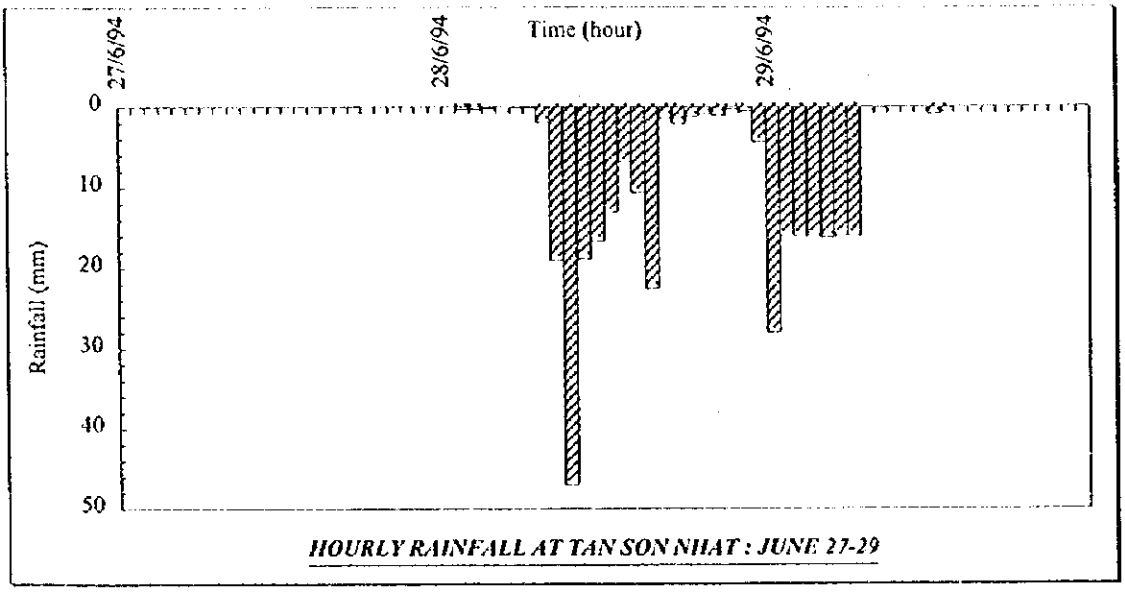
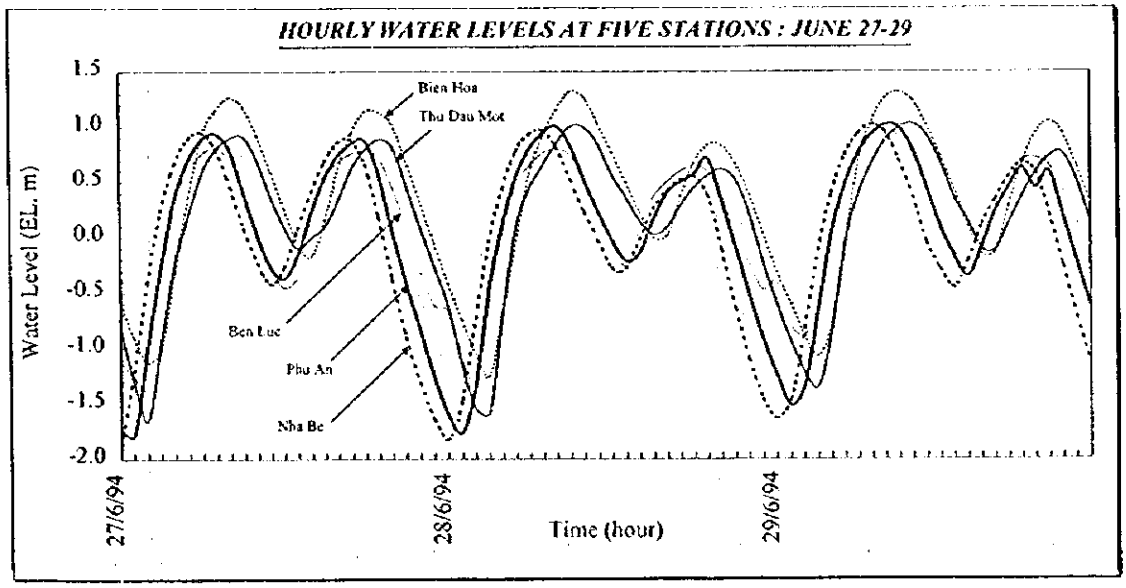
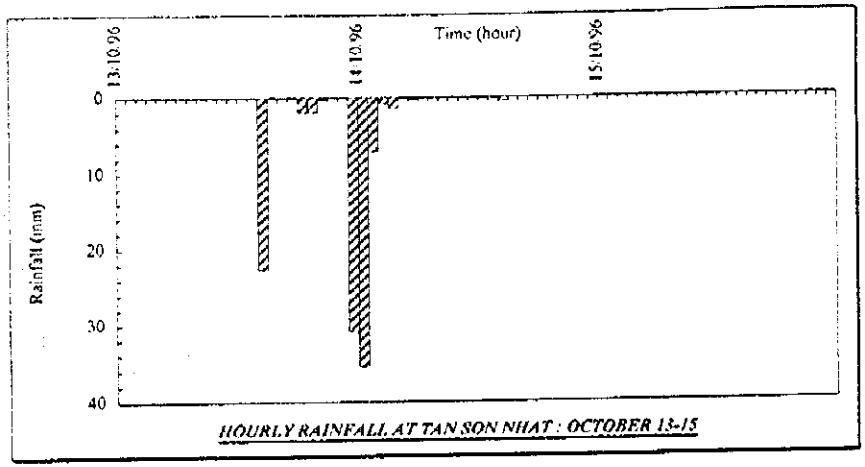
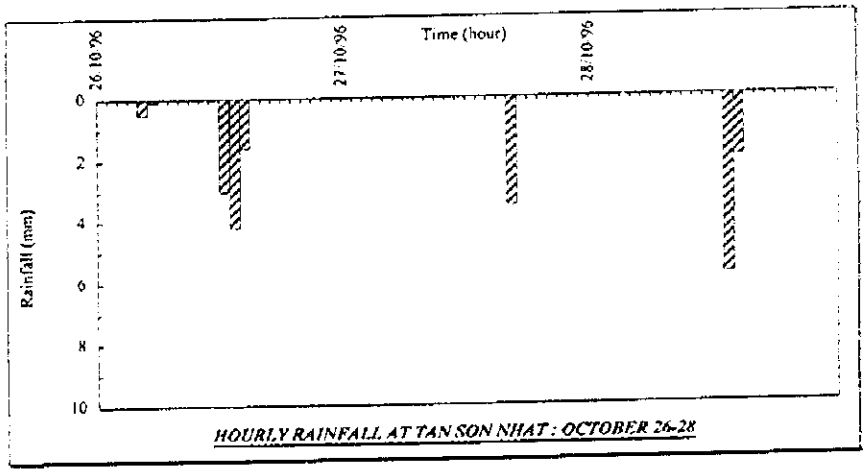


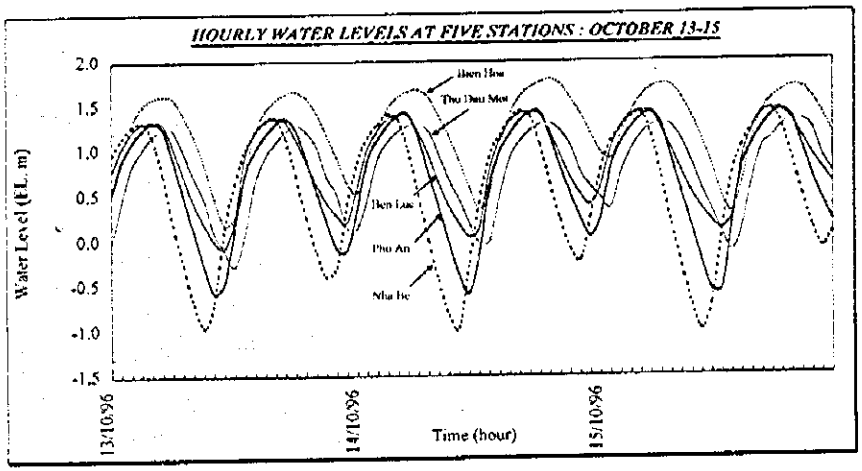


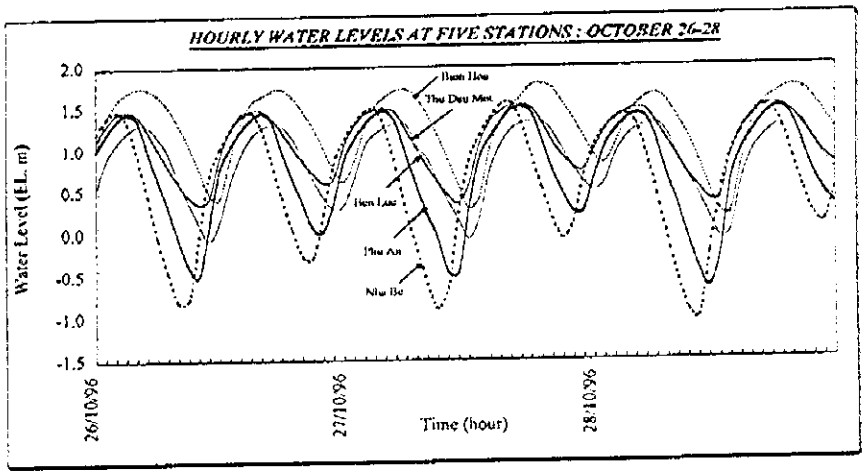
Data Source : Southern Region Hydro Meteorological Center, Ho Chi Minh City

Figure C.5.1 HOURLY RAINFALL AND WATER LEVELS DURING JUNE 1994 FLOOD



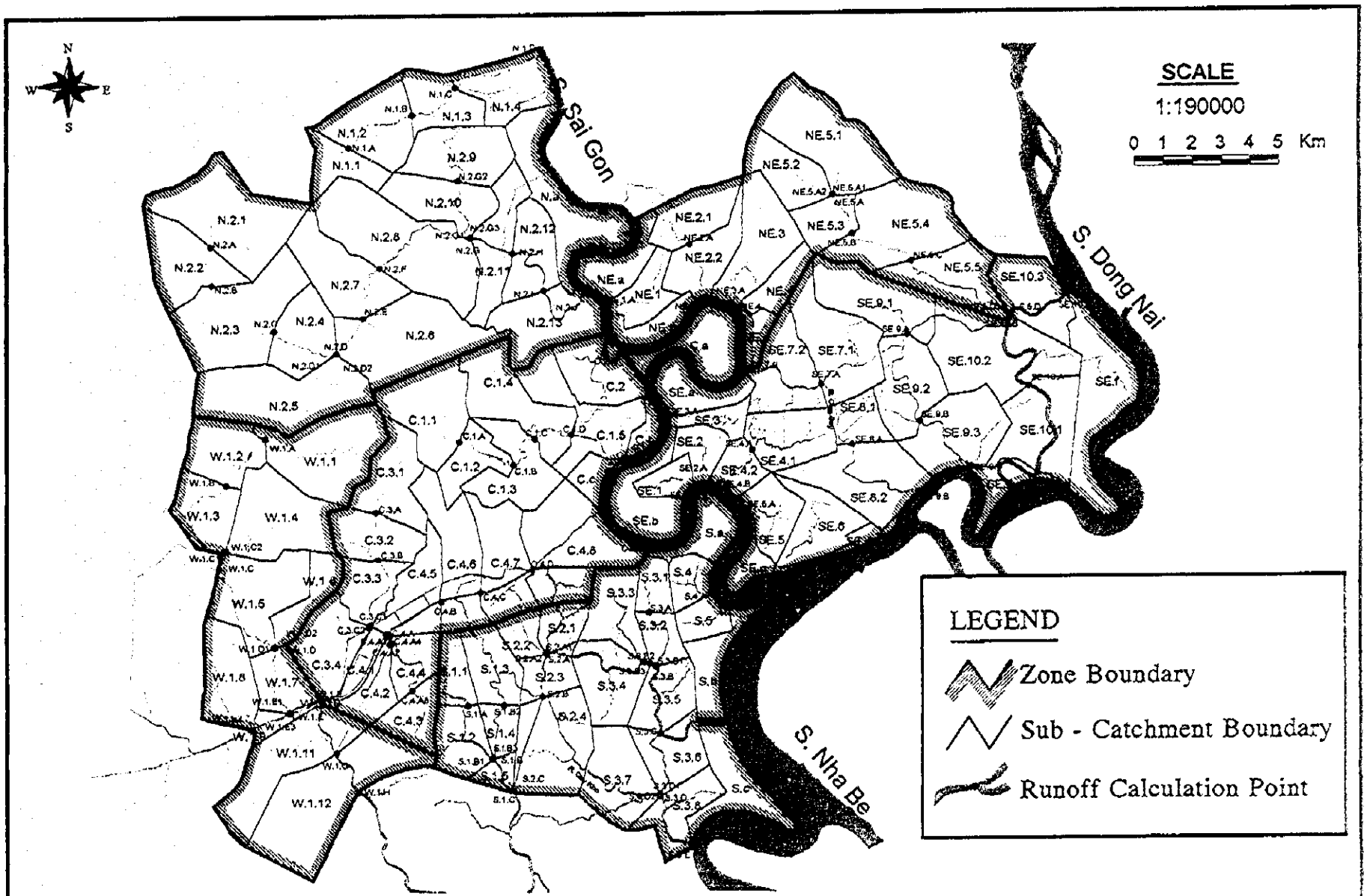






Data Source : Southern Region Hydro Meteorological Center, Ho Chi Minh City

Figure C.5.2 HOURLY RAINFALL AND WATER LEVELS DURING OCTOBER 1996 FLOOD



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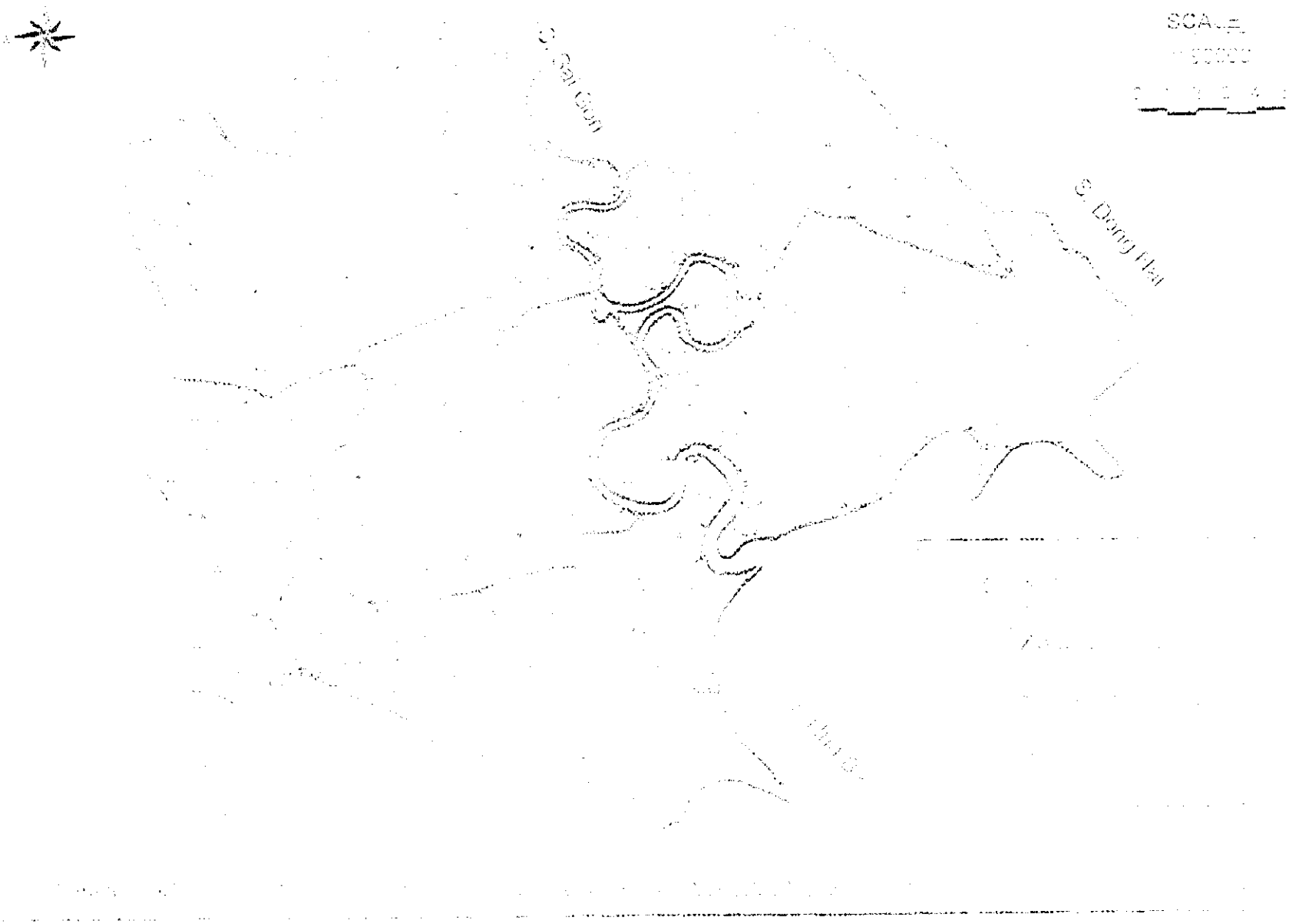

