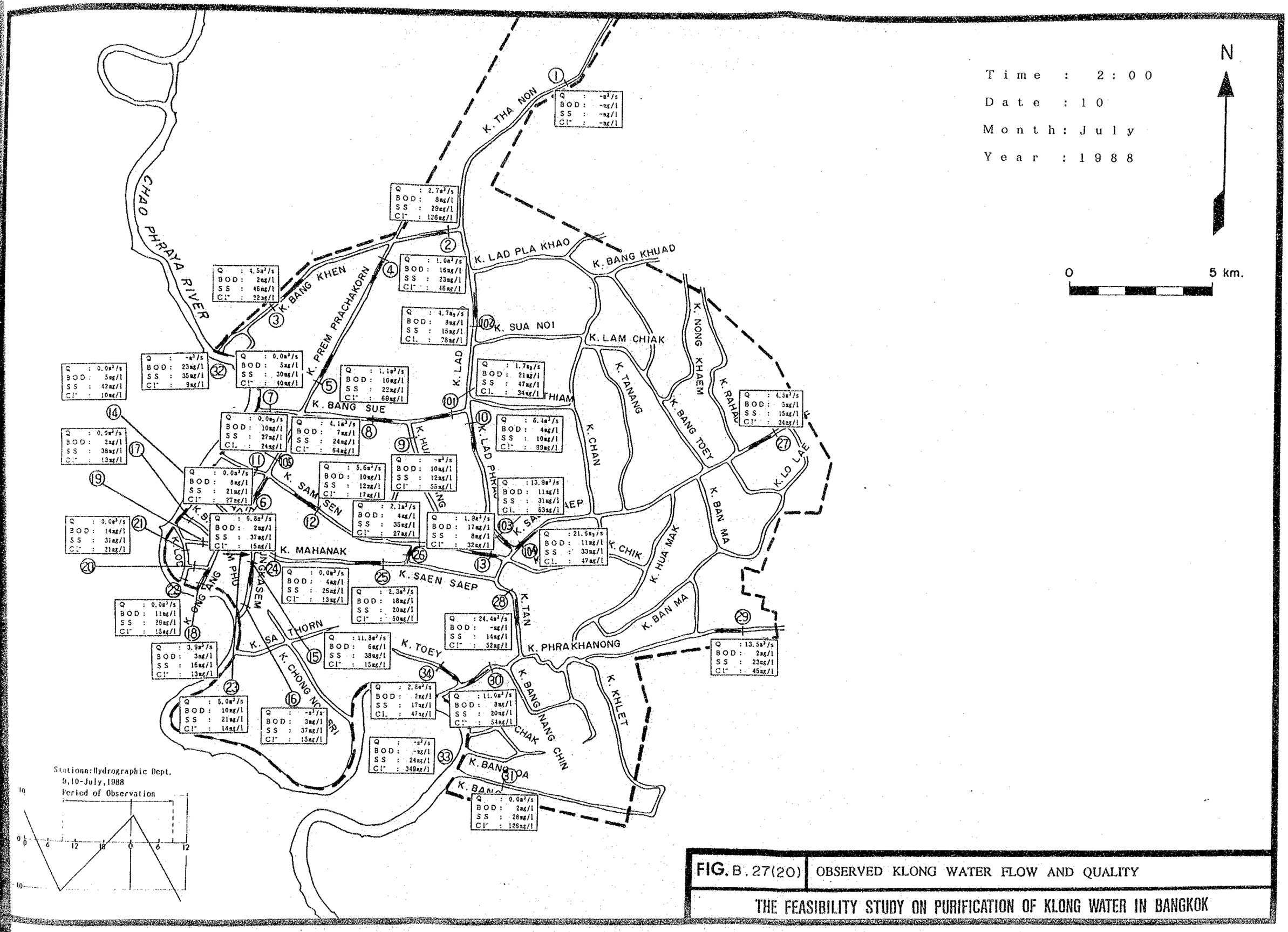


FIG. B.27(20) OBSERVED KLONG WATER FLOW AND QUALITY

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

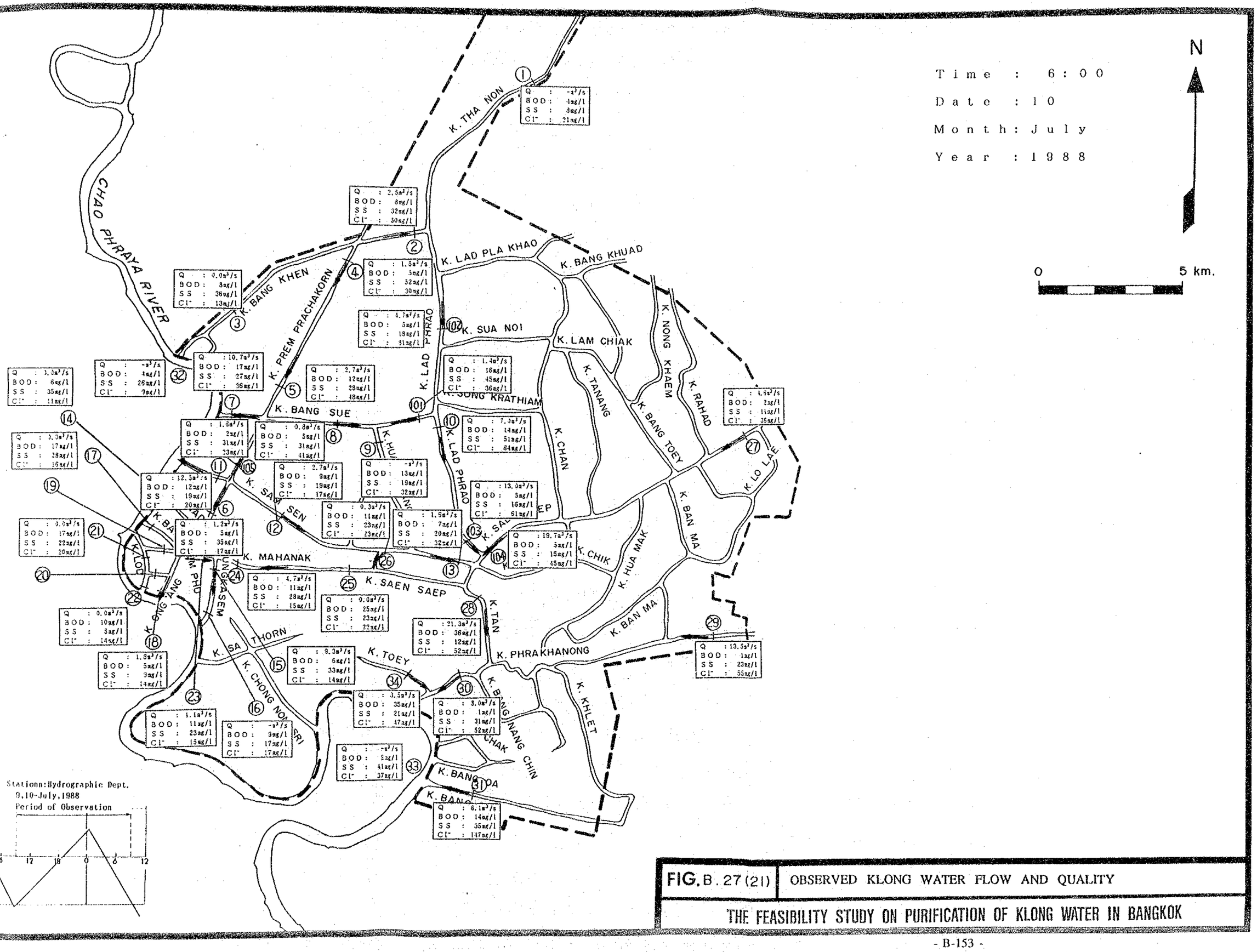


FIG. B. 27 (21) OBSERVED KLONG WATER FLOW AND QUALITY

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

Time : 10:00
Date : 16
Month: July
Year : 1988

N

0 5 km.

CHAO PHRAYA RIVER
K. THA NON
K. LAD PLA KHAO
K. BANG KHUAD
K. BANG KHEN
K. PREM PRACHAKORN
K. LAD PHRAO
K. SUA NOI
K. LAM CHIAK
K. NONG KHAEM
K. RAHAD
K. SONG KRATHIAM
K. TANANG
K. BANG TOEY
K. CHAN
K. BANG SUE
K. LO LAE
K. SAEN SAEP
K. KACHA
K. CHIK
K. HUA MAK
K. BAN MA
K. MAHANAK
K. PHRAKHANONG
K. TOEY
K. KHLET
K. SA THORN
K. CHONG NONSI
K. BANG CHAK
K. BANG CHIN
K. BANG NA
K. BANG
K. LOD
K. ONG ANG
K. LAM PHU
K. PHA
K. SAN SEN
K. HU
K. TAN
K. B

Stations:Hydrographic Dept.
16,17-July,1988
Period of Observation

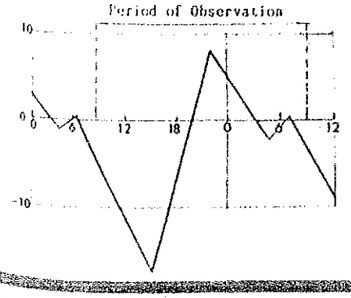


FIG. B.27(22) OBSERVED KLONG WATER FLOW AND QUALITY

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

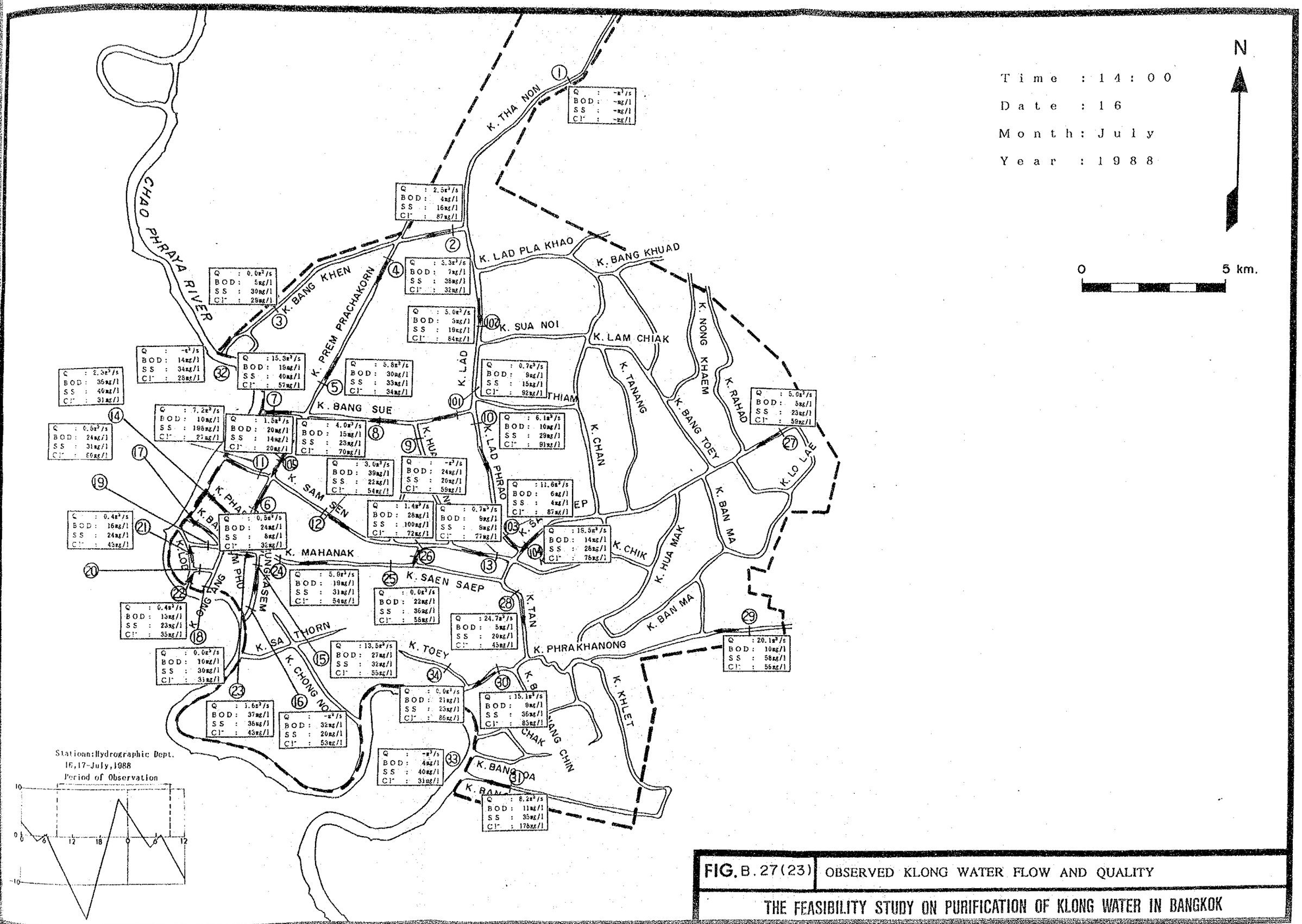


FIG. B.27(23) OBSERVED KLONG WATER FLOW AND QUALITY

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

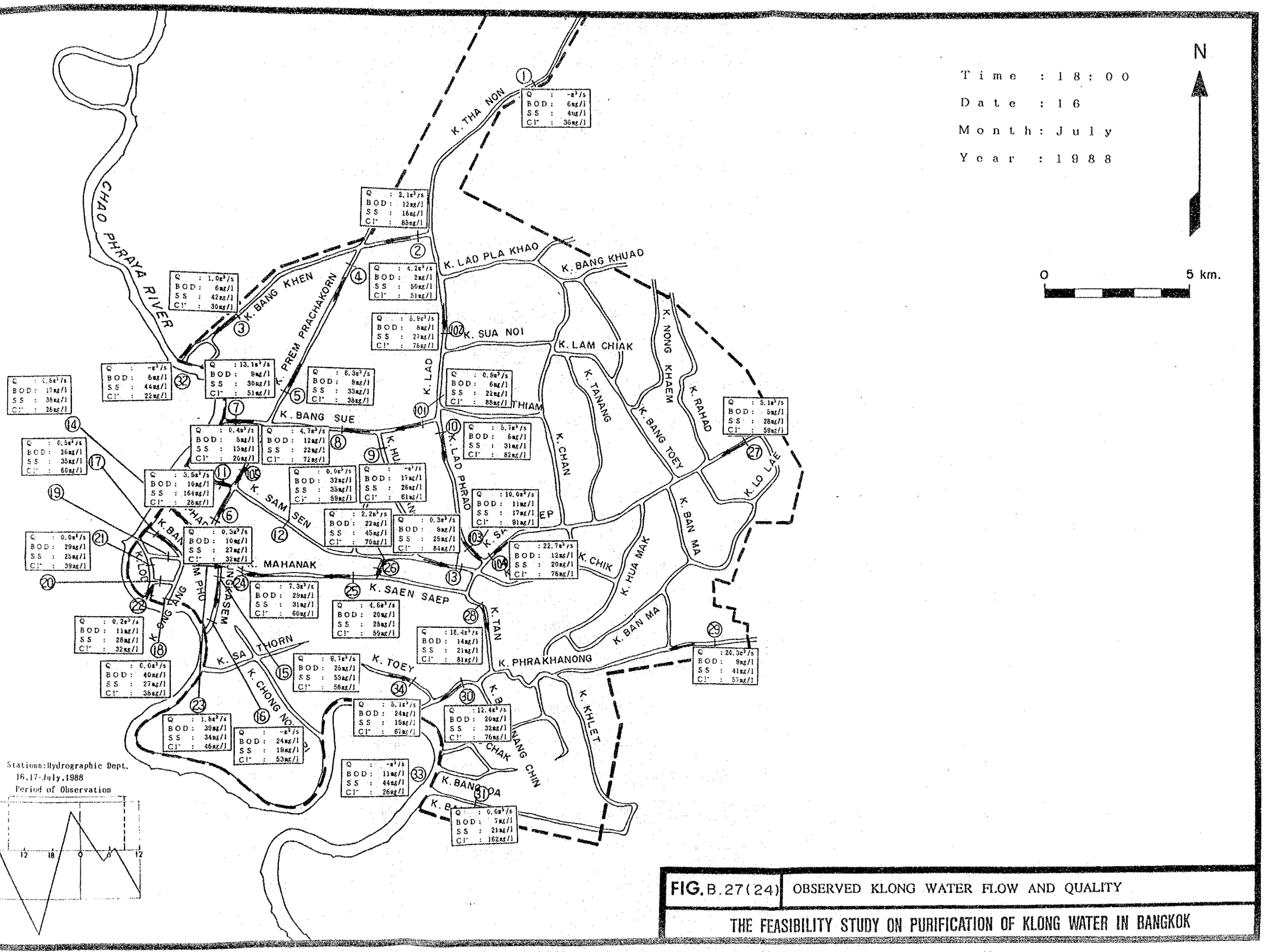


FIG. B.27(24) OBSERVED KLONG WATER FLOW AND QUALITY

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

Time : 22:00
Date : 16
Month: July
Year : 1988

N

0 5 km.

CHAO PHRAYA RIVER
K. BANG KHEN
K. PREM PRACHAKORN
K. THA NON
K. LAD PLA KHAO
K. BANG KHUAD
K. LAD PHRAO
K. SUA NOI
K. LAM CHIAK
K. NONG KHAEM
K. RAHAD
K. TANANG
K. BANG TOEY
K. SONG KRATHIAM
K. BANG SUE
K. CHAN
K. LO LAE
K. SAM SEN
K. SAEN SAEP
K. KACHA
K. CHIK
K. HUA MAK
K. BAN MA
K. PHA
K. BANG LIM PHU
K. LOD
K. ONG ANG
K. MAHANAK
UNGKASSEM
K. SA
K. CHONG NONSI
K. TOEY
K. TAN
K. PHRA KHANONG
K. KHLET
K. BANG CHAK
K. BANG CHIN
K. BANG

Q : -m³/s
BOD : -mg/l
SS : -mg/l
Cl⁻ : -mg/l

① Q : 1.9m³/s BOD : 3mg/l SS : 16mg/l Cl⁻ : 84mg/l
② Q : 4.4m³/s BOD : 8mg/l SS : 34mg/l Cl⁻ : 33mg/l
③ Q : 5.8m³/s BOD : 8mg/l SS : 78mg/l Cl⁻ : 58mg/l
④ Q : 11.3m³/s BOD : 9mg/l SS : 30mg/l Cl⁻ : 51mg/l
⑤ Q : 4.6m³/s BOD : 9mg/l SS : 21mg/l Cl⁻ : 50mg/l
⑥ Q : 0.5m³/s BOD : 24mg/l SS : 20mg/l Cl⁻ : 26mg/l
⑦ Q : 0.0m³/s BOD : 7mg/l SS : 14mg/l Cl⁻ : 37mg/l
⑧ Q : 4.4m³/s BOD : 23mg/l SS : 21mg/l Cl⁻ : 77mg/l
⑨ Q : 1.5m³/s BOD : 20mg/l SS : 41mg/l Cl⁻ : 57mg/l
⑩ Q : 5.7m³/s BOD : 6mg/l SS : 26mg/l Cl⁻ : 79mg/l
⑪ Q : 0.6m³/s BOD : 14mg/l SS : 14mg/l Cl⁻ : 37mg/l
⑫ Q : 2.0m³/s BOD : 19mg/l SS : 18mg/l Cl⁻ : 75mg/l
⑬ Q : 0.0m³/s BOD : 7mg/l SS : 28mg/l Cl⁻ : 80mg/l
⑭ Q : 0.0m³/s BOD : 17mg/l SS : 28mg/l Cl⁻ : 58mg/l
⑮ Q : 0.6m³/s BOD : 19mg/l SS : 34mg/l Cl⁻ : 62mg/l
⑯ Q : 0.0m³/s BOD : 12mg/l SS : 22mg/l Cl⁻ : 39mg/l
⑰ Q : 0.6m³/s BOD : 24mg/l SS : 25mg/l Cl⁻ : 32mg/l
⑱ Q : 0.0m³/s BOD : 3mg/l SS : 71mg/l Cl⁻ : 27mg/l
⑲ Q : 5.5m³/s BOD : 6mg/l SS : 25mg/l Cl⁻ : 68mg/l
⑳ Q : 3.9m³/s BOD : 9mg/l SS : 22mg/l Cl⁻ : 53mg/l
㉑ Q : 6.6m³/s BOD : 20mg/l SS : 23mg/l Cl⁻ : 27mg/l
㉒ Q : 1.4m³/s BOD : 26mg/l SS : 31mg/l Cl⁻ : 43mg/l
㉓ Q : -m³/s BOD : 16mg/l SS : 20mg/l Cl⁻ : 45mg/l
㉔ Q : 4.0m³/s BOD : 51mg/l SS : 32mg/l Cl⁻ : 107mg/l
㉕ Q : -m³/s BOD : 2mg/l SS : 34mg/l Cl⁻ : 46mg/l
㉖ Q : 5.6m³/s BOD : 23mg/l SS : 17mg/l Cl⁻ : 64mg/l
㉗ Q : 0.7m³/s BOD : 10mg/l SS : 16mg/l Cl⁻ : 84mg/l
㉘ Q : 9.3m³/s BOD : 9mg/l SS : 19mg/l Cl⁻ : 89mg/l
㉙ Q : 20.6m³/s BOD : 6mg/l SS : 16mg/l Cl⁻ : 81mg/l
㉚ Q : 5.1m³/s BOD : 2mg/l SS : 29mg/l Cl⁻ : 55mg/l
㉛ Q : 25.3m³/s BOD : 5mg/l SS : 28mg/l Cl⁻ : 74mg/l
㉜ Q : 16.8m³/s BOD : 5mg/l SS : 34mg/l Cl⁻ : 74mg/l
㉝ Q : 0.0m³/s BOD : 7mg/l SS : 17mg/l Cl⁻ : 165mg/l
㉞ Q : 22.0m³/s BOD : 6mg/l SS : 67mg/l Cl⁻ : 59mg/l

