APPENDIX D

EXISTING SEWER SYSTEM

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1. Existing Trunk Sewers

In the Study Area, there are six(6) trunk sewers (1-2-3 A/B,UNIWAX,21-22,24-25-26,33-34,35-36), which were constructed in 1984. Most of these trunk sewers are located along the storm water drainage canals.

These sewers are seriously damaged because of lack of proper maintenance for the sewers and drainage canals. The main cause of the damage is the heavy erosion of soil in the earthen canals. Existing sewerage network in the Study Area is shown in Fig.D.1.

The number in the Fig.D.1 indicates the parts of damaged sewer.

More detailed information about damaged sewers are shown in Table D.1 - D.10.

2. Requirement of Additional Pumps at Existing Pumping Stations

2.1 S1 Pumping Station

When a pump is operated, there are various losses in the suction pipe, discharge pipe, discharge pipe outlet, etc.

The Total Head (H) is the sum of the Actual Head (H_a), which represents the head difference between the discharge liquid surface and the suction liquid surface, the pipeline head loss (H_p), and the discharge flow velocity head ($V^2/2g$). However the discharge flow velocity head will be neglected because of small value. The Total Head (H) is described by the following equation:

$$H = H_a + H_p + h_a$$

Where
H = Total head, m
H_a = Actual Head, m
H_p =pipe line head loss, m
h_a = allowance, 2.0m is mostly adopted

The pipeline head loss (H_p) is calculated using the Hazen-Williams equation. The Hazen-Williams equation is shown as follows:

$$H_p = 10.67 \times Q^{1.85} \times C^{-1.85} \times D^{-4.87} \times L$$

Where
Q = Design sanitary wastewater (m^3/s) in 2003, ($2.09 m^3/s$)
C = Hazen-Williams discharge coefficient (C= 110)
D= diameter of pipe, m (1.0m)
L= pipeline length, m (600m)

Actual head (H_a) will be given by the difference between the low water elevation of pump pit (-2.49m) and the top elevation of pipe attached by Pont de Gaulle (+7.4m). The actual head (H_a) is 9.89 m. The Total Head is calculated as follows.

$$H_a = 9.89 + 10.67 x 2.09^{1.85} x 110^{-1.85} x 1.0^{-4.87} x\ 600$$
$$= 9.9 + 10.67 \times 3.91 \times 1.67 \times 10^{-4} \times 1.0 \times 600 + 1.0$$
$$= 9.9 + 4.2 + 1.0 \quad = 15.1\ (m)$$

Comparing to the result of computation (H_a=15.1m), the existing pump head capacity (8.4 m) will be insufficient. The discharge flow rate should be controlled to recover the lack of the head capacity. According to the characteristic curve of a centrifugal pump, it will be required to reduce the discharge flow rate from 0.57m^3/s(existing pump capacity) to 0.35m^3/s to recover the lack of the pump head capacity. Therefore the number of pump required at S1 pumping station will be 6 units to carry the design wastewater in 2003 as follows:

Number of required pump = 2.09m^3/s $\div$ 0.35m^3/s = 5.97 = 6

2.2 7J1 Pumping Station

The following information is known.

Q = Design wastewater in 2003, 2.81m^3/s
H_a = Actual head, 5.5m
D = Diameter of pipe, 0.8m
L = Pipeline length, 150m
C = 110

Therefore the total head can be obtained as follows in the same way as S1 P/S.

$$\begin{aligned} H &= 5.5 + 10.67 \times 2.81^{.85} \times 110^{-1.85} \times 0.8^{-4.87} \times 150 + 1.0 \\ &= 5.5 + 10.67 \times 6.76 \times 1.67 \times 10^{-4} \times 2.96 \times 150 + 1.0 \\ &= 5.5 + 5.4 + 1.0 = 11.9 \text{ m} \end{aligned}$$

Comparing to the result of computation (H=11.9m), the existing pump head capacity (10.2m) is also insufficient. As same way of S1 P/S, the discharge pump capacity will be reduced from 0.53m^3/s(existing pump capacity) to 0.47m^3/s according to the characteristic curve of a centrifugal pump.

The number of required pump will be obtained considering the design wastewater (Q=2.81m^3/s) in 2003 as follows:

The number of required pump = 2.81m^3/s / 0.47m^3/s
= 6 units

Three pumps have been already installed, therefore, three additional pumps will be required.

2.3 Koumassi Pre-Treatment Plant

There are two pump houses in Koumassi Pre-Treatment Plant. Different type of pumps are installed in the each pump house. One is of screw type and the other is of submerged type. The pump head capacity of screw type pump is sufficient to discharge the design wastewater ($Q=3.38m^3/s$) in 2003.On the other hand, the pump discharge amount is insufficient. Two additional pumps will be required as follows:

The number of required pump	$= 3.38\ m^3/s \div 0.91\ m^3/s$ (existing pump capacity)
	= 4 units (2 units are already installed)

The decision of required number of submerged pump should be made considering the required total head to discharge the design wastewater to the ocean through the ocean outfall.

Conditions to compute the required capacity of submerged pump are as follows.

Design wastewater, Q	$= 3.38m^3/s$
Diameter of ocean outfall pipe	= ϕ 1200mm (see Fig.D.2)
Pipeline length	= 1200m (see Fig. D.2)
Mean sea level	= ± 0.00m (see Fig.D.2)
Diameter of discharge pipe from Koumassi P-T/P to the sea	
	= ϕ 1400mm (see Fig.D.2)
Pipeline length	= 2600m (see Fig.D.2)

At first, it will be necessary to obtain the required total head to discharge the design wastewater to the sea before decision of the submerged pump capacity. The required total head will be obtained concerning the above conditions. In this case the total head will become same value of the ocean outfall pipe head loss because mean sea level is 0.00m.

$$\text{The required total head} = 10.67 \times Q^{1.85} \times C^{-1.85} \times D^{-4.87} \times L$$
$$= 10.67 \times 3.38^{1.85} \times 110^{1.85} \times 1.2^{-4.87} \times 1200$$
$$= 10.67 \times 9.52 \times 1.995 \times 10^{-4} \times 0.411 \times 1200$$
$$= 10.0$$

Pipeline head loss between the Koumassi P-T/P and the sea is as follows:

$$\text{The pipeline head loss} = 10.67 \times Q^{1.85} \times C^{-1.85} \times D^{-4.87} \times L$$
$$= 10.67 \times 3.38^{1.85} \times 110^{-1.85} \times 1.4^{-4.87} \times 2600$$
$$= 10.67 \times 9.52 \times 1.995 \times 10^{-4} \times 0.194 \times 2600$$
$$= 10.22$$

And the L.W.L (low water level where pump stops) of wet well pit of submerged pump is -1.6 m. Therefore, the required total head of submerged pump is as follows,

$$\text{The required total head of submerged pump} = 10.0 + 10.22 + 1.6$$
$$= 21.8$$
$$= 22.0\text{m}$$

As a result of computation, hydraulic gradient line from Koumassi Pre T/P to the ocean outfall is shown in Fig.D.2.

The total head of existing submerged pump is only 8.0 m. On the other hand, the required total head is 22.0m.

Therefore it is recommendable that four existing submerged pumps will be replaced to the new pumps because of the insufficient total head of the existing pumps.

3. Improvement of Existing Pumping Station

As mentioned in former sections, additional pumps required at each pumping station are as follows,

S1 P/S	4 units pumps (0.35m^3/s x 15m x 80kw)
7J1 P/S	3 units pumps (0.47 m^3/s x 12m x 90kw)
Koumassi Pre-TM	2 units pumps (0.91 m^3/s x 4m x 75kw)
	4 units pumps (0.91 m^3/s x 20m x 250kw)

Costs for additional equipment at each pumping station are shown in Table D.11, 12 and 13.

TABLE D.1 EXISTING CONDITIONS OF DAMAGED SEWER- 2-3AB ①

Trunk Sewer: 2-3AB	Area: Niangon	Location:Distance from outfall into Lagoon=0.9km

Trunk Sewer	Damaged stretch	6m
	Crossing with Drainage Canal	River bed
	Diameter	ϕ=800mm
	Material	Concrete pipe
	Corrosion	non
	Others	
Cause of Damage	Erosion of drainage canal	Scouring of river bed
	Washing away of ground	-
	Washing away of bridge foundation	-
	Others	
Drainage Canal	Width	8m
	Depth	1.5m
	Soil	Sand
	Conditions of bank erosion etc.	Scouring of river bed
	Bank protection of canal	no exist
	Others	

Photograph;

Sketch;

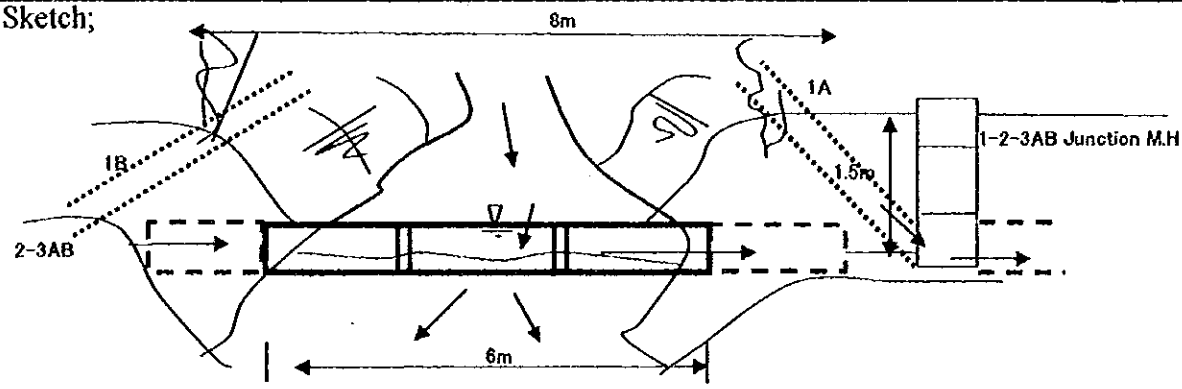

TABLE D.2 EXISTING CONDITIONS OF DAMAGED SEWER- PORT BOUET II ②

Trunk Sewer:PORT BOUET II	Area:Socogi	Location:Distance from outfall into Lagoon=4.16km

Trunk Sewer	Damaged stretch	10m
	Crossing with Drainage Canal	Under UNIWAX canal bed
	Diameter	ϕ=600mm
	Material	Concrete pipe
	Corrosion	-
	Others	
Cause of Damage	Erosion of drainage canal	-
	Washing away of ground	Scouring
	Washing away of bridge foundation	-
	Others	
Drainage Canal	Width	30m
	Depth	10m
	Soil	Clayey sand
	Conditions of bank erosion etc.	Waterfall H=10m
	Bank protection of canal	no exist
	Others	

Photograph;

Sketch;

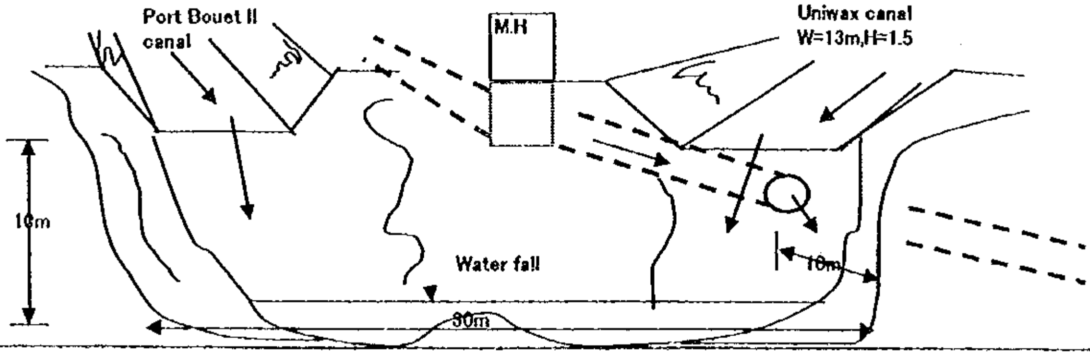

TABLE D.3 EXISTING CONDITIONS OF DAMAGED SEWER- PORT BOUET II ③

Trunk Sewer: PORT BOUET II	Area:Socogi	Location:Distance from outfall into Lagoon=4.08km

Trunk Sewer	Damaged stretch	25m
	Crossing with Drainage Canal	no exist, parallel
	Diameter	ϕ=600mm
	Material	Concrete pipe
	Corrosion	-
	Others	
Cause of Damage	Erosion of drainage canal	Erosion of embankment
	Washing away of ground	-
	Washing away of bridge foundation	-
	Others	
Drainage Canal	Width	15m
	Depth	10m
	Soil	Clayey sand
	Conditions of bank erosion etc.	Sliding, Slope failure
	Bank protection of canal	no exist
	Others	

Photograph;

Sketch;

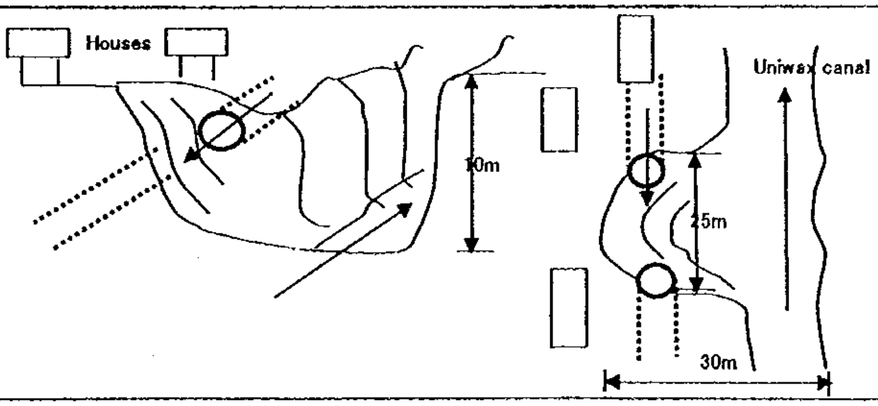

TABLE D.4 EXISTING CONDITIONS OF DAMAGED SEWER- UNIWAX ④

Trunk Sewer: UNIWAX	Area:Koute	Location:Distance from outfall into Lagoon=2.5km

Trunk Sewer	Damaged stretch	30m
	Crossing with Drainage Canal	Aqueduct
	Diameter	ϕ=900mm
	Material	Asbestos pipe
	Corrosion	Corrosion
	Others	H pile foundation
Cause of Damage	Erosion of drainage canal	Seriously
	Washing away of ground	-
	Washing away of bridge foundation	-
	Others	Corrosion of the material
Drainage Canal	Width	30m
	Depth	10m
	Soil	Clayey sand
	Conditions of bank erosion etc.	Scouring, Sliding, Bank erosion, Bank failure
	Bank protection of canal	no exist
	Others	-

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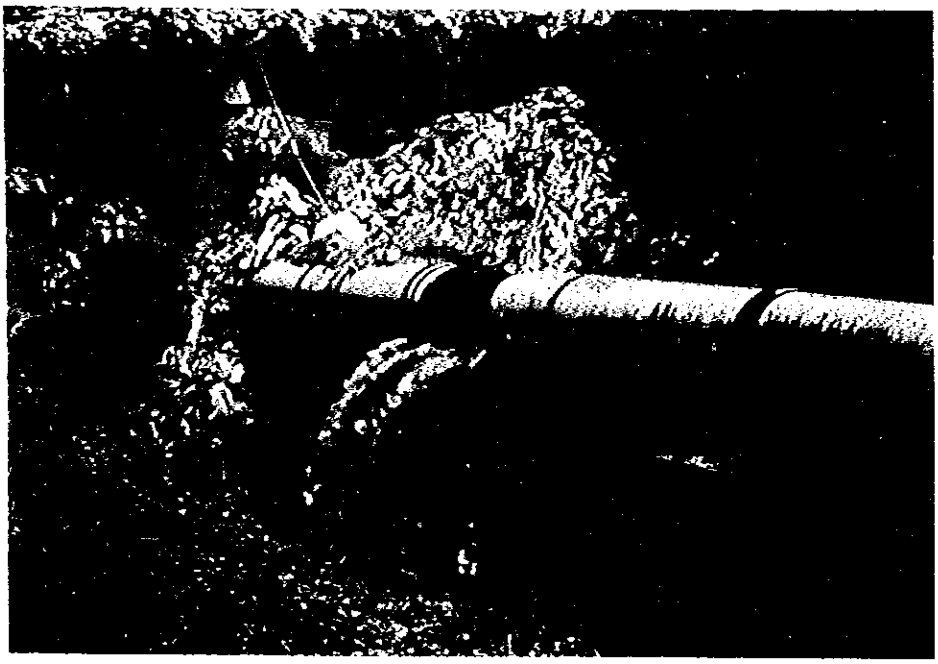

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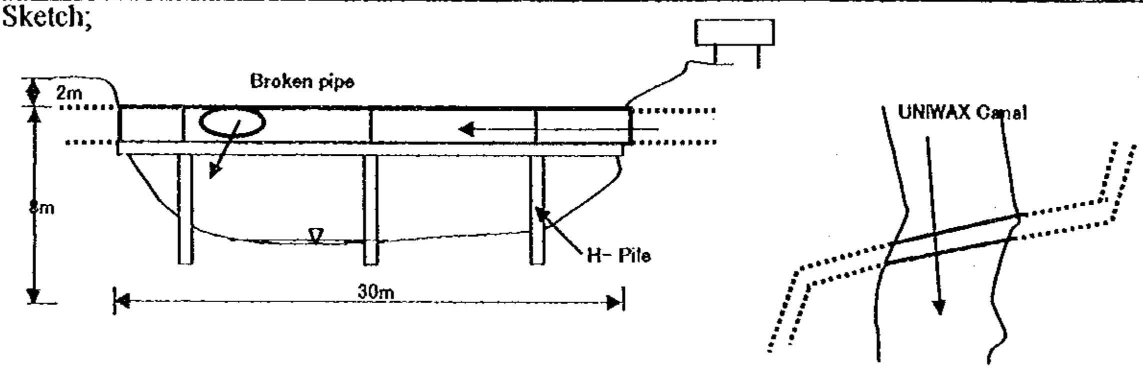

TABLE D.5 EXISTING CONDITIONS OF DAMAGED SEWER- 21-22 ⑤

Trunk Sewer:21-22	Area:Koute	Location:Distance from outfall into Lagoon=1.7km

Trunk Sewer	Damaged stretch	5m
	Crossing with Drainage Canal	Aqueduct type
	Diameter	φ=400mm
	Material	PVC pipe at crossing point
	Corrosion	-
	Others	Concrete support
Cause of Damage	Erosion of drainage canal	Scouring
	Washing away of ground	Seriously
	Washing away of bridge foundation	-
	Others	-
Drainage Canal	Width	10m
	Depth	5m
	Soil	Clayey sand
	Conditions of bank erosion etc.	Scouring
	Bank protection of canal	non
	Others	

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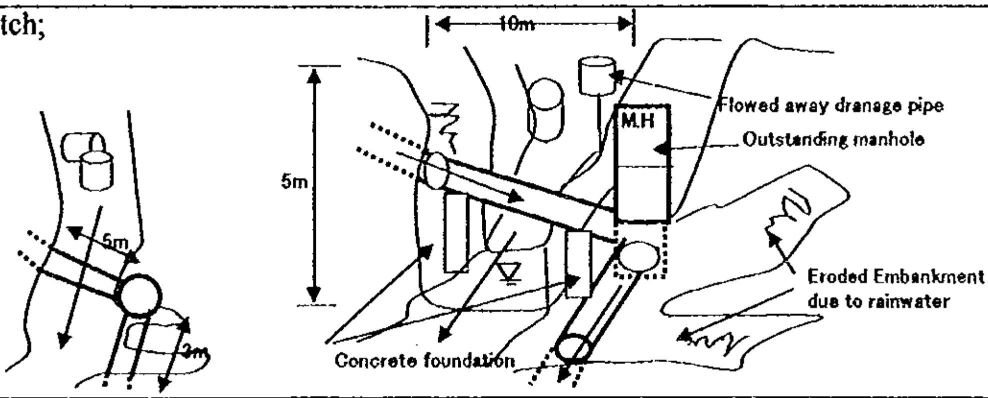


TABLE D.6 EXISTING CONDITIONS OF DAMAGED SEWER- 21-22 ⑥

Trunk Sewer:21-22	Area: Koute	Location:Distance from outfall into Lagoon=800m

Trunk Sewer	Damaged stretch	15m
	Crossing with Drainage Canal	River bed
	Diameter	ϕ=400mm
	Material	Concrete pipe
	Corrosion	-
	Others	-
Cause of Damage	Erosion of drainage canal	Scouring heavily
	Washing away of ground	-
	Washing away of bridge foundation	-
	Others	Bank failure
Drainage Canal	Width	5m
	Depth	6m
	Soil	Clayey sand
	Conditions of bank erosion etc.	Scouring of river bed, Bank failure
	Bank protection of canal	no exist
	Others	-

Photograph;

Sketch;

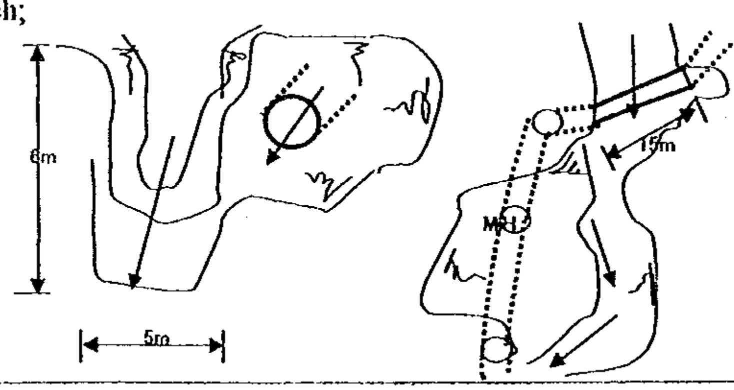


TABLE D.7 EXISTING CONDITIONS OF DAMAGED SEWER- 21-22 ⑦

Trunk Sewer:21-22	Area:Koute Est	Location:Distance from outfall into Lagoon=500m
Trunk Sewer	Damaged stretch	42m
	Crossing with Drainage Canal	40m in river, Parallel with river course
	Diameter	φ=400mm
	Material	Concrete pipe
	Corrosion	-
	Others	
Cause of Damage	Erosion of drainage canal	Mainly scouring
	Washing away of ground	-
	Washing away of bridge foundation	-
	Others	-
Drainage Canal	Width	10m
	Depth	5m
	Soil	Clayey sand
	Conditions of bank erosion etc.	Scouring
	Bank protection of canal	no exist
	Others	-

Photograph;

Sketch;

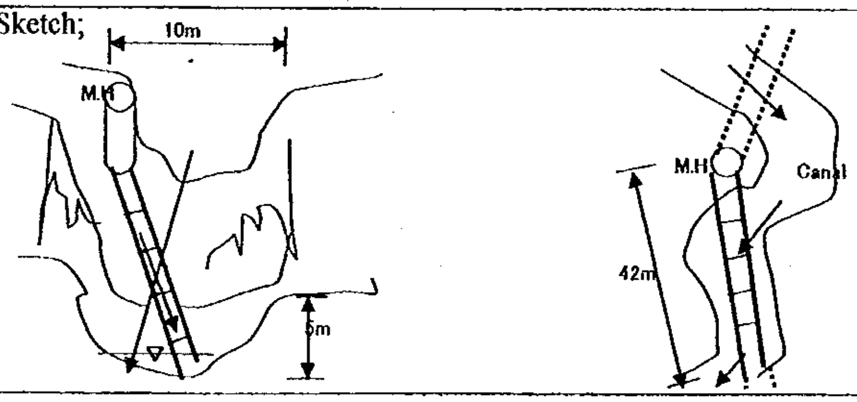
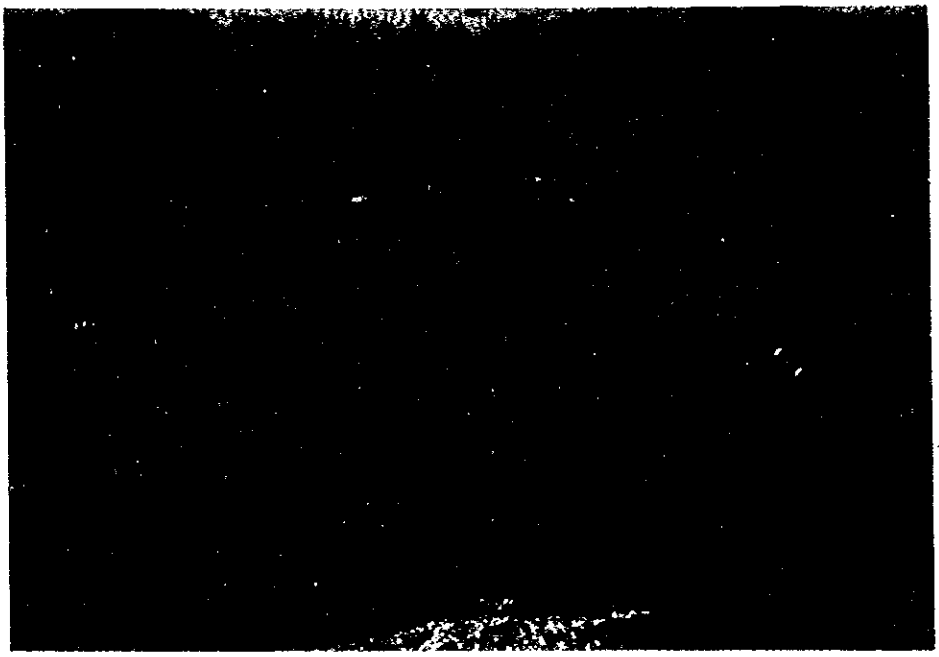


TABLE D.8 EXISTING CONDITIONS OF DAMAGED SEWER- 25-26-27 ⑧

Trunk Sewer:25-26-27	Area:Koute	Location:Distance from outfall into Lagoon=1.43km

Trunk Sewer	Damaged stretch	50m
	Crossing with Drainage Canal	Parellel
	Diameter	ϕ=400mm
	Material	PVC pipe
	Corrosion	-
	Others	-
Cause of Damage	Erosion of drainage canal	Serious scouring and bank erosion
	Washing away of ground	-
	Washing away of bridge foundation	-
	Others	-
Drainage Canal	Width	30m
	Depth	14m
	Soil	Clayey sand
	Conditions of bank erosion etc.	Water fall, Seriously
	Bank protection of canal	no exist
	Others	-

Photograph;



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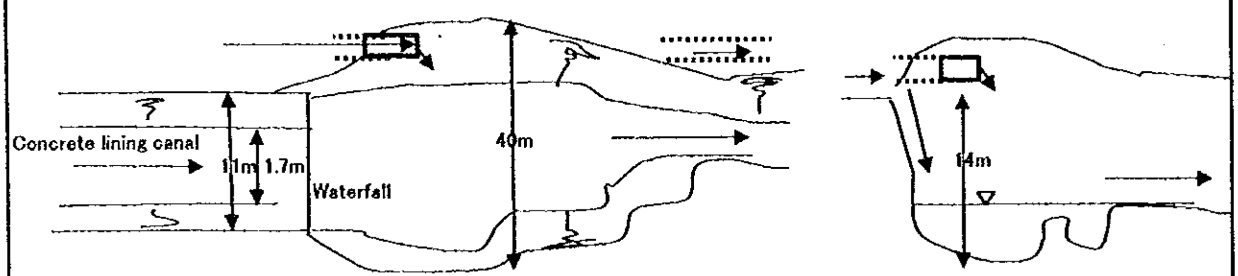

TABLE D.9 EXISTING CONDITIONS OF DAMAGED SEWER- 25-26-27 ⑨

Trunk Sewer: 25-26-27	Area:Sante Villa.	Location:Distance from outfall into Lagoon=1.0-1.4km

Trunk Sewer	Damaged stretch	500 m
	Crossing with Drainage Canal	Parellel
	Diameter	ϕ=500mm
	Material	Concrete pipe
	Corrosion	-
	Others	-
Cause of Damage	Erosion of drainage canal	Erosion of river bed
	Washing away of ground	-
	Washing away of bridge foundation	-
	Others	-
Drainage Canal	Width	15-20m
	Depth	15m
	Soil	Clayey sand
	Conditions of bank erosion etc.	Serious bank erosion, Lowering of river bed
	Bank protection of canal	no exist
	Others	-

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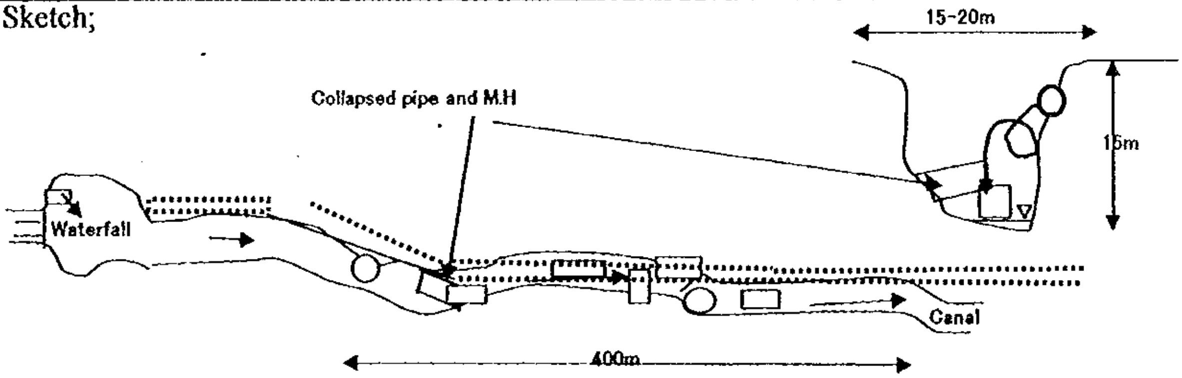