SCALE
S. Sài Gòn
S. Đồng Nai

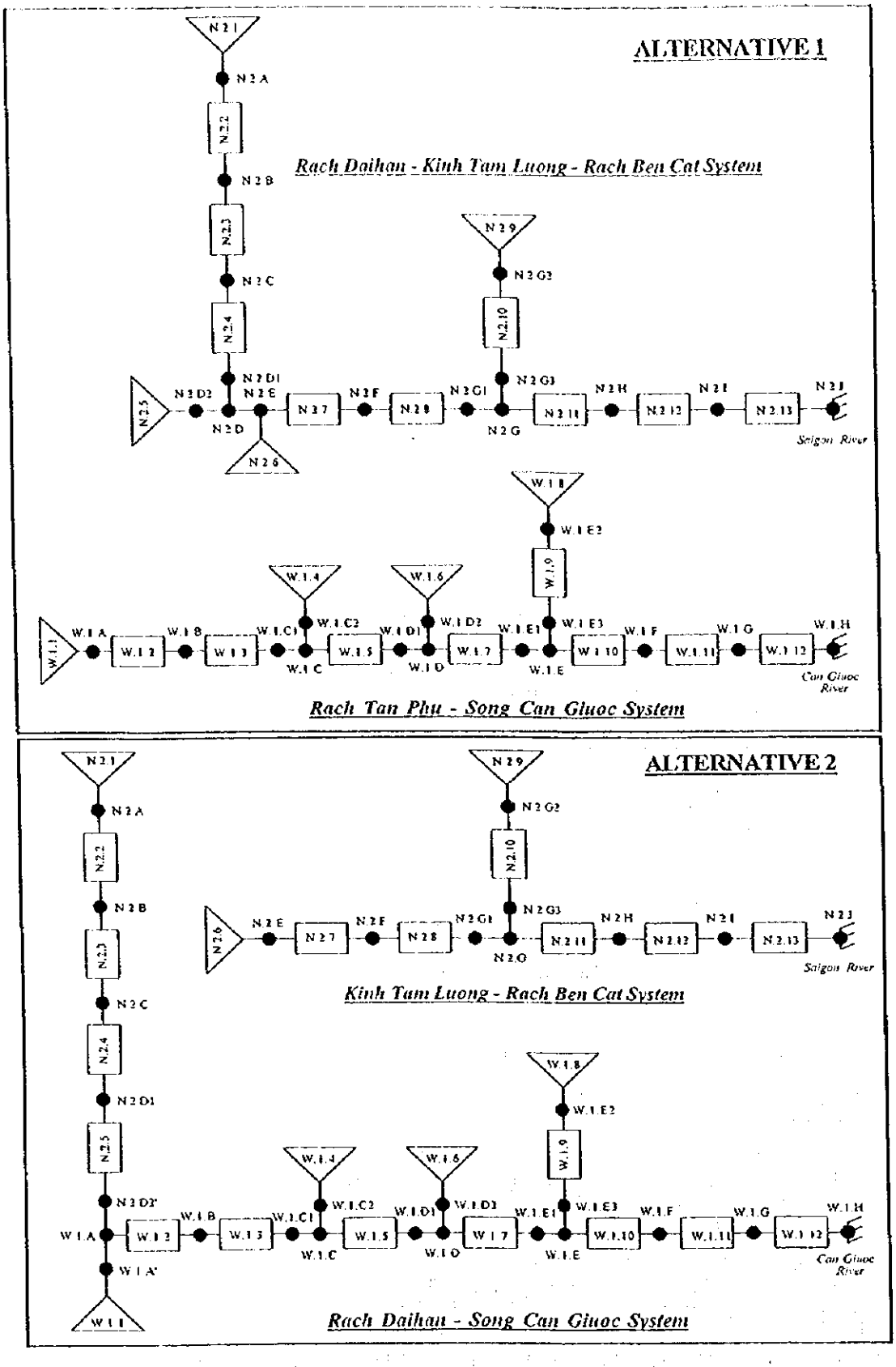


Figure C.6.2 ALTERNATIVES FOR OUTFLOW FROM DAIHAN CANAL

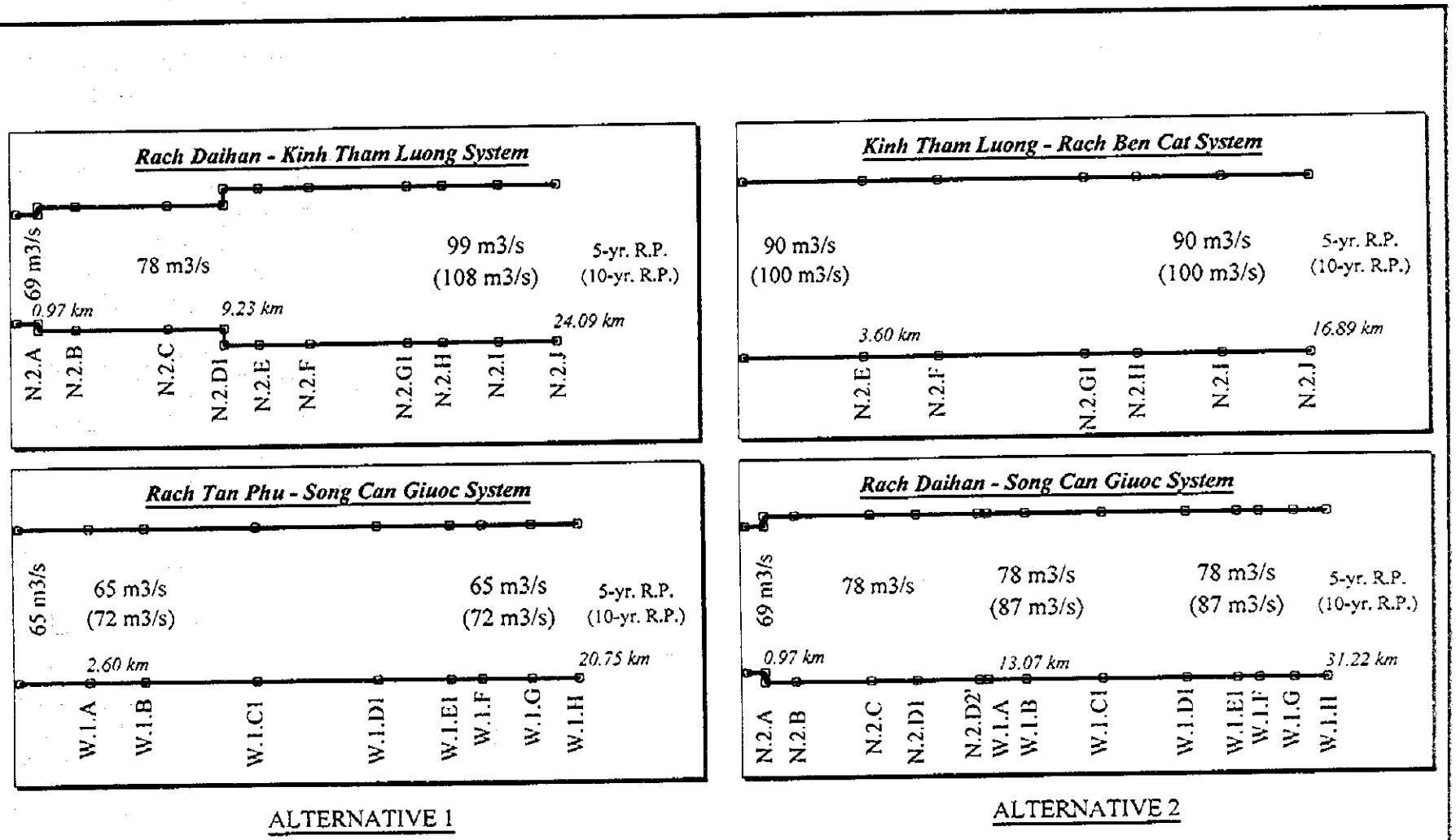


Figure C.6.3 COMPARISON OF DISCHARGE DISTRIBUTIONS FOR ALTERNATIVES 1 AND 2

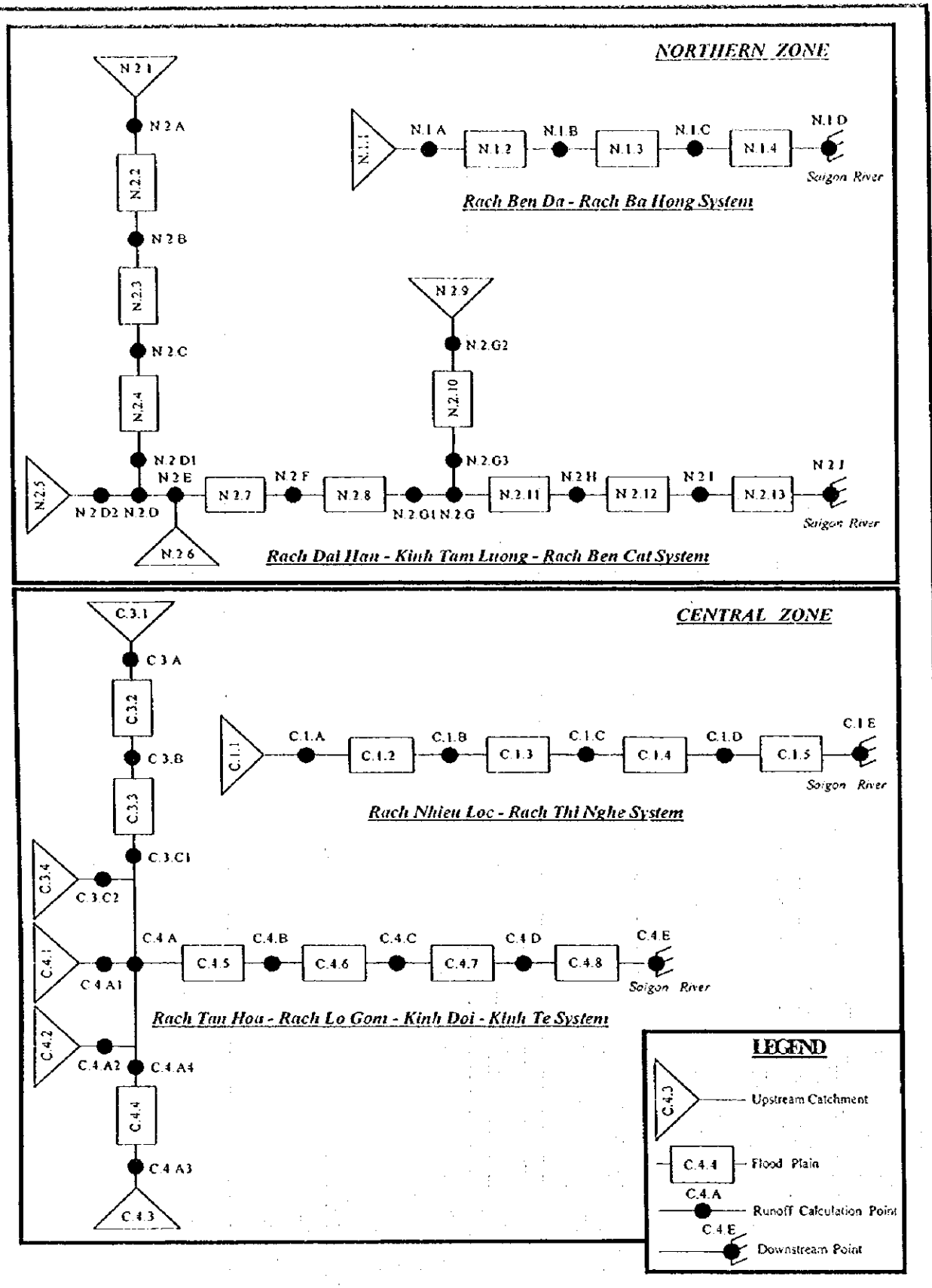


Figure C.6.4 RUNOFF CALCULATION POINTS OF CANAL SYSTEMS (1/3)

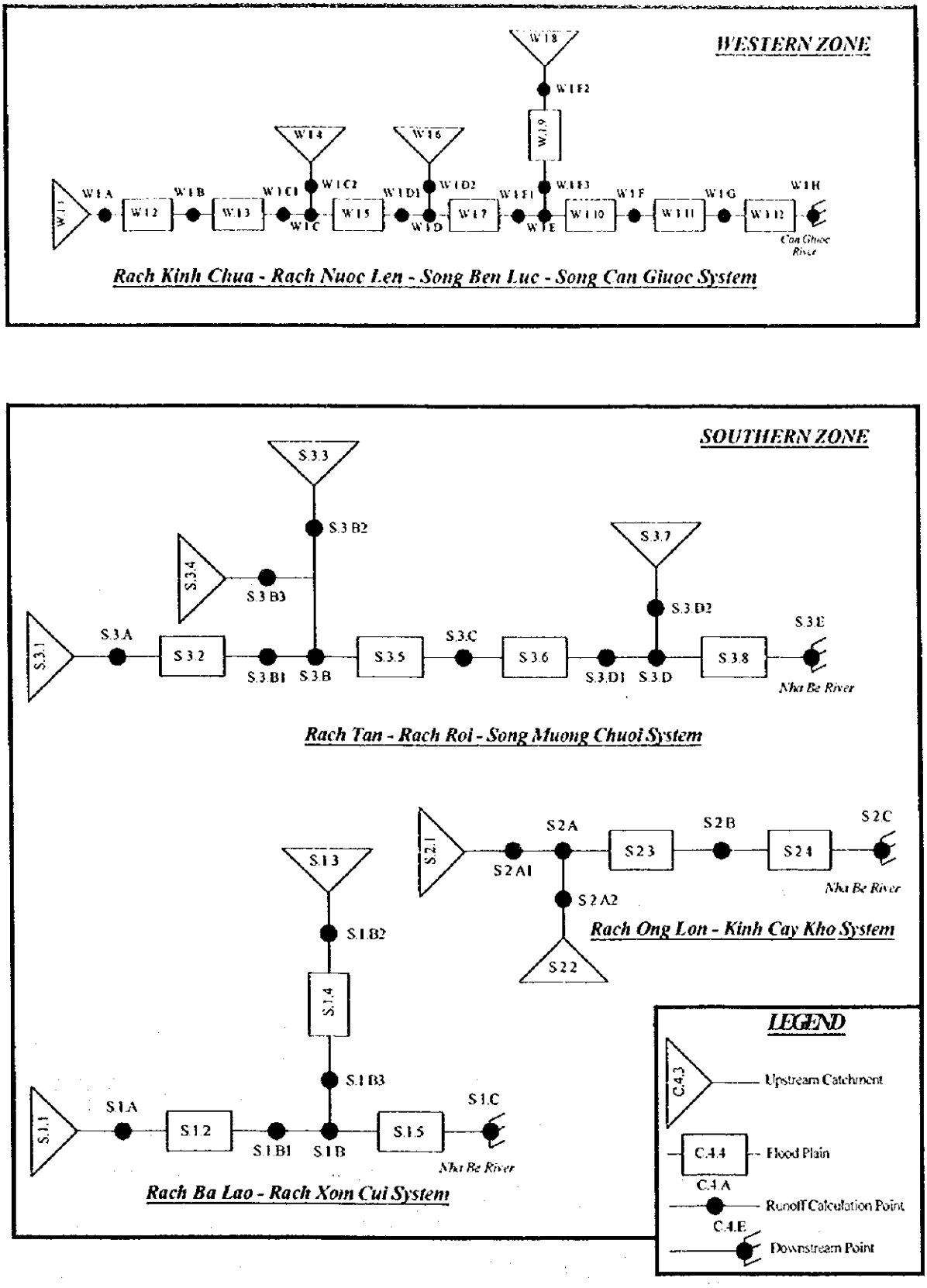


Figure C.6.4 RUNOFF CALCULATION POINTS OF CANAL SYSTEMS (2/3)

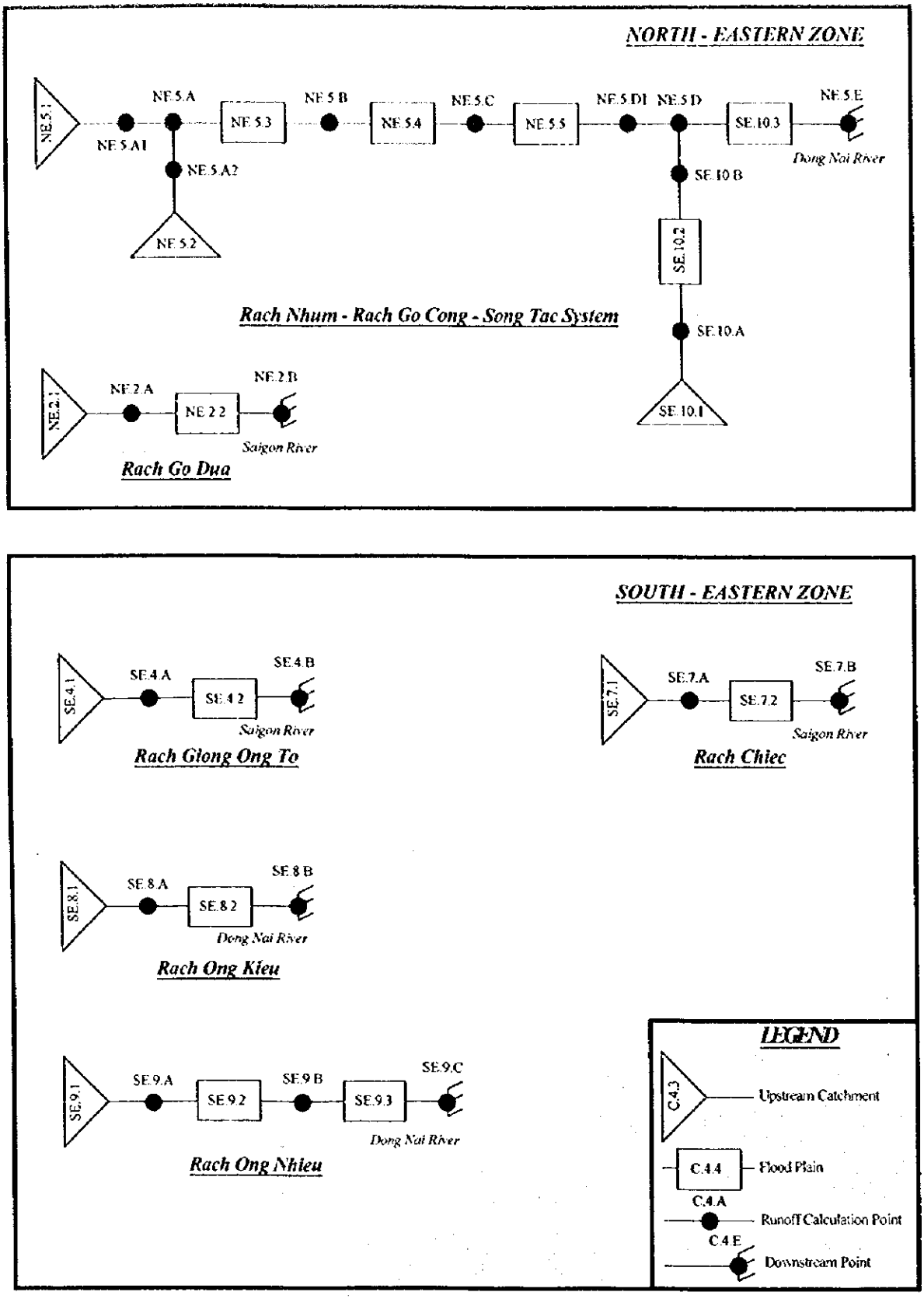


Figure C.6.4 RUNOFF CALCULATION POINTS OF CANAL SYSTEMS (3/3)

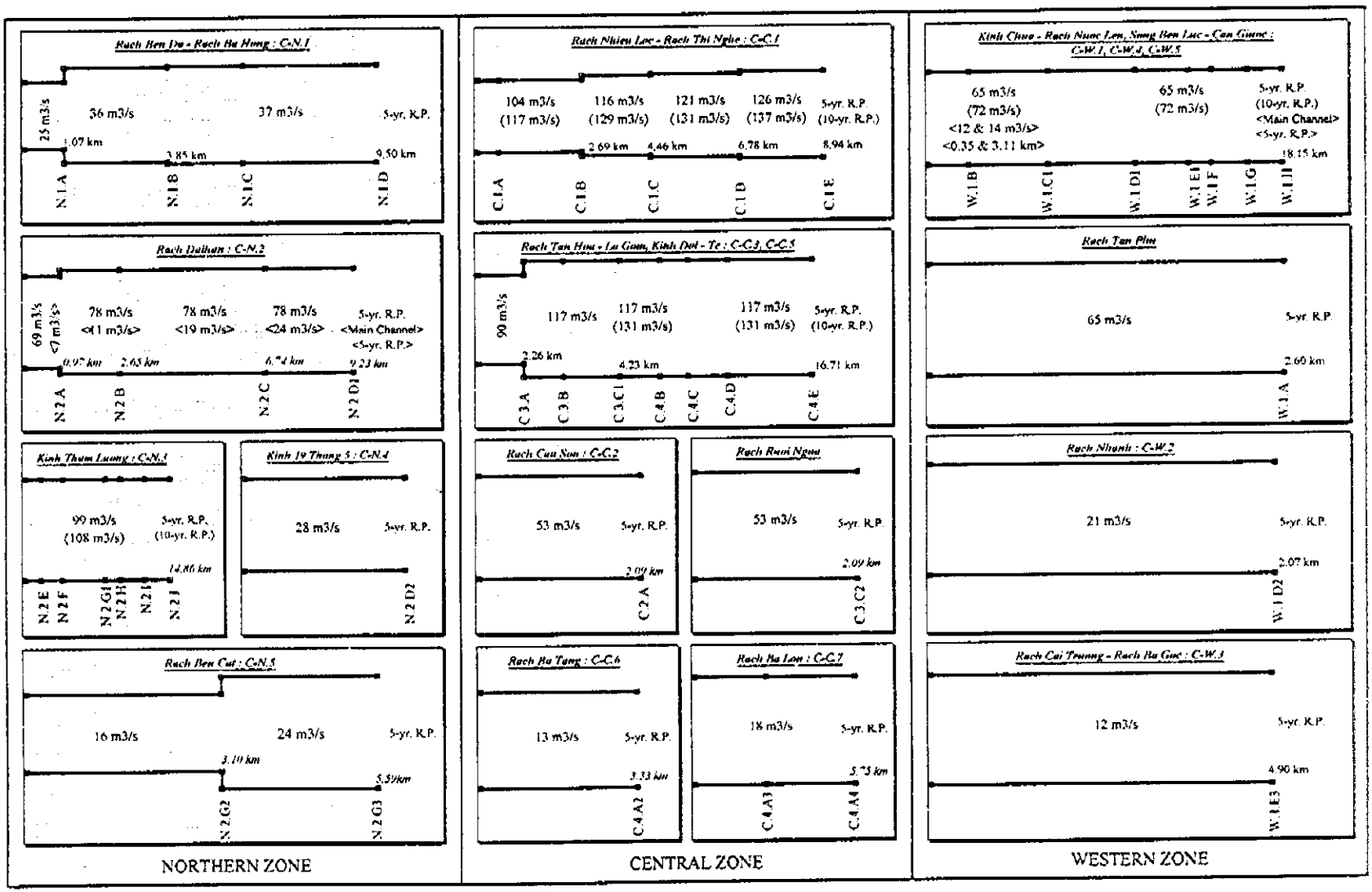


Figure C.6.5 DESIGN DISCHARGE DISTRIBUTIONS OF THE CANALS (1/3)

