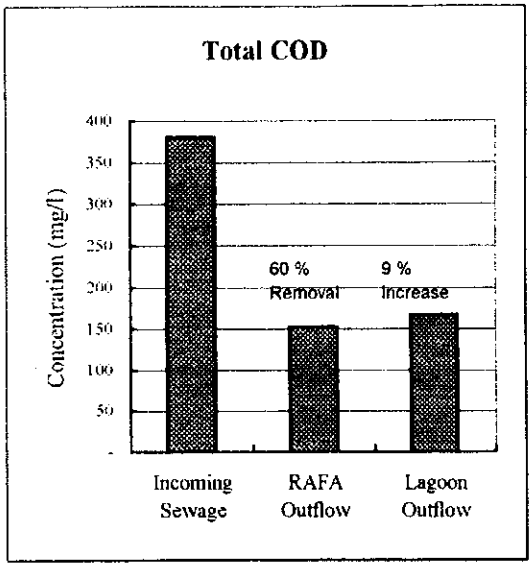
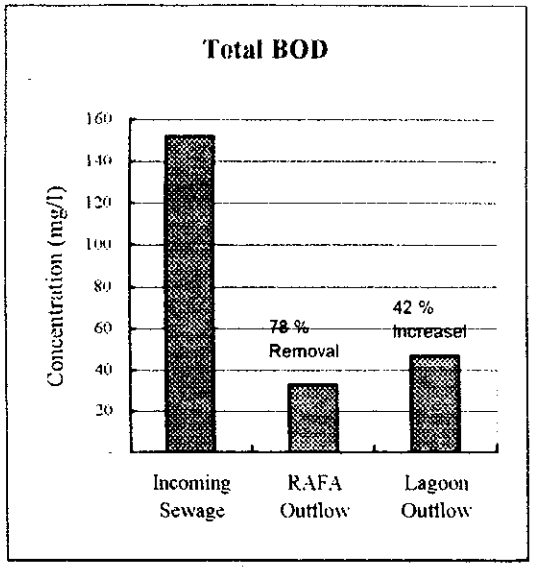
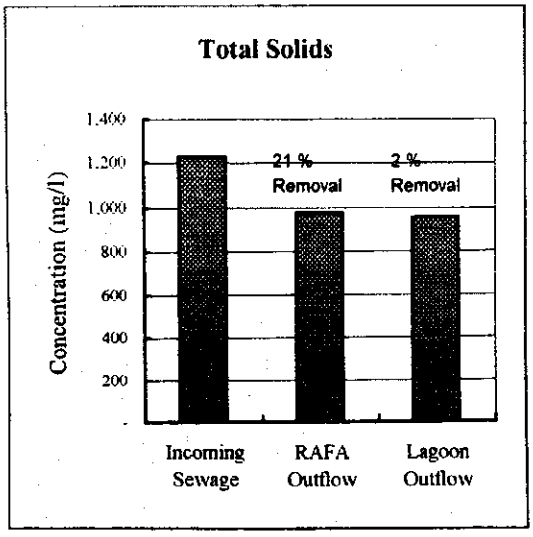
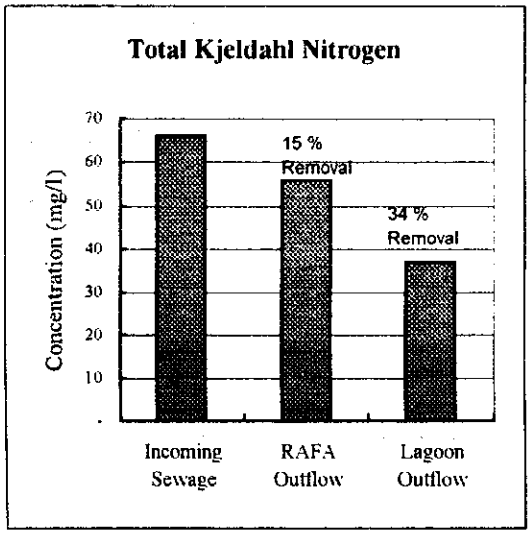
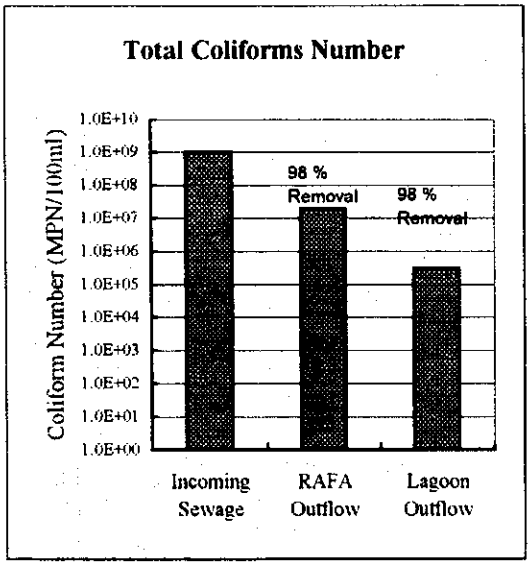








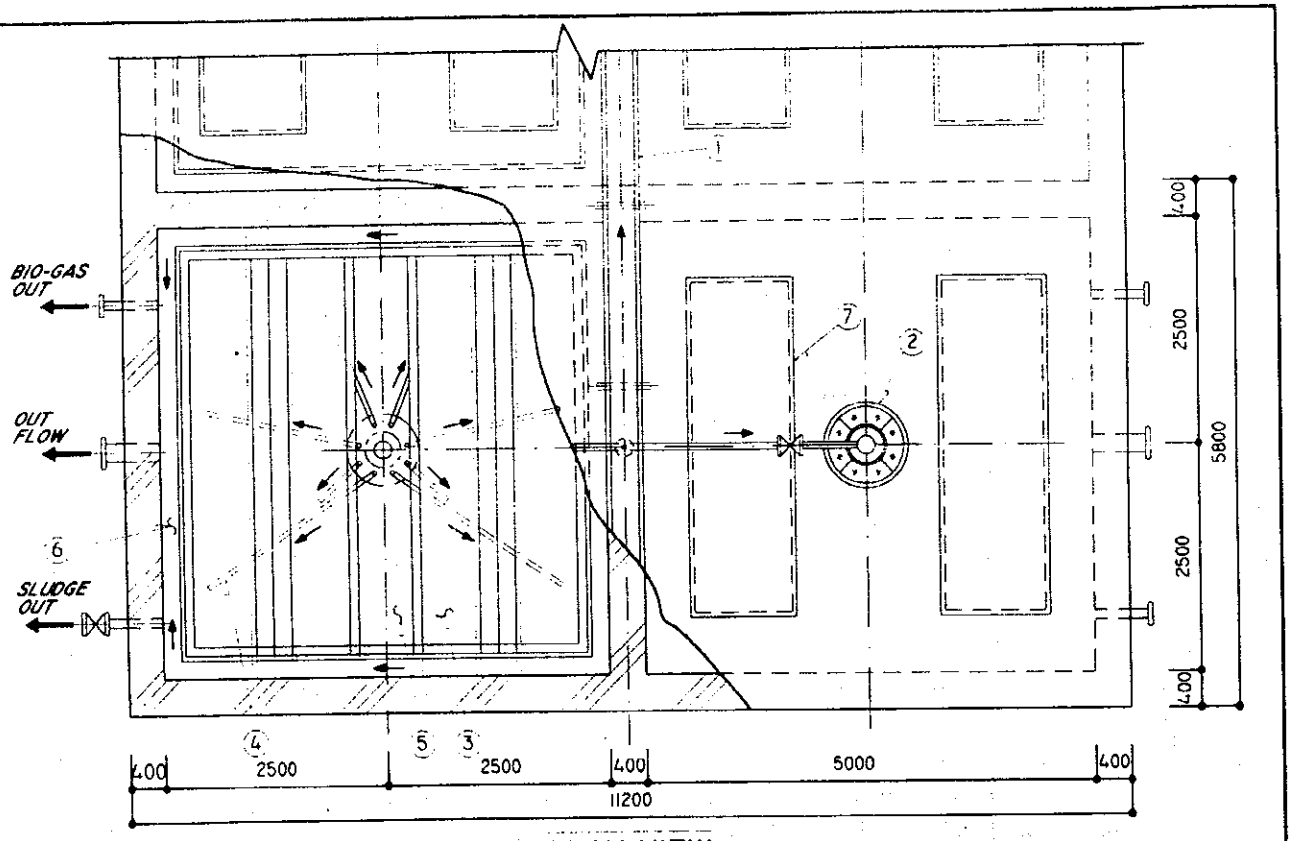


Source: Presented at the Technology Transfer Seminar by Mario Takayuki Kato of Environmental Engineering, the Fedral University of Pernanbuco, on 23rd. May.

Remark: The data were collected during the period between December 1997 and March 2000.

Fig. B.4-1 **Pollutant Removal Rate of Mangueira Treatment Plant**

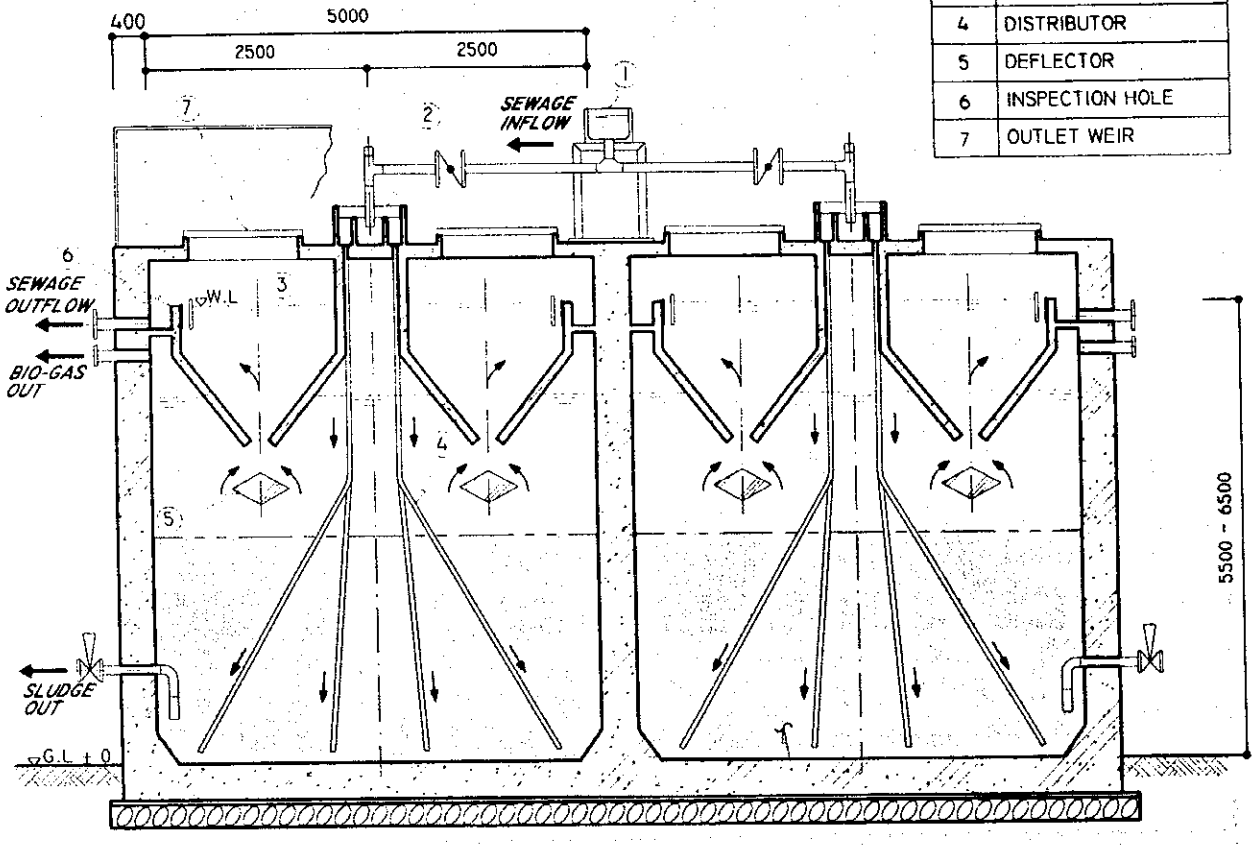
THE STUDY ON STORM WATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR



PLAN VIEW

COMPONENTS LIST

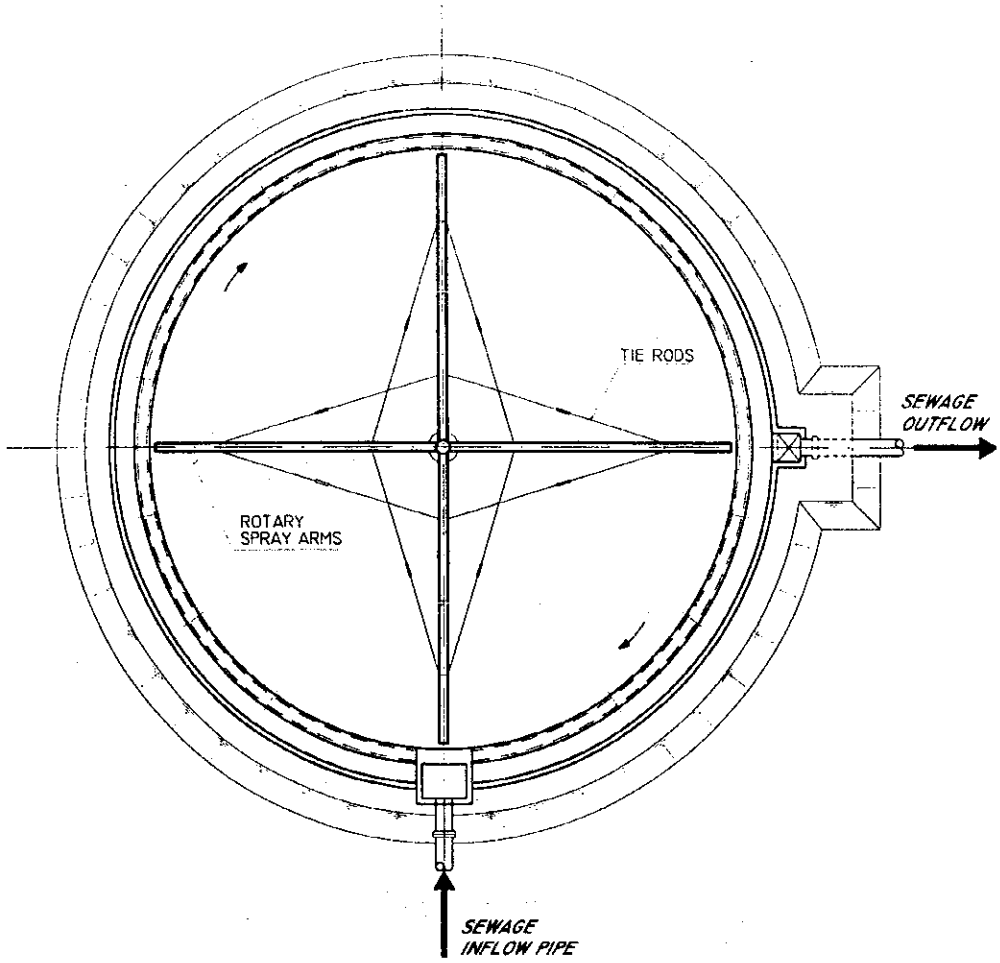
No	NAME
1	DISTRIBUTION TROUGH
2	DISTRIBUTION BOX
3	SEPARATOR
4	DISTRIBUTOR
5	DEFLECTOR
6	INSPECTION HOLE
7	OUTLET WEIR



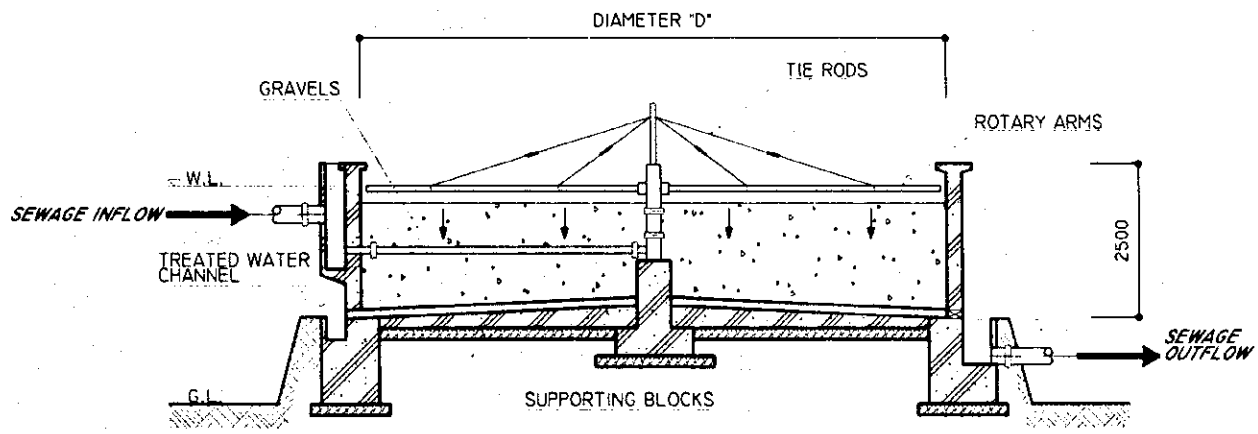
SIDE VIEW

ANAEROBIC SLUDGE LAYER

Fig. B.5-1 Standard Configuration of RAFA Reactor



PLAN VIEW



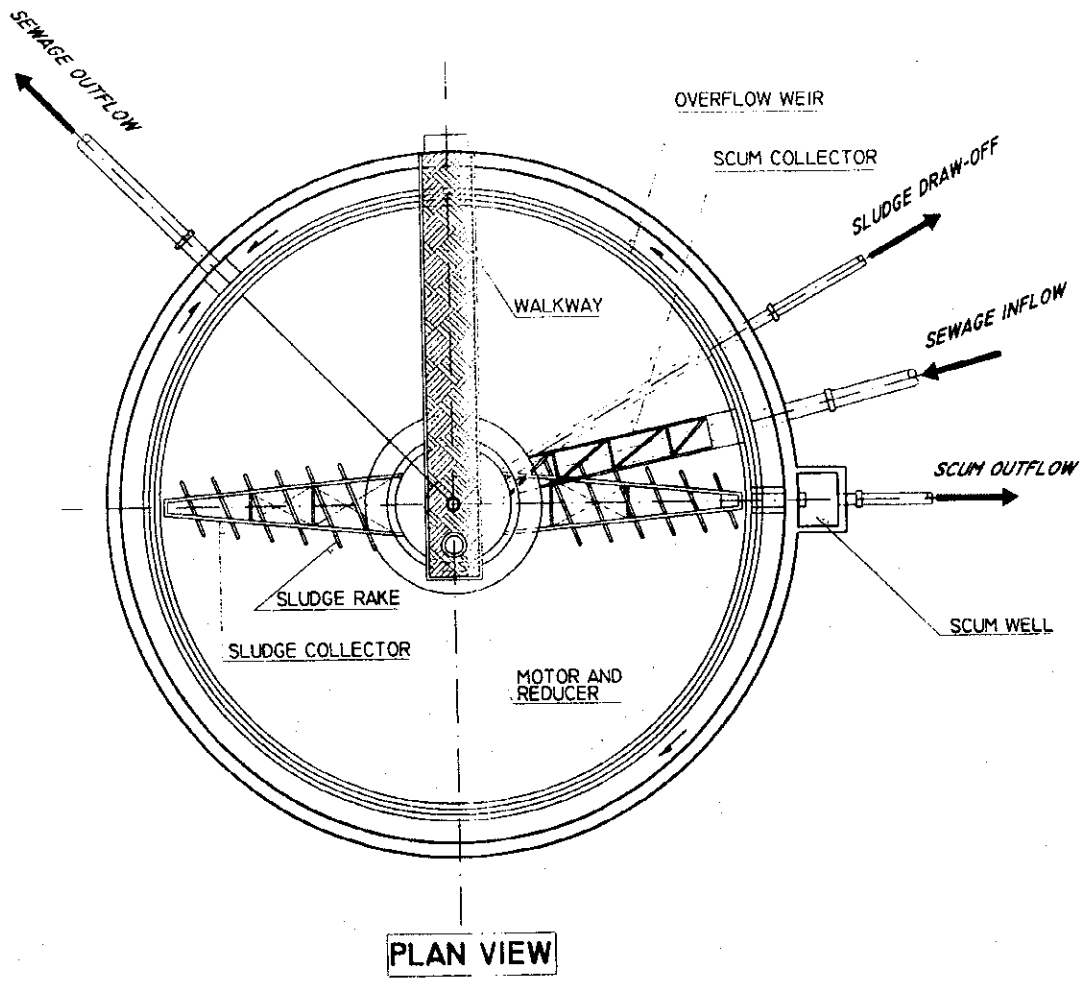
SIDE VIEW

REMARK:

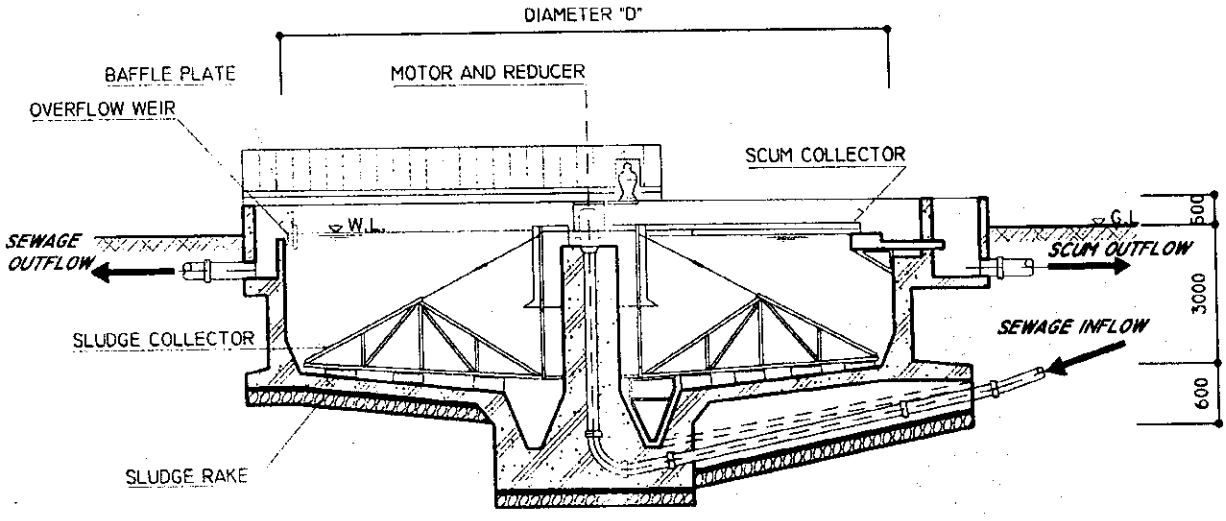
(1) THE DIMENSION OF DIAMETER "D" IS DEPENDING ON THE SEWAGE FLOW.

Fig. B.5-2	Standard Configuration of Bio-Filter

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR



PLAN VIEW



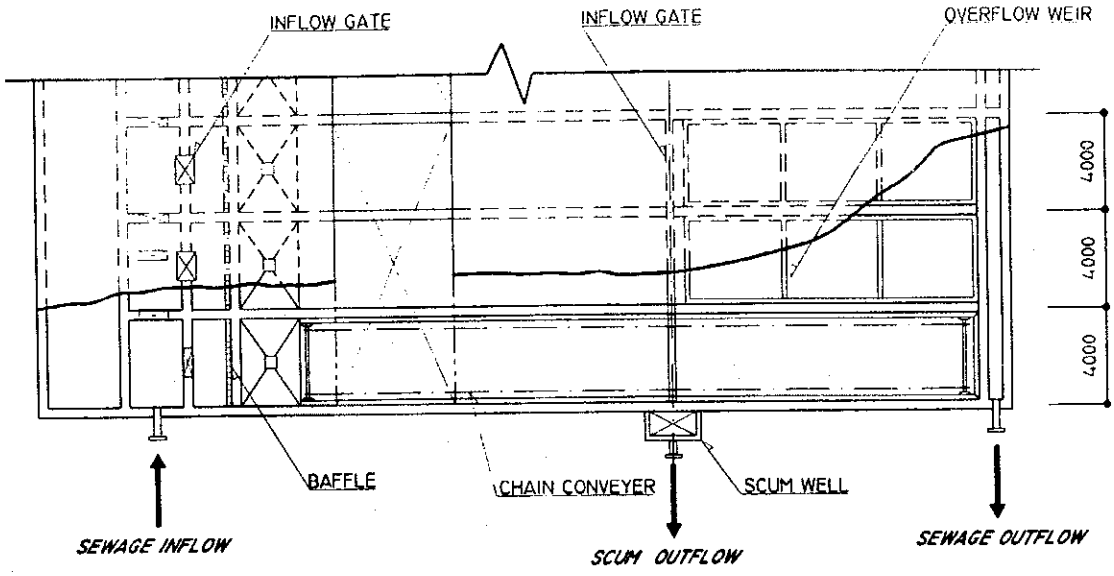
SIDE VIEW

REMARK:

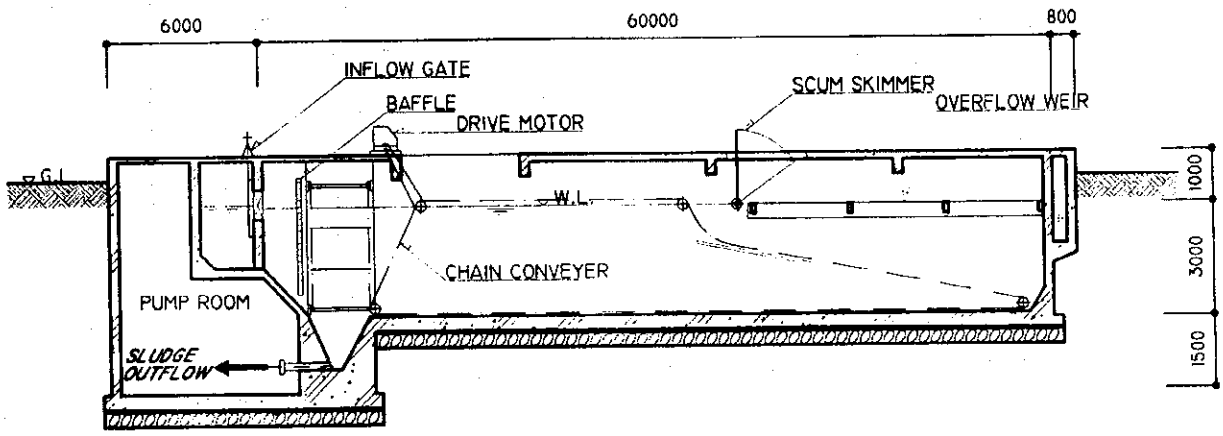
(1) THE DIMENSION OF DIAMETER "D" IS DEPENDING ON THE SEWAGE FLOW.

