7.6.5 Saigon West (SW) Sewerage Zone

(1) General

The SW zone covers an area of 1,315 ha in District 12 consisting of 7 wards. This zone is enclosed by Tham Luong canal to the east, boundary of District 12 to the south and west and provincial Rd. No. 16 to the north. The existing population in this sewerage zone is 97,782 with an average population density of all wards of 42persons/ha, which ranges from 19 person/ha in Ward Tan Chanh Hiep to 76 person/ha in Ward Dong Hung Thuan.

The existing land use pattern in this zone is summarized as follows.

(a) Agricultural area and other areas still occupy about 60 % of this zone.
(b) Residential area is now being developed.

Based on the future land use plan, all agricultural area will be converted into the residential, commercial and institutional areas. The existing and future land use of this zone are compared below.

Land use	Existing	Future (2020)
Residential area including commercial and institutional areas	531 ha	1,186 ha
Industrial area	23 ha	0 ha
Green area	0 ha	0 ha
Agricultural area	626 ha	0 ha
Others	135 ha	129 ha
Total	1,315 ha	1,315 ha

Future residential area including commercial and institutional areas of 1,186 ha will be covered by sewerage system. The projected future population in the year 2020 is 398,000 with an average net population density of 336 person/ha.

(2) Collection System

The separate sewer system is proposed to collect wastewater of SW sewerage development zone. Main sewer is proposed along National Rd. No. 1 and Provincial Rd. 22. Two (2) pumping stations are proposed to convey wastewater to the treatment plant. The capacity of two (2) pumping stations are 32 m^3/min and 54 m^3/min. The location of main sewer and two (2) pumping stations are shown in Fig. 7.14. Proposed collection sewer length is presented in Table 7.5. The collection system of SW sewerage zone is summarized as follows:

Type of Collection system	Separate System
Service Area (ha)	1,186
Service population in 2020	398,000
Population Density (per./ha)	336
Sewer (m)	
Secondary & tertiary	63,120
Main	143,066
Conveyance	2,899
Total	209,085

(3) Treatment Plant

Green space enclosing May 19 canal and provincial Rd. 13 and Tan Ky Tan Cuy Rd. is proposed as the location of the treatment plant for SW sewerage zone. Conventional activated sludge system with a capacity of 111,000 m^3/day is proposed. The required area for the treatment plant including wastewater treatment, sludge treatment and other auxiliary facility is about 11 ha.

The treated effluent is proposed to be discharged to May 19 canal. Layout of treatment plant is shown in Fig. 7.15.

7.6.6 Saigon South (SS) Sewerage Zone

(1) General

Saigon South zone covers the future developed residential area of District 7 consisting of 11 wards. This zone is bordered by Te canal to the north, Ong Lon river to the west, Phu Xuan river to the south and provincial Rd. 15 and boundary of residential area development to the east. This zone covers an area of 1,555 ha with an existing population of 80,960. The average population density of all wards covered by this zone is 43 person/ha with ranging from 5 person/ha in Ward Tan Phong to 137 person/ha in Ward Tan Qui.

The existing land use pattern in this zone is summarized as follows.

(a) Agricultural area and other areas still occupy more than 83% of this zone.
(b) Residential area is developed along Te canal and provincial Rd. 15.

Based on the future land use plan, all agricultural area will be converted to the residential, commercial and institutional areas. And green space will also be developed. The existing and future land use of this zone are compared below.

Land use	Existing	Future (2020)
Residential area including commercial and institutional areas	254 ha	1,162 ha
Industrial area	7 ha	0 ha
Green area	0 ha	131 ha
Agricultural area	1,201 ha	0 ha
Others	93 ha	262 ha
Total	1,555 ha	1,555 ha

Future residential area including commercial and institutional areas of 1,162 ha will be covered by sewerage system. The projected future population in the year 2020 is 320,000 with an average net population density of 275 person/ha.

(1) Collection System

No combined sewer has been developed in SS sewerage zone. The separate system is proposed to collect wastewater of this zone. Main sewer is proposed along Te canal, provincial Roads 15 and 34 and communal Rd. 1. Diameter of main sewer ranges from 600 mm to 1,100 mm with a total length of 165 km. Pumping station at the crossing communal Rd. 1 and Thay Tieu canal, and along Provincial Rd. 15 in Ward Phu Thuan with a capacity of 26 m^3/min. and 43 m^3/min. are proposed. The location of main sewer and pumping station are shown in Fig. 7.16.

Details of proposed collection system are presented in Table 7.5 and summary summary of collection system are mentioned below.

Type of Collection System	Separate System
Service Area (ha)	1,162
Service population in 2020	320,000
Population Density (per./ha)	275
Sewer (m)	
Secondary & tertiary	71,424
Main	165,168
Conveyance	0
Total	236,592

(2) Treatment Plant

Green space enclosed by Dia and Roi rivers in Ward Phuoc Kien of District Nha Be is proposed as the location of the treatment plant for SS sewerage zone. Conventional activated sludge system with a capacity of 89,000 m^3/day is

proposed. The required area for the treatment plant including wastewater treatment, sludge treatment and other auxiliary facility is about 8 ha.

The treated effluent is proposed to be discharged into Dia river. Layout of treatment plant is shown in Fig. 7.17.

7.6.7 Saigon North I (SN-I) Sewerage Zone

(1) General

Saigon North I (SN-I) sewerage zone covers an area of 2,324 ha in District Thu Duc consisting of 12 wards. This zone is enclosed by National Road Hanoi to the east, boundary of the industrial area to the north and green belt along Saigon river to the west and south. The existing population in this sewerage zone is 171,165 with an average population density of 74 person/ha.

The existing land use pattern in this zone is summarized as follows.

(a) Agricultural area occupies about 70 % of this zone.
(b) Residential area is developed in the hilly area and also areas along the main roads.

Based on the future land use plan, all agricultural area will be converted to the residential, commercial and institutional areas. The existing and future land use of this zone are compared below.

Land use	Existing	Future (2020)
Residential area including commercial and institutional areas	642 ha	1,968 ha
Industrial area	56 ha	0 ha
Green area	0 ha	10 ha
Agricultural area	1,624 ha	3 ha
Others	2 ha	343 ha
Total	2,324 ha	2,324 ha

Future residential area including commercial and institutional areas of 1,968 ha will be covered by sewerage system. The projected future population in the year 2020 is 500,000 with an average net population density of 254 person/ha.

(2) Collection System

The separate sewerage system is proposed to collect wastewater of SN-I zone. Main sewer is proposed along main roads of Quoc Lo 13, Kha Van Can, To Ngoc

Van and Vo Van Ngan. Three (3) pumping stations along Quoc Lo 13, Kha Van Can and the junction of Kah Van Can and To Ngoc Van are required to lift up wastewater to the treatment plant. The capacity of three (3) pumping station are 14 m^3/min., 41 m^3/min. and 68 m^3/min. The location of three (3) pumping stations and the location of the main sewer are shown in Fig. 7.18.

Length of proposed collection system is presented in Table 7.5. The collection system of SN-I zone is summarized below.

Type of Collection System	Separate System
Service Area (ha)	1,968
Service population in 2020	500,000
Population Density (per./ha)	254
Sewer (m)	
Secondary & tertiary	101,472
Main	234,654
Total	336,126

(3) Treatment Plant

Green space enclosed by Dao canal and National Rd. Hanoi is proposed as the location of the treatment plant for SN-I sewerage zone. Conventional activated sludge system with a capacity of 139,000 m^3/day is proposed. The required area for the treatment plant including wastewater treatment, sludge treatment and other auxiliary facility is about 10 ha.

The treated effluent is proposed to be discharged to Dao canal. Layout of treatment plant is shown in Fig. 7.19.

7.6.8 Saigon North II (SN-II) Sewerage Zone

(1) General

Saigon North II zone covers an area of 1,152 ha in District 9 with 8 wards. This zone is enclosed by the National road Hanoi to the west, Chiec and Dong Nhien canals to the south, Kinh Ong Hong and Dinh canals to the east and Cau canal to the north. The existing population of this SN-II sewerage zone is 63,410 with an average population density of 55 person/ha.

The existing land use pattern in this zone is summarized as follow.

(a) Agricultural area occupies more than 60 % of this zone.
(b) Residential area is developed only along the main roads.

Based on the future land use plan, all agricultural area will be converted to the residential, commercial and institutional areas. The existing and future land use of this zone are compared as shown below.

Land use	Existing	Future (2020)
Residential area including commercial and institutional areas	372 ha	1,027 ha
Industrial area	37 ha	0 ha
Green area	0 ha	0 ha
Agricultural area	741 ha	0 ha
Others	2 ha	125 ha
Total	1,152 ha	1,152 ha

Future residential area including commercial and institutional areas of 1,027 ha will be covered by sewerage system. The projected future population in the year 2020 is 196,500 with an average net population density of 191 person/ha.

(2) Collection System

The separate sewerage system is proposed to collect wastewater of SN-II zone. Main sewer is proposed along main roads. Two (2) pumping stations are proposed to transfer wastewater to the treatment plant. The capacity of two (2) pumping stations are 16 m^3/min. and 27 m^3/min. The location of two (2) pumping stations and main sewer are shown in Fig..7.20. Length of proposed collection system is presented in Table 7.5. The collection system of SN-II zone is summarized below.

Type of Collection System	Separate System
Service Area (ha)	1,027
Service population in 2020	196500
Population Density (per./ha)	191
Sewer (m)	
Secondary & tertiary	55,296
Main	127,872
Total	183,168

(3) Treatment Plant

Green space near-by Con canal is proposed as the location of treatment plant for SN-II sewerage zone. Conventional activated sludge system with a capacity of 55,000 m^3/day is proposed. The required area for the treatment plant including wastewater treatment, sludge treatment and other auxiliary facilities is about 7 ha. The treated effluent is proposed to be discharged into Con canal. Layout of

treatment plant is shown in Fig. 7.21.

7.6.9 Saigon East (SE) Sewerage Zone

(1) General

Saigon East (SE) sewerage zone covers an area of 1,690 ha in District 2 with 12 wards. SE zone includes the new city center which will be developed at Thu Thiem. This zone is enclosed by Saigon river to the west and south, proposed inner ring road to the east and Rd. Duong So 33 to the north. The existing population in this zone is 68,100 with an average population density of 40 person/ha.

The existing and future land use of this zone are compared below.

Land use	Existing	Future (2020)
Residential area including commercial and institutional areas	455 ha	1,515 ha
Industrial area	5 ha	0 ha
Green area	0 ha	0 ha
Agricultural area	1,138 ha	0 ha
Others	92 ha	175 ha
Total	1,690 ha	1,690 ha

Future residential area including commercial and institutional areas of 1,515 ha will be covered by sewerage system. The projected future population in the year 2020 is 600,000 with an average net population density of 396 person/ha.

(2) Collection System

The separate sewerage system is proposed to collect wastewater of SE sewerage zone. Main sewer is proposed along main roads of Luong Dinh Cua and Tinh Lo 25. Three (3) pumping stations are proposed to transfer wastewater to the treatment plant. The capacity of three (3) pumping stations are 16 m^3/min., 49 m^3/min. and 81 m^3/min. The location of three (3) pumping stations and main sewer are shown in Fig. 7.22. Length of proposed sewerage system is presented in Table 7.5. The collection system of SE zone is summarized below.

Type of Collection System	Separate System
Service Area (ha)	1,515
Service population in 2020	600,000
Population Density (per./ha)	396
Sewer (m)	
Secondary & tertiary	81,120
Main	187,590
Total	268,710

(3) Treatment Plant

Green space enclosed by Saigon river, Giong Ong To river and Ca Tre Nho canal is proposed as the location of treatment plant for SE sewerage zone. Conventional activated sludge system with a capacity of 167,000 m^3/day is proposed. The required area for the treatment plant including wastewater treatment, sludge treatment and other auxiliary facility is about 12 ha.

The treated effluent is proposed to be discharged to Saigon river. Layout of treatment plant is shown in Fig. 7.23.

7.6.10 Integration of Sludge Treatment

Integration of sludge treatment of some wastewater treatment plants nearby will be considered one of the optimum sludge treatment system. Sludge treatment of the three (3) wastewater treatment plants on the left side bank of Saigon River (SN-I, SN-II, SE) will be integrated. And other three (3) wastewater treatment plants of THBNDT, NLTN and SS on the right side bank of Saigon River have also high possibility of integration of sludge treatment. Integrated sludge treatment plant at the wastewater treatment plant site of SE on the left bank side and the plant side of THBNDT on the right bank side are respectively proposed. The further discussion will be done in the detailed design stage.

7.7 Sanitation Plan

On Site sanitation system is proposed in the wards mainly in rural areas having population density less than 200 person/ha. The total population to be covered by the sanitation system will be 1,656,237 which is 22 % of the total population of the study area in 2020. Septic tank with up-flow anaerobic filter is proposed to treat wastewater from each household. The facility should be laid under the house. Treated water can be discharged to public water body near the house. Purchasing, installing, connecting discharge pipe to the public water bodies and O&M cost are to be borne by the owner of the house. Each sanitation treatment unit should be desludged once in a year. About

91,812 m^3/year (252 m^3/day) of sludge is expected to be generated from these sanitation facilities. The sludge is proposed to be treated at the sludge treatment facilities of sewerage zone such as NLTN, THBNDT etc.

7.8 Project Cost

7.8.1 Basic Conditions for Cost Estimation

The Project cost and operation and maintenance cost are estimated under the following basic conditions:

The project cost consists of (i) construction cost, (ii) administration cost, (iii) land acquisition cost and house compensation cost, (iv) engineering cost, and (v) physical contingency cost. The price escalation is excluded from this estimation.

(a) All base cost are estimated under the economic conditions prevailing in February 1999.

(b) The exchange rates of foreign currencies are assumed as follows:
US$ 1.00 = Yen 111.1 = VND 13,332.

(c) The cost is classified into foreign currency (F/C) and local currency (L/C) portion, based on the following conditions:

- The foreign currency portions includes the cost of (i) imported equipment, materials and supplies, (ii) domestic materials of which the country is a net importer, (iii) wages of expatriate personnel, and (iv) overhead and profit of foreign firms,

- The local currency portions include the cost of (i) domestic materials and supplies, (ii) wages of local personnel, (iii) overhead and profit of local firms, and (iv) taxes

7.8.2 Estimated Cost

Total Project cost is estimated at 23,958.5 billion VND. The estimated project cost by sewerage development zone is shown in the table below:

(Billion VND)

Zone	Construction Cost	Land Acquisition Cost	Administra-ti on Cost	Engineering Cost	Physical Contingency	Total
(1) TLBC	1,051.3	2.2	31.6	73.6	105.1	1,263.9
(2) NLTN	3,226,0	13.7	97.2	225.8	322.6	3,885.3

(3) THLG	1,887.1	8.1	56.9	132.1	188.7	2,272.9
(4) THBNDT	3,156.0	14.6	95.1	220.9	315.61	3,802.1
(5) SS	1,932.3	2.2	58.0	135.3	193.2	2,321.0
(6) SE	2,570.0	2.4	77.2	179.9	257.0	3,086.4
(7) SN-I	2,708.5	2.0	81.3	189.6	270.8	3,252.2
(8) SN-II	1,445.5	1.4	43.4	101.2	144.5	1,736.1
(9) SW	1,939.4	10.8	58.5	135.8	193.9	2,338.5
Total	19,916.2	57.4	599.2	1,394.1	1,991.6	23,958.5

Note : 1. Administration cost is assumed at 3% of a total cost of construction and land acquisition/house compensation.
2. Engineering cost is assumed at 7% of the construction cost.
3. Physical contingency is assumed at 10% of the construction cost.

Annual O/M cost for nine (9) sewerage development zones are estimated at 123.1 billion VND. Annual O/M cost of each zone is as follows:

Zone	Annual O/M Cost (million VND)			
	Sewage Pumping Station	Sewer Line	Treatment Plant	Total
(1) TLBC	667	359	7,985	9,011
(2) NLTN	9,574	1,696	20,377	31,647
(3) THLG	3,184	680	12,250	16,115
(4) THBNDT	2,778	2,495	20,700	25,973
(5) SS	555	215	6,110	6,880
(6) SE	1,019	421	9,478	10,918
(7) SN-I	907	351	8,348	9,606
(8) SN-II	408	138	4,356	4,902
(9) SW	629	279	7,118	8,026
Total	19,722	6,634	96,722	123,078

7.9 Project Evaluation

7.9.1 Technical Evaluation

All the major rivers and canals in HCMC have been severely polluted by untreated domestic and industrial wastewater and solid wastes from houses and industrial estates. A study of evaluating water quality in terms of BOD_5 of major rivers and canals in the year 2020 is carried out for the following cases.

(a) Case I: If the present situation continues, leaving both of untreated domestic and industrial wastewater discharge to rivers and canals.

(b) Case II: If only industrial wastewater is discharged to rivers/canals after appropriate treatment to the level of the discharge standard, leaving

domestic wastewater discharge to rivers and canals without any treatment.

(c) Case III: If both of domestic and industrial wastewater are discharged to rivers and canals after appropriate treatment with 90 % of BOD_5 removal rate.

Predicted water quality is shown below:

River/Canal	BOD_5 (mg/l)			
	Present (1997)	Case I (2020)	Case II (2020)	Case III (2020)
Saigon River at Tan Tuan reach	50～210	95～400	88～370	5 – 7
Tau Hu at Y Bridge	80～250	130～400	125～395	10 – 15
Tan Hoa-Lo Gom at Tan Hoa street	330～540	460～760	460～760	10 – 20
Nhieu Loc-Thi Nghe at Ly Bridge	120～210	200～360	200～360	10 – 15
Tham Luong-Vam Thuat at Ben Pham Bridge	35～140	90～360	80～320	10 – 20

Although the figures of BOD_5 concentration in the above table are the result of simplified calculation, ignoring change in hydraulic characteristics of rivers/canals, the results suggest the following things.

(a) Domestic wastewater seems to be the major organic pollution source, therefore, industrial wastewater treatment alone to the level of the discharge standard will not reduce organic pollution of water bodies such as rivers and canals

(b) By simultaneous wastewater treatment of domestic wastewater by sewerage and on-site sanitation improvement system and industrial wastewater treatment with 90% of BOD_5 removal rate will considerably improve water quality of rivers and canals.

7.9.2 Financial Evaluation

(1) Existing Tariff System of Water Supply

In principle, a sewerage charge is corresponding to the water supply charge

Existing water supply charge for domestic use, industrial use and commercial use are as follows:

Domestic use: VND1,300/m^3 until 4m^3 per month per person
VND 2,100/m^3 of more than 4m^3 per month per person

Industrial use: VND 3,100 /m^3
Commercial use: VND 5,200 to 8,700 / m^3

Based on the "Social Survey of Relocation/Resettlement" (hereinafter referred to as "the Social Survey") and "Survey on Sewerage and Environmental Sanitation in Ho Chi Minh City" (hereinafter referred to as "Environmental Survey") both conducted by JICA Study Team in 1998, average monthly expenditure of water supply were VND 50,077/household/month and VND 57,945/HH/month respectively.

(2) Willingness of People to Pay for Sewerage Services

Based on the Environmental Survey and Flood Damage Survey, the amount of willingness of people to pay (WTP) for sewerage services are estimated about VND 6,000/HH/month and VND 12,000/HH/month respectively.

According to these figures, an average WTP for sewerage services may be assumed at VND9,000/HH/month.

(3) Affordability of People to Pay for Sewerage Services

Based on the Social Survey, an amount of payment as VND169,148 per HH is expended for utilities consisting of water supply, electricity and garbage treatment.

According to the existing tariff system of water supply, estimated expenditure for water supply paid by users has resulted at VND29,692/HH/month. On the other hand, the cost proportion for electricity and garbage services is estimated at 2:1.

Therefore, the actual payment amount for water and electricity can be estimated at VND122,663 per HH/month, which is 6.3% to the family income level in share rate. This share rate may be rather high comparing the standard rate of 5% in developing countries.

