(5) S S

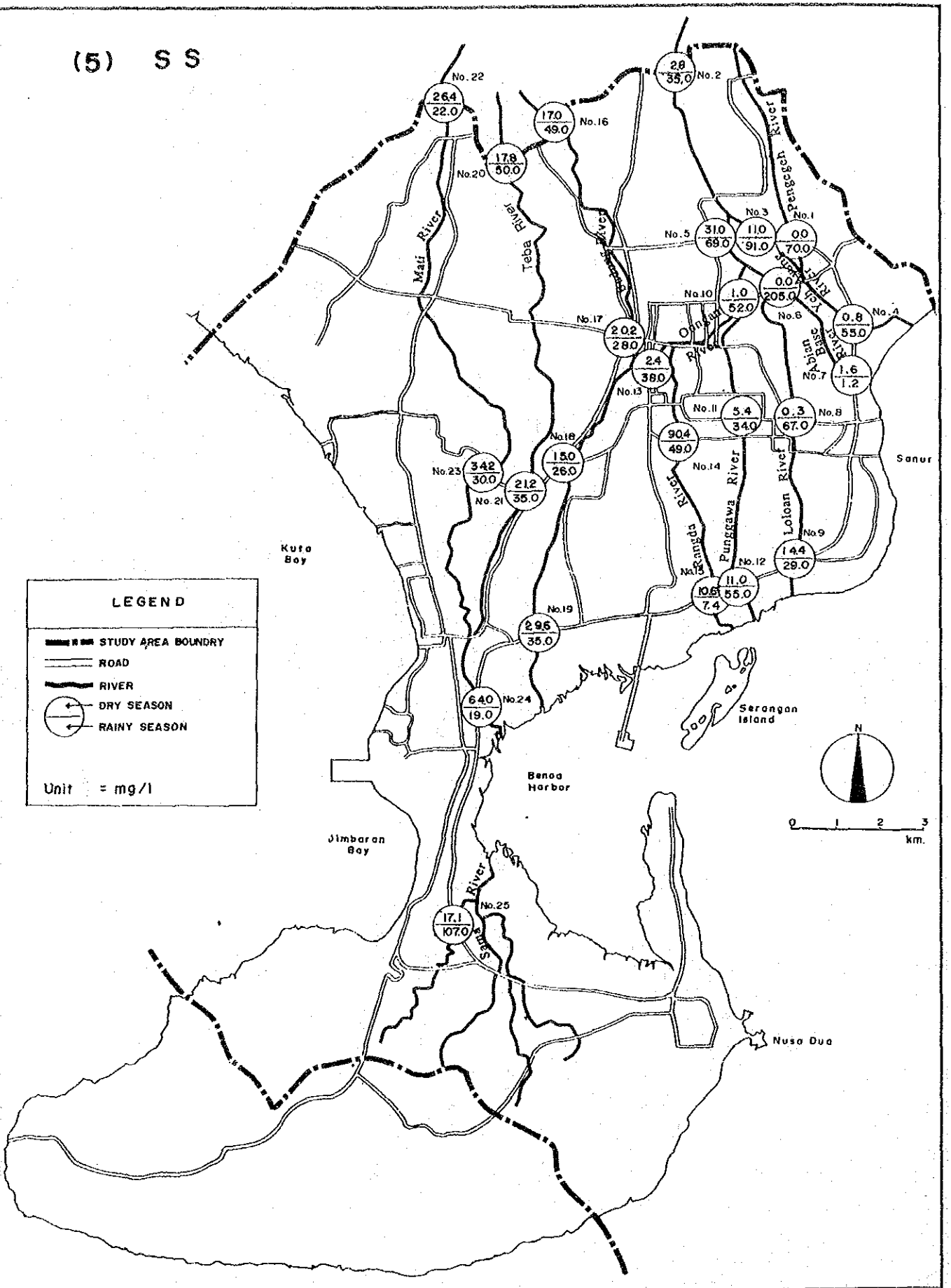


FIG. B.2.6(5) OBSERVED RIVER WATER QUALITY BY JICA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

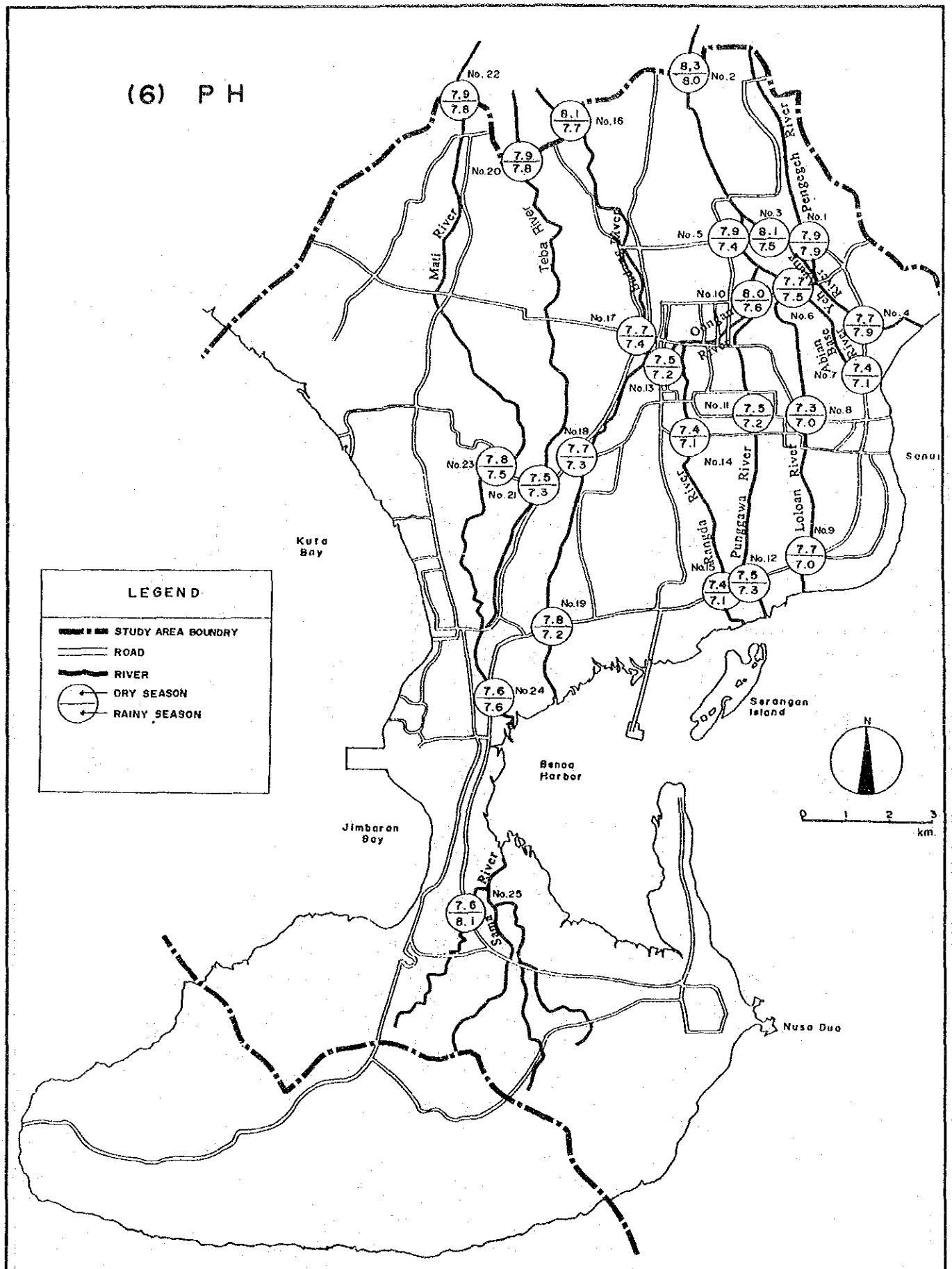


FIG. B.2.6(6) OBSERVED RIVER WATER QUALITY BY JICA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

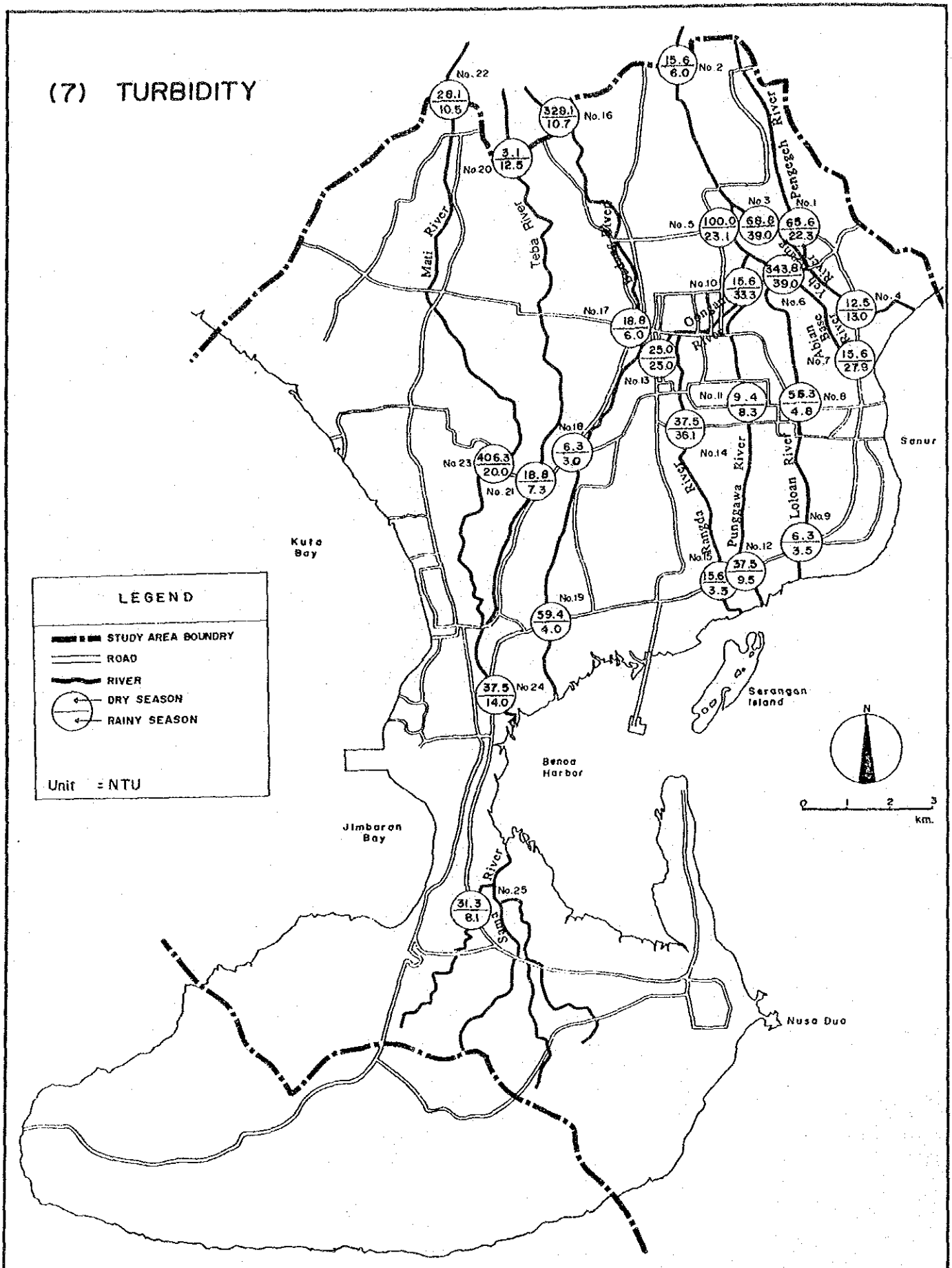


FIG. B.2.6(7) OBSERVED RIVER WATER QUALITY BY JICA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

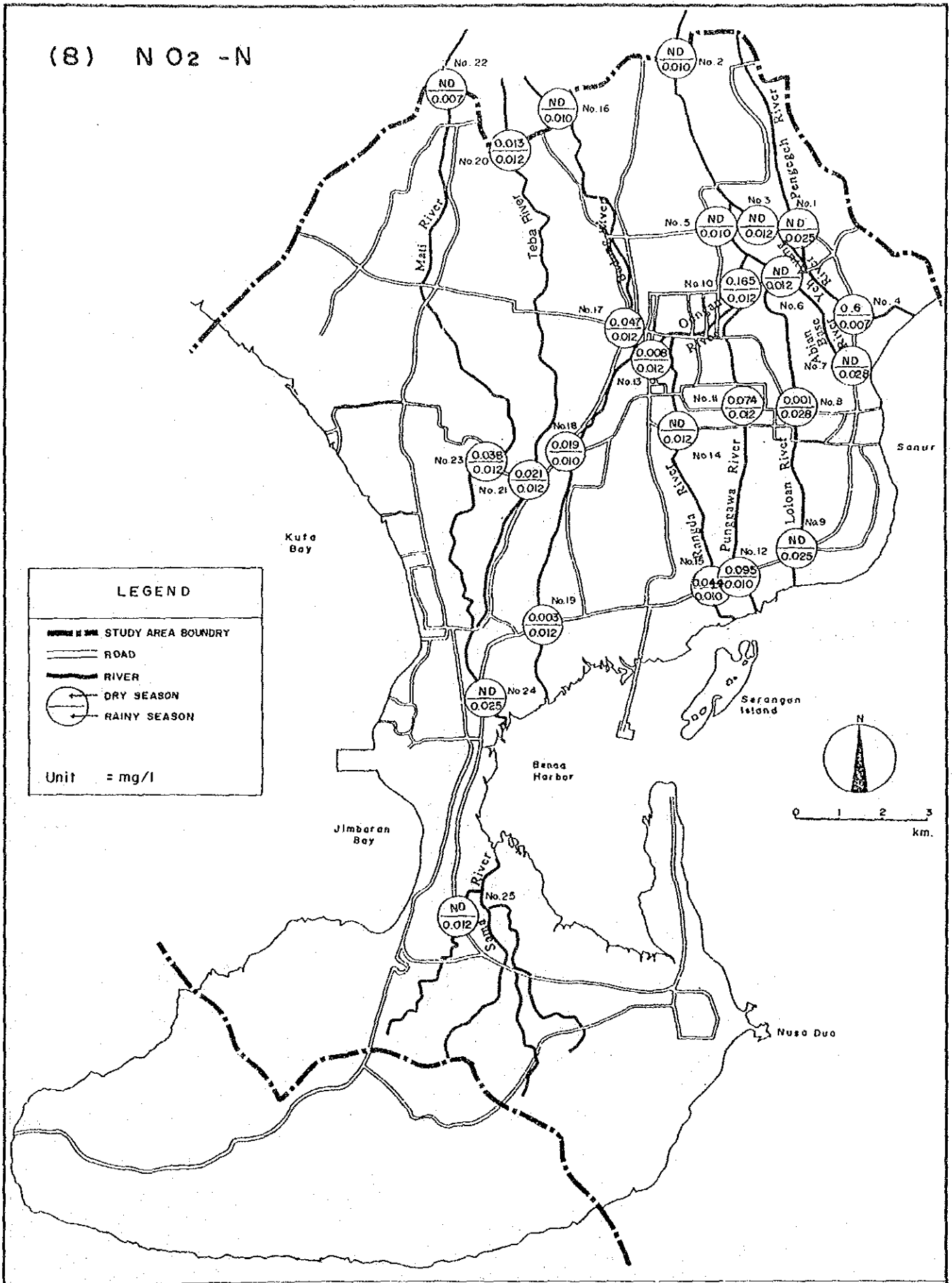


FIG. B.2.6(8). OBSERVED RIVER WATER QUALITY BY JICA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

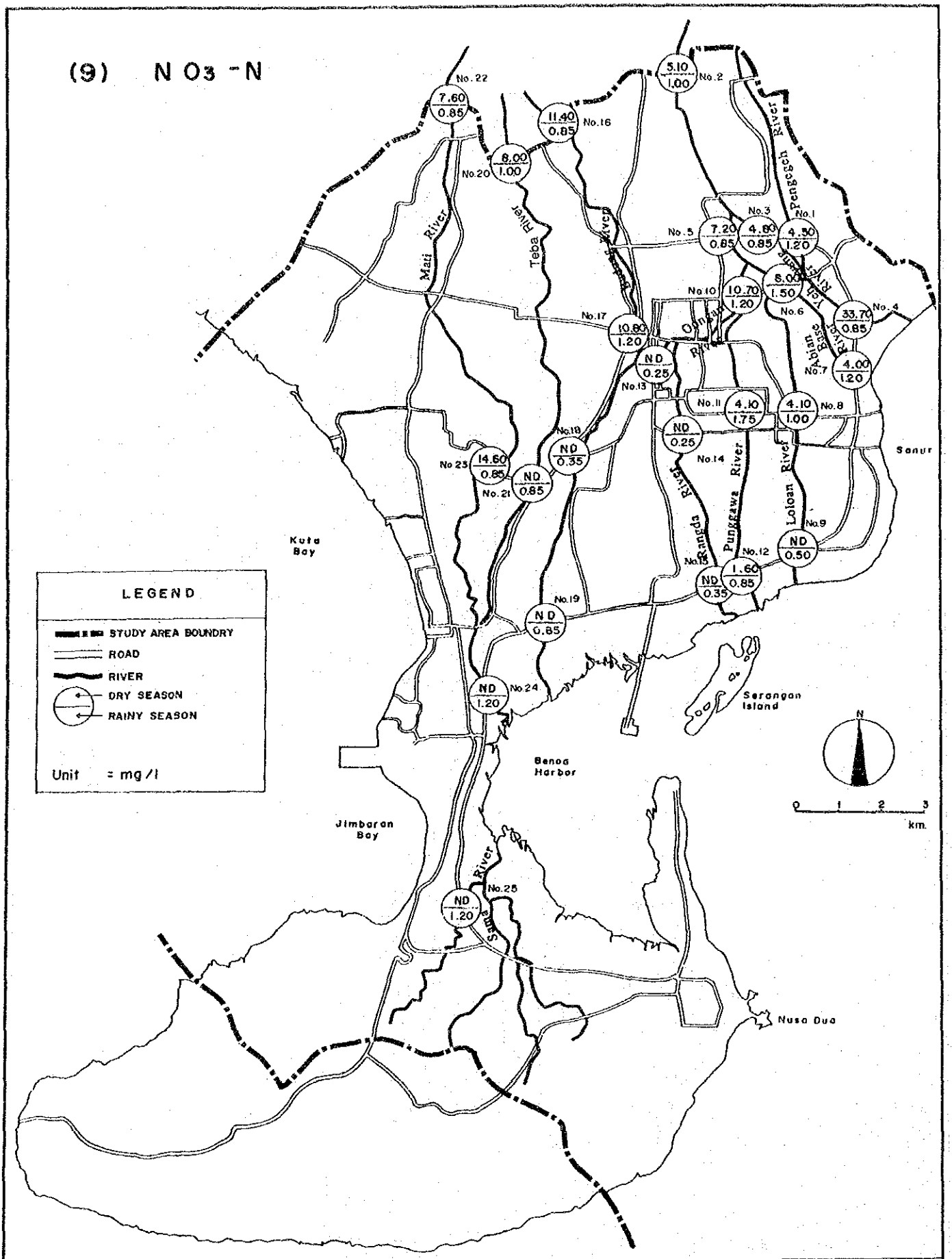


FIG.B.2.6(9) OBSERVED RIVER WATER QUALITY BY JICA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

JICA A.D 1993

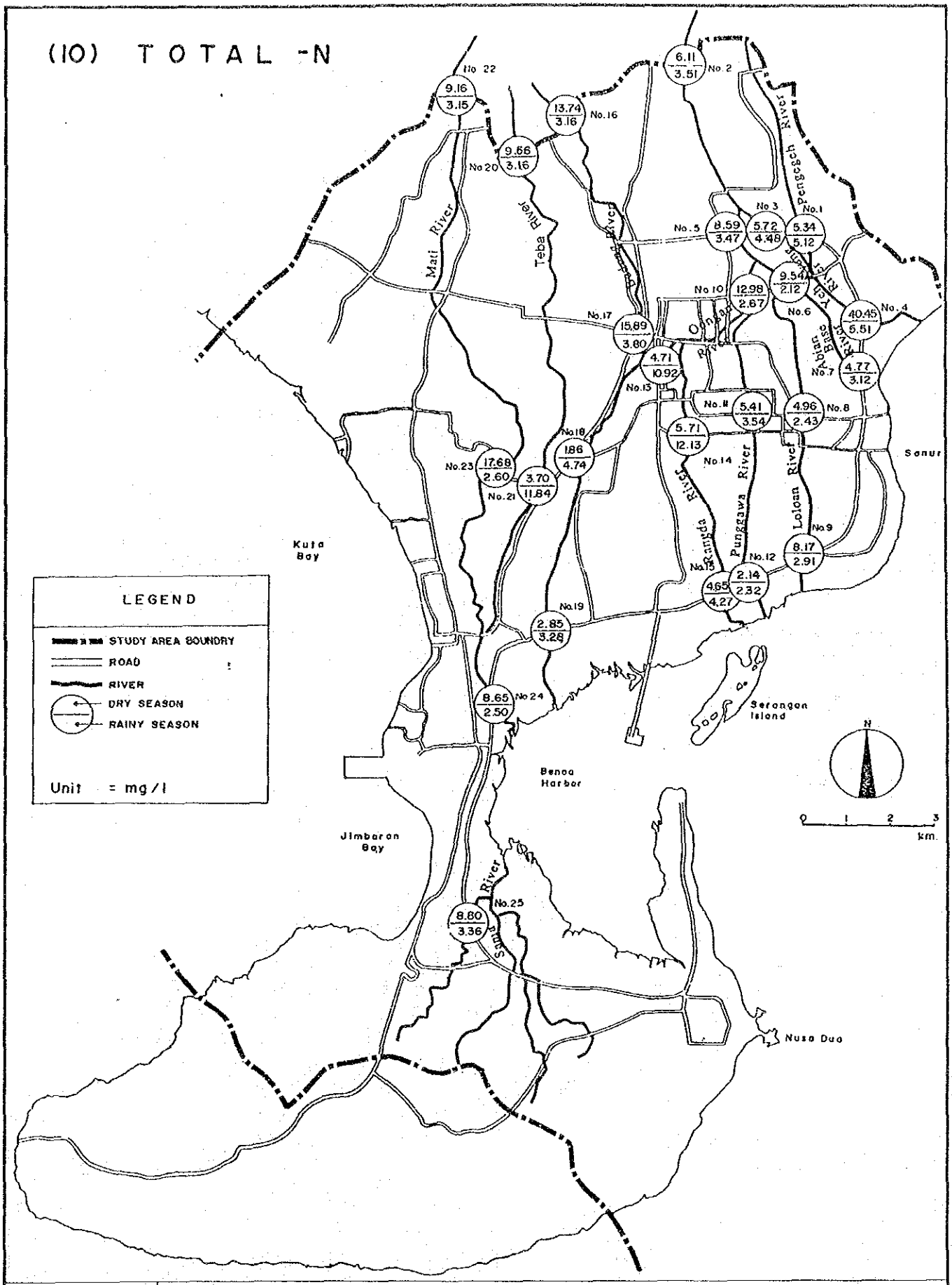


FIG.B.2.6(10) OBSERVED RIVER WATER QUALITY BY JICA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

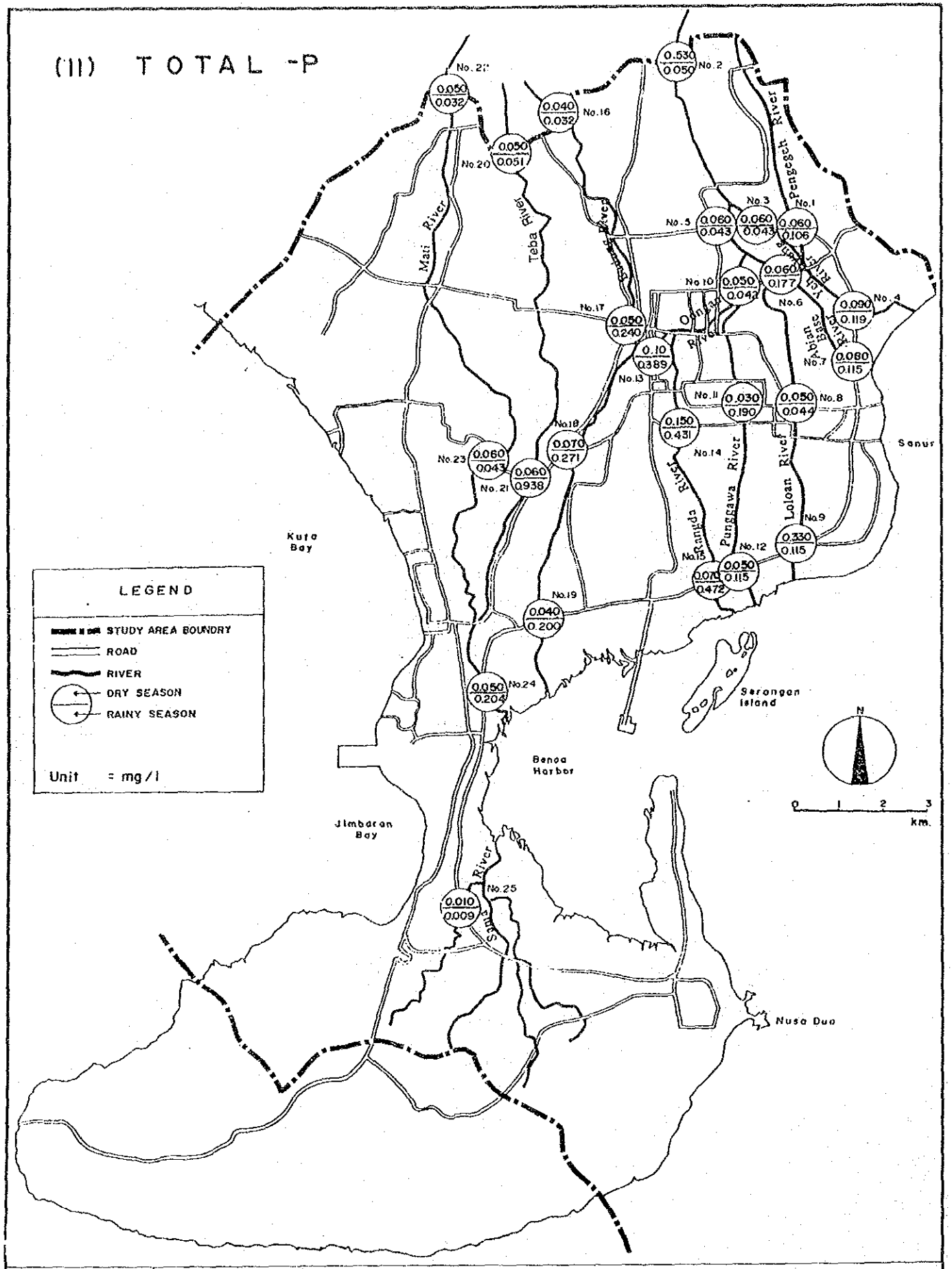


FIG. B.2.6(11) OBSERVED RIVER WATER QUALITY BY JICA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

JICA A.D 1993

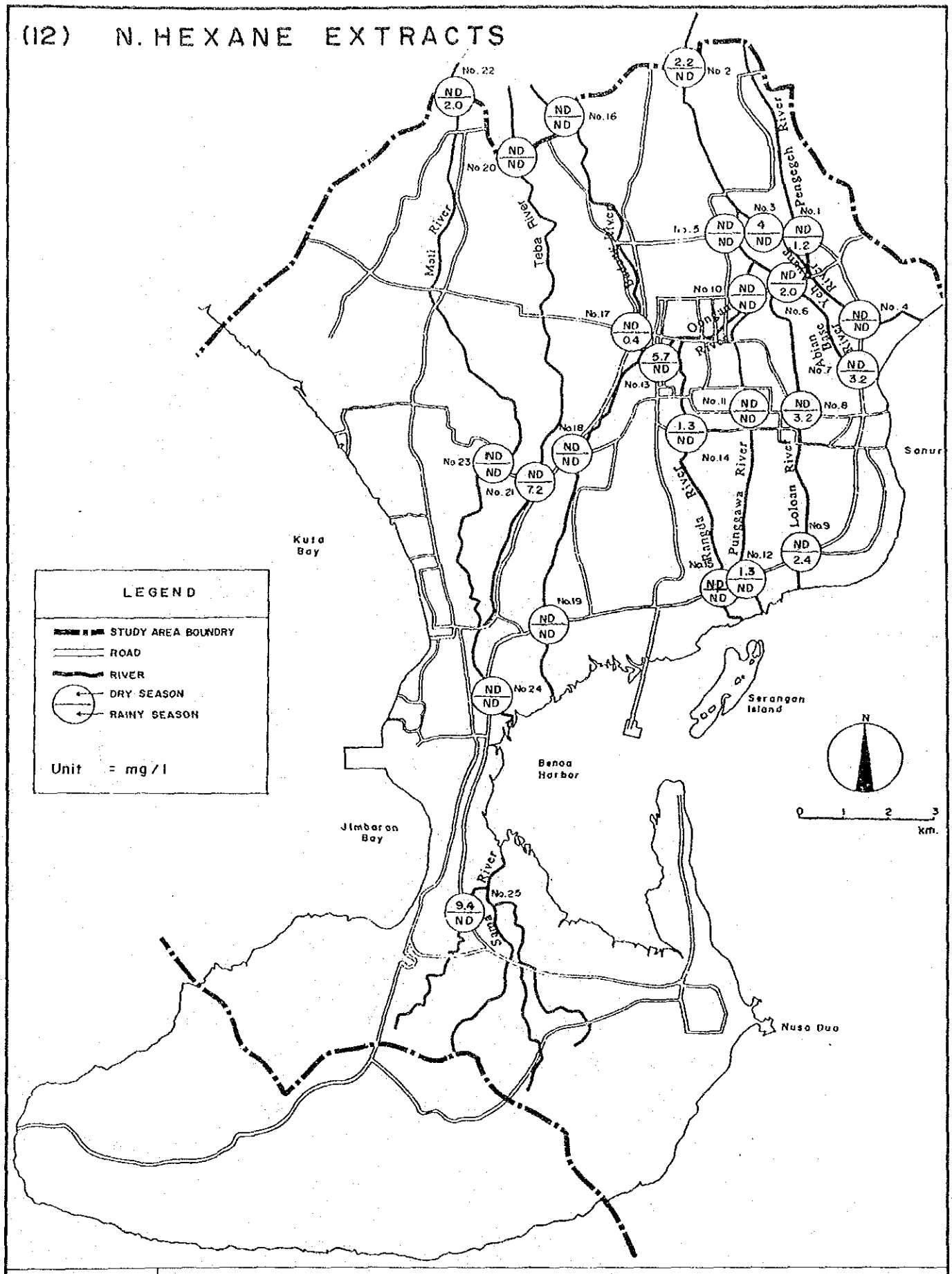


FIG.B.2.6(12) OBSERVED RIVER WATER QUALITY BY JICA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

