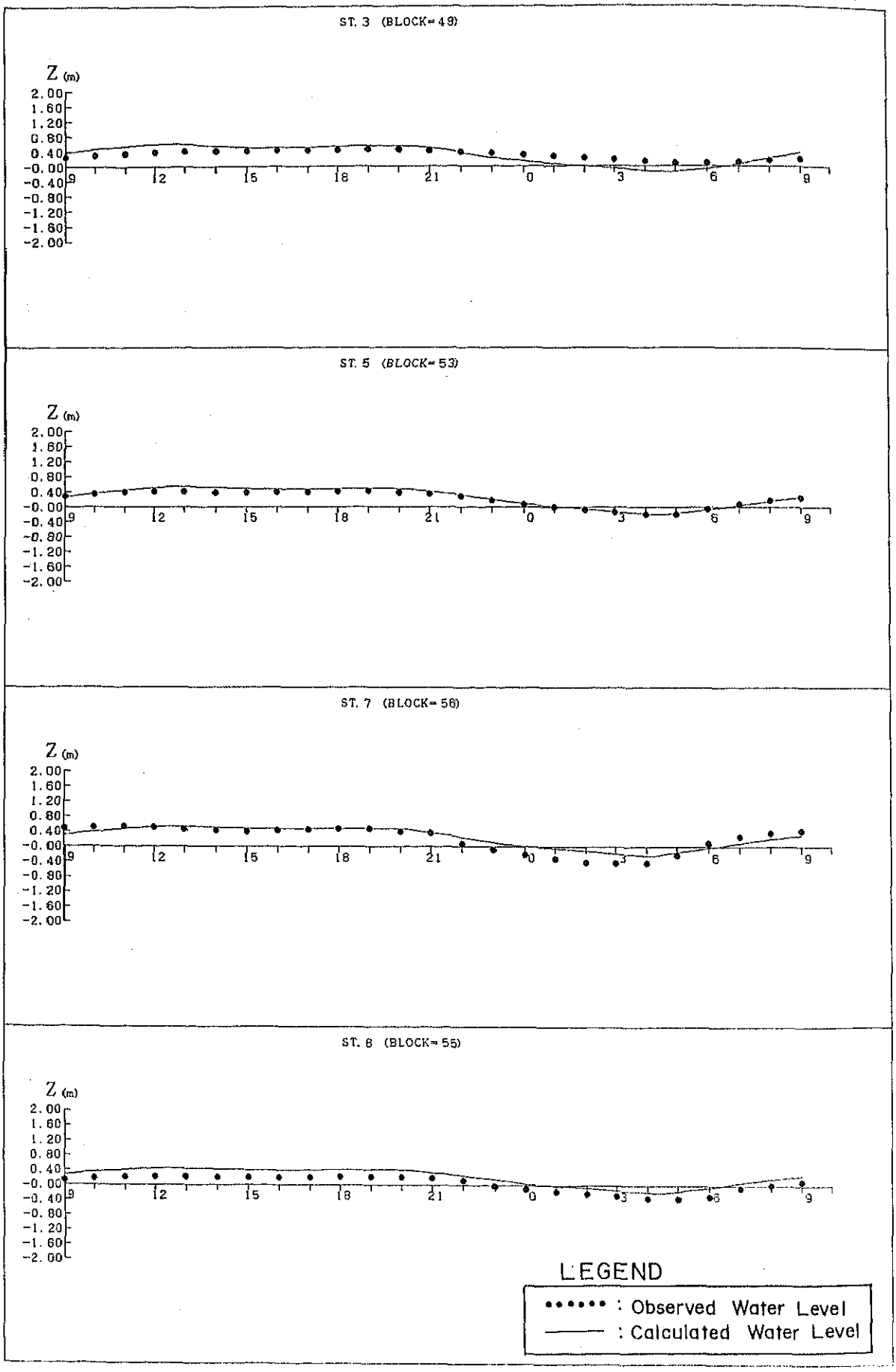

FIG. E.11 (1) OBSERVED AND CALCULATED WATER LEVEL IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

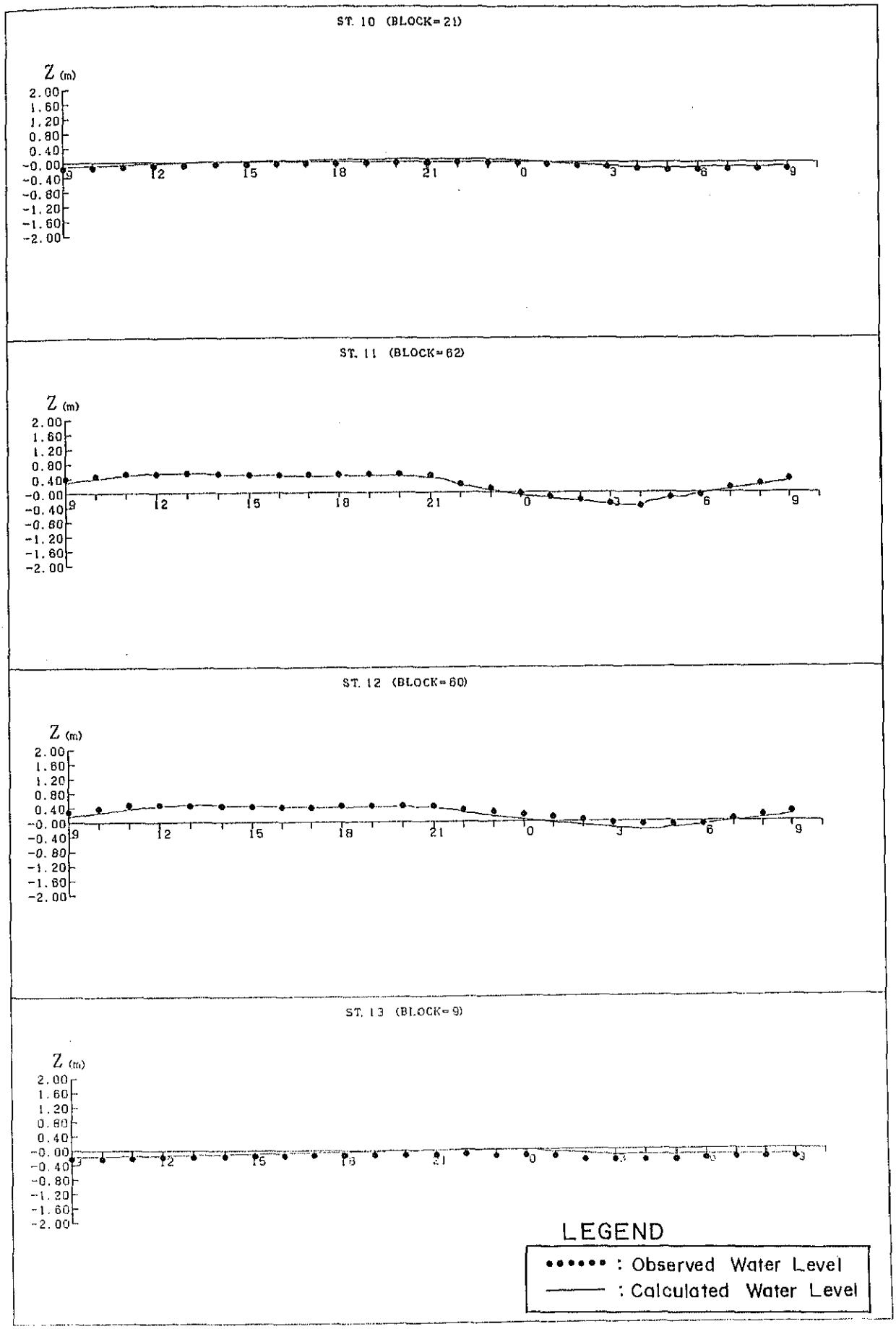

FIG. E.11 (2) OBSERVED AND CALCULATED WATER LEVEL IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

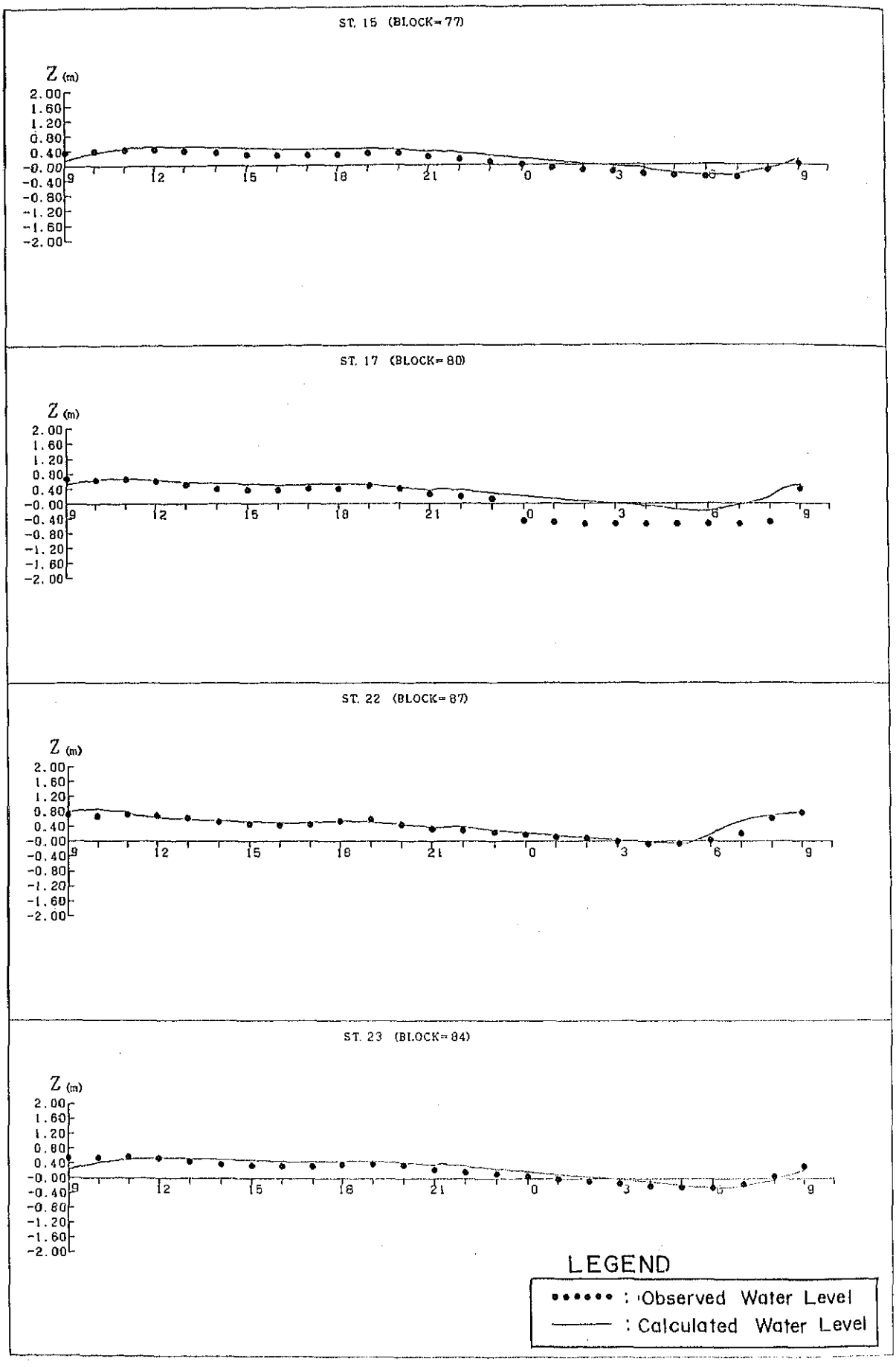

FIG. E.11 (3) OBSERVED AND CALCULATED WATER LEVEL IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

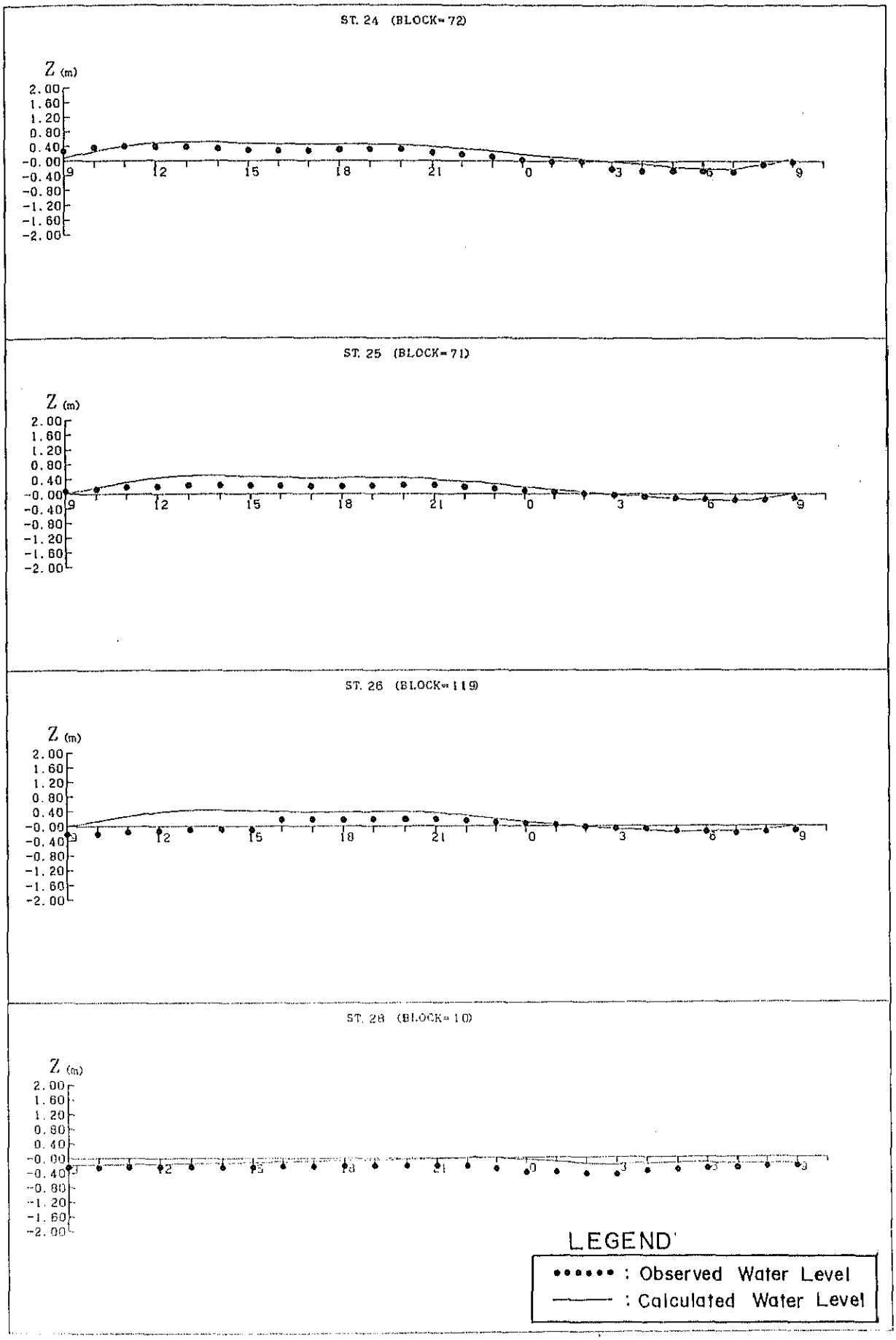

FIG. E.11 (4) OBSERVED AND CALCULATED WATER LEVEL IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

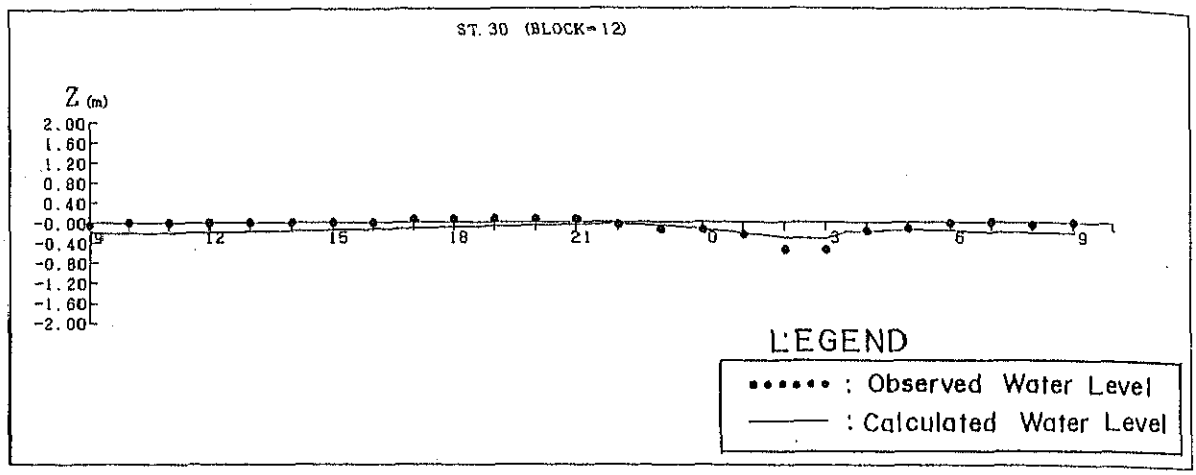

FIG. E.11(5) OBSERVED AND CALCULATED WATER LEVEL IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

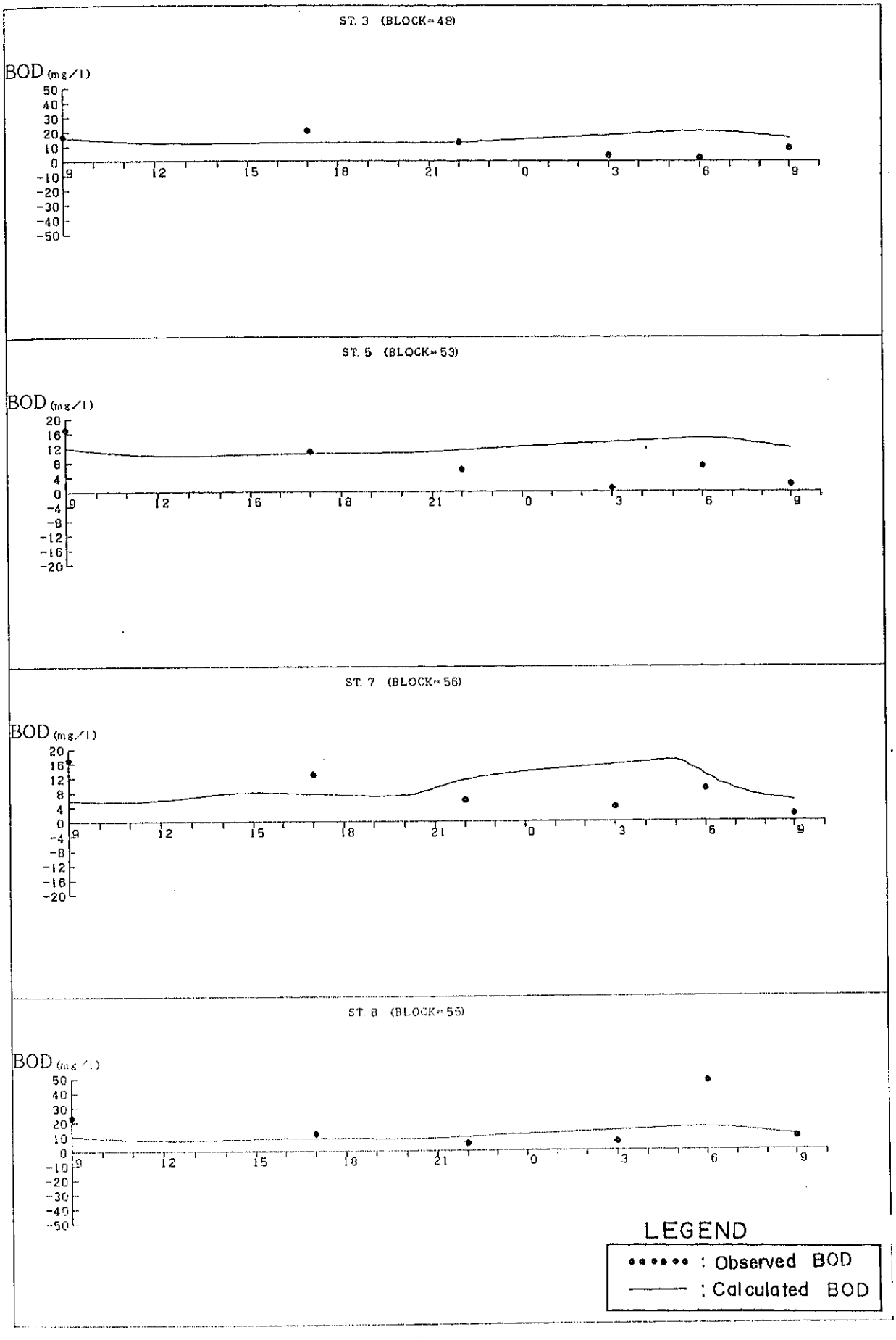

FIG. E.12 (1) OBSERVED AND CALCULATED WATER QUALITY (BOD) IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

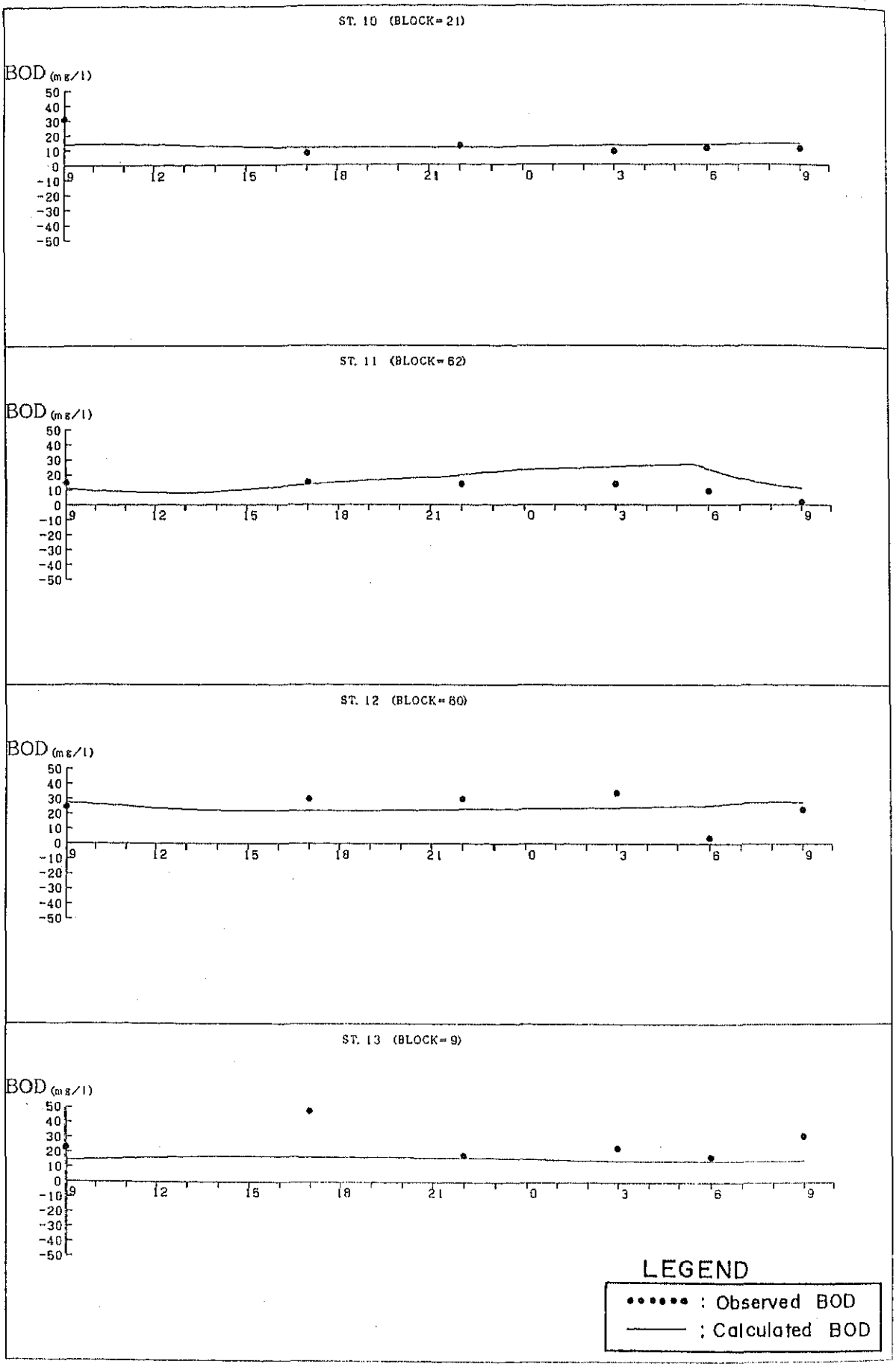

FIG. E.12 (2) OBSERVED AND CALCULATED WATER QUALITY (BOD) IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

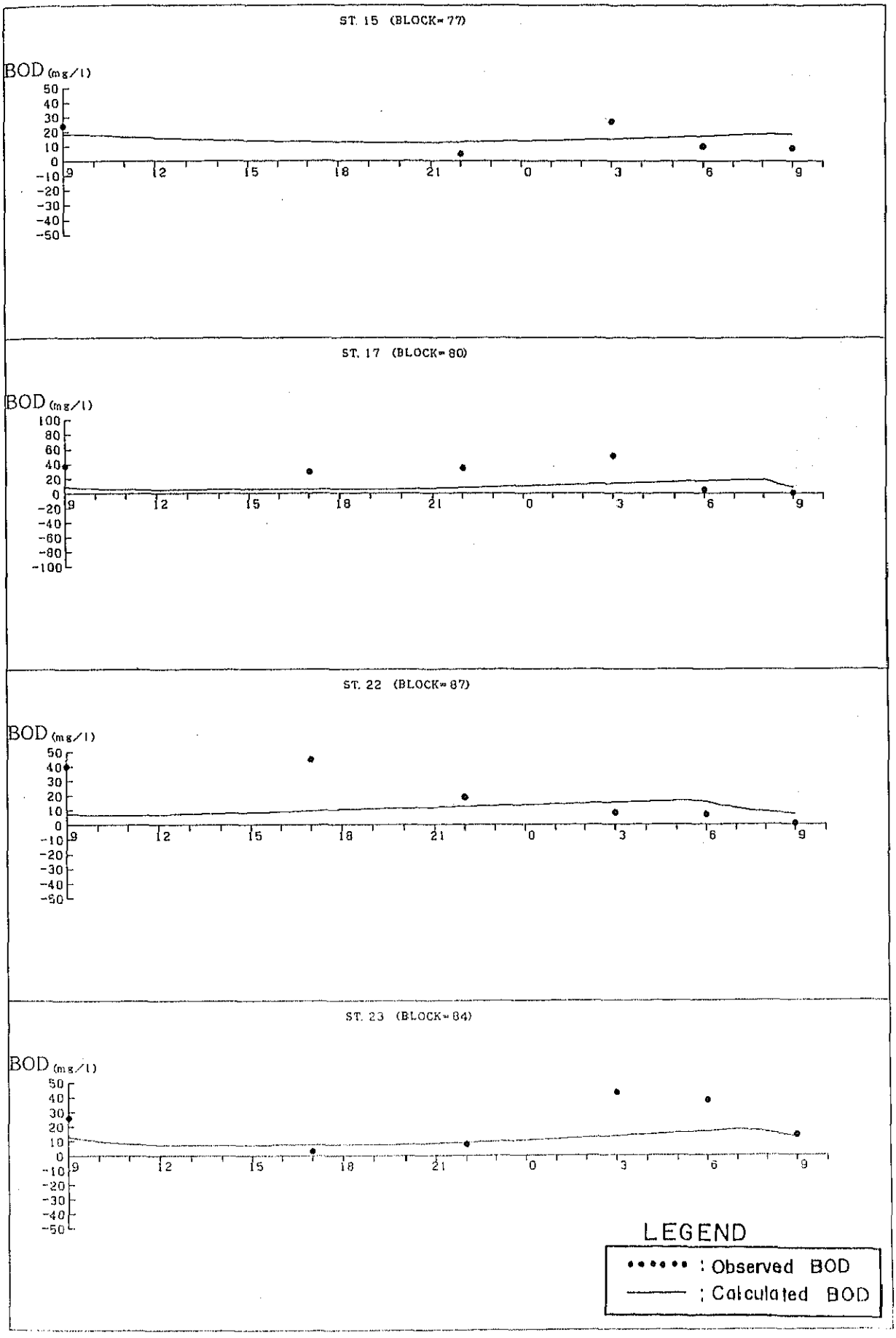

FIG. E.12(3) OBSERVED AND CALCULATED WATER QUALITY (BOD) IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

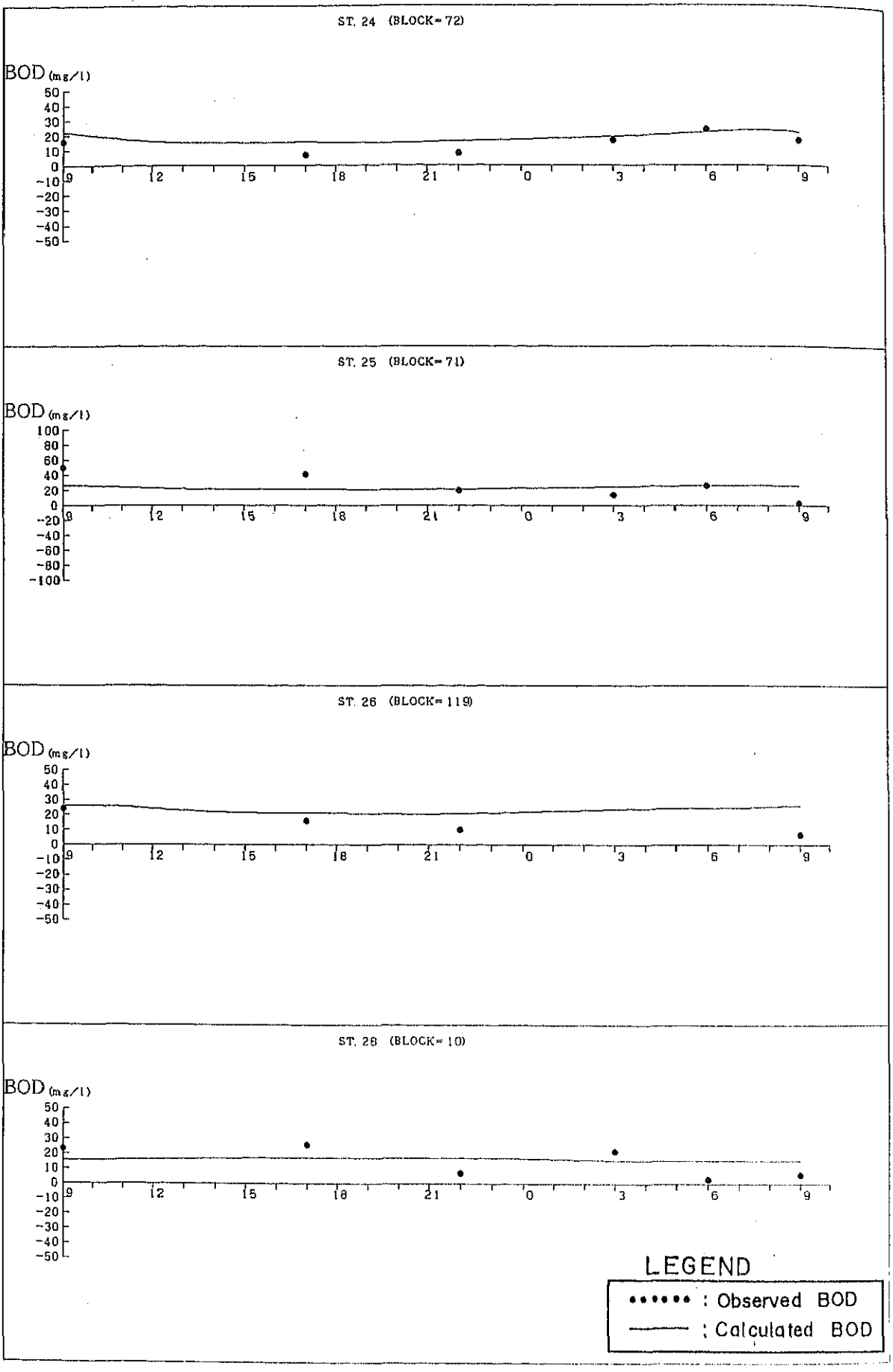

FIG. E.12 (4) OBSERVED AND CALCULATED WATER QUALITY (BOD) IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

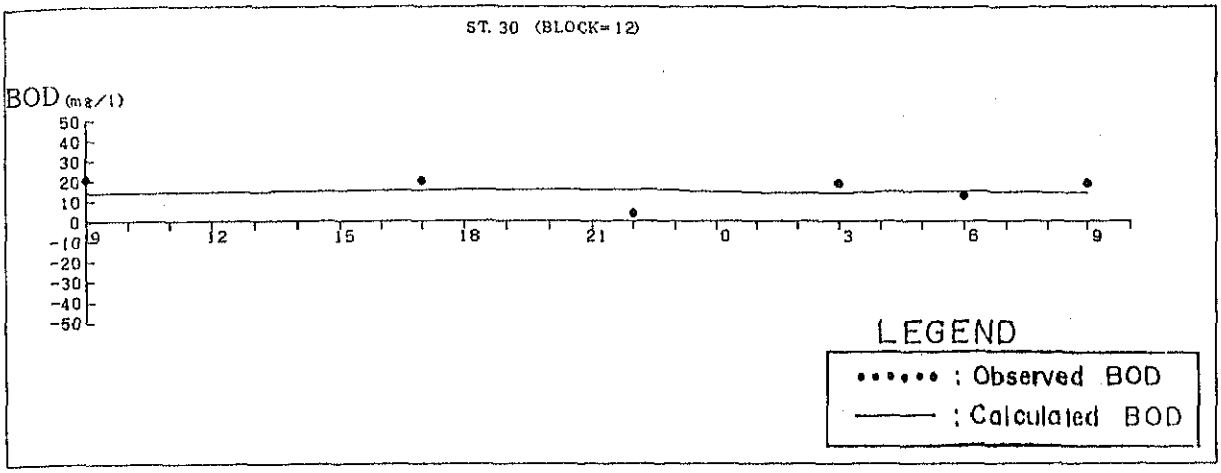

FIG. E.12 (5) OBSERVED AND CALCULATED WATER QUALITY (BOD) IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

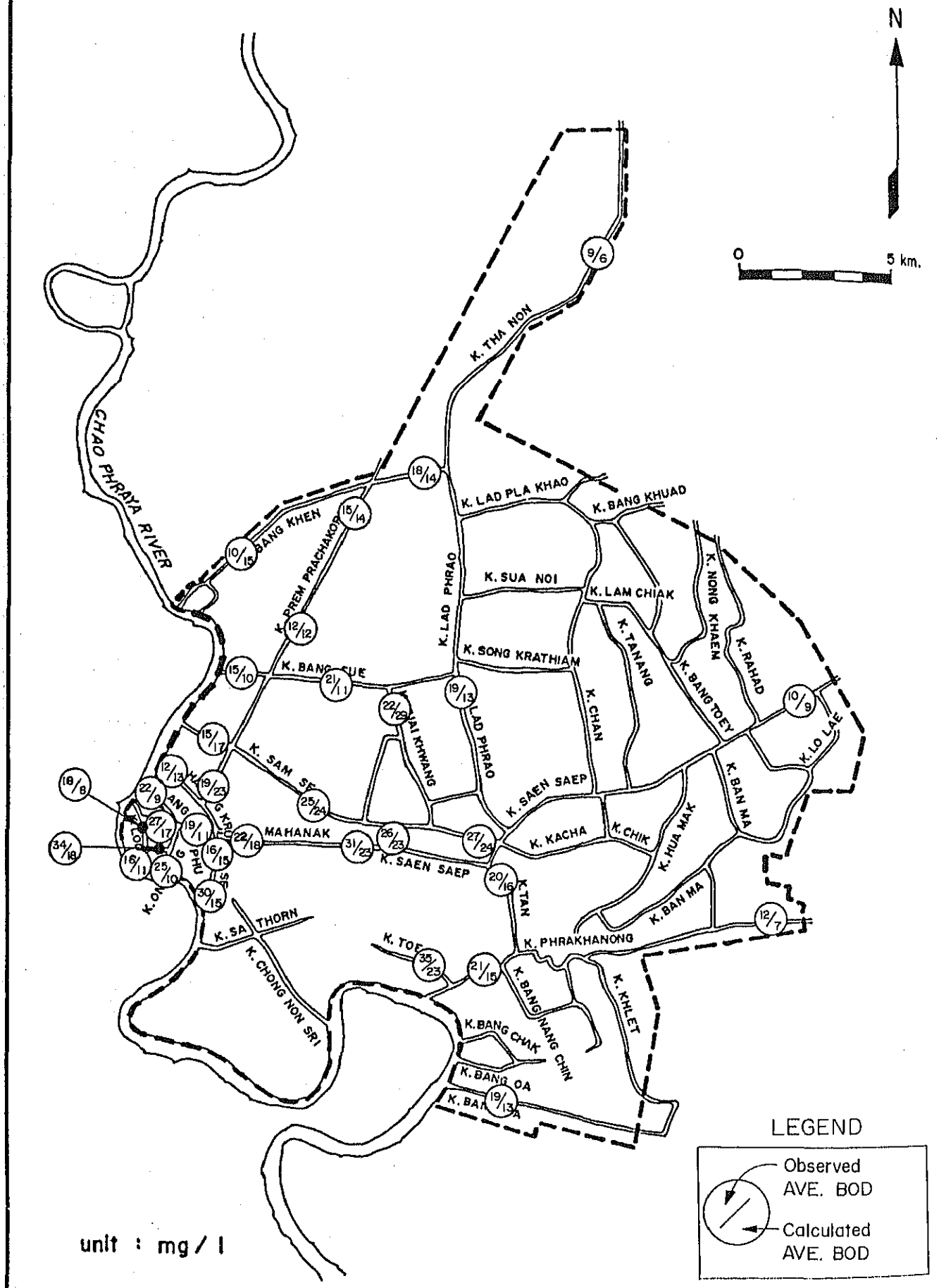

FIG. E. 13 OBSERVED AVERAGE BOD AND CALCULATED AVERAGE BOD IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

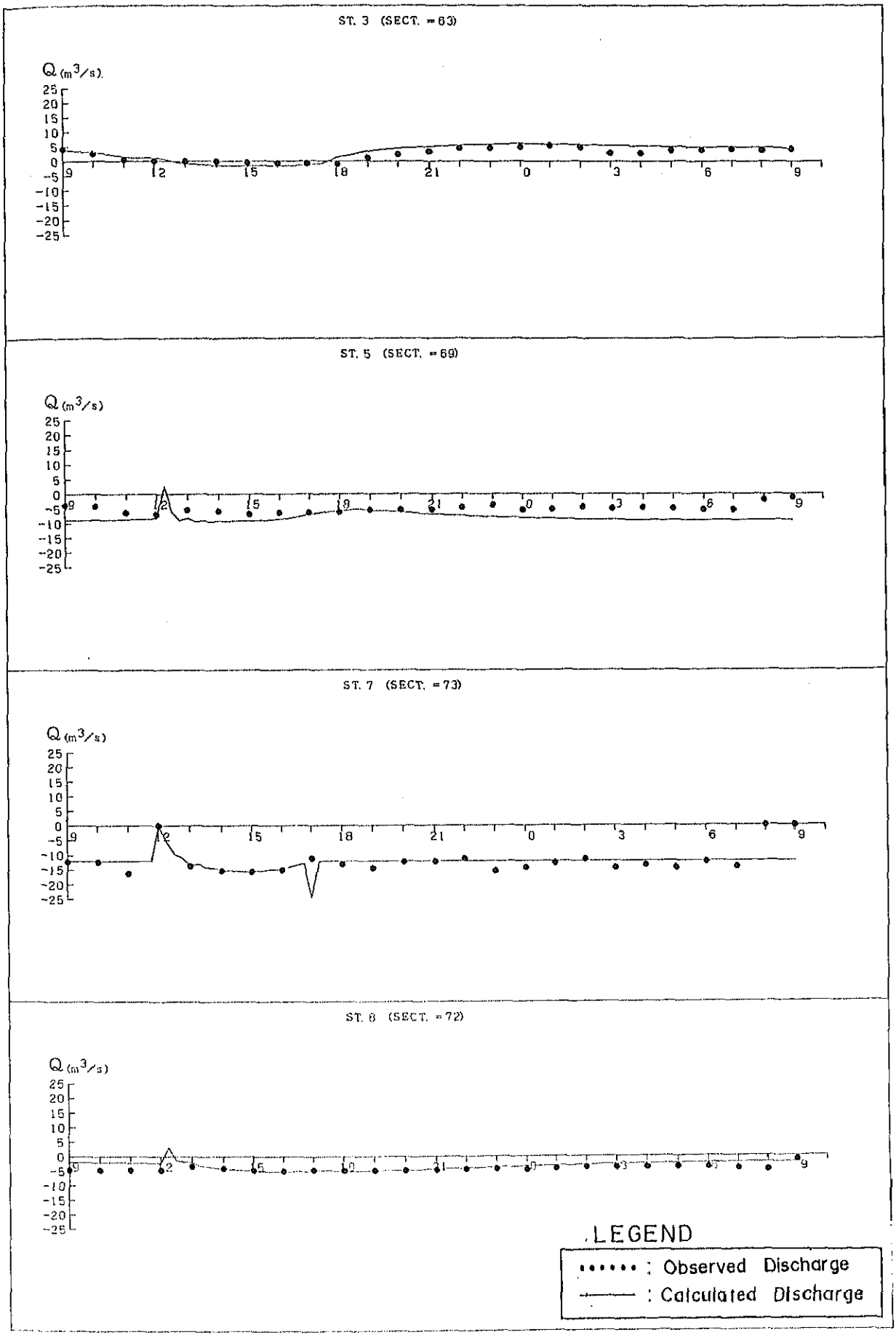

FIG. E.14 (1) OBSERVED AND CALCULATED DISCHARGES IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

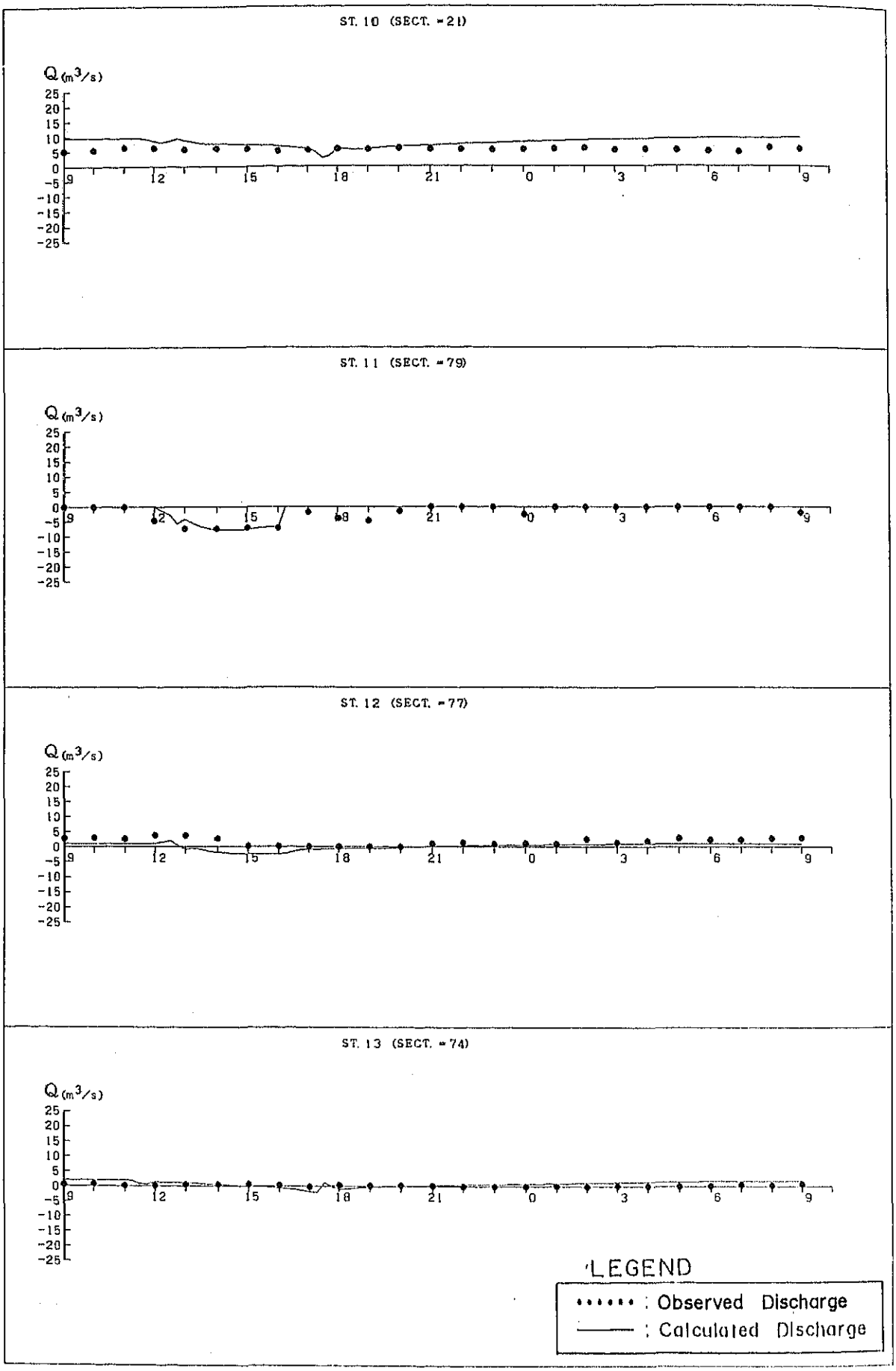

FIG. E.14(2) OBSERVED AND CALCULATED DISCHARGES IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

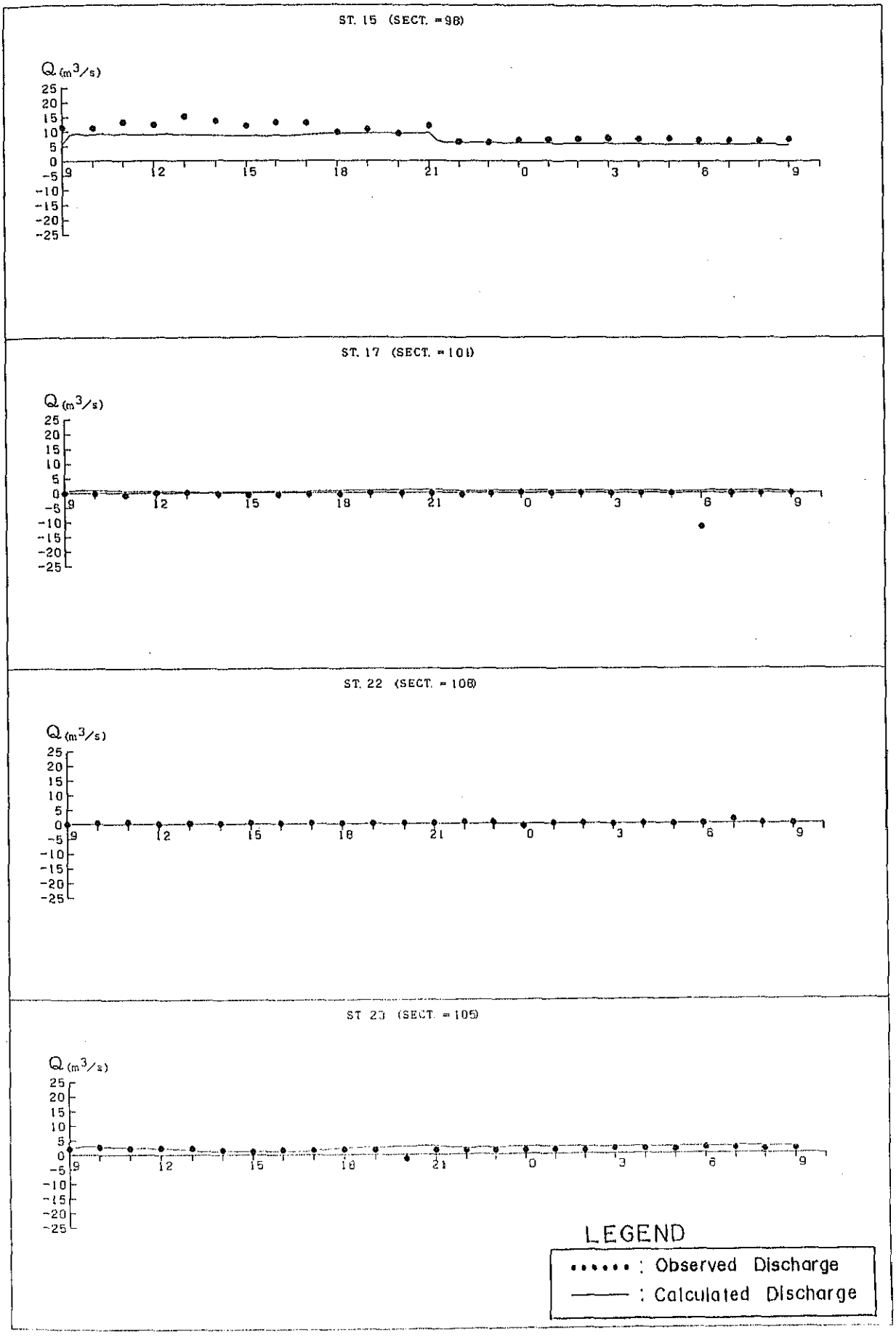

FIG. E.14(3) OBSERVED AND CALCULATED DISCHARGES IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

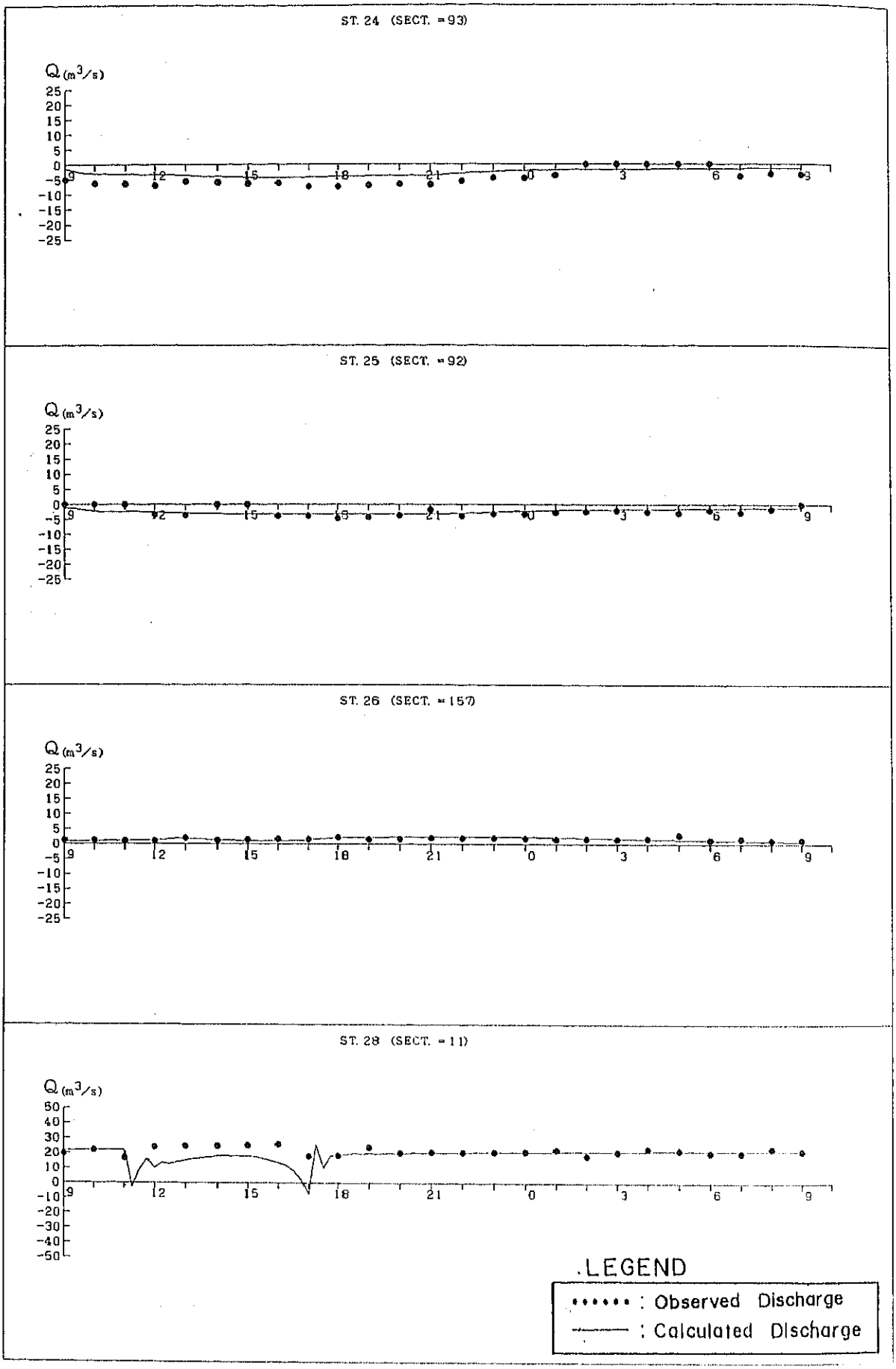

FIG. E.14(4) OBSERVED AND CALCULATED DISCHARGES IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

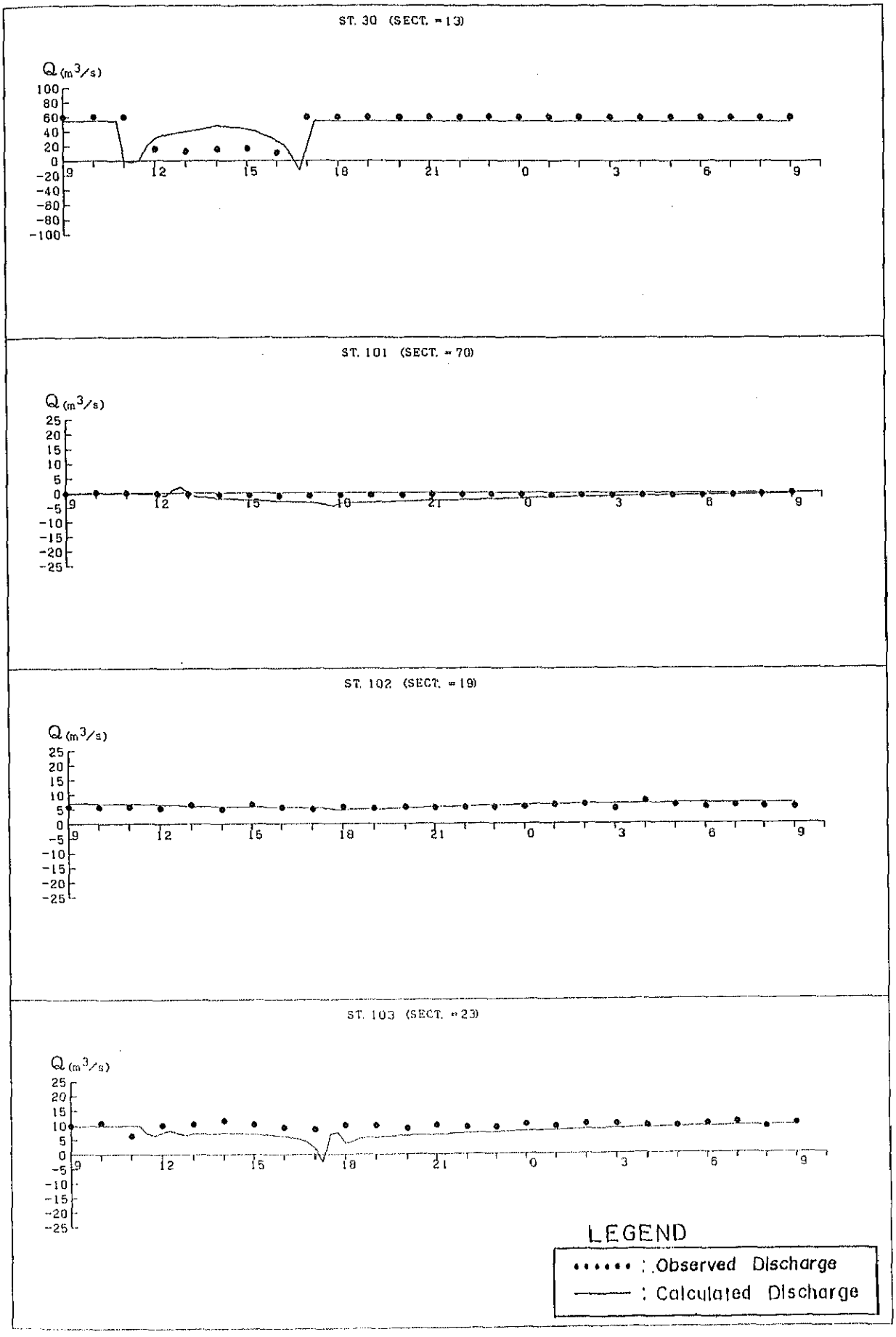

FIG. E.14(5) OBSERVED AND CALCULATED DISCHARGES IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

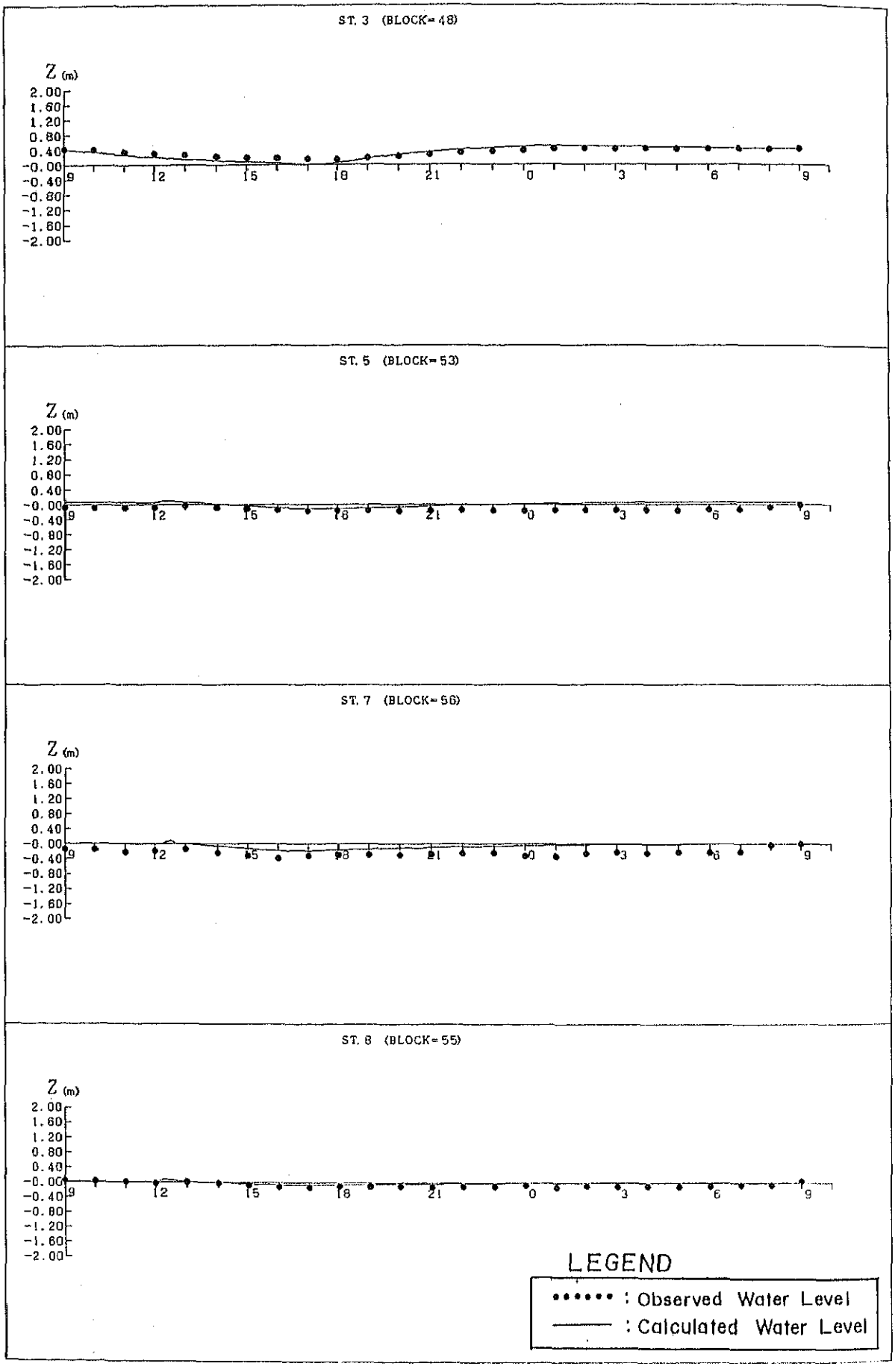

FIG. E.15 (1) OBSERVED AND CALCULATED WATER LEVEL IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

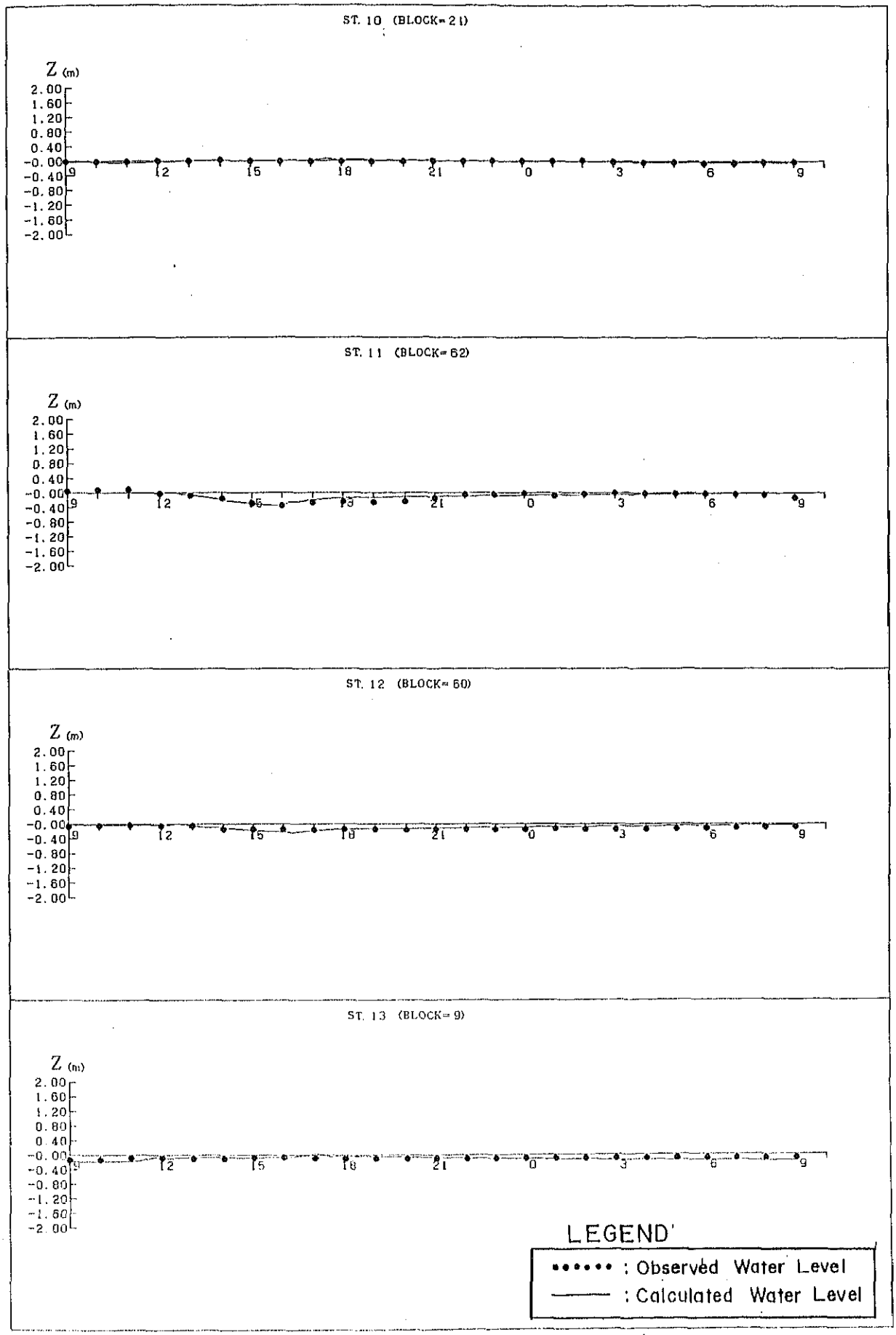

FIG. E.15(2) OBSERVED AND CALCULATED WATER LEVEL IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

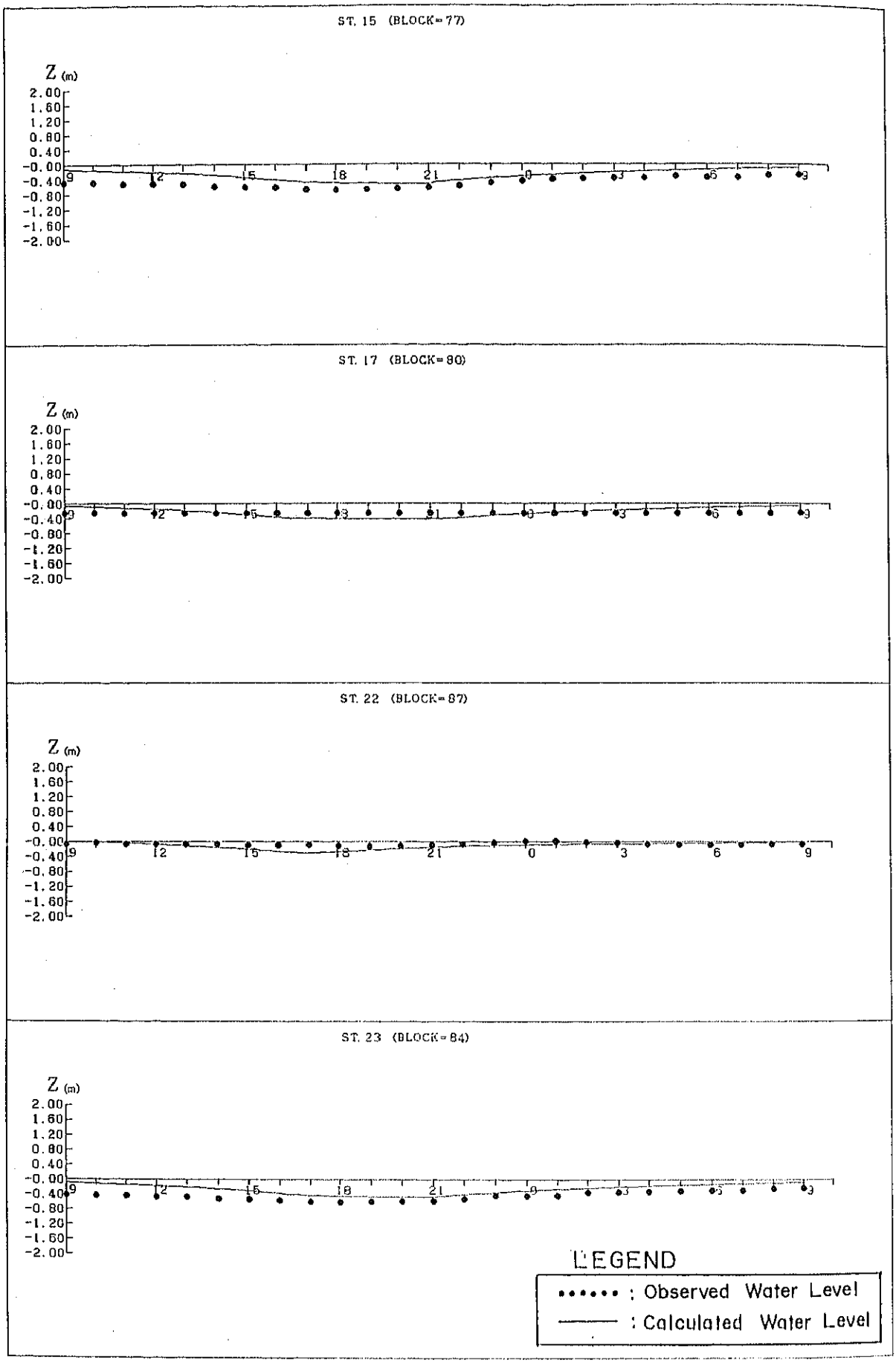

FIG. E. 15 (3) OBSERVED AND CALCULATED. WATER LEVEL IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

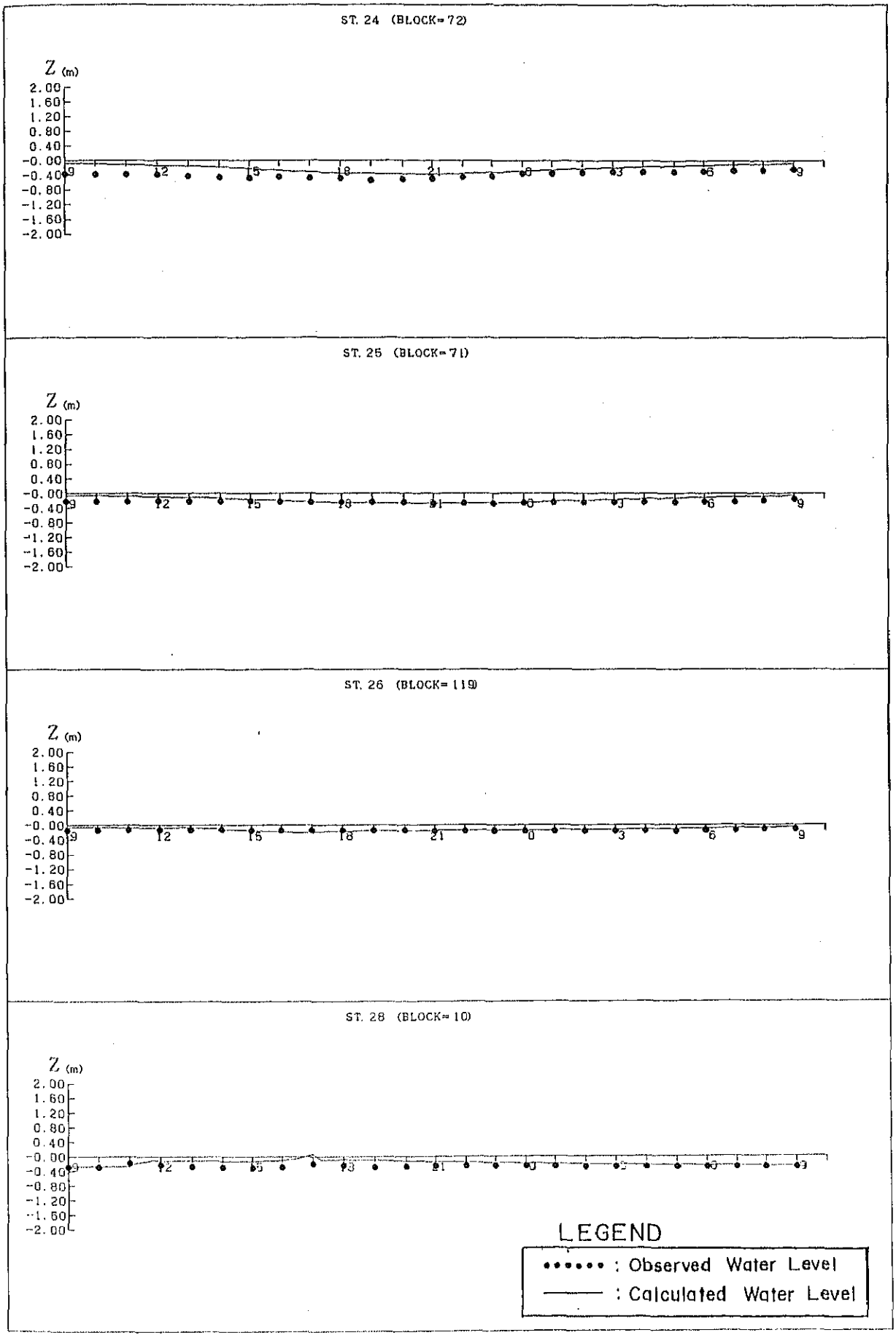

FIG. E.15(4) OBSERVED AND CALCULATED WATER LEVEL IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

