4.1.2 Inflow Pump and Screen

The design pump capacity by the year 2000 is determined as 70 m^3/min, with 1 No. 50 m^3/min capacity and 1 No. 20 m^3/min capacity pumps. Additional 1 No. 50 m^3/min capacity of pump is installed as a standby.

Pump type : Vertical Axial Mixed Flow Pump

The design hydraulic pump head is 7.4 m.

The design power of pump motor is 119.5 kW with 1 No. 84.5 kW (for 50 m^3/min capacity pump) and 1 No. 35.0 kW (for 20 m^3/min capacity pump).

The design dimension of screen preceding the pump is as follows :
2.5 m (W) x 1.0 m (H) x 2 units.

The details of pump facilities are shown in Fig. B.4.1.

4.2 Lagoon Treatment System

4.2.1 Basic Consideration

(1) Design High Water Level (HWL)

The design high water level in the lagoon treatment system consisting of aerated lagoon, facultative aerated lagoon and polishing pond is determined as +1.0m, which is 0.5m higher than the high tide in Benoa Bay.

By allowing an overall free board of 0.5m the design land elevation of the treatment plant is set at +1.5 m.

(2) Flow Stream

In order to enhance the system reliability two parallel streams of identical treatment units with necessary interconnections will be provided.

Accordingly, the system capacity per flow stream is 50% of the urgent project capacity of 44,000m^3/d, which becomes 22,000 m^3/d.

4.2.2 Aerated Lagoon

The system is two (2) parallel streams.
Capacity per stream is 22,000 m^3/d.
Detention time is 2 day.
Effective depth is 4 m.

Effective area requirement is 11,000 m^2 x 2 No.
Effective dimension selected is 150 m(L) x 75.0 m(W) x 4 m(D) x 2 No.

Provide a slope of 1:1.5 with masonry protection to slopes and cobble stone bed protection for base.

Dimension at design land elevation (+ 1.5 m) : 157.5m x 82.5 m x 2 No.
Dimension at base elevation (-3.0 m) : 144 m x 69 m x 2 No.

Power rating of aerator is governed by mixing requirement of 5 W/m^3 of lagoon wastewater volume. Computed power requirement is 220 kW per lagoon.

Design power rating of aerator : 75 kW x 3 units per lagoon.
: 75 kW x 6 units (Total).

Nevertheless, using Equation-(8) of Chapter 3, the oxygen requirement as BOD_L exerted, as the medium value of Mara and Rao & Datta, is determined as 2,950 kg/d per lagoon (Q of 22,000 m^3/d).

The corresponding aerator power requirement to realize the above oxygen transfer is computed as 70 kW per lagoon. The proposed design power rating of aerator of 225 kW can satisfy the oxygen requirement.

4.2.3 Facultative Aerated Lagoon

Capacity per stream is 22,000 m^3/d.
Detention time is 2 day.

Effective depth is 4.0 m, with additional 0.5 m depth at base for digested sludge storage.

Effective area requirement is 11,000 m^2 x 2 No.

Effective dimension selected is 150 m(L) x 75 m(W) x 4.0 m(D) x 2 No.

Provide a slope of 1:1.5 with masonry protection for side slopes of lagoon.

Dimension at design land elevation (+1.5 m) : 157.5 m x 82.5 m x 2 No.
Dimension at base elevation (-3.5 m) : 142.5 m x 67.5 m x 2 No.

Power rating of aerator is based on maintaining the top 1 m surface layer of lagoon under aerobic condition.

Computed power requirement : 61 kW per lagoon.
Design power rating of aerator : 22 kW x 3 units per lagoon.
Design power rating of aerator : 22 kW x 6 units (Total).

Nevertheless, the purpose of aerator of aeration is basically to prevent anaerobic condition from developing near the surface, and will be kept at minimum to facilitate setting of microbial mass. Hence, the overal operational power requirement of both lagoons is considered as 66 kW, which is 50% of the installed total aerator power rating of 132 kW.

4.2.4 Polishing Pond

Capacity per stream is 22,000 m^3/d.
Detention time is 0.5 day.
Effective depth is 1.5m with additional 0.5m at base for sludge stabilization.

Effective area requirement is 7,340 m^2 x 2 No.

Effective dimension selected is 93.25 m(L) x 78.75 m(W) x 1.5 m(D).
Provide a slope of 1:1.5 with masonry protection for side slopes of pond.

Dimension at design land elevation (+1.5 m) : 97 m x 82.5 m x 2 No.
Dimension at base elevation (-1.0 m) : 89.5 m x 75 m x 2 No.

4.2.5 Sludge Drying Bed

The quantity of desludging from facultative aerated lagoon was determined considering an annual per capita sludge accumulation of 35 liters in the lagoon.

The total annual accumulation of sludge in both lagoons becomes 7,700 m^3/year.

The total sludge storage capacity provided in the 0.5m base depth of both lagoons is about 6,800 m^3.

Hence the theoretical frequency of lagoon desludging is once in 10 months.

However in order to limit the requirement of area for sludge drying bed a desludging frequency of once in two(2) months is assumed.

Accordingly, the design dimension of drying bed, with a sludge spread thickness of 250 mm, is determined as : 10 m(W) x 25 m(L) x 0.25 m(D) x 22 No.

4.2.6 Treatment System

The design dimension of the treatment system at the design land elevation of the treatment plant is shown in Fig. B.4.2.

The respective typical design sections of embankments are shown in Fig. B.4.3, assuming a minimum surface clearance of 5 m between treatment units at design land elevation of treatment plant.

The land area of treatment system for this urgent project is about 9.2 ha, covering the areas of treatment facility (8.0 ha) and control building (1.2 ha). No green belt (buffer zone) is required since the proposed treatment plant is surrounded by the existing and planned mangrove forests.