However, the average families have a capability to pay more because they have a saved money amounting to VND490,074 per month with a share rate of around 25% to the total income.

In principle, the sewerage service charge should not be higher than the charge of potable water supply, but sometimes there may be almost the same amount with that for potable water.

In case that the maximum amount of charge for sewerage services, for example VND 30,000/HH/month as almost the same amount of potable water supply, is

applied, the share rate of water supply and electricity including the said charge will become 7.85% to their total family income, and this amount has an affordability, if any considering their family economy.

As a result, an affordable amount of charge for sewerage services will be within VND 30,000/HH/month.

(4) Assumed Tariff System for Sewerage Services

The following three (3) sewerage tariff system are assumed for the financial evaluation of sewerage development.

Case	Basic assumption of the tariff system	Assumed tariff system
Case-1	VND9,000/HH/month	Residence: VND9,000/HH/month Commercial: VND36,800/shop/month Industry: VND16,400/factory/month
Case-2	VND20,000/HH/month	Residence: VND20,000/HH/month Commercial: VND81,800/shop/month Industry: VND36,500/factory/month
Case-3	VND30,000/HH/month	Residence: VND30,000/HH/month Commercial: VND122,650/shop/month Industry: VND54,700/factory/month

(5) Financial Cost, Operation and maintenance and Replacement Cost

Annual financial construction cost by Sewerage Zone according the work schedule is summarized below together with O/M cost and replacement cost by each zone.

(billion VND)

Zone	TLBC	NLTN	THLG	THBN DT	SS	SE	SN-1	SN-2	SW	TOTAL
Construction cost	1,263	3,885	2,272	3,802	2,321	3,086	3,252	1,736	2,338	23,958
O/M cost	9	31	16	26	6	10	9	4	8	123
Replacement cost	440	1,585	834	1,151	357	549	483	250	398	6,052

(6) Financial Evaluation of Sewerage Development

(a) Financial Availability to Cover the Construction Cost and O/M Cost by Sewerage Charge

Under the conditions of three (3) assumed sewerage charge mentioned

before, financial evaluation was conducted and the results are as follows:

Case	Basic service charge	Net Present Value	FIRR(%)	B/C
Case-1	VND9,000/HH/month	-8,532.9	(unavailable)	0.10
Case-2	VND20,000/HH/month	-7,429.9	-2.18	0.21
Case-3	VND30,000/HH/month	-6,428.4	0.78	0.32

(Note : Net present values are expressed by billion VND)

This means that the Project is not viable to be executed but by means of service charge only, the Governmental capital expenditure is needed as investment..

(b) Financial Availability to Cover O/M Cost and Replacement Cost by Service Charge

Financial evaluation under three (3) assumed service charges are as follows:

Case	Basic service charge	B/C
Case-1	VND9,000/HH/month	0.66
Case-2	VND20,000/HH/month	1.48
Case-3	VND30,000/HH/month	2.21

In case of B/C resulted at 1.0, the amount of revenue is just equal with the cost at present value, and revenue can recover the cost with applied tariff system. The justifiable tariff system is assumed to be in between "VND9,000/HH system" and "VND20,000/HH system". And justifiable tariff system is estimated at "VND13,532/HH system".

(7) Recommended Tariff System for Sewerage Services

Based on the above results of financial evaluation and taking business firms as state owned enterprises in Vietnam into consideration, a tariff system of VND15,000/HH/month as a basic fixed charge is recommended so that the company dealing with the sewerage services can get around 10% of surplus after paying the O/M cost and making outlay as reservation for replacement.

The recommended tariff system is shown below:

For Residence : VND15,000/HH/month
For Commercial : VND61,320/shop/month
For Industry : VND27,350/factory/month

7.10 Implementation Program of Sewerage Development

7.10.1 Prioritization

Priority sequences for implementation of sewerage developments are determined from the aspects of demands/benefits, adverse effects and constraints of the respective development projects. Major evaluation indexes for the proposed projects are as follows.

(Demands/Benefits)

(a) Population Density:

Population density is the typical index representative to sewerage development requirement. Higher priority will be given to a zone with high population density.

(b) Public Land Use Rate:

This index represents contribution of sewerage development to public interest. Higher priority will be given to a zone with a high public land use rate.

(c) Pollution Load Generation:

Higher priority will be given to a zone with high pollution load generation.

(d) Waterborne Disease Contraction Rate:

This is the typical index representing unsanitary condition of an area, in other words, extent of sewerage development requirement. Higher priority will be given to a zone with a high waterborne disease contraction rate.

(Adverse Effect)

(a) Construction and O/M Cost:

These are the typical indexes representing adverse effects of the project. Higher priority will be given to a zone with a low construction and O/M costs.

(Constraints)

(a) Treatment Plant Site Availability:

A considerable land space is required for provision of the proposed treatment plants. Successful implementation of the projects much depends on land space

availability for the treatment plants. Higher priority will be given to a zone where its land acquisition is easy.

These seven (7) items are evaluated for the respective zones. Integrated evaluation is obtained assigning points ranging from 1 to 5 on each item and by summing up the given points.

The highest priority is given to Tau Hu, Ben Nghe – Doi, Te Zone, followed by Nhieu Loc – Thi Nghe Zone, Tan Hoa – Lo Gom Zone and Tham Long – Ben Cat Zone.

7.10.2 Implementation Schedule

Since respective nine (9) sewerage zones do not intersect each other, the implementation program is established according to the descending order of priority sequences of each zone, independently. Implementation is planed to commence in the year 2000 and be completed in the year 2020.

Proposed implementation schedule of respective sewerage developments are shown in Fig. 7.24.

7.11 Identification of the Priority Project for Feasibility Study

Tau Hu, Ben Nghe – Doi, Te sewerage zone is identified as the first priority zone for sewerage development. The components of sewerage development plan are:

(a) Construction of 35 km of interceptor, with the Ø 700-1500 mm, along the canals
(b) Construction of lift pump with the capacity of 533 m^3/min
(c) Construction of Ø 1500-2500 mm conveyance pipe with the total length of 5.4 km
(d) Construction of conventional activated sludge treatment plant for wastewater treatment having capacity about 512,000 m^3/d.

Table 7.1 DOMESTIC WASTEWATER GENERATION BY DISTRICTS

Year	1997			2020		
	Population (person)	Unit Wastewater Daily Ave. (L/person/day)	Wastewater Daily Ave. (m3/day)	Population (person)	Unit Wastewater Daily Ave. (L/person/day)	Wastewater Daily Ave. (m3/day)
Total of Study Area	**4,416,638**	**161**	**711,370**	**7,430,985**	**278**	**2,071,050**
Urban Area	**3,541,040**	**170**	**601,977**	**4,000,000**	**335**	**1,340,000**
District 1	282,063	170	47,951	270,000	335	90,450
District 3	260,418	170	44,271	250,000	335	83,750
District 4	220,650	170	37,511	210,000	335	70,350
District 5	251,387	170	42,736	220,000	335	73,700
District 6	280,336	170	47,657	300,000	335	100,500
District 8	347,090	170	59,005	430,000	335	144,050
District 10	271,593	170	46,171	270,000	335	90,450
District 11	260,159	170	44,227	250,000	335	83,750
Go Vap	234,966	170	39,944	450,000	335	150,750
Tan Binh	512,185	170	87,071	600,000	335	201,000
Binh Thanh	417,739	170	71,016	520,000	335	174,200
Phu Nhuan	202,454	170	34,417	230,000	335	77,050
New Urban Area	**611,669**	**140**	**85,634**	**2,270,000**	**253**	**574,310**
District 12	127,459	140	17,844	450,000	253	113,850
Thu Duc	171,165	140	23,963	500,000	253	126,500
District 2	95,219	140	13,331	600,000	253	151,800
District 9	119,446	140	16,722	400,000	253	101,200
District 7	98,380	140	13,773	320,000	253	80,960
Rural Area	**263,929**	**90**	**23,754**	**1,160,985**	**135**	**156,733**
Hoc Mon	34,241	90	3,082	99,244	135	13,398
Binh Chanh	185,378	90	16,684	977,241	135	131,928
Nha Be	44,310	90	3,988	84,500	135	11,408

(Remarks)

1. Water consumption = Domestic Wastewater Generation
2. Ignore underground water infiltration

Table 7.2 DOMESTIC POLLUTION GENERATION BY DISTRICT

Year	1997			2020		
	Population (person)	BOD_5 Unit Load (g/person/day)	BOD_5 Load (kg/day)	Population (person)	BOD_5 Unit Load (g/person/day)	BOD_5 Load (kg/day)
Total of Study Area	**4,416,638**	**38**	**169,650**	**7,430,985**	**51**	**382,790**
Urban Area	**3,541,040**	**40**	**141,642**	**4,000,000**	**60**	**240,000**
District 1	282,063	40	11,283	270,000	60	16,200
District 3	260,418	40	10,417	250,000	60	15,000
District 4	220,650	40	8,826	210,000	60	12,600
District 5	251,387	40	10,055	220,000	60	13,200
District 6	280,336	40	11,213	300,000	60	18,000
District 8	347,090	40	13,884	430,000	60	25,800
District 10	271,593	40	10,864	270,000	60	16,200
District 11	260,159	40	10,406	250,000	60	15,000
Go Vap	234,966	40	9,399	450,000	60	27,000
Tan Binh	512,185	40	20,487	600,000	60	36,000
Binh Thanh	417,739	40	16,710	520,000	60	31,200
Phu Nhuan	202,454	40	8,098	230,000	60	13,800
New Urban Area	**611,669**	**35**	**21,408**	**2,270,000**	**45**	**102,150**
District 12	127,459	35	4,461	450,000	45	20,250
Thu Duc	171,165	35	5,991	500,000	45	22,500
District 2	95,219	35	3,333	600,000	45	27,000
District 9	119,446	35	4,181	400,000	45	18,000
District 7	98,380	35	3,443	320,000	45	14,400
Rural Area	**263,929**	**25**	**6,598**	**1,160,985**	**35**	**40,634**
Hoc Mon	34,241	25	856	99,244	35	3,474
Binh Chanh	185,378	25	4,634	977,241	35	34,203
Nha Be	44,310	25	1,108	84,500	35	2,958

(Remarks)

1. Water consumption = Domestic Wastewater Generation
2. Ignore underground water infiltration

Table 7.3 POTENTIAL SITES OF WASTEWATER TREATMENT PLANT

No.	Location	Area (ha)	Unit Price (VND/m2)	Ownership	Present Land Use	Future Land Use
1	Enclosed by Tan Ky - Tan Quy Str. & May 19 Canal & Binh Long Str.	60	-	government	Agricultural area with low population density	Green area
2	Enclosed by Le Minh Xuan st.. & Ba Goc Canal	160	38.600	private	Agricultural Area	Agricultural area
3	Enclosed by Ba Tang Canal & Ba Lon Canal.	70	19.300	private	Agricultural area	Green area
4	Southern of Saigon South (between Ba Lao Canal and Xom Cui Canal)	75	19.300	private	Agricultural area	Green area
5	Southern of Saigon South (enclosed by Tac Ben Ro Canal and Cay Kho Canal)	70	38.600	private	Agricultural area	Agricultural area
6	Enclosed by Roi Canal, far from Vinh Phuoc st. about 500m	150	26.000	private	Agricultural area	Agricultural area
7	Thanh Da area (Southern of proposed tourist area, near Saigon River)	50	256.000	private	Rice field with low population density	Green area
8	Enclosed by Luong Dinh Cua Str & Giong Ong To River & Saigon River.	15	19.300	private	Agricultural area	Green area
9	Near Ben Do Nho River and Ben Do Lon River.	90	19.300	private	Agricultural area	Green area
10	Near Cau Ong Nhieu canal and Dong Nai River	80	19.300	private	Agricultural area	Green area

Table 7.4 Comparison of Treatment System

	Adaptability to Overload	Required O&M		Required Cost		Required Sludge Disposal		Required Land Acquisition	Integrated Evaluation (Total point)
		Facility Maintenance	Operation Technology	Construction	O&M	Amount	Property		
1) Stabilization Pond	B 2	B 2	B 2	B 2	A 3	A 3	B 2	E very huge	**Out of Evaluation**
2) Aerated Lagoon	B 2	C 1	A 3	B 2	B 2	B 2	B 2	D 0	**14**
3) Oxidation Ditch	B 2	C 1	C 1	D 0	C 1	C 1	B 2	C 1	**9**
4) Conventional Activated Sludge	D 0	C 1	B 2	C 1	C 1	C 1	C 2	A 3	**11**
5) Rotating Biological Contactor	C 1	C 1	B 2	C 1	C 1	C 1	D 0	B 2	**9**

Note : 1) A : Excellent : 3 point
B : Good : 2 point
C : Moderate : 1point
D : Inferior : 0 point
E : Much inferior : out of evaluation
2) Figures in the colum : point of evaluation

Table 7.5 Main Features of Wastewater Collection System for 9 Zones

THBNDT Zone

Sewer Type	Diameter (mm)	Length (m)
Interceptor	500 - 2,500	34,750
Conveyance	3,000	3,169
Total		37,919

NLTN Zone

Sewer Type	Diameter (mm)	Length (m)
Interceptor	500 - 2,500	32,033
Conveyance	3,000	9,358
Total		41,391

THLG Zone

Sewer Type	Diameter (mm)	Length (m)
Interceptor	800 - 2,000	16,305
Conveyance	2,500	6,564
Total		22,869

TLBC Zone

Sewer Type	Diameter (mm)	Length (m)
Interceptor	700 - 1,600	9,356
Conveyance	1,600	635
Total		9,991

SW Zone

Sewer Type	Diameter (mm)	Length (m)
Secondary/Tertiary	150 - 500	63,120
Main	600 - 1100	143,066
Conveyance	1,100	2,899
Total		209,085

SS Zone

Sewer Type	Diameter (mm)	Length (m)
Secondary/Tertiary	150 - 500	71,424
Main	600 - 1100	165,168
Total		236,592

SN-I Zone

Sewer Type	Diameter (mm)	Length (m)
Secondary/Tertiary	150 - 500	101,472
Main	600 - 1200	234,654
Total		336,126

SN-II Zone

Sewer Type	Diameter (mm)	Length (m)
Secondary/Tertiary	150 - 500	55,296
Main	600 - 1,000	127,872
Total		183,168

SE Zone

Sewer Type	Diameter (mm)	Length (m)
Secondary/Tertiary	150 - 500	81,120
Main	600 - 1,300	187,590
Total		268,710