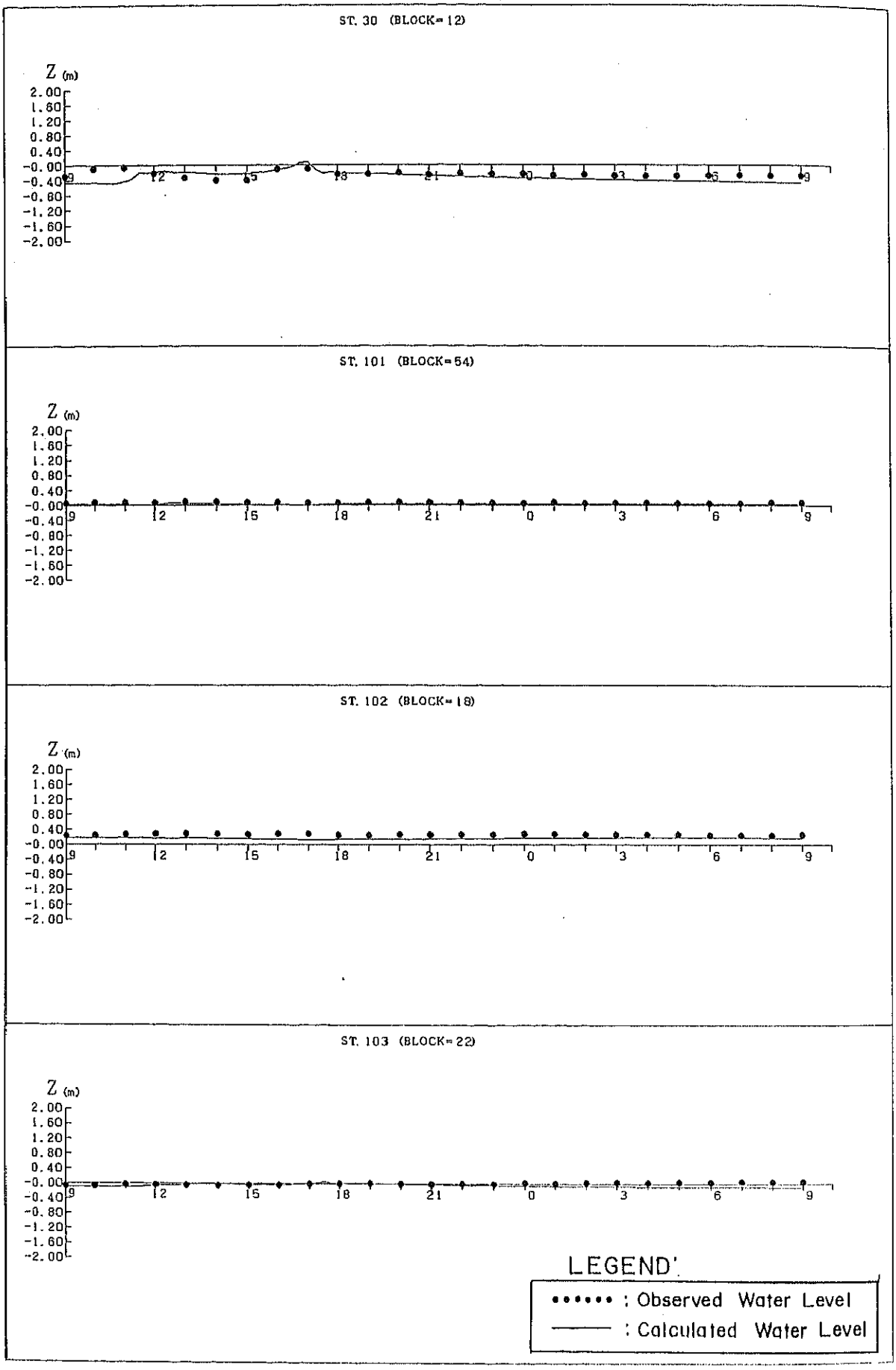

FIG. E.15(5) OBSERVED AND CALCULATED WATER LEVEL IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

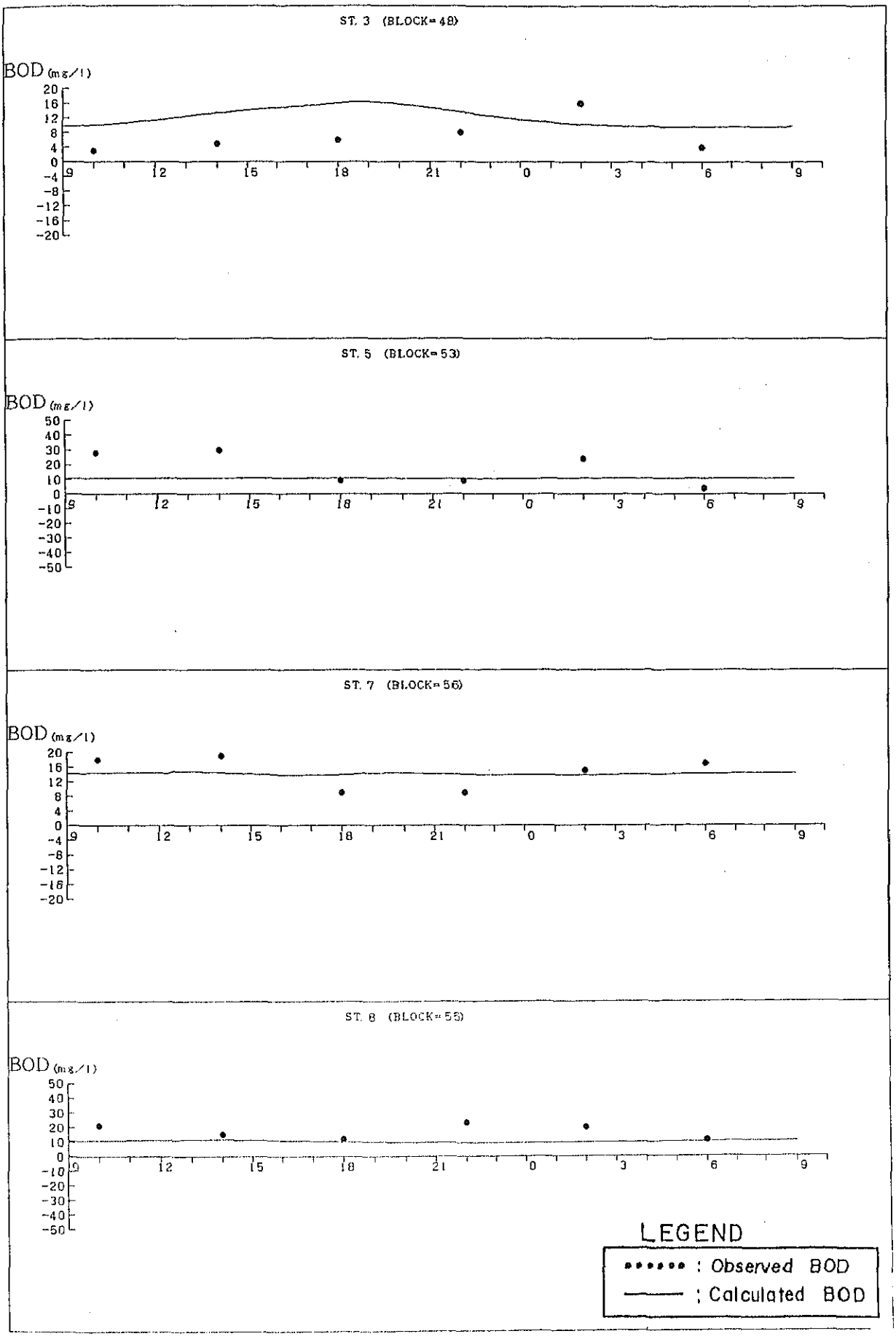

FIG. E.16 (1) OBSERVED AND CALCULATED WATER QUALITY (BOD) IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

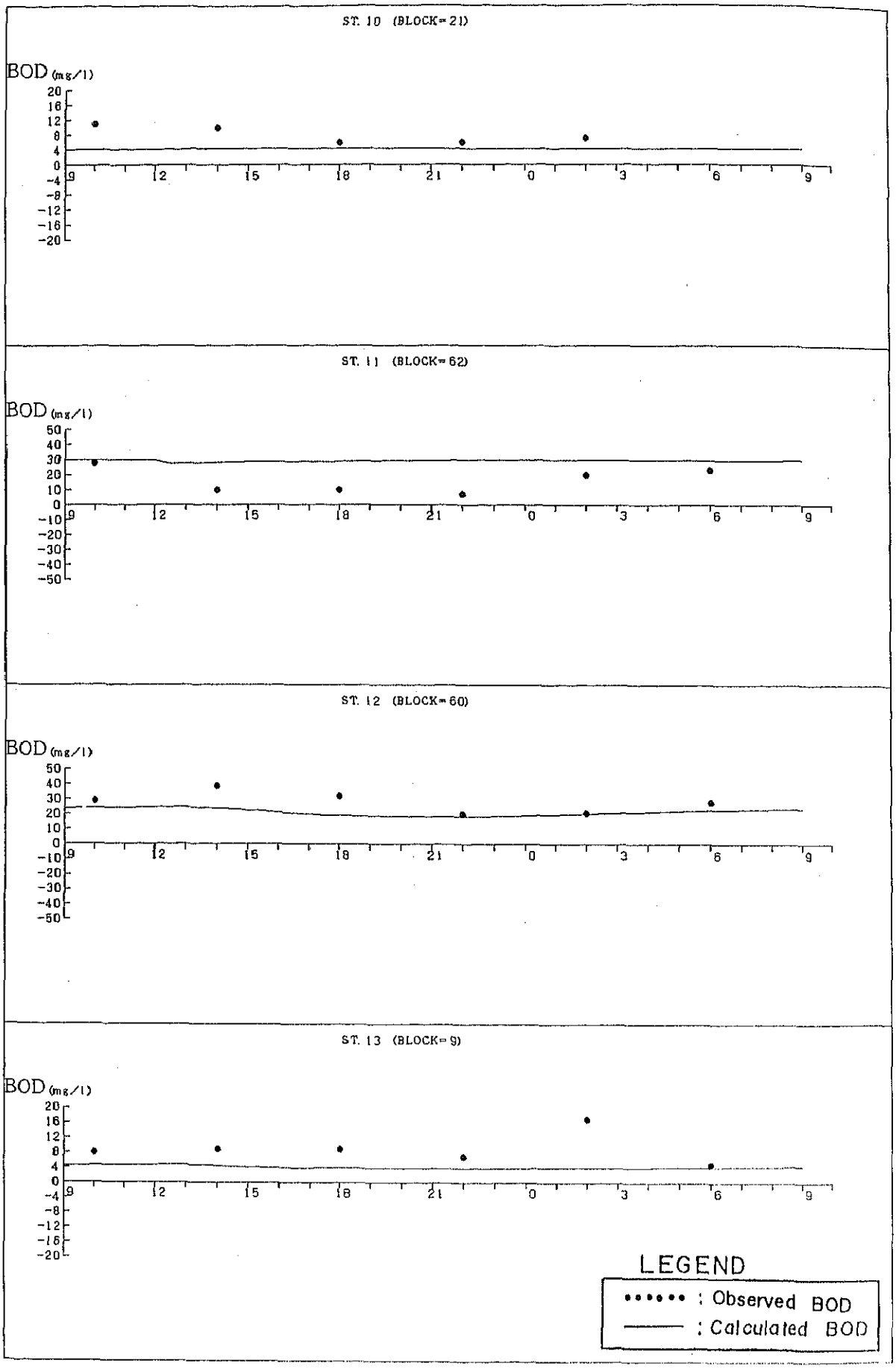

FIG. E.16(2) OBSERVED AND CALCULATED WATER QUALITY (BOD) IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

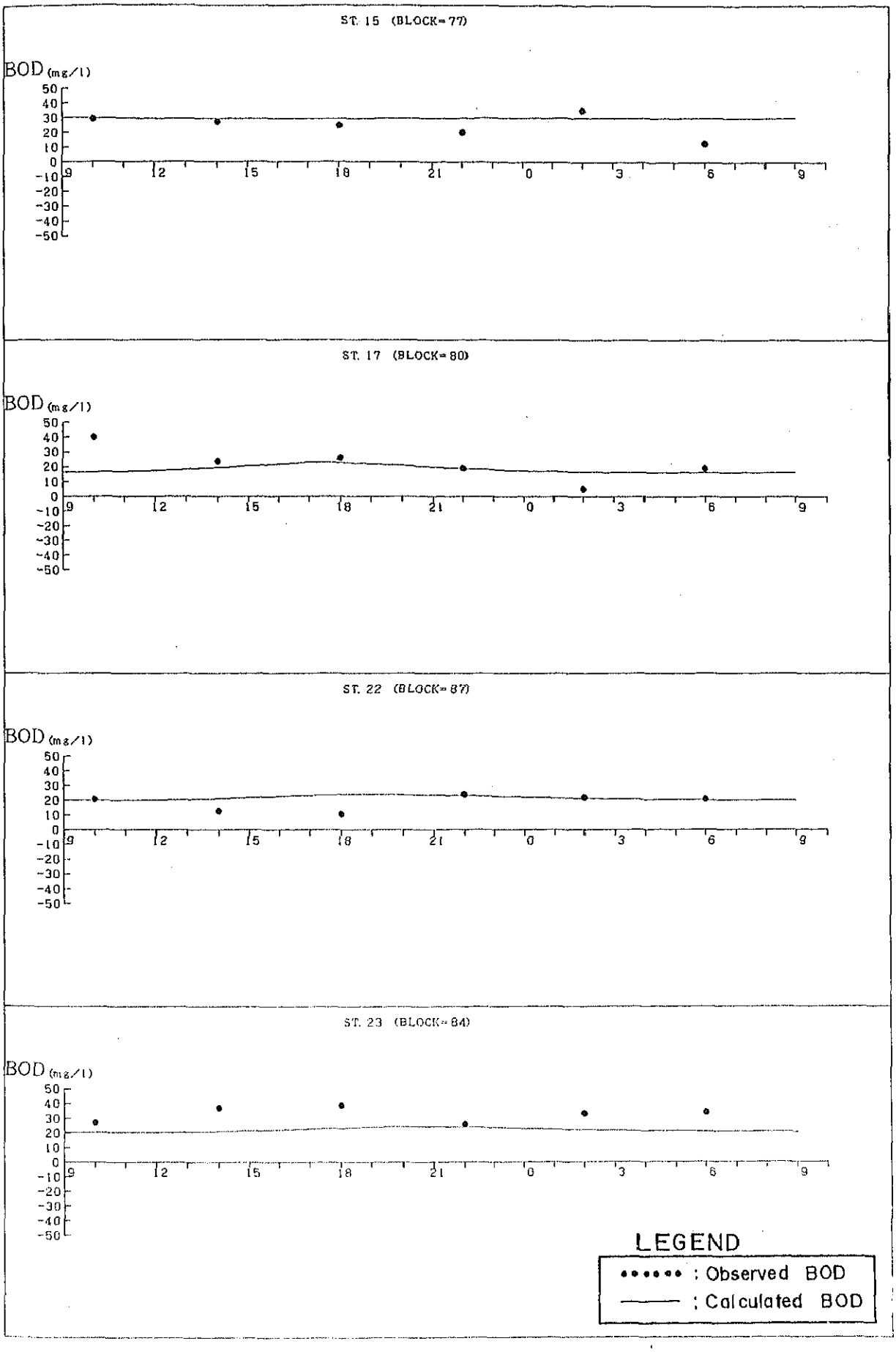

FIG. E.16 (3) OBSERVED AND CALCULATED WATER QUALITY (BOD) IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

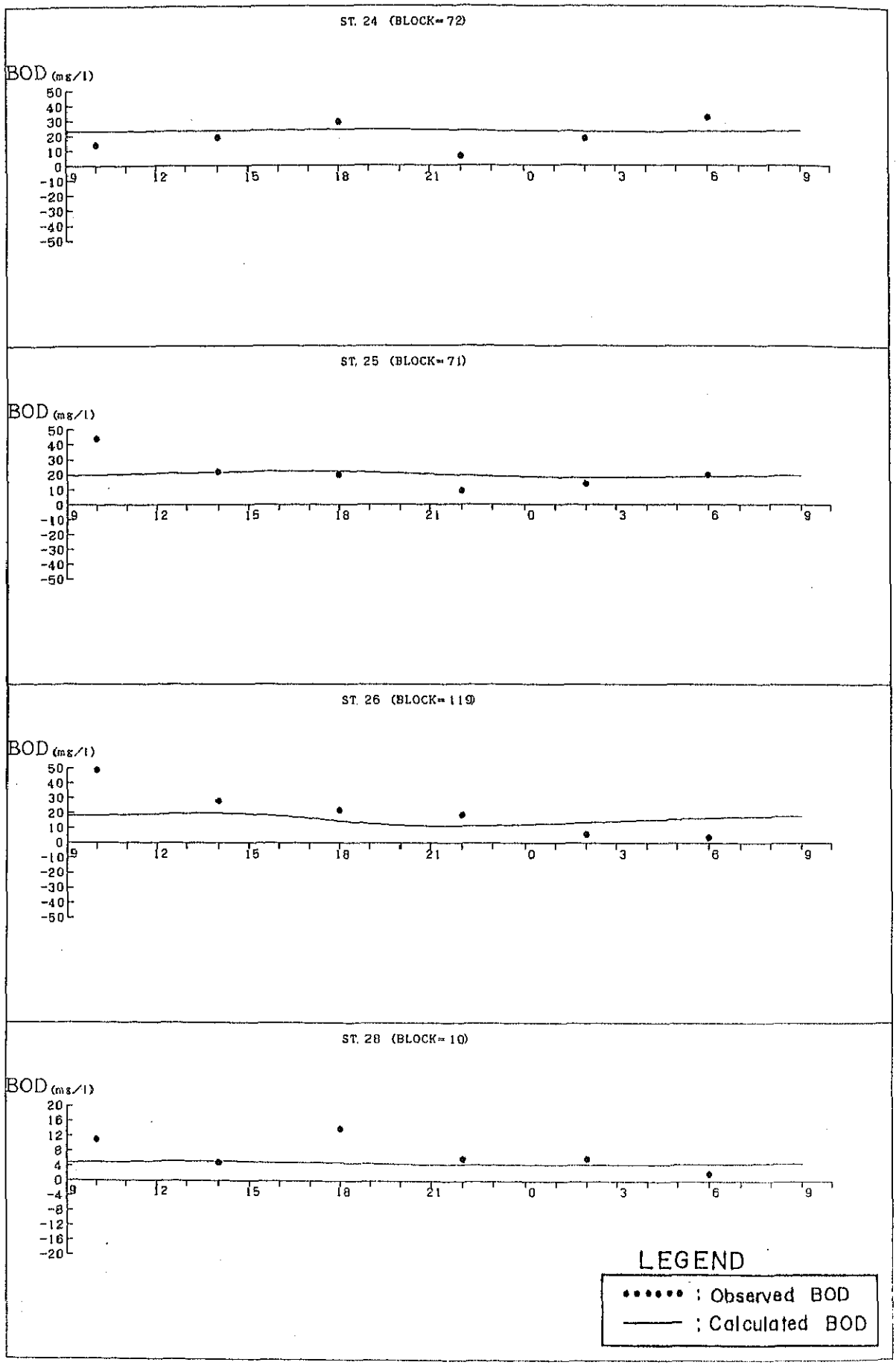

FIG. E .16(4) OBSERVED AND CALCULATED WATER QUALITY (BOD) IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

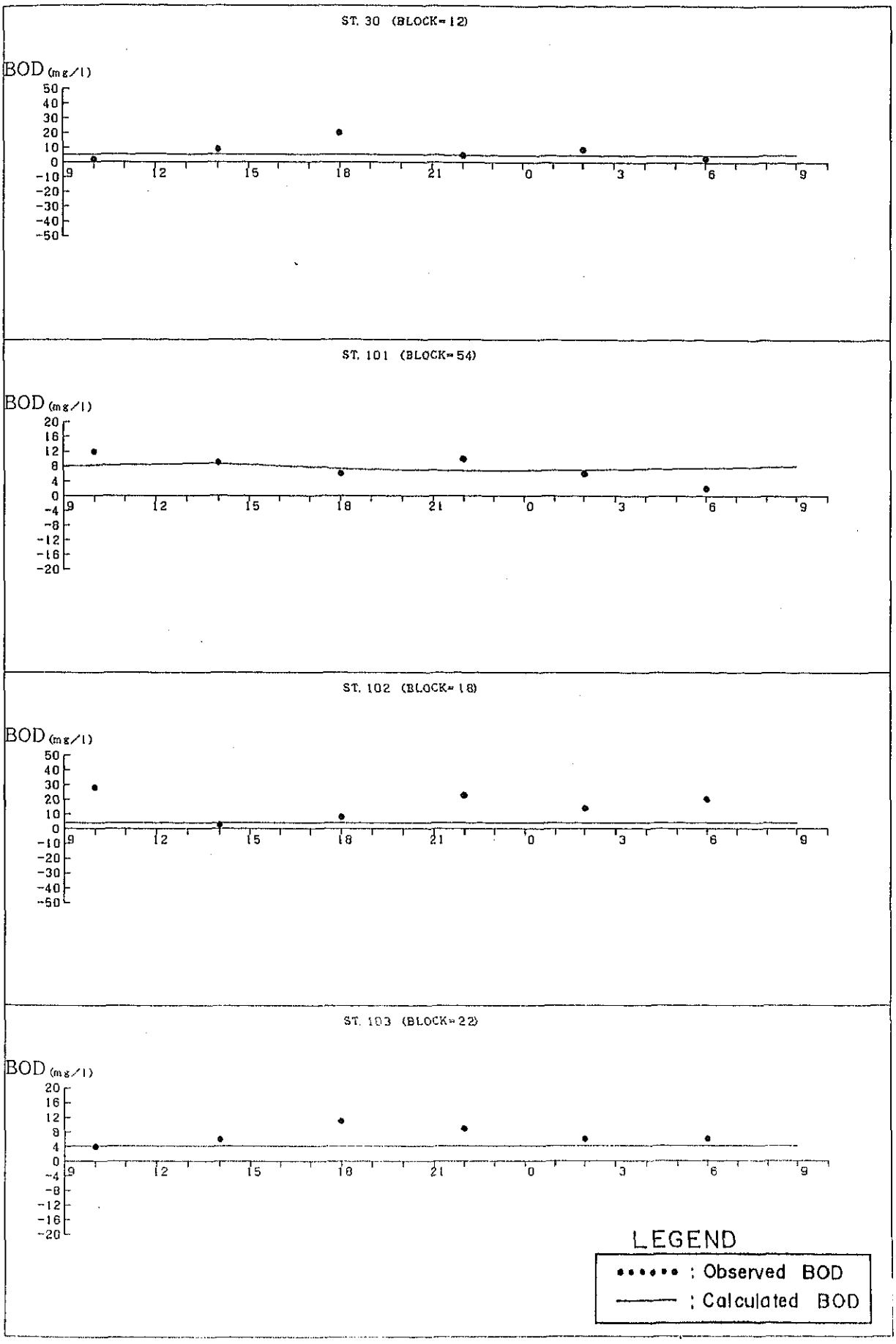

FIG. E.16(5) OBSERVED AND CALCULATED WATER QUALITY (BOD) IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

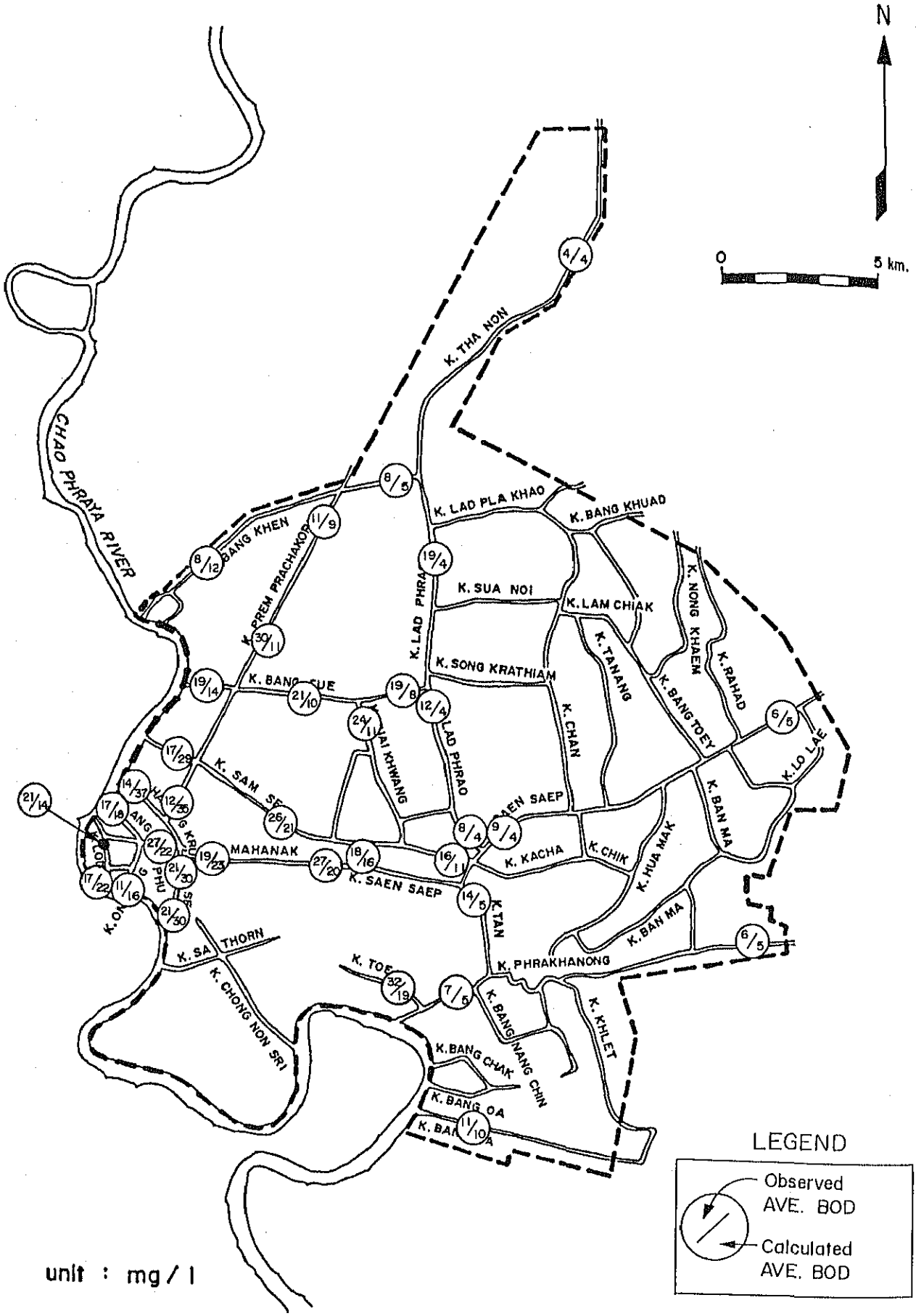

FIG. E. 17 OBSERVED AVERAGE BOD AND CALCULATED AVERAGE BOD IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

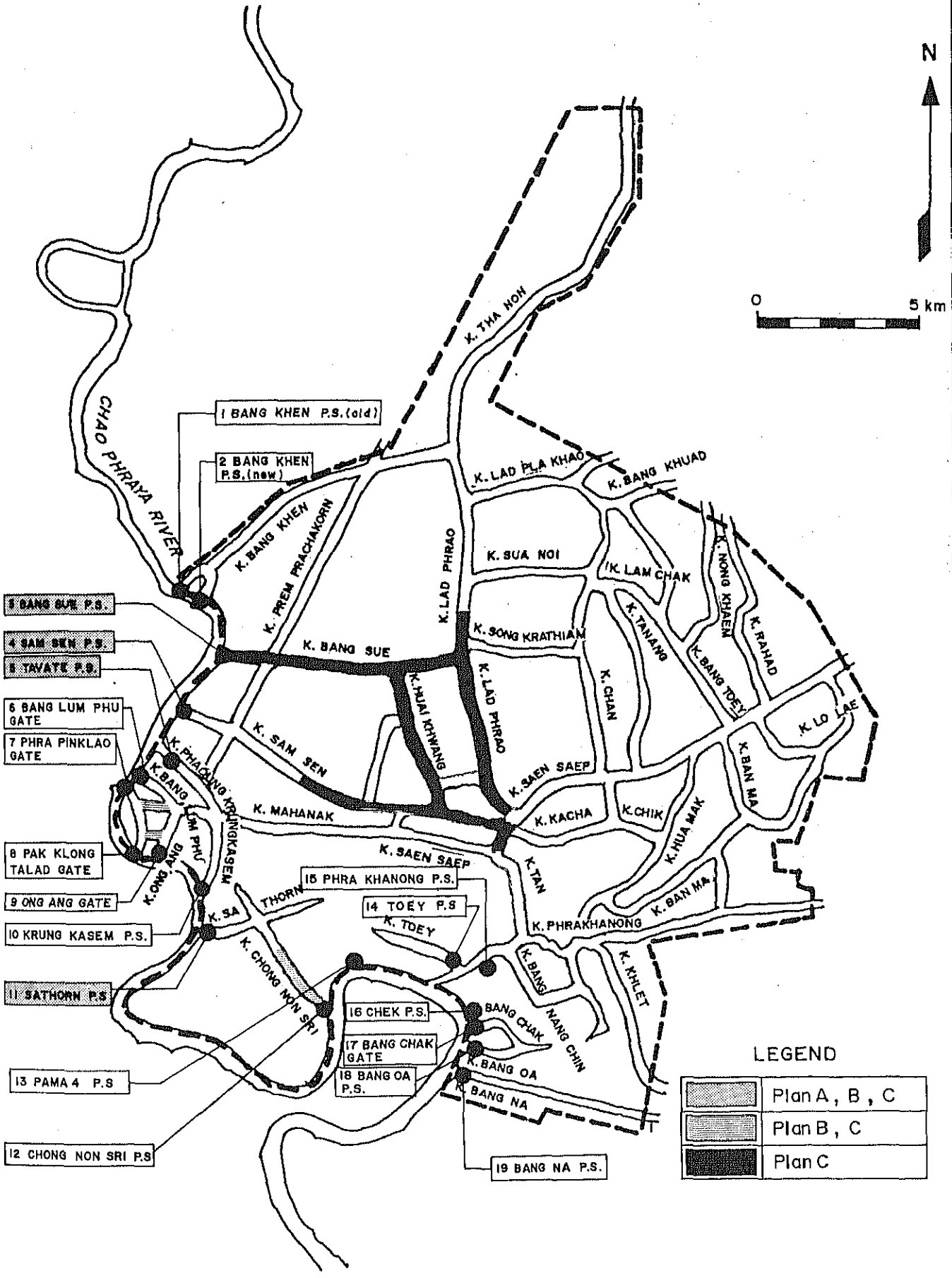

FIG. E.18 LOCATION OF THE PROPOSED FACILITIES

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

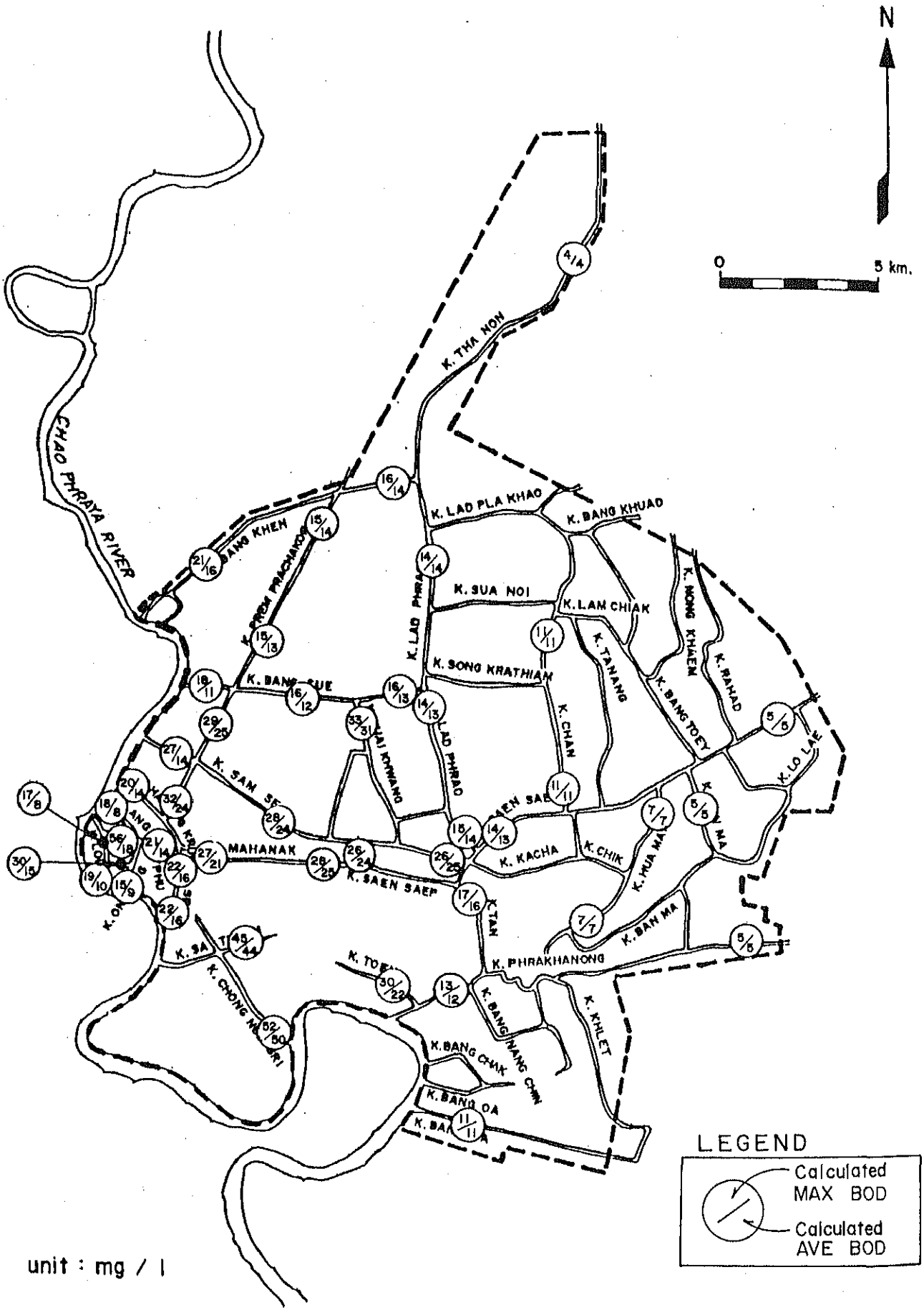

FIG. E.19 SIMULATED BOD DISTRIBUTION IN - DRY SEASON UNDER THE EXISTING CONDITIONS

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

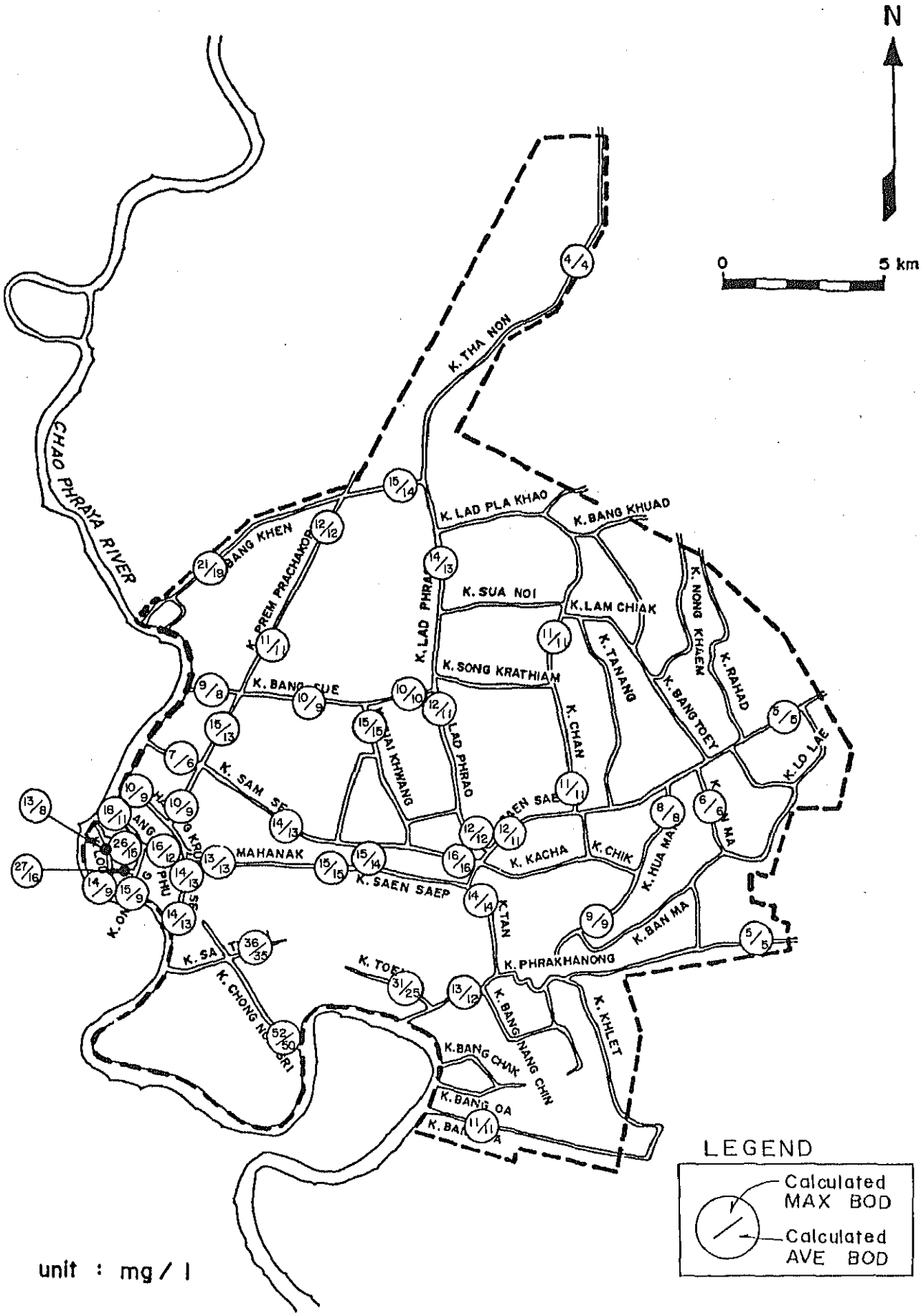

FIG. E. 20 SIMULATED BOD DISTRIBUTION IN DRY SEASON UNDER THE PLAN A

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

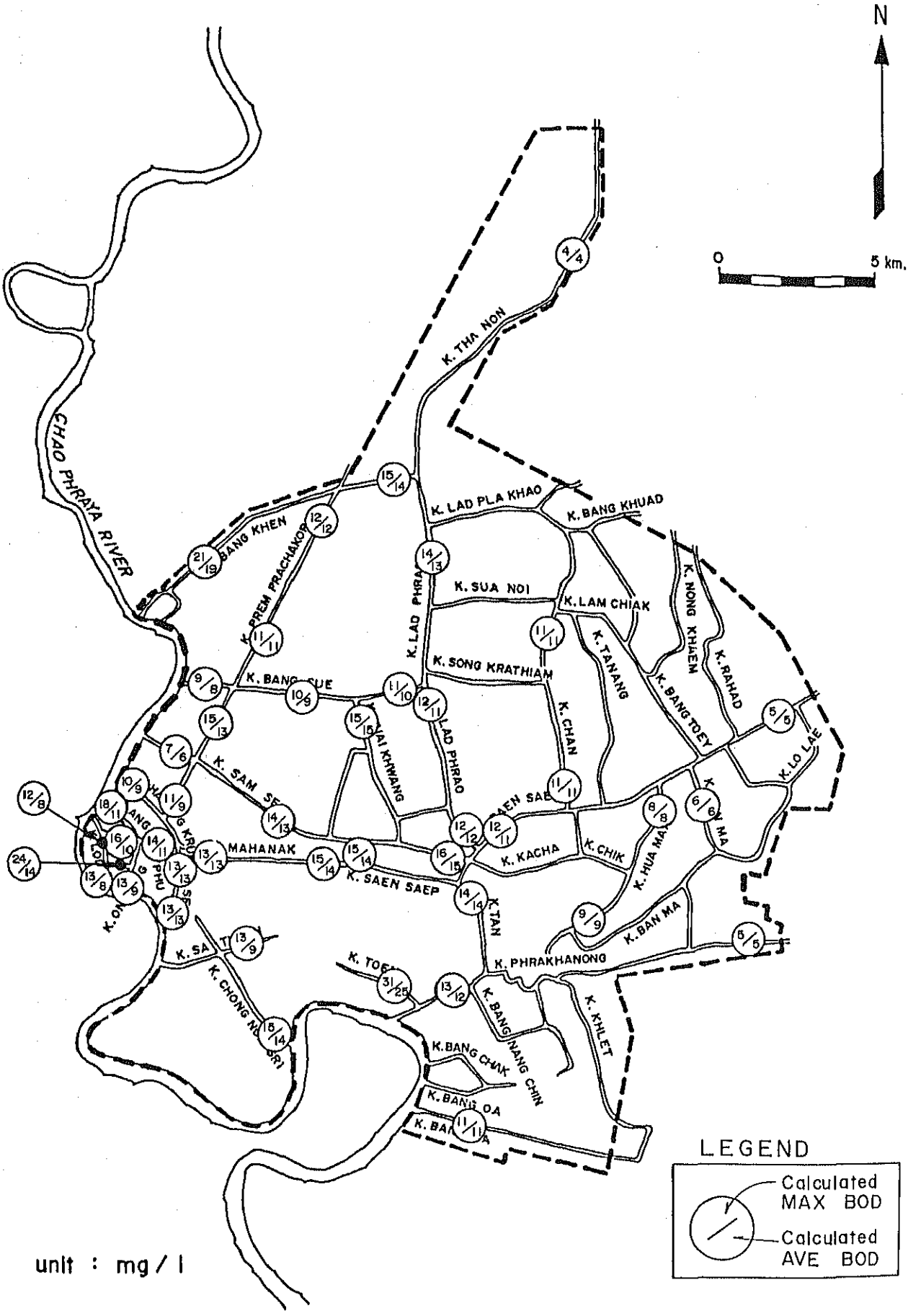

FIG. E.21 SIMULATED BOD DISTRIBUTION IN DRY SEASON UNDER THE PLAN B

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

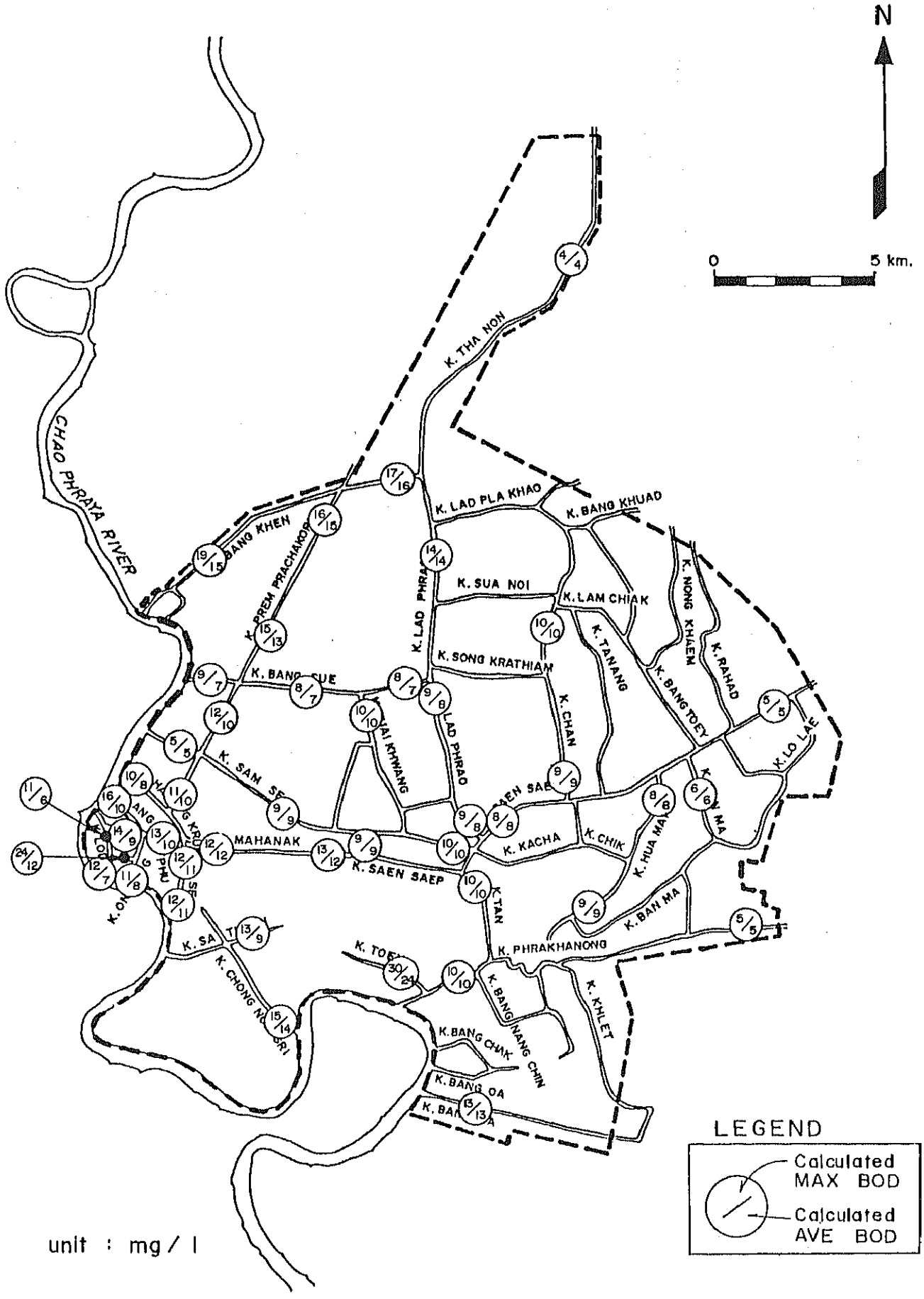

FIG. E. 22 SIMULATED BOD DISTRIBUTION IN DRY SEASON UNDER THE PLAN C

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

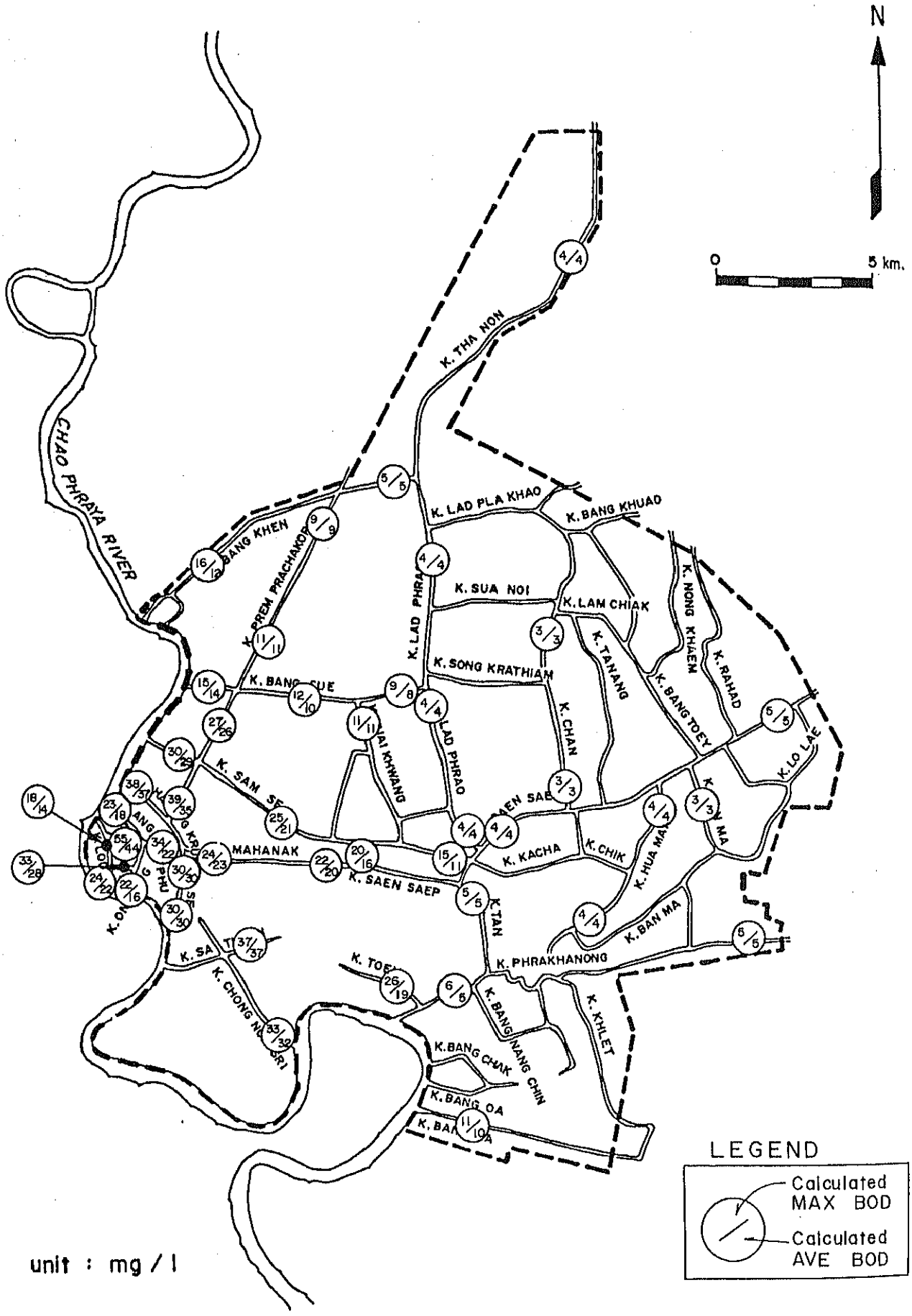

FIG. E. 23 SIMULATED BOD DISTRIBUTION IN RAINY SEASON UNDER THE EXISTING CONDITIONS

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

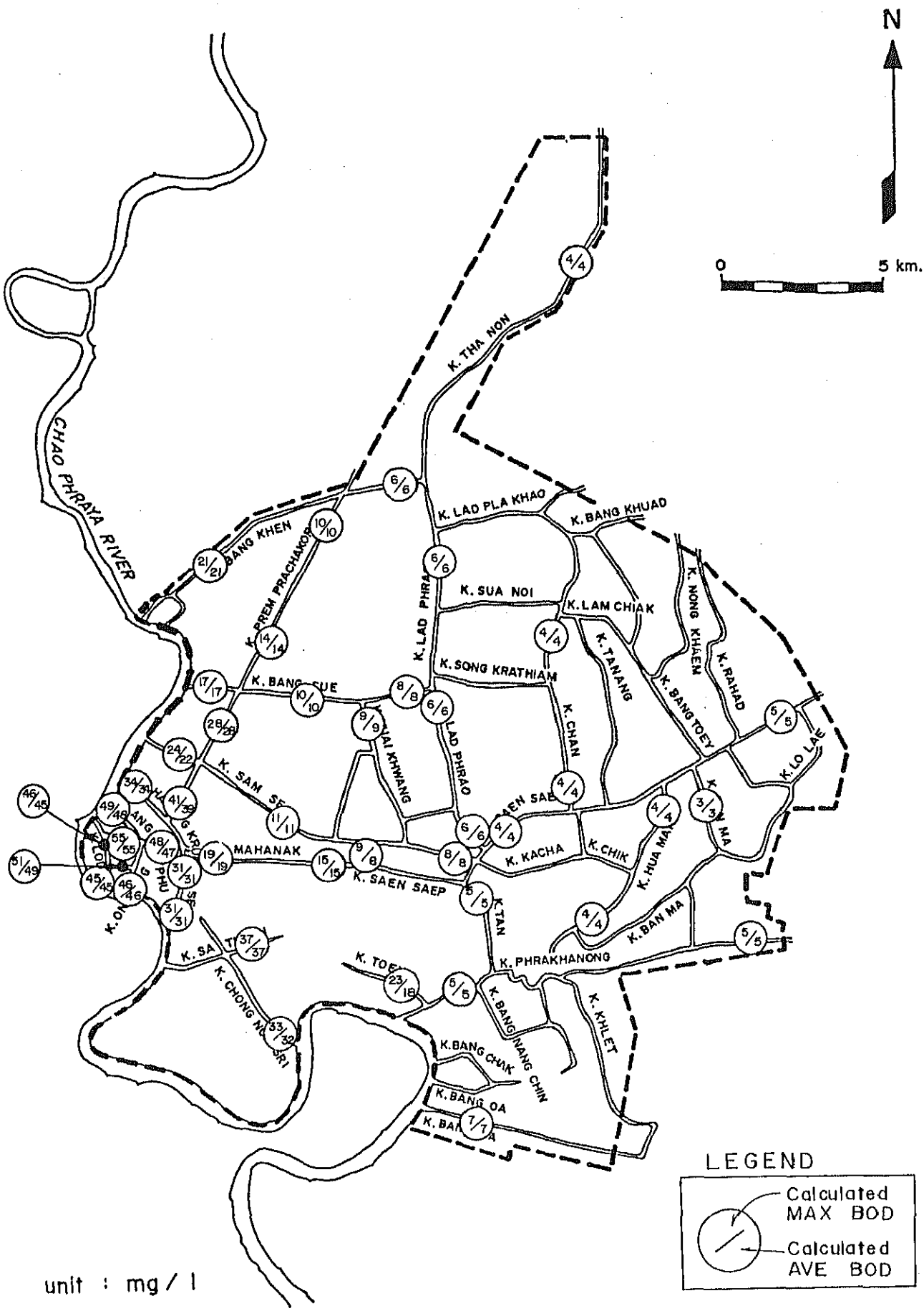

FIG. E.24 SIMULATED BOD DISTRIBUTION IN RAINY SEASON UNDER THE PLAN A

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

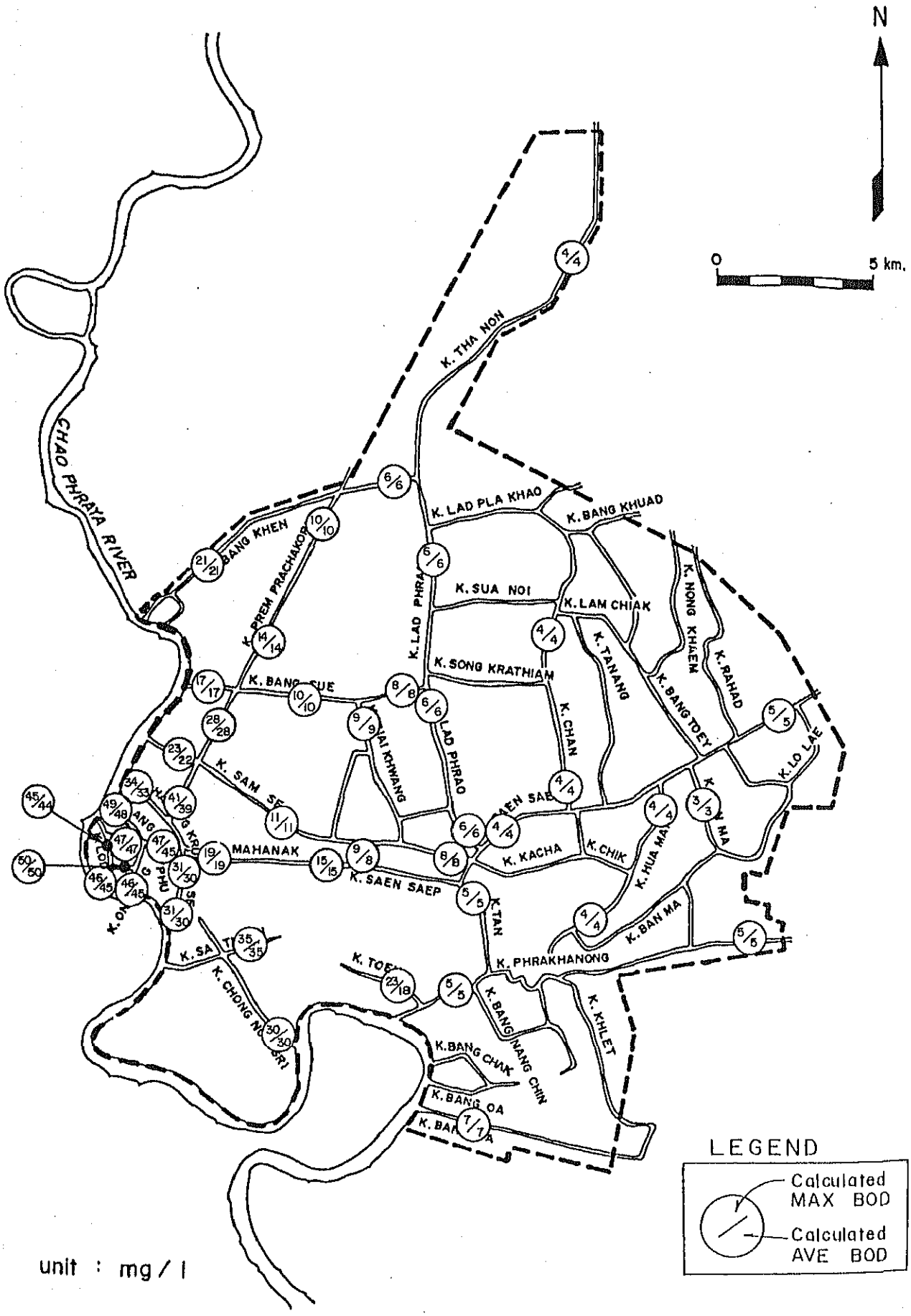

FIG. E.25 SIMULATED BOD DISTRIBUTION IN RAINY SEASON UNDER THE PLAN B

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

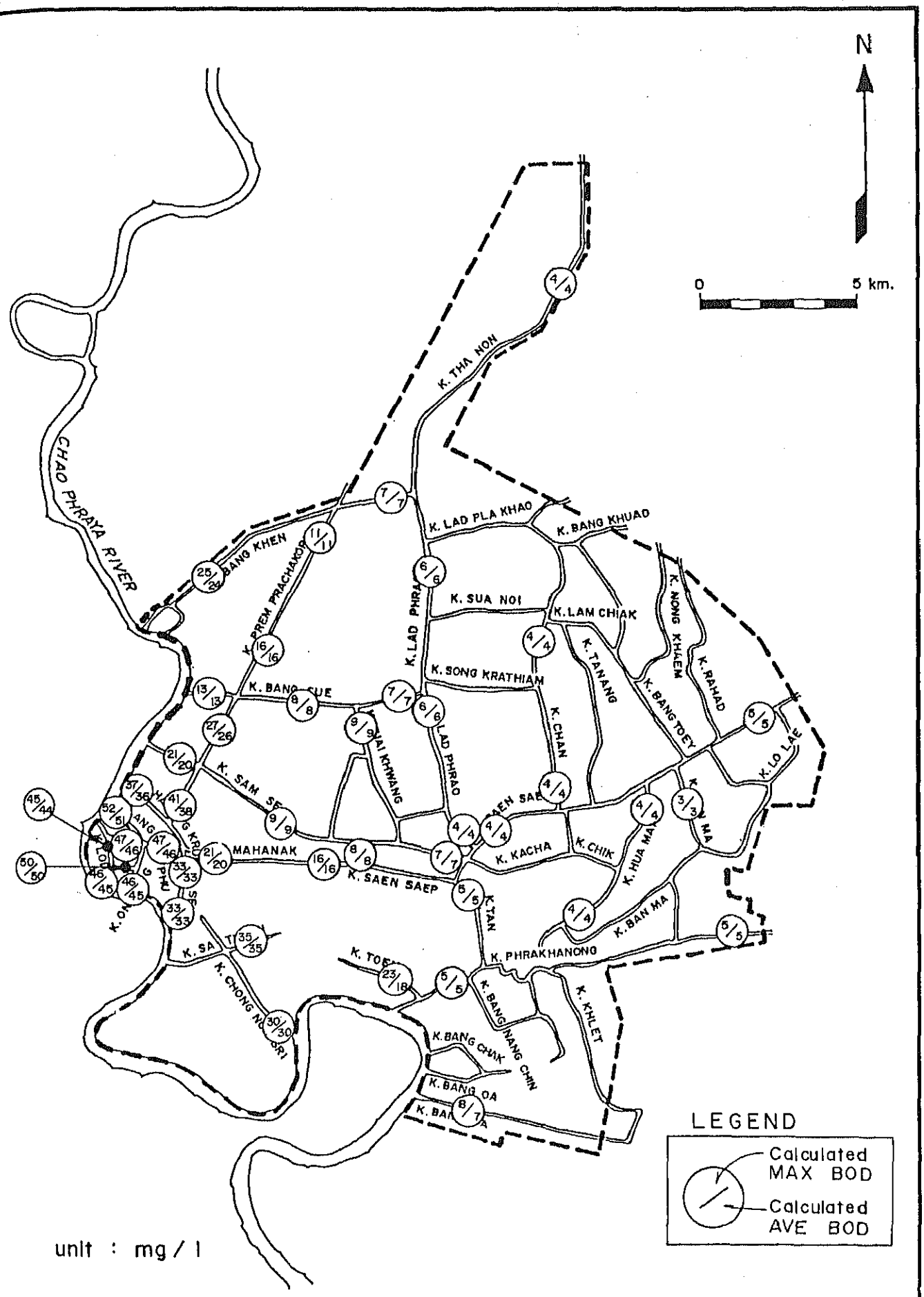

FIG. E.26 SIMULATED BOD DISTRIBUTION IN RAINY SEASON UNDER THE PLAN C

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

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APPENDIX F.

CONSTRUCTION PLAN AND COST ESTIMATE

APPENDIX F. CONSTRUCTION PLAN AND COST ESTIMATE

1. Proposed Construction Plan

1.1 Reconstruction of Existing Pump Station

Four (4) existing pump stations are reconstructed into reversible type to introduce the dilution water from the Chao Phraya River at the low tide. The proposed pump stations for reconstruction are Bang Sue, Sam Sen, Tavate and Sathorn.

