4.6 MANAGEMENT OF THE PROJECT

The existing organization and institution or new organization proposed by the government for the urban drainage project are basically applied during construction stage of this project. After completion of construction of the facilities, following organization is proposed for operation/maintenance.

The urban drainage network of the priority project can be divided into three systems, i.e. Pikine Urban South System, Pikine Urban North System and Thiaroye System.

It is recommended that site offices be established to manage those systems. One site office will take care of one drainage system. Therefore, there will be three site offices.

Manpower required for the management of drainage facilities such as drainage channels (storm sewers, transmission pipes and open channels) and pumping stations is proposed to be as follows:

Item	Chief	Sub-Chief	Workers	Driver	Total
1. Pikine Urban North System	1	1	2	1	5
2. Pikine Urban South System	1	1	2	1	5
3. Thiaroye System	1	1	2	1	5
4. Overheads					2
TOTAL					17

The eligibility of the chief and sub-chief will be engineer. One vehicle will be stationed in each site office to be used essentially for the operation and maintenance of facilities. Office personnel will come from both SONEES and CUD.

4.7 ECONOMIC ANALYSIS

4.7.1 Estimation of Flood Damage

1) Flood Damage in the 1989-Scale Flood and the Annual Flood

The feasibility study area covers the Central Pikine and some part of its surroundings. The number of inundation areas is 15 as shown in *Table C.4.15*. Their code numbers succeed those used in the master plan study. They are 1, 2, 3, 4, 6, 7, 8, 10, 11, 13, 14, 15, 46, 47 and 48. Their locations are shown in *Figure C.1.6*.

The inundation areas, the number of houses in the inundation areas, the average depths and durations of inundation in 1993 under the 1989-scale flood and the annual flood are shown in *Table C.1.4*.

Flood damage amounts were estimated for houses, household effects, commercial establishments, institutions, industrial establishments and agricultural crops.

The method for the calculation of flood damage is essentially to formulate the relationship between the inundation depth and the damage ratio, to estimate the inundation depth in a particular inundation area, to estimate the unit value of a particular property, to estimate the number of that property in that inundation area and by doing so to calculate the flood damage of that property in that inundation area. This method is followed in every inundation area, in every property and under each of the 1989-scale flood and the annual flood.

The results are shown in *Tables C.4.15*, *C.4.16*, *C.4.17* and *C.4.18*.

Table C.4.15 shows estimated flood damage in 1993 at the 1994 prices under the 1989-scale flood for each type of properties. According to it damage to residential buildings, household effects, commerce & institutions, industry and gardening crops come to 885.3, 438.9, 74.8, 182.7 and 0.1 in million FCFA respectively. Nos. 7 and 6, that is, "Thiaroye sur Mer" and "Djidda II, Pikine" are the two most serious inundation areas. Damage to industry is greater in Nos. 1 and 7, that is, "Lanssar" and "Thiaroye Sur Mer".

Table C.4.16 shows estimated flood damage amounts in 1993 under the annual flood. Damages to residential buildings, household effects, commerce & institutions, industry and gardening crops are 109.0, 91.9, 11.3, 20.5 and 0 in million FCFA respectively. Nos 13, 4, 6 and 7, that is, "Entree Tally Boubess", "Medina, Gounass, etc.", "Djidda II, Pikine" and "Thiaroye sur Mer" suffer greater damage. Damage to industry is greater in Nos. 1 and 7, that is, "Lanssar" and "Thiaroye Sur Mer".

Damage will increase as years go by because the number of damageable properties will increase in future. The number of properties is assumed to increase in proportion to the growth of population in each inundation area.

Table C.4.17 shows estimated flood damage amounts at the 1994 prices in 1993, 2000 and 2010 under the 1989-scale flood, totaling 1,582, 1,994 and 2,583 in million FCFA respectively.

Table C.4.18 shows estimated flood damage amounts in 1993, 2000 and 2010 under the annual flood, totaling 233, 292 and 377 in million FCFA respectively.

2) Average Annual Flood Damage

Using the data in *Tables C.4.17* and *C.4.18*, average annual flood damage amounts in 1993, 2000 and 2010 were estimated employing the probability density function. The annual flood is assumed to take place 3 times a year based on the past record. Also, the relationship between the return period of rainfall and flood damage is assumed to take the convex logarithmic curve. Further, design capacity of drainage facilities is assumed to be based on the 10-year return period of rainfall.

The resultant average annual flood damages worked out at 886, 1,114 and 1,440 in million FCFA in 1993, 2000 and 2010 respectively.

They turn into benefits in the "with project" case.

4.7.2 Cost Benefit Streams

As *Table C.4.13* shows, total initial costs of the priority project are estimated at 10,647.63 million FCFA at the 1994 prices, which are distributed over 10 years from 1995 to 2004. Out of the total initial costs, foreign components are estimated at 5,877.303 million FCFA accounting for 55.2%, while local components come to 4,770.328 million FCFA accounting for 45.8%.

The operation and maintenance costs will arise from 1998 and they will reach 43.434 million FCFA in 2005.

Benefits are assumed to be realized in accordance with the progress of the construction works.

The preconditions and assumptions applied for this economic analysis are summarized below:

a. Period of project life: 50 years
b. Opportunity cost of capital (OCC): 10%
c. Standard conversion factor to be applied to local components, O & M costs and benefits : 0.8981
d. Durable life
   Electro-mechanical equipment : 15 years
   Other facilities : 50 years

Based on the above premises the cost benefit streams for the economic analysis of the project were prepared as shown in *Table C.4.19*.

4.7.3 Economic Evaluation

Using the cost benefit streams economic criteria were calculated. The results are shown hereunder:

Net present value (NPV) : 430 million FCFA

Benefit Cost Ratio (B/C) : 1.07

Economic Internal Rate of Return (EIRR): 10.8%

That is to say, the cumulative surpluses estimated at the present value during the project life period of 50 years come to 430 million FCFA. The rate of the cumulative surpluses to the cumulative costs is estimated at 7%. The average annual rate of surpluses works out at 10.8%, which is by 0.8% greater than the opportunity cost of capital (OCC).

These values in itself testify to the viability of the project. It is not usual for the public project such as this one to have the EIRR exceeding OCC partly because of the constraints in expressing the benefits in quantitative terms.

Other major benefits regarding the project are listed below:

a. Reduction of water-borne epidemics which tend to break out during and after the inundation.

b. Reduction of impediment to human and vehicular traffic movement.

c. Reduction of income loss due to the closure of offices, shops and factories.

d. Reduction of damages to roads and other infrastructures

e. Removal of psychological burden before and during inundation.

f. Improvement of environment from sanitary as well as esthetic standpoint.

If all the above benefits would have been expressed, the economic criteria represented by EIRR would go up much more. Taking all these factors into consideration, it can safely be said that the project is highly feasible.

4.8 PROJECT EVALUATION

The proposed urban drainage project for Central Pikine area is evaluated as follows:

1) The project is technically sound without any difficulty in construction, and no serious problem is expected in drainage function of the facilities and in operation/maintenance.

2) The project is economically feasible with high value of EIRR 10.1%.

3) Negative impacts of the project are expected to occur during construction of the proposed facilities. However, these are expected to be small because the facilities are small in scale.

4) The project has positive impacts other than above mentioned tangible economic benefits as described below:

- Urban functions in the flood prone areas such as traffic, commercial and social ones will be improved.
- Water born disease will be reduced.

- THE RESIDENTS WILL BE ABLE TO LIVE IN THE FLOOD FREE LANDS CREATED BY THE PROJECT.

4.9 RECOMMENDATION

Immediate construction of the facilities is recommended in consideration of serious flood problem.

The following non-structural measures are also recommended to support the proposed structural measures and to achieve successful drainage of the project area.

1) Drainage of all areas having elevation of higher than 4 m should be done by infiltration, in principle. The depressed area in each closed catchment area, except the proposed pump drainage areas, should be kept for infiltration/ retention, and on-site infiltration should be applied in high areas.

2) In relation to the Technopole development, an open channel for drainage of a part of Pikine urban and Technopole project areas into Grand Niaye should be provided. Excavated soils during construction of the channel can be used for reclamation of the Technopole area.

3) There are small scale flood prone areas in Pikine irregular area located in the north of the pump drainage area. These areas should be slightly reclaimed for easy infiltration when the areas will be redeveloped.

4) Areas with elevation of less than 2 m and 1 m in the north and south of the Rufisque Road respectively are flood prone. These areas, except the proposed retention pond areas, should be reclaimed if developed.

5) A depressed area located at the northern edge of the project area is an important land for drainage and should not be urbanized.

6) Operation and maintenance of the proposed drainage facilities will be done by the Community of Dakar and SONEES or new organization proposed by the government. A part of the work is recommended to be done under participation of the residents in the flood prone areas who are the direct beneficiaries of the project. Such work items are as follows:

   - Maintenance work of the drainage channels in the flood prone areas such as cleaning of the channels before rainy season, preventive activities to keep the channel clean, etc.

   - Management of the retention ponds by the farmers who have agricultural activities in the pond areas.

TABLE C.4.1 SUMMERY OF FEASIBILITY STUDY AREA (km^2)

<table>
<tr><td>S1 (0.281)
S2 (0.179)
S3 (0.213)
S4 (0.344)
S5 (0.244)</td><td>C.P.1-1
(1.261)</td><td rowspan="2">C.P.1
(3.119)</td><td rowspan="3">Main Drainage Area
(5.211)</td><td rowspan="4">Central Pikine
(9.096)</td><td rowspan="7">Feasibility Study Area
(11.293)</td></tr>
<tr><td>N1 (0.745)
N2 (0.483)
N3 (0.185)
N4 (0.445)</td><td>C.P.1-2
(1.858)</td></tr>
<tr><td>W1 (0.208)
W2 (1.055)
W3 (0.245)
W4 (0.584)</td><td colspan="2">C.P.2
(2.092)</td></tr>
<tr><td></td><td colspan="3">Rest
of
C.P.
(3.885)</td></tr>
<tr><td>E1 (0.242)
E2 (0.865)</td><td colspan="4">Added
from
E.C.P.
(1.107)</td></tr>
<tr><td>W5 (0.789)</td><td colspan="4">Added
from
S.C.P.
(0.789)</td></tr>
<tr><td>OS (0.076)
ON1 (0.134)
ON2 (0.091)</td><td colspan="4">Outlet
of C.P.
(0.301)</td></tr>
</table>

TABLE C.4.2 COMPARISON OF ALTERNATIVE STRUCTURAL TYPE FOR DRAINAGE CHANNEL ALONG THE RUFISQUE ROAD

	OPEN CHANNEL	BOX CULVERT
1 Construction		
1) Cost	331,000 FCFA/m (Low)	1,794,000 FCFA/m (High)
2) Ease of Work	Easy and short	Long period
2 Maintenance		
1) Cost	Low	High
2) Sureness	High	Low
3 Land Acquisition		
1) Cost	11,550 FCFA/m	13,200 FCFA/m
2) Social problem	Not serious	Not serious
4 Compensation		
1) Cost	11,550 FCFA	13,200 FCFA
2) Sureness	Not serious	Not serious
5 Safety		
1) Against flood	High	Medium
2) For Traffic	Medium	High
6 Flexibility for future urbanization	High	Low

COMPARISON OF ALTERNATIVES FOR DRAINAGE CHANNEL ALONG THE NATIONAL ROAD

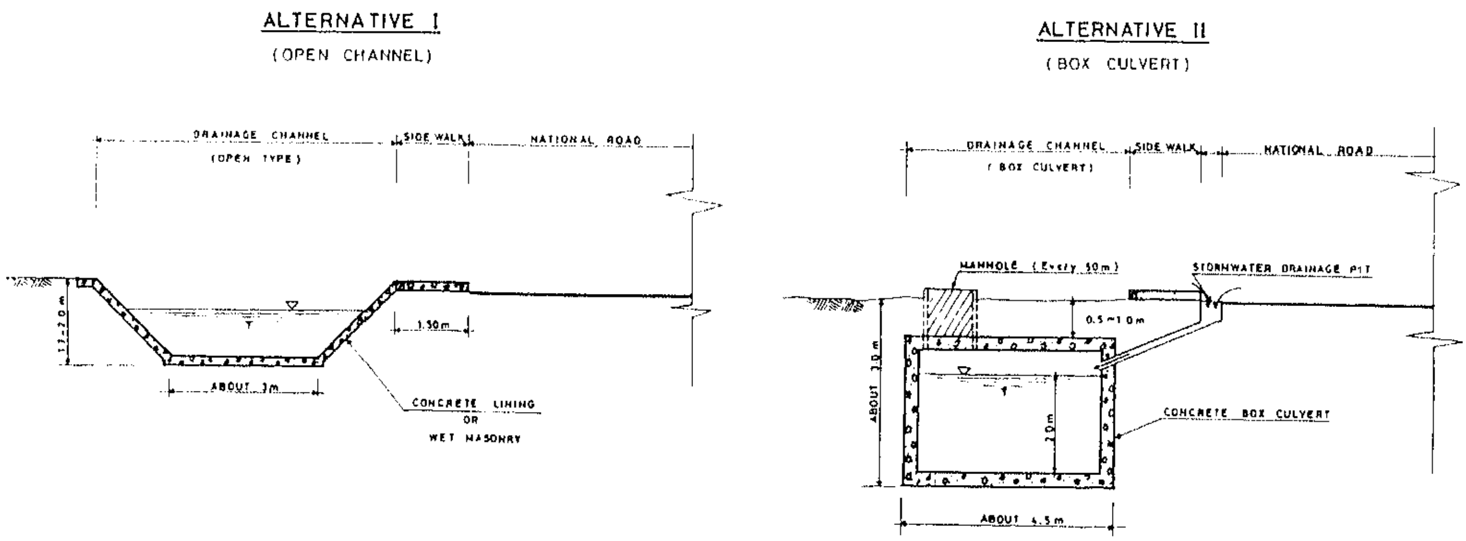


TABLE C.4.3 DETAILS OF PUMPING STATIONS

Pump Station	Location	Design Capacity (m³/sec)	Design Head (m)	Required Volume of Pond (m³)
P/S-S1	S1-S5	1.0	7.0	13,300
P/S-S2	S3-S4	1.0	8.5	6,700
P/S-S3	S2	0.3	5.0	1,900
P/S-N1	N1	1.5	15.0	17,800
P/S-N2	N2	1.0	6.0	5,500
P/S-N3	N3	0.3	5.0	2,000
P/S-N4	N4	0.5	13.0	5,500
P/S-Th	W5	1.5	5.0	(81,100)
	Grand - Total	8 Pump Stations		

TABLE C.4.4 RESULTS OF HYDROLOGIC COMPUTATIONS OF DRAINAGE AREAS

Drainage Area	Area of Catchment (km²)	Length of Flow (m)	Time of Concentration (min)	Rainfall Intensity (mm/hr)	Peak Discharge (m³/sec)
S1	0.281	1160	29.67	79.20	1.55
S2	0.179				0.30
S3	0.213	570	24.75	85.51	1.26
S4	0.344	880	27.33	82.07	1.96
S5	0.244				
OS	0.076	380	23.17	87.76	0.46
N1	0.745				
N2	0.483				
N3	0.185				
N4	0.445	260	30.00	78.80	1.46
ON1	0.134	450	23.75	86.92	0.81
ON1+ON2	0.225	750	26.25	83.47	1.30
W1	0.208	670	25.58	84.36	1.22
W1+W2	1.263	960	28.00	81.22	7.12
E2	0.865	580	24.83	85.39	5.13
E2+E1	1.107	1100	29.17	79.79	6.13
E2+E1+W4	1.691	1470	32.25	76.23	8.95
E2+E1+ W4+W3	1.936	1980	36.50	71.82	9.66
W5	0.789				

TABLE C.4.5 DETAILS OF STORM SEWERS

Storm Sewer	Location	Area of Catchment (km^2)	Peak Discharge (m^3/sec)	Length (m)	Diameter (mm)	Bed Slope (l/1000)	Design Capacity (m^3/sec)
S-S1	S1	0.130	0.71	440	900	1.6	0.72
		0.195	1.07	250	1000	2.5	1.20
		0.281	1.55	470	1000	4.5	1.61
S-S2	S1-S5		1.00	130	800	12.5	1.48
S-S3	S3	0.095	0.87	220	800	4.3	0.87
		0.213	1.56	330	1000	4.3	1.57
S-S4	S4	0.084	0.48	180	800	1.3	0.48
		0.191	1.09	270	800	6.7	1.09
		0.247	1.41	180	900	6.4	1.45
		0.344	1.96	250	1100	4.0	1.96
S-OS	OS	0.072	1.44	250	800	12.0	1.45
			Total of C.P.1-1	2,970			
S-N1	N1		0.50	200	600	18.5	0.84
S-N2	N1	0.252	2.38	100	1000	10.0	2.40
S-N3	N2	0.060	0.33	200	600	3.0	0.34
S-N4	N2		0.30	140	600	12.9	0.70
			0.30	140	600	3.5	0.36
S-N5	N4	0.445	1.46	260	1100	2.3	1.48
S-ON	ON1	0.118	2.21	290	1000	9.6	2.35
		0.134	2.31	160	1000	9.3	2.31
			Total of C.P.1-2	1,490			
			Grand Total	4,460			

TABLE C.4.6 CAPACITIES OF TRANSMISSION PIPE

Size (mm)	Flow Area (m^2)	Velocity (m/s)	Flow Capacity (m^3/s)
600	0.28	2	0.56
800	0.50	2	1.00
1,100	0.95	2	1.90

TABLE C.4.7 DETAILS OF TRANSMISSION PIPES

Transmission Pipe	Location	Length (m)	Diameter (mm)	Design Capacity (m^3/sec)
T-S1	S3-S4	240	800	1.0
T-S2	S1-S5	180	800	1.0
T-S3	S2	270	600	0.3
T-N1	N1	450	1100	1.5
T-N2	N1-N2-N4	760	600	0.5
T-N3	N1-N2	570	800	1.0
T-N4	N3	160	600	0.3
	Grand - Total	2,630		

TABLE C.4.8 DETAILS OF OPEN CHANNELS AND BOX CULVERTS

Open Channel or Box Culvert	Location	Area of Catchment (km^2)	Peak Discharge (m^3/sec)	Length (m)	Bottom Width (m)	Bed Slope (l/1000)	Design Water Depth (m)	Design Capacity (m^3/sec)
C-1	W1-W2	0.038	0.22	200	1.0	1.33	0.35	0.26
		0.069	0.40	200	1.0	11.76	0.52	1.60
		0.208	1.22	300	1.0	6.67	1.07	4.86
		1.263	7.12	300	2.0	2.35	1.63	10.66
			Total of C-1	1,000				
C-2	E2-E1-W4-W3	0.865	5.13	530	3.0	1.33	1.10	5.38
		1.691	8.95	910	3.0	1.43	1.44	9.04
		1.936	9.66	500	3.0	1.05	1.63	9.74
			Total of C-2	1,940				
C-3	W5			770	3.0	0.26	0.91	1.70
C-OS	OS	0.076	1.46	100	2.0	10.10	0.36	1.47
C-ON	ON2	0.225	2.80	300	2.0	7.40	0.58	2.84
			Total of C-3	1,170				
			Grand Total	4,110				

TABLE C.4.9 SUMMARY OF PROPOSED FACILITY

Area	Proposed Facilities				Total
CP 1	Drain to Grand Niaye				
	Construction of Storm Sewer			2 Systems Total	L= 4,460 m
		C.P.1-1 .			(L=2,970m)
			d=1,100mm CP		(250m)
			d=1,000mm CP		(1,050m)
			d=900mm CP		(620m)
			d=800mm CP		(1,050m)
		C.P.1-2			(L=1,490m)
			d=1,100mm CP		(260m)
			d=1,000mm CP		(550m)
			d=600mm CP		(680m)
	Construction of open channel (2m x 0.4 - 0.6m, 1)			2 Systems Total	L = 400m
		C.P.1-1			(100 m)
		C.P.1-2			(300 m)
	Stormwater Pumping Station			2 Systems Total	7 pls
	C.P.1-1 (1.0 m3/s 2pls, 0.3 m3/s 1pls)				3 pls
	C.P.1-2 (1.5 m3/s , 1.0 m3/s, 0.5m3/s, 0.3m3/s)				4 pls
	Stormwater Transmission Pipe (Ductile Iron Pipe)			2 Systems Total	L= 2,630m
		C.P. 1-1			(L=690m)
			d=600mm DCIP		(420m)
			d=800mm DCIP		(270m)
		C.P. 1-2			(L=1,940m)
			d=600mmDCIP		(570m)
			d=1100mm DCIP		(920m)
			d=801mm DCIP		(450m)
CP 2	Drain to Sea				
	Construction of main Drainage Channel (1-3m x 0.4-1.6m, 1)				L = 2,940 m
	Improvement of Existing Drainage Channel (3m x 0.9m, 1)				L= 770 m
	Stormwater Pumping Station (1.5 m3/s)				1 Place
	Retention Pond			Total	5 .1ha

TABLE C.4.10 UNIT PRICE/COST FOR WORK ITEMS

Item	Unit	Unit Price/Cost (FCFA)
Concrete Lining Open Channel		
Type F-1 (Bottom Width=3m)	m	311,000
Type F-2 (Bottom Width=2m)	m	196,000
Type F-3 (Bottom Width=1m)	m	162,000
Storm Sewer		
Type F-1 (d=600mm Concrete Pipe)	m	316,000
Type F-2 (d=800mm Concrete Pipe)	m	378,000
Type F-3 (d=900mm Concrete Pipe)	m	413,000
Type F-4 (d=1,000mm Concrete Pipe)	m	466,000
Type F-5 (d=1,100mm Concrete Pipe)	m	525,000
Retention Pond	ha	42,500,000
Stormwater Pumping Station		
Type F-1 (1.5m3/s)	pls	395,900,000
Type F-2 (1.0m3/s)	pls	311,800,000
Type F-3 (0.5m3/s)	pls	242,800,000
Type F-4 (0.3m3/s)	pls	209,800,000
Transmission Pipe Line		
Type F-1 (d=600mm Ductile Iron Pipe)	m	283,700
Type F-2 (d=800mm Ductile Iron Pipe)	m	387,300
Type F-3 (d=1,100mm Ductile Iron Pipe)	m	608,600
Land Acquisition	m2	1,650

TABLE C.4.11 WORK VOLUME (FEASIBILITY STUDY)