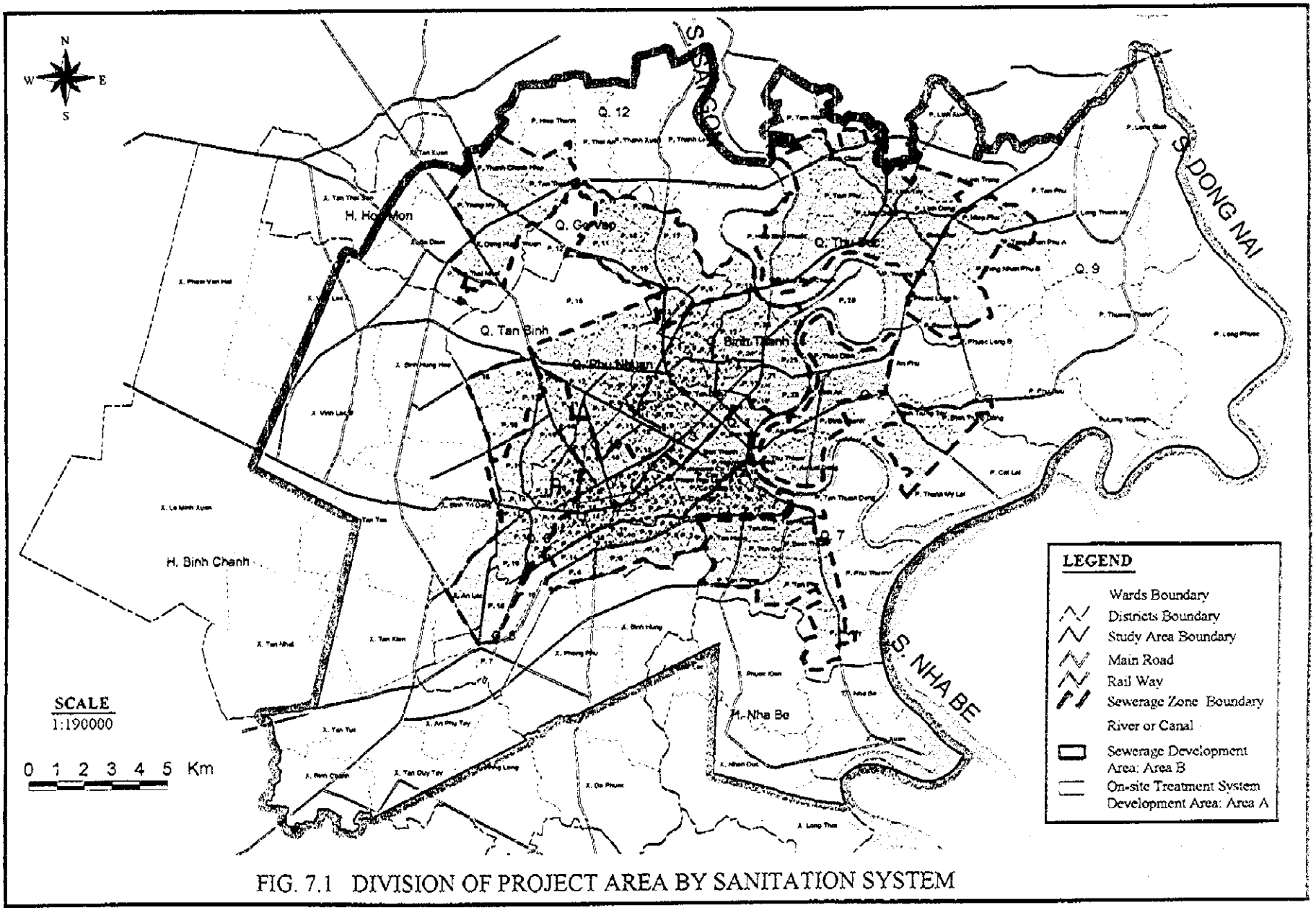

FIG. 7.1 DIVISION OF PROJECT AREA BY SANITATION SYSTEM

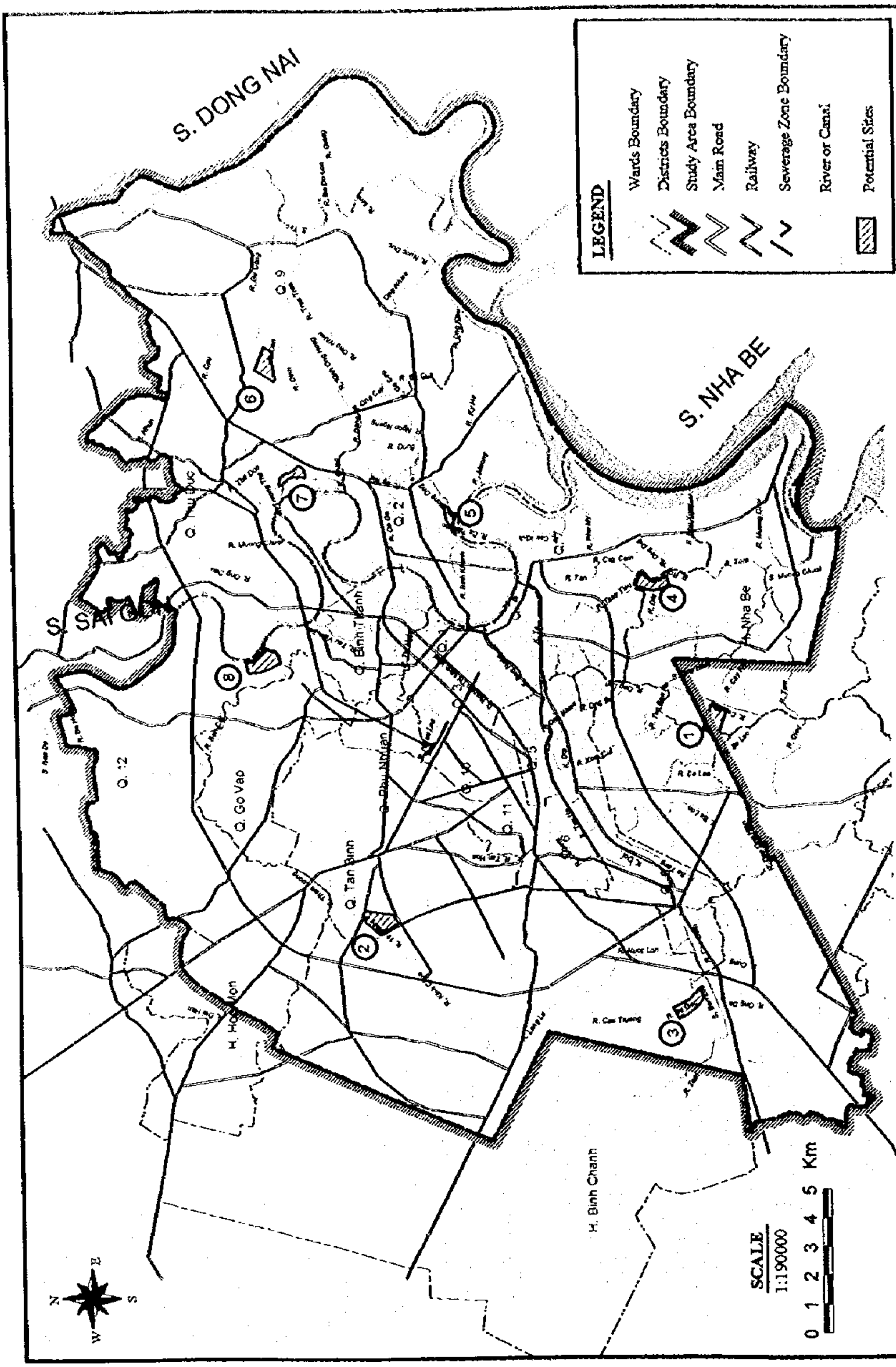

FIG. 7.2 PROPOSED WASTEWATER TREATMENT PLAN SITES

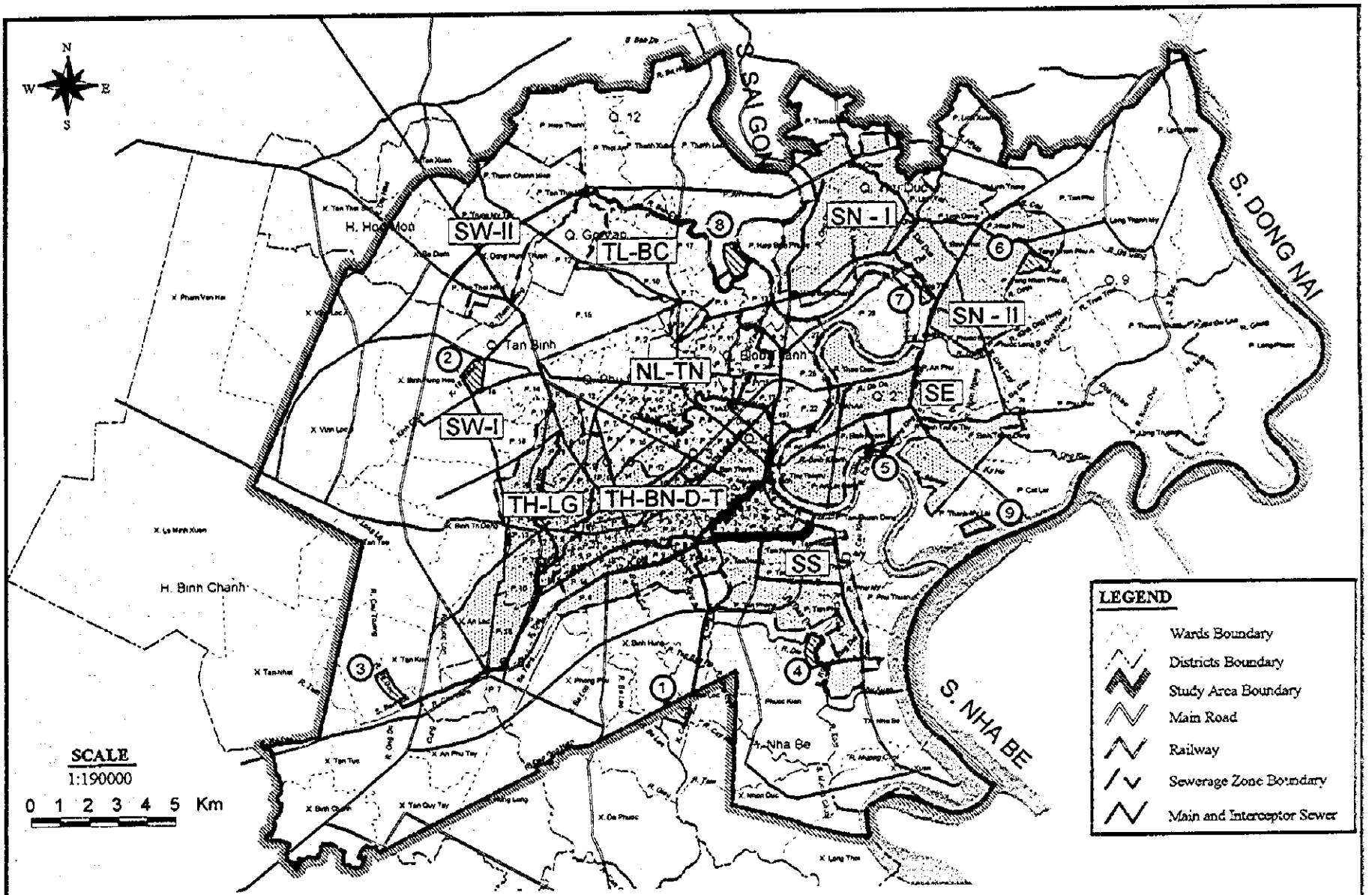

FIG. 7.3 ALTERNATIVE I INDIVIDUAL SMALL SCALE TREATMENT SYSTEM

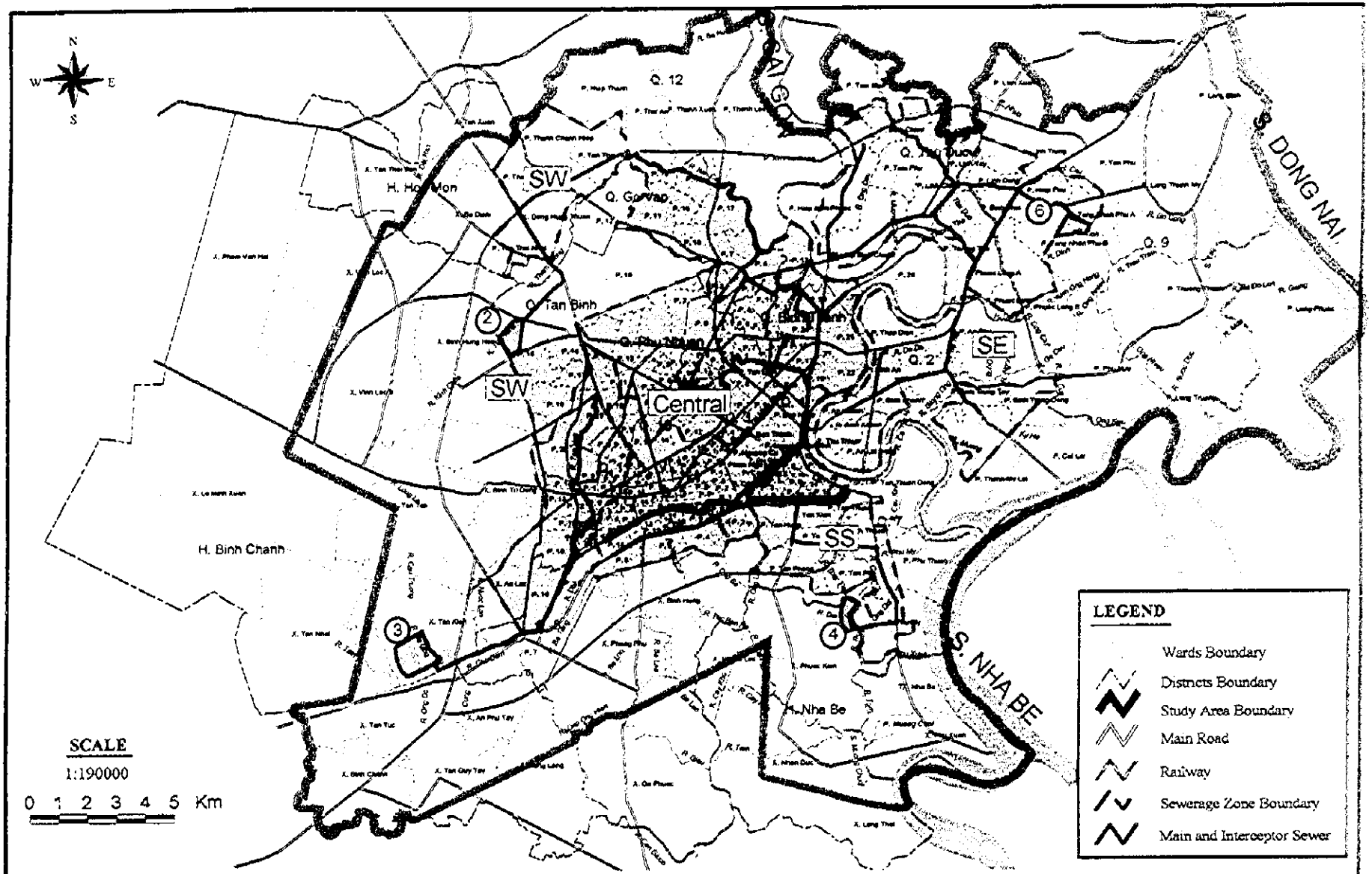

FIG. 7.4 ALTERNATIVE II TWO LARGE SCALE AND TWO SMALL SCALE TREATMENT SYSTEM

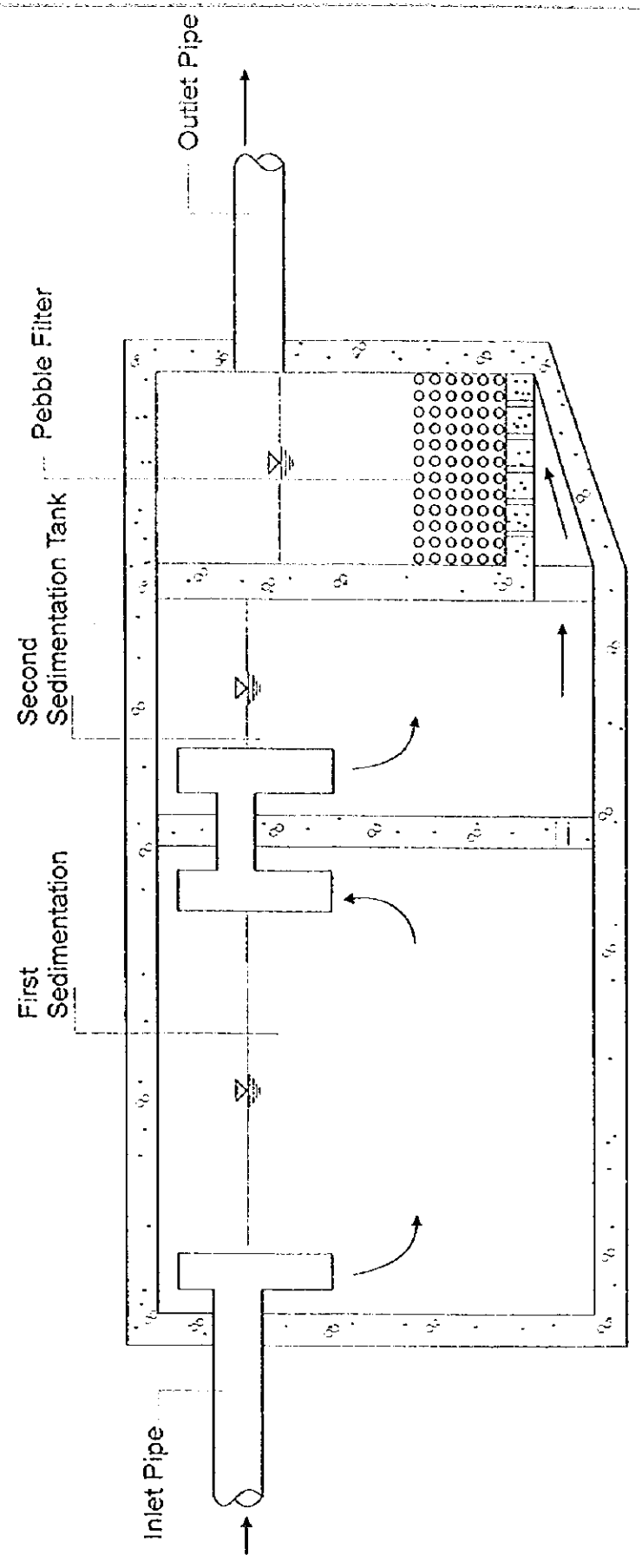

Fig. 7.5 SEPTIC TANK WITH ANAEROBIC UP-FLOW FILTER

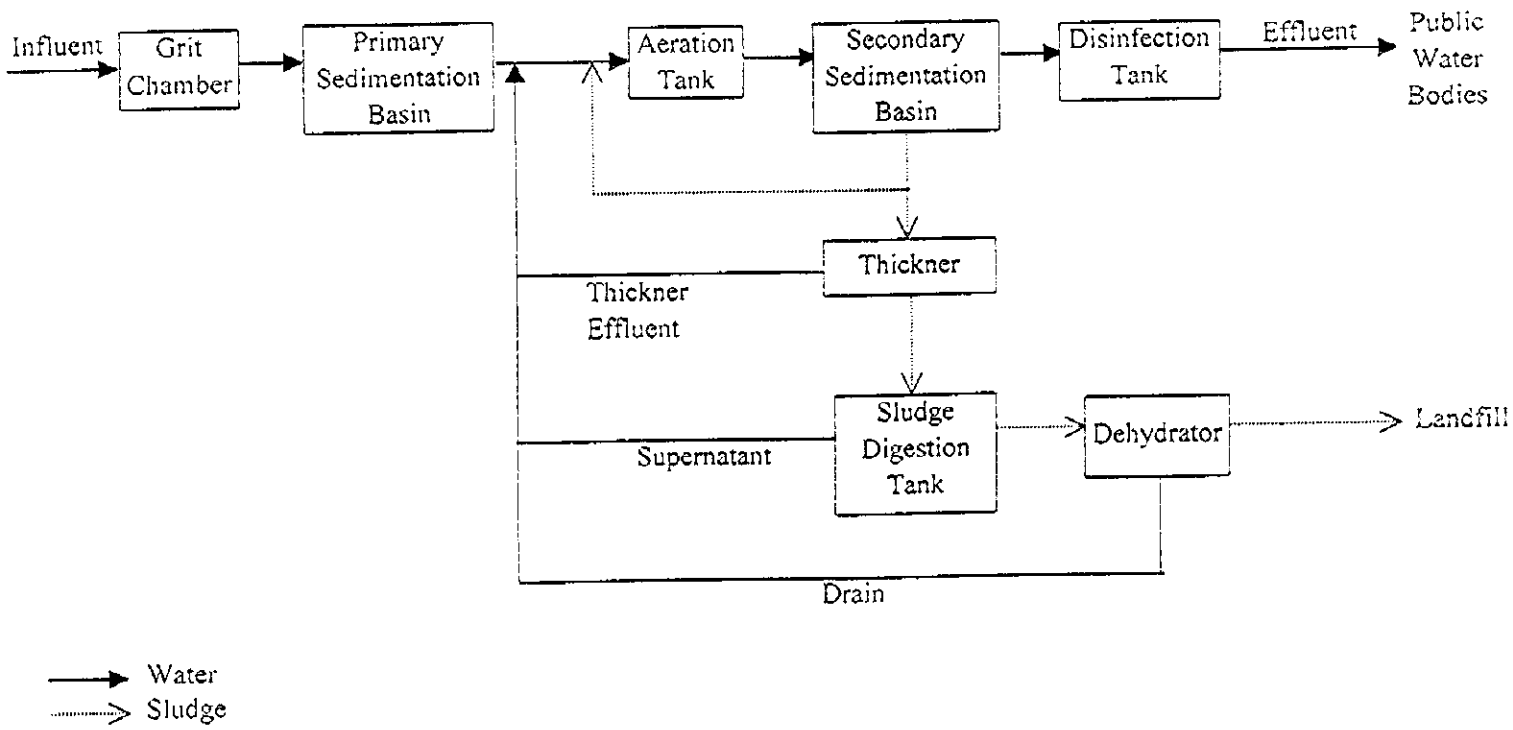

FIG. 7.6 FLOW CHART OF ACTIVATED SLUDGE PROCESS

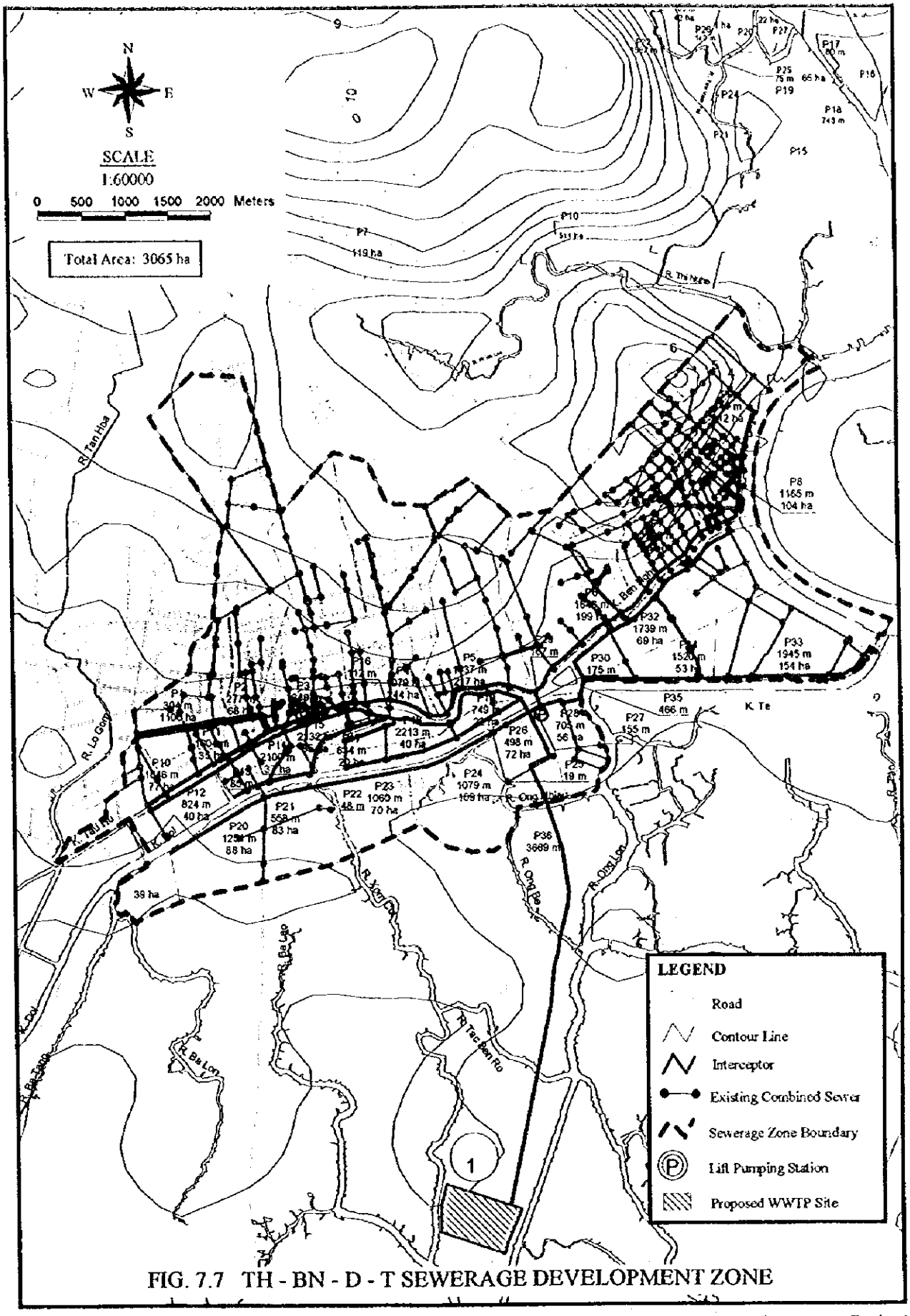

FIG. 7.7 TH - BN - D - T SEWERAGE DEVELOPMENT ZONE

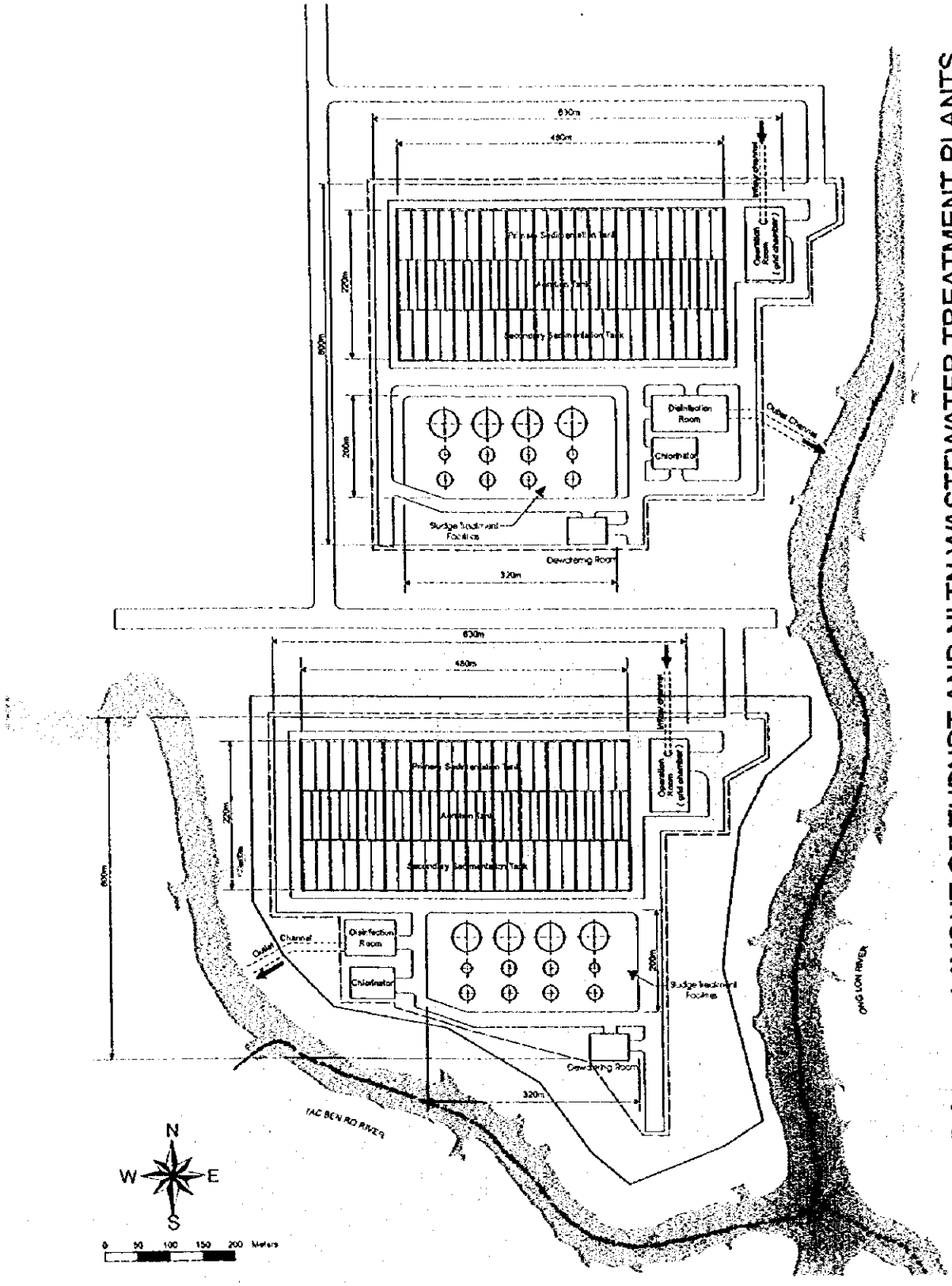

FIG. 7.8 LAYOUT OF THBNDT AND NLTN WASTEWATER TREATMENT PLANTS

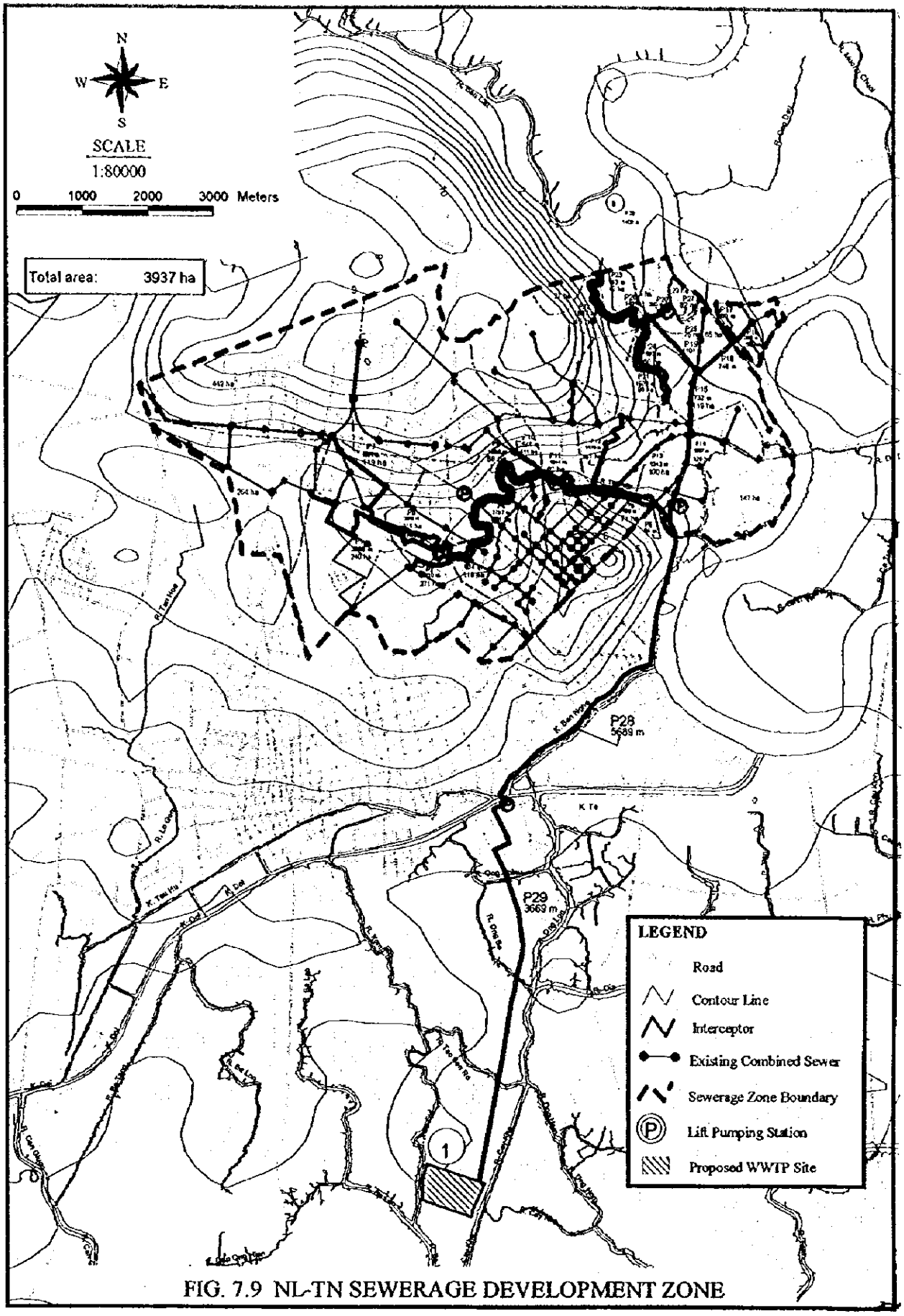

FIG. 7.9 NL-TN SEWERAGE DEVELOPMENT ZONE

JICA - Ho Chi Minh City Urban Drainage & Sewerage Project

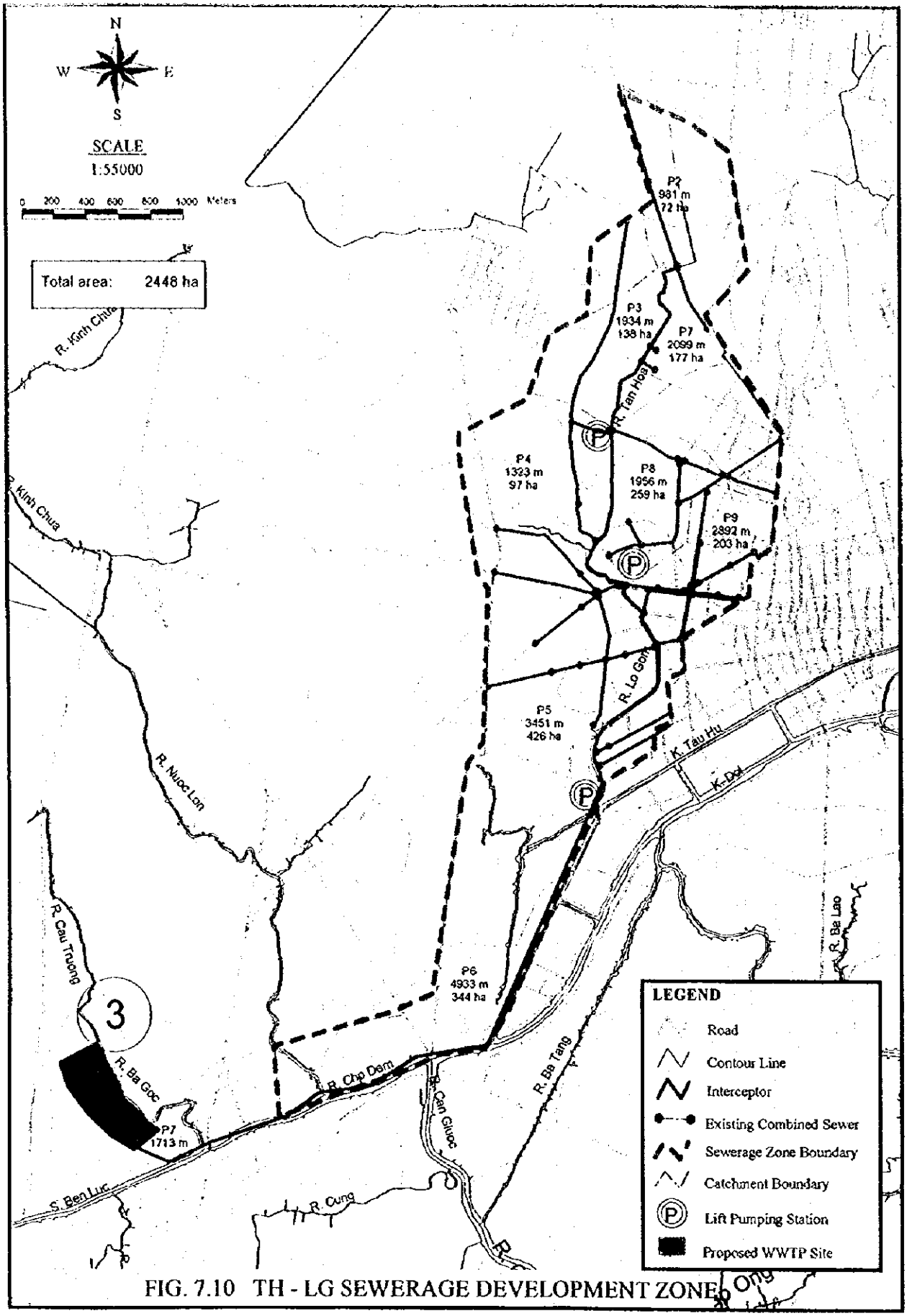

FIG. 7.10 TH - LG SEWERAGE DEVELOPMENT ZONE

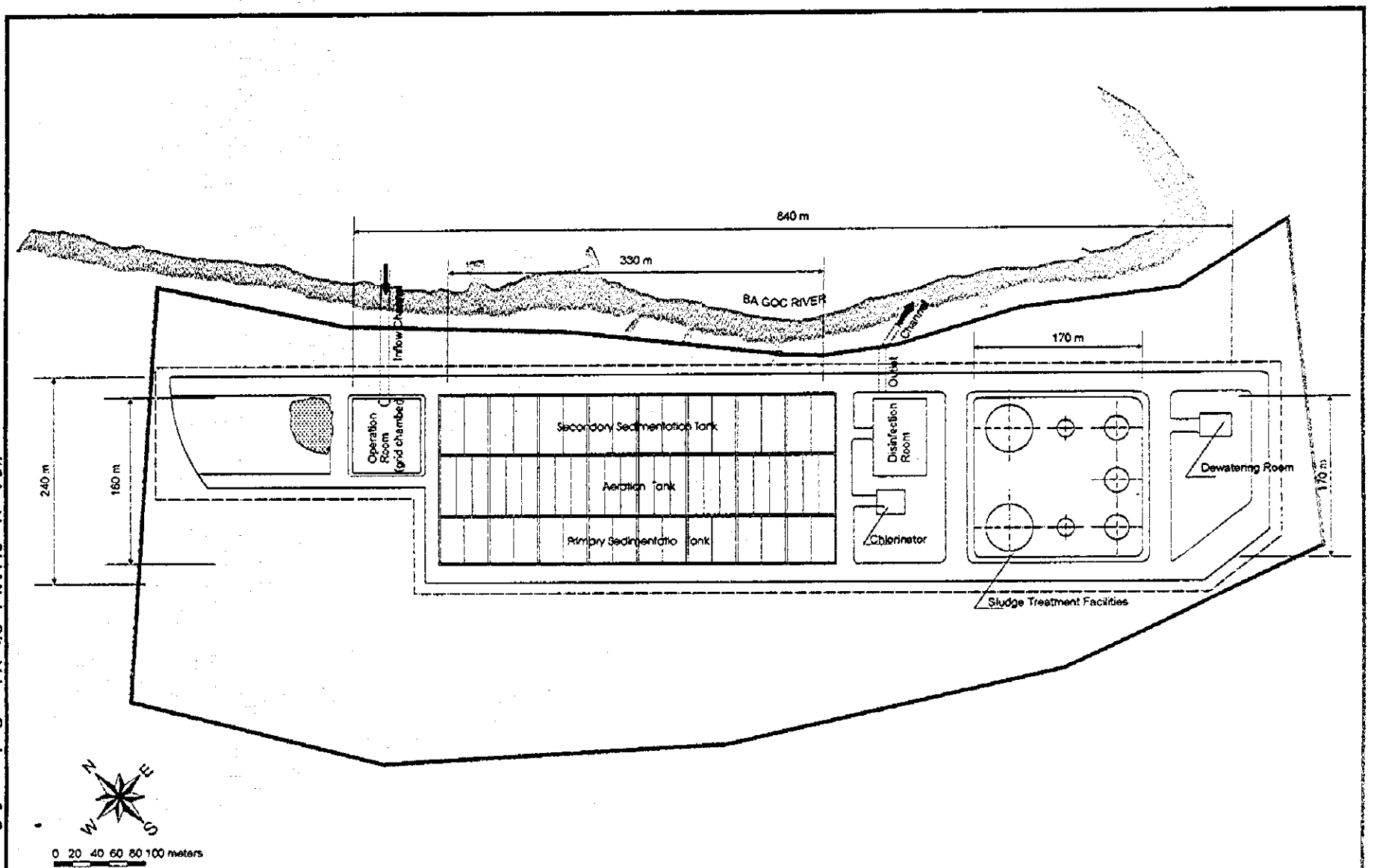

FIG. 7.11 LAYOUT OF THLG WASTEWATER TREATMENT PLANT

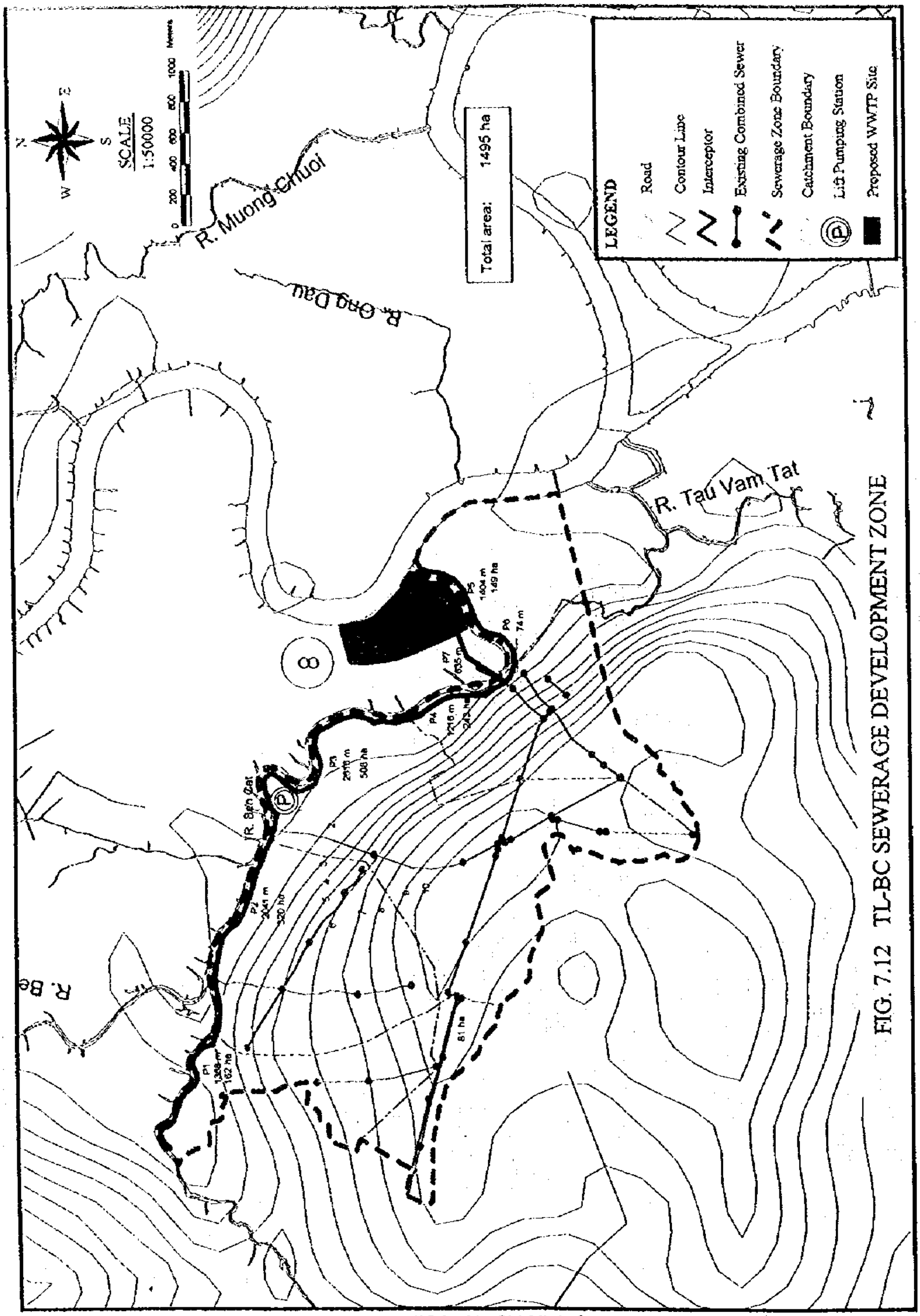

FIG. 7.12 TL-BC SEWERAGE DEVELOPMENT ZONE

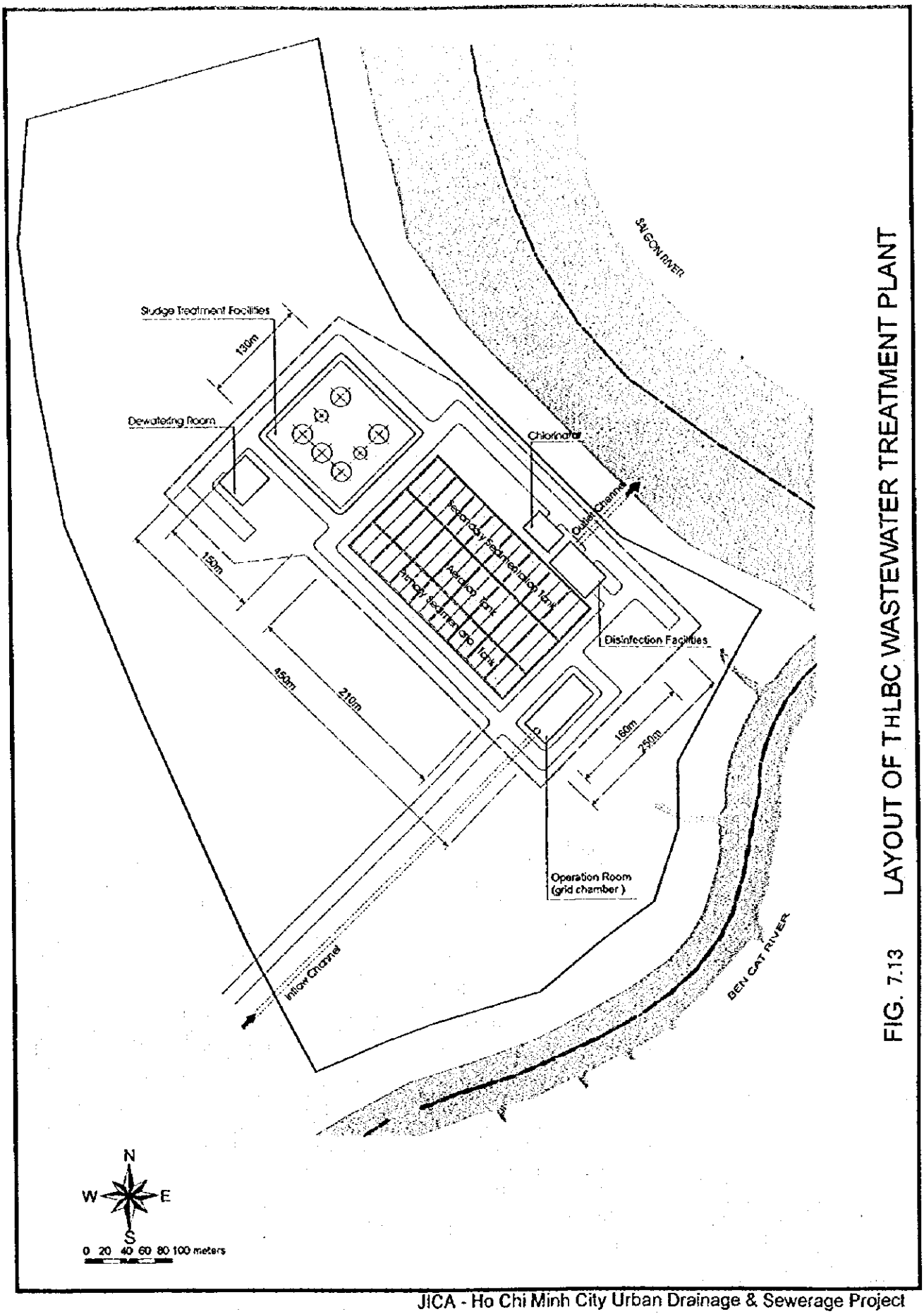

FIG. 7.13 LAYOUT OF THLBC WASTEWATER TREATMENT PLANT

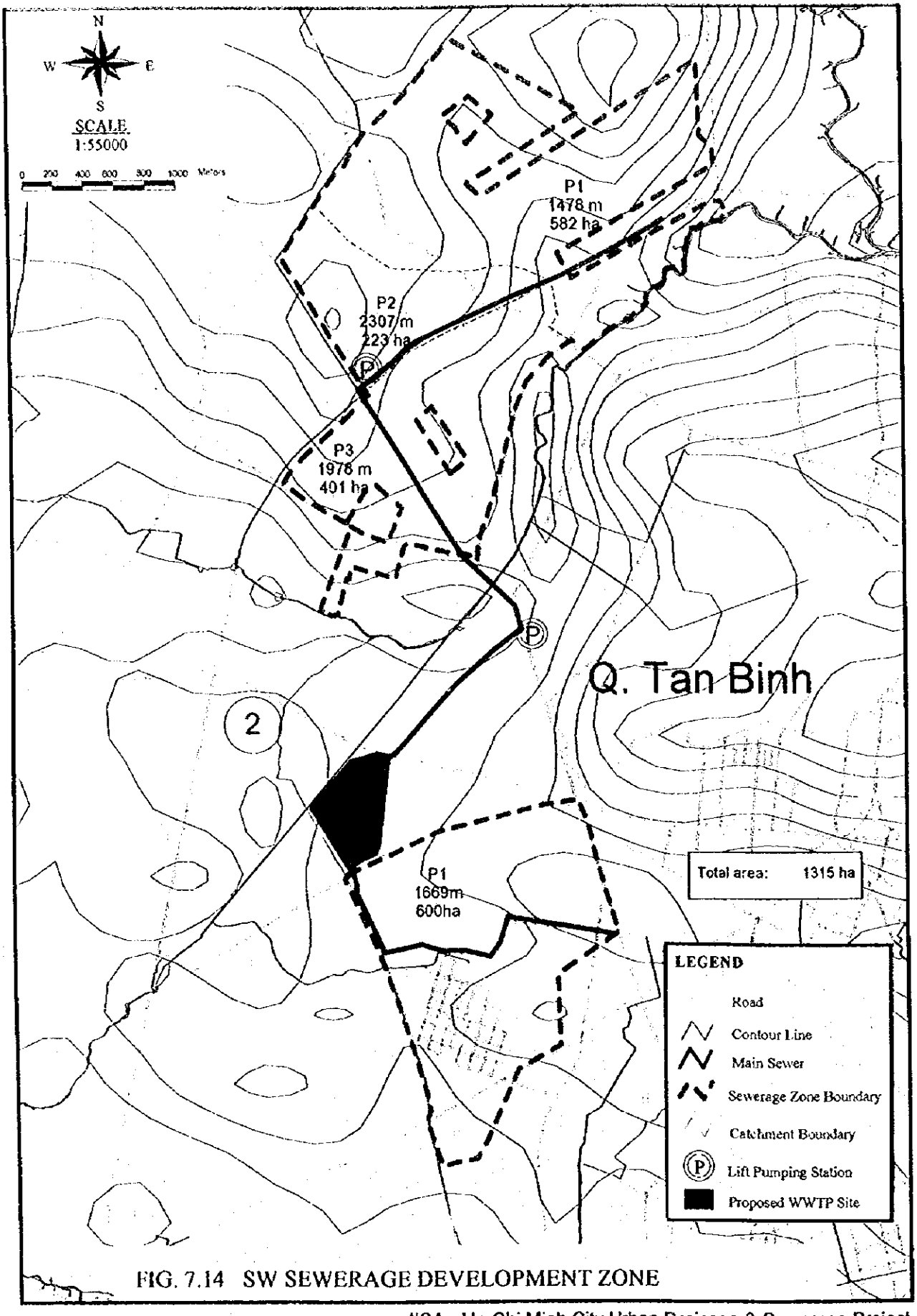

FIG. 7.14 SW SEWERAGE DEVELOPMENT ZONE

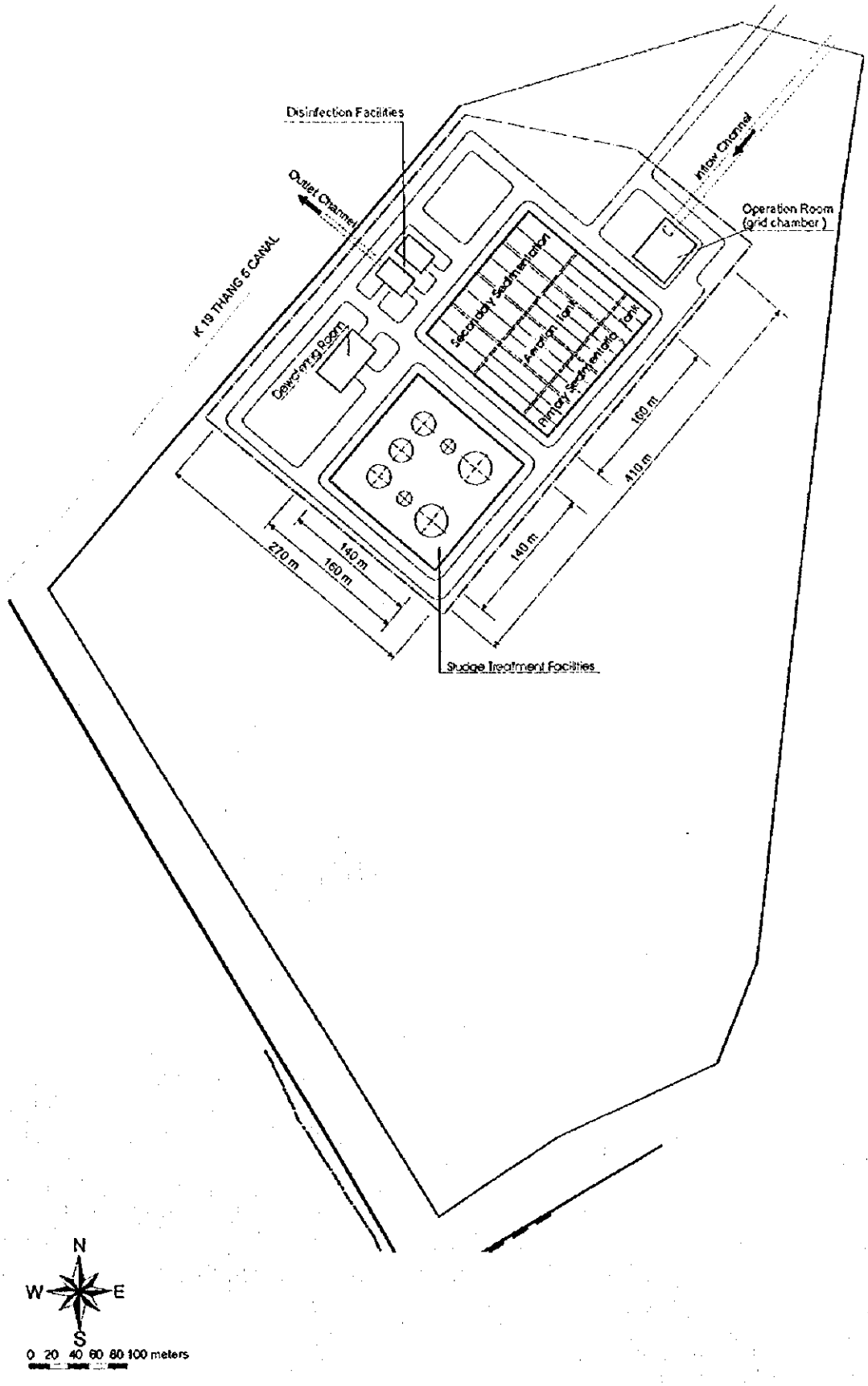

FIG. 7.15 LAYOUT OF SW WASTEWATER TREATMENT PLANT

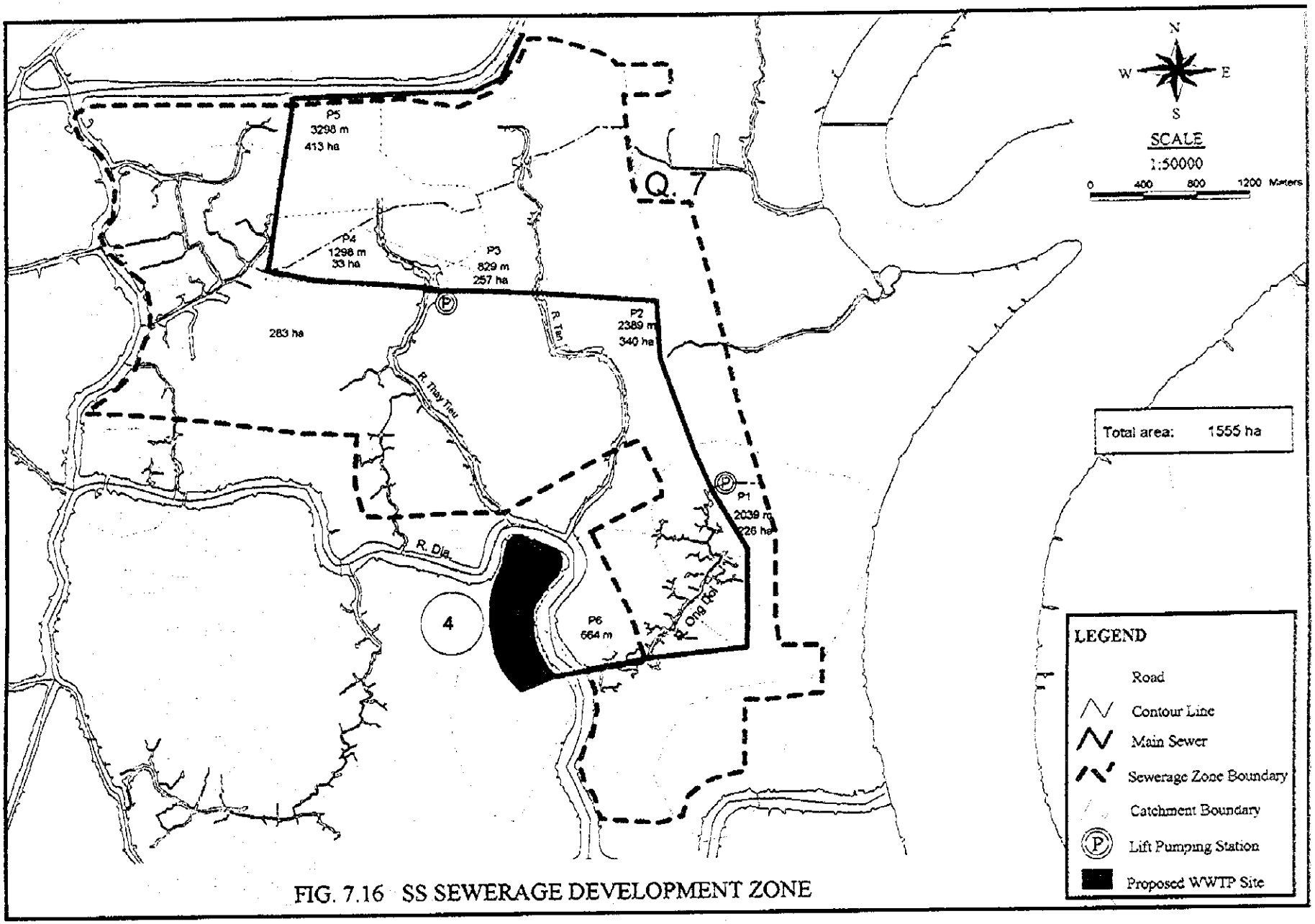

FIG. 7.16 SS SEWERAGE DEVELOPMENT ZONE

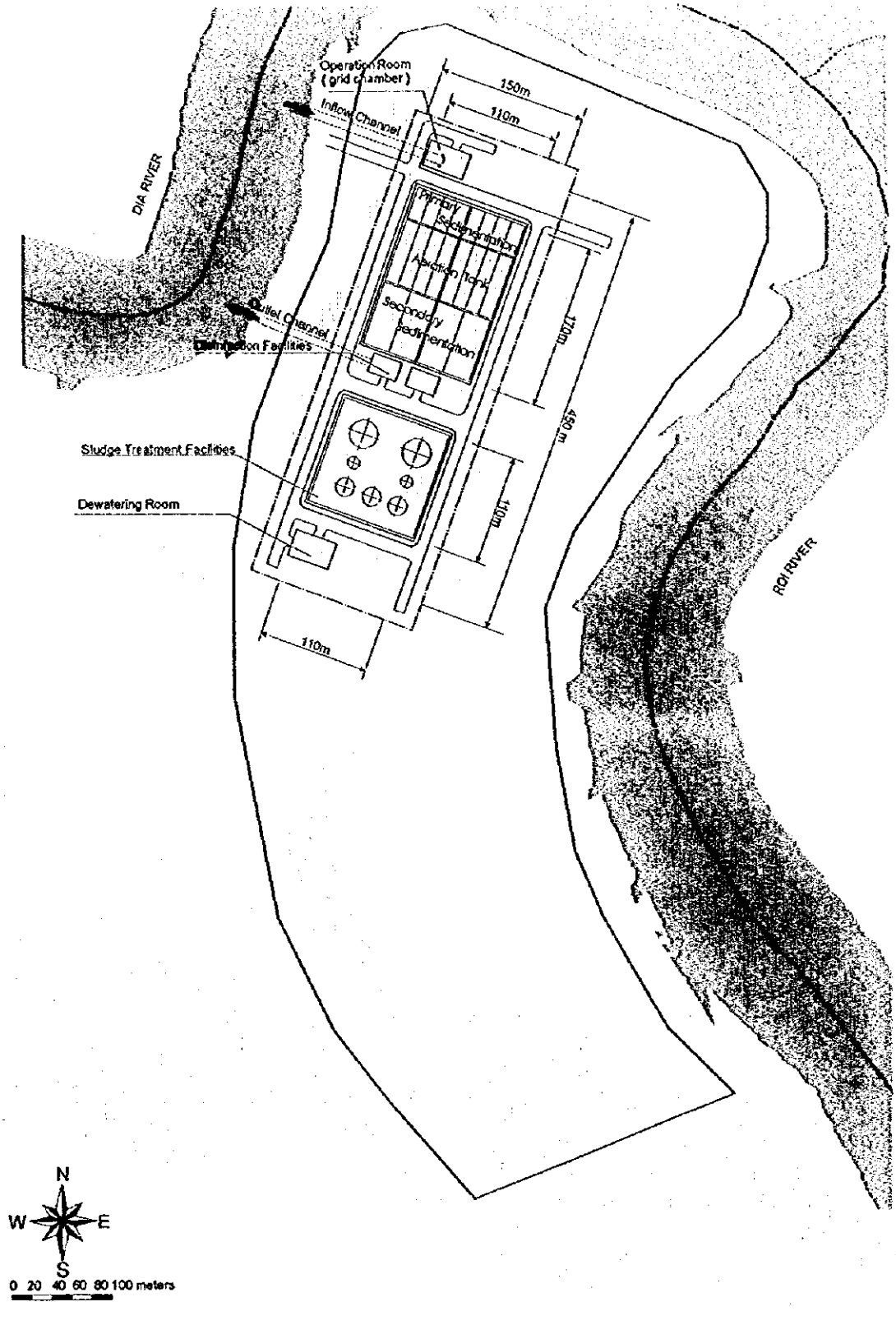

FIG. 7.17 LAYOUT OF SS WASTEWATER TREATMENT PLANT

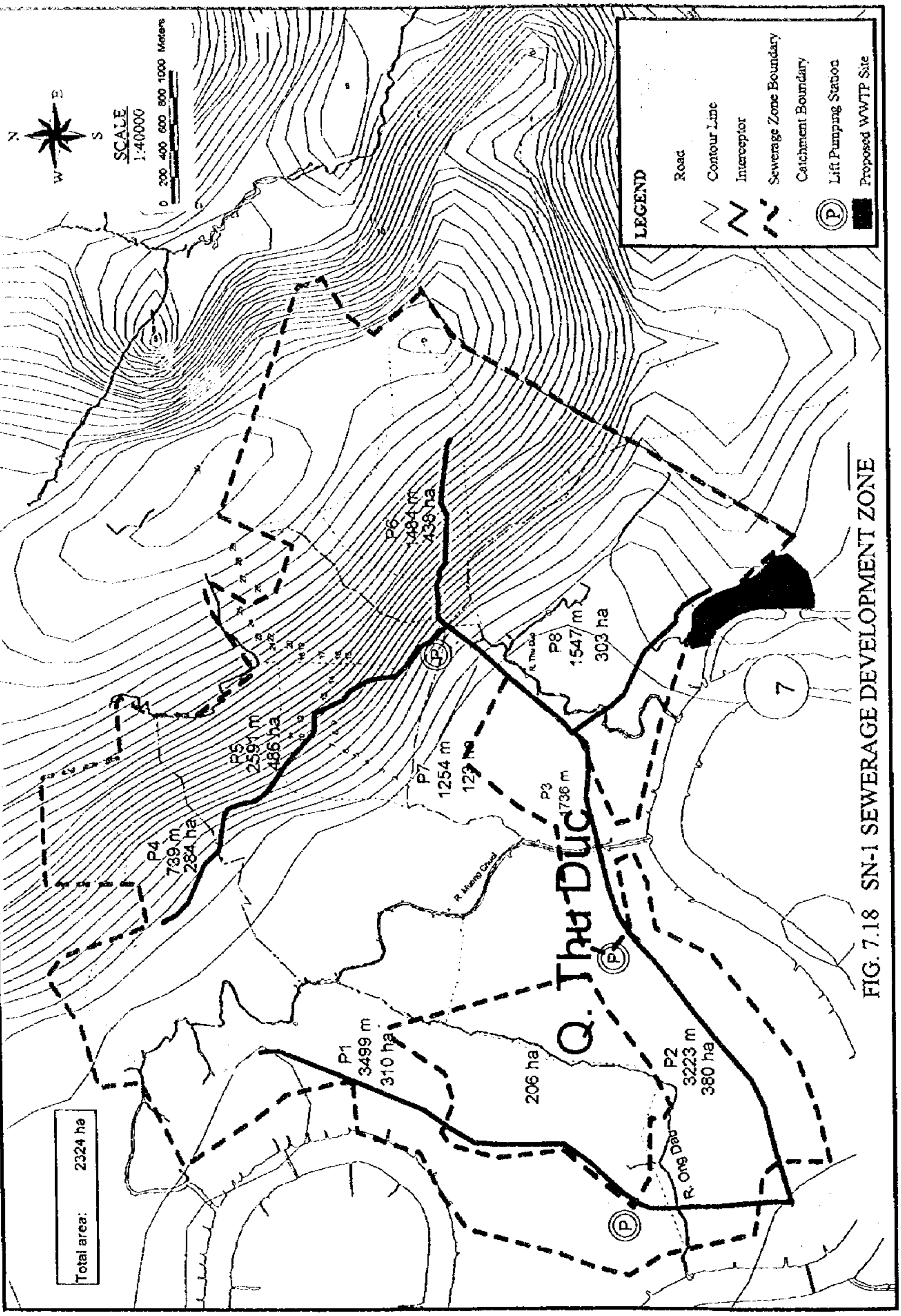

FIG. 7.18 SN-1 SEWERAGE DEVELOPMENT ZONE

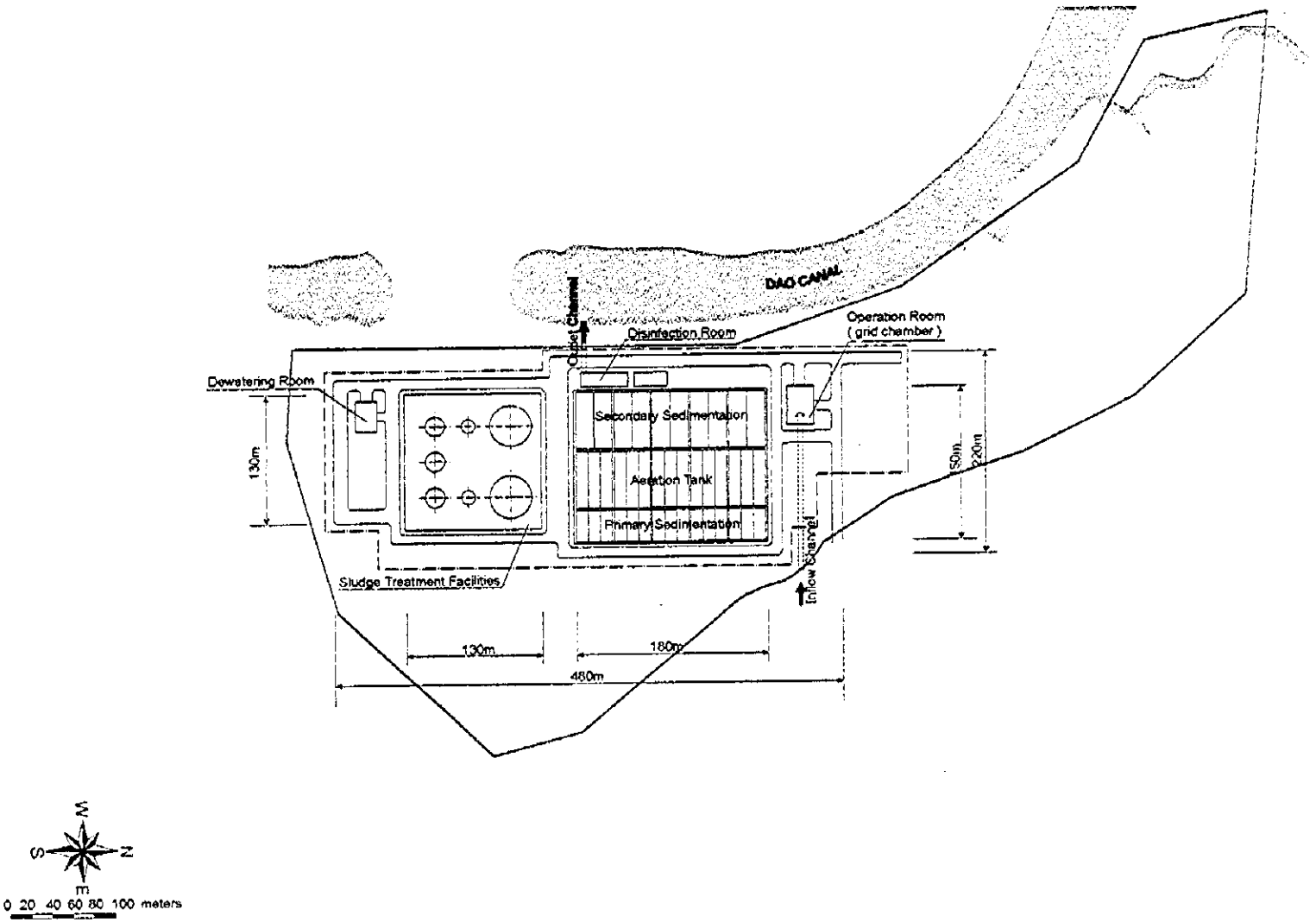

FIG. 7.19 LAYOUT OF SN-1 WASTEWATER TREATMENT PLANT

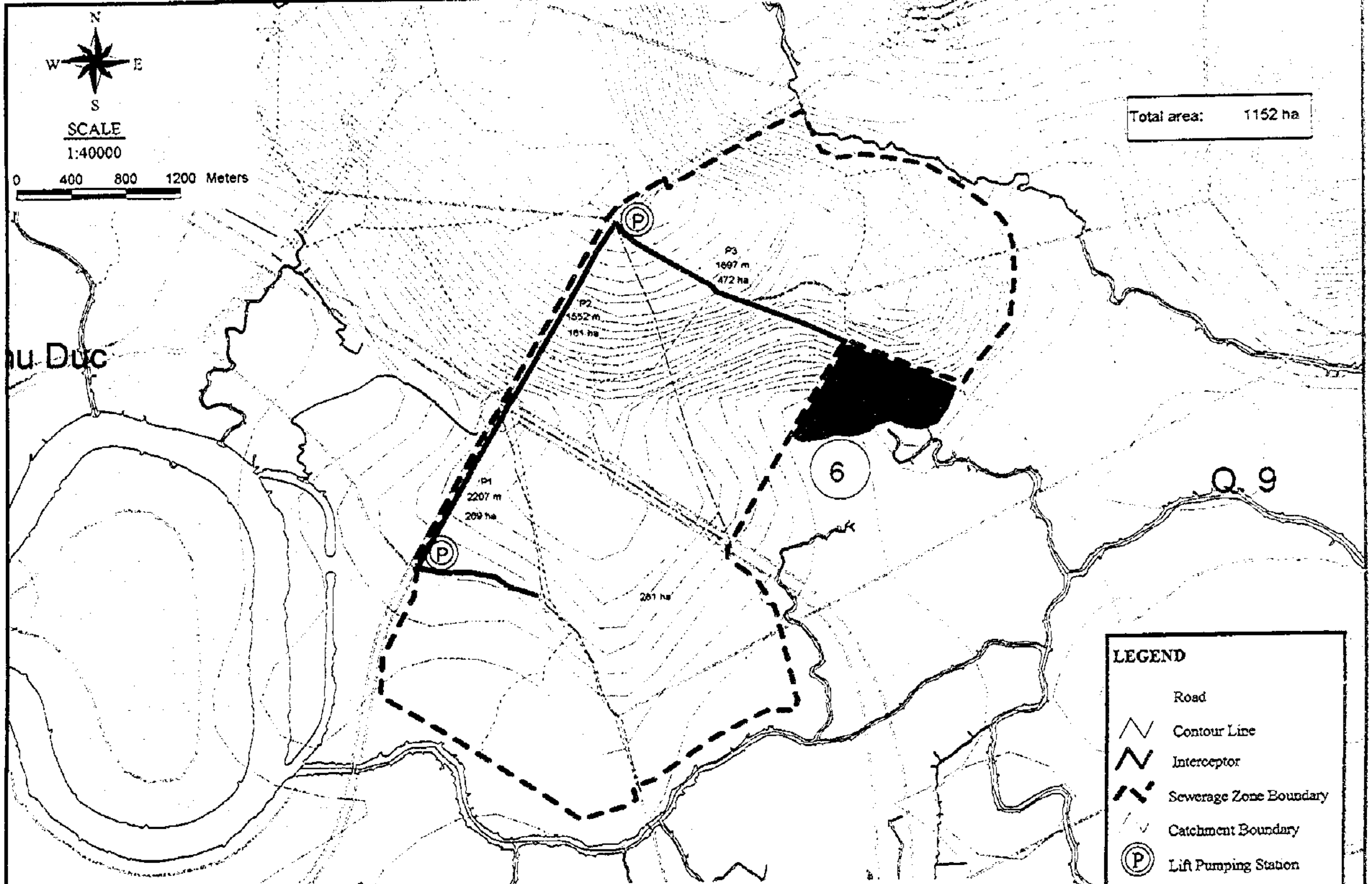

FIG. 7.20 SN-2 SEWERAGE DEVELOPMENT ZONE

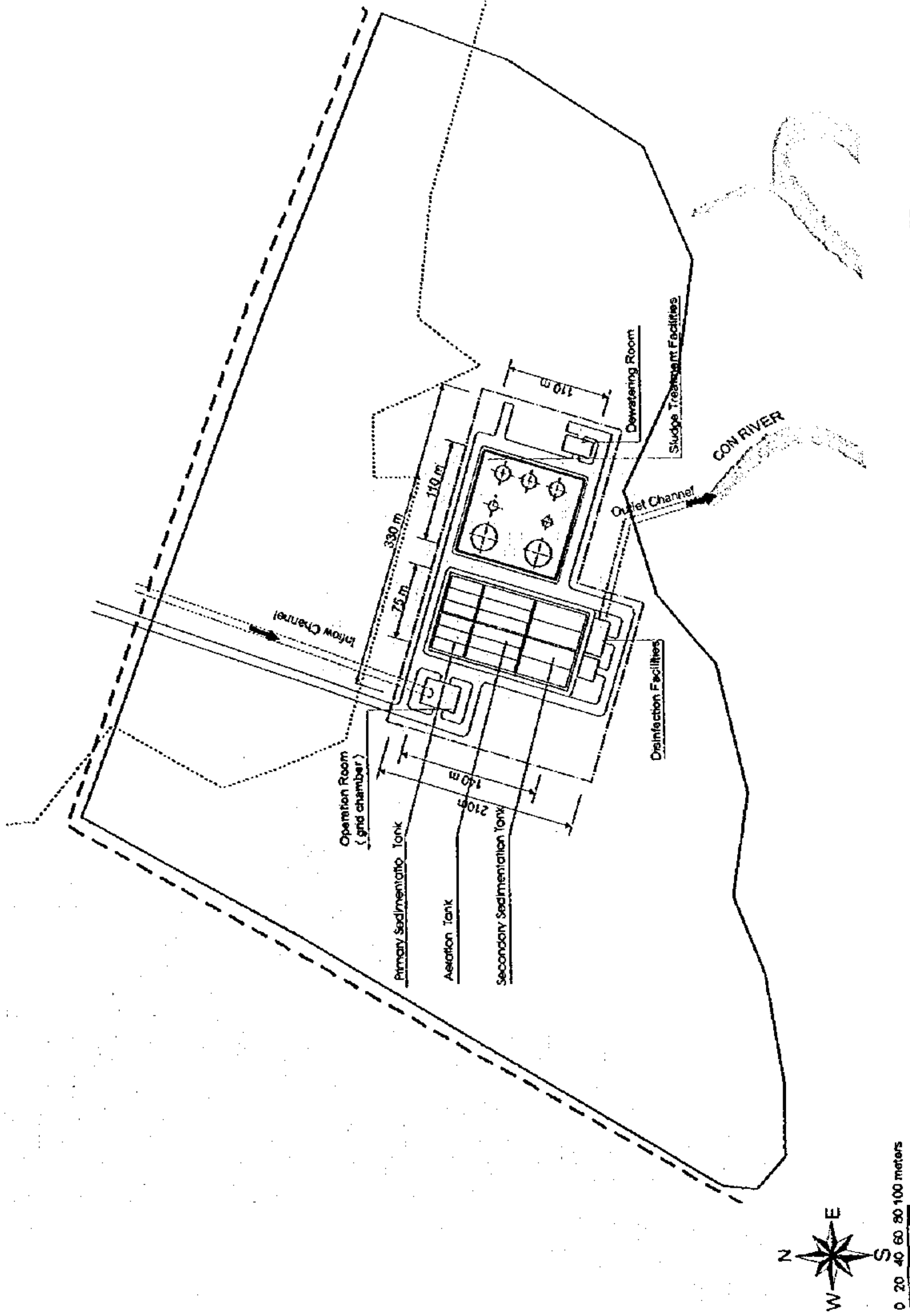

FIG. 7.21 SN-II WASTEWATER TREATMENT PLANT

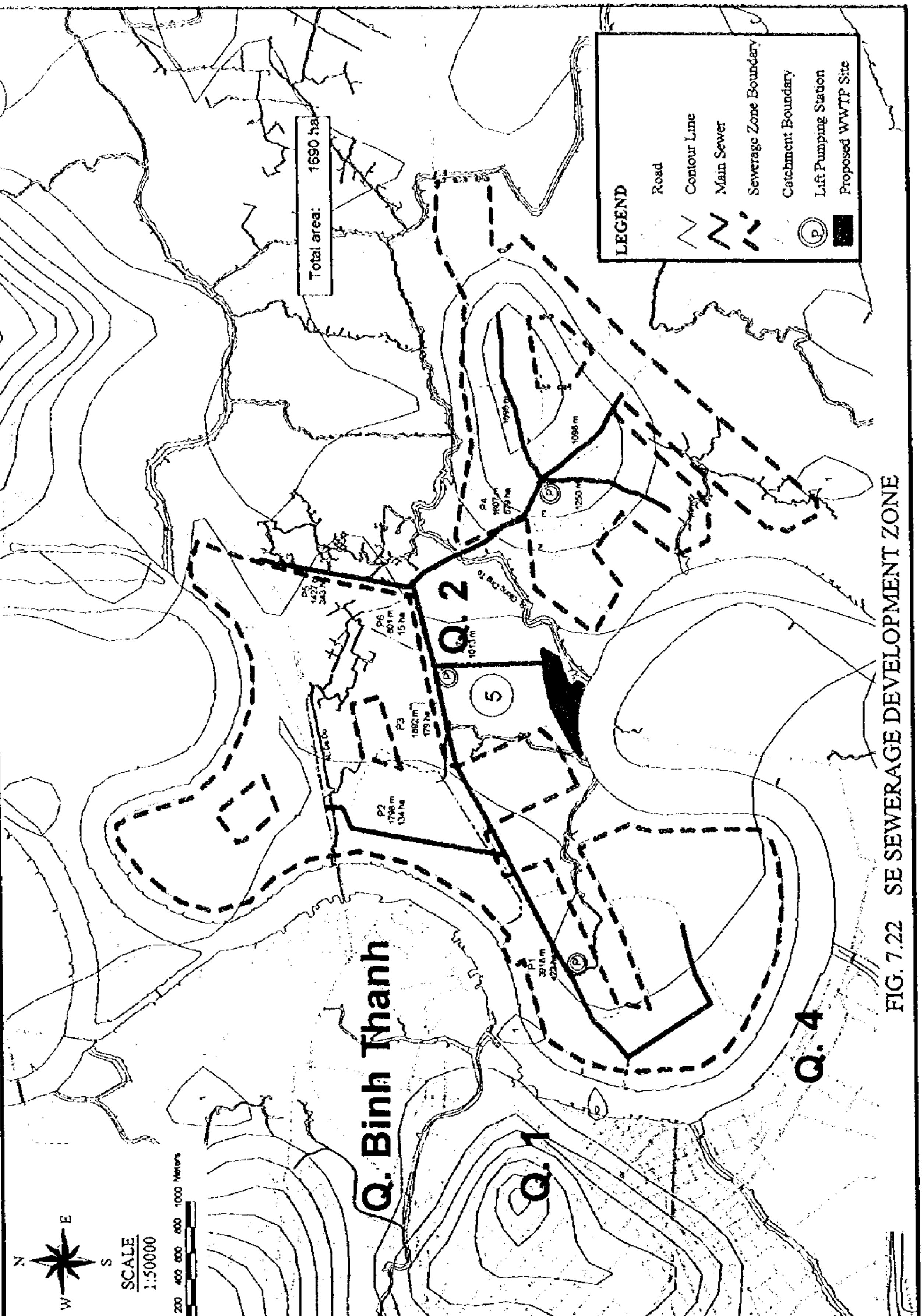

FIG. 7.22 SE SEWERAGE DEVELOPMENT ZONE

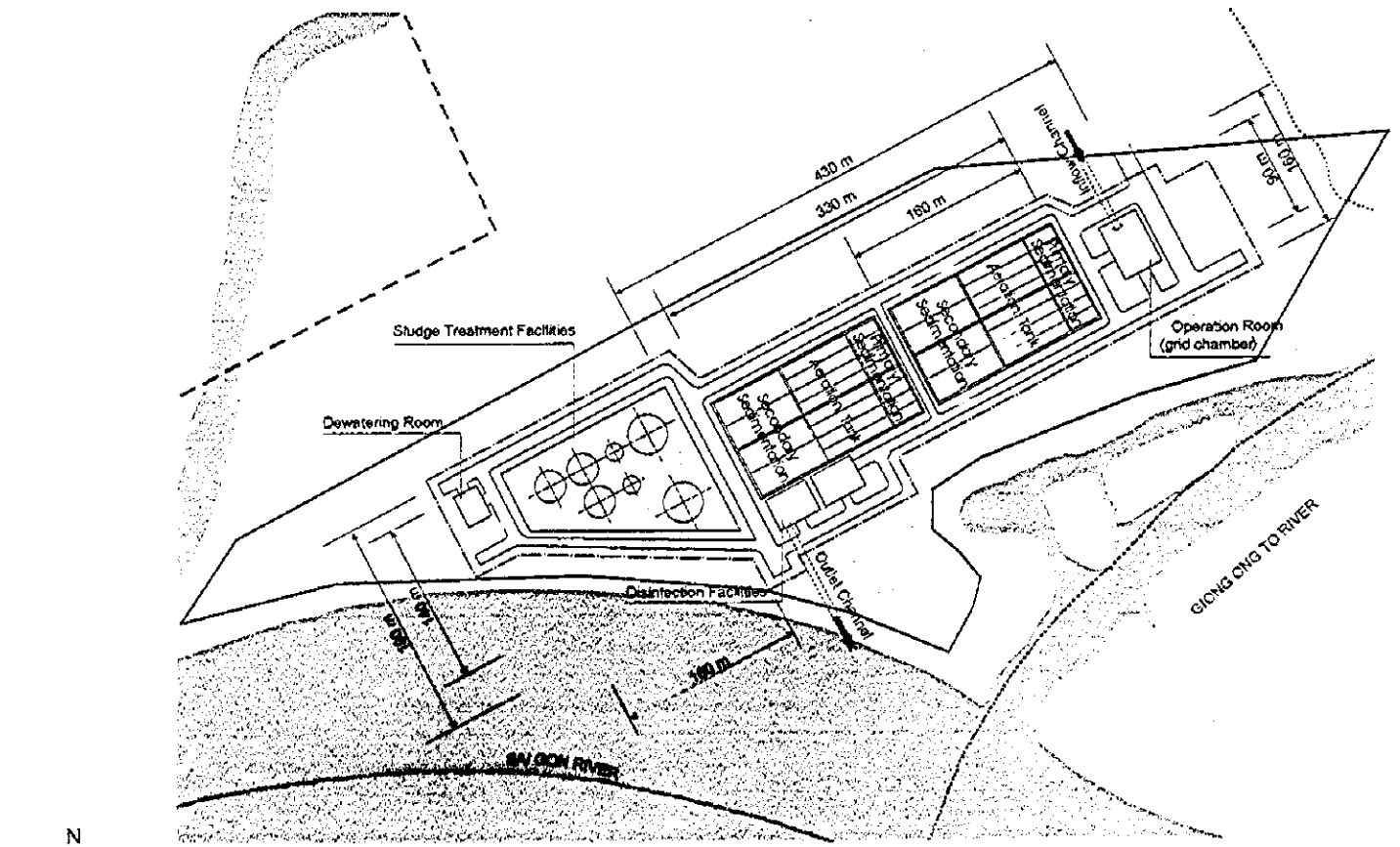

FIG. 7.23 LAYOUT OF SE WASTEWATER TREATMENT PLANT

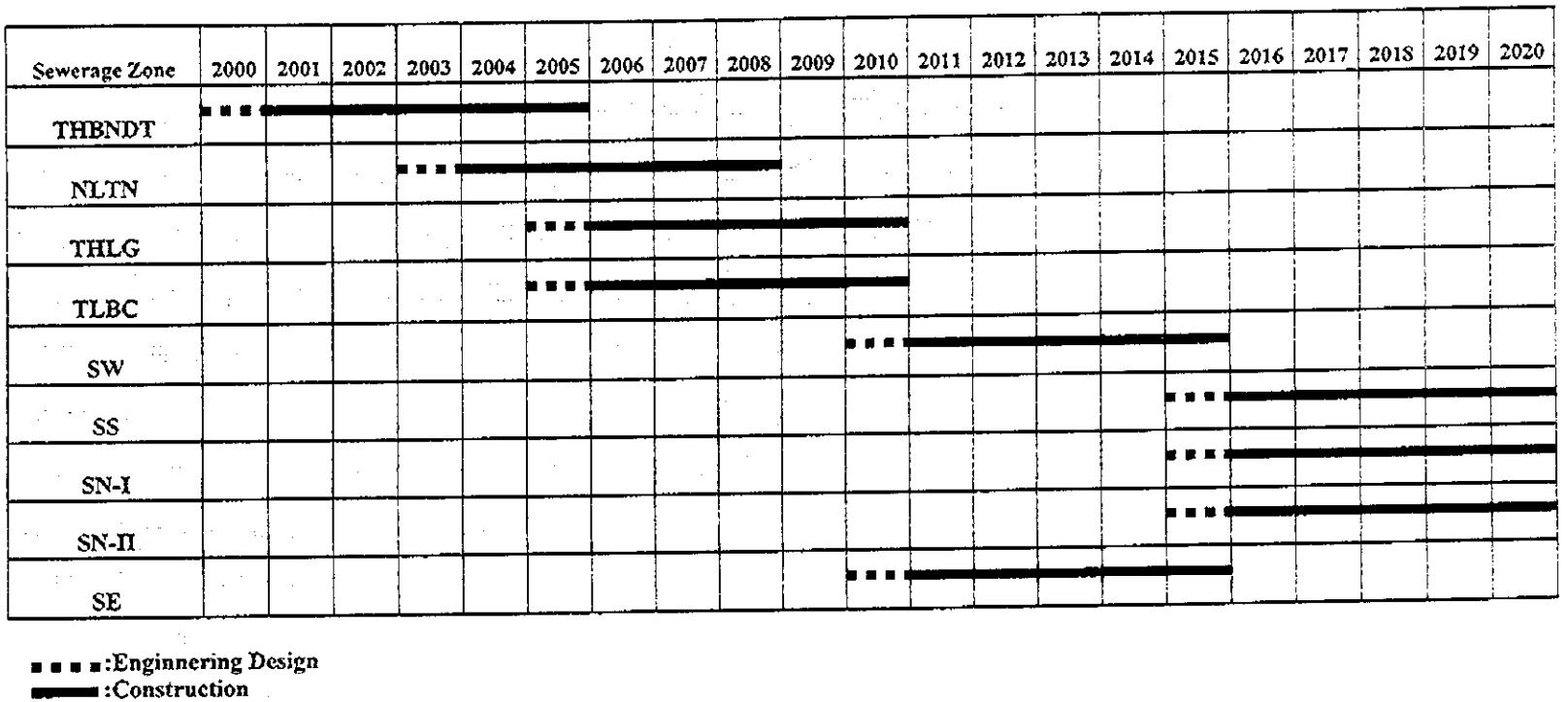

Fig. 7.24 IMPLEMENTATION PROGRAM FOE SEWERAGE DEVELOPMENT

CHAPTER 8

PRIORITY PROJECT PLAN AND ITS PRELIMINARY DESIGN

CHAPTER 8 FEASIBILITY STUDY ON PRIORITY PROJECT

8.1 Planning Conditions

8.1.1 Scope of Priority Project

(1) Project Area

The Priority Project area covers the central part of HCMC with an area of 30.65 km^2 defined as Tau Hu-Ben Nghe-Doi-Te basin. As shown in Fig. 8.1, the area also includes the isolated area of Than Da of 15.4 ha, Ben Me Coc (1) of 70.9 ha and Ben Me Coc (2) of 46.0 ha as pump drainage improvement area. The area encompasses 9 Districts (District 1, 3, 4, 5, 6, 8, 10, 11 and Binh Than) with total existing and future population of 1.47 million in 1997 and 1.39 million in 2020.

(2) Scope of Project

The Priority Project consists of the following sub-projects:

Urban Drainage Improvement

(a) Tau Hu - Ben Nghe Canal Improvement
(b) Pump Drainage Improvement