Stations:Hydrographic Dept.
16,17-July,1988
Period of Observation

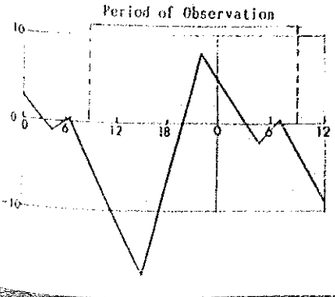


FIG. B.27(25) OBSERVED KLONG WATER FLOW AND QUALITY

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

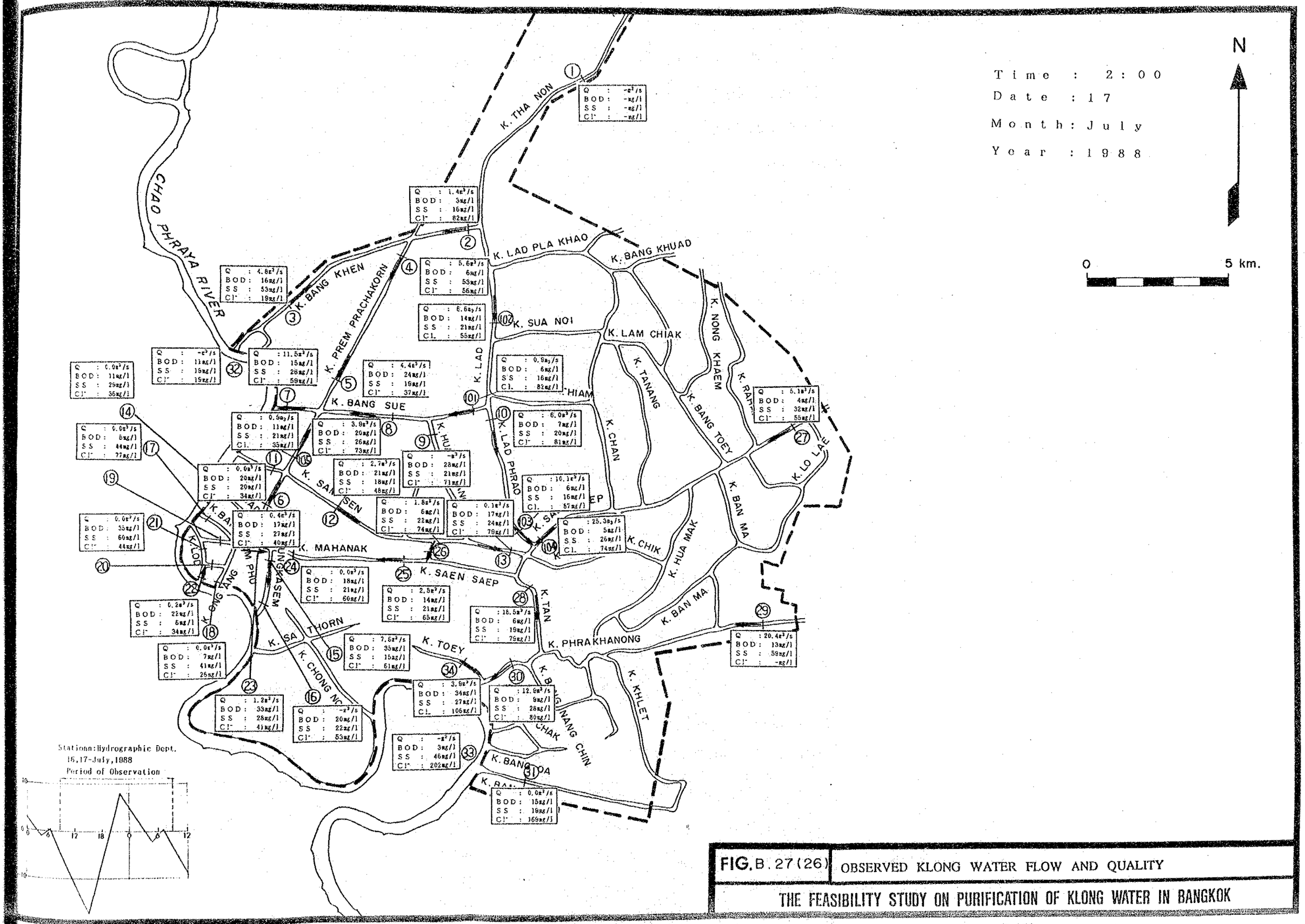


FIG. B. 27 (26) OBSERVED KLONG WATER FLOW AND QUALITY

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

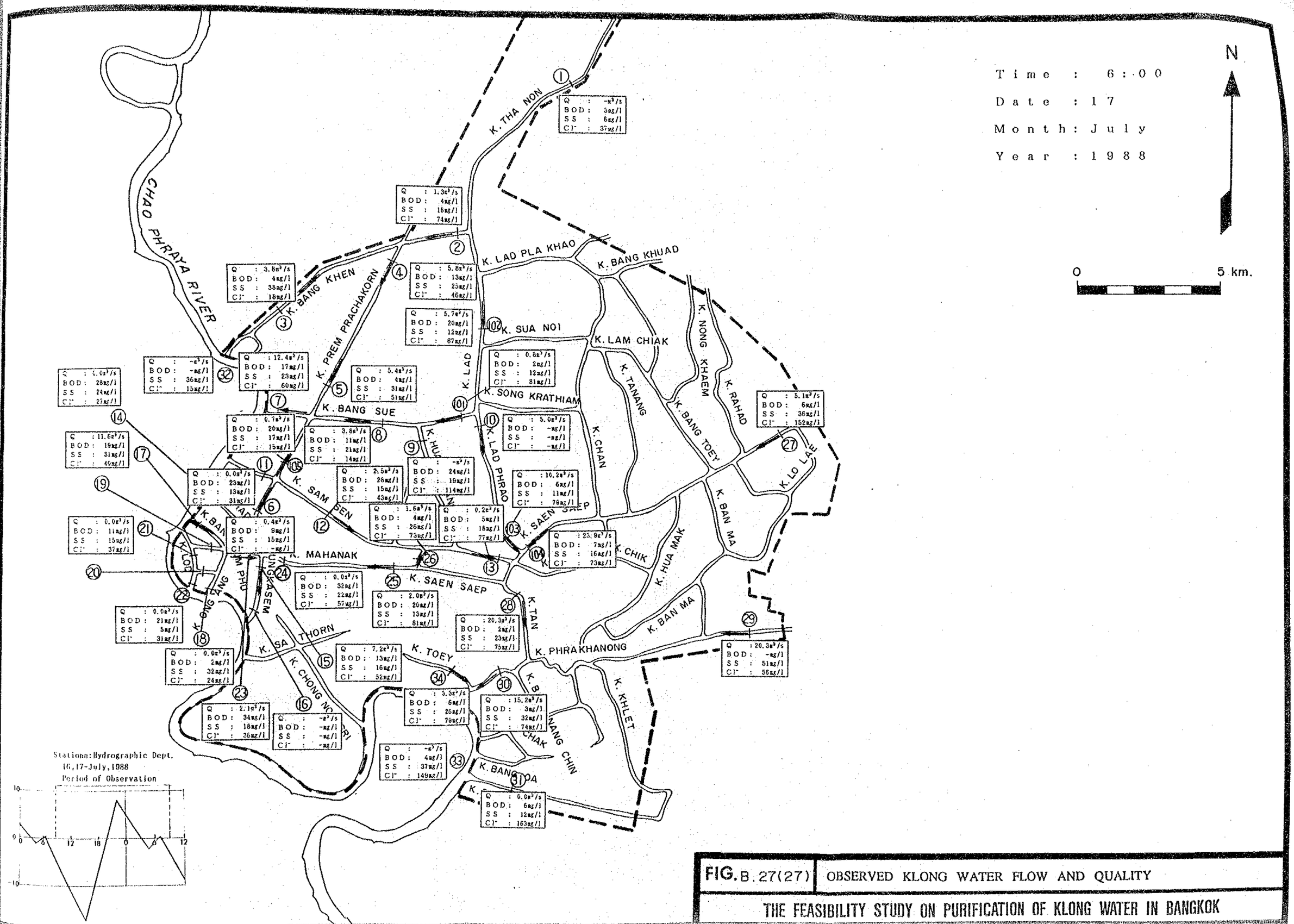


FIG. B.27(27) OBSERVED KLONG WATER FLOW AND QUALITY

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

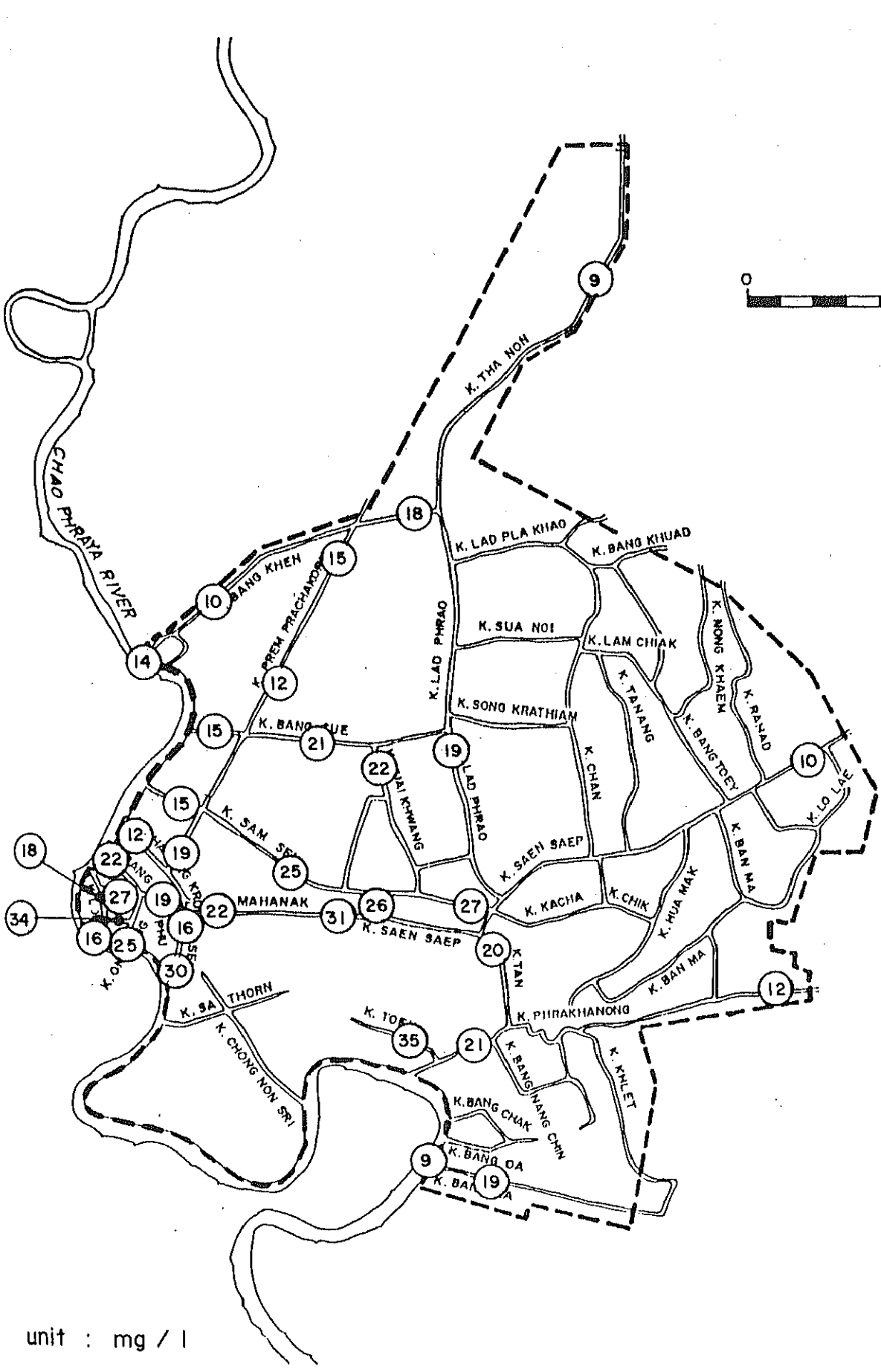


FIG. B. 28 (1) AVERAGE OBSERVED WATER QUALITY IN DRY SEASON 1988 (BOD)

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

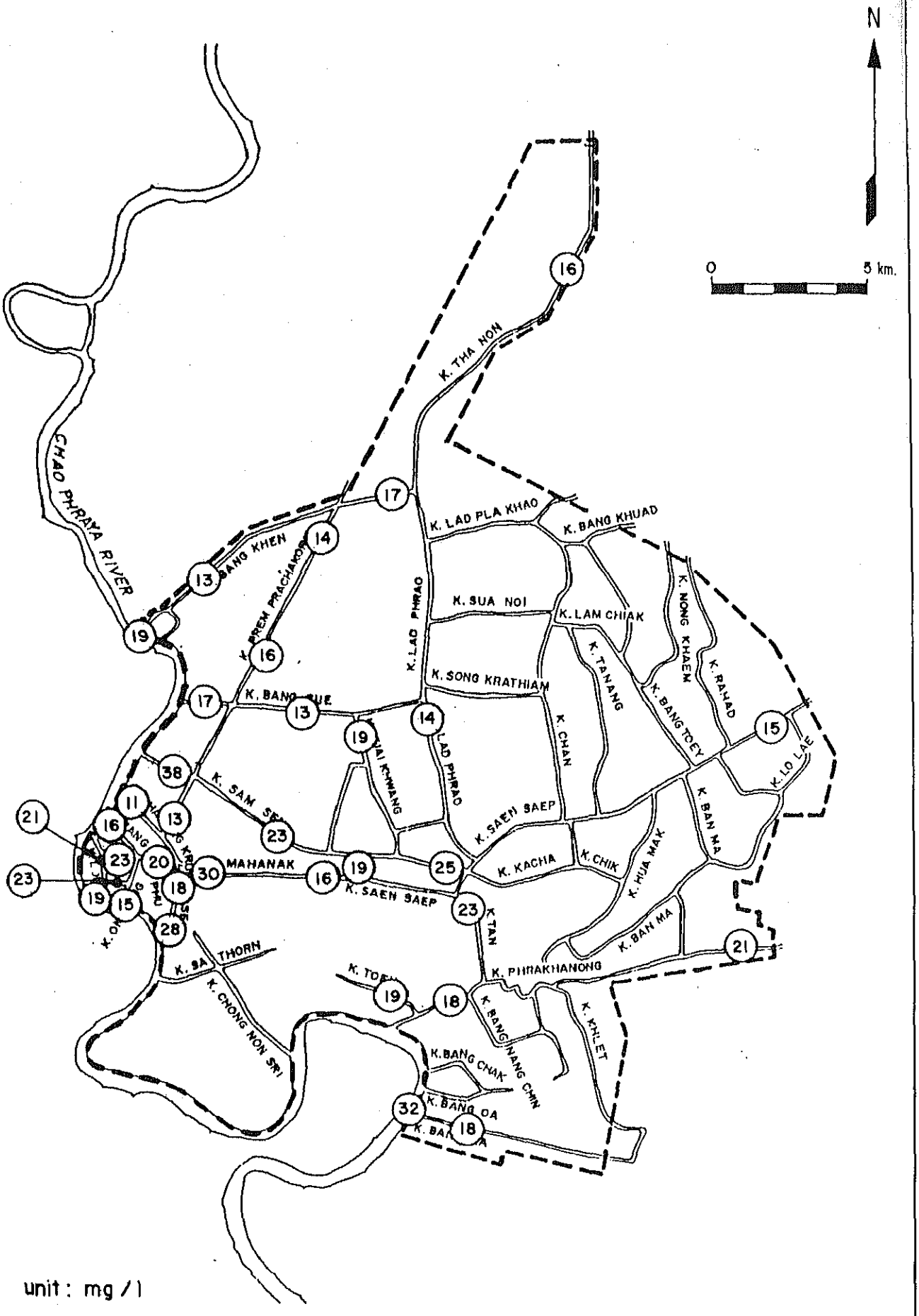


FIG. B.28(2) AVERAGE OBSERVED WATER QUALITY IN DRY SEASON 1988 (SS)

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

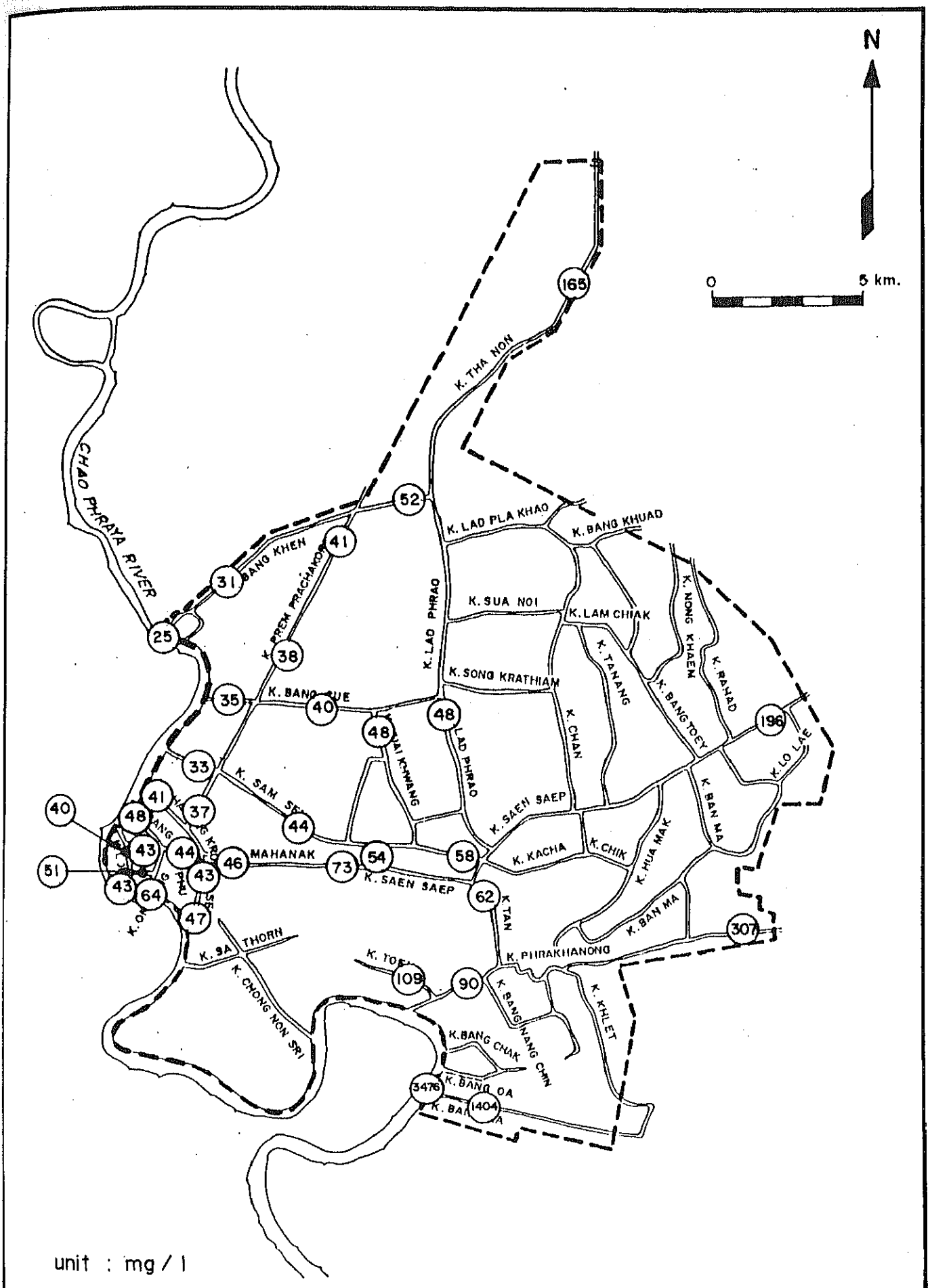


FIG. B.28(3) AVERAGE OBSERVED WATER QUALITY IN DRY SEASON 1988 (Cl^-)