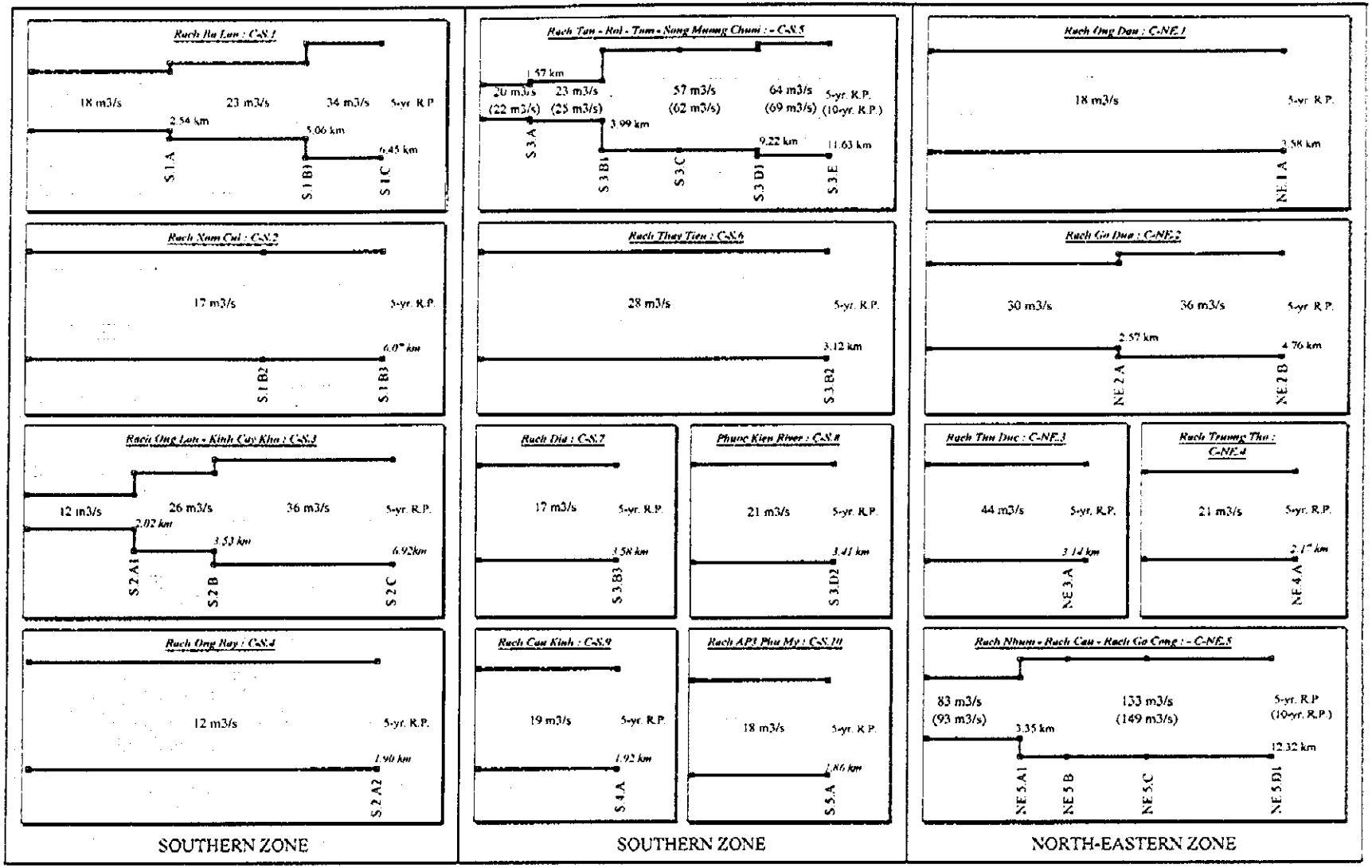


Figure C.6.5 DESIGN DISCHARGE DISTRIBUTIONS OF THE CANALS (2/3)

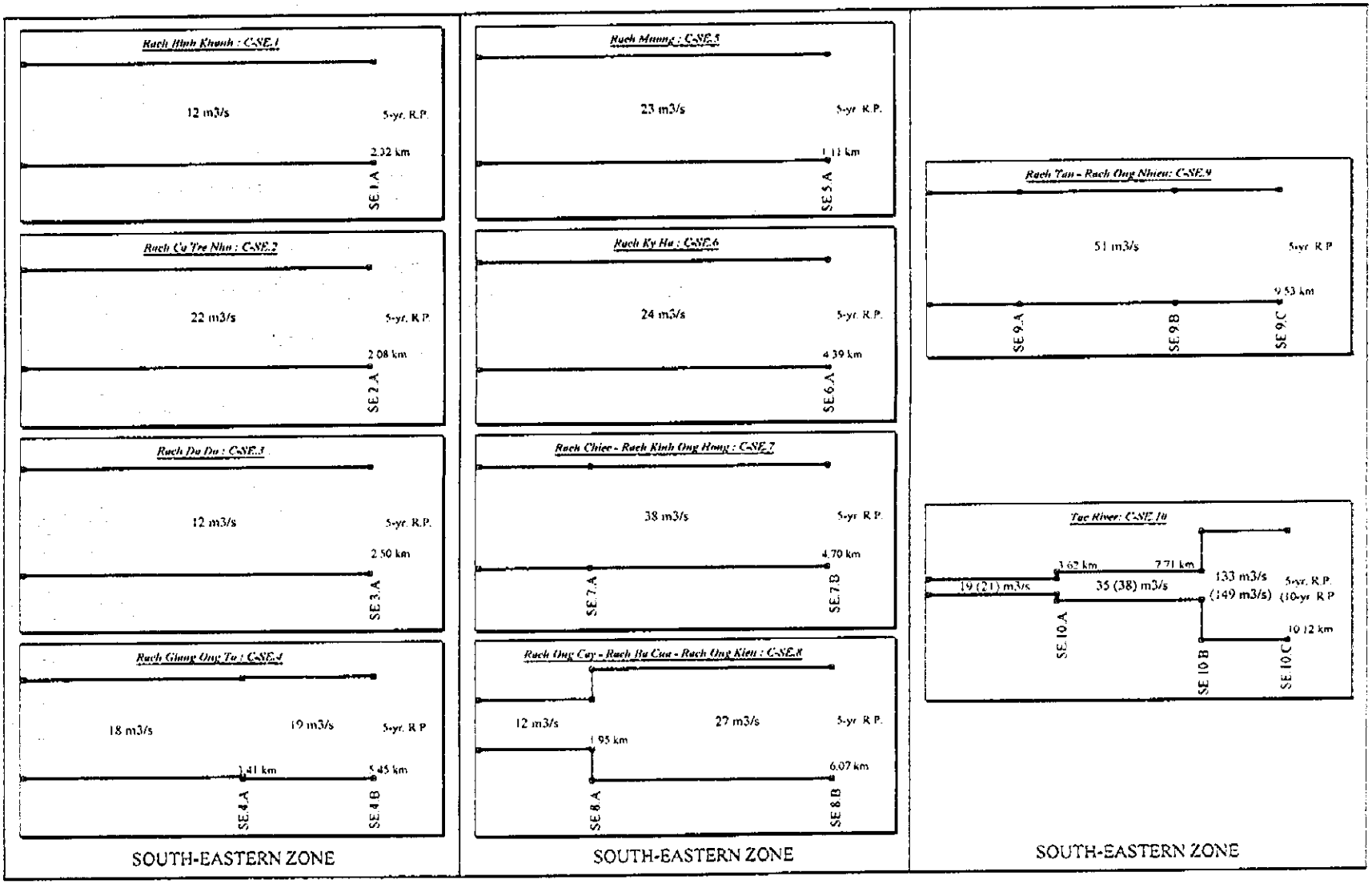


Figure C.6.5 DESIGN DISCHARGE DISTRIBUTIONS OF THE CANALS (3/3)

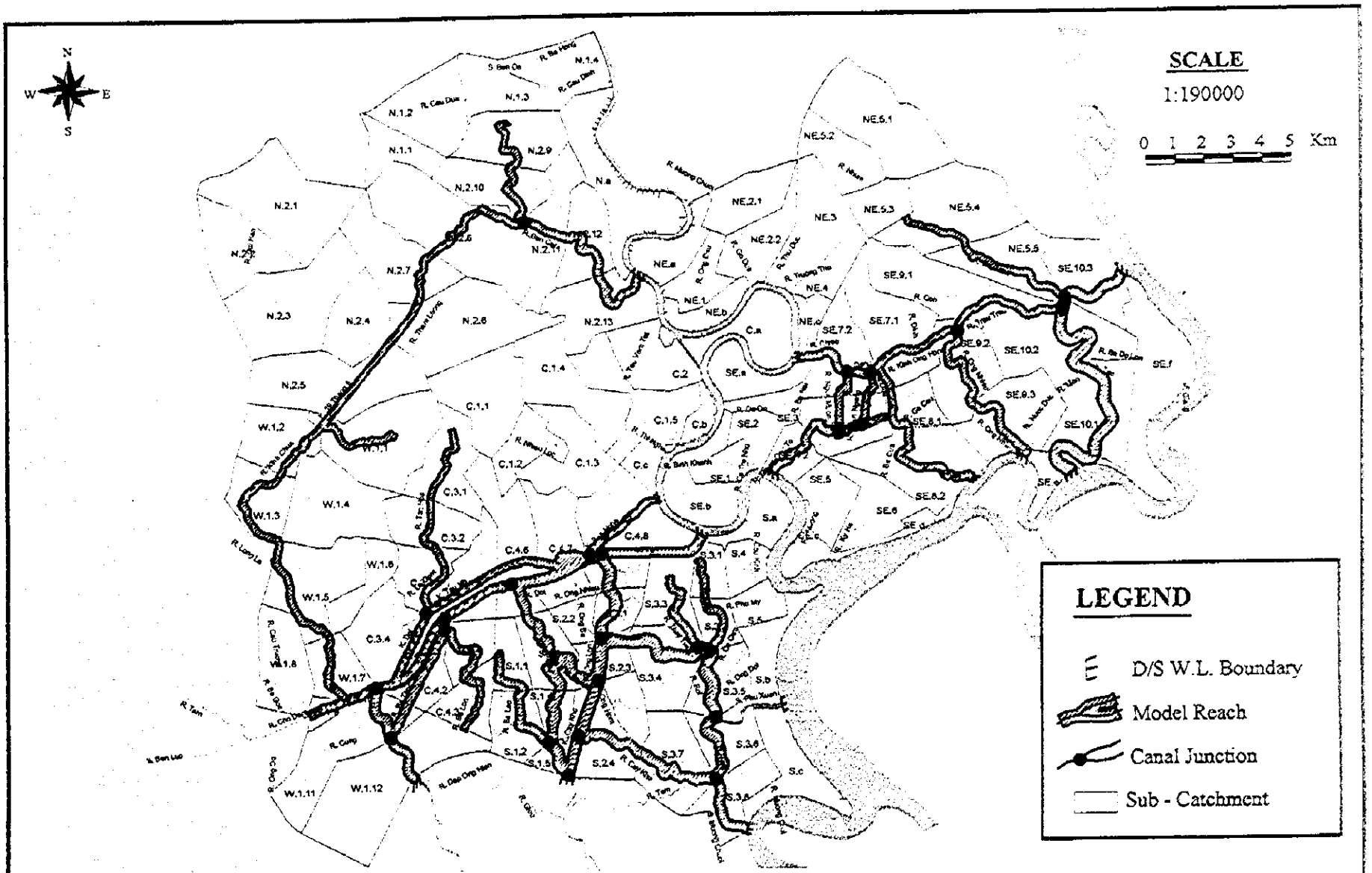


Figure C.7.1 MODEL NETWORK FOR HYDRODYNAMIC SIMULATION (1/2)

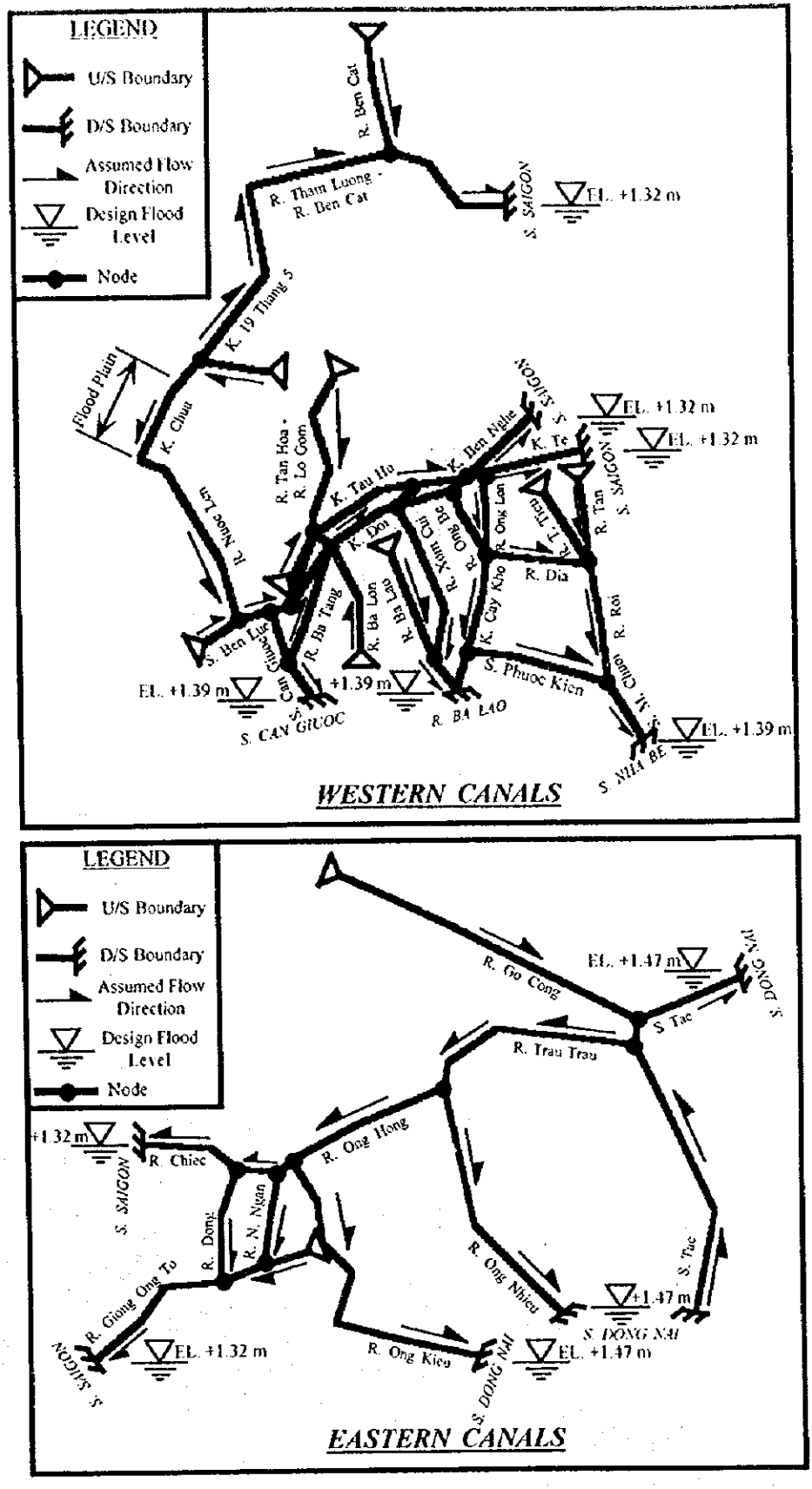


Figure C.7.1 MODEL NETWORK FOR HYDRODYNAMIC SIMULATION (2/2)

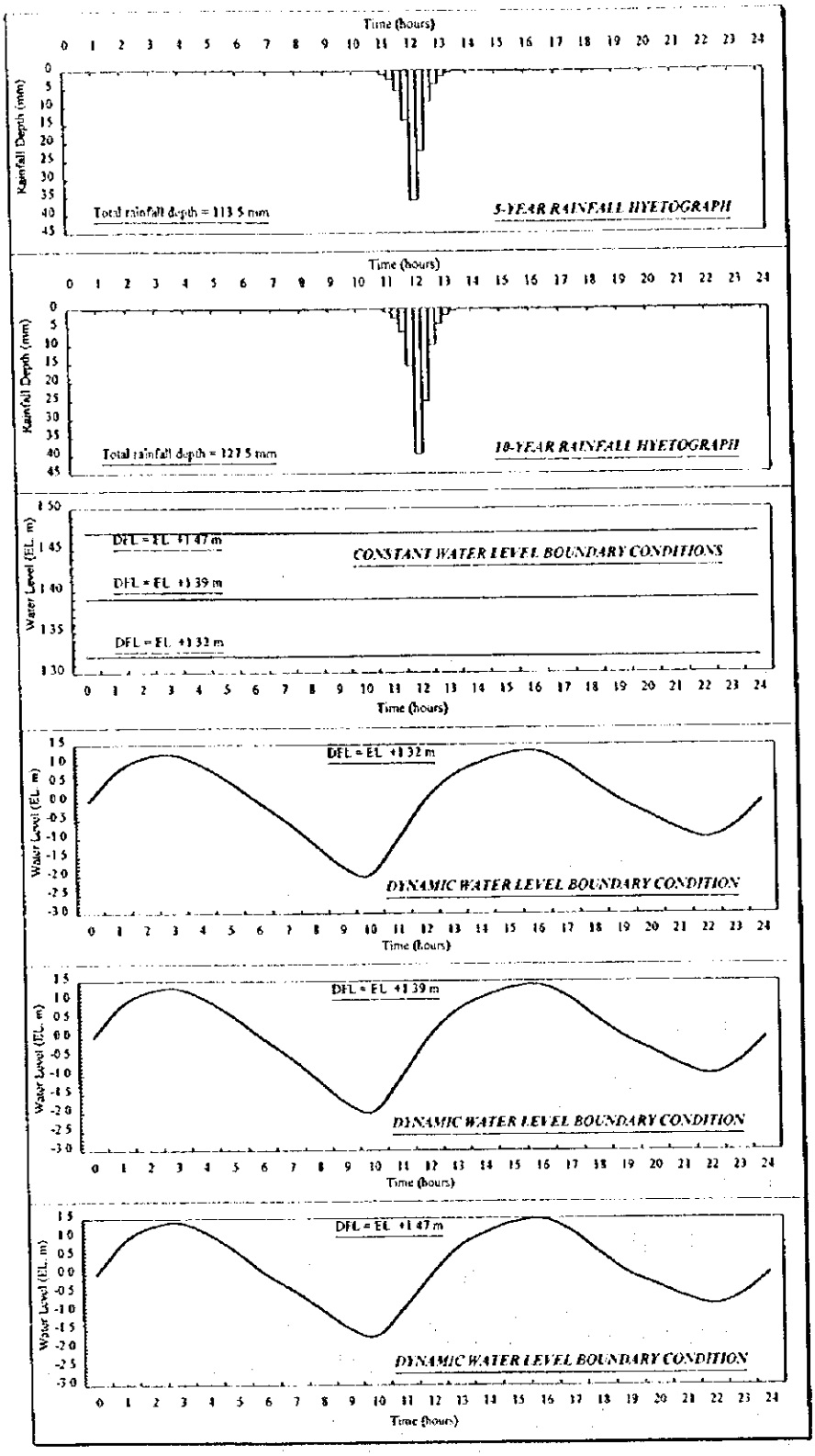
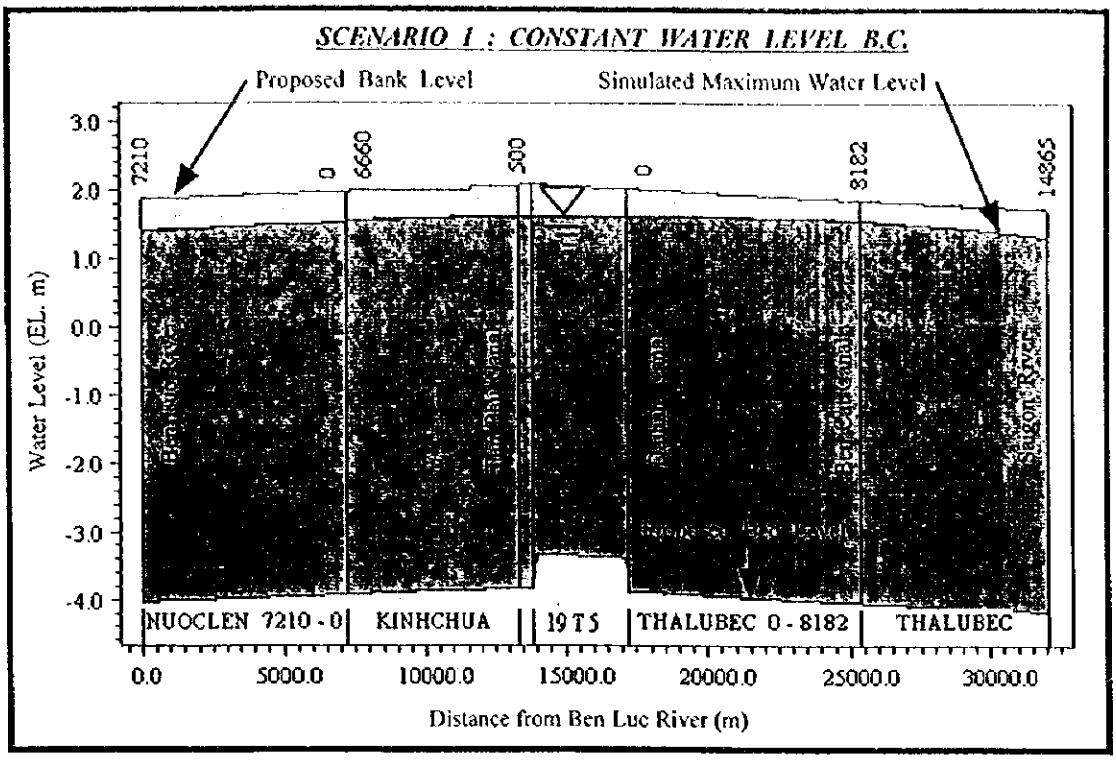