Item	Unit	Work Volume			
		C.P.1-1	C.P.1-2	C.P.2	Total
Concrete Lining Open Channel					
Type F-1 (Bottom Width=3m)	m			2,710	2,710
Type F-2 (Bottom Width=2m)	m	100	300	300	700
Type F-3 (Bottom Width=1m)	m			700	700
Storm Sewer					
Type F-1 (d=600mm Concrete Pipe)	m		680		680
Type F-2 (d=800mm Concrete Pipe)	m	1,050			1,050
Type F-3 (d=900mm Concrete Pipe)	m	620			620
Type F-4 (d=1,000mm Concrete Pipe)	m	1,050	550		1,600
Type F-5 (d=1,100mm Concrete Pipe)	m	250	260		510
Retention Pond	ha	1.2	1.3	5.1	7.6
Stormwater Pumping Station					
Type F-1 (1.5m3/s: 0.5m3/sx3sets)	pls		1	1	2
Type F-2 (1.0m3/s: 0.33m3/sx3sets)	pls	2	1		3
Type F-3 (0.5m3/s: 0.25m3/sx2sets)	pls		1		1
Type F-4 (0.3m3/s: 0.15m3/sx2sets)	pls	1	1		2
Transmission Pipe Line					
Type F-1 (d=600mm Ductile Iron Pipe)	m	270	920		1,190
Type F-2 (d=800mm Ductile Iron Pipe)	m	420	570		990
Type F-3 (d=1,100mm Ductile Iron Pipe)	m		450		450
Land Acquisition	m2	12,000	13,000	51,000	76,000

TABLE C.4.12 CONSTRUCTION COST (FEASIBILITY STUDY)

Item	Unit Price/Cost (FCFA)	Unit	Construction Cost (x1000 FCFA) C.P.1-1	C.P.1-2	C.P.2	Total
I. Direct Construction Cost						
1. Concrete Lining Open Channel						
Type F-1 (Bottom Width=3m)	311,000	m			842,810	842,810
Type F-2 (Bottom Width=2m)	196,000	m	19,600	58,800	58,800	137,200
Type F-3 (Bottom Width=1m)	162,000	m			113,400	113,400
2. Storm Swer						
Type F-1 (d=600mm Concrete Pipe)	316,000	m		214,880		214,880
Type F-2 (d=800mm Concrete Pipe)	378,000	m	396,900			396,900
Type F-3 (d=900mm Concrete Pipe)	413,000	m	256,060			256,060
Type F-4 (d=1,000mm Concrete Pipe)	466,000	m	489,300	256,300		745,600
Type F-5 (d=1,100mm Concrete Pipe)	525,000	m	131,250	136,500		267,750
3. Retention Pond	42,500,000	ha	51,000	55,250	216,750	323,000
4. Stormwater Pumping Station						
Type F-1 (1.5m3/s)	395,900,000	pls		395,900	395,900	791,800
Type F-2 (1.0m3/s)	311,800,000	pls	623,600	311,800		935,400
Type F-3 (0.5m3/s)	242,800,000	pls		242,800		242,800
Type F-4 (0.3m3/s)	209,800,000	pls	209,800	209,800		419,600
5. Transmission Pipe Line						
Type F-1 (d=600mm Ductile Iron Pipe)	283,700	m	76,599	261,004		337,603
Type F-2 (d=800mm Ductile Iron Pipe)	387,300	m	162,666	220,761		383,427
Type F-3 (d=1,100mm Ductile Iron Pipe)	608,600	m		273,870		273,870
6. Secondery Drain		L.S.	725,033	791,300	488,298	2,004,630
Sub-Total			3,141,808	3,428,965	2,115,958	8,686,730
II. Land Acquisition and Compensation						
1. Land Acquisition	1,650	m2	19,800	21,450	84,150	125,400
2. Compensation	1,650	m2	19,800	21,450	84,150	125,400
Sub-Total			39,600	42,900	168,300	250,800
III. Engineering Service	7% of I		219,927	240,028	148,117	608,071
IV. Government Administration	1.5% of I + II		47,721	52,078	34,264	134,063
V. Physical Contingency	10% of (I to IV)		344,906	376,397	246,664	967,966
VI. Project Cost			3,793,961	4,140,367	2,713,303	10,647,630

TABLE C.4.13 BREAKDOWN OF CONSTRUCTION COST (FEASIBILITY STUDY)

	CONSTRUCTION COST		
	FC	LC	TT
CP-1 and CP-2			
Engineering Service	425,650	182,421	608,071
Land Acquisition / Compensation	0	250,800	250,800
CP-1 Drainage System			
System-S			
Pumping Stations	625,050	208,350	833,400
Transmission Pipe	203,375	35,890	239,265
Storm Sewer	1,082,484	191,027	1,273,510
Drainage Channel	2,940	16,660	19,600
Retention Pond	7,650	43,350	51,000
System-N			
Pumping Stations	870,225	290,075	1,160,300
Transmission Pipe	642,290	113,345	755,635
Storm Sewer	516,528	91,152	607,680
Drainage Channel	8,820	49,980	58,800
Retention Pond	8,288	46,963	55,250
Sub-total of CP1	3,967,649	1,086,791	5,054,440
CP-2 Drainage System			
Pumping Station	296,925	98,975	395,900
Drainage Channel	152,252	862,759	1,015,010
Retention Pond	32,513	184,238	216,750
Sub-total of CP2	481,689	1,145,971	1,627,660
Secondary Drain	1,002,315	1,002,315	2,004,630
Government Administration	0	134,063	134,063
Physical Contingency	0	967,966	967,966
Project Cost	5,877,303	4,770,328	10,647,630
Operation and Maintenance	0	270,122	
Grand Total	5,877,303	5,040,450	10,917,752

Unit : x 1000 FCFA

TABLE C.4.14 COST DISBURSEMENT SCHEDULE (FEASIBILITY STUDY)

	Construction Cost			O/M Cost	Total
	F.C.	L.C.	Sub-Total		
1995	121,614	69,494	191,108		191,108
1996	121,614	162,833	284,447		284,447
1997	1,982,306	904,917	2,887,223		2,887,223
1998	2,173,964	1,458,636	3,632,600	12,084	3,644,684
1999	475,489	938,593	1,414,083	27,506	1,441,589
2000	200,463	247,171	447,634	33,411	481,044
2001	200,463	247,171	447,634	35,415	483,049
2002	200,463	247,171	447,634	37,420	485,054
2003	200,463	247,171	447,634	39,424	487,058
2004	200,463	247,171	447,634	41,429	489,063
2005	0	0	0	43,434	43,434
Total Cost (1995-2010)	5,877,303	4,770,328	10,647,630	270,122	10,917,752

Unit : x 1000 FCFA

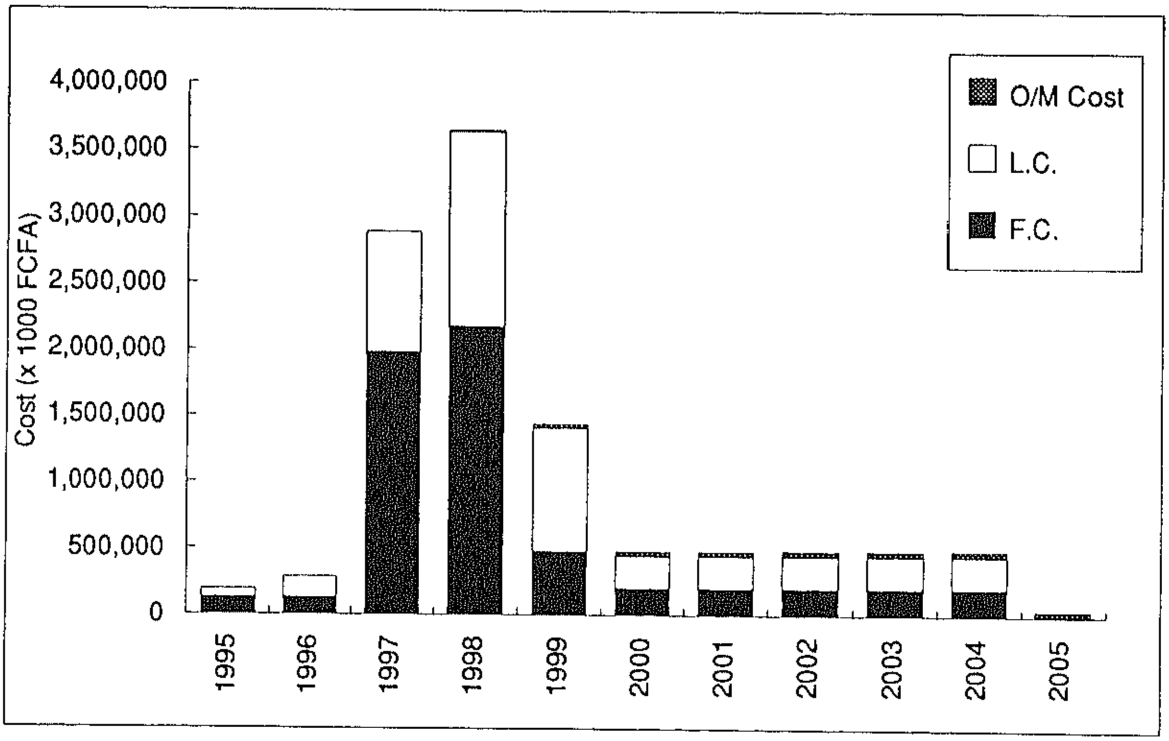


TABLE C.4.15 ESTIMATED FLOOD DAMAGE IN 1993 BY TYPE OF PROPERTY AND BY INUNDATION AREA UNDER 1989-SCALE FLOOD

Legend:
RSBLD=Residential Buildings, HHEFF=Household Effects, CM/IN=Commerce & Institutions, INDUS=Industry, GDCRP=Gardening Crops

(Unit: FCFA million)

Code No.	Name of Inundation Areas	RSBLD	HHEFF	CM/IN	INDUS	GDCRP
1	Lanssar	12.1	7.9	1.1	82.6	0.0
2	Diamaguene, Diaksao	50.1	25.4	4.3	7.1	0.1
3	Wakhine	0.0	0.0	0.0	0.0	0.0
4	Medina, Gounass, etc.	91.4	46.9	7.8	0.0	0.0
6	Djidda II, Pikine	155.0	78.0	13.2	0.0	0.0
7	Thiaroye sur Mer	273.6	114.9	21.9	80.9	0.0
8	Ganaw Rail	16.4	10.2	1.5	0.0	0.0
10	Thiaroye SOTRAC	2.0	1.2	0.2	0.0	0.0
11	Cite Pepiniere Pikine	43.1	19.5	3.5	12.1	0.0
13	Entree Tally Boubess	76.6	38.3	6.5	0.0	0.0
14	Traversiere	0.0	0.0	0.0	0.0	0.0
15	Rue 10	34.2	18.4	3.0	0.0	0.0
46	Medine	70.9	45.5	6.6	0.0	0.0
47	Sud-Est de Medine	50.2	25.9	4.3	0.0	0.0
48	Medina Gounass	9.7	6.9	0.9	0.0	0.0
	Total	885.3	438.9	74.8	182.7	0.1

Source: Results of the on-the-spot questionnaire survey conducted by JICA

TABLE C.4.16 ESTIMATED FLOOD DAMAGE IN 1993 BY TYPE OF PROPERTY AND BY INUNDATION AREA UNDER ANNUAL FLOOD

Legend:
RSBLD=Residential Buildings, HHEFF=Household Effects, CM/IN=Commerce & Institutions, INDUS=Industry, GDCRP=Gardening Crops

(Unit: FCFA million)

Code No.	Name of Inundation Areas	RSBLD	HHEFF	CM/IN	INDUS	GDCRP
1	Lanssar	0.0	1.1	0.1	10.7	0.0
2	Diamaguene, Diaksao	0.8	0.6	0.1	0.2	0.0
3	Wakhine	0.0	0.0	0.0	0.0	0.0
4	Medina, Gounass, etc.	19.0	15.2	1.9	0.0	0.0
6	Djidda II, Pikine	14.8	15.4	1.7	0.0	0.0
7	Thiaroye sur Mer	13.7	11.6	1.4	8.0	0.0
8	Ganaw Rail	0.0	0.5	0.0	0.0	0.0
10	Thiaroye SOTRAC	0.5	0.5	0.1	0.0	0.0
11	Cite Pepiniere Pikine	2.7	2.7	0.3	1.6	0.0
13	Entree Tally Boubess	26.3	14.3	2.3	0.0	0.0
14	Traversiere	0.0	0.0	0.0	0.0	0.0
15	Rue 10	12.1	8.3	1.2	0.0	0.0
46	Medine	7.0	12.5	1.1	0.0	0.0
47	Sud-Est de Medine	10.2	7.6	1.0	0.0	0.0
48	Medina Gounass	1.8	1.6	0.2	0.0	0.0
	Total	109.0	91.9	11.3	20.5	0.0

Source: Results of the on-the-spot questionnaire survey conducted by JICA

TABLE C.4.17 ESTIMATED FLOOD DAMAGE IN 1993, 2000 AND 2010 BY INUNDATION AREA UNDER 1989-SCALE FLOOD

(Unit: FCFA million)

Code No.	Name of Inundation Areas	1993	2000	2010
1	Lanssar	104	132	173
2	Diamaguene, Diaksao	87	116	158
3	Wakhine	0	0	0
4	Medina, Gounass, etc.	146	175	217
6	Djidda II, Pikine	246	308	397
7	Thiaroye sur Mer	491	625	815
8	Ganaw Rail	28	32	37
10	Thiaroye SOTRAC	3	4	4
11	Cite Pepiniere Pikine	78	99	129
13	Entree Tally Boubess	121	154	200
14	Traversiere	0	0	0
15	Rue 10	56	70	91
46	Medine	123	156	202
47	Sud-Est de Medine	80	102	132
48	Medina Gounass	18	21	26
	Total	1,582	1,994	2,583

Source: Results of the on-the-spot questionnaire survey conducted by JICA

TABLE C.4.18 ESTIMATED FLOOD DAMAGE IN 1993, 2000 AND 2010 BY INUNDATION AREA UNDER ANNUAL FLOOD

(Unit: FCFA million)

Code No.	Name of Inundation Areas	1993	2000	2010
1	Lanssar	12	15	20
2	Diamaguene, Diaksao	2	2	3
3	Wakhine	0	0	0
4	Medina, Gounass, etc.	36	43	54
6	Djidda II, Pikine	32	40	51
7	Thiaroye sur Mer	35	44	58
8	Ganaw Rail	1	1	1
10	Thiaroye SOTRAC	1	1	1
11	Cite Pepiniere Pikine	7	9	12
13	Entree Tally Boubess	43	54	71
14	Traversiere	0	0	0
15	Rue 10	22	27	36
46	Medine	21	26	34
47	Sud-Est de Medine	19	24	31
48	Medina Gounass	4	4	5
	Total	233	292	377

Source: Results of the on-the-spot questionnaire survey conducted by JICA

TABLE C.4.19 COST BENEFIT STREAMS

CC=Capital Costs; OM=O/M Costs; CS=Costs; BF=Benefits
CF=Cash Flow (=BF - CS)

(Unit:FCFA Million)

NO.	YEAR	CC	OM	CS	BF	CF
1	1995	184	0	184	0	-184
2	1996	268	0	268	0	-268
3	1997	2795	0	2795	0	-2795
4	1998	3484	11	3495	314	-3181
5	1999	1318	25	1343	647	-696
6	2000	422	30	452	1000	548
7	2001	422	32	454	1030	576
8	2002	422	34	456	1059	603
9	2003	422	35	458	1088	630
10	2004	422	37	460	1118	658
11	2005	0	39	39	1147	1108
12	2006	0	39	39	1176	1137
13	2007	0	39	39	1205	1166
14	2008	0	39	39	1235	1196
15	2009	0	39	39	1264	1225
16	2010	0	39	39	1293	1254
17	2011	0	39	39	1293	1254
18	2012	563	39	602	1293	692
19	2013	783	39	822	1293	471
20	2014	534	39	573	1293	720
21	2015	0	39	39	1293	1254
22	2016	0	39	39	1293	1254
23	2017	0	39	39	1293	1254
24	2018	0	39	39	1293	1254
25	2019	0	39	39	1293	1254
26	2020	0	39	39	1293	1254
27	2021	0	39	39	1293	1254
28	2022	0	39	39	1293	1254
29	2023	0	39	39	1293	1254
30	2024	0	39	39	1293	1254
31	2025	0	39	39	1293	1254
32	2026	0	39	39	1293	1254
33	2027	563	39	602	1293	692
34	2028	783	39	822	1293	471
35	2029	534	39	573	1293	720
36	2030	0	39	39	1293	1254
37	2031	0	39	39	1293	1254
38	2032	0	39	39	1293	1254
39	2033	0	39	39	1293	1254
40	2034	0	39	39	1293	1254
41	2035	0	39	39	1293	1254
42	2036	0	39	39	1293	1254
43	2037	0	39	39	1293	1254
44	2038	0	39	39	1293	1254
45	2039	0	39	39	1293	1254
46	2040	0	39	39	1293	1254
47	2041	0	39	39	1293	1254
48	2042	563	39	602	1293	692
49	2043	783	39	822	1293	471
50	2044	534	39	573	2921	2347