(c) Drainage Pipe System Improvement

Sewerage Development

(a) Construction of Interceptor Sewer
(b) Construction of Conveyance Sewer
(c) Construction of Intermediate Pumping Station
(d) Construction of Wastewater Treatment Plant
(e) Sewerage Collection System Development

8.1.2 Target Year

The target completion year of the Priority Project is set at 2010 on the premise that the project implementation consisting of Phase 1 (2001 to 2005) and Phase 2 (2006 to 2010) will be taken up at least 10 years.

8.2 Tau Hu - Ben Nghe Canal Improvement

8.2.1 Present Condition of the Canal

Tau Hu - Ben Nghe canal situated along southern edge of the central business area of HCMC connect with Saigon River to the east and Phu Dinh Port to the west. A total length of the canal is about 12.2 km. The canals have 3 functions, urban drainage for 10 districts of about 61.7 km^2 (District 1, 3, 4, 5, 6, 8, 10, 11, Tan Binh and Binh Chang District), waterway transportation between Mekong Delta and HCMC, and water open space including landscape for the city life. However, due to much sedimentation of garbage, waste disposal and soil deposit, encroachment of illegal houses along the canal, and lacking of sufficient operation/maintenance, Tau Hu - Ben Nghe canal has been made shallow and narrow. Decreasing of flow sections of the canal has resulted in a great hindrance to urban drainage and navigation. The existing hydraulic characteristics of Tau Hu - Ben Nghe canal is shown in Fig. 3.2 (1/2).

Tau Hu - Ben Nghe canal receives untreated domestic and industrial wastewater of about 300,000 m^3/day from surrounding districts and water quality of the canal has been deteriorated to an alarming level. The canal water is black in color and emanates offensive odor. At Chu Y bridge, Tau Hu canal has BOD as high as 150 - 250 mg/l. Water quality in Ben Nghe is relatively better due to dilution of Saigon River and BOD is about 100 - 150 mg/l, however, quality of canal is similar to wastewater.

According to 1996 housing survey data by DLH, the number of residents on and along Tau Hu - Ben Nghe canals is reported about 65,000 with 7,800 households. Among them, illegal houses account for 80 % and most of them encroach on the canal water. Almost half of them have been living in the low level or temporary houses without electricity and water supply services for more than 20 years. Many houses supported by wooden or concrete piles have been constructed in the canal and disturb the above canal functions.

There are 4 kinds of existing structures related to the canal improvement. These are 14 electric power lines, 16 road and footbridges, 7 quays and bank protection/revetment with total length of about 5,200 m as shown in Fig. 8.2.

8.2.2 Related On-going Project

Two (2) on-going projects are studied for preparation of canal improvement plan. These are summarized below.

(1) Dredge and Rehabilitation Project on Ben Nghe - Tau Hu - Lo Gom for Navigation

OMW has completed the feasibility study on the captioned project in December