(1) Bang Sue Pump Station

The existing pump station consists of:

- 17 sets of pump with a total discharge capacity of 51 m^3/s (17 set x 3 m^3/s)
- One (1) gate with two (2) spans

It functions only for drainage.

The proposed plan employs four (4) sets of pump among the existing 17 pumps for introduction of the dilution water. To introduce the dilution water from the Chao Phraya River, three (3) additional gates shall be constructed. No pump device is incorporated. The main features of the proposed gates are as follows.

		(H) x (W)	
- Gate I :	roller gate,	6.5 m x 6.0 m	(Type A)
- Gate II :	roller gate,	6.5 m x 3.0 m	(Type B)
- Gate III :	roller gate,	6.5 m x 6.0 m x 2 span	(Type C)

The proposed reconstruction plan is shown in Fig. F.1. Details of the proposed gate structures (Type A, B and C) are shown in Fig. F.2 and Fig. F.3.

Drainage of the inner water and introduction of the dilution water is performed by the following operation (Refer to Fig. F.1).

1) Drainage of the Inner Water
   - Existing pumps : Operated, the maximum 17 pumps
   - Existing gate : Closed
   - Proposed gates of I and III : Open
   - Proposed gate of II : Closed

2) Introduction of the Dilution Water
   - Existing pumps : Operated, the maximum 4 pumps
   - Existing gate : Open
   - Proposed gates of I and III : Closed
   - Proposed gates of II : Open

The flow directions of drainage and dilution water are shown in Fig. F.4.

(2) Sam Sen Pump Station

The existing pump station consists of:
- 15 sets of pump with a total discharge capacity of 45 m^3/s (15 set x 3 m^3/s)
- One (1) gate with two (2) spans

It functions only for drainage.

The proposed plan uses four (4) sets of pump for introduction of the dilution water among the existing 15 pumps. To introduce the dilution water from the Chao Phraya River, three (3) additional gates are installed. No pump device is incorporated. The main features of the proposed gates are as follows.

		(H) x (W)	
- Gate I :	roller gate,	6.0 m x 6.0 m	(Type A)
- Gate II :	roller gate,	6.0 m x 3.0 m	(Type B)
- Gate III :	roller gate,	6.0 m x 6.0 m	(Type A)

The proposed reconstruction plan is shown in Fig. F.5. Details of the proposed gate structures (Type A, and B) are shown in Fig. F.2.

Drainage of the inner water and introduction of the dilution water is performed in the same manner as San Sen. The flow directions of drainage and dilution water are shown in Fig. F.4.

(3) Tavate Pump Station

The existing pump station consists of:

- Five (5) sets of pump with a total discharge capacity of 5 m^3/s (5 set x 1 m^3/s)
- Two (2) gates with a multi-use of drainage and navigation

It functions only for drainage.

Installation of additional two (2) sets of pump is proposed for the introduction of dilution water from the Chao Phraya River. The main features of the proposed pump facilities are as follows.

- Discharge capacity : 6 m^3/s (2 set x 3 m^3/s)
- Type : submersible motor pump