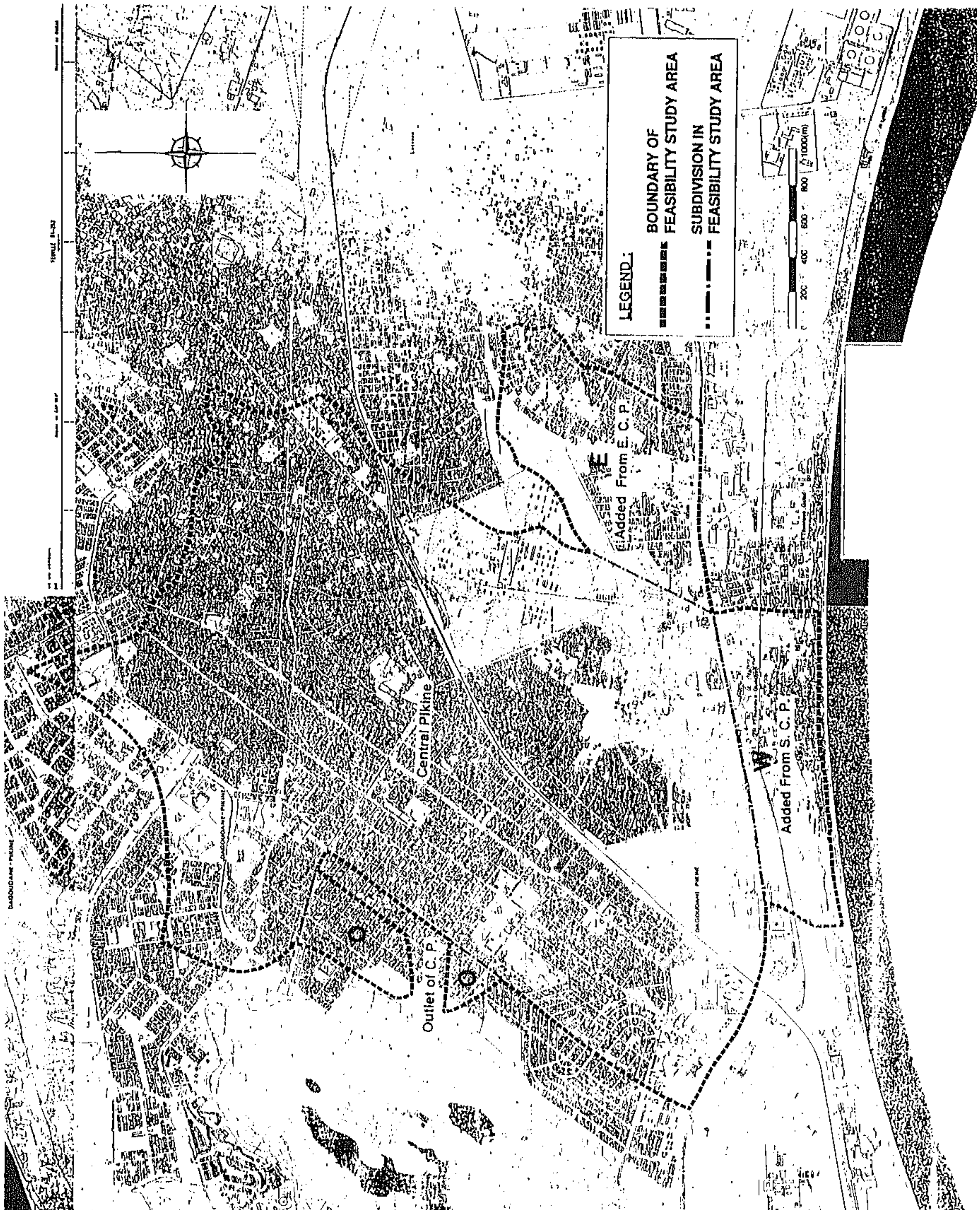


FIGURE C.4.1 FEASIBILITY STUDY AREA

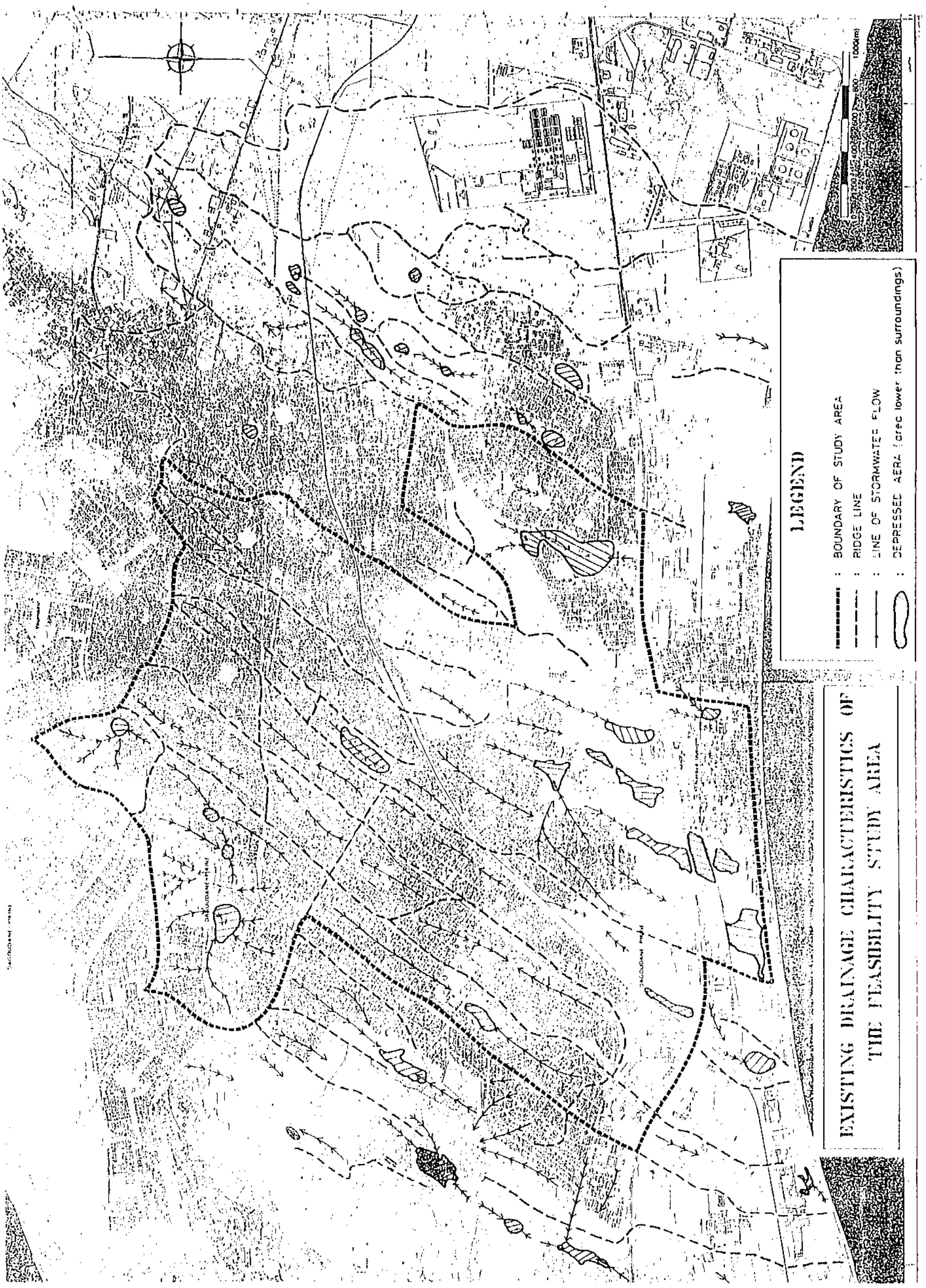


FIGURE C.4.2 EXISTING DRAINAGE CONDITION

FIGURE C.4.3 DRAINAGE SUB-AREAS

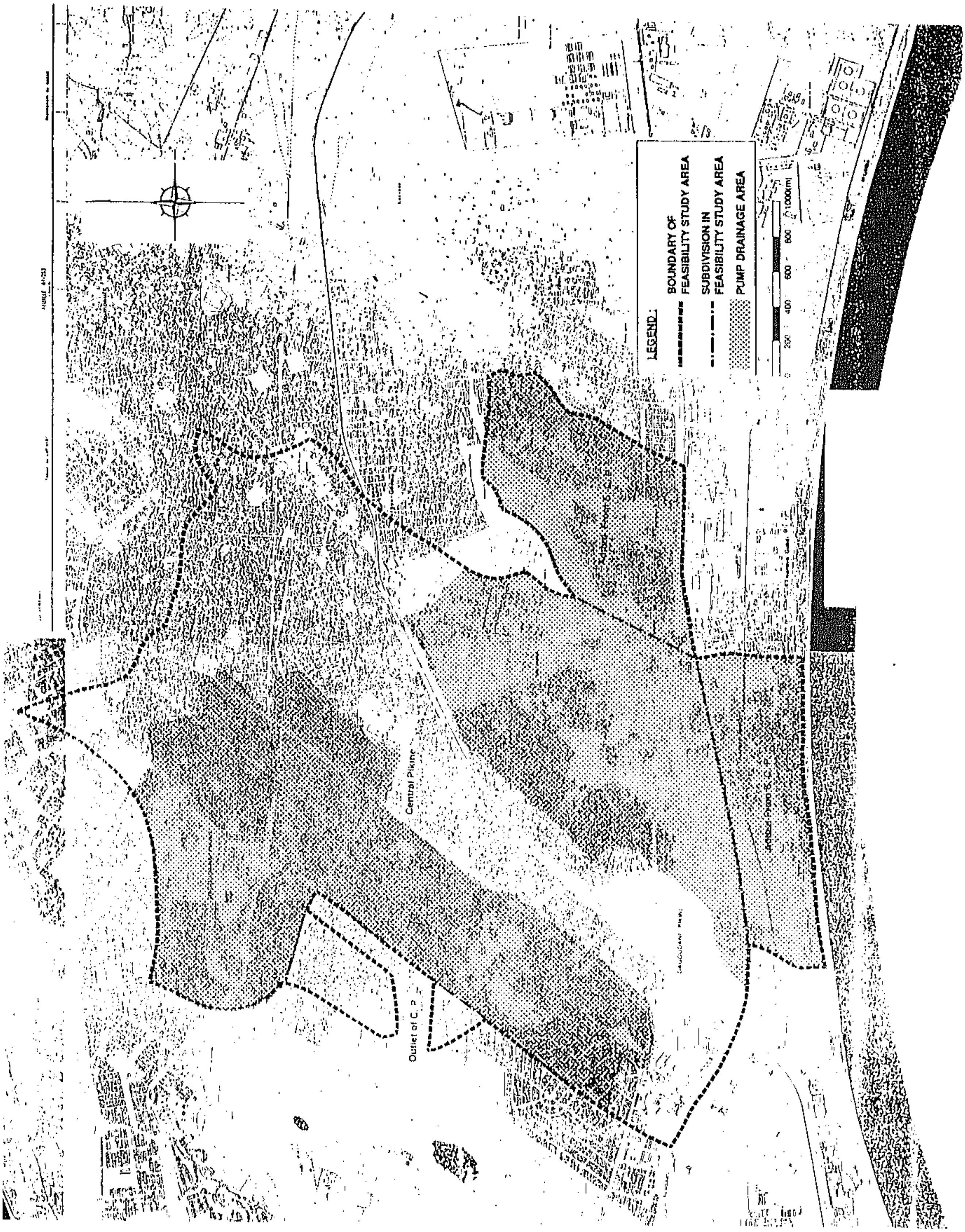


FIGURE C.4.4 CLASSIFIED PUMP DRAINAGE AREA

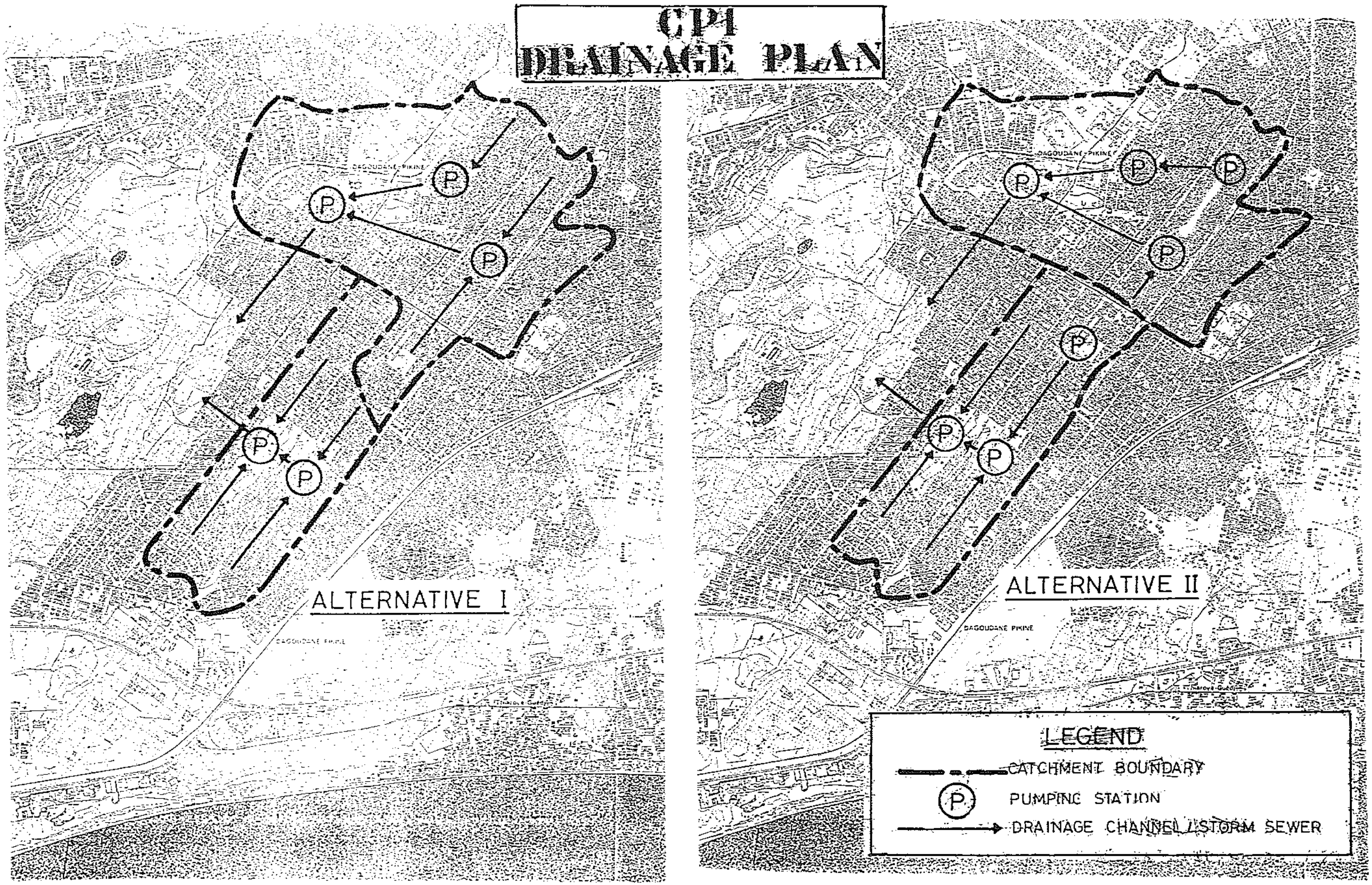


FIGURE C.4.5 ALTERNATIVES OF C.P.1 DRAINAGE PLAN

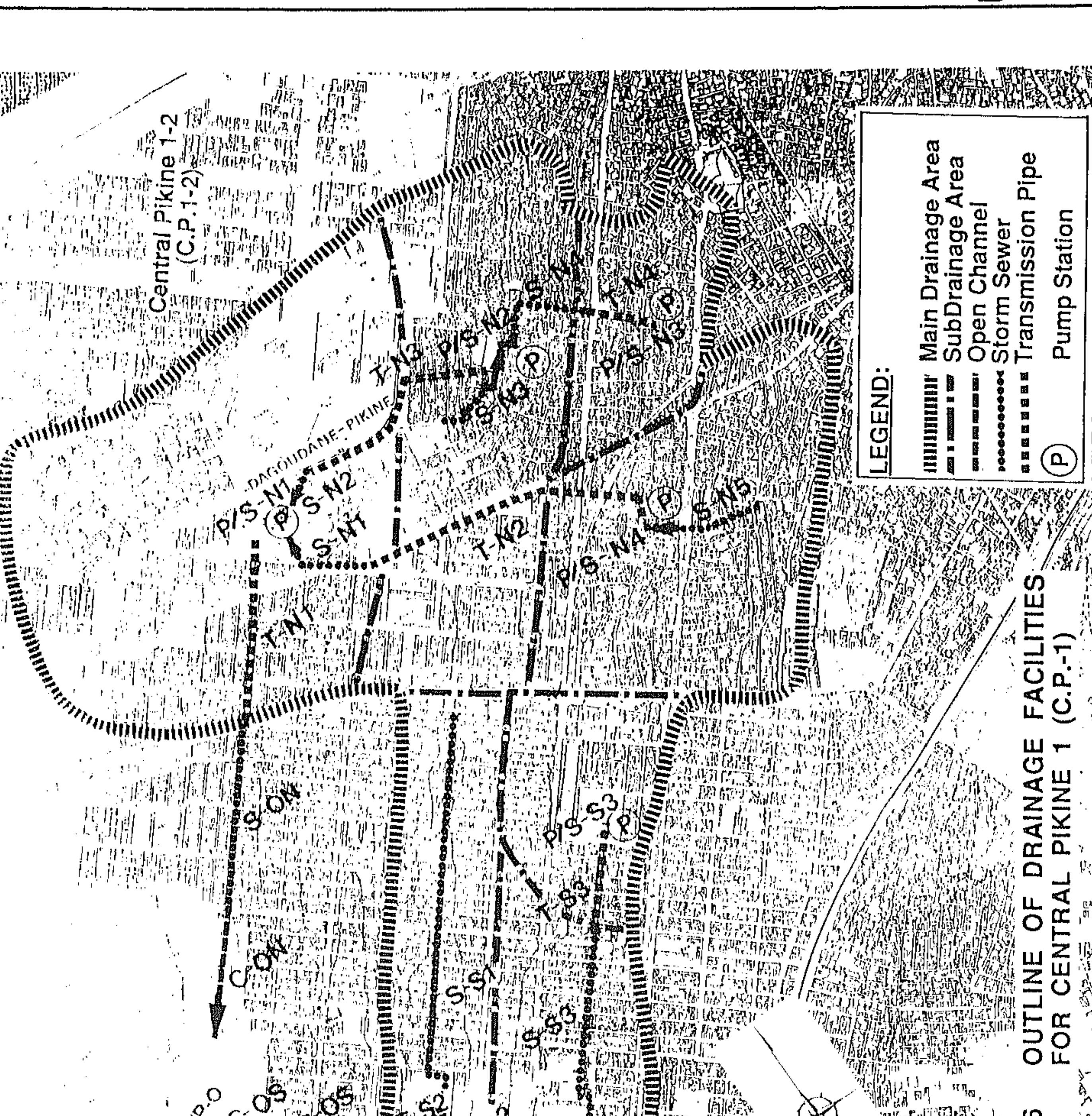


FIGURE C.4.6 OUTLINE OF DRAINAGE FACILITIES FOR CENTRAL PIKINE 1 (C.P.-1)

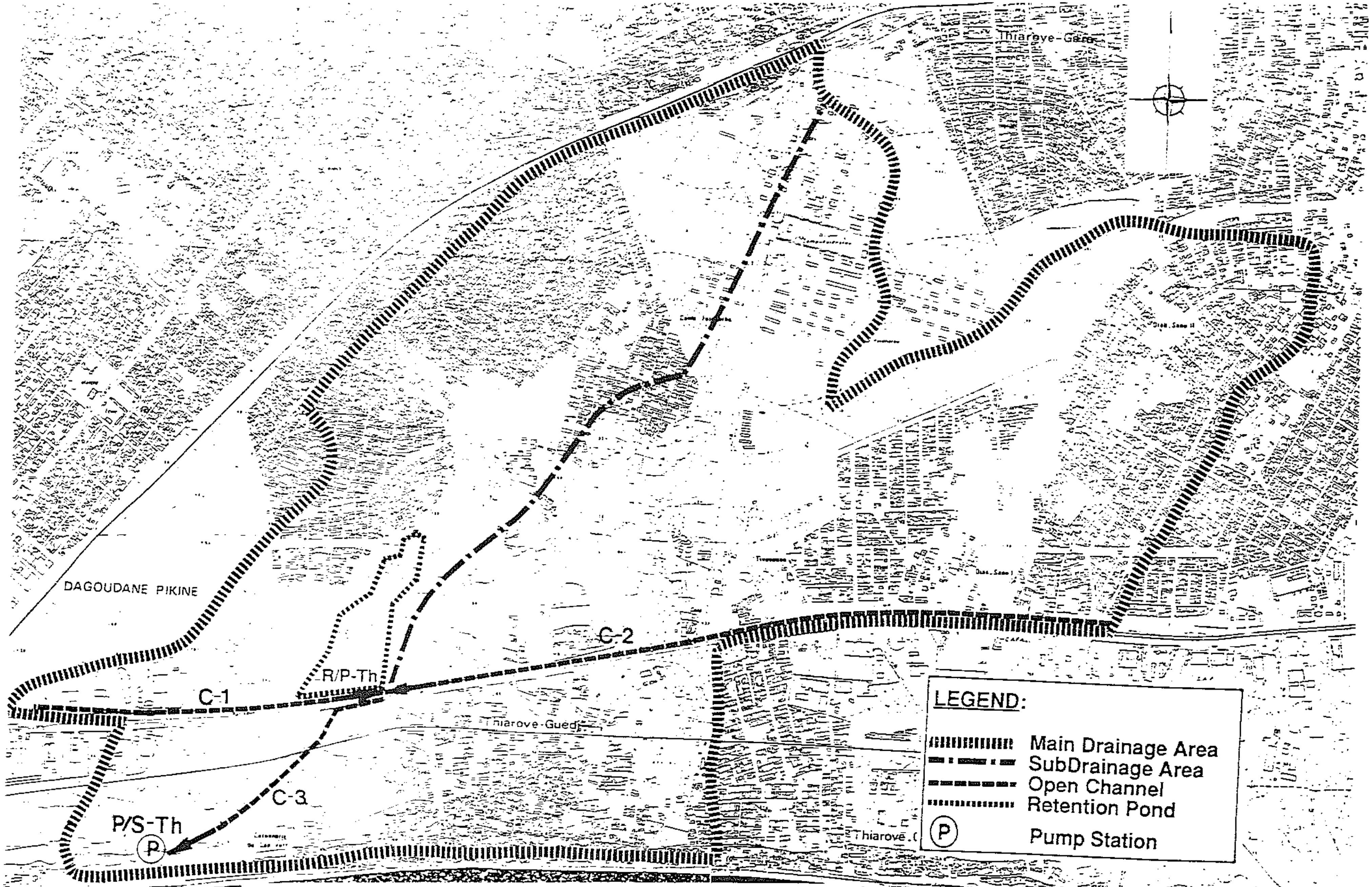


FIGURE C.4.7 OUTLINE OF DRAINAGE FACILITIES FOR CENTRAL PIKINE 2 (C.P.-2)

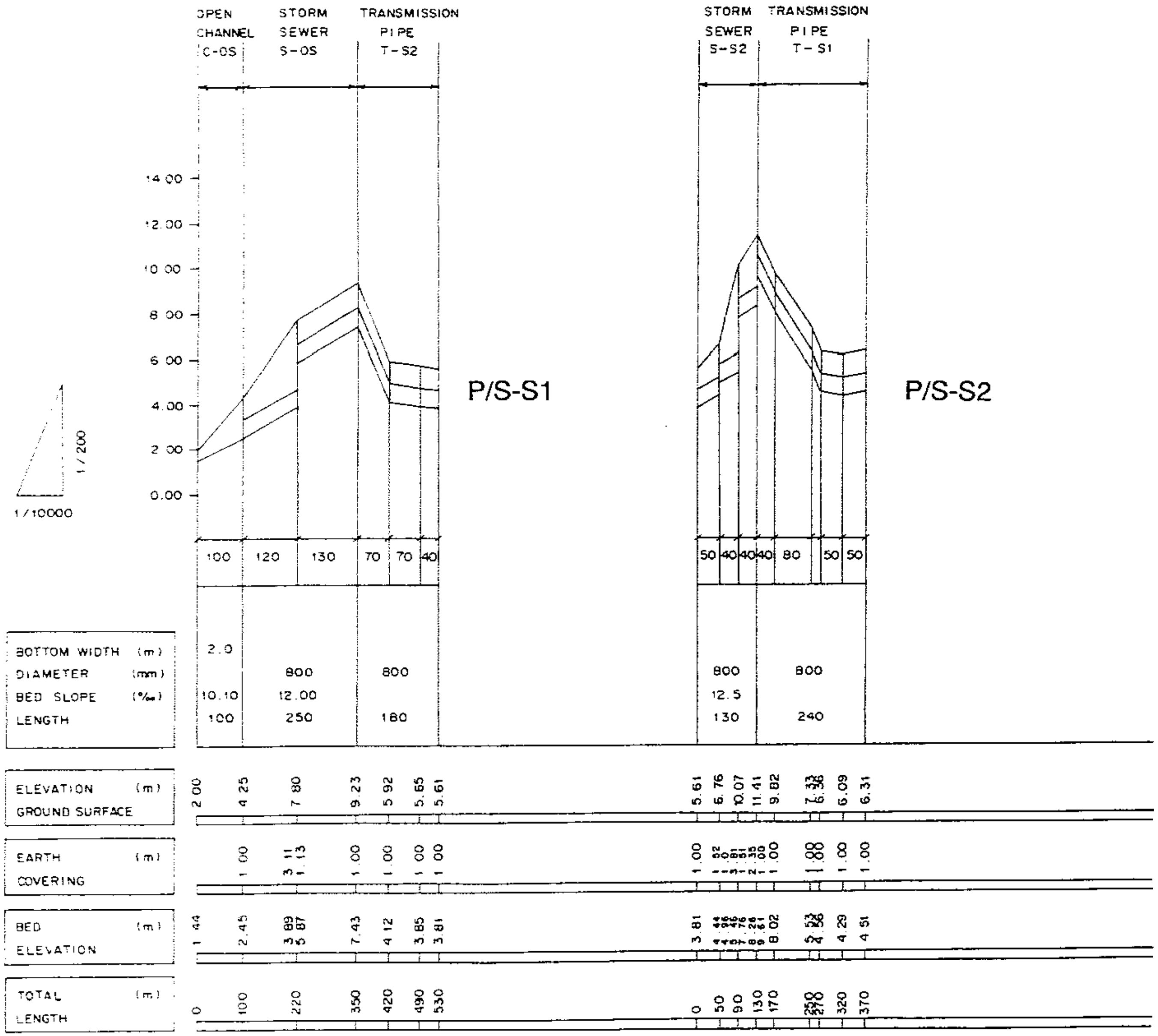
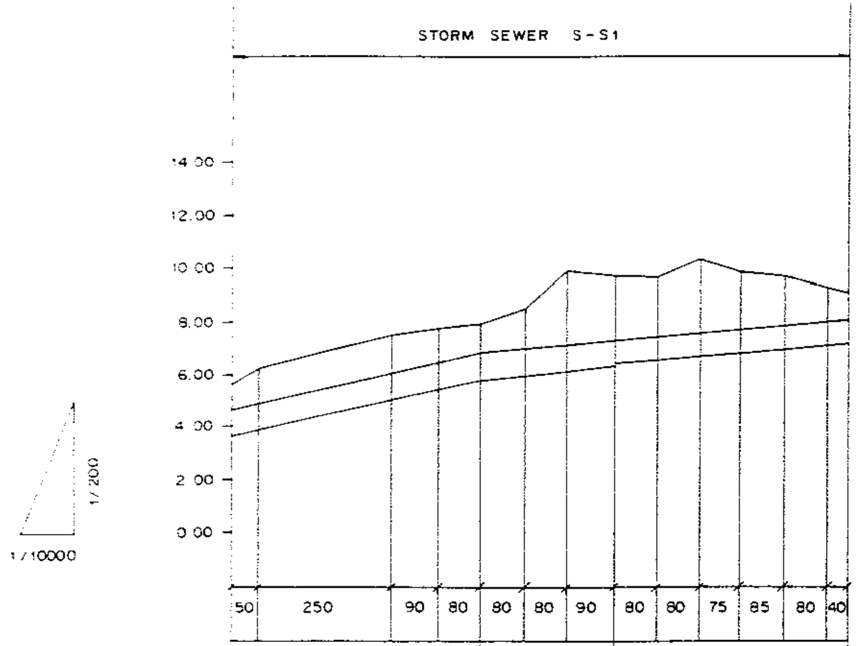