TABLE D.10 EXISTING CONDITIONS OF DAMAGED SEWER - 35-36 ⑩

Trunk Sewer: 35-36	Area: Banco Nord	Location:Distance from outfall into Lagoon=0-1.5km
Trunk Sewer	Damaged stretch	1500 m
	Crossing with Drainage Canal	Parelle
	Diameter	ϕ=200mm
	Material	Concrete pipe
	Corrosion	-
	Others	
Cause of Damage	Erosion of drainage canal	Scouring/sediment/sliding
	Washing away of ground	-
	Washing away of bridge foundation	-
	Others	-
Drainage Canal	Width	5-15m
	Depth	1-3m
	Soil	Sand
	Conditions of bank erosion etc.	Erosion and sedimentation
	Bank protection of canal	Concrete lining at downstream
	Others	-

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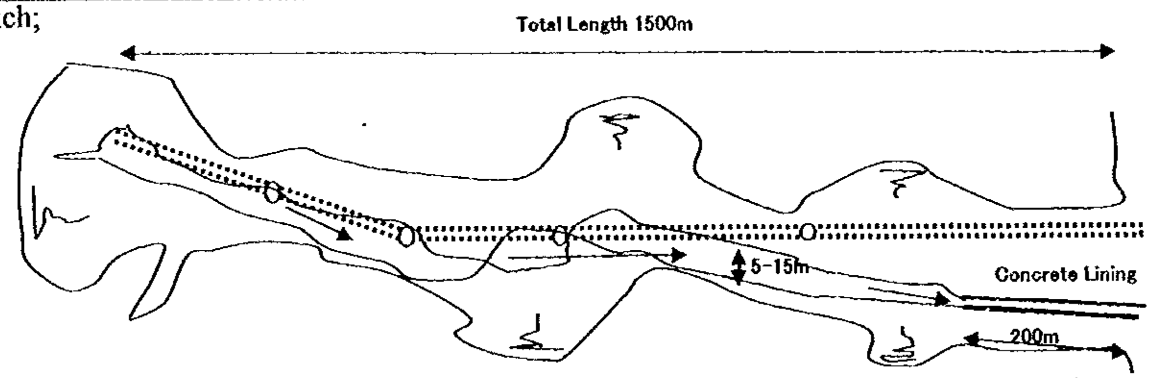

TABLE D.11 COST FOR ADDITIONAL EQUIPMENTS AT S1 PUMPING STATION

Item	Description	Unit	Quantity	Unit Price (FCFA)	Price (FCFA)
ϕ450 Vertical Axis Pump	0.35m^3/s×15m×80kW	No.	4	9,280,000	37,120,000
Vertical Induction Motor	80kW×4P×400V×50Hz	No.	4	8,000,000	32,000,000
Check Value	ϕ450	No.	4	5,120,000	20,480,000
Pipes and Fittings	ϕ500	I.S.	1	12,800,000	12,800,000
Automatic Trash Rake Screen		No.	1	41,600,000	41,600,000
Submerged Sand Pump		No.	2	9,600,000	19,200,000
Low Voltage Incoming Panel		No.	1	25,600,000	25,600,000
Low Voltage Pump Starter Panel		No.	4	11,200,000	44,800,000
Materials for Installation		I.S.	1	83,200,000	83,200,000
Spare Parts		I.S.	1	32,000,000	32,000,000
Installation Work		I.S.	1	76,800,000	76,800,000
Cost of Transportation				32,000,000	32,000,000
Total					457,600,000

TABLE D.12 COST FOR ADDITIONAL EQUIPMENTS AT 7J1 PUMPING STATION

Item	Description	Unit	Quantity	Unit Price (FCFA)	Price (FCFA)
ϕ600 Vertical Axis Pump	0.47m^3/s×12m×90kW	No.	3	92,800,000	278,400,000
Vertical Induction Motor	90kW×4P×400V×50Hz	No.	3	8,000,000	24,000,000
Check Value	ϕ600	No.	3	9,600,000	28,800,000
Pipes and Fittings	ϕ700	I.S.	1	9,600,000	9,600,000
Automatic Trash Rake Screen		No.	1	41,600,000	41,600,000
Low Voltage Incoming Panel		No.	1	25,600,000	25,600,000
Low Voltage Pump Starter Panel		No.	3	11,200,000	33,600,000
Materials for Installation		I.S.	1	51,200,000	51,200,000
Spare Parts		I.S.	1	???	???
Installation Work		I.S.	1	48,000,000	48,000,000
Cost of Transportation				25,600,000	25,600,000
Total					566,400,000

TABLE D.13 COST FOR ADDITIONAL EQUIPMENTS AT KOUMASSI PRE TREATMENT PLANT

Item	Description	Unit	Quantity	Unit Price (FCFA)	Price (FCFA)
ϕ 1000 Screw Pump	0.91m^3/s×4m×75kW	No.	2	70,400,000	140,800,000
Horizontal Squirrel-cage Induction Motor	75kW×4P×400V×50Hz	No.	2	4,800,000	9,600,000
Reduction Gear Unit		No.	2	28,800,000	57,600,000
ϕ 700 Diagonal Volute Submerged Pump	0.91m^3/s×20m×250kW	No.	4	51,200,000	204,800,000
Check Valve	ϕ 700	No.	4	16,000,000	64,000,000
Sluce Valve	ϕ 700	No.	4	9,600,000	38,400,000
Pipes and Fittings		I.S.	1	9,600,000	9,600,000
Low Voltage Incoming Panel		No.	1	19,200,000	19,200,000
Low Voltage Incoming Panel		No.	1	25,600,000	25,600,000
Low Voltage Pump Starter Panel		No.	2	11,200,000	22,400,000
Low Voltage Pump Starter Panel		No.	4	11,200,000	44,800,000
Materials for Installation		I.S.	1	80,000,000	80,000,000
Spare Parts		I.S.	1	25,600,000	25,600,000
Installation Work		I.S.	1	64,000,000	64,000,000
Cost of Transportation		I.S.	1	38,400,000	38,400,000
Total					844,800,000

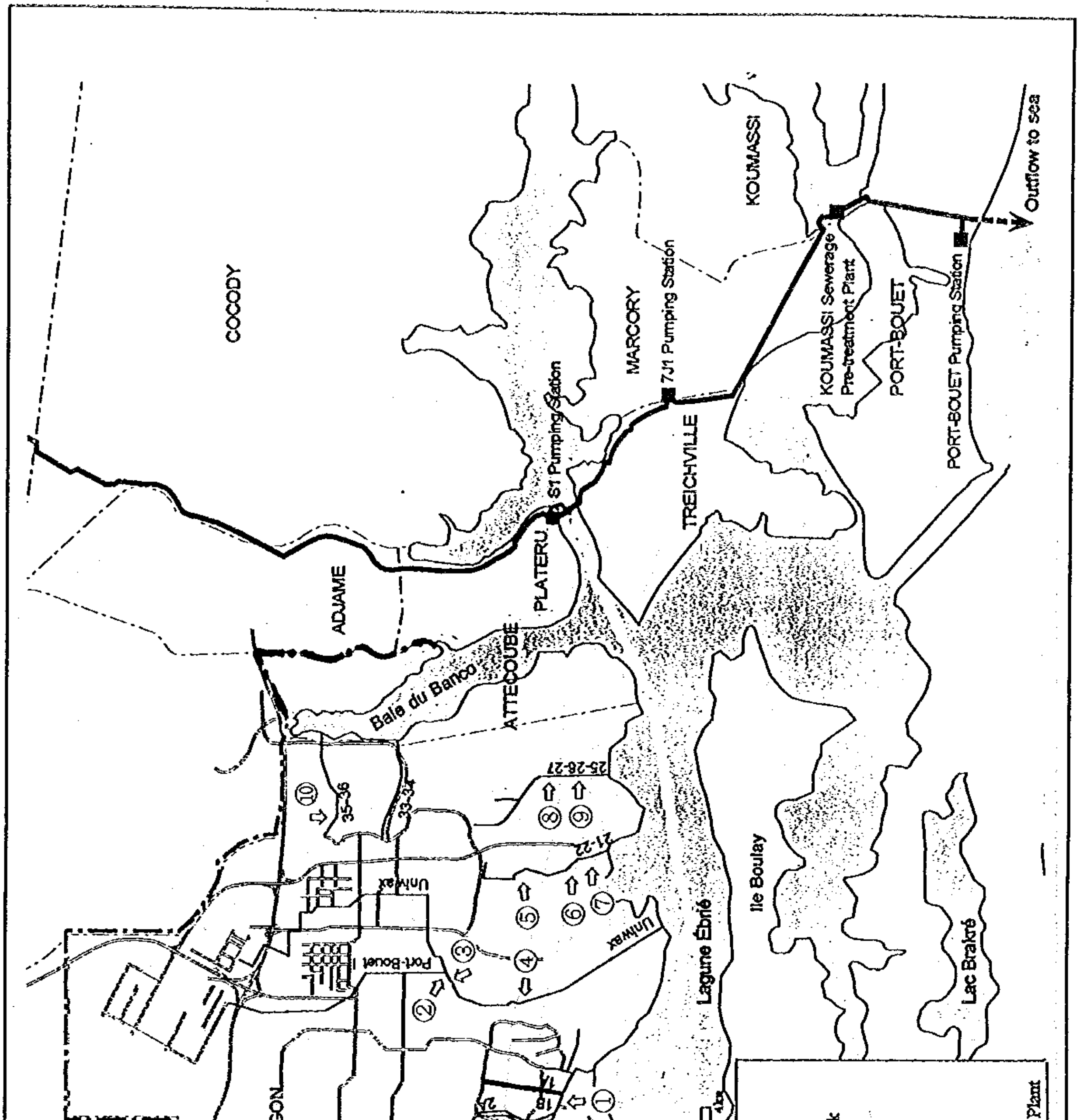

FIG. D.1 LOCATIONS OF DAMAGED EXISTING TRUNK SEWERS

THE FEASIBILITY STUDY ON SEWERAGE FACILITIES IN WESTERN DISTRICT OF ABIDJAN CITY IN THE REPUBLIC OF COTE D'IVOIRE

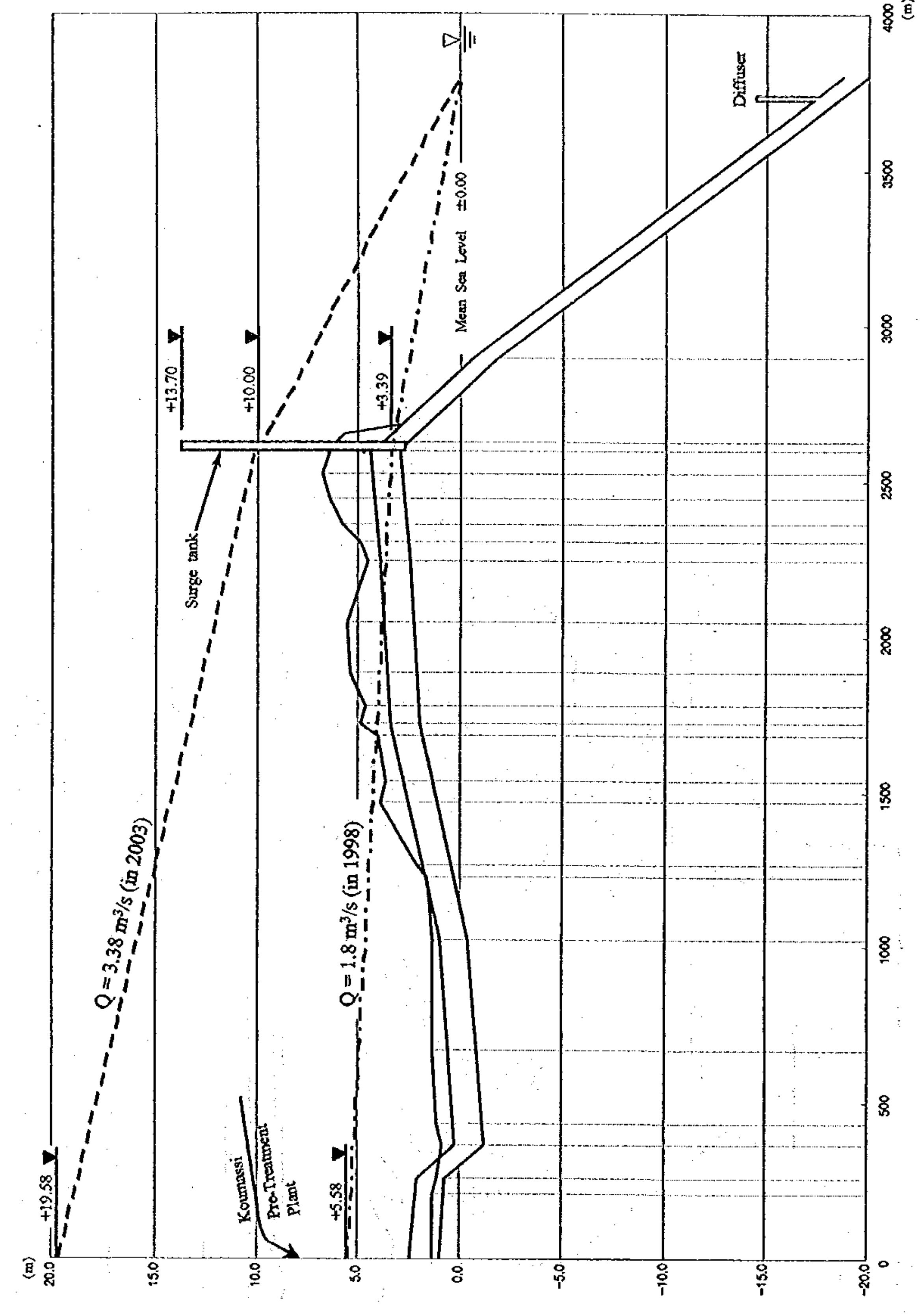

FIG. D.2	HYDRAULIC GRADIENT OF SEWAGE FLOW BETWEEN KOUMASSI PRE-TREATMENT PLANT AND OCEAN OUTFALL

THE FEASIBILITY STUDY ON SEWERAGE FACILITIES IN WESTERN DISTRICT OF ABIDJAN CITY IN THE REPUBLIC OF COTE D'IVOIRE

APPENDIX E

ALTERNATIVE INTERCEPTOR STUDY

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1. Selection of Pressure Interceptor

In this Study, the optimum diameter of multiple pressure pipeline, which corresponds to the most economical construction and operation cost, is decided. The peak flows for the hydraulic calculation of the interceptor is the sum of inflow from each trunk sewer as shown in Table E.1.

For selection of the diameter of the pipeline as shown in Table E.2, as minimum velocity required for self-cleaning, 0.60 m/sec was used. The peak factor adapted is approximately twice the minimum value of actual flow rate of the Quantity and Quality investigations as shown in Fig. E.1.

The cost depends on the diameter of the pipeline of each span. A comparison of the cost is shown in Table E.3 and E.4. The optimum diameter of the pipeline, which corresponds to the most economical construction and operation cost, is decided: Case.3 was decided for the South interceptor and Case.2 was decided for the West interceptor.

The above-mentioned comparative study for the optimum pipeline was based on the following assumptions:

1) Based on Design Consideration

(1) Calculation of Pump Head

The Total Head (H) is expressed by the following equation:

$H = H_a + H_p + h_a$

Where H = Total head, m

H_a = Actual head, m

H_p = Pipeline head loss, m

h_a = Allowance, 2.0 m is adopted

The pipeline head loss (H_p) is estimated by using the Hazen-Williams equation as described below:

$H_p = 10.67 \times (Q \;\; / C)^{1.85} \times D^{-4.87} \times \;\; L$

Where Q = Design sanitary wastewater in year 2003,(m^3/s)

C = Hazen-Williams discharge coefficient (C= 110)

D = Diameter of pipeline, (m)

L = Pipeline length, (m)

Actual head (H_a) is estimated by the difference between the LWL (low water level where the pump stops) of the wet-well pit and control water level of the discharge tank.

(2) Calculation of Pump Electric Power Input

The pump electric power input is estimated using the following formula:

$P = 0.163 \times \gamma \times Q \times H_T / \eta_p$

Where γ : Specific gravity of water (1 kgf / l)

Q : Pump capacity per unit (m^3 / min)

H_T : Pump total head (m)

η_p : Pump efficiency (53%)

2) Based on Cost Consideration

(1) Unit cost of the pipeline is assumed as follows based on the cost estimate:

Unit Cost = $0.00089X^2 - 0.37X + 311$ (1000 FCFA/m)

Where X : Diameter of pipe (mm)

However, small diameters pipelines, such as 200 mm and/or 250 mm, were assumed to cost 187,000/m and 226,000 CFCA/m, respectively.

(2) Cost of Pumping Station

The cost of the Pumping Station, which consists of the cost of machine, electric equipment, and civil work, is roughly estimated as follows. The difference of cost among the different capacity pumps is small. The cost of each Pumping Station is estimated as follows (Unit; Mil. FCFA).

P1 P/S	P2 P/S	P3 P/S	P4 P/S	P5 P/S
5,000	6,000	4,000	4,000	3,000

(3) Operation cost of pump was assumed based on the following equation:

Operating Cost (FCFA/Year)

= {Motor Output x 0.8 x 24 hr/d x 30 d x 38.2 FCFA

+ (68,000 FCFA + 311,404 FCFA)} x 12

2. Selection of Diameter of Gravity Interceptor

The proposed pipeline diameter under the assumed maximum flow is decided based on the hydraulic gradient line to be below the control water level of the discharge tank, which is 21 m. The maximum hydraulic gradient line is based on the water level 0.0 m of the inlet of the S1 Pumping Station. The pipeline head loss (H_p) was calculated using Hazen-Williams equation as shown earlier. The selected pipeline is as shown in Table E.5.

Drawings of longitudinal profile of Interceptor are shown in Fig. E2 – E.14, and drawings of protection for pressurized bend pipes are shown in E.15, E.16.

TABLE E.1 PEAK INFLOW OF EACH SPAN

	South Interceptor				West Interceptor
	Span Ⅰ	Span Ⅱ	Span Ⅲ	Span Ⅳ	
Trunk Sewer	1-2-3 A/B	UNIWAX	21-22	25-26	33-3・35-36
Length (m)	1600	2000	1600	1000	1000
Inflow (m^3/s)	0.233	0.537	0.118	0.104	0.078
Peak Flow (m^3/s)	0.233	0.770	0.888	0.992	0.078

TABLE E.2 EXAMINED DIAMETER OF EACH SPAN

South Interceptor												West Interceptor		
Span Ⅰ			Span Ⅱ			Span Ⅲ			Span Ⅳ					
Q=0.233m^3/s			Q=0.770m^3/s			Q=0.888m^3/s			Q=0.992m^3/s			Q=0.078m^3/s		
Dia-meter (mm)	Velocity(m/s)		Dia-meter (mm)	Velocity(m/s)		Dia-meter (mm)	Velocity(m/s)		Dia-meter (mm)	Velocity(m/s)		Dia-meter (mm	Velocity(m/s)	
	Max	Min		Max	Max		Max	Min		Max	Min		Max	Min
450	1.465	0.773	800	1.532	0.766	800	1.767	0.883	900	1.559	0.780	200	2.482	1.241
500	1.187	0.593	900	1.210	0.605	900	1.396	0.698	1000	1.263	0.632	250	1.589	0.794

TABLE E.3 CAMPARISON COST OF SOUTH INTERCEPTOR (1,000,000 FCFA)

	Discharge (m3/s)				Diameter (mm)				Length (m)				$H_{pump\ head}$ (m)				Pump Output culc. (Kw)				Pump Output STD (Kw)			
Pumping Sta. / Span	P1	P2	P3	P4	Span I	Span II	Span III	Span IV	Span I	Span II	Span III	Span IV	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4
Case.1	0.233	0.537	0.118	0.104	450	800	800	800	1600	2000	1600	1000	46.8	31.9	25.0	13.2	67	105	27	13	75	110	30	15
Case.2	0.233	0.537	0.118	0.104	450	800	900	900	1600	2000	1600	1000	41.6	26.6	19.8	10.9	60	88	22	10	75	90	22	11
Case.3	0.233	0.537	0.118	0.104	500	800	900	900	1600	2000	1600	1000	37.8	26.6	19.8	10.9	54	88	22	10	55	90	22	11
Case.4	0.233	0.537	0.118	0.104	450	900	900	900	1600	2000	1600	1000	38.7	23.8	19.8	10.9	56	79	22	10	75	90	22	11
Case.5	0.233	0.537	0.118	0.104	500	900	900	900	1600	2000	1600	1000	35.0	23.8	19.8	10.9	50	79	22	10	55	90	22	11

	Construction Cost									Operating Cost								Total Cost
	Pipeline				Pumping Station				Sub Total	Electric Charge (Kw)				Operating				
Pumping Sta. / Span	Span I	Span II	Span III	Span IV	P1	P2	P3	P4		P1	P2	P3	P4	P1	P2	P3	P4	
Case.1	520	1,170	936	585	1,080	1,345	510	452	6,558	225	396	60	30	1,719	3,019	464	236	11,996
Case.2	520	1,170	1,118	699	1,080	1,335	500	442	6,854	225	270	44	22	1,719	2,061	342	175	11,151
Case.3	558	1,170	1,118	699	1,070	1,335	500	442	6,892	165	270	44	22	1,262	2,061	342	175	10,732
Case.4	520	1,398	1,118	699	1,080	1,335	500	442	7,082	225	270	44	22	1,719	2,061	342	175	11,379
Case.5	558	1,398	1,118	699	1,070	1,335	500	442	7,120	165	270	44	22	1,262	2,061	342	175	10,960

Note; The above costs are for comparison only and do not cover entire project costs.

TABLE E.4 CAMPARISON COST OF WEST INTERCEPTOR (1,000,000 FCFA)

	Discharge (m3/s)	Diameter (mm)	Length (m)	$H_{pumphead}$ (m)	Pump Output culc. (Kw)	Pump Output STD (Kw)
Case.1	0.078	200	1000	54.2	39	45
Case.2	0.078	250	1000	27.5	20	22

	Construction Cost			Operating Cost		Total Cost
	Pipeline	Pumping Station	Sub Total	Electric Charge (Kw)	Operating	
Case.1	187			90	138	
Case.2	226			44	68	

Note; The above costs are for comparison only and do not cover entire project costs.

TABLE E.5 DIAMETER OF GRAVITY FLOW PIPELINE

Section	Urban Road S1	Existing road of West BANCO bay	BANCO bay	Existing pipeline	Existing road of West BANCO bay
Length (m)	700	2000	1000	2400	1600
Inflow (m^3/s)	0.992	0.992	1.070	1.187	1.187
Diameter of pipe (mm)	900	900	900	1000	1200
Velocity (m/s)	1.559	1.559	1.682	1.511	1.050
Loss Head (m)	2.055	5.872	3.378	5.880	1.613
Max. Hydraulic Gradient Line.(m)	18.798	16.743	10.871	7.493	1.613

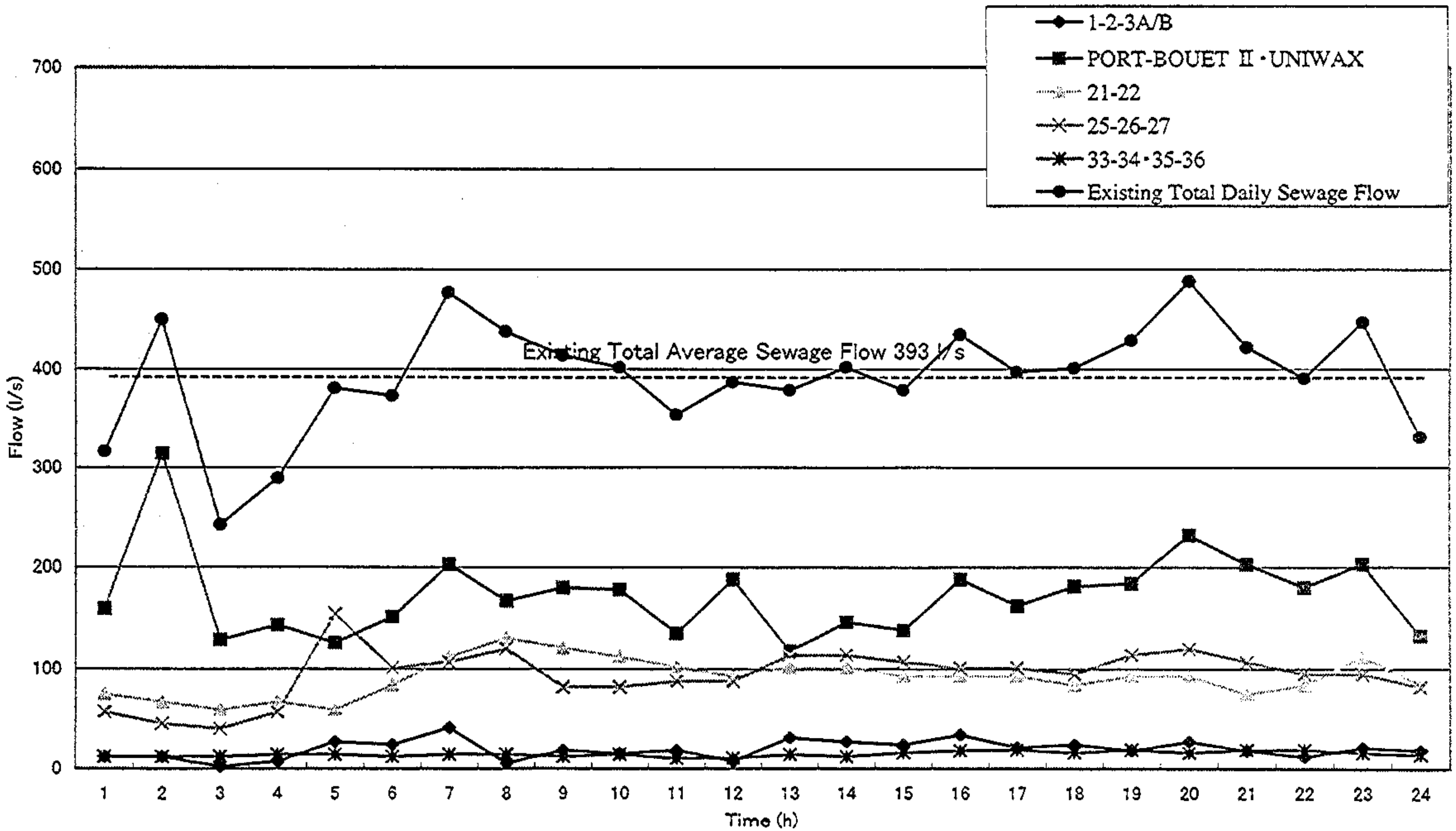
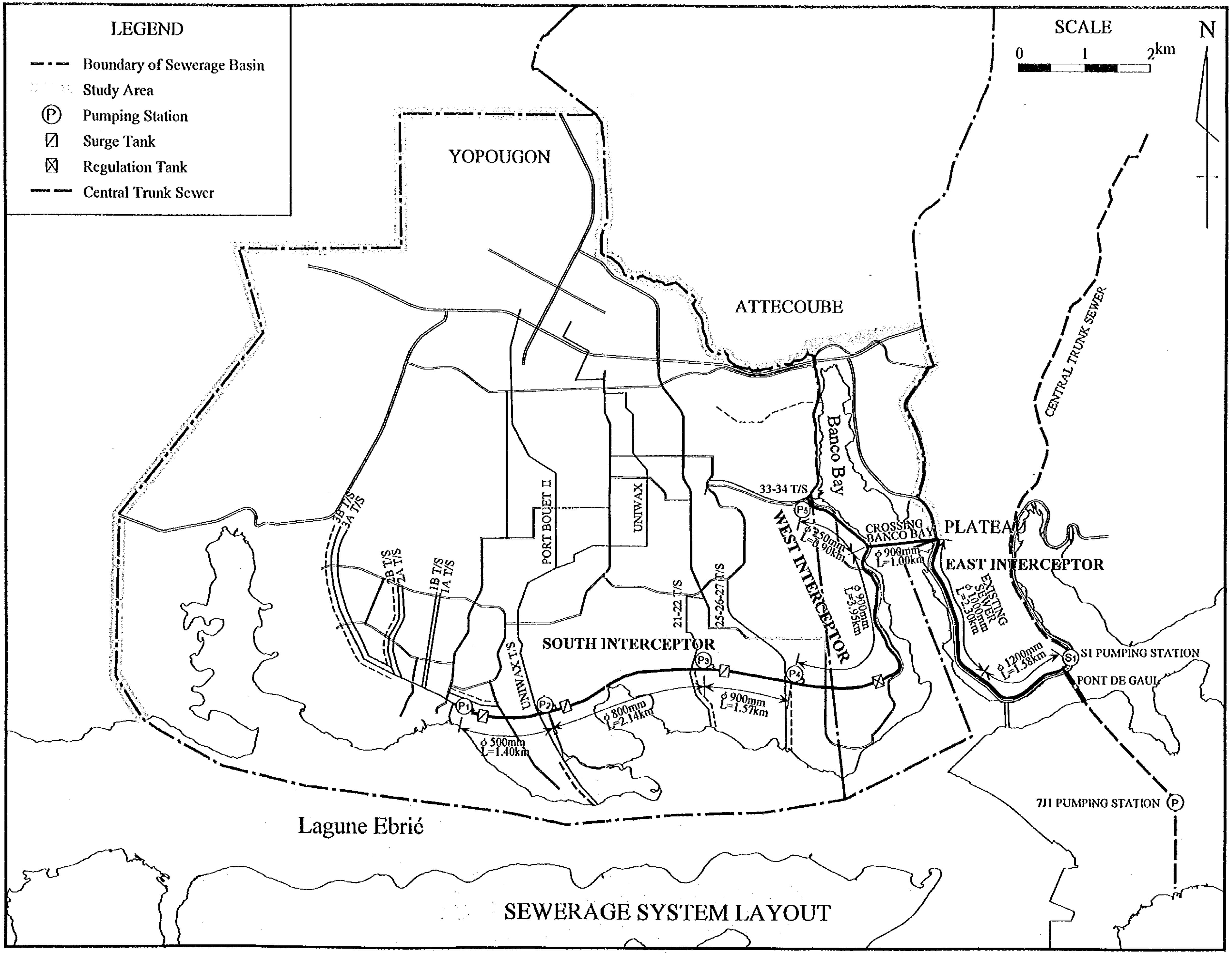