Figure C.7.2 RAINFALL HYETOGRAPHS AND W.L. B.C. USED IN HD MODEL DEVELOPMENT



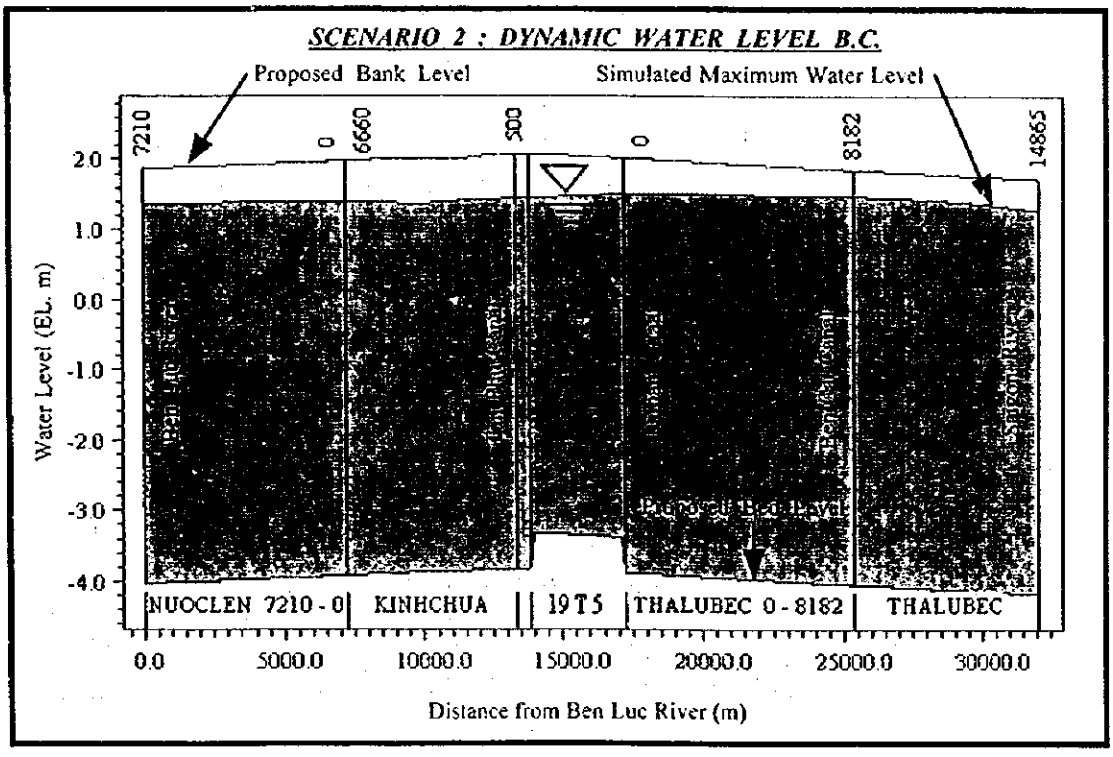
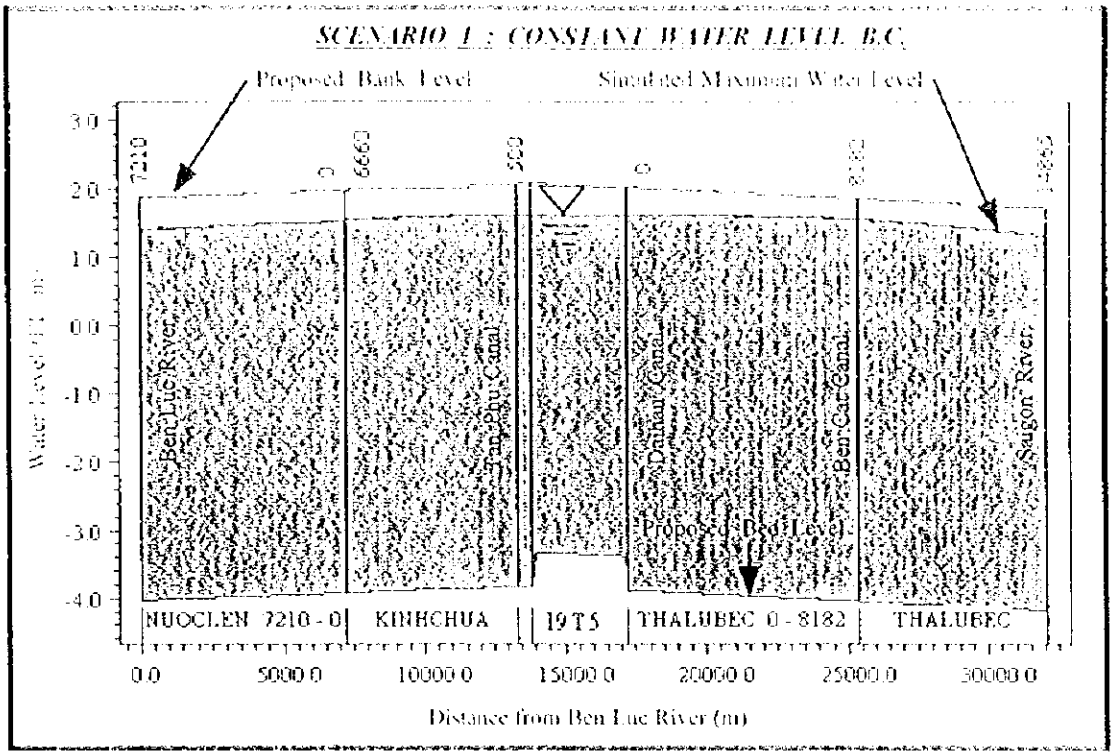


Figure C.7.3 SIMULATED MAXIMUM W.L. PROFILES ALONG NUOC LEN - THAM LUONG - BEN CAT CANAL (10-YEAR R.P.)



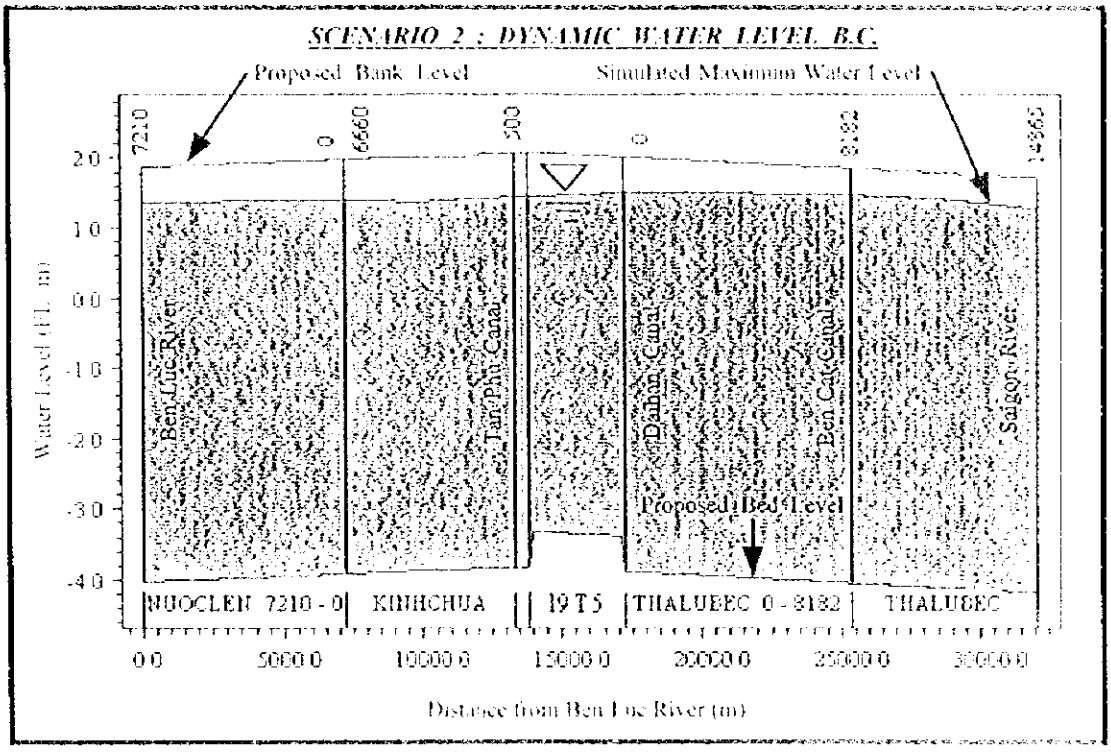
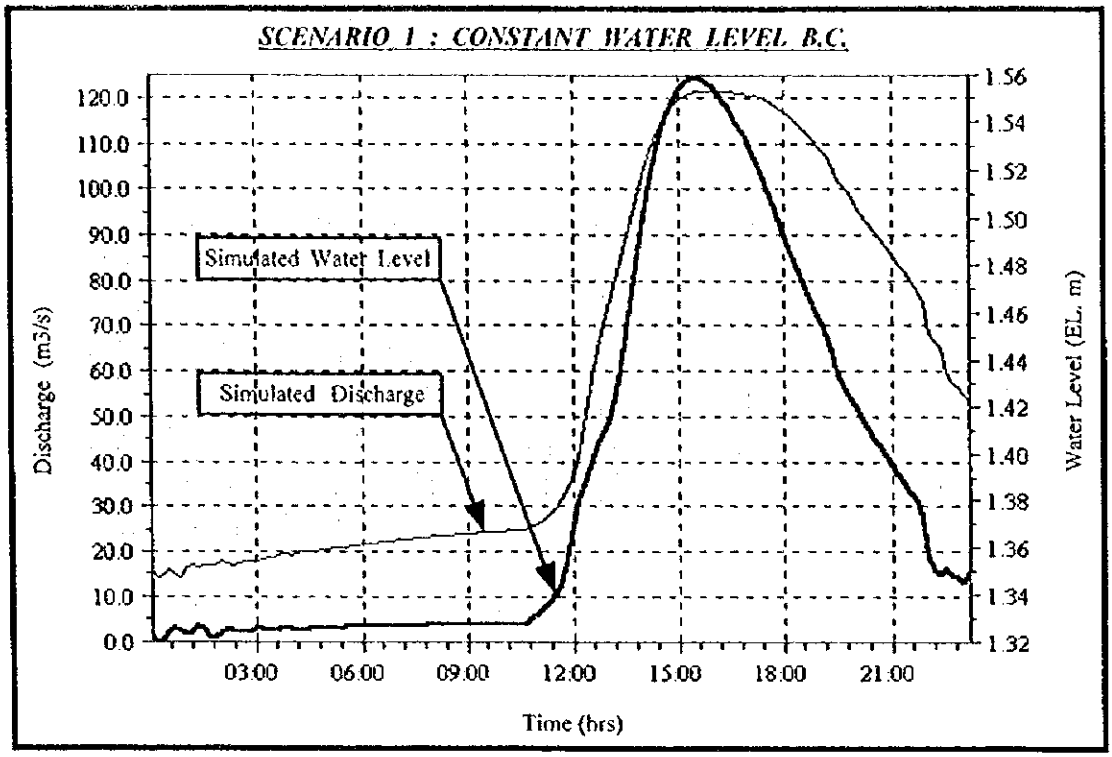


Figure C.7.3 SIMULATED MAXIMUM W.L. PROFILES ALONG NUOC LEN - THAM LUONG - BEN CAT CANAL (10-YEAR R.P.)



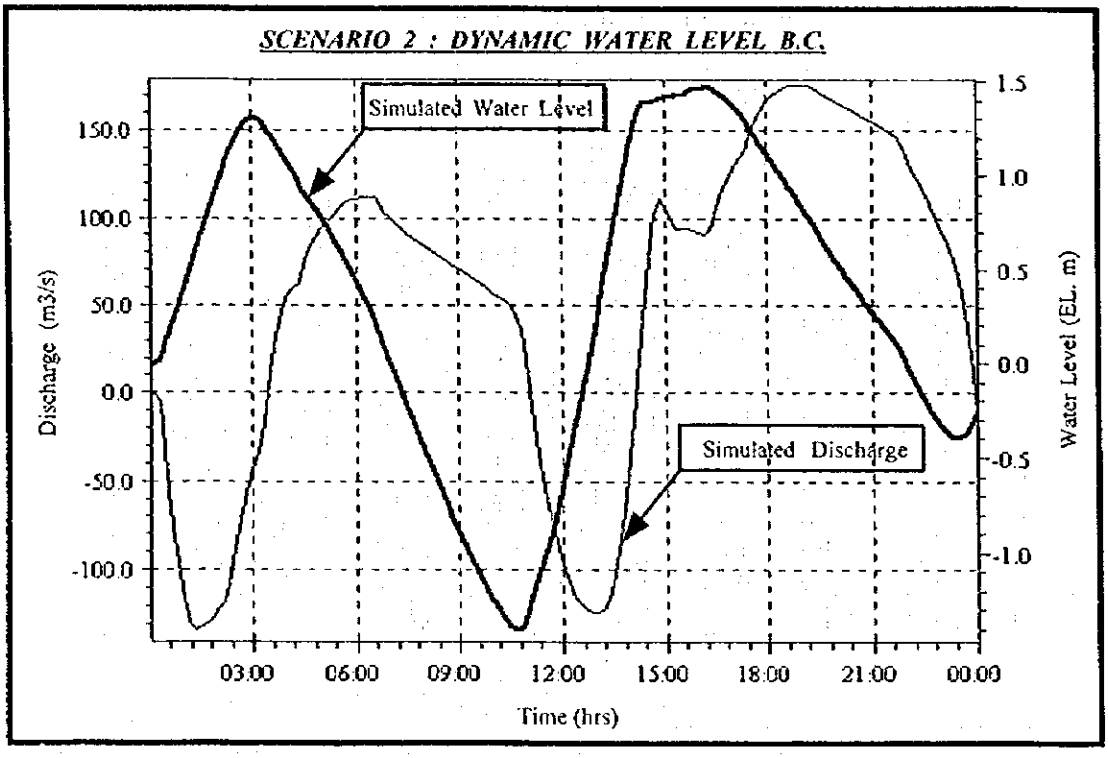
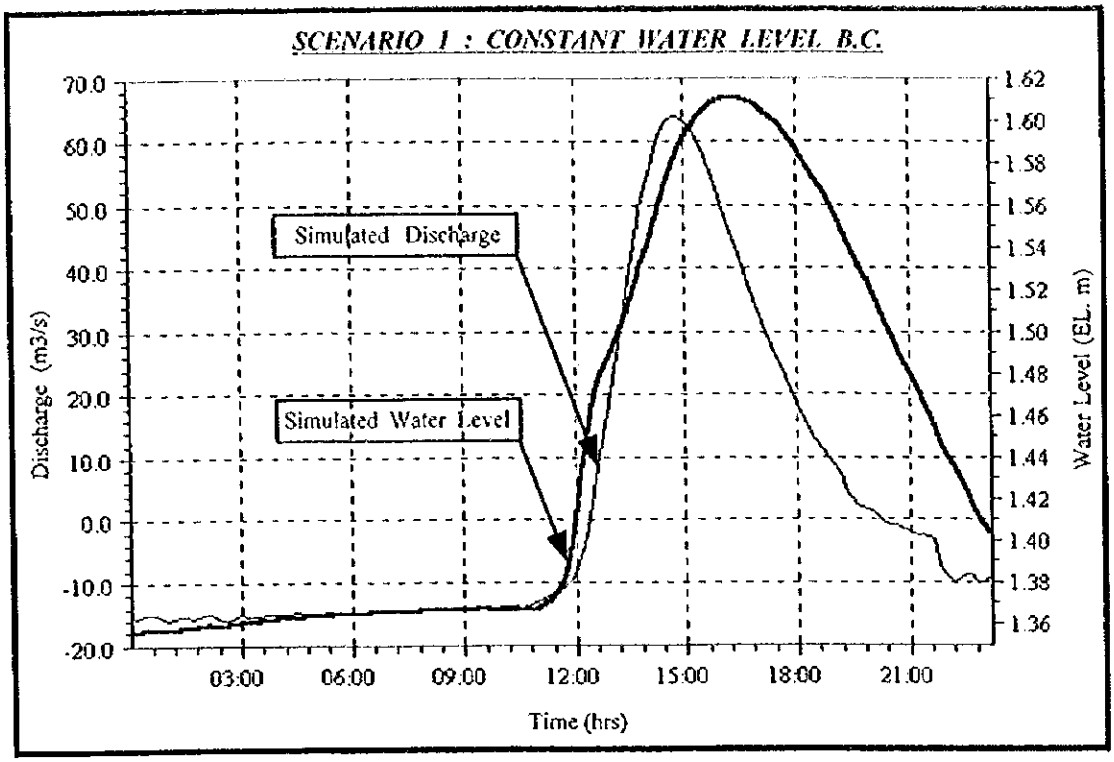


Figure C.7.4 SIMULATED STAGE AND DISCHARGE HYDROGRAPHS AT RUNOFF POINT N.2.G ON THAM LUONG - BEN CAT CANAL (10-YEAR R.P.)