- Related facilities : discharge pipe, retaining wall

The proposed pump facilities are shown in Fig. F.6. These are exclusively for the introduction of dilution water.

(4) Sathorn Pump Station

The existing pump station consists of:

- Two (2) sets of pump with a total discharge of 6 m^3/s (2 set x 3 m^3/s)
- Two (2) gates with a multi-use of drainage and navigation

It functions only for drainage.

Construction of additional two (2) sets of pump is proposed for the introduction of dilution water from the Chao Phraya River. The main features of the proposed pump facilities are as follows.

- Discharge capacity : 6 m^3/s (2 set x 3 m^3/s)
- Type : submersible motor pump
- Related facilities : discharge pipe, retaining wall

The proposed pump facilities are shown in Fig. F.7. These are exclusively for the introduction of dilution water.

1.2 Dredging of Klong

Three (3) shallow klongs: Wat Tep Tida, Wat Rajabopit and Chong Non Sri are to be dredged to carry the required dilution water. The proposed dredging works are as follows.

	Length (m)	Width (m)	Volume (m^3)	Bed EL. (M.S.L., m)
K. Wat Tep Tida	745	7.0	4,000	-1.5
K. Wat Rajabopit	1,122	6.8	8,000	-1.5
K. Chong Non Sri	3,600	6.0 ~ 10.0	77,000	-1.5 ~ -2.0
Total	5,467		89,000	

1.3 Construction of Aerated Lagoon.

Among the eight (8) potention ponds for the aerated lagoon in the Study Area, the Makkasan Pond and the Rama IX Pond are proposed to be used as Aerated Lagoon for klong water quality improvement.

(1) Makkasan Pond

The area of the Makkasan Pond is about 16 ha and pond depth is less than four (4) meter.
Total storage capacity is approximately 310,000 m^3.

The raw wastewater (klong water) to the aerated lagoon will be introduced from K. Sam Sen (discharge, 3 m^3/sec) and after being treated will be discharged into the same klong by pumping.

The conversion of Makkasan Pond into acrated lagoon mainly consists of the following works :

(i) Installation of inlet gate, outlet pump and outlet gate

(ii) Construction of central partition wall to separate the pond into two (2) longitudinal portions, consisting of an initial aeration zone followed with a final sedimentation zone, while allowing a series flow from inlet to outlet

(iii) No additional pond excavation works in required

The main features of the acrated lagoon is as follows :

- Inlet facility : stop log 5.0 m(H) x 1.5 m(W) x 2 spans
  : bar screen 5.0 m(H) x 1.5 m(W) x 2 spans
- Aerator : Floating type 11 kw 10 units
- Discharge Pump : submersible motor $60m^3/_{min}$ x 3m 3 units pump
- Control Gate : roller gate 5.0 m (H) x 4.0 m (W) (installed in K. Sam Sen)
- Partition Wall : 1600 m (L) x 5 m (H)

The proposed construction plan is shown in Fig. F.8.

(2) Rama IX Pond

The potential pond area at Rama IX Pond is about 20 ha with a storage capacity of 300,000 m^3.

The raw wastewater to the acrated lagoon will be introduced from K. Lad Phrao (discharge, 3 m^3/sec) by pumping and after being treated will be discharged into same Klong by gravity.