FIG. E.1 EXISTING TOTAL DAILY FLOW



SEWERAGE SYSTEM LAYOUT

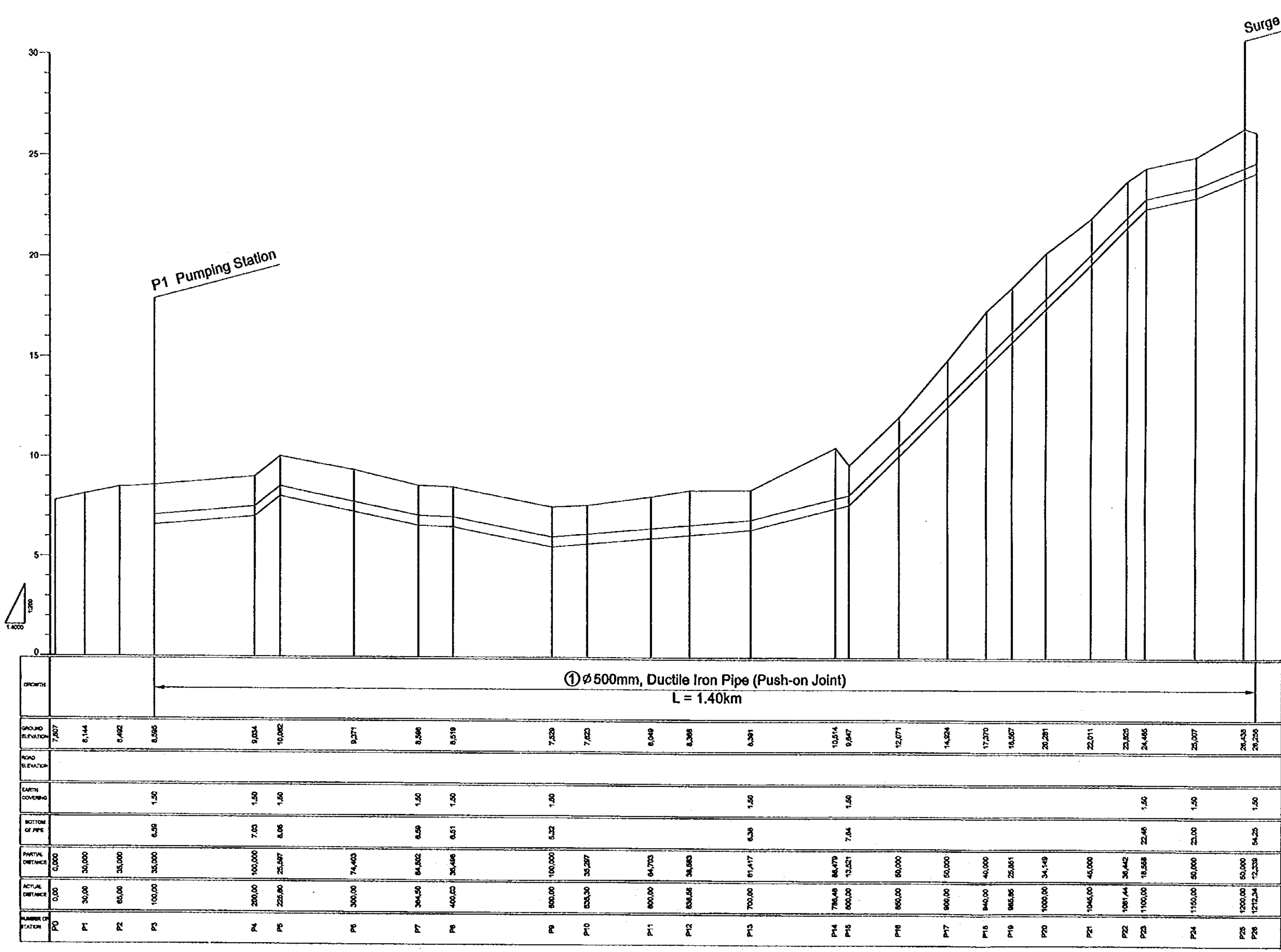


FIG. E.2 LONGITUDINAL PROFILE OF INTERCEPTOR

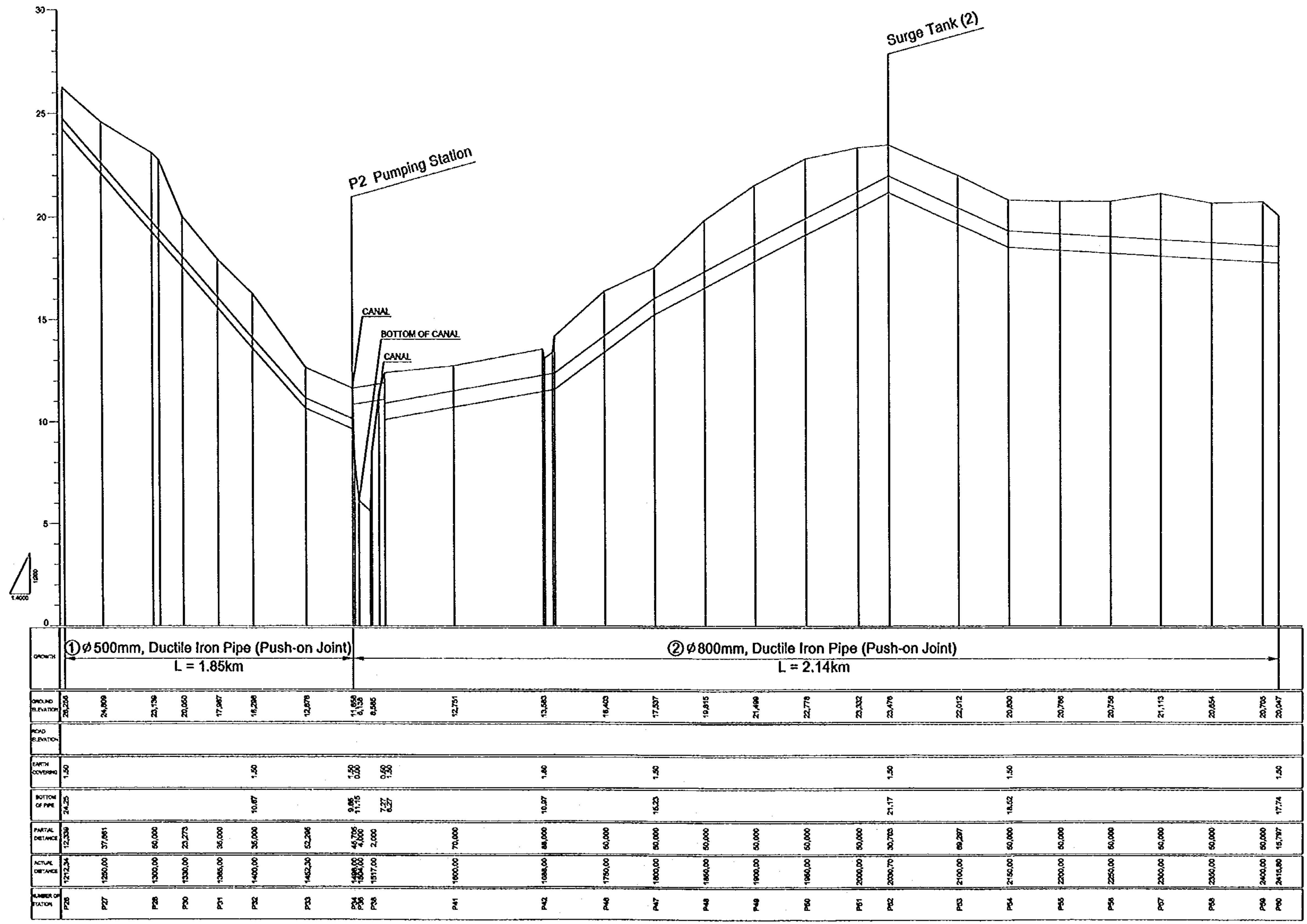


FIG. E.3 LONGITUDINAL PROFILE OF INTERCEPTOR

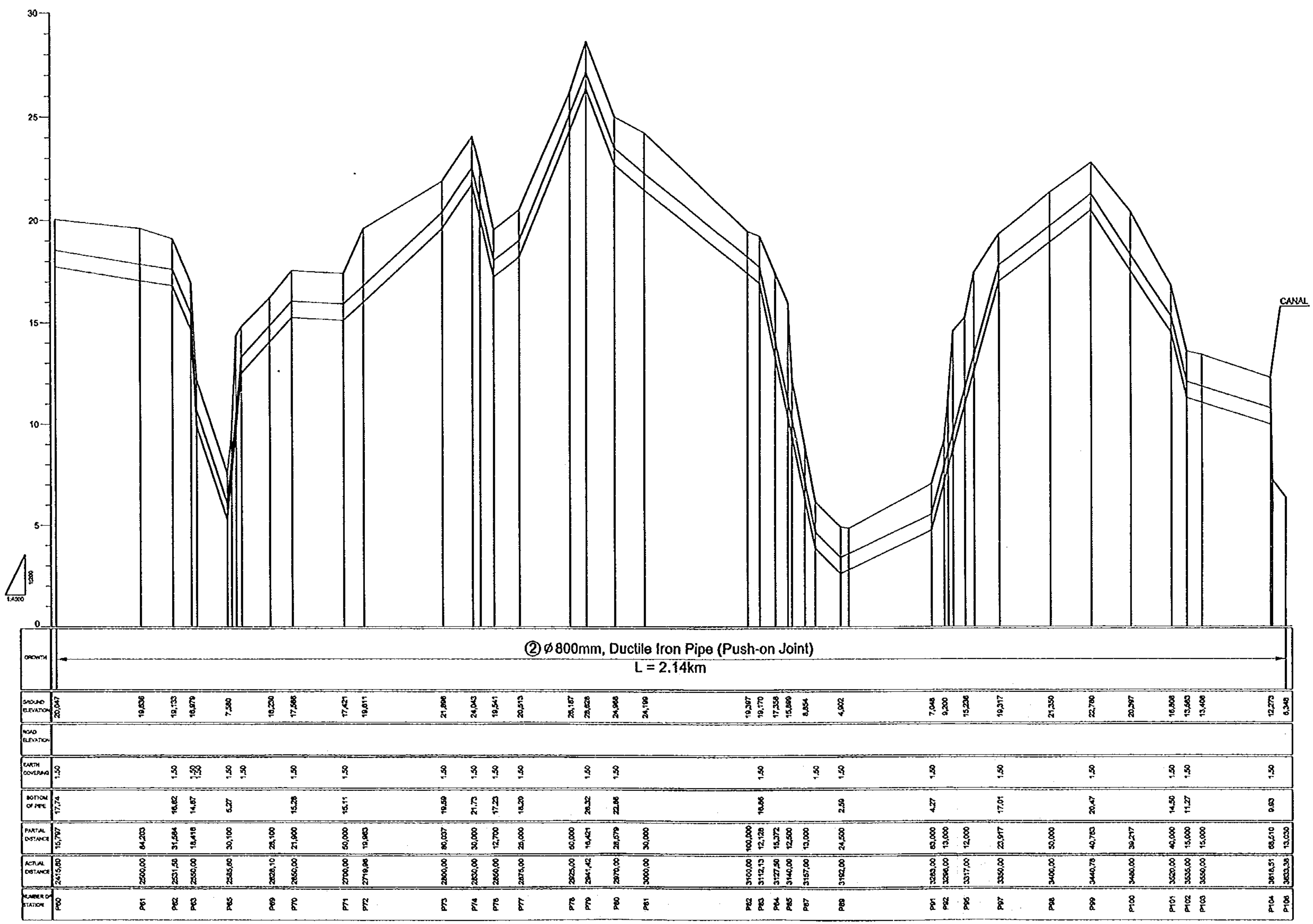
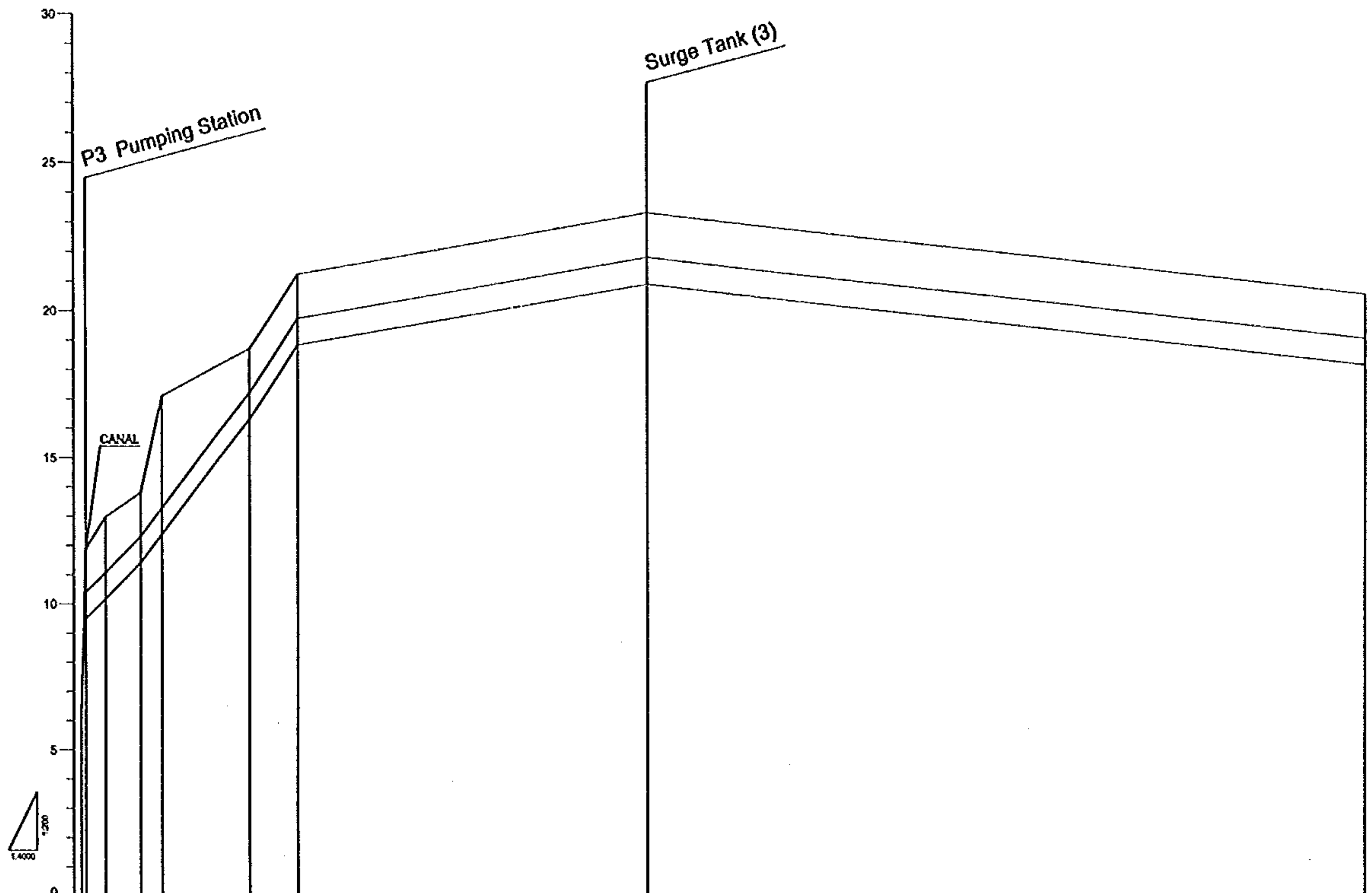


FIG. E.4 LONGITUDINAL PROFILE OF INTERCEPTOR



	P107	P108	P109	P110	P111	P112	P113	P114
GROWTH	③ ø900mm, Ductile Iron Pipe (Push-on Joint) L = 1.57km							
GROUND ELEVATION	11,897	12,989	13,819	17,116	18,726	21,261	23,351	20,701
ROAD ELEVATION								
EARTH COVERING	1,50		1,50		1,50	1,50	1,50	1,50
BOTTOM OF PIPE	9,49		11,41		16,31	18,85	20,94	18,29
PARTIAL DISTANCE	2,800	13,820	25,000	15,000	60,000	33,237	241,700	496,620
ACTUAL DISTANCE	3636,18	3650,00	3675,00	3690,00	3750,00	3783,24	4024,94	4520,56
NUMBER OF STATION	P107	P108	P109	P110	P111	P112	P113	P114

FIG. E.5 LONGITUDINAL PROFILE OF INTERCEPTOR

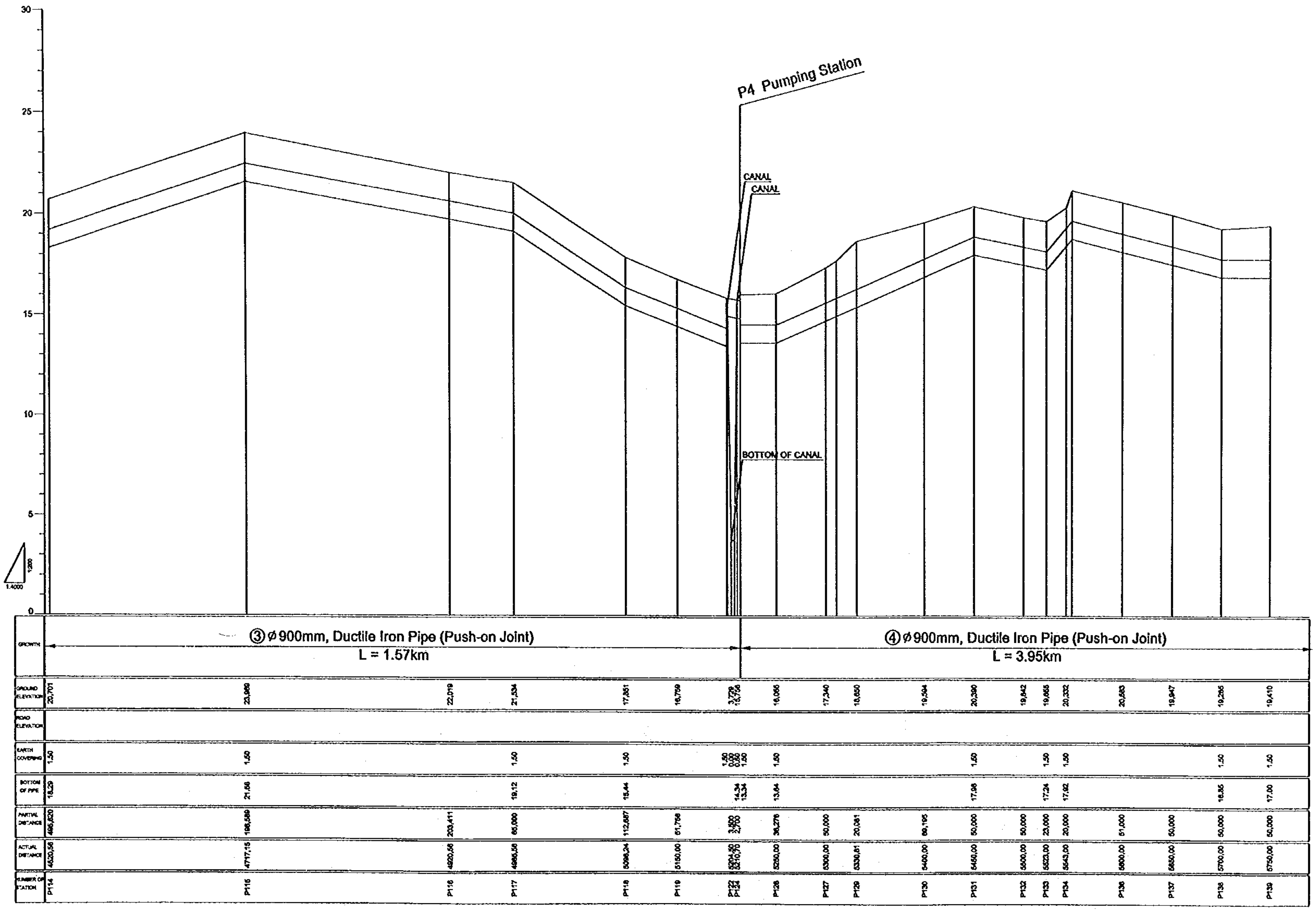
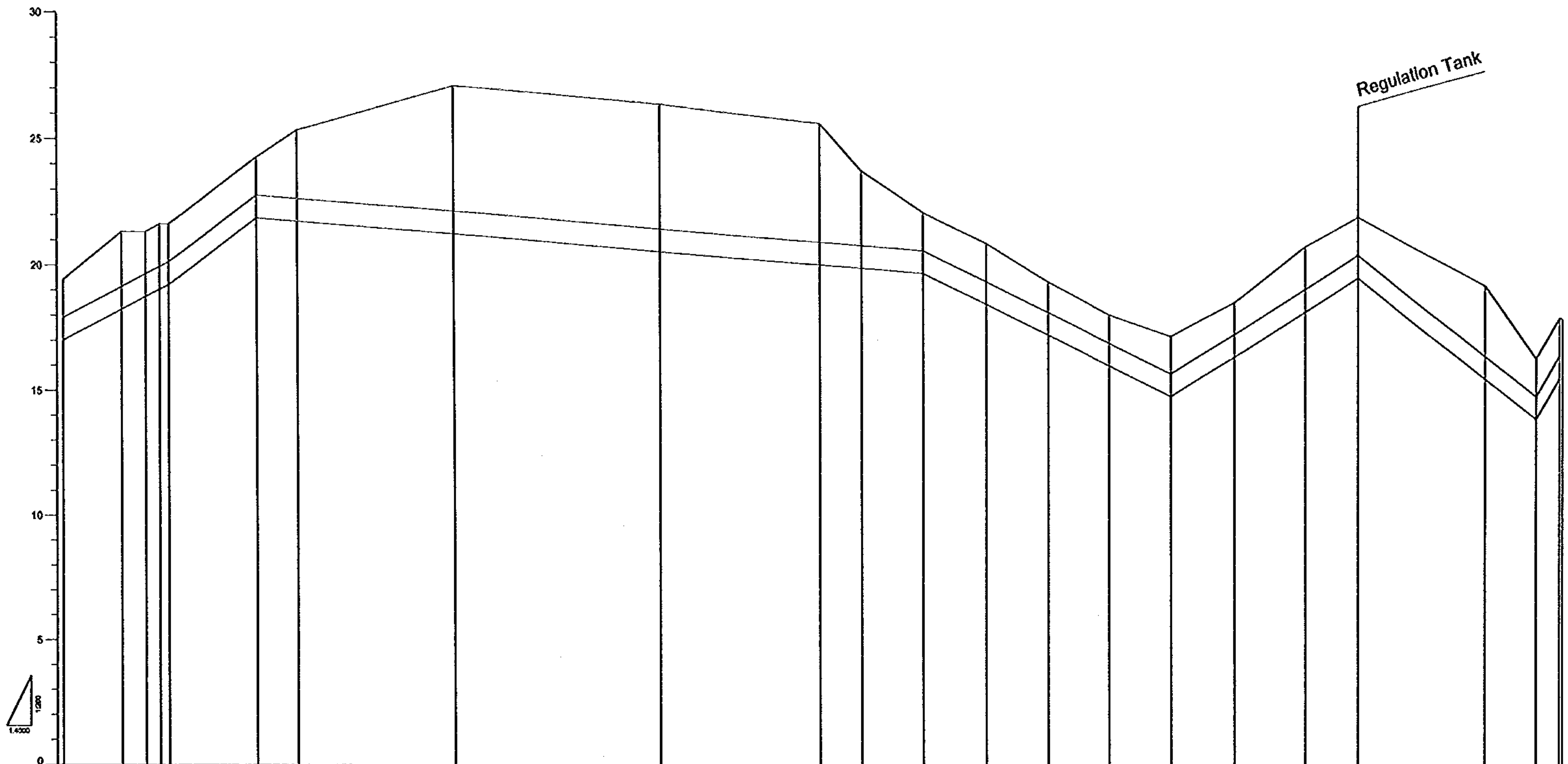


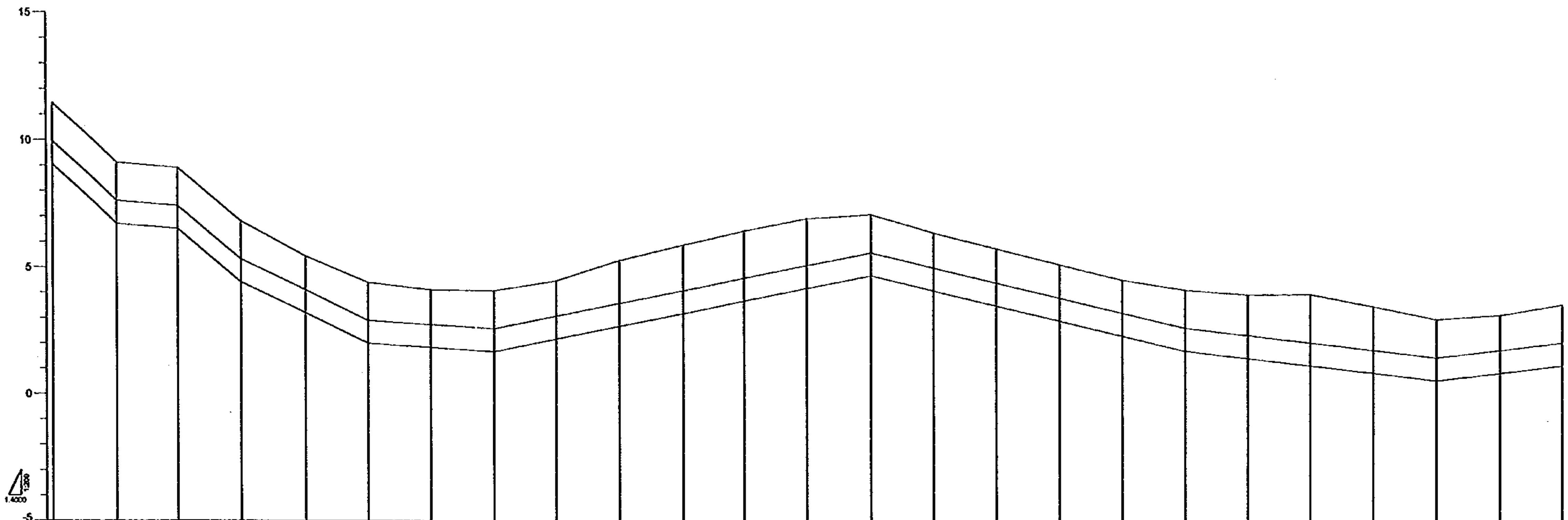
FIG. E.6 LONGITUDINAL PROFILE OF INTERCEPTOR



④ ⌀ 900mm, Ductile Iron Pipe (Push-on Joint)
L = 3.95km

NUMBER OF STATION	GROUND ELEVATION	ROAD ELEVATION	EARTH COVERING	BOTTOM OF PIPE	PARTIAL DISTANCE	ACTUAL DISTANCE
P139	19,410		1.50	17.00	50,000	5750,00
P140	21,330				48,000	5798,00
P141	21,320				19,580	5817,58
			1.50			
P144	24,274		1.50	21.86	71,504	5907,66
P145	25,341				33,281	5940,94
P146	27,045				128,449	6069,39
P147	26,394				167,083	6236,47
P148	25,631				129,498	6365,97
P149	23,756				34,033	6400,00
P150	22,107		1.50	19.89	50,000	6450,00
P151	20,896				50,000	6500,00
P152	19,396				50,000	6550,00
P153	18,083				50,000	6600,00
P154	17,241		1.50	14.83	50,000	6650,00
P155	18,576				50,000	6700,00
P156	20,791				57,010	6757,01
P157	21,963		1.50	19.54	42,990	6800,00
P158	19,234				101,509	6901,51
P159	16,336		1.50	13.92	40,160	6941,67
P160	17,947		1.50	15.34	19,000	6960,67
P163	12,804				16,000	6967,92

FIG. E.7 LONGITUDINAL PROFILE OF INTERCEPTOR



GROWTH	④ Ø900mm, Ductile Iron Pipe (Push-on Joint) L = 3.95km												
GROUND ELEVATION	11,447	9,103	8,911	6,809	5,430	4,390	4,104	4,065	4,456	5,263	5,867	6,432	6,915
ROAD ELEVATION													
EARTH COVERING	1.50	1.50	1.50	1.50		1.50		1.50					
BOTTOM OF PIPE	9.54	6.69	6.50	4.40		1.98		1.65					
PARTIAL DISTANCE	0,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
ACTUAL DISTANCE	0,00	50,00	100,00	150,00	200,00	250,00	300,00	350,00	400,00	450,00	500,00	550,00	600,00
NUMBER OF STATION	P0	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12

GROUND ELEVATION	7,072	6,361	5,740	5,119	4,516	4,124	3,943	3,957	3,479	2,979	3,151	3,568
ROAD ELEVATION												
EARTH COVERING	1.50					1.50				1.50		1.50
BOTTOM OF PIPE	4.56					1.71				0.57		1.09
PARTIAL DISTANCE	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
ACTUAL DISTANCE	650,00	700,00	750,00	800,00	850,00	900,00	950,00	1000,00	1050,00	1100,00	1150,00	1200,00
NUMBER OF STATION	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	P24