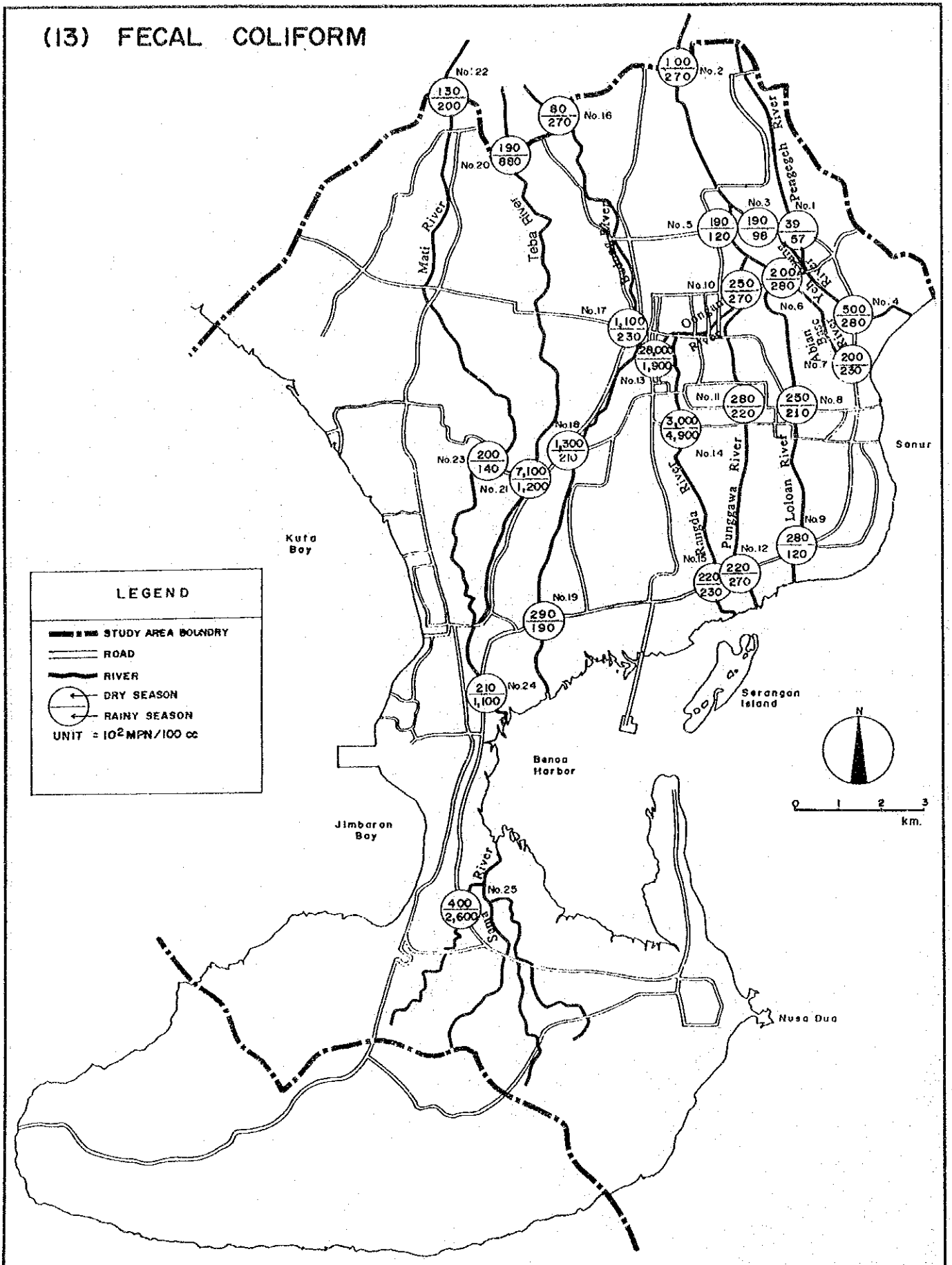


FIG.B.2.6(13) OBSERVED RIVER WATER QUALITY BY JICA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

JICA A.D 1993

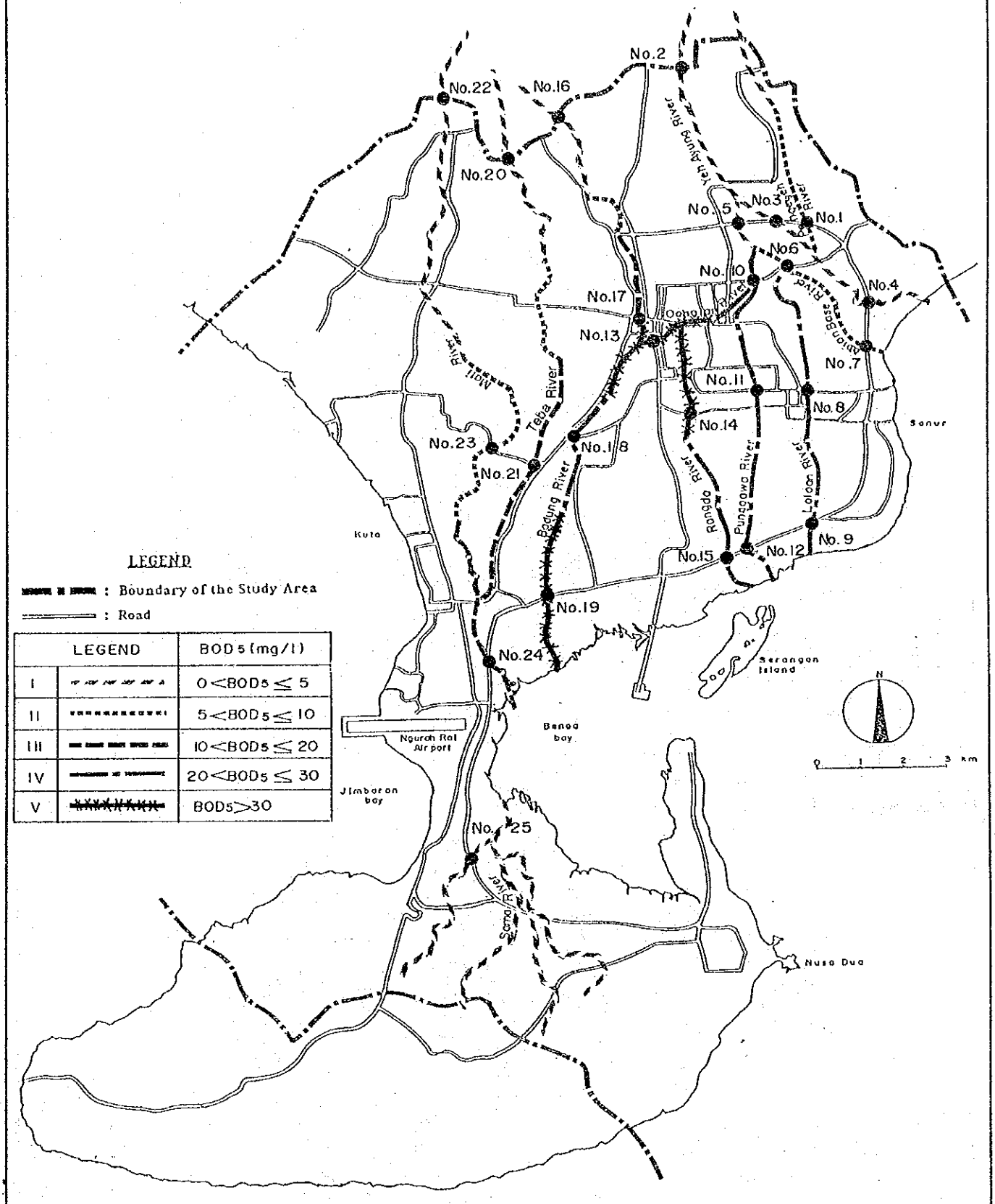


FIG. B.2.7 CLASSIFICATION OF RIVER STRETCHES BY WATER QUALITY (DRY SEASON)

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

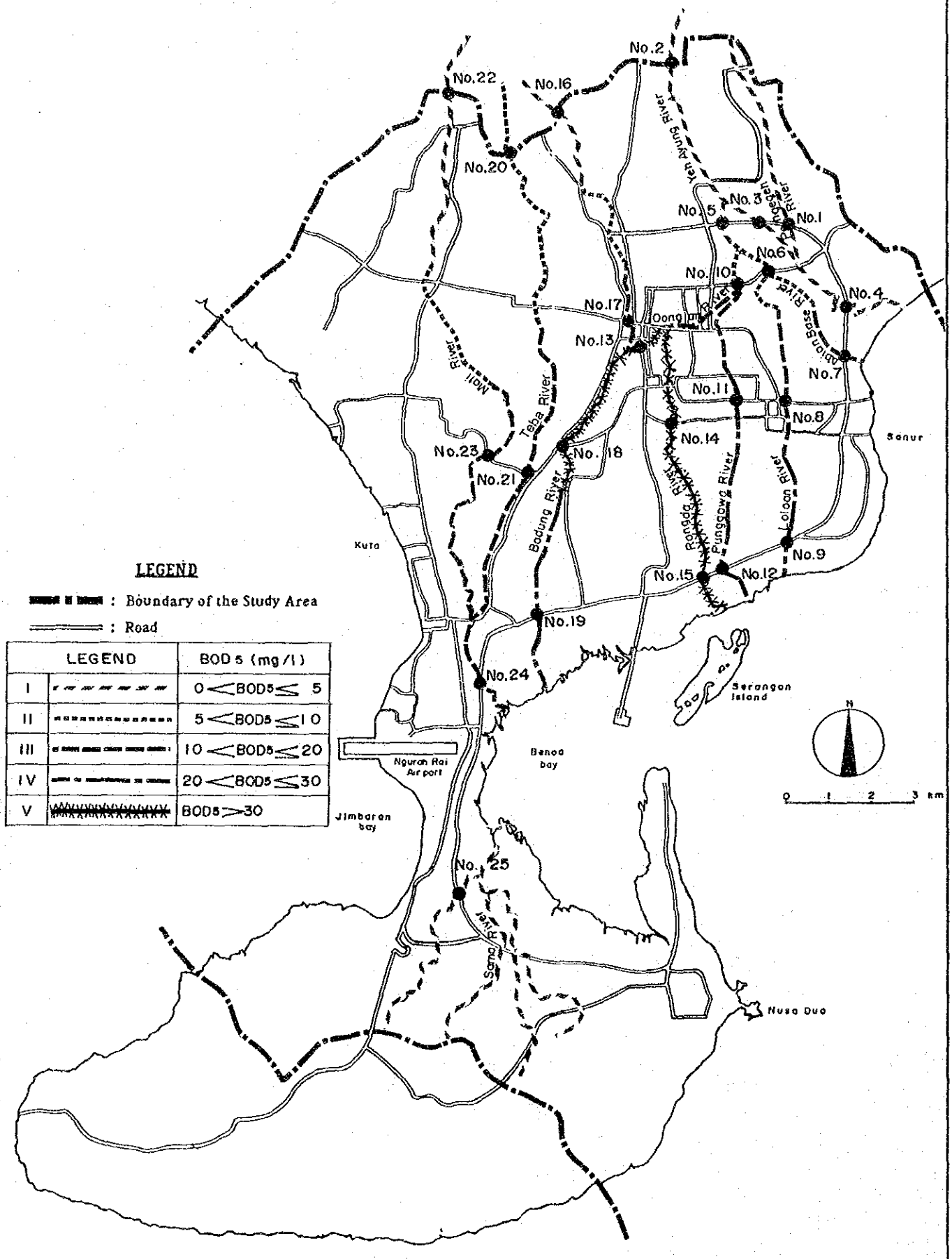


FIG. B.2.8 CLASSIFICATION OF RIVER STRETCHES BY WATER QUALITY (RAINY SEASON)

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

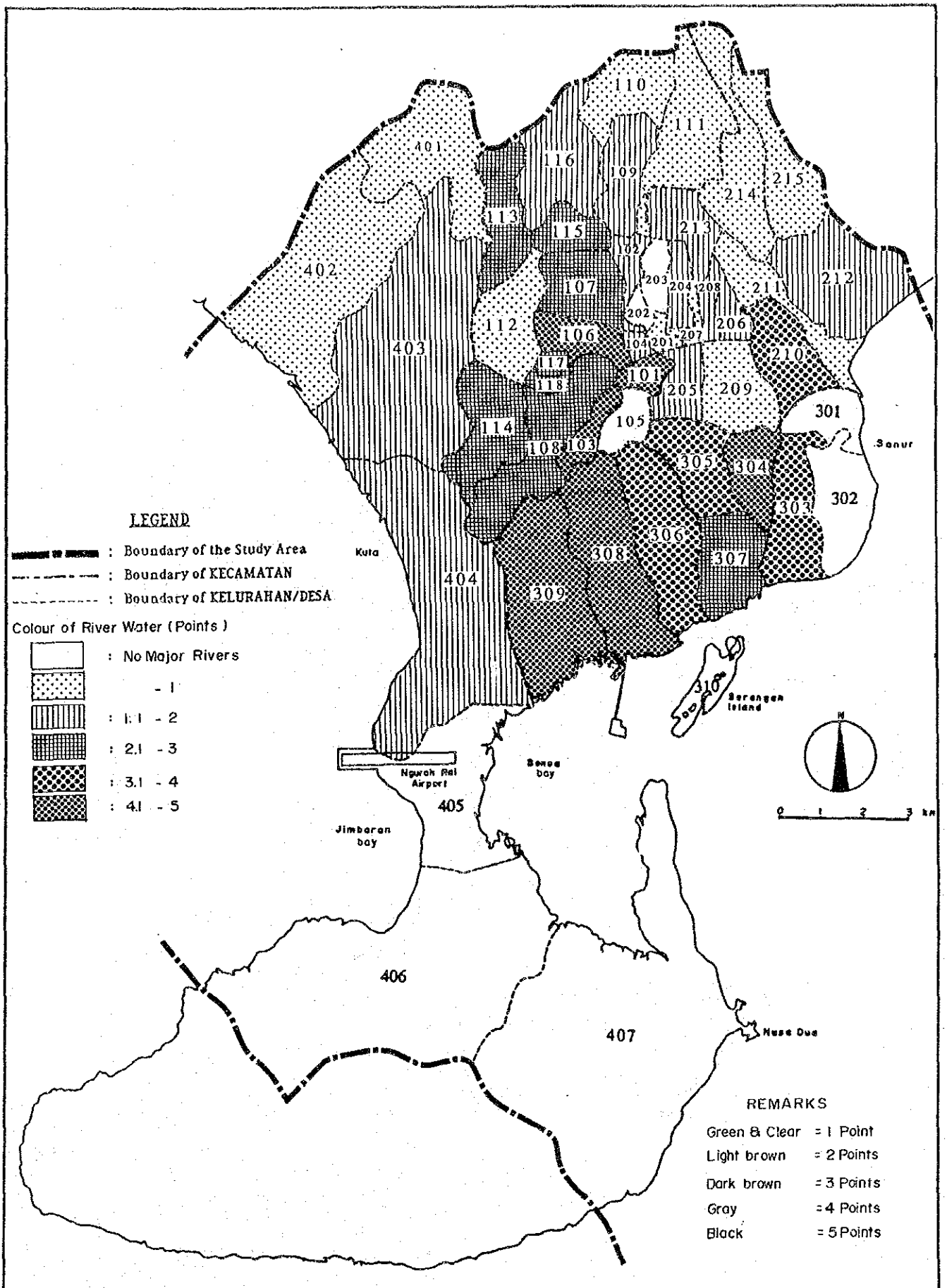


FIG. B.2.9 COLOUR OF RIVER WATER BY KELURAHAN/DESA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

JICA A.D 1993

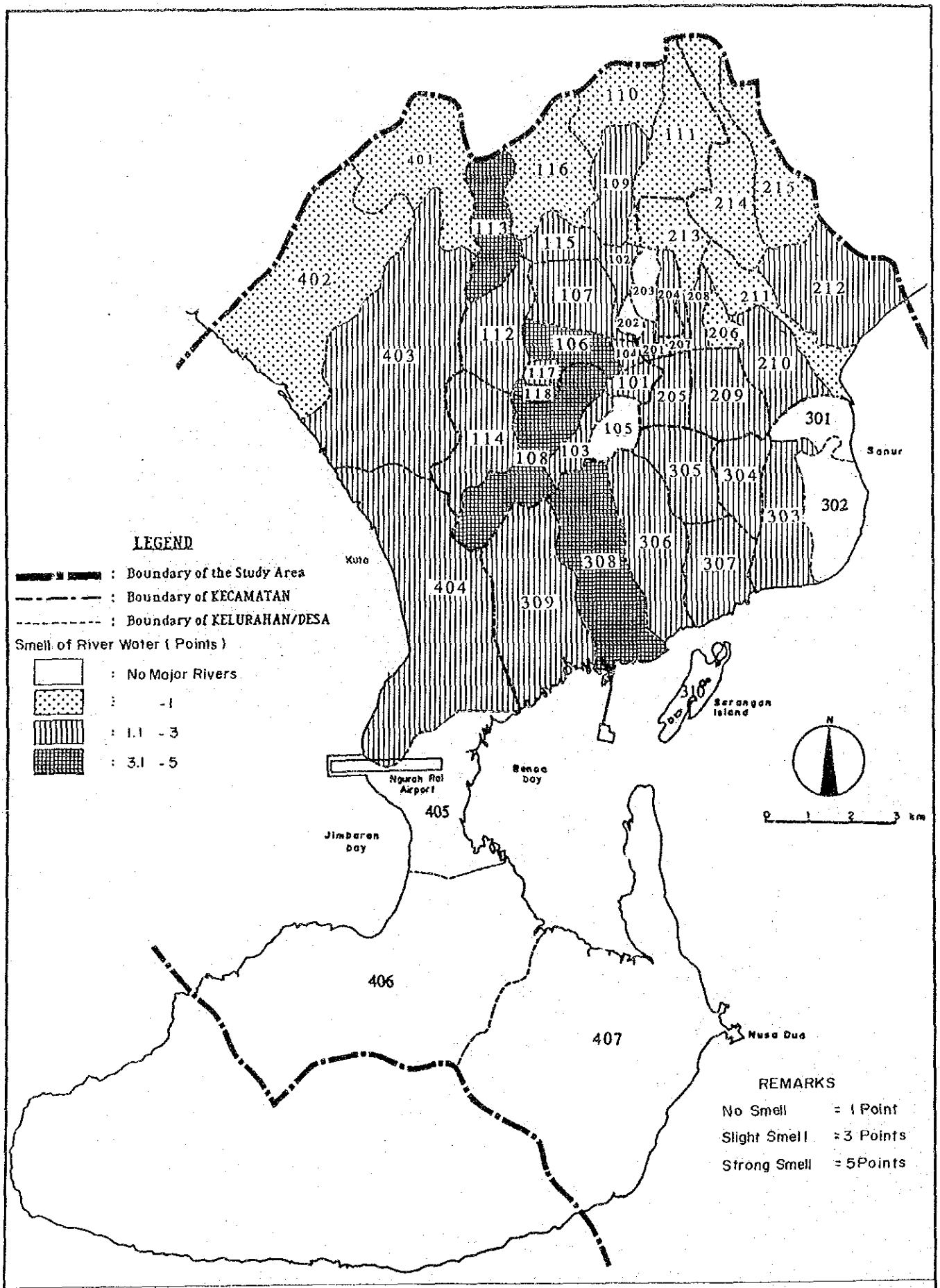
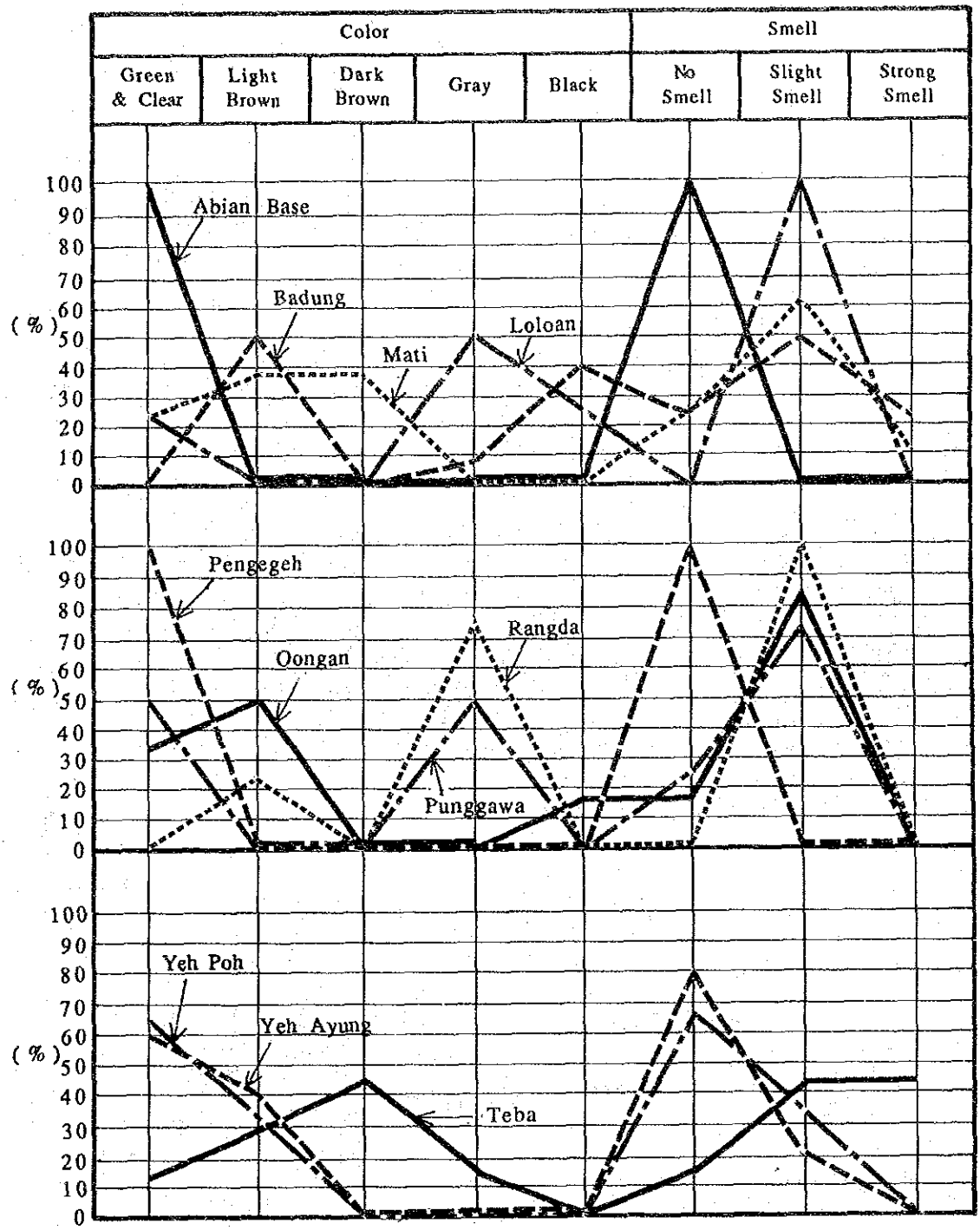


FIG. B.2.10 SMELL OF RIVER WATER BY KELURAHAN/DESA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR



Note : Results of the interview survey conducted toward the chairmen of Kelurahan/Desa. A percentage expresses the ratio of affirmative replies regarding a particular water color or smell of a river.