Fig. B.5-3	Standard Configuration of Circular-Type Sedimentation Tank

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR



PLAN VIEW



SIDE VIEW

Fig. B.5-4	Standard Configuration of Rectangular-Type Sedimentation Tank

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

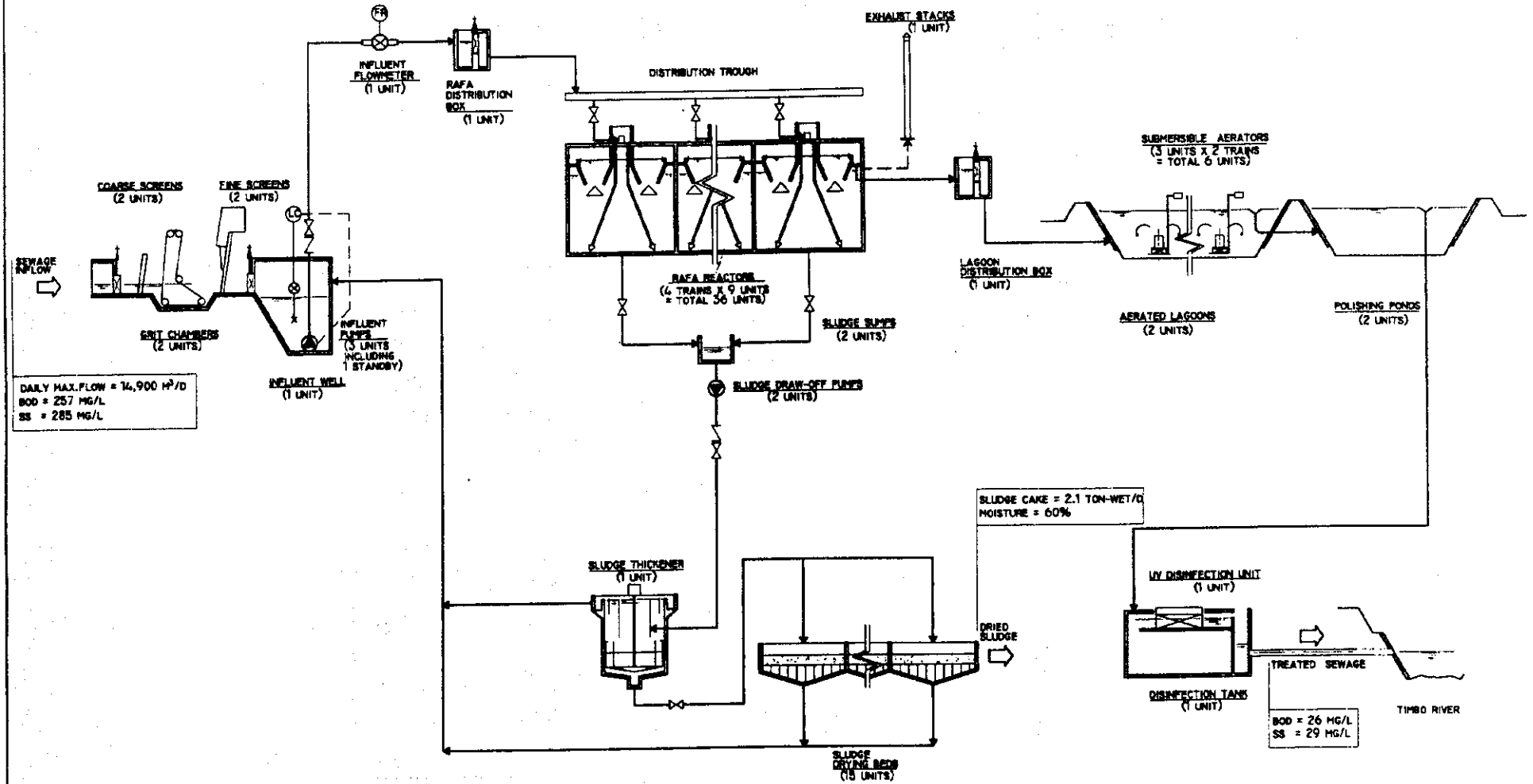


Fig. B.6-1 Conceicao Sewage Treatment Facilities Flow Diagram

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

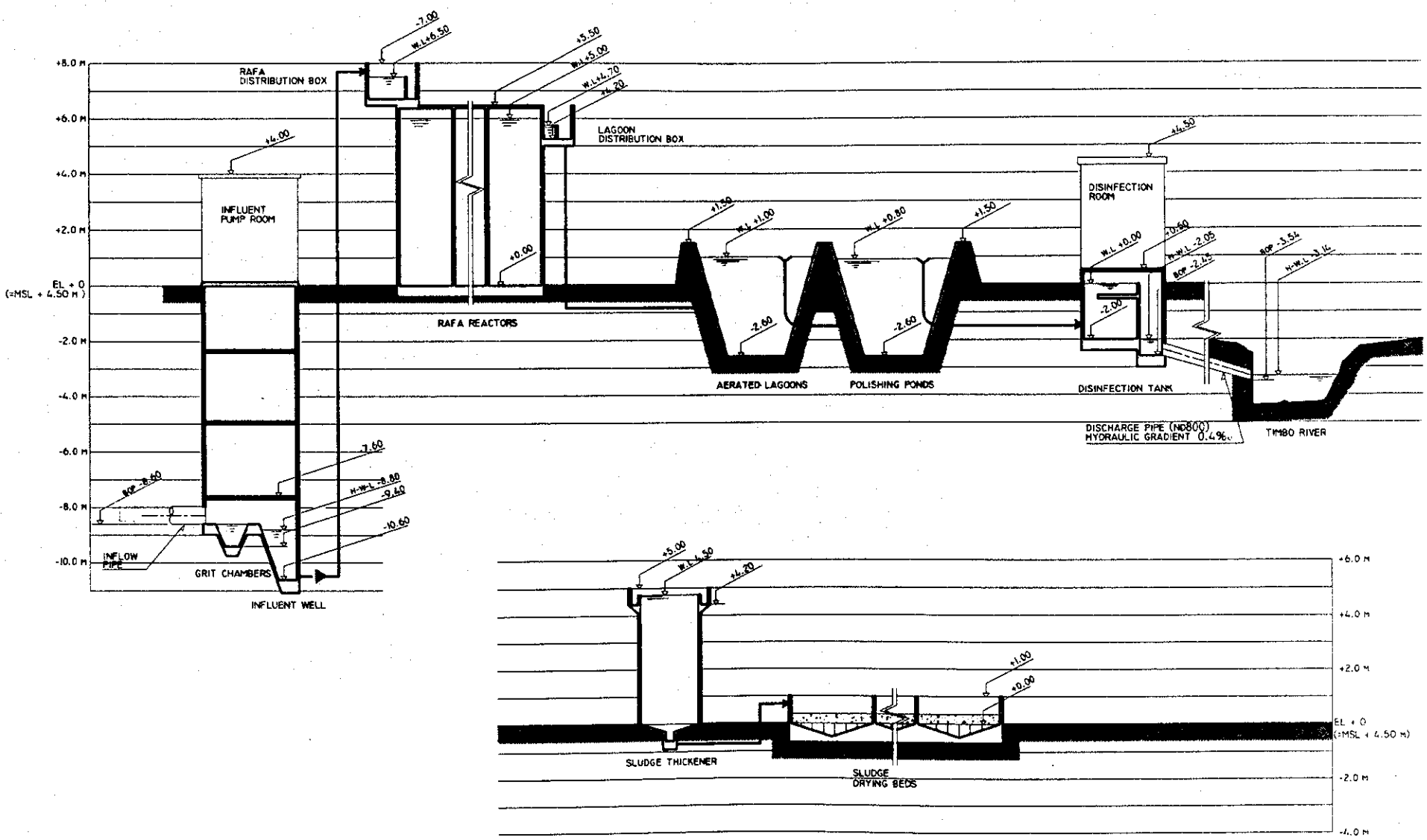
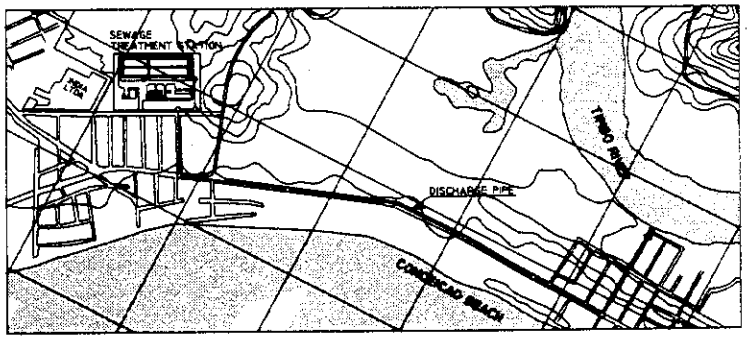


Fig. B.6-2	Conceicao SewageTreatment Facilities Hydraulic Profile
THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR	



TREATED SEWAGE DISCHARGE PIPE

SCALE: 1/20,000

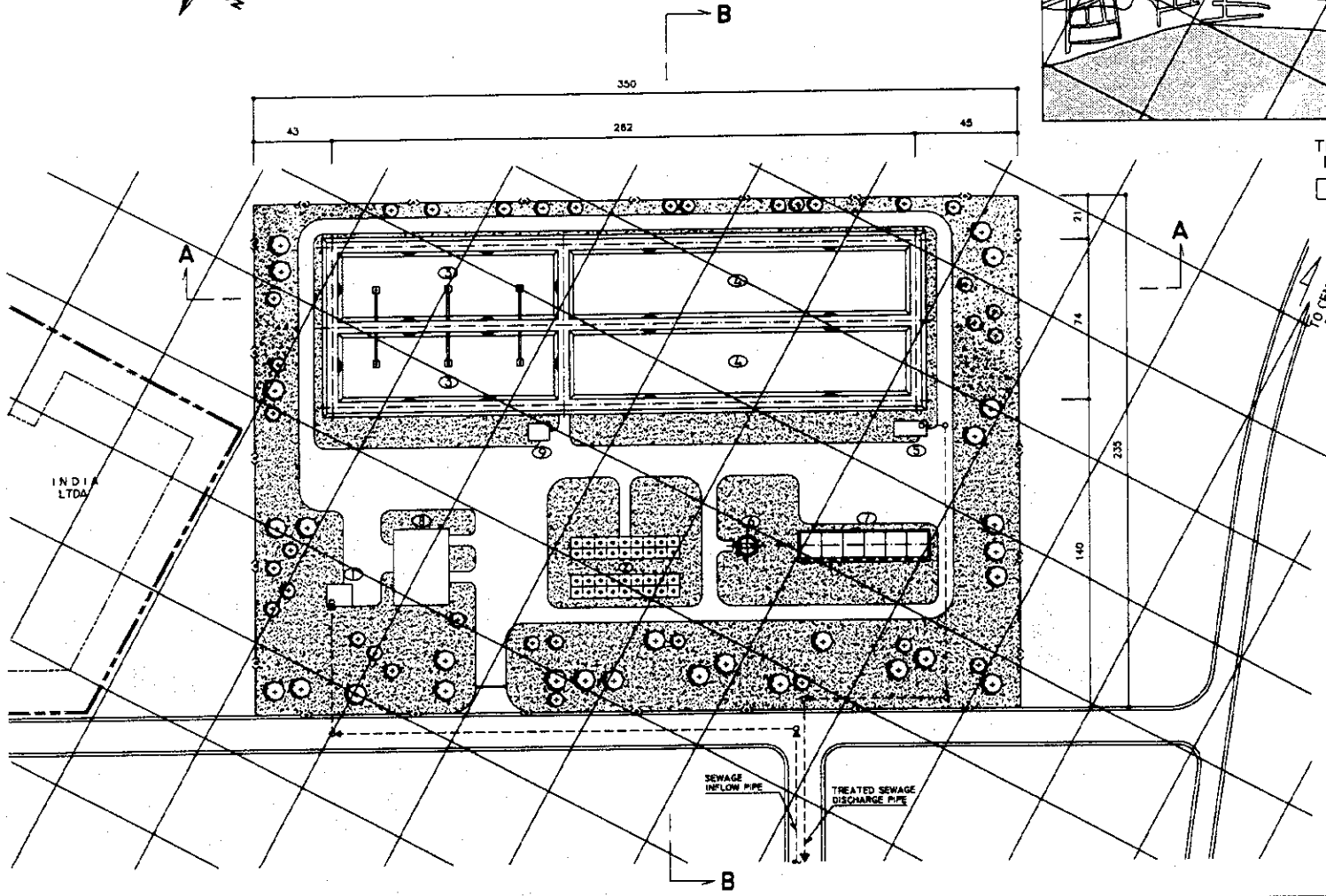


TABLE OF FACILITIES

NUMBER	NAME
1	GRIT CHAMBERS AND INFLUENT WELL
2	RAFA REACTORS
3	AERATED LAGOONS
4	POLISHING PONDS
5	DISINFECTION TANK
6	SLUDGE THICKENER
7	SLUDGE DRYING BEDS
8	ADMINISTRATION BUILDING
9	ELECTRICAL ROOM

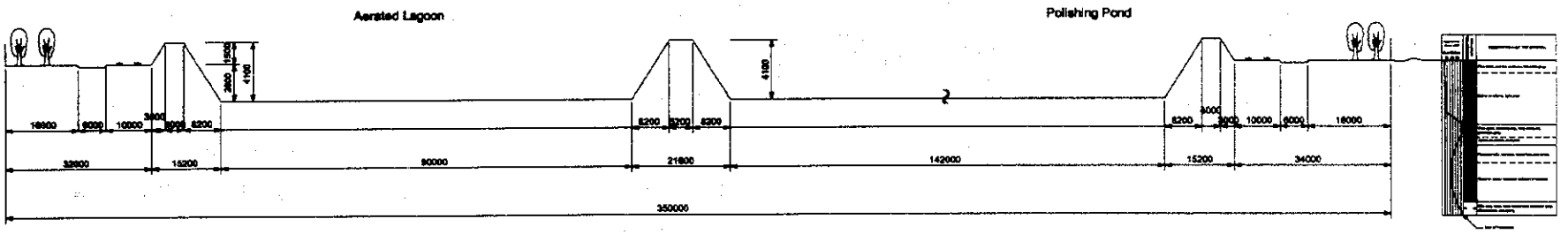
REMARKS:
(1) THE UNIT OF COORDINATE IS 50M.
(2) THE UNIT OF DIMENSIONS IS "METER".