FIG. E.8 LONGITUDINAL PROFILE OF INTERCEPTOR

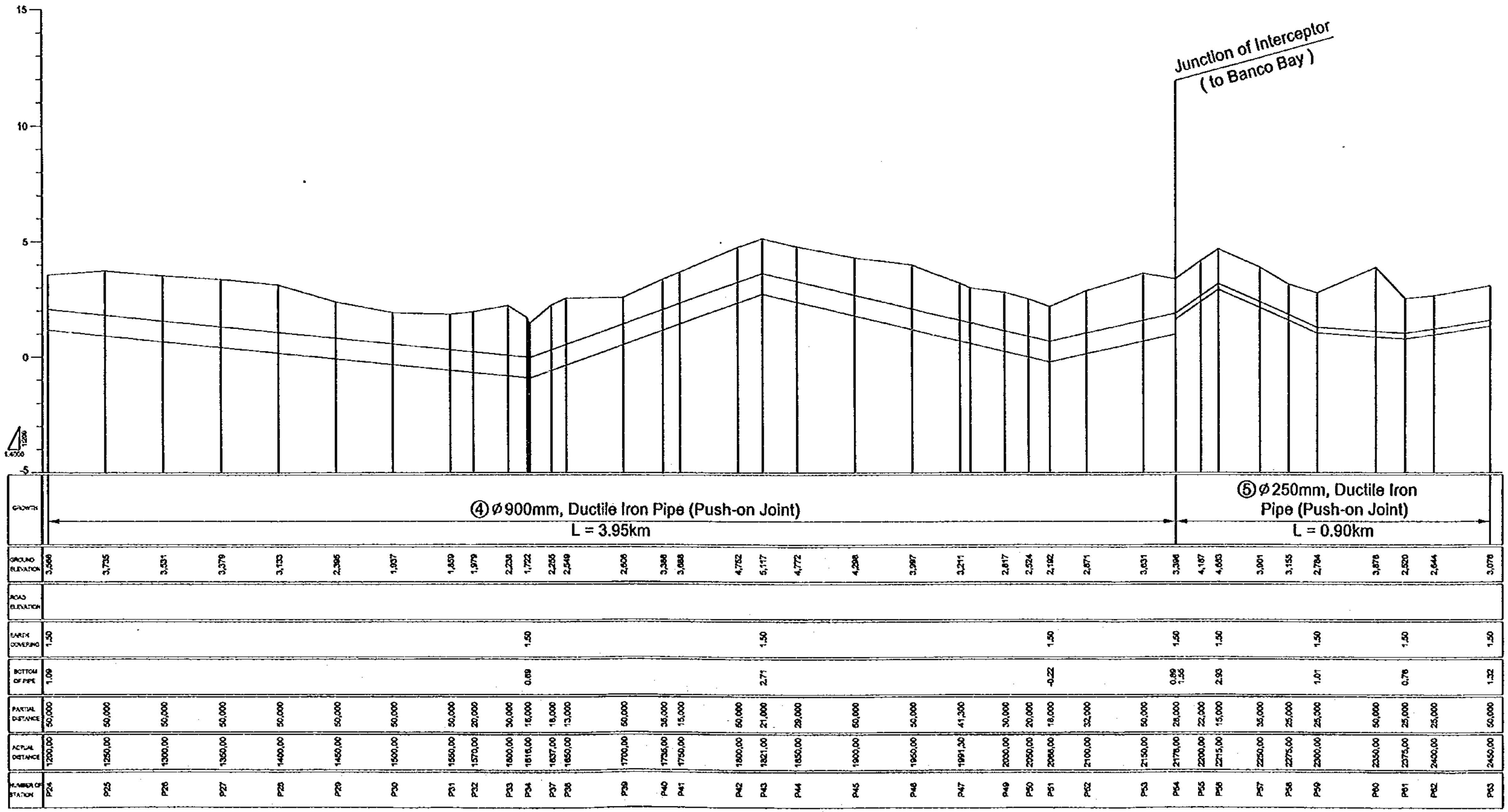
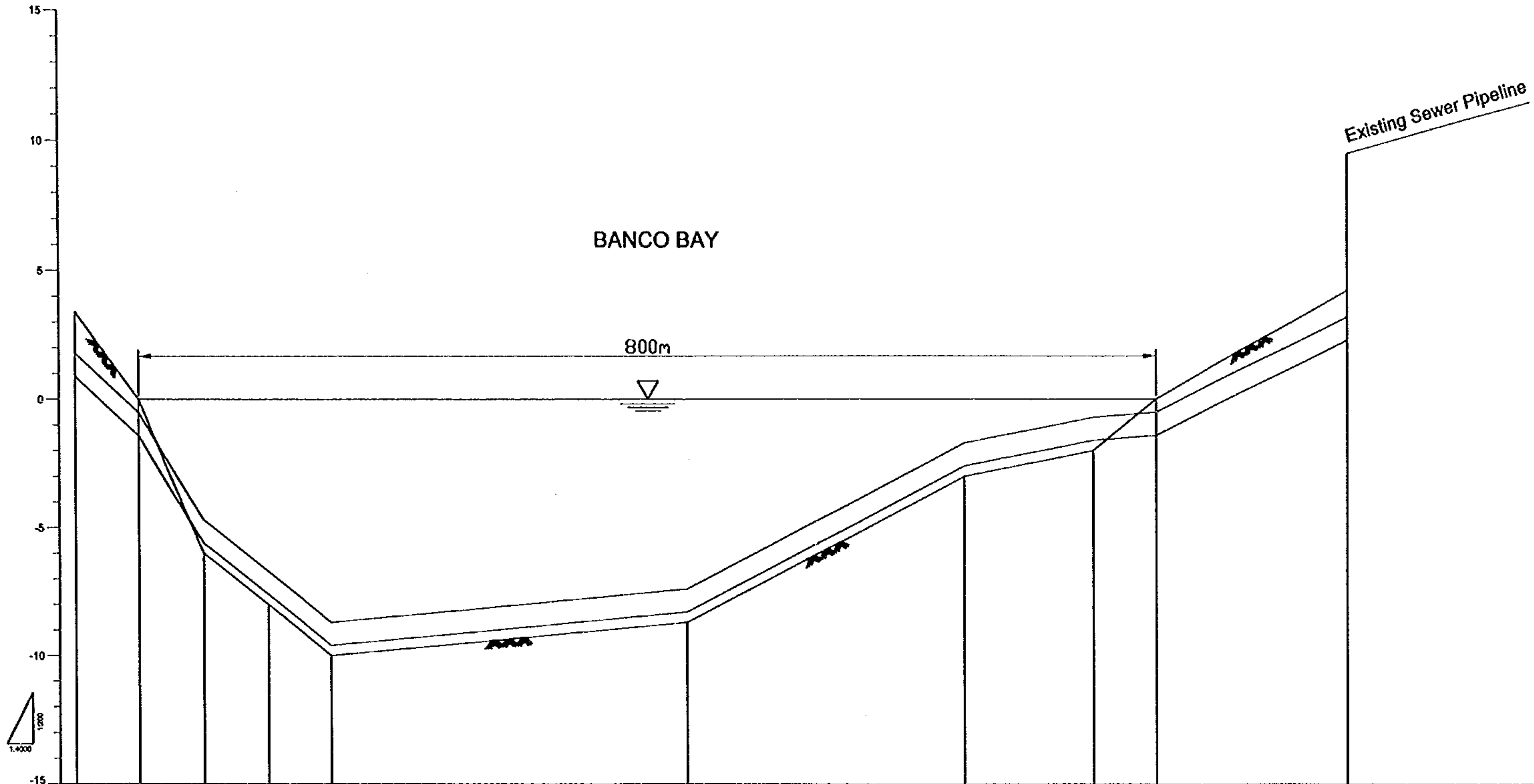


FIG. E.9 LONGITUDINAL PROFILE OF INTERCEPTOR

GROWTH	⑤ ø250mm, Ductile Iron Pipe (Push-on Joint) L = 0.90km															
GROUND ELEVATION	3,076	4,572	5,058	4,379	4,598	5,283	5,935	4,703	3,568	2,338	1,658	2,167	2,303	2,639	2,527	2,598
ROAD ELEVATION																
EARTH COVERING	1,50		1,50					1,50			1,50					1,50
BOTTOM OF PIPE	1,32		3,30					2,96			-0,10					0,75
PARTIAL DISTANCE	50,000	50,000	50,000	50,000	23,000	20,600	22,000	28,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	24,800
ACTUAL DISTANCE	2450,00	2500,00	2550,00	2600,00	2623,00	2643,60	2672,00	2700,00	2750,00	2800,00	2850,00	2900,00	2950,00	3000,00	3050,00	3074,80
NUMBER OF STATION	P63	P64	P65	P66	P67	P68	P70	P71	P72	P73	P74	P75	P76	P77	P78	P79

FIG. E.10 LONGITUDINAL PROFILE OF INTERCEPTOR



GROWTH	⑥ ø900mm, Ductile Iron Pipe (Push-on Joint) L=1.00km									
GROUND ELEVATION	3.386	0.000	-6.000	-8.000	-10.000	-8.700	-3.000	-2.000	0.000	4.20
ROAD ELEVATION										
EARTH COVERING	1.50	0.50	-	-	-	-	-	-	0.50	0.82
BOTTOM OF PIPE	0.89	-1.41	-5.80	-7.80	-9.80	-8.30	-2.80	-1.80	-1.41	2.28
PARTIAL DISTANCE	0.00	50.00	50.00	50.00	50.00	280.00	220.00	100.00	50.00	150.00
ACTUAL DISTANCE	0.00	50.00	100.00	150.00	200.00	480.00	700.00	800.00	850.00	1000.00
NUMBER OF STATION										

FIG.E.11 LONGITUDINAL PROFILE OF INTERCEPTOR

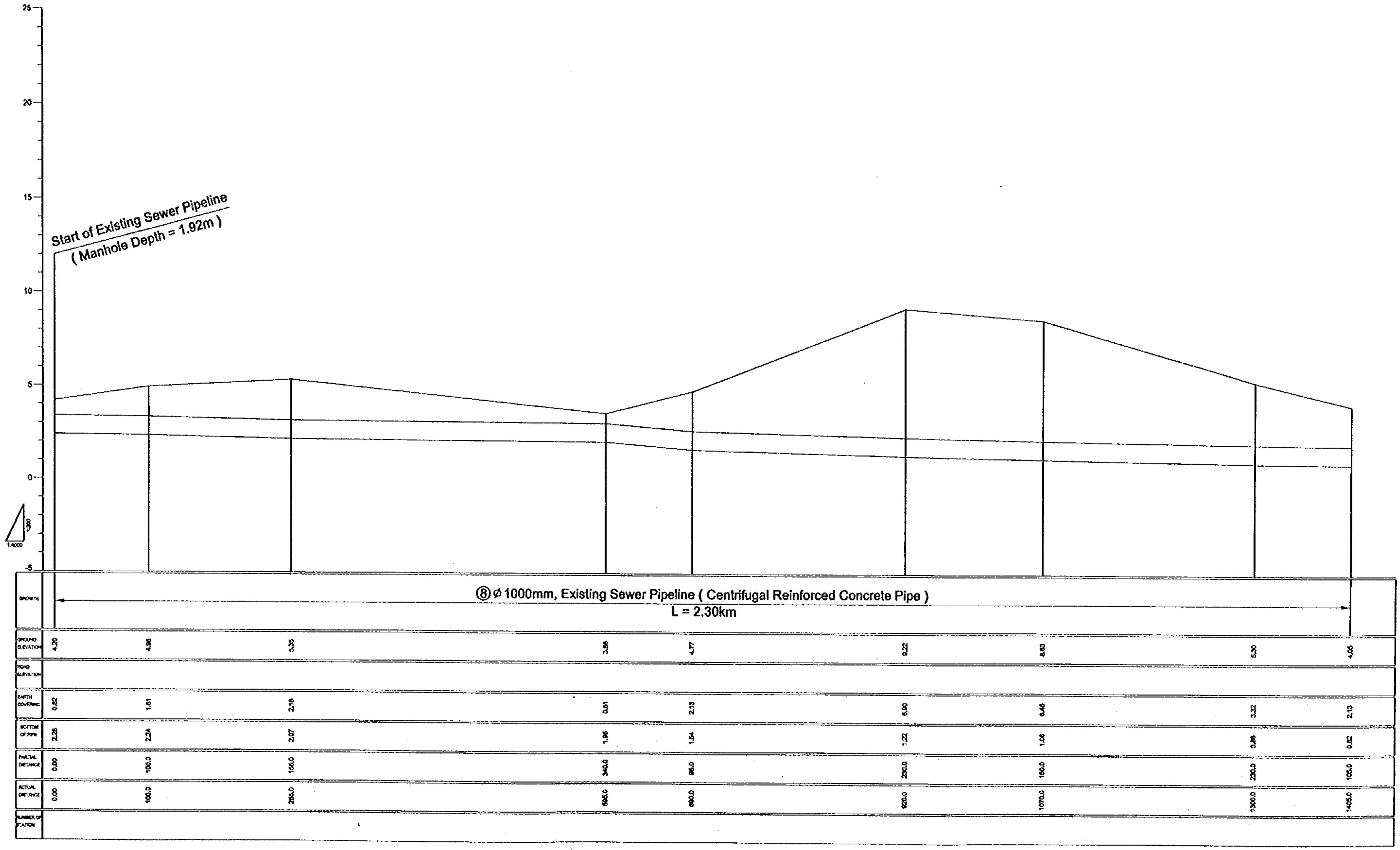
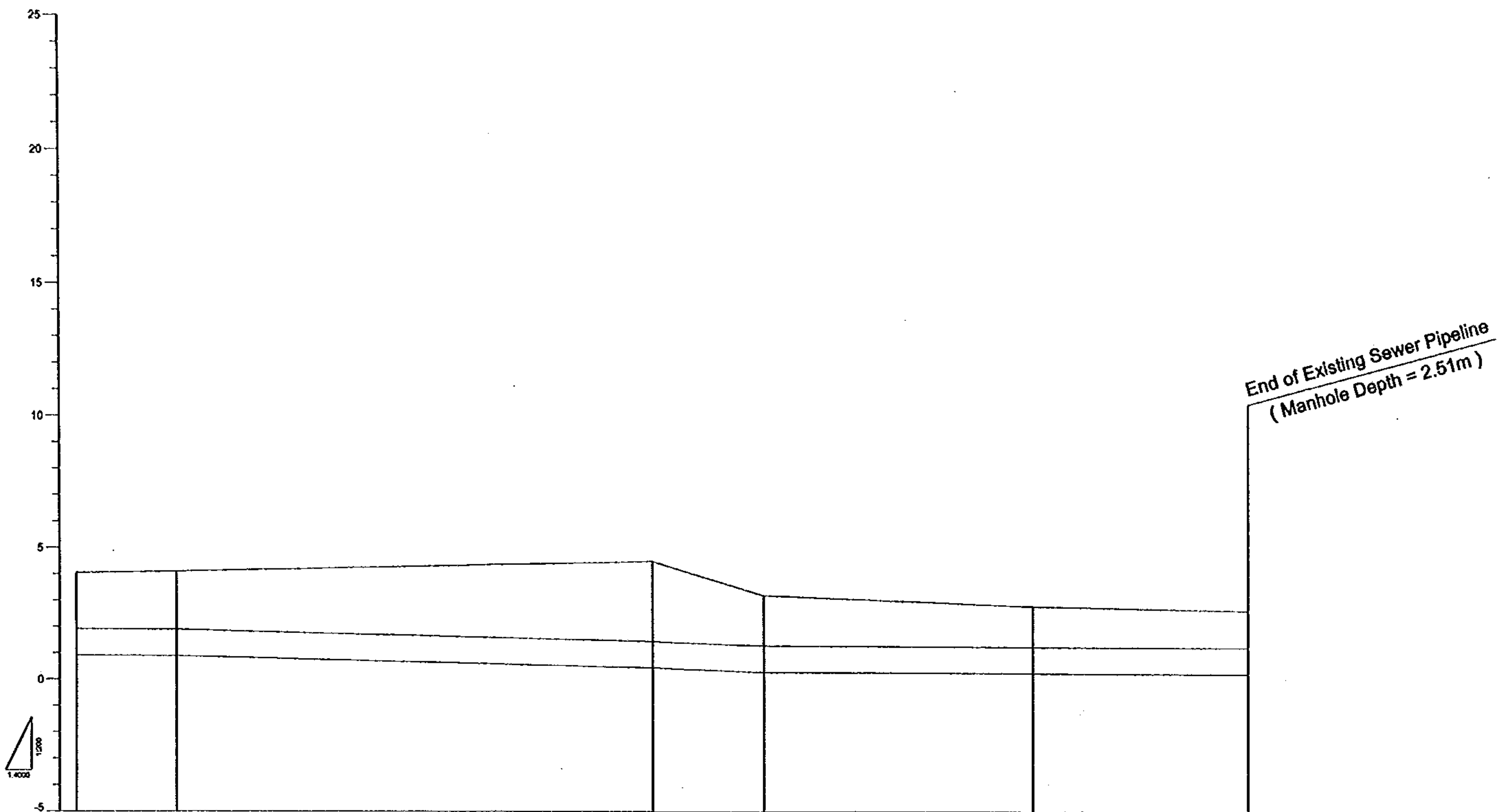


FIG.E.12 LONGITUDINAL PROFILE OF INTERCEPTOR



GROWTH	⑧ ø 1000mm, Existing Sewer Pipeline (Centrifugal Reinforced Concrete Pipe) L = 2.30km					
GROUND ELEVATION	4.05	4.11	4.49	3.19	2.78	2.62
ROAD ELEVATION						
EARTH COVERING	2.13	2.21	3.04	1.91	1.54	1.41
BOTTOM OF PIPE	0.82	0.80	0.35	0.18	0.14	0.11
PARTIAL DISTANCE	0.00	75.0	365.0	85.0	205.0	165.0
ACTUAL DISTANCE	1405.0	1480.0	1845.0	1930.0	2135.0	2300.0
NUMBER OF STATION						

FIG.E.13 LONGITUDINAL PROFILE OF INTERCEPTOR

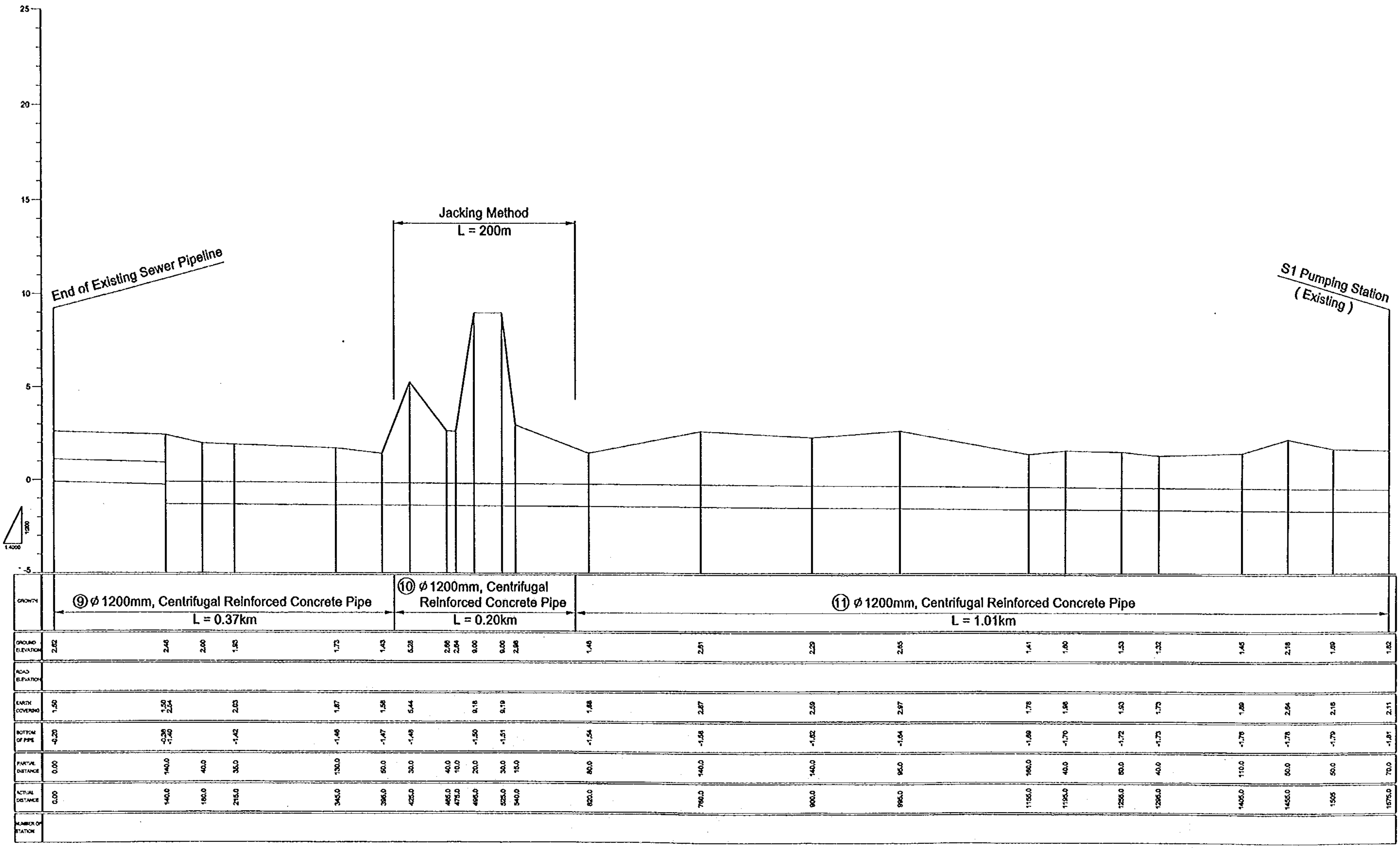
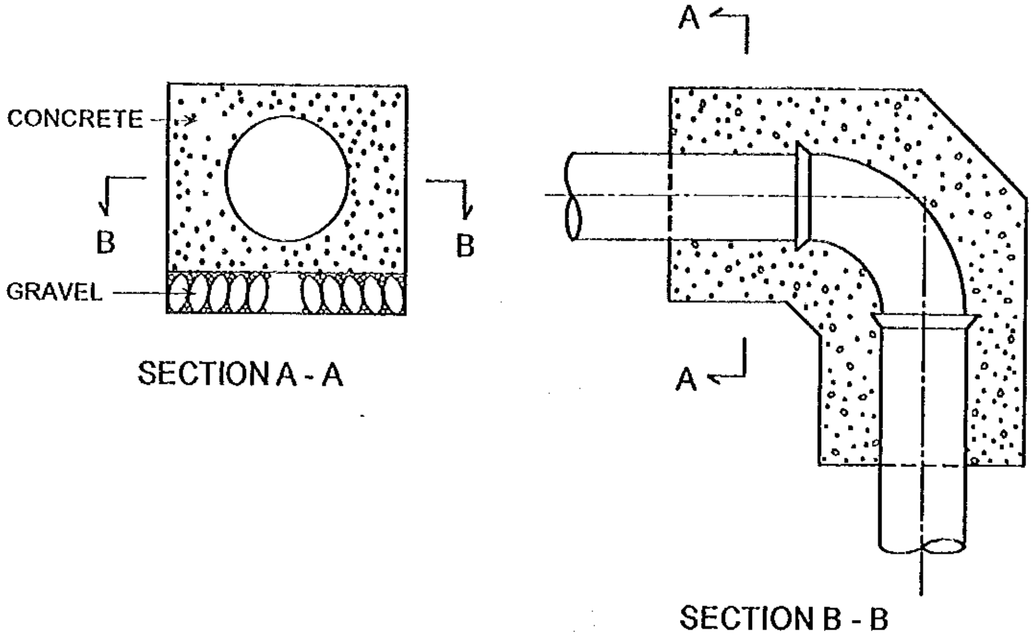
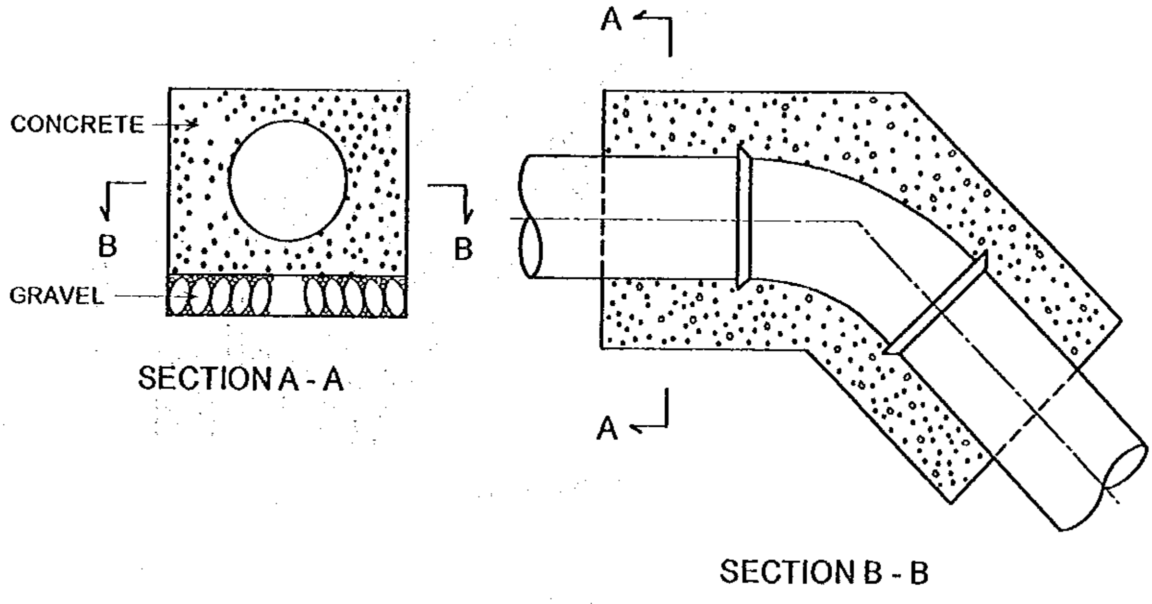