FIG. B.2.11 COLOR AND SMELL OF RIVER WATER

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

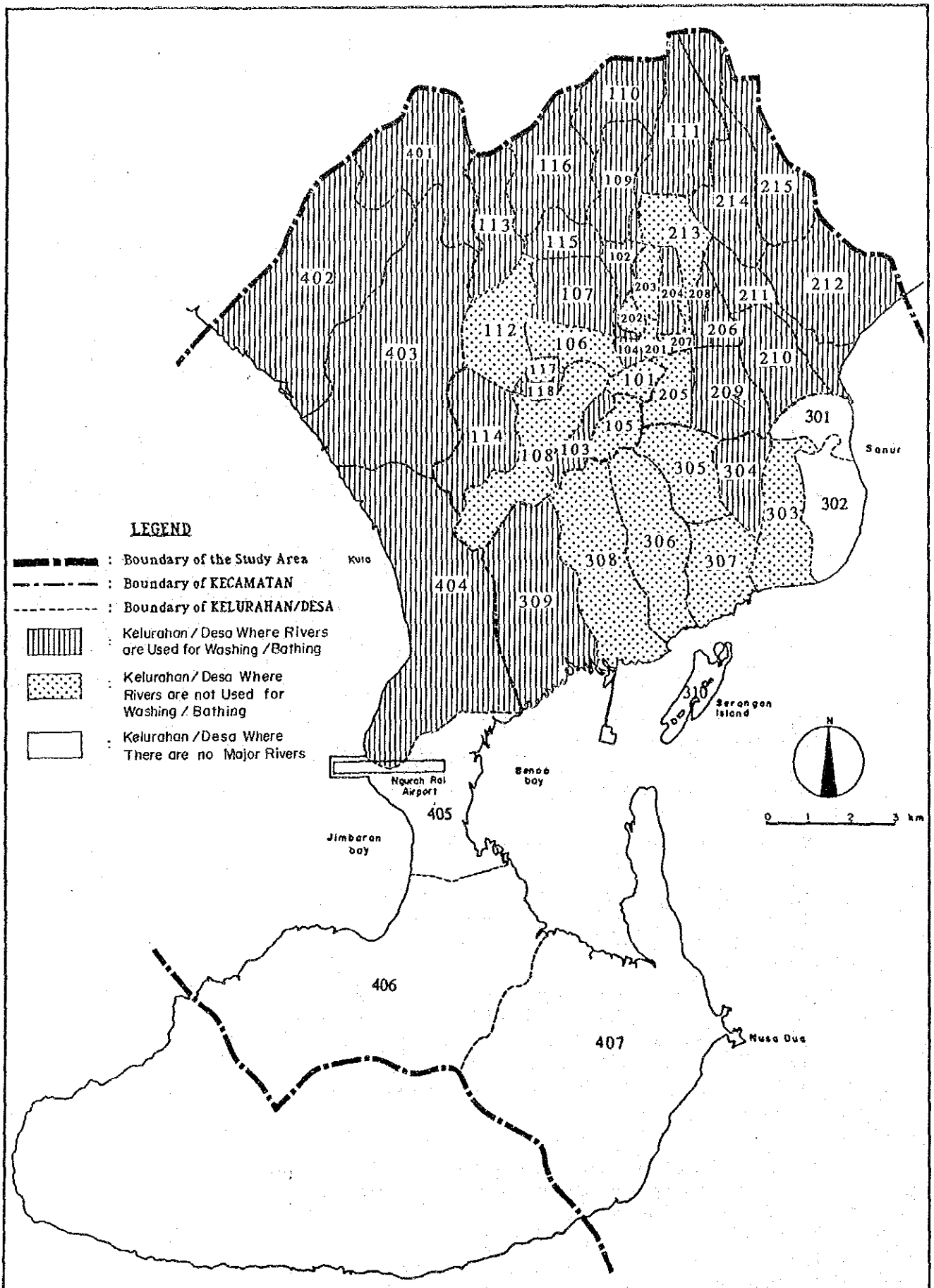


FIG. B.2.12 DISTRIBUTION OF KELURAHAN/DESA WHERE RIVERS ARE USED FOR WASHING/BATHING

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

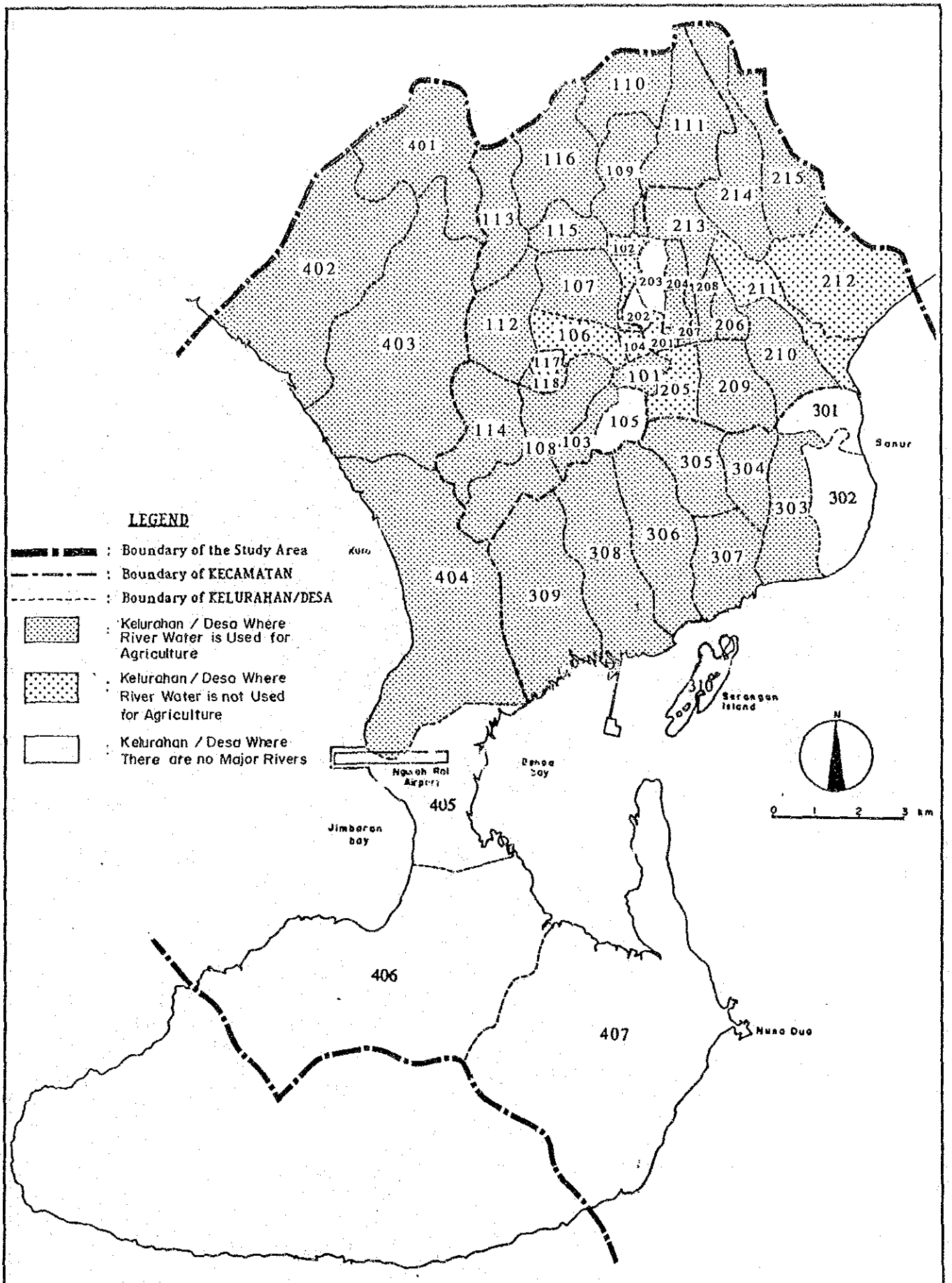


FIG. B.2.13 DISTRIBUTION OF KELURAHAN/DESA WHERE RIVER WATER IS USED FOR AGRICULTURE

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

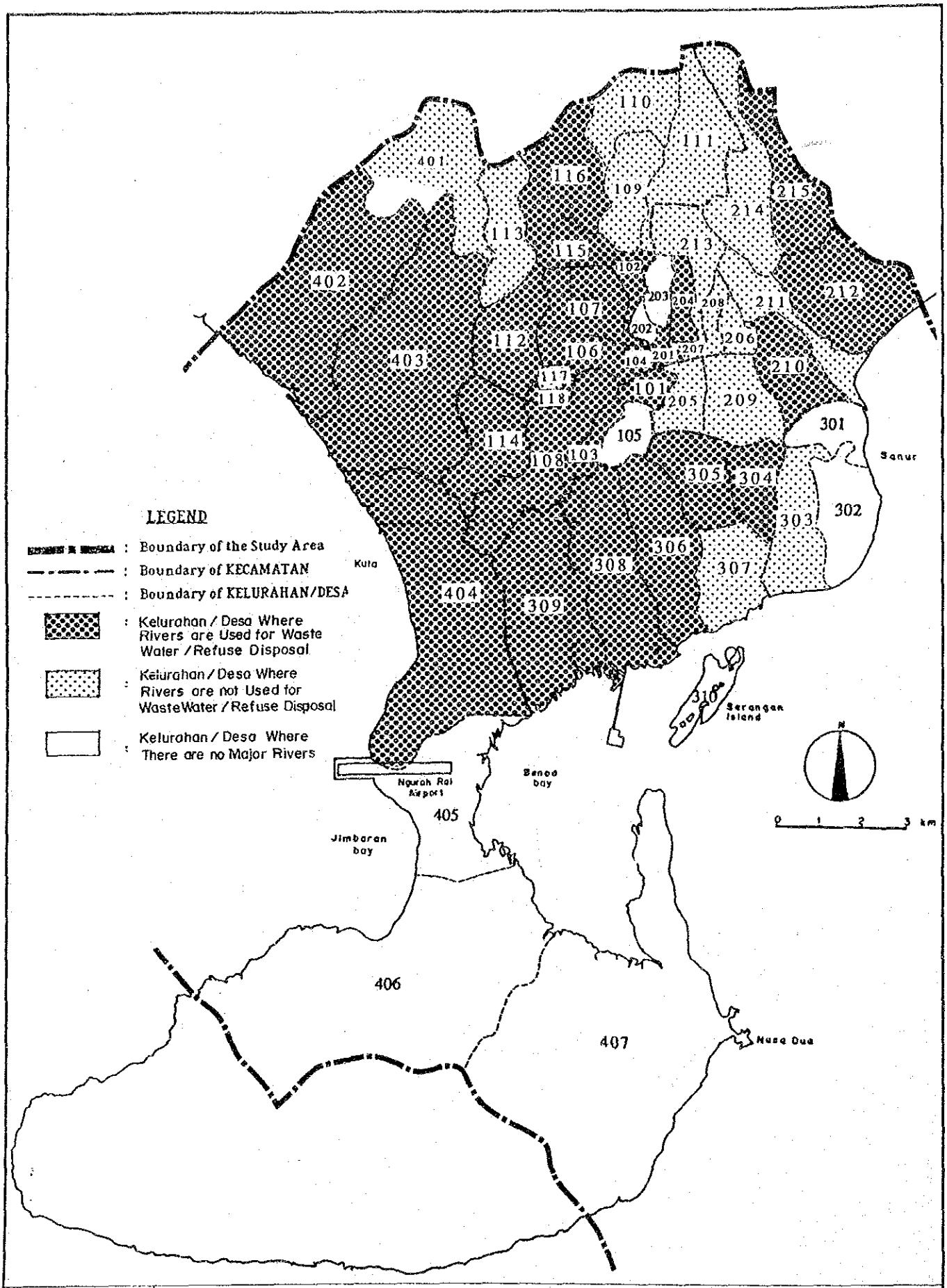
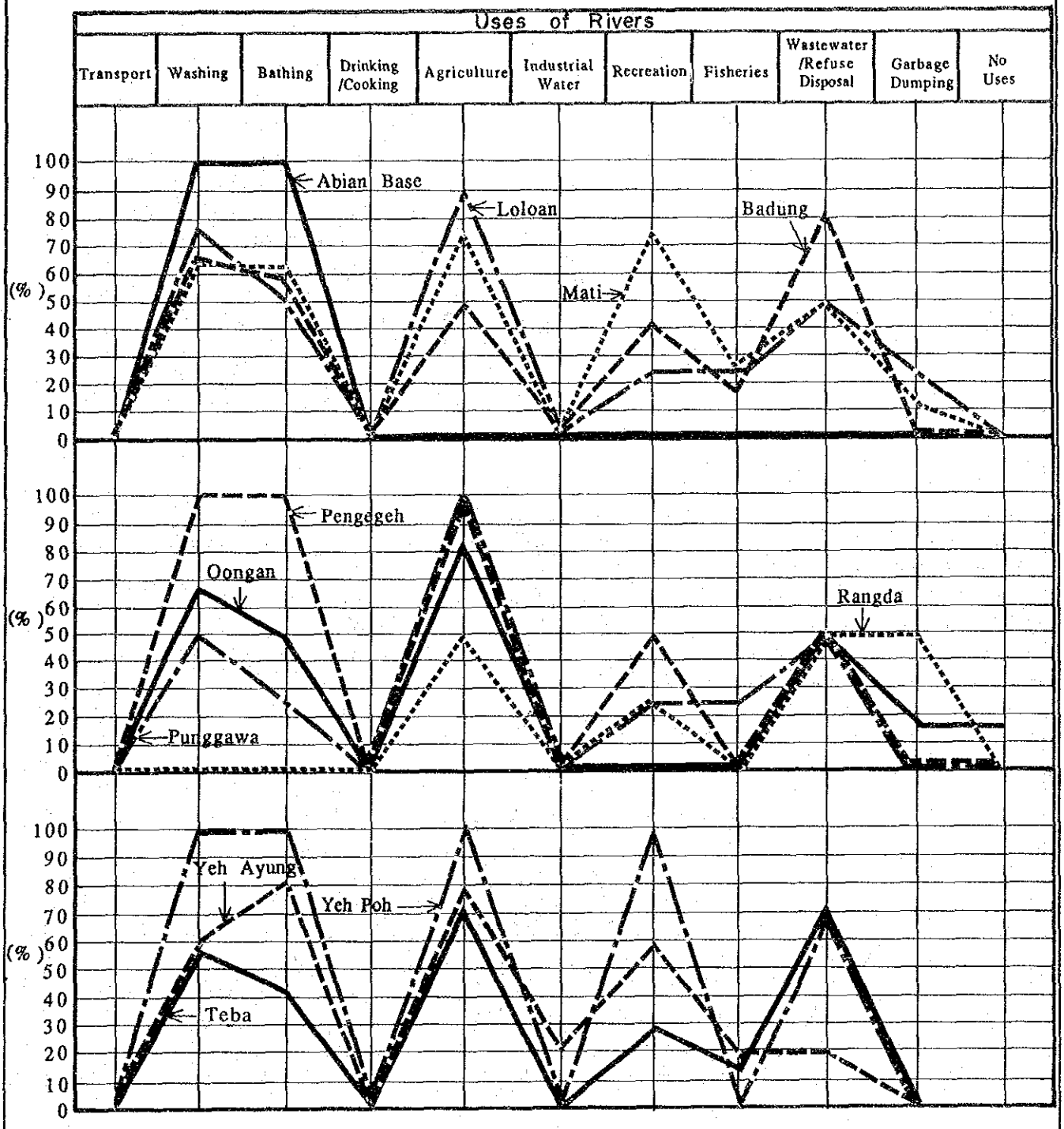


FIG. B.2.14 DISTRIBUTION OF KELURAHAN/DESA WHERE RIVERS ARE USED FOR WASTEWATER/REFUSE DISPOSAL

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR



Note : Results of the interview survey conducted toward the chairmen of Kelurahan/Desa.
A percentage expresses the ratio of affirmative replies regarding a particular use of a river.

FIG. B.2.15 USES OF RIVERS

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

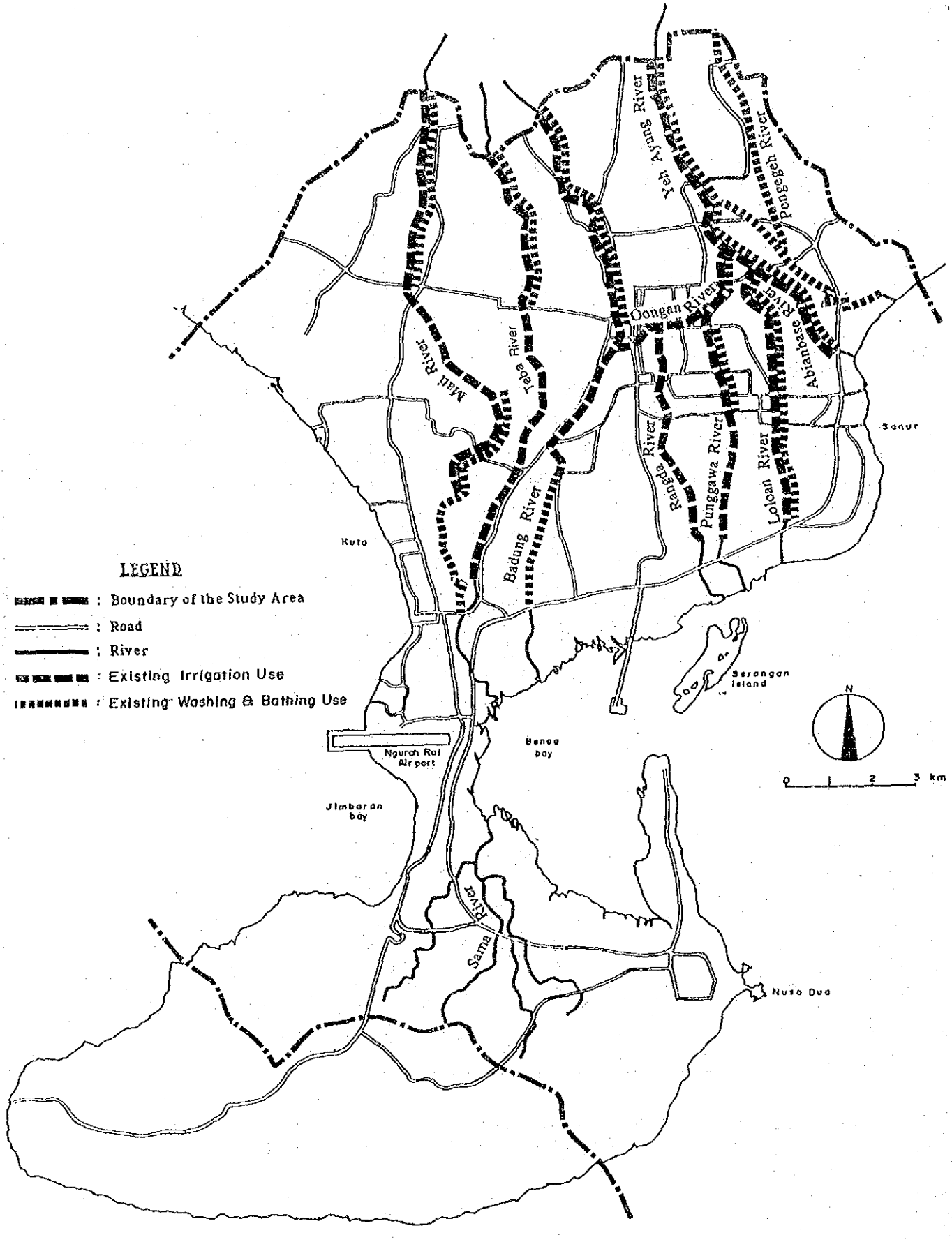


FIG. B.2.16 EXISTING MAJOR WATER USE BY RIVER SECTION

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

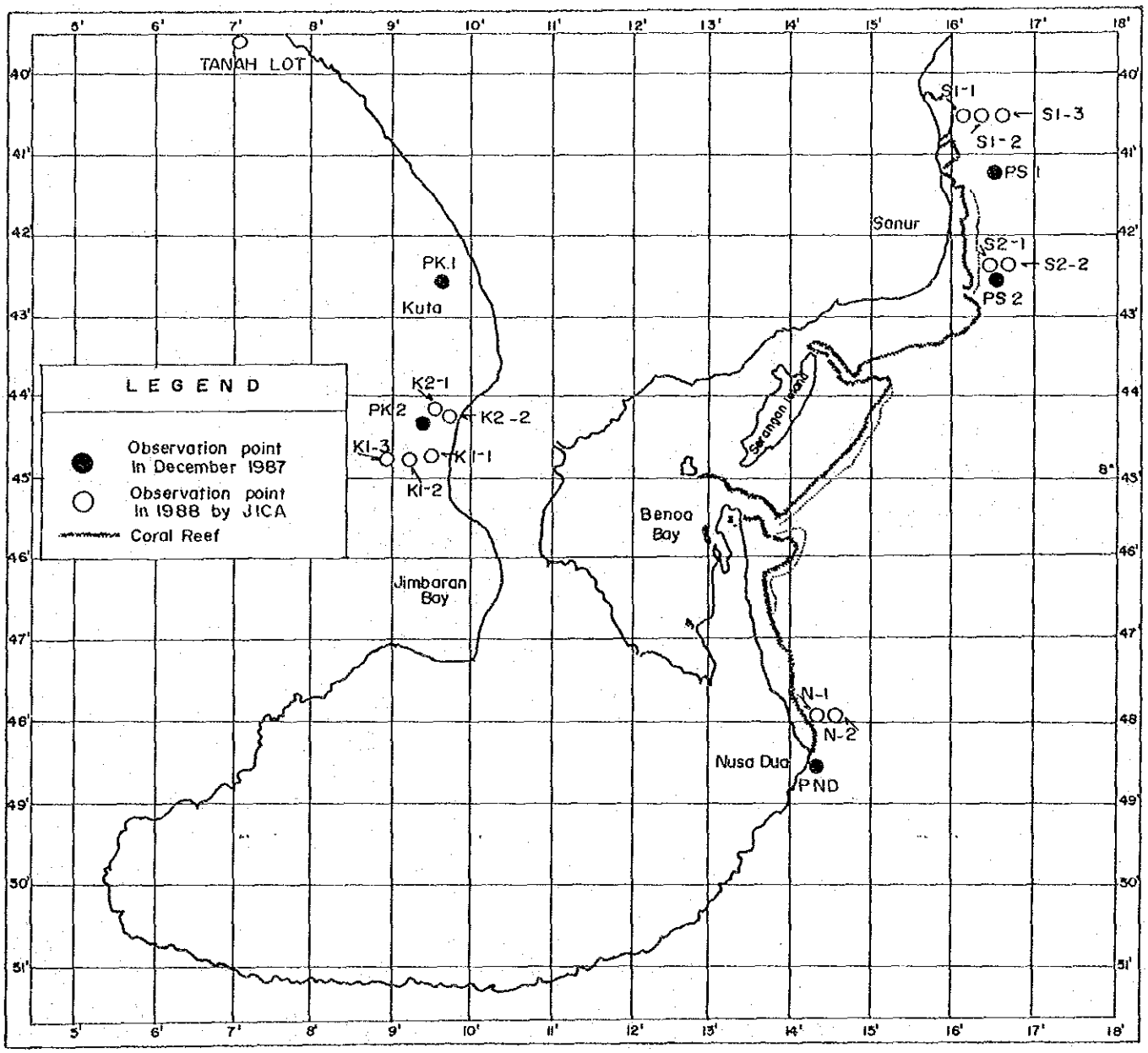


FIG. B.3.1 SEA WATER QUALITY OBSERVATION POINT

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

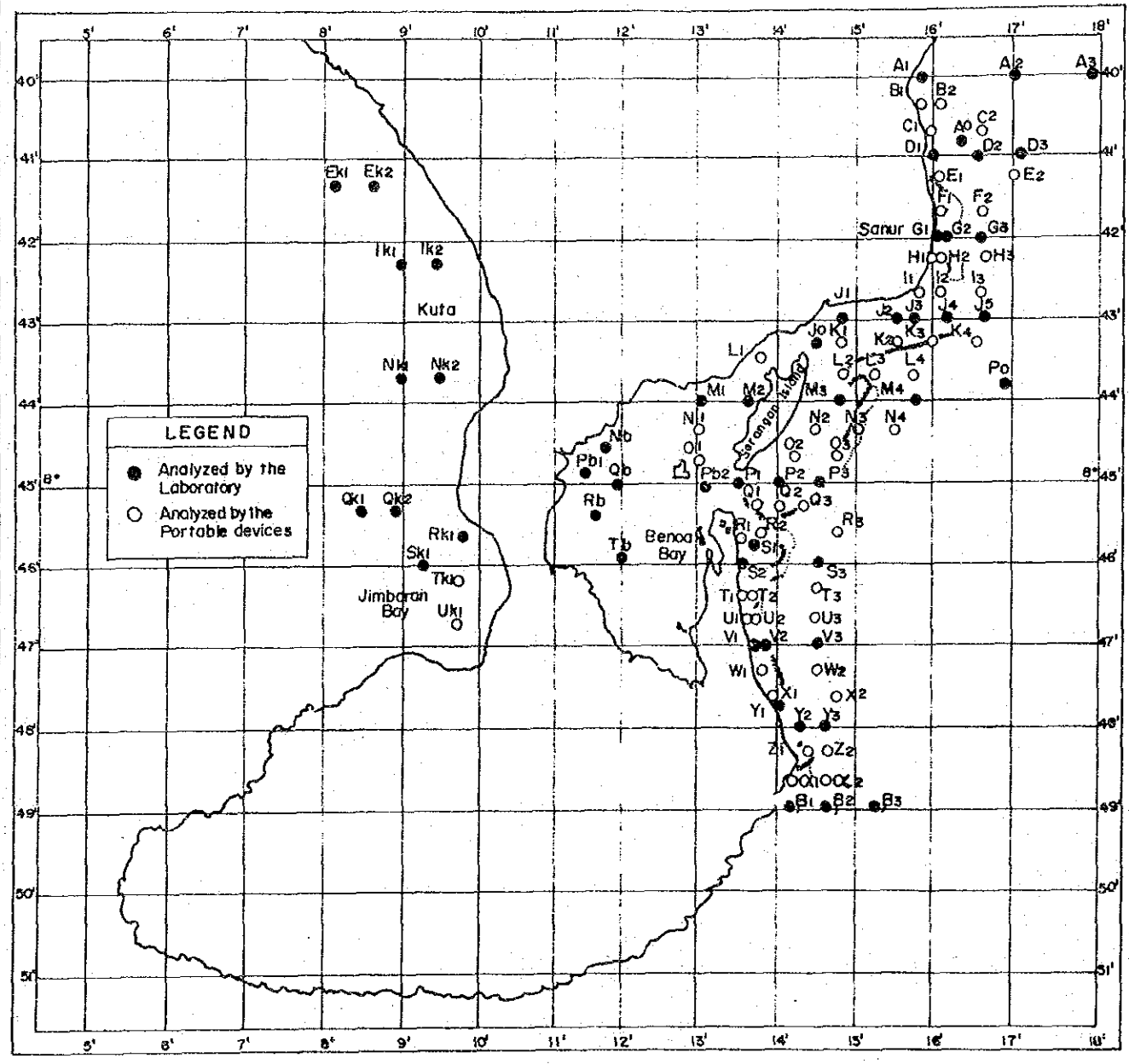


FIG. B.3.2 SEA WATER QUALITY OBSERVATION POINT BY JICA (1991~1992)

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

(1) D O

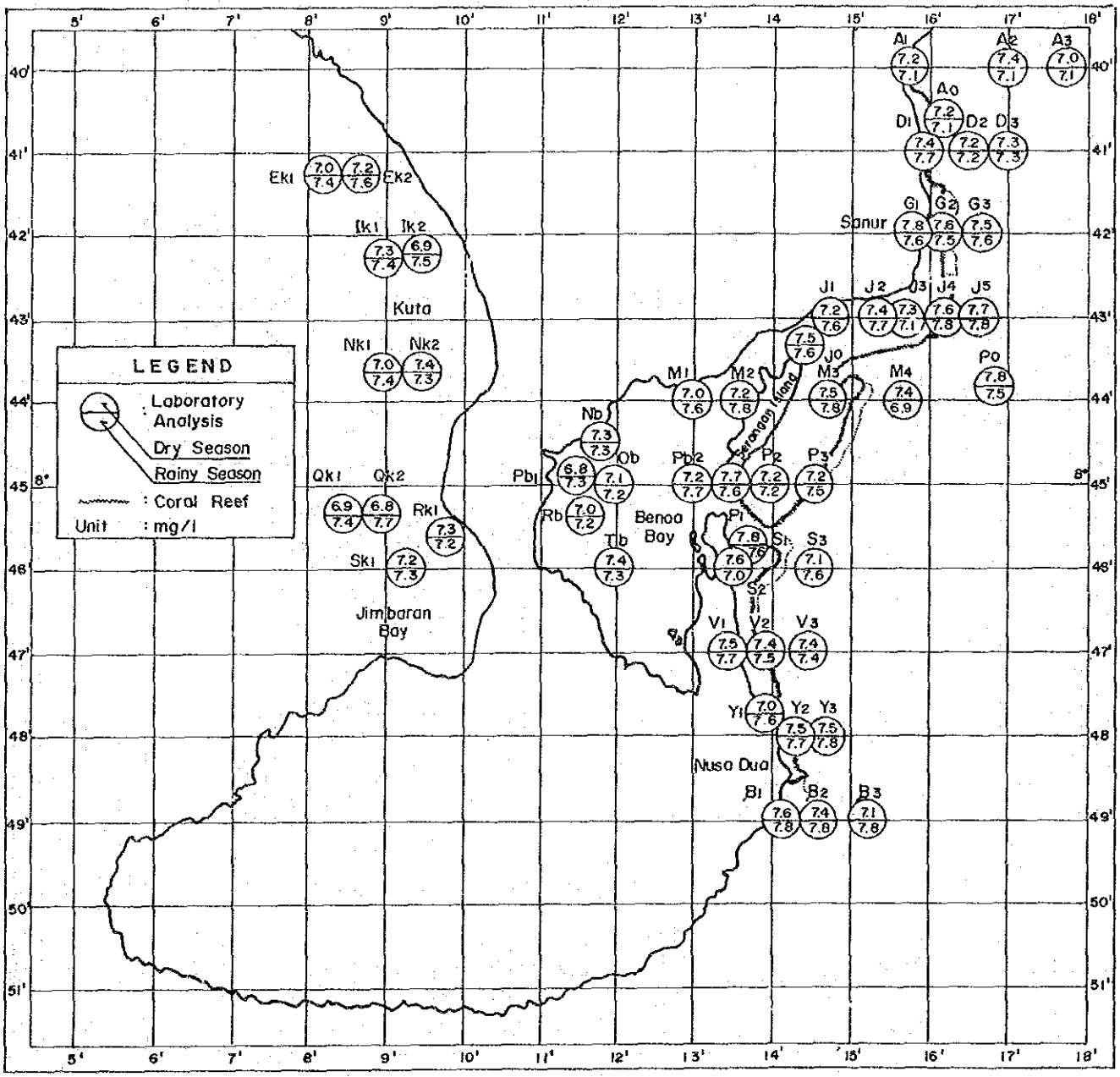


FIG. B.3.3(1) OBSERVED SEA WATER QUALITY BY JICA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

(2) CODcr

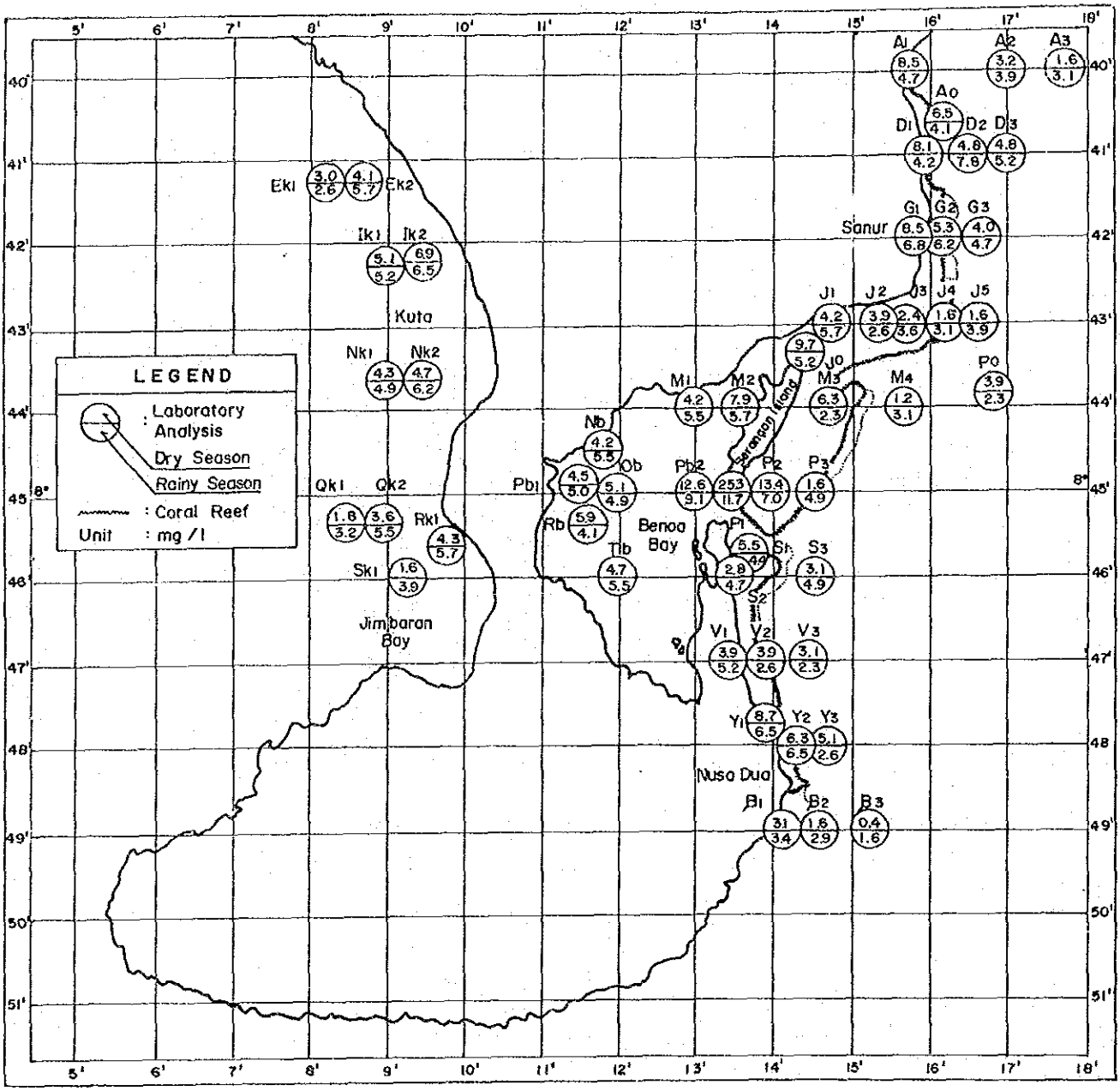


FIG. B.3.3(2) OBSERVED SEA WATER QUALITY BY JICA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