The conversion of Rama IX Pond into acrated lagoon mainly consists of the following works:

(i) Pond excavation works of 150,000 m^3.

(ii) Installation of inlet pump, inlet gate and outlet gate

(iii) Construction of partition walls to divide the pond into six (6) number cells while allowing a series flow from inlet to outlet. The initial five (5) cells will be utilized as aeration zones while the final one as sedimentation zone.

The main features of the aerated lagoon is as follows :

- Inlet Facility : submersible motor pump 60 m^3/min x 3 m 3 units
  : roller gate 6.0 m (H) x 3.0 m (W)
  : bar screen 6.0 m (H) x 3.0 m (W)
- Aerator : Floating type 11 kw 10 units
- Discharge Facility : stop log 6.0 m (H) x 1.5 m (W) x 2 spans.

The proposed construction plan is shown in Fig. F.9.

2 Construction Cost Estimate

2.1 Basis of Cost Estimates

(1) The estimates are made on the assumption that all construction works will be contracted to general contractors through local tender.

(2) All base costs are expressed under the economic conditions that prevailed in October, 1988.

(3) Overhead including profit and tax is assumed at 30% of the total cost of equipment and civil works.

(4) Engineering service and administration costs are assumed at 10% of the total direct construction cost.

(5) A physical contingency allowance is established at 10% of the total cost of direct construction cost, engineering service cost and administration cost.

(6) Annual price escalation is considered to be 5%.

2.2 Unit Construction Cost

The unit labor costs are presented in Table F.1. The unit basic construction costs are presented in Table F.2. Based on these data, unit costs of the proposed facilities and klong dredging works are estimated.

2.3 Estimated Project Cost

The total project cost, consisting of direct construction cost, engineering and administration costs, and physical contingency, amounts to Baht 203.0 million at October 1988 prices as given below (B223.0 million including price escalation).

Cost Item		Amount (10^3 B)
A.	Direct Const. Cost	167,790
	(1) Reconst. of Ban Sue P.S.	9,280
	(2) Reconst. of Sam Sen P.S.	7,910
	(3) Reconst. of Tavate P.S.	10,370
	(4) Reconst. of Sathorn P.S.	10,420
	(5) Dredging of Klong	11,010
	(6) Const. of Aerated Lagoon at Makkasan Pond	59,500
	(7) Const. of Aerated Lagoon at Rama IX Pond	59,300
B.	Engineering & Administration Costs (10%)	16,779
C	Physical Contingency (10%)	18,456
	Total (1)	203,025
D.	Price Escalation (10%)	19,975
	Total (2)	223,000

Break-down of the direct construction cost is shown in Table F.3.

Table F.1 Unit Labor Cost

Type of Labor	Labor Cost per Day (฿)
Common Labor	80
Skilled Labor	100
Foreman	200
Carpenter	150
Plumber	200
Welder	200
Driver (Truck)	150
Operator (Heavy Machine)	200
Painter	150
Mason	150
Mechanic	200
Electrician	200

Table F.2 Unit Basic Construction Cost

Work Item	Unit Price	
Excavation (clay, by hand)	50 ฿/m^3	
Excavation (clay, under water, by hand)	100 ฿/m^3	
Excavation (clay, by machine)	30 ฿/m^3	