FIG.E.14 LONGITUDINAL PROFILE OF INTERCEPTOR



1/4 BEND



1/8 BEND

FIG.E.15	TYPICAL HORIZONTAL CROSS SECTION OF PROTECTION FOR 1/4 AND 1/8 BEND

THE FEASIBILITY STUDY ON SEWERAGE FACILITIES IN WESTERN DISTRICT OF ABIDJAN CITY IN THE REPUBLIC OF COTE D'IVOIRE

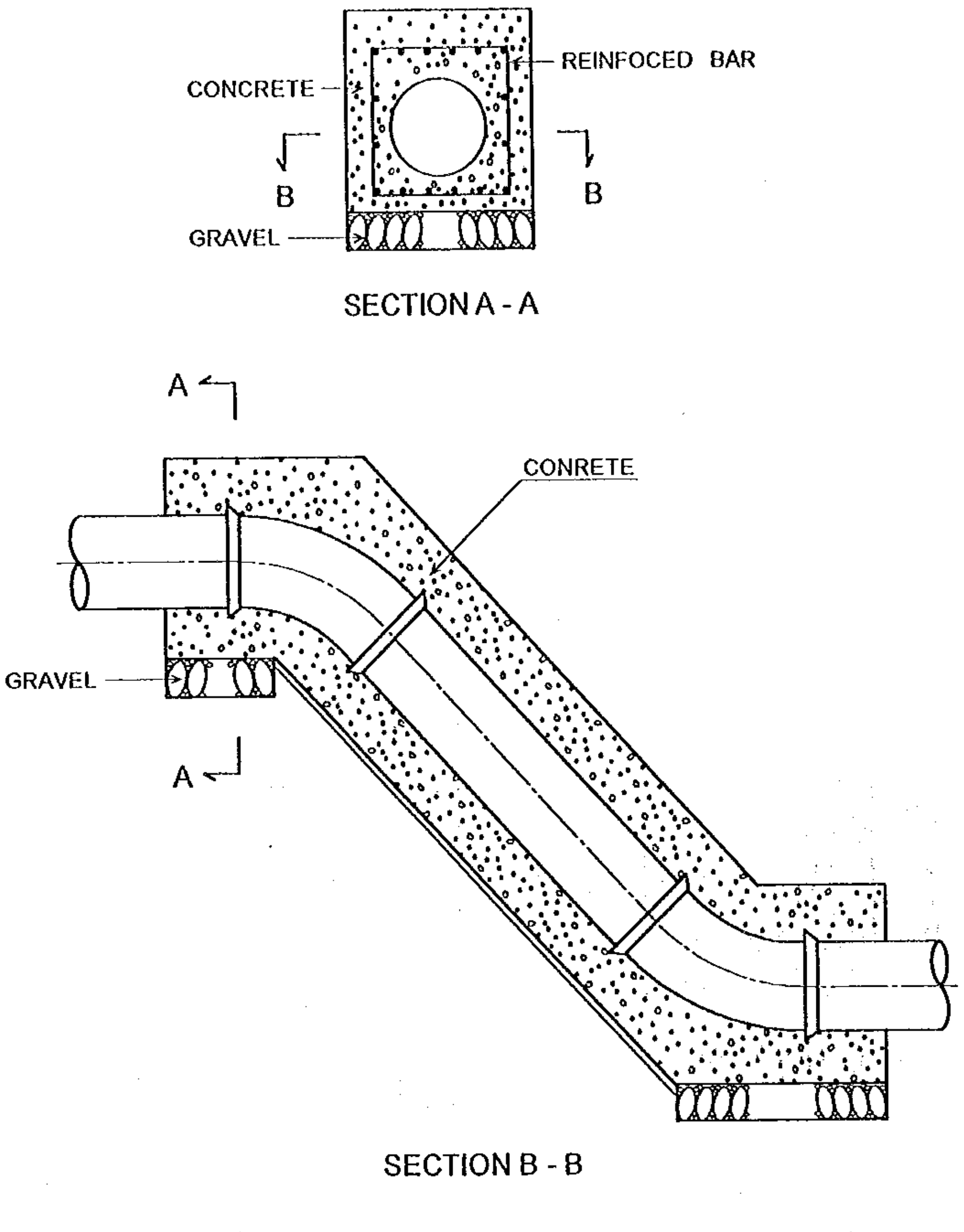
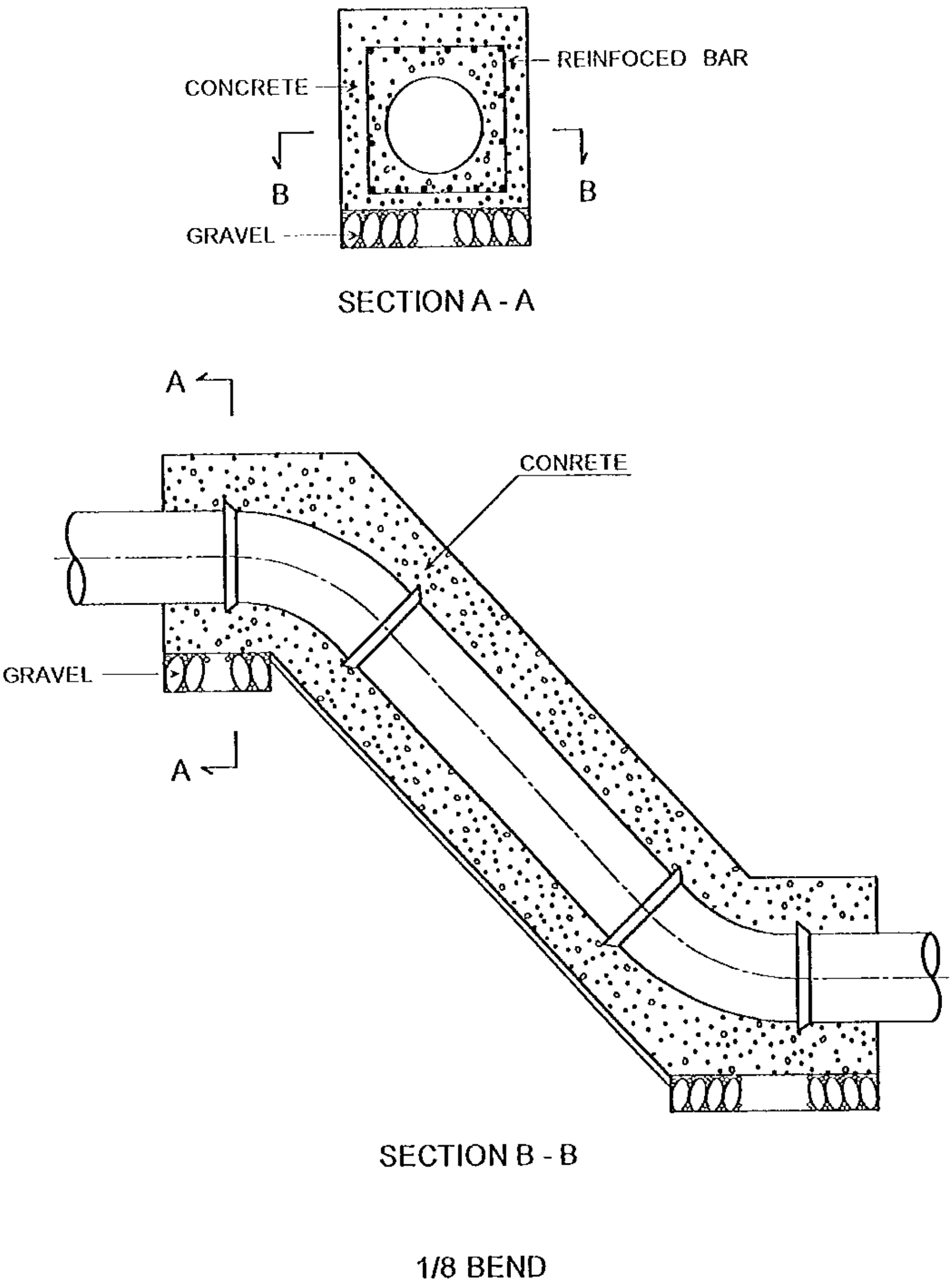


FIG. E.16	TYPICAL LONGITUDINAL PROFILE OF PROTECTION FOR 1/8 BEND

THE FEASIBILITY STUDY ON SEWERAGE FACILITIES IN WESTERN DISTRICT OF ABIDJAN CITY IN THE REPUBLIC OF COTE D'IVOIRE



1/8 BEND

FIG. E.16	TYPICAL LONGITUDINAL PROFILE OF PROTECTION FOR 1/8 BEND

THE FEASIBILITY STUDY ON SEWERAGE FACILITIES IN WESTERN DISTRICT OF ABIDJAN CITY IN THE REPUBLIC OF COTE D'IVOIRE

APPENDIX F

PUMPING STATIONS

TABLE OF CONTENTS

LIST OF TABLES

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1. Pump Total Head

During the operation of pump, head losses occur in the suction, discharge, discharge-outlet pipes etc. The total Head (H) is the sum of actual head (H_a), which represents the head difference between the discharge liquid surface and the suction liquid surface, pipeline head loss (H_p), and velocity head (V/2g) loss. However, the velocity head loss is negligible. A total head (H) is described by the following equation:

$$H = H_a + H_p + h_a$$

Where,
- H = Total head, m
- H_a = Actual head, m
- H_p = Pipe line head loss, m
- h_a = Allowance, 2.0 m is mostly adopted

The pipeline head loss (H_p) is calculated using the Hazen-Williams equation as described below:

$$H_p = 10.67 \times (Q / C)^{1.85} \times D^{-4.87} \times L$$

Where
- Q = Design sanitary wastewater (m^3/s) in the year 2003
- C = Hazen-Williams discharge coefficient (C= 110)
- D = Diameter of pipe, (m)
- L = Pipe line length, (m)

The actual head (H_a) is calculated by the difference between LWL (low water level where the pump stops) of the wet-well pit and control water level of the discharge tank. The total head of pump is shown in Table F.1.

2. Selection of Pump Type

In general, the selection of pump type should be comprehensively considered and examined based on usage/purpose, water quantity, pump head, cost, control system, water quality, and other factors. The small-sized pumps with a bore of 300 mm or less should be considered economically more advantageous based on usage/purpose: standard type models meet such requirements as water demand, pump head and speed.

In this Study, basic points for the selection of pump type for sewage are durability, reliability and pump efficiency because these pumps are operated continuously. Also, non-clogging type pumps shall be adopted because of floating materials in the inflow.

2.1 Comparison of Pump Types

Table F.2 shows the general comparison for the three types of sewage pump based on the above considerations.

2.2 Selection of Pump Type

As shown in Tables F.3 and F.4, horizontal type screw pump is recommended for the Pumping Stations P1 and P2. Regarding Pumping Stations P3, P4 and 33-34, submersible type screw pump is recommended.

3. Number of Pump and Suction Bore of Pump

The number of pumps to be installed depends on the peak and minimum flow, construction plan, and standby pump requirement. Moreover, all the pumps installed in each of the pumping station should have the same capacity because of easy maintenance and also the variations in sewage flows are small.

According to the sewage quality and quantity survey by JICA Study Team as described in Appendix C, the ratio of the existing total sewage flow and estimated for the year 1998 is about 60 %. However, high accuracy in the survey could not be obtained because of large quantity of floating materials and solids in the sewage flows in addition due to influence of rainwater inflow. Moreover, the sudden increase in flow for a short time in the midnight and in the early morning was supposed to be due to industrial wastewater discharges and it could be assumed that the industrial wastewater discharge in the sewer is actually more than the amount obtained from SIIC. From these observations, an overall ratio is assumed to be about 60% or less and the sewage flow in each trunk sewer is assumed to be as follows.

① 1-2-3A/B and West Yopougon Basin

The pattern of variations in sewage flow through the survey results is difficult to know because the sewer is broken. It is assumed that the ratio in year 2003, which is the target year of the Project, is about 60% or less based on the sewer connection ratio and assumption that the West Yopougon basin will not be served in the near future.

② UNIWAX Basin

In this basin, sewage flow ratio measured during the survey was about 50% compared to the estimated flow for year 1998. Therefore, even if the existing broken sewer in the downstream is rehabilitated, the ratio is presumed to be about 60% of estimated flow in the year 2003.

③ 21-22, 25-26 Basin

The amount of sewage flow measured during the survey is almost same as the estimated flow for the year 1998.

④ 33-34Basin

The flow ratio measured during the survey is about 75% compared to the estimated flow for the year 1998.

Based on the above-mentioned observations, the ratio of flow in year 2003, which is the target year for the Project and year 1998 is assumed to be differed not so much. Therefore, the construction is planned in two stages. The number of pumps to be installed in the first stage is decided based on the flow ratio of the year 2003. The number of pumps at the first stage and the second stage is shown in Table 5 and Table 6.

4. Analysis of Water Hammer

To investigate the complicated pipeline system accurately, analysis based on the characteristic curves using the computer is the most appropriate method. Therefore, a computerized analysis is performed in this Study using characteristic curves, which have the following advantages:

(1) By general numerical analysis of equations of partial derivatives, which are formulated for wave movements, equations dealing with differentials suitable for computerized analysis have been yielded without omitting the minor terms of basic equations.

(2) Calculation accuracy is very high because the discontinuity of wave propagation is exactly shown.

(3) Head loss effects of pipeline gradients and others are programmable without difficulty.

(4) Applications to special problems such as complicated pipeline systems or water column separation are easily performed.

The computerized analysis of water hammer by the above-mentioned method is as shown in the following sections. The pipeline diagram for analysis model is shown in Fig. F.1.

To examine the water hammer phenomena, it was assumed that all the pumps are in operation. Further, the minimum allowable negative pressure was assumed to be -0.058842 MPa (-6m).

The following cases were investigated using computer.

Case 1: No countermeasure for water hammer

Case 2: Countermeasure using surge tank and flywheel.

4.1 Basic Conditions

(1) Main Pump

1) Pump station	:	P1	P2	P3	P4
2) Pump service	:	Sewage water			
3) Pump type	:	Horizontal screw		Submersible screw	
4) Number of installed pumps (set)	:	4	4	3	3
5) Number of operating pumps (set)	:	3	3	2	2
6) Rated pump capacity (m^3/min)	:	4.66	10.74	3.54	3.13
7) Rated pump total head (m)	:	38	27	20	11
8) Rated speed of rotation (min^{-1})	:	1,485	1,485	1,485	1,485

(2) Motor and GD2

1) Motor output (kW)	:	55	110	22	11
2) Motor type	:	Induction type		Dry type submersible	
3) Motor voltage (V)	:	380	380	380	380
4) Motor frequency (Hz)	:	50	50	50	50
5) Number of pole (P)	:	4	4	4	4
6) Pump & motor GD2 (kg-m^2)	:	10.95	14.30	24.00	13.50
		(Including Flywheel)			

(3) Check Valve

1) Valve bore (mm)	:	200	300	200	200
2) Valve type	:	Ordinary swing check valve			

(4) Pipeline

1) Pipe No.	:	1	2	3	4
2) Location	:	P1→P2	P2→P3	P3→P4	P4→TANK
3) Pipe material	:	Ductile cast iron			
4) Pipe diameter (mm)	:	500	800	900	900

5) Wave speed (m/sec)	:	1,179	1,122	1,108	1,108
6) Pipeline length (m)	:	1,600	2,000	1,600	1,000
7) Loss co-efficient (C)	:	110	110	110	110
8) Pipeline loss (m)	:	5.639	6.523	3.828	2.938

(5) Operating Conditions

1) Pump station	:	P1	P2	P3	P4
2) Flow condition	:	Design capacity			
3) Flow capacity (m^3/min)	:	13.98	32.22	7.08	6.26
4) Suction water level (m)	:	4.113	9.651	10	15
5) Discharge water level (m)	:	-	-	-	21

4.2 Calculation Results without Countermeasure (CASE 1)

	Pressure (MPa)	Distance from PS (m)	Elevation (EL m)
Minimum pressure	-0.505	1,200	23
Maximum pressure	0.334	0	6.31

The results of the water hammer phenomena calculations are shown in the Fig. F.2 which consists of pipeline profile, hydraulic gradient line, and maximum and minimum pressure lines. In Case 1, negative pressure is observed and water column separation occurs in the pipeline. After column separation occurrence, abnormal high pressure will be generated in the pipeline due to return of water after the column separation and pipeline may be damaged. Therefore, countermeasures are necessary to protect pipeline from the water hammer.

4.3 Recommended Water Hammer Protection Devices

(1) Additional flywheel

1) Pump station	:	P1	P2	P3	P4
2) Flywheel GD2 (kg-m2)	:	10	-	Including	Including
3) Total GD2 (kg-m2)	:	20.95	14.30	24.00	13.50
4) Flywheel type	:	Coupling type	-	-	-

(2) Installation of universal surge tank

1) Location from P1 (m)	:	1,200	2,000	4,000
2) Installed elevation (EL m)	:	23.0	22.0	21.9

3) Initial water level (EL m) : 35.697 32.982 26.807
4) Diameter of universal surge tank (m) : 3 3 3

4.4 Calculation Results after Installation of Protection Devices (CASE 2)

	Pressure (MPa)	Distance from PS (m)	Elevation (EL m)
Minimum pressur	-0.003	5,800	21.20
Maximum pressure	0.547	0	6.31

The results of water hammer calculations are shown in Fig. F.3. In Case 2, water hammer protection devices are added. Negative pressure in the pipeline is within the allowable value (-0.058842 MPa). Regarding the maximum pressure, it should be checked with the company when purchasing whether the maximum pressure is within the allowable pressure of the pipeline or not. If the maximum pressure is within allowable pressure, these protection devices are effective and recommendable.

4.5 Water Hammer Protection Equipment

Flywheel and universal surge tanks to protect from water hammer are recommended.

TABLE F.1 PUMP TOTAL HEAD OF EACH PUMPING STATION

Interceptor	Pumping Station	Discharge (m3/s)	Diameter (mm)	Length (m)	H_{actual} (m)	H_{loss} (m)		H_{pump} (m)	Pump Total Head(m)	Motor (kw)			
						h_{loss}	Σh_{loss}			Input	No.Pump	ΣInput	Output
South	P1	(0.233) 0.233	500	1600	16.9	5.6	18.9	2.0	38	54.42	③(+1) 2(+1)	163.3	55
	P2	(0.537) 0.770	800	2000	11.4	6.6	13.3	2.0	27	89.11	③(+1) 2(+1)	267.3	110
	P3	(0.118) 0.888	900	1600	11.0	3.8	6.7	2.0	20	21.76	②(+1) 2(+1)	43.5	22
	P4	(0.104) 0.992	900	1000	6.0	2.9	2.9	2.0	11	10.58	②(+1) 2 (+1)	21.2	11
West	In Future	0.078	250	1000	11.9	13.6		2.0	28	20.20	②(+1)	40.4	22
	In 2003	0.027	250	1000	11.9	1.9		2.0	16	7.98	1(+1)	8.0	11

Notes : (0.537) is inflow of Trunk Sewer,0.770 is accumulated wastewater flow in the interceptor.

: ③(+1) is the number required in the future, and 2(+1) is the number required in year 2003.
And, (+1) is standby.

: L.W.L (Low Water Level where Pump stops) of each pumping station is in the table below.

Pumping Station	P1 (m)	P2 (m)	P3 (m)	P4 (m)	West
L.W.L	4.11	9.65	10.00	15.00	−1.00

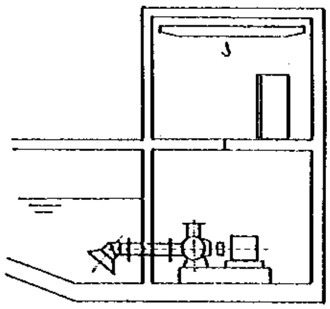
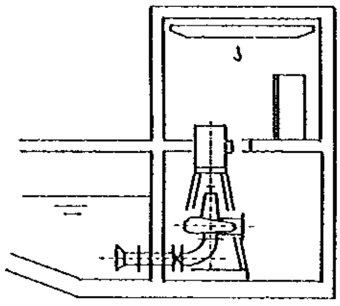
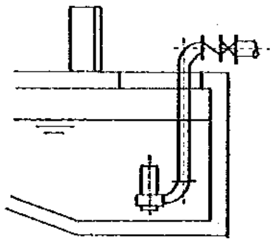
: The flow in the west interceptor in the future flow as shown in the above table is combined of 33.34 and 35.36 basin.
However, the flow in 2003 the target year is assumed to be only from 33.34 basin because 33.35trunksewer is not functioning.

: The pump electric power input is estimated using the following formula:

$$P = 0.163 \times \gamma \times Q \times HT / \eta p$$

Where γ : Specific gravity of water (1 kgf / l)
Q : Pump capacity per unit (m^3 / min)
HT : Pump total head (m)
ηp : Pump efficiency (53%)

TABLE F.2 GENERAL COMPARISON OF PUMP TYPE

	HORIZONTAL, SCREW TYPE (Plan 1)		VERTICAL, VOLUTE TYPE (Plan 2)		SUBMERSIBLE, SCREW TYPE(Plan 3)	
LAYOUT						
PUMP CONSTRUCTION AND FEATURES	Since horizontal suction and vertical discharge layout, pump can be disassembled without disassembling of pipings. Non-clog impeller of screw type is adopted.		Flange layout is under suction and horizontal discharge. Because single suction and volute casing, this type has a merit for clogging. Thrust force for lower direction is generated. Motor is installed on the pump casing.		Since the impeller is always submerged in the water, pump starting can be carried out easily. However, also electric motor is in the water, this type has a demerit for water leakage into the motor and deteriorating of insulation.	
SPACE OF PUMP ROOM	×	Dry-pit for installation of equipment is necessary. Also, wide space is necessary because horizontal pump, valves, pipes, etc. shall install same floor.	△	Dry-pit for installation of equipment is necessary. However, it will be narrow compare with Plan 1 because motor is installed on the pump.	O	Dry-pit is not necessary because pump is installed in the suction pit.
HEIGHT OF PUMP ROOM	O	Height of pump room is low because horizontal pump.	△	Height of pump room shall be considered for maintenance of vertical motor.	O	Out-door type can be applied.
LOAD FOR PUMP FLOOR	O	Pump weight is light and equipment load is supported by wide floor area.	△	Total weight for pump and motor is supported by pump floor. If distance between ground level and suction water level is high, separate floor for electric motor is necessary.	O	Weight of submersible pump is light. Also, load for bottom pit is light.
EASINESS FOR INSTALLATION	O	Installation of equipment such as shaft alignment is easy because pump, motor, valves, pipings are installed horizontally.	△	The installation requires well trained technicians with special pump installation skills for leveling and shaft alignment.	O	The installation is the easiest among those three.

DURABILITY	O	Longer device life, comparing with submergible pumps, can be expected because the motor unit is free from suction water contact. By employing some anti-erosion and or non-metal materials, the pump life can be enhanced.	O	Same as left.	×	A long life span cannot be expected. Submergible pumps are generally used for short-time or temporally stations. Leakage may occur because motor unit and pump itself are always in the suction water.
		HORIZONTAL, SCREW TYPE (Plan 1)		VERTICAL, VOLUTE TYPE (Plan 2)		SUBMERSIBLE, SCREW TYPE(Plan 3)
RELIABILITY	Δ	If the periodically check and maintenance are carried out, long life operation and higher reliability are expected.	O	Same as left.	×	Because of possible leakage into the motor unit due to the temperature changes caused by intermittent operation, it has the lowest reliability.
WATER HAMMER PROTECTION	O	Because of horizontal pump, flywheel as a water hammer protection can be applied. In this case, flywheel has a merit for maintenance free and high reliability.	Δ	Because of vertical pump, flywheel as a water hammer protection can not be applied. Other method such as surge tank or air chamber shall be applied. Air valves which are installed in the pipeline can not be recommended because foreign materials are included in the sewerage water.	Δ	Generally, flywheel can not be applied for submersible pump. However, it can be applied for special pump as a option.
CLOGGING	O	Screw impeller has a merit for clogging.	Δ	This pump has a volute casing, if foreign materials are passed in the impeller it will not be clogged in the casing.	O	Screw impeller or vortex type impeller has a merit for clogging.
MAINTENANCE	O	Operating condition can be checked directly because all the rotating components, including the motor, are above the water.	Δ	When disassembling of the pump, vertical motor shall be dismantled. Also, special skills for leveling and shaft alignment are necessary.	Δ	Operating condition cannot be checked directly because all the components, including the motor, are submerged in water.
OPERATION METHOD	Δ	If suction water level is higher than center of pump, pump can be easily started because impeller is always submerged in the water.	Δ	Same as left.	O	Pump can be easily started because impeller is always submerged in the water.
RECORDS FOR SAME PROJECT	O	For the small capacity this type of pump is used for many cases of sewerage purpose. Because this pump is expected for non-clogging.	Δ	For the large capacity this type of pump is used for many cases of sewerage purpose. Because this pump is expected for non-clogging. However, in case of small capacity, there is no merit.	Δ	Same as left.
FACILITIES COST	O	Horizontal pump and motor are not expensive compare with vertical one.	Δ	Most expensive among three types.	O	Standard submersible pump is not expensive. However, if there is a special requirement such as flywheel, it will be expensive.

CIVIL COST	×	If positive suction method is adopted, quantity of excavation will be large and pump floor area is wide. Accordingly, civil cost is most expensive among three plans.	△	Middle cost among three plans.	O	Quantity of excavation is most small because there is not dry pit. Accordingly, civil cost is cheapest.
RUNNING COST	△	Low pump efficiency compare with plan 2.	O	Highest pump efficiency among three plans.	×	Lowest pump efficiency among three plans.

TABLE F.3 P1(1-2-3A/B)、P2(UNIWAX) PUMPING STATION

	HORIZONTAL, SCREW TYPE		VERTICAL, VOLUTE TYPE		SUBMERSIBLE, SCREW TYPE	
RESULT	◎	MOST RECOMMENDED	O	NOT STRONGLY RECOMMENDED	△	NOT RECOMMENDED
REASON FOR SELECTION	If positive suction method is adopted, civil cost will be expensive. However, this pump has a merit for durability, reliability, non-clogging, water hammer protection (flywheel can be adopted), etc. compare with other plans. Accordingly, this pump is most recommendable in consideration of total judgement.		Initial cost is expensive, however, in case that running cost, durability and reliability are considered as first priority, this pump should be considered for comparison. However, when this pump is adopted in sewerage purpose, large pump bore (ex. over ϕ500) is necessary because of clogging of materials.		Pump station P1: as a water hammer protection, flywheel is necessary. However, there is no submersible pump with flywheel in this rating. Pump station P2: flywheel is not necessary, so that submersible pump can be applied. However, capacity of this pumping station is large and this pumping station is important. Accordingly, submersible pump can not be recommended because of its low durability and reliability.	

TABLE F.4 P3(21-22)、P4(25-26-27) AND 33-34 PUMPING STATION

	HORIZONTAL, SCREW TYPE		VERTICAL, VOLUTE TYPE		SUBMERSIBLE, SCREW TYPE	
RESULT	O	NOT STRONGLY RECOMMENDED	△	NOT RECOMMENDED	◎	MOST RECOMMENDED
REASON FOR SELECTION	In case that durability and reliability are considered as first priority, this pump should be considered for comparison. However, initial cost such as facilities and civil is expensive. Accordingly, pump type should be selected in consideration of total budget.		Since total capacity is too small, this pump can not be recommended as a sewerage pump.		In this pumping station, total capacity is small and submersible pump with flywheel is adopted. Accordingly, submersible pump is low durability and reliability, however, initial cost including facilities and civil cost is cheapest among three. So that this pump is most recommendable.	

TABLE F.5 NUMBER OF PUMP FOR SECOUND STAGE IN FUTURE

Pumping Station	33-34・35-36 basin	21-22 basin	25-26-27 basin	1-2-3A/B basin	UNIWAX basin
Peak Flow	4.68 m^3/min	7.08 m^3/min	6.24 m^3/min	13.98 m^3/min	32.22 m^3/min
No. of Pump unit	Qp= 1 / 2 Q 3 units (standby 1 unit)			Qp= 1 / 3 Q 4 units (standby 1 unit)	
Suction bore	150 mm	200 mm	200 mm	200 mm	300 mm

TABLE F.6 NUMBER OF PUMP FOR FIRST STAGE IN 2003

Pumping Station	33-34 basin	21-22 basin	25-26-27 basin	1-2-3A/B basin	UNIWAX basin
Peak Flow	1.62m^3/min	7.08 m^3/min	6.24 m^3/min	8.39 m^3/min	19.33 m^3/min
No. of Pump unit	Q_p=Q 1 units (standby 1 unit)	Q_p= 1 /2Q 3 units (standby 1 unit)		Q_p= 1 /2Q 3 units (standby 1 unit)	
Suction bore	100 mm	200 mm	200 mm	200 mm	300 mm

The suction bore of the pump is calculated by the equation below.

$$D = 146\,(Q / V)^{0.5}$$

Where, D: suction bore (mm).

Q: discharge flow of pump (/ min).