JICA A.D 1993

(3) SS

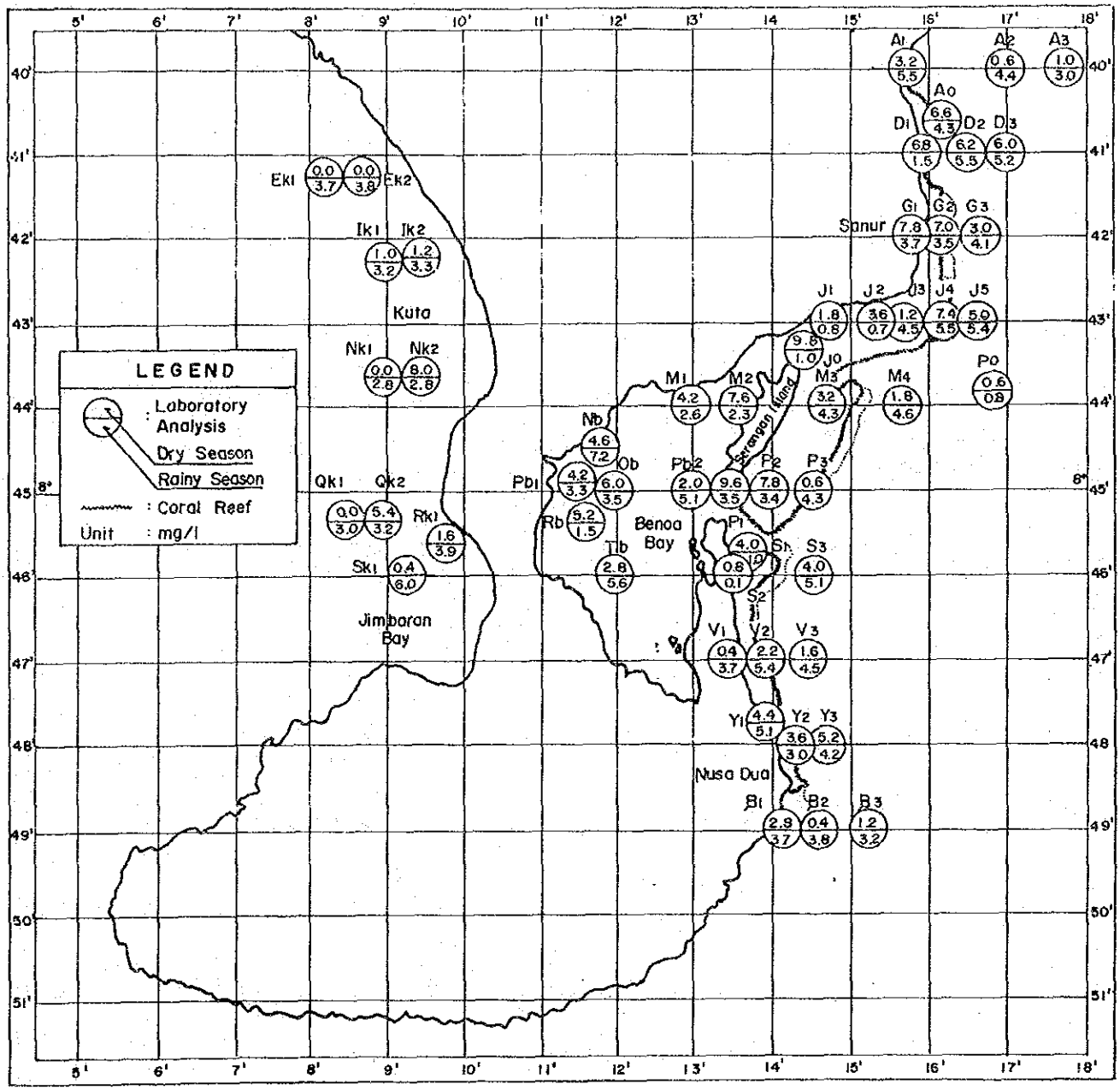


FIG. B.3.3(3) OBSERVED SEA WATER QUALITY BY JICA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

JICA A.D 1993

(4) PH

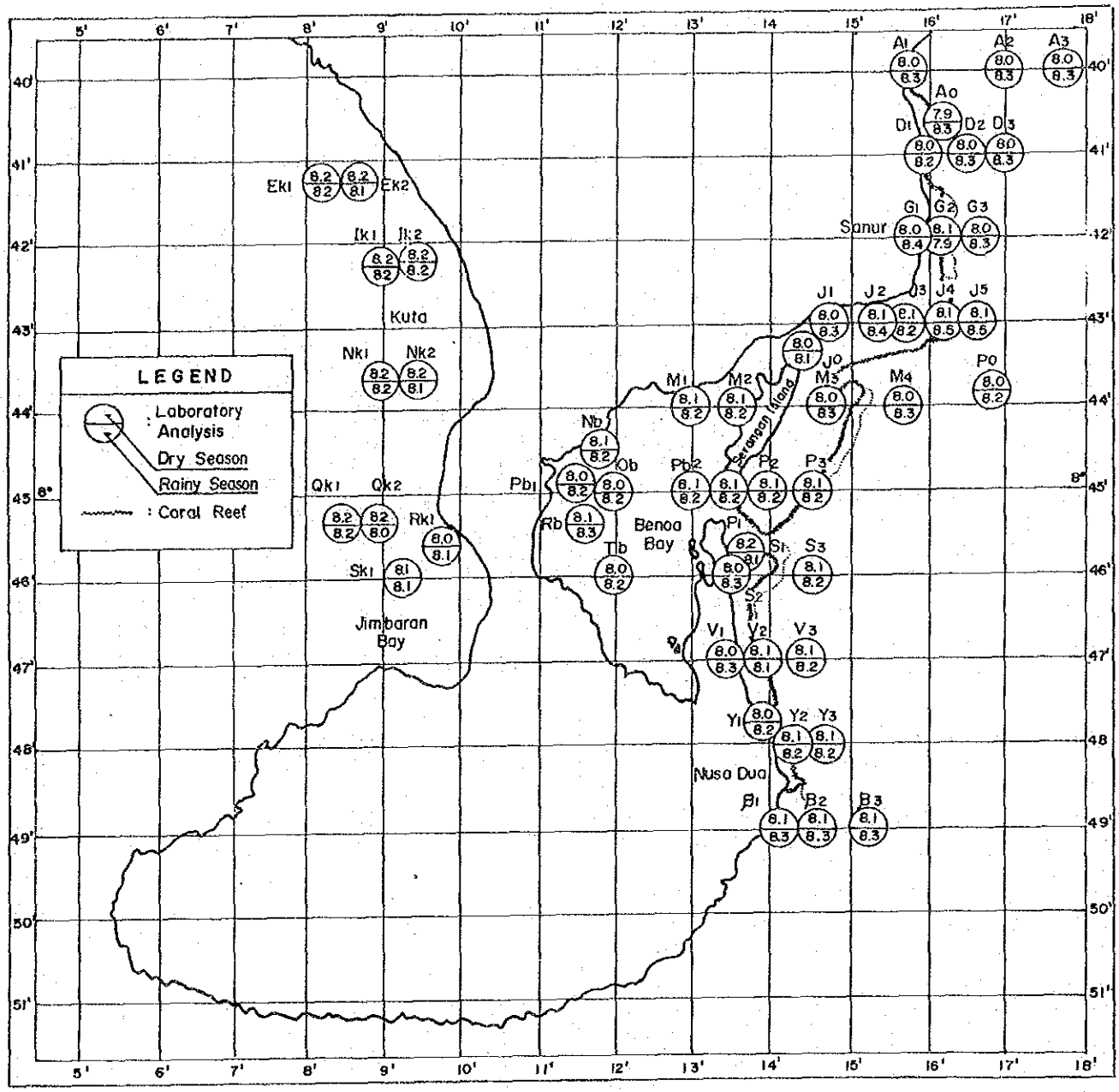


FIG. B.3.3(4) OBSERVED SEA WATER QUALITY BY JICA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

JICA A.D 1993

(5) NO3 -N

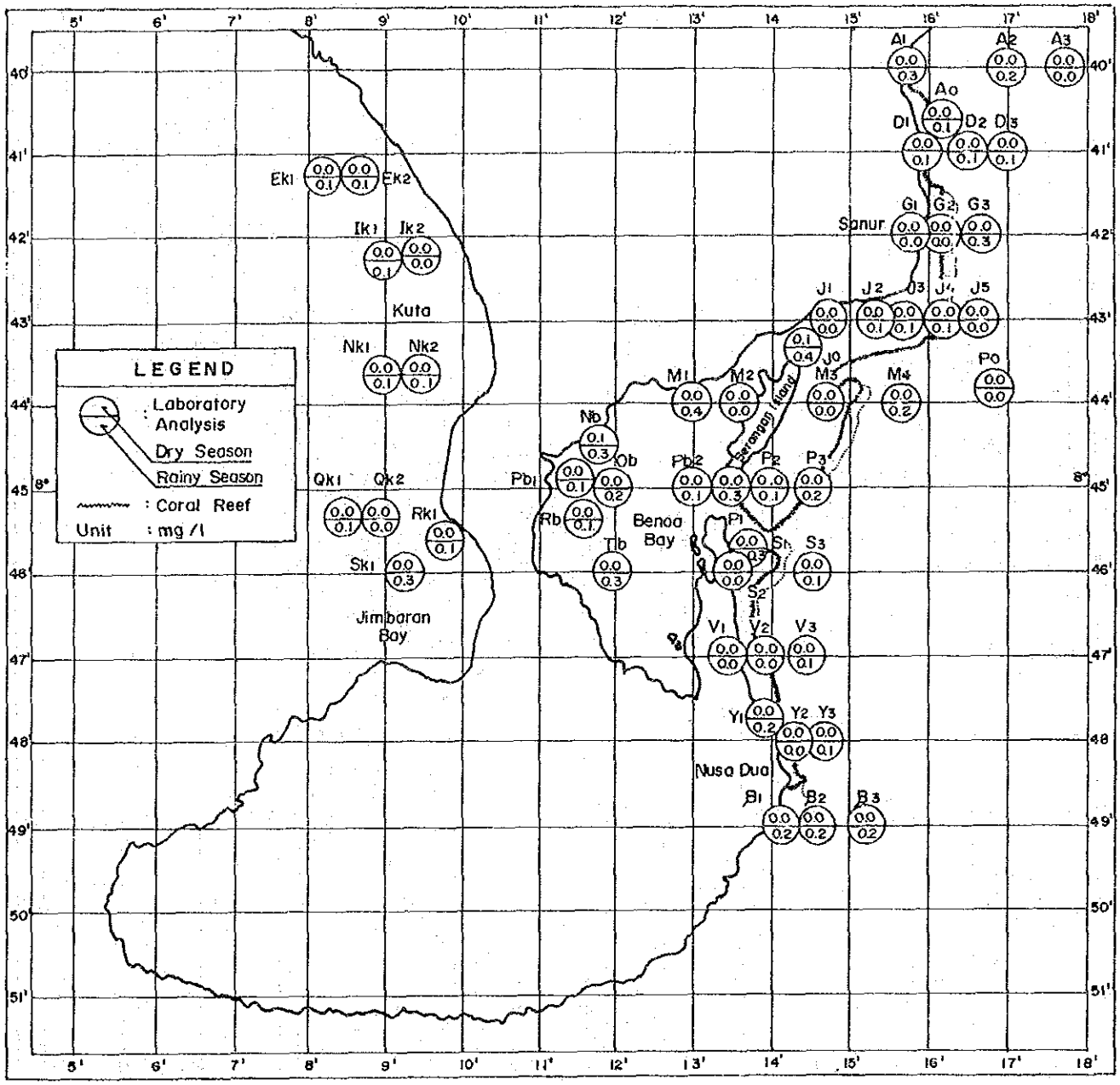


FIG. B.3.3(5) OBSERVED SEA WATER QUALITY BY JICA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

JICA A.D 1993

(6) NO2 - N

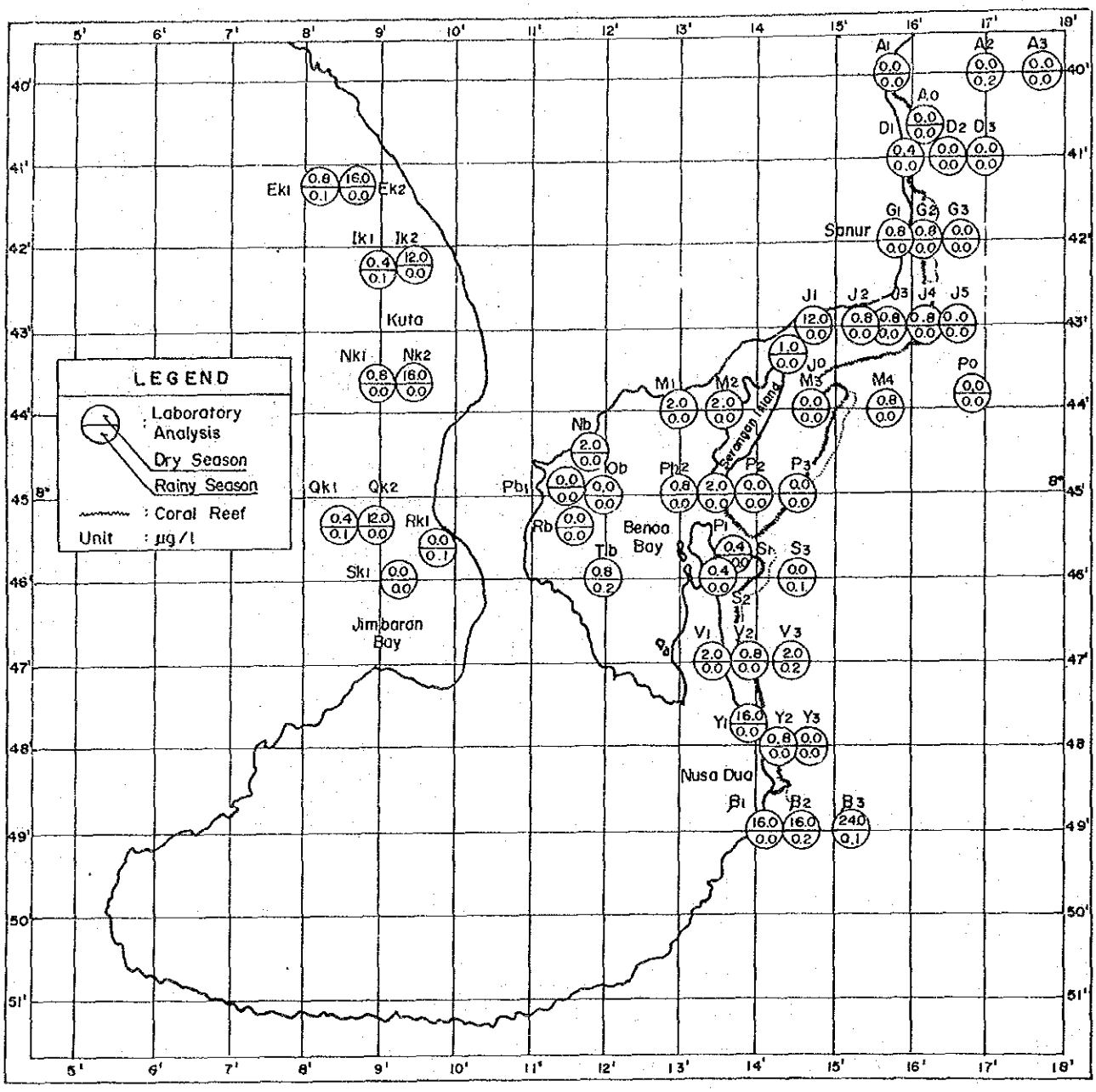


FIG. B.3.3(6) OBSERVED SEA WATER QUALITY BY JICA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

(7) TOTAL -N

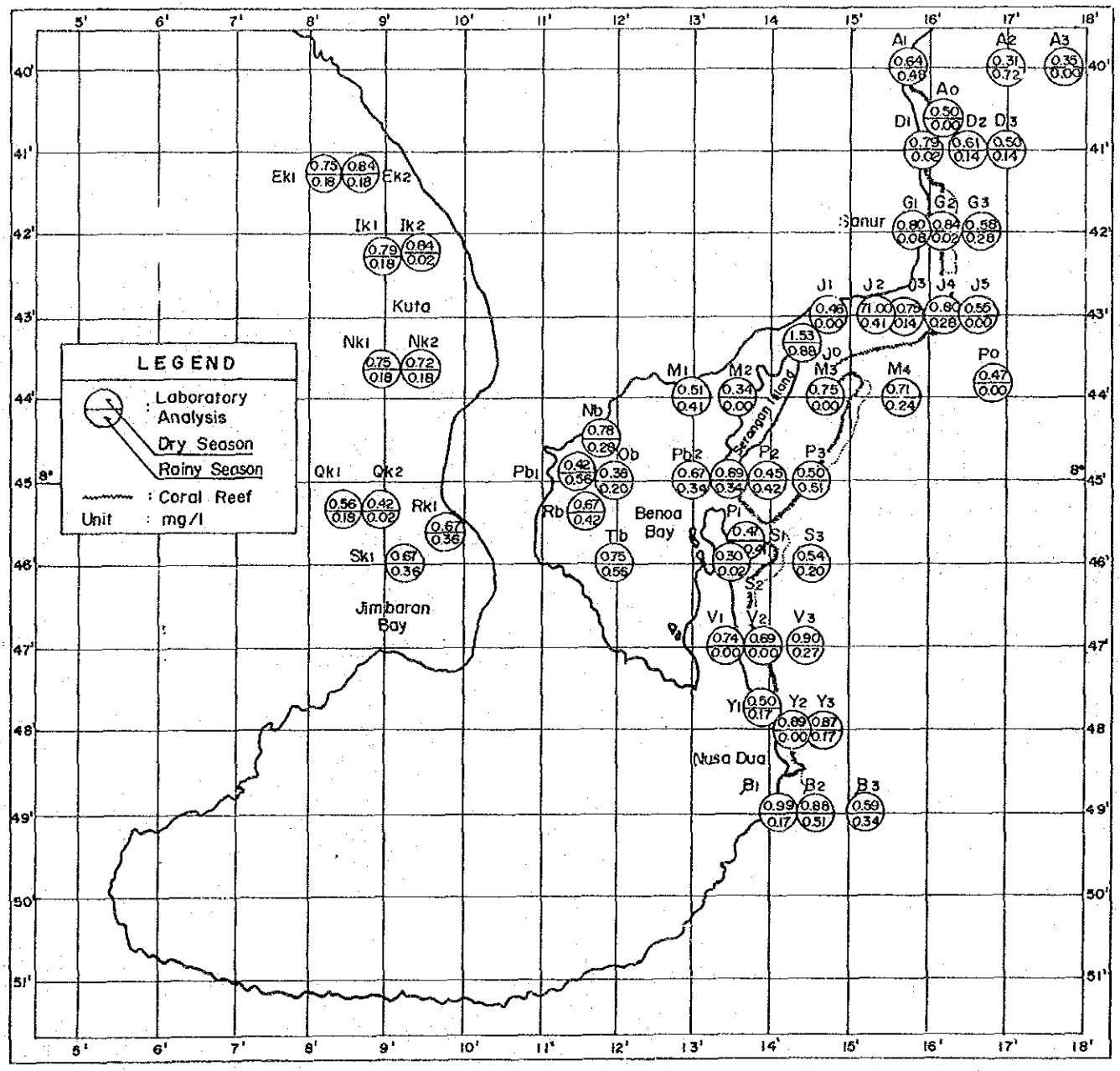


FIG. B.3.3(7) OBSERVED SEA WATER QUALITY BY JICA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

(8) TOTAL - P

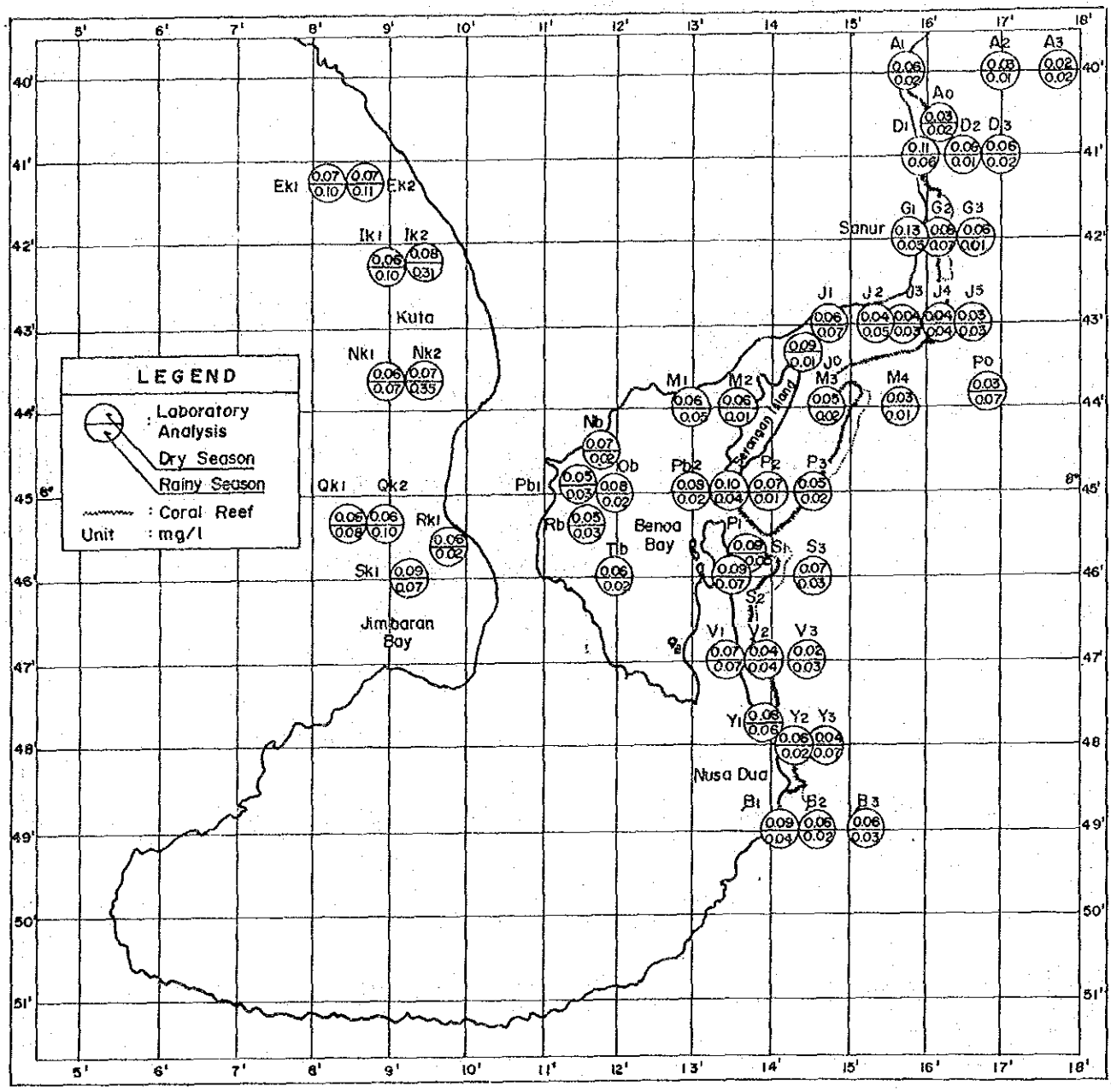


FIG. B.3.3(8) OBSERVED SEA WATER QUALITY BY JICA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

(9) n- HEXAN EXTRACTS

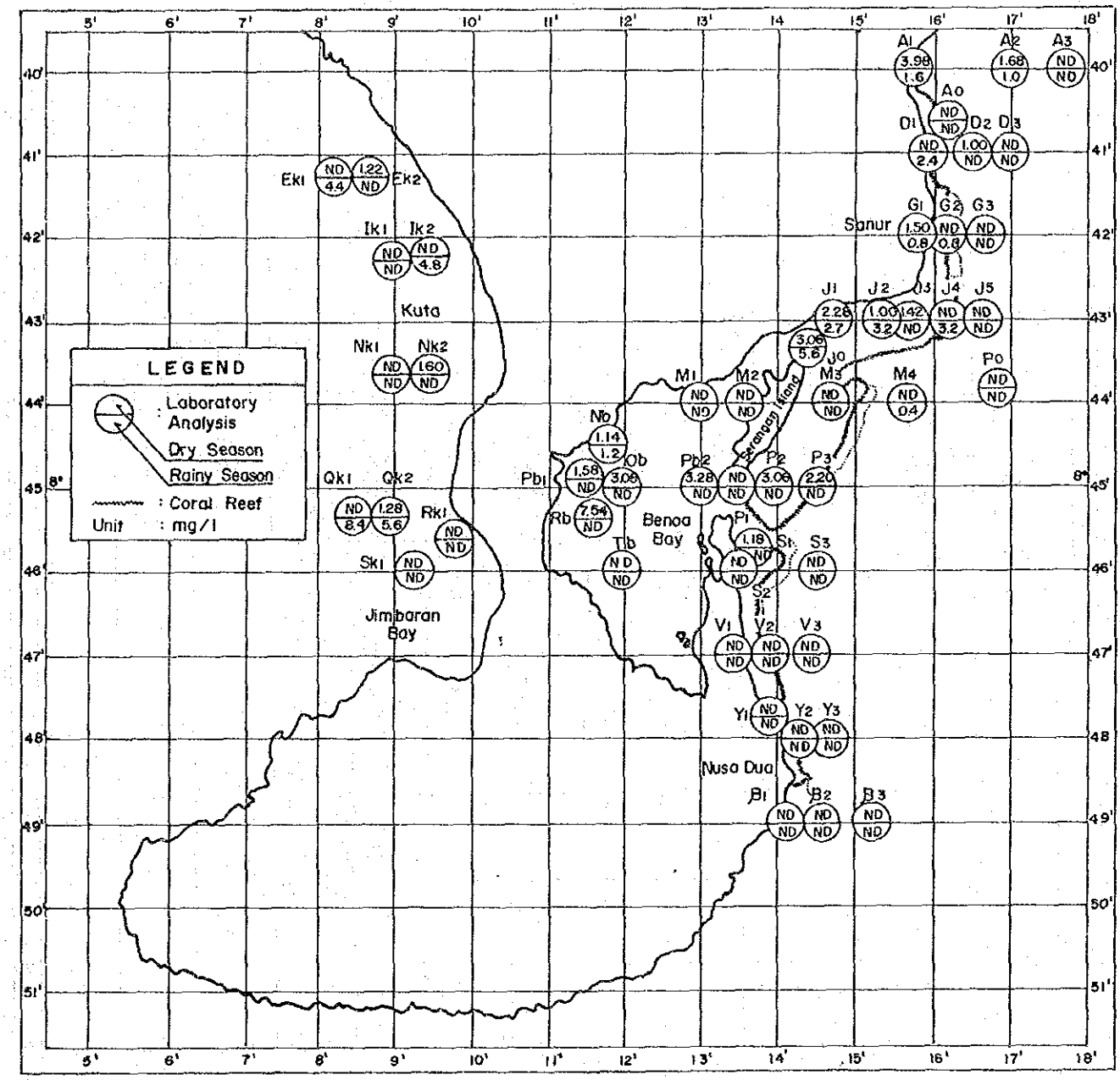


FIG. B.3.3(9) OBSERVED SEA WATER QUALITY BY JICA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

(10) FECAL COLIFORM

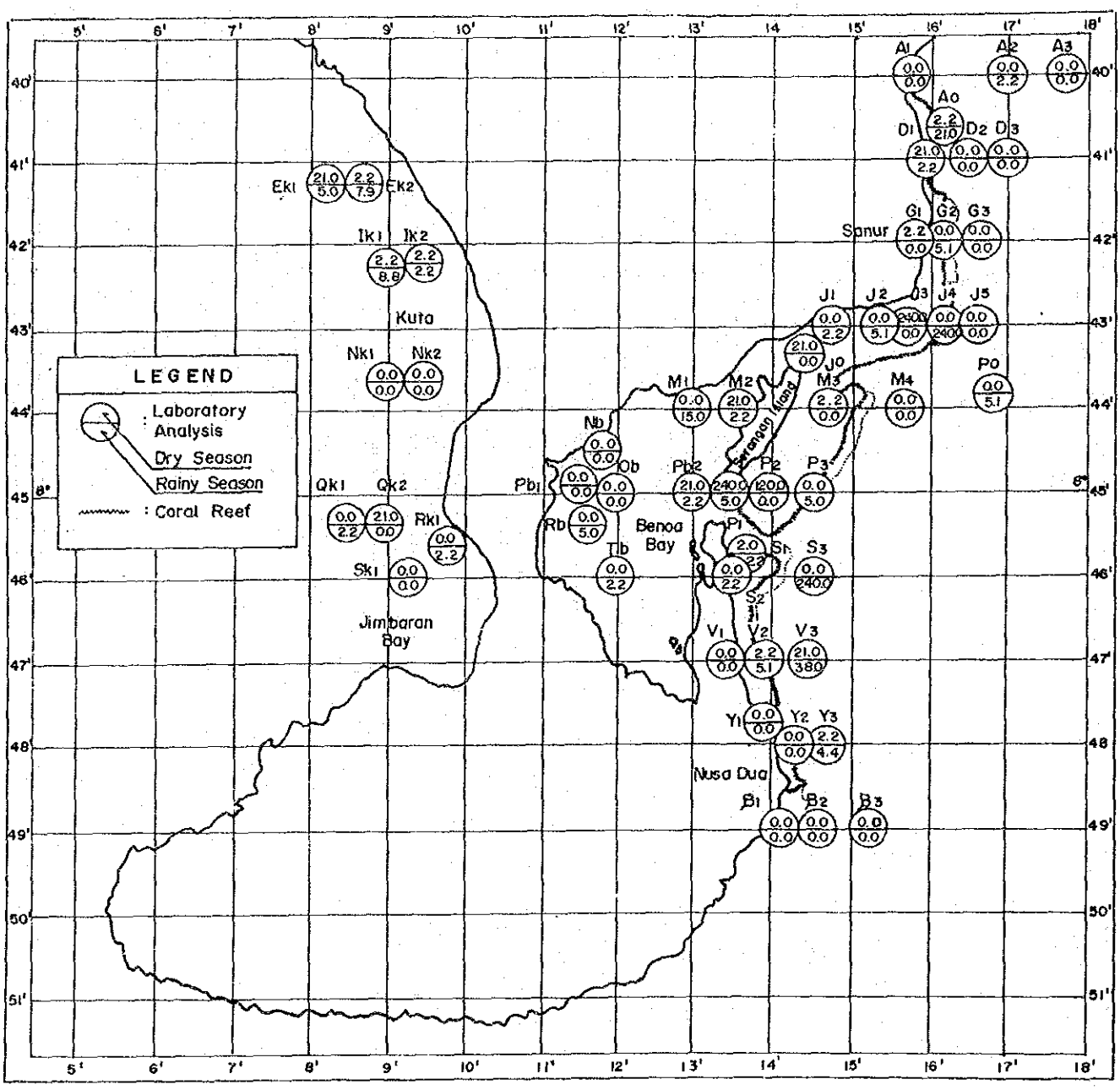


FIG.B.3.3(10) OBSERVED SEA WATER QUALITY BY JICA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