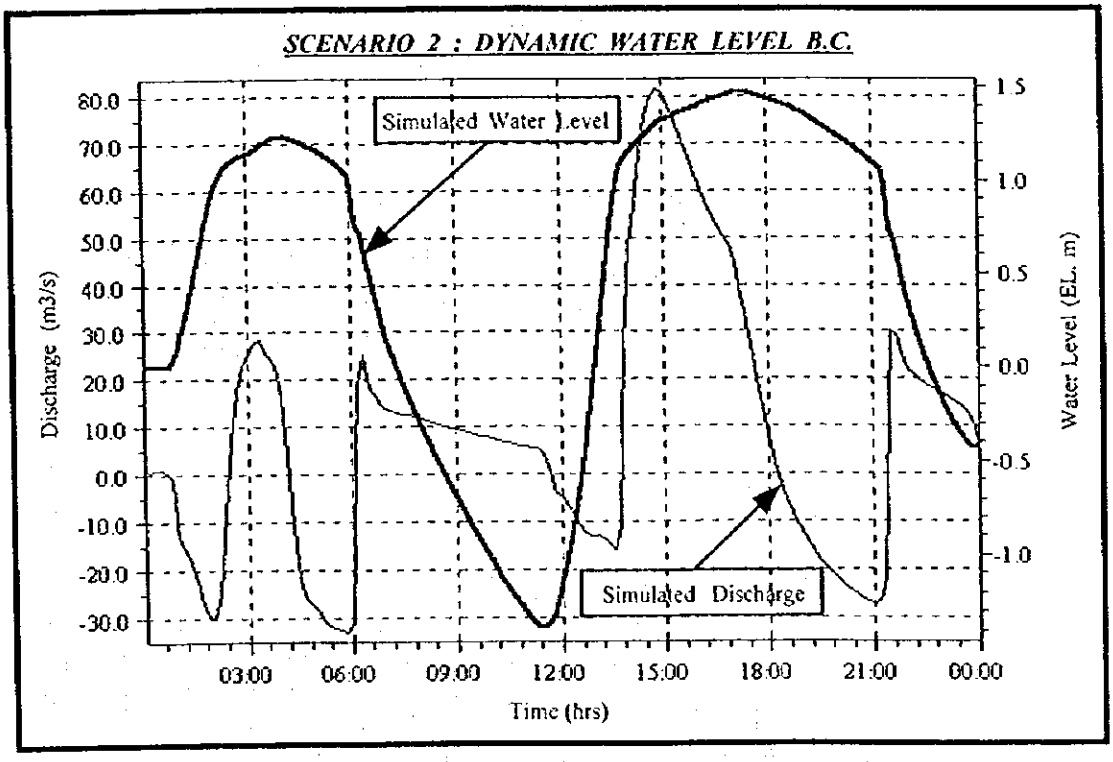
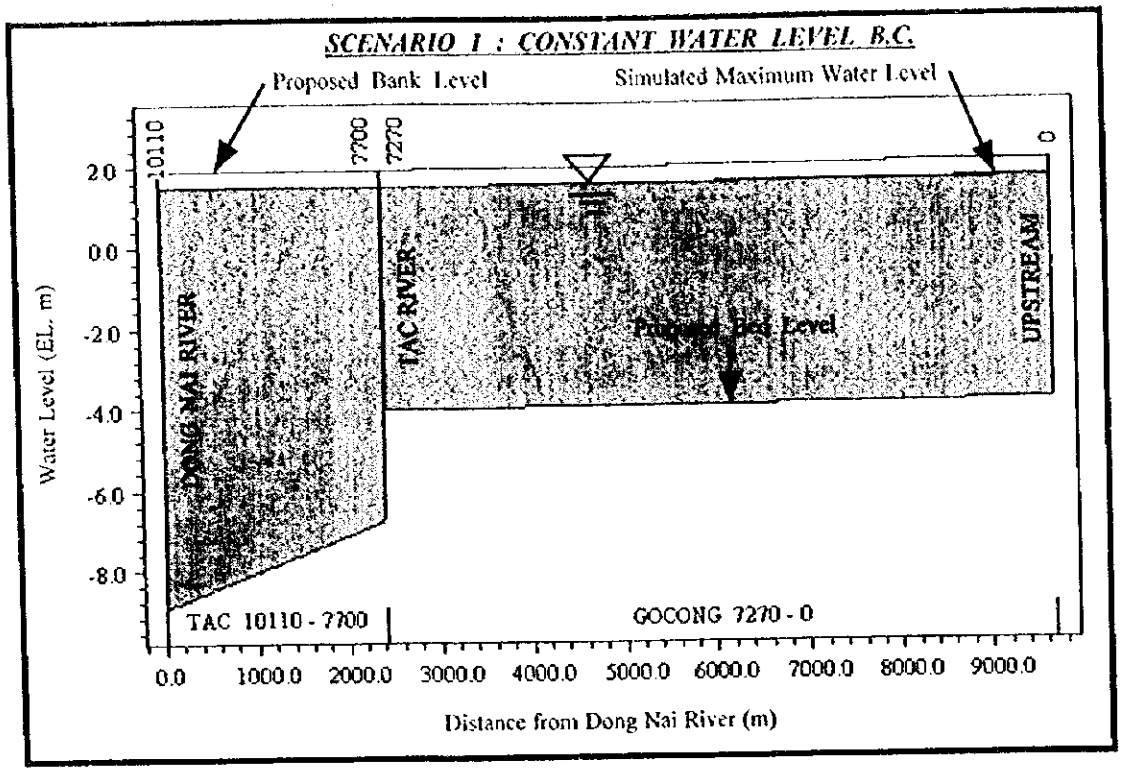


Figure C.7.5 SIMULATED STAGE AND DISCHARGE HYDROGRAPHS AT RUNOFF POINT W.1.B ON KINH CHUA (10-YEAR R.P.)



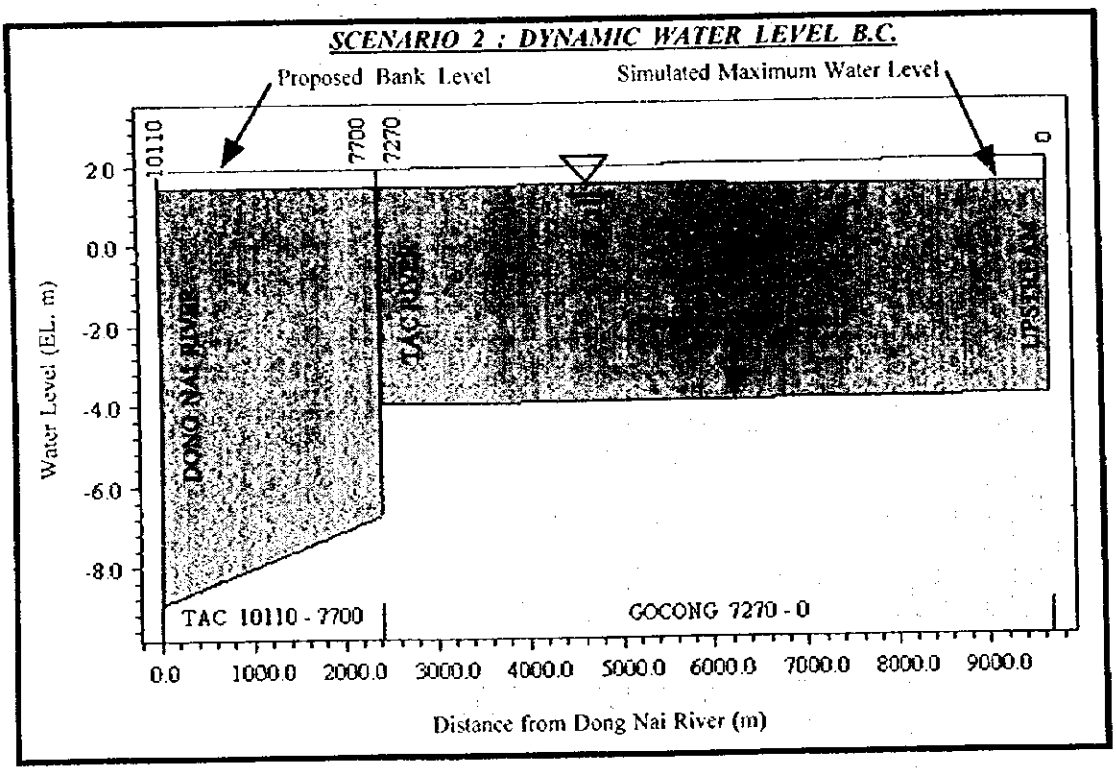
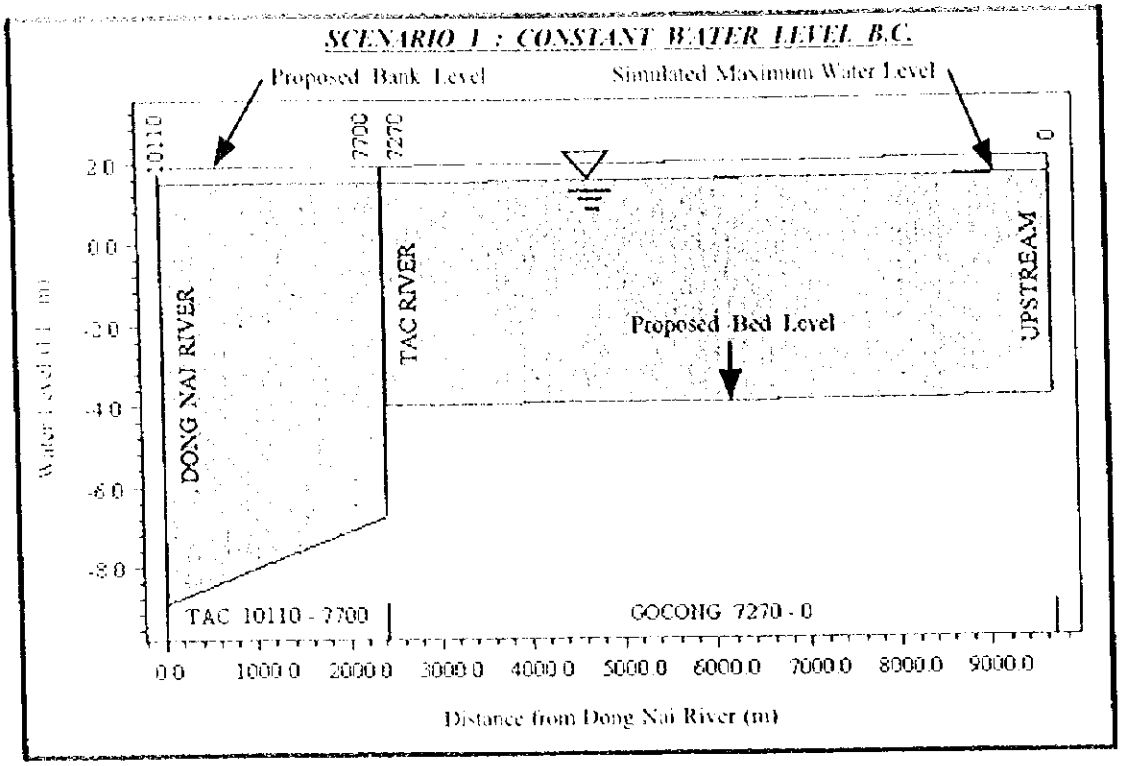


Figure C.7.6 SIMULATED MAXIMUM W.L. PROFILES ALONG GO CONG CANAL - TAC RIVER (10-YEAR R.P.)



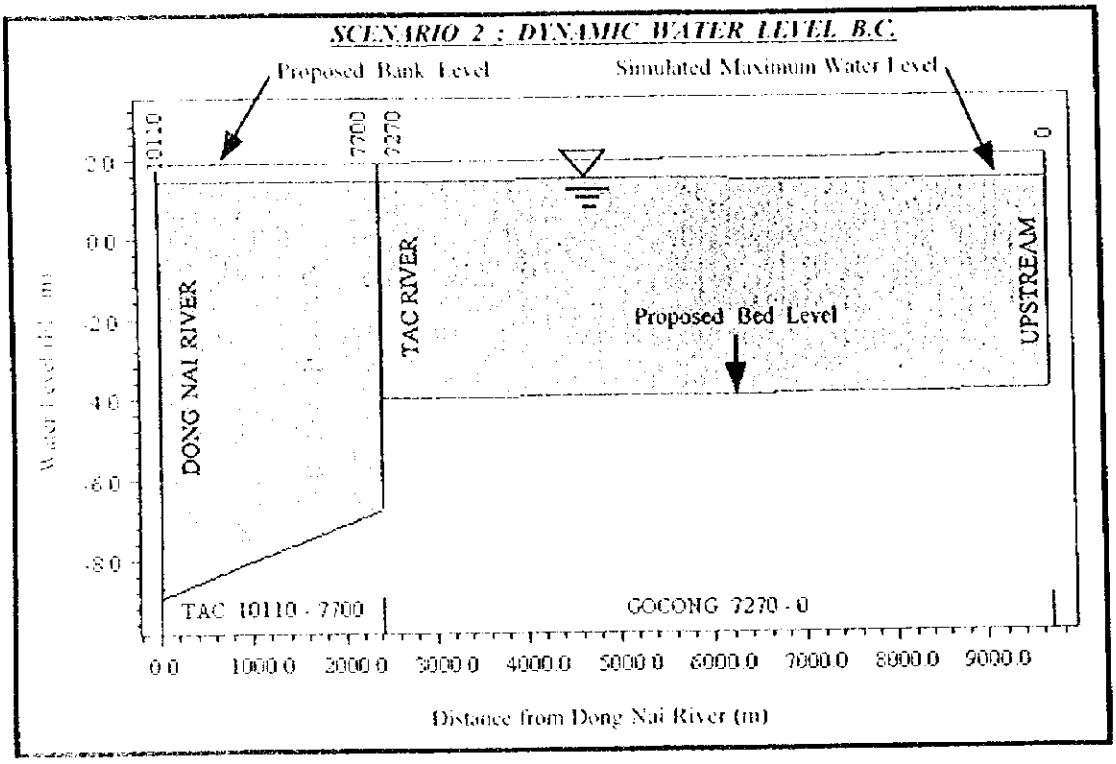
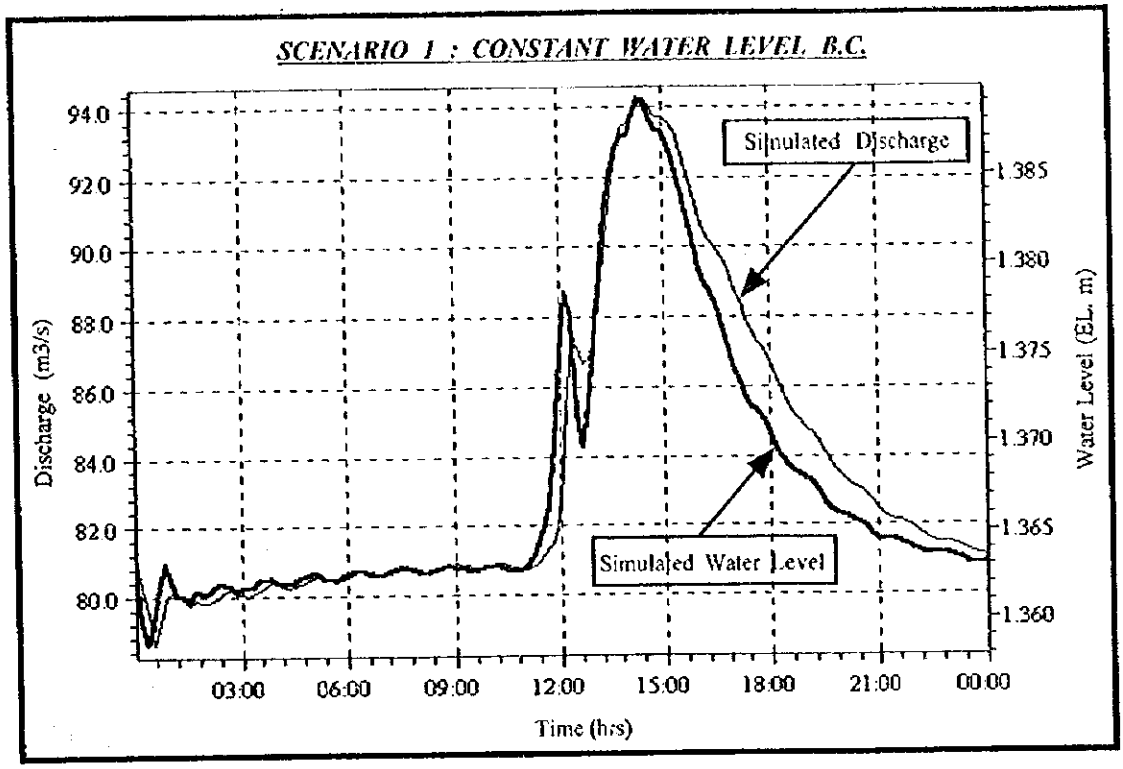


Figure C.7.6 SIMULATED MAXIMUM W.L. PROFILES ALONG GO CONG CANAL - TAC RIVER (10-YEAR R.P.)