V: velocity: 2.0 ~ 2.5 m /sec on the suction side

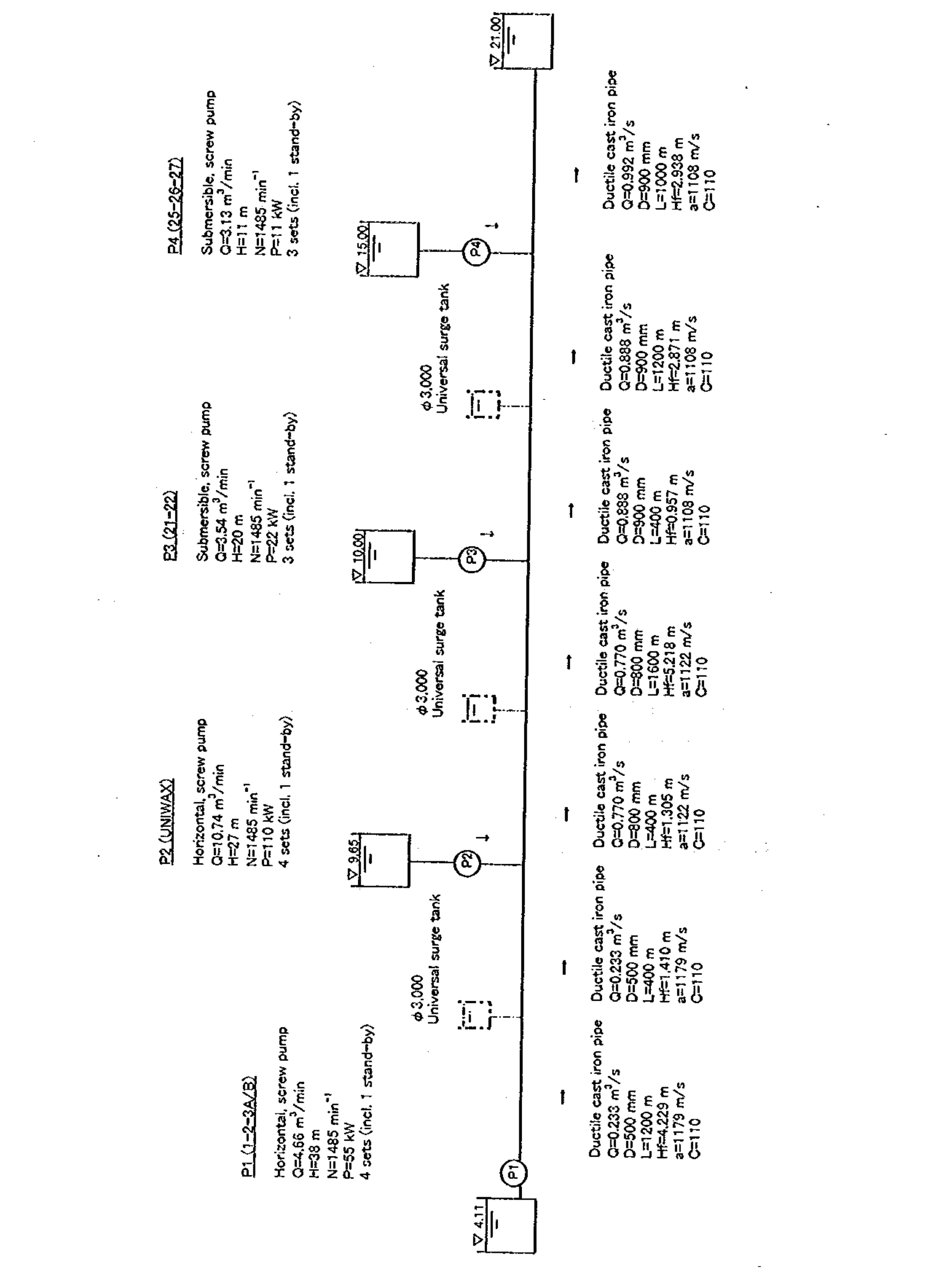


FIG. F.1	PIPELINE DIAGRAM

THE FEASIBILITY STUDY ON SEWERAGE FACILITIES IN WESTERN DISTRICT OF ABIDJAN CITY IN THE REPUBLIC OF COTE D'IVOIRE

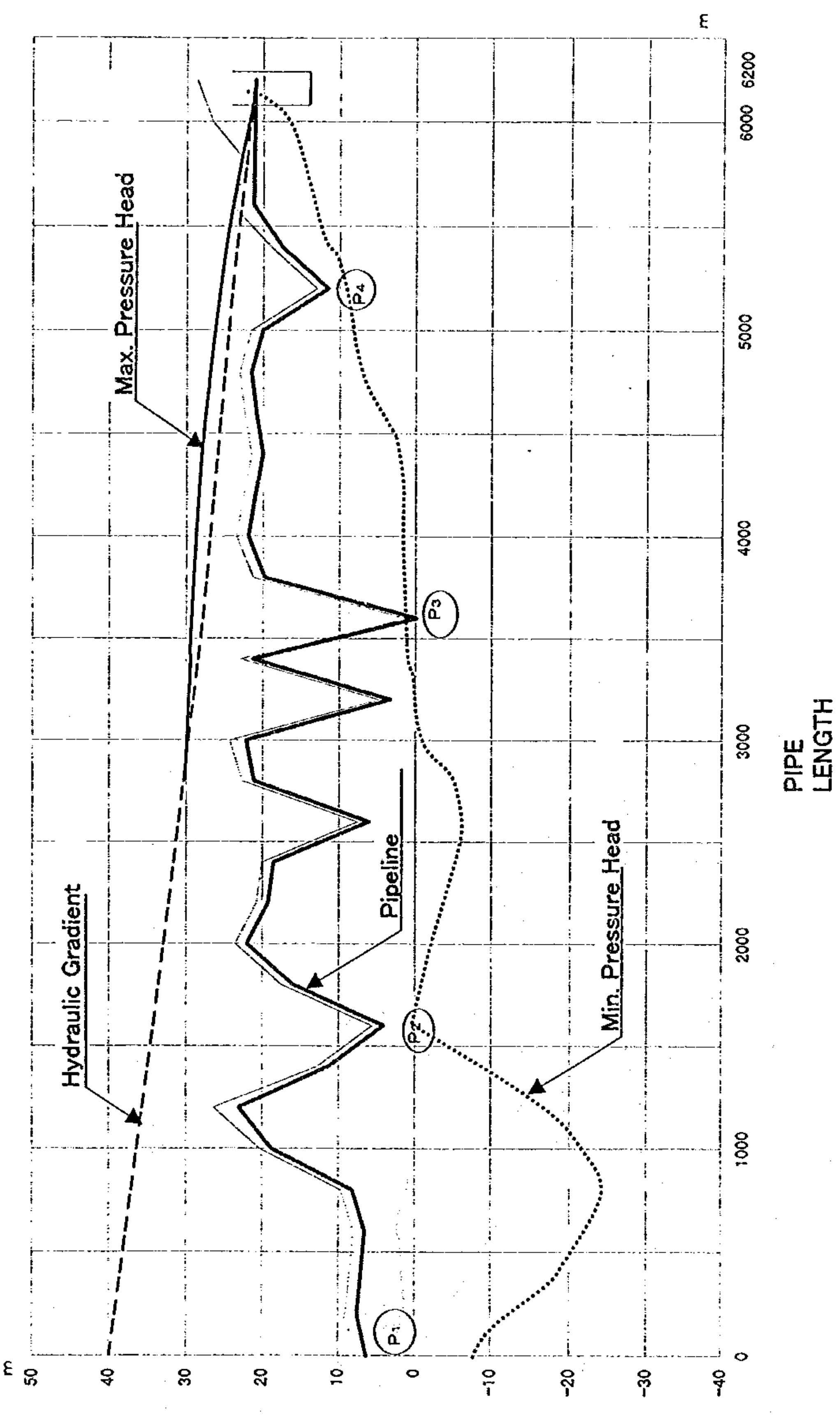


FIG. F.2	MAX. AND MIN. HEAD LINE UNDER WATER HAMMER PHENOMENON —CASE 1—

THE FEASIBILITY STUDY ON SEWERAGE FACILITIES IN WESTERN DISTRICT OF ABIDJAN CITY IN THE REPUBLIC OF COTE D'IVOIRE

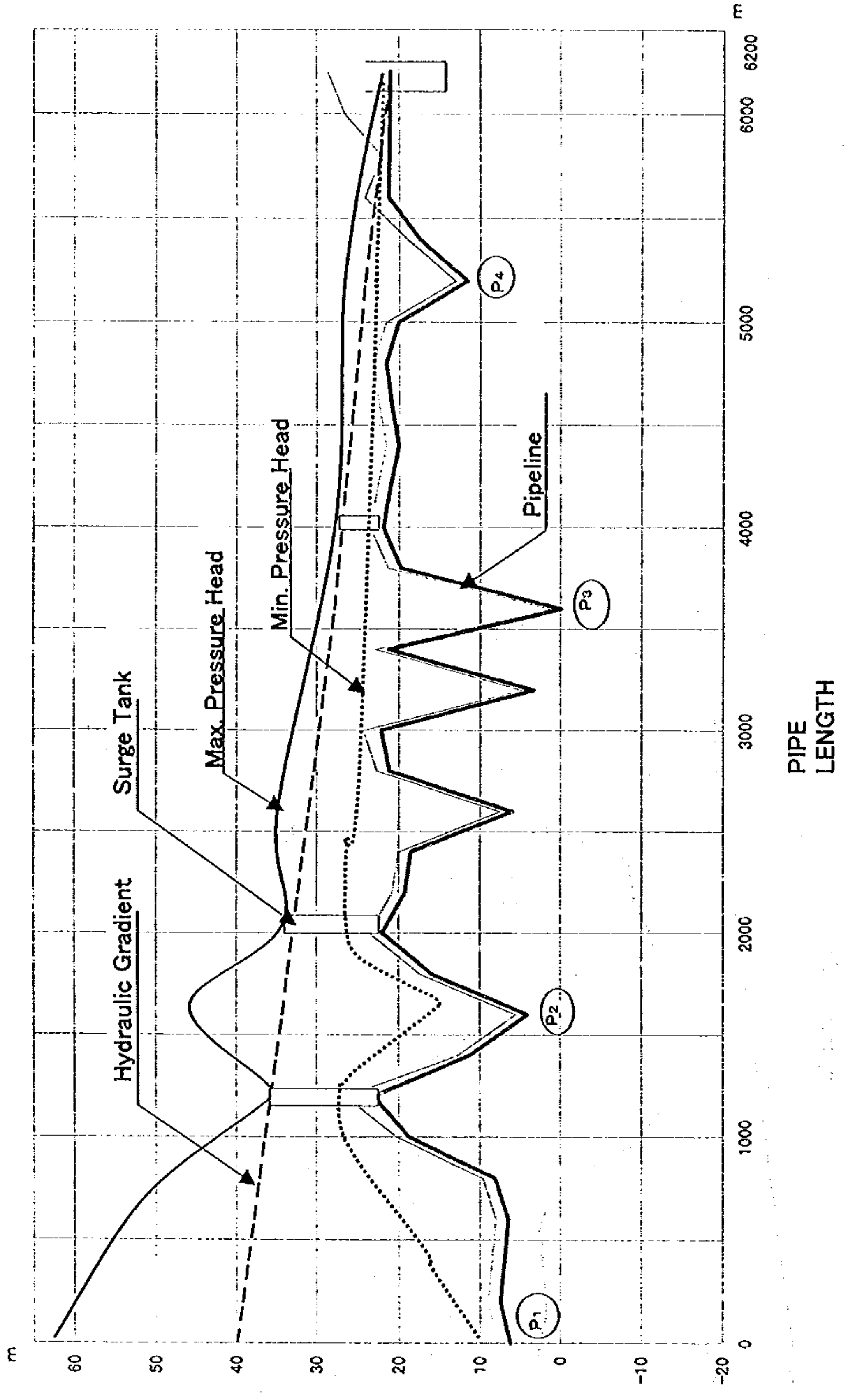


FIG. F.3	MAX. AND MIN. HEAD LINE UNDER WATER HAMMER PHENOMENON —CASE 2—

THE FEASIBILITY STUDY ON SEWERAGE FACILITIES IN WESTERN DISTRICT OF ABIDJAN CITY IN THE REPUBLIC OF COTE D'IVOIRE

JICA

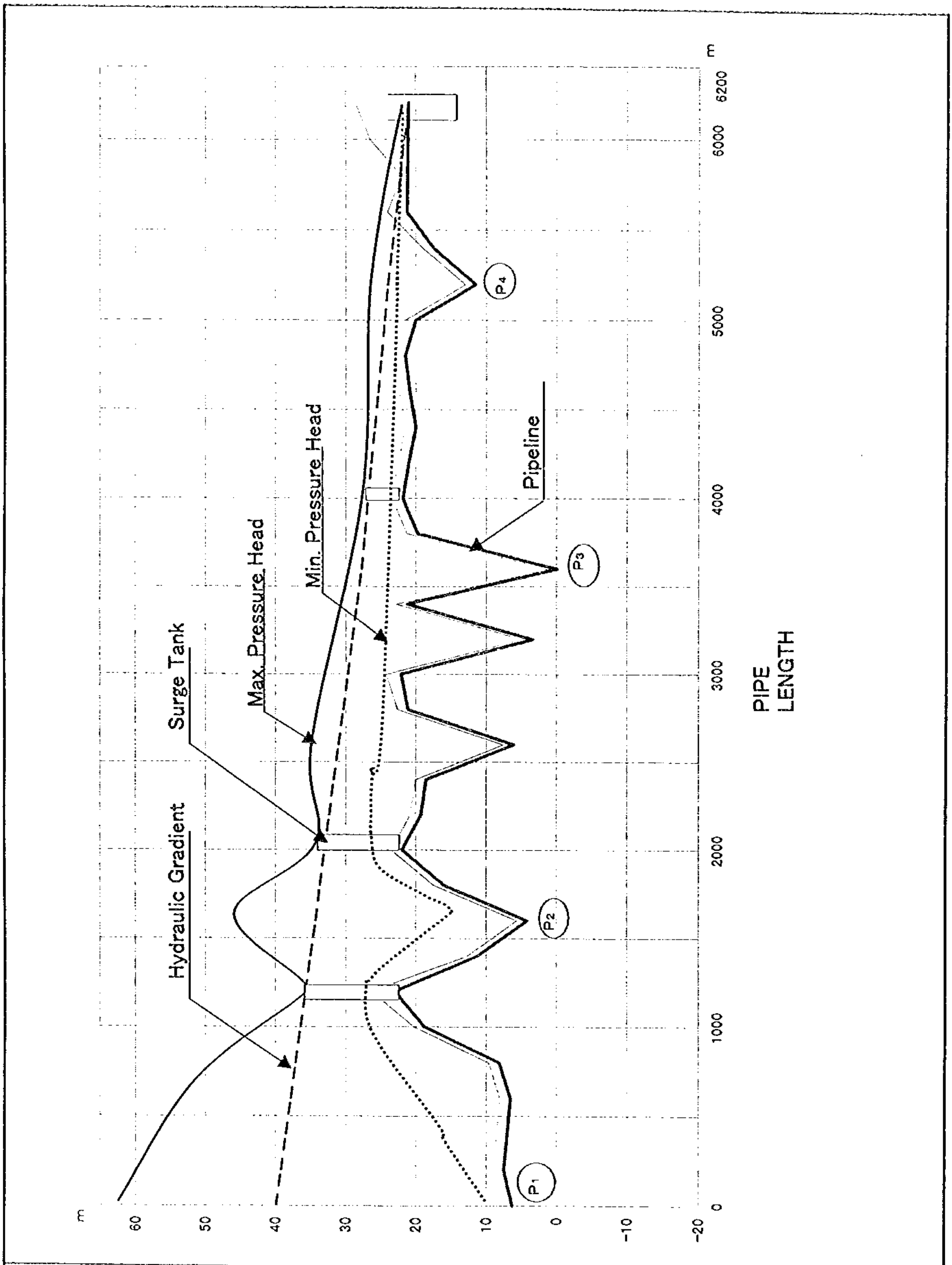


FIG. F.3	MAX. AND MIN. HEAD LINE UNDER WATER HAMMER PHENOMENON —CASE 2—

THE FEASIBILITY STUDY ON SEWERAGE FACILITIES IN WESTERN DISTRICT OF ABIDJAN CITY IN THE REPUBLIC OF COTE D'IVOIRE

JICA

APPENDIX G

COST ESTIMATE

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1. Current Situation of Construction Cost

The inquiry for the basic construction cost (materials, equipment and labour) was conducted by visiting the main construction companies and suppliers in Abidjan in June and July 1999 (refer to Table G.1). The current situation on the procurement of construction materials and labour and the mobilization of construction equipment were also investigated through those inquiries.

The following are the situation of the procurement of construction materials, labour and equipment in the Abidjan area.

1.1 Construction Materials

Among the basic materials for construction, only cement and coarse/fine aggregate for concrete are manufactured and provided domestically to the market. There are several manufacturing companies in Abidjan that produce concrete tubes/pipes, steel tubes/pipes and tanks and provide those products for construction works.

SIBM (Société Ivoirienne de Béton Manufacturé) is a manufacturing company of pre-cast concrete products such as tubes, pipes, poles, blocks and so on. In the line-up of the products, there appeared a large variety of RC (reinforced concrete) pipes to be used for the construction works of water supply and/or sewerage system.

The company has the experience to provide the RC pipes to be used in Jacking Method. Those products are manufactured in accordance with Norme Française and the prices (including VAT 20%) are seen as half of the similar products in the Japanese Market. It is advised that the prices of products are stable after the devaluation of CFA franc in January 1994.

Steel construction materials in the market are imported products mainly from Europe. It was informed that the sewer pipes of steel or iron products from middle to large diameter (nominal diameter is 900 mm and above) are imported mainly from France. Then, the prices of steel products seemed rather higher compared with that of the current Japanese market.

Table G.2, (1) and (2) show the prices of miscellaneous construction materials. STCA (Société de Tuyauterie Chaudronnerie d'Abidjan) is a manufacturing company of steel tubes, steel tanks and miscellaneous steel-processed products. The company also deals in installation of those products, and a department of this company (Travaux sous Marins) carried out the construction of lagoon crossing of sewerage (Marcory – Brocosso) as the sub-contractor of SONITRA.

1.2 Construction Equipment

The unit prices of construction equipment informed from the construction companies in Abidjan are shown in Table G.3. Those are from two to five times higher than that of current market prices in Japan. All the construction equipment, vehicles and machines in this country are imported from the European countries, the United States and Japan and the market does not seem to have the wide range line-up of equipment.

Therefore, the construction cost in this market has a tendency that the work depending its major portion on mechanical execution becomes much higher than manual execution.

There are a few companies that deal with the leasing business of construction equipment in Abidjan (THINET, LOCATP, SIMPO, etc.).

1.3 Labor Conditions and Cost

The Ivorian labor market seemed to be segmented. Unskilled and day labour is readily available, while clerical, technical, managerial, and professional talent is more difficult to find.

By regional standards, Cote d'Ivoire has a highly-trained and highly-capable work force and the government has traditionally encouraged the hiring of Ivorian nationals. Wage rates are relatively high by regional standards, but costs of capital goods, transport, and energy are also high; it is therefore not obvious that high labor costs provoke overspending on labor-saving technology.

The unit prices of construction labours informed from the construction companies in Abidjan are shown in Table G.4. Those are rather lower than that of the developed countries.

The following are the institutional conditions of labour in Côte d'Ivoire.

Working hours:		40 hours a week
Allowance for overtime:	weekdays:	15% increase for 5:00～21:00;
		75% increase for 21:00～5:00
	holidays:	75% increase for 5:00～21:00;
		100% increase for 21:00～5:00
Guaranteed minimum monthly wage:		29,000 FCFA (about USD 58; 1996)

Average monthly wages

Unskilled worker:	29,000 F/CFA (about USD 58)
Semi-skilled worker:	48,500 F/CFA (about USD 105)
Skilled worker:	50,000–63,000 F/CFA (about USD 108 - 136)
Bilingual Skilled Office Worker:	750,000 F/CFA (about USD 1500)
Typist:	45,000-54,000 F/CFA (about USD 90-108)
Bilingual Receptionist:	330,000 F/CFA (about USD 660)
Secretary:	64,000 F/CFA (about USD 128)

Public Holidays

New Year's Day	January 1
End of Ramadan	March
Easter Monday	March - April
Labor Day (Fête du Travail)	May 1
Ascension Day (Fête de l'Ascension)	May

Tabaski	May
Pentecost Monday	June
Independence Day (Fête Nationale)	August 7
Assumption Day (Assomption)	August 15
Prophet Mohammed's Birthday	August
All Saint's Day (Toussaint)	November 1
National Peace Day	November 15
Commemoration du Décès F. Houphouet Boigny	December 7
Christmas (Noël)	December 25

2. Basis of Cost Estimate

2.1 Unit Price of Labor, Material and Equipment

Unit price of each element such as labour, major material and major equipment were determined on the basis of the data collected in the field investigation in June and July 1999. The social and market conditions of Abidjan are to be taken into account to determine the unit cost of each construction work.

2.2 Basic Cost of the Works

The basic costs of the construction works are obtained by accumulating labor cost, material cost, equipment cost for the assumed typical and conceptual design. Cost of general temporary works (20% of accumulated direct cost of each construction work) and indirect cost (30% of the summation of the cost of direct construction works and general temporary works) which consists of overhead expenses, profit and so on are to be added.

The construction methods, equipment and labors, proceeding speed of the works are applied in accordance with STANDARDS FOR COST ESTIMATIONS OF PUBLIC WORKS (Ministry of Construction in Japan, 1999).

2.3 Procurement of Sewer Pipes

Three kinds of sewer pipes are assumed to be used in the conceptual design stage, i.e., ductile cast-iron (DCI) pipes, reinforced concrete (RC) pipes and steel pipes.

DCI pipes are unique goods that have only a few manufacturers in the world. The procurement of DCI pipe is, therefore, assumed as importation from Europe. Unit price of DCI pipe is based on the market price of FOB at UK port and was adjusted considering customs, insurance and freight and transportation cost inside Abidjan.

In case of RC pipes there is a few reputed manufacturers, such as SIBM, in Abidjan. RC pipes are to be procured at lower prices in Abidjan as domestic products of Côte d'Ivoire.

Import of steel pipe products from foreign countries was considered costing and uneconomical. The possibility of domestic procurement of steel pipes has been sought for. There are a few manufacturers of steel tubes, pipes and/or tanks, such as STCA and SOTACI, and those companies in Abidjan have technology and capabilities of processing (bending, welding) of steel sheet to form steel pipes.

Steel sheet may be imported from European countries economically, and combining this with the technology of Ivorian manufacturers and the process of inner coating of steel pipes by mortar, the necessary quantity of steel sewer pipes can be provided domestically.

The cost estimation here assumes the above-mentioned conditions of procurement.

2.4 Procurement of Pump Equipment

The procurement of Pump Equipment are assumed as import from Japan at this stage but not limited to this method.

Unit cost of Pump Equipment for pumping station includes costs of design, manufacturing in factory in Japan, workshop test, spare parts, cost of delivery and installation, based on the FOB Tokyo prices and is to be adjusted considering customs, insurance and freight.

2.5 Capability of Local Construction Companies

Three stages of construction projects of sewerage facilities had been implemented in the past 24 years in Abidjan and several of the local construction companies engaged in the projects as a main contractor and/or sub-contractors. Therefore those companies in the region have experience with equipment and key staff to carry out the construction works at the acceptable level.

Although a significant labour force will be needed when the construction starts, there would be no serious difficulty in finding common labor. But skilled labour, foremen and construction supervisors at various levels could pose some difficulty in their availability.

The project of sewerage facilities often involves the construction works of large-scale, such as pumping stations, and/or of complicated method and equipment, such as tunneling under existing urban structures using of jacking method, to require skills and experience of the contractors. For such important portion of construction works would require experienced foreign contractor, dispatch of expatriate engineers and/or instruction of them.

3. Estimate of Construction Cost for Planned Facilities

After the preliminary design of the proposed facilities and equipment is prepared based upon the topographic and geographic survey, the quantities of works of such designed facilities and equipment are estimated.

The construction costs of all the works and facilities are estimated and divided into the local currency portion and the foreign currency portion depending on the components of materials or works.

The local currency portion is the estimated cost of the materials, equipment, labor and products that are available to be procured domestically in Côte d'Ivoire. The foreign currency portion is the estimated cost of the imported materials and services such as steel products, DCI pipes, use of imported construction equipment and/or employment of expatriate engineers.

Considering the above aspects for each component of works, the proportion of the local currency and foreign currency was introduced to the unit prices in the breakdown of cost estimation.

4. Operation and Maintenance (O&M) Costs

Operation and maintenance for this project are composed of sewer pipeline, and pumping stations.

Pumping stations are composed of electricity, repairing costs and personnel expenses. And that of sewer pipeline is composed of repairing costs, daily inspection, cleaning works and personnel expenses. The frequency of these works are assuming that it will be inspected twice a year and to be cleaned at least every two years by use of thrusting rods and minor repair of the equipment.

The annual O&M costs of the sewerage system is shown in Table G.5.

4.1 Pumping Station

O/M costs of the pumping stations are composed of electricity, repairing costs and personnel expenses. The method of costs estimate are as follows.

Electricity ;

Cost (FCFA/Year) = {Motor Output x 0.8 x 24 hr/d x 30 d x 38.2 FCFA
+ (68,000 FCFA + 311,404 FCFA)} x 12

Repairing Cost ;

Cost (FCFA/Year) = Construction Cost x 0.5 %
= 3,335,000,000 x 0.005
= 16,675,000FCFA

Required electricity cost of pumping stations is in shown in Table G.6.

4.2 Sewer Pipeline

It is assuming that the daily inspection and cleaning works of pipeline will be carried out twice per year and once every two years, respectively. The daily inspection is estimated 400 m/day by two to three (2-3) crews in each team. The cleaning works is estimated 200 m/day by three to four (3-4) crews in each team.

For the daily inspection and cleaning of the sewer pipeline, required costs of working cars, trucks, fuels and repairs of them are as follows.

M = 900 FCFA / m-pipeline (See Table G.7)

where:

M : unit maintenance cost of pipeline
(except the personnel expenses and repairing costs)

Repairing Cost ;

Cost (FCFA) = construction Cost x 0.5%
= 9,740,965,000 x 0.005
= 48,705,000 FCFA

Detailed annual operation and maintenance costs are shown in Table G.8.

TABLE G.1 LIST OF THE COMPANIES VISITED FOR PRICE INQUIRIES IN ABIDJAN

ICI
Ingenieurs Conseils en Infrastructure
13, Rue Paris Village, Abidjan-Plateau, 01 BP. 8466

A consultants company of civil engineering and public works.

COLAS – CI
COLAS Côte d'Ivoire
Rue du Chevalier de Clieu (Zone 4C) – 01 BP. 1082

A construction company of civil engineering and public works, and a member company of the Bouygue Group with SODECI and SEATO. The company has its fortes in the fields of construction of road and/or sewerage facility.

FRANZETTI
01 BP. 1724 Abidjan 01

A construction company of civil engineering and public works established in 1953, and a member company of the SADE Group. The company has its fortes especially in the fields of construction of water supply and/or sewerage facility.

SIBM
Société Ivoirienne de Béton Manufacturé
12 Rue Thomas Edison – 01 BP. 902 Abidjan 01

A manufacturing company of pre-cast concrete products such as tubes, pipes, poles, blocks and so on.

STCA
Société de Tuyauterie Chaudronnerie d'Abidjan
Rue des Alizes, Bietry – 01 BP. 1912 Abidjan 01

A manufacturing company of steel tubes, steel tanks and miscellaneous steel-processed products. The company deals in installation of those products, and a department of this company (Travaux sous Marins) carried out the construction of lagoon crossing of sewerage (Marcory – Brocosso) as the sub-contractor of SONITRA.

FLUTEC Brossette
Zone 4A Boulevard Valéry Giscard d'Estaing, 01 BP 1593 Abidjan 01

A supplier company of construction materials.

SONITRA (Société Nationale Ivoirienne de Travaux) -- 01 BP. 2609 Abidjan 01

SOTACI
Yopougon – 01 BP 2747 Abidjan 01

SIPEL
Rue Dr Fleming, Zone 4 C, 11 BP 30 Abidjan 11

SOTRA Dragage
01 BP 1237 Abidjan 01

SOTELCO
01 BP 6824 Abidjan 01

TABLE G.2 COST INVESTIGATION (MATERIAL 1/2; June 1999)

* J Yen : CFA F = 1: 0.20

No.	Item	Description	Unit	Price (CFA F)	Price (J Yen)	Remarks
1	PVC Pipe DN110 mm	t=3.0 mm	m	3,310	662	FLUTEC Brossette
2	PVC Pipe DN125 mm	t=3.0 mm	m	3,780	756	FLUTEC Brossette
3	PVC Pipe DN160 mm	t=3.2 mm	m	5,230	1,046	FLUTEC Brossette
4	ditto	t=3.5 mm	m	5,680	1,136	FLUTEC Brossette
5	PVC Pipe DN200 mm	t=3.9 mm	m	7,860	1,572	FLUTEC Brossette
6	ditto	t=4.7 mm	m	9,400	1,880	FLUTEC Brossette
7	PVC Pipe DN250 mm	t=4.9 mm	m	12,280	2,456	FLUTEC Brossette
8	ditto	t=6.1 mm	m	15,270	3,054	FLUTEC Brossette
9	PVC Pipe DN315 mm	t=6.2 mm	m	19,650	3,930	FLUTEC Brossette
10	ditto	t=7.7 mm	m	24,130	4,826	FLUTEC Brossette
11	PVC Pipe DN400 mm	t=7.8 mm	m	31,170	6,234	FLUTEC Brossette
12	ditto	t=9.8 mm	m	38,860	7,772	FLUTEC Brossette
13	Centrifugal RC Pipe					
	DN 800 mm	L=4.0 m, 60A	no	157,988	31,598	SIBM
14	ditto	L=4.0 m, 90A	no	177,046	35,409	SIBM
15	ditto	L=4.0 m, 135A	no	194,824	38,965	SIBM
16	Centrifugal RC Pipe					
	DN 1000 mm	L=2.5 m, 60A	no	163,501	32,700	SIBM
17	ditto	L=2.5 m, 90A	no	173,704	34,741	SIBM
18	ditto	L=2.5 m, 135A	no	188,178	37,636	SIBM
19	Centrifugal RC Pipe					
	DN 1200 mm	L=2.5 m, 60A	no	225,505	45,101	SIBM
20	ditto	L=2.5 m, 90A	no	242,122	48,424	SIBM
21	ditto	L=2.5 m, 135A	no	264,707	52,941	SIBM
22	Centrifugal RC Pipe					
	DN 1400 mm	L=2.5 m, 60A	no	336,833	67,367	SIBM
23	ditto	L=2.5 m, 90A	no	357,534	71,507	SIBM
24	ditto	L=2.5 m, 135A	no	415,706	83,141	SIBM
25	Ductile Cast-Iron Pipe	DN 600 mm	m	96,942	19,388	FOB at UK Port
26	ditto	DN 800 mm	m	114,050	22,810	FOB at UK Port
27	ditto	DN 900 mm	m	136,364	27,273	FOB at UK Port
28	ditto	DN 1000 mm	m	170,455	34,091	FOB at UK Port
29	ditto	DN 1100 mm	m	202,922	40,584	FOB at UK Port
30	ditto	DN 1200 mm	m	241,574	48,315	FOB at UK Port
31	Ready-mixed Concrete	350 kg/cm2	m3	63,000	12,600	SN SATCI
32	ditto	250 kg/cm2	m3	57,000	11,400	SN SATCI
33	Mortar for Pipe Coating		m3	300,000	60,000	by hearing
34	Cement		ton	49,000	9,800	COLAS
	Cement		ton	54,000	10,800	SOTELCO
35	Portland Cement		ton	52,000	10,400	FRANZETTI
36	Sand		ton	2,500	500	COLAS
37	Sand for Filling	d=0 - 5 mm	m3	2,500	500	SOTELCO
	ditto	ditto	m3	11,400	2,280	FRANZETTI
38	Transportation of Sand		ton*km	300 - 500	60 - 100	COLAS
39	Aggregate		ton	7,800	1,560	COLAS
37	Coarse Aggregate		ton	7,200	1,440	SOTELCO
	Coarse Aggregate		ton	13,920	2,784	FRANZETTI
38	Fine Aggregate		ton	8,000	1,600	SOTELCO
	Fine Aggregate		ton	16,160	3,232	FRANZETTI

TABLE G.2 COST INVESTIGATION (MATERIAL 2/2; June 1999)

* J Yen : CFA F = 1: 0.20

No.	Item	Description	Unit	Price (CFA F)	Price (J Yen)	Remarks
39	Ready-mixed Concrete	300 kg/cm2	m3	45,000	9,000	FRANZETTI
	ditto	250 kg/cm2	m3	43,000	8,600	FRANZETTI
	ditto	180 kg/cm2	m3	40,000	8,000	FRANZETTI
	ditto	120 kg/cm2	m3	37,500	7,500	FRANZETTI
40	Gravel for Filling	d=5 - 25 mm	m3	10,200	2,040	SOTELCO
41	ditto	d=25 - 100 mm	m3	8,500	1,700	SOTELCO
42	ditto	d=100 - 300 mm	m3			
43	Gravel for Filling	d=5 - 25 mm	m3	14,800	2,960	FRANZETTI
	ditto	d=25 - 100 mm	m3	12,320	2,464	FRANZETTI
	ditto	d=100 - 300 mm	m3	12,000	2,400	FRANZETTI
44	Stone for Pitching		m3	14,000	2,800	COLAS
45	Structural Steel		ton	235,000	47,000	COLAS
46	Steel Sheet Pile		ton	345,000	69,000	SOTELCO
	Steel Sheet Pile		ton	300,000	60,000	FRANZETTI
47	As-Con Hot Mix		ton	70,000	14,000	FRANZETTI
48	Reinforcing Bar	Deformed Bar: 6mm	ton	290,000	58,000	Bernabe CI
49	ditto	D8 - D16	ton	260,000	52,000	Bernabe CI
50	ditto	D20 - D32	ton	300,000	60,000	Bernabe CI
51	Deformed Reinforcing Bar		ton	450,000	90,000	FRANZETTI
51	Form Material	t=15 mm	m2	5,400	1,080	SOTELCO
52	ditto	t=12 mm	m2	4,000	800	SOTELCO
53	Form Material	t=15 mm	m2	7,500	1,500	FRANZETTI
54	ditto	t=12 mm	m2	6,500	1,300	FRANZETTI