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

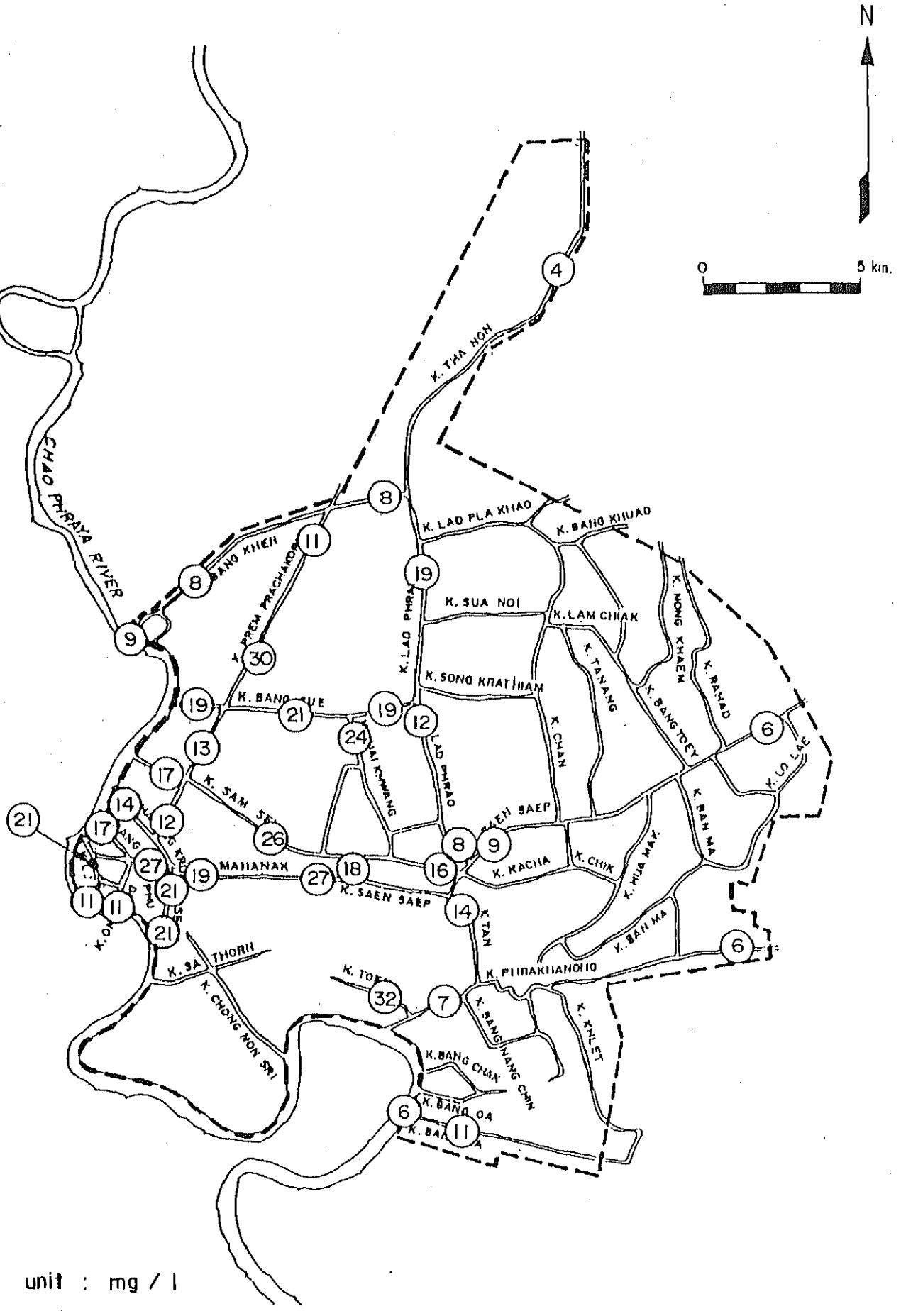
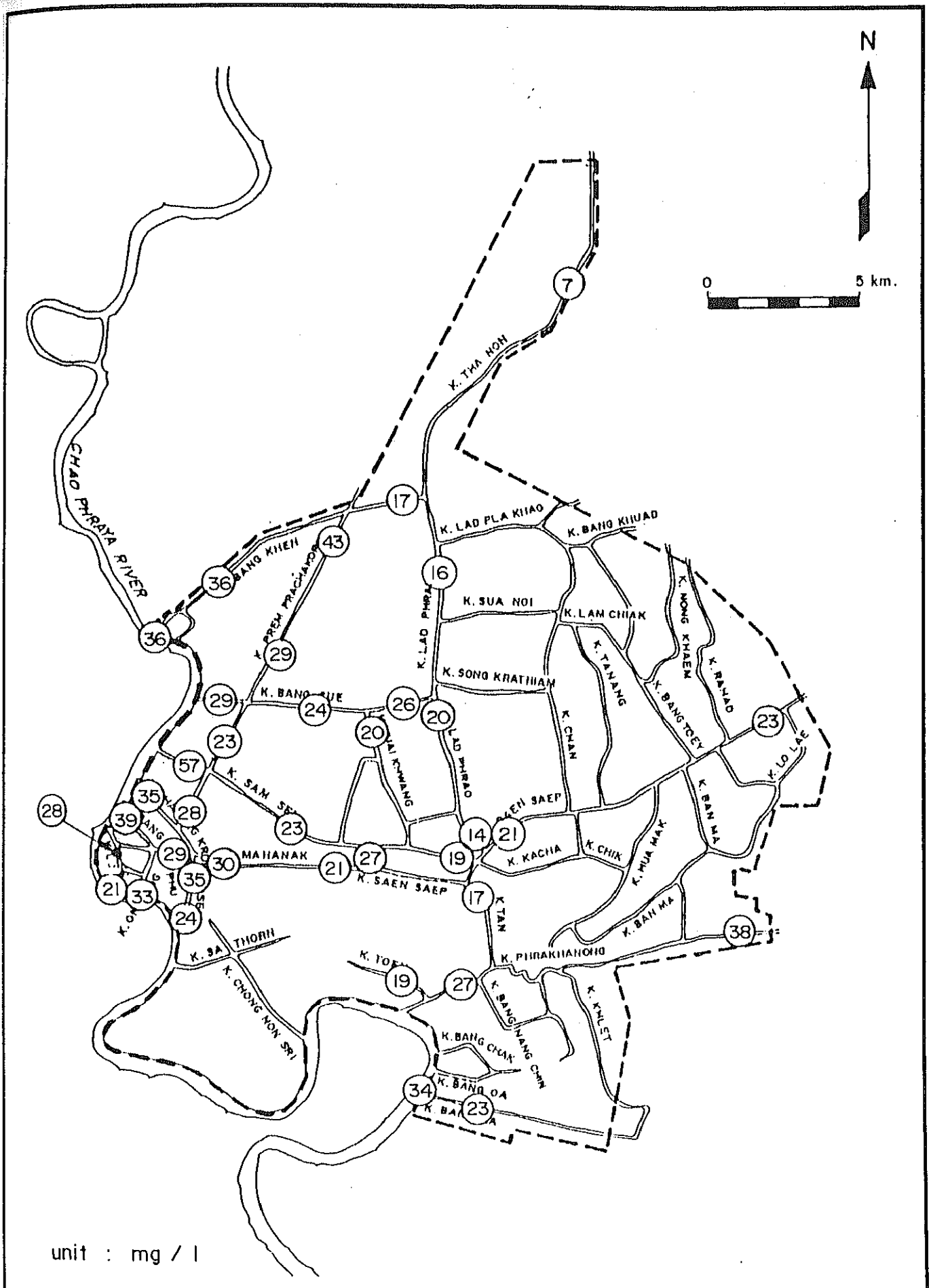


FIG. B.29 (1) AVERAGE OBSERVED WATER QUALITY IN RAINY SEASON 1988 (BOD)

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

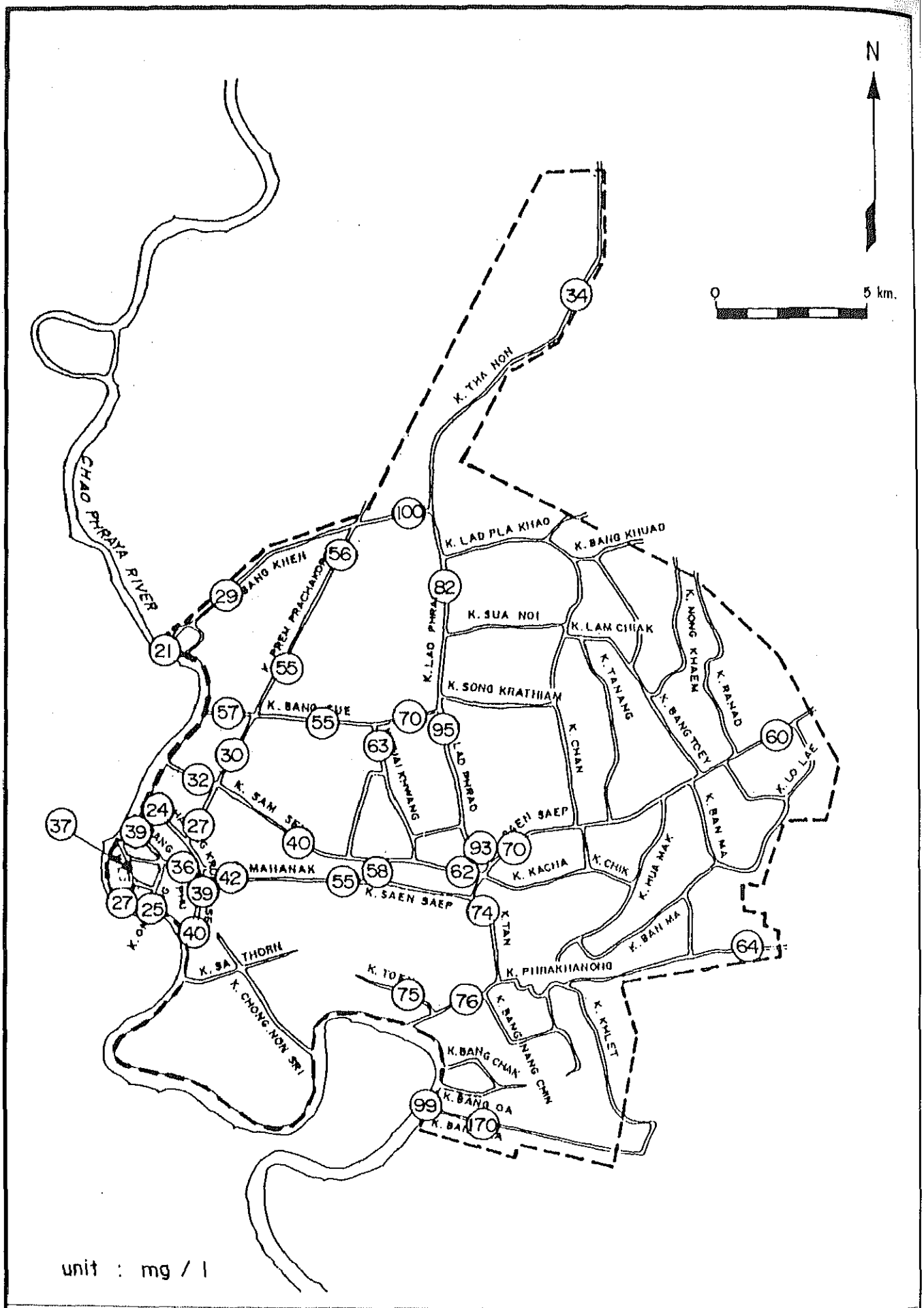


unit : mg / l

FIG. B.29(2) AVERAGE OBSERVED WATER QUALITY IN RAINY SEASON 1988 (SS)

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.



unit : mg / l

FIG. B.29(3) AVERAGE OBSERVED WATER QUALITY IN RAINY SEASON 1988 (Cl^-)