SCALE: 1/2,000

Fig, B,6-3 **Conceicao Sewage Treatment Facilities Layout Plan**

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

Section A-A (H=1/1000,V=1/300)



Section B-B (H=1/1000,V=1/300)

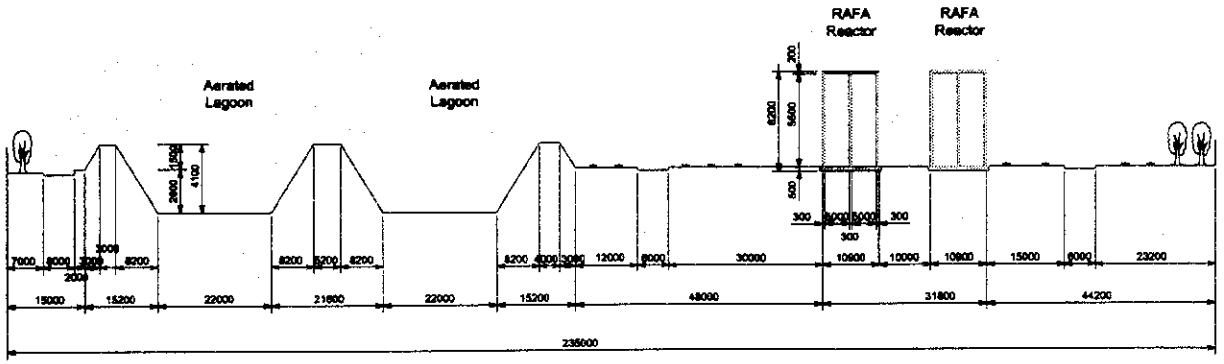


Fig. B.6-4	Conceicao Sewage Treatment Facilities Cross Section (Section A-A,B-B)

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

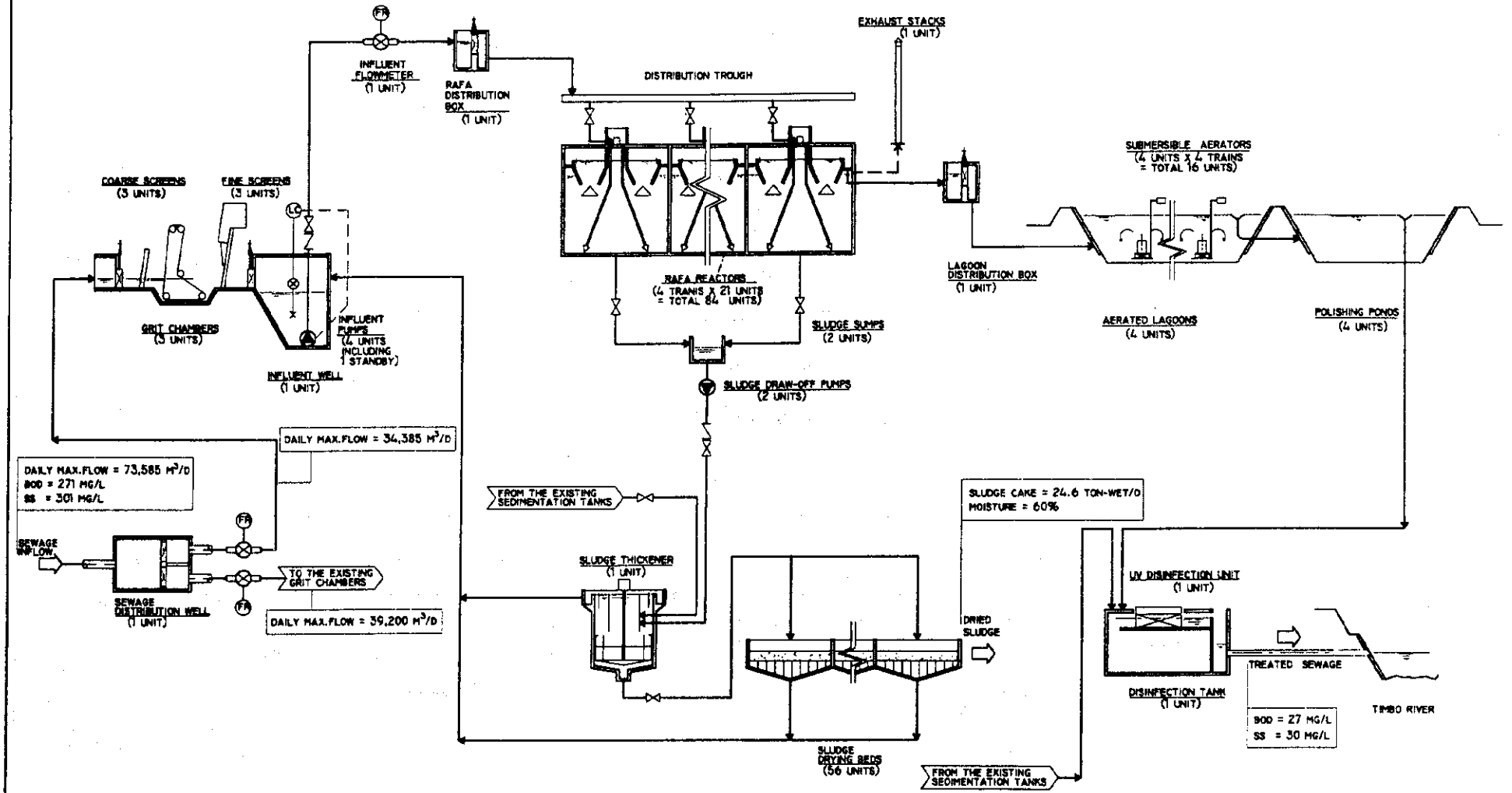


Fig. B.6-5 Janga Sewage Treatment Facilities Flow Diagram

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

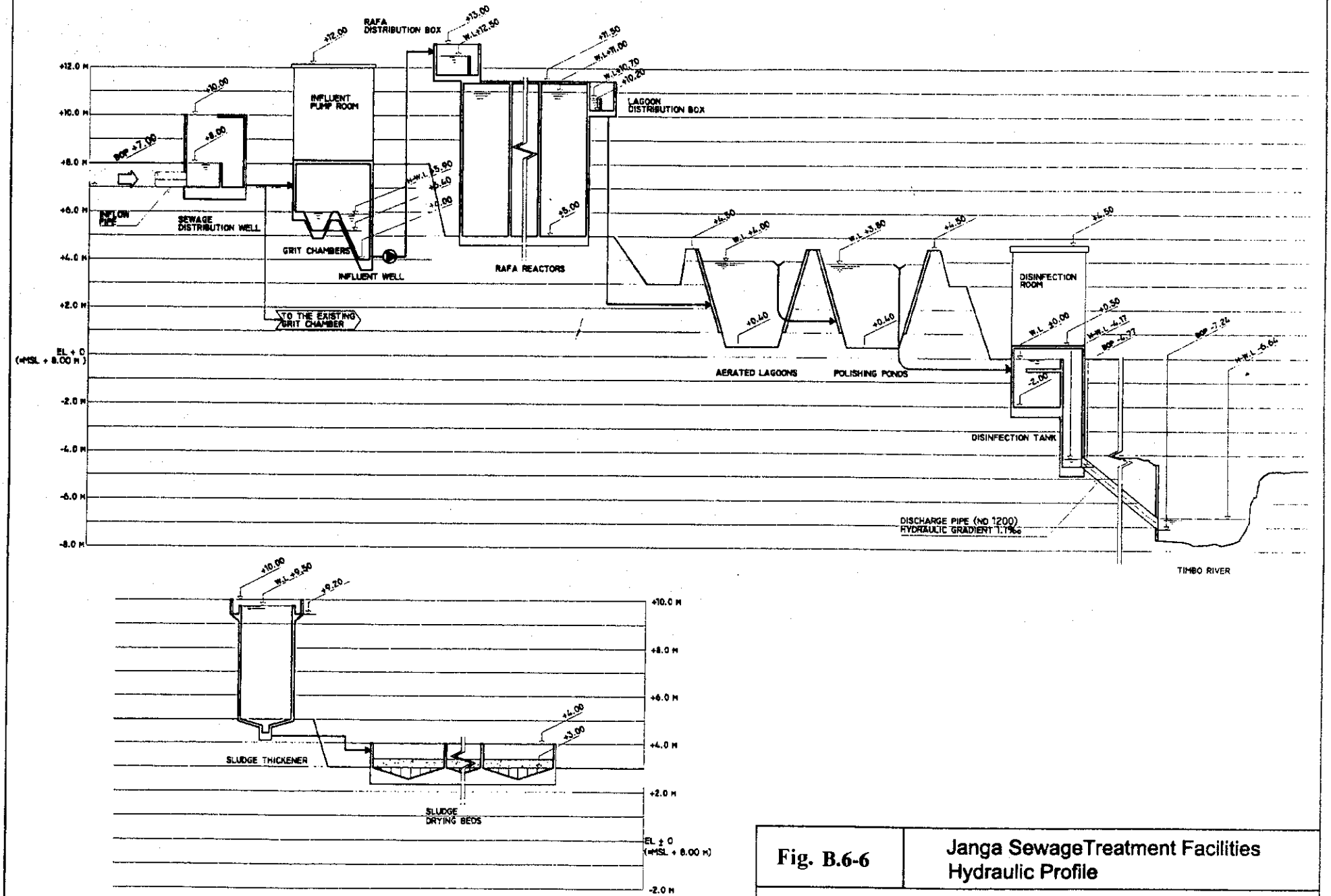
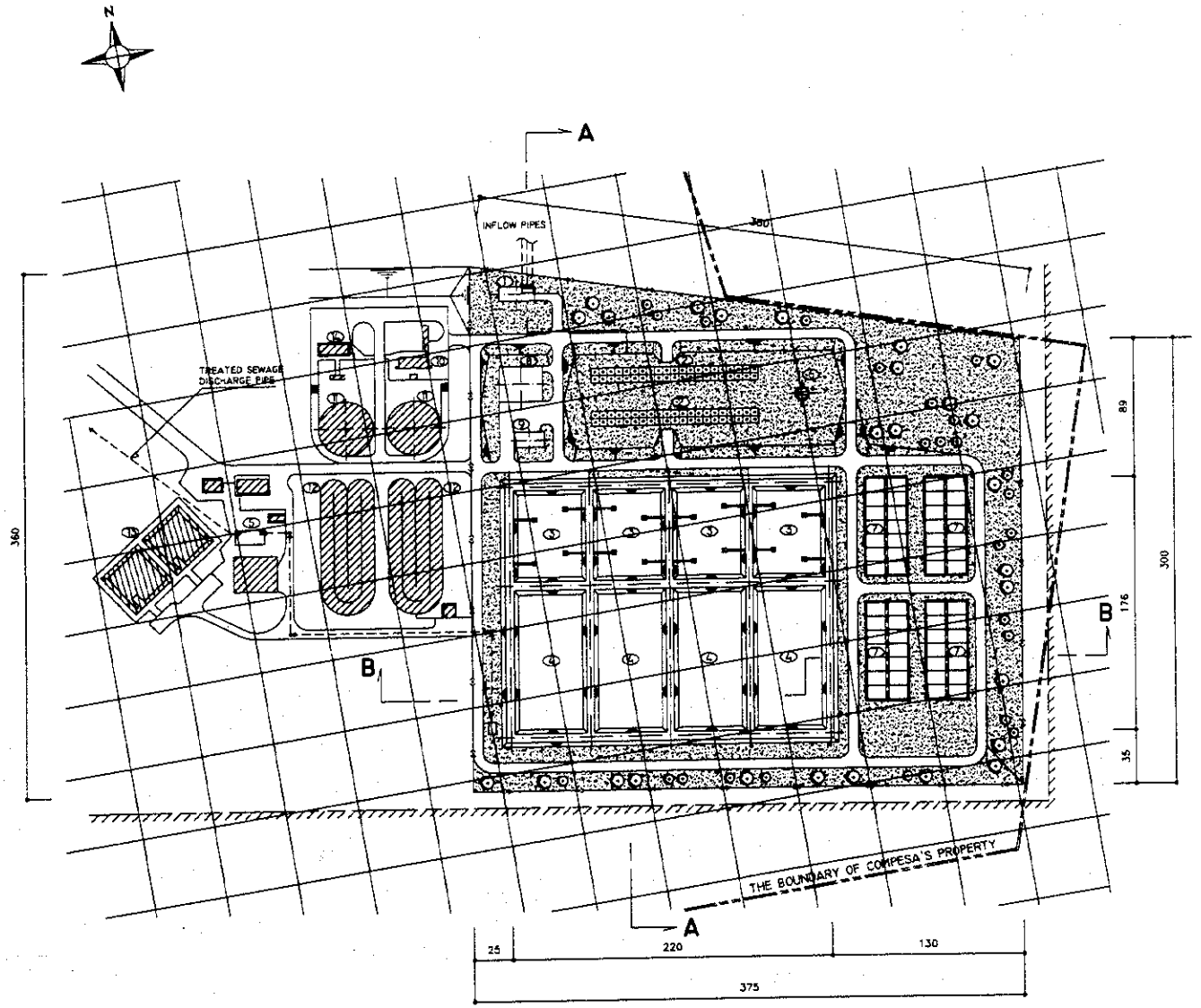
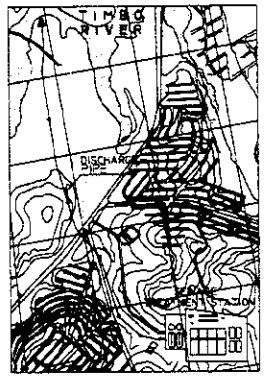


Fig. B.6-6	Janga SewageTreatment Facilities Hydraulic Profile
THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR	





TREATED SEWAGE
DISCHARGE PIPES

SCALE: 1/30,000

TABLE OF FACILITIES

NUMBER	NAME
1	GRIT CHAMBERS AND INFLUENT WELL
2	RAFA REACTORS
3	AERATED LAGOONS
4	POLISHING PONDS
5	DISINFECTION TANK
6	SLUDGE THICKENER
7	SLUDGE DRYING BEDS
8	ADMINISTRATION BUILDING
9	ELECTRICAL ROOM
10	GRIT CHAMBERS (EXISTING)
11	SEDIMENTATION TANKS (EXISTING)
12	OXIDATION DITCHES (EXISTING)
13	SLUDGE LAGOON (EXISTING)
14	ADMINISTRATION ROOM (EXISTING)

REMARKS:
(1) THE UNIT OF COORDINATE IS 50m.
(2) THE UNIT OF DIMENSIONS IS "METER".
(3) THE FACILITIES MARKED BY HATCHING ARE EXISTING ONES.