TABLE G.3 COST INVESTIGATION (EQUIPMENT; June 1999)

* Unit Prices include fuel and operator, and do not include governmental taxes.
** J Yen : CFA F = 1: 0.20

No.	Item	Description	Unit	Price (CFA F)	Price (J Yen)	Remarks
1	Bulldozer (Ripper)	32 ton	hour	96,038	19,208	COLAS
2	Bulldozer	21 ton	hour	76,248	15,250	COLAS
3	Bulldozer	15 ton	hour	58,805	11,761	COLAS
	Bulldozer	11 ton	day	400,000	80,000	FRANZETTI
4	Wheel Loader	2 m3 Bukket	hour	65,699	13,140	COLAS
	Wheel Loader	CAT 950	day	350,000	70,000	FRANZETTI
5	Excavator	1.0 m3	day	450,000	90,000	FRANZETTI
6	Backhoe	0.9 m3	day	375,000	75,000	FRANZETTI
7	Backhoe	0.6 m3	day	300,000	60,000	FRANZETTI
	Backhoe	0.6 m3	hour	49,623	9,925	COLAS
8	Backhoe	0.4 m3	hour	41,936	8,387	COLAS
9	Dump Truck	10 ton	day	226,338	45,268	COLAS
	Dump Truck	12 m3	day	200,000	40,000	FRANZETTI
10	Flat Body Truck	20 ton	day	250,000	50,000	FRANZETTI
11	Vibration Roller	10 ton	hour	65,720	13,144	COLAS
12	Vibration Roller	4 ton	hour	44,558	8,912	COLAS
13	Hydraulic Crawler Crane	35 ton	hour	98,665	19,733	COLAS
	Hydraulic Crawler Crane	35 ton	day	450,000	90,000	FRANZETTI
14	Hydraulic Crawler Crane	50 - 60 ton	day	650,000	130,000	FRANZETTI
15	Hydraulic Crawler Crane	80 ton	day	800,000	160,000	FRANZETTI
16	Hydraulic Crane	20 ton	hour	144,295	28,859	COLAS
17	Hydraulic Crane	15 ton	hour	116,267	23,253	COLAS
18	Hydraulic Crane	5 ton	hour	73,316	14,663	COLAS
19	Truck with Crane	4 ton	day	273,239	54,648	COLAS
20	Hydraulic Truck Crane	25 ton	day	350,000	70,000	FRANZETTI
21	Engine Cutter	for steel	day	136,364	27,273	by hearing
22	Crawler Drill		hour	83,419	16,684	COLAS
23	Air Compresser	17 m3	day	117,482	23,496	COLAS
24	Air Compresser	5 m3	day	50,036	10,007	COLAS
25	Road Roller	8 - 20 ton	hour	45,200	9,040	COLAS
26	Generator	100 kVA	hour	24,401	4,880	COLAS
27	Generator	150 kVA	day	250,000	50,000	FRANZETTI
28	Generator	200 kVA	hour	41,801	8,360	COLAS
	Generator	200 kVA	day	300,000	60,000	FRANZETTI
29	Motor Grader	Blade = 3.1 m	hour	46,505	9,301	COLAS
30	Tyre Roller	10 - 12 ton	hour	71,120	14,224	COLAS
31	Pick-up	Utility Car	day	82,194	16,439	COLAS
32	Concrete Batching Plant	10 m3/hour				
	Mobilization and Demob		l. s.	5,000,000	1,000,000	FRANZETTI
	Daily Rental Charge		day	75,000	15,000	FRANZETTI
	Operation Cost		day	80,000	16,000	FRANZETTI
33	Plant Mobilization	30 ton Trailer	trip	200,000	40,000	COLAS
	Concrete Truck Mixer	5 m3	day	300,000	60,000	FRANZETTI
	Concrete Mixer	0.7 m3	day	45,000	9,000	FRANZETTI
34	Water Pump	5 m3/min	day	25,000	5,000	FRANZETTI
35	Testing Equipment	Water Pressure	unit	4,500,000	900,000	by hearing
36	Undestructive Test	Welding	m	318	64	by hearing

TABLE G.4 COST INVESTIGATION (LABOR; June 1999)

* J Yen : CFA F = 1: 0.20

No.	Item	Description	Unit	Price (CFA F)	Price (J Yen)	Remarks
1	Foreman		hour	1,190	238	COLAS
	Foreman		day	15,000	3,000	FRANZETTI
	Foreman		day	25,000	5,000	SIPEL
2	Skilled Labour		hour	910	182	COLAS
	Skilled Labour		day	6,000	1,200	FRANZETTI
	Skilled Labour		day	2,500	500	SIPEL
3	Common Labour		hour	630	126	COLAS
	Common Labour		day	5,000	1,000	FRANZETTI
	Common Labour		day	2,000	400	SIPEL
4	Operator	Heavy Equipment	hour	1,050	210	COLAS
5	Operator	Light Equipment	hour	1,050	210	COLAS
6	Driver	Heavy Equipment	hour	1,050	210	COLAS
7	Driver	Light Equipment	hour	1,050	210	COLAS
8	Driver of Truck		day	8,000	1,600	FRANZETTI
	Driver of Truck		day	15,000	3,000	SIPEL
9	Electrician		hour	1,050	210	COLAS
	Electrician		day	10,000	2,000	FRANZETTI
	Electrician		day	15,000	3,000	SIPEL
10	Mechanic		hour	1,050	210	COLAS
	Mechanic		day	10,000	2,000	FRANZETTI
11	Concrete Worker		hour	910	182	COLAS
12	Steel Fixer		hour	910	182	COLAS
	Steel Fixer		day	8,000	1,600	FRANZETTI
13	Carpenter		hour	910	182	COLAS
	Carpenter		day	8,000	1,600	FRANZETTI
14	Welder		hour	910	182	COLAS
	Welder		day	8,000	1,600	FRANZETTI
15	Masonry		hour	910	182	COLAS
16	Pavement Worker		hour	910	182	COLAS
17	Plumber		hour	910	182	COLAS
18	Plasterer		hour	910	182	COLAS
19	Earth Worker		hour	630	126	COLAS
20	Supervisor (Expatriate)		day	200,000	40,000	FRANZETTI
21	Supervisor (Local)		day	40,000	8,000	FRANZETTI
	Supervisor (Local)		day	35,000	7,000	SIPEL
22	Assistant Engineer	Civil	month	450,000	90,000	COLAS
23	Assistant Engineer	Mechanical	month	450,000	90,000	COLAS
24	Assistant Engineer	Electric	month	450,000	90,000	COLAS
25	Assistant Engineer	Plumbing	month	450,000	90,000	COLAS
26	Surveyor		month	450,000	90,000	COLAS
27	Assistant Surveyor		month	350,000	70,000	COLAS
28	Clerk		month	250,000	50,000	COLAS
29	Store Keeper		month	250,000	50,000	COLAS
30	Secretary		month	350,000	70,000	COLAS
31	Typist		month	150,000	30,000	COLAS
32	Guradsman		month	90,000	18,000	COLAS
33	Yardman		month	90,000	18,000	COLAS

TABLE G.5 SUMMARY OF ANNUAL OPERATION AND MAINTENANCE COSTS

Unit : 1000FCFA

No.	Year	Sewer Pipeline	Punping Station	Personal Expenses	Total O & M Cost
1	2001	0	0	0	0
2	2002	0	0	0	0
3	2003	0	0	0	0
4	2004	62,205	147,000	18,000	227,205
5	2005	62,205	147,000	18,000	227,205
6	2006	62,205	147,000	18,000	227,205
7	2007	62,205	196,000	18,000	276,205
8	2008	62,205	196,000	18,000	276,205
9	2009	62,205	196,000	18,000	276,205
10	2010	62,205	196,000	18,000	276,205
11	2011	62,205	196,000	18,000	276,205
12	2012	62,205	196,000	18,000	276,205
13	2013	62,205	196,000	18,000	276,205
14	2014	62,205	196,000	18,000	276,205
15	2015	62,205	196,000	18,000	276,205
16	2016	62,205	196,000	18,000	276,205
17	2017	62,205	196,000	18,000	276,205
18	2018	62,205	196,000	18,000	276,205
19	2019	62,205	196,000	18,000	276,205
20	2020	62,205	196,000	18,000	276,205
21	2021	62,205	196,000	18,000	276,205
22	2022	62,205	196,000	18,000	276,205
23	2023	62,205	196,000	18,000	276,205
24	2024	62,205	196,000	18,000	276,205
25	2025	62,205	196,000	18,000	276,205

Note 1) Exchange Rate :
2) Cost : as of August 1997.
3) Repairing Cost : Direct Construction Cost x 0.5%/year

TABLE G.6 REQUIRED ELECTRICITY COST OF PUMPING STATIONS

Unit : 1000 FCFA

No.	Year	Electricity Cost					Total
		P1	P2	P3	P4	P5	
1	2001	0	0	0	0	0	0
2	2002	0	0	0	0	0	0
3	2003	0	0	0	0	0	0
4	2004	33,597	62,421	16,171	10,362	7,457	130,228
5	2005	33,597	62,421	16,171	10,362	7,457	130,228
6	2006	33,597	62,421	16,171	10,362	7,457	130,228
7	2007	48,119	91,685	16,171	10,362	10,362	176,699
8	2008	48,119	91,685	16,171	10,362	10,362	176,699
9	2009	48,119	91,685	16,171	10,362	10,362	176,699
10	2010	48,119	91,685	16,171	10,362	10,362	176,699
11	2011	48,119	91,685	16,171	10,362	10,362	176,699
12	2012	48,119	91,685	16,171	10,362	10,362	176,699
13	2013	48,119	91,685	16,171	10,362	10,362	176,699
14	2014	48,119	91,685	16,171	10,362	10,362	176,699
15	2015	48,119	91,685	16,171	10,362	10,362	176,699
16	2016	48,119	91,685	16,171	10,362	10,362	176,699
17	2017	48,119	91,685	16,171	10,362	10,362	176,699
18	2018	48,119	91,685	16,171	10,362	10,362	176,699
19	2019	48,119	91,685	16,171	10,362	10,362	176,699
20	2020	48,119	91,685	16,171	10,362	10,362	176,699
21	2021	48,119	91,685	16,171	10,362	10,362	176,699
22	2022	48,119	91,685	16,171	10,362	10,362	176,699
23	2023	48,119	91,685	16,171	10,362	10,362	176,699
24	2024	48,119	91,685	16,171	10,362	10,362	176,699
25	2025	48,119	91,685	16,171	10,362	10,362	176,699

TABLE G.7 MAINTENANCE COSTS OF SEWER PIPELINE

Unit : 1000 FCFA

Item	Description		Daily Inspection	Cleaning	Total
Car Lease	nos		1	1	
	unit price	(FCFA)	2,000	2,000	
	Sub-Total	(FCFA)	2,000	2,000	4,000
Truck-lease	nos		0	2	
	unit price	(FCFA)	3,500	3,500	
	Sub-Total	(FCFA)	0	7,000	7,000
Fuel	Q' ty		1,040	840	
	unit price	(FCFA)	0.45	0.45	
	Sub-Total	(FCFA)	468	378	846
Repairing Cost		(FCFA)	100	400	500
Total		(FCFA)			12,346

Item	Unit	Total
Pipe Length	(m)	15,000
Unit Maintenance Cost	(FCFA/m)	0.82 ≒ 0.9

Note ;

1) Car Lease Cost = 2,000,000 Yen/0.2Yen/FCFA x 5 Year = 2,000 FCFA/Year
2) Truck Lease Cost = 3,500,000 Yen/0.2 Yen/FCFA x 5 Year = 3,500 FCFA/Year
3) Fuel

   For Daily Inspection = 20 km/d/nos x 260 Day/Year x 1 nos/5 km/liter = 1,040 liter-gasoline

   For Cleean Works = 20 km/d/nos x 70 Day/Year x 3 nos/5 km/liter = 840 Liter-gasoline

TABLE G.8 DETAILED ANNUAL OPERATION AND MAINTENANCE COSTS

Unit = 1000FCFA

No.	Year	Sewer			Pumping Stations (P/S)			Total O & M Cost
		Inspection Cleaning	Repairing	Sub Total	Electricity	Repairing	Sub Total	
1	2001	0	0	0	0	0	0	0
2	2002	0	0	0	0	0	0	0
3	2003	0	0	0	0	0	0	0
4	2004	13,500	48,705	62,205	130,228	16,674	146,902 ≒147,000	209,205
5	2005	13,500	48,705	62,205	130,228	16,674	146,902 ≒147,000	209,205
6	2006	13,500	48,705	62,205	130,228	16,674	146,902 ≒147,000	209,205
7	2007	13,500	48,705	62,205	176,699	19,175	195,874 ≒196,000	258,205
8	2008	13,500	48,705	62,205	176,699	19,175	195,874 ≒196,000	258,205
9	2009	13,500	48,705	62,205	176,699	19,175	195,874 ≒196,000	258,205
10	2010	13,500	48,705	62,205	176,699	19,175	195,874 ≒196,000	258,205
11	2011	13,500	48,705	62,205	176,699	19,175	195,874 ≒196,000	258,205
12	2012	13,500	48,705	62,205	176,699	19,175	195,874 ≒196,000	258,205
13	2013	13,500	48,705	62,205	176,699	19,175	195,874 ≒196,000	258,205
14	2014	13,500	48,705	62,205	176,699	19,175	195,874 ≒196,000	258,205
15	2015	13,500	48,705	62,205	176,699	19,175	195,874 ≒196,000	258,205
16	2016	13,500	48,705	62,205	176,699	19,175	195,874 ≒196,000	258,205
17	2017	13,500	48,705	62,205	176,699	19,175	195,874 ≒196,000	258,205
18	2018	13,500	48,705	62,205	176,699	19,175	195,874 ≒196,000	258,205
19	2019	13,500	48,705	62,205	176,699	19,175	195,874 ≒196,000	258,205
20	2020	13,500	48,705	62,205	176,699	19,175	195,874 ≒196,000	258,205
21	2021	13,500	48,705	62,205	176,699	19,175	195,874 ≒196,000	258,205
22	2022	13,500	48,705	62,205	176,699	19,175	195,874 ≒196,000	258,205
23	2023	13,500	48,705	62,205	176,699	19,175	195,874 ≒196,000	258,205
24	2024	13,500	48,705	62,205	176,699	19,175	195,874 ≒196,000	258,205
25	2025	13,500	48,705	62,205	176,699	19,175	195,874 ≒196,000	258,205

APPENDIX H

ENVIRNMENTAL CONSIDERATIONS

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LIST OF FIGURES

1. Water Quality of Coast

The sewerage system of Abidjan has been discharging through ocean outfall to Gulf of Guinea after pretreatment at Koumassi treatment plant. Data concerning sea water quality of Gulf of Guinea has been executed by Denmark International Development Agency in 1993 as shown in Table H.1. The sampling location is shown in Fig. H.1. Such survey and an analysis are necessary to understand the water quality environment of Gulf of Guinea once a month in the future.

2. Resettlement Projects Executed by the Ivorian Government

The Ivorian Government has executed three Resettlement Projects, such as Washington Resettlement Project, Cocody-Marcory Bridge Project and Azito Power Plant Project in Abidjan. These projects were executed through a steering committee, which consisted of Ministère du Logement et de l'Urbanisme, Ministère de l'Environnement et de la Forêt and BNETD. Caritas Côte d'Ivoire (NGO) participated in mediation, evaluation and to see the fairness in compensation modalities. Resettlement was completed in accordance with the Guideline of the World Bank (OD 4.30 June 1990).

The compensation guideline in Côte d'Ivoire for resettlement and property damage as a result of project is explained in the following sections.

1) Principles

In application of Ivorian regulations or Directive 4.30 of the World Bank, when this one is more favorable than the Ivorian regulations, the Government of the Republic of Côte d'Ivoire has accepted the Principle that individuals whose properties, housing or sources of income affected by the project is entitled to a compensation permitting them to reconstruct, at least as identical, the said properties or to find within an acceptable deadline housing or equivalent sources of income.

Principles of compensation according to different types of damages are as follows:

Type of Damage	Principles of Compensation
1. Loss of house for precarious occupants owner of the house	- Cash indemnification for the house lost and given if possible an area for reconstruction
2. Total or partial loss of land for landowners with a land certificate	- Indemnification within the framework of the common expropriation procedure
3. Loss of land and of house for private owners	- Indemnification for house within the framework of the common expropriation procedure
4. Loss of rent for owner no matter their status	- Cash indemnification of lost rents due to resettlement
5. Moving of resident households affected by the project no matter their status	- Indemnification for moving costs
6. Loss of housing for tenant	- Cash indemnification destinée à compenser le relogement provisoire éventuellement nécessaire
7. Moving of an activity no matter its status (legally installed on the private property or precarious on the public property)	- Indemnification for house and for specific equipment if available -Indemnification for temporary loss of income due to moving or more generally due to the project - Indemnification for moving - Indemnification for loss of income of permanent employees if available.
8. Impact on accesses or parking lots of an activity	- Correction works aiming at reducing the impact

2) Expropriation of titled lands affected by the project

Owners concerned by a partial expropriation will be indemnified according to the stipulations of the decree of 1930. In practice, an amicable agreement is sought between an indemnification steering committee and the concerned. It is only when an agreement cannot be reached that the matter is transferred to the Judge for a final expropriation judgment.

3) Expropriation and destruction of buildings located on titled lands

The procedure is the same as the previous one: the owner is invited to negotiate for compensation in front of the commission.

4) Activities on public property

Principles of compensation are based on the scale of the activities (small, medium and large activities), search for a substitute, negotiation and expert appraisal.

5) Aspiration of people affected by project

The people affected by project are invited to express their wish as far as compensation modalities are concerned. Caritas Côte d'Ivoire (NGO) is invited to participate in mediation, evaluation and to see the fairness in compensation modalities.

The above Ivorian guideline can be summarized as follow. Land certificate is the pre-requisite for the claim of the resettlement. If the household does not have one, then he is considered as an illegal occupant. In the case of illegal occupants, the Government offered them free land at a designated location and each household regardless of the number of members is offered 150-m^2 area of land. In the case of occupants having land certificate, an expert does the existing house and land appraisal. The household having land certificate can choose any one alternative among the three of the following alternatives.

i) Household has option to have constructed house in the resettlement site

ii) Household has option to have land and capital to construct his house

iii) Household has option to have capital both for land and house

3. Regulations and Institutions related to Environment/Water Sector Management

3.1 Existing Laws and Regulations

1) Forest Law of December 20, 1965 related to Forestry Code; Decree of 1978 allowing the Transfer of Reserved Forests as Rural Domain.

2) Industrial Environment: Decree of October 20, 1926 related to Classified Industries and the order of June 28, 1989 Fixing their Nomenclature.

3) Protection of Nature: Law of August 4, 1965 related to Protection of Fauna against Hunting Practices; order No 3 of February 20, 1974 Prohibiting Hunting all over the Country.

4) Waters: Decree of March 5, 1921, of May 25, 1955 related to Regulation of Public Domain; Decree of March 19, 1921 sur la police et la conservation des eaux; recommendation of September 7, 1955 for services in charge of Drinking Water Distribution.

5) Law No. 88-651 of July 1988 related to Protection of Public Health and Environment

against Effects of Toxic and Nuclear Waste, and Harmful Substances.

6) Law No 95-553 of July 18, 1995 related to Mines including Arrangements for the Protection of Environment.

7) Law No. 96-766 of November 3, 1996 related to Establishment of a Legislative Framework: Environment Code, Decree of Classified Industries, Decree on EIA, Decree for Individual Exploitation.

8) Decree No. 98-43 of January 28, 1998 about the Classified Industries for Protection of Environment

3.2 Proposed Laws and Regulations

1) Texts in Preparation (noise, waste, etc)
2) Water: Project de code de l'eau regroupant et complétant les texts existants

3.3 Treaties and International Conventions

Côte d'Ivoire has ratified several international conventions in the area of coastal and marine environment.

1) The Protocol related to International Convention of 1973 for Prevention of Pollution by Ships (MARPOL, came into force on October 2, 1983). Côte d'Ivoire is one of the members since October 5, 1987.

2) International Convention for Intervention in Sea in case of Accident leading or can lead to Hydrocarbons Pollution (came into force on May 6, 1985); came into force in Côte d'Ivoire on April 7, 1988.

3) International Convention of 1973 for Prevention of Pollution by Ships (MARPOL 1973); ratified in Côte d'Ivoire through the law No 87-776 in 1987.

4) International Convention on Civil Liability for Damages caused by Pollution through Hydrocarbons. Ratified on June 21, 1973, and came into force on June 15, 1975.

5) International Convention related to Creation of an International Indemnification Fund for Damages caused by Pollution through Hydrocarbons (faite à Bruxelles le December 18, 1971, came into force on October 16, 1978); Côte d'Ivoire adhere to it from October 5, 1987.

6) Convention on Protection of Sea against Pollution resulting from the Disposal of Waste; came into force on August 30, 1975; Côte d'Ivoire adhere to it from October 9, 1987.

7) Convention related to Cooperation on Protection and Exploitation of Sea and Coastal Areas of West and Central Africa Region (WACAF); ratified on March 23, 1981 and came into force in Côte d'Ivoire on August 5, 1984.

8) Protocol related to Cooperation on Fight against Pollution in case of Critical Situation; came into force on August 5, 1984; came into force in Côte d'Ivoire on August 5, 1984.

9) Africa Convention on Conservation of Nature and Natural Resources, Alger 1968; came into force in Côte d'Ivoire on June 16, 1969.

10) Convention on Protection of World, Cultural and Natural Patrimony, Paris 1972; came into force in Côte d'Ivoire on April 9, 1981.

11) Convention on International Trade of Endangered Wild Species of Fauna and Flora (Washington, 1973), came into force in Côte d'Ivoire on February 1993.

12) RAMSAR Convention relating to Humid Areas of International Importance aiming at Guaranteeing Strengthened Protection of Stay and Nestling Places of Some Migratory Species; ratified in Côte d'Ivoire on February 1993.

13) Bâle Convention on Control of Transboundry Movements of Dangerous Wastes and their Destruction (March 22, 1989); Côte d'Ivoire is member since June 9, 1994.

14) Bamako Convention on Prohibition of Importing to Africa of Dangerous Wastes (signed on January 31, 1991); ratified by Côte d'Ivoire on June 9, 1994.

15) Rio Convention on Biological Diversity (June 1992); ratified by Côte d'Ivoire on November 14, 1994.

16) Rio Convention on Climate Changes (June 1992); ratified by Côte d'Ivoire on November 14, 1994.

3.4 Institutions

1) Ministère de l'Environnement et de la Forêt (MINEF)

MINEF is the governmental structure responsible of the formulation and the coordination of the national environmental policy and the examination of EIA. The organization chart of MINEF is shown in Fig. H.2. Direction de l'Environnemnt is belonged to MINEF.

2) National Agency for Environment (ANDE)

ANDE, which has been just created, is in charge of National Plan Implementation for Environment Action (PNAE). PNAE includes measures to control and minimize degradation of marine and coastal environment of Côte d'Ivoire. PNAE was elaborated to improve environmental management through strengthening institution capacity, formulation of standards for environmental quality, development of economic incentive to promote environmental management and establishment of national environmental data management system. Also envisaged are developments of integrated coastal area management, biodiversity preservation and integrated management of water resources.

<u>ANDE aims:</u>

- To assure the coordination of development project implementation in relation with the environment
- To start a follow-up of PNAE project

- To evaluate the PNAE projects
- To take care of implementation and management of national system of environmental information
- Implementation of international conventions regarding the environment
- To participate, jointly with the competent ministerial department, to getting financing for PNAE

3) CIAPOL (Centre Ivoirien d'Anti-Pollution)

CIAPOL is under the authority of the Ministry of Environment and Forest.

The missions assigned to CIAPOL are to:

- Follow up and investigate the quality of continental, sea and lagoon waters
- Analytical support to SIIC
- Control of accidental toxic and hydrocarbons pollution in sea, lagoon and coastal areas
- Environmental data exchange
- Warning
- Surveillance and control of pollution in sea and lagoon
- Training, information, sensibilization and campaign for environment protection

CIAPOL has revenue from the analysis of industrial wastewater. The total number of staff is about 50 people. Among them, 25 people are involved in the analytical work.

4) SIIC (Service de l'Inspection des Installations Classées)

SIIC is under the authority of the Ministry of Environment and Forest.

The missions assigned to SIIC are to:

- Actualize of the data base on the classified installations
- Elaboration thematic data base (water, air, wastes, noise, odor, and security)

- Control and inspect the classified installations (application and respect of regulation in force)
- Instruct the files of the authorization and declaration demand
- Instruct the complaints
- Study and implement the projects for the protection of environment
- List the existing classified installations
- Assure the inspection and control of the classified installations
- Take care of application and respect of regulation in force in industries working on national territory.
- Assure the management of industrial wastes (dangerous or toxic) and promote the clean technologies
- Permit the access to clean technologies and encourage the industries' interest for these kind of technologies
- Integrate industries to the plan for fighting against pollution by assuring their sensibilization, information, and training

The total number of staff is about 23. Among them, 14 staffs are assigned for the inspection activity of 2,230 factories in Abidjan. An inspection fee is levied to the factories.

5) LANEMA (Laboratoire National d'Essais de Qualité, de Métrologie et d'Analyses)

The Ministère de la Promotion du Commerce Exterieur is charge of industrial environment. It has under its responsibility LANEMA specialized in the control and analysis of industrial pollution. The total number of staff of LANEMA is about 50.

6) CRO (center de Recherches Océanologiques)

CRO is under the authority of the Ministry of University Education, research and Technological Innovation. Created in 1958 as a government service managed until November 1991 by ORSTOM, the center was recognized as a National Public Institution (Decree No. 91-646 of October 9, 1991).

CRO carry out the research necessary to:

- Understand the aquatic environmental interactions enabling its environment conservation and protection
- Put into practice the rational exploitation and management of living or non-living aquatic resources

The JICA Study Team concluded that some legislation existed in Côte d'Ivoire but problems were with implementation and enforcement because many provisions were not specified and penalties were obsolete. However, the new legislation (Environment Code Law No. 96-766 of October 3, 1996) with its pursuance law under preparation, takes into account all environmental aspects including public health, pollution, natural resource management, EIA, etc. The environment code represents the first action of the Government to create a legal, integrated and inter-sector-based framework for the management of national challenges concerning environment.

4. Terms of Reference for EIA

4.1 Introduction

This Feasibility Study of the sewerage facilities in the Western District of Abidjan City is on intercepting the existing trunk sewers to transport the wastewater to S1 Pumping Station to be disposed of to the Gulf of Guinea through the ocean outfall after pre-treatment at the Koumassi Sewage Pre-treatment Plant. The sewerage system in Abidjan will be completed after the installation of the interceptor in the Study Area. With the completion, the wastewater of the entire Abidjan will be discharged to the Gulf of Guinea through the ocean outfall. As a result of discharge of all wastewater of Abidjan to the Gulf of Guinea, the water quality of the lagoon is sure to be improved gradually. At present, the trunk sewers in the Study Area are discharging wastewater into the lagoon, resulting in high pollution of the lagoon water, and posing a serious threat to the environment and the sanitary condition of the communities.

On the other hand, after completion of the proposed Project, the total amount of wastewater discharged into the Gulf of Guinea through the ocean outfall will be increased substantially. The wastewater, which composed of domestic, commercial and industrial wastewater, is discharged to the ocean only after a simple pre-treatment at the Koumassi Sewage pre-treatment plant in which minimal amount of pollutant load is removed. The wastewater contains human and hospital waste, which poses a public health hazard through parasitic infections and various waterborne diseases. The harmful effects to the aquatic life in the Gulf of Guinea may occur due to the discharged of the untreated domestic, commercial and industrial wastewater.

In order to support sustainable marine environment, it is necessary to give sufficient consideration to the environmental effects that could be from the proposed Project on the marine environment. The environmental impact assessment is designed to make full surveys, predictions and assessments in advance on the possible environmental impact that may arise from the implementation of a project; release the findings; and listen to the views of community residents so that environmental conservation measures may be implemented to the full. It is an effective means to prevent environmental pollution.

4.2 Côte d'Ivoire EIA Guidelines

In Côte d'Ivoire, decree no. 96-894 of November 1996, which determines the rules and procedures for EIA, is one of the application decrees of Environment Code (law no. 96-766 of November 3 1996). The decree includes 21 articles and 4 annexes dealing with dispositions, rules, administrative procedures and content of EIA. Fig. H.3 shows the flow of procedures for implementation of EIA in Côte d'Ivoire.

In the following sections, the guidelines of EIA are explained.