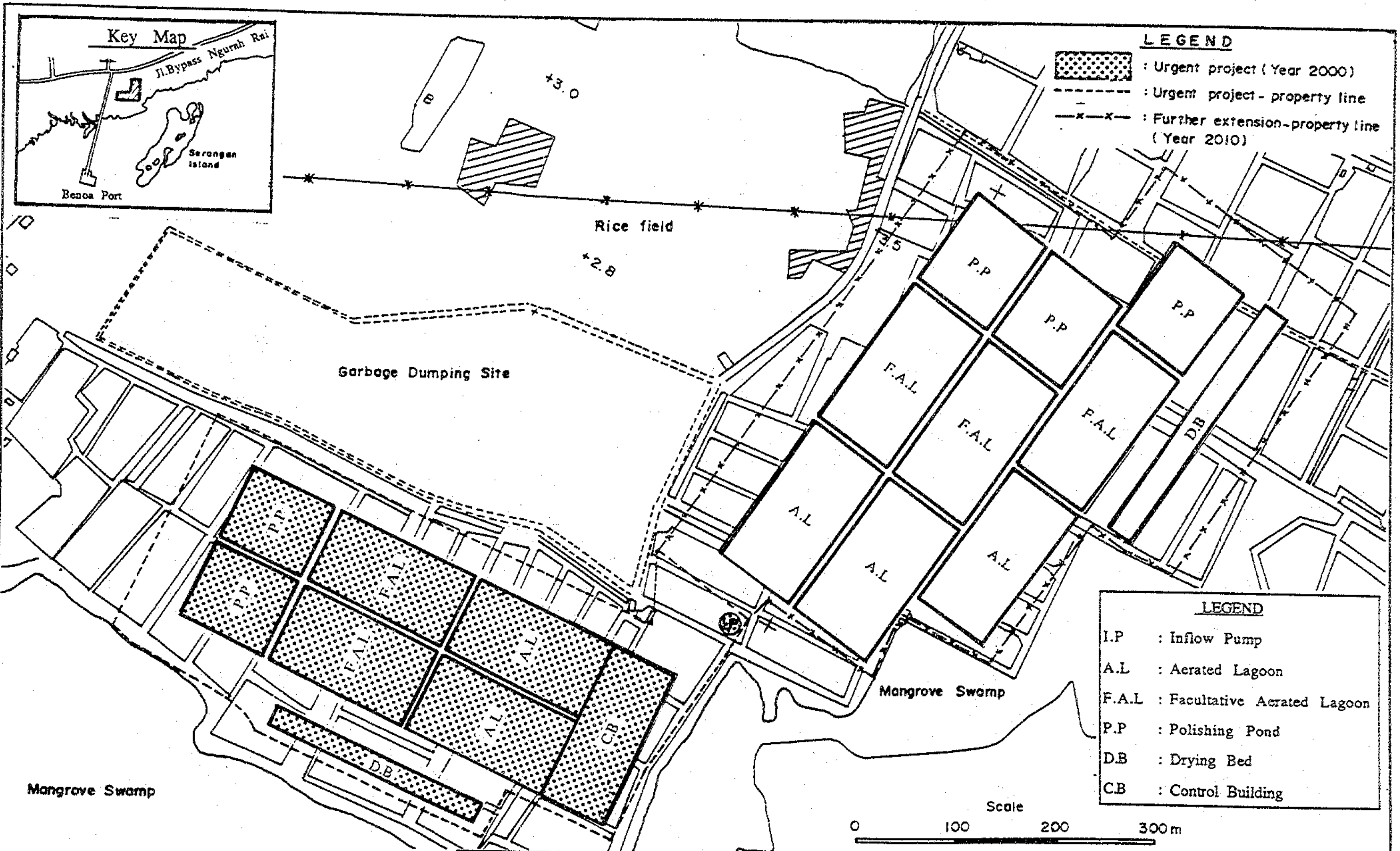

FIG. B.1.1 LAYOUT OF TREATMENT PLANT

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

JICA A.D 1993

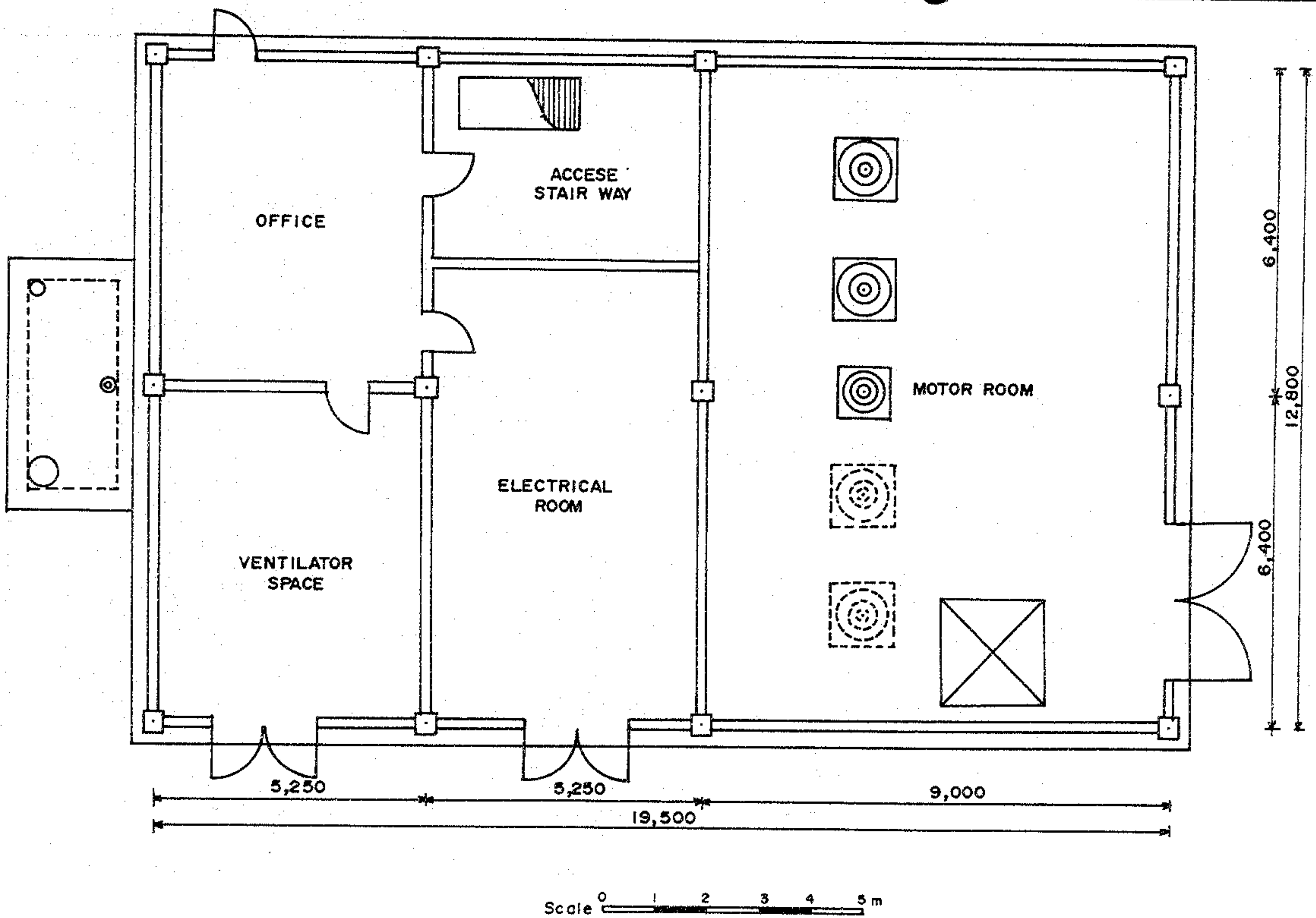

FIG.B.4.1(1)	INFLOW PUMP FACILITY OF TREATMENT PLANT

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

JICA A.D 1993

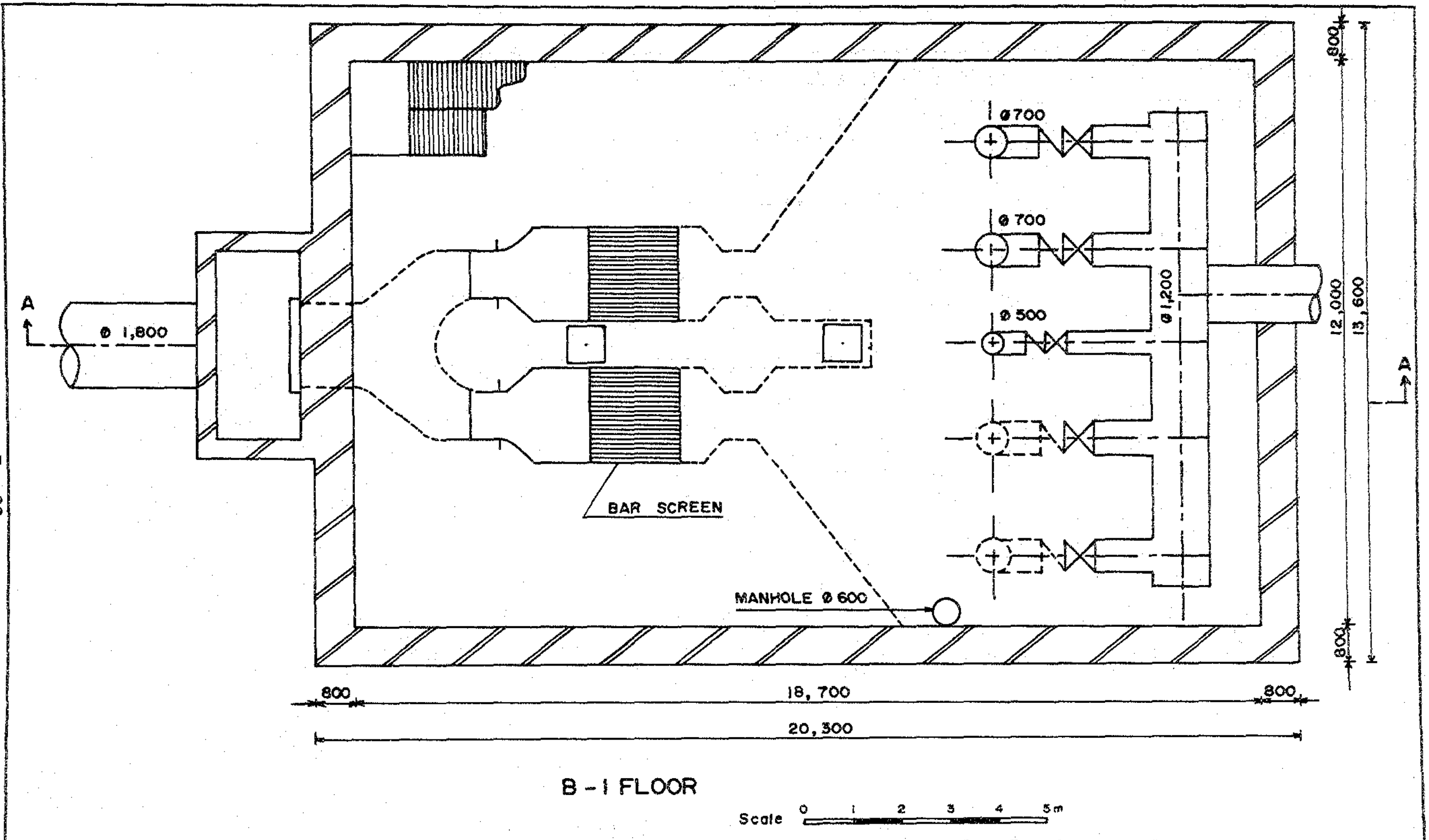

FIG.B.4.1(2) INFLOW PUMP FACILITY OF TREATMENT PLANT

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

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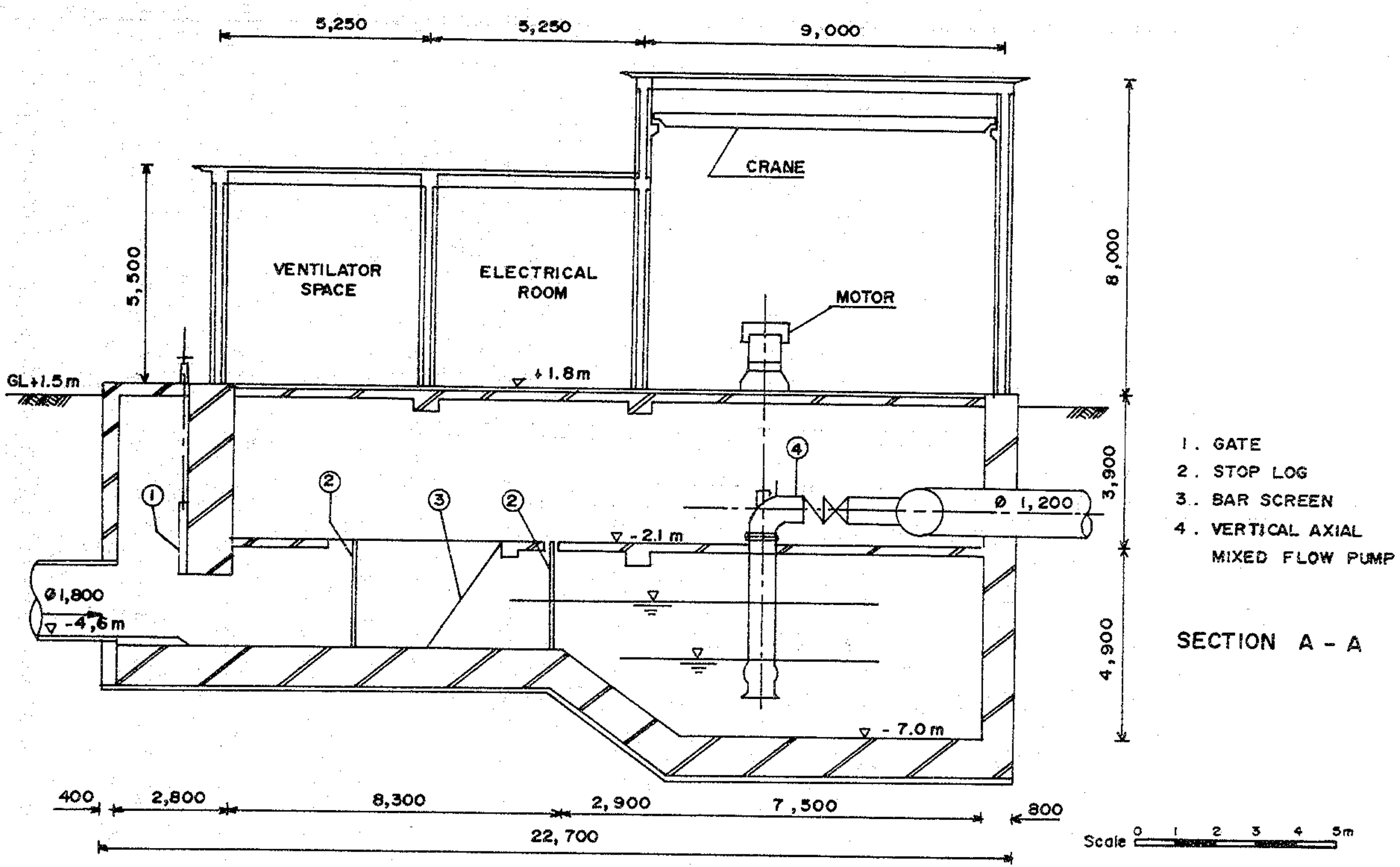
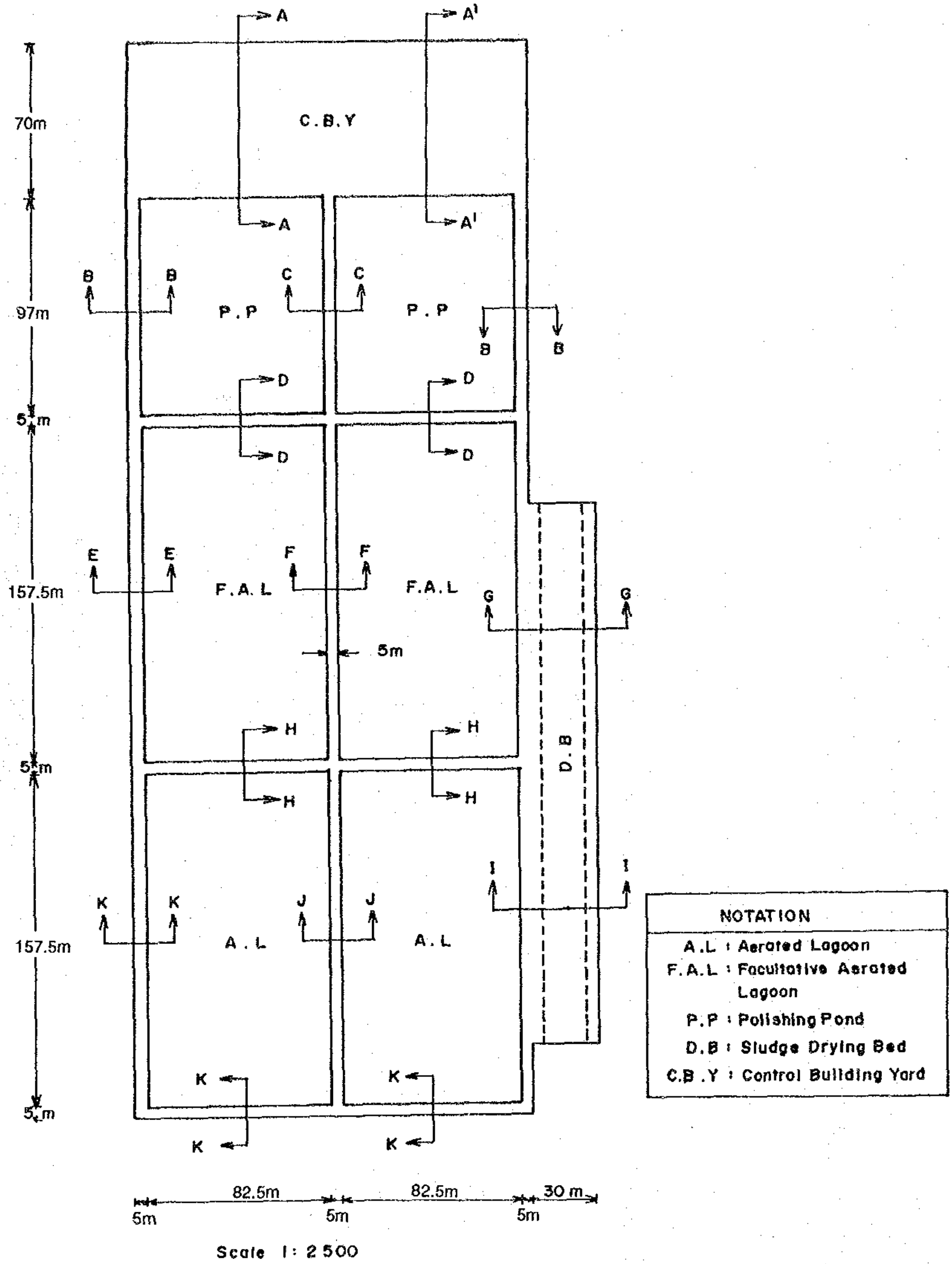


FIG.B.4.1(3) INFLOW PUMP FACILITY OF TREATMENT PLANT

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

JICA A.D 1993



Note : All dimensions at design land elevation of treatment plant (+ 1.5 m).
For sections of embankments refer to subsequent figure.

FIG. B.4.2 DESIGN DIMENSION OF LAGOON TREATMENT SYSTEM

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

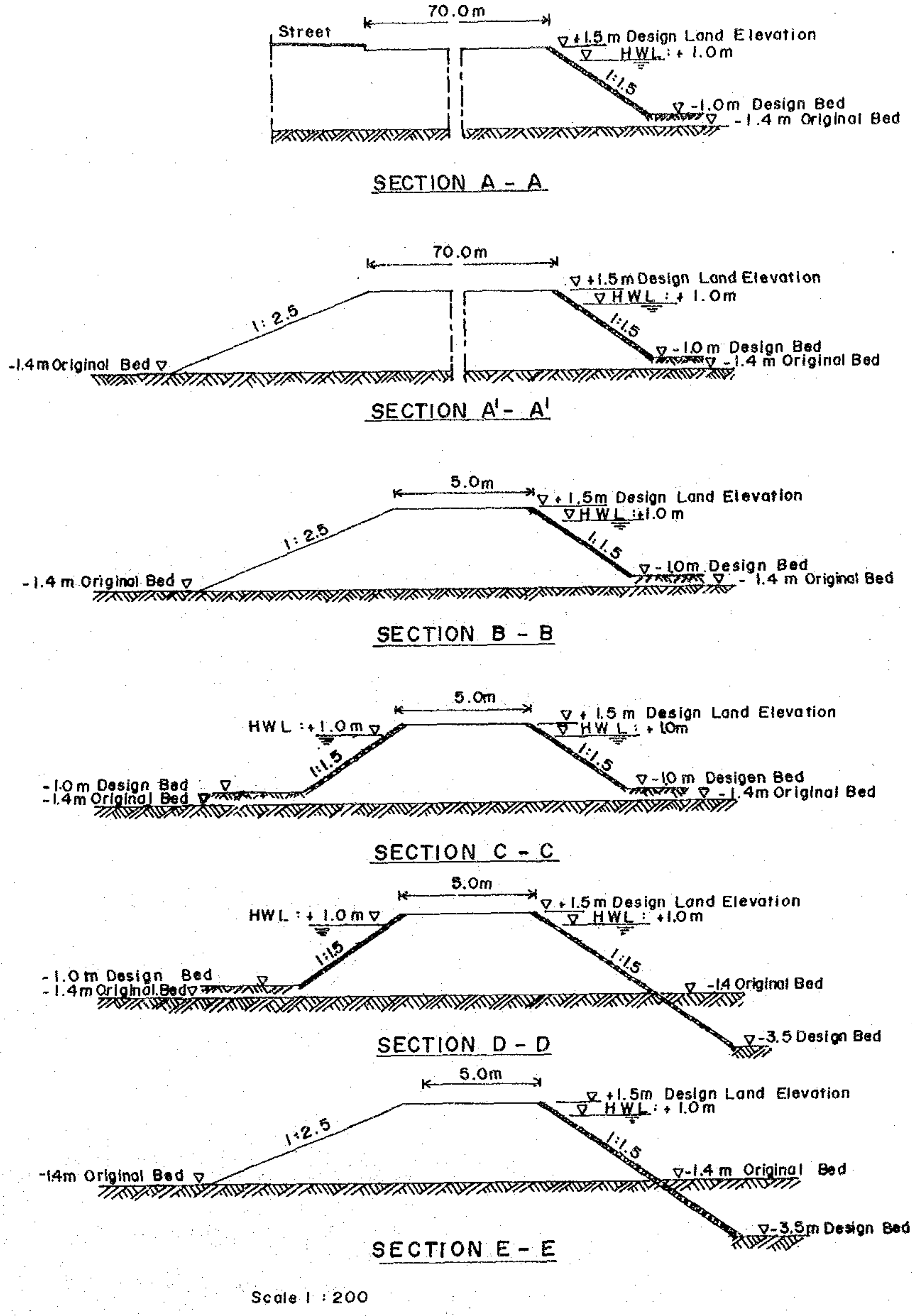


FIG. B.4.3(1) TYPICAL SECTION OF LAGOON EMBANKMENT

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

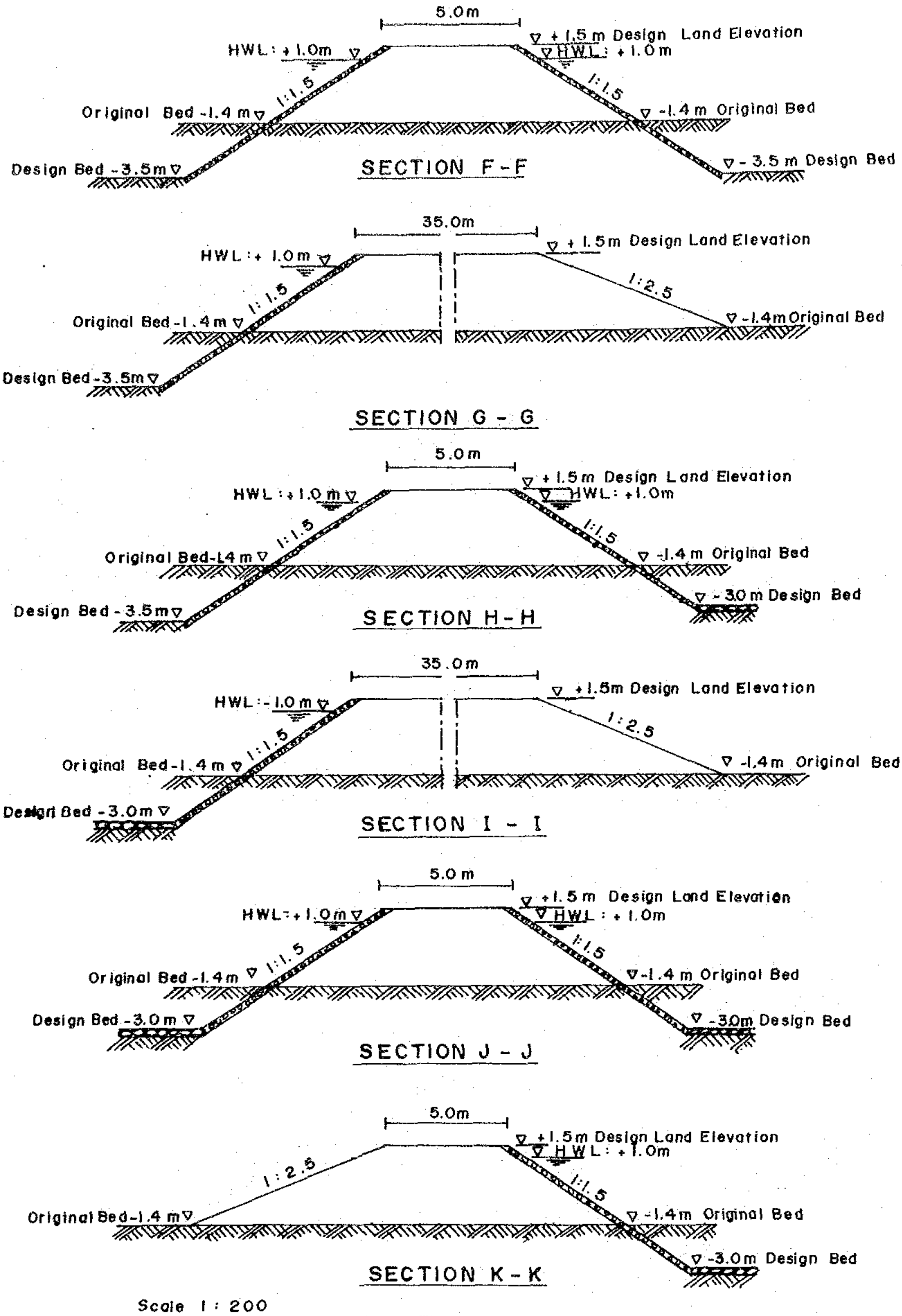


FIG. B.4.3(2) TYPICAL SECTION OF LAGOON EMBANKMENT

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

APPENDIX C

COST ESTIMATE AND IMPLEMENTATION PROGRAMME

APPENDIX C COST ESTIMATE AND IMPLEMENTATION PROGRAMME

1. Construction Plan

1.1 Geology and Groundwater

1.1.1 Geology

The Project Area is covered by alluvial deposits composed of volcanic rock, clastic rock and coral/coral limestone origins. They are found as a form of river deposits and beach sand.

The JICA Team conducted test boring at six (6) locations in the Project Area. The boring location and profile of the boring cores are shown in Fig. C.1.1.

In the Denpasar sewerage development area, the sub-soil properties are as follows (see, boring core No. 1 and No. 2).

- Soft sandy silt mixed with fine to medium/coarse sand in the layer between ground surface and 4.0 m depth.

- Dense gravelly coarse sand with clay or dense silty sand with gravel in the layer of 4.0 - 10.0 m depth.

In the Sanur sewerage development area, the sub-soil conditions are as follows (see, boring core No. 5).

- Loose fine to medium beach sand in the top layer of 0.0 - 2.0 m depth. The beach sand is formed from disintegrated coral and sea shell.

- Loose medium to coarse beach sand in the layer of 2.0 - 10.0 m depth. The beach sand is also formed from disintegrated coral and sea shell.

In the swamp area along the Benoa Bay where the sewage treatment plant is to be constructed, the sub-soil strata are composed of the following soil characteristics (see, boring core No. 4).

- Very soft clay in the top layer of 0.0 - 2.0 m depth.

- Soft clay with disintegrated coral in the layer of 2.0 - 11.0 m depth.

- Soft to stiff sandy clay with disintegrated coral in the layer of 12.0 - 23.0 m depth.

- Stiff sandy clay with disintegrated coral in the layer of 25.0 - 30.0 m depth.

Thin coral layers with holes are sandwiched at two (2) depths of 11.0 m and 23.0 m.

The sub-soil at the proposed sewage treatment plant site is soft. The N-value is as follows (see, boring core No. 4).

- Less than 10 in the shallower layer up to 11.0 m deep
- 15 - 20 in the layer of 12.0 - 22.0 m depth
- More than 20 in the deeper layer of 23.0 m and more

The deeper layer of more than 23.0 m depth is considered as the bearing stratum for the construction of heavy structures.

1.1.2 Groundwater Table

The Project Area is affected by shallow groundwater table (see, Fig. C.1.1). The groundwater table depth is :

- Less than 3.0 m in the southern part of Denpasar where most of the sewer installation works will be done
- 3.0 - 5.0 m in the Sanur sewerage development area
- Less than 1.0 m at the proposed sewage treatment plant site

The soil infiltration capacity of the Project Area is estimated as follows (see Interim Report, Fig. B.6.1).

- Medium infiltration capacity of 0.03 - 0.2 cm/min. for the Denpasar sewerage development area
- High infiltration capacity of 0.2 - 1.0 cm/min. for the Sanur sewerage development area
- Low infiltration capacity of less than 0.03 cm/min. for the proposed sewage treatment plant site

1.2 Construction Method

1.2.1 Sewer Pipe

(1) General

Three (3) typical construction method of open trench, shield tunneling and micro-tunneling are economically applicable for installation of sewer pipes in general.

Open trench method is applied for laying a shallow sewer. This method is further classified into the following three (3) types according to trench depth and pipe diameter.

- Open trench with no sheeting
- Open trench with retaining wall
- Open trench with sheet piling

Dewatering from trench is required for either case during rains or in case of high groundwater table.

Shield tunneling method is widely applied for laying a deep sewer. Applicable diameter for shield tunneling is larger than ø1,350 mm. Construction of a vertical shaft is necessary in every 1.0 to 2.0 km distance.

Micro tunneling method is usually applicable for a short distance tunnel of small/medium diameter. A vertical shaft is required in every 80 to 100 m distance.

The most economical construction method shall be selected from among the above methods. The diameter and earth covering depth of the sewer pipes in this Project are not large. The maximum diameter and earth covering depth are ø1,800 mm and 7.0 m respectively. Hence, only open trench method is applied.