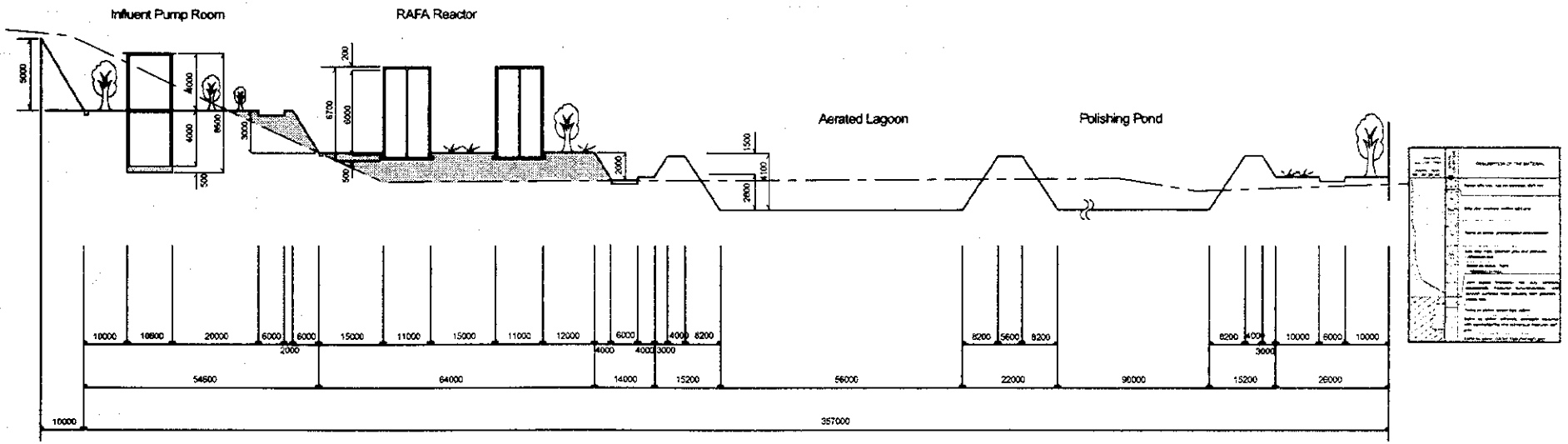
SCALE: 1/3,000

Fig, B,6-7 **Janga Sewage Treatment Facilities Layout Plan**

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

Section A-A

(H=1/1000, V=1/300)



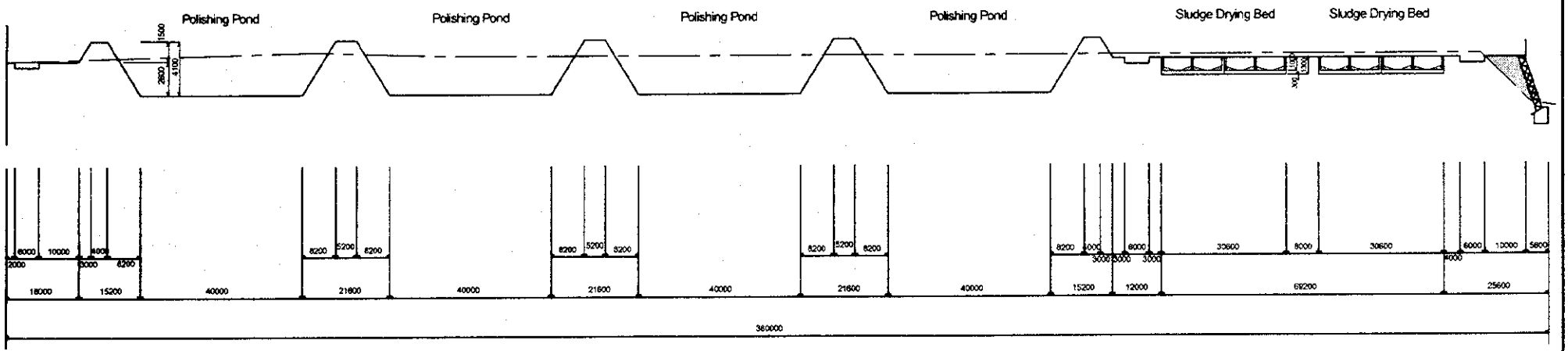
Legend

———	Existing Ground Surface Line
▒▒▒	Embankment

Fig. B.6-8	Janga Sewage Treatment Facilities Cross Section (Section A - A)
THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR	

Section B-B

(H=1/1000, V=1/300)



Legend

———	Existing Ground Surface Line
	Embankment

Fig. B.6-9	Janga Sewage Treatment Facilities Cross Section (Section B - B)
THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR	

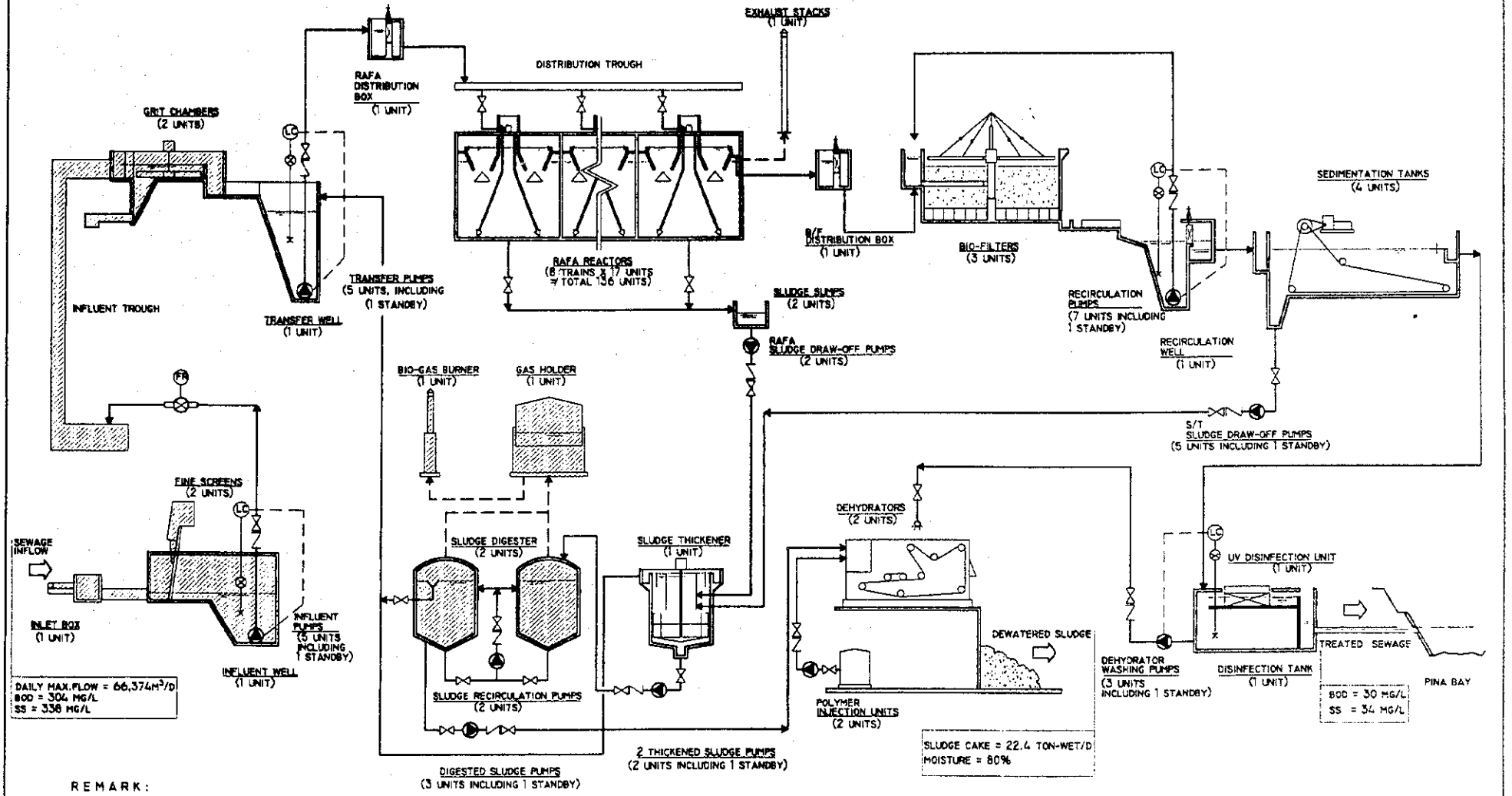
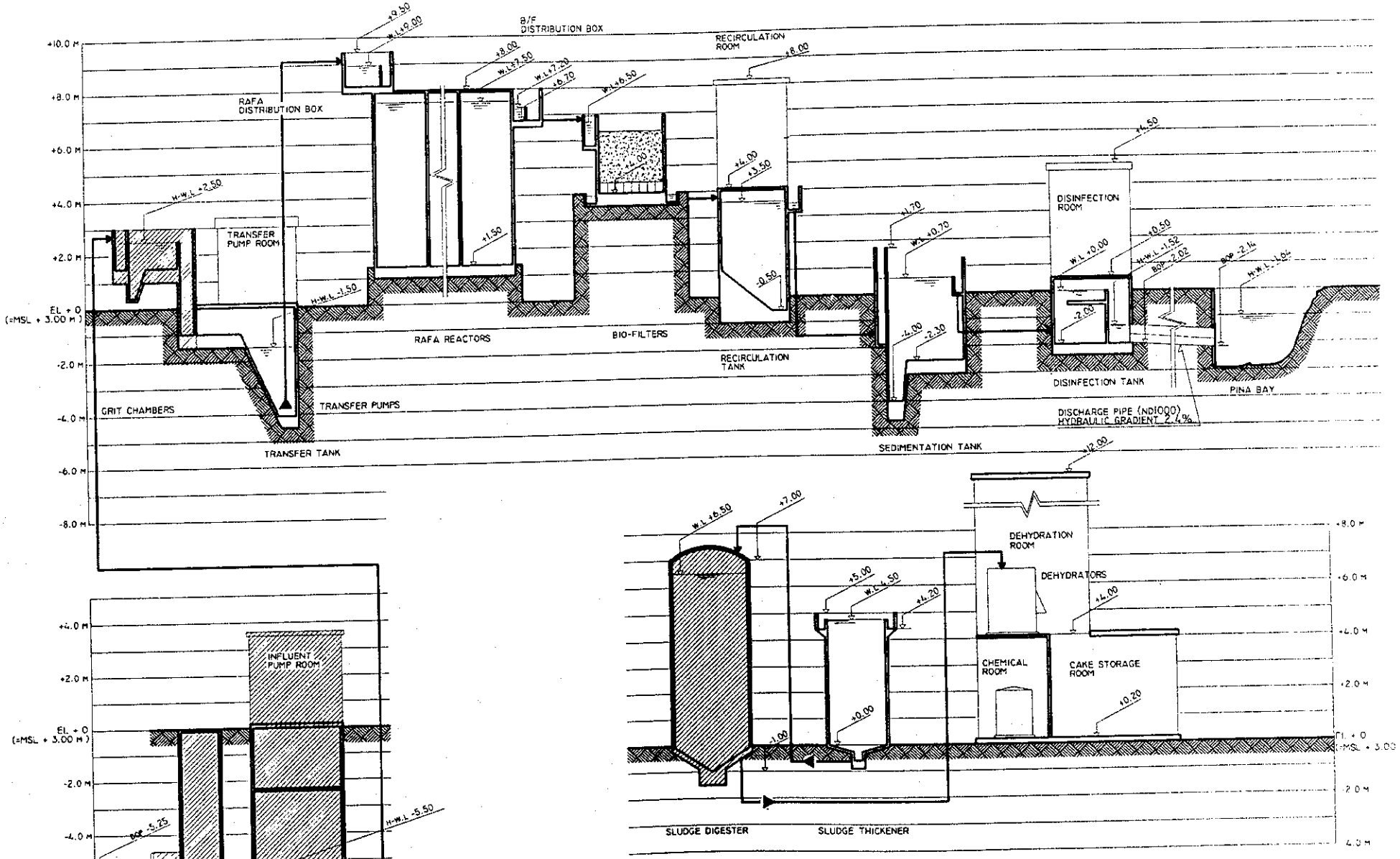