1995. The main objectives of the project are to dredge the canal in order to recover the enough draft for the navigation and to contribute as much as possible for the improvement of urban drainage condition in the central parts of the city. Objective channels are Ben Nghe canal of 3.45 km, Tau Hu canal of 6.30 km, Lo Gom canal of 2.75 km and three (3) Ngang canals of 1.35 km. Estimated total dredging volume is more than 1.0 million m^3. The project cost is estimated at 36.4 billion VND including physical contingency. The proposed project was approved by PCHCMC on 9 April 1998, however, the construction is not started yet.

(2) Rehabilitation and Widening of Ben Chuong Duong - Ben Ham Tu - Tran Van Kieu Road

In 1995, DTPW has conducted the feasibility study on the rehabilitation and widening project of Ben Chuong Duong - Ben Ham Tu - Tran Van Kieu Road. The existing road with total length of about 9.1 km runs along and close to Tau Hu - Ben Nghe canal and mainly functions as a regional road. These roads were constructed in the French colonial time, so the road is very narrow, only 6 to 10 m in width. DTPW has proposed to rehabilitate and widen these roads in order to create a new urban road, to meet with the transport requirement for the communication between Northeast and Southwest regions of the city and to contribute the improvement of city traffic condition.

Objective roads are Ben Chuong Duong Road of 2.7 km, Ben Ham Tu Road of 2.8 km, Tran Van Kieu Road of 3.6 km and new road from Lo Gom bridge to National Highway No. 1 of 4.3 km. The proposed typical road width is 40 m including two sidewalks of 17 m. Number of house to be relocated is counted at 4,650 houses. The project cost is estimated at 912,052 billion VND including land acquisition and house compensation. According to PCHCM, this project has been short-listed as a priority project by the financial assistance of Japanese Government. Special Assistance for Project Formation (SAPROF) Study has being undertaken by Overseas Economic Cooperation Fund (OECF).

8.2.3 Planning Criteria

(1) Flood Protection Level and Design Rainfall

Flood protection level (design scale) for Tau Hu - ben Nghe canal improvement is applied at 10 year frequency flood. The following rainfall intensity-duration formula developed in Master Plan is employed for Tau Hu - Ben Nghe canal improvement. (refer to Fig. 2.10)

(a) $I = 29,125/(t^{1.25} + 154)$: $t < 3$ hours
(b) $I = 1,669/(t^{0.80} - 16)$: 3 hours $< t < 24$ hours

where, I: Point rainfall intensity (mm/hour),
t: Duration (minutes)

(2) Design High Water Level

Design High Water Level (DHWL) at the mouth of Ben Nghe canal is applied at EL +1.32 m above MSL, which is the average of monthly maximum water levels during August and November. Design 24 hours consecutive water level variation developed in Master Plan is employed for evaluation of the proposed improvement plan by hydrodynamic model.

(3) Navigation Requirement

Tau Hu – Ben Nghe canal improvement plan is to be met the following navigation requirements proposed by OWM.

Navigation Requirements for Tau Hu - Ben Nghe Canals

Canal	Section		Min. Canal	Design Water	Proposed Canal	Boat Size
	Start	End	Width (m)	Level (m)	Bed Elevation (m)	(ton)