1) Area subjected to EIA

- Protected area and analog reserves
- Zones humides et mangroves
- Area with scientific, cultural and tourist interest
- Areas defined as sensitive ecological areas

- Sea area regulated by national or international jurisdiction or other international waters

2) The client or petitioner could be free from paying tax to the environment fund for examining the EIA file by the Bureau of Impact Assessment (BIA) in the Ministry of Environment and Forest. BIA is in-charge of:

- Technical assistance to different structures involved
- Definition of terms of reference of EIA in consultation with parent technical administration in charge, client or petitioner, or its representatives and eventually the public
- Registration and evaluation of impacts noticing and EIA in order to get authorization under the signature of the Ministry of Environment and Forest
- Control and follow-up of measures recommended by EIA
- Public survey for an organization with the administrations involved
- The publication of information susceptible to objectively lighten the appreciation of measures envisaged and their impacts

3) The public survey is made in the framework of EIA decree organized by client or BIA. The whole document is dropped at the public hall. A commissioner collects the public observations. Some public meetings are organized in the public hall. The project and its impacts are communicated and every person can make known his observation. At the end of the public survey, the commissioner prepares a report on public observations to communicate to the client to take into account the observations.

4) According to article 12 of EIA decree, the content of EIA consists on 5 major activities: Identification, Analysis, Evaluation, Corrective Measures, and Follow-up and Control.

(1) Identification

The detailed description of the project

(2) Analysis

The analysis of actual conditions of site: The analysis must deal with natural area elements (fauna, flora, natural resources, hydrographic system, climate, soil etc.), nature of activities (agricultural, tourism, industrial, commercial, etc.) and human environment (population and sanitary situation, occupation), le statut juridique du site and its environment, defined by national development plans and by decrees of specified-area protection. An analysis of direct or indirect, predictable, reversible, irreversible, cumulating and synergic consequences (mainly those deriving from works) of the projects or unit program on environment and in particular site and landscapes. The resources and natural areas: The ecological equilibrium, living condition of citizen on hygiene, healthiness and commodities of neighborhood, consequences of light emission, odors, and other unforeseen effects.

(3) Appraisal

The environmental reasons why the project has been selected, particularly among the envisaged-options. The presentation of other envisaged-variants would be done for projects mentioned in the decree.

(4) Corrective Measures

The measures of prevention, elimination, mitigation and/or compensation envisaged by the owner or the petitioner to prevent, eliminate and mitigate and eventually compensate the damageable consequences of the project.

(5) Follow-up and Control

The limits of scientific knowledge in the field particularly those that burden net appreciation of damageable consequences of the project. The indicators allow follow-up and control of effective implementation of measures of prevention, elimination, mitigation and compensation prescribed by EIA.

The Ivorian Government EIA guidelines and specific guidelines by JICA Study Team for this particular proposed Project should be followed in preparing the EIA report for this proposed Project.

4.3 General Concerns of the Proposed Project

After completion of the proposed Project, the total design amount of untreated wastewater, which composed of domestic, commercial and industrial, discharged into the Gulf of Guinea through the ocean outfall will increase to 3.38 m^3/s in year 2003. With the increase in population and expansion in the sewerage connection in the future, this amount is sure to be increased substantially. In addition to increase in wastewater quantity, the quality of the industrial wastewater discharged to the sewerage system will change as a result of rapid industrialization in Abidjan.

The function of ocean outfall could be judged acceptable if there is no influence on the ecosystem of ocean by the disposal of untreated wastewaters. The effluent discharged to ocean should not degrade significant water areas, contaminate shellfish beds and beaches. A mathematical model can be used to simulate the processes of dilution, dispersion, diffusion, assimilative capacity of the Gulf of Guinea, die-off of microorganisms, effect on aquatic life and so on to determine the influence of the proposed Project. The model will require data on current, temperature, salinity and water quality, along with detailed bathymetric and ecological information.

In Côte d'Ivoire, there are no water quality standards for raw water used for drinking, standards for protection of aquatic ecosystem in fresh water, standards for protection of aquatic ecosystem in marine waters, and standards for recreation and aesthetics values. Because of this lack of standards, waterbodies in the country have not been classified as to their most beneficial or intended use. There is no basis therefore to evaluate if the ocean has already exceeded its acceptable limits for its intended use. The WHO guidelines or standards of other countries may be adopted.

The ocean outfall to dispose of the wastewater was constructed in 1995 based on 1971 Master Plan. After completion of the proposed Project, the total design amount of wastewater discharged into the Gulf of Guinea through the ocean outfall will increase to 3.38 m^3/s in year 2003. With the increase in population and expansion in the sewerage connection in the future, this amount is sure to be increased substantially. The characteristics of the ocean outfall are as follows:

Diameter of the pipe	1,200 mm
Length of pipe through water	1,200 m
Depth of diffuser	-20 m
Diffuser	4 orifices spaced over 20 m
Diameter of orifices	0.50 m

According to USEPA (United States Environmental Protection Agency), the following conditions are considered to be important while selecting a discharge point in the ocean.

- 50 times dilution based on treated effluent suspended solids concentration: The sewage is almost like fresh water so that it is lighter than seawater and rises toward the water surface while being mixed with seawater by the buoyancy. The density of the sewage is increased by mixing in the perpendicular direction and becomes almost the same as the density of seawater. This mixing takes within 2-3 minutes and 10 meter from the diffuser. In addition, the mixing of sewage is continued while rising due to horizontal diffusion by tidal currents. According to USEPA, about 30-meter depth is necessary to achieve 50 times dilution.
- Enough distance in the offshore so that the discharged solids do not reach the shoreline during high tide.
- Avoid the damage to scarce oceanic resources (fishes and coral etc.)

Based on the above consideration, it seems to be important to reevaluate the effectiveness of the existing ocean outfall in terms of dilution and necessary depth.

4.4 Contents of EIA Report

1) Baseline Data

i) The water quality (physical and chemical) of the wastewater and receiving water surrounding the outfall in the Gulf of Guinea should be carried out. Appropriate sampling locations should be established in the Sewage Pre-treatment Plant (before disposing to ocean), receiving water surrounding the outfall, and major effluent discharge points of the factories. In the receiving water, the water quality investigations should be carried out at M1, M9, P1, P5, M6, and M8 locations established by CIAPOL (APPENDIX C). The parameters, i.e. pH, Temp., oxygen saturation, conductivity, salinity, BOD, COD, SS, NO2, NO3, NH4, PO4, microbial content (total and faecal coliform bacteria) should be investigated. In addition, sediments should be analyzed/observed for COD, T-P, T-N, color and benthic organisms at two locations (one near outfall discharge point and other far from outfall discharge point) atleast one time. The composite sampling for the analysis (pH, Temp. conductivity, salinity, BOD, COD, SS, NO2, NO3, NH4, organic nitrogen, T-P, sulfate, microbial content (total and faecal coliform bacteria), oil & grease, heavy metals) and composite measurement of flow should be carried out at least two times in the Koumassi Sewage Pre-treatment Plant (before disposal) and manholes in which major industrial effluents are discharged. Trained staff using sampling equipment and methods that are valid for the analysis required should take samples. Qualified technicians in the laboratory should analyze samples.

ii) The chemical analysis, although important and necessary, does not provide all the information required in pollution assessments. Biological studies are of more particular value in providing a realistic assessment of pollution. The marine environment (e.g. benthic invertebrates, plankton, fish, seabirds, marine mammals and flora) with the discharge of untreated domestic, commercial and industrial wastewaters may accumulate toxic metals and chemicals. According to the expert of CRO, there are no coral reefs in Cote d'Ivoire. The present state of aquatic environment (such as fish fauna communities, numbers etc) and accumulation of toxic metals (Cd, Hg, Zn, Pb) in some fishes of the waters at two locations (one near outfall discharge point and other far from outfall discharge point) should be investigated at least one time.

iii) Test should be conducted to confirm the distribution of effluent discharge along the diffuser and the minimum initial dilution under weak and typical current condition as predicted originally. Monitoring of head losses to detect any problems due to sediment accumulation or blockage of the pipes: Outfall should be inspected for the following items: i) ports-open or clogged/marine growths; ii) sediment accumulation inside diffuser; iii) damage to coatings; iv) corrosion or decline in structural integrity v) scour and undercutting; vi) objects attached to outfall-anchors; and vii) lack of anchors or of attachment to piles.

iv) A mathematical model to simulate the processes of dilution, dispersion, diffusion, assimilative capacity of the Gulf of Guinea, die-off of microorganisms, effect on aquatic life and so on to determine the influence of the proposed Project. Based on the consideration of USEPA, it seems to be also important to reevaluate the effectiveness of the existing ocean outfall in terms of dilution and necessary depth.

2) Impact Assessment: This section should include identification and assessment of the positive and negative impacts likely to result from the proposed Project. Mitigation measures, and any residual negative impacts that cannot be mitigated, should be identified. Opportunities for environmental enhancement should be explored.

3) A long-term monitoring and investigation program to evaluate the environmental impact of the outfall on the receiving water should be proposed. This program should include effluent, industrial wastewaters, and receiving water in addition to aquatic marine environment. The monitoring can serve as a management tool to provide directions in the management of the discharge and water quality objectives of the receiving water. As a preventive measure to control contamination of toxic, hazardous and corrosive materials into the sewerage system, water quality monitoring of the industrial effluents is included.

4) Public Consultation: Consultation with affected communities is recognized as key to identifying environmental impacts and designing mitigation measures. The establishments along the coast, coastal population and fishermen may be at risk with discharge of untreated wastewater to the ocean. Information about the project and its likely environmental effects should be disseminated to local affected communities.

5) Overall evaluation of the proposed Project

6) Policy, Legal and Administrative Framework: Discussion of the policy, legal and administrative framework within which the EIA is prepared.

7) Appendixes

(i) List of EIA report prepares

(ii) References-written materials both published and unpublished, used in study preparation.

(iii) Record of interagency and consultation meetings, including consultations for obtaining the informed views of the affected people. The record specifies any means other than consultations (e.g., surveys) that were used to obtain the views of the affected groups.

(iv) Tables presenting the relevant data referred to or summarized in the main text.

(v) List of associated reports

TABLE H.1 WATER QUALITY OF COAST IN 1993 (1/3)

Site	Mon.	Dep.	pH	Temp.	O_2	Cond.	Sal.	SS	NO_2	NO_3	NH_4	PO_4
		m		°C	%	μS	0/00	mg/l	μM	μM	μM	μM
M1	Feb	S	-	27.4	-	46,400	34.1	-	0.0	5.9	0.9	0.4
		10	-	27.0	-	47,200	34.8	-	0.0	3.0	0.3	0.1
		20	-	26.7	-	47,200	34.8	-	0.0	2.1	2.3	0.1
	Aug	S	8.0	20.0	63	46,400	33.6	-	2.3	14.7	0.5	0.4
		10	-	-	-	49,000	-	-	-	-	-	-
		20	8.0	18.5	50	49,000	35.8	-	1.4	17.6	0.1	0.5
	Oct	S	8.2	27.1	-	39,700	28.5	-	2.4	4.6	2.4	1.2
		10	8.2	26.7	-	41,400	29.8	-	0.9	1.7	2.9	0.4
		20	8.2	26.2	-	-	-	-	0.4	0.6	1.0	0.7
	Dec	S	8.2	29.6	-	32,000	31.9	-	-	-	-	0.0
		10	8.2	28.3	-	46,400	34.2	-	-	-	-	0.1
		20	8.1	26.1	-	47,800	35.4	-	-	-	-	0.5
M2	Feb	S	-	27.5	-	46,600	34.4	-	0.0	7.2	2.1	0.0
		10	-	27.2	-	47,300	34.9	-	0.0	1.3	0.7	0.0
		20	-	24.4	-	48,000	35.2	-	0.0	2.8	1.5	0.0
	Aug	S	8.0	20.9	65	43,000	32.2	-	3.2	17.1	0.4	1.5
		10	8.0	19.0	56	49,000	35.8	-	1.5	15.9	0.1	0.2
		20	-	-	-	-	-	-	-	-	-	-
	Oct	S	8.2	27.2	-	36,700	26.0	-	2.0	3.9	3.7	1.1
		10	8.2	26.7	-	-	-	-	0.4	0.7	0.5	0.8
		20	8.2	26.3	-	-	-	-	0.4	0.6	0.4	1.0
	Dec	S	8.2	29.5	-	42,300	31.1	-	-	-	-	0.5
		10	8.2	28.3	-	46,600	34.5	-	-	-	-	0.7
		20	-	-	-	-	-	-	-	-	-	-
M3	Feb	S	-	27.5	94	46,600	34.4	-	0.0	0.4	1.2	0.0
		10	-	27.0	81	47,300	34.9	-	0.0	4.1	0.4	0
		20	-	24.3	80	48,000	35.3	-	0.0	2.1	0.6	0
	Aug	S	8.0	20.6	64	45,000	33.0	-	3.6	18.4	0.2	1.4
		10	8.05	19.2	61	49,000	35.8	-	-	-	-	-
		20	8.0	18.3	48	49,000	35.8	-	2.1	17.7	0.1	0.4
	Oct	S	8.2	27.1	-	32,000	23.5	-	1.9	3.7	1.5	1.4
		10	8.2	26.7	-	46,300	34.0	-	0.3	0.3	0.9	1.1
		20	8.2	26.4	-	46,500	34.2	-	0.9	1.4	2.9	1.4
	Dec	S	8.2	29.6	-	43,100	31.5	-	-	-	-	0.8
		10	8.16	28.5	-	46,500	34.3	-	-	-	-	-
		20	8.1	26.0	-	48,100	35.5	-	-	-	-	0.7
M4	Feb	S	-	27.6	95	46,600	34.3	-	0.0	7.6	1.4	0.0
		10	-	24.6	84	47,800	35.2	-	0.0	4.4	0.8	0.4
		20	-	23.9	-	48,000	35.4	-	0.0	1.3	0.7	0.5
	Aug	S	8.0	20.2	65	46,000	33.6	-	3.0	14.7	0.4	0.4
		10	8.03	19.1	59	49,000	35.9	-	-	-	-	-
		20	8.0	18.9	56	49,100	35.9	-	1.8	16.7	0.1	0.4
	Oct	S	8.2	27.0	-	38,000	27.4	-	1.1	1.2	0.8	1.3
		10	8.2	26.8	-	46,500	34.2	-	0.4	0.8	0.3	1.5
		20	8.2	26.7	-	46,700	34.3	-	0.4	0.9	0.5	1.3
	Dec	S	8.2	28.7	-	45,500	33.5	-	-	-	-	0.8
		10	8.16	28.5	104	46,600	34.4	-	-	-	-	-
		20	8.1	25.1	-	48,200	35.7	-	-	-	-	-

TABLE II.1 WATER QUALITY OF COAST IN 1993 (2/3)

Site	Mon.	Dep. m	pH	Temp. °C	O_2 %	Cond. μS	Sal. 0/00	SS mg/l	NO_2 μM	NO_3 μM	NH_4 μM	PO_4 μM
M5	Feb	S	-	27.5	99	46,400	34.2	-	0.0	3.1	1.4	0.2
		10	-	24.5	97	48,000	35.4	-	0.0	4.8	0.8	0.2
		20	-	23.9	83	48,200	35.4	-	0.0	1.3	1.5	0.5
	Aug	S	8.1	19.7	66	48,000	35.4	-	2.4	13.9	0.1	0.3
		10	8.2	19.1	57	49,000	35.8	-	-	-	-	-
		20	8.0	18.4	52	49,000	35.8	-	1.6	20.4	0.1	0.3
	Oct	S	8.2	27.1	-	34,000	24.5	-	2.2	3.2	0.1	1.3
		10	8.2	26.7	-	46,000	34.1	-	0.4	0.4	0.6	1.0
		20	8.2	26.7	-	46,500	34.2	-	0.5	0.3	0.9	0.8
	Dec	S	8.2	28.6	-	45,900	33.7	-	-	-	-	0.8
		10	8.16	28.3	102	46,600	34.4	-	-	-	-	-
		20	8.5	25.5	99	48,000	35.5	-	-	-	-	-
M6	Feb	S	-	27.8	97	46,300	34.1	-	0.0	3.0	0.0	0.1
		10	-	24.2	81	48,000	35.3	-	0.0	1.5	0.3	0.2
		20	-	23.8	78	48,000	35.4	-	0.0	3.3	0.4	0.2
	Aug	S	8.0	20.3	65	47,000	34.1	-	1.9	12.6	0.1	0.6
		10	8.02	19.0	58	49,000	35.8	-	-	-	-	-
		20	8.0	18.7	55	49,100	36.8	-	2.4	12.9	0.2	0.4
	Oct	S	8.2	27	-	39,000	27.8	-	0.0	1.8	0.4	1.2
		10	8.2	26.7	-	46,600	34.3	-	0.6	0.9	0.8	0.9
		20	8.2	26.7	-	46,700	34.4	-	1.2	0.9	0.1	1.2
	Dec	S	8.2	28.7	-	46,100	34.1	-	-	-	-	0.9
		10	8.2	28.5	-	46,600	34.4	-	-	-	-	-
		20	8.1	25.2	-	48,100	35.7	-	-	-	-	0.8
M7	Feb	S	-	27.8	99	46,600	34.3	-	0.0	6.5	0.9	0.2
		10	-	25.5	87	47,600	35.5	-	0.0	8.5	1.1	0.2
		20	-	23.7	74	48,200	35.4	-	0.0	2.9	0.4	0.2
	Aug	S	8.0	19.7	59	47,500	34.8	-	2.4	18.6	0.1	0.5
		10	8.02	18.9	62	48,900	35.8	-	-	-	-	-
		20	8.0	18.8	59	49,000	35.8	-	2.2	17.1	0.4	0.5
	Oct	S	8.2	27.2	-	39,400	28.2	-	1.2	0.5	1.4	1.1
		10	8.2	26.8	-	47,100	34.6	-	0.6	1.1	0.6	1.3
		20	8.1	26.7	-	47,000	34.6	-	0.7	0.4	0.3	1.2
	Dec	S	8.1	28.5	-	45,700	33.6	-	-	-	-	0.8
		10	8.2	28.5	-	46,500	34.3	-	-	-	-	-
		20	8.1	25.3	-	48,400	35.7	-	-	-	-	-
M8	Feb	S	-	28.4	101	46,500	34.2	-	0.0	5.1	1.9	0.3
		10	-	27.1	86	48,000	35.0	-	0.0	5.3	0.3	0.2
		20	-	24.2	83	48,000	35.4	-	0.0	4.8	0.7	0.5
	Aug	S	8.1	20.5	71	47,500	34.0	-	1.8	13.9	0.1	0.4
		10	8.05	19.1	65	49,000	35.8	-	-	-	-	-
		20	8.0	18.6	48	48,900	35.8	-	1.6	18.3	0.3	0.5
	Oct	S	8.1	27.2	-	42,100	30.5	-	0.9	0.3	0.2	1.3
		10	8.1	26.8	-	47,100	34.6	-	0.3	0.9	0.6	1.2
		20	8.1	26.3	-	47,300	34.7	-	0.9	0.6	0.9	1.2
	Dec	S	8.1	29.0	-	45,400	33.4	-	-	-	-	0.9
		10	8.1	28.5	-	46,400	34.3	-	-	-	-	-
		20	8.1	25.7	-	48,300	36.6	-	-	-	-	-

TABLE H.1 WATER QUALITY OF COAST IN 1993 (3/3)

Site	Mon.	Dep.	pH	Temp.	O_2	Cond.	Sal.	SS	NO_2	NO_3	NH_4	PO_4
				℃	%	μS	0/00	mg/l	μM	μM	μM	μM
M9	Feb	S	-	27.4	-	46,800	34.1	-	0.0	2.5	0.4	0.0
		10	-	27.0	-	47,200	34.8	-	0.0	0.0	0.0	0.0
		20	-	26.9	-	47,200	34.8	-	0.0	0.0	0.0	0.0
	Aug	S	8.1	20.5	81	48,700	35.7	-	1.4	14.2	0.1	0.3
		10	8.01	18.7	65	49,100	35.8	-	-	-	-	-
		20	8.0	18.6	69	49,100	35.8	-	1.6	19.0	0.1	0.5
	Dec	S	8.2	29.2	-	45,000	33.2	-	-	-	-	0.0
		10	8.2	28.3	-	46,400	34.2	-	-	-	-	-
		20	8.1	25.5	-	48,200	35.6	-	-	-	-	-
P1	Jul	S	8.2	23.6	-	48,000	35.0	-	-	-	-	-
	Oct	S	8.2	28.3	115	44,000	31.9	-	-	-	-	0.1
	Dec	S	8.1	28.8	116	44,100	32.4	-	-	-	-	-
P2	Feb	S	-	-	-	-	-	-	-	-	-	0.0
	Jul	S	-	-	-	48,000	-	-	-	-	-	-
	Oct	S	8.1	26.7	123	43,000	31.0	-	0.0	0.3	-	0.3
	Dec	S	-	29.0	96	45,800	33.7	-	-	-	-	-
P3	Feb	S	-	-	-	-	-	-	0.0	0.0	0.0	0.0
	Jul	S	8.1	21.5	119	47,500	34.7	-	-	-	-	-
	Oct	S	8.1	25.9	111	45,000	32.9	-	0.1	2.1	-	0.2
	Dec	S	8.1	29.0	88	44,400	32.6	-	-	-	-	-
P4	Feb	S	-	-	-	-	-	-	-	-	-	-
	Jul	S	8.1	22.6	164	46,000	33.6	-	-	-	-	-
	Oct	S	8.1	26.2	112	41,000	29.9	-	0.0	1.1	-	0.3
	Dec	S	8.1	29.0	94	45,000	33.1	-	-	-	-	-
P5	Feb	S	-	-	-	-	-	-	-	-	-	-
	Jul	S	8.1	22.6	204	46,000	33.6	-	-	-	-	-
	Oct	S	8.2	26.5	112	43,000	31.1	-	0.2	1.6	-	0.3
	Dec	S	8.0	29.0	95	45,800	33.8	-	-	-	-	-
P6	Feb	S	-	-	-	-	-	-	-	-	-	-
	Jul	S	8.0	23.0	209	44,000	32.0	-	-	-	-	-
	Oct	S	8.1	26.5	115	44,000	32.3	-	0.0	1.0	-	0.3
	Dec	S	8.1	29.0	94	45,700	33.7	-	-	-	-	-

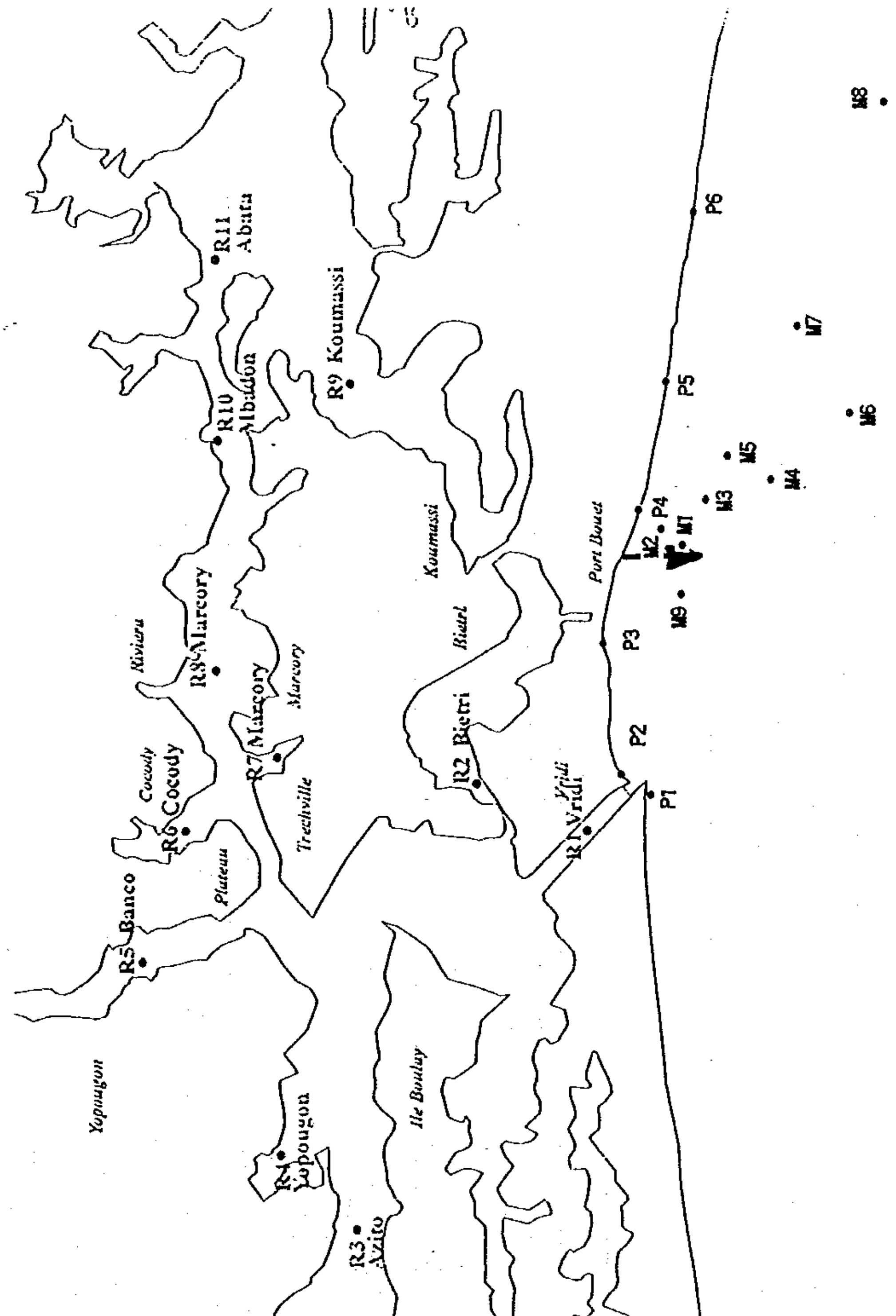

FIG. H.1	SAMPLING LOCATION OF EXISTING WATER QUALITY DATA IN COAST

THE FEASIBILITY STUDY ON SEWERAGE FACILITIES IN WESTERN DISTRICT OF ABIDJAN CITY IN THE REPUBLIC OF COTE D'IVOIRE

FIG.H.2 ORGANIZATION CHART OF THE MINISTRY OF ENVIRONMENT AND FOREST

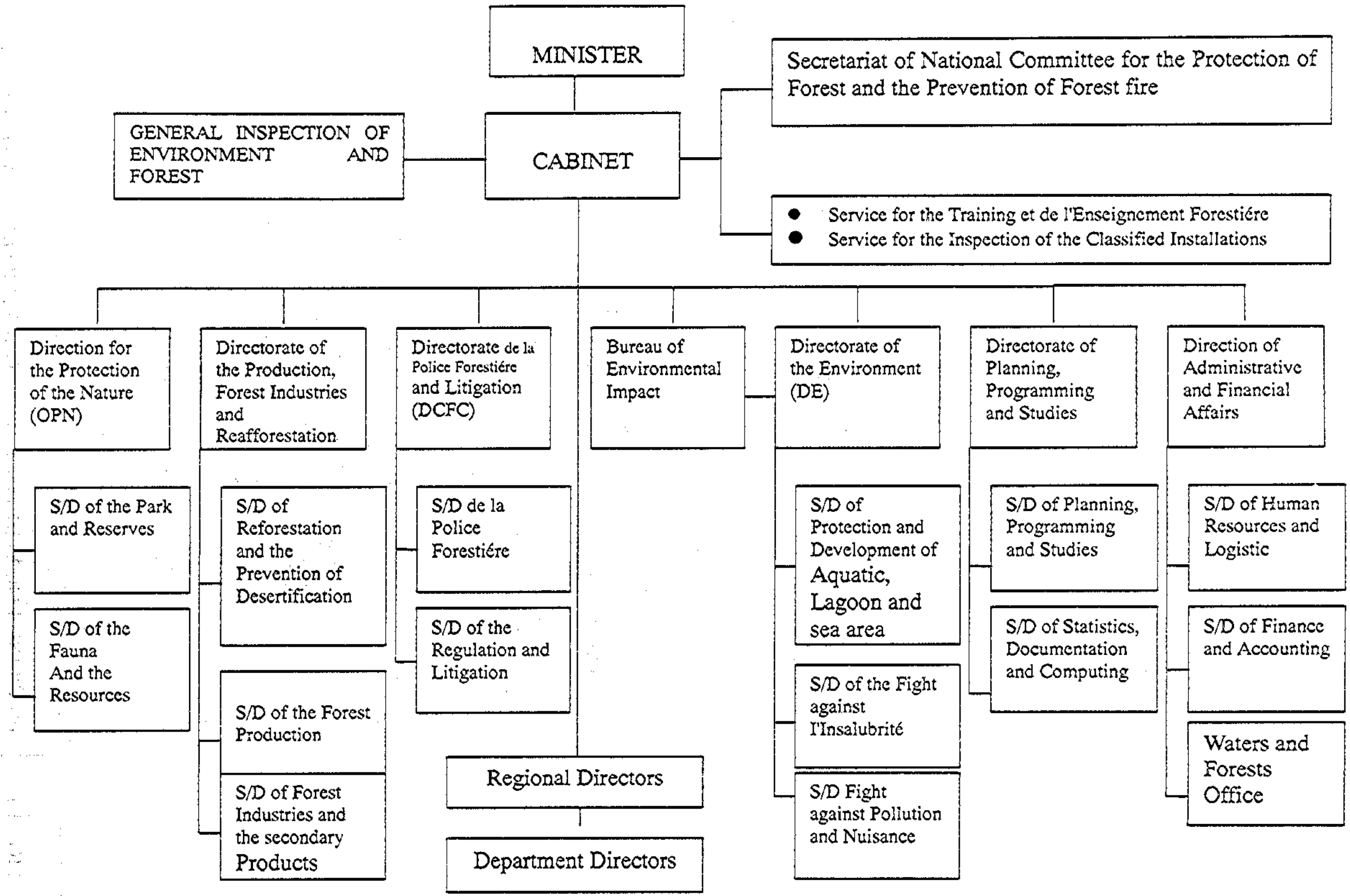

FIG. II.3 FLOW OF PROCEDURES FOR IMPLEMENTATION OF EIA