The most economical type of open trench method is selected corresponding to pipe diameter and earth covering depth as shown below.

Covering Depth / Diameter	0 - 2.0 m (1.5 m)	2.0 - 4.0 m (3.0 m)	4.0 - 6.0 m (5.0 m)	6.0 - 8.0 m (7.0 m)
150 - 600 mm	I	II	III	III
700 - 1,000 mm	I	III	III	III
1,100 - 1,800 mm	II	III	III	III

Note: I : Open trench with no sheeting
II : Open trench with retaining wall
III : Open trench with sheet piling

(2) Sewer Pipe of Free Flow

The sewer pipes of free flow excluding river crossing and force main with a total length of 176,740 m will be constructed as described below :

1) All the secondary and tertiary sewers (ø150 - 300 mm) of 158,740 m will be constructed by open trench with no sheeting.

2) Main sewers (ø350 - 1,500 mm) with a total length of 18,000 m will be installed by open trench with no sheeting, or open trench with retaining wall or open trench with sheet piling as shown below :

- Open trench with no sheeting : 8,780 m
- Open trench with retaining wall : 2,280 m
- Open trench with sheet piling : 6,940 m

3) The coveyance sewer (ø1,500 - 1,800 mm) of 4,390 m connecting the Denpasar sewerage service area and sewage treatment plant will also be laid by open trench with sheet piling under Jl. Raya sesetan. The earth covering depth ranges from 2.0 m to 6.0 m.

The above open trench will be excavated by man-power and back-hoe.

(3) Inverse Siphon

The main sewer crosses the Oongan River by siphon at two (2) locations. The siphons will be constructed by micro tunneling method. The length of the siphons is approximately 40 m each.

4) Force Main

The force main of 5,160 m x 2 units connecting the Sanur sewerage service area and sewage treatment plant will be laid under the side reserved zone of Jl. Bypass Sanur by open trench with no sheeting. The each pipe diameter and earth covering depth of the force main are ø500 mm and 1.5 m respectively.

1.2.2 Treatment Plant

The major construction works of the sewage treatment plant are embankment and excavation for the aerated lagoon and inflow pump station.

The required earth volume of the embankment is estimated to be approximately 103,000 m^3 including the earth volume for filling up the control building yard and sludge drying bed. Out of the above volume, 14,000 m^3 will be transported from the borrow pits in the Bukit Badung hilly area for protection of the embankment surface (crown surface and back slope surface) and the remaining 89,000 m^3 will be filled up by using the soils excavated from the aerated lagoon. The embankment surface facing the pond water will be protected by wet masonry. The materials of the wet masonry will be transported from the rivers located outside the Project Area.

The required excavation volume of the aerated lagoon is estimated to be approximately 89,000 m^3. The earth works of the aerated lagoon are well balanced. All the above excavated soils will be used for the embankment works. The excavation will be conducted under dry conditions by a combination of man-power, bull-dozer and power shovel/drag line.

Pile foundation will be used to support the weight of the inflow pump station because the sub-soil is soft.

1.2.3 Spoil Bank

A total amount of 301,000 m^3 of residual soil will be produced from the construction works of the Project as follows.

(1) Sewer pipe installation

A total amount of 301,000 m^3 of residual soil will be produced during the construction period of three (3) to four (4) years. The break-down by work is as follows.

- Secondary and Tertiary : 182,000 m^3
- Main : 68,000 m^3
- Conveyance, Inverse Siphon & Force Main : 51,000 m^3

(2) Construction of treatment plant

All the excavated soils will be used for the embankment works. No residual soils will be produced from the construction works of the sewage treatment plant.

The housing development areas scattered in the Project Area are potential spoil banks. The residual soils produced from the sewer installation works will be dumped on these spoil banks.

1.3 Required Major Construction Equipment

Major construction equipment and materials for installation of the sewer pipes are as follows.

- Hammer for sheet piling
- Back-hoe for trench excavation
- Micro tunneling machine

- Dump truck for soil hauling

- Bull-dozer for earth work on the spoil banks

- Concrete/steel sheet pile

- Concrete sewer pipe

- Steel pipe for force main

The following major construction equipment will also be required for the construction of the aerated lagoon.

- Bull-dozer, back hoe/power shovel/drag line and dump truck for excavation, loading, hauling and embankment at the site of the aerated lagoon

- Bull-dozer, back hoe/power shovel and dump truck for excavation, loading and hauling at the site of the borrow pits

The other major construction equipment required will include concrete mixer, crawler crane and dewatering pump.

1.4 Workable Time

The construction of sewer pipes will be done throughout the year. Annual workable days is estimated to be 260 days based on the following considerations.

Sunday per annum	:	50 days
National holiday per annum	:	20 days
Rainy day per annum	:	30 days (more than 20 mm/day)
Others	:	5 days

All the construction works will be done during day time in principle. The working time is eight (8) hours per day.

2. Cost Estimate

2.1 Basis of Cost Estimate

The project costs are estimated under the following conditions.

(1) It is assumed that all construction works will be contracted to general contractors by international tender.

(2) All base costs are expressed under the economic conditions that prevailed in June, 1992.

(3) Overhead is assumed at 20% of the total cost of equipment and civil works and incorporated in the direct construction cost.

(4) Engineering service and administration costs are assumed respectively at 12% and 2% of the total direct construction cost.

(5) Physical contingency allowance at 10% of the direct construction cost is assumed.

(6) Currency exchange rate of 1 US$ = 2,020 Rp. = 127 ¥ is assumed.

2.2 Basic Unit Cost

Basic unit costs of labour, fuel and material, and equipment rental are shown in Table C.2.1, C.2.2 and C.2.3.

2.3 Unit Construction Cost of Sewer Pipe

The secondary and tertiary sewer pipes with a diameter of 150 - 300 mm are of polyvinyl chloride (PVC) pipe. However, main and conveyance sewers with a diameter of 350 - 1,800 mm are of reinforced concrete (RC) pipe.

Unit construction cost (construction cost per meter) of the above sewer pipes varies according to diameter of pipe and earth covering depth of pipe laying. The unit construction cost by pipe diameter and by earth covering depth is shown in Table C.2.4. Its break-down is shown in Table C.2.5.

2.4 Unit Construction Cost of Manhole

Unit construction cost (construction cost per place) of manhole changes according to depth of manhole and diameter of connected sewer pipe. The unit construction cost by manhole depth and by pipe diameter is shown in Table C.2.6.

2.5 Estimated Project Cost

The total project cost, consisting of direct construction cost, land acquisition cost, administration cost, engineering cost and physical contingency amounts to Rp.82,400 million at 1992 price. Its break-down is shown below.

	(Unit : million Rp.)
(A) Direct Construction Cost	66,000
1) Collection Sewer	53,800
(1) Secondary & Tertiary	20,590
(2) Main Sewer	18,365
(3) Conveyance Sewer	11,558
(4) Force Main	1,992
(5) Booster Pump	1,295
2) Treatment Plant	12,200
(1) Inflow Pump	7,100
(2) Aerated Lagoon	4,200
(3) Other Facilities	900
(B) Land Acquisition Cost	500
(C) Administration Cost	1,320
(D) Engineering Cost	7,920
(E) Physical Contingency	6,660
Total	82,400

The above direct construction costs are further broken down as shown in Table C.2.7, C.2.8, C.2.9 and C.2.10.

2.6 Estimated O & M Cost

A major portion of the O & M cost of the Project is electric power charge for the operation of aerators and pumps. It will increase according to the increase of wastewater discharge. The electric power charges in 2000 is estimated as follows.

(1) Aerator

The estimated annual electric power charge for the operation of the aerators is as follows.

Aerated Lagoon:

75 kW x 6 x 24 hr. x 365 days x 130 Rp./kWh = 512.5 million Rp.

Facultative/Aerated Lagoon:

22 kW x 6 x 12 hr. x 365 days x 130 Rp./kWh = 75.2 million Rp.

(2) Pump

The pumps will perform an intermittent operation since they are provided with the capacity to meet an hourly peak discharge. The annual electric power charge for the pump operation are estimated as follows.

Inflow pump of treatment plant :

119.5 kW x 24 hr. x 365 days x 0.46* x 130 Rp/KWh = 62.6 million Rp.

Booster pump of force main :

205 kW x 24 hr. x 365 days x 0.37* x 130 Rp/KWh = 86.4 million Rp.

* : Ratio of average discharge to peak discharge

The annual O & M cost in 2000, consisting of sewer maintenance and O & M of the booster pump and sewage treatment plant, is estimated at

Rp.1,194 million at 1992 price. Its break-down is shown in Table C.2.11.

3. Implementation Programme

3.1 Implementation Schedule

The proposed urgent project will be completed within 7 years from 1994 to 2000. The detailed design will be completed within 15 months in the years of 1994 and 1995. The construction works will commenced in 1996 and be completed in 2000 with a net construction period of 60 months.

The proposed implementation schedule is shown in Fig. C.3.1.

3.2 Disbursement Schedule

The proposed disbursement schedule of the project cost is shown in Table C.3.1.

Table C.2.1 Labour Wages

Item No.	Description	Unit	Unit Cost (Rp.)
1	Common labor	Man-day	3,500
2	Semi Skiled labor	Man-day	3,750
3	Mason	Man-day	5,500
4	Concrete worker	Man-day	6,600
5	Steel worker	Man-day	5,500
6	Carpenter	Man-day	7,000
7	Foreman	Man-day	6,600
8	Welder	Man-day	6,000
9	Electrician	Man-day	5,000
10	Plumber	Man-day	5,500
11	Operator	Man-day	6,000
12	Driver (dump truck)	Man-day	6,500
13	Mechanic	Man-day	6,600

Table C.2.2 Fuel and Materials Cost

Item No.	Description	Unit	Unit Cost (Rp.)
1	Gasoline	lit.	550
2	Diesel oil	lit.	340
3	Hydraulic oil	lit.	6,000
4	Lubricant oil	lit.	3,500
5	Grease	kg	9,000
6	Portland cement	bag	8,500
7	Sand for concrete	m3	22,000
8	Sand for others	m3	14,000
9	Sand gravels	m3	19,000
10	Crushed stone for concrete	m3	22,000
11	Broken stone	m3	22,500
12	Brick (Class I)	pc	150
13	Selected soil	m3	8,000
14	Meranti Wood :		
	a. Plank	m3	420,000
	b. Square	m3	305,000
15	Plywood 124 x 244 cm, t = 9 mm	sheet	16,000
16	Plywood 124 x 244 cm, t = 12 mm	sheet	22,500
17	Dolken wood D = 80 mm	m	3,000
18	Reinforced steel bar	kg	1,100
19	Steel materials :		
	a. Sheet pile type II (48 kg/m)	kg	1,750
	b. Sheet pile type III (60 kg/m)	kg	1,750
	c. Sheet pile type VL (105 kg/m)	kg	1,750
	d. H Shape steel	kg	1,750
20	Concrete wire	kg	2,750
21	Nails	kg	2,300
22	Polyvinyl Chloride (PVC) pipes :		
	a. Diametre 150 mm	m	24,250
	b. Diametre 200 mm	m	43,700
	c. Diametre 250 mm	m	74,750
	d. Diametre 300 mm	m	98,550
23	Reinforced Concrete (RC) pipes :		
	(including rubber joint)		
	a. Diameter 350 mm	m	76,000
	b. Diameter 400 mm	m	83,800
	c. Diameter 450 mm	m	101,700
	d. Diameter 500 mm	m	112,600
	e. Diameter 600 mm	m	163,100
	f. Diameter 700 mm	m	189,800
	g. Diameter 800 mm	m	210,700
	h. Diameter 900 mm	m	276,700
	i. Diameter 1000 mm	m	325,900
	j. Diameter 1100 mm	m	383,200
	k. Diameter 1200 mm	m	445,900
	l. Diameter 1350 mm	m	581,800
	m. Diameter 1500 mm	m	765,900

Table C.2.3 Rental Cost of Equipment

Item No.	Description	Capacity	Unit Cost (Rp./day)
1	Concrete mixer	0.1 m 3	60,000
2	Concrete vibrator	dia. 40 mm	40,000
3	Water pump	dia. 75 mm	40,000
4	Excavator / backhoe	0.6 m 3	460,000
5	Bulldozer	11 ton	500,000
6	Crawler crane	16 ton	523,000
7	Dump truck	2 ton	100,000
8	Dump truck	8 ton	135,000
9	Vibro hammer	2.4 ton	840,000
10	Tamping rammer	80 kg	35,000
11	Compressor	3 m3/min	433,000
12	Vibratory compactor	23 ton	483,000
13	Generator set	-	50,000

Table C.2.4 Unit Construction Cost of Pipe by Diameter and by Earth Covering Depth

(Unit : x 1,000 Rp./m)

Earth Covering Depth (m)	ø 150 mm (PVC)	ø 200 mm (PVC)	ø 250 mm (PVC)	ø 300 mm (PVC)	ø 350 mm (RC)	ø 400 mm (RC)	ø 450 mm (RC)	ø 500 mm (RC)	ø 600 mm (RC)
1.5	115.8	147.5	183.6	217.1	223.8	242.3	271.7	297.1	386.1
3.0	200.2	243.6	282.0	317.3	328.3	348.9	380.5	408.2	501.7
5.0	1,709.8	1,762.2	1,816.5	1,868.5	1,924.0	1,962.0	2,013.9	2,060.3	2,196.9
7.0	2,634.8	2,694.5	2,752.4	2,809.9	2,874.9	2,918.7	2,976.9	3,029.3	3,178.0
9.0	4,826.3	4,899.6	4,967.6	5,037.0	5,129.1	5,184.6	5,256.5	5,321.7	5,498.2
10.0	5,336.7	5,412.8	5,481.8	5,553.5	5,647.2	5,705.1	5,779.0	5,845.0	6,026.7

Earth Covering Depth (m)	ø 700 mm (RC)	ø 800 mm (RC)	ø 900 mm (RC)	ø 1000 mm (RC)	ø 1100 mm (RC)	ø 1200 mm (RC)	ø 1350 mm (RC)	ø 1500 mm (RC)
1.5	438.6	474.4	550.5	627.6	763.9	861.3	1,063.6	1,304.5
3.0	955.7	1,004.8	1,093.7	1,187.3	1,286.6	1,384.8	1,621.6	1,880.7
5.0	2,294.7	2,364.5	2,469.2	2,591.8	2,719.7	2,841.0	3,118.0	3,412.6
7.0	3,289.7	3,368.7	3,474.9	3,609.4	3,746.3	3,875.7	4,167.8	4,472.4
9.0	5,644.6	5,742.6	5,861.2	6,021.6	6,182.7	6,331.7	6,666.0	6,999.9
10.0	6,181.1	6,281.0	6,393.9	6,557.7	6,720.3	6,871.3	7,201.0	7,536.6

Note Method : Open Trench
PVC : Polyvinyl Chloride Pipe
RC : Reinforced Concrete Pipe

Table C.2.5 (1) Breakdown of Collection Sewer Unit Cost

(Unit : 1,000Rp./m)

Diameter (mm)		150	200	250	300	350	400	450	500	600
(1) Quantity										
Earth Covering Depth (m)		1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Outside of Diameter (m)		0.16	0.212	0.265	0.318	0.466	0.52	0.584	0.642	0.774
Width of Excavation (m)		0.7	0.85	0.9	1	1.1	1.2	1.3	1.4	1.6
Excavation Depth (m)		1.86	1.912	1.965	2.018	2.166	2.22	2.284	2.342	2.474
Volume of Pavement (m3)		0.504	0.612	0.648	0.72	0.792	0.864	0.936	1.008	1.152
Excavation (Backhoe m3)		1.302	1.6252	1.7685	2.018	2.3826	2.664	2.9692	3.2788	3.9584
Backfill (granular m3)		0.30	0.40	0.45	0.54	0.67	0.77	0.88	1.00	1.25
Backfill (original m3)		0.29	0.36	0.40	0.46	0.59	0.67	0.76	0.86	1.08
Backfill (selected soil m3)		0.21	0.255	0.27	0.3	0.33	0.36	0.39	0.42	0.48
Residual Soil (m3)		1.02	1.27	1.37	1.56	1.79	2.00	2.21	2.42	2.88
Pavement (m2)		1.3	1.45	1.5	1.6	1.7	1.8	1.9	2	2.2
(2) Construction Cost (1,000 Rp./m3)										
	Unit Cost									
Excavation (Backhoe)	4.631	6.0	7.5	8.2	9.3	11.0	12.3	13.8	15.2	18.3
Backfill (granular)	22.088	6.6	8.8	9.9	11.9	14.8	17.0	19.4	22.1	27.6
Backfill (original)	0.868	0.3	0.3	0.3	0.4	0.5	0.6	0.7	0.7	0.9
Backfill (selected soil)	10.168	2.1	2.6	2.7	3.1	3.4	3.7	4.0	4.3	4.9
Residual Soil	2.068	2.1	2.6	2.8	3.2	3.7	4.1	4.6	5.0	6.0
Pavement	45.810	59.6	66.4	68.7	73.3	77.9	82.5	87.0	91.6	100.8
Pipe/Laying	1 ls	24.3	43.7	74.8	98.6	95.2	104.3	123.7	139.2	206.5
Dewatering/Others	1 ls	2.4	3.2	3.8	4.9	4.9	5.4	6.1	6.6	8.7
Total		103.4	135.1	171.2	204.7	211.4	229.9	259.3	284.7	373.7

Table C.2.5 (2) Breakdown of Collection Sewer Unit Cost

(Unit : 1,000Rp./m)