Fig. B.6-10 Cabanga Sewage Treatment Facilities Flow Diagram



REMARK:

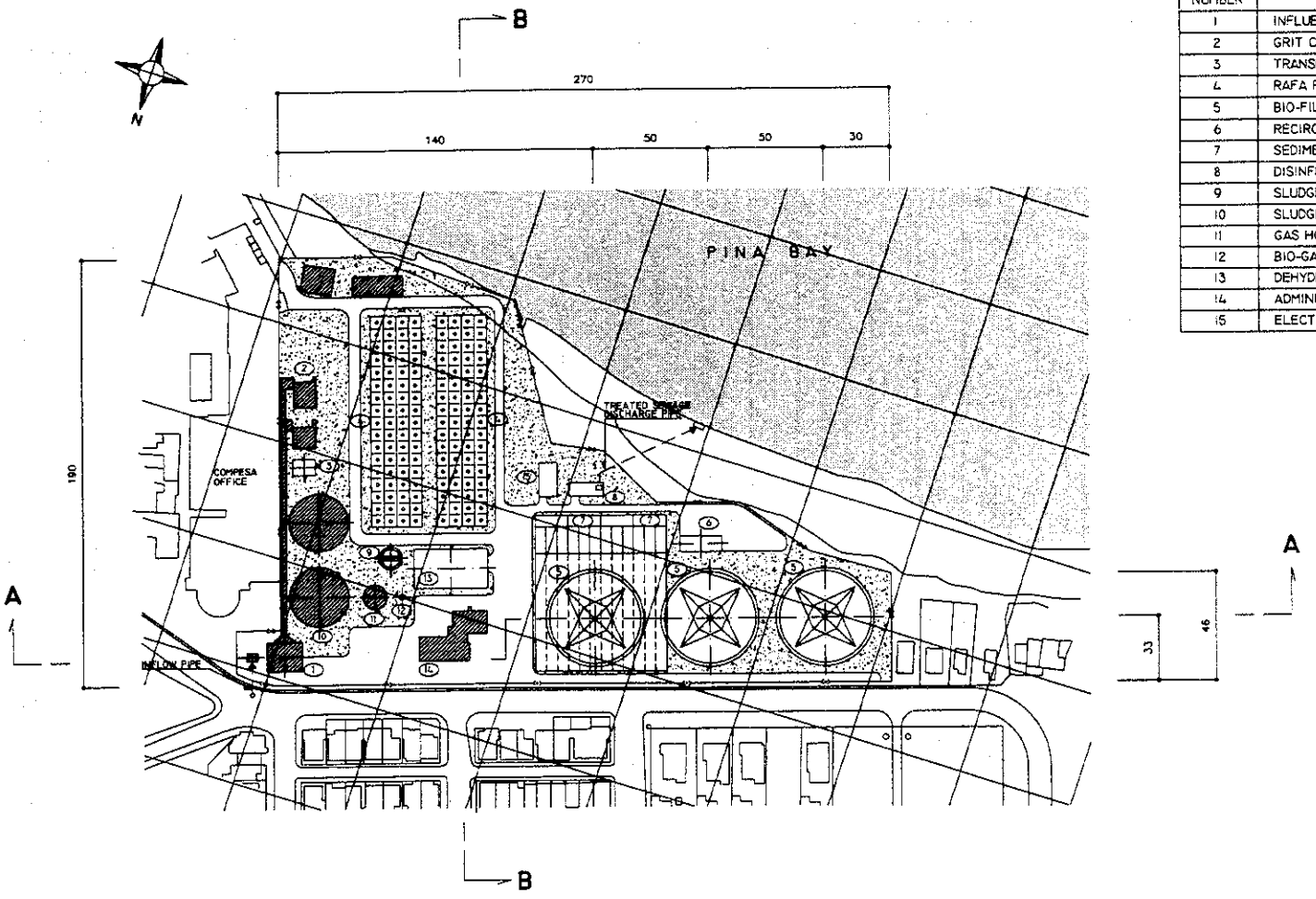
(1) ▨ : EXISTING UNITS

Fig. B.6-11 Cabanga Sewage Treatment Facilities Hydraullic Profile

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

TABLE OF FACILITIES

NUMBER	NAME
1	INFLUENT WELL AND INFLUENT PUMPS (EXISTING)
2	GRIT CHAMBERS
3	TRANSFER PUMPS
4	RAFA REACTORS
5	BIO-FILTERS
6	RECIRCULATION PUMPS
7	SEDIMENTATION TANKS
8	DISINFECTION TANK
9	SLUDGE THICKENER
10	SLUDGE DIGESTERS (EXISTING)
11	GAS HOLDER (EXISTING)
12	BIO-GAS BURNER
13	DEHYDRATION ROOM AND CONTROL ROOM
14	ADMINISTRATION ROOM (EXISTING)
15	ELECTRICAL ROOM



REMARKS:
(1) THE UNIT OF COORDINATE IS 50m.
(2) THE UNIT OF DIMENSIONS IS "METER".
(3) THE FACILITIES MARKED BY HATCHING ARE EXISTING ONES.

SCALE: 1/2,000

Fig, B,6-12 Cabanga Sewage Treatment Facilities Layout Plan

SECTION A-A

(H = 1/1000, V = 1/300)

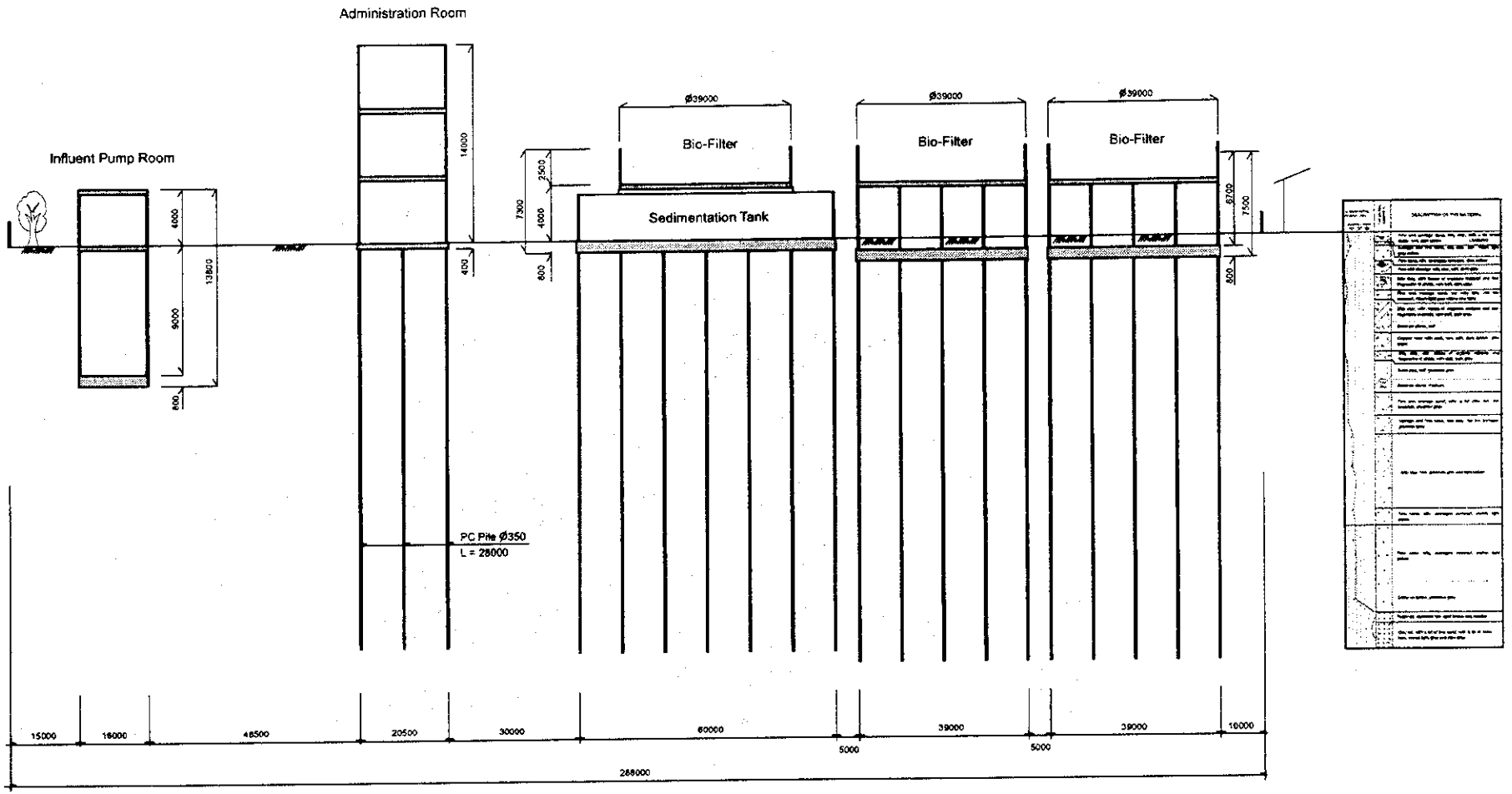


Fig. B.6-13	Cabanga Sewage Treatment Facilities Cross Section (Section A - A)
THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR	

SECTION B-B

(H = 1/1000, V = 1/300)

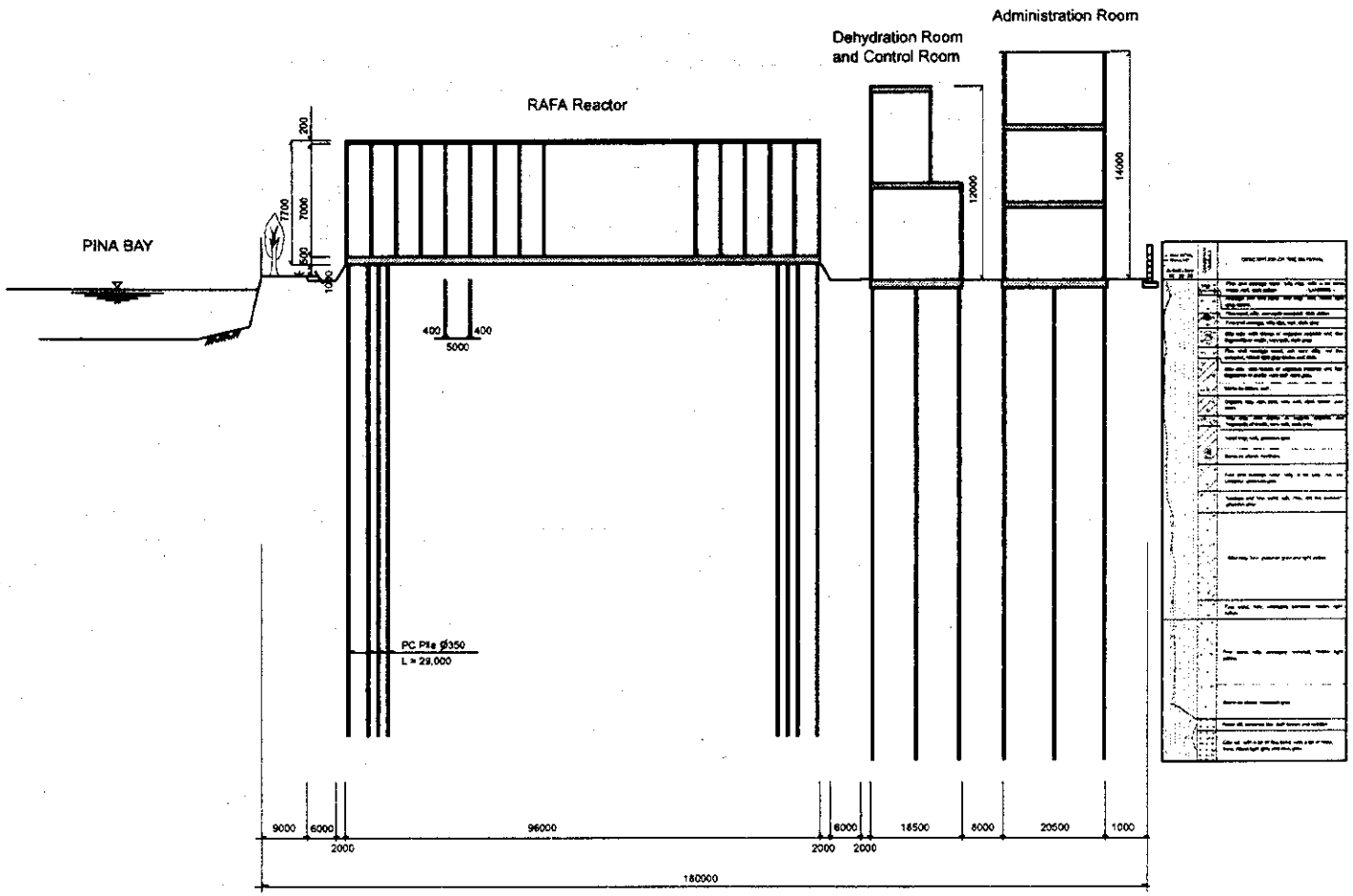


Fig. B.6-14	Cabanga Sewage Treatment Facilities Cross Section (Section B - B)
THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR	