Ben Nghe	Saigon River	Chu Y Bridge	21.0	- 1.20	- 3.30	100 - 200
Tau Hu (Downstream)	Chu Y Bridge	Ngang No.1	21.0	- 1.20	- 3.30	100 – 200
Tau Hu (Upstream)	Ngang No.1	Phu Dinh Port	22.0	- 1.20	- 4.30	300
Ngang No.1 to No.3	Tau Hu Canal	Doi Canal	22.0	- 1.20	- 4.30	300

(4) Other Criteria

Other criteria, such as run-off formula, Manning's roughness coefficient, freeboard, etc. are the same as those in Master Plan study.

8.2.4 Proposed Channel Improvement Plan

(1) Alignment

The alignment of the courses of Tau Hu - Ben Nghe canal is proposed considering the following technical viewpoints:

(a) to coincide with the existing channel alignment to minimize land acquisition and house evacuation
(b) to ensure the curve within the radius from 200 to 300 m for the smooth navigation
(c) not to reduce the existing canal width
(d) to coincide the road alignment proposed in the pre-feasibility study on Ben Chuong Duong - Ben Ham Tu - Tran Van Kieu Road improvement project

The proposed alignment of Tau Hu - Ben Nghe canal is shown in Fig. 8.3.

(2) Longitudinal Profile

As mentioned before, the proposed canal bed has to be designed principally to meet the requirements of waterway transportation. The canal bed slope is planned at 1:20,000 to maintain the canal bed and to be more gentle hydraulic gradient of DHWL, which is nearly equal to or lower than the existing ground level in principle so as not create drainage problems inside the embankment.

The proposed longitudinal profile of Tau Hu - Ben Nghe canal is shown in Table 8.1 and Fig. 8.4.

(3) Cross Section

A single cross section with some slope protection and/or revetment is employed for the canal improvement to be protected from bank erosion. The proposed cross sections are classified broadly into the following three (3) types:

(a) Type A: Trapezoidal shape channel with 1:1.5 slope lined by stone masonry
(b) Type B: Trapezoidal shape channel with 1:0.5 slope lined by stone masonry
(c) Type C: Rectangular shape channel lined by concrete retaining wall or concrete pile revetment

These types are sub-divided into seven types, A1 to A4, B1 to B3, C1 and C2, based on the combination with the available existing slope protection /revetment as shown in Figs. 8.5 (1/2) and (2/2). Table 8.2 shows the design cross section of Tau Hu - Ben Nghe canal.

(4) O/M Road

Generally, O/M road has to be provided along the river/canal to supervise and maintain the channels. Since there are public roads along the both banks of Tau Hu - Ben Nghe canal, it is not necessary to provide newly O/M road along the canal. However, the channel improvement aims to improve not only urban drainage and navigation, but also water body environment and landscape of the

city. So, in order to maintain the amenity of water body environment it is proposed to provide principally open space of maximum 5.0 m in width along both banks of the canal, in which tree planting and installation of some facilities for recreation/relaxation are recommended.

(5) Slope Protection and Revetment