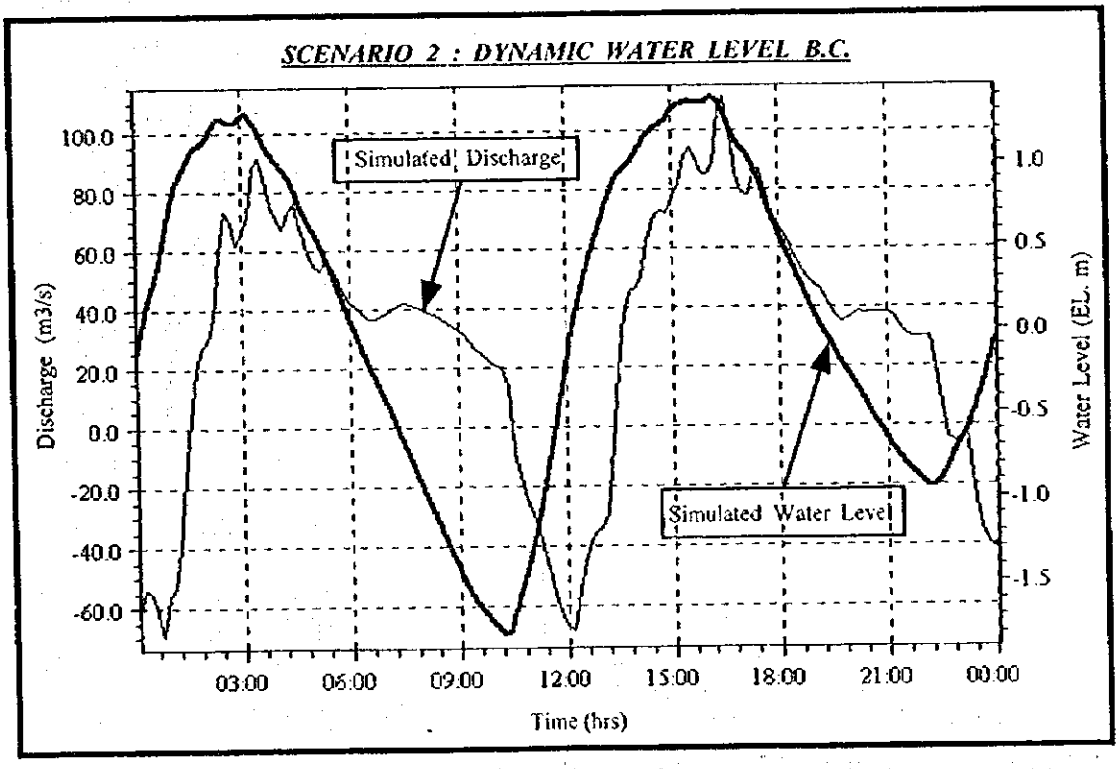
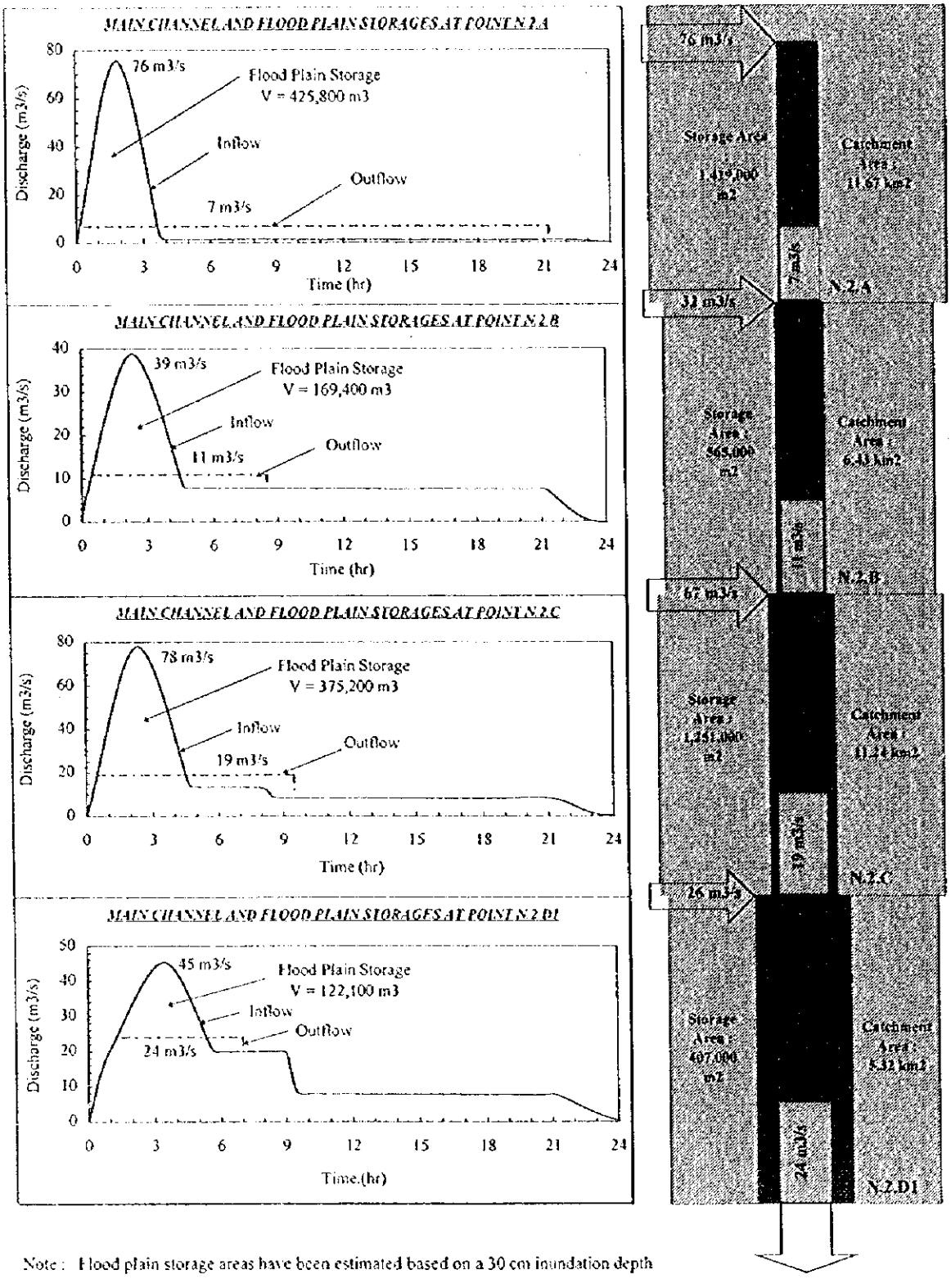
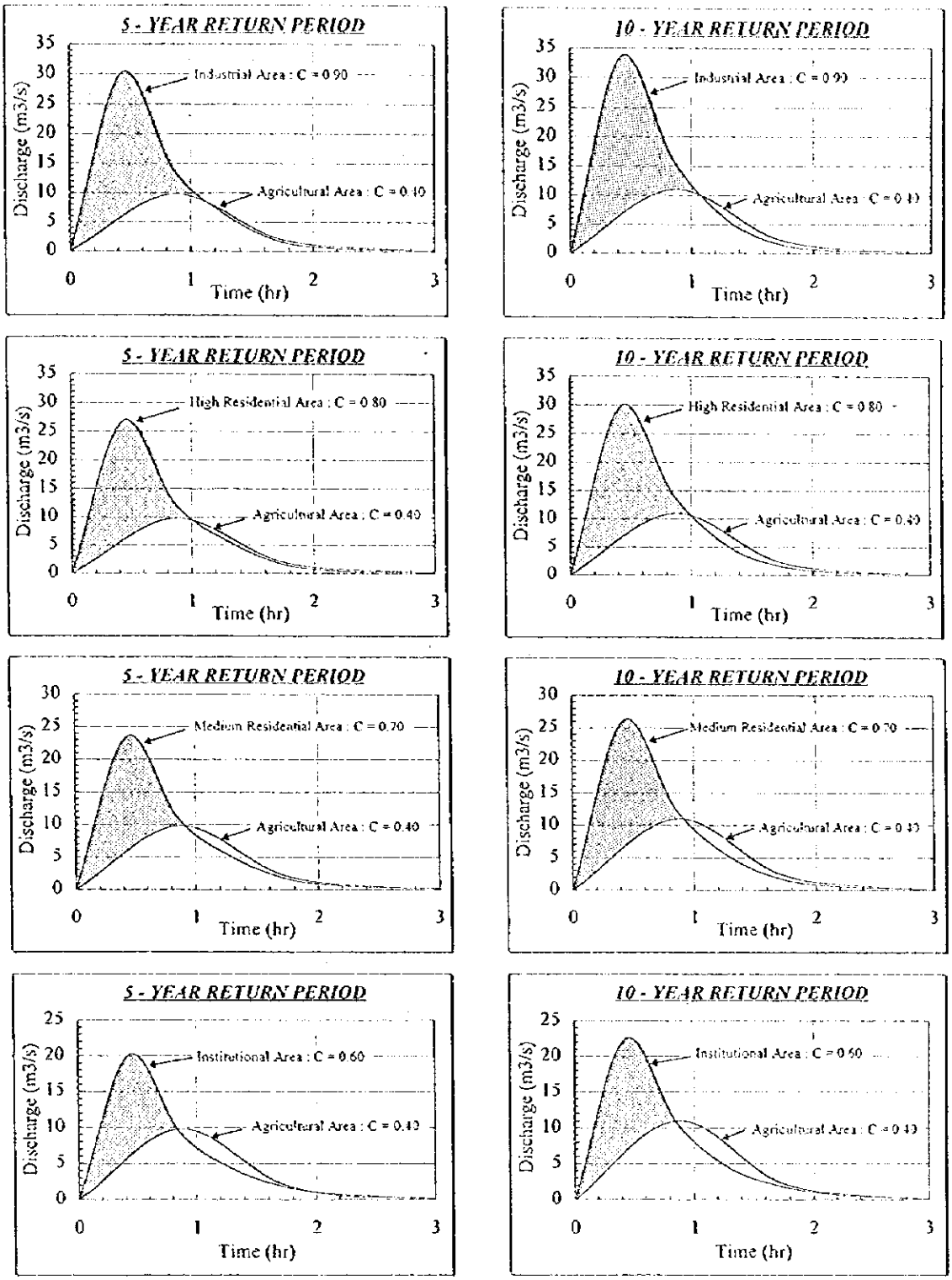


Figure C.7.7 SIMULATED STAGE AND DISCHARGE HYDROGRAPHS AT RUNOFF POINT SE.7.A ON CHIEC CANAL (10-YEAR R.P.)



Note : Flood plain storage areas have been estimated based on a 30 cm inundation depth

Figure C.9.1 FLOOD PLAIN STORAGE ALONG DAIHAN CANAL (5-YEAR R.P.)



For non-urbanized area (C = 0.40) : Time of concentration = 10 + 1.25 * 1000/(0.5*60) = 51.67 minutes.
For urbanized area (C = 0.60, 0.70, 0.80, 0.90) : Time of concentration = 5 + 1.25 * 1000/(1.0*60) = 25.83 minutes.

Required specific storage volume (m3/km2) due to urbanization.

Figure C.9.2 EFFECT OF URBANIZATION ON RUNOFF HYDROGRAPHS (A = 1.0 km2)

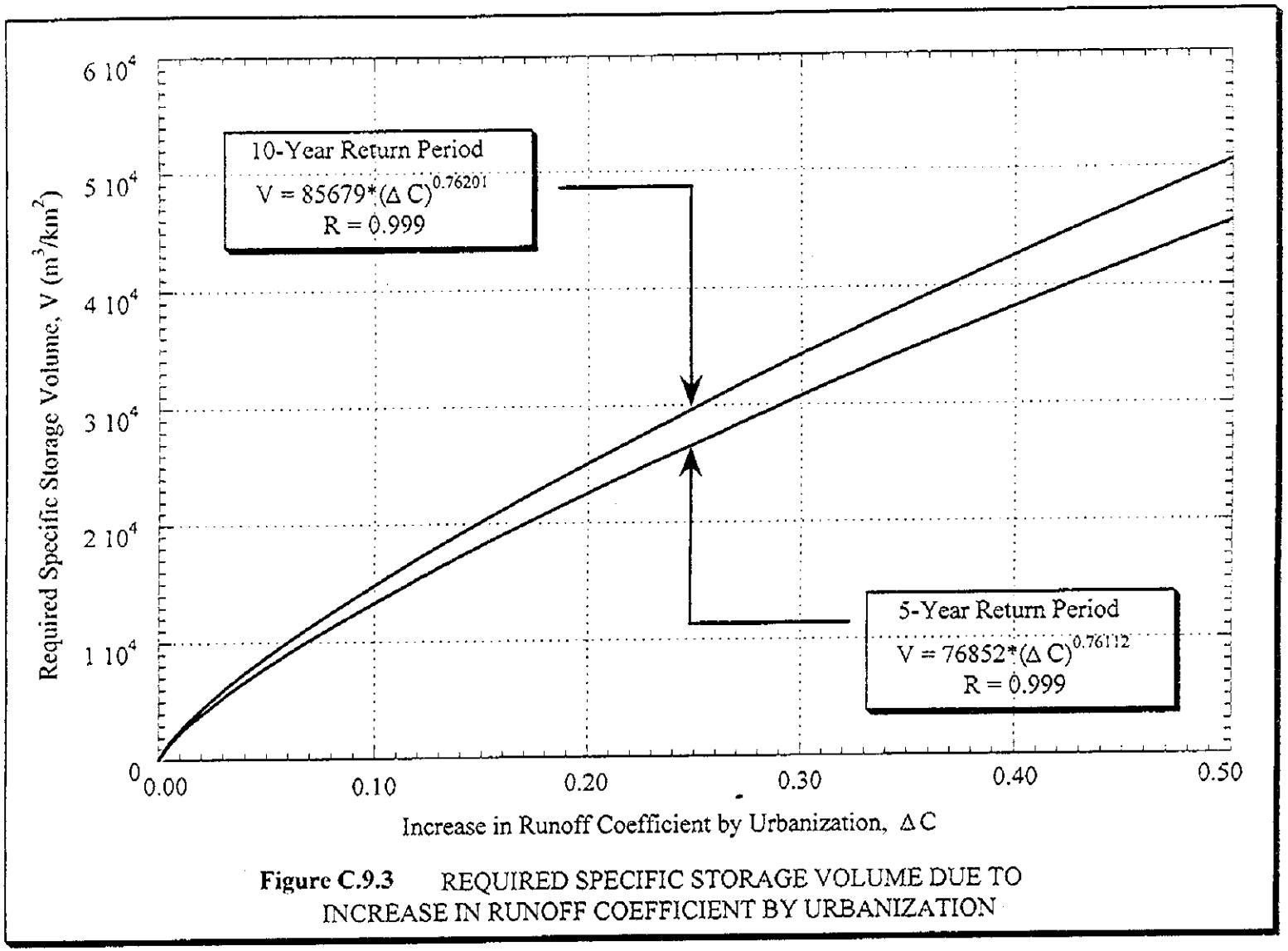
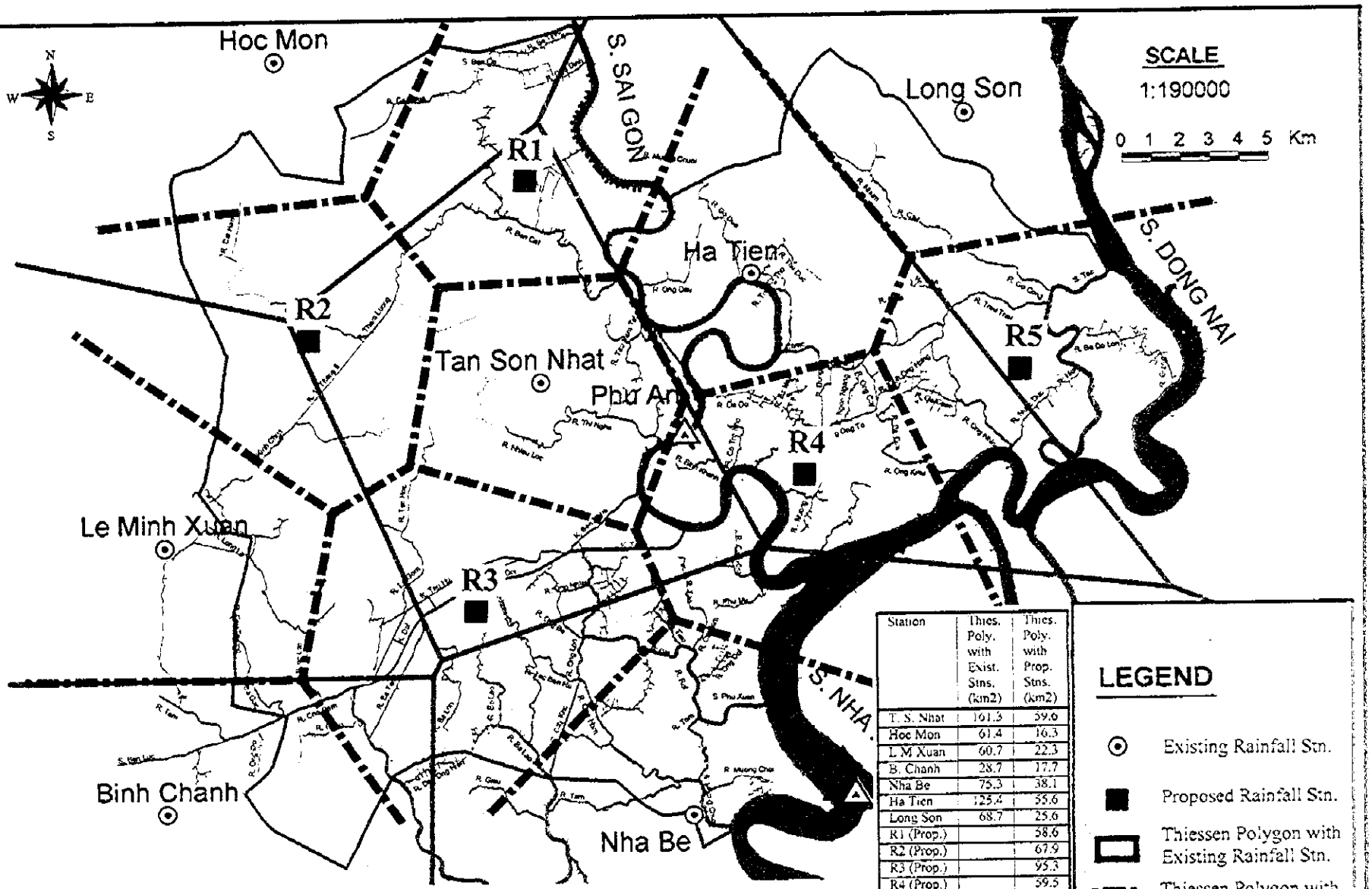


Figure C.9.3 REQUIRED SPECIFIC STORAGE VOLUME DUE TO INCREASE IN RUNOFF COEFFICIENT BY URBANIZATION



Station	Thies. Poly. with Exist. Stns. (km2)	Thies. Poly. with Prop. Stns. (km2)
T. S. Nhat	161.5	59.6
Hoc Mon	61.4	16.3
L.M.Xuan	60.7	22.3
B. Chanh	28.7	17.7
Nha Be	75.3	38.1
Ha Tien	125.4	35.6
Long Son	68.7	25.6
R1 (Prop.)		58.6
R2 (Prop.)		67.9
R3 (Prop.)		95.3
R4 (Prop.)		59.5
R5 (Prop.)		65.0
Total	581.5	581.5

Figure C.10.1 PROPOSED MONITORING NETWORK ON RAINFALL

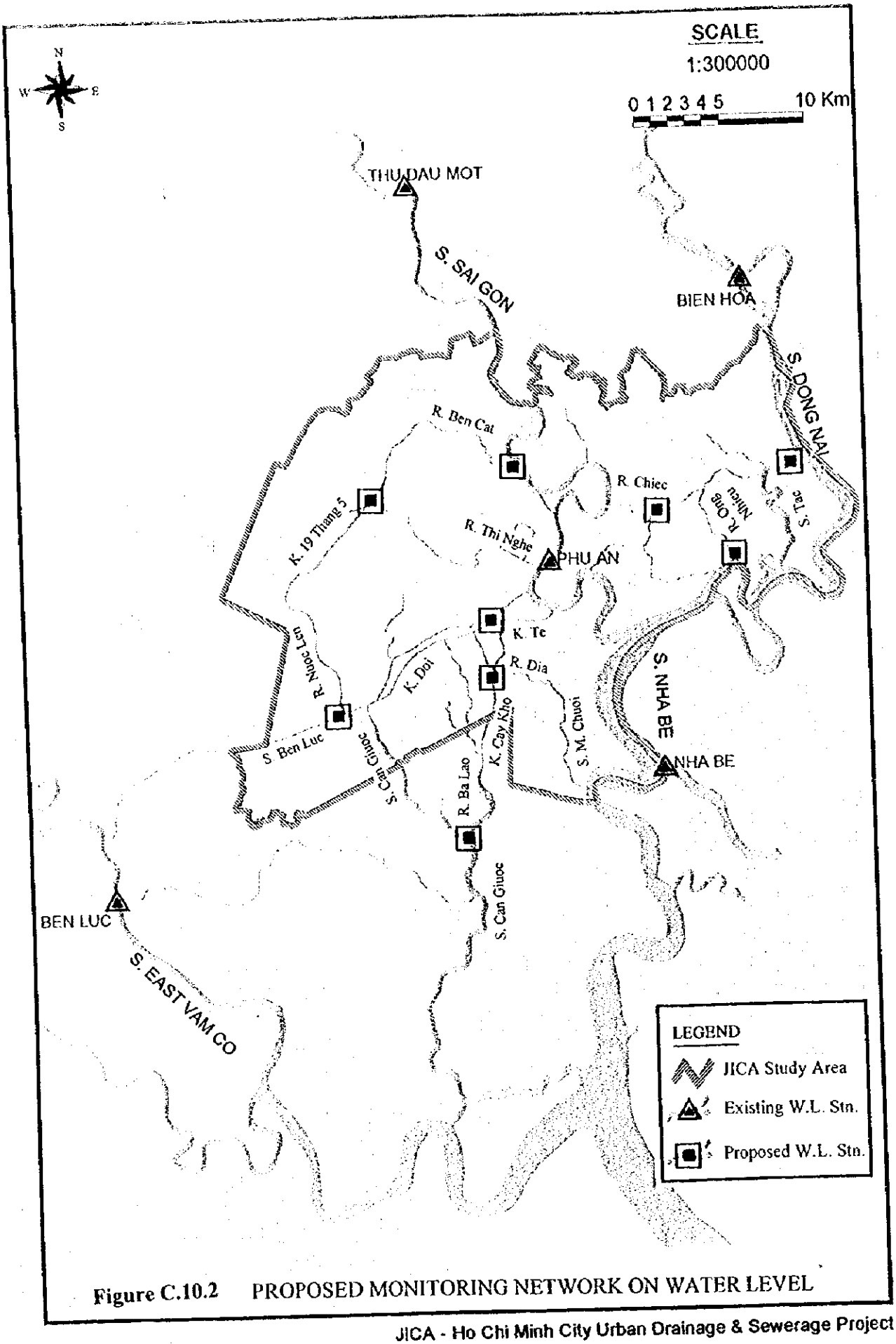


Figure C.10.2 PROPOSED MONITORING NETWORK ON WATER LEVEL

APPENDIX D
WATER QUALITY AND ENVIRONMENT

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APPENDIX D WATER QUALITY AND ENVIRONMENT

1. Rivers and Canals

1.1 Rivers

The study area is situated in the extreme north-eastern part of the Mekong Delta plain, in the downstream regions of the Saigon and Dong Nai river basins. Dong Nai, Saigon and Nha Be are the major rivers in the study area. Saigon and Dong Nai rivers join together near the city center to form the Nha Be river, which runs for about 20 km through the southern half of HCM city to the East sea.