FIGURE C.4.8 PROFILES OF DRAINAGE CHANNELS (CP.1-1)



DIAMETER (mm)	1000	1000	900
SLOPE (‰)	4.50	2.50	1.60
LENGTH (m)	470	250	440

ELEVATION GROUND SURFACE (m)	5.61	6.20	7.45	7.74	7.90	8.43	9.84	9.70	9.68	10.32	9.90	9.69	9.26	9.05
EARTH COVERING (m)	1.00	1.36	1.49	1.37	1.18	1.51	2.72	2.35	2.20	2.71	2.17	1.83	1.27	1.0
ELEVATION SEWER INVERT (m)	3.61	3.84	4.96	5.37	5.72	5.92	6.12	6.45 6.35	6.58	6.71	6.83	6.96	7.09	7.15
TOTAL LENGTH (m)	0	50	300	390	470	550	630	720	800	880	955	1040	1120	1160

FIGURE C.4.9 PROFILES OF DRAINAGE CHANNELS (CP.1-1)

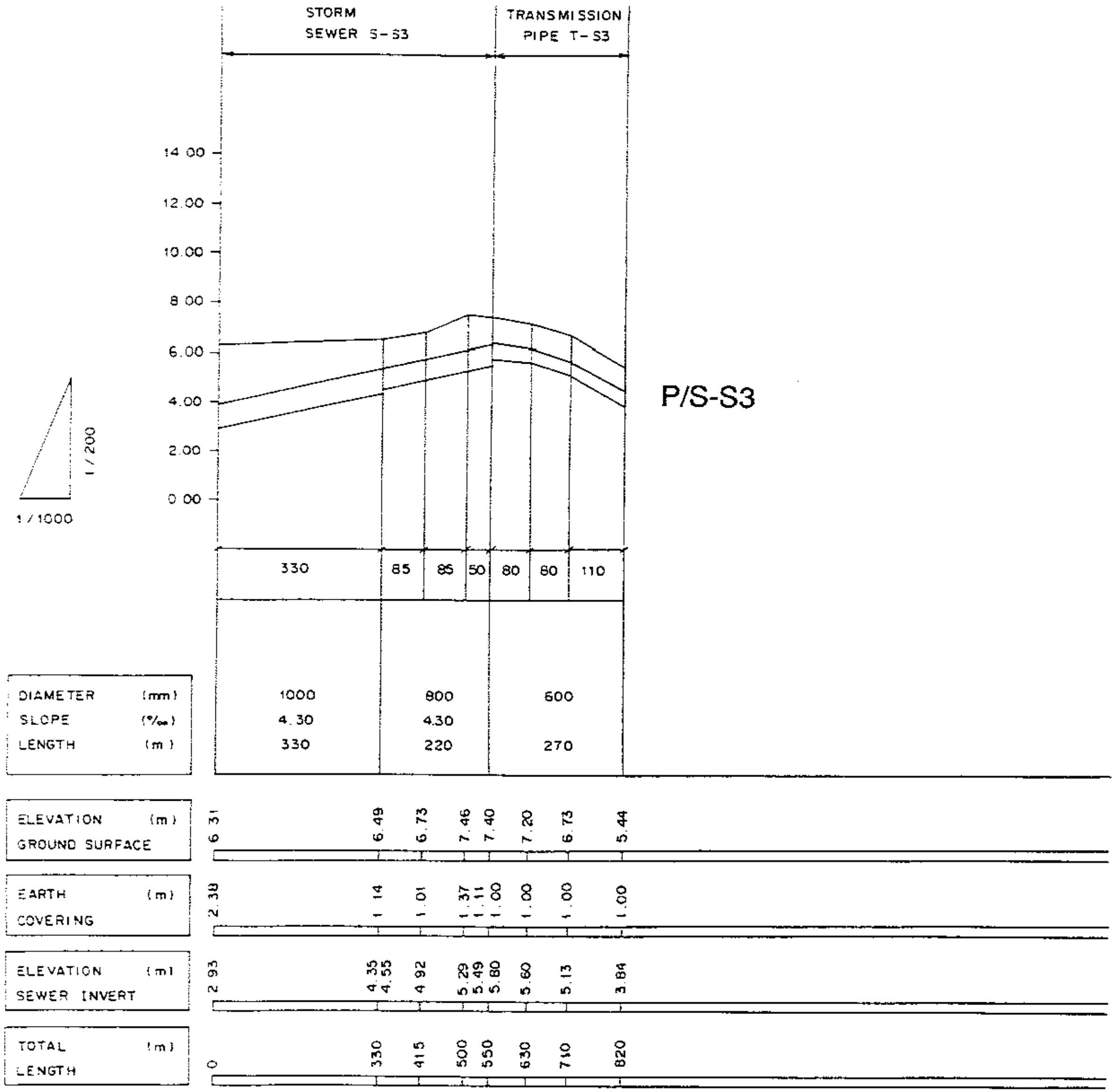


FIGURE C.4.10 PROFILES OF DRAINAGE CHANNELS (CP.1-1)

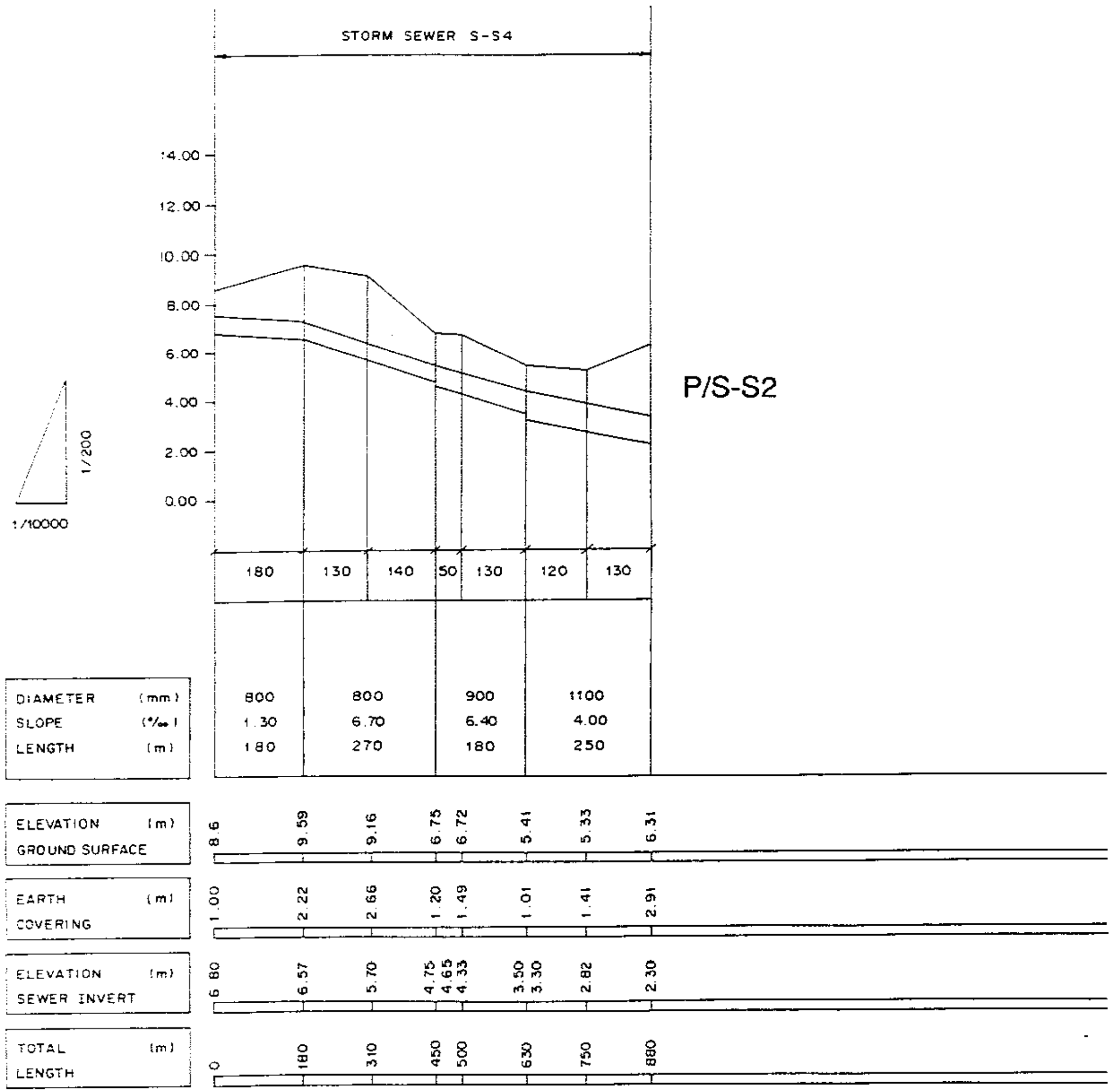


FIGURE C.4.11 PROFILES OF DRAINAGE CHANNELS (CP.1-1)

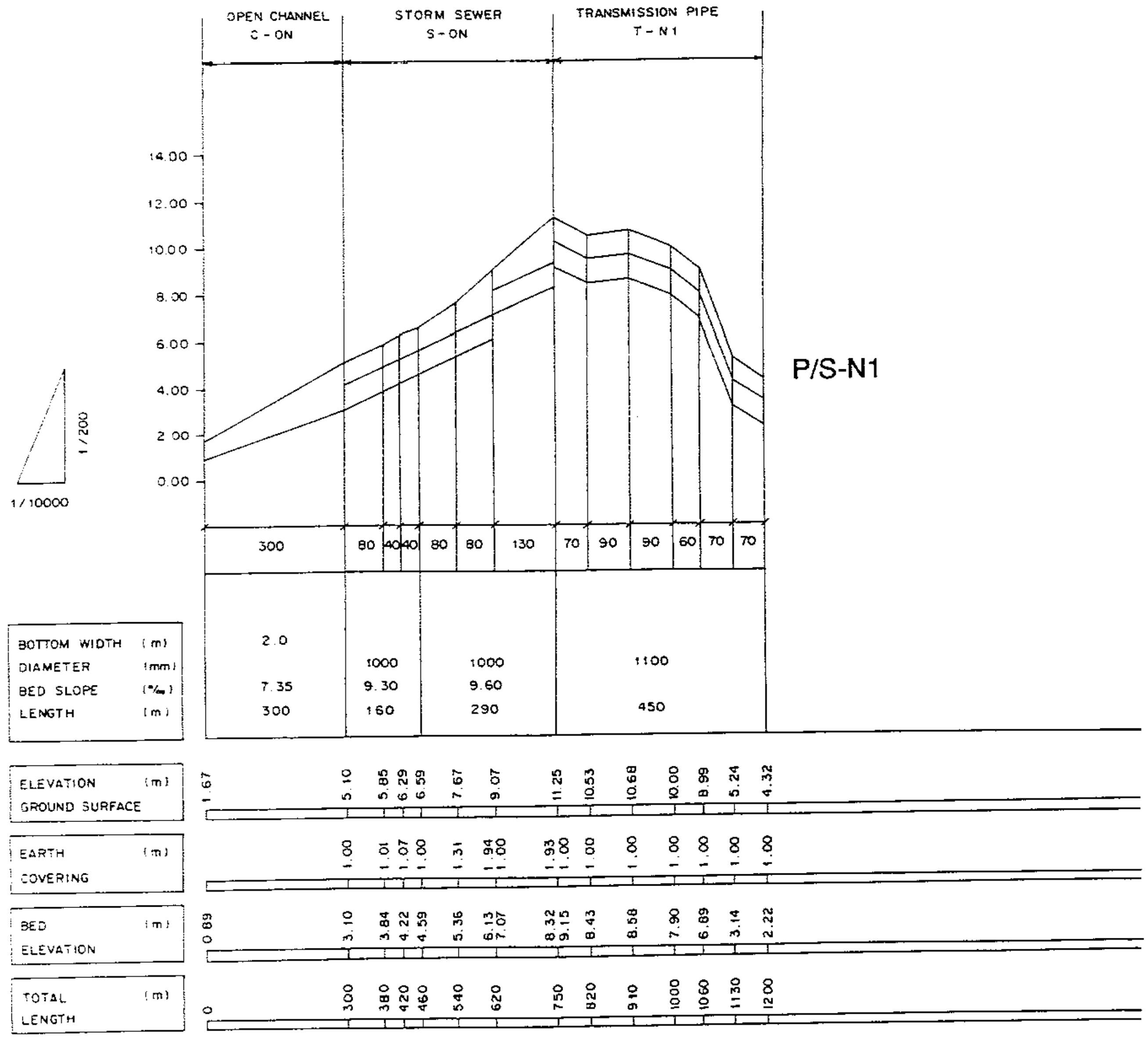


FIGURE C.4.12 PROFILES OF DRAINAGE CHANNELS (CP.1-2)

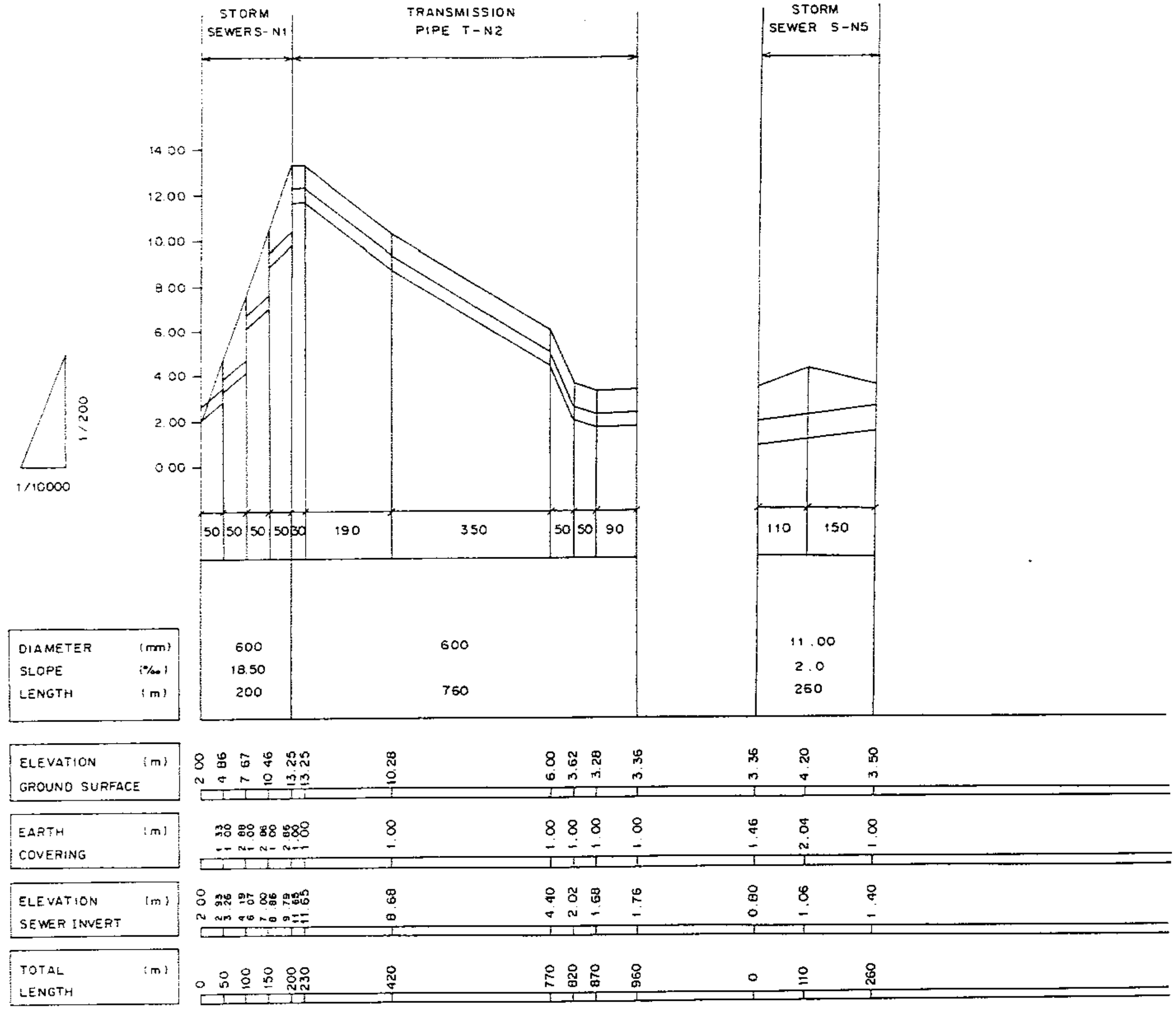


FIGURE C.4.13 PROFILES OF DRAINAGE CHANNELS (CP.1-2)

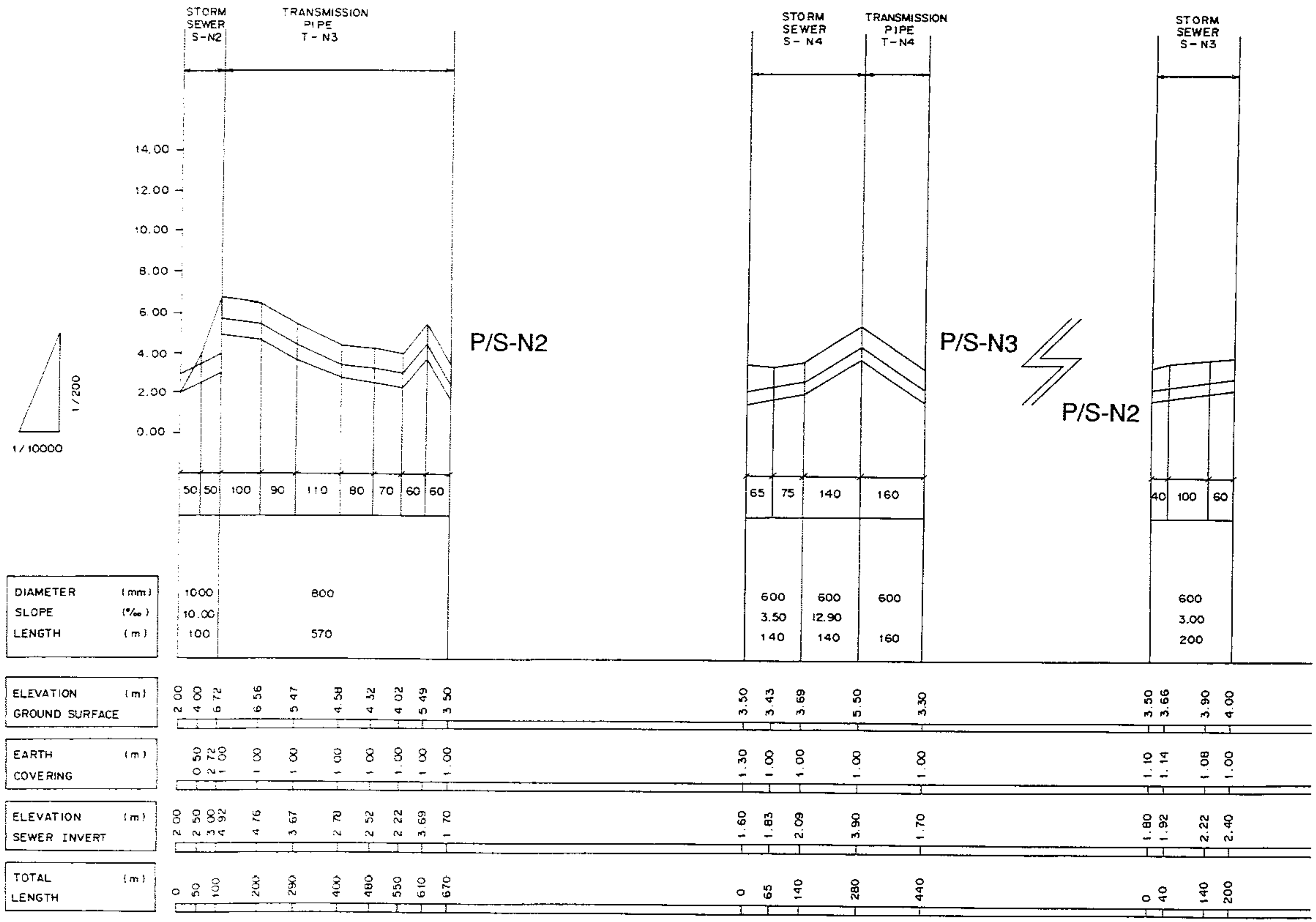
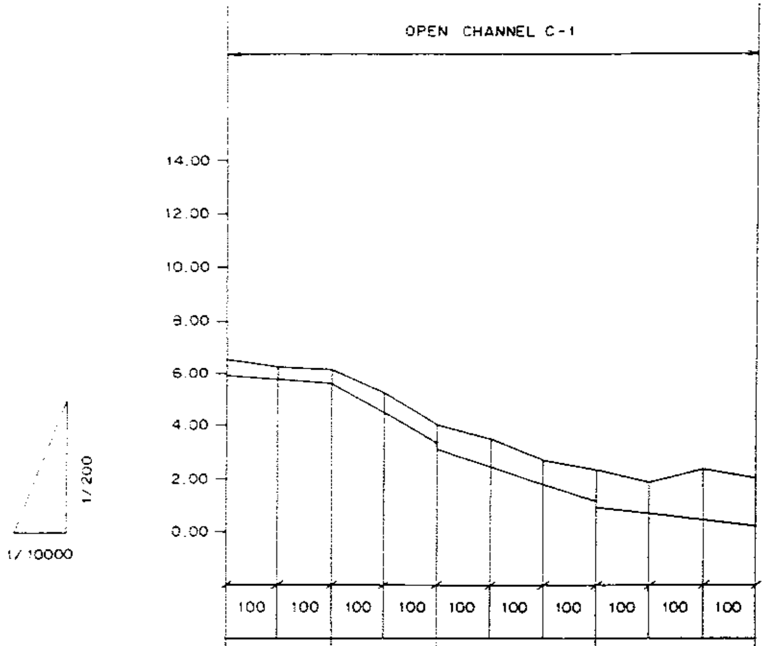