Diameter (mm)		700	800	900	1000	1100	1200	1350	1500
(1) Quantity									
Earth Covering Depth (m)		1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Outside of Diameter (m)		0.88	0.98	1.1	1.22	1.35	1.45	1.65	1.81
Width of Excavation (m)		1.7	1.8	1.9	2.1	2.2	2.4	2.5	2.6
Excavation Depth (m)		2.58	2.68	2.8	2.92	3.05	3.15	3.35	3.51
Volume of Pavement (m3)		1.224	1.296	1.368	1.512	1.584	1.728	1.8	1.872
Excavation (Backhoe m3)		4.386	4.824	5.32	6.132	6.71	7.56	8.375	9.126
Backfill (granular m3)		1.40	1.55	1.71	2.02	2.20	2.55	2.74	2.91
Backfill (original m3)		1.25	1.44	1.67	1.97	2.27	2.56	3.09	3.56
Backfill (selected soil m3)		0.51	0.54	0.57	0.63	0.66	0.72	0.75	0.78
Residual Soil (m3)		3.13	3.39	3.65	4.17	4.44	5.00	5.29	5.56
Pavement (m2)		2.3	2.4	2.5	2.7	2.8	3	3.1	3.2
Retaining Wall (m2)		–	–	–	–	6.1	6.3	6.7	7.02
(2) Construction Cost (1,000 Rp./m3)	Unit Cost								
Excavation (Backhoe)	4.631	20.3	22.3	24.6	28.4	31.1	35.0	38.8	42.3
Backfill (granular)	22.088	30.9	34.2	37.8	44.6	48.6	56.3	60.5	64.3
Backfill (original)	0.868	1.1	1.2	1.4	1.7	2.0	2.2	2.7	3.1
Backfill (selected soil)	10.168	5.2	5.5	5.8	6.4	6.7	7.3	7.6	7.9
Residual Soil	2.068	6.5	7.0	7.5	8.6	9.2	10.3	10.9	11.5
Pavement	45.810	105.4	109.9	114.5	123.7	128.3	137.4	142.0	146.6
Retaining Wall	8.594	0.0	0.0	0.0	0.0	52.4	54.1	57.6	60.3
Pipe/Laying	1 ls	236.8	260.9	335.0	388.3	456.6	526.7	697.2	917.0
Dewatering/Others	1 ls	9.6	10.5	12.4	14.3	17.3	19.5	23.8	29.0
Total		415.8	451.5	539.0	616.0	752.2	848.8	1,041.1	1,282.0

Table C.2.5 (3) Breakdown of Collection Sewer Unit Cost

(Unit : 1,000Rp./m)

Diameter (mm)	Unit Cost	150	200	250	300	350	400	450	500	600
(1) Quantity										
Earth Covering Depth (m)		3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Outside of Diameter (m)		0.16	0.212	0.265	0.318	0.466	0.52	0.584	0.642	0.774
Width of Excavation (m)		0.9	1.05	1.1	1.2	1.3	1.4	1.5	1.6	1.8
Excavation Depth (m)		3.36	3.412	3.465	3.518	3.666	3.72	3.784	3.842	3.974
Volume of Pavement (m3)		0.648	0.756	0.792	0.864	0.936	1.008	1.08	1.152	1.296
Excavation (Backhoe m3)		3.024	3.5826	3.8115	4.2216	4.7658	5.208	5.676	6.1472	7.1532
Backfill (granular m3)		0.39	0.50	0.57	0.66	0.83	0.94	1.06	1.18	1.46
Backfill (original m3)		1.71	2.01	2.12	2.34	2.61	2.84	3.09	3.33	3.85
Backfill (selected soil m3)		0.27	0.315	0.33	0.36	0.39	0.42	0.45	0.48	0.54
Residual Soil (m3)		1.31	1.57	1.69	1.89	2.15	2.36	2.59	2.82	3.30
Pavement (m2)		1.5	1.65	1.7	1.8	1.9	2	2.1	2.2	2.4
Retaining Wall (m2)		6.72	6.824	6.93	7.036	7.332	7.44	7.568	7.684	7.948
(2) Construction Cost (1,000 Rp./m3)										
Excavation (Backhoe)	4.631	14.0	16.6	17.7	19.6	22.1	24.1	26.3	28.5	33.1
Backfill (granular)	22.088	8.6	11.0	12.6	14.6	18.3	20.8	23.4	26.1	32.2
Backfill (original)	0.868	1.5	1.7	1.8	2.0	2.3	2.5	2.7	2.9	3.3
Backfill (selected soil)	10.168	2.7	3.2	3.4	3.7	4.0	4.3	4.6	4.9	5.5
Residual Soil	2.068	2.7	3.2	3.5	3.9	4.4	4.9	5.4	5.8	6.8
Pavement	45.810	68.7	75.6	77.9	82.5	87.0	91.6	96.2	100.8	109.9
Retaining Wall	8.594	57.8	58.6	59.6	60.5	63.0	63.9	65.0	66.0	68.3
Pipe/Laying	1 ls	24.3	43.7	74.8	98.6	95.2	104.3	123.7	139.2	206.5
Dewatering/Others	1 ls	4.5	5.2	5.9	7.1	7.2	7.7	8.4	9.2	11.3
Total		184.8	218.8	257.2	292.5	303.5	324.1	355.7	383.4	476.9

Table C.2.5 (4) Breakdown of Collection Sewer Unit Cost

(Unit : 1,000Rp./m)

Diameter (mm)	Unit Cost	700	800	900	1000	1100	1200	1350	1500
(1) Quantity									
Earth Covering Depth (m)		3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Outer of Diameter (m)		0.88	0.98	1.1	1.22	1.35	1.45	1.65	1.81
Width of Excavation (m)		2.0	2.1	2.2	2.4	2.5	2.6	2.8	2.9
Excavation Depth (m)		4.08	4.18	4.3	4.42	4.55	4.65	4.85	5.01
Sheetpile Length (m)		6.12	6.27	6.45	6.63	6.825	6.975	7.275	7.515
Volume of Pavement (m3)		1.44	1.512	1.584	1.728	1.8	1.872	2.016	2.088
Excavation (Backhoe m3)		8.16	8.778	9.46	10.608	11.375	12.09	13.58	14.529
Backfill (granular m3)		1.75	1.93	2.13	2.48	2.69	2.90	3.32	3.55
Backfill (original m3)		4.37	4.70	5.09	5.68	6.13	6.54	7.40	8.03
Backfill (selected soil m3)		0.6	0.63	0.66	0.72	0.75	0.78	0.84	0.87
Residual Soil (m3)		3.79	4.08	4.37	4.93	5.24	5.55	6.18	6.50
Pavement (m2)		2.6	2.7	2.8	3	3.1	3.2	3.4	3.5
Sheetpile (m)		12.24	12.54	12.9	13.26	13.65	13.95	14.55	15.03
Sheetpile (kg)		587.52	601.92	619.2	636.48	655.2	669.6	698.4	721.44
Bracing (kg)		146.88	150.48	154.8	159.12	163.8	167.4	174.6	180.36
(2) Construction Cost (1,000 Rp./m3)									
Excavation (Backhoe)	4.631	37.8	40.7	43.8	49.1	52.7	56.0	62.9	67.3
Backfill (granular)	22.088	38.7	42.6	47.0	54.8	59.4	64.1	73.3	78.4
Backfill (original)	0.868	3.8	4.1	4.4	4.9	5.3	5.7	6.4	7.0
Backfill (selected soil)	10.168	6.1	6.4	6.7	7.3	7.6	7.9	8.5	8.8
Residual Soil	2.068	7.8	8.4	9.0	10.2	10.8	11.5	12.8	13.4
Pavement	45.810	119.1	123.7	128.3	137.4	142.0	146.6	155.8	160.3
Sheetpile	15.000	183.6	188.1	193.5	198.9	204.8	209.3	218.3	225.5
Sheetpile	0.340	199.8	204.7	210.5	216.4	222.8	227.7	237.5	245.3
Bracing	0.500	73.4	75.2	77.4	79.6	81.9	83.7	87.3	90.2
Pipe/Laying	1 ls	236.8	260.9	335.0	388.3	456.6	526.7	697.2	917.0
Dewatering/Others	1 ls	20.4	21.5	23.8	26.0	28.2	30.4	35.4	41.0
Total		927.3	976.3	1,079.4	1,172.9	1,272.1	1,369.6	1,595.4	1,854.2

Table C.2.5 (5) Breakdown of Collection Sewer Unit Cost

(Unit : 1,000Rp./m)

Diameter (mm)		150	200	250	300	350	400	450	500	600
(1) Quantity										
Earth Covering Depth (m)		5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Outer of Diameter (m)		0.16	0.212	0.265	0.318	0.466	0.52	0.584	0.642	0.774
Width of Excavation (m)		1.0	1.15	1.2	1.3	1.4	1.5	1.6	1.7	1.9
Excavation Depth (m)		5.36	5.412	5.465	5.518	5.666	5.72	5.784	5.842	5.974
Sheetpile Length (m)		8.04	8.118	8.1975	8.277	8.499	8.58	8.676	8.763	8.961
Volume of Pavement (m3)		0.72	0.828	0.864	0.936	1.008	1.08	1.152	1.224	1.368
Excavation (Crum m3)		0.36	0.4738	0.558	0.6734	0.9324	1.08	1.2544	1.4314	1.8506
Excavation (Backhoe m3)		5	5.75	6	6.5	7	7.5	8	8.5	9.5
Backfill (granular m3)		0.44	0.55	0.62	0.72	0.90	1.02	1.15	1.28	1.57
Backfill (original m3)		3.90	4.50	4.71	5.12	5.60	6.03	6.48	6.92	7.84
Backfill (selected soil m3)		0.3	0.345	0.36	0.39	0.42	0.45	0.48	0.51	0.57
Residual Soil (m3)		1.46	1.73	1.85	2.05	2.33	2.55	2.78	3.01	3.51
Pavement (m2)		1.6	1.75	1.8	1.9	2	2.1	2.2	2.3	2.5
Sheetpile Length (m)		40.2	40.59	40.9875	41.385	42.495	42.9	43.38	43.815	44.805
Sheetpile (kg)		1,929.60	1,948.32	1,967.40	1,986.48	2,039.76	2,059.20	2,082.24	2,103.12	2,150.64
Bracing (kg)		482.4	487.08	491.85	496.62	509.94	514.8	520.56	525.78	537.66
(2) Construction Cost (1,000 Rp./m3)	Unit Cost									
Excavation (Crum)	15.914	5.7	7.5	8.9	10.7	14.8	17.2	20.0	22.8	29.5
Excavation (Backhoe)	4.631	23.2	26.6	27.8	30.1	32.4	34.7	37.0	39.4	44.0
Backfill (granular)	22.088	9.7	12.1	13.7	15.9	19.9	22.5	25.4	28.3	34.7
Backfill (original)	0.868	3.4	3.9	4.1	4.4	4.9	5.2	5.6	6.0	6.8
Backfill (selected soil)	10.168	3.1	3.5	3.7	4.0	4.3	4.6	4.9	5.2	5.8
Residual Soil	2.068	3.0	3.6	3.8	4.2	4.8	5.3	5.7	6.2	7.3
Pavement	45.810	73.3	80.2	82.5	87.0	91.6	96.2	100.8	105.4	114.5
Sheetpile Driving	15.000	603.0	608.9	614.8	620.8	637.4	643.5	650.7	657.2	672.1
Sheetpile (kg)	0.340	656.1	662.4	668.9	675.4	693.5	700.1	708.0	715.1	731.2
Bracing (kg)	0.500	241.2	243.5	245.9	248.3	255.0	257.4	260.3	262.9	268.8
Pipe/Laying	1 ls	24.3	43.7	74.8	98.6	95.2	104.3	123.7	139.2	206.5
Dewatering/Others	1 ls	34.5	35.4	36.7	38.2	39.3	40.1	40.9	41.7	44.8
Total		1,680.5	1,731.3	1,785.6	1,837.6	1,893.1	1,931.1	1,983.0	2,029.4	2,166.0

Table C.2.5 (6) Breakdown of Collection Sewer Unit Cost

(Unit : 1,000Rp./m)

Diameter (mm)		700	800	900	1000	1100	1200	1350	1500
(1) Quantity									
Earth Covering Depth (m)		5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Outer of Diameter (m)		0.88	0.98	1.1	1.22	1.35	1.45	1.65	1.81
Width of Excavation (m)		2.0	2.1	2.2	2.4	2.5	2.6	2.8	2.9
Excavation Depth (m)		6.08	6.18	6.3	6.42	6.55	6.65	6.85	7.01
Sheetpile Length (m)		9.12	9.27	9.45	9.63	9.825	9.975	10.275	10.515
Volume of Pavement (m3)		1.44	1.512	1.584	1.728	1.8	1.872	2.016	2.088
Excavation (Crum m3)		2.16	2.478	2.86	3.408	3.875	4.29	5.18	5.829
Excavation (Backhoe m3)		10.0	10.5	11.0	12.0	12.5	13.0	14.0	14.5
Backfill (granular m3)		1.75	1.93	2.13	2.48	2.69	2.9	3.32	3.55
Backfill (original m3)		8.37	8.90	9.49	10.48	11.13	11.74	13.00	13.83
Backfill (selected soil m3)		0.6	0.63	0.66	0.72	0.75	0.78	0.84	0.87
Residual Soil (m3)		3.79	4.08	4.37	4.93	5.24	5.55	6.18	6.50
Pavement (m2)		2.6	2.7	2.8	3.0	3.1	3.2	3.4	3.5
Sheetpile Length (m)		45.6	46.35	47.25	48.15	49.125	49.875	51.375	52.575
Sheetpile (kg)		2,188.8	2,224.8	2,268.0	2,311.2	2,358.0	2,394.0	2,466.0	2,523.6
Bracing (kg)		547.2	556.2	567	577.8	589.5	598.5	616.5	630.9
(2) Construction Cost (1,000 Rp./m3)									
	Unit Cost								
Excavation (Crum)	15.914	34.4	39.4	45.5	54.2	61.7	68.3	82.4	92.8
Excavation (Backhoe)	4.631	46.3	48.6	50.9	55.6	57.9	60.2	64.8	67.1
Backfill (granular)	22.088	38.7	42.6	47.0	54.8	59.4	64.1	73.3	78.4
Backfill (original)	0.868	7.3	7.7	8.2	9.1	9.7	10.2	11.3	12.0
Backfill (selected soil)	10.168	6.1	6.4	6.7	7.3	7.6	7.9	8.5	8.8
Residual Soil	2.068	7.8	8.4	9.0	10.2	10.8	11.5	12.8	13.4
Pavement	45.810	119.1	123.7	128.3	137.4	142.0	146.6	155.8	160.3
Sheetpile Driving	15.000	684.0	695.3	708.8	722.3	736.9	748.1	770.6	788.6
Lease of Sheetpile (kg)	0.340	744.2	756.4	771.1	785.8	801.7	814.0	838.4	858.0
Bracing (kg)	0.500	273.6	278.1	283.5	288.9	294.8	299.3	308.3	315.5
Pipe/Laying	1 ls	236.8	260.9	335.0	388.3	456.6	526.7	697.2	917.0
Dewatering/Others	1 ls	47.3	47.8	50.5	53.1	55.6	58.2	63.9	70.0
Total		2,245.6	2,315.3	2,444.5	2,567.0	2,694.7	2,815.1	3,087.3	3,381.9

Table C.2.5 (7) Breakdown of Collection Sewer Unit Cost

(Unit : 1,000Rp./m)

Diameter (mm)	Unit Cost	150	200	250	300	350	400	450	500	600
(1) Quantity										
Earth Covering Depth (m)		7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Outer of Diameter (m)		0.16	0.212	0.265	0.318	0.466	0.52	0.584	0.642	0.774
Width of Excavation (m)		1.0	1.15	1.2	1.3	1.4	1.5	1.6	1.7	1.9
Excavation Depth (m)		7.36	7.412	7.465	7.518	7.666	7.72	7.784	7.842	7.974
Sheetpile Length (m)		11.04	11.118	11.1975	11.277	11.499	11.58	11.676	11.763	11.961
Volume of Pavement (m3)		0.72	0.828	0.864	0.936	1.008	1.08	1.152	1.224	1.368
Excavation (Crum m3)		2.36	2.7738	2.958	3.2734	3.7324	4.08	4.4544	4.8314	5.6506
Excavation (Backhoe m3)		5.0	5.75	6.0	6.5	7.0	7.5	8.0	8.5	9.5
Backfill (granular m3)		0.44	0.55	0.62	0.72	0.90	1.02	1.15	1.28	1.57
Backfill (original m3)		5.90	6.80	7.11	7.72	8.40	9.03	9.68	10.32	11.64
Backfill (selected soil m3)		0.3	0.345	0.36	0.39	0.42	0.45	0.48	0.51	0.57
Residual Soil (m3)		1.46	1.73	1.85	2.05	2.33	2.55	2.78	3.01	3.51
Pavement (m2)		1.6	1.75	1.8	1.9	2.0	2.1	2.2	2.3	2.5
Sheetpile Length (m)		55.2	55.59	55.9875	56.385	57.495	57.9	58.38	58.815	59.805
Sheetpile (kg)		3,312.0	3,335.4	3,359.3	3,383.1	3,449.7	3,474.0	3,502.8	3,528.9	3,588.3
Bracing (kg)		828	833.85	839.813	845.775	862.425	868.5	875.7	882.225	897.075
(2) Construction Cost (1,000 Rp./m3)	Unit Cost									
Excavation (Crum)	15.914	37.6	44.1	47.1	52.1	59.4	64.9	70.9	76.9	89.9
Excavation (Backhoe)	4.631	23.2	26.6	27.8	30.1	32.4	34.7	37.0	39.4	44.0
Backfill (granular)	22.088	9.7	12.1	13.7	15.9	19.9	22.5	25.4	28.3	34.7
Backfill (original)	0.868	5.1	5.9	6.2	6.7	7.3	7.8	8.4	9.0	10.1
Backfill (selected soil)	10.168	3.1	3.5	3.7	4.0	4.3	4.6	4.9	5.2	5.8
Residual Soil	2.068	3.0	3.6	3.8	4.2	4.8	5.3	5.7	6.2	7.3
Pavement	45.810	73.3	80.2	82.5	87.0	91.6	96.2	100.8	105.4	114.5
Sheetpile Driving	15.000	828.0	833.9	839.8	845.8	862.4	868.5	875.7	882.2	897.1
Lease of Sheetpile (kg)	0.340	1,126.1	1,134.0	1,142.1	1,150.3	1,172.9	1,181.2	1,191.0	1,199.8	1,220.0
Bracing (kg)	0.500	414.0	416.9	419.9	422.9	431.2	434.3	437.9	441.1	448.5
Pipe/Laying	1 ls	24.3	43.7	74.8	98.6	95.2	104.3	123.7	139.2	206.5
Dewatering/Others	1 ls	51.7	52.7	53.7	55.0	56.2	57.1	58.2	59.3	62.3
Total		2,599.1	2,657.2	2,715.1	2,772.6	2,837.6	2,881.4	2,939.6	2,992.0	3,140.7

Table C.2.5 (8) Breakdown of Collection Sewer Unit Cost

(Unit : 1,000Rp./m)