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

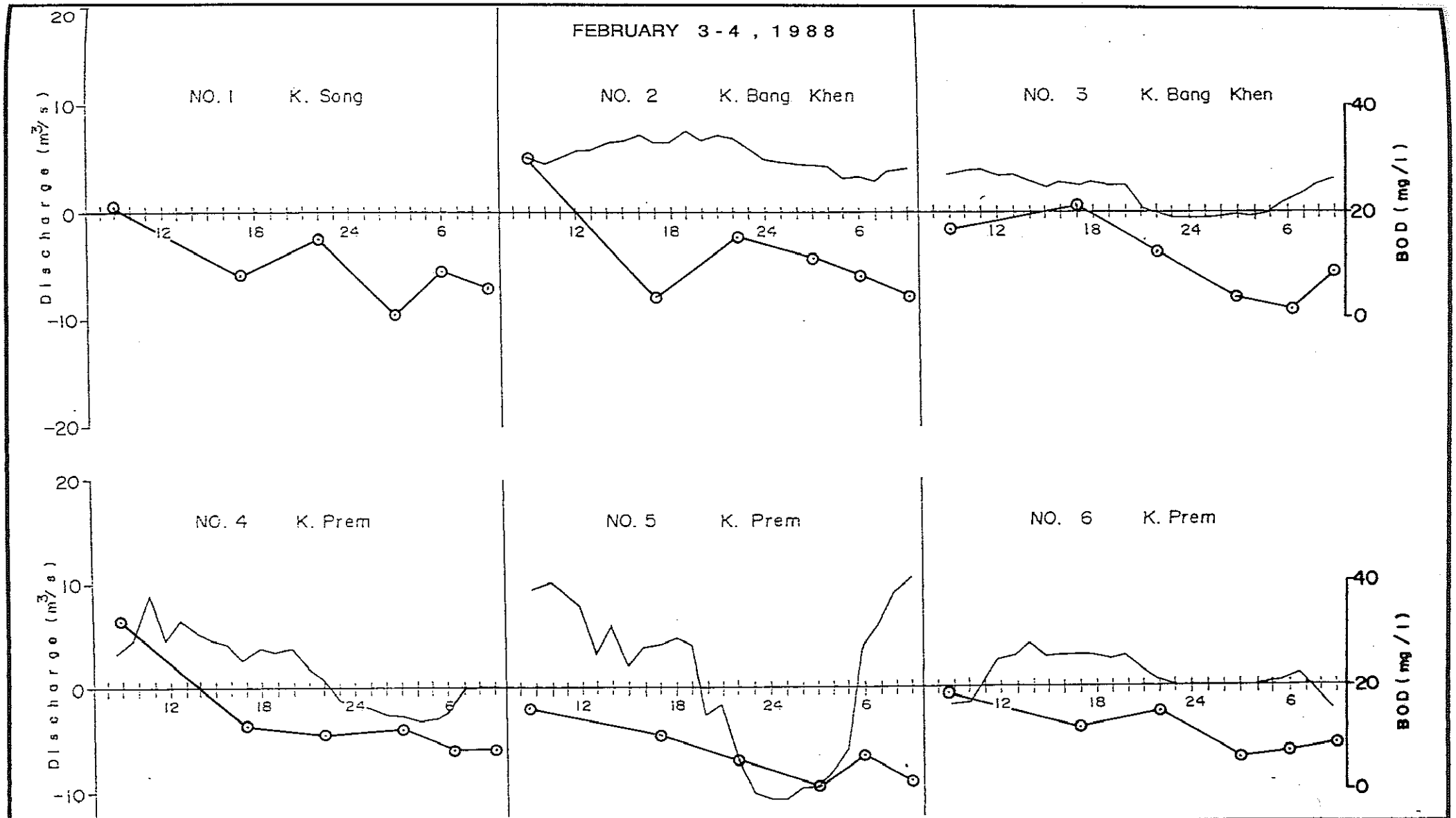


FIG. B.30(1) HOURLY VARIATION OF KLONG WATER QUALITY IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

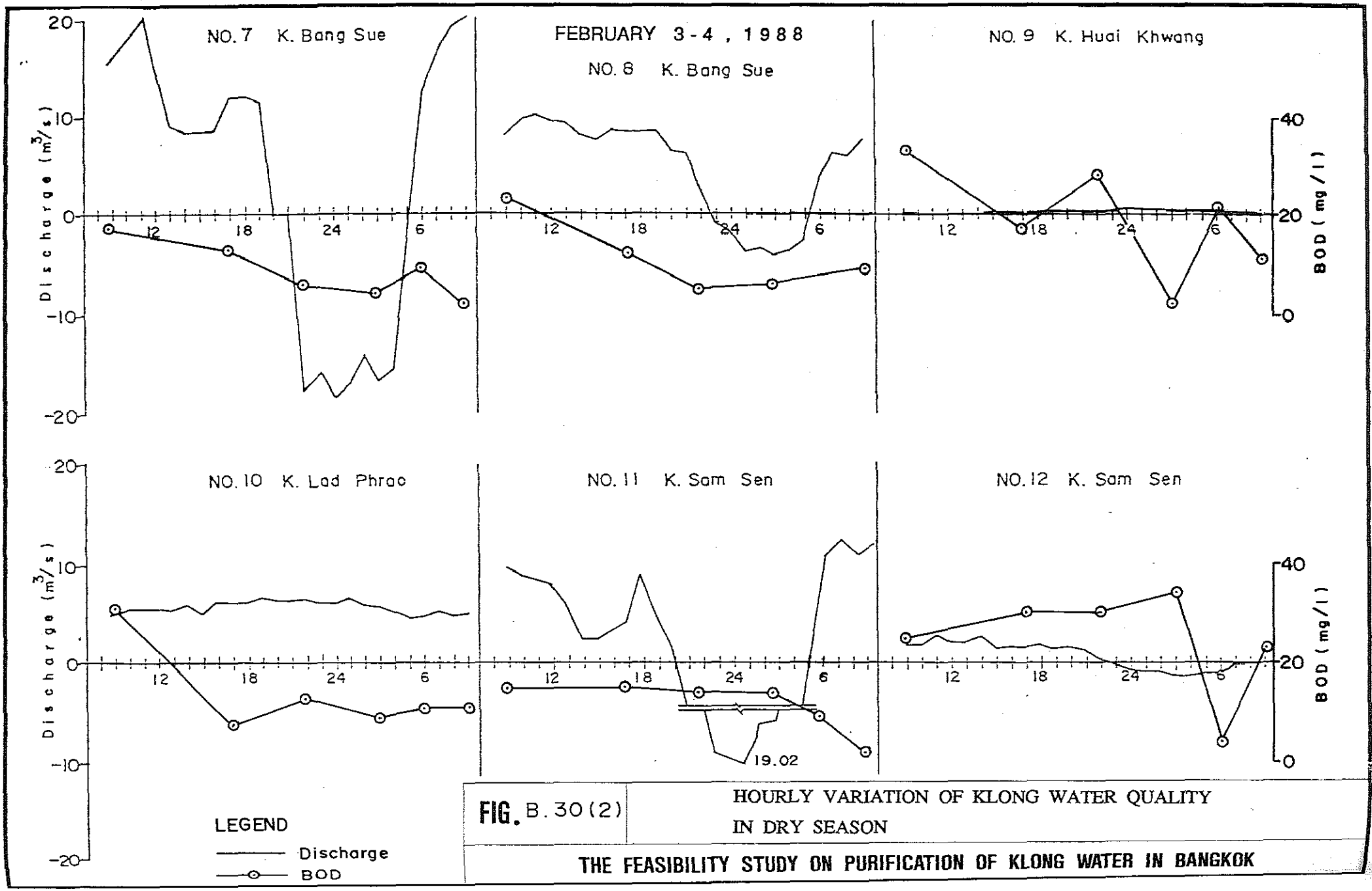


FIG. B.30(2) HOURLY VARIATION OF KLONG WATER QUALITY IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

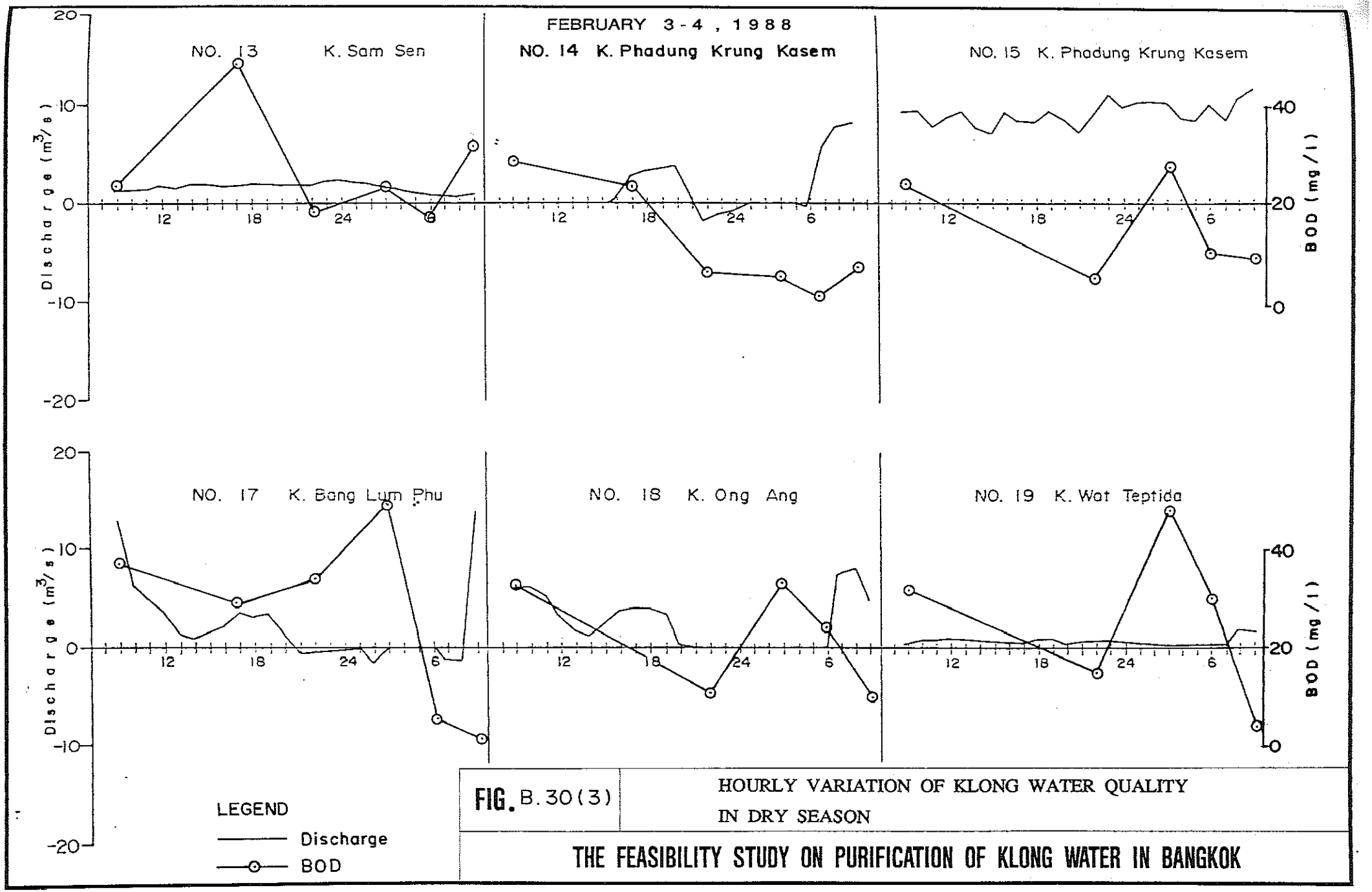


FIG. B.30(3) HOURLY VARIATION OF KLONG WATER QUALITY IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

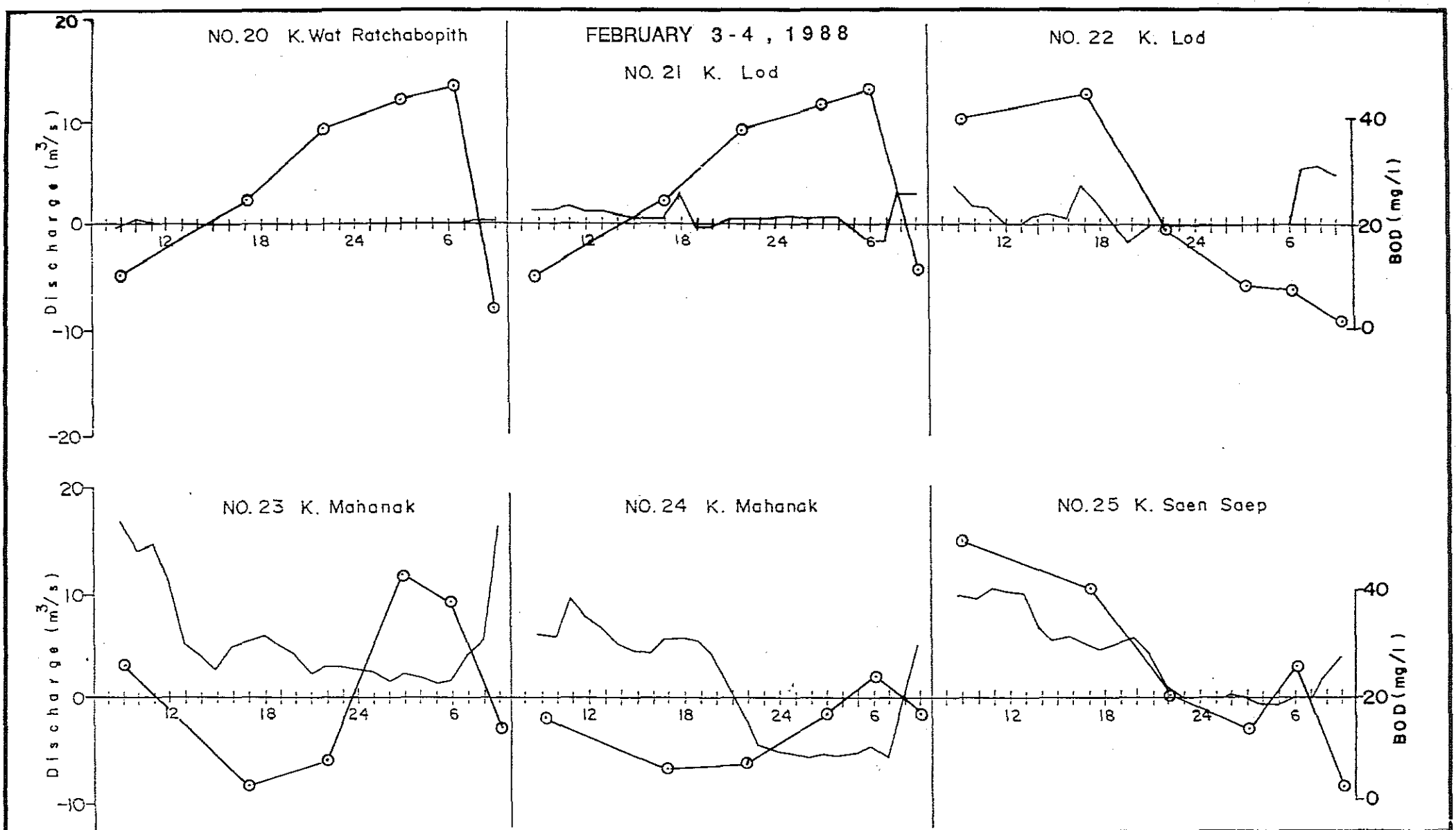


FIG. B.30 (4) HOURLY VARIATION OF KLONG WATER QUALITY IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

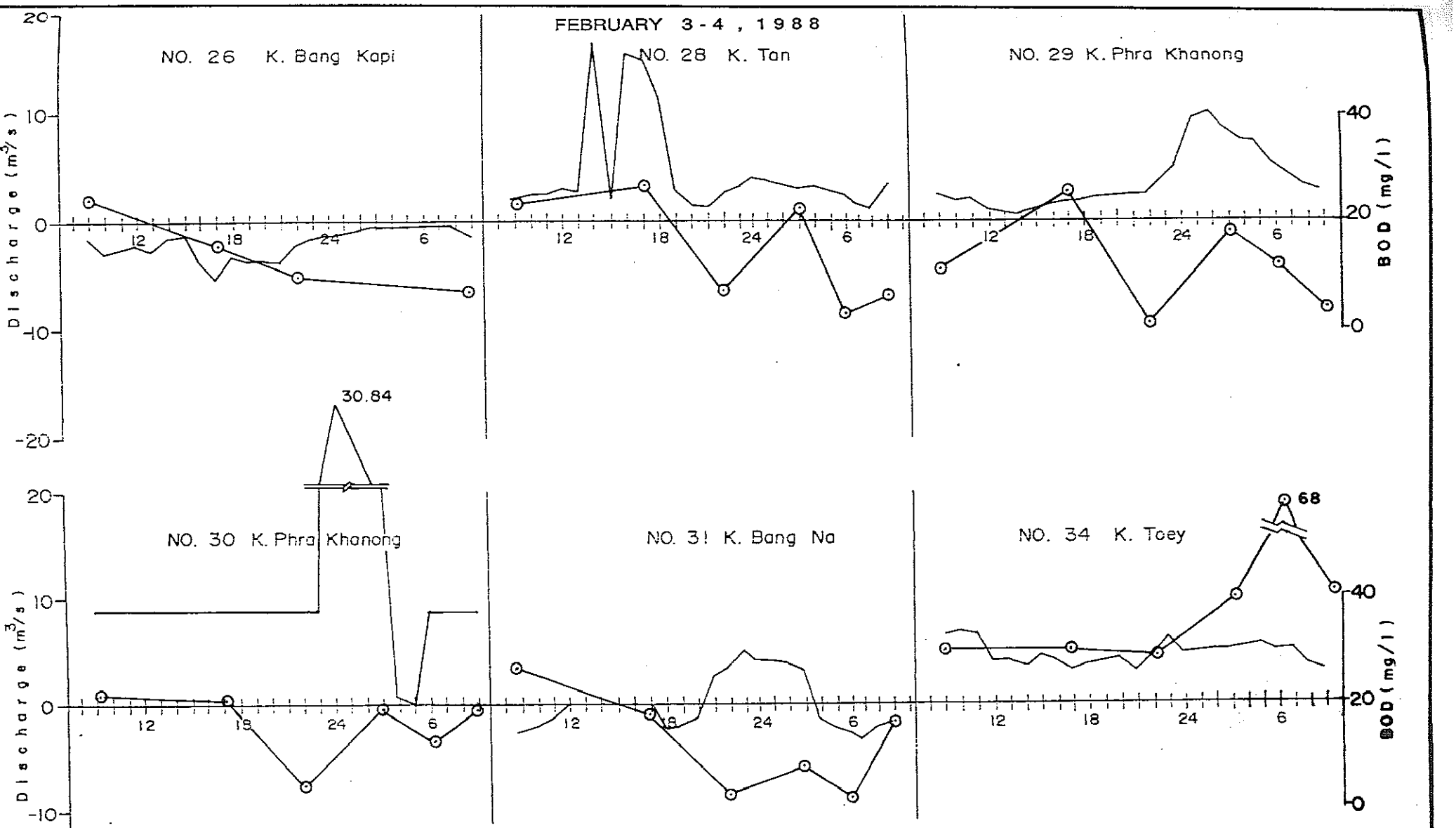


FIG. B.30(5) HOURLY VARIATION OF KLONG WATER QUALITY IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532 B.E. 1989 A.D.

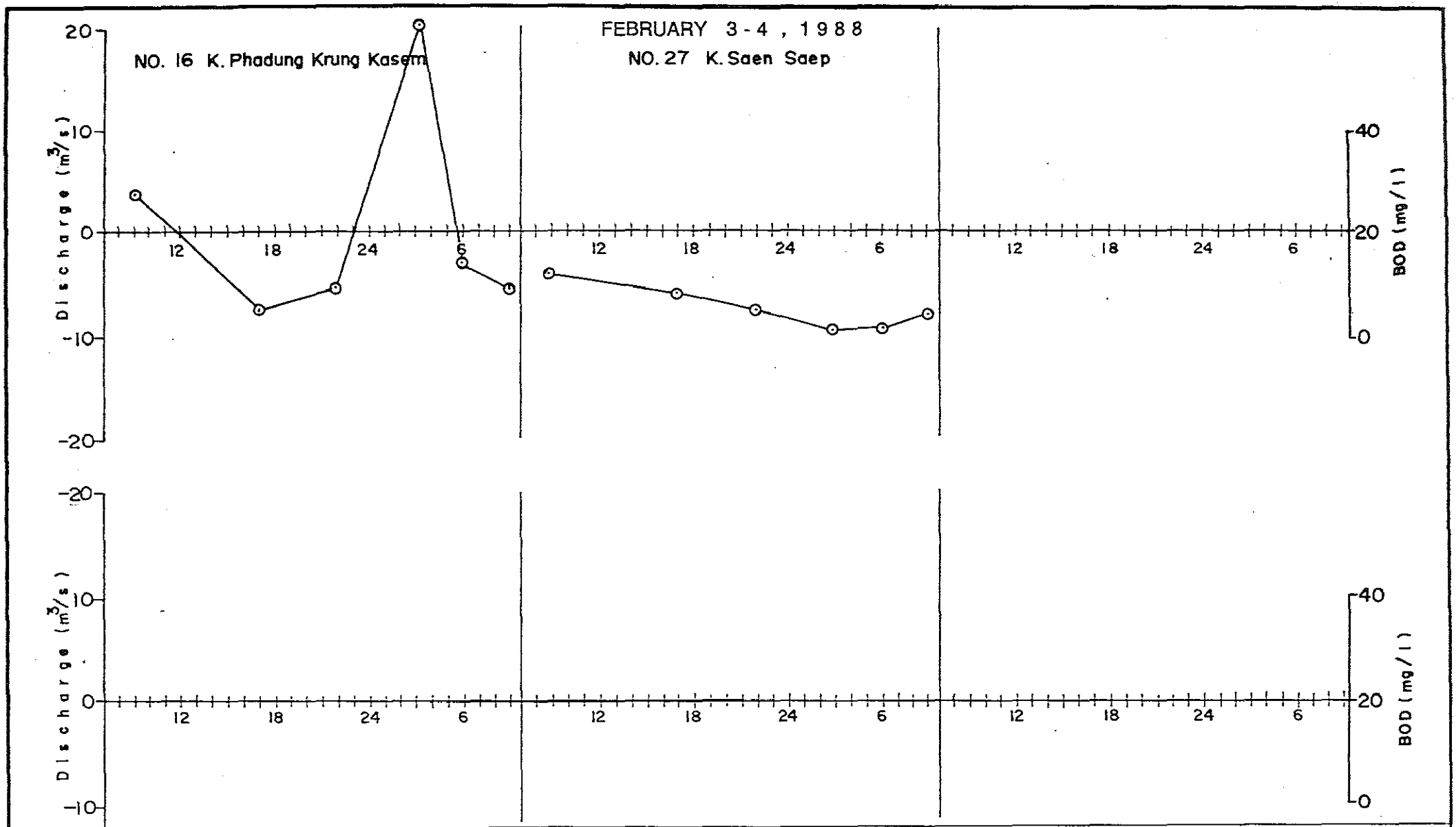


FIG. B.30 (6) HOURLY VARIATION OF KLONG WATER QUALITY IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532 B.E. 1989 A.D.