In due consideration of technical and economical aspects and easiness of land acquisition and house evacuation, three (3) types of slope protection and revetment are preliminarily designed as shown in Fig. 8.6.

(a) Type A: This is a slope protection lined stone masonry with 1:1.5 slope, which is the most typical type and applied for the channels having no land acquisition and house evacuation problems.

(b) Type B: This is the slope protection lined stone masonry with 1: 0.5 slope. This type is applied for channel improvement from Cha Va Bridge to the junction of Ngang No. 1 (about 1.2 km) and from Chu U Bridge to Ngang No. 2 (about 0.6 km), which have a restriction of land.

(c) Type C: This is reinforced concrete revetment lined T-shaped concrete retaining wall of 4.5 m in height. This type is employed for the channel improvement near Cha Quan Hospital of 525 m in length, which has strict limitation of land.

8.2.5 Evaluation of Proposed Canal Improvement Plan by Hydrodynamic Model

Hydrodynamic simulation by MIKE 11 software has been carried out to evaluate the proposed canal improvement prepared on mainly navigation requirements against the design rainfall event and design water level conditions. Canal network for hydrodynamic model is shown in Fig. 8.7. In total, four cases with nine sub-cases for existing canal condition and ten sub-cases for proposed one have been investigated.

Case 1: Represents closed canal system (without interaction with southern canals) with constant water levels at the boundaries

Case 2: Represents closed canal system with dynamic water levels at the boundaries (3 sub-cases)

Case 3: Represent open canal system (with interaction with southern canals) with constant water levels at the boundaries (2 sub-cases)

Case 4: Represents open canal system with dynamic water levels at the boundaries (3 sub-cases)

Hydrodynamic simulation has given the following findings:

Under the existing canal condition, Tau Hu upstream reaches are expected to inundate during 10 year rainfall event. Maximum water level is estimated at +1.89 m under the most severe Case 1. However, it is founded to be at +1.68 m under the most practical Case 4. In general, maximum water levels for different cases are found to be about 20 cm higher under the existing canal condition than under the proposed one. Maximum discharge along Tau Hu and Ben Nghe canals are estimated at +132 m^3/s and +123 m^3/s for Case 2 and 4 respectively. Maximum discharge along Doi and Te canals is estimated at +522 m^3/s and +691 m^3/s respectively.

Under the proposed canal condition, maximum water level of Tau Hu canal is estimated at + 1.69 m in the most severe Case 1. Whereas, it is found to be +1.50 m in the most practical Case 4. For the Case 1 and 2 of closed canal system, a free board of 30 to 40 cm can be maintained from the proposed dyke level of +2.0 m. On the other hand, for the Case 3 and 4 of open canal system (more practical cases), a free board of more than 40 cm can be expected from the top elevation of proposed dike. Maximum discharge along Tau Hu - Ben Nghe and Doi – Te canals are estimated at +168 to +275 and +548 to +654 m^3/s in Case 2 and 4 respectively.