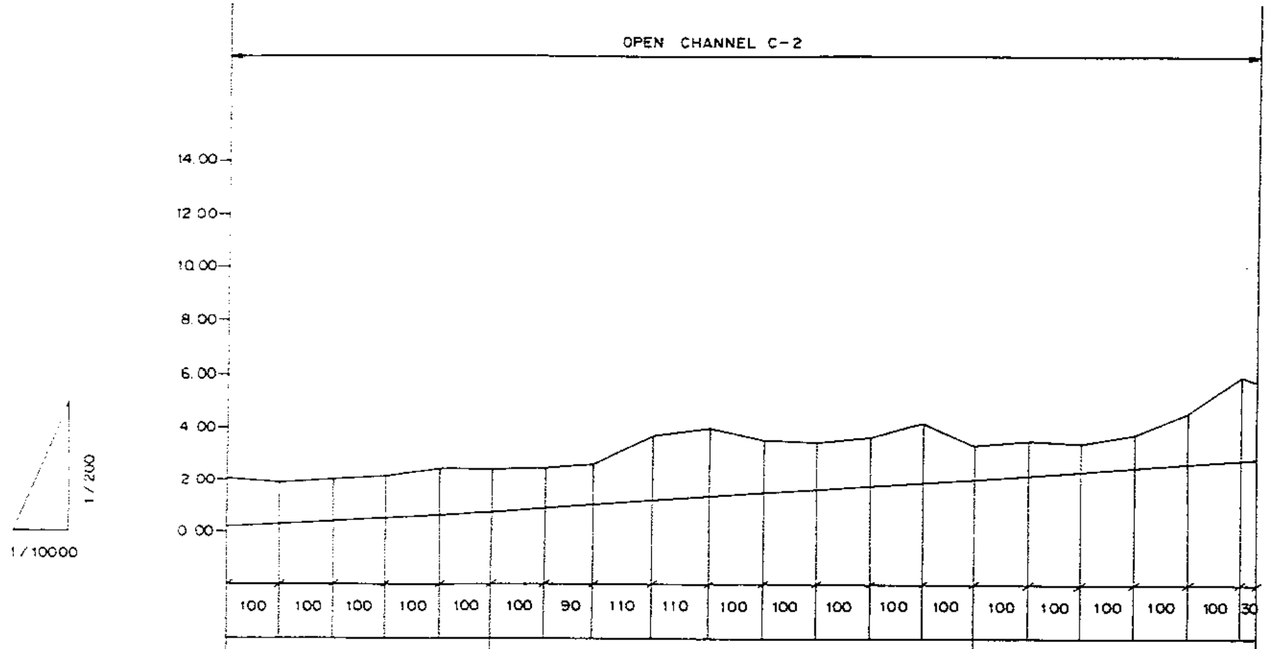
FIGURE C.4.14 PROFILES OF DRAINAGE CHANNELS (CP.1-2)



BOTTOM WIDTH (m)	3.0	3.0	3.0	3.0
BED SLOPE (‰)	1.33	11.76	6.67	2.35
LENGTH (m)	200	200	300	300

ELEVATION GROUND SURFACE (m)	6.47	6.27	6.17	5.22	3.99	3.45	2.69	2.36	1.82	2.33	2.03
EARTH COVERING (m)											
ELEVATION CHANNEL BED (m)	5.88	5.75	5.62	4.44	3.27 3.09	2.42	1.75	1.09 0.91	0.67	0.44	0.2
TOTAL LENGTH (m)	0	100	200	300	400	500	600	700	800	900	1000

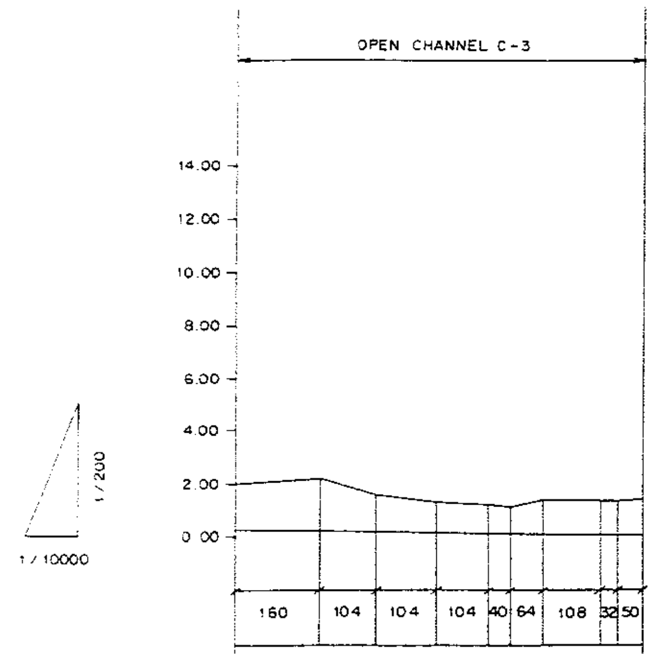
FIGURE C.4.15 PROFILES OF DRAINAGE CHANNELS (CP.1-2)



BOTTOM WIDTH (m) / BED SLOPE (‰) / LENGTH (m)	0–500	500–1410	1410–1940
BOTTOM WIDTH (m)	3.0	3.0	3.0
BED SLOPE (‰)	1.05	1.43	1.33
LENGTH (m)	500	910	530

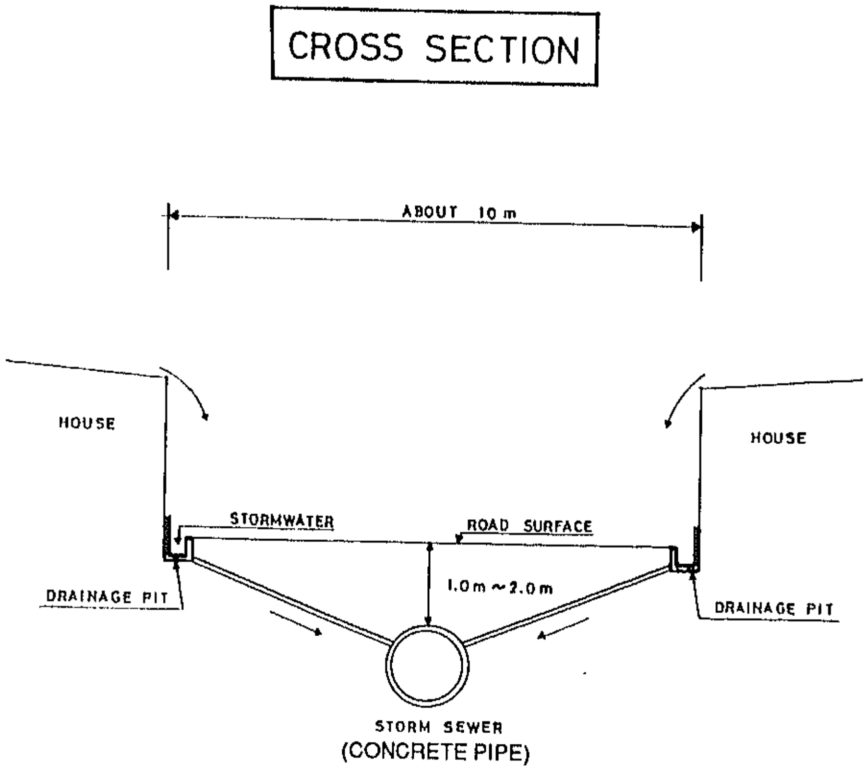
TOTAL LENGTH (m)	ELEVATION GROUND SURFACE (m)	EARTH COVERING (m)	ELEVATION CHANNEL BED (m)
0	2.03		0.2
100	1.94		0.31
200	2.01		0.41
300	2.11		0.52
400	2.40		0.62
500	2.37		0.73
600	2.39		0.87
690	2.52		1.00
800	3.63		1.16
910	3.97		1.32
1010	3.53		1.46
1110	3.44		1.60
1210	3.61		1.74
1310	4.17		1.89
1410	3.33		2.03
1510	3.43		2.16
1610	3.40		2.30
1710	3.63		2.43
1810	4.54		2.57
1910	5.87		2.70
1940	5.74		2.74

FIGURE C.4.16 PROFILES OF DRAINAGE CHANNELS (CP.1-2)



BOTTOM WIDTH (m)	3.0									
BED SLOPE (‰)	0.26									
LENGTH (m)	766									
ELEVATION (m) GROUND SURFACE	2.03	2.14	1.53	1.35	1.26	1.18	1.35	1.30	1.30	1.37
EARTH (m) COVERING										
ELEVATION (m) CHANNEL BED	0.20	0.16	0.13	0.10	0.08	0.07	0.05	0.02	0.01	0.00
TOTAL (m) LENGTH	0	160	264	368	472	512	576	684	716	766

FIGURE C.4.17 PROFILES OF DRAINAGE CHANNELS (CP.1-2)



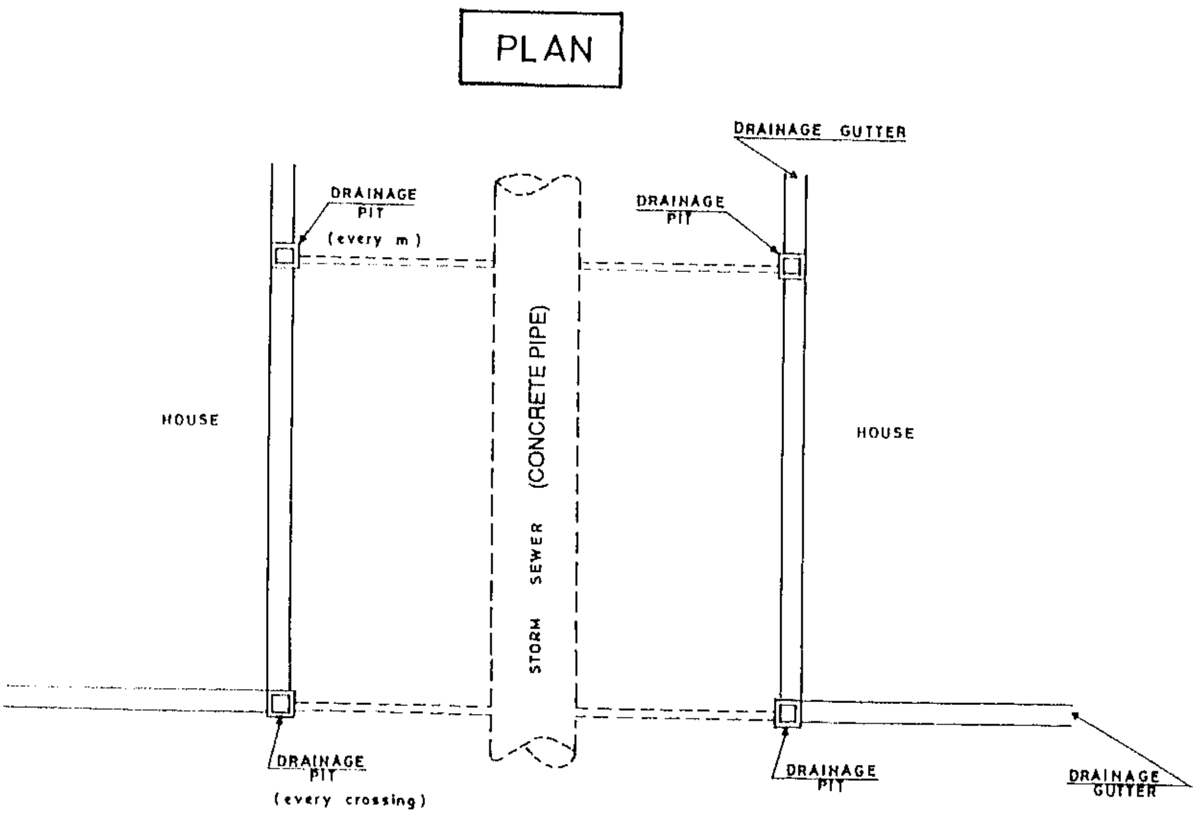
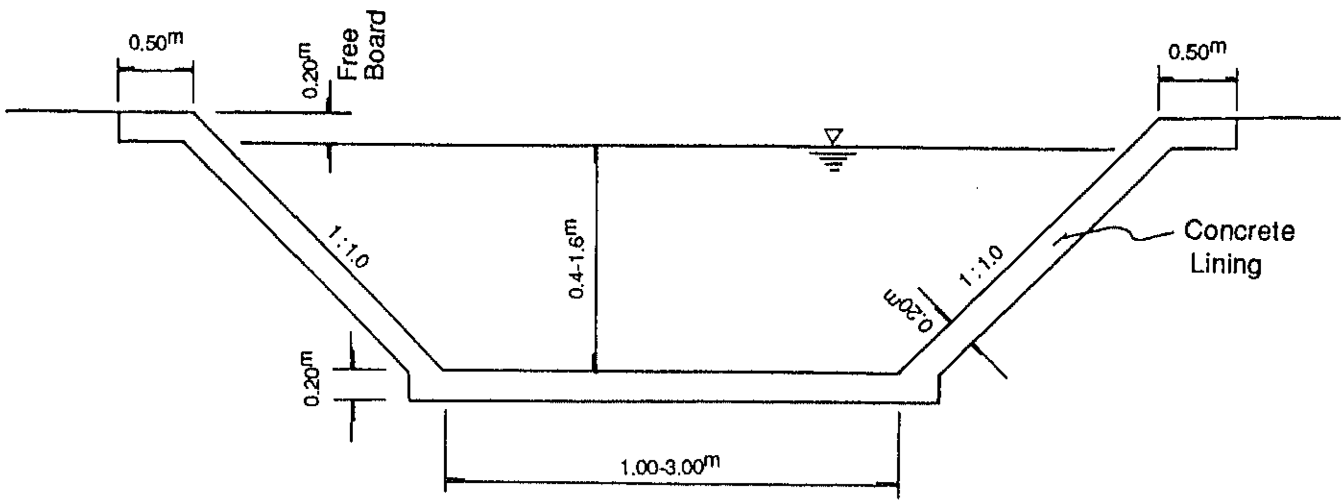
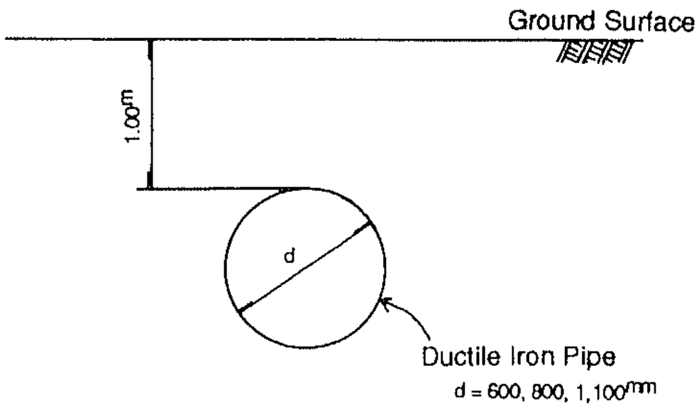