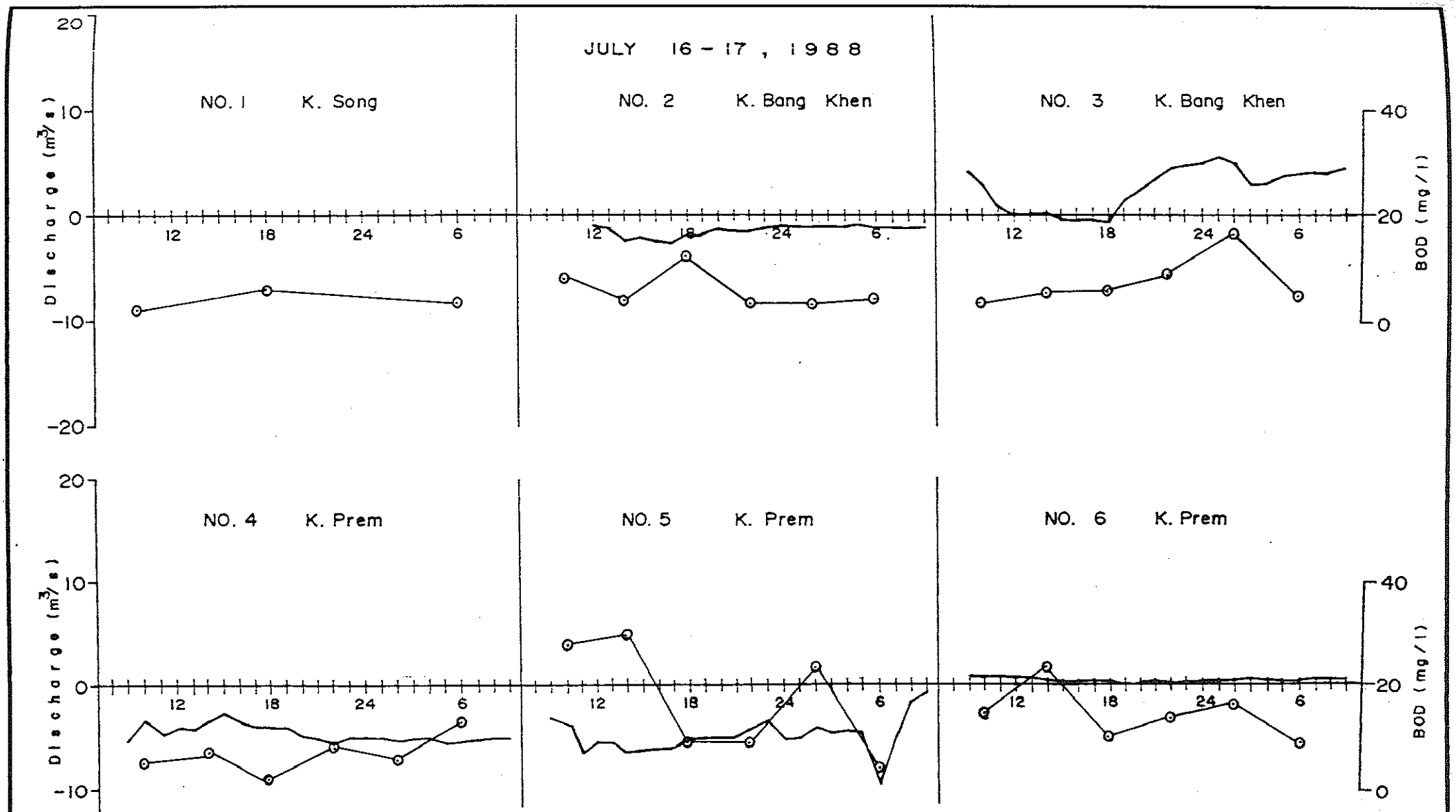


FIG. B.31(1) HOURLY VARIATION OF KLONG WATER QUALITY IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

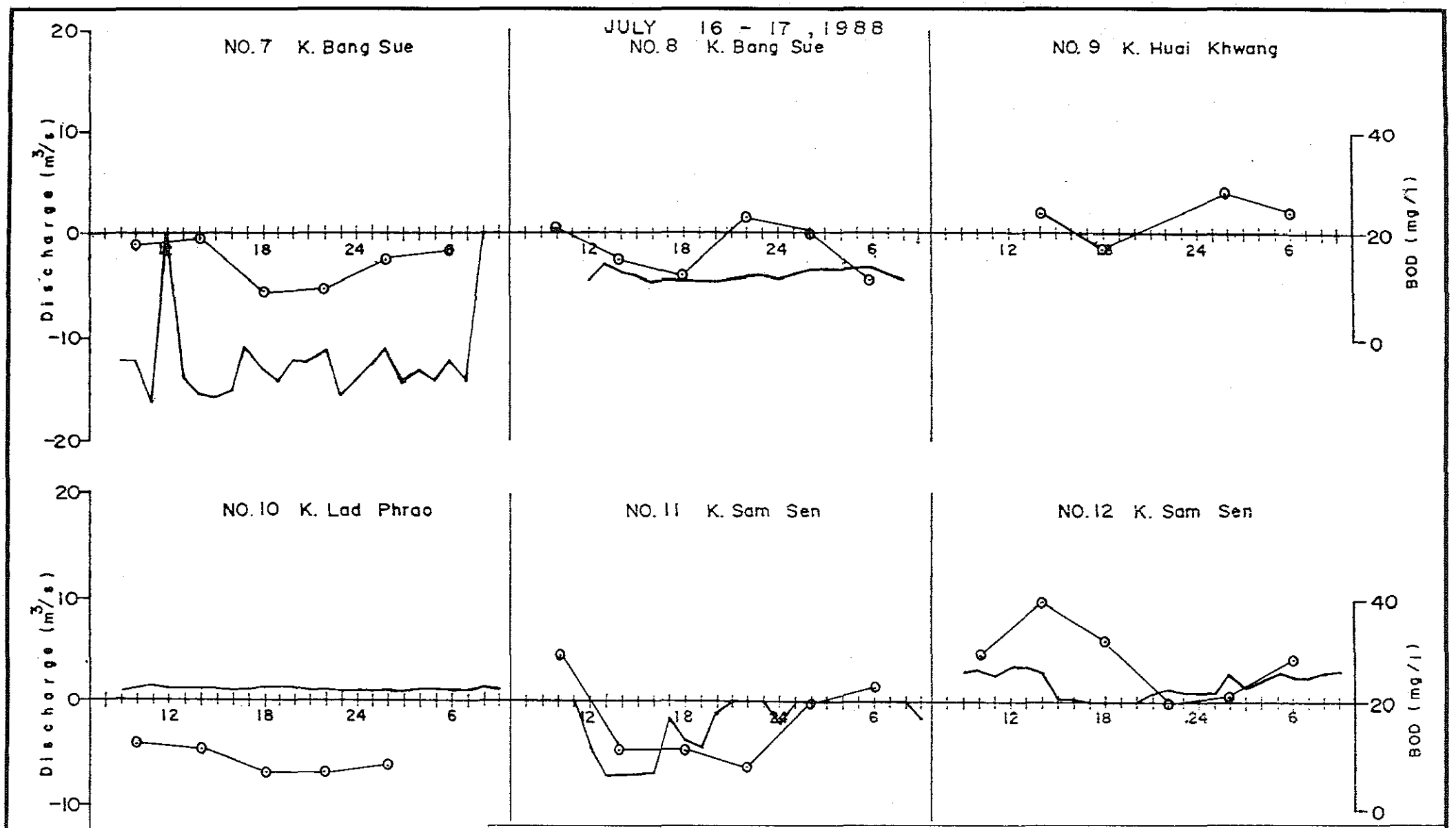


FIG. B.31(2) HOURLY VARIATION OF KLONG WATER QUALITY IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

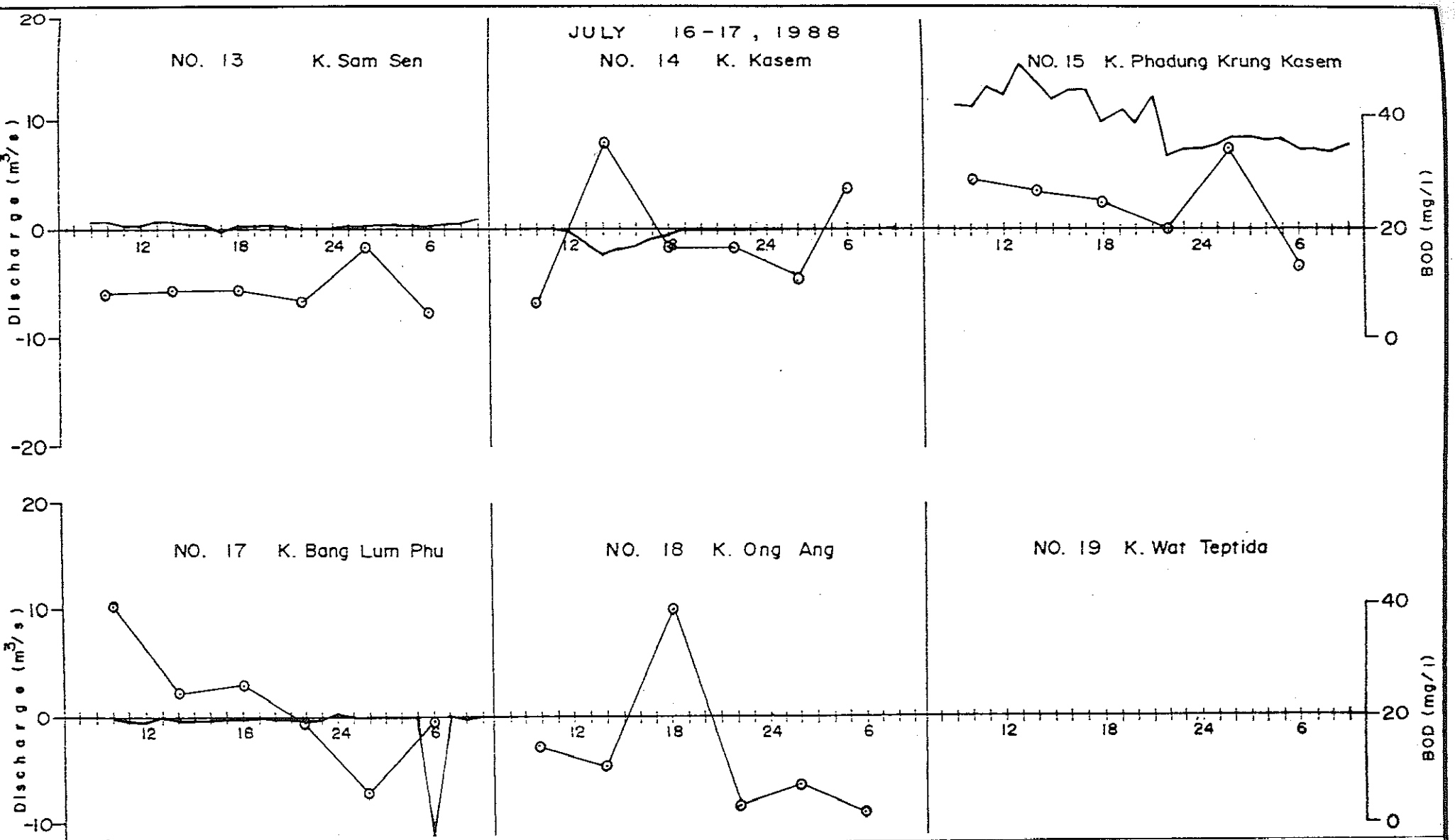


FIG. B.31(3) HOURLY VARIATION OF KLONG WATER QUALITY IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

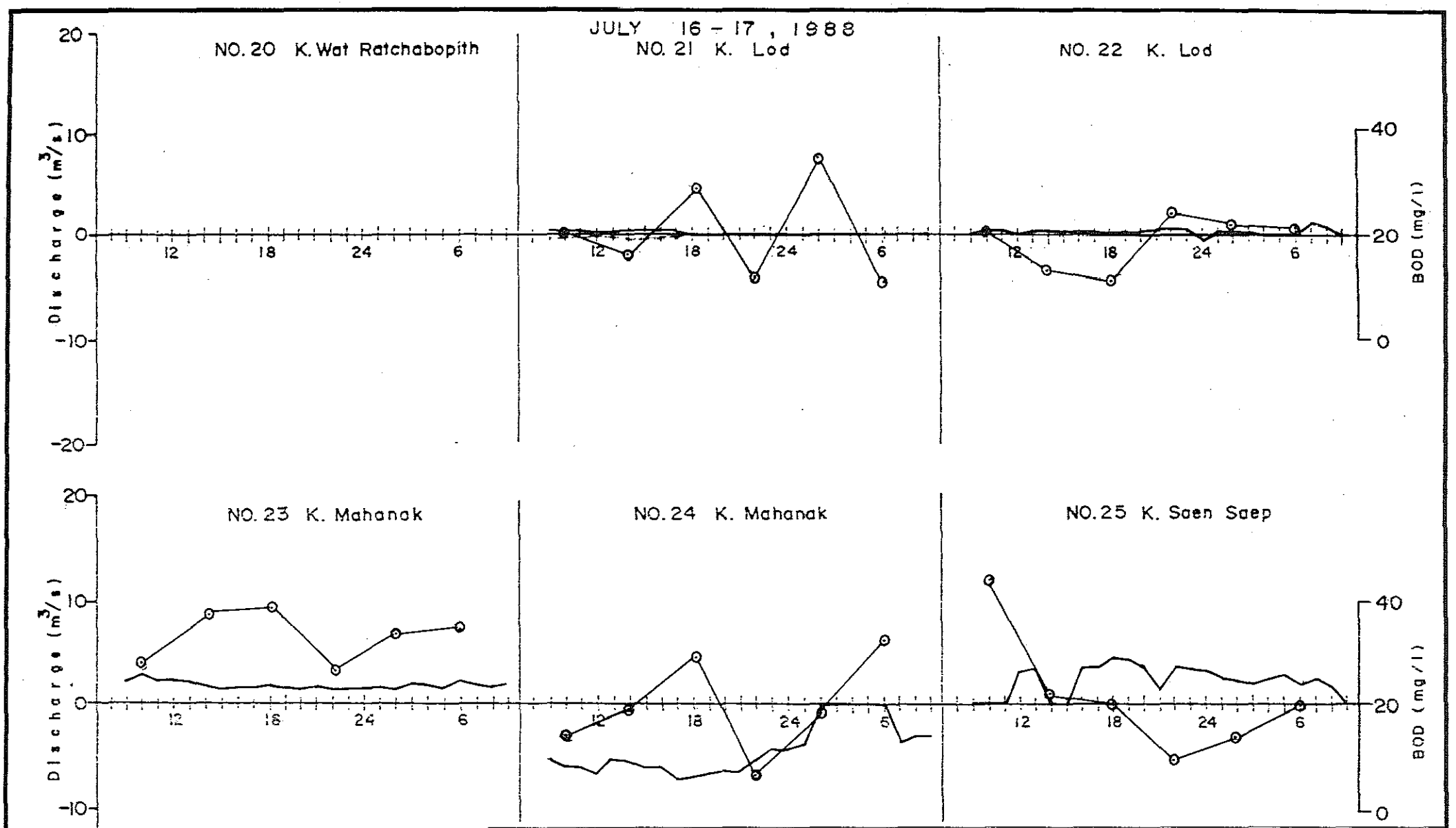


FIG. B.31(4) HOURLY VARIATION OF KLONG WATER QUALITY IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

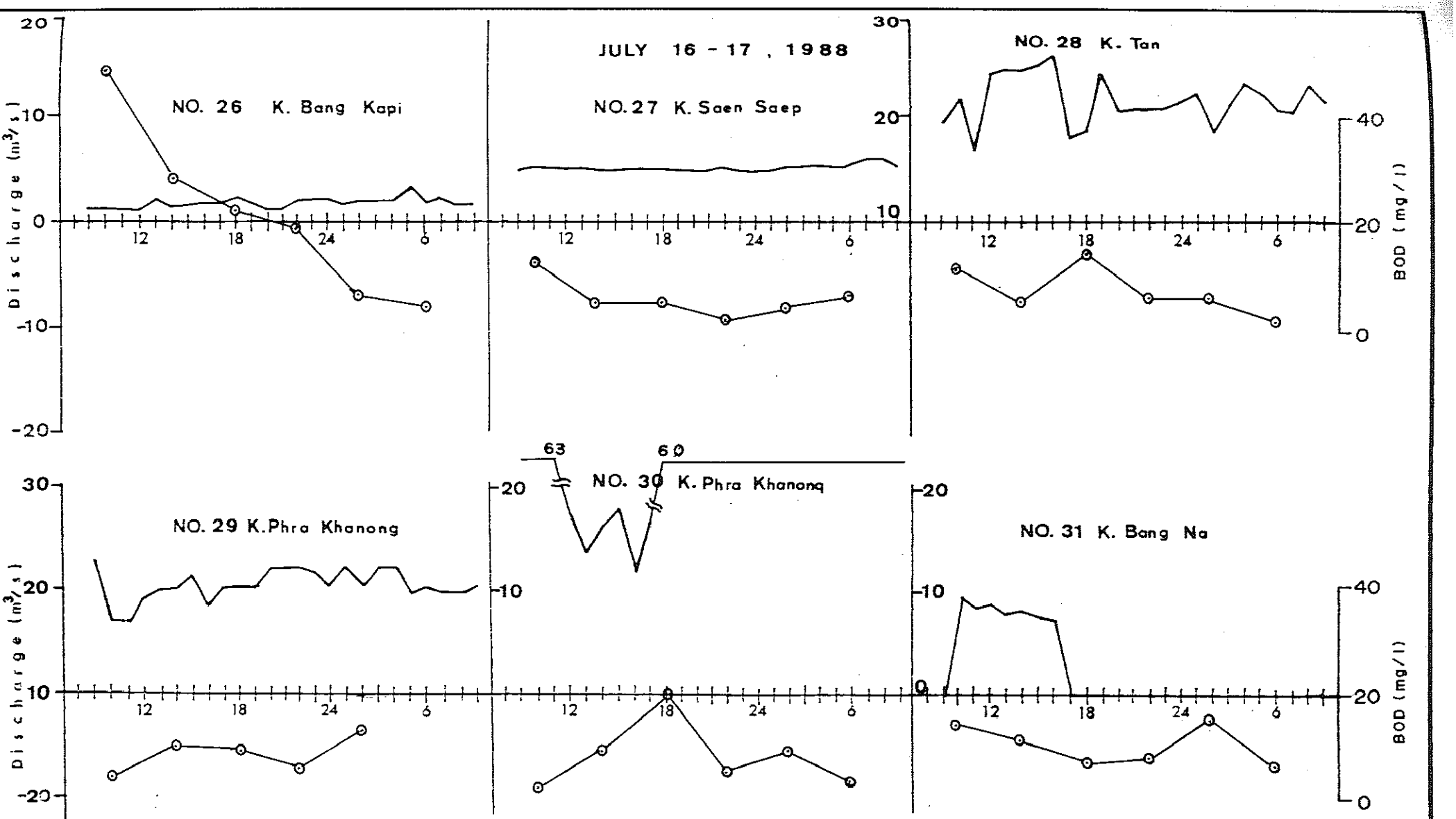


FIG. B.3.1(5) HOURLY VARIATION OF KLONG WATER QUALITY IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

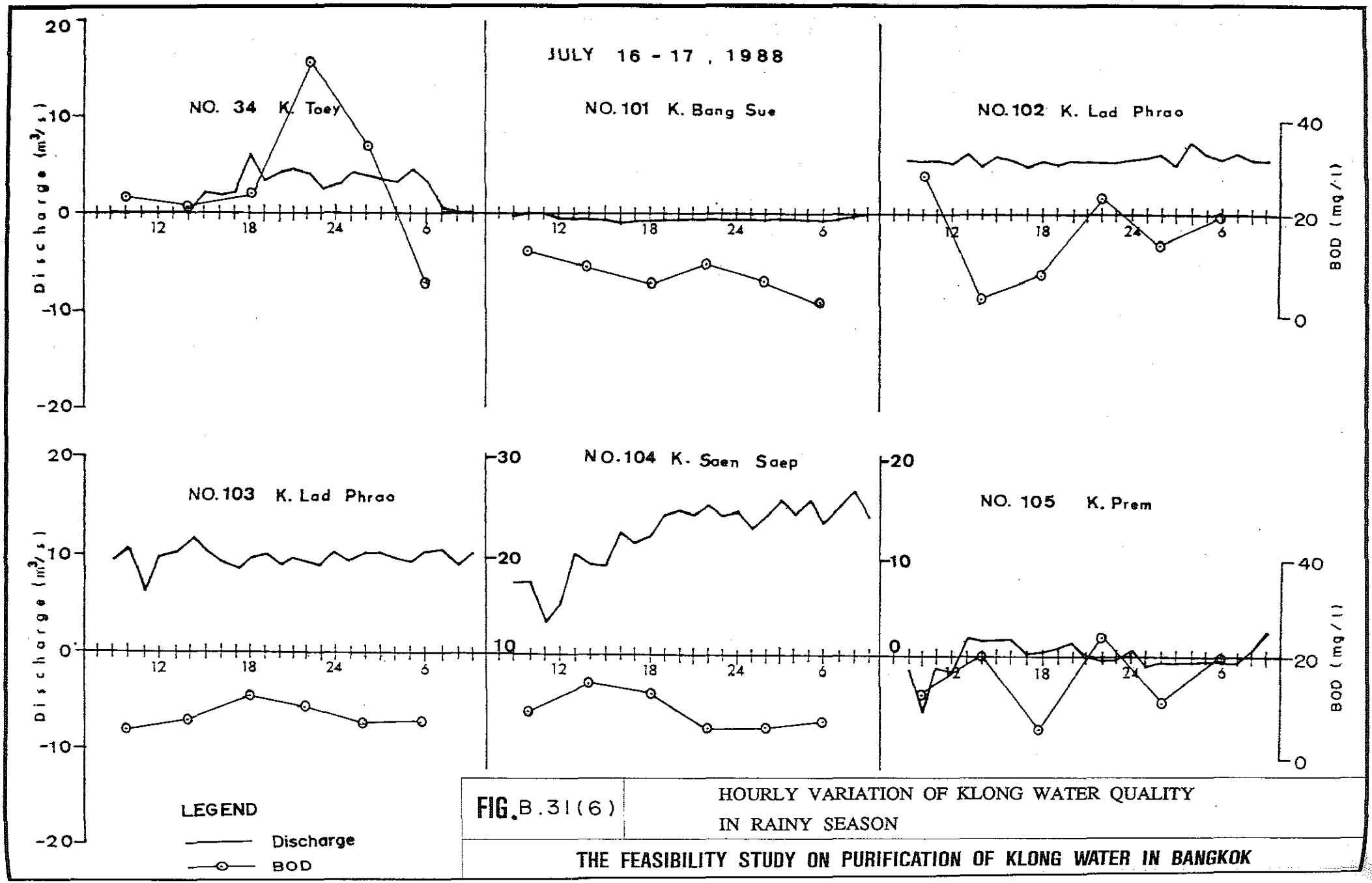


FIG. B.3.1(6) HOURLY VARIATION OF KLONG WATER QUALITY IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

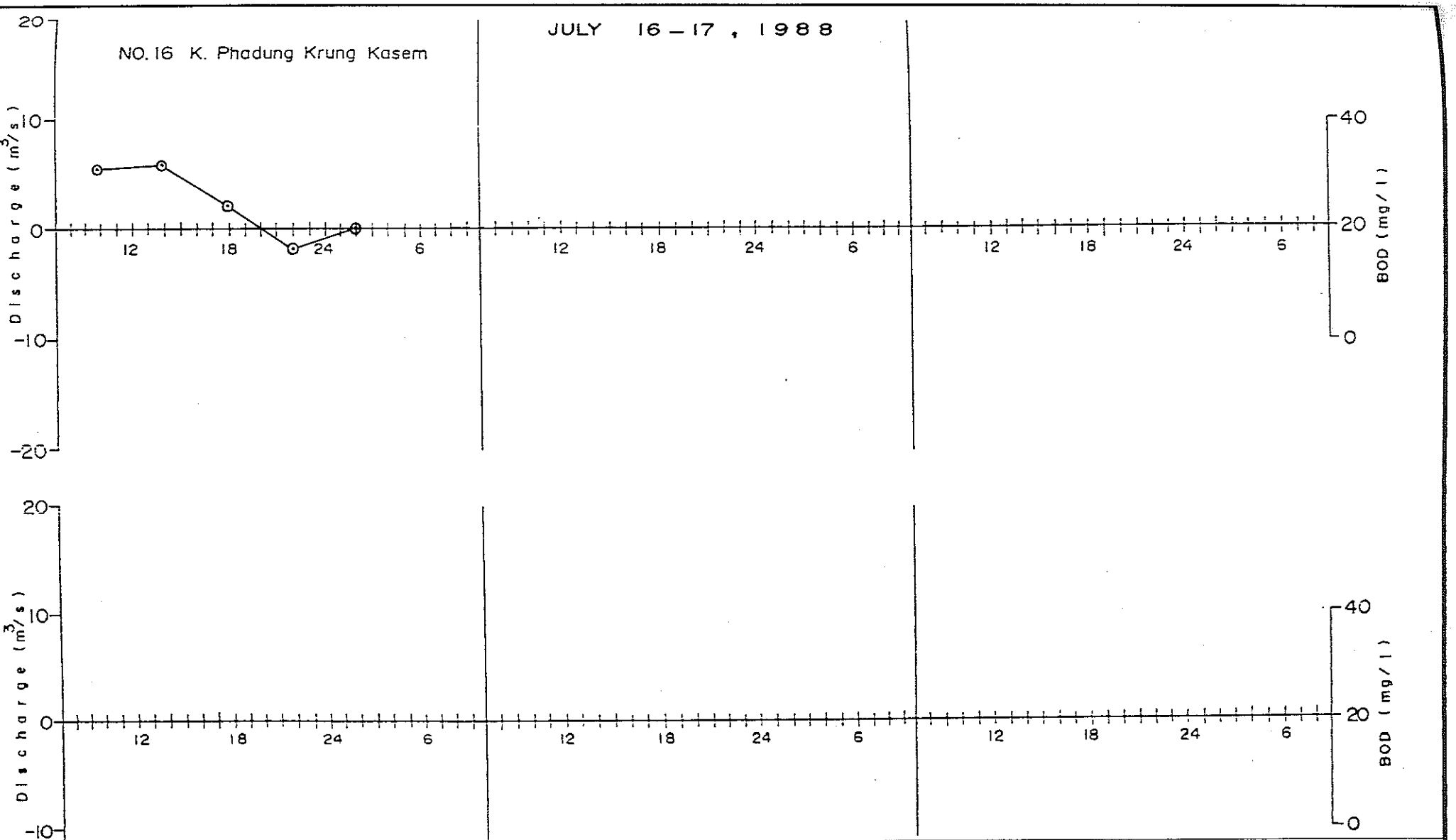
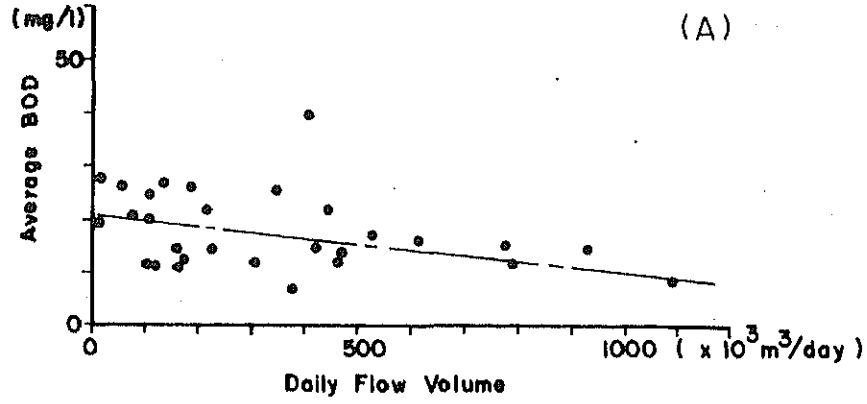
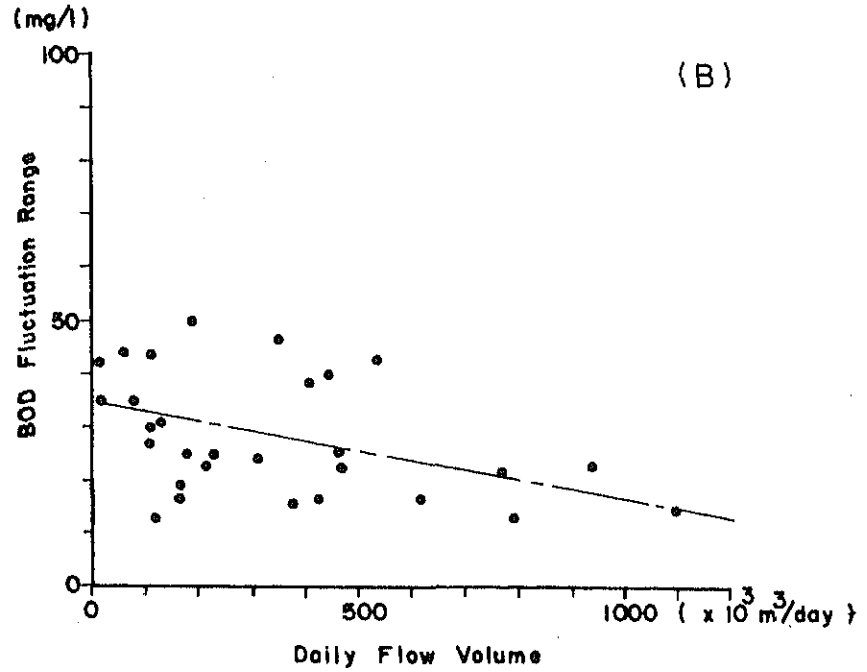


FIG. B.31(7) HOURLY VARIATION OF KLONG WATER QUALITY IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.





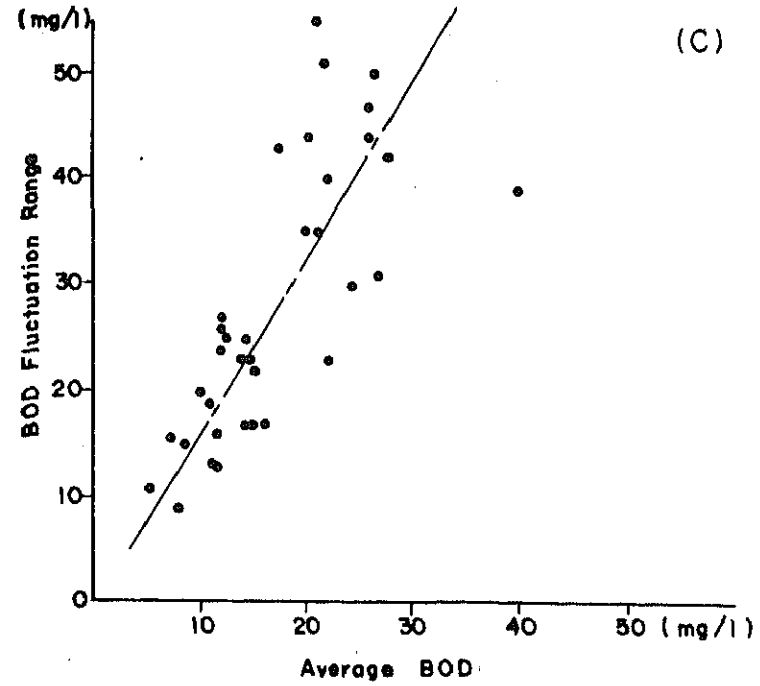
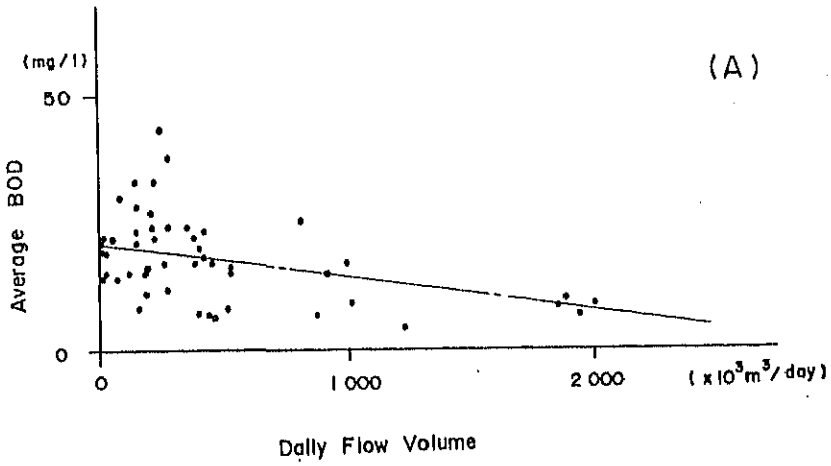
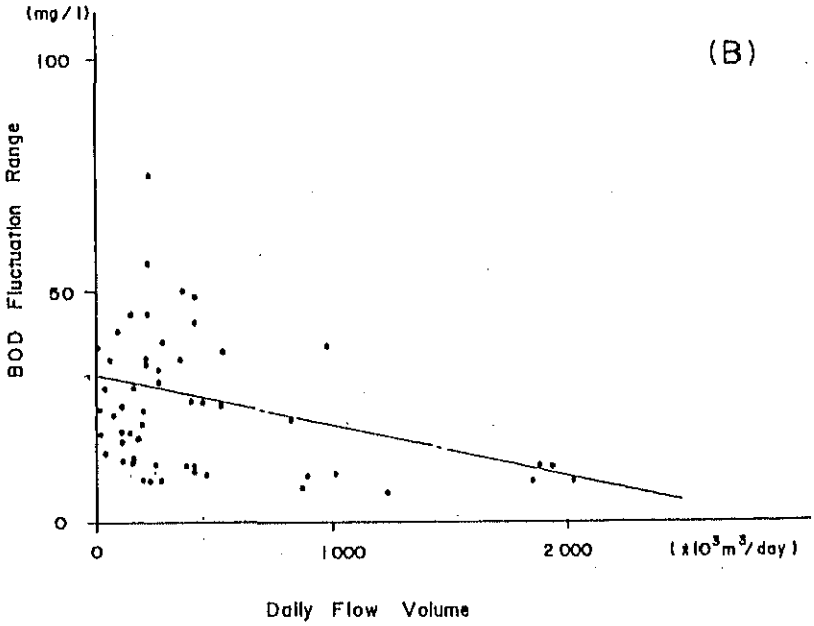


FIG. B.32(1) RELATION AMONG DAILY FLOW VOLUME, AVERAGE-BOD AND BOD-FLUCTUATION RANGE (IN DRY SEASON)

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.