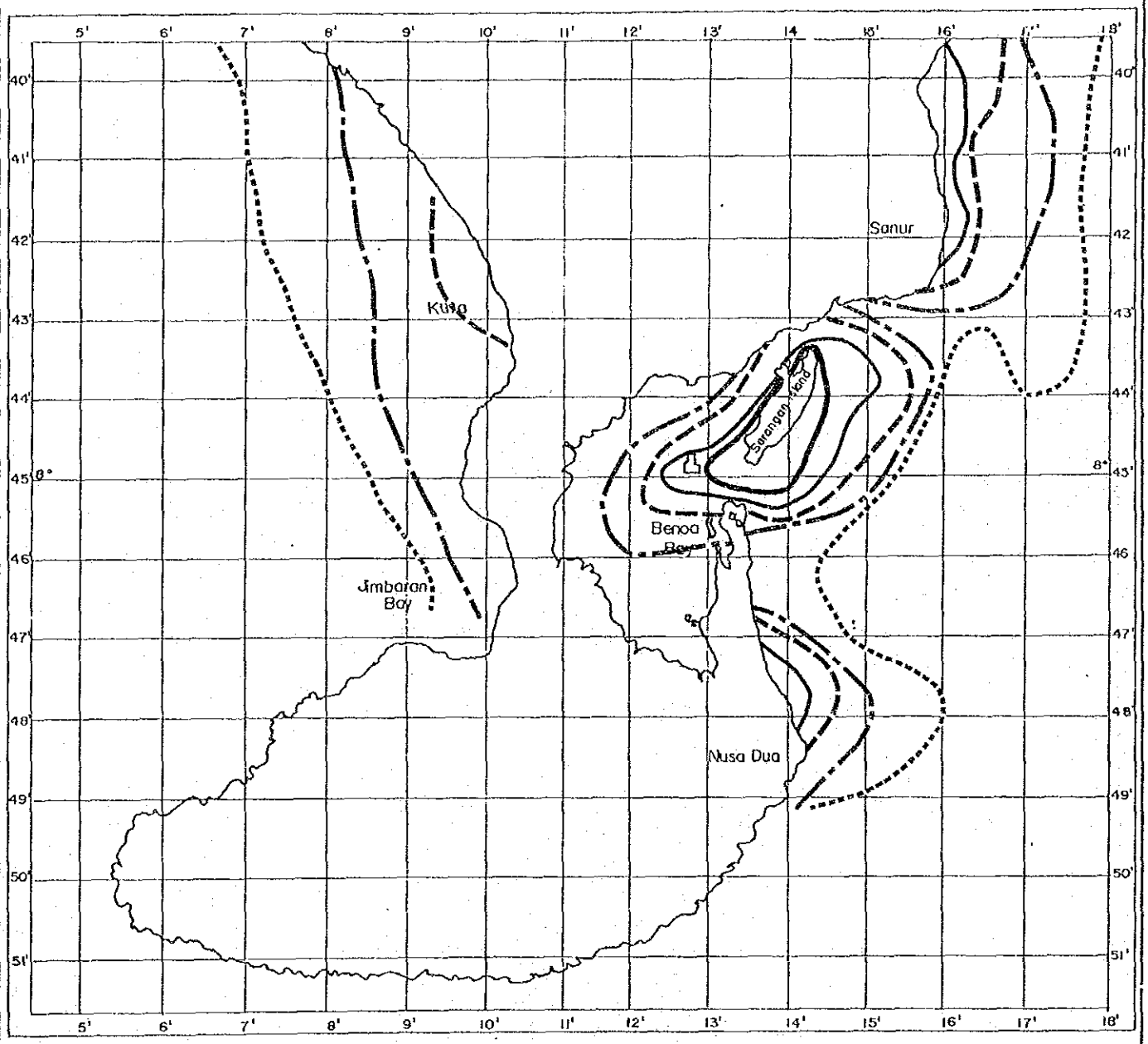
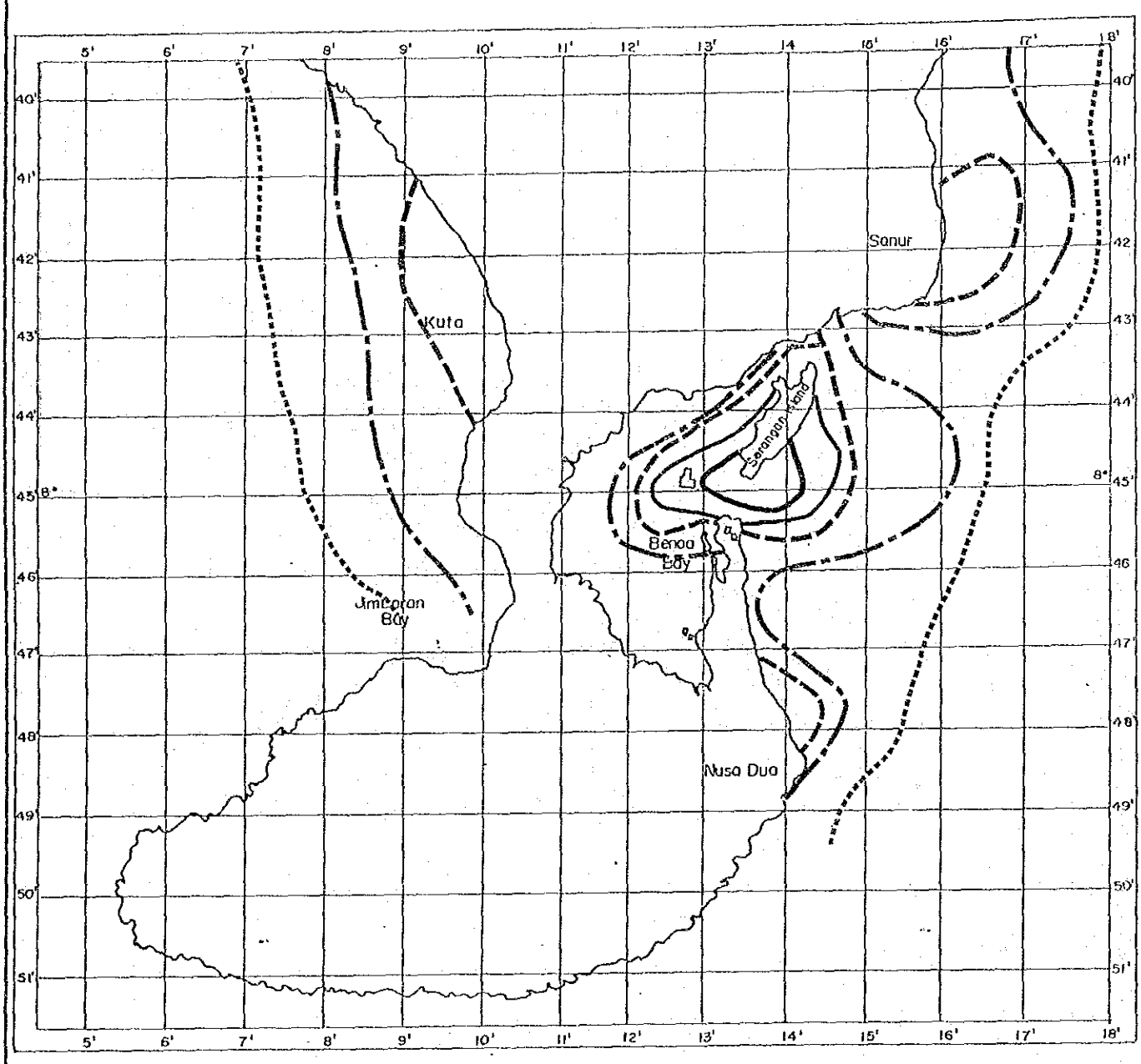


FIG. B.3.4(1) COD POLLUTION DISTRIBUTION IN DRY SEASON BY JICA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR



LEGEND

: 10 mg/l

: 8 mg/l

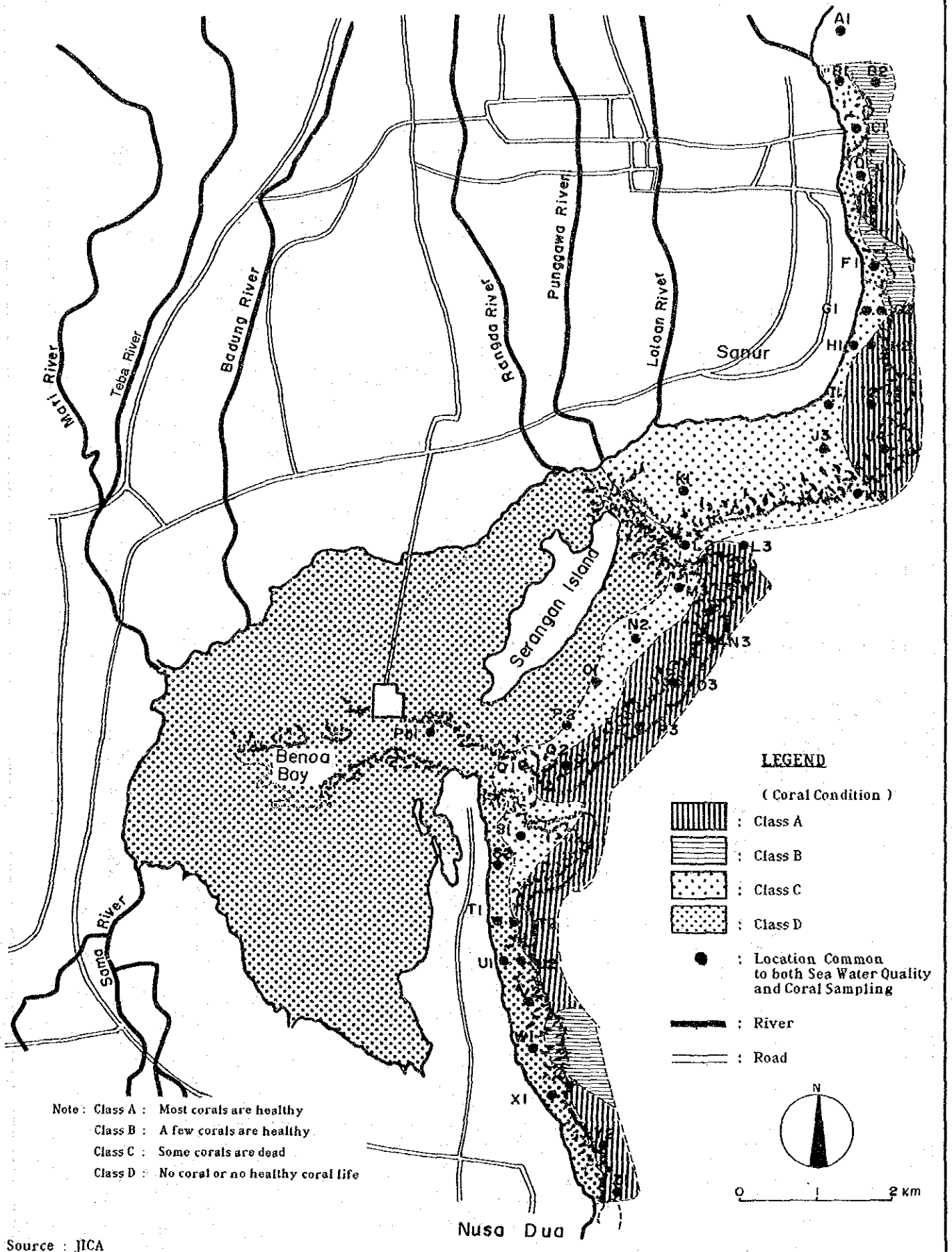
: 6 mg/l

: 4 mg/l

: 2 mg/l

FIG. B.3.4(2) COD POLLUTION DISTRIBUTION IN RAINY SEASON BY JICA

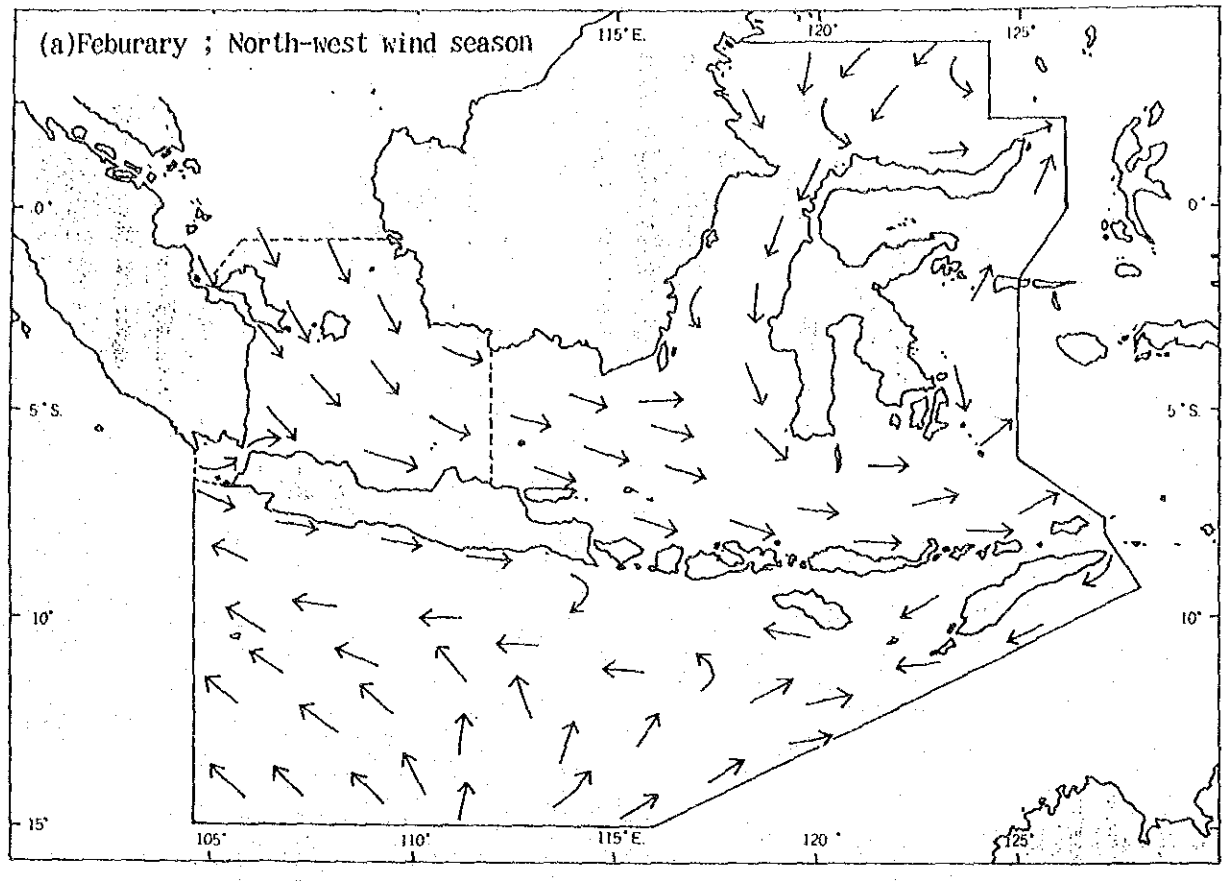
THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR



Source : JICA

FIG. B.3.5 DISTRIBUTION OF CORAL LIFE

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR



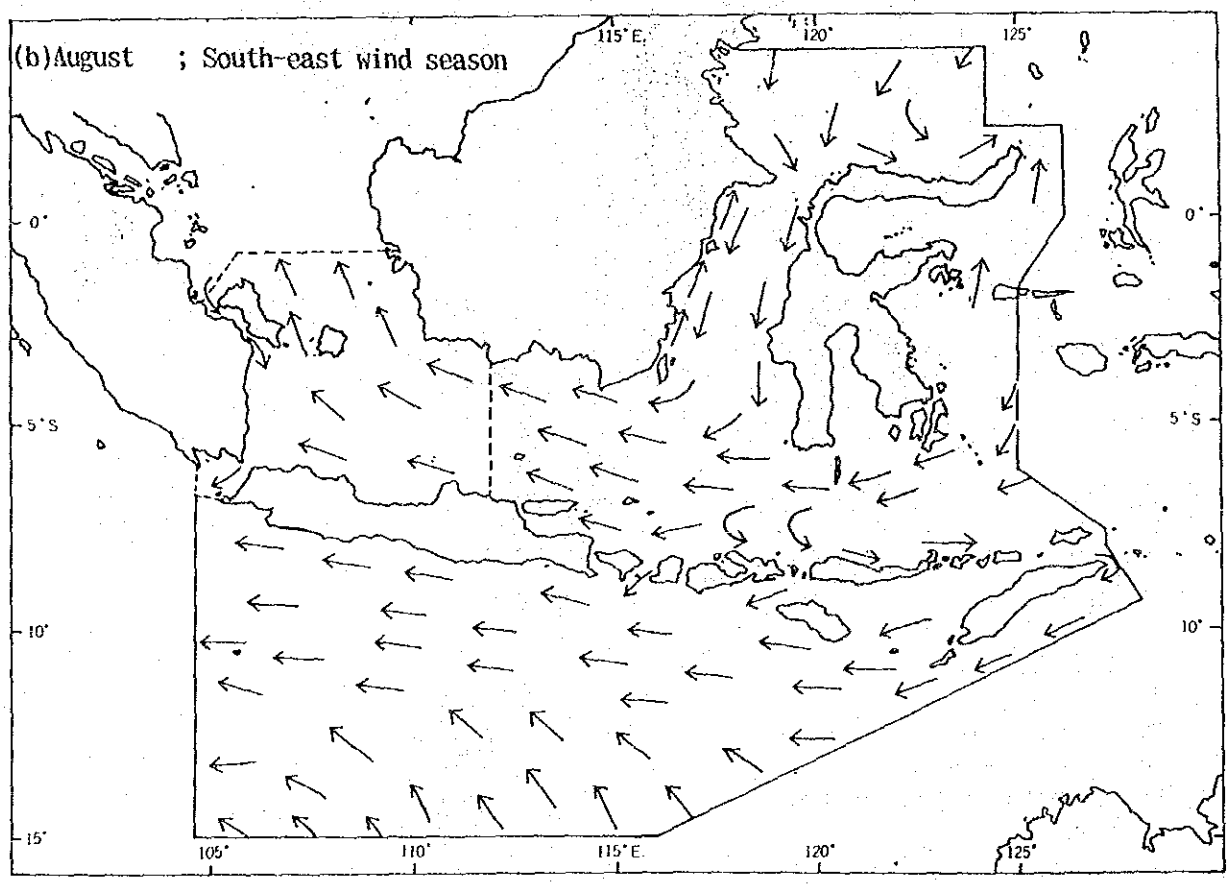


FIG. B.4.1 DISTRIBUTION OF OFF-SHORE CURRENTS

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

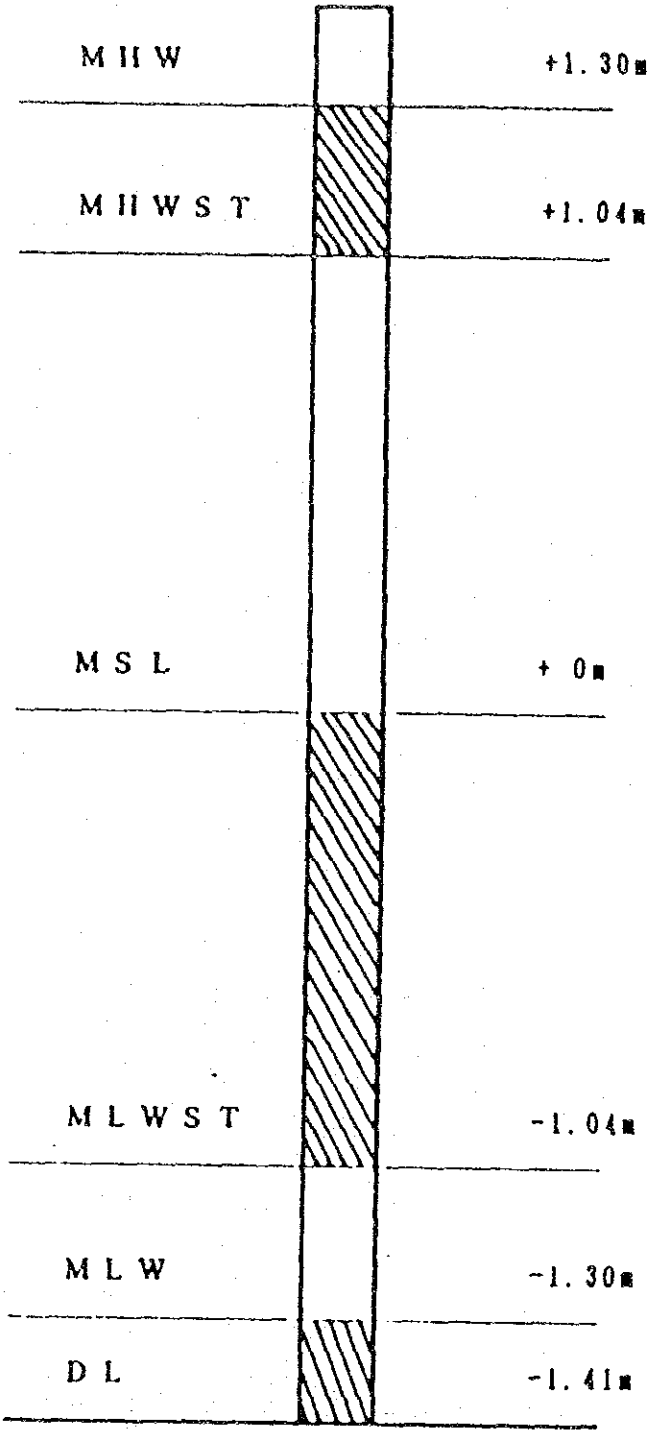
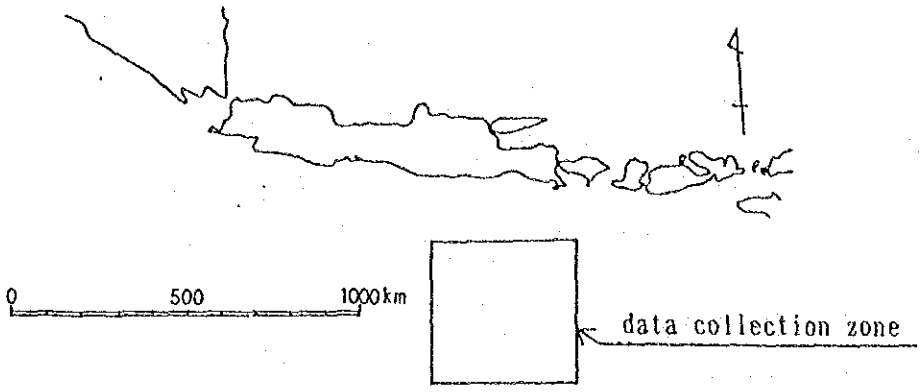
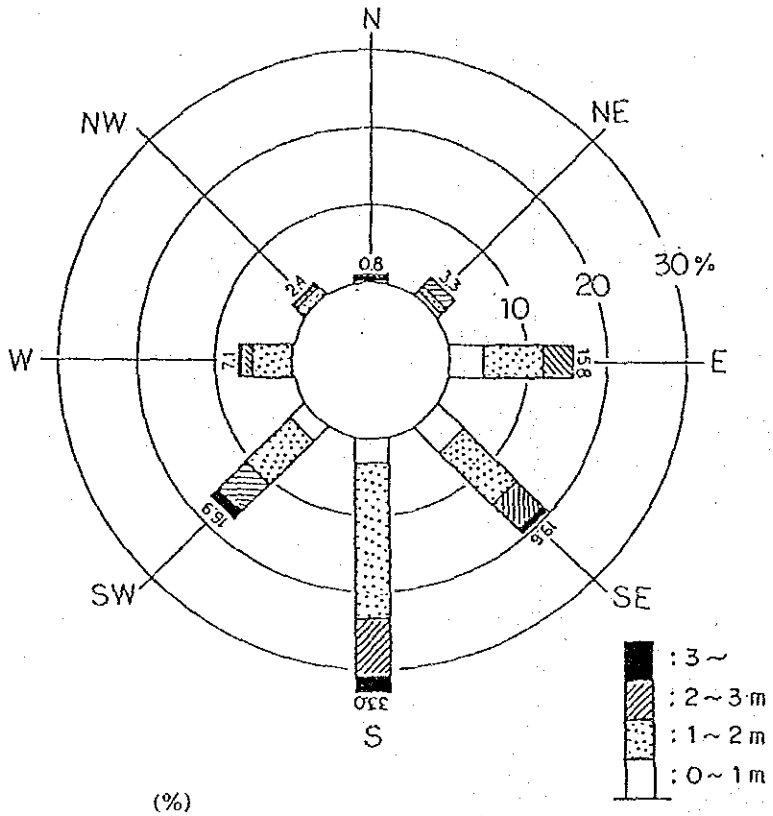


FIG. B.4.2 TIDAL LEVELS IN BENOA HARBOR

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR





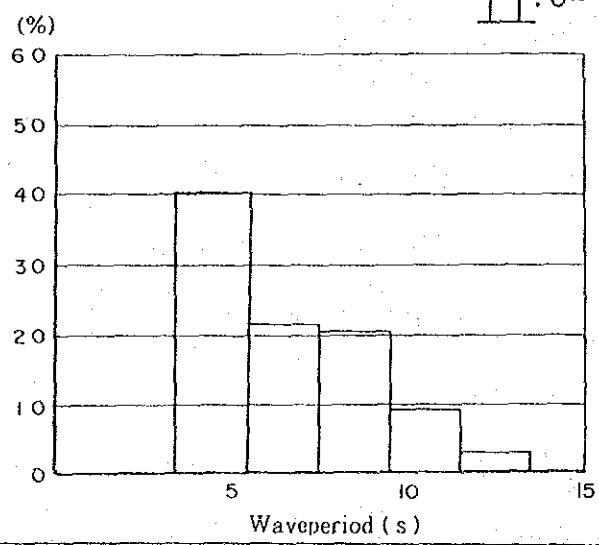
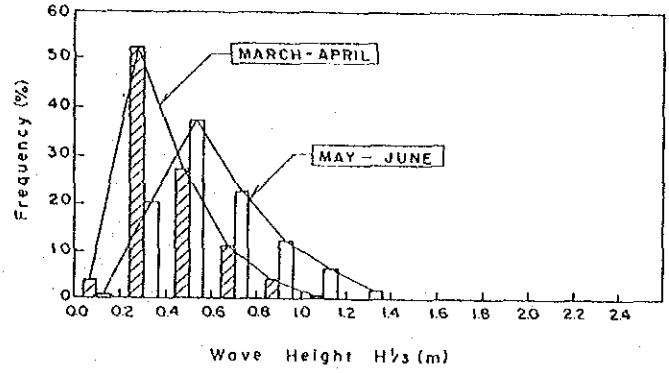
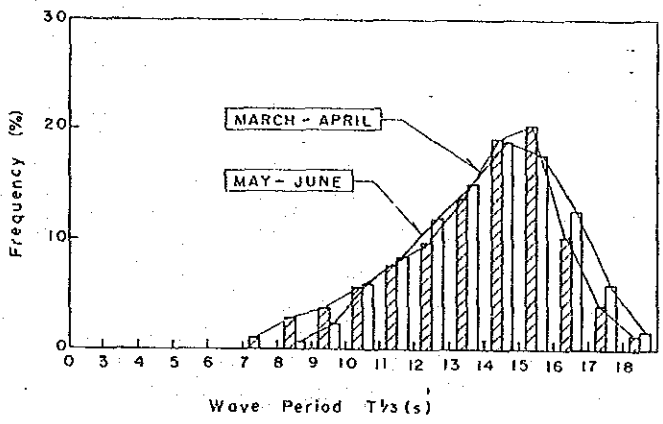


FIG. B.4.3 DEEP WATER WAVES

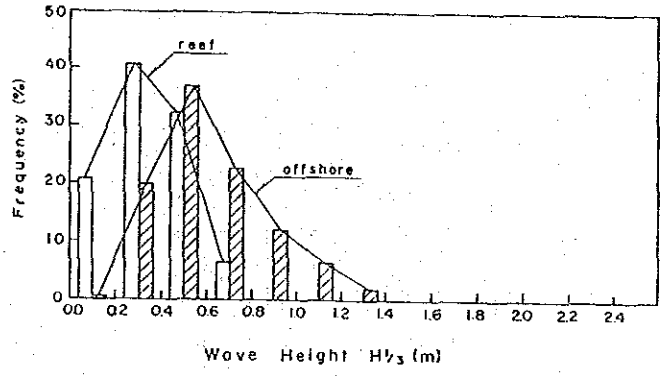
THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

NUSA DUA(OFFSHORE:1988)





NUSA DUA(MAY-JUNE:1988)