Diameter (mm)	Unit Cost	700	800	900	1000	1100	1200	1350	1500
(1) Quantity									
Earth Covering Depth (m)		7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Outer of Diameter (m)		0.88	0.98	1.1	1.22	1.35	1.45	1.65	1.81
Width of Excavation (m)		2.0	2.1	2.2	2.4	2.5	2.6	2.8	2.9
Excavation Depth (m)		8.08	8.18	8.3	8.42	8.55	8.65	8.85	9.01
Sheetpile Length (m)		12.12	12.27	12.45	12.63	12.825	12.975	13.275	13.515
Volume of Pavement (m3)		1.44	1.512	1.584	1.728	1.8	1.872	2.016	2.088
Excavation (Crum m3)		6.16	6.678	7.26	8.208	8.875	9.49	10.78	11.629
Excavation (Backhoe m3)		10.0	10.5	11.0	12.0	12.5	13.0	14.0	14.5
Backfill (granular m3)		1.75	1.93	2.13	2.48	2.69	2.90	3.32	3.55
Backfill (original m3)		12.37	13.10	13.89	15.28	16.13	16.94	18.60	19.63
Backfill (selected soil m3)		0.6	0.63	0.66	0.72	0.75	0.78	0.84	0.87
Residual Soil (m3)		3.79	4.08	4.37	4.93	5.24	5.55	6.18	6.50
Pavement (m2)		2.6	2.7	2.8	3	3.1	3.2	3.4	3.5
Sheetpile Length (m)		60.6	61.35	62.25	63.15	64.125	64.875	66.375	67.575
Sheetpile (kg)		3,636.0	3,681.0	3,735.0	3,789.0	3,847.5	3,892.5	3,982.5	4,054.5
Bracing (kg)		909.0	920.3	933.8	947.3	961.9	973.1	995.6	1,013.6
(2) Construction Cost (1,000 Rp./m3)	Unit Cost								
Excavation (Crum)	15.914	98.0	106.3	115.5	130.6	141.2	151.0	171.6	185.1
Excavation (Backhoe)	4.631	46.3	48.6	50.9	55.6	57.9	60.2	64.8	67.1
Backfill (granular)	22.088	38.7	42.6	47.0	54.8	59.4	64.1	73.3	78.4
Backfill (original)	0.868	10.7	11.4	12.1	13.3	14.0	14.7	16.1	17.0
Backfill (selected soil)	10.168	6.1	6.4	6.7	7.3	7.6	7.9	8.5	8.8
Residual Soil	2.068	7.8	8.4	9.0	10.2	10.8	11.5	12.8	13.4
Pavement	45.810	119.1	123.7	128.3	137.4	142.0	146.6	155.8	160.3
Sheetpile Driving	15.000	909.0	920.3	933.8	947.3	961.9	973.1	995.6	1,013.6
Lease of Sheetpile (kg)	0.340	1,236.2	1,251.5	1,269.9	1,288.3	1,308.2	1,323.5	1,354.1	1,378.5
Bracing (kg)	0.500	454.5	460.1	466.9	473.6	480.9	486.6	497.8	506.8
Pipe/Laying	1 ls	236.8	260.9	335.0	388.3	456.6	526.7	697.2	917.0
Dewatering/Others	1 ls	64.1	65.8	68.4	71.1	73.9	76.5	82.4	88.6
Total		3,227.3	3,306.0	3,443.5	3,577.8	3,714.4	3,842.4	4,130.0	4,434.6

Table C.2.5 (9) Breakdown of Collection Sewer Unit Cost

(Unit : 1,000Rp./m)

Diameter (mm)		150	200	250	300	350	400	450	500	600
(1) Quantity										
Earth Covering Depth (m)		9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Outer of Diameter (m)		0.16	0.212	0.265	0.318	0.466	0.52	0.584	0.642	0.774
Width of Excavation (m)		1.0	1.15	1.2	1.3	1.4	1.5	1.6	1.7	1.9
Excavation Depth (m)		9.36	9.412	9.465	9.518	9.666	9.72	9.784	9.842	9.974
Sheetpile Length (m)		14.0	14.1	14.2	14.3	14.5	14.6	14.7	14.8	15.0
Volume of Pavement (m3)		0.72	0.828	0.864	0.936	1.008	1.08	1.152	1.224	1.368
Excavation (Crum m3)		4.36	5.0738	5.358	5.8734	6.5324	7.08	7.6544	8.2314	9.4506
Excavation (Backhoe m3)		5.0	5.75	6.0	6.5	7.0	7.5	8.0	8.5	9.5
Backfill (granular m3)		0.44	0.55	0.62	0.72	0.90	1.02	1.15	1.28	1.57
Backfill (original m3)		7.90	9.10	9.51	10.32	11.20	12.03	12.88	13.72	15.44
Backfill (selected soil m3)		0.3	0.345	0.36	0.39	0.42	0.45	0.48	0.51	0.57
Residual Soil (m3)		1.46	1.73	1.85	2.05	2.33	2.55	2.78	3.01	3.51
Pavement (m2)		1.6	1.75	1.8	1.9	2.0	2.1	2.2	2.3	2.5
Sheetpile Length (m)		70.2	70.59	70.9875	71.385	72.495	72.9	73.38	73.815	74.805
Weight of Sheetpile (kg)		7,371.0	7,412.0	7,453.7	7,495.4	7,612.0	7,654.5	7,704.9	7,750.6	7,854.5
Bracing (kg)		1,842.8	1,853.0	1,863.4	1,873.9	1,903.0	1,913.6	1,926.2	1,937.6	1,963.6
(2) Construction Cost (1,000 Rp./m3)	Unit Cost									
Excavation (Crum)	15.914	69.4	80.7	85.3	93.5	104.0	112.7	121.8	131.0	150.4
Excavation (Backhoe)	4.631	23.2	26.6	27.8	30.1	32.4	34.7	37.0	39.4	44.0
Backfill (granular)	22.088	9.7	12.1	13.7	15.9	19.9	22.5	25.4	28.3	34.7
Backfill (original)	0.868	6.9	7.9	8.3	9.0	9.7	10.4	11.2	11.9	13.4
Backfill (selected soil)	10.168	3.1	3.5	3.7	4.0	4.3	4.6	4.9	5.2	5.8
Residual Soil	2.068	3.0	3.6	3.8	4.2	4.8	5.3	5.7	6.2	7.3
Pavement	45.810	73.3	80.2	82.5	87.0	91.6	96.2	100.8	105.4	114.5
Sheetpile Driving	15.000	1,053.0	1,058.9	1,064.8	1,070.8	1,087.4	1,093.5	1,100.7	1,107.2	1,122.1
Lease of Sheetpile (kg)	0.340	2,506.1	2,520.1	2,534.3	2,548.4	2,588.1	2,602.5	2,619.7	2,635.2	2,670.5
Bracing (kg)	0.500	921.4	926.5	931.7	936.9	951.5	956.8	963.1	968.8	981.8
Pipe/Laying	1 ls	24.3	43.7	74.8	98.6	95.2	104.3	123.7	139.2	206.5
Dewatering/Others	1 ls	90.8	92.1	93.2	94.9	96.5	97.4	98.8	100.2	103.5
Total		4,784.2	4,855.9	4,923.9	4,993.3	5,085.4	5,140.9	5,212.8	5,278.0	5,454.5

Table C.2.5 (10) Breakdown of Collection Sewer Unit Cost

(Unit : 1,000Rp./m)

Diameter (mm)		700	800	900	1000	1100	1200	1350	1500
(1) Quantity									
Earth Covering Depth (m)		9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Outer of Diameter (m)		0.88	0.98	1.1	1.22	1.35	1.45	1.65	1.81
Width of Excavation (m)		2.0	2.1	2.2	2.4	2.5	2.6	2.8	2.9
Excavation Depth (m)		10.08	10.18	10.3	10.42	10.55	10.65	10.85	11.01
Sheetpile Length (m)		15.1	15.3	15.5	15.6	15.8	16.0	16.3	16.5
Volume of Pavement (m3)		1.44	1.512	1.584	1.728	1.8	1.872	2.016	2.088
Excavation (Crum m3)		10.16	10.878	11.66	13.008	13.875	14.69	16.38	17.429
Excavation (Backhoe m3)		10.0	10.5	11.0	12.0	12.5	13.0	14.0	14.5
Backfill (granular m3)		1.75	1.93	2.13	2.48	2.69	2.90	3.32	3.55
Backfill (original m3)		16.37	17.30	18.29	20.08	21.13	22.14	24.20	25.43
Backfill (selected soil m3)		0.6	0.63	0.66	0.72	0.75	0.78	0.84	0.87
Residual Soil (m3)		3.79	4.08	4.37	4.93	5.24	5.55	6.18	6.50
Pavement (m2)		2.6	2.7	2.8	3.0	3.1	3.2	3.4	3.5
Sheetpile Length (m)		75.6	76.35	77.25	78.15	79.125	79.875	81.375	82.575
Weight of Sheetpile (kg)		7,938.0	8,016.8	8,111.3	8,205.8	8,308.1	8,386.9	8,544.4	8,670.4
Bracing (kg)		1,984.5	2,004.2	2,027.8	2,051.4	2,077.0	2,096.7	2,136.1	2,167.6
(2) Construction Cost (1,000 Rp./m3)	Unit Cost								
Excavation (Crum)	15.914	161.7	173.1	185.6	207.0	220.8	233.8	260.7	277.4
Excavation (Backhoe)	4.631	46.3	48.6	50.9	55.6	57.9	60.2	64.8	67.1
Backfill (granular)	22.088	38.7	42.6	47.0	54.8	59.4	64.1	73.3	78.4
Backfill (original)	0.868	14.2	15.0	15.9	17.4	18.3	19.2	21.0	22.1
Backfill (selected soil)	10.168	6.1	6.4	6.7	7.3	7.6	7.9	8.5	8.8
Residual Soil	2.068	7.8	8.4	9.0	10.2	10.8	11.5	12.8	13.4
Pavement	45.810	119.1	123.7	128.3	137.4	142.0	146.6	155.8	160.3
Sheetpile Driving	15.000	1,134.0	1,145.3	1,158.8	1,172.3	1,186.9	1,198.1	1,220.6	1,238.6
Lease of Sheetpile (kg)	0.340	2,698.9	2,725.7	2,757.8	2,790.0	2,824.8	2,851.5	2,905.1	2,947.9
Bracing (kg)	0.500	992.3	1,002.1	1,013.9	1,025.7	1,038.5	1,048.4	1,068.0	1,083.8
Pipe/Laying	1 ls	236.8	260.9	335.0	388.3	456.6	526.7	697.2	917.0
Dewatering/Others	1 ls	105.5	107.4	110.4	113.6	116.8	119.7	126.0	132.9
Total		5,561.4	5,659.2	5,819.3	5,979.6	6,140.4	6,287.7	6,613.8	6,947.7

Table C.2.5 (11) Breakdown of Collection Sewer Unit Cost

(Unit : 1,000Rp./m)

Diameter (mm)	Unit Cost	150	200	250	300	350	400	450	500	600
(1) Quantity										
Earth Covering Depth (m)		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Outer of Diameter (m)		0.16	0.212	0.265	0.318	0.466	0.52	0.584	0.642	0.774
Width of Excavation (m)		1.0	1.15	1.2	1.3	1.4	1.5	1.6	1.7	1.9
Excavation Depth (m)		10.36	10.412	10.465	10.518	10.666	10.72	10.784	10.842	10.974
Sheetpile Length (m)		15.5	15.6	15.7	15.8	16.0	16.1	16.2	16.3	16.5
Volume of Pavement (m3)		0.72	0.828	0.864	0.936	1.008	1.08	1.152	1.224	1.368
Excavation (Crum m3)		5.36	6.2238	6.558	7.1734	7.9324	8.58	9.2544	9.9314	11.3506
Excavation (Backhoe m3)		5.0	5.75	6.0	6.5	7.0	7.5	8.0	8.5	9.5
Backfill (granular m3)		0.44	0.55	0.62	0.72	0.90	1.02	1.15	1.28	1.57
Backfill (original m3)		8.90	10.25	10.71	11.62	12.60	13.53	14.48	15.42	17.34
Backfill (selected soil m3)		0.3	0.345	0.36	0.39	0.42	0.45	0.48	0.51	0.57
Residual Soil (m3)		1.46	1.73	1.85	2.05	2.33	2.55	2.78	3.01	3.51
Pavement (m2)		1.6	1.75	1.8	1.9	2.0	2.1	2.2	2.3	2.5
Sheetpile Length (m)		77.7	78.09	78.4875	78.885	79.995	80.4	80.88	81.315	82.305
Sheetpile (kg)		8,158.5	8,199.5	8,241.2	8,282.9	8,399.5	8,442.0	8,492.4	8,538.1	8,642.0
Bracing (kg)		2,039.6	2,049.9	2,060.3	2,070.7	2,099.9	2,110.5	2,123.1	2,134.5	2,160.5
(2) Construction Cost (1,000 Rp./m3)	Unit Cost									
Excavation (Crum)	15.914	85.3	99.0	104.4	114.2	126.2	136.5	147.3	158.0	180.6
Excavation (Backhoe)	4.631	23.2	26.6	27.8	30.1	32.4	34.7	37.0	39.4	44.0
Backfill (granular)	22.088	9.7	12.1	13.7	15.9	19.9	22.5	25.4	28.3	34.7
Backfill (original)	0.868	7.7	8.9	9.3	10.1	10.9	11.7	12.6	13.4	15.1
Backfill (selected soil)	10.168	3.1	3.5	3.7	4.0	4.3	4.6	4.9	5.2	5.8
Residual Soil	2.068	3.0	3.6	3.8	4.2	4.8	5.3	5.7	6.2	7.3
Pavement	45.810	73.3	80.2	82.5	87.0	91.6	96.2	100.8	105.4	114.5
Sheetpile Driving	15.000	1,165.5	1,171.4	1,177.3	1,183.3	1,199.9	1,206.0	1,213.2	1,219.7	1,234.6
Lease of Sheetpile (kg)	0.340	2,773.9	2,787.8	2,802.0	2,816.2	2,855.8	2,870.3	2,887.4	2,902.9	2,938.3
Bracing (kg)	0.500	1,019.8	1,024.9	1,030.1	1,035.4	1,049.9	1,055.3	1,061.6	1,067.3	1,080.3
Pipe/Laying	1 ls	24.3	43.7	74.8	98.6	95.2	104.3	123.7	139.2	206.5
Dewatering/Others	1 ls	102.6	104.2	105.5	107.6	109.4	110.8	112.5	113.9	118.1
Total		5,291.4	5,365.9	5,434.9	5,506.6	5,600.3	5,658.2	5,732.1	5,798.9	5,979.8

Table C.2.5 (12) Breakdown of Collection Sewer Unit Cost

(Unit: 1,000Rp./m)

Diameter (mm)	Unit Cost	700	800	900	1000	1100	1200	1350	1500
(1) Quantity									
Earth Covering Depth (m)		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Outer of Diameter (m)		0.88	0.98	1.1	1.22	1.35	1.45	1.65	1.81
Width of Excavation (m)		2.0	2.1	2.2	2.4	2.5	2.6	2.8	2.9
Excavation Depth (m)		11.08	11.18	11.3	11.42	11.55	11.65	11.85	12.01
Sheetpile Length (m)		16.6	16.8	17.0	17.1	17.3	17.5	17.8	18.0
Volume of Pavement (m3)		1.44	1.512	1.584	1.728	1.8	1.872	2.016	2.088
Excavation (Crum m3)		12.16	12.978	13.86	15.408	16.375	17.29	19.18	20.329
Excavation (Backhoe m3)		10.0	10.5	11.0	12.0	12.5	13.0	14.0	14.5
Backfill (granular m3)		1.75	1.93	2.13	2.48	2.69	2.90	3.32	3.55
Backfill (original m3)		18.37	19.40	20.49	22.48	23.63	24.74	27.00	28.33
Backfill (selected soil m3)		0.6	0.63	0.66	0.72	0.75	0.78	0.84	0.87
Residual Soil (m3)		3.79	4.08	4.37	4.93	5.24	5.55	6.18	6.50
Pavement (m2)		2.6	2.7	2.8	3.0	3.1	3.2	3.4	3.5
Sheetpile Length (m)		83.1	83.85	84.75	85.65	86.625	87.375	88.875	90.075
Weight of Sheetpile (kg)		8,725.5	8,804.3	8,898.8	8,993.3	9,095.6	9,174.4	9,331.9	9,457.9
Bracing (kg)		2,181.4	2,201.1	2,224.7	2,248.3	2,273.9	2,293.6	2,333.0	2,364.5
(2) Construction Cost (1,000 Rp./m3)	Unit Cost								
Excavation (Crum)	15.914	193.5	206.5	220.6	245.2	260.6	275.2	305.2	323.5
Excavation (Backhoe)	4.631	46.3	48.6	50.9	55.6	57.9	60.2	64.8	67.1
Backfill (granular)	22.088	38.7	42.6	47.0	54.8	59.4	64.1	73.3	78.4
Backfill (original)	0.868	15.9	16.8	17.8	19.5	20.5	21.5	23.4	24.6
Backfill (selected soil)	10.168	6.1	6.4	6.7	7.3	7.6	7.9	8.5	8.8
Residual Soil	2.068	7.8	8.4	9.0	10.2	10.8	11.5	12.8	13.4
Pavement	45.810	119.1	123.7	128.3	137.4	142.0	146.6	155.8	160.3
Sheetpile Driving	15.000	1,246.5	1,257.8	1,271.3	1,284.8	1,299.4	1,310.6	1,333.1	1,351.1
Lease of Sheetpile (kg)	0.340	2,966.7	2,993.4	3,025.6	3,057.7	3,092.5	3,119.3	3,172.8	3,215.7
Bracing (kg)	0.500	1,090.7	1,100.5	1,112.3	1,124.2	1,137.0	1,146.8	1,166.5	1,182.2
Pipe/Laying	1 ls	236.8	260.9	335.0	388.3	456.6	526.7	697.2	917.0
Dewatering/Others	1 ls	114.8	116.9	120.0	123.1	126.1	129.0	135.4	142.3
Total		6,082.9	6,182.5	6,344.5	6,508.1	6,670.4	6,819.4	7,148.8	7,484.4

Table C.2.6 (1) Unit Construction Cost of Manhole by Diameter and by Manhole Height

Manhole Height	Unit Cost (x 1,000 Rp.)	Remarks
2.0 m	1,239	Type 1 : Sewer Diameter 150 mm ~ 600 mm
2.5 m	1,403	" Manhole Height 2.0 m ~ 7.5 m
3.0 m	1,538	"
3.5 m	2,478	Type 2 :
4.0 m	2,611	"
4.5 m	2,772	"
5.0 m	2,932	"
5.5 m	3,092	"
6.0 m	3,253	"
6.5 m	3,413	"
7.0 m	3,574	"
7.5 m	3,734	"

Table C.2.6 (2) Unit Construction Cost of Manhole by Diameter and by Manhole Height

Manhole Hight	700 mm	800 mm	900 mm	1,000 mm	1,100 mm	1,200 mm
4.0 m	4,560	4,575	4,600	4,624	4,686	4,984
6.0 m	5,670	5,693	5,717	5,743	5,803	6,092
8.0 m	6,814	6,838	6,862	6,887	6,947	7,236
10.0 m	9,820	9,849	9,881	9,912	9,989	10,371

Table C.2.6 (3) Unit Construction Cost of Manhole by Diameter and by Manhole Height

Manhole Height	Unit Cost (x 1,000 Rp.)	Remarks
3.0 m	4,495	Sewer Diameter 1,350 mm ~ 1,500 mm
4.0 m	5,036	Manhole Height 3.0 m ~ 10.0 m
4.5 m	5,291	
6.0 m	6,145	
6.5 m	6,408	
8.0 m	7,289	
8.5 m	7,553	
10.0 m	10,436	

Table C.2.7 Construction Cost of Collection Sewer

(Unit : million Rp.)