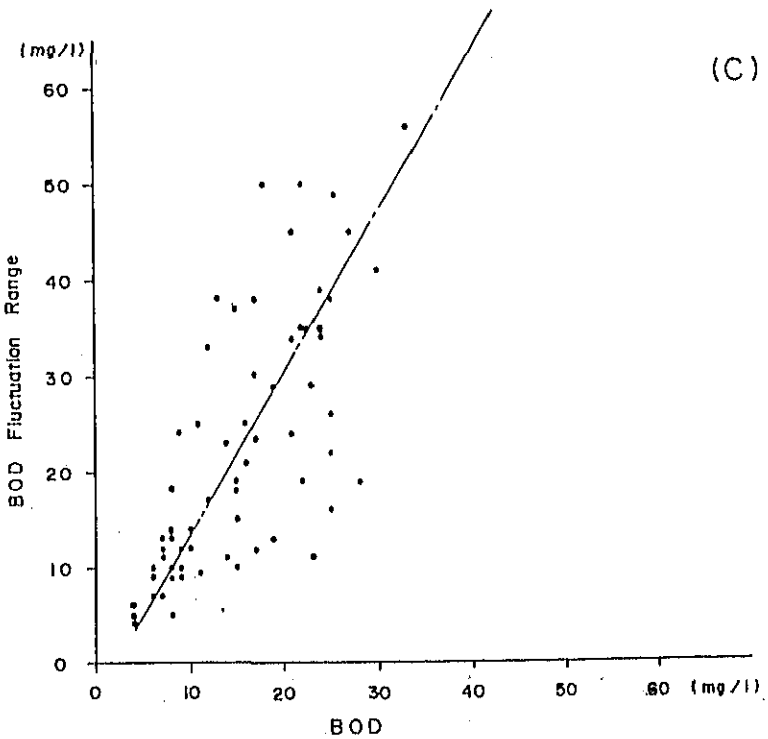


FIG. B.32(2) RELATION AMONG DAILY FLOW VOLUME, AVERAGE-BOD AND BOD-FLUCTUATION RANGE (IN RAINY SEASON)

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

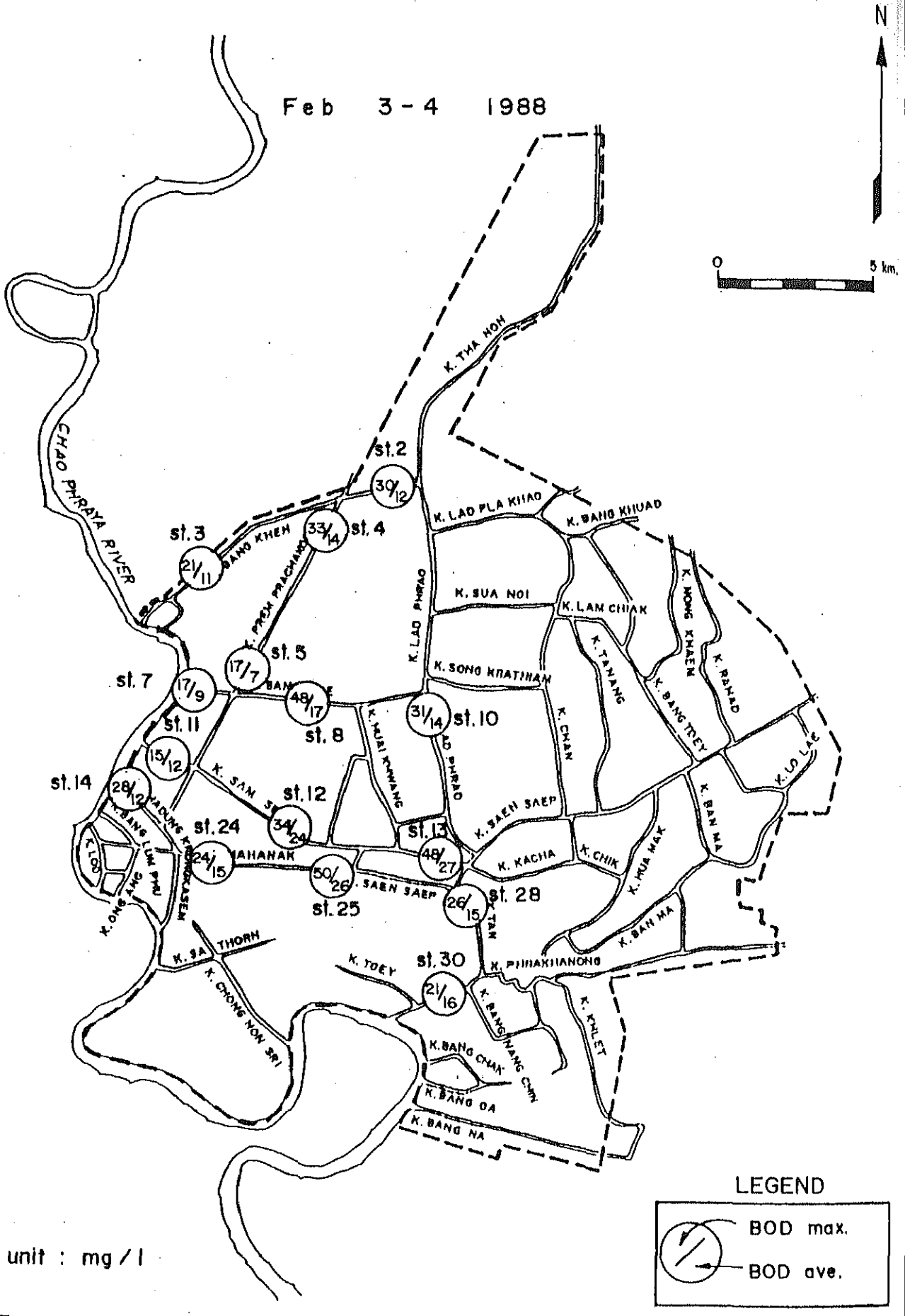


FIG. B.33 WATER QUALITY VARIATION ALONG KLONG WATER FLOW ROUTE IN DRY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

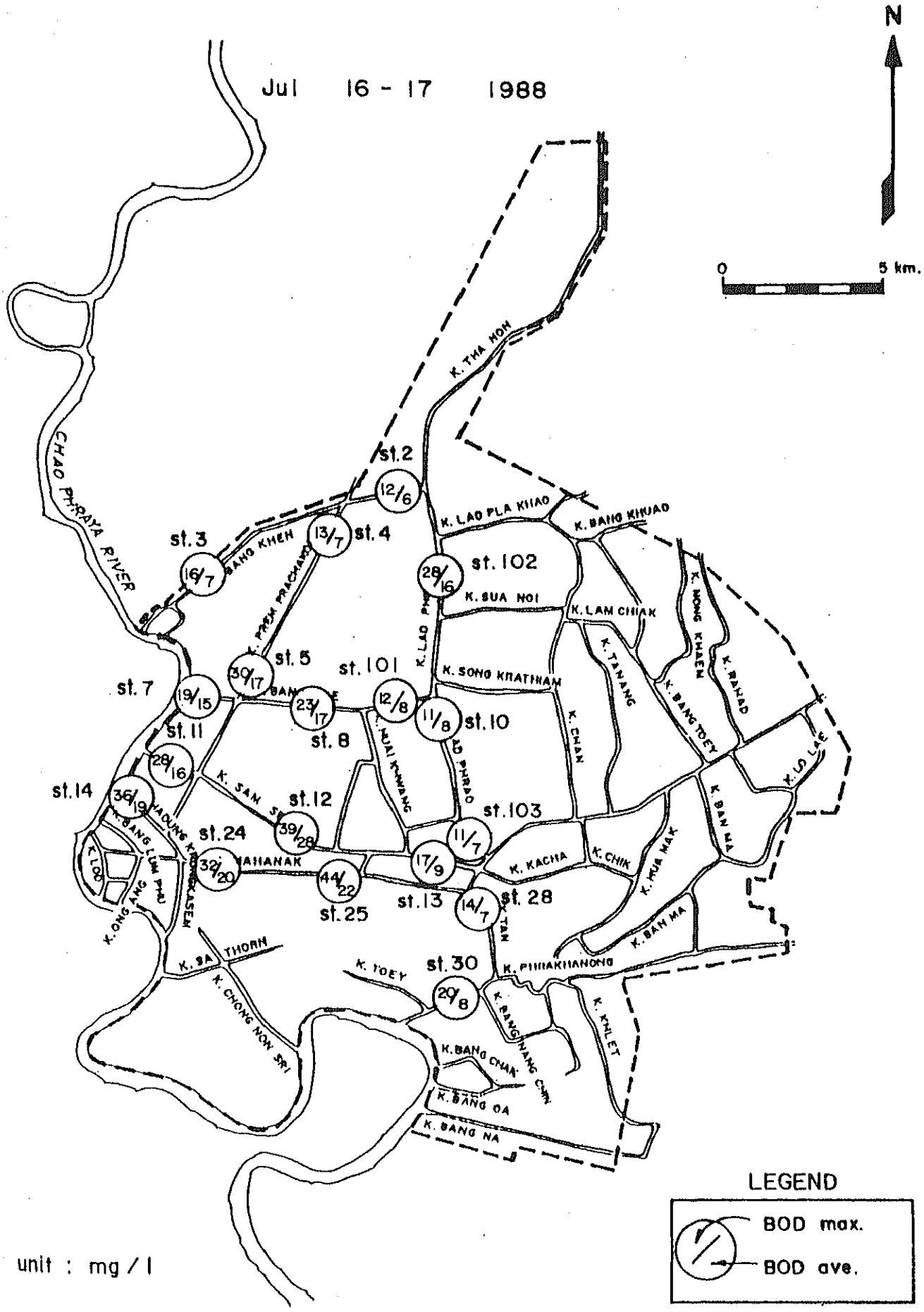
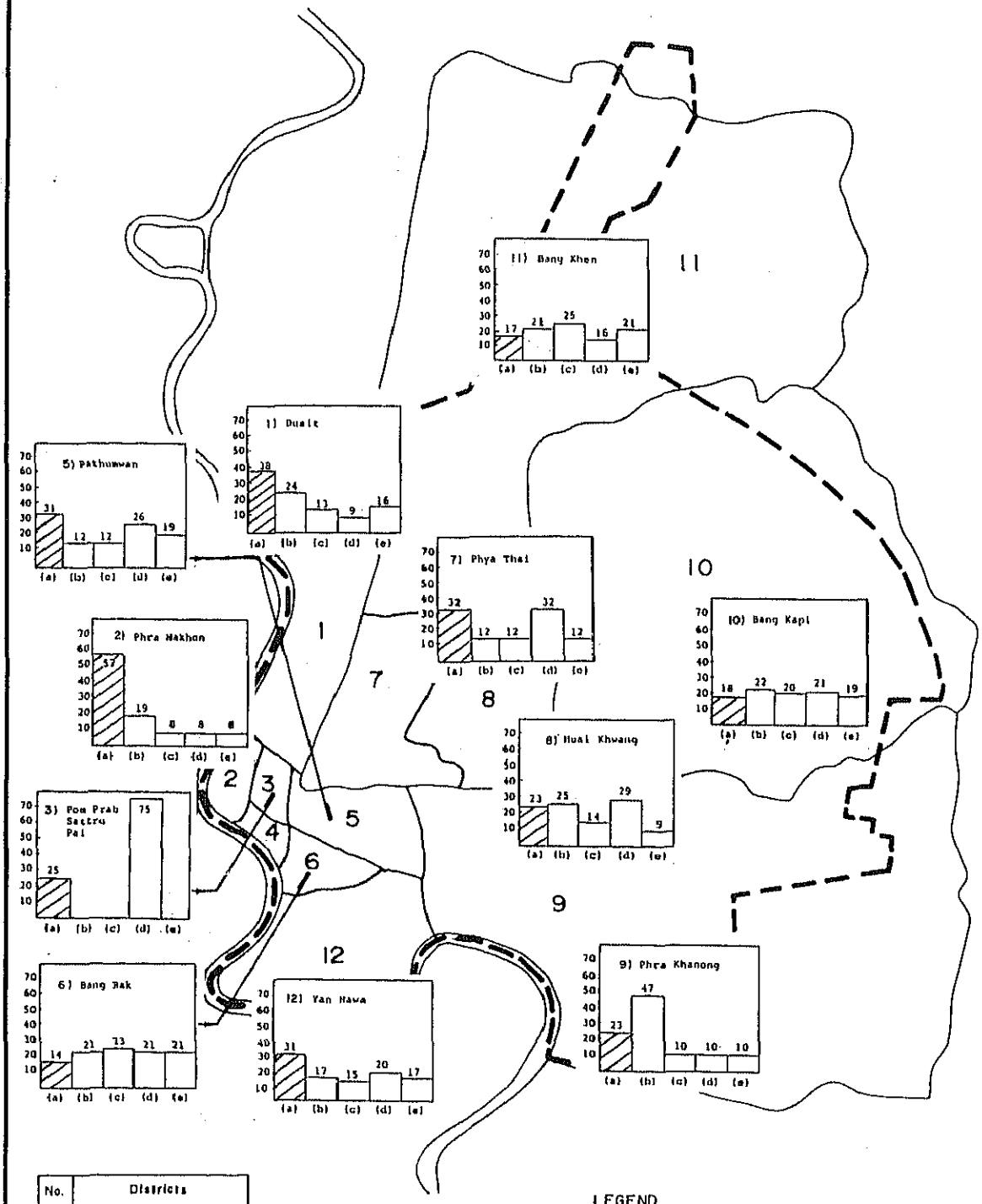


FIG. B.34 WATER QUALITY VARIATION ALONG KLONG WATER FLOW ROUTE IN RAINY SEASON

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.



No.	Districts
1	Dusit
2	Phra Nakhon
3	Pom Prab Sattru Pol
4	SamPanthawong
5	Pathumwan
6	Bang Rak
7	Phya Thai
8	Huai Khwang
9	Phra Khanong
10	Bang Kapi
11	Bang Khen
12	Yan Nawa

LEGEND

——— Districts

— — — Study Area

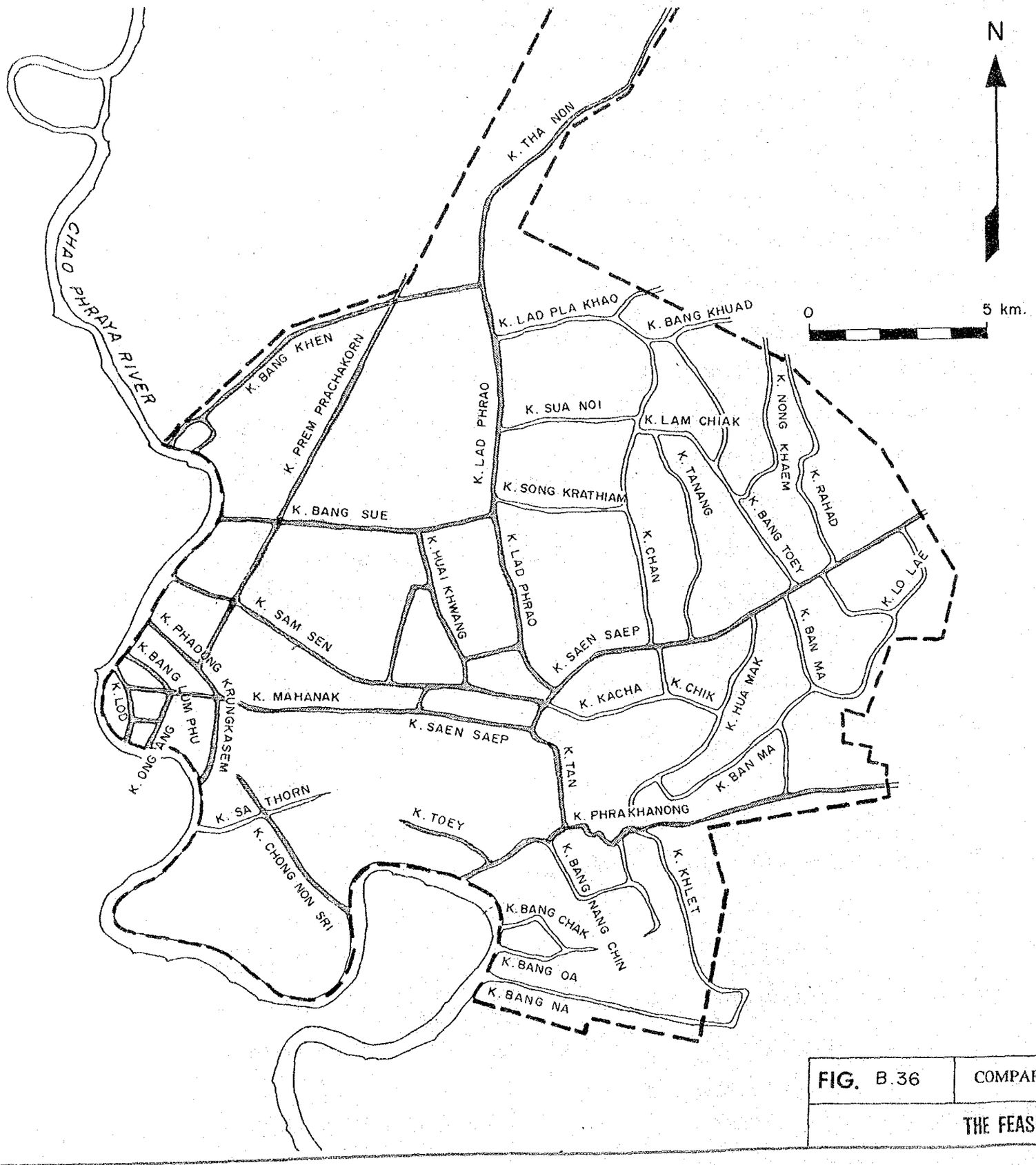
NOTE

* A bar over a particular project expresses the percentage of interviewees who answered the project is the most important.

(a): Purification of Klong Water
(b): Mitigation of Floods
(c): New Construction/Expansion of Water Supply System
(d): New Construction/Expansion of Sewerage System
(e): New Construction/Improvement of Roads

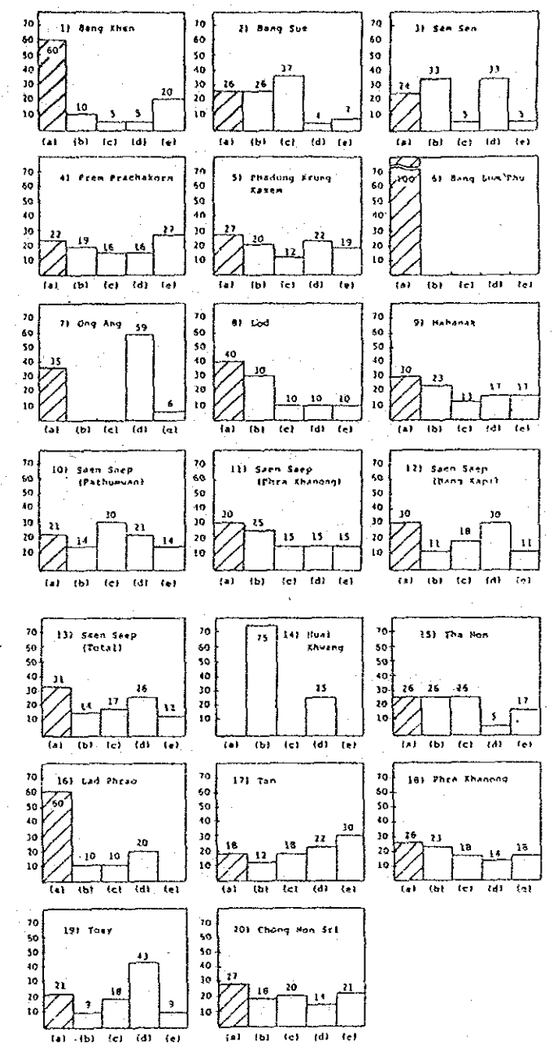
FIG. B.35 COMPARATIVE RANKING OF MAJOR PROJECTS BY DISTRICTS

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK



By Klong

* Based on answers by interviewees living near a particular Klong

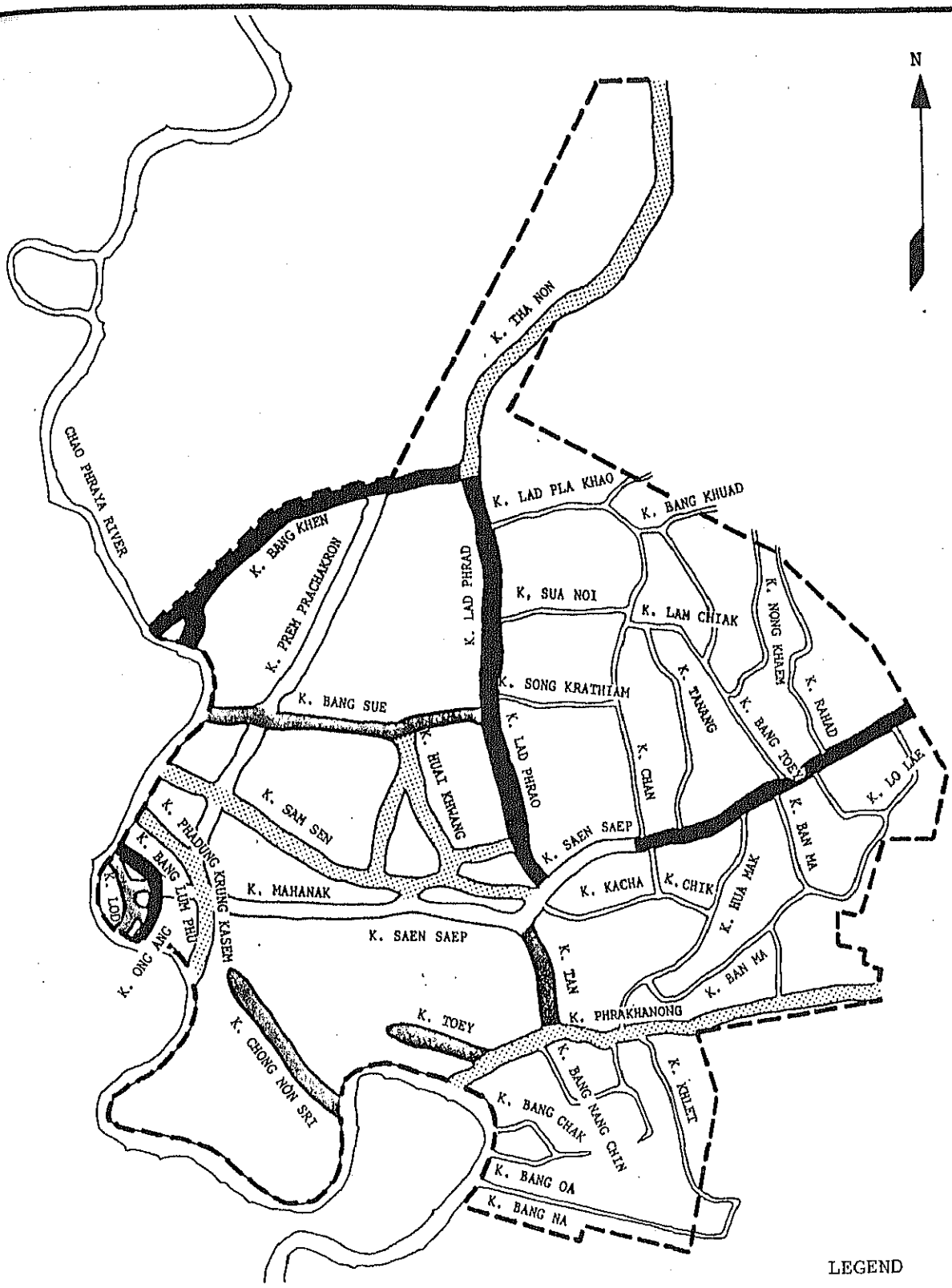


* A bar over a particular project expresses the percentage of interviewees who answered the project is the most important.