FIGURE C.4.18 TYPICAL DESIGN OF STORM SEWER



Main Drainage Channel



STORM WATER TRANSMISSION PIPE

FIGURE C.4.19 TYPICAL DESIGN OF OPEN CHANNEL AND STORMWATER TRANSMISSION PIPE

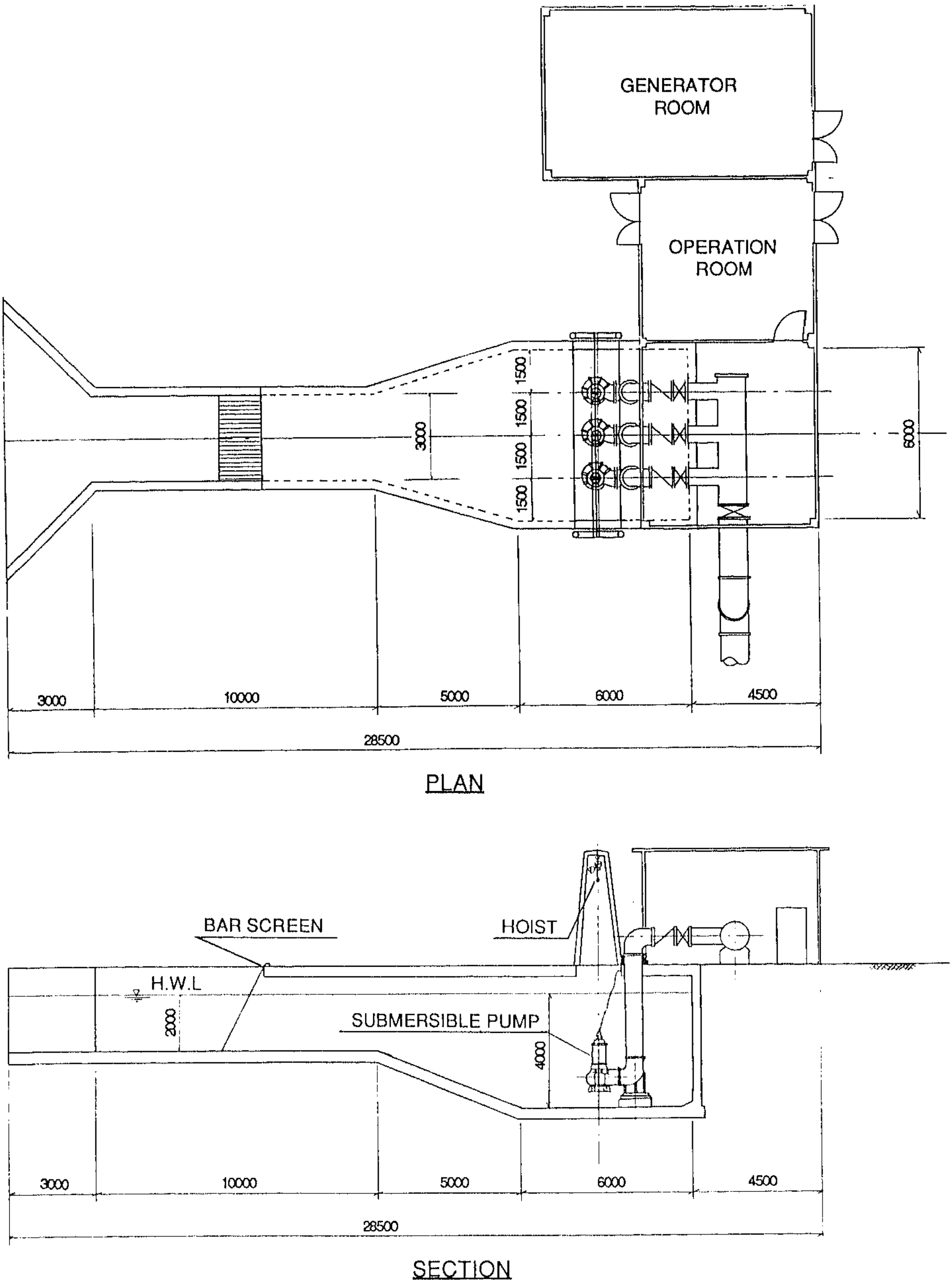


FIGURE C.4.20 TYPICAL DESIGN OF MAIN PUMPING STATION

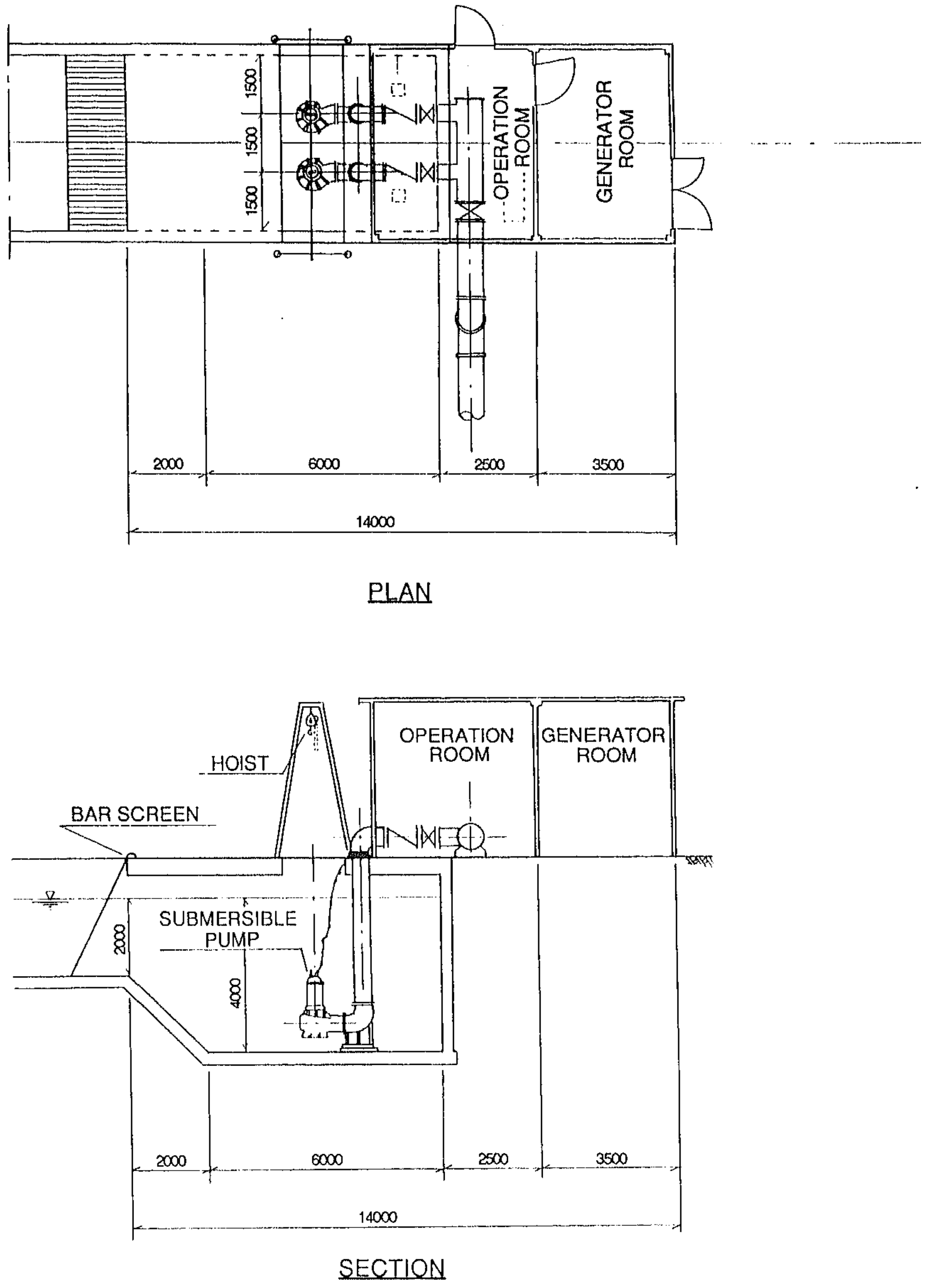
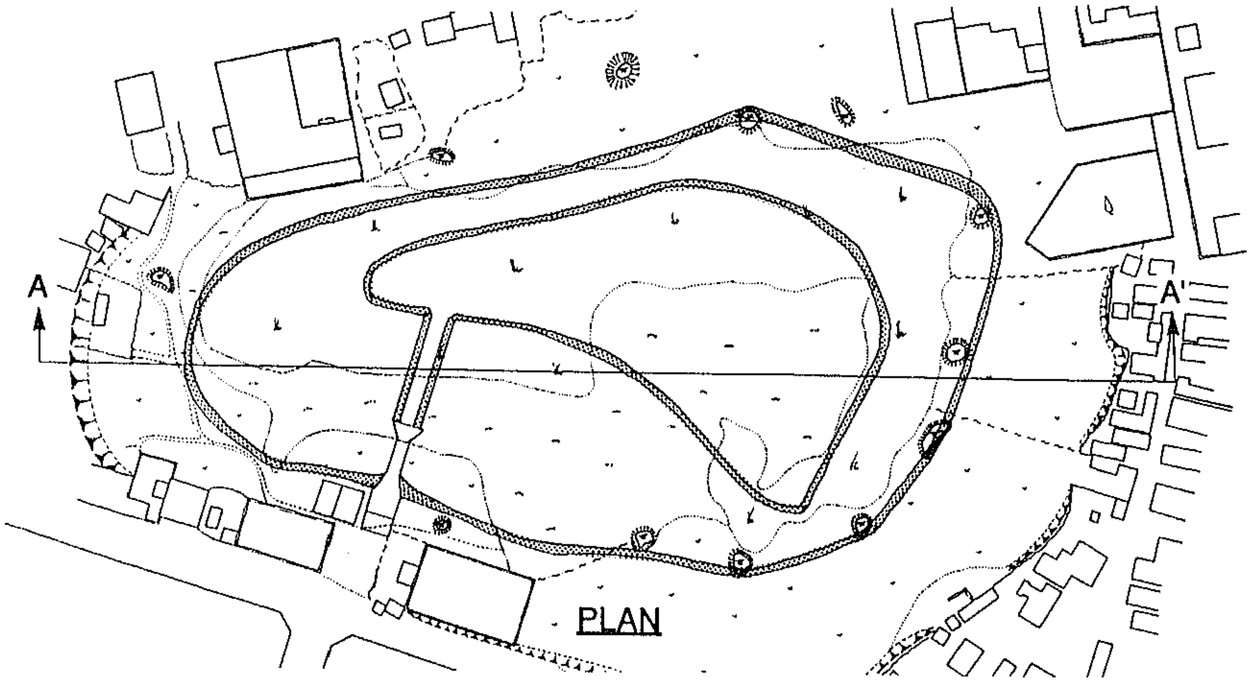


FIGURE C.4.21 TYPICAL DESIGN OF SUB-PUMPING STATION



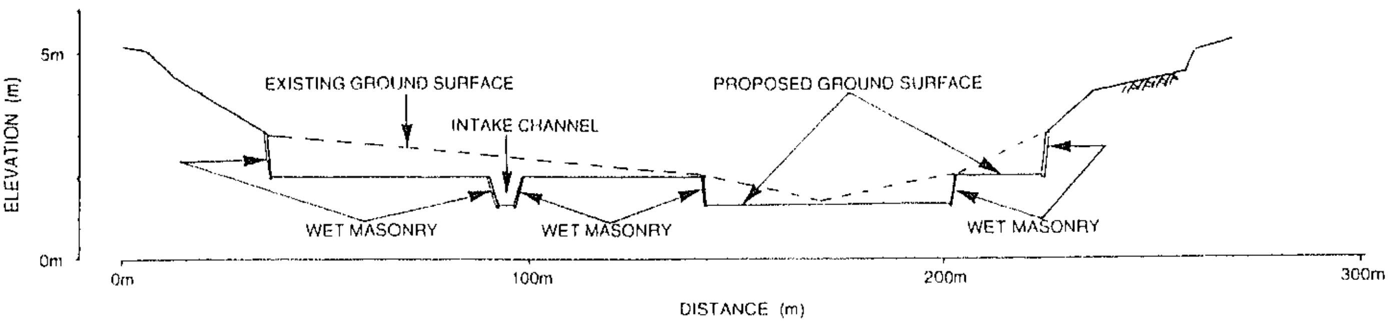


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FIGURE C.4.22 TYPICAL DESIGN OF RETENTION POND

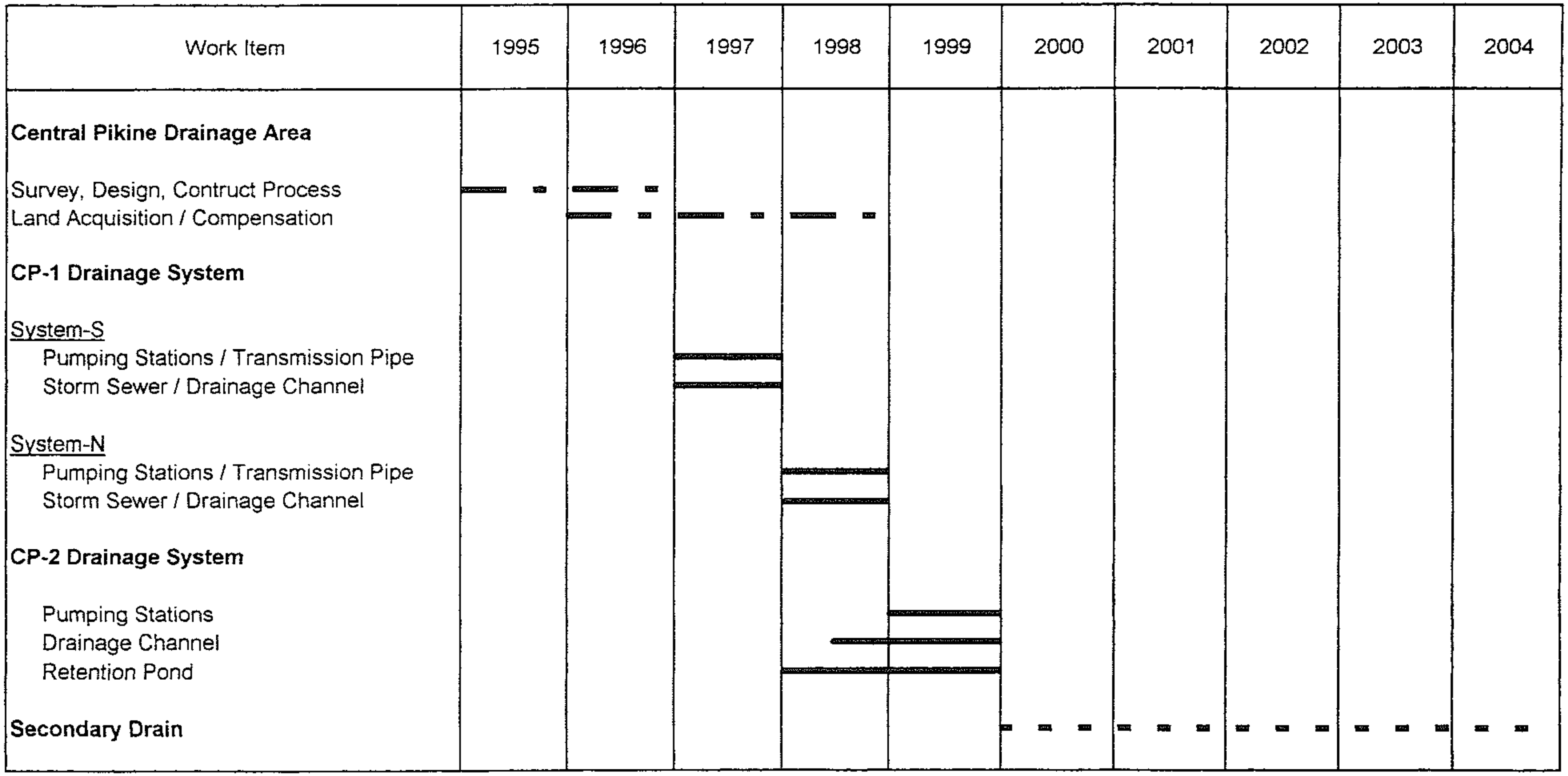

FIGURE C.4.23 PROPOSED IMPLEMENTATION SCHEDULE OF PRIORITY PROJECT

SUPPORTING REPORT - D

ENVIRONMENTAL EXAMINATION

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CHAPTER 1

CHAPTER 1 INITIAL ENVIRONMENTAL EXAMINATION

The objective of this project is to improve and expand sewerage and drainage facilities in Dakar and Pikine cities and as such is an environmental improvement project with the aim of upgrading the living environment in the Dakar-Pikine region. Being an environmental improvement project, the impacts from this project on the environment - physical, human, natural - is mainly positive. However, there exists the possibility of some negative impacts inadvertently arising from the implementation of this project. Therefore, an initial environmental examination (IEE) has been carried out to ensure that the positive impacts of the project are maximized and the negative impacts minimized.

As the first step of the initial environmental examination, a baseline study was carried out alongwith the other surveys carried out and described in the sections on sewerage and drainage. The objective of this baseline environmental study was to assess the present condition of the Study Area from the environmental angle so as to create a framework on which to place the components of the project. By doing so, it becomes easier to visualize the nature of impacts the project will have on the environment and facilitates the process of making adjustments to the plan so as to enhance the positive impacts and mitigate the negative impacts. Particular attention was also paid to the following parameters in the Study Area :

1. Designated green belts
2. Traditional villages
3. National parks and forests
4. Cultural assets and historic / archeological monuments
5. Bathing beaches

1.1 BASELINE STUDY

1.1.1 General

This project involves provision of drainage and sewerage facilities in Dakar and Pikine and rehabilitation / improvements to some existing facilities. These include pipelines and open channels , pumping stations, retention / infiltration ponds, sewage treatment facilities, effluent discharge outfalls and effluent reuse pipelines. The exact nature of facilities to be provided have been outlined in earlier chapters separately for drainage and sewerage facilities. In brief, pipelines and open channels are to be installed in Pikine and to a lesser extent in north Dakar for rainwater and sewage collection. Since the terrain is fairly flat, pumping stations to convey the collected rain water to retention / infiltration ponds and to the sea and sewage to treatment plants, are also to be constructed. Three sewage treatment plants are to be built - two new plants at Malika, with a capacity of 22,500 m^3/d and at Mbaw, with a capacity of 44,600 m^3/d and expansion of the existing treatment plant at Camberene from a current capacity of 10,000 m^3/d to 100,000 m^3/d.

Effluent discharge channels are to be constructed from the Malika plant to the Atlantic Ocean, north of the Malika green belt and from the Mbaw plant to Hann bay, between Mbaw village and the Cap de Biches power plant. The existing effluent pipeline from the Camberene plant to Camberene village is to be made larger in diameter to accommodate the greater flow. Further, the pipe is to be extended about 250 m into the Atlantic Ocean at Camberene village, from its present outlet on the beach.

Effluent reuse pipelines are also to be constructed from the treatment plants to provide for irrigation of nearby agricultural, horticultural or forest lands. Sludge produced at all three plants, after anaerobic digestion and sand drying, is to be sent by trucks for use as fertilizer in agricultural fields.

1.1.2 Designated Green Belts

There are four designated green belts within the Study Area, as given below, along with the area allocated to each green belt. However, the exact areas are slightly less than these figures because of encroachment from the surrounding human settlements. The establishment of each of these four green belts have been decreed by the government of Senegal at various times, and these are given in parentheses below.

1. **Corniche** Green Belt on the east coast of Dakar - 100 ha
   (decree No. 2614 dated 27th July 1943)

2. **Hann Park** - 80 ha
   (decree 3042 dated 29th August 1947)
3. **Malika Forest Reserve** on the north coast - 681 ha
   (decree 0972 dated 7th June 1946)
4. **Mbaw Forest Reserve,** off National Road No. 1 - 771 ha
   (decree 0568 dated 1st January 1950)

While the green areas at Corniche, Hann and Mbaw were created to provide green areas within present and future urban settlements, the Malika Forest Reserve was created as a barrier against sand and wind erosion from the north. The exact location of each designated green belt within the Study Area is given in *Figure D.1.1*, which also shows the location of the three treatment plants.

1.1.3 Villages Designated as Traditional Villages

Villages in the Study Area that have been declared as traditional villages, according to Decree No. 78-599 of 27th June 1978, are given below. The exact location of each traditional village is also given in *Figure D.1.1*.

1. Ouakam
2. Ngor
3. Yoff
4. Camberene
5. Hann
6. Thiaroye-Mer
7. Thiaroye-Gare
8. Yeumbeul
9. Malika
10. Mbaw / Mbaw Gou Ndaw
11. Keur Massar

The traditional villages are inhabited, for the most part, by the Lebou people, who are a sub-group of the Wolof ethnic group. The latter are the major ethnic group in Senegal. The language of the Lebou people is also the Wolof language, spoken by about 80 per cent of the population of Senegal. However, the Wolof spoken by the Lebou people is somewhat distinctively accented. The Lebou in the traditional villages have been accorded special status in Senegal. The Lebou people are farmers and expert fishermen.

The traditional villages are mostly situated along the coast or within easy access of the sea, since fishing is a major activity of the Lebou people. Village life along the coast is entirely dominated by the sea. Each community or village has access to a strip of beach and keeps its own pirogues, or traditional fishing boats. These boats are colorfully decorated and lined with high-water marks. These elegant boats are the product of generations of craftsmanship and design. Constructed from an easily carved red wood similar to teak, the main frame consists of planks warped to a flat center board which defines the pirogue's narrow, high-sided profile. Its length can vary from two to 20 meters and its width generally accommodated side-by-side paddlers with a central well for net and catch. Present day pirogues are often equipped with motors, enabling them to go farther into the ocean to catch shoals of migrating fish such as sea bass, tunny, hake, swordfish, barracuda and shark.

The Lebou group are the native inhabitants of the region. Two theories exist about their origin. One states that the word Lebou probably originates from a Greek word meaning black and that the Lebou people originated from the early black kingdoms of Ancient Egypt. The second theory is that they came from the region near the Senegal river and migrated southwards.

The Lebou were among the first populations on the African continent to set up a system of government similar to a modern republic. The Lebou are unique in that they operate their own mini-government in the Cap Vert region even at present, which is recognized by the Senegalese government. This represents the continuation of a tradition founded in the early 19th century, when the French colonial government recognized the legitimacy of a fledging Lebou republic. Elections are held to nominate the Serigne Ndakaru or head of state, and the representatives of the 12 Lebou constituencies known as pinthie.

1.1.4 National Parks and Forests

There are six national parks designated by the government of Senegal. These are :

1. **Niokolo-Koba National Park** (Parc National de Niokolo-Koba), established in 1952 in the south-east of Senegal, near the border of Gambia and Guinea-Conakry

2. **Oiseaux de Djoudj National Park** (Parc National des Oiseaux de Djoudj), established in 1971 with an area of 16,000 ha north of St. Louis, near the border of Mauritania

3. **Basse Casamance National Park** (Parc National de la Basse Casamance), established in 1972 with an area of 5000 ha in the Casamance region near the border with Guinea-Bissau

4. **Madeleine Island National Park** (Parc National des Iles de la Madeleine) with an area of 450 ha, 4 km west of Dakar

5. **Langue de Barbarie National Park** (Parc National de la Langue de Barbarie) with an area of 2,000 ha about 25 km north-east of St. Louis

6. **Saloum Delta National Park** (Parc National du Delta de Saloum) with an area of 73,000 ha north of the border with Gambia.

Only one of the six above mentioned national parks are in the study region - the Madeleine Island National Park. This park is about 4 km to the south-west of Dakar. This island is an archipelago formed of three islands. The island offers a fascinating landscape, coarsely modeled by the sea and the wind. Wonderful treasures, such as dwarf baobab trees that do not exist anywhere else on the mainland, are available on the island. It is home to various animal species like the hissing viper snake, Seba snake, tortoises, among others.

1.1.5 Bathing Beaches

The main beaches where bathing is common in the Study Area are at the following locations and shown in *Figure D.1.1.*

While the sea water quality at most of the beaches is quite good, some places have been affected by industrial waste and sewage / drainage discharge and solid waste disposal. The worst affected beaches are near the Hann village, Bel-air and Corniche-East. Industrial waste discharge and sewage branch lines connected to storm water drains discharging into the Hann bay are the primary cause of this, as also sewage discharge from the Hann village and an ocean outfall near Pointe de Fann.

The beach near the university of Dakar have been greatly affected in the summer of 1993 due to repairs to the Universite pumping station. This forced stoppage of sewage pumping from the university to Pointe de Fann for eventual discharge there and caused premature discharge near the university.

The discharge pipe of effluent from the Camberene Wastewater Treatment Plant terminates at the Camberene beach, after which the effluent flows into the beach in the open. This causes water quality problems at this beach, and this is compounded by the occasional bypassing of raw sewage from the Camberene plant into this pipe during periods of power failure, etc.

1.1.6 Cultural Assets and Historic / Archeological Monuments and Sites

The Government of Senegal has declared several monuments and sites around the entire country as important cultural assets and having historic and archeological importance. As per Ministerial Decree No. 6876/MC/DPHE/DSMH, dated 19th August 1991, the following monuments and sites located in the Study Area fall under this category and placed under the charge of the Ministry of Culture, which has taken steps to ensure their continued protection and preservation.

1. Goree Island
2. Madeleines Island
3. Ngor Island
4. Grand Mosque and Islamic Institute of Dakar

5. Les mamelles
6. Toundeup Riya Yoff Cliffs
7. Pointe des Almadies
8. Palace of Justice
9. National Assembly
10. Grand Mosque (corner of Blanchot and Carnot roads)
11. African Memorial Cathedral
12. Presidential Palace
13. Military Museum
14. Dakar City Hall
15. Ministry of Foreign Affairs
16. Chamber of Commerce
17. Dakar Museum
18. Kermel Market
19. Sandaga Market
20. Dakar Station
21. Protestant Church
22. Khadres Mosque

The exact location of these above monuments and sites is given in *Figure D.1.2.*

Monuments in the study area included in the World Heritage of UNESCO

Goree Island is the only monument in the Study Area that is included in the World Cultural and Natural Heritage List, compiled by the United Nations Educational, Social and Cultural Organization (UNESCO), under the Convention Concerning the Protection of the World Cultural and Natural Heritage, which was adopted by the General conference of UNESCO in 1972 and to which 115 states have become signatories by 1 January 1991.

1.1.7 Ocean Currents and Its Effect on Dispersion of Discharged Sewage

Raw sewage collected through the Hann-Fann collector is pumped out into the Atlantic Ocean, west of Dakar from the Pointe de Fann, through an outfall that has its outlet about 250 meters from the coast.

As was discussed earlier, when there is a problem at the intermediate pumps that convey sewage to the Pointe de Fann, sewage flows out directly by gravity into the sea immediately near the coastline near the University of Dakar. This was the case between July and September 1993 and it was observed that the two beaches on either side of the university outlet was full of sewage, making the two beaches unfit for bathing or even walking along the beach due to foul odors from the sea. However, this is a problem only when the intermediate pumps at the university of Dakar develop a problem that cannot be repaired quickly.

There is another problem from the discharge of raw sewage from the Pointe de Fann outfall. This is seasonal and is serious in July and August affecting the beaches along the west coast of Dakar, from the southern tip of the Dakar Plateau, along the Corniche west road all the way to Pointe des Almadies, viz., Pointe des Almadies, around Les Mamelles, university of Dakar and Soumbedienc.

The nature of ocean currents is shown in *Figure D.1.3.* It can be seen from *Figure D.1.3* that while the ocean currents between December to April and between September and November take wastes discharged out into the open ocean, those in July and August tend to push the discharged wastes on to the west coast of Dakar. While there are no measurements available of the water quality at the beaches along the west coast, some pollution will reach the shore. This is a problem in July and August and to a smaller extent in May and June when the ocean current patterns are in transition between those in April and those in July. As the volume of untreated raw wastes discharged at Pointe de Fann increase over the years, water quality problems at the west coast beaches will be aggravated. In the future, perhaps after 2010, there is definite need for the construction of a treatment plant near Ouakam to treat all the wastes currently being discharged from Pointe de Fann.

1.1.8 Effect of Water Pollution in the Near Season Commercial Fishing

Recent trends is commercial fishing in the near seas around the study region aboard traditional fishing boats called pirogues, mainly by the Lebou people, show that there is a gradual fall in the catch over the last couple of years. An analysis of the fish catch by pirogues near the study area - Hann Bay and Atlantic Ocean - between 1985 and 1991 is given in *Table D.1.1* and graphically presented in *Figure D.1.4*. It can be seen from *Table D.1.1* and *Figure D.1.4* that after a peak fish catch in 1987, there has been sharp in all succeeding years. This drop is due to a variety of factors - water pollution in the near seas, especially the Hann Bay and use of motorized pirogues that can reach greater distances from the seashore. However, it should be noted that the introduction of motorized pirogues was partly due to increasing pollution in the Hann bay which forced fishermen to look out into the outer ocean to make up for lost fish catch in the Bay.

1.2 ENVIRONMENTAL IMPACT ASSESSMENT

The previous section gives an idea of the baseline environmental conditions in the project study area at present. By overlaying the impacts from the sewerage and drainage components of the project on this background, the impacts, both positive and negative, emanating from this project will become evident.