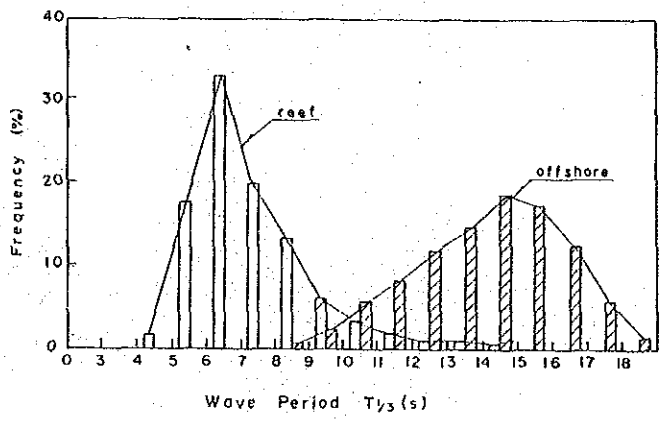


FIG. B.4.4 DISTRIBUTION OF WAVE HEIGHT AND PERIOD AT NUSA DUA

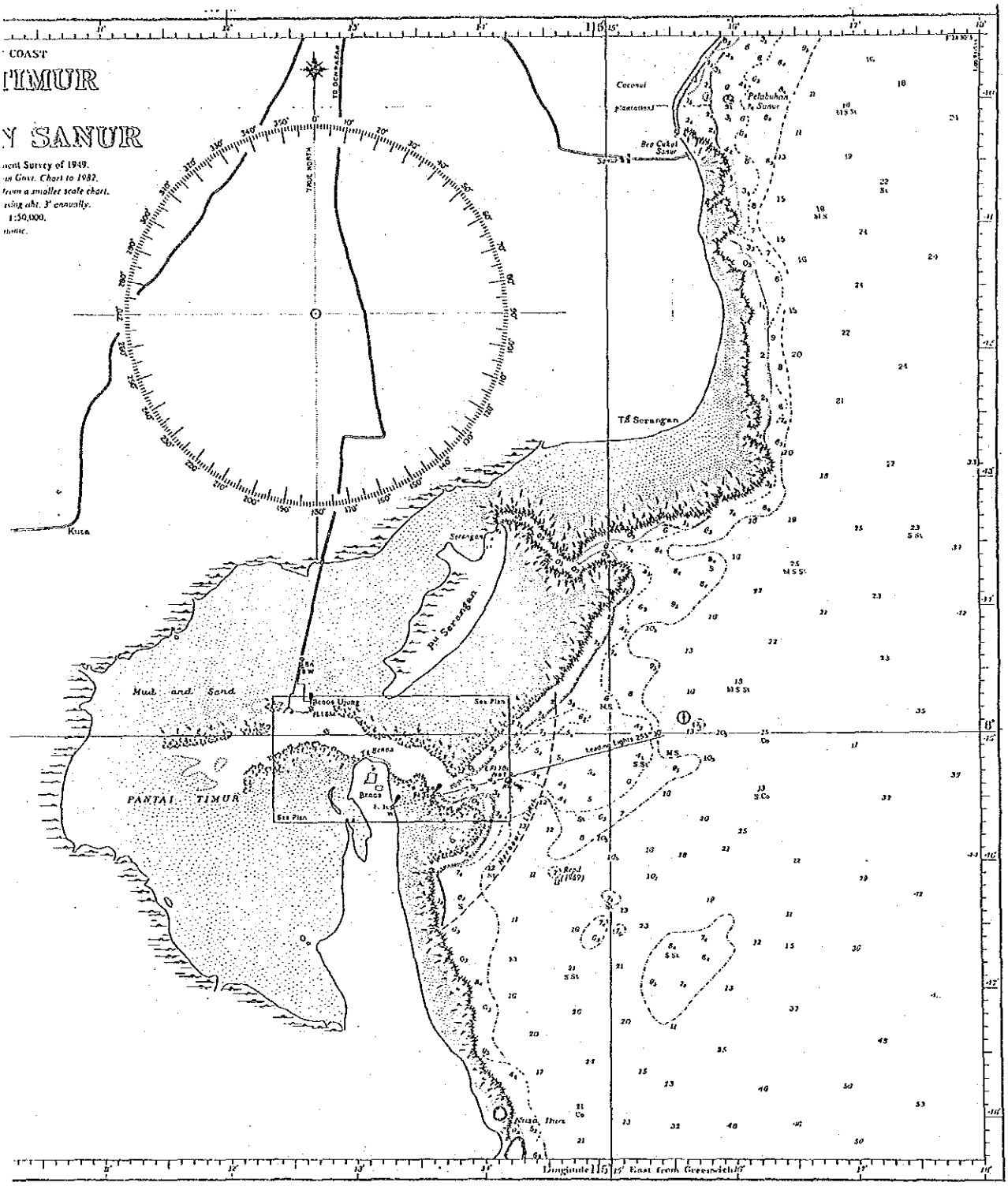


FIG. B.4.5 SEA BOTTOM TOPOGRAPHY IN STUDY SEA AREA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

JICA A.D 1993

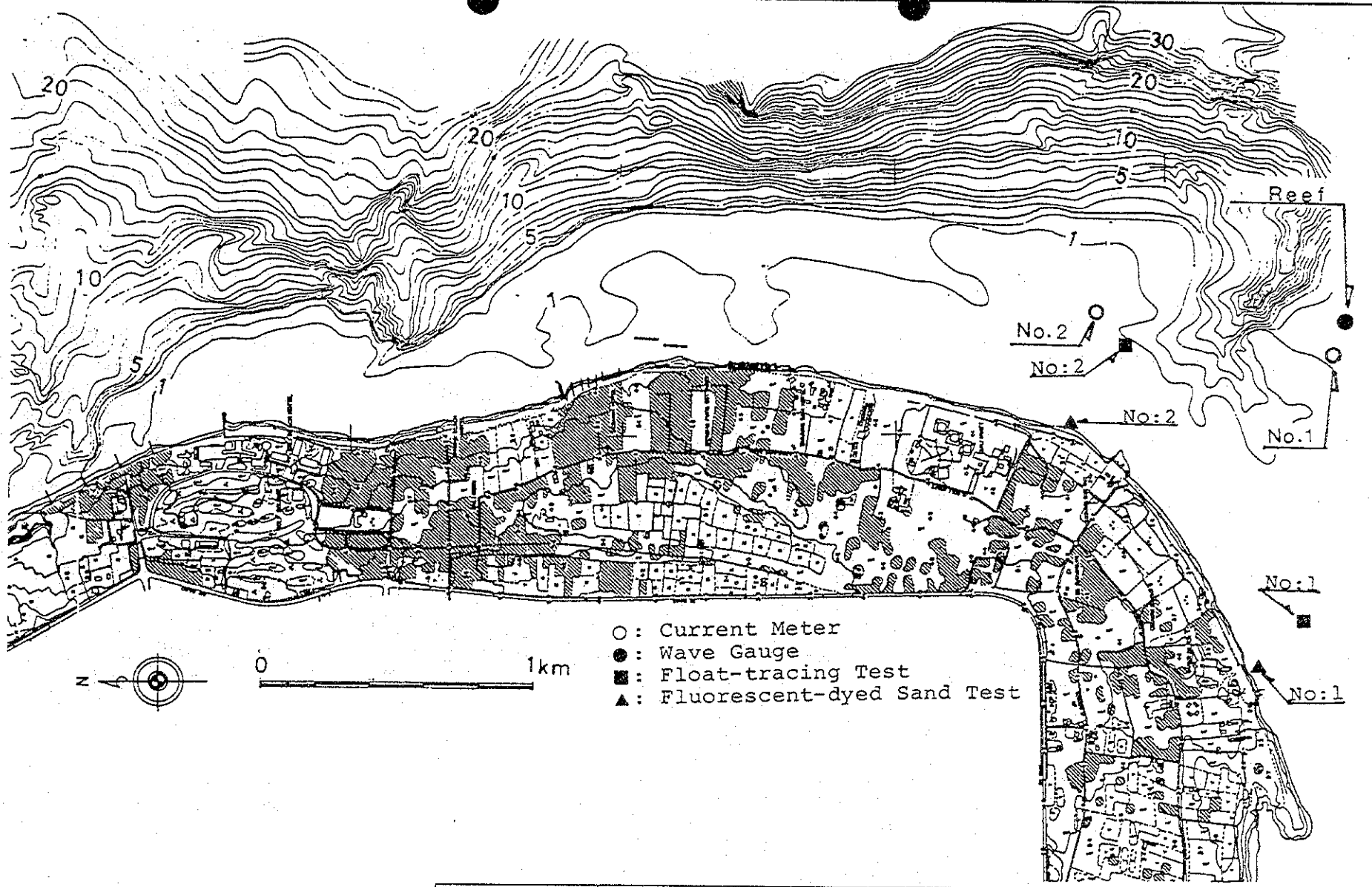


FIG. B.4.6 SEA BOTTOM TOPOGRAPHY AND LOCATION OF INSTRUMENTS IN SANUR

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

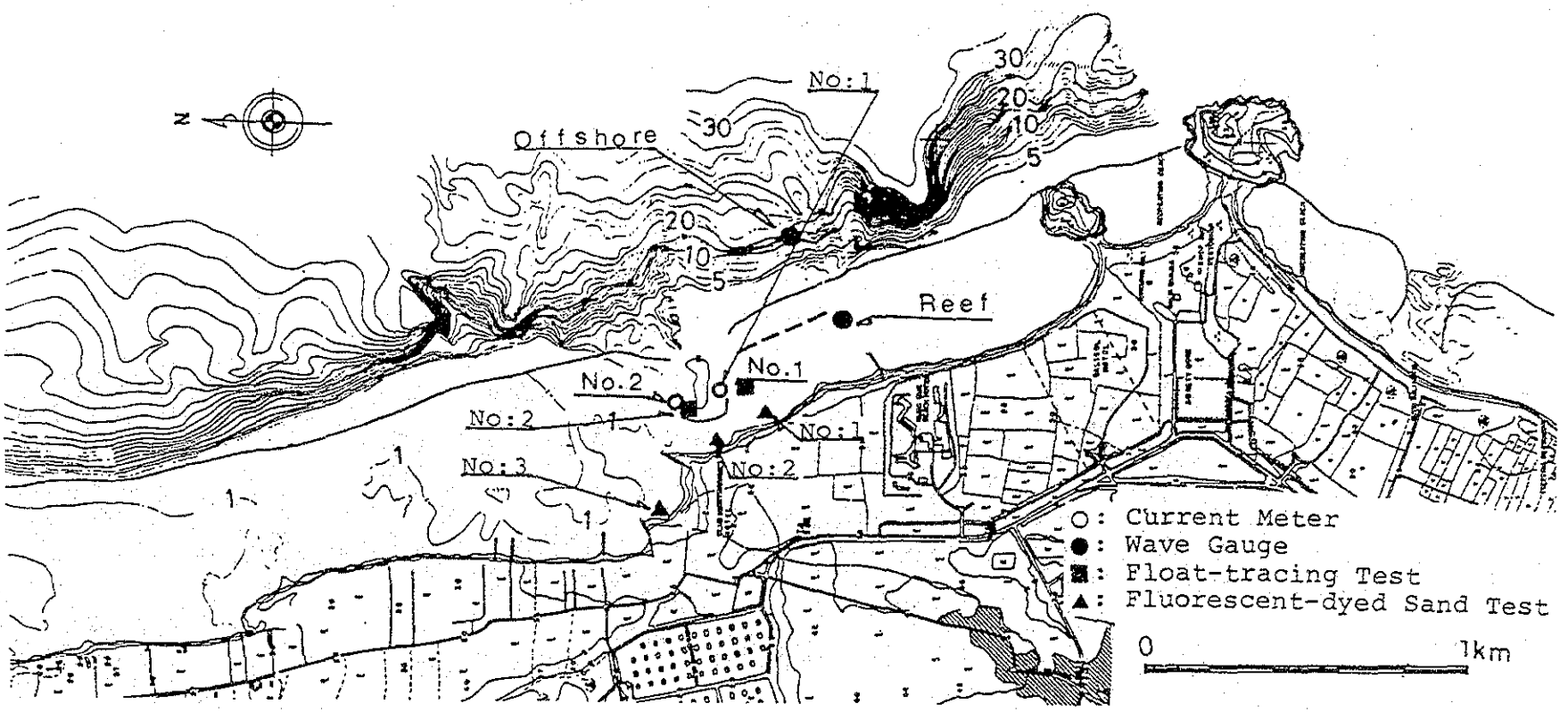


FIG. B.4.7 SEA BOTTOM TOPOGRAPHY AND LOCATION OF INSTRUMENTS IN NUSA DUA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