(a): Purification of Klong Water
(b): Mitigation of Floods
(c): New Construction/Expansion of Water Supply System
(d): New Construction/Expansion of Sewerage System
(e): New Construction/Improvement of Roads

FIG. B.36 COMPARATIVE RANKING OF MAJOR PROJECTS BY KLONGS

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK



LEGEND

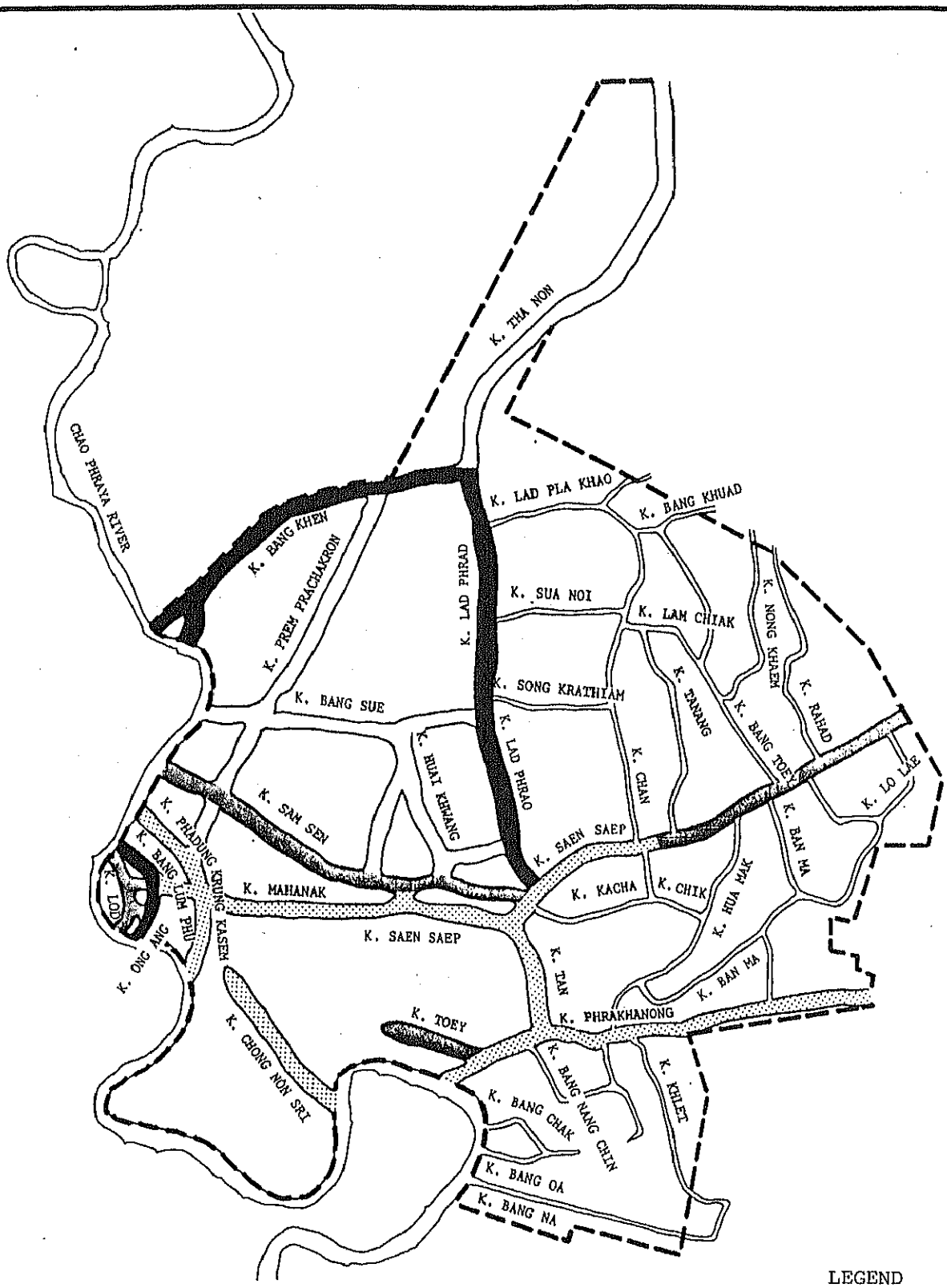
Pattern	Percentage*
	under 30
	30 - 59
	60 - 99
	100 & Over

* Combined percentage of those who use a particular klong for sewerage and of those who use it for a dumping ground.

FIG. B.37 NEGATIVE USES OF KLONGS

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.



LEGEND

Pattern	Percentage*
	under 40
	40 - 49
	50 - 64
	65 & over

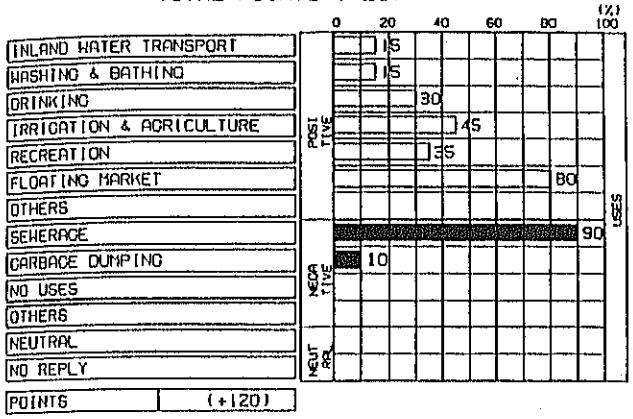
* Combined percentage of those place the top priority on purification of klong water and of those who place the top priority on new construction/expansion of sewerage system.

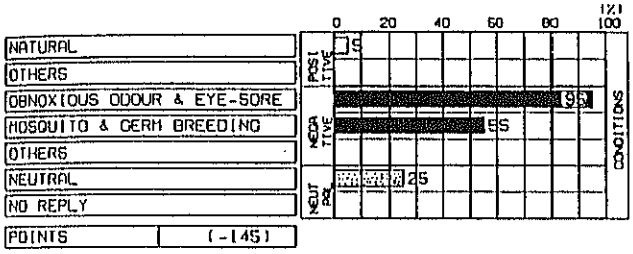
FIG. B.38 PRIORITY FOR KLONG WATER PURIFICATION

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

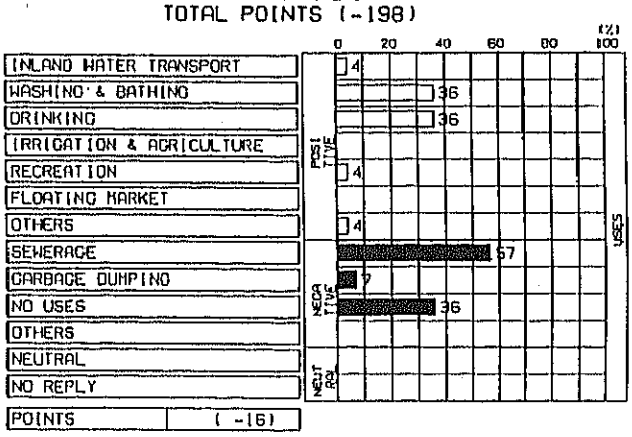
JICA 2532B.E. 1989A.D.

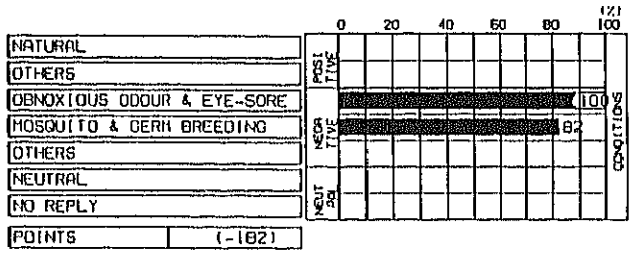
KLONG : BANG KHEN
TOTAL POINTS (-25)



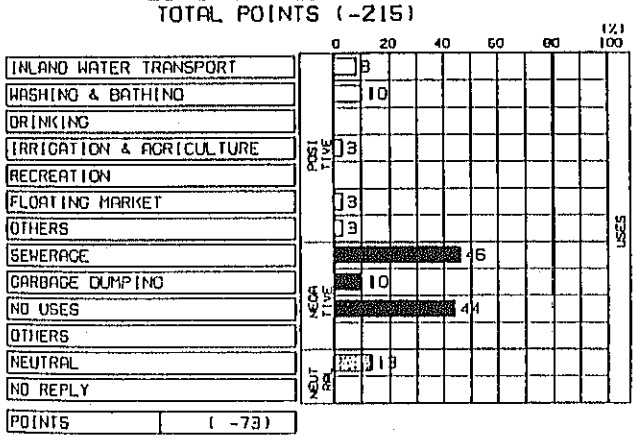


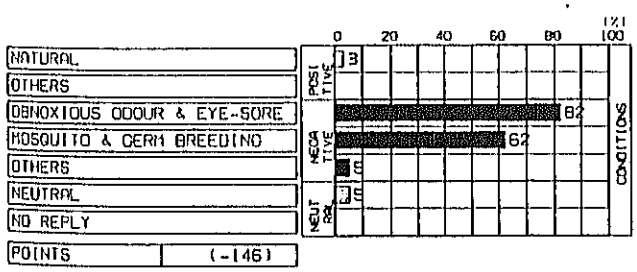
KLONG : BANG SUE
TOTAL POINTS (-198)



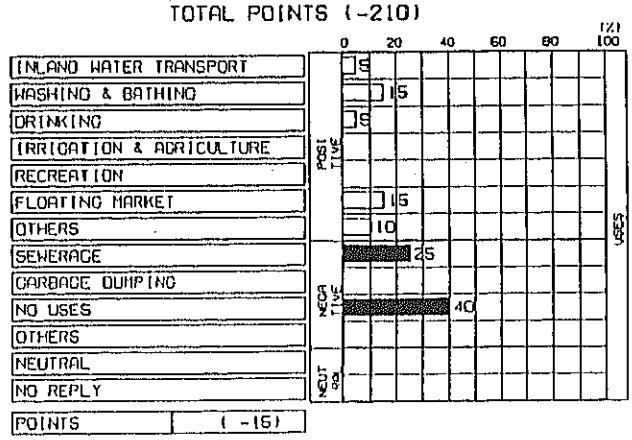


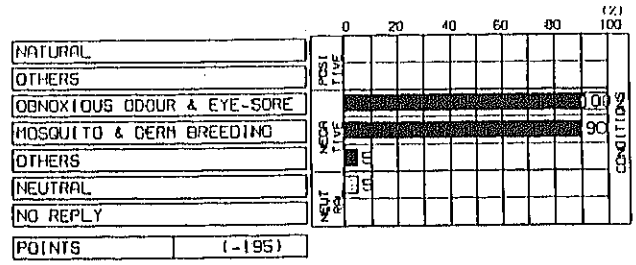
KLONG : SAM SEN
TOTAL POINTS (-215)





KLONG : PREM PRACHAKORN
TOTAL POINTS (-210)



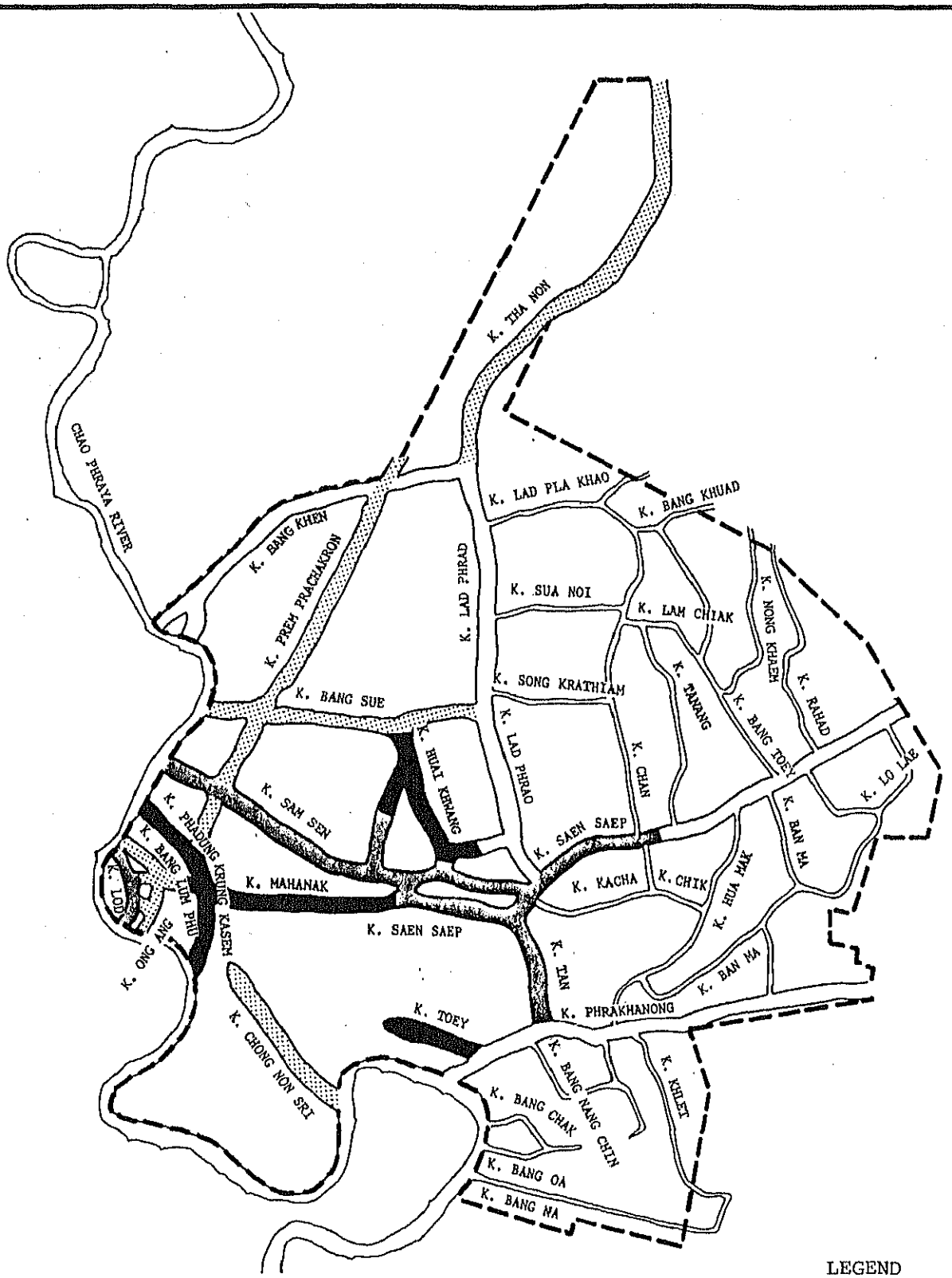


Note : Figures for other klongs are shoun in Data Book

FIG. B.39 USES AND CONDITIONS OF EACH KLONG

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.



LEGEND

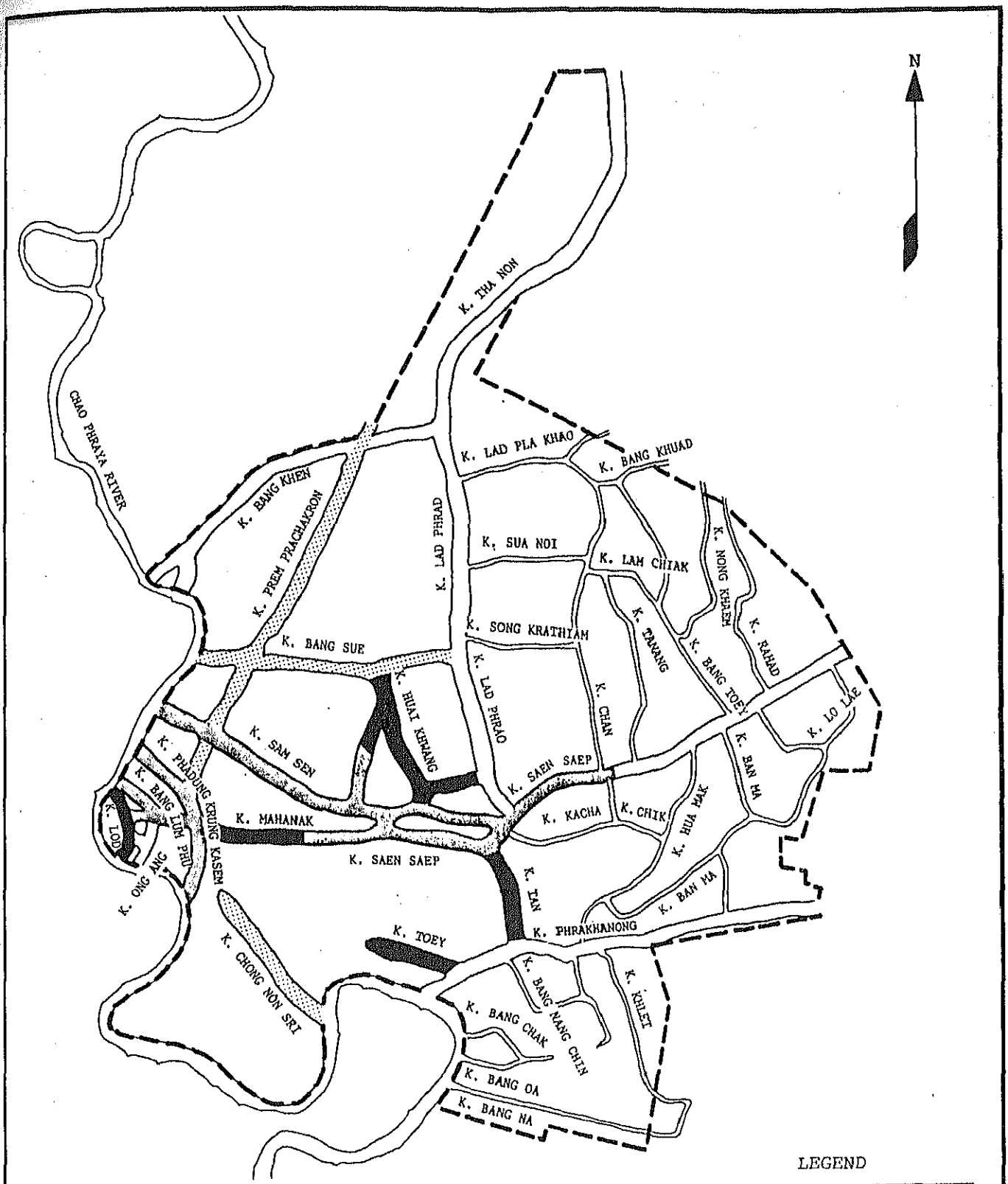
Pattern	Points*
	100 & over
	50 - 99
	20 - 49
	under 20

* The points signifies the degree and extent of positive uses of a klong.

FIG. B.40 POSITIVE USES OF KLONGS .

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.



LEGEND

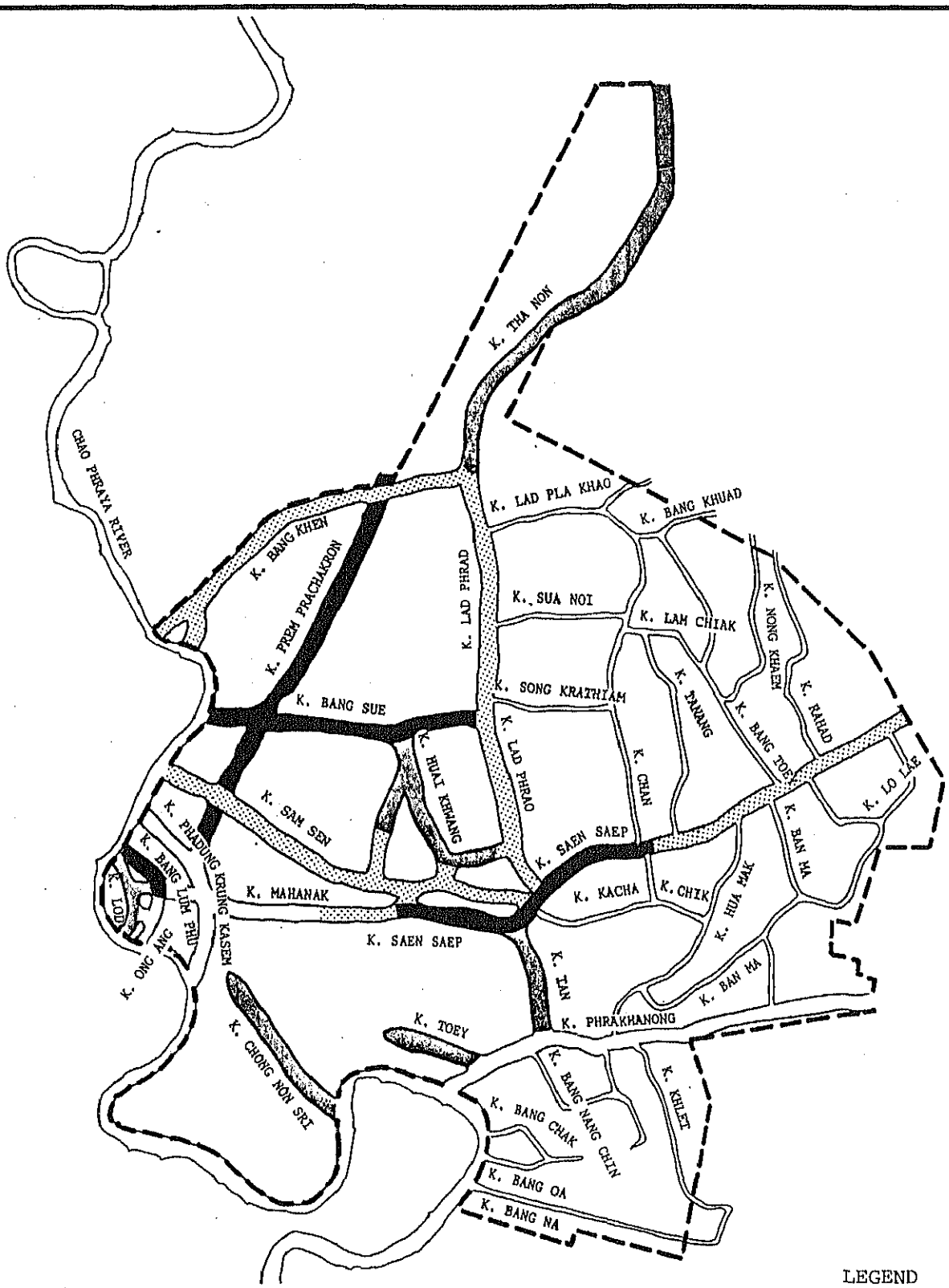
Pattern	Points*
	Over 0
	0 - -49
	-50 - -79
	-80 & under

* The abolute value of the points expresses the degree and extent of negative uses of a klong.

FIG. B.41 NEGATIVE USES OF KLONGS

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.