Excavation (clay, under water, by machine)	50 ฿/m^3	
Backfilling	30 ฿/m^3	
Banking	30 ฿/m^2	
Dredging (by hand)	37-127 ฿/m	
Dredging (by machine)	15-100 ฿/m	
Transportation, less than 20 km	50 ฿/m^3	
Concrete Work (Placing & Curing)		
210 kg/cm^2	1,500 ฿/m^3	(M+L)
180 kg/cm^2	1,450 ฿/m^3	(M+L)
Reinforcing Bar Arrangement	18 ฿/kg	(M+L)
Mortar Flushing	200 ฿/m^2	(M+L)
Concrete Lining, 16 cm thick	250 ฿/m^2	(M+L)
Concrete Piling, 35 x 35 x 12 m	430 ฿/pc	(L)
Steel Sheet Pile Driving, 5 m long	260 ฿/m	(L)
Form Work		
Wooden Form	200 ฿/m^2	(L)
Metal Form	250 ฿/m^2	(L)
Piping		
RC (Reinforced Concrete)	20% x material cost	
PVC (Polyvinyl Chloride)	20% x material cost	
SP (Steel Pipe)	20% x material cost	
Steel Work	24 ฿/kg	(M+L)
Pavement (including subbase)		
Asphalt, 5 cm thick	150 ฿/m^2	
10 cm thick	250 ฿/m^2	
Concrete 15 cm thick	250 ฿/m^2	
25 cm thick	400 ฿/m^2	

Note: M: Material Cost
L: Labour Cost

Table F.3 Estimated Direct Construction Cost

Work Item	Quantity	Unit Cost (B)	Amount (B)
Reconstruction of P.S.			
Ban Sue			
Coffering	40 m	11,300	452,000
Gate, Type A	1 unit	1,898,000	1,898,000
Gate, Type B	1 unit	1,374,000	1,374,000
Gate, Type C	1 unit	2,974,000	2,974,000
Floring	1 unit	38,000	38,000
R.C. Retaining Wall	20 m	20,000	400,000
Overhead (30%)			2,144,000
Total			9,280,000
Sam Sen			
Coffering	35 m	11,300	395,500
Gate, Type A	2 units	1,850,000	3,700,000
Gate, Type B	1 unit	1,351,000	1,351,000
Flooring	1 unit	39,000	39,000
R.C. Retaining Wall	30 m	20,000	600,000
Overhead (30%)			1,824,500
Total			7,910,000
Tavate			
Coffering	20 m	11,300	226,000
Pump Pit	1 unit	543,000	543,000
Pump & Electrical Eq.	2 units	3,250,000	6,500,000
Discharge Pipe	36 m	8,500	306,000
R.C. Retaining Wall	20 m	20,000	400,000
Overhead (30%)			2,395,000
Total			10,370,000
Sathorn			
Coffering	10 m	11,300	113,000
Pump Pit	1 unit	802,000	802,000
Pump & Electrical Eq.	2 units	3,250,000	6,500,000
Discharge Pipe	24 m	8,500	204,000
R.C. Retaining Wall	20 m	20,000	400,000
Overhead (30%)			2,401,000
Total			10,420,000
Dredging of Klong			
Chong Non Sri	77,000 m^3	110	8,470,000
Overhead (30%)			2,540,000
Total			11,010,000
Construction of Aerated Lagoon			
Makkasan Pond			
Aerator and Installation	10 units	950,000	9,500,000
Pump Facilities	3 units	5,600,000	16,800,000
Inlet Facilities	1 unit	3,000,000	3,000,000
Partition Wall	1,600 m	6,000	9,600,000
Coffering	10 m	11,300	113,000
Gate, 5 m (H) x 4 m(W)	1 unit	1,410,000	1,410,000
Other Miscellaneous Works			5,400,000
Overhead (30%)			13,677,000
Total			59,500,000
Rama IX Pond			
Excavation	150,000 m^3	100	15,000,000
Aerator and Installation	7 units	950,000	6,650,000
Pump Facility	3 units	5,600,000	16,800,000
Gate 6.0m (H) x 3.0 m (W)	1 unit	1,268,000	1,268,000
Outlet Facility	1 unit	1,400,000	1,400,000
Other Miscellaneous Works			4,500,000
Overhead (30%)			13,682,000
Total			59,300,000
Grand Total			167,790,000

Note: Overhead includes profit and tax.
Three (3) aerators in the existing Rama IX pond will be reused.