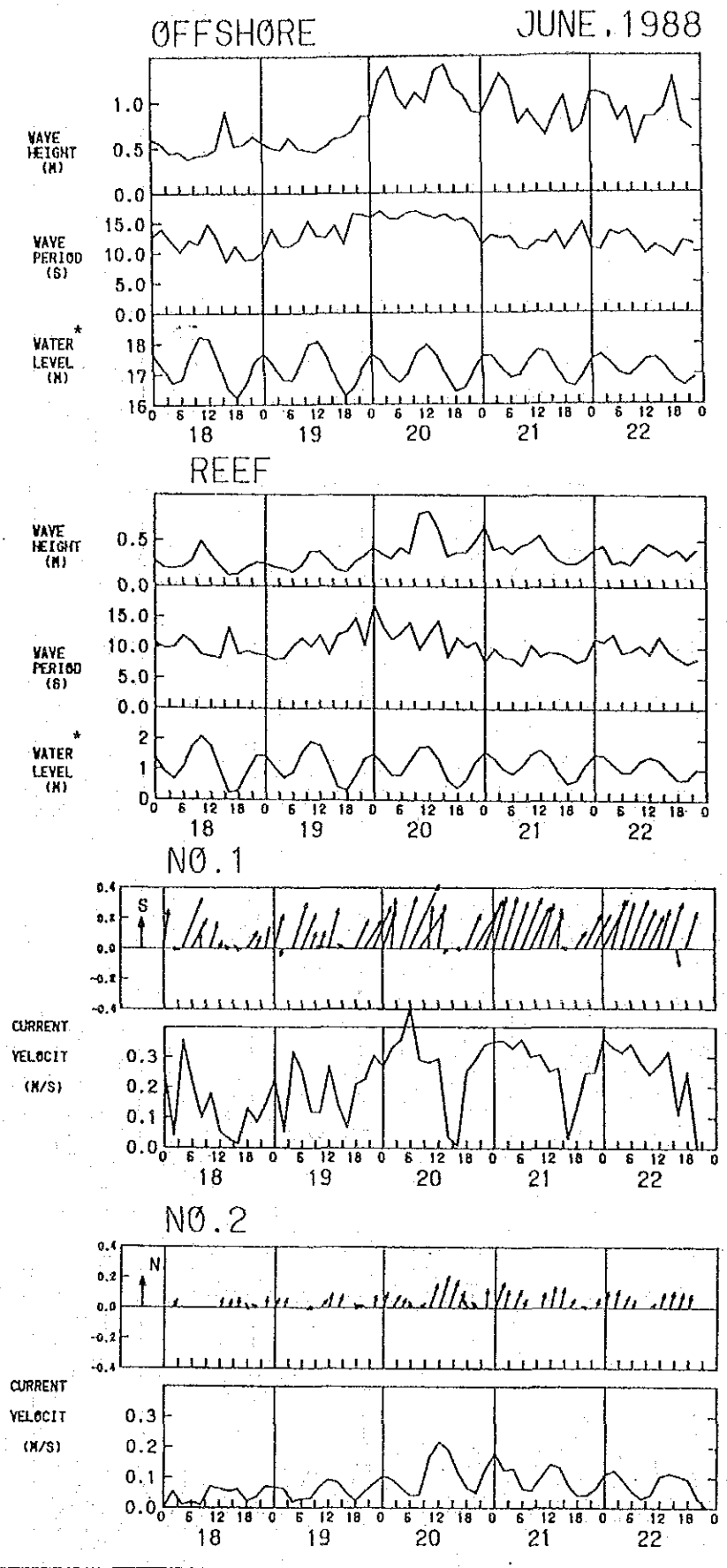


FIG. B.4.8 PAST RECORD ON WAVES AND CURRENTS AT SANUR

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

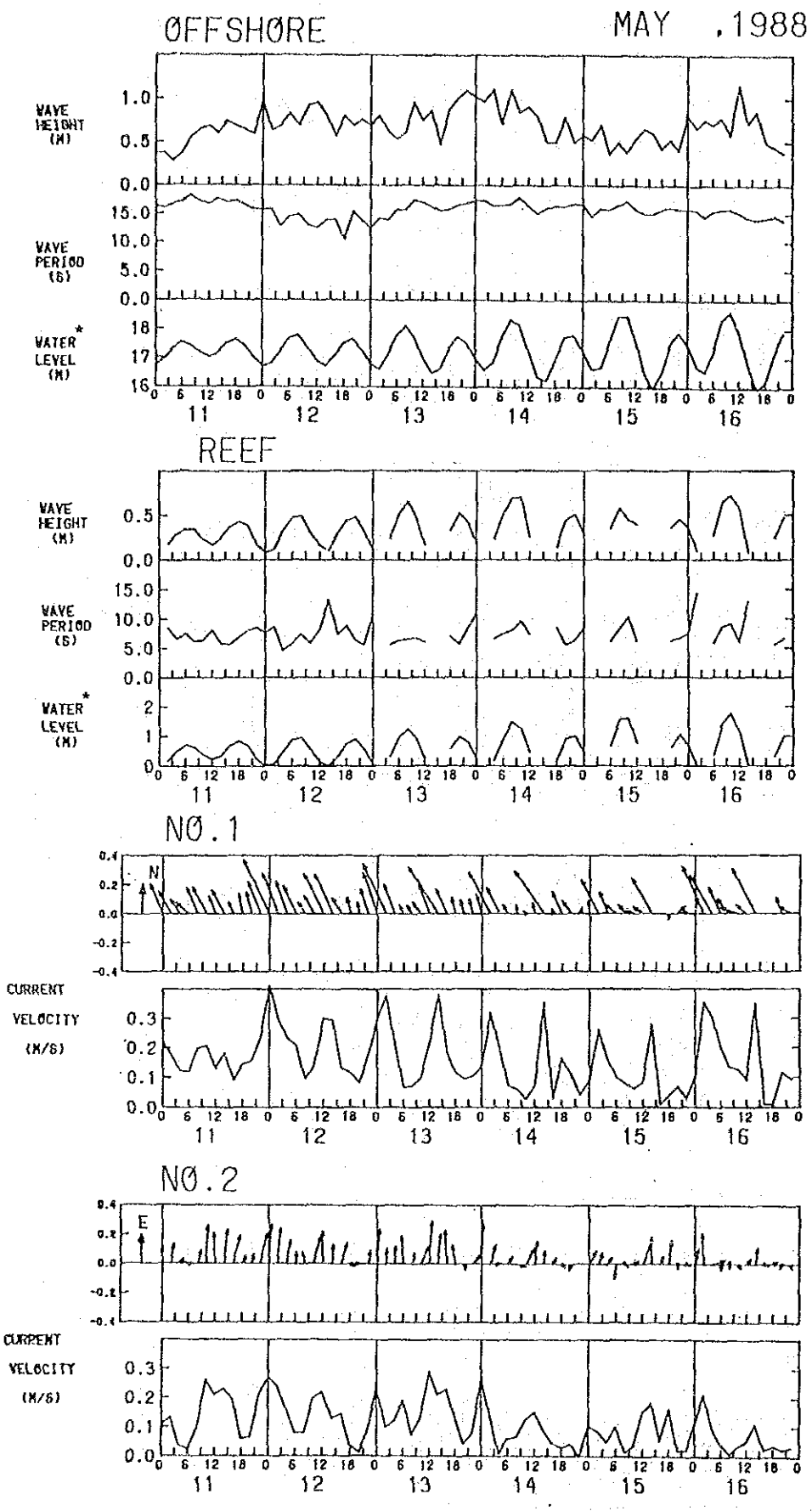


FIG. B.4.9 PAST RECORD ON WAVES AND CURRENTS AT NUSA DUA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

St.A : S8-45-01 E115-11-57

St.B : 45-03 13-04

St.C : 43-18 14-29

St.D : 40-48 16-20

St.E : 43-41 15-50

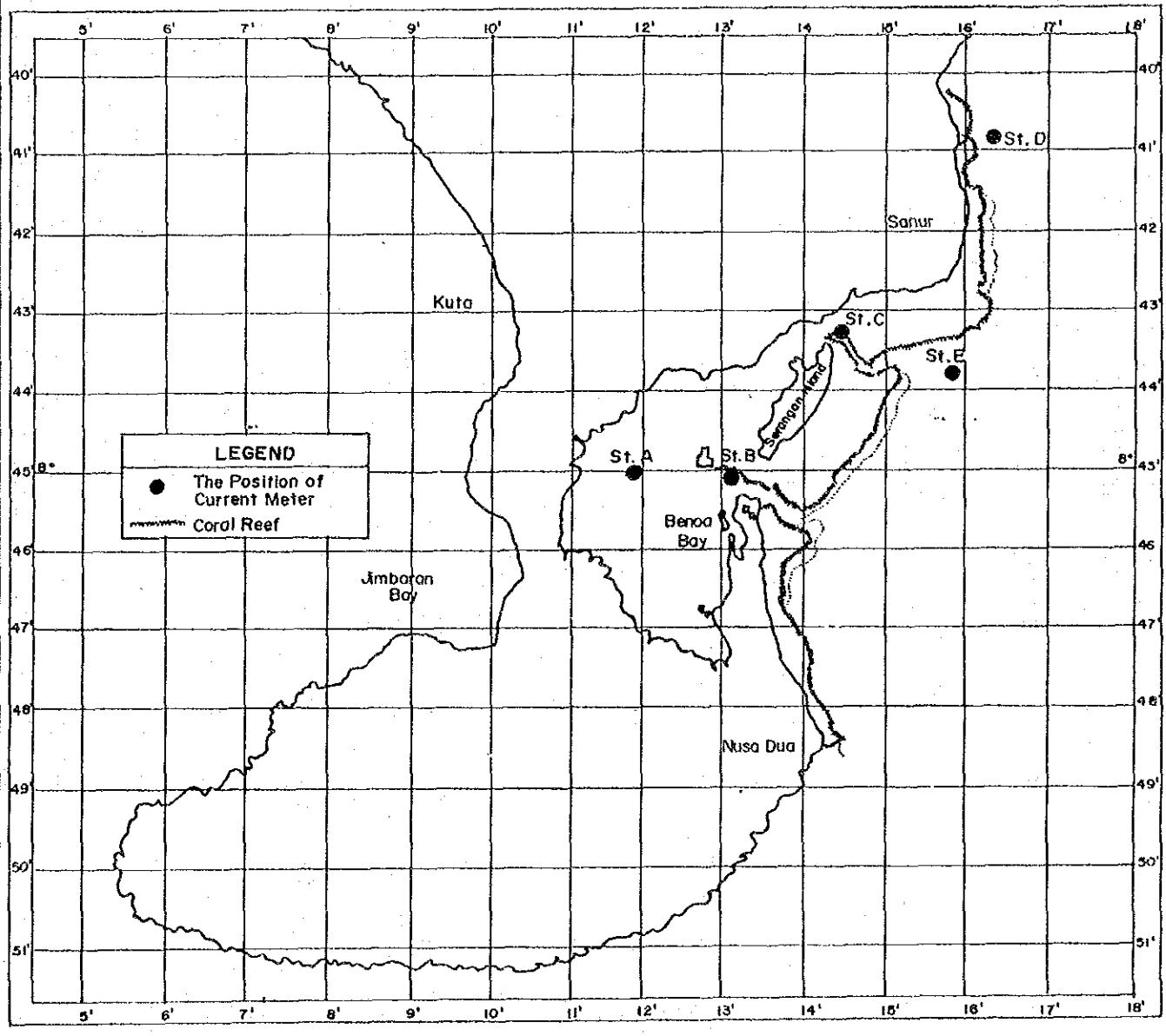


FIG. B.4.10 LOCATION OF CURRENT METERS

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

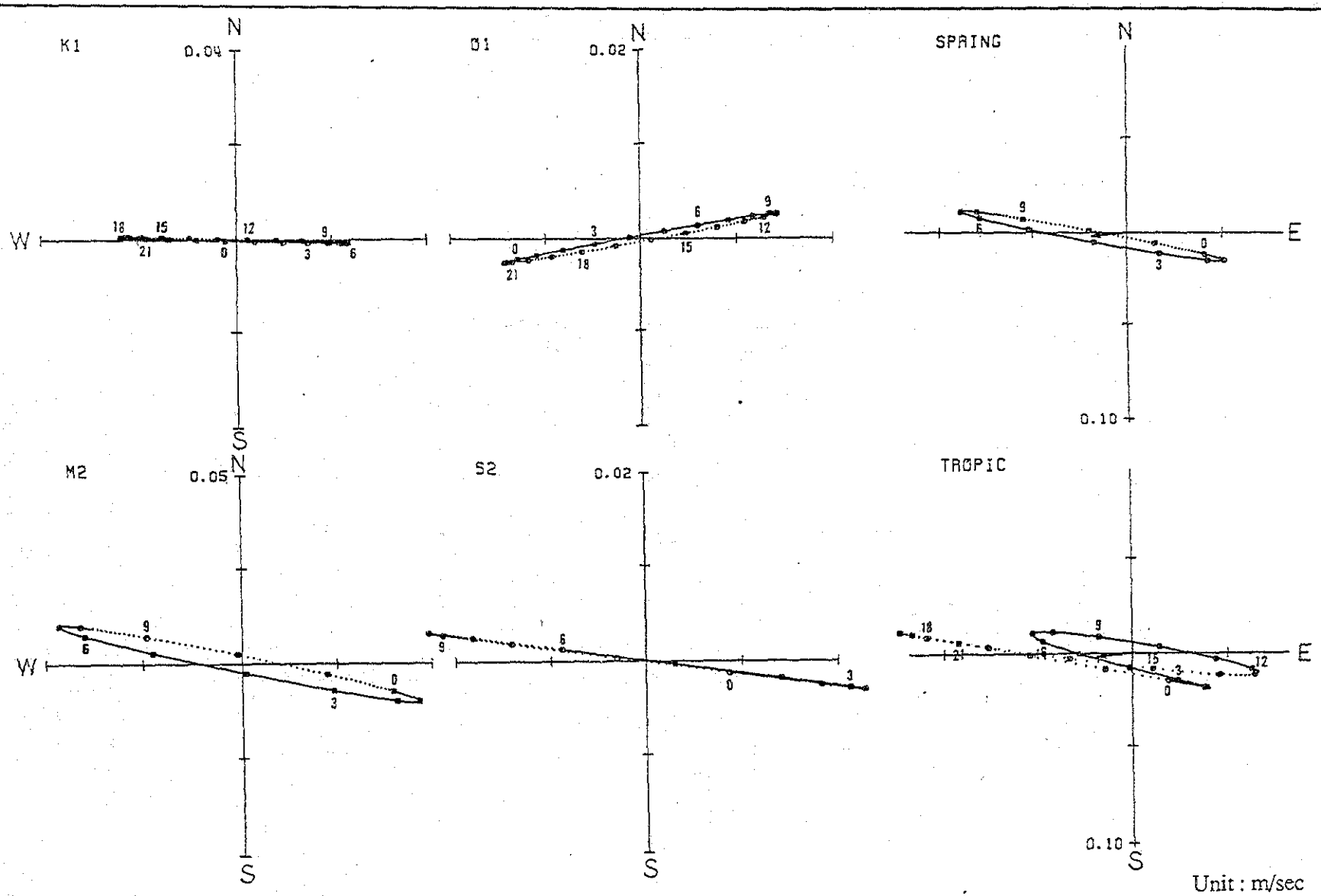


FIG. B.4.11(1) TIDAL ELLIPSES AT ST.A

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

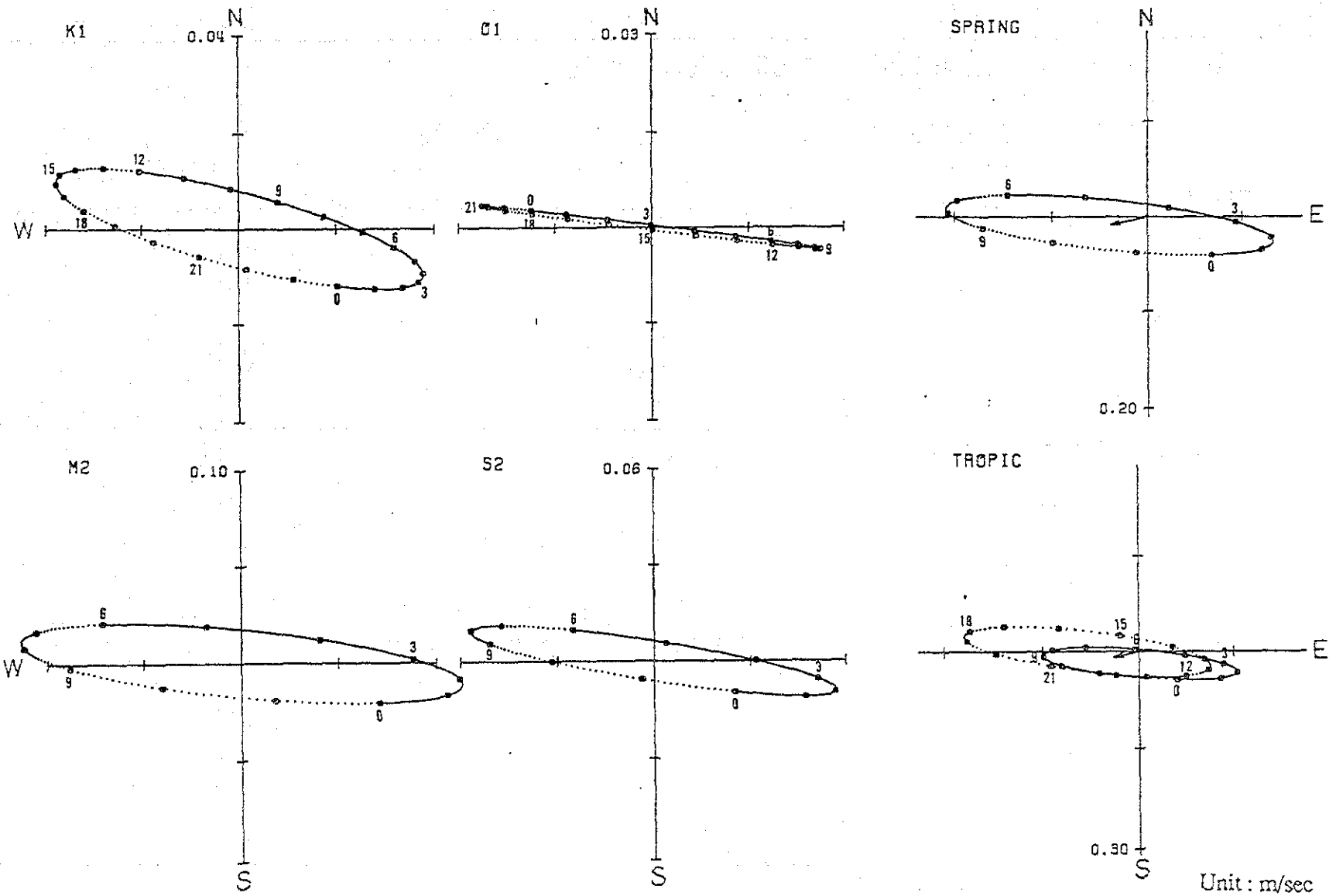


FIG. B.4.11(2) TIDAL ELLIPSES AT ST.B

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

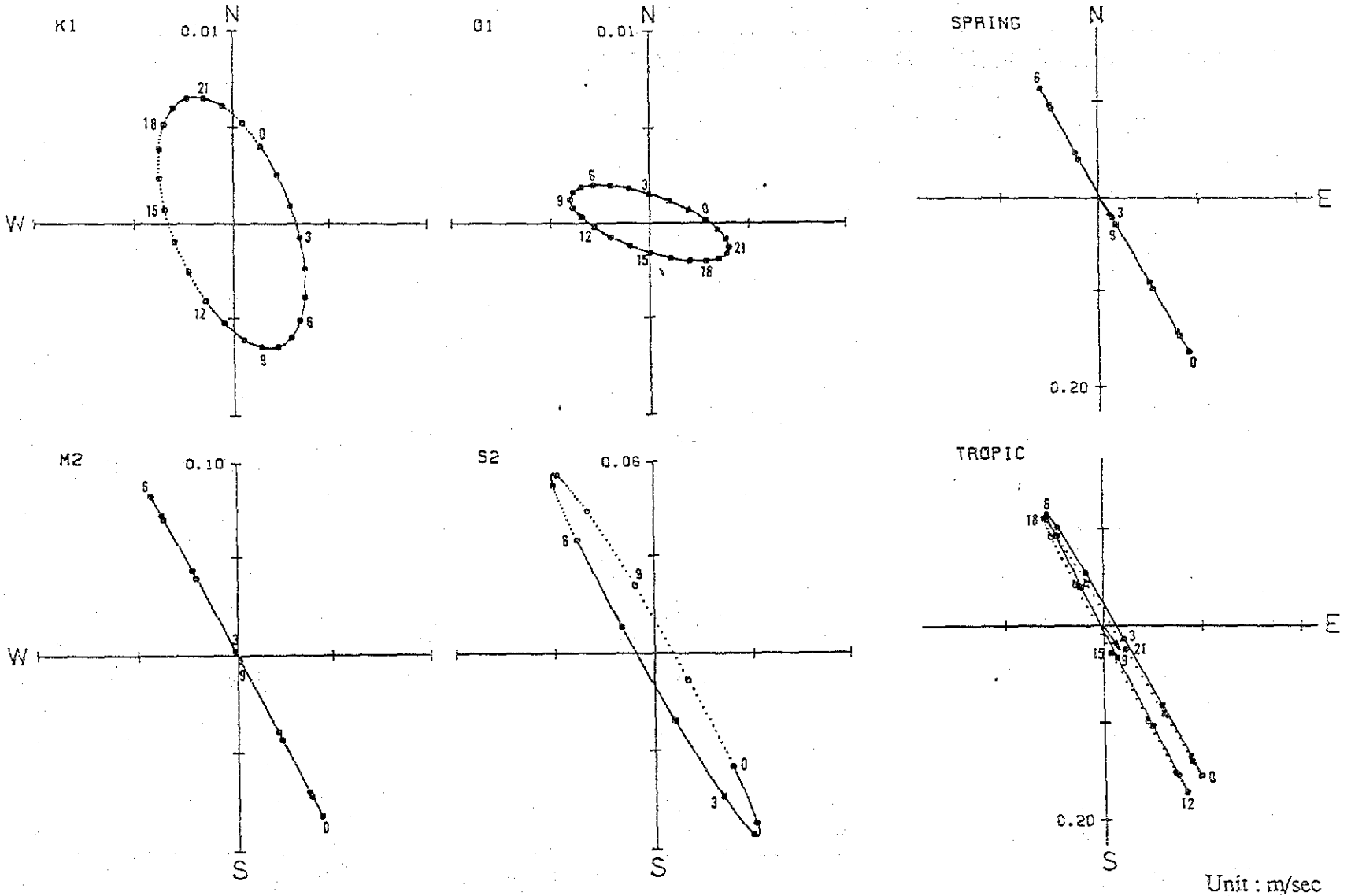


FIG. B4.11(3) TIDAL ELLIPSES AT ST.C

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

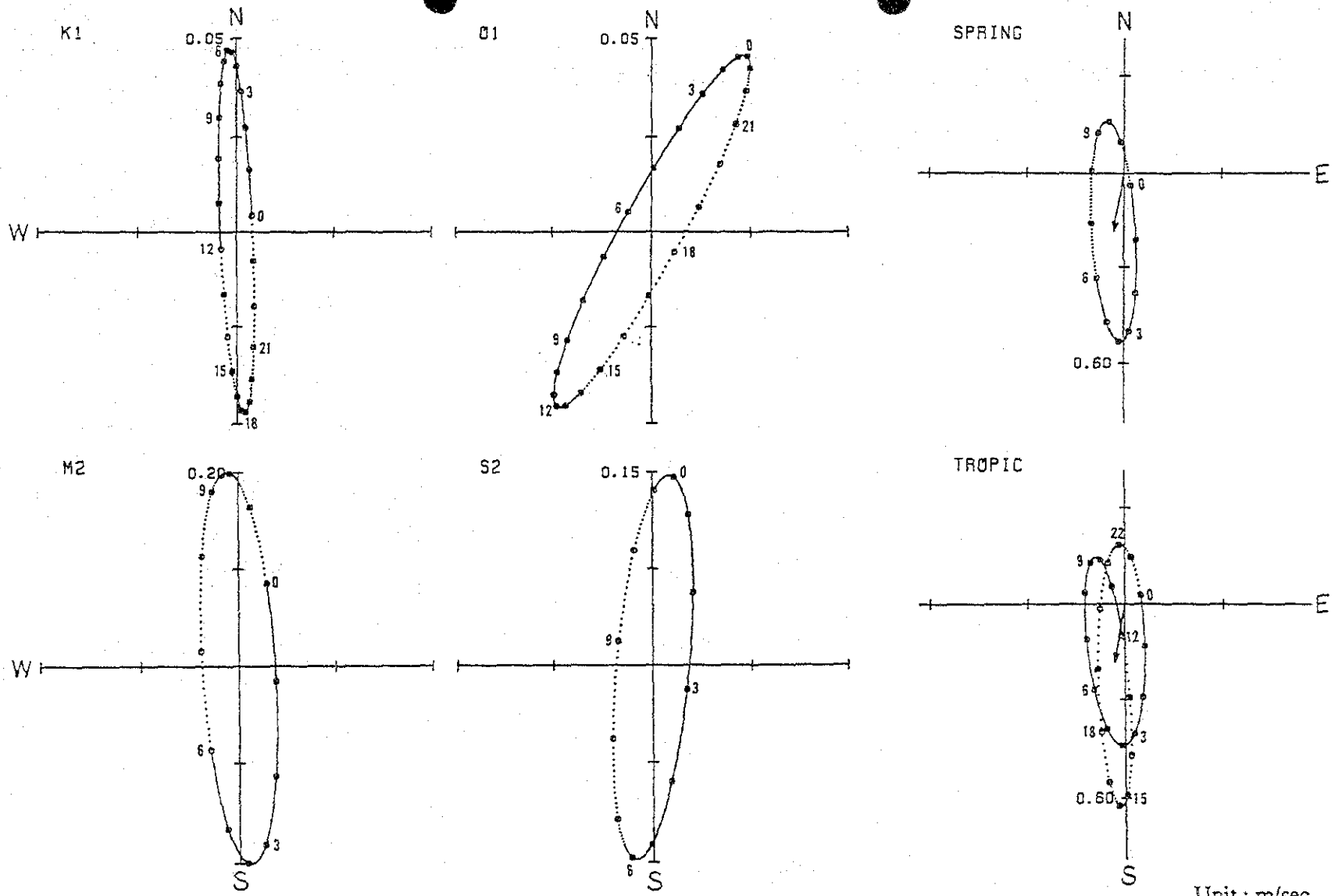


FIG. B4.11(4) TIDAL ELLIPSES AT ST.D

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

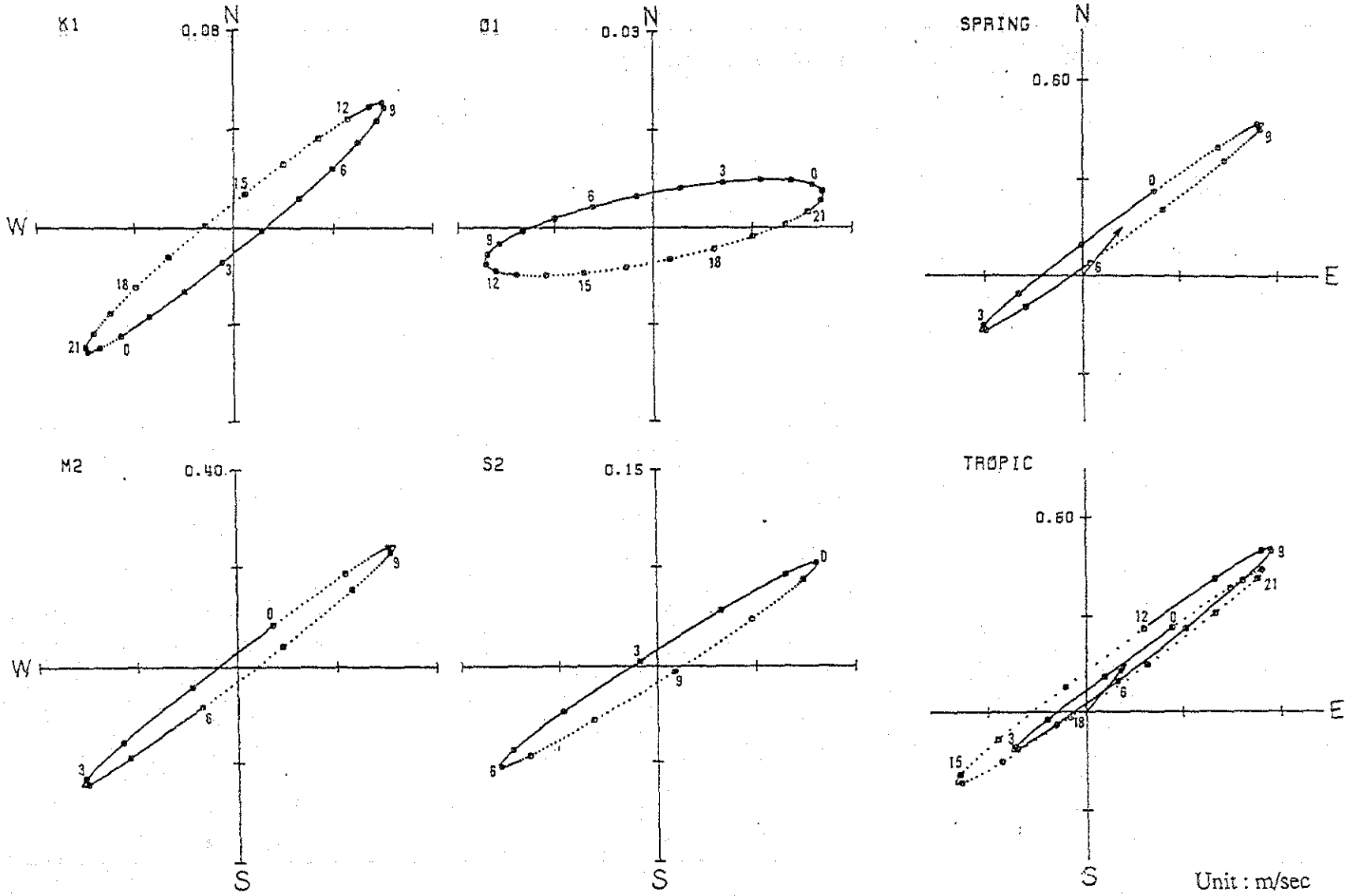


FIG. B4.11(5) TIDAL ELLIPSES AT ST.E

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

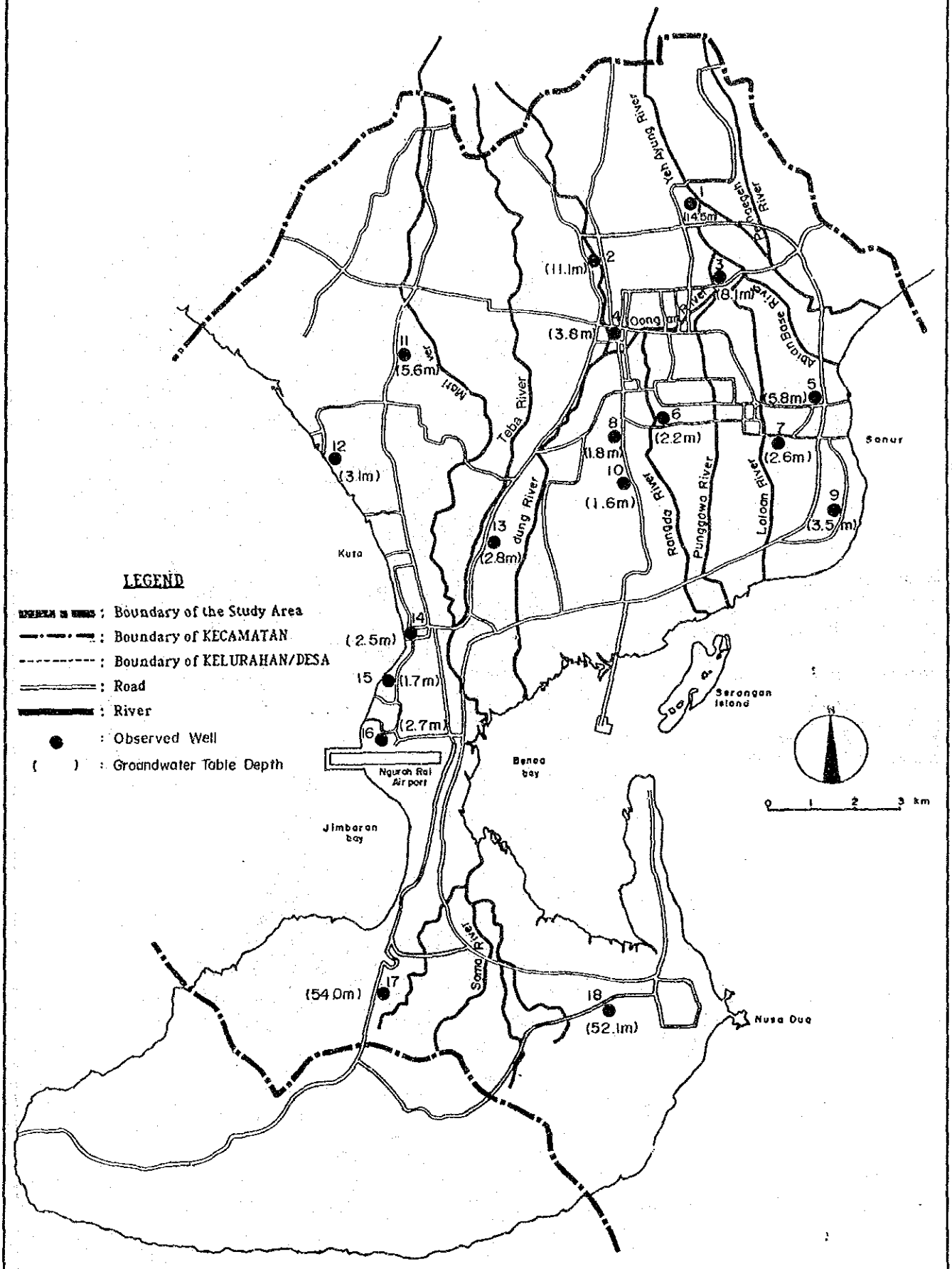


FIG. B.5.1 LOCATION OF OBSERVED WELLS IN THE PAST

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

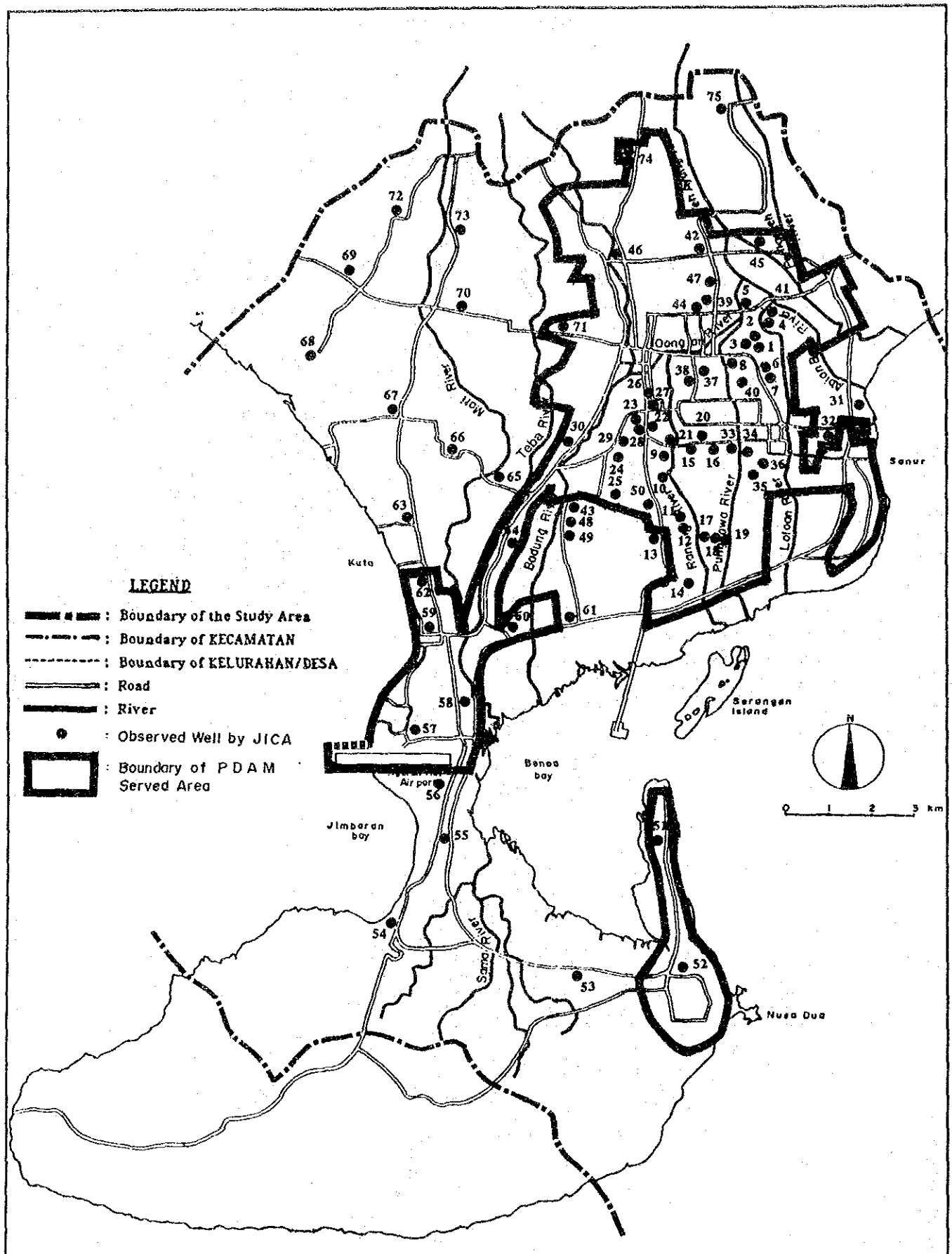


FIG. B.5.2 LOCATION OF OBSERVED GROUNDWATER TABLE AND WATER QUALITY BY JICA IN 1991

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

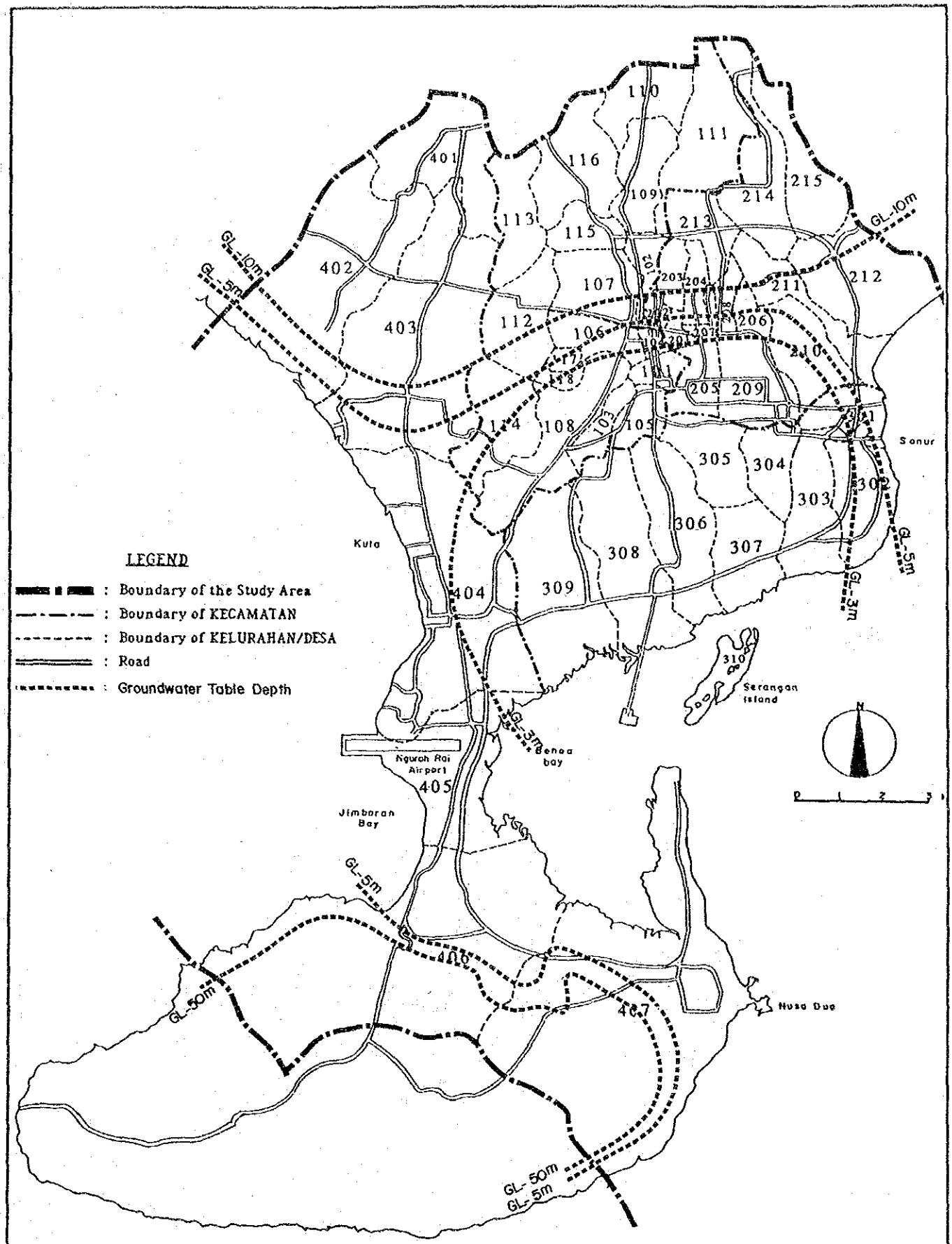


FIG. B.5.3 CONTOUR OF GROUNDWATER TABLE DEPTH

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

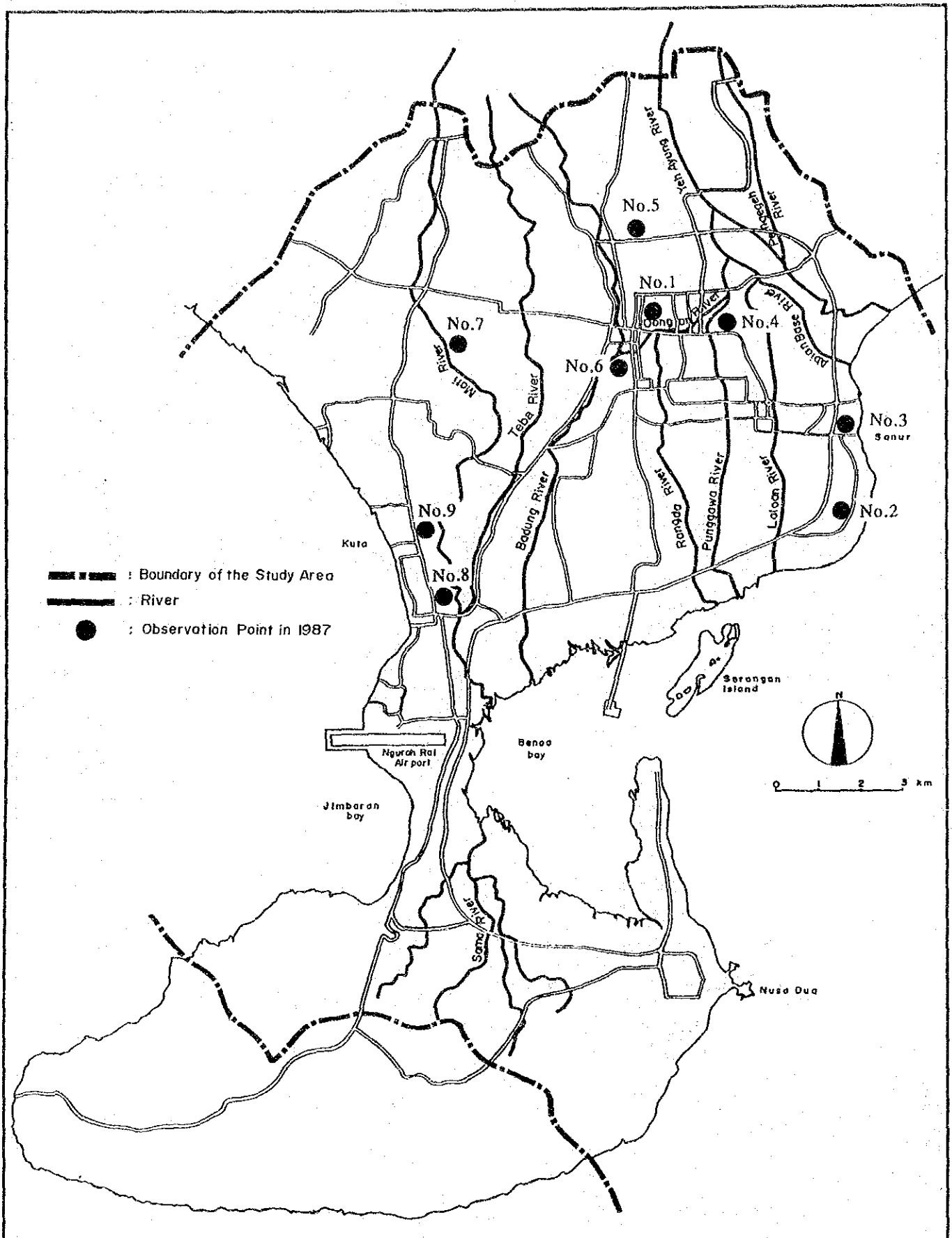


FIG. B.5.4 LOCATION OF OBSERVED GROUNDWATER QUALITY IN DECEMBER, 1987

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

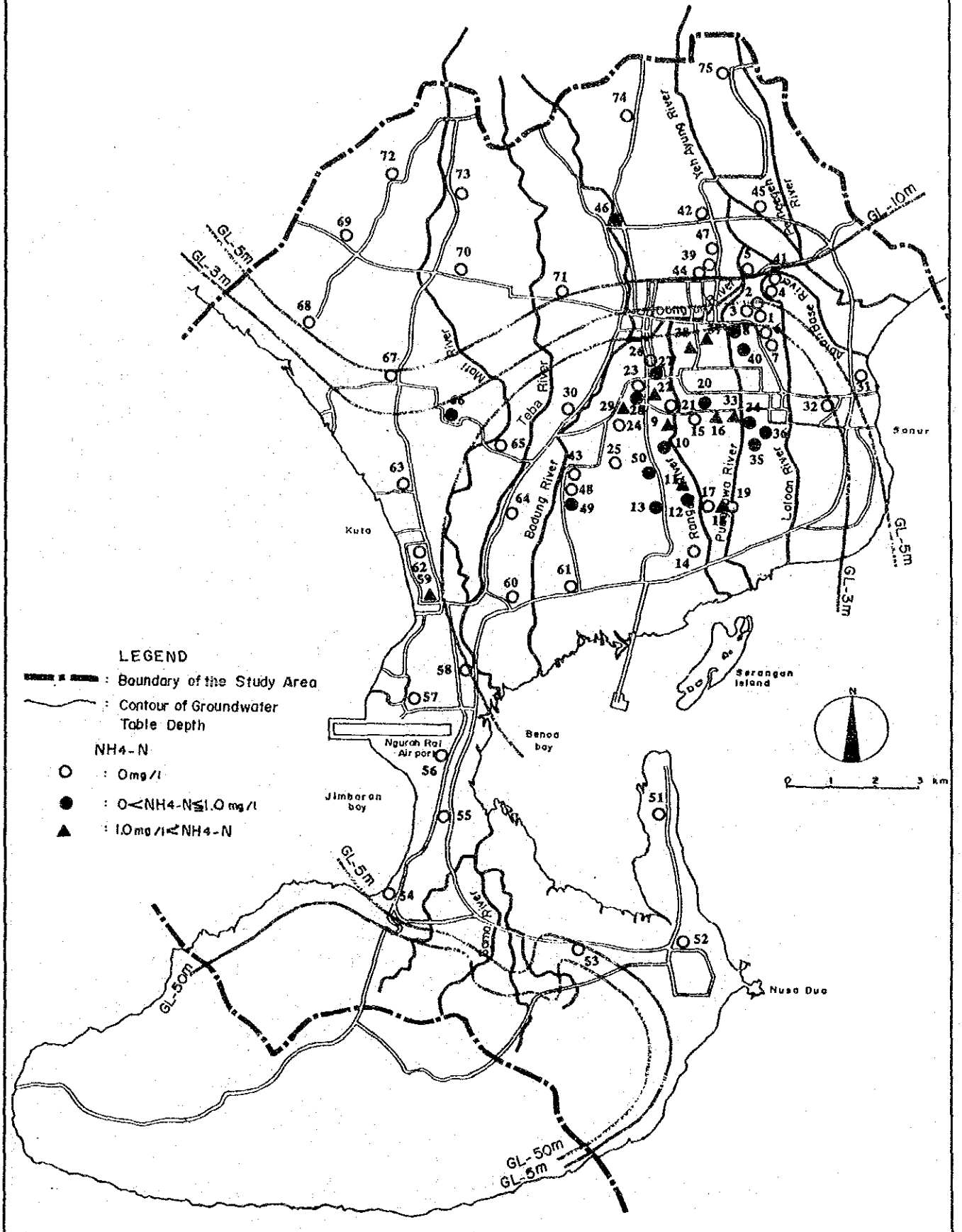


FIG. B.5.5 OBSERVED GROUNDWATER QUALITY BY JICA IN 1991 (NH_4-N)