1.1.1 Dong Nai River

Dong Nai river is the second largest river in southeren Vietnam, after the Mekong, both in terms of length and discharge. Originating in the South Central Highlands near Da Lat, the river flows for over 300 km to HCM city. The stretch of Dong Nai river which runs through the city is 25 km with a width of 500 - 800 m. Its basin covers an area of 28,000 sq km which includes nearly all of Dong Nai Province, most of Song Be and Lam Dong Provinces and large portions of Thuan Hai and Dac Lac provinces. The river is e deep, high tides penetrate far inland and the flow depends on whether it is dry or rainy season. In rainy season flow is as high as 200 m^3/s and reduces to 75 m^3/s in dry season. The port of Saigon, the biggest in Vietnam, is located on the bank of Dong Nai river, and provides access for ships of upto 30,000 tons. Dong Nai river is the main water supply source for HCM city. Water is extracted from the Dong Nai river at Hoa An and pumped a distance of 10.8 km to the Thu Duc water treatment plant.

1.1.2 Saigon River

The Saigon river extends 220 km upstream where it joins with the Dong Nai river in HCM city. Its tributaries are relatively small but numerous. The Saigon river basin covers an area of 5,400 sq km which includes HCM city and portions of Tay Ninh province and Song be province. Saigon river is the biggest river running through the city with a width of 225 m to 370 m and about 20 m deep. The section running through HCM city is about 23 km long. In rainy season flow is as high as 40 - 60 m^3/s and reduces to 10 m^3/s in dry season. The hydrology of saigon river, Dong Nai river and other canals are affected by tidal flows. The primary affect of the tides on the water quality is the increase of salinity due to mixing of fresh and salt waters. Salinity intrusion varies seasonally as well as with the tides. At high tide the specific conductivity in Saigon river is in the range of 100 - 400 ms/m. High salinity is a major concern with respect to usage of Saigon river for water supply purpose. Saigon river plays an important role in all activities of the city. It is a significant aquatic source and one of the productive means of transport. Saigon river receives the whole amount of drainage of the city flowing from canals and enter into

Nha Be river. Saigon river also receives immediately discharged water from the Ba Son Vessel building plant, Carie plant etc.

1.1.3 Nha Be River

Nha Be river starts near the city center, where Saigon and Dong Nai river join together, and runs for about 30 km through the southeren half of HCM city to the East Sea. The width of river varies from 1000 - 1500 m. HCM city drains via small streams, canals to Saigon river which in turn drains to Nha Be river. The catchment area of Nha Be river, which includes the Saigon, Dong Nai, and Vam Co river basin is about 42,000 sq km. Tributaries of Nha Be river form an extensive network of estuarine rivers that run throughout the Can Gio district, an inter-tidal mangrove and salt marsh area which comprises the southeastern third of HCM city. Nha Be river system including most of the tributaries and canals within the central city, is subject to tidal influences and salinity intrusions. Therefore Nha be river is not suitable for drinking purpose however has ecological and commercial importance as breeding area for many types of aquatic life.

1.2 Canal Network

Network of canals in the city is relatively dense. These canals are being used for draining wastewater of the study area. Total length is nearly 100 km. Major canals (about 55 km long) are listed below:

- Tan Hoa - Lo Gom Canal
- Tau Hu - Doi - Te
- Nhieu Loc - Thi Nghe
- Tham Luong - Vam That
- Ben Nghe

The water slope of most of the canals is very small. The canal beds have been filled up by settlement from discharged water and solid wastes thrown by the inhabitants living along the canals. The special feature of canal network in HCMC is that it is strongly influenced by tides and some canals are influenced from more than one direction. As a result the pollutants remain in the canals and have been accumulating. The water pollution in these canals has not only damaged the landscape, especially in accessible parts of the city but has also negatively influenced the health of people as described in the following sections.

1.2.1 Tan Hoa - Lo Gom Canal

Tan Hoa - Lo Gom canal, about 7.2 km long, runs from the North East to the West-South West through districts Tan Binh, 11, 6, 8 and ends at the Tau Hu junction. The Tan Hoa - Lo Gom catchment has an area of 1484 ha, spreading on to five districts namely Tan Binh, 11, 6, 8 and Binh Chanh. The depth of these canals was originally 6 m, which is now reduced to 3 - 4 m. The canal, receives wastewater from above mentioned districts. The

canal bed is small, shallow and is encroached by illegal squatters. The canal is influenced by tide as water level rises in Can Giuoc river. The tidal affect has been seen upto Tan Hoa bridge leaving upstream of canal stagnant by wastewater resulting in serious pollution.

1.2.2 Tau Hu - Doi - Te Canal

Tau Hu - Doi - Te canal, excavated in 1819, lies to the immediate south of the central business district of HCM city. The canal runs through 7 districts: 4, 5, 6, 7, 8, and 11. Total length of Tau Hu - Doi - Te canal is 19.5 km. The canal is limited by Can Giuoc canal and Saigon river at the two ends. The canal receive domestic and industrial wastewater from the above mentioned districts. Further direct discharge of solid waste by the inhabitants of these districts and illegal squatters has worsened the environmental conditions of these canals. This canal is influenced by tide from two directions. The water quality is discussed in the following sections.

1.2.3 Nhieu Loc - Thi Nghe Canal

Nhieu Loc - Thi Nghe Canal lies in inner City and runs through 5 district : Tan Binh, Phu nhuan, 3, 1 and Binh Thanh. This canal has catchment area of 3,324 ha , spreading on to seven districts namely : 1, 3, 10, Phu Nhuan, Tan Binh, Binh Thanh and Go Vap. This canal is also affected by semi diurnal tide from Sai Gon river. As a result a part from Kieu bridge to Sai Gon river mouth gets diluted during high tide but other part from Kieu bridge to upstream is stagnant with wastewater resulting in serious pollution. Also, velocity of stream in high tide is 0.8 - 0.9 m/s only, so canal bed is full of sediments.

1.2.4 Tham Luong - Vam Thuat Canal

Tham Luong - Vam Thuat located in the side boundary in the Northwestern and SouthEastern for the city to connect the Saigon river and Cho Dem river. The catchment consists of 5 districts : Hoc Mon. Go Vap, 12, Tan Binh and Binh Chanh. Its length is more than 14 km. Domestic and Industrial wastewater has led to the filling of canal beds, specially the middle segment of the canal is only 0.5 - 1 m. Industrial pollution is severe as more than 150 industries along this canal continuously discharge untreated wastewater.

1.2.5 Ben Nghe Canal

Ben Nghe canal is 5.9 km long and receives wastewater primarily from district 1 and 4. At this moment of study further data is requested.

2. Uses of Rivers and Canals

Most of the canals in the study area are being used as a part of drainage system. These canals receive stormwater and wastewater from the study area. Some canals are being

used for transportation also. Finally the wastewater from these canals is discharged to the Saigon river and Nha Be river. Uses of major rivers and canals in the study area are summarized in Table D.2.1.

3. Water Environment of Rivers and Canals

All the canals in study area are being used as a part of drainage system. These canals receive stormwater and wastewater generated in the study area and discharge to Saigon river and then to Nha Be river. Apart from the partial treatment of toilet wastes in septic tanks, wastewater treatment is practically absent, resulting in the discharge of untreated wastewater to canals. Consequently all the canals have been seriously polluted and pollution level in rivers is also rising to the alarming level. Since 1992, Department of Science and Technology (DOSTE) has initiated monitoring program for surface water quality which is being executed by the Sub-Institute of Water Resources Planning and Management. This monitoring program involves routine sampling weekly and analysis of water quality of surface water bodies both upstream and downstream of the city center. The monitoring station locations are as shown in Fig. D.3.1. There are very few monitoring stations in the canals. However several short-term studies have been conducted to evaluate the water quality of canals. The results have been published in "Master Plan on Urban Drainage and Sewerage System (1996)" and "Prefeasibility Studies on canals" prepared by Dept. of Transport & Public Works. Fig. D.3.2 shows status of pollution in major rivers and canals of study area.

3.1 Water Quality of Rivers

Water quality of Dong Nai river near the water supply intake at Hoa An has low pollution levels. Most of the pollutants are below the maximum limit prescribed in Standard TCVN 5942-1995. Table D.3.1 shows the range of pollutants in the Dong Nai river at Hoa An. Sometimes BOD has been found to exceed the maximum limit. Fecal coliforms and other pollutants are within the prescribed limits.

Water quality of Saigon river is deteriorating. Average BOD of Saigon river at Nha Rong was as high as 16 mg/l in the year 1997 compared with 10 mg/l in the year 1993. Fig. D.3 .3 shows change of water quality in terms of BOD since 1993.

Table D.3.2 shows water quality of Saigon river in terms of BOD5 varies from 7- 35 mg/l. The level of pollution is low at upstream, however is more polluted at Nha Rong after receiving discharges from Tau Hu - Ben Nghe canal and Doi - Te canal. Due to self-purification/dilution water quality is found to be improved at Nha Be monitoring station. Also in rainy season due to dilution water quality is improved in Saigon river.

Concentration of pollutants in Saigon river is higher than the prescribed maximum limit for domestic use, however is still acceptable for other uses. Besides organic pollution, salt intrusion also makes Saigon river unsuitable for water supply purpose. Saigon river

is also an important source of aquatic products. If organic pollution is not controlled, DO in Saigon river will be depleted further making it impossible for fish and other aquatic organisms to survive. The less tolerant migratory fish are unlikely to survive if DO is less than 4 mg/l.

Nha Be river receives discharge from Saigon river and Dong Nai river. At present monitoring station is at the starting point of Nha Be river. Table D.3.3 shows the water quality of Nha Be river at Nha Be monitoring station.

Water qualiy at Nha Be is improved compared with Saigon river. DO is increased to 7 - 7.8 mg/l. Nha Be is subjected to tidal influences and salinity intrusion and is not a suitable source for drinking water supply. However it is important to maintain low organic pollution so as to maintain ecology of the river.

3.2 Water Quality of Canals

Table D.3.4 shows water quality of major canals in the study area. Tan Hoa - Lo Gom receives untreated wastewater of district Tan Binh, 11, 6, 8 and Binh Chanh. District Tan Binh, 11 and 6. These districts have high number of industries in the study area. Hence pollution due to industrial wastewater is severe in this canal. Table shows low concentration of Hg but Pb as high as 0.3 mg/l is reported. Further Heavy metals might have been settled in the sludge and may resuspend to wastewater. Besides the untreated wastewater, solid waste is discharged directly to canals. Due to tidal influence the wastewater in the d/s of Tan Hoa - Lo Gom is diluted as water from Can Giuoc river goes into the canal but u/s of the canal is stagnant for many days in the canal. The solids in the wastewater keep on accumulating in the canal. The canal is in anaerobic phase and emanates bad smell of CH_4 and H_2S. DO is 0 mg/l and BOD varies from 50 - 400 mg/l. COD in the canal varies from 75 - 2000 mg/l. Fecal concentration is very high of the order of 1.5 E +07.

Water quality of Tau Hu - Doi - Te - Ben Nghe is also not much different from Tan Hoa - Lo Gom Canal. Besides district 1, 4, 5, 6, 7 and 8 Tau Hu canal System receives wastewater from Tan Hoa Canal system also. Fecal concentration is about 4.6 E + 07. And has led to spread of infectious diseases. The sludge at the bottom is not only a result of pollution but also adds to a continuous release of pollutants to the water and air. Organic pollutants get resuspended to the water and decomposition results in biogas and H_2S volatilization to the air causing foul odor. Further sludge accumulation is disturbing the hydraulic drainage system of the canal and if dredging of sludge is not carried out it may lead to flooding and spreading of infectious diseases.

Nhieu loc - Thi Nghe receives wastewater from district 1, Binh Thanh and Phu Nhuan. The bed of ditch is shallow. With semi diurnal tidal influence, the tide does not go fully down once it rises, so in the upper parts pollutants are received and accumulate and do not move away. Owing to this COD in the upper parts reaches as high as 1200 mg/l,

10 times higher than in the downstream where it borders with Saigon river. Upstream and downstream are only 3 km apart. Domestic wastewater is the main source of pollution for Nhieu Loc canal. Wastewater from Hospitals is another source of pollution.

Tham Luong - Vam Thuat has been severely polluted by industrial wastewater. More than 150 industries discharge untreated wastewater. DO is almost depleted in this canal. BOD varies from 100 - 200 mg/l. High concentration of Hg, Cr, and Pb in the sludge, has been also reported in the Prefeasibility report.

In short all most all the canals are polluted. In some cases water quality has been worsened by the effect of semi diurnal tide. DO is zero in all the canals making it virtually impossible for fauna to survive. Fecal contamination is severe which has already resulted in spreading of water-borne diseases such as diarrhea, typhoid, and dysentery. Sludge is under going anaerobic degradation and emanate offensive odor. The canal banks have been illegally encroached by squatters damaging the landscape of city center. Sludge has been accumulating and most of the canals have not been dredged for long time. The filling of the canals disturb the hydraulic drainage system and may cause flooding which will enhance the spread of infectious diseases. In future toxic compounds discharged to canals from untreated industrial wastewater may cause health hazards such as cancer, skin diseases etc.

3.3 Characteristics of Bed Sediments

The solids in the drainage from the study area settles at the bed of canal to form sludge. Further influence of tide has resulted wastewater to be stagnant in some reaches of canal. Hence solids have been accumulating and most of the canals have not be dredged for long time. Sludge is a source of continuous release of organic pollutants and nutrients. Anaerobic decomposition of the sludge has resulted in the foul odour along the canals. Data about bed characteristics is available only for Tau Hu canal which is shown in Table D.3.5. Although the results show low concentration of Heavy metals. But could be serious problem in future, if proper control of industrial wastewater discharge to canals is not monitored. Dredging and proper sludge treatment is necessary to improve the environment and hydrology of canals.

During this study water quality and characteristics of sludge at selected locations have been investigated for the major rivers and canals. Results are described in the section 3.5.2.

3.4 Major Sources of Pollution

Domestic, industrial and commercial are the major sources of pollution of canals. Quantity of wastewater discharged, from these sources of inner city, to the canals in the year 1995 are mentioned below in the Table D.3.6. Unit pollution load from domestic source or pollution load from each industry is not known so it is difficult to assess the

total pollution loads from these industries. The pollution from these sources is described below.

Domestic Source

Except from the partial treatment of toilet wastes in some areas of the study area, there is no treatment of wastewater. As a result sewage is one of the major source of pollution for the canals. Exact data about the domestic pollution load being discharged to canals is not available. However this aspect is further discussed in the following chapter.

Industrial Source

The main pollutant source other than from domestic wastewater is from industries. Ho Chi Minh City has roughly 28,000 industries, the vast majority of which are household industries located mainly within residential areas of the urban districts. There are about 700 medium and large scale industries, about 500 of which are located in urban districts. These industries are classified into different groups as shown below:

- State Enterprise	298
Central	120
City, Province	137
Districts	41
- Foreign-invested	288
- Stock, Ltd., Private	895
- Cooperative	70
- Other industries	117
- Private, household	27,006

Table D.3.7 shows the distribution of industries in each district and the type of industry. The data has been compiled from the information received from respective district office and "Master Plan on Sewerage and Drainage, 1996". Although data is not complete and include only comparatively large industries, concentration of industries in District 6, 11, Tan Binh and Thu Duc is clearly visible as shown in Fig. D.3.4. Few industries have any kind of treatment facilities and most discharge untreated wastewater into public sewers, canals or directly to rivers.

A survey of industrial pollution in HCMC was conducted by DOSTE in 1994 and 1996. The survey report concentrated on 85 major polluting industries in urban districts. These industries were chosen based on their size, type of production activities and knowledge of prior environmental incidents. Besides this survey, information about major polluting industries were collected from district offices. Distribution of these major polluting industries in districts is shown in Table D.3.8. The present condition of industrial wastewater in these industries is shown in Table D.3.9.

Data shows that most of the industries lack treatment facilities and only few have primary sedimentation/septic tanks. As a result untreted wastewater with not only organic impurties but also containing toxic or hazardous material is discharged into public sewers or public water bodies. Specially Tham Luong Canal, Vam Thuat Canal, Tan Hoa-Lo Gom Canal and Suoi Cai Canal are polluted by industrial wastewater. These canals smell very bad and are visibly polluted.

During the survey two severe incidence of industrial pollution were noted. In Binh Chanh district one worker was severly burned by industrial wastewater while working along the canal. In another incidence during water quality sampling blue color wastewater was seen flowing in the Suoi cai canal. At present monitoring of industrial effluent is almost absent although industrial effluent standards are existing. DOSTE is responsible for monitoring the quality of Industrial effluent being discharged to public water bodies. Serious efforts are being made to control industrial pollution of canals. In future DOSTE Plans to implement strict monitoring system with more authority to District Environmental Officer.

3.5 Water Quality Survey

To confirm the water quality and bed characteristics of rivers and canals, water quality surveys were conducted in the study area. Surveys were conducted during the period of August-December 1998.

3.5.1 Sampling Locations and Analytical Parameters

For water quality of rivers and canals, sampling was done during low tide and high tide in September (rainy season) and November (early dry season). Sampling locations were selected based on their suitability for the purppose, accessibility and the availability of the information required. Fig. D.3.5 shows the location of sampling points. Table D.3.10 shows the sampling location, sample numbers and sample types. The parameters measured and analytical method used are shown in Table D.3.11. Sample for dissolved oxygen was fixed at the site.

For bed characteristics of rivers and canals, sampling was done only once in dry season. Table D.3.12 shows the location, sample numbers and sample types. Parameters measured were Zn, Cu, Cd, Pb, Hg, R2Hg, Cr, Al, Cn, Total P, As and PCB. All the metals were analysed by Neutron Activation Technique (NAT) and X-Ray Fluorescence (XRF) and PCBs were measured by Gas Chromatography (GC). All the analysis for water quality and bed characteristics were conducted at the laboratory of Center of Water Quality and Environment.

3.5.2 Results

Water quality

In this study water quality survey was conducted in September 98 (rainy season) and November 98 (early dry season). Based on these results it is difficult to generalize water quality of rivers and canals in the two seasons as average rainfall recorded in November this year was more than the previous years. However, based on these results all the canals showed more pollution in September because of flushing of pollutants from the drainage system. The results are described in Table D.3.13 - D.3.16 and organic and fecal contamination are illustrated in Fig. D.3.6 - D.3.13.

Saigon River

Results shows that water quality of Saigon river deteriorates considerably at Tan Thuan after receiving wastewater from almost entire city. BOD varies between 30 - 75 mg/l and in rainy season at low tide BOD as high as 200 mg/l was recorded. This is e high compared with previous data available. Probably sampling was done at the intersection point of Te canal and Saigon river which contains sewage from Te canal especially during low tide. Fecal coliforms are also high compared with previous data.

Dong Nai River

Water quality of Dong Nai river at Hoa An (water supply intake) is also getting affected from the discharges of upstream basin. BOD varies between 5 - 9 mg/l. According to Vietnamese standard TCVN 5942-1995, BOD of surface water being used for domestic water supply should be less than 4 mg/l. Fecal coliforms also exceeded the limit in dry season especially during low tide.

Tan Hoa - Lo Gom Canal

Organic and fecal contamination is severe in Tan Hoa Lo Gom canal. DO is completely depleted in the canal and BOD varies from 300 - 500 mg/l. At high tide dilution takes place. Fecal coliforms are 1.5E+05-1.5E+06 MPN/100 ml exceeding the permissible concentration in the surface water. Heavy metal concentration is still below the maximum allowable concentration as prescribed in Standard TCVN 5942-1995.

Vam Thuat - Tham Luong Canal

Water Quality of the canal is improved at Vam Thuat near Saigon river, DO is recovered in the canal due to dilution especially during high tide but DO is less than 4 mg/l at Cho Cau bridge and Ben Phan Bridge. BOD varies between 80 - 180 mg/l. Fecal coliforms vary between 1.5E+04-2.1E+06 MPN/100 ml. Heavy metal concentration is still below the maximum allowable concentration as prescribed in Standard TCVN 5942-1995.

Nhieu Loc - Thi Nghe Canal

DO at Cong Ly bridge is almost 0 mg/l and BOD is 120 - 210 mg/l but water quality is slightly improved at the BA Son bridge near Saigon river. During high tide at Ba Son bridge DO is about 6 mg/l and BOD is less than 20 mg/l. Fecal coliforms at Cong Ly bridge, during low tide in dry season are 1.5E+05 MPN/100 ml. Heavy metal concentration is still below the maximum allowable concentration as prescribed in Standard TCVN 5942-1995.