Tables 8.3 and 8.4 show the maximum discharge and water levels by case for each canal. Longitudinal profiles of water levels under the existing and proposed condition are shown in Fig. 8.8 and 8.9 respectively.

The hydrodynamic simulation reveals that under the existing canal condition, inundation is expected to occur along Tau Hu - Ben Nghe canal for 10 year frequency flood. However, under the proposed optimum canal improvement plan, a free board of more than 40 cm can be maintained from the proposed dyke level of + 2.00 m.

8.3 Pump Drainage Improvement

8.3.1 Present Condition of the Pump Drainage Area

(1) Thanh Da Area

Thanh Da drainage area of about 49.5 ha belongs to Ward 27 of Binh Than District. Almost 90 % of the area have been development before 1975 as a residential area consisting of many high story apartments and few independent houses. Remaining 10 % of the area is low-lying and still undeveloped, but will be developed as a residential area near future.

Systematic drainage pipe network system was prepared in Thanh Da area before 1975. The northern part of 20.0 ha from Xo Viet Nghe Tinh Road drains directly into Saigon River through four (4) trunk sewers and has no inundation problems. The southern area of 15.4 ha from this road provided four (4) main sewers of ø 800 to ø1,000 mm as shown in Fig. 8.10, has flooded at least 10 times during the high tide season in every year, due to its low ground elevation of 0.90 to 1.20 m. Inundation area, depth and duration have been surveyed at about 16 ha, 30 to 50 cm and four (4) hours respectively. In the past, one small pumping station was constructed and operated, however, it was damaged and broken, due to the budgetary constrain for the sufficient operation and maintenance work. Existing sewers are mostly blocked by garbage, solid disposal and debris, which is one of the cause of serious inundation. Cleaning of the sewer pipes shall be done immediately.

(2) Ben Me Coc (1) and (2) Area

Ben Me Coc (1) drainage area of 70.9 ha belong to Ward 15 of District 8. The area is rectangular shape surrounded by Tau Hu, Lo Gom, Ngang No.2/No. 3 and Doi canals, and is divided into eastern and western parts by the pond as shown in Fig. 8.10. The eastern part of the area (32.6 ha) has been fully developed as warehouse and residential areas without satisfactory urban development plan. Secondary and tertiary sewers (ø 400 - ø 600) have constructed under the narrow streets. On the other hand, the western part of the area has not fully developed yet and tertiary pipe drains (ø 400) has been constructed in only limited area. Many warehouses and residents have been constructed along Lo Gom and Doi canals respectively. Inland areas are used to agricultural land and fishponds. District 8 has planned to develop as residential area including some green and open spaces, but no definitive implementation schedule is yet.

Ben Me Coc (1) area is topographically low from about 0.9 to 1.3 m. During high tide season, almost all area has inundated about 10 times per year. No sufficient dike around the area and no gate at the sewer outlets make more serious inundation. Inundation depth and duration have surveyed at 30 to 50 cm and 4 to 6 hours respectively.

Ben Me Coc (2) drainage area of 46.0 ha is a part of Ward 15 of District 8. The area is also rectangular shape surrounded by Lo Gom, Doi and Ngang No. 3 canals as the same as Ben Me Coc (1). Even though the area is not so far from Cho Long commercial center and has a potential to develop as a residential area, it is still not fully developed due to insufficient transportation, water supply and drainage system shown in Fig. 8.10. Almost all houses have been constructed along the ring road, however, a residential development has recently being progressed towards inland low-lying area by filling up. Flood condition of the area is almost the same as that of the western parts of Ben Me Coc (1).

8.3.2 Planning Criteria

(1) Flood Protection Level and Design Rainfall

Design scale for pumping station and drainage pipe is applied at 5-year and 2-year frequency flood respectively. The following design rainfall is employed for pump drainage improvement.

(a) For pumping station, 6 hours consecutive rainfall with 5-year frequency (R = 113.47 mm) is to be applied. (refer to Fig. 2.11)

(b) For drainage pipe, the following IDF formula with 2 year return period is to be applied. (refer to Fig. 2.10)

$I = 13{,}567/(t^{1.18} + 89)$: t < 3 hours
where, I: Point rainfall intensity (mm/hour),
t: Duration (minutes)

(2) Design Water Level

Design water levels at Than Da and Ben Me Coc areas are applied as follows:

Location	High Water Level	Mean Water Level	Low Water Level
Than Da Area	+1.32	+0.23	-2.11
Ben Me Coc (1) & (2)	+1.50	+0.27	-2.12

(3) Other Criteria

Other criteria, such as drainage criteria, specific requirement of pump and retarding pond, are the same as that of Master Plan.

8.3.3 Preliminary Design of Dike

During the high tide season from September to January, the proposed pump drainage areas have affected about 10 times a year by the external flood from the surrounding rivers and canals, due to lower existing dike elevation than that of proposed one of EL +2.0 m. A polder dike system is proposed to employ for these areas as the most suitable and economical flood mitigation measure.

(1) Thanh Da Area

HCMC constructed the dike along Saigon River to protect the proposed pump drainage area of 15.4 ha in Thanh Da from the external flood. However, intermediate section of about 74 m has never been provided any dike, due to the difficulty of construction by some illegal houses. New dike shown in Fig. 8.11, which is the same type as existing one, is proposed to construct for 74 m including relocation of illegal houses. Location of the proposed dike is shown in Fig. 8.12.

(2) Ben Me Coc (1) and (2) Area

At present, the existing ring roads in Ben Me Coc (1) and (2) have two function, transportation and dike to protect from the external flood of Doi, Tau Hu and Lo Gom canals. However, top elevation of the existing ring roads is 50 to 80 cm lower than the proposed dike of +2.00 m. This is a main reason to occur the serious external floods from the surrounding canals in high tide season in every year. New dikes shown in Fig. 8.11 are proposed to construct along Tau Hu, Lo Gom and Ngang No.2 and 3 simultaneously in the canal improvement work. The proposed new dike length of Ben Me Coc (1) and (2) is 2.59 and 1.76 km respectively. However, as Doi canal improvement is excluded in the priority project, temporary dike shown in Fig. 8.11 is proposed to construct along Doi canal. Proposed length of temporary dike is about 1.45 km for Ben Me Coc (1) and 1.43 km for Ben Me Coc (2). Location of the proposed dike is shown in Figs. 8.13 and 8.14.

8.3.4 Preliminary Design of Drainage Pipe

In order to complete the drainage pipe network in Thanh Da area, construction of some new pipes to be connected between the existing sewers and proposed pumping station and/or retarding pond are proposed. Then, in Ben Me Coc (1) and (2) areas, new drainage pipelines are proposed to construct along the ring road, in order to mitigate flood damages along the ring road and to integrate the existing many small outlets of secondary drains. These sewers have been designed to convey a 2 year flood runoff calculated by Rational Method.

The proposed sewers by each pump drainage area are summarized below:

Area	Pipe Size (mm)	Pipe Length (m)
Thanh Da	ø 800 to ø 1,200	655
Ben Me Coc (1)	ø 900 to ø 1,800	4,607
Ben Me Coc (2)	ø 600 to ø 1,850	4,206

Figs. 8.12 to 8.14 show the proposed drainage pipe network for three (3) pump drainage systems respectively.

8.3.5 Preliminary Design of Pumping Station and Retarding Pond

(1) Division of Pump Drainage Area

Taking into consideration of the existing situation of topography, urbanization, existence of pond, difficulty of land acquisition, and prioritization of each pump drainage area, only Ben Me Coc (1) area is divided into two (2) pump drainage areas, east and west. Other two (2) areas is planned to be one (1) pump drainage basin.

(2) Specific Requirement of Pumping Station and Retarding Pond

To economize on total pump drainage cost by reducing the required pump capacity, each pumping station is proposed to provide the retarding pond. The specific requirements of pump station and the retarding pond (pump capacity and storage volume) are proposed to be 2.1 $m^3/s/km^2$ and 69,000 m^3/km^2 by the mass curve method in M/P study.

Calculation results are summarized below:

Name of Drainage Area	Area (ha)	Required Pump Capacity (m^3/s)	Required Storage Capacity of Retarding Pond (m^3)
Thanh Da	15.4	0.32	7,600
Ben Me Coc (1) (East)	32.6	0.68	16,700
Ben Me Coc (1) (West)	38.3	0.80	19,600
Ben Me Coc (2)	46.0	0.97	23,500

(3) Proposed Pumping Station

Considering sufficient combination with drainage pipe network and pump drainage system and easiness of land acquisition, construction sites of these pumping stations are proposed as shown in Figs. 8.12 to 8.14.

Regarding the design high and low water level (DHWL and DLWL) of these pumping stations are proposed as follows:

Name of P.S.	Inlet Side		Outlet Side	
	DHWL (m)	DLWL (m)	DHWL (m)	DLWL (m)
Thanh Da P.S.	0.90	-1.00	+1.32	-1.10
Ben Me Coc (1) P.S.	0.90	-1.00	+1.50	-1.10
Ben Me Coc (2) P.S.	0.90	-1.00	+1.50	-1.10

Note: 1. DHWL of inlet side is planned to be the same as minimum ground elevation of residential area.
2. DLWL of inlet side is planned to easily maintain the water level by tidal effect of Saigon River and Doi canal.
3. DHWL and DLWL of outlet side is planned to be average of maximum monthly high water level and low water level of Saigon River and Doi canal respectively.

(4) Proposed Retarding Pond

Each pumping station is proposed to provide with retarding pond at inlet side to reduce the required pump capacity and to economize on total pump drainage cost. Existing ponds in Thanh Da and Ben Me Coc (1) areas are utilized as the retarding pond. However, as no pond to be utilized as retarding pond is in Ben Me Coc (2) area, inland possible site of about 12,375 m^2, where is almost 100 m far from the proposed pumping station and is no house to be relocated, is proposed to have land acquisition.

The proposed hydraulic requirement of each retarding pond is shown below:

Retarding Pond	DHWL (m)	DLWL (m)	Effective Depth (m)	Pond Area (m^2)	Storage Cap. (m^3)
Thanh Da R.P.	+0.90	-1.00	1.90	4,050	7,695
Ben Me Coc (1) (East)	+0.90	-0.20	0.70	19,000	13,300
Ben Me Coc (1) (Total)	+0.90	-1.00	1.90	19,000	36,100
Ben Me Coc (2) R.P.	+0.90	-1.00	1.90	12,400	23,560

Proposed drainage systems for three (3) pump drainage areas are shown in Figs 8.12 to 14.

8.3.6 Hydraulic Evaluation by Hydrodynamic Simulation Model

The proposed pump drainage systems for three (3) areas have been evaluated under 5 year return period rainfall event and DHWL condition by hydrodynamic simulation model, "MOUSE". Hydrodynamic simulation has been carried out the following three (3) cases:

Case 1: Thanh Da pump drainage improvement plan for total area

Case 2: Ben Me Coc (1) pump drainage improvement plan has been investigated two sub-cases.
Case 2.A: Represent drainage improvement plan for East area
Case 2.B: Represent drainage improvement plan for the total (East and West) area
Case 3: Ben Me Coc (2) pump drainage improvement plan for total area

As shown in Table 8.5, hydrodynamic simulation has given the following findings:

(a) High water level of retarding pond varies from about +0.85 to +0.95, which is almost the same or lower than minimum ground elevation of residential area.
(b) Pump operation time for one food will very from 4.0 to 4.5 hours.
(c) Maximum temporary inundation depth will vary from 10 to 15 cm.

Therefore, the proposed pump drainage system can be considered to be able to cope with a 5 year flood.

8.3.7 Preliminary Design of Proposed Facilities

(1) Major Mechanical and Electrical Equipment

(a) Pump Equipment

The conventional pump applied for urban drainage system is generally classified into (i) Mixed Flow Pump, (ii) Axial Flow Pump, (iii) Centrifugal Flow Pump, (iv) Screw Pump and (v) Submersible Pump. In view point of these applicable ranges in pump head and bore size, the following pump type alternatives are selected.

- Alternative I: Vertical Shaft Axial Flow Pump
- Alternative II:Horizontal Shaft Axial Flow Pump
- Alternative III: Submersible Motor Pump

As the results of comparative study for these alternatives shown in Table 8.6, Alternative III, "Submersible Motor Pump" is recommended as the most applicable and economical pump type.

Considering the economical viewpoint and easiness of O/M, the pump unit number, pump capacity and its bore for each pumping station is proposed as follows:

Pumping Station	Pump Capacity (m^3/s)		Number	Bore of Pump
	Total	Unit	of Unit	(mm)
Thanh Da P.S.	0.35	0.35	1	ø 400
Ben Me Coc (1) (East) P.S.	0.70	0.35	2	ø 400
Ben Me Coc (1) (West) P.S.	0.80	0.80	1	ø 750
Ben Me Coc (2) P.S.	1.05	0.35	1	ø 400
		0.70	1	ø 600

The proposed submergible pump is driven by an electric motor. The pump power source is supplied from the existing power line of Electric Company No.2 located near the proposed pump sites, of which voltage is 15 KV.

(b) Other Major Equipment

The other major mechanical and electrical equipment to be required for the installation, operation and maintenance works of the pumping stations are listed in Table 8.7.

(2) Layout of Proposed Pumping Station with Retarding Pond

The proposed pumping stations consist of inlet pits, pump pit, discharge basin, sluice way and related structures. The civil works of these structures are composed of earth work, foundation work, reinforced concrete work, masonry and others. The proposed retarding ponds of Thanh Da and Ben Me Coc (1) are planned to improve the existing pond. However, Ben Me Coc (2) retarding pond is planned to newly constructed at inland agricultural land far from about 100 m from the proposed pumping station. The general layouts of these pumping stations and retaring ponds are shown in Figs. 8.15 to 17. These pumping stations will be constructed in the following phasing:

- Phase I (2001 - 2005): Thanh Da P.S. and Ben Me Coc (1) (East) P.S.
- Phase II (2006 - 2010): Ben Me Coc (1) (West) P.S. and Ben Me Coc (2) P.S.

Design concept of each structure and these preliminary drawings are shown in Appendix E.

8.4 Drainage Pipe System Improvement

8.4.1 Present Condition of Main Combined Sewer

The priority project for the main combined sewer improvement is focused on the sub-catchments of C.4.3, C.4.4, C.4.5 and C.c in Central City Drainage Zone (C-zone).

The total length of the existing main combined sewer installed in the project area amounts to 102 km.

The priority area is divided into 5 sewer network zones based on the main combined network as shown in Fig. 8.18. The length of the sewer by each sewer network zone is presented below.

Sewer Network Zone	Length (km)
A	36.2
B	3.4
C	23.9
D	24.3
E	14.5
Total	102.3

8.4.2 Planning Criteria

More than 50 % of the sewer in the sewer network zone A is considered to be old sewer installed in 1980s. However, a sever inundation can not be identified by the flood survey in this zone. It can be said that most of them work well according to the field survey in Master Plan stage.

The existing main combined sewer networks shall be utilized to minimize the project cost and to achieve an immediate improvement of the main combined sewer system. Consequently, two (2) options for the sewer improvement are considered as follows;

1) In case that the road width is sufficient to install, an additional sewer is proposed to supplement the shortage.
2) In case that the road width is insufficient to install, the existing sewer is proposed to be replaced to a sewer dealing with the full discharge.

8.4.3 Proposed Drainage Pipe System Improvement Plan

For consideration of the network and the hydraulic condition at the outlet, unsteady sewer pipe flow modeling software called "MOUSE" has been applied to Hydrodynamic simulation.

The evaluation for the discharge capacity of the main combined sewer has been carried out for the design rainfall of 3 year return period and the design flood water level of 2 year return period under the condition of existing land use.

The simulation concluded 10 lines pf the main combined sewers to be improved because of an insufficient discharge capacity.

The location and the proposed plan of the sewer to be improved is shown Fig. 8.18.

8.4.4 New Drainage Pipe for Separate Sewer System Area

The right bank area of Doi – Te canal is proposed to be developed by separate sewer system according to the Vietnamese standard for a new development area. Hence new drainage pipe system is proposed to be installed in this area. The area consists of Rach Ong, Pham The Hien and Binh Dang areas and the total amounts to 537 ha (refer to Fig, 8.18).

The drainage pipe system is designed based on a 2-year flood runoff calculated by Rational Method The total length of drainage pipe is 26 km and the pipe diameter ranges from ϕ 600 mm to ϕ 3,000 mm. Main Features of the new drainage pipe are presented in the table below.

Diameter (mm)	Rach Ong (133 ha)	Pham The Hien (196 ha)	Binh Dang (208 ha)	Total
Total	7,176	10,011	9,273	26,460

8.5 Interceptor Sewer

8.5.1 General

(1) Sewerage Service Area

The Project Area of sewerage development covers an area of 3,065.4 ha, which consists of nine (9) districts of District 1, 3, 4, 5, 6, 8, 10, 11 and Tan Binh located in the central area of Ho Chi Minh City. The project area is shown in Fig. 8.1.

Tau Hu - Ben Nghe canal and Doi – Te canal run from west to east in the Project Area. Saigon River flows the east boundary of the Project area. These waterways and the areas of zoo, national stadium, etc. of 273.8 ha are not included in the sewerage service area. The details of exclusive area from the sewerage service area are as follows.

Saigon River : 59.6 ha, Tau Hu - Ben Nghe canal : 46.5 ha, Doi - Te canal : 66.8 ha, Other canals : 15.7 ha, Zoo : 20.6 ha, Thong Nhat Palace : 12.6 ha, Tao Dan Park : 19.7 ha, Phu Tho Stadium : 32.3 ha

Hence, the sewerage service area covers 2,791.6 ha with a total population of 1,421,778 in 2010 and 1,309,282 in 2020 respectively.

(2) Division of Sewerage Zone

The sewerage zone of 2,791.6 ha is divided into three (3) zones as left bank area of Tau Hu, Ben Nghe canal, island area between Tau Hu, Ben Nghe canal and Doi, Te canal and right bank area of Doi, Te canal. Then, these three (3) sewerage zones are further divided into 24 sub-zones as shown in Fig. 8.19. This division is made based on existing sewer network, canals, rivers and proposed interceptor route.

Sewerage service area and served population and by three (3) zones are shown in table below.

Area	1997		2010		2020	
	Covered Population	Population Density (person/ha)	Covered Population	Population Density (person/ha)	Covered Population	Population Density (person/ha)
Tan Hu – Ben Nghe Canal Left Bank (1,693 ha)	959,759	567	931,649	550	910,634	538
Island between Tan Hu-Ben Nghe and Doi-Te Canal (561 ha)	360,828	643	338,291	603	324,577	578
Doi – Te Canal Right Bank Area (537 ha)	148,116	288	151,838	295	155,071	302
Total (2,792 ha)	1,468,703	526	1,421,778	509	1,390,282	498

Note: Covered population and population density by 24 sub-zones are shown in Table 8.8.

8.5.2 Design Wastewater Discharge for Interceptor and Conveyance Sewers

Size of interceptor and conveyance sewer is designed to meet the possible maximum wastewater discharge since flow capacity of interceptor and conveyance sewers cannot be enlarged in stage easily. Hence, design wastewater discharge of interceptor and conveyance sewers is determined to be wet weather discharge in 2020 plus groundwater infiltration of 10 % of dry weather daily average wastewater discharge in 2020.

Design wastewater discharge consisting of wet weather discharge and groundwater infiltration in each zone is estimated as below.

Zone	Design Wastewater Discharge (m^3/day) (2020)		
	Wastewater	Groundwater	Total
Tan Hu – Ben Nghe Canal Left Bank (1,639 ha)	427,088	30,506	457,594
Island between Tan Hu-Ben Nghe and Doi-Te Canal (561 ha)	152,227	10,873	163,100
Doi – Te Canal Right Bank Area (537 ha)	72,728	5,195	77,923
Total (2,792 ha)	652,043	46,574	698,617

Note: Design wastewater discharge of 24 sub-zones is shown in Table 8.9.