	Denpasar Area		Sanur Area		Total	
	Q'ty	Cost	Q'ty	Cost	Q'ty	Cost
Secondary & Tertiary	126,020 m	16,933.4	32,720 m	3,656.4	158,740 m	20,590
Maim						
- Normal Main	13,690 m	13,737.1	4,310 m	4,221.6	18,000 m	17,959
- Inverse Siphon	80 m	406.4	-	-	80 m	406
Conveyance	4,390 m	11,557.5	-	-	4,390 m	11,558
Force Main	-	-	5,160 m	1,992.0	5,160 m	1,992
Booster Pump	-	-	17.5 m3/min.	1,295.0	17.5 m3/min.	1,295
Total		42,634.4		11,166.0		53,800

Table C.2.8 Construction Cost by Diameter and by Earth Covering Depth for Denpasar in Urgent Works

(Secondary/Tertiary)

Diameter (mm)	Pipe Length (m)	Unit Cost (Million Rp. /m)	Construction Cost (Million Rp.)
150	77,300	0.1158	8,951.3
200	30,600	0.1475	4,513.5
250	9,300	0.1836	1,707.5
300	8,820	0.2171	1,761.1
Total of Secondary /Tertiary	126,020		16,933.4

(Main)

Diameter (mm)	Earth Covering Depth (m)	Pipe Length (m)	Unit Cost (Million Rp./m)	Construction Cost (Million Rp.)
350	0 - 2 (1.5 m)	750	0.2238	167.9
	2 - 4 (3.0 m)	280	0.3283	91.9
	sub-total	1,030		259.8
450	0 - 2 (1.5 m)	340	0.2717	92.4
	sub-total	340		92.4
500	0 - 2 (1.5 m)	860	0.2971	255.5
	sub-total	860		255.5
600	0 - 2 (1.5 m)	920	0.3861	355.2
	2 - 4 (3.0 m)	750	0.5017	376.3
	4 - 6 (5.0 m)	120	2.1969	263.6
	sub-total	1,790		995.1
700	0 - 2 (1.5 m)	2,280	0.4386	1,000.0
	2 - 4 (3.0 m)	360	0.9557	344.1
	4 - 6 (5.0 m)	40	2.2947	91.8
	sub-total	2,680		1,435.9
800	0 - 2 (1.5 m)	1,390	0.4744	659.4
	2 - 4 (3.0 m)	970	1.0048	974.7
	sub-total	2,360		1,634.1
900	0 - 2 (1.5 m)	1,480	0.5505	814.7
	2 - 4 (3.0 m)	330	1.0937	360.9
	sub-total	1,810		1,175.6
1,000	2 - 4 (3.0 m)	540	1.1873	641.1
	4 - 6 (5.0 m)	1,300	2.5918	3,772.7
	sub-total	1,840		4,413.8
1,100	0 - 2 (1.5 m)	580	0.7639	443.1
	2 - 4 (3.0 m)	500	1.2866	643.3
	sub-total	1,080		1,086.4
1,500	2 - 4 (3.0 m)	1,270	1.8807	2,388.5
	sub-total	1,270		2,388.5
Total of Main		15,060		13,737.1

(Conveyance)

Diameter (mm)	Earth Covering Depth (m)	Pipe Length (m)	Unit Cost (Million Rp./m)	Construction Cost (Million Rp.)
1,500	2 - 4 (3.0 m)	1,980	1.8807	3,723.8
	4 - 6 (5.0 m)	1,060	3.4126	3,617.4
	sub-total	3,040		7,341.2
1,800	2 - 4 (3.0 m)	740	2.3989	1,775.2
	4 - 6 (5.0 m)	610	4.0018	2,441.1
	sub-total	1,350		4,216.3
Total of Conveyance		4,390		11,557.5

(Siphon)

Diameter (mm)	Earth Covering Depth (m)	Pipe Length (m)	Unit Cost (Million Rp./m)	Construction Cost (Million Rp.)
350 x 2	6 - 8 (7.0 m)	40	5.06	202.4
400 x 2	4 - 6 (5.0 m)	40	5.1	204.0
Total of Siphon		80		406.4

GRAND TOTAL (Million Rp.) 42,634.4

Table C.2.9 Construction Cost by Diameter and by Earth Covering Depth for Sanur in Urgent Works

(Secondary/Tertiary)

Diameter (mm)	Pipe Length (m)	Unit Cost (Million Rp. /m)	Construction Cost (Million Rp.)
150	16,700	0.1158	1,533.9
200	12,220	0.1475	1,364.5
250	2,000	0.1836	367.2
300	1,800	0.2171	390.8
Total of Secondary /Tertiary	32,720		3,656.4

(Main)

Diameter (mm)	Earth Covering Depth (m)	Pipe Length (m)	Unit Cost (Million Rp./m)	Construction Cost (Million Rp.)
350	0 - 2 (1.5 m)	770	0.2238	172.3
	2 - 4 (3.0 m)	230	0.3283	75.5
	sub-total	1,000		247.8
400	0 - 2 (1.5 m)	150	0.2423	36.3
	sub-total	150		36.3
500	0 - 2 (1.5 m)	350	0.2971	104.0
	sub-total	350		104.0
600	0 - 2 (1.5 m)	580	0.3861	223.9
	2 - 4 (3.0 m)	720	0.5017	361.2
	sub-total	1,300		585.1
700	2 - 4 (3.0 m)	250	0.9557	238.9
	4 - 6 (5.0 m)	1,150	2.2947	2,638.9
	sub-total	1,400		2,877.8
800	6 - 8 (7.0 m)	110	3.3687	370.6
	sub-total	110		370.6
Total of Main		4,310		4,221.6

(Force Main)

Diameter (mm)	Earth Covering Depth (m)	Pipe Length (m)	Unit Cost (Million Rp./m)	Construction Cost (Million Rp.)
500	0 - 2 (1.5 m)	5,160	0.3861	1,992.3
Total of Force Main		5,160		1,992.3

GRAND TOTAL (Million Rp.) 9,870.3

Table C.2.10 Construction Cost of Treatment Plant

	Work Item	Quantity	Unit Cost	Const. Cost (million Rp.)
1.	Pump Station			7,100
	Civil/Architecture	1 ls.		4,364
	Mech./Elect. Equipment	66.0m^3/min.		2,632
	Miscellaneous Works	1 ls.		104
2.	Aerated Lagoon			4,200
	Excavation	89,000 m^3	7,000 Rp./m^3	623
	Embankment			
	Excavated Soil	89,000 m^3	8,300 Rp./m^3	739
	Transported Soil	14,000 m^3	29,000 Rp./m^3	406
	Slope Protection (Wet Masonry)	18,000 m^2	46,000 Rp./m^2	828
	Bed Protection (Cobble Stone)	19,000 m^2	12,000 Rp./m^2	228
	Drying Bed	4,900 m^2	20,000 Rp./m^2	98
	Aerator			
	Aerated Lagoon	75 KW x 6 units	2.0 million Rp./KW	900
	Facultative Aerated Lagoon	22 KW x 6 units	2.0 million Rp./KW	264
	Ancillaries			114
3.	Other Facilities & Equipments			900
	Control Building	500 m^2	200,000 Rp./m^2	100
	Access Road	1 ls.		50
	Drainage & Utilities	1 ls.		500
	Auxiliary Equipments	1 ls.		250
4.	Total			12,200

Table C.2.11 Breakdown of O & M Cost

Item / Year	2000 Q'ty	2000 Unit Cost	2000 Cost (million Rp)	Remarks
(1) Sewer pipe				
Secondary/tertiary	158,740 m	300 Rp./m	48	
Main	19,370 m	300 Rp./m	6	
Conveyance	4,390 m	300/Rp./m	1	
Inverse Siphon/Force Main	5,240 m	300 Rp./m	2	
Sub-total			57	
(2) Booster pump				
Electricity	664,446 Kwh	130 Rp./Kwh	86	
Repairing	1 ls.		10	Cons.Cost x 0.5%
Personnel Expenditure	1 ls.		7	2,400,000 Rp x 3 Persons
Sub-total			103	
(3) Treatment Plant				
Electricity				
Aerator	4,520,160 Kwh	130 Rp./Kwh	663	
Inflow pump	481,537 Kwh	130 Rp./Kwh	63	
Others	1 ls.		10	
Chemicals	1 ls.		51	
Repairing	1 ls.		38	Const.Cost x 0.5%
Personnel expenditure	1 ls.		24	2,400,000 Rp x 10 Persons
Sub-total			849	
(4) Overhead			185	2,400,000 Rp x 77 Persons
Total			1,194	

Table C.3.1 Disbursement Schedule of Urgent Project Cost

	1994	1995	1996	1997	1998	1999	2000	Total
(A) Direct Construction Cost			16,414	19,560	14,667	7,730	7,629	66,000
1) Collection Sewer								
(1) Denpasar								
Secondary & Tertiary			3,400	3,400	3,400	3,400	3,333	16,933
Main Sewer			2,750	2,750	3,156	2,750	2,737	14,143
Conveyance Sewer			3,850	3,850	3,858			11,558
(2) Sanur								
Secondary & Tertiary			730	730	730	730	737	3,657
Main Sewer			850	850	850	850	822	4,222
Force Main				996	996			1,992
Booster/Lift Pump Civil				518				518
Booster/Lift Pump Mech					777			777
2) Treatent Plant								
Inflow Pump Civil			2,500	1,968				4,468
Inflow Pump Mech.			816	1,816				2,632
Aerated Lagoon Civil			1,518	1,518				3,036
Aerated Lagoon Mech.				1,164				1,164
Other Facilities					900			900
(B) Land Acquisition		100	400					500
(C) Administration Cost			328	391	293	155	153	1,320
(D) Engineering Cost	1,220	2,900	1,100	1,100	600	600	400	7,920
(E) Physical Contingency			1,640	1,960	1,470	820	770	6,660
Total	1,220	3,000	19,882	23,011	17,030	9,305	8,952	82,400

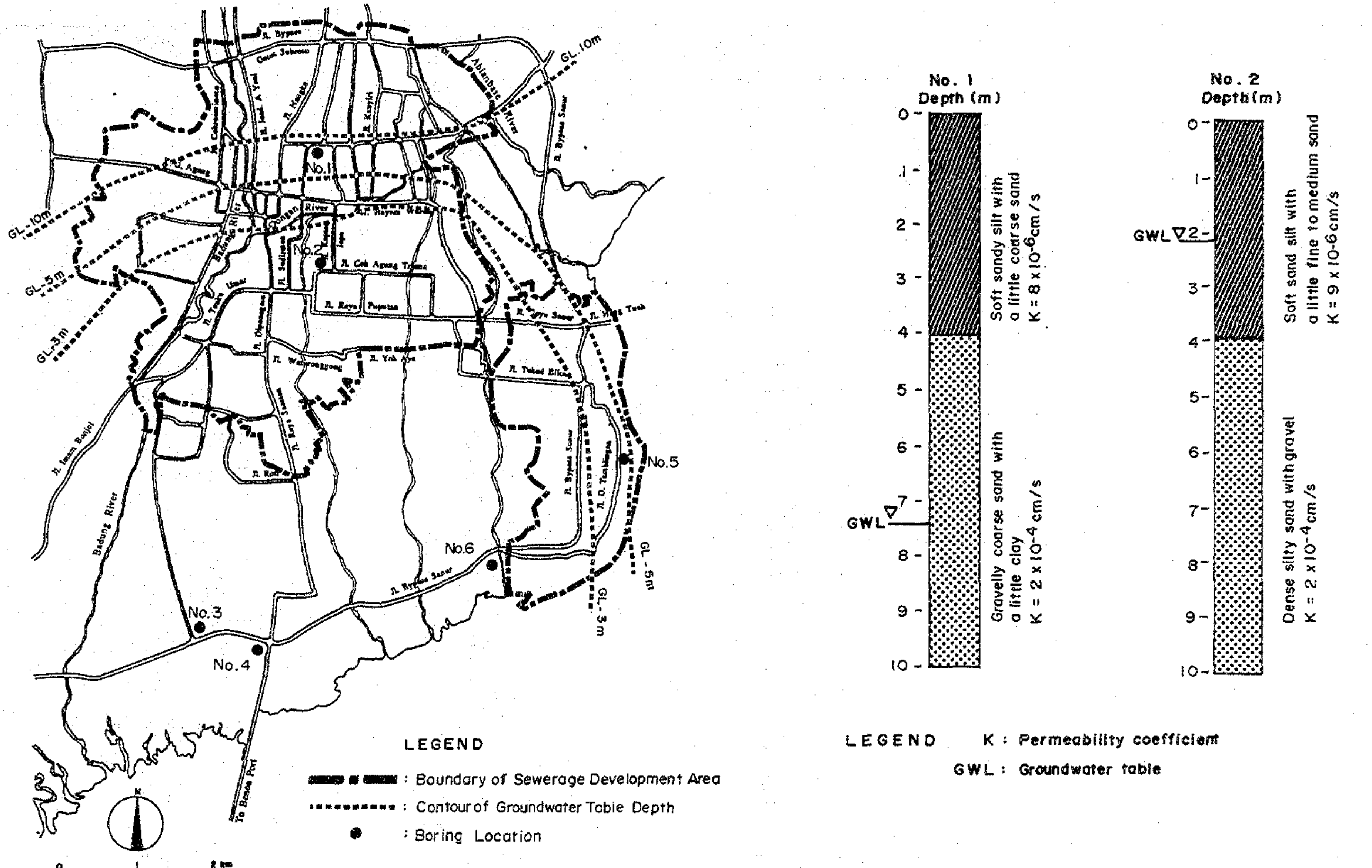
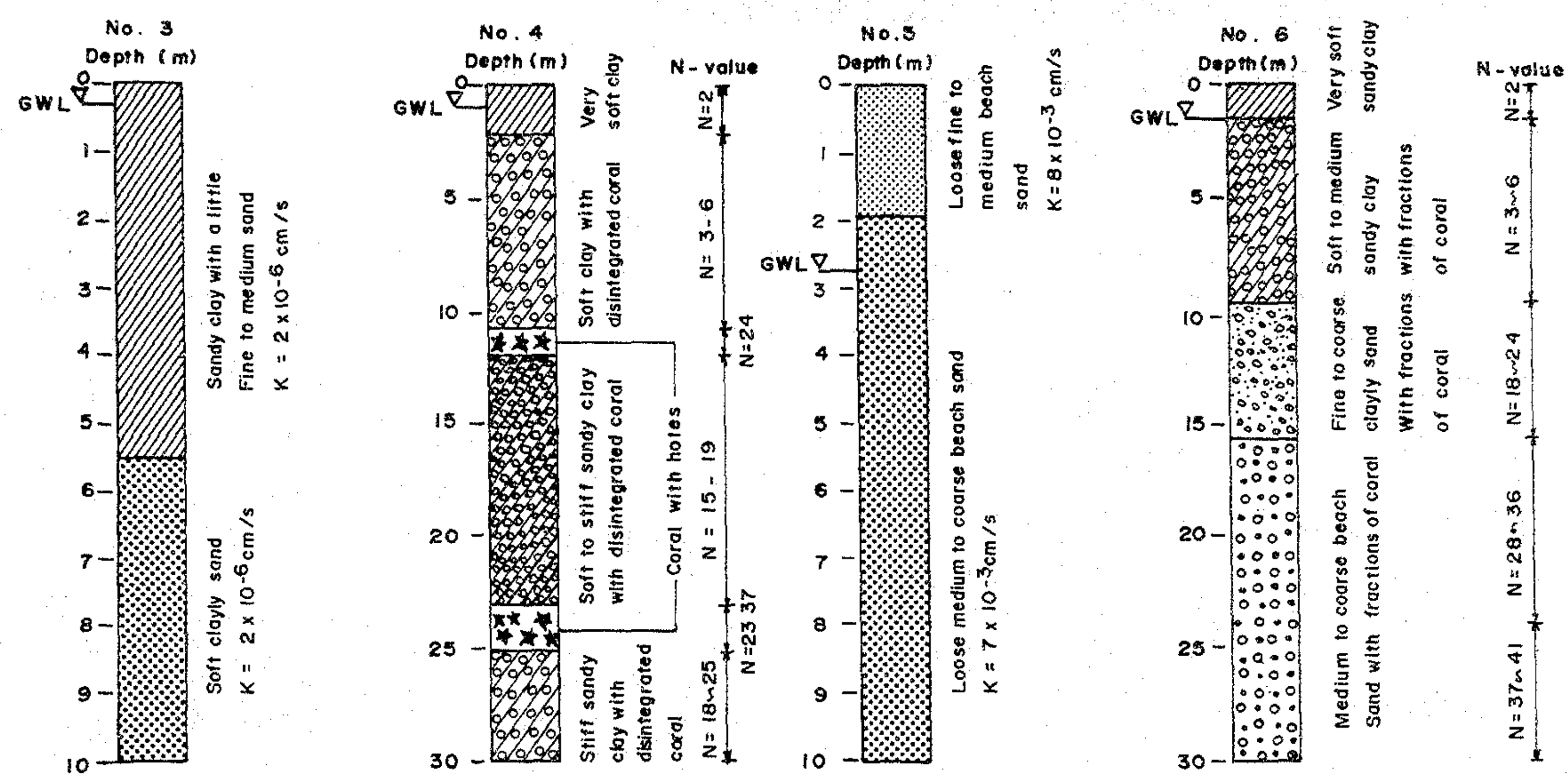