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

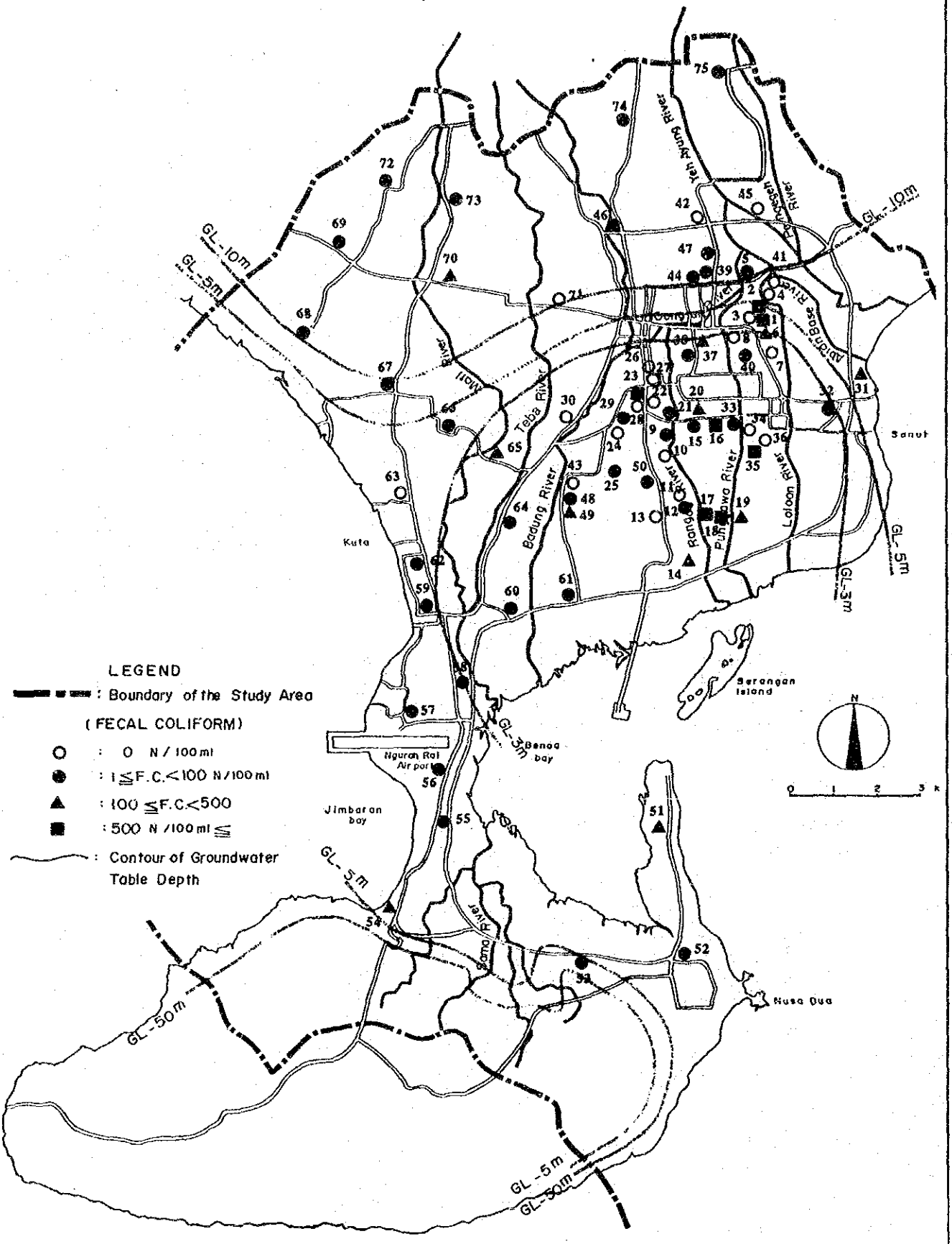


FIG. B.5.6 OBSERVED GROUNDWATER QUALITY BY JICA IN 1991 (FECAL COLIFORM)

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

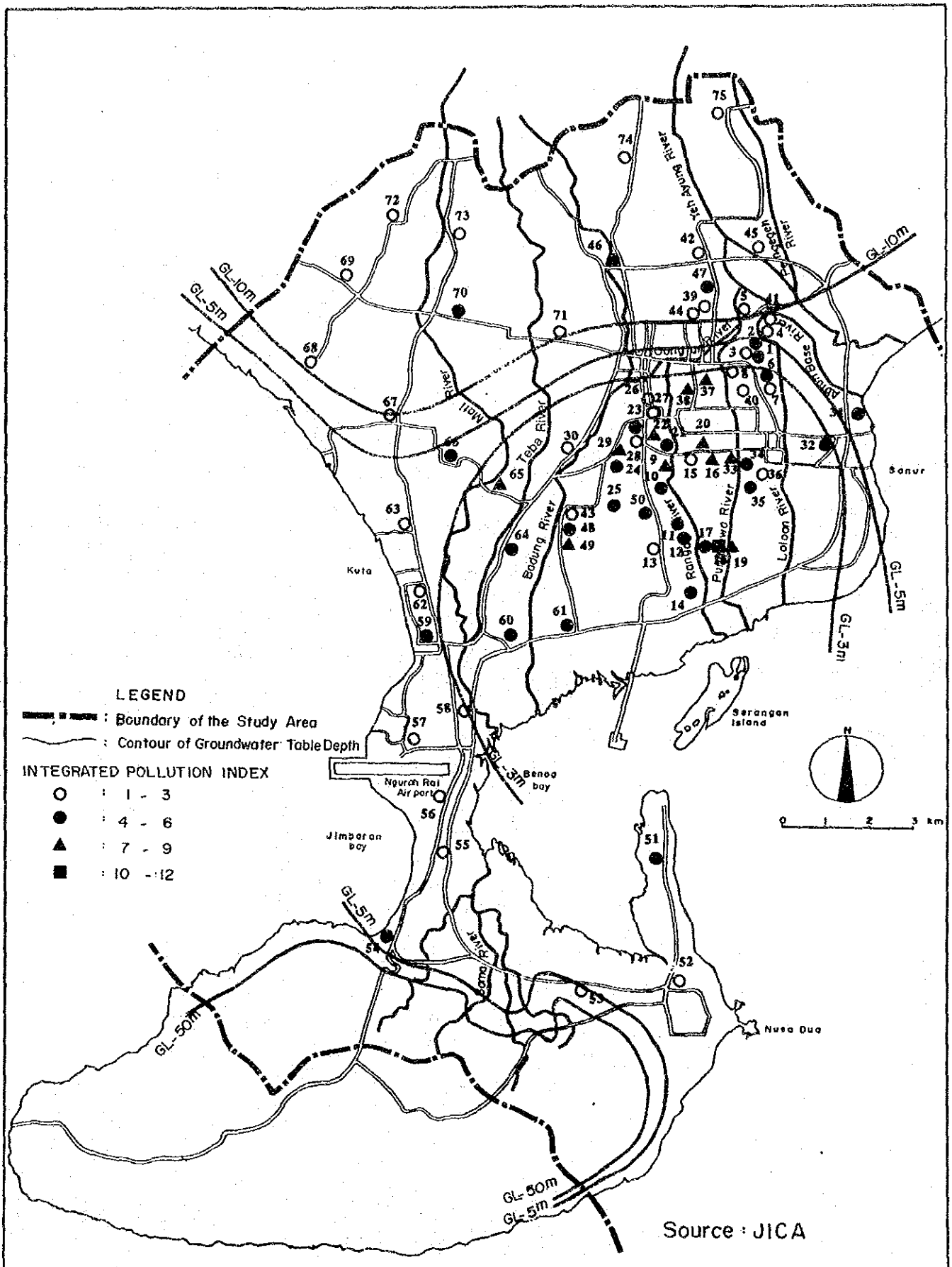


FIG. B.5.7 EXISTING SITUATION OF GROUNDWATER CONTAMINATION (INTEGRATED POLLUTION INDEX)

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

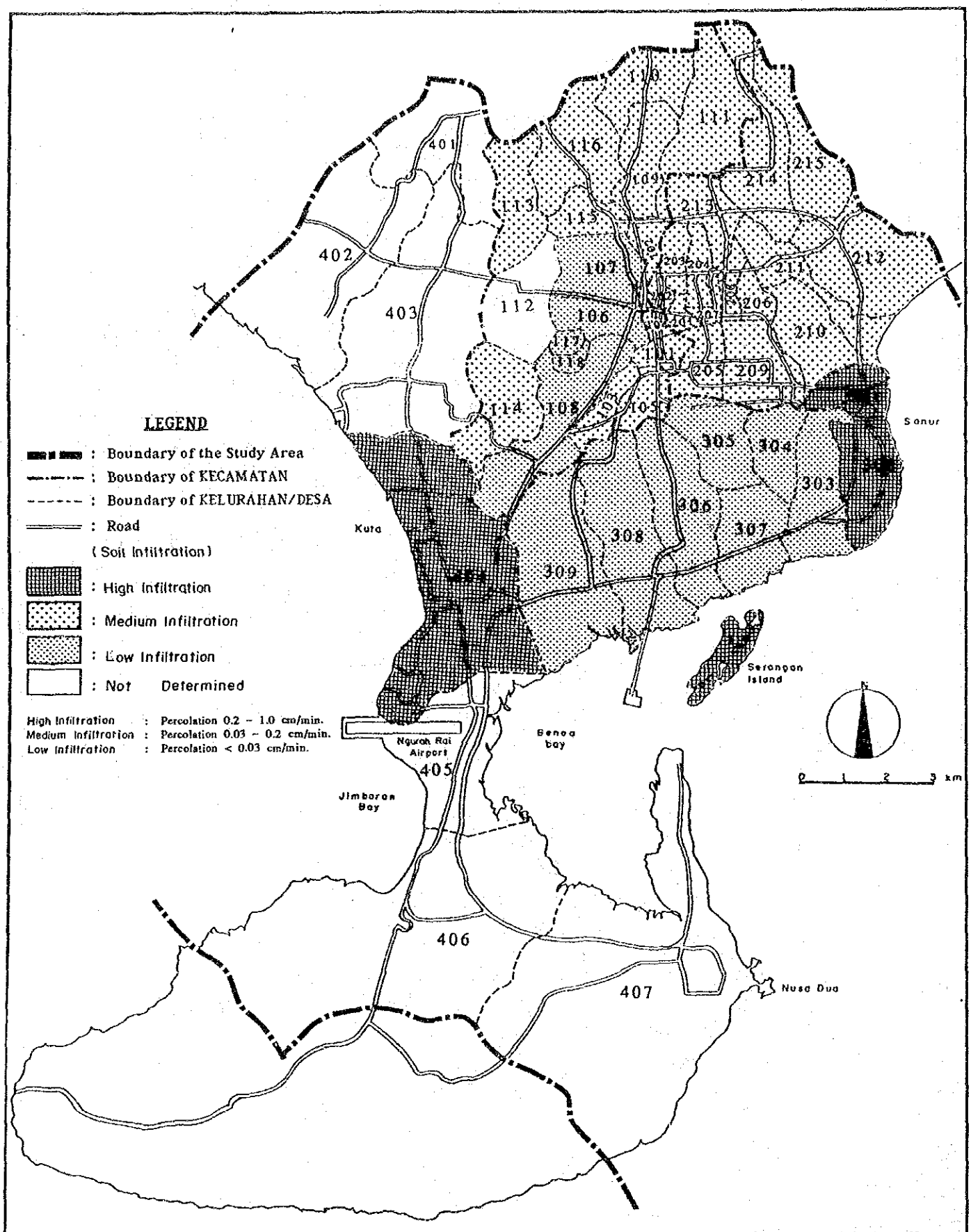


FIG. B.6.1 SOIL INFILTRATION CAPACITY BY KELURAHAN/DESA IN PREVIOUS STUDY

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

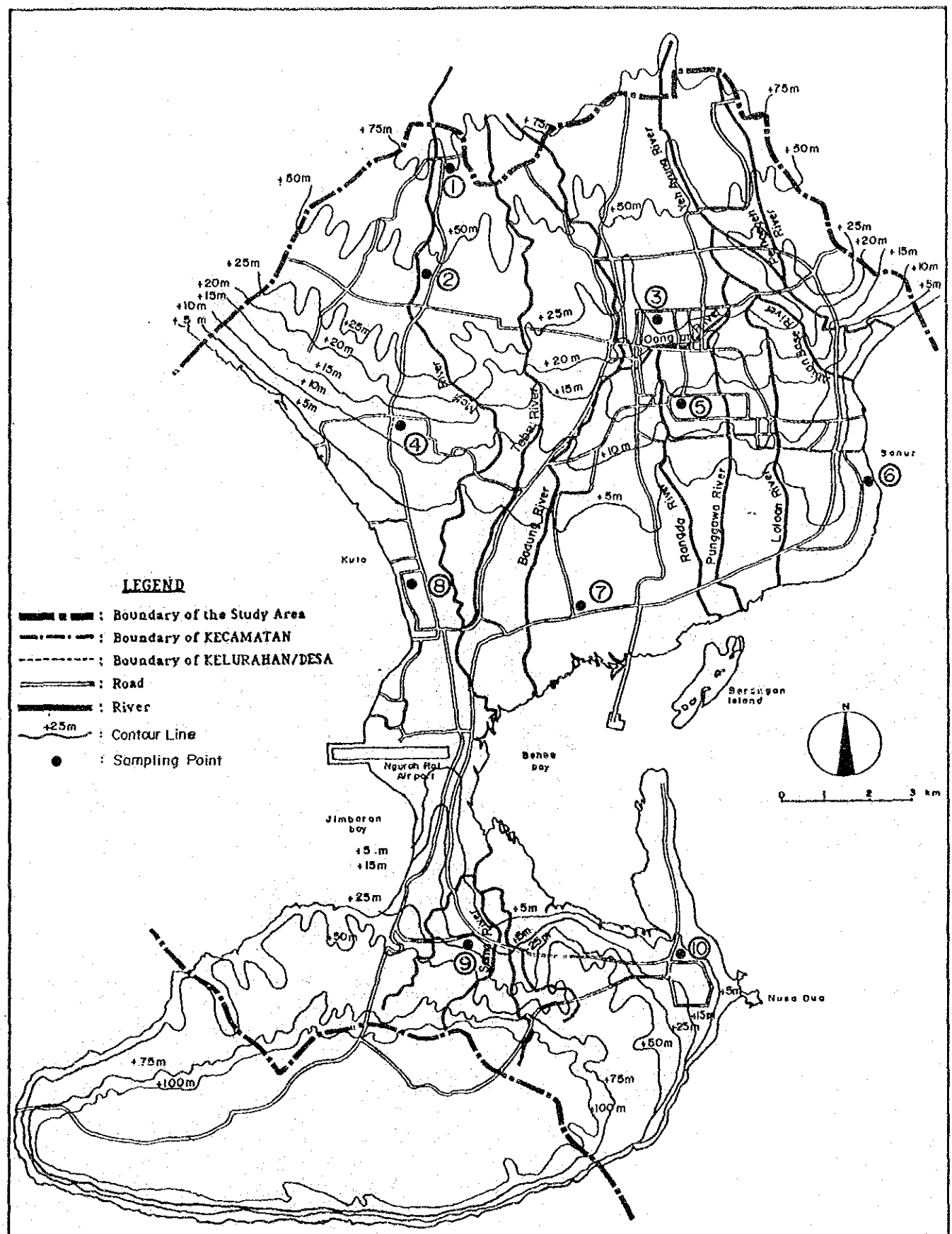


FIG. B.6.2 LOCATION OF PERMEABILITY TEST

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

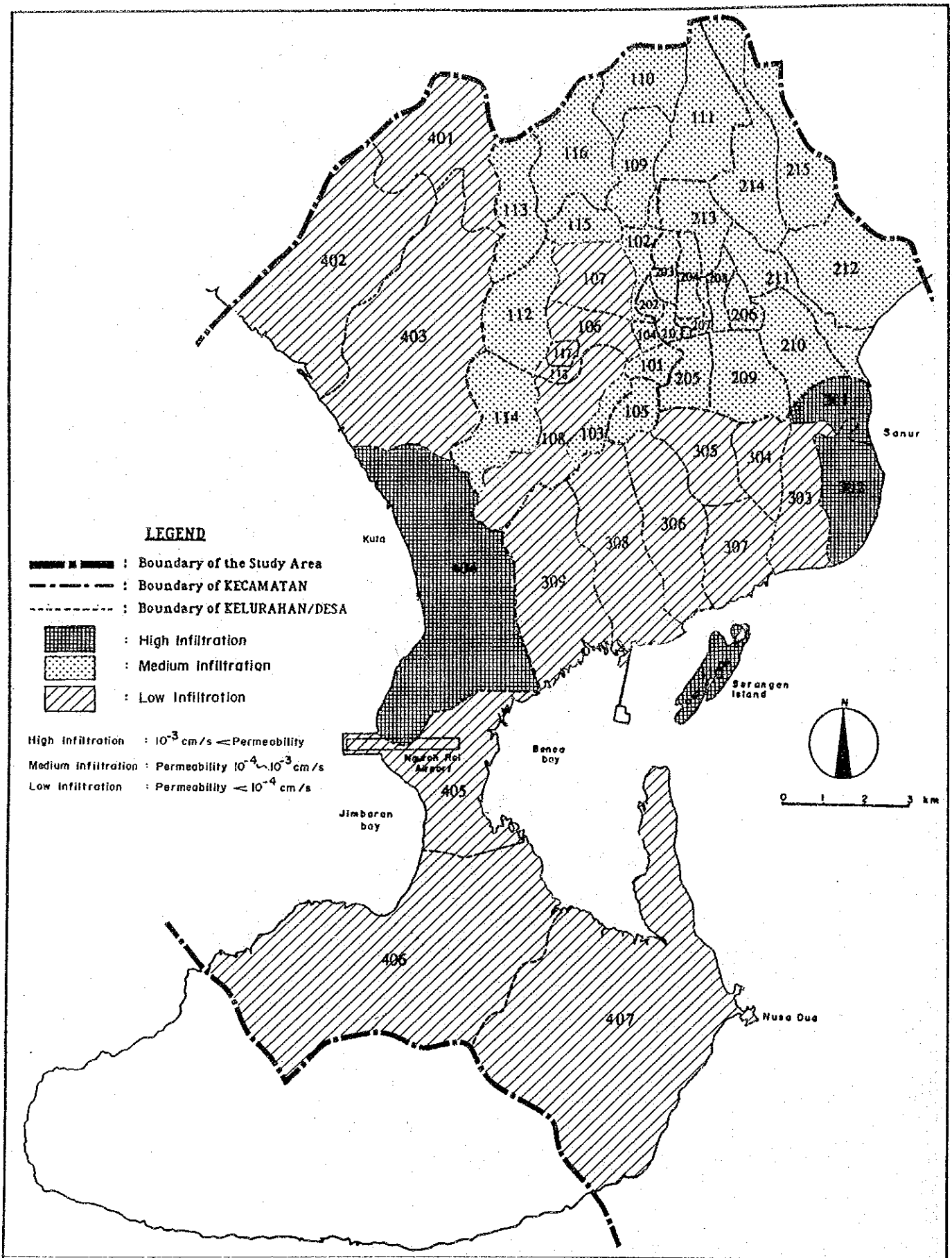


FIG. B.6.3 SOIL INFILTRATION CAPACITY BY KELURAHAN/DESA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

APPENDIX C

POLLUTION LOAD GENERATION

APPENDIX C POLLUTION LOAD GENERATION

1. Water Consumption

1.1 PDAM and BTDC Water Supply

All piped water service for the Study Area is provided by Badung Water Supply Company (PDAM) since BTDC water supply system was integrated into PDAM Badung in 1987. The Study Area is covered by 10 service areas of PDAM. However, the service areas are still limited to the central part of Denpasar, and the tourism areas of Sanur, Kuta and Nusa Dua as shown in Fig. C.1.1.

The existing piped water service is small. Major portion of the water demand in the Study Area is met by individual groundwater wells. The total piped water supply of the Study Area in October, 1991 was as follows.

Water Use	Nos. of Connection	Water Supply (m^3/month)
Domestic	20,999	815,839
Commercial & Institutional	2,824	164,235
Tourism	341	18,203
Industry	21	323,889
Others	1	3,079
Total	24,186	1,329,882

The existing total population served is estimated at 148,000, or 33% of the total population (447,437) of the Study Area, assuming seven (7) persons are served by one (1) connection. Then, the average domestic piped water consumption per capita per day comes to 179 liter. While, no data on the existing individual groundwater supply is available.

Therefore, the existing water consumption was estimated by a sampling survey.

1.2 Domestic Water Consumption

1.2.1 Existing Water Consumption

The JICA Study Team conducted a sampling survey on water consumption at the same time of unit pollution load survey. The survey was conducted at 12 households by measuring the water meter of PDAM and counting the pump operation hour of well.

The water consumption varies according to household income level. The average unit water consumption by income class was estimated to be 328 lcd (liter per capita per day) for high class, 206 lcd for middle class and 156 lcd for low class. The average unit water consumption of whole classes was 187 lcd.

The sampling survey results are summarized in Table C.1.1.

Based on the above sampling survey data and PDAM water supply data, the existing unit water consumption of the Study Area for each income class is determined as follows :

High class	:	330 lcd
Middle class	:	210 lcd
Low class	:	160 lcd

The existing domestic water consumption of the Study Area is obtained by multiplying the above per capita water consumption by its existing total population. For the existing population of the Study Area by income class, see Appendix A. The estimated existing total water consumption of the Study Area is 85,460 m^3/day with an average per capita water consumption of 191 liter.

1.2.2 Future Water Consumption

The existing average unit consumption of piped water in the Study Area is 179 lcd. It is projected to increase to 200 lcd in the year 2010 by the Bali Water Resources Study of IUIDP in 1989.

While, the actual existing average unit water consumption of the Study Area is estimated to be 191 lcd, close to the future unit water consumption of piped water. This is because the people of the Study Area is using cheap groundwater in abundance.

The existing unit water consumption is already in a higher level than the estimated future level of Jakarta Metropolis. Hence, the future unit domestic water consumption of the Study Area in the year 2010 is assumed to be the same as the existing one. Then, the future unit water consumption is as follows.

High income class	:	330 lcd
Middle income class	:	210 lcd
Low income class	:	160 lcd

The future domestic water consumption of the Study Area is estimated in the same manner as the existing one. The estimated total water consumption of the Study Area in the year 2010 is 155,258 m^3/day with an average per capita water consumption of 219 liter.

1.3 Commercial and Institutional Water Consumption

1.3.1 Existing Water Consumption

Commercial and institutional water consumption of an area can be estimated by multiplying its domestic water consumption by a certain ratio. This ratio varies mainly, depending on land use pattern of the area.

Average ratio between the commercial and institutional piped water consumption, and domestic piped water consumption of each service district of PDAM Badung during October and November, 1991 are shown in Table C.1.2. While, average ratio between the commercial and institutional land area and residential land area of each service district of PDAM Badung are shown in Table C.1.3. There is a high correlation between both ratio as shown in Fig. C.1.2.

Based on the above analysis, the existing commercial and institutional water consumption by Kelurahan is estimated by the following formula.

Existing Commercial & Institutional Water Consumption by Kelurahan/Desa = Existing Domestic Water Consumption by Kelurahan/Desa x Existing Commercial & Institutional Water Consumption Ratio by Kelurahan/Desa.

where,

Existing Commercial & Institutional Water Consumption Ratio :

$Y(\%) = 1.143 \times X(\%) - 3.556$

X(%) = Existing Commercial & Institutional Land Area / Existing Residential Land Area x 100

The existing total commercial and institutional water use in the Study Area is estimated to be 16,947 m^3/day.

1.3.2 Future Water Consumption

The future commercial and institutional water consumption ratio is assumed to be the same as the existing one.

The future commercial and institutional water consumption by Kelurahan/Desa is estimated in the same manner as the existing one.

The future total commercial and institutional water use in the Study Area is estimated to be 27,973 m^3/day in the year 2010.

1.4 Tourism Water Consumption

1.4.1 Existing Water Consumption

The JICA Study Team conducted a sampling survey on water consumption for hotels and restaurants of the Study Area. The survey was conducted for nine (9) hotels and three (3) restaurants.

(1) Hotel

Hotels in the Study Area are classified into three (3) classes as follows.

High class hotel : Star class hotel
Middle class hotel : Inn
Low class hotel : Home stay

The water consumption of a hotel varies according to its class. Unit water consumption, excluding that of gardening, per hotel guest in a high class hotel ranges from 0.95 m^3/day to 1.23 m^3/day with an average of 1.11 m^3/day. In a middle class hotel, the unit water consumption ranges from 0.74 m^3/day to 1.05 m^3/day with an average of 0.87 m^3/day. And in a low class hotel, it ranges from 0.29 m^3/day to 1.17 m^3/day with an average of 0.63 m^3/day.

The sampling survey results are summarized in Table C.1.4.

According to the statistical yearbook of Bali, in 1991, the average number of guest per one (1) room is 1.99 person. Accordingly, the unit water consumption of one (1) room comes to 2.21 m^3/room/day for a high class hotel, 1.73 m^3/room/day for a middle class one and 1.25 m^3/room/day for a low class one. The average unit water consumption of both the middle and low classes comes to 1.49 m^3/room/day.

These figures are very close to the proposed unit water consumption of 2.1 m^3/room/day for large hotel and 1.5 m^3/room/day for small hotel by the Upgrading and Development Programme for Water Supply Project, IUIDP, Bali in 1989.

Based on the above discussions, the existing unit water consumption per hotel room is determined as follows.

High class hotel : 2.1 m^3/room/day
Middle and low class hotel : 1.5 m^3/room/day
Note : High class hotel covers all star hotels.

According to the statistical yearbook of Bali, the number of available guest rooms in the Study Area in 1990 was 6,558 for high class hotel and 7,957 for middle and low class hotels. The average occupancy rate was 71.3% for high class hotel, and 29.3% for middle and low class hotels.

While, 17 high class hotels, and 17 middle and low class hotels were newly opened in the Study Area in 1991, increasing the total available room number to 11,425 rooms in high class hotel and 7,811 rooms in middle and low class hotels. Hence, the average room occupancy rate in 1991 is assumed to be 35.6% for high class hotel, and 15.2% for middle and low class hotels. In this estimation, a 12.7% increase of tourist numbers to the Study Area was considered since the average annual growth rate of tourist number to Bali during the recent four (4) years was 12.7%.

Based on the above discussions, the total water consumption of hotels in the Study Area in 1991 is estimated to be about 16,438 m^3/day.

(2) Restaurant

The results of the sampling survey for water consumption of restaurant are shown in Table C.1.5. The obtained water consumption per seat ranges from 9 l/seat/day to 33 l/seat/day averaging 22 l/seat/day.

Based on the above results, existing unit water consumption of restaurant is assumed to be 22 l/seat/day. There are 293 restaurants with a total seat number of 18,380 in the Study Area in 1991. The total water consumption of restaurant of the Study Area in 1991 is estimated to be 404 m^3/day.

1.4.2 Future Water Consumption

(1) Hotel

The future unit water consumption of hotel is assumed as the same as the existing one.

The total room number in the Study Area in 2010 is projected to 30,069 in high class hotel, and 14,255 in middle and low class hotels.

The estimated total water consumption of hotel in the Study Area in 2010 is 53,983 m^3/day.