Tau Hu - Doi - Te Canal

Tau Hu at Y bridge is more polluted than Te at Tan Tuan due to intrusion of water from Saigon river during high tide which helps in diluting the canal water at Tan Tuan. DO varies between 0 - 4 mg/l and BOD between 100 - 250 mg/l. Fecal coliforms vary between 1.5 E+04-5.7 E+05 MPN/100 ml. At high tide due to dilution water quality is improved. Heavy metal concentration is still below the maximum allowable concentration as prescribed in Standard TCVN 5942-1995.

Ben Nghe Canal

DO is less than 4 mg/l and BOD is between 50 - 150 mg/l. Fecal coliforms are more than the prescribed limits however heavy metal concentration is still below the maximum allowable concentration as prescribed in Standard TCVN 5942-1995.

Other Canals

Ong Lon, Vinh Binh, Nuoc Len, Ben Luc and Suoi Cai canals are also polluted with most of them having DO less than 4 mg/l and BOD more than 100 mg/l.

Characteristics of Bed Sediments

In this study heavy metal content of the sediments were analyzed in the laboratory. Table D.3.17 - D.3.18 shows the concentration of heavy metals in the dried sludge in the rivers and canals. Although sampling was done only once but the results clearly show that all most all the canals contain considerably high concentrations of these metals. Tham Luong Vam Thuat canal has Hg as high as 12.56 mg/kg. Tan Hoa Lo Gom canal has 179 mg/kg of Pb and 336 mg/kg of Cr in the sediments. Nhieu Loc Thi Nghe has 2.21 mg/kg of Hg, 210 mg/kg of Cu and 2307 mg/kg of Zn in the sediments. Ong lon canal has 4.32 mg/kg of Cd and Ben Luc canal has 7182 mg/kg of Zn in the sediments.

Table D.3.19 shows regulation standards for heavy metals in the sediments to be used on land or to be used for agricultural purpose. Netherlands heavy metal limits are the most stringent and sediments of most of the canals can not be used on land. Tham Luong Vam Thuat and Nhieu loc Thi Nghe can not pass Japanese standards for Hg. It can be concluded that industrial wastewater is severely polluting the sediments in the canals and

industrial effluent standards should be strictly enforced. Further it is time now to set standards in Vietnam for the heavy metals in the sludge to be disposed on the land.

4. Ground Water Quality

Besides rivers, Groundwater is the main water source for domestic and industrial purpose. Groundwater is extracted from both shallow and deeper aquifers throughout the HCM city. Table D.4.1 shows number of ground wells managed by Dept. of Industry and their withdrawl capacity in each district. Table D.4.2 summarizes the details of these ground water wells. Outside the urban center groundwater is the primary source of drinking water supply, particularly in the northern half of the city, which includes Thu Duc, Go Vap, Tan Binh, Hoc Mon and Binh Chanh. Table D.4.3 shows groundwater quality. Only limited parameters are analysed for groundwater quality. High acidity is the major problem in these wells. High salinity is also reported in some groundwater wells of District 8 and Thu Duc. Iron content is more than permissible value for all the wells in district 7 and some wells of district 8, 11 and Tan Binh. Concentration of nitrate is higher in some wells of district 9. Although Fecal contamination is not measured. But problem of fecal pollution in Plesistocen aquifers (less than 10 m deep) has been reported.

5. Public Health Conditions

There is practically no treatment of wastewater in the Ho Chi Minh City and untreated wastewater is discharged into canals. As already mentioned in the previous sections, all the canals are severly polluted and many slum setteled along the canals are using this polluted water for many purposes. These unhygenic conditions have led to break down of many water borne diseases. Mater plan on Sewerage and Drainage (1996) has reported some major causes of water-borne diseases which are listed below:

- poor sanitary conditions
- high population density
- insufficient water source
- poor water quality of groundwater
- unawareness of imporatance of sanitary conditions
- low income

Table D.5.1 shows that District 8, 6 and 5 which are along the canals Tau Hu-Ben Nghe, Doi-Te and Lo Gom have much higher incidences of water borne diseases. In the year 1997, there were about 1427 cases of water borne diseses only in district 8, which is almost 3 times compared with other districts. The deteriorating water environment has increased the cases of water borne diseases in the past years. There is no clear trend available since 1993, but overall cases of water borne diseases in 1997 are more than 1.8 times that of in 1993. Table D.5.2 shows the relation between population density and water-borne cases. Although overall density of district 8 is shown as only 185 but actually it is as high as 800-1000 for the wards 10, 11, 12 along the canal.

Table D.5.3 shows breakdown of major water-borne diseases since 1993. Diarrhoea and Dysentry are the major waterborne diseases prevalent in the study area. In the year 1997, 73.26 cases/100,000 of Diarrhoea were reported in the study area.

6. Laws, Regulations and Standards on Water Pollution Control

Table D.6.1 shows the laws, regulations and standards related to environmental protection. Among these, Law on Environmental Protection (1993), Water Quality Standards and Effluent Standards are directly related to this study and are discussed below in detail.

6.1 Law on Environmental Protection

This Law requires EIA report for new activities/projects affecting the Environment be submitted to National Environmental Agency (NEA) for appraisal. According to this law the Department of science, Technology and Environment (DOSTE) shall be responsible to the people's committees of provinces and cities directly under the Central Government, for environmental protection in their localities. Organizations, individuals engaged in production, business and other activities that cause environmental degradation, environmental pollution, environmental incidents must implement remedial measures as specified by the local people's committees and by the NEA for environmental protection and shall be liable for damages according to regulations by the law.

6.2 Water Quality Standards

Water Quality Standards are established to control the quality of surface water, coastal water and ground water. The objectives of these standards are protection of human health and conservation of the living environment. In TCVN 5942 - 1995 Surface water sources are classified into two categories; surface water being used for domestic water supply and surface water being used for the purpose other than domestic water supply. Table D.6.2 describes various parameters and their maximum allowable concentrations in surface water. In TCVN 5943 - 1995 Coastal water source being used for bathing and recreation are differentiated from the one being used for aquatic cultivation. Table D.6.3 describes various parameters and their maximum allowable concentrations in coastal water. TCVN 5944 - 1995 specifies parameter and their maximum allowable concentrations in Ground water as shown in Table D.6.4.

6.3 Effluent Standards (TCVN 5945 - 1995)

TCVN 5945 - 1995 standard is applied to control the quality of industrial wastewater before being discharged to water body. Water body means; inland water, include any reservoir, pond, lake, river, stream, canal, drain, spring, or well, any part of the sea abutting on the foreshore, and any other body of natural or artificial surface or subsurface water. This standard specifies the parameters and their maximum allowable

concentration in the Industrial wastewater as shown in Table D.6.5. More stringent limits are imposed in case industrial effluent is to be discharged to water bodies being used for domestic water supply as shown in column A of Table D.6.5. Industrial wastewater having concentration of pollutants more than those described in column C can not be discharged to water bodies.

7. Status of Fauna and Flora in the Study Area

This section describes the present status of fauna and flora in the Study Area. The data and information ware mainly collected through the review of existing materials and field sampling. Field survey was carried out between October 1998 and December 1998.

7.1 Aquatic Fauna

The Study Area locates in an urban area of HCM city, which is surrounded by the Sai Gon - Dong Nai river system with an intensive canal network throuhout the area. The water system of the Study Area has a strong influence of the East Sea through the estuary of Long Tau and Soai Rap rivers with a semi tidal regime. In this area with frequent floodings, various forms of aquatic environment has been created such as rivers, swamps, ponds and flooded fields with every gradation of salinity level. This heterogeneous aquatic environment accommodates diverse aquatic creatures.

7.1.1 Phytoplankton, Zooplankton and Zoobenthos

The distribution of aquatic creature is greatly influenced by the water quality of the habitat area. The composition and quantity of river water plankton show a considerable change following the seasonal fluctuation of salinity level of the tidal rivers. Fig. D.7.1 shows the classification of river and canal system in the Study Area in terms of salinity and pH level. Fig. D.7.2 shows the dominant plankton species of each types of water environment. Fig. D.7.3 shows the zoning of water environment in the Study Area. The distributions of dominant species of phytoplankton, zooplankton and zoobenthos are shown in Fig. D.7.4, D.7.5, and D.7.6, respectively.

Apart form the seasonal change, it is important to monitor the species composition trend with a long-team observation. The relationship between river/canal water pollution and aquatic ecology can be analyzed from the long-term research.

According to the data in the rainy season of 1989, *Schmackeria bulbosa* (Pseudodiaptomidae - Copepoda) was a dominant zooplankton species for the large area from Ban Nong creek, Tra creek, Saigon River, to Lang The canal. In 1997 and 1998, however, the species was not recorded in any of 4 samplings carried out in the same season. In contrast, the density of zooplankton as *Bosmina longirostris, Thermocyclops hyalinus,* and *Nauplius copepoda* was only 34 - 187 idv./m^3 in the rainy season of 1989, but has increased up to 2,669 - 35,870 idv./m^3 by 1998. The species composition has

changed from the large Copepoda dominance to Rotatoria, Cladocera, and small Copepoda community. It indicates that the water has been more polluted by organic matters. As for the phytoplanktons, the density is lower in the water area with higher SS and turbidity level, where the light resource is limited.

7.1.2 Fish

Fish population found in the Study Area is composed of 178 species in 15 orders, 42 families, 97 genus including some species registered as rare in the Red Book of Vietnam* (1992) (Table D.7.1)

Besides local species, various fishes had been introduced from diverse sources. Especially, carps, tilapias, and other edible fishes from other countries are important source of income for local fishermen.

7.2 Aquatic flora

The aquatic vegetation is often found at low areas in valleys of the Dong Nai River, along watercourses, irrigation canals, and dead river arms. The aquatic vegetation type varies depending on the salinity level of the water body and the degree of tidal influence in the area. The distribution of natural vegetation types is shown in the Fig. D.7.7. The representative aquatic vegetation type in the Study Area is summarized as follows.

7.2.1 Blackish Water Zone

(1) The Nypa - Sonneratia Type

This vegetation type is often observed along blackish water rivers and canals with 5 to 15 % of salinity level. The dominant species of this vegetation are nipa palm (*Nypa fruticans*) and marsh fern (*Acrostichum aureum*).

(2) The Sonneraria - Dolichandrone Type

The vegetation is found in the transitional zone of blackish and fresh water. The dominant species are *Sonneratia caseola, Dolichandrone spathacea*, and *Acrostichum aureum.*

(3) The Cyperus Type

Deserted rice fields affected by half-daily tide regime are often taken over with this type of vegetation. The dominant specie are chinese mat-grass (*Cyperus malaccensis*), and readmace (*Typha angustifolia*).

* A data book that lists rare and endangered species and their distribution in the nation.

7.2.2 Freshwater Zone

(1) The Barringtonia - Horsfieldia Type

This type of vegetation is often found in the freshwater zone with the salinity level less than 1 %, especially in Hoc Mon and Thu Duc area. The upper stratum is mainly consists of Barringtonia (*Barringtonia racemosa*), *Horsefiedia irya*, and *Alexandrian laurel* (Calophyllum inophyllum), and the lower stratum of *Lasia spinosa, Cryptocoryne ciliata,* and *Derris trifolia.*

(2) The Floating Vegetation

Dominant species of wild rice (*Oryza rufipogon*), water morning glory (*Ipomoea aquatica*) create floating blanket along the water ridge.

7.2.3 Sulfate Acid Water Zone

(1) The Eleocharis Dulcis Type

The soil becomes very acidic after exploited for rice cultivation. The abandoned rice field with sulfate acid soil is often taken over by *Eleocharis dulcis*, which make vegetation with low species variety.

(2) The Melaleuca Cajeputi Type

This type of vegetation is distributed along the An Ha canal that flows through sulfate acid soil areas of Binh Chanh and Hoc Mon districts. Bottle brush (*Melaleuca cajeputi*) forms both high and low strata with other species such as *Scleria poaeformis, Stenochlaena palustris, Phragmites karka,* and *Morinda citrifolia.*

7.3 Terrestrial Fauna

7.3.1 Amphibian and Reptile

9 amphibian and 27 reptile species have been recorded within HCM city. It is especially scarce to observe these animals in the urban area of the City, where there is no ample habitat for them. Therefore, the species composition of amphibian and reptile in the Study Area is not very diverse, and the distribution is limited to parks, gardens, and pagodas with vegetation. Nonetheless, 9 reptile species found in the Study Area are among those registered as rare in the Red Book of Vietnam (1992) (Table D.7.2)

7.3.2 Bird

Either Passeriformes or aquatic bird species depending on the vegetation types characterizes the bird fauna in the Study Area. In the biomes of rice field, sparrows and waterfowls are dominant bird species. In the area of vegetation type represented by Eucalyptus, bamboo, and banana, four species of egrets (*Egretta alba, E. Intermedia, E. garzetta, Bubulcus ibis*) and herons (*Ardeola speciosa, A. bacchus*) are commonly observed in large colonies. The bird fauna in the Study Area inhabits mostly in the secondary natural environment, which is managed and maintained by human activities.

The changes in human life style and land use are consequently affecting the composition of bird fauna in the Study Area. For example, the dominant species has been changing from Passeriformes to Sylviidae as the rice fields are abandoned in the suburban area of the city.

7.3.3 Mammal

21 species of mammals belonging to 9 families, 5 orders are recorded in the suburban area of the city - Thu Duc, Hoc Mon, Binh Chanh, Nha Be districts. Most of the mammalian species observed in the Study Area are small animals as bats and rats (Table D.7.3)

7.4 Terrestrial Flora

7.4.1 Natural Vegetation

Originally the vegetation of the Study Area belongs to the tropical humid forests typical in the southeast Vietnam. The local topographic and climatic conditions have created distinct forest ecosystems. However, the latest urbanization and rapid changes in land use have restricted the distribution of natural forest in the area. The trace of natural vegetation describes the natural environment of the previous ages.

The representative natural ecosystem in the area is the monsoon tropical humid forest formation. The forest consist of evergreen and/or semi-deciduous trees including *Dipterocarpaceae - Fabaceae - Eleocarpaceae - Tiliacaea - Lythraceae* species. This type of forest formation had been found previously in the districts of Cu Chi, Thu Duc, and in some parts of existing urban area.

The other type of typical forest ecosystem is formulated on the sulfate acid soil. At present, only a remaining trace of *Mecaleuca* forests is observed on the natural sulfate acid soil surface in the districts of Cu Chi, Binh Chanh, Hoc Mon, and Nha Be.

Furthermore, the mangrove formation is also a common forest ecosystem in the Southeastern Vietnam. In HCM city, however, the coverage of natural mangrove forests has been decreased due to the human activities such as cultivation and water culture of shrimps.

The distribution of natural vegetation types is shown in Fig. D.7.7.

7.4.2 Planted Vegetation

(1) Suburban Area

In the suburban area of Can Gio and Cu Chi District, there are 4,019 km^2 of planted forests and 800 km^2 of orchards. The dominant tree structure of a typical forest in the suburban area is described in Table D.7.4.

There is no natural vegetation remained in this area because of various human impacts. The substitutive community of the green area is represented by the species listed in Table D.7.5. These dominant species constitute the canopy of low shrub vegetation with the height of 3 - 4 m's.

As for the herbaceous community, monocots represented by *Iperata cyclindrica* dominate savannas on gray soils.

(2) Urban Area

Of the total city area of 2,086 km^2, 6.7 % (cr. 140 km^2) has been developed as urban area. This area constitutes of 12 districts holding more than 70 % of total population of the city. Therefore, the human impact on the vegetation in this area is considerably high, and the distribution of green area is mostly limited to parks and roadside trees. The distribution of different types of green area is summarized in Table D.7.6.

There are 15 parks with 23,108 tree individuals and roadside green area comprised of 26,062 individuals within the urbanized area of the city.

The roadside trees are mainly distributed in the districts of 1, 3, 5, 10 and Tan Binh.

The dominant canopy species above 6 m in height are listed on Table D.7.7.

The roadside trees in urban area have the following functions: 1) to shade the ground surface from sun light, 2) to absorb traffic noise, 3) to absorb CO_2 in the emission gas and supply Oxygen, 4) to provide habitats for local fauna, 5) to cool down the air temperature by transpiration, 6) to create comfortable landscape for citizens, 7) to prevent the dust from scattering, 8) to prevent strong wind, 9) to mitigate damages in traffic accident. Since it is difficult to secure green area in urbanized zone, roadside plantation is a valuable component for the improvement of urban environment.

In the newly developed urban area, which includes the districts of 2, 7, 9, 12, and Thu Duc, the roadside green area is consist of 19,404 individual trees in 132 streets (267.43 km in total length). However, most of tall old trees in this area have been lumbered due to the rapid urbanization of the districts. At the moment, in the newly

developed urban area, there remain only 8 trees with diameter above 70 cm. The dominant species in the area are shown in Table D.7.8. The most dominant trees (*Acacia auriculaeformis, Terminalia catappa, and Eucalyptus camaldulensis*) are fast growing species adapted to arid climate.

The planted tree composition in the urban area of HCM city is relatively diverse as for the species variety, but the density of the plantation is not high. The average distance between two individual trees is 47.03 m in the planted road within the newly developed districts.

7.4.3 Agricultural Ecosystem

Agricultural land has the significance not only in food production but also in its function of landscape conservation, water retention and prevention of natural disasters, and ecological conservation. In the Study Area, however, farmland is reducing its size in the recent years due to the expansion of urban area. Among the City districts, the suburban area such as Thu Duc, Binh Chanh, Hoc Mon, and Nha Be still hold relatively large cultivation lands which provide substantial nutrients for City dwellers. Among these agricultural lands in the City, majority, is used for rice cultivation. Fruit production is also prospering in this region and variety of species as rambuttan, durian, mangosteen, pomelo, longan, mango, and coconut are widely cultivated. Apart from the industrial cultivation, typical households in the suburban area have gardens in their property land where they grow flowers, fruits and spice-herbs for additional income. The actual land use for representative crops is shown in Fig. D.7.8

8. Initial Environmental Examination (IEE)

At Master Plan Stage, Initial Environmental Examination (IEE) was conducted for the priority project to identify major environmental issues, which could be of concern. Initial Environmental Examination for various environmental aspects is described in Table. D. 8.1. The items which need to be assessed in detail are identified in the above mentioned Table and TOR for EIA has been prepared.

9. Terms of Reference for EIA Survey for Tau Hu Ben Nghe Doi Te Project

9.1 Introduction

The Terms of Reference shall be applied to the Environmental Impact Assessment (EIA) for the Project on Urban Drainage and Sewerage System for Tau Hu-Ben-Nghe-Doi-Te Basin.

9.2 Background

9.2.1 Objectives of the Study

An environmental impact assessment survey shall be carried out in accordance with legal requirements of the Socialist Republic of Vietnam and Ho Chi Minh Municipality. The objectives of the survey are:

i) To identify project activities, particularly those which may have significant impact on the environment;

ii) To describe the existing environmental setting, particularly those features which may experience impact;

iii) To predict and evaluate the significant environmental impact whether negative and positive; and

iv) To provide countermeasures and recommendations to be taken for environmental management and monitoring

9.2.2 Project Area

Project area is shown in the Fig. D.3.2. Project involves improvement of Tau Hu Ben Nghe canal. Total length of 14 km will be improved in two phases. Sediments at the bottom will be dredged to increase the conveyance capacity and embankment will be constructed to improve the city environment.

Pump drainage system at Thanda consists of construction of storage tank with the capacity of 7,695 m^3 and installation of pumps with capacity of 0.32 m^3/s. Ben Me Coc (1) pump drainage system will have storage tank of 20,900 m^3 initially which will be upgraded to 36,100 m^3 in phase II. Similarly initial pumps with the capacity of 0.68 m^3/s will be upgraded to 1.49 m^3/s. Ben me Coc (2) pump drainage system consists of construction of storage tank with the capacity of 23,500 m^3 and installation of pumps with the capacity of 0.97 m^3/s.

Interceptor sewer of about 5.5 km length and 700 - 1500 mm of dia will be constructed in Phase I and remaining 30 km of Interceptor sewer will be constructed in phase II. Conveyance sewer with dia of 1500 - 2500 mm and length of 5.4 km will be constructed in phase I. Lift pumping station with the capacity of 147 m^3/min will be installed in phase I and will be upgraded to 533 m^3/min in phase II. Wastewater Treatment plant with modified aeration process having capacity of 141,000 m^3/d is proposed for phase I which will be upgraded to conventional activated sludge process having capacity of 512,000 m^3/d in phase II.