FIG.C.1.1(1) PROFILE OF BORING CORES

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

JICA A.D 1993



LEGEND

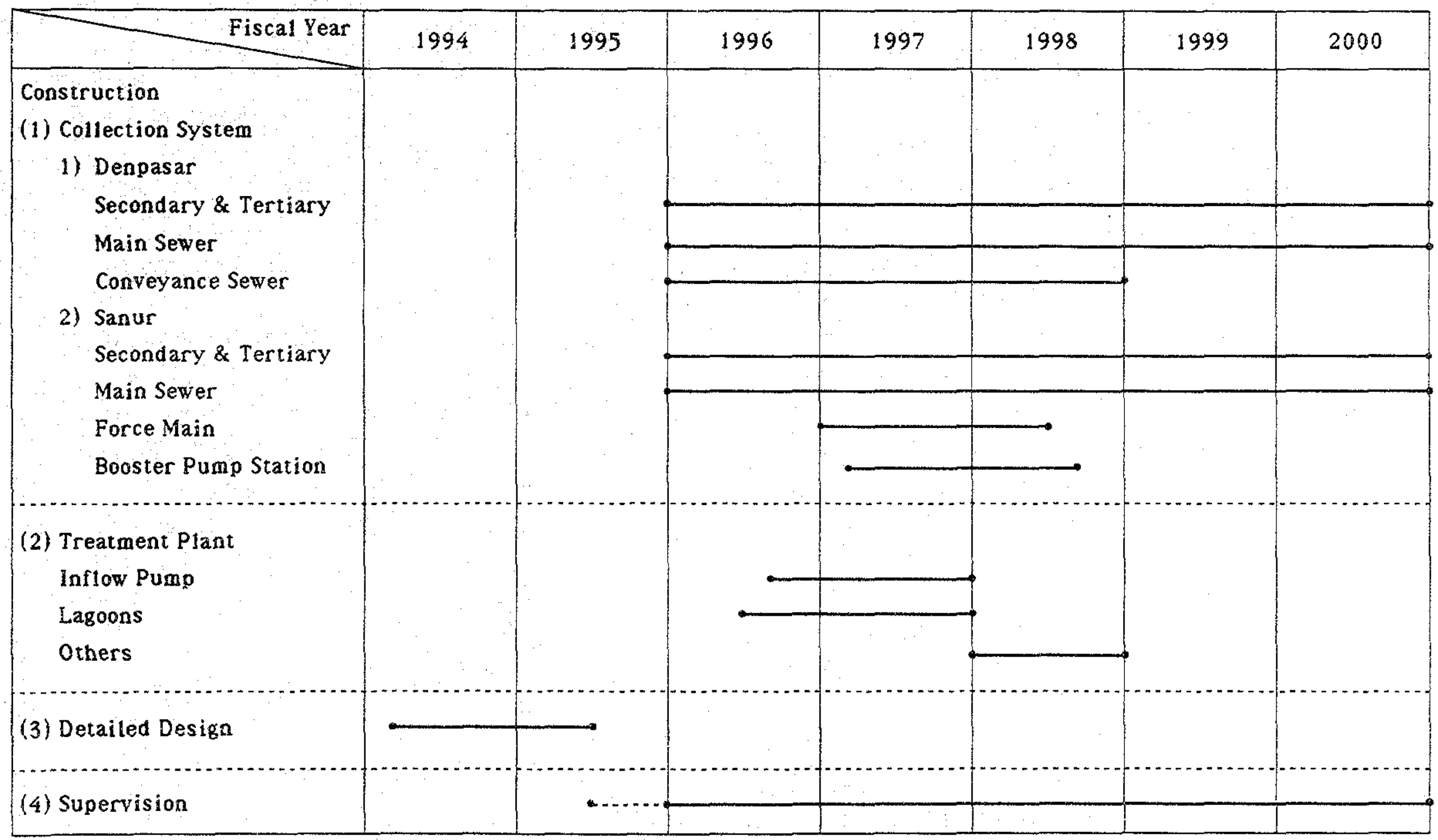
K : Permeability coefficient

GWL : Groundwater table

FIG.C.1.1(2)	PROFILE OF BORING CORES
THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR	

JICA A.D 1993

Fig. C.3.1 Implementation Schedule of Urgent Project



APPENDIX D

ECONOMIC, SOCIAL, AND ENVIRONMENTAL EVALUATION

APPENDIX D ECONOMIC, SOCIAL AND ENVIRONMENTAL EVALUATION

1. River and Sea Water Quality Improvement

1.1 River Water Quality Improvement

The river water quality of the Study Area in the year 2000 without project and with urgent sewerage development project were estimated by using the simulation model proposed in the Master Plan Study (refer to Supporting Report E.1.1, Master Plan Study). The simulated river water quality in dry and rainy seasons of the year 2000 are shown in Fig. D.1.1(1) and Fig. D.1.1(2) respectively, compared to the existing river water quality.

The proposed urgent sewerage development project will improve the water quality of the Oongan, Badung, Rangda and Punggawa rivers running through central and southern Denpasar areas.

The average river water quality of the central and southern Denpasar areas in dry and rainy seasons under the existing, future without project and future with urgent sewerage development project conditions are summarized below:

(unit: BOD mg/ℓ)

	Range	Average
Existing (1990)	22.9 - 51.8	32.2
Future (2000) without Project	35.1 - 80.3	52.7
Future (2000) with Project	15.3 - 30.8	23.0

The proposed urgent sewerage development project is expected to achieve a significant improvement of the river water quality in central and southern Denpasar areas. The average river water quality of the central and southern Denpasar areas in the year 2000 will be maintained around BOD 20 mg/ℓ.

1.2 Sea Water Quality Improvement

The pollution loads to the sea from the Study Area under the existing, future without project and future with urgent sewerage development project are as follows :

	Pollution Load to Sea (BOD, kg/day)		
	Dry Season	Rainy Season	Average
Existing (1990)	8,294	13,238	10,766
Future (2000) without Project	12,904	21,274	17,090
Future (2000) with Project	8,930	14,342	11,636

The sea water quality of the Study Area in the year 2000 without project and with urgent sewerage development project were estimated by the simulation model proposed in the Master Plan Study (refer to Supporting Report E.1.2, Master Plan Study). The simulated sea water quality in dry and rainy seasons are shown in Fig. D.1.2(1) through Fig. D.1.2(4). For the sea water quality under the existing condition, refer to Supporting Report E.1.1, Master Plan Study.

The polluted sea areas with COD of more than 5 mg/ℓ in dry and rainy seasons under the existing, future without project and future with urgent sewerage development project are estimated as follows:

(unit: km^2)

	Existing (1990)		Future (2000) without Project		Future (2000) with Project	
	Dry	Rainy	Dry	Rainy	Dry	Rainy
North Sanur	1.7	1.3	2.1	2.6	2.1	2.6
South Sanur + Benoa	27.3	26.2	32.8	33.1	28.5	28.9
Total	29.0	27.5	34.9	35.7	30.6	31.5

2. No. of Beneficiaries

2.1 Classification of Beneficiaries

Beneficiaries were classified into nine (9) types or categories, namely, households, hotels, restaurants, shops, factories, offices, educational institutions, medical institutions and religious institutions. There remain some beneficiaries which do not belong to the above types such as theaters, movie houses, military facilities, dormitories, markets, discotheques, fitness centers, barber shops, amusement centers, sport facilities (for golf, tennis, etc.), nurseries, libraries, etc. They are grouped together and classified as "others".

Households are divided into "high", "middle" and "low" income classes. In the same way, hotels are divided into "classified hotels" and "non-classified hotels and other accommodations". Restaurants, shops and factories are each divided into "large", "medium" and "small" ones. Offices are divided into "banks" and "other offices", the latter being comprised of "private" and "government". Educational institutions consist of "kindergartens", "primary schools", "junior high schools", "senior high schools", "religious schools", and "colleges/universities". Medical institutions consist of "hospitals", "health centers" and "clinics". Religious institutions are made up of "Hindu temples", "mosques" and "churches".

The definition of the above sub-divisions of households, restaurants, shops and factories are shown in Table D.2.1.

Beneficiaries can be grouped into four (4) broad categories, namely "domestic", "industrial", "commercial" and "institutional". Households and factories belong to "domestic" and "industrial" categories respectively. Likewise, hotels, restaurants, shops, some offices and some medical institutions belong to "commercial" category. Some offices, educational institutions, some medical institutions and religious institutions are "institutional".

2.2 Estimation of No. of Beneficiaries

The existing status of the number of beneficiaries in the study area was estimated based on the results of the questionnaire survey gathered at Kelurahan/Desa offices.

The projection of the number of households for 2000 and 2010 was done in accordance with projected population for the two years. The number of hotel rooms and restaurant seats in the future was estimated based on the official projections. The number of factories was forecast based on the projected industrial production and population growth. The estimation of future number of other beneficiaries was made taking into consideration the projected growth of population and tourists.

The number of the type of beneficiaries classified as "others" was not surveyed.

The number of beneficiaries was estimated for the overall sewerage service area as well as for the urgent sewerage service area. The urgent sewerage service area is divided into the conventional and interceptor areas.

The estimated number of beneficiaries for 1990 in the overall sewerage service area is theoretical. That is to say, it is the number in an imaginary case where it is assumed that the project were completed according to the master plan in 1990. The same holds true for 2000. The estimated number of beneficiaries for 2010 is real in the sense that the project will be completed in 2010 according to the master plan.

The estimated number of beneficiaries for 1990 in the urgent sewerage service area is theoretical. That is to say, it is the number in an imaginary case where it is assumed that the urgent project were completed in 1990. The number for 2000 is real in the sense that the urgent project will be completed in 2000. The same holds true for 2010. It is to be noted that in 2010 sewerage services will be available for the wider master plan area.

2.2.1 No. of Beneficiaries in Overall Sewerage Service Area

The existing and future number of each type of beneficiaries in the overall sewerage service area is shown in Tables D.2.2 to D.2.10.

As Table D.2.2 shows, the total number of households in 1990 is estimated at 37,621, of which 34,401 is for the Denpasar area and 3,220 for the Sanur area. It will increase to 45,791 in 2000 and 53,903 in 2010.

Table D.2.3 shows that there existed 4,513 hotel rooms in 1990, of which 1368 were for the Denpasar area and 3,145 for the Sanur area. Of these, 2,384 belonged to classified hotels and 2,129 to non-classified hotels and other accommodations. The number of hotel rooms will increase to 7,360 in 2000 and 10,217 in 2010.

Table D.2.4 shows that there were 8,685 restaurant seats in 1990, of which 4,253 were for the Denpasar area and 4,432 for the Sanur area. Of the total, 3,150 belonged to large restaurants, 3,452 to medium ones and 2,083 to small ones. The number of restaurant seats will increase to 9,549 in 2000 and 10,336 in 2010.

According to Table D.2.5 the number of shops was counted at 2,056 in 1990, of which 1871 was in the Denpasar area and 185 in the Sanur area. Of these, 11 belonged to large shops, 475 to medium ones and 1,570 to small ones. The number of shops is estimated to increase to 2,591 in 2000 and 3,134 in 2010.

According to Table D.2.6 the number of factories was counted at 211 in 1990, of which 154 was in the Denpasar area and 57 in the Sanur area. Of these, 7 belonged to large factories, 66 to medium ones and 138 to small ones. The number of factories is estimated to increase to 344 in 2000 and 462 in 2010.

It is shown in Table D.2.7 that there were 625 offices in 1990, of which 598 were for the Denpasar area and 27 for the Sanur area. Out of the total, 127 belonged to banks, 352 to other private offices and 144 to other government offices. The number of offices will increase to 815 in 2000 and 999 in 2010.

It is shown in Table D.2.8 that there were 261 educational institutions in 1990, of which 242 were for the Denpasar area and 19 for the Sanur area. Out of the total, 50 belonged to kindergartens, 122 to primary schools, 33 to junior high schools, 32 to senior high schools, 4 to religious schools and 20 to colleges/universities. The number of educational institutions will increase to 313 in 2000 and to 379 in 2010.

Table D.2.9 reports that there were 30 medical institutions in 1990, of which 27 were in the Denpasar area and 3 in the Sanur area. Nine (9) were hospitals, 10 health centers and 11 clinics. The number of medical institutions is projected to be 35 in 2000 and 45 in 2010.

Table D.2.10 reports that there were 280 religious institutions in 1990, of which 252 were in the Denpasar area and 28 in the Sanur area. 245 were Hindu temples, 15 mosques and 20 churches. The number of religious institutions is projected to reach 347 in 2000 and 421 in 2010.

2.2.2 No. of Beneficiaries in Urgent Sewerage Service Area

(1) Conventional Area

The existing and future number of each type of beneficiaries in the urgent conventional sewerage service area is shown in Tables D.2.11 to D.2.19.

As Table D.2.11 shows, the total number of households in 1990 is estimated at 13,270, of which 11,697 is for the Denpasar area and 1,573 for the Sanur area. It will increase to 16,305 in 2000 and 26,810 in 2010.

Table D.2.12 shows that there existed 3,946 hotel rooms in 1990, of which 801 were for the Denpasar area and 3,145 for the Sanur area. Of these, 2,340 belonged to classified hotels and 1,606 to non-classified hotels and other accommodations. The number of hotel rooms will increase to 6,577 in 2000 and 9,487 in 2010.

Table D.2.13 shows that there were 6,207 restaurant seats in 1990, of which 1,775 were for the Denpasar area and 4,432 for the Sanur area. Of the total, 2,319 belonged to large restaurants, 2,452 to medium ones and 1,436 to small ones. The number of restaurant seats will increase to 6,974 in 2000 and 7,932 in 2010.

According to Table D.2.14 the number of shops counted 740 in 1990, of which 555 was in the Denpasar area and 185 in the Sanur area, or 7 belonged to large shops, 162 to medium ones and 571 to small ones. The number of shops is estimated to increase to 969 in 2000 and 1,565 in 2010.

According to Table D.2.15 the number of factories counted 61 in 1990, of which 30 was in the Denpasar area and 31 in the Sanur area, or 4 belonged to large factories, 19 to medium ones and 38 to small ones. The number of factories is estimated to increase to 92 in 2000 and 165 in 2010.

It is shown in Table D.2.16 that there were 378 offices in 1990, of which 359 were for the Denpasar area and 19 for the Sanur area. Out of the total, 57 belonged to banks, 252 to other private offices and 69 to other government offices. The number of offices will increase to 502 in 2000 and 719 in 2010.

It is shown in Table D.2.17 that there were 109 educational institutions in 1990, of which 101 were for the Denpasar area and 8 for the Sanur area. Out of the total, 22 belonged to kindergartens, 48 to primary schools, 16 to junior high schools, 13 to senior high schools, 2 to religious schools and 8 to colleges/universities. The number of educational institutions will increase to 131 in 2000 and 209 in 2010.

Table D.2.18 shows that there were 14 medical institutions in 1990, of which 13 were in the Denpasar area and 1 in the Sanur area. Five (5) were hospitals, 4 health centers and 5 clinics. The number of medical institutions is projected to increase to 16 in 2000 and 25 in 2010.

Table D.2.19 shows that there were 68 religious institutions in 1990, of which 57 were in the Denpasar area and 11 in the Sanur area. 47 were Hindu temples, 8 mosques and 13 churches. The number of religious institutions will increase to 82 in 2000 and 163 in 2010.

(2) Interceptor Area

The existing and future number of each type of beneficiaries in the urgent interceptor sewerage service area is shown in Tables D.2.20 to D.2.28. In the Sanur area there will be no interceptor area. Also, in 2010 there will be no interceptor area any more.

As Table D.2.20 shows, the total number of households in 1990 is estimated at 4,755. It will increase to 6,123 in 2000.

Table D.2.21 shows that there existed 190 hotel rooms in 1990, all of which belonged to non-classified hotels and other accommodations. The number of hotel rooms will increase to 235 in 2000.

Table D.2.22 shows that there were 164 restaurant seats in 1990, all of which belonged to small restaurants. The number of restaurant seats will increase to 190 in 2000.

According to Table D.2.23 the number of shops counted 232 in 1990, of which 36 belonged to medium shops and 196 to small ones. The number of shops will increase to 298 in 2000.

According to Table D.2.24 the number of factories counted 16 in 1990, of which 6 belonged to medium factories and 10 to small ones. The number of factories will increase to 25 in 2000.

It is shown in Table D.2.25 that there were 61 offices in 1990, of which 13 belonged to banks, 20 to other private offices and 28 to other government offices. The number of offices will increase to 77 in 2000.

It is shown in Table D.2.26 that there were 32 educational institutions in 1990, of which 6 belonged to kindergartens, 15 to primary schools, 4 to junior high schools, 4 to senior high schools, 1 to religious school and 2 to colleges/universities. The number of educational institutions will increase to 47 in 2000.

Table D.2.27 shows that there were 3 medical institutions in 1990, one each for the hospital, health center and clinic. The number of medical institutions will increase to 4 in 2000.

Table D.2.28 shows that there were 41 religious institutions in 1990, of which 38 were Hindu temples, 1 mosque and 2 churches. The number of religious institutions will increase to 52 in 2000.

3. Reduction of Waterborne Diseases

At the master plan study stage the sampling questionnaire survey was conducted to know the contraction rate of water-borne disease over the master plan study area comprised of 50 Kelurahans/Desas (refer to 7. Water-Borne Disease in Master Plan Study Supporting Report Appendix B).

Water-borne diseases included malaria, diarrhea, cholera, tuberculosis, D.H.F., typhoid, dysentery, diphtheria, measles, hepatitis A and hepatitis B.

The results are shown in Table B.7.1. According to the table, the annual contraction rate of water-borne diseases across the study area is 57.1 cases per 1,000 population.

Also, at the master plan study stage the average economic costs per water-borne disease case were estimated (refer to 1.1 Reduction of Water-Borne Disease in Master Plan Study Supporting Report Appendix F).

The economic costs of a water-borne disease consist of two (2) factors, namely medical cost and the opportunity cost of time spent by a hospitalized patient. They were on average estimated at Rp.129,839 and Rp.9,873 in the above order respectively, adding up to Rp.139,712.

The population of the urgent sewerage service area in 2000 is estimated at 129,377. Supposing the above contraction rate is still applicable in 2000, the annual number of water-borne disease cases and the related economic costs in the area are estimated to be 7,387 and Rp.1,032 million in the same year. This is the situation where it is assumed that the project will not be implemented.