LEGEND

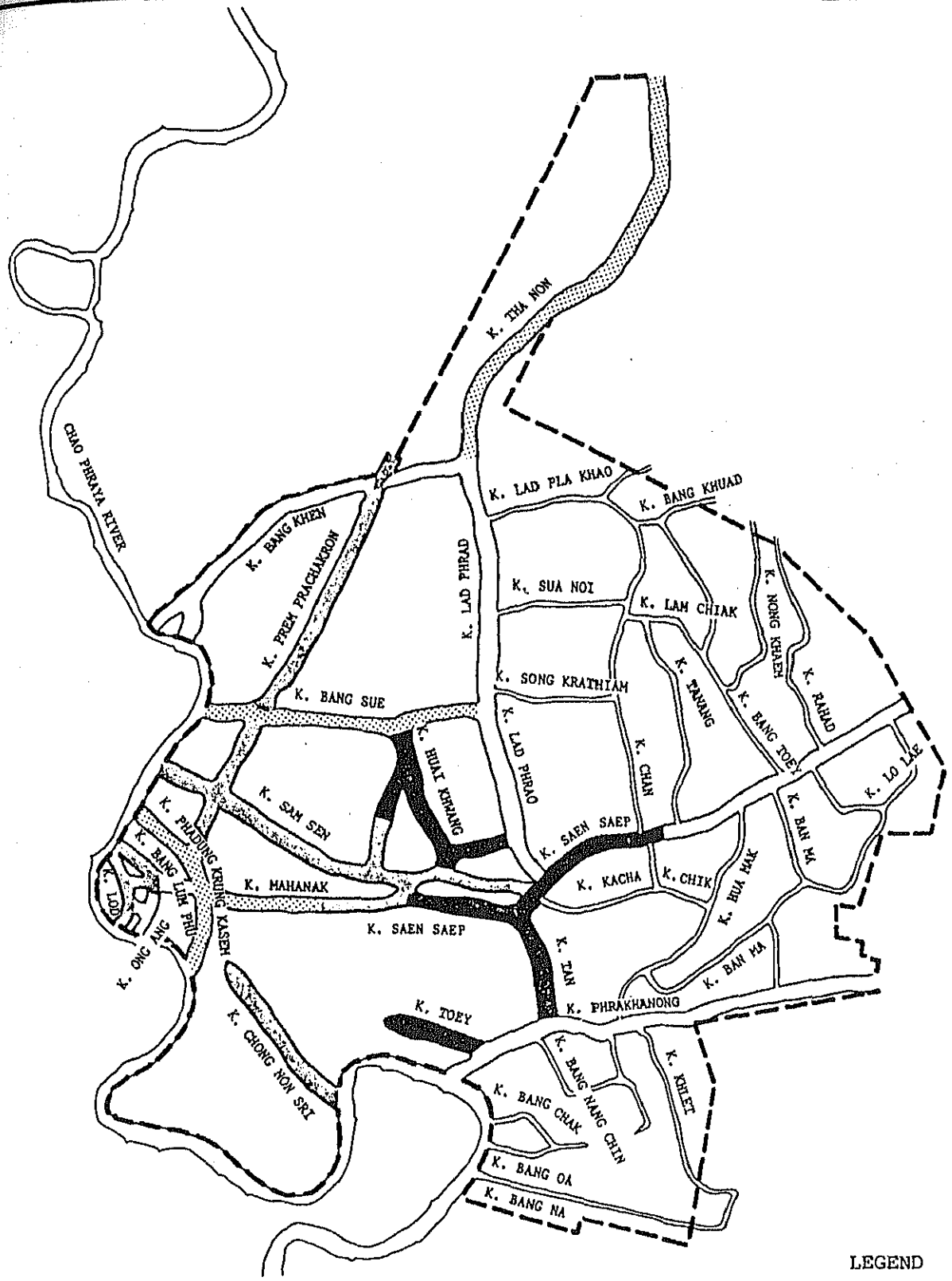
Pattern	Points*
	Over -110
	-110 - -149
	-150 - -179
	-180 & under

* The absolute value of the points expresses the degree and extent of negative conditions of a klong.

FIG. B.42 CONDITIONS OF KLONGS

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.



LEGEND

Pattern	Points*
	Over -100
	-100 - -199
	-200 - -249
	-250 & under

* The absolute value of the points expresses the degree and extent of negative uses and conditions of a klong.

FIG. B.43 USES AND CONDITIONS OF KLONGS

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

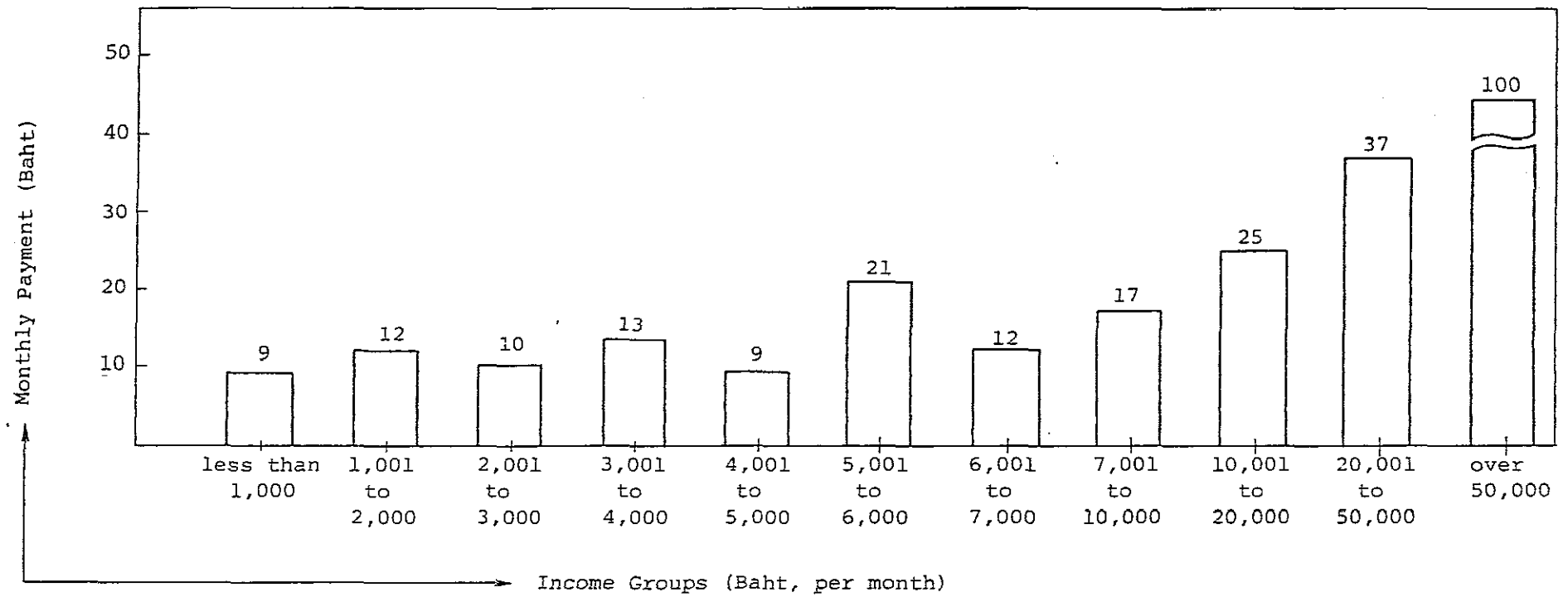


FIG. B.44 WILLINGNESS TO PAY FOR PURIFICATION OF KLONG BY INCOME GROUP

THE FEASIBILITY STUDY ON PURIFICATION OF KLONG WATER IN BANGKOK

JICA 2532B.E. 1989A.D.

APPENDIX C.

POLLUTION LOAD

APPENDIX C. POLLUTION LOAD

1. Population and Land Use

1.1 Existing Conditions

1.1.1 Urbanization and Population

The last 20 years have become the era of rapid urbanization and industrialization of Bangkok, the capital of Thailand. The population in the metropolitan area has been continuously growing from 5,070,000 in 1980 to 5,470,000 in 1986, and accounts for roughly 10% of the total population of Thailand. (Table C.1)

The metropolitan area has been expanding since the 1900s, and its progress is given below.

Year	Area (km^2)
1900	13
1936	43
1953	66
1958	96
1971	183
1980	345

The rate of urbanization in the study area is graphically presented in Fig. C.1.

The Study Area, situated to the left-side of the Chao Phraya River, occupies 380 km^2 and encompasses 12 districts. The current population distribution in the Study Area is given in Table C.2.

1.1.2 Existing Land Use

The study area can be broadly divided into the City Core Area and the Eastern suburbs. The City Core Area, with the exception of a portion of Yan Nawa District, is already highly urbanized. However in the Eastern suburbs, there are still large tracts of open space and agricultural land.

Existing land use patterns in 1980 is given in Table C.3 and Fig. C.2.

1.2 Future Population and Land Use

1.2.1 Projection of Population

The future population of the Bangkok Metropolitan Area was projected by the following four (4) Studies. The projected populations by the respective studies are also shown below.

Ref. 1 Statistical Profile of the Bangkok Metropolitan Administration
Department of policy and planning
6.53 million in 1992

Ref. 2 Bangkok Flood Control and Drainage Project (City Core)
NEDECO
7.4 million in 2000

Ref. 3 Development of a Framework for Water Quality Management of Chao Phraya and Thachin Rivers
NEB
7.85 million in 2001

Ref. 4 Flood Protection/Drainage Project in Eastern Suburban Bangkok
JICA
7.7 million in 2000

No significant difference is found among the future populations projected by the above four (4) Studies.

This Study adopts the future population projected by the Flood Protection/Drainage Project in Eastern Suburban Bangkok, JICA. The projected population in the year 2000 is 7.7 million.

According to the Report for "Flood Protection/Drainage Project in Eastern Suburban Bangkok, JICA", the Bangkok Metropolis is categorized into three areas: Urban Core Area, Core Fringe Area and Suburban Area. The projected population of the Bangkok Metropolis in the year 2000 (7.7 million) is broken down into each categorized area as shown in Fig. C.3. The districts included in each categorized area are also listed in the same figure. In the above-mentioned report, the population break down of the Eastern Suburban area according to each district is also provided.

(1) Urban Core Area

In the Report "Flood Protection/Drainage in Eastern Suburban Bangkok, JICA", the population of the Urban Core Area is estimated to decrease from 390,000 in 1980 to 270,000 in 2000, in conformity with the land use policy of BMA. The population of the area has already decreased to 250,951 in 1986.

However, as a factor of safety, it is assumed in this project preparation that the population of the City Core will remain in the present level until the year 2000. The rate of population distribution among three districts: Phra Nakhon, Pom Prap Sattru Pai and Sam Phan Thawong is also assumed to remain the same at the present level.

(2) Core Fringe Area

BMA estimated the annual growth rates of population in the districts: Phatumwan, Bang Rak, Dusit, Yan Nawa and Phya Thai, for the period between 1987 and 1992, as shown below.

District	Annual Growth Rate (1987 - 1992)
Phatumwan	-1.40%
Bang Rak	3.15%
Dusit	2.65%
Yan Nawa	-0.08%
Phya Thai	-1.70%

For the safety of project preparation, the following assumptions are made in this study concerning the population projection.

- The population of the districts: Bang Rak and Dusit, will increase up to the year 2000 at the annual growth rates estimated by BMA.

- The population of the districts: Phatumwan, Yan Nawa and Phya Thai will be stabilised at the existing level up to the year 2000.

(3) Eastern Suburban Area

The Study Team adopted the future populations estimated by "Flood Protection/Drainage in Eastern Suburban Bangkok, JICA" for the four (4) districts of Huai Khwang, Phra Khanong, Bang Khen and Bang Kapi.

The present and future populations of the Study Area are estimated to be 3,666,142 in 1986 and 4,751,000 in 2000 respectively. The population break-down according to district is shown in Table C.4.

1.2.2 Future Land Use

No substantial change will occur in the land use pattern of the Urban Core and Core Fringe areas. Because the land of the areas is already fully developed. Therefore, the land use of the areas in the year 2000 is assumed to remain the same as the existing condition.

For the Eastern Suburban areas, the land use pattern in the year 2000 projected by "Flood Protection/Drainage in Eastern Suburban Bangkok, JICA" is applied.

Accordingly the estimated future land use of the Study Area is shown in Table C.5 and Fig. C.4.

2. Water Consumption in the Study Area

2.1 Existing Water Supply by MWA and Its Consumption

Water service for the Study Area is controlled by Metropolitan Waterworks Authority (MWA). The Study Area consists of seven (7) service areas namely, Nonthaburi, Bang Khen, Phya Thai, Thung Mahamek, Man Sri, Phra Khanong and Samut Prakarn as shown in Fig. C.5.

The water supply of MWA for the seven (7) service areas in 1986 is shown in Table C.6. The table presents the daily water supply and unit water supply (liter per capita per day: lcd) by service area and by use.

The average unit water supply of the seven (7) service areas in 1986 is 435 lcd with a break-down of 263 lcd for domestic use, 0.5 lcd for institutional use and 171 lcd for commercial & enterprise use. These figures include the unaccounted water.

According to the information from MWA, the existing effective water service ratio is 59% on an average. Therefore, the average unit water consumption of the Study Area is estimated to be as follows.

- Domestic use : 155 lcd
- Institutional use : 0.3 lcd
- Commercial & enterprise use : 101 lcd
- Total : 256.3 lcd

Unit water consumption for domestic use in the four (4) service areas of Nonthaburi, Bang Khen, Phya Thai and Thung Mahamek is about 140 lcd. Unit water consumption for domestic use in Man Sri and Phra Khanong service areas are 165 lcd and 221 lcd respectively. The ratio of the maximum to the minimum unit water supply for domestic use is about 1.6. Per capita water consumption for commercial / enterprise use is very high at 287 lcd in Man Sri, but only 39 lcd in Nonthaburi. Table C.7 shows the existing unit water consumption by service area and by use.

The JICA Study Team conducted a sampling survey on the existing unit water consumption in the Study Area to confirm the above estimated unit water consumption. Sampling were conducted at 300 households in the neighborhood of Siam JASCO, 200 households of the housing estate (NHA) in Klong Chan area and 100 households of DDS staff. Results of the sampling survey is shown in Fig. C.6 and the questionnaires are shown in Data Book.

Based on the responses to the questionnaire, about 20 percent of total families consume between 120 lcd and 160 lcd of water for domestic use and another 18 percent between 160 lcd and 200 lcd. The average unit water consumption obtained from the survey is 210 lcd.

According to the Master Plan for Water Supply in Bangkok prepared in 1981 by MWA, the water demand in 1986 was estimated to be 161 lcd for domestic use, 13 lcd for institutional use and 109 lcd for business/ enterprise. With the exception of institutional demand, all other figures are in agreement with the determined water consumption values of this survey.

The existing unit water consumption estimated in Table C.7 is considered reasonable and is adopted as the present water consumption in this study.

2.2 Existing Water Supply and Consumption of Groundwater

The existing water supply system of MWA does not cover the entire population of the Study Area. The ratio of the population served to that of total population in five service areas: Thung Mahamek, Man Sri, Phya Thai, Bang Khen and Phra Khanong, ranges from 35% to 50% with an average of 40% as shown in Table C.8. Water for the remaining population of 60% is supplied by groundwater.

According to a study of MWA in 1985, the daily groundwater consumption for domestic use in the whole service area of MWA was about 360,000 m^3/d and the population served by groundwater is 2,533,000.

In this study, the above-mentioned MWA's study relating to the existing groundwater supply is adopted.

Water Consumption for Domestic Use	Population Served	Unit Water Consumption
360,000 m^3/d	2,533,000	142 lcd

The unit water consumption of groundwater for each use is estimated on the assumption that share of the unit water consumption for each use to the total unit water consumption in groundwater is the same as that of MWA water supply.

2.3 Existing Unit Water Consumption of Total Water Source

The existing unit water consumption of all the water sources in the respective districts of the Study Area is shown in Table C.9. The table also presents the unit water consumption according to the usage.

2.4 Future Unit Water Consumption

MWA estimated the unit water consumption in the year 2000 as follows.

- Residential : 215 lcd
- Commercial : 136 lcd
- Institutional : 10 lcd
- Total : 361 lcd

In this Study, the above values are applied for the whole Study Area, except some districts, as the unit water consumptions of MWA water supply in the year 2000.

Concerning the unit water consumption of MWA water supply, the existing consumption is higher than the future ones estimated by MWA for the residential use of Phra Khanong, and the commercial & other water uses of Dusit, Phra Nakhon, Pom Prab Sattru Pai, Sampanthawong, Pathumwan and Bang Rad (See Table C.9). In these cases, the future unit water consumptions proposed by MWA are replaced by the existing ones for safety of project preparation.

It is further assumed that all the existing groundwater source will be substituted by MWA water supply before 2000 and all the water requirement in the year 2000 will be met by MWA water supply.

The unit water consumptions of the Study Area by district and by use in the year 2000 are shown in Table C.10, along with the existing ones.

2.5 Present and Future Water Consumption

Based on the above considerations, the water consumptions of the Study Area in 1986 and 2000 are calculated as shown in Table C.11. The table also presents a break-down of the water consumption according to each district and each usage.

3. Unit Pollution Load Generation

3.1 General

The major sources of pollution load in the Study Area are residential zones, large scale factory, small to medium scale factory and commercial enterprises. The pollution load generation of the Study Area is conceptualized as shown in Fig. C.7.

3.1.1 Residential Wastewater

Wastewater of residence is classified into two kinds. One is wastewater from toilet and another is wastewater from kitchen, bathroom and laundry, called miscellaneous wastewater. Miscellaneous wastewater is discharged into klongs through side ditches and sewers. While, wastewater from toilet is treated by septic tank or cess pool installed at each house. The treated wastewater is permeated into the ground or discharged into public water ways.

Approximately 70% of the population in Bangkok is served by cess pools and the rest is treated by septic tanks. Sludge settled in septic tanks is withdrawn once a year, though this is only 560 kl/day or approximately 5 to 10% of the amount generated in Bangkok, according to the estimate of the Department of Public Cleansing, BMA.

The residential source of pollution load is further classified into the sources of general residence and housing estate.

The pollution load generation of general residences is estimated, based on an assumed unit pollution load generation (pollution load generation per capita per day).

No significant purification effects are expected from the existing septic tanks and cess pools since they are not controlled and maintained effectively. Therefore, in estimating the unit pollution load generation from general residences, the effects of septic tank and cess pool are not taken into considerations.

However, in the housing estates of NHA, data of the effluents from the housing estates are available. Therefore, the pollution load generation of housing estate is estimated for each estate.

3.1.2 Commercial Wastewater

The pollution load generation of commercial establishments is estimated, based on an assumed unit pollution load generation in the same manner as the residential one.

3.1.3 Industrial Wastewater

There is a large number of factories scattered in Bangkok. Most of them are small to medium scale factories and are not provided with wastewater treatment facilities. The wastewater of small to medium scale factories are included in that of commercial establishments since water consumption of the small to medium scale factories is considered to be not large.

However, in case of large factories discharging large amount of wastewater, data on the wastewater characteristics are available. Therefore, the pollution load generation of the large factories is estimated individually.

3.2 Previous Studies on Unit Pollution Load Generation

Unit pollution loads estimated by the previous studies are shown in Table C.12. Unit pollution loads surveyed by NHA in the housing estates are shown in Table C.13.

3.3 Observation of Unit Pollution Load

3.3.1 Unit Pollution Load from Resident

The JICA Study Team carried out a field survey on unit pollution load generation from resident for two (2) housing estates in Din Daeng and Bon Kai.

The observation at Din Daeng was carried out on Feb. 24-25, Jul. 21-22 and Sep. 7-8, 1988. The observation at Bon Kai was carried out on Aug. 10-11 and Sep. 7-8, 1988.

A part of Din Daeng housing estate with a population of 1,320 is provided with a community treatment plant (Activated Sludge System) for final treatment but no septic tank is installed.

A part of Bon Kai housing estate with a population of 1,900 is provided the same treatment system as Din Daeng housing estate.

The location of the observation sites are shown in Fig. C.8.

The observation conditions are as follows:

Water Sampling	:	Every Three (3) hours during 24 hours at the influent of the community treatment plant
Discharge Measurement	:	Estimated by pump operation records
Observed Water Quality Parameter	:	BOD, COD, SS, T-N, T-P

The results of the observation are summarized in Table C.14.

3.3.2 Unit Pollution Load from Commercial Enterprise

The JICA Study Team also carried out a field survey of unit pollution load generation from commercial enterprise for three (3) commercial areas in Suriwong Rd., Silom Rd. and Siam Square on Aug. 3-4, 1988.

Suriwong Rd. and the Silom Rd. are defined as the typical business areas and the Siam Square as the typical commercial area.

The observation conditions are as follows.

Water Sampling	:	Every Three (3) hours during 24 hours from manhole at the site
Discharge Measurement	:	Measured by current meter
Observed Water Quality Parameter	:	BOD, COD, SS, T-N, T-P

The results of the observation are summarized in Table C.15.

From the results of observation, commercial wastewater quality is classified into two categories. One is from restaurant and the other is from other businesses. The wastewater from restaurant is more polluted than that of domestic wastewater and the wastewater from other businesses is less polluted than that of domestic wastewater.

According to the study report on "Domestic Waste Waters and Water Pollution Problems in Bangkok and Its Vicinity", one third of the total amount of commercial wastewater is from restaurants and the rest from other businesses. The total amount of commercial wastewater in the study area is estimated to be about 94,000 m^3/d, and the wastewater from the restaurant is 31,000 m^3/d while that of other businesses is 63,000 m^3/d.

Based on the above considerations and the observation results, pollution load from the restaurants and other businesses are estimated as summarized in Table C.16.

3.4 Estimation of Unit Pollution Load Generation

Present and future unit pollution load generation are estimated as follows.

(1) Unit pollution load (g/person/day) is estimated by multiplying unit water consumption and average observed water quality in this study.

(2) Observed average water quality of wastewater discharged from residential and commercial / institutional facilities are as follows:

Wastewater sources	BOD_5	COD	SS
Resident	130 mg/l	270 mg/l	110 mg/l
Commercial/Institution	145 mg/l	235 mg/l	80 mg/l

Present and future estimated unit pollution load generation of residential and commercial / institutional wastewater are shown in Table C.17.

4. Regional Distribution of Pollution Load Generation

4.1 Regional Distribution of Population

Regional distributions of the existing and future population in the Study Area are estimated based on the land use patterns shown in Fig. C.2 and Fig. C.4.

The regional distributions of population density in 1986 and 2000 are shown in Fig. C.9.

4.2 Regional Distribution of Pollution Load Generation

Regional distribution of the pollution loads of residence and commercial establishment & others are obtained by multiplying the distributed population with the assumed unit pollution load generation. While, the pollution load generations of each housing