There are two project activities and impacts from these two activities are somewhat different. The two project activities are:

i. Construction of facilities
ii. Operation

The facilities involved in this project are as given below :

a. Pipelines and open channels (sewerage and drainage)
b. Pumping stations (sewerage and drainage)
c. Stormwater retention / infiltration ponds
d. Treatment plants
e. Treated effluent reuse pipelines
f. Treated effluent discharge pipelines

In addition to these facilities, it has been proposed that a part of the contributing area to the Hann-Fann sewage collector be converted to become part of the Camberene collection area. This will serve to reduce the amount of sewage that will flow out of this collector at the Pointe de Fann over the years.

There are a variety of impacts possible from a project of this nature. Broadly, the impacts, both positive and negative, can be classified as follows :

1. those on the physical environment
2. those on the ecological environment
3. those that affect human use values and resources and
4. those that affect the quality of life in the Study Area.

Under each of these broad impact classes, there are several sectors on which there will be impacts. For example, the physical environment can be divided into the water, air, land, solid waste and noise sectors. The ecological environment can be divided into the aquatic, terrestrial and endangered species sectors. The human use level can be divided into sectors like water supply, transport, etc. The quality of life level can be divided into socio-economic, cultural and aesthetic sectors. Under each of these sectors, further subdivision is possible.

This project is an environmental and sanitation improvement project in Dakar-Pikine and as such, most of the impacts are very positive and benefit the citizens of the area. None of the project components have any negative impact any of the environmental sectors and ethnic groups in the area. The location of the three treatment plants do not adversely any of the traditional villages or for that matter, any group of inhabitants. The outfalls from the treatment plant are all to be extended about 250 meters into the sea, thereby avoiding any health risks to the nearby populace and tourists. The pipelines and pumping stations might cause some inconvenience to nearby residents during the construction stage; however, they provide immeasurable public health and sanitation benefits. The facilities to be constructed in this project do not affect any of the green belts or the rich cultural assets/historical and archeological monuments of the region.

To facilitate impact assessment from each of the different project components on the various sectors, an environmental impact assessment matrix has been constructed. This matrix will provide easy identification of the impact (both positive and negative) of all project activities / components and its relative magnitude on the different aspects of the environment. This environmental impact matrix is given in *Table D.1.2*.

1.2.1 Physical Environment

1) Water

Construction of all facilities have no impact on both ground water and surface water, both their hydrology and their quality. However, laying of undersea pipelines to convey the treated effluents into the sea from the three treatment plants would entail some disturbance of the marine environment during the construction phase.

During operation, the existence and operation of sewerage pipelines and treatment plants would divert a large volume of domestic sewage in the presently unsewered areas (e.g. Pikine regular) to the treatment plants. This would result in a dramatic reduction in the number of on-site sewage treatment and disposal facilities, which would result in a large reduction of polluted water infiltration to the ground water table. Treated effluent reuse would result in recharging the ground water table with good quality water. Similarly, greater sewerage coverage and operation of treatment plants would serve to ensure that lesser volume of untreated sewage is sent into the sea all around the Study Area, thereby reducing the pollution incident into the sea and thereby improving sea water quality.

Retention and infiltration ponds for stormwater will serve to allow infiltration of rainwater into the ground over a wider area (i.e. away from the point of rainfall). Further, conversion of a part of the Hann-Fann collection area to the Camberene area would reduce the raw sewage inflow into the sea at the Pointe de Fann, bringing beneficial effect on the sea water quality in western Dakar.

2) Air

While none of the project activity components have any effect on the meteorology, there is moderate impact during the construction phase of all components due to generation of dust. Further, operation of treatment plants will result in treated sludge which needs to be transported to farm lands for use as fertilizer. Dust dispersion en route to the farms will result, and the magnitude of this can be controlled by proper loading and covering of the transport vehicle. Some noxious odors will emanate from pumping and the treatment process. However, this will not be a major problem from an analysis of the prevailing wind patterns in the region and described below.

Table D.1.3 gives the results of the monthly dominant wind direction analysis between 1981 and 1991. All wind directions given therein are directions from where the wind is blowing. All the wind directions viz., N, NE, SE, etc. have been converted to a 360 degree scale with east being represented by 0 degrees, north by 90 degrees, west by 180 degrees and south by 270 degrees. The decadal monthwise average is then calculated, with care taken to ensure that for each month, any odd direction, if any, in one of the 10 years that is drastically different from that month's trend is not given undue weightage. It can be seen that in all months, the predominant wind direction is from the northerly direction.

It can be noted that in the case of the Camberene plant, since there are no major housing plots in the vicinity of the plant, wind direction will not pose any problem. In the case of the Mbaw plant, wind from the northerly direction will ensure that all odors are dissipated over the forested areas and the Hann bay and will not cause any problem to the new housing development north of National Road No. 1. Since the plant is situated quite far from both the Mbaw village and the Cap de Biches power plant (where there is a housing colony), which are located southwest and southeast of the plant, respectively, there should be no odor problems. In the case of the Malika plant, there are no housing plots immediately to the south and southeast of the plant. Hence, winds from the north will not pose any problems.

The conversion a part of the Hann-Fann collection area to Camberene would result in less sewage flow into the sea as mentioned earlier and would result in less foul odor arising from discharge in the western Dakar area.

3) Land

There are no impacts on the soils and land from this project, with the exception that effluent reuse will cause some soil quality problems at the locations of reuse. This is because effluent for reuse is secondary treatment effluent, without any treatment to remove salts, which might cause some salinity problems for soils at the reuse locations.

4) Noise

There are moderate noise and vibration problems that will be encountered during the construction phase for all facilities, with it affecting more people for sewage and drainage pipelines / open channels due to the long distances of the pipelines. During operation, some noise is inevitable from pumping station operation. However, this can easily be minimized by provision of noise control devices and construction of thicker walls.

5) Solid wastes disposal

Solid wastes generated from digging at pipeline sites need to be properly disposed and given the length of pipelines and channels (both collection and discharge channels and pipelines) to be constructed, this will have moderate impact on the solid waste disposal sites during the construction phase. Similar solid waste problems, albeit lesser in volume, will occur in the excavations at the treatment plant and retention /infiltration pond sites. During operation of the facilities, scum and grit at pumping stations and sludge at treatment plants need to be disposed. The latter can be used as fertilizer; however, excess sludge will need to be disposed.

1.2.2 Ecology

Treatment plants will improve the quality of effluent disposed into the seas around Dakar and Pikine and this will have a beneficial effect on the fisheries and aquatic biology. There are no wildlife or endangered species in the study area. However, there are baobab trees between National Road No. 1 and Hann bay in the Mbaw area and some trees may need to be felled to accommodate the Mbaw treatment plant as well as the effluent channel/pipeline into Hann bay. Treated wastewater available at the three treatment plants for reuse can have a beneficial effect on forest resource due to availability of good water, as also stormwater diverted to infiltration ponds.

Reduction of the Hann-Fann collection area would result in lesser sewage flow into the sea and in better quality sea water and serve to protect Madeleines Island, which serves as a wayside landing point for migratory birds, especially in winter.

1.2.3 Human Use Values

1) Water supply

Provision of sewerage systems and treatment facilities will enable diversion of wastes from on-site waste treatment facilities, which have a negative effect on ground water quality, as was discussed earlier.

The location of wells utilized by SONEES for water supply was earlier presented in *Figure D.1.5*. There are wells both in Dakar and in Pikine and further east. While SONEES is able to provide piped water supply after proper treatment to almost all areas in Dakar and Pikine regular, many households rely on wells in Pikine irregular and the traditional villages as a source of water, in addition to SONEES water supply through public standpipes and individual connections. In these locations, people have private wells. Therefore, the water quality of well water is important from the public health standpoint.

Nitrate nitrogen is an important parameter in judging the quality of water, especially groundwater. Excessive nitrates in water will lead to occurrence of infantile methaemoglobinaemia, which affects children in particular. SONEES regularly analyses the water quality of its wells and this will give an idea of the quality at private wells in nearby locations. The nitrate nitrogen content of the water in the SONEES wells in *Figure D.1.5* is listed in *Table D.1.4*. For reference, the WHO standard for maximum nitrate nitrogen allowable in drinking water is 10 mg/l.

It can be seen that all wells exhibit nitrate nitrogen concentrations in excess of WHO prescribed limits and those in Pikine and further east are about 10 times greater than values in Dakar. The main cause of this is infiltration from on-site sanitation facilities. Therefore, provision of sewerage facilities will improve the ground water quality and this will, in turn, have a positive effect on the quality of water supply to those communities which still rely on groundwater wells as a source of drinking water.

2) Transport/Lifestyle

There will be unavoidable obstructions to traffic during the construction phase of all components of this project and will cause some disruption to daily normal life. However, this is only a minor problem and limited to the construction phase.

3) Agriculture

This project will benefit agriculture from the availability of treated water for irrigation and possibly aquaculture in the Grand Niaye area. The extent of this benefit will depend on the volume of water to be reused.

4) Flood control / drainage

This is one of the most important positive impacts of this project. With the provision of drainage channels and improvements to existing channels and pipelines, the drainage situation will greatly improve and even during period of intense rainfall, flooding should not be a problem as has been the case in the past, like in 1989. This will much downstream positive impacts like less disruption to the economic life of the area and produce great economic benefits to citizens.

5) Power

Operation of pumping stations and treatment plants will impose a load on the power supply facilities in the Study Area, and to this extent, this project will have a negative impact on power available.

6) Recreation

With the diversion of sewage from part of the Hann-Fann collector to the Camberene system and with the provision of treatment facilities at Malika and Mbaw and extension of the Camberene effluent outfall into the sea, the quality of the beaches will improve considerably and this in turn would have enhance the recreational values of the Dakar-Pikine beaches, in particular, along the west coast, at Camberene village and at Mbaw village.

Further, there will be beneficial effect on the beaches in western Dakar from reduction of the collection area in the Hann-Fann area and the consequent reduction in raw sewage flowing out at Pointe de Fann.

7) Land use

There will be some negative impact on land use due to the setting up of treatment plants at Malika and Mbaw and retention / infiltration ponds at several locations in the study area to the extent that land required for these facilities will preclude use of nearby land for other purposes like habitation, etc. However, in the case of retention / infiltration ponds, the land to be used is low-lying land, and therefore, the effect is considered minor. In the case of the Malika plant, the site is near the solid waste dumping ground. More than the plant, the dumping ground precludes many uses of the nearby land. In the light of these factors, the negative impact is considered to be very minor on land use values.

1.2.4 Quality of Life Values

1) Socio-economic sector

This project involves no resettlement or movement of people. It has a positive impact on the public sanitation and public health of the populace, especially in Pikine. The benefits include :

1. Better sanitation due to coverage of sewerage and drainage pipelines.

2. Lesser infiltration of water from on-site facilities and therefore lesser pollution of ground water, which is a source of drinking water for some people in Pikine irregular and further east and the traditional villages.

3. Provision of drainage facilities and improvement of existing drainage pipes and channels would result in lesser economic damage by direct flooding of housing and other establishments and in lost time fighting flooding. It will also provide better protection against disease like malaria that are perpetrated in stagnant stormwater pools over extended periods.

4. Improvements in the sea water quality available for bathing in western Dakar from reduction of the Hann-Fann collection area, in Camberene village and in the Hann bay.

However, caution must be taken during construction of facilities, especially pipelines, since there is the possibility of danger to public safety (both cars and pedestrians) from uncovered pits for pipelines at night times and holidays. Therefore, sufficient notices should be posted at all sites.

2) Cultural

None of the project facilities are coming up near historic or archeological sites or cultural assets and monuments, nor do any components interfere adversely with life in any community, including the traditional villages. However, with respect to religious structures, like mosques and churches, updated location maps, especially in Pikine, are not available. Therefore, it is proposed that during the feasibility study stage, when the routes for the sewerage and drainage pipelines / channels are finalized, the sites and routes be confirmed to ensure that pipelines and especially open channels do not pass in front of mosques and churches. Pumping station sites will also be checked to ensure that they are not too near religious structures.

The drainage and sewerage facilities that will come up will improve the lot of the traditional villages, as has been discussed earlier. Among the improvements are :

1. Improved sea water quality at Camberene village

2. Improved sea water quality in Hann Bay benefiting both the Hann and the Mbaw villages

3. Extension of sewerage coverage in Pikine would reduce infiltration into the ground water from on-site sanitation facilities, leading to reduction of pollution of the ground water resources. This will be beneficial to areas where wells are an important source of water supply like Yeumbeul, Thiaroye-Gare, Malika and others.

3) Aesthetics

This project will adversely affect the landscape during the construction phase, especially due to open-cut laying of pipelines and open channels. Once the construction is completed, the treatment plants will have some negative effect on the surrounding landscape, especially at Mbaw, where it will be located on forested lands. Odor problems, as was discussed earlier, will also have some minor impacts near treatment plants and more so in the case of pumping stations.

Drainage facilities in Pikine will serve to improve the aesthetics of the areas by faster draining of rain water and reduction in the time that water is stagnant. This will reduce flooding and the consequent occurrence of stagnant pools of dirty water for long periods of time. The sewerage facilities will serve to improve sanitation and reduction of on-site facilities, which also contribute to improving the aesthetics qualities of the areas covered. Consequently, odor from on-site facilities are also reduced.

Reduction of the collection area of the Hann-Fann area will lead to less discharge of raw sewage at Pointe de Fann and lead to better aesthetics in the beaches of western Dakar and reduction of odor problems.

1.3 ENVIRONMENT IMPACT BY PRIORITY PROJECT

Environmental impacts of the sewerage and urban drainage priority projects were examined according to the checklist shown in Table *D.1.5*. In the table, items to be examined are selected from the items evaluated to have any impacts by the evaluation for the Master Plans.

1.3.1 SEWERAGE PROJECT

1) Construction phase

(1) Air

While no impacts that are considered as air pollution are expected, construction activities may cause dust during excavation works in pipe installation, site preparation of wastewater treatment plant. However, this can be mitigated within allowable extent by applying proper construction method.

(2) Noise

A certain degree of noise would be unavoidable during the installation of the sewer pipe and construction of pump stations. However, the impact can be minimized by selecting low-noise type equipment as far as practicable.

(3) Solid Waste

Excavation works may be generated by digging at pipeline sites. This must be disposed at proper sites.

(4) Traffic/Business Activity

Traffic will be hindered during construction works at road sides foe mainly pipe installation. However, all roads where construction works will be done have enough width to allow a minimum traffic and no diversion of traffic will be required. Therefore, the impacts will be considered to be practically very minor.

(5) Aesthetics

Generally, any construction works have negative effect visually.

2) Operation Phase

(1) Noise

Operation of pumping stations may increase noise level around the pumping stations. However, every pumping station proposed in the priority project are replacement of the existing pumping stations or construction of new stations just next to the present pumping station. Thus the project will not increase the noise level compared to the present conditions.

(2) Solid Waste

As result of operation of the wastewater treatment plant, excess sludge will be generated. The sludge are to be stabilized and dried by anaerobic digestion and dry bed. While it can be utilized as fertilizers, it is necessary to keep proper land to dispose excess sludge.

(3) Water Supply

The project will increase amount of wastewater to be collected. This will slightly reduce the infiltration of untreated wastewater into the ground.

(4) Sanitation

Improvement of sanitation conditions of the areas is a main purpose of the sewerage project.

(5) Aesthetics

Development of sewer collection will provide a rapid elimination of the wastewater, resulting improvement of aesthetics quality of the area.

1.3.2 URBAN DRAINAGE PROJECT

1) Construction phase

(1) Air

While no impacts that are considered as air pollution are expected, construction activities may cause dust during excavation works in pipe installation, site preparation of wastewater treatment plant. However, this can be mitigated within allowable extent by applying proper construction method.

(2) Noise

A certain degree of noise would be unavoidable during the installation of the drainage pipe and construction of pump stations and open channels. However, the impact can be minimized by selecting low-noise type equipment as far as practicable.

(3) Solid Waste

Excavation works may be generated by digging at pipeline sites. This must be disposed at proper sites.

(4) Traffic/Business Activity

Traffic will be hindered during construction works at road sides foe mainly pipe installation. However, all roads where construction works will be done have enough width to allow a minimum traffic and no diversion of traffic will be required. Therefore, the impacts will be considered to be practically very minor.

(5) Agriculture

A retention pond will be constructed at Thiaroye. The site is presently cultivated. Thus during construction works, present farming activities would be hindered. However, once the pond is constructed, it is possible to allow to cultivate the pond. Therefore, the impact is very limited.

(6) Landuse

Several pump stations will be constructed in residential area. However, the sites are selected at the lowest area where the residents have already gone out due to repeated inundation, or in the public facilities, such as school and foot ball ground. Therefore, the impact is considered to be minor.

(7) Aesthetics

Generally, any construction works have negative effect visually.

2) Operation Phase

(1) Noise

Operation of pumping stations may increase noise level around the pumping stations. However, operation of drainage pumps occurs very limited time, only in heavy rain, and the duration is very short, maximum one day. Thus, the impact is considered to be minor.

(2) Traffic and Business Activities

Presently traffic and business activities are hindered by flood occurred in the rainy season. The project mitigates such flood damages.

(3) Sanitation

Mitigation of flood could improve the sanitation conditions of the areas.

(4) Aesthetics

Mitigation of flood could improve the aesthetic quality of the areas.

TABLE D.1.1 TREND IN FISH CATCH BY PIROGUES NEAR STUDY AREA IN RECENT YEARS

Year	Weight of fish landed tonnes	Increase / Decrease wrt previous year, %	Decrease since best year, 1987, %	Estimated Commercial Value, million CFA	Increase / Decrease wrt previous year, %	Decrease since best year, 1987, %
1985	30671.4			4369.721		
1986	40302.9	31.40		6387.065	46.17	
1987	55502.6	37.71		8120.935	27.15	
1988	41455.5	-25.31	-25.31	6816.358	-16.06	-16.06
1989	34886.5	-15.85	-37.14	6268.358	-8.04	-22.81
1990	29858.5	-14.41	-46.20	6201.667	-1.06	-23.63
1991	21132.8	-29.22	-61.92	5190.289	-16.31	-36.09

TABLE D.1.2 ENVIRONMENTAL IMPACT MATRIX

Level	Sector	Environmental resource or value	Construction: Pipeline /open channel	Construction: Retention /infiltration pond	Construction: Pumping Station	Construction: Treatment Plants	Construction: Effluent reuse facilities	Construction: Effluent discharge channels	Construction: Conversion of part of Hann-Fann to Camberene	Operation: Pipeline /open channel	Operation: Retention /infiltration pond	Operation: Pumping Station	Operation: Treatment Plants	Operation: Effluent reuse facilities	Operation: Effluent discharge channels	Operation: Conversion of part of Hann-Fann to Camberene
PHYSICAL	Water	Ground water quality											++			
		" " hydrology									+++			++		
		Surface water quality														
		" " hydrology														
		Seawater quality						-					++			+++
	Air	Meteorology														
		Air quality	--	-	-	-	-	-	-				-			
		Odor										-	-	-		+
	Land	Land subsidence														
		Soil quality												-		
		Soil Erosion														
	Noise	Noise	--	-	-	-	-	-	-			-				
		Vibration	--	-	-	-	-	-	-							
	Solid waste disposal		--	-		-		-	-			-	-			
ECOLOGY	Aquatic	Fisheries											++			+
		Aquatic biology											++			+
	Terrestrial	Forests									+			+		
		Wildlife														
		Baobab				-		-								
	Endangered species															
HUMAN USES	Water supply									+			+			
	Transport / Lifestyle		--	-	-	-		-	-							
	Agriculture	Aquaculture												+		
		Irrigation												++		
	Flood control / drainage									+++	+++					
	Power											-	-			
	Recreation												+++			++
	Land uses										-		-			
QUALITY OF LIFE	Socio-economic	Resettlement														
		Public health									+		+++			+
		Public safety	*1					*1		*1					*1	
		Economic / Social Structure														
		Institutional														
	Cultural	Historic sites														
		Archeological sites														+
		Cultural assets														
		Religious structures	*2		*2			*2	*2							
		Traditional village						-		+			+			+
	Aesthetics	Landscape	--	-	-	-		-					-			
		Aesthetics														+
		Odor										-	-			+

Note : Pipelines and pumping stations include both those for sewerage and for drainage

Legend :
+ positive impact
- negative impact
blank no impact
+++/--- significant impact
++/-- moderate impact
+/- minor impact

*1 During pipeline / effluent channel construction, notices are required around sites at night & on holidays so that people/cars do not accidentally fall in.