It is known that the incidence of water-borne diseases is positively related to the unsanitary conditions of surface and underground water. The majority of the rivers flowing through the urgent sewerage service area are polluted as analysed and stated from various angles in Master Plan Study Reports. It can be reasoned that a high incidence of the diseases is strongly connected with this polluted state of water courses.

It is expected, therefore, that the introduction of sewerage and the resultant purification of river water will greatly contribute to the reduction of water-borne diseases and related economic costs. Such a reduction will be further reinforced by the overall introduction of water supply and an efficient garbage collection measure.

4. Increase of Tourism Income

It is estimated in the master plan study report that the number of tourists who stayed in commercial accommodations in the master plan study area was 1,917,882 in 1990. Such tourists are projected to increase to 3,963,210 in 2000 and to 6,214,930 in 2010.

On the assumptions that the number of tourists to stay in the feasibility study area be determined by the ratio of the number of hotel rooms in the feasibility area to the number of hotel rooms in the master plan study area, it is estimated that 456,122 tourists or 23.8% stayed in the commercial accommodations in the F/S area in 1990. They are projected to increase to 996,924 (or 24.5%) in 2000 and to 1,595,989 (or 25.7%) in 2010 (refer to Table D.4.2).

Based on the number of tourists, tourism income in the master plan study area was estimated in the master plan study report. It amounted to Rp.183,096 million in 1990 and is projected to reach Rp.424,012 million in 2000 and Rp.717,150 million in 2010. Tourism income of the F/S area is estimated to be Rp.40,388 million or 22.1% of that of the master plan study area in 1990. It is projected to reach Rp.94,984 million (or 22.4%) in 2000 and Rp.161,250 million (or 22.5%) in 2010 (refer to Table D.4.7).

Projected tourism income in the F/S area can be realized only if the state of the sea water concerned is kept clean and clear in future through the implementation of the wastewater disposal project.

If such a project were not implemented and as a result the quality of sea water got deteriorated more than now, then the number of tourists coming to the F/S area would be severely affected. According to the results of the sampling questionnaire survey conducted towards tourists at the master plan study stage 67.6% of interviewees replied negatively to the question, "Suppose the conditions of the seas and the rivers get worse than now in the coming years, do you want to visit Bali again as a tourist?". This time, a similar survey was again conducted towards the tourists staying in the Sanur area and it was found that 64.9% of sampled tourists were negative in revisiting the F/S area supposing the quality of sea water deteriorated more.

In 2010 the conditions of sea water in the Sanur area are in the without project case projected to get deteriorated to a substantial extent. It is reasonable, therefore, to assume that the number of tourists visiting the F/S area would be in the without project case reduced to 35.1% of the number of tourists expected in the with project case in the same year. The difference of tourism income between the two cases, or "tourism benefits" will amount to Rp.104,651 million in 2010.

"The without (project) case" means the case where it is assumed that the project will not be implemented, while "the with (project) case" means the case where it is assumed that the project will be implemented.

It is reasonable to assume that in the without project case other infrastructures such as road network, water supply system, drainage system, telecommunications network, electricity network and garbage disposal system in the F/S area would not be newly developed so much as in the with project case because the coming of tourists would be limited. In the same way, in the with project case other infrastructures would be increasingly newly developed in parallel with the increase of tourists. It means that "tourism benefits" have to be shared by the infrastructures concerned.

According to the results of the questionnaire survey conducted towards the entire 18 star hotels in the F/S area, the contribution of sewerage system to the development of tourism comes to 35.0%. That is, out of the tourism benefits of Rp.104,651 million in 2010 Rp.36,628 million would be attributed to the project. In 2000 project benefits work out at Rp.10,788 million (refer to Table D.4.7).

4.1 Results of Subsequent Questionnaire

4.1.1 Probable Impacts of Polluted Seas on Tourism

As mentioned above the JICA Study Team conducted a subsequent questionnaire survey towards tourists in the F/S area in addition to the similar survey conducted towards tourists in the master plan study area at the master plan study stage to confirm the results of the previous study regarding the negative impacts of sea water quality deterioration on tourism. The number of samples was 114.

The profile of the respondents was as follows :

1. Nationality

Australia	=28.9%	Britain	= 10.5%	U.S.A.	= 9.6%
Germany	= 7.9%	Others	= 43.1%		

2. Age = 36.3 years

3. Sex — Male = 50.9% Female = 49.1%

4. Marriage Status — Single = 45.9% Married = 54.1%

5. Purpose of Visit

Holiday	=91.1%	Business	= 7.1%	Official	= 0.9%
Family union	= 0.9%				

6. Frequency of Visits

1st visit	=42.4%	2nd visit	=25.7%
3rd visit	= 8.0%	4th visit	= 6.2%
5th visit	= 4.4%	More than 5 times	= 13.3%

When one compares the above results with those of the master plan study report, one finds that the percentage of Australian nationality is less this time than the last time, average age of respondents is older, the percentage of female is greater, the percentage of the married is greater, the ratio of holiday makers is less and the ratio of new visitors is less.

The questionnaire assumes a without project situation in the F/S area in the year 2010, and tourists were asked to choose one out of the two statements below.

a. "People here are innocent and friendly. I like them. The hotel where I stay suits my taste with big pools, exotic foods and drinks, etc. I can see green and peaceful rural scenery with paddy fields, groves of coconut trees, tropical flowers, etc. And the mild temperature soothes my nerves.

   However, just think a Bali surrounded by polluted seas that are no longer clean and clear as before. I cannot get away from their influences mentally wherever I am and wherever I go. The above-mentioned attractions lose their original meanings and lusters without the clean, clear, beautiful, live seas.

   Bali is finished. I will pack up, leave and never come back again."

b. "When I meet local people in the hotel, beaches or roads, it often happens that they, children and adults alike, flash friendly smiles at me. It deeply encourages my inner self. I feel I regain my confidence in life.

   There are nice pools in our hotel. I can swim and sun-bathe there. Besides, there are other attractions in this hotel such as exotic food and drinks, Balinese dance performances and souvenirs.

   I can see green and peaceful rural scenery with paddy fields, groves of coconut trees, tropical flowers, etc.

And this mild climate! The seas may be no longer clean and clear as before. However, I can ignore them so long as there are other attractions as listed above.

I will continue to stay here. I will continue to love and visit this island."

The results were that 64.9% of the respondents chose a. and 35.1% b. In a similar, but simpler question asked at the master plan study stage 67.6% gave negative answer and 32.4% positive answer as already mentioned. A major reason behind some difference in the results seems to lie in the difference of profile as mentioned above between the respondents in the current and previous surveys. Because it was discovered as a result of the current survey that if the respondent is other than Australian, older in age, female, married or a holiday maker, he is more likely to give positive answer than he is otherwise as shown in Table D.4.1.

4.1.2 Contribution of Sewerage to Tourism

The tourism benefits as the difference of tourism income in without and with project cases in future cannot be entirely attributed to the sewerage project. Those benefits will be realized only by the combined and concerted efforts in all related fields.

The JICA Study Team conducted a questionnaire survey towards the general managers of the entire 18 star hotels in the F/S area to know the position/importance of the sewerage project among various future infrastructure projects in further developing tourism. As a result such a contribution ratio worked out at 35.0%.

The Team considered the value to be reasonable and proper, and adopted it as a major information for further analysis.

4.2 Estimation of Tourism Benefit

4.2.1 Estimation of Tourism Income

The number of tourists to stay in the master plan study area is already estimated from 1990 to 2010 as shown in Table A.5.3 of the master plan study report. Based on the table as well as the ratio of the number of hotel rooms in the F/S area to the total number of hotel rooms in the master plan study area, the number of tourists to stay in the F/S study area was estimated from 1990 to 2010 as shown in Table D.4.2.

As it shows, tourists, who are estimated to have numbered 456,122 in 1990 are projected to reach 996,924 in 2000 and 1,595,989 in 2010.

As 2.02 tourists share one hotel room on average as already mentioned in the master plan study report, the number of rooms to be occupied by tourists works out at 225,802 in 1990, 493,528 in 2000 and 790,093 in 2010. (Refer to Table D.4.3.)

The average length of stay in classified hotels is 4.3 days for international tourists and 3.1 days for domestic tourists, while the average length of stay in no-classified hotels & other accommodations is 3.8 days for international tourists and 2.3 days for domestic tourists as mentioned in the master plan study report. From this information room nights to be realized by tourists work out at 684,802 in 1990, 1,543,718 in 2000 and 2,535,224 in 2010. (Refer to Table D.4.4.)

Multiplying room nights by 2.02, which is the average number of occupants in one room one gets bed nights. They are calculated at 1,383,300 in 1990, 3,118,311 in 2000 and 5,121,155 in 2010. (Refer to Table D.4.5.)

It is estimated that international and domestic tourists who stayed in classified hotels in 1990 on average per day spent Rp.150,000 and Rp.100,000, respectively as mentioned in the master plan study report. Likewise, international and domestic tourists who stayed at non-classified hotels & other accommodations in 1990 on average per day spent Rp.75,000 and Rp.50,000, respectively. Based on the above estimation the total expenditures by tourists in the F/S area are calculated at Rp.134,627 million in 1990, Rp.316,621 million in 2000 and Rp.537,500 million in 2010. (Refer to Table D.4.6.)

It is estimated that the gross profit ratio of the commercial businesses catering for tourists is on average 30%. Thus, by multiplying tourists expenditures by 30% one obtains tourism income. It is calculated at

Rp.40,388 million in 1990, Rp.94,986 million in 2000 and Rp.161,250 million in 2010. (Refer to Table D.4.7.)

4.2.2 Estimation of Tourism Benefits

The above estimation of tourism income will be realized in the "theoretical with project case". It means the imaginary case where it is assumed that sewerage services were already partially started in 1991.

In the without project case, according to the results of the sampling questionnaire survey, the number of tourists visiting the F/S area is expected to drastically decline in the coming years. It is assumed based on the results of the survey that in the ultimate target year of 2010 the number of tourists coming to the study area will be in the without project case 35.1% of the number of tourists expected under the with project case. During the interim years between 1990 and 2010 the impacts of deteriorating sea water will be increasingly felt. It is assumed that the number of tourists in the without project case in the interim years from 1990 to 2010 as percentage of the number of tourists in the theoretical with project case will decline following a simple equation, i.e. tracing a straight line.

Tourism income in the without project case calculated upon the above assumptions comes to Rp.40,388 million in 1990, Rp.64,163 million in 2000 and Rp.56,599 million in 2010.

The actual with project case lies between the theoretical with project case and the without project case. According to the implementation schedule, partial sewerage services will start in 1998. Until that time the conditions of sea water will be left to deteriorate bit by bit and as a results tourism income will not increase so much as in the theoretical with project case. That is to say, from 1990 to 1987 tourism income in the with project case is exactly the same as in the without project case. From 2000 in which the implementation of the urgent wastewater disposal project will be completed full tourism income expected under the theoretical with project case will be realized in the with project case.

So far as tourism income in the specific years of 1990, 2000 and 2010 is concerned, it is the same both in the theoretical with project case and the actual with project case.

Tourism benefits defined as the difference of tourism income between the without and with project cases work out at Rp.30,823 million in 2000 and Rp.104,651 million in 2010.

Out of them, 35% can be attributed to the wastewater disposal project. Thus, one gets Rp.10,788 million for 2000 and Rp.36,628 million for 2010 as the tourism benefits of the project (refer to Table D.4.7 and Fig. D.4.1).

5. Economic Analysis

As has been mentioned, two (2) types of benefits, namely the reduction of water-borne diseases and increase of tourism income will result from the realization of the project. Out of them, benefits of the reduction of water-borne diseases were not quantitatively analysed. Benefits of the increase of tourism income are already quantified on annual basis as shown in Table D.4.7. The benefit stream was used for economic analysis.

The cost stream was derived from the disbursement schedules of the Urgent and Phase II Projects by converting financial costs into economic costs on annual basis.

After establishing preconditions economic analysis was performed based on cost benefit streams. By reading and interpreting the calculated values of decision criteria such as economic internal rate of return (EIRR), net present value (NPV) and benefit cost ratio (B/C), the feasibility of the project was economically evaluated.

To see whether the project is robust enough to withstand unfavorable conditions, sensitivity analysis was performed.

5.1 Preconditions

In conducting economic analysis, preconditions were established as follows:

The opportunity cost of capital (OCC)	:	10%
Period of project life	:	50 years
Standard conversion factor (SCF) for local components (LC) of initial capital costs	:	97.4%
Durable life of (a) facilities	:	50 years
(b) pumps & aerators	:	15 years

The value of SCF was calculated based on the data collected from Yearbook of Indonesia, 1990 as shown in Table D.5.1.

5.2 Calculation of Decision Criteria

In accordance with disbursement schedules of the Urgent and Phase II Projects, SCF and durable life of facilities and equipment the capital cost stream was prepared for the project life period of 50 years as shown in Table D.5.2. Likewise, in accordance with the disbursement schedules the O/M cost stream was prepared.

The benefit stream is represented by tourism benefits.

By using cost benefit streams economic analysis was performed.

The results are as follows:

NPV	:	Rp.42,321 million
B/C	:	1.40
EIRR	:	14.1%

The net benefits of Rp.42,321 million correspond to 40% of the combined capital costs of Urgent and Phase II Projects. EIRR is by 4.1% above OCC. It can be safely said, therefore, that the project is economically feasible.

Moreover, if the reduction of water-borne diseases were quantified and added to the benefits, one would get even better results.

5.3 Sensitivity Analysis

Unknown and uncertain factors surround the estimation of costs and benefits. To see how the feasibility of the project will be affected under unfavorable conditions, sensitivity analysis was conducted by increasing costs and/or trimming benefits. By doing so the economic robustness of the project was tested.

Four cases were established. In Case I O/M costs were assumed to be by 100% greater than in the base case. In Case II capital costs are by 20% greater than in the base case. Case III assumes that benefits are by 20% less than the base case. Under Case IV costs are by 15% greater and at the same time benefits are by 15% less than in the base case.

The results of sensitivity analysis are shown as follows:

Case	O/M Costs	Capital Costs	Benefits	NPV (Rp. million)	B/C	EIRR (%)
I	+100%	-	-	31,190	1.27	13.1
II	-	+20%	-	23,436	1.19	12.0
III	-	-	-20%	12,746	1.12	11.3
IV	+15%	+15%	-15%	4,306	1.04	10.4

As the table shows, supposing O/M costs double, the feasibility of the project will be little affected with the net benefits of Rp.31,190 million corresponding to 27% of capital costs and the EIRR exceeding OCC by 3.1%. Supposing capital cost overrun reaches 20%, the project will be still sufficiently viable with the net benefits of Rp.23,436 million corresponding to 19% of capital costs and the EIRR exceeding OCC by 2.0%.

Supposing benefits turn out to be less by 20%, the project will be still sufficiently viable with the net benefits of Rp.12,746 million corresponding to 12% of capital costs and the EIRR exceeding OCC by 1.3%. Even supposing 15% O/M and capital cost overrun as well as 15% reduction of benefits, the project will be still feasible with the net benefits of Rp.4,306 million accounting for 4% of capital costs and the EIRR by 0.4% greater than OCC.

Thus, it was revealed that the project will maintain its economic robustness under any conceivable adverse circumstances.

6. Environmental Evaluation

6.1 Baseline Environment of Benoa Coast

A sewerage development project is essentially an environmental improvement project, hence beneficial to environment. However, potential adverse effects still may prevail in the sewage treatment plant area and its surroundings, on a long term basis.

Accordingly, a baseline environmental survey was conducted covering the Suwung Swamp area at south of Sanur along the Benoa Coast, up to the Cape of Benoa. The proposed treatment plant of this project as well the existing Nusa Dua treatment plant are located in this swampy area. The environmental survey area along with the project area for sewerage development until the year 2000 is shown in Fig. D.6.1.

The existing land use, social and cultural aspects and ecological condition are preliminarily studied in this Suwung Swamp and its coastal environment of Benoa Bay with a land area of about 2220 ha.

6.1.1 Land Use, Social and Cultural Aspects

(1) Land Use

Mangrove forestation and shrimp aquaculture ponds, both lands under the jurisdiction of the Ministry of Forestry, Government of Indonesia, is the major land use in the swamp portion of survey area, accounting for about 59%. While, in the remaining dry lands, residential and other variety of uses like industrial estate, oil storage, power station, restaurant and others are dominant.

The existing land use of this Benoa Coast area is shown in Fig. D.6.2. Its major composition of land use is as follows:

Mangrove plantation	:	44.8%
Shrimp aquaculture	:	14.3%
Dry land	:	35.2%
Rice field	:	0.8%
Resident/settlement	:	4.9%
Total	:	100%

The annual production of shrimp ponds is estimated at about 12 ton/ha/year. In monetary terms this is equivalent to Rp.90 million/ha/year.

(2) Social and Cultural Aspect

There are no major culturally/archaeologically important assests in the survey area other than four (4) temples, located between Jl. Bay Pass Ngurah Rai and Benoa Coast (ref. Fig. D.6.2), the swampy area. Nevertheless, when the vicinity of the objective area is also considered, the number of temples account to twelve (12) in total.

The names of the four temples in the objective area (environmental survey area), in the order from south of Sanur to Cape of Benoa, are Ketapang, Warung, Dalem and Paibon.

However, all these temples are located at upstream (north) of the fish ponds and mangrove plantation, nearby the Jl. Bay Pass Ngurah Rai. Accordingly, the proposed sewage treatment plant of this project in the shrimp pond area along Jl. Pelabuhan Benoa will exeret no social/cultural adverse effect to any of these temples.

6.1.2 Swamp Ecology

It is noted about 60% of the lands, including rice fields of 0.8%, in the objective area is swampy lands (wetlands).

The major land use are mangrove plantation/forestation and shrimp ponds, that predominates in Suwung area. Theses shrimp ponds, that were created in the past at the expense of mangrove forestation, are expected to be converted back to its original form of mangrove in the near future, as per the Governors' Instruction of 1988 (No. 522.4/23866/BKLH).

Mangrove forestation is the dominant ecological component of this swampy area, which is still extensive along the Benoa Coast (ref. Fig. D.6.2).

The proposed sewage treatment plant of this project (ref. Appendix B) will require a minimum of nine (9) ha land in this shrimp pond area for urgent sewerage project until the year 2000. Nevertheless, high nutrient content of the treated effluent, that would be discharged to Benoa Bay through mangrove swamp, is expected to be only beneficial to mangrove