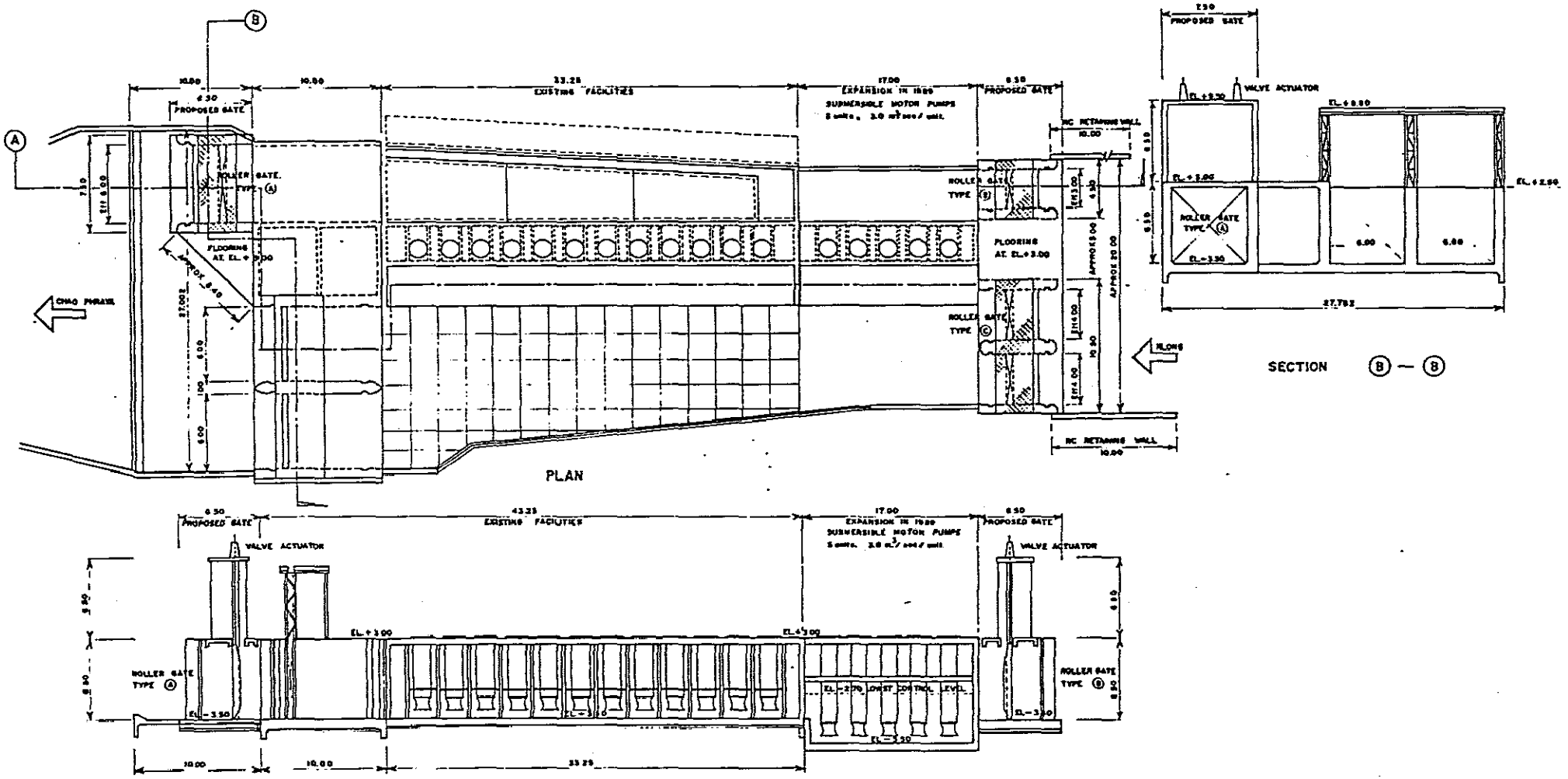
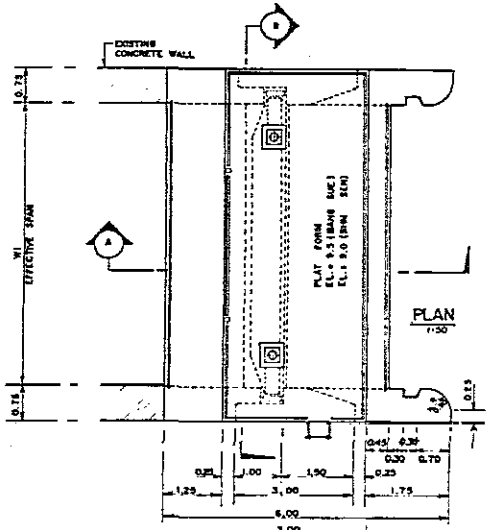
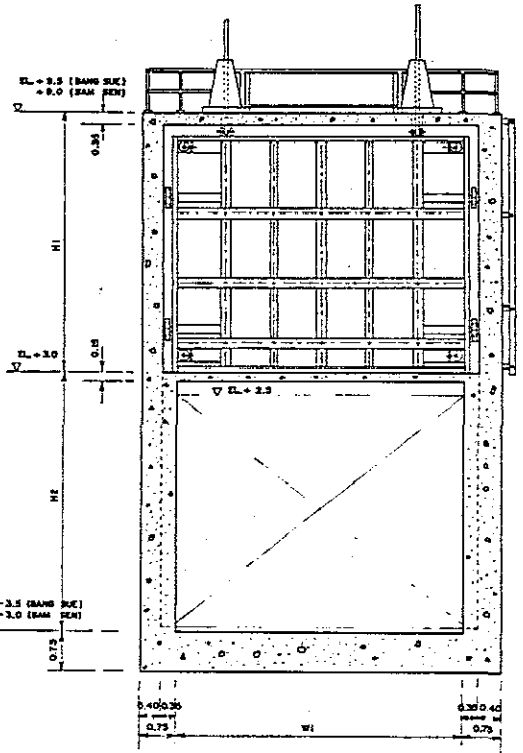


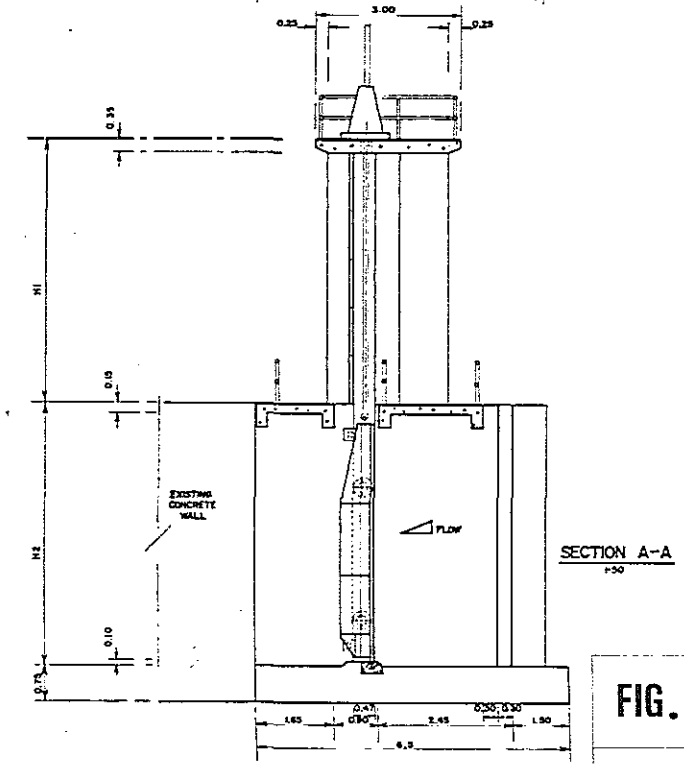
FIG. F.1 PROPOSED RECONSTRUCTION PLAN OF BANG SUE PUMP STATION

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532 B.E. 1989 A.D.







	BANG SUE	SAM SEN
TYPE (A)		
H1	6.5	6.0
H2	6.5	6.0
W1	6.0	6.0

	BANG SUE	SAM SEN
TYPE (B)		
H1	6.5	6.0
H2	6.5	6.0
W1	3.0	3.0

FIG. F.2 DETAILS OF PROPOSED GATE TYPE A AND B

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

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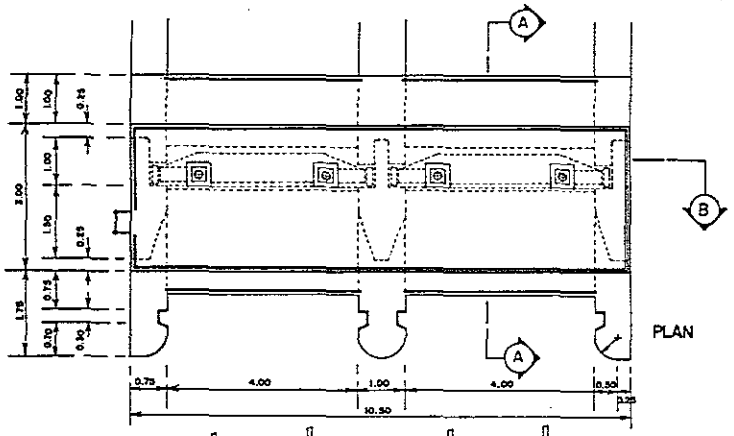

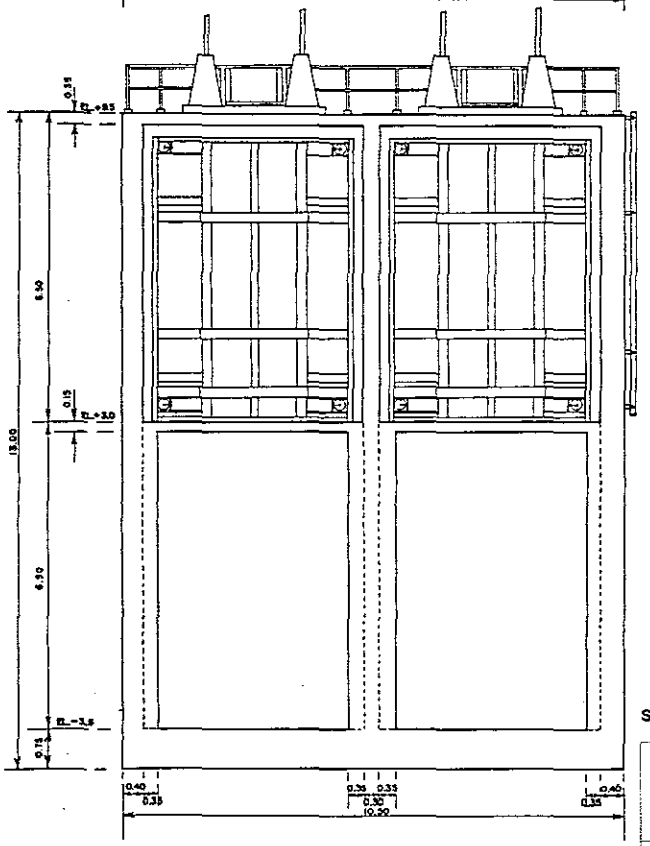

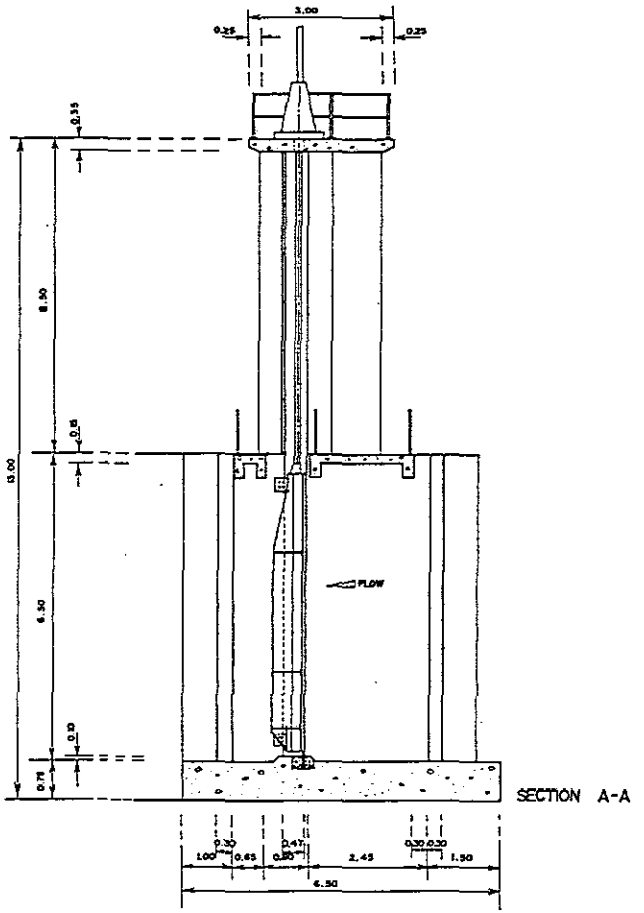

FIG. F.3 DETAILS OF PROPOSED GATE TYPE C

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

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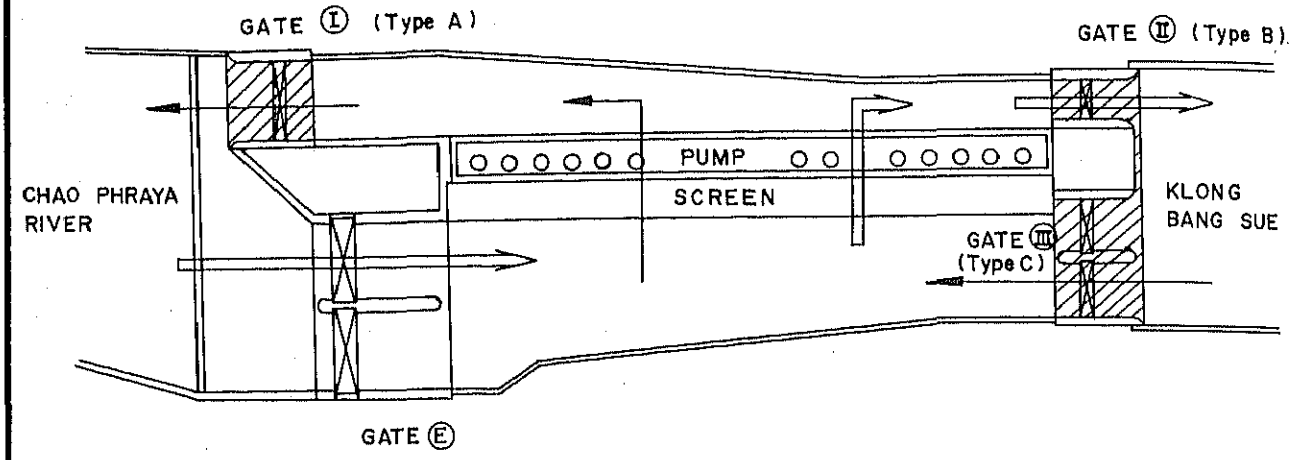
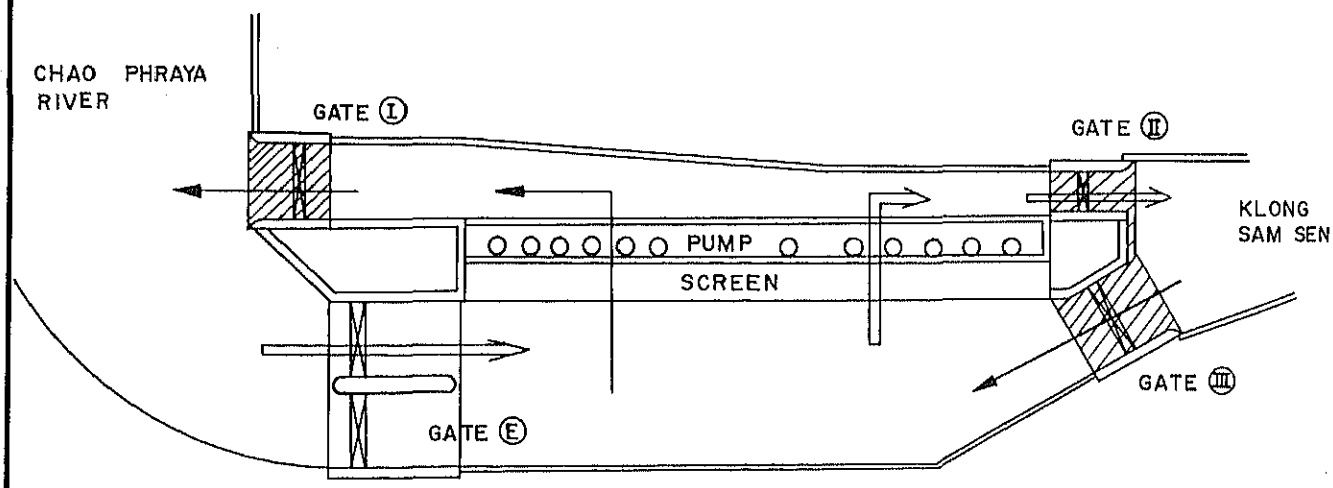


BANG SUE PUHP STATION



SAM SEN PUMP STATION

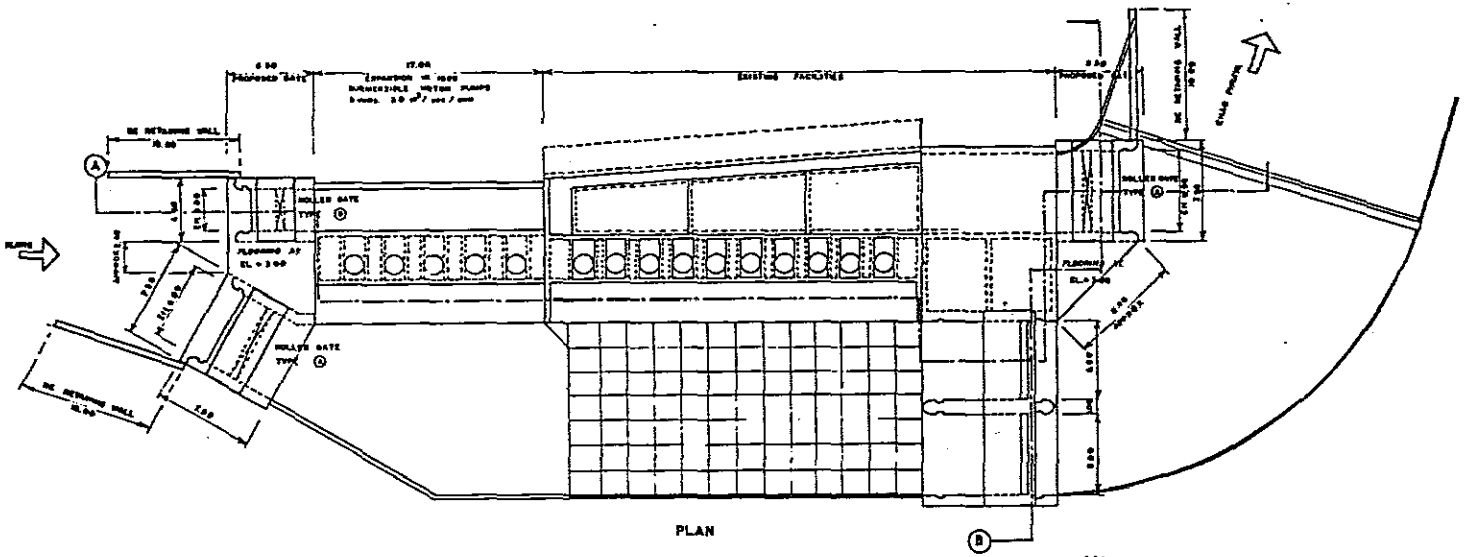
LEGEND

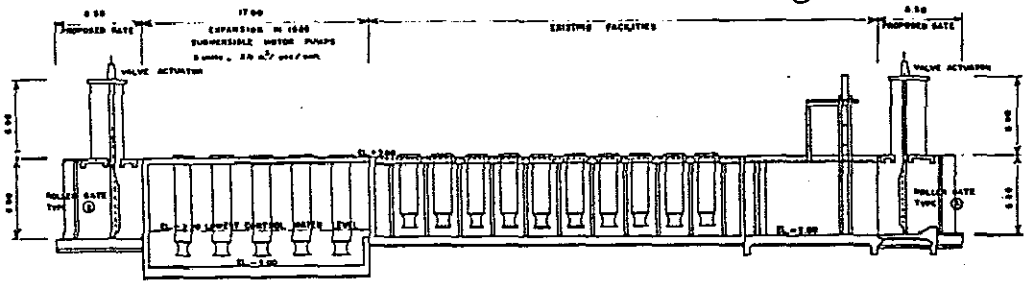
⇨	Introduction Flow
→	Drainage Flow
▨	Proposed Gate

FIG. F.4 FLOW DIRECTION OF DRAINAGE AND DILUTION WATER

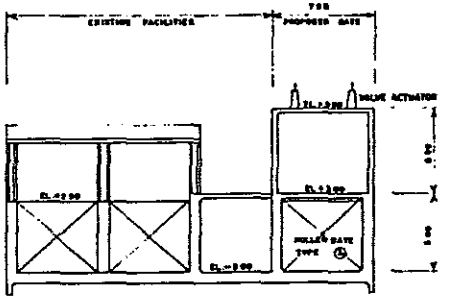
THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.





SECTION Ⓐ – Ⓐ



SECTION Ⓑ – Ⓑ

FIG. F.5	PROPOSED RECONSTRUCTION PLAN OF SAM SEN PUMP STATION

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

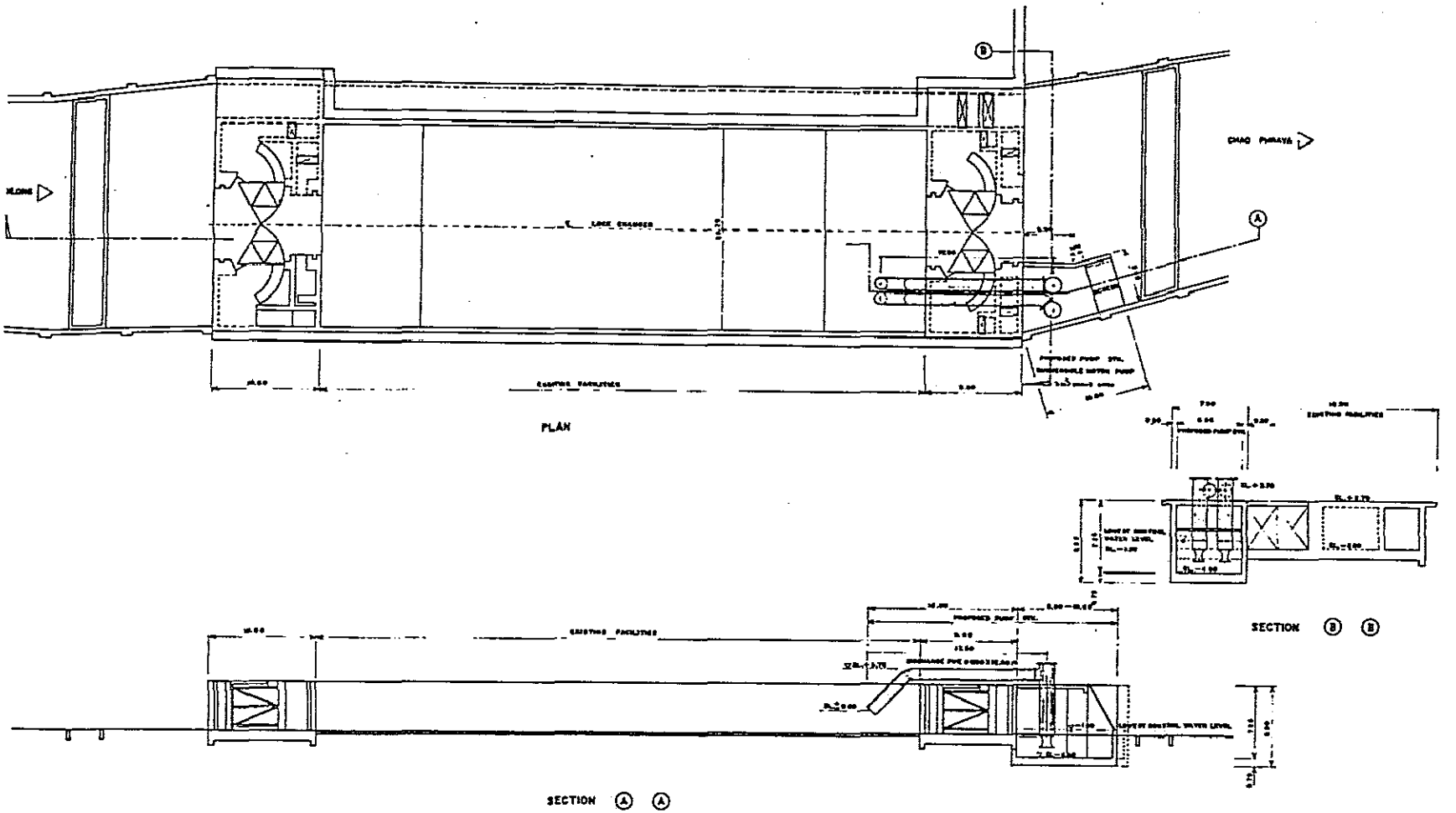


FIG. F.6	PROPOSED IMPROVEMENT PLAN OF TAVATE PUMP STATION
THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK	

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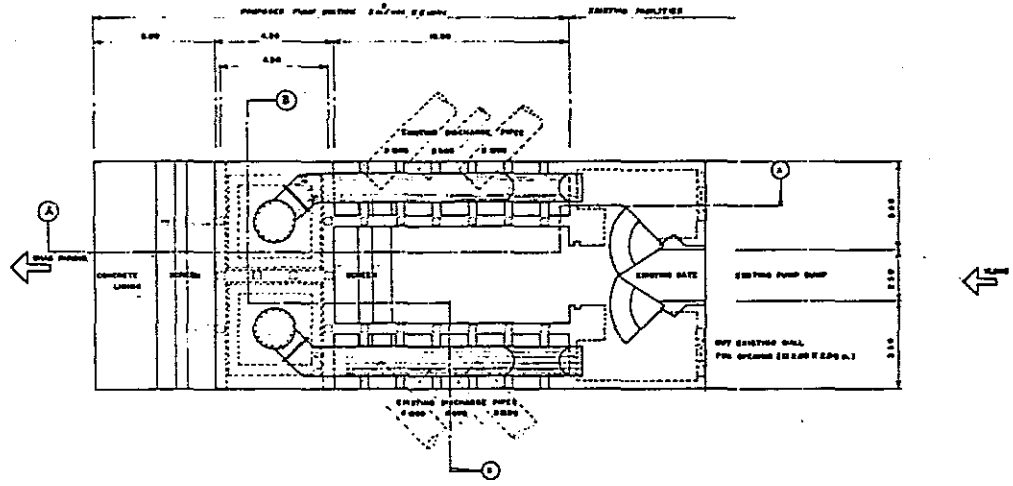
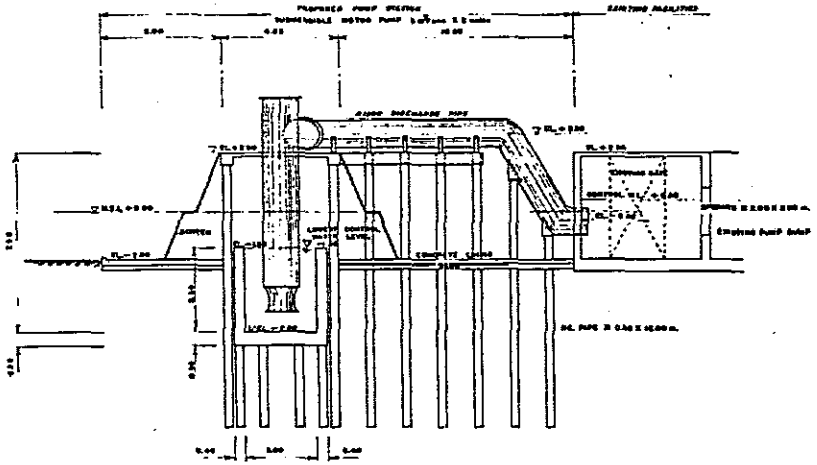
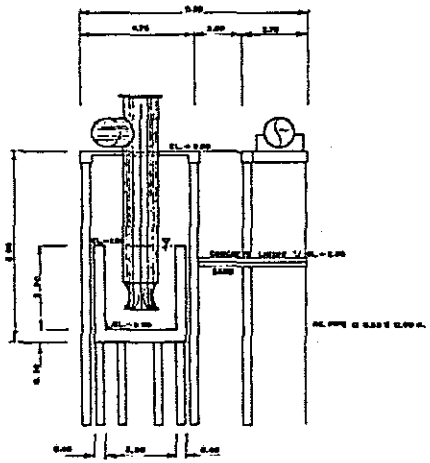


PLAN



SECTION Ⓐ–Ⓐ



SECTION Ⓑ–Ⓑ

FIG. F.7 PROPOSED IMPROVEMENT PLAN OF SATHORN PUMP STATION

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532 B.E. 1989 A.D.