*2 During detailed route selection, pipelines and pumping stations should avoid crossing mosques & churches (Detailed locations maps are not available for areas outside Dakar)

TABLE D.1.3 MONTHLY DOMINANY WIND DIRECTION ANALYSIS FROM 1981 TO 1991

Wind Direction in degrees
0 - East; 90 - North; 180 - West; 270 - South

	1981		1982		1983		1984		1985		1986		1987		1988		1989		1990		1991		Average	
	Directio	Degrees	Directio	Degrees	Directio	Degrees	Directio	Degrees	Directio	Degrees	Directio	Degrees	Directio	Degrees	Directio	Degrees	Directio	Degrees	Directio	Degrees	Directio	Degrees	Directio	Degrees
January	N	90.0	N	90.0	NNE	67.5	N	90.0	N NNE	78.8	N	90.0	N	90.0	N NE	67.5	N NE	67.5	N	90.0	N	90.0	N NE	82.8
February	N	90.0	N NW	112.5	N	90.0	N	90.0	N NNE	78.8	N	90.0	N	90.0	N	90.0	NW	135.0	N	90.0	N	90.0	N	95.1
March	N	90.0	N	90.0	N	90.0	N	90.0	NNE NNW	90.0	N	90.0	N	90.0	N	90.0	N	90.0	N	90.0	N	90.0	N	90.0
April	NW N	112.5	N	90.0	N	90.0	N NW	112.5	N	90.0	N	90.0	N NW	112.5	N NE	67.5	N	90.0	N NW	112.5	N	90.0	N	96.1
May	NW	135.0	N	90.0	N	90.0	N NW	112.5	N NNW	101.3	NW N	112.5	N	90.0	N	90.0	NW	135.0	NW	135.0	N NW	112.5	N NW	109.4
June	NW	135.0	NW	135.0	NW	135.0	NW	135.0	WSW WN	180.0	WNW NN	135.0	N	90.0	N NW	112.5	W NW	157.5	W NW	157.5	W NW	157.5	NW	139.1
July	NW	135.0	NW	135.0	W	180.0	NW	135.0	SW W	202.5	W	180.0	N	90.0	W	180.0	W NW	157.5	W NW	157.5	W	180.0	NW W	157.5
August	NW	135.0	NW	135.0	SW	225.0	NW	135.0	SSW NNW	180.0	S W	225.0	N NW	112.5	SW	225.0	W	180.0	W NW	157.5	W NW	157.5	W	169.8
September	SW	225.0	NW	135.0	NW	135.0	NW	90.0	SW	225.0	W	180.0	N	90.0	N	90.0	NW	135.0	W NW	157.5	NW	135.0	NW	145.2
October	N	90.0	N	90.0	NW NNW	123.8	N	90.0	NNW N	101.3	N NW	112.5	N	90.0	N	90.0	N NW	112.5	W NW	157.5	N	90.0	N NW	104.3
November	N	90.0	N	90.0	N	90.0	N	90.0	N	90.0	NNW N	101.3	N NE	67.5	N	90.0	N	90.0	N	90.0	N	90.0	N	89.0
December	N NE	67.5	N NE	67.5	N	90	N	90.0	N NNE	78.8	N	90.0	E NE	22.5	N NE	67.5	N	90.0	N	90.0	N	90.0	NE	76.7

TABLE D.1.4 NITRATE NITROGEN CONCENTRATION IN SONEES WATER SUPPLY WELLS IN THE STUDY AREA

Well Name or Number	Area	Nitrate Nitrogen, mg/l
F15	Thiaroye-Gare	143.9
F17	Pikine	175.2
F18	Pikine	285.6
F19	Pikine	174.9
F21	Yeumbeul	266.0
F22	Pikine	268.3
Camp Penal	Dakar	11.7
Terme Nord	Dakar	13.3
Point M	Dakar	15.8
Terme Sud	Dakar	21.2

TABLE D.1.5 CHECKLIST FOR ENVIRONMENTAL IMPACTS OF PRIORITY PROJECTS

Activity	Sewerage Project			Urban Drainage Project		
	During Construction	During Facility operation		During Construction	During Facility operation	
	Negative	Positive	Negative	Negative	Positive	Negative
Physical Environment						
Air	XX	--	--	XX	--	--
Noise	XX	--	X	XX	--	X
Solid Waste	XX	--	X	XX	--	--
Human use value						
Water supply	--	X	--	--	--	--
Traffic	XX	--	--	XX	XX	--
Business activities	X	--	--	X	XX	--
Agriculture	--	--	--	X	--	--
Landuse	--	--	--	X	--	--
Qualty of Life value						
Sanitation	--	XX	--	--	XX	--
Caltural	--	--	--	--	--	--
Asthetics	X	X	--	X	X	--

XX: Some extent of impact, X: Very small impact, --: No impact

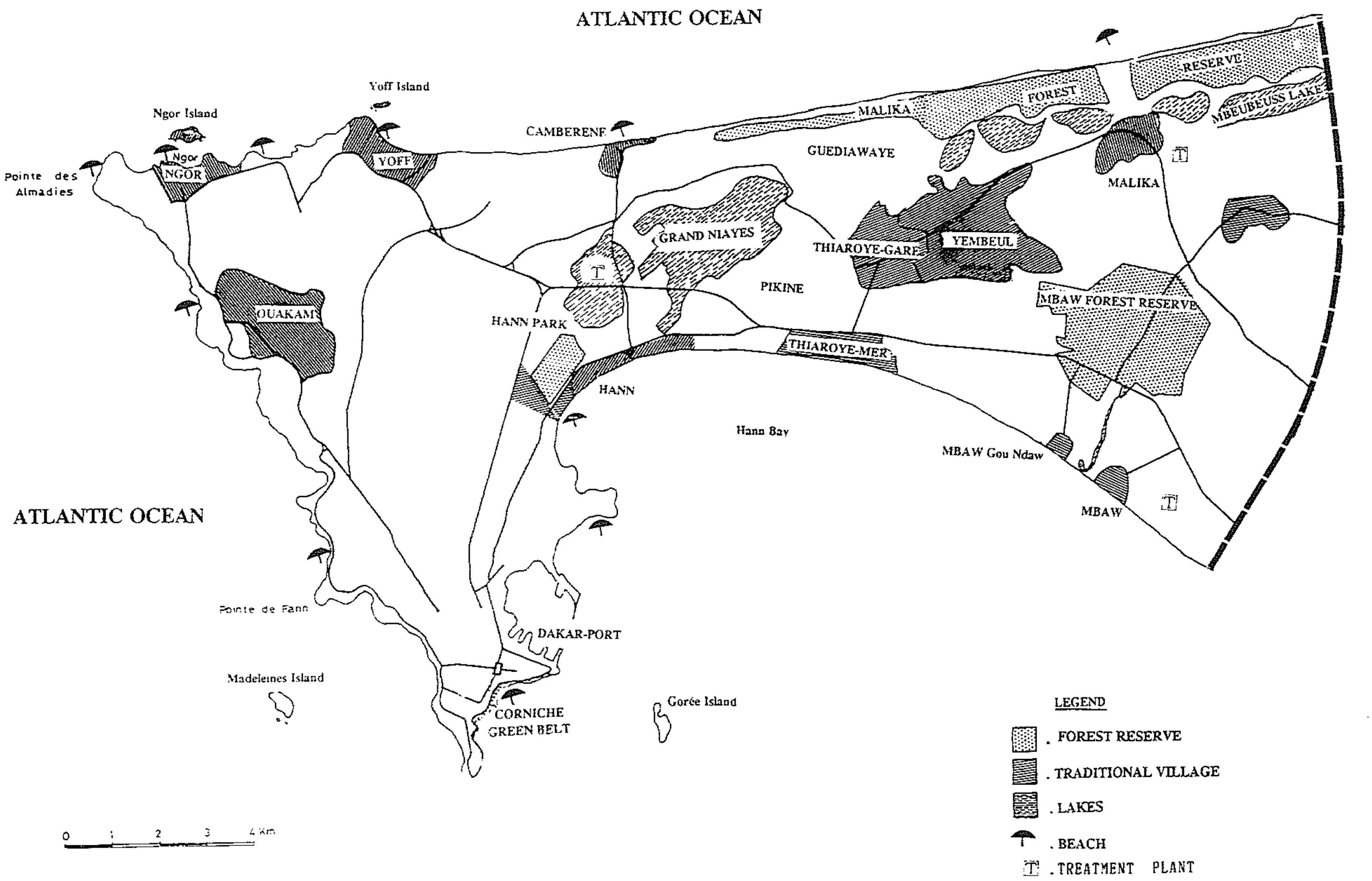
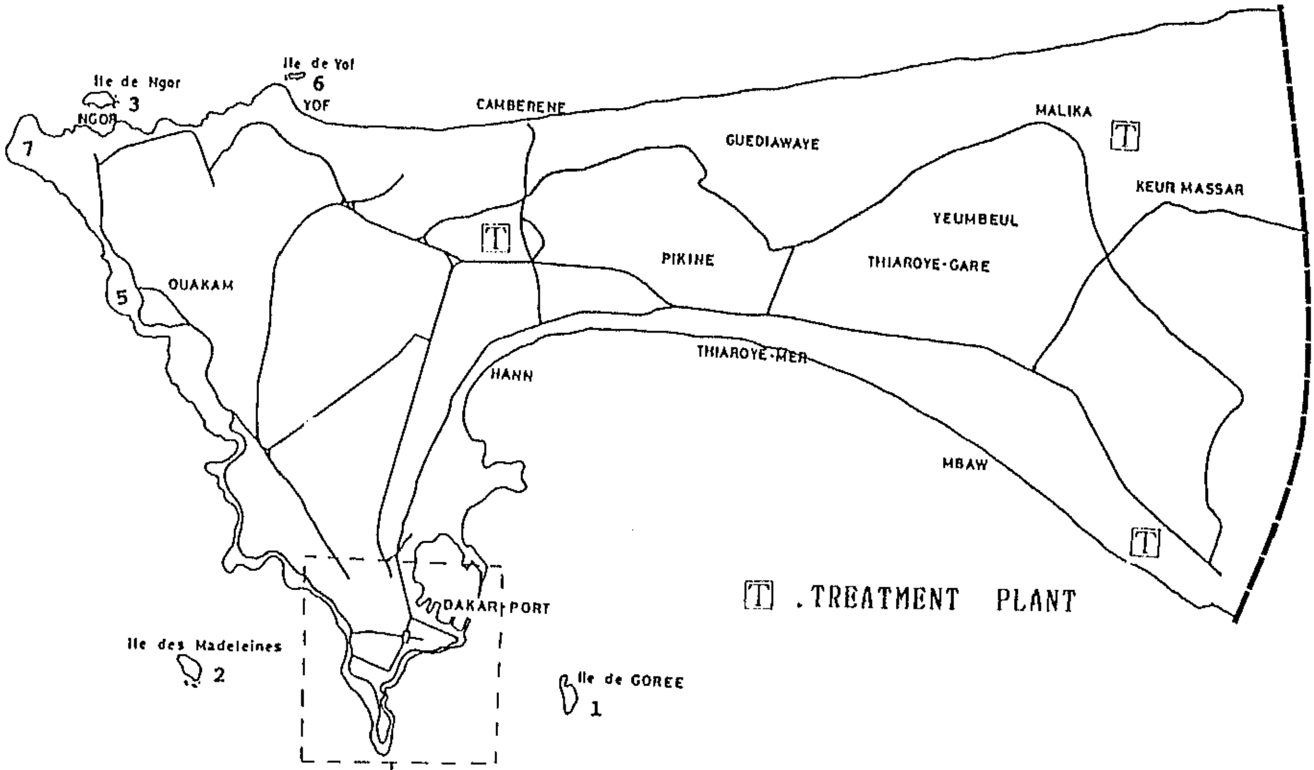
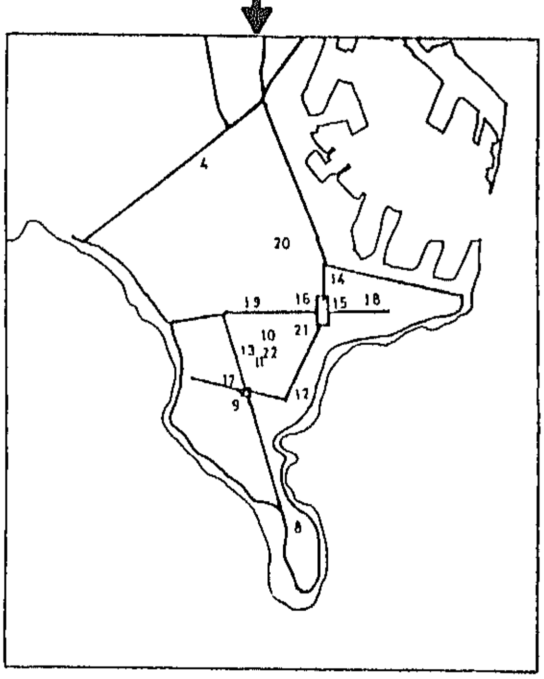


FIGURE D.1.1 TRADITIONAL VILLAGE, BELTS, NATIONAL PARKS AN DBEACHES IN THE STUDY AREA





1 Goree Island
2 Madeleines Island
3 Ngor Island
4 Grand Mosque Complex
5 Les Mamelles
6 Toundeup Riya Yoff Cliffs
7 Pointe des Almadies
8 Palace of Justice
9 National Assembly
10 Grande Mosque (corner of Blanchot and Carnot roads)
11 African Memorial Cathedral
12 Presidential Palace
13 Military Museum
14 Dakar City Hall
15 Ministry of Foreign Affairs
16 Chamber of Commerce
17 Dakar Museum
18 Kermel Market
19 Sandaga Market
20 Dakar Station
21 Protestant Church
22 Khadres Mosque

FIGURE D.1.2 LOCATION OF CULTURAL ASSETS, HISTORICAL / ARCHEOLOGICAL SITES AND MONUMENTS IN THE STUDY AREA

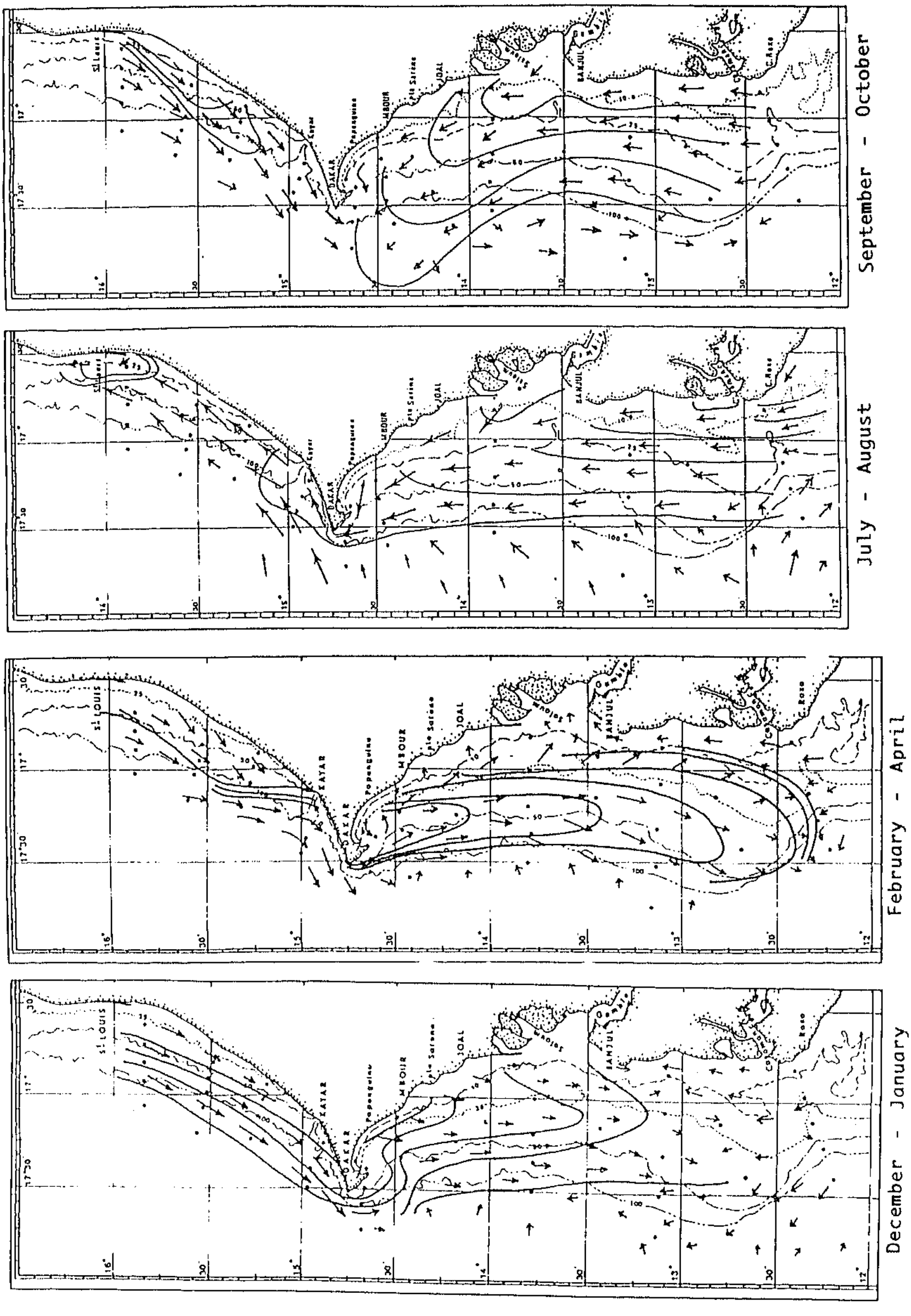


FIGURE D.1.3 OCEAN CURRENTS IN THE ATLANTIC OCEAN AROUND SENEGAL

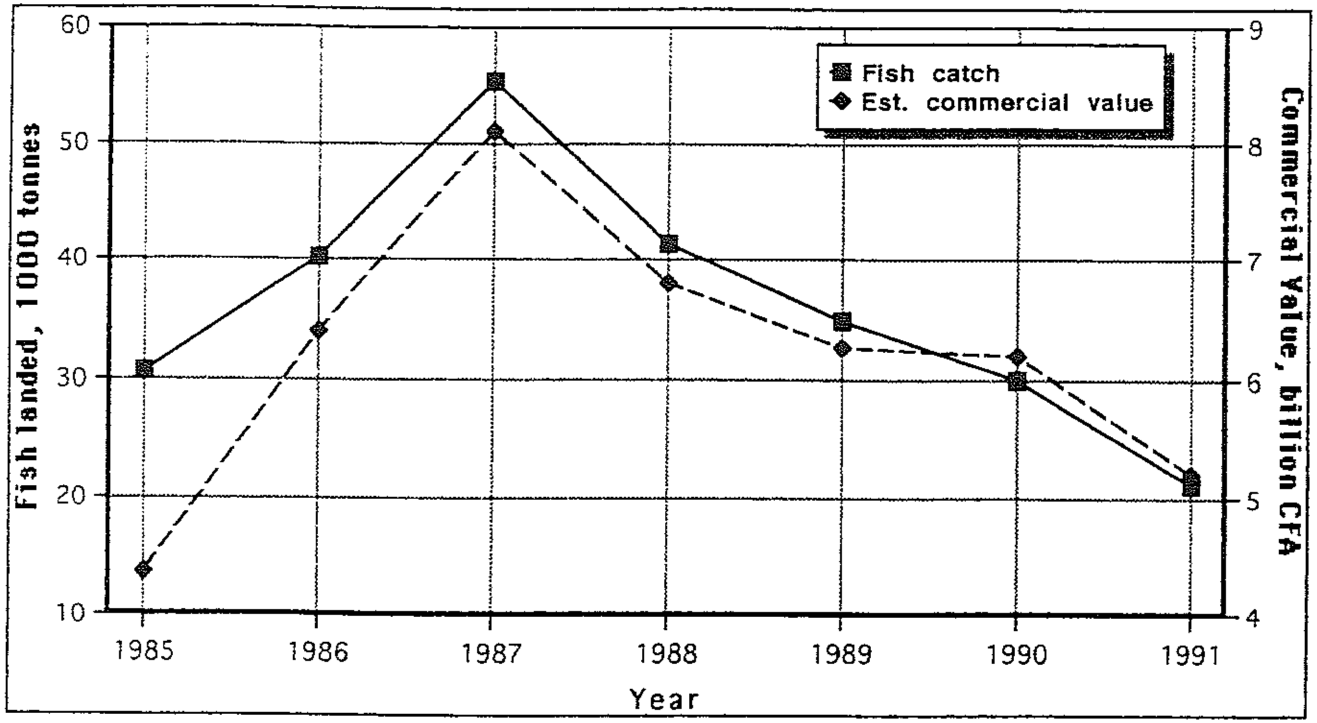


FIGURE D.1.4 NEAR SEA FISH CATCH BY PIROGUES IN DAKAR REGION, 1985-91

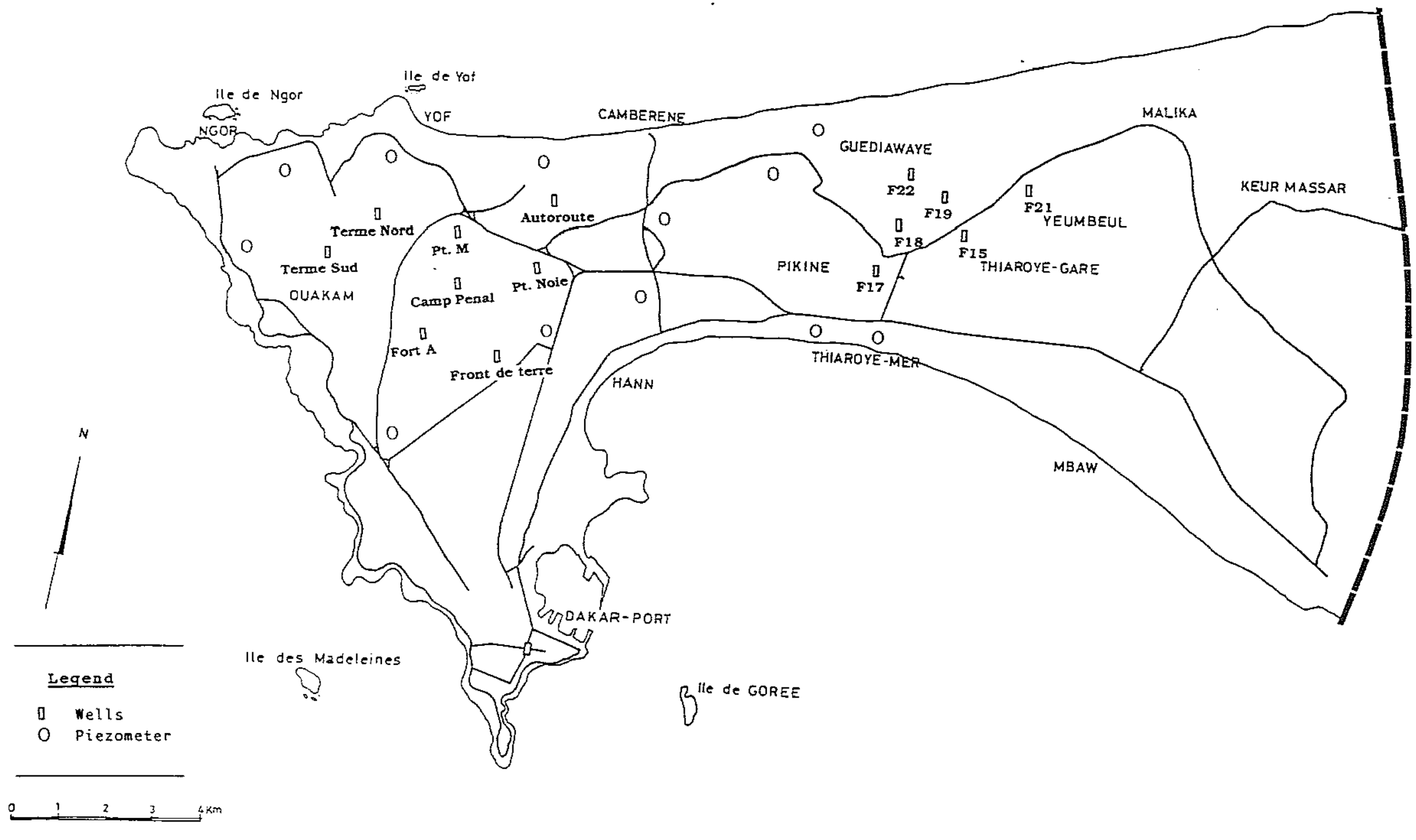


FIGURE D.1.5 LOCATION OF WELLS UTILIZED BY SONEES IN THE STUDY AREA