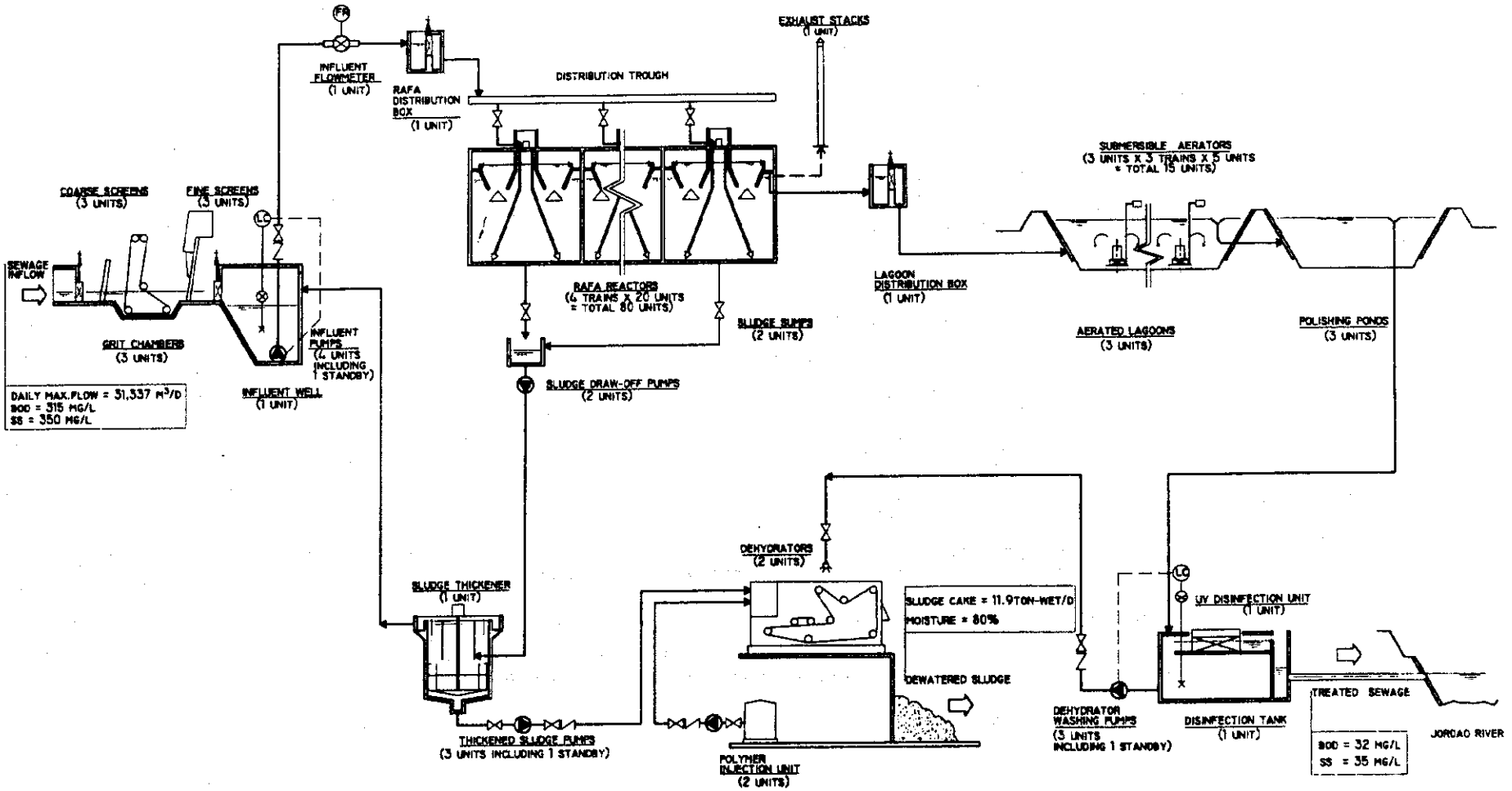


Fig. B.6-15 Boa Viagem Sewage Treatment Facilities Flow Diagram

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

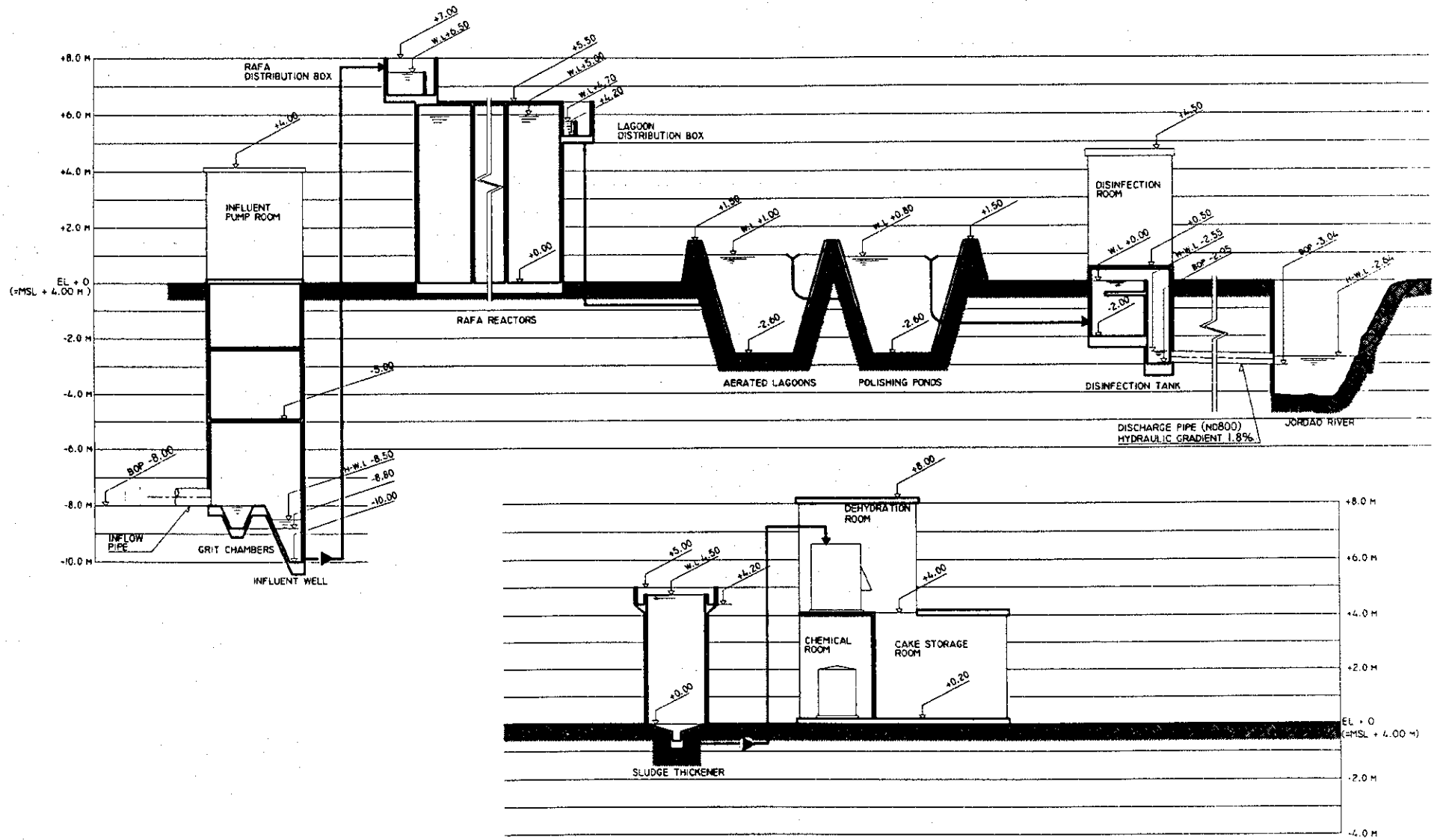


Fig. B.6-16	Boa Viagem Sewage Treatment Facilities Hydraulic Profile
THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR	

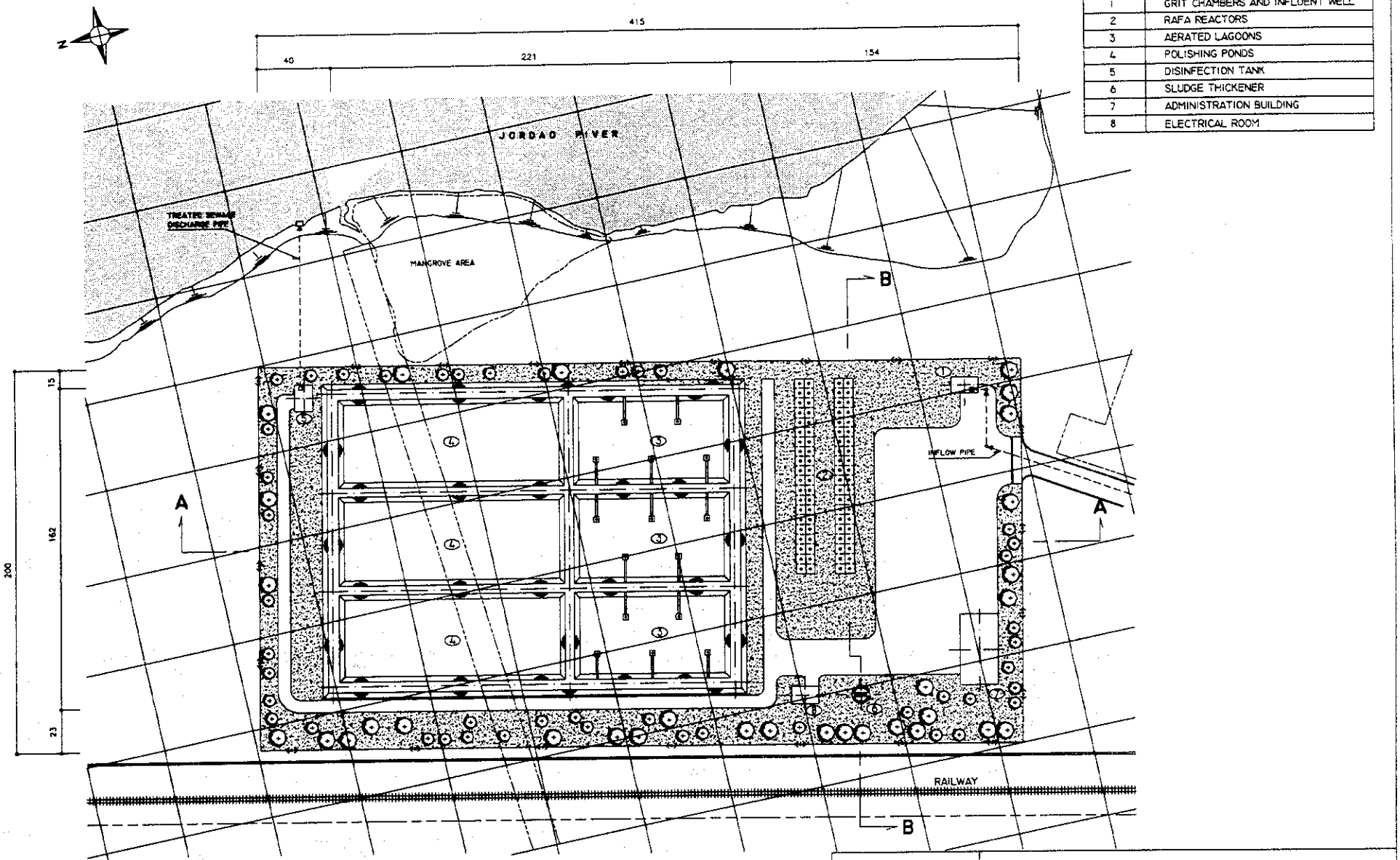


TABLE OF FACILITIES

NUMBER	NAME
1	GRIT CHAMBERS AND INFLUENT WELL
2	RAFA REACTORS
3	AERATED LAGOONS
4	POLISHING PONDS
5	DISINFECTION TANK
6	SLUDGE THICKENER
7	ADMINISTRATION BUILDING
8	ELECTRICAL ROOM

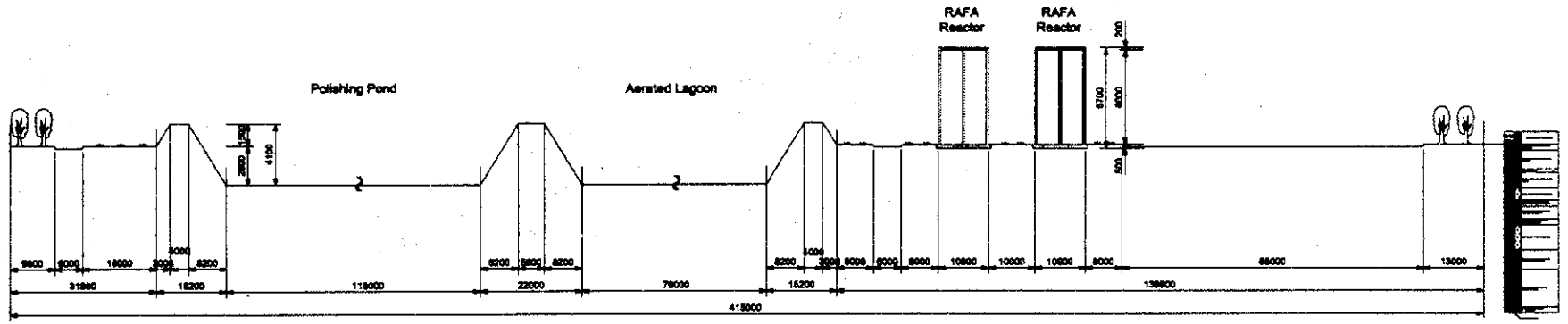
REMARKS:
(1) THE UNIT OF COORDINATE IS 50M..
(2) THE UNIT OF DIMENSIONS IS "METER".

SCALE: 1/2,000

Fig, B,6-17 Boa Viagem Sewage Treatment Facilities Layout Plan

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

Section A-A (H=1/1000,V=1/300)



Section B-B (H=1/1000,V=1/300)

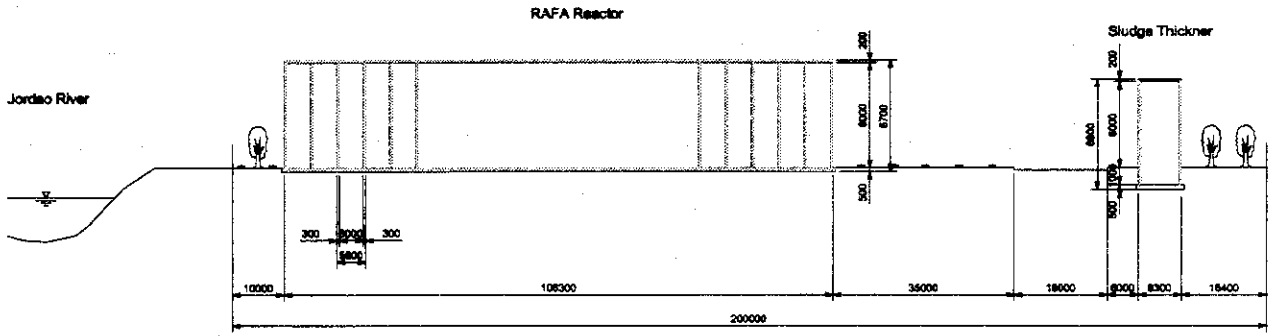


Fig. B.6-18	Boa Vigem Sewage Treatment Facilities Cross Section (Section A-A,B-B)
THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR	

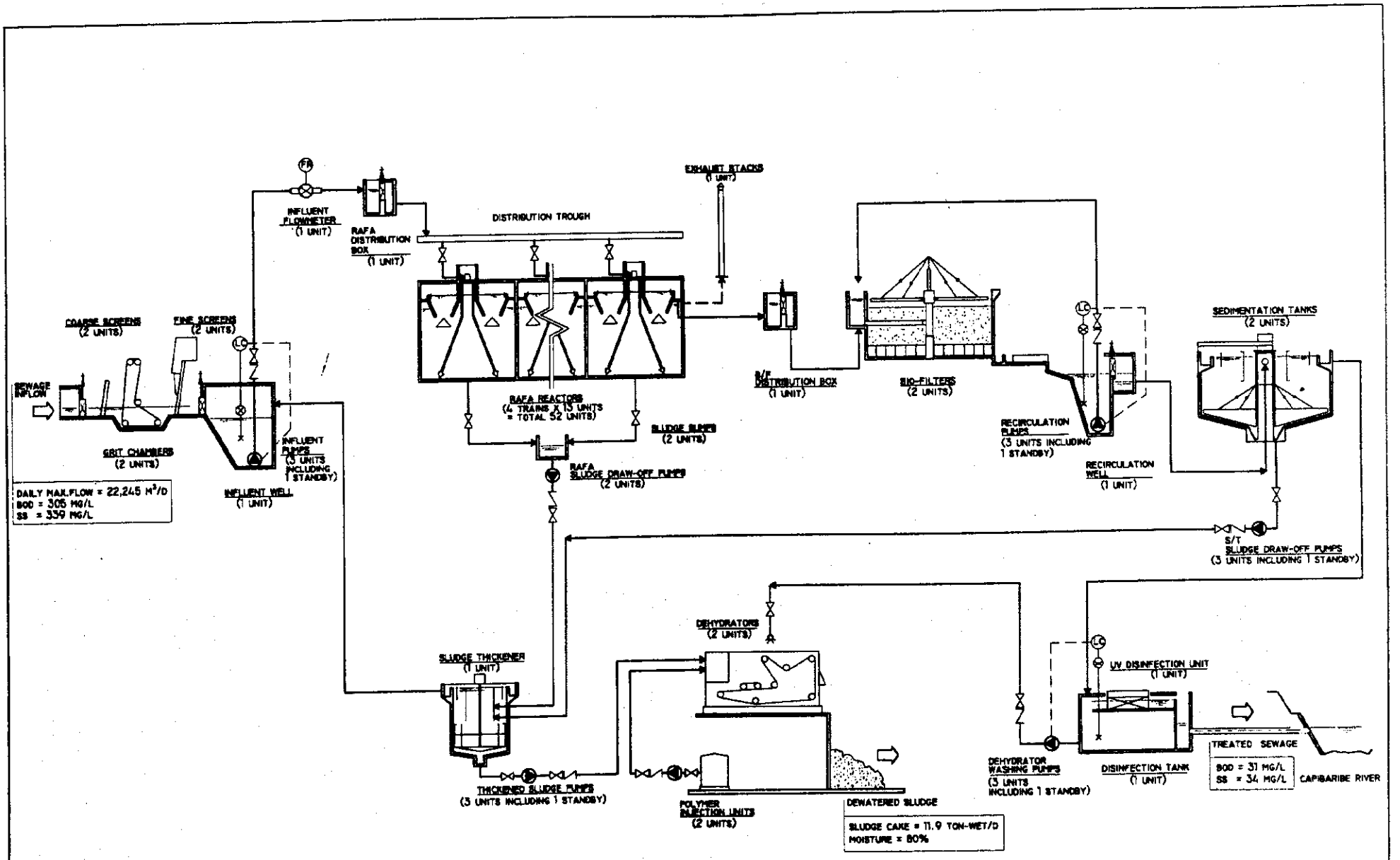


Fig. B.6-19 Cordeiro Sewage Treatment Facilities Flow Diagram

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

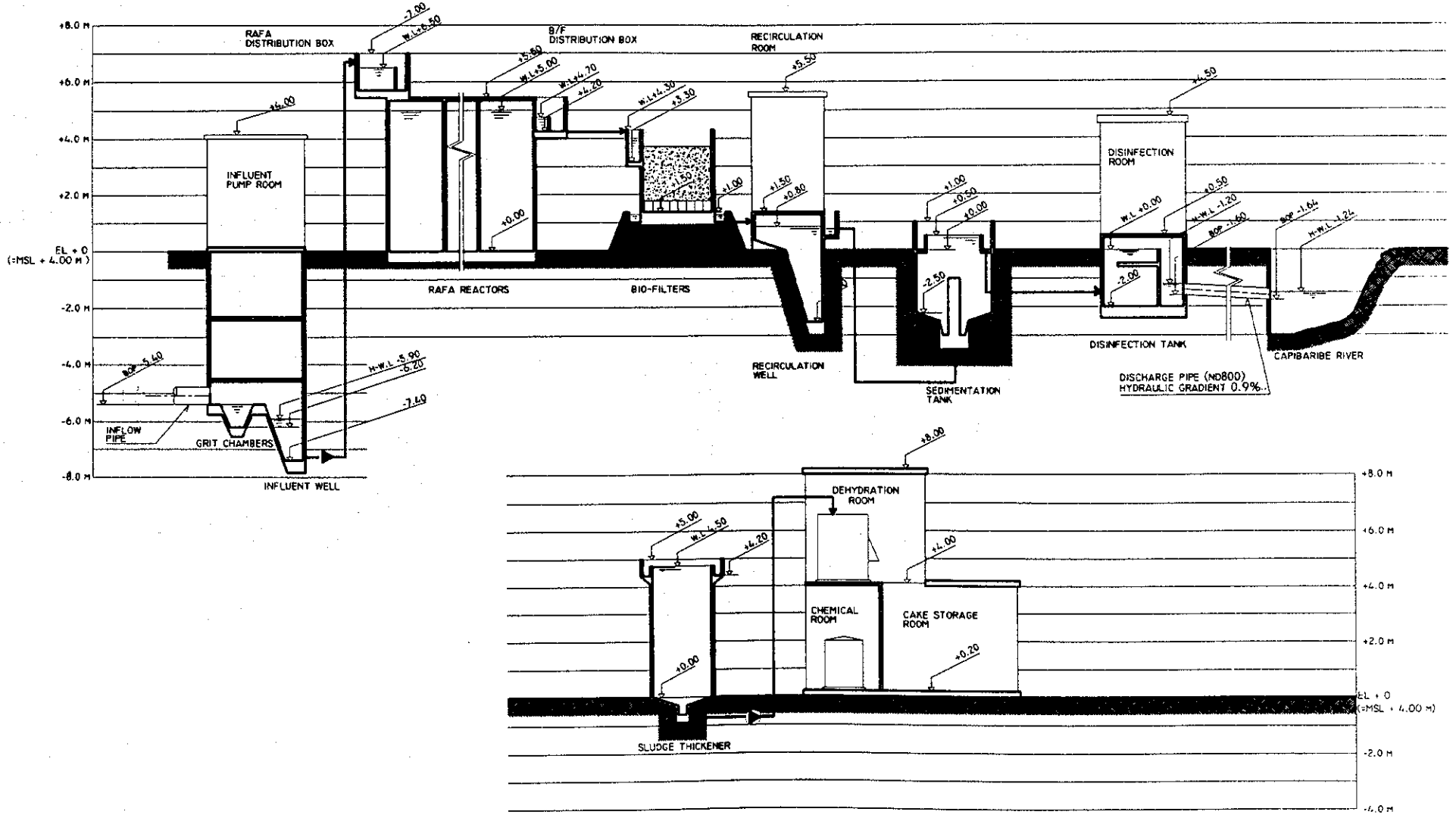
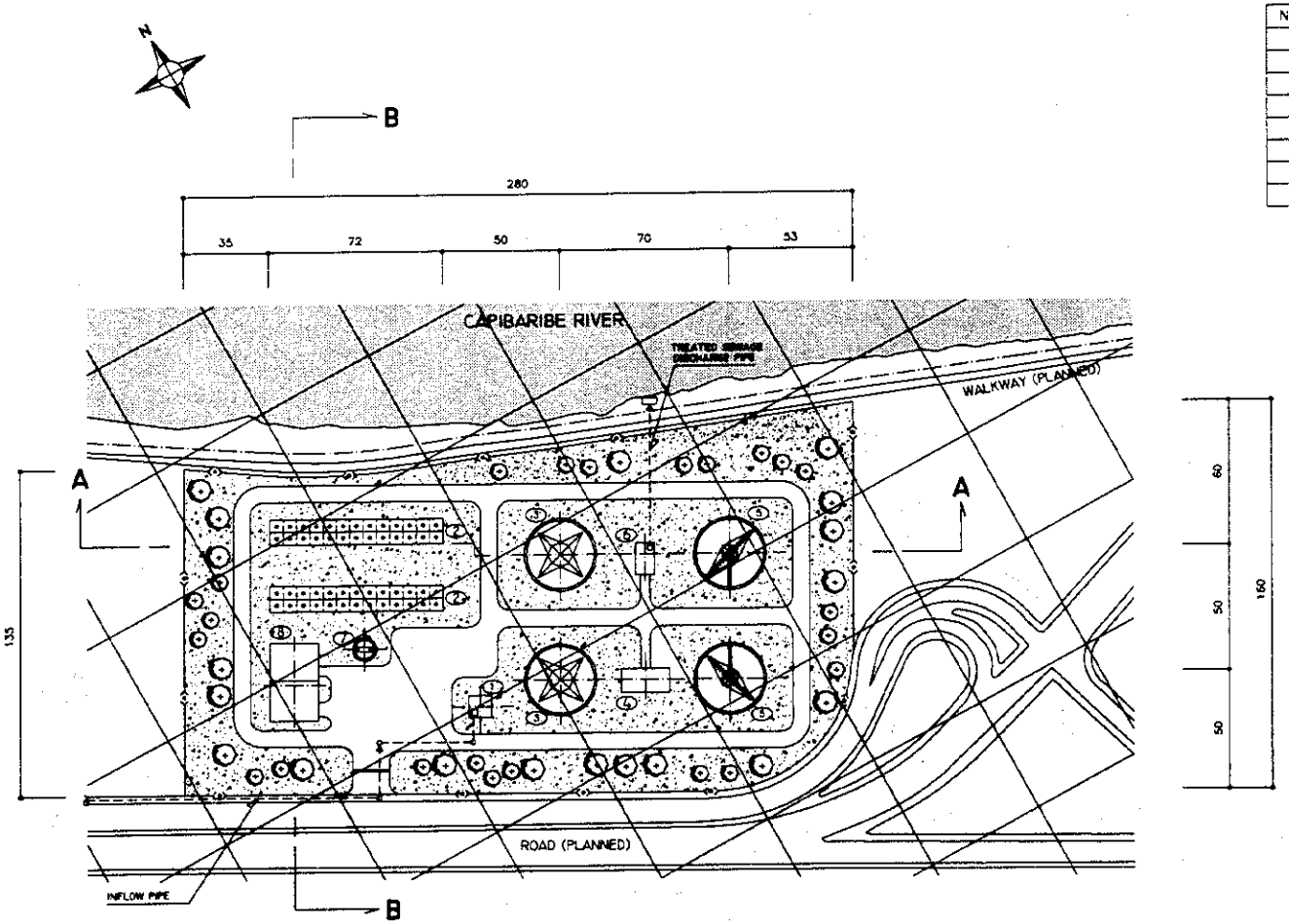


Fig. B.6-20	Cordeiro Sewage Treatment Facilities Hydraulic Profile

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

TABLE OF FACILITIES

NUMBER	NAME
1	GRIT CHAMBERS AND INFLUENT WELL
2	RAFA REACTORS
3	BIO-FILTERS
4	TRANSFER TANK
5	SEDIMENTATION TANKS
6	DISINFECTION TANK
7	SLUDGE THICKENER
8	ADMINISTRATION BUILDING



REMARKS:
(1) THE UNIT OF COORDINATE IS 50m.
(2) THE UNIT OF DIMENSIONS IS "METER".

SCALE: 1/2,000

Fig, B,6-21 Cordeiro Sewage Treatment Facilities Layout Plan

SECTION A-A

(H = 1/1000, V = 1/300)