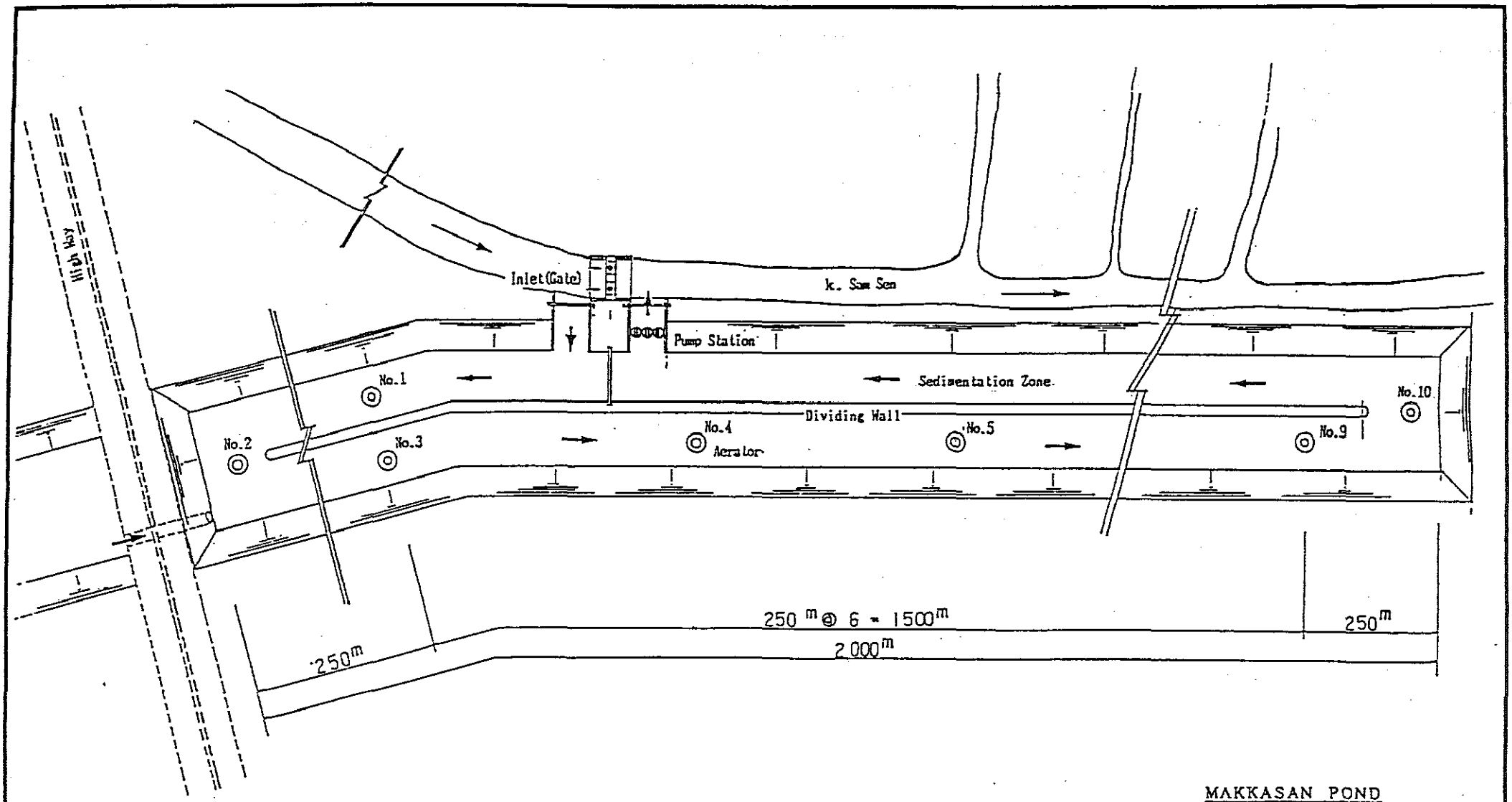
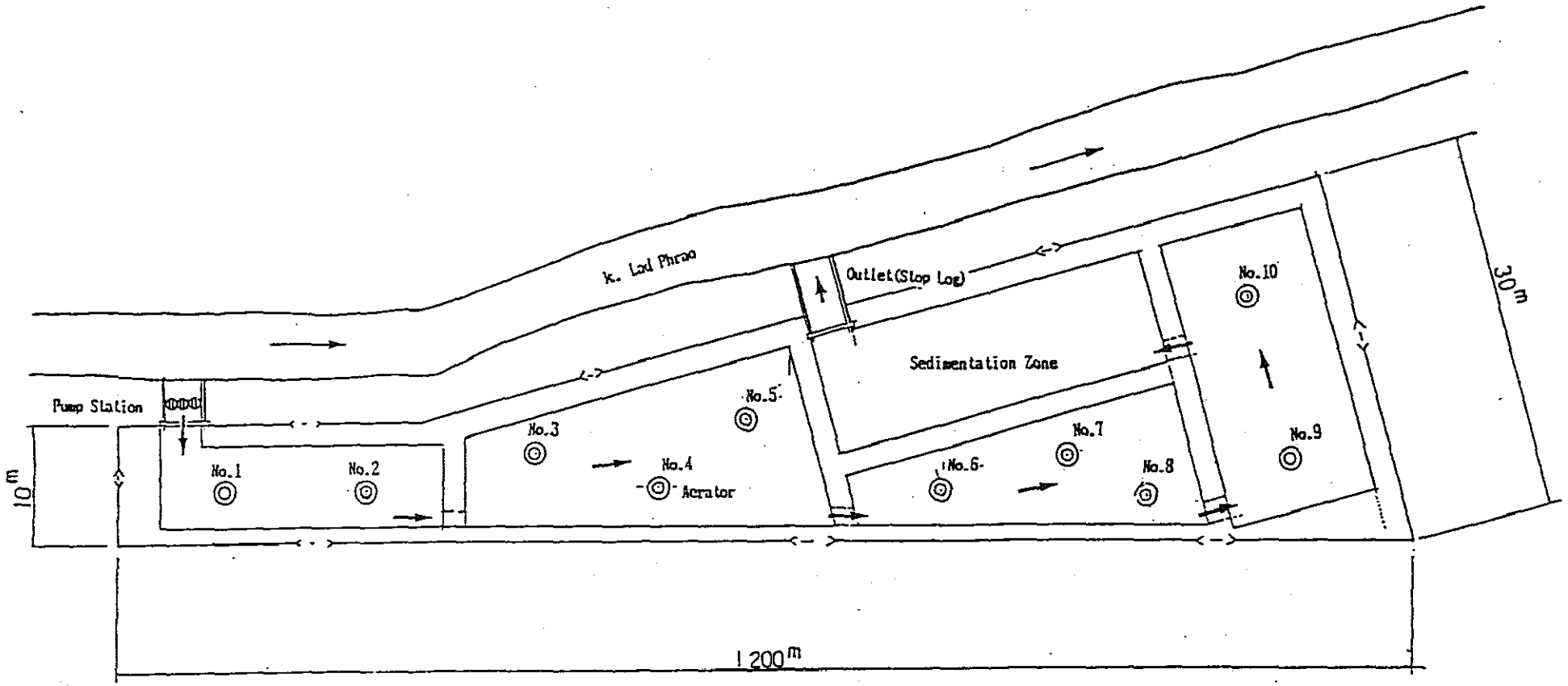


FIG. F.8 PROPOSED CONSTRUCTION PLAN OF AERATED LAGOON IN MAKKASAN POND

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532 B.E. 1989 A.D.



RAMA IX POND

FIG. F.9	PROPOSED CONSTRUCTION PLAN OF AERATED LAGOON IN RAMA IX POND

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532 B.E. 1989 A.D.

APPENDIX G.

OPERATION AND MAINTENANCE

APPENDIX G. OPERATION AND MAINTENANCE

1. Operation Mode of Gate and Pump

1.1 Existing Operation Mode

At present the introduction of dilution water from the Chao Phraya River to the klongs for the purpose of flushing is being conducted only during dry season on an experimental basis. The dilution water is introduced during high river tide through the opened gates along the Chao Phraya River bank, namely, Bang Khen Old and New P.S., Bang Sue P.S., Sam Sen P.S., Tavate P.S., Bang Lum Phu Gate, Phra Pinklao Gate, Pak Klong Talad Gate and Ong Ang Gate. The water introduced is discharged by Krung Kasem P.S. and Phra Khanong P.S.

For dilution water introduction, maintenance water levels at the respective pump and gate station are decided by DDS as follows:

Station	Maintenance Water Level : M.S.L.(m)
Bang Sue P.S.	+0.77
Sam Sen P.S.	+0.77
Tavate P.S.	+0.77
Bang Lum Phu Gate	+0.77
Phra Pinklao Gate	+0.77
Pak Klong Talad Gate	+0.77
Ong Ang Gate	+0.77
Krung Kasem P.S	+0.47

Maintenance water level for Bang Khen Old and New P.S., and Phra Khanong are yet to be decided.

The responsibility concerning the operation of the pumps and gates are delegated to the personnel stationed at the respective sites.

By these dilution water introductions, the water quality of the klongs along and near the Chao Phraya River can be improved to a certain

degree. However, the klongs in inland areas, such as Bang Sue, Sam Sen and Huai Kuwan, are not benefited to any significant degree.

During rainy season, the water level in the klongs are maintained low to have sufficient flood mitigation storage capacity in the klongs. In principle no dilution water is introduced from the Chao Phraya River. The water level decided by DDS at major stations under various conditions are provided in Data Book, for the purpose of reference.

1.2 Proposed Operation Mode

The Study Team proposes the following gate and pump operation mode for the introduction of dilution water into the klongs from the Chao Phraya River.

1.2.1 Operation Mode for Dry Season

The proposed operational functions of the gates and pumps located along the Chao Phraya River banks, during dry season, can be classified into the following four (4) categories:

(1) Introduction of Dilution Water by Combined Gate and Reversible Pump Operations:

These measures are proposed to be conducted at Bang Sue, Sam Sen, Tavate and Sathorn Pumping Stations. While the dilution water is being introduced from the Chao Phraya River, the inner water levels of the pump stations are to be maintained below +0.70m M.S.L. at Bang Sue, Sam Sen and Tavate Pumping Stations, and +0.40m M.S.L. at Sathorn Pumping Station.

- During low tide periods, the dilution water shall be introduced by operating the reversible pump.
- During high tide periods, the dilution water shall be introduced by opening the gate.

(2) Introduction of Dilution Water by Gate Operation Only

The introduction of dilution water by gate operation only is proposed at the four (4) gates in Ratanakosin Area, namely, Bang Lum Phu, Phra Pinklao, Pak Klong Talad and Ong Ang.

While the dilution water is being introduced from the Chao Phraya River through the opened gates, the inner water level be maintained below +0.70m M.S.L..

- The dilution water shall be introduced through the opened gate at high tide.
- The gate shall be closed at low tide.

(3) Introduction of Dilution Water by Normal Pump and Gate Operation

Bang Khen Old and New pump stations shall continue to be operated by the same mode as present. At high tide period, the dilution water be introduced through the opened gates, while at the low tide, the water in the klongs be discharged to the Chao Phraya River through the same gates.

(4) Discharge by Pump and Gate Operations

These measures are proposed to be conducted at the Krung Kasem, Chong Non Sri, and Phra Khanong pumping stations.

The inner water level shall be maintained below +0.30m M.S.L. at Krung Kasem pump station, ±0.00m M.S.L. at Phra Khanong pump station and +0.30m M.S.L. at Chong Non Sri pump station. When the outer water level is lower than the inner water level, the klong water be discharged through the opened gates. When the outer water level is higher than the inner water level, the klong water be discharged by pump.

1.2.2 Operation Mode for Rainy Season

During rainy season, principally, all gates shall remain closed and the pumps of all pump stations be used for drainage only and not for the introduction of dilution water. At the all gate sites, the inner water level shall be maintained below -0.23m M.S.L. for the purpose of flood mitigation. The inner water levels at Krung Kasem and Phra Khanong Pumping Stations shall be maintained below -0.35m M.S.L..

2. Monitoring System

2.1 Existing Monitoring System

Monitoring of klong water quality has been periodically conducted by DDS at 37 stations in the Study Area since 1981. The locations of monitoring stations are shown in Fig. B.16. The water quality parameters monitored are pH, DO, BOD, COD, SS, Cl^-, NH_4-N, NO_3-N, T-P, H_2S and Coliform count.

Pump and gate operations are recorded manually for the flood mitigation purpose but not for the introduction of dilution water. Hourly water level at all the pump and gate stations are also recorded manually. The data of the major stations are transmitted to the central flood operation center in DDS by telephone and walkie-talkie. The data of daily max. and min. water levels at the following 11 major pump and gate stations are also compiled by DDS.

- Bang Sue, Sam Sen, Tavate, Krung Kasem, Sathorn, Rama IV, Phra Khanong, Klong Chak, Bang Oa, Bang Na and Dusit Gate.

2.2 Proposed Monitoring System

For satisfactory attainment of the dilution water introduction from the Chao Phraya River, effectively, the JICA Study Team proposes the following improvements to the monitoring systems. The items of monitoring shall be comprised of klong water quality, water stage, rainfall and operating conditions of pumps and gates.

2.2.1 Monitoring of Klong Water Quality

It is not necessary to conduct a real time continuous monitoring of the klong water quality for this project. It is proposed to continue with the existing periodical klong water monitoring programme conducted by DDS, unchanged. Obtained data shall be compiled and utilized for effective pump and gate operations to optimize the dilution water introduction.

For ensuring the effectiveness of monitoring and the preservation of klong water quality, the analysis of toxic compounds and heavy metals shall also be incorporated as the monitoring parameters of klong water quality. The compounds recommended for monitoring are as follows:

CN, Alkyl Hg, Organophosphate, Pb, Cr^{6+}, As, F and Cd.

2.2.2 Monitoring of Water Stage and Pump and Gate Operation Conditions

For estimating the required dilution water quantity of introduction and discharge from and to the Chao Phraya River, the hourly water stage, and pump and gate operation conditions at the following 13 stations shall be monitored.

- Bang Khen Old P.S., Bang Khen New P.S., Bang Sue P.S., Sam Sen P.S., Tavate P.S., Bang Lum Phu Gate, Phra Pinklao Gate, Pak Klong Talad Gate, Ong Ang Gate, Krung Kasem P.S., Sathorn P.S., Chong Non Sri P.S. and Phra Khanong P.S. (Ref. Fig. G.1)

The quantity of introduced and discharged dilution water by pumping is estimated based on the number of pumps in operation, their operation mode (for introduction or discharge) and their capacities. While, such a quantity for gate operation (opening) is estimated based on the difference in level between the inner and outer water stages, which also would indicate the direction of flow of introduction or discharge, and the area of flow (opening).

For estimating the quantity of the introduced surplus irrigation water from the north and east boundary areas, the hourly water stage and the operating conditions of gates at the following three (3) stations shall be monitored.

- K. Song Gate at Don Muang, K. Saen Saep Gate in Minburi and K. Phra Khanong Gate in Lat Krabang. (Ref. Fig. G.1)

2.2.3 Monitoring of Rainfall

Three (3) rainfall monitoring stations are proposed for this project. While the pumps and gates are operated under the mode of dilution water introduction to the klongs, an occurrence of sudden heavy rainfall may require immediate change in the operation mode of pumps and gates, to storm water drainage of flood control, based on the monitored rainfall. As the rainfall monitoring stations in the Study Area, the three monitoring stations that are under implementation as a separate project as dealt with in the following section are proposed to be used for this project as well. The locations of the proposed monitoring stations at K. Lad Phrao in Bang Khen, Flood Control Center in Din Deang and K. Saen Saep in Bang Kapi are shown in Fig. G.1.

2.2.4 Monitoring Stations of Flood Control Center Project

According to the project, "The Procurement of Equipment for Flood Control Center in Bangkok and its Vicinity", which is under implementation at present, the following monitoring stations would commence functioning once the project is completed.

- Monitoring stations for water stage and pump and gate operation conditions:
  Bang Khen New P.S., Bang Sue P.S., Sam Sen P.S., Tavate P.S., Krung Kasem P.S., Phra Khanong P.S., K. Song Gate, K. Saen Saep Gate and K. Phra Khanong Gate.

- Monitoring station for rainfall:
  K. Lad Phrao in Bang Khen
  Flood Control Center at Din Daeng
  K. Saen Saep in Bang Kapi

The proposed monitoring stations of this project, "Project for the Procurement of Equipment for Flood Control Center in Bangkok and Its Vicinity", are shown in Fig. G.2 and Table G.1.

3. Operation and Maintenance Cost

3.1 Existing Pump and Gate Operation and Maintenance Cost

The average annual budget of BMA for the four (4) year period, 1984-1987, is about 6,500 million Bhat. Of this budget, about 15% is expended for flood mitigation works. The average annual budget of DDS, a subsidiary of BMA, during this four (4) year period is about 545 million Bhat, of which about 80% is expended for drainage works and maintenance of klongs (Refer to Table G.8).

The two (2) previous year operation records (1985-1986) of typical pumping stations under the administration of DDS are given below:

Pump Station	Pump Capacity	Operated Time[1] (hr)		Operation Cost[2]		Operation Cost[3] per Pump		
		[4] 1985	[4] 1986	[4] 1985	[4] 1986	[4] 1985	[4] 1986	Ave.
Phadung Krung Kasem P. St.	5 x 5 CMS = 25 CMS	17,132	21,366	5.8	6.0	340	280	310
Rama IV P. St.	4 x 5 CMS = 20 CMS	8,872	8,454	5.9	5.2	665	615	640
K. Sam Sen P. St.	10 x 3 CMS = 30 CMS	4,525	4,309	2.0	1.4	440	325	380

Note: (1) Total pump operating hours per year
(2) Million Baht/year
(3) Bahts/unit/hour
(4) Fiscal year

The pump types used in these three (3) pump stations, Krung Kasem P.S., Rama IV P.S. and Sam Sen P.S., are respectively, electric motor driven, engine driven and electric motor driven. As shown in the above table, their respective average unit cost of operation are 310 Baht / unit (m^3/s) / hr, 640 Bhat / unit / hr and 380 Baht / unit / hr.

3.2 Operation and Maintenance Cost for Proposed System

The proposed system of klong water quality improvement consists of dilution water introduction from the Chao Phraya River, dredging of klongs to facilitate dilution water introduction and aerated lagoon treatment of klong water.

(1) Cost of Dilution Water Introduction

The klong water quality improvement plan by the introduction of dilution water will utilize either all or a portion of the existing flood protection facilities.

The facilities to be utilized for the water quality improvement (purification) plan are as follows:

Name of Facility	Present Pump No. and Capacity	Pump Capacity to be Used to Introduce and Discharge Dilution Water
K. Bang Sue P. St.	17 x 3 m^3/sec = 51 m^3/sec	4 x 3 m^3/sec = 12 m^3/sec
K. Sam Sen P. St.	15 x 3 m^3/sec = 45 m^3/sec	4 x 3 m^3/sec = 12 m^3/sec
Tavate P. St.	5 x 1 m^3/sec = 5 m^3/sec	2 x 3 m^3/sec = 6 m^3/sec
Krung Kasem P. St.	5 x 5 m^3/sec = 25 m^3/sec	1 x 5 m^3/sec = 5 m^3/sec
Phra Khanong P. St.	35 x 3 m^3/sec = 105 m^3/sec	5 x 3 m^3/sec = 15 m^3/sec
Chong Non Sri P. St.	2 x 1 m^3/sec + 1 x 0.5 m^3/sec = 2.5 m^3/sec	2 x 1 m^3/sec + 1 x 0.5 m^3/sec = 2.5 m^3/sec
Sathorn P. St.	2 x 3 m^3/sec = 6 m^3/sec	2 x 3 m^3/sec = 6 m^3/sec

Pump operating conditions at each of the above facility for the water quality improvement plan shall be as follows:

- At the Bang Sue and Sam Sen pumping stations, the existing pumps will be used to introduce dilution water with modifications to gates only.

- At the Tavate and Sathorn pumping stations, new pumps are to be installed for the purpose of dilution water introduction.

- At the Phra Khanong, Chong Non Sri, and Krung Kasem pumping stations, the existing pump units will be used to drain the klong water with the introduced dilution water to the Chao Phraya River.

The estimation of the operation and maintenance costs for the water quality improvement plan (dilution water introduction plan) at the

Krung Kasem, Phra Khanong, and Chong Non Sri pumping stations was made based on would be the pump operating time, that was obtained by subtracting the number of pump operating hours that will be used for inner water drainage from that of the total operating time.

By assuming the period of dilution water introduction in an year is 8 months, from November to June, the total annual operating hours of pumps for water quality improvement at each pumping station will be as follows:

Bang Sue P. St.	14,048 hours
Sam Sen P. St.	10,072 hours
Tavate P. St.	4,244 hours
Sathorn P. St.	4,416 hours
Phra Khanong P. St.	48,480 hours
Chong Non Sri P. St.	4,066 hours
Krung Kasem P. St.	7,832 hours*

(See Table G.2 for details)

Based on the above operating hours, the annual pump operating costs for the water quality improvement plan is estimated as follows:

Pumping Station	Electricity Charges (million Baht)
Bang Sue P. St.	5.3
Sam Sen P. St.	3.8
Tavate P. St.	1.6
Sathorn P. St.	1.7
Phra Khanong P. St.	18.4
Chong Non Sri P. St.	1.5
Krung Kasem P. St.	2.4
Total	34.7

Since the personnel expenditures for the operation and maintenance of pumping stations and the costs of repairs has been appropriated in the flood protection plan, they shall not be included in the water

quality improvement plan. However, the repair costs for the pumps and gates to be installed for the purpose of dilution water introduction only are estimated at 121,000 Baht/year (5% of the total construction cost).

Assuming the average service years of pumps as 7 years, it is decided to appropriate the pump replacement costs of water quality improvement plan by proportioning the operating time for the water quality improvement plan to that of the flood protection plan. The estimated portion of pump replacement costs for the water quality improvement plan are as follows:

Foreign portion	:	6.21 million Baht per annum
Local portion	:	0.47 million Baht per annum

(2) Cost of Aerated Lagoon Treatment

Aerated lagoon is one of the economical wastewater treatment system in tropical regions if adequate land is available.

By assuming the proposed aerated lagoons at Makkasan Pond and Rama IX Pond operate all the year round, the total annual operation hours of pumps and aerators are estimated at 26,280 hrs and 87,600 hrs, respectively. The total annual electrical charge for operation of the two aerated lagoons is approximately 6.3 million Baht.

The personnel expenditures for the operation and maintenance of these aerated lagoons is about 1.3 million Baht per annum.

The personnel proposed to be assigned for each aerated lagoon treatment plant is given below.

	Makkasan Pond	Rama IX Pond
Chief	1	1
Mechanical Engineer	1	1
Electrical Engineer	1	1
Workers	3	3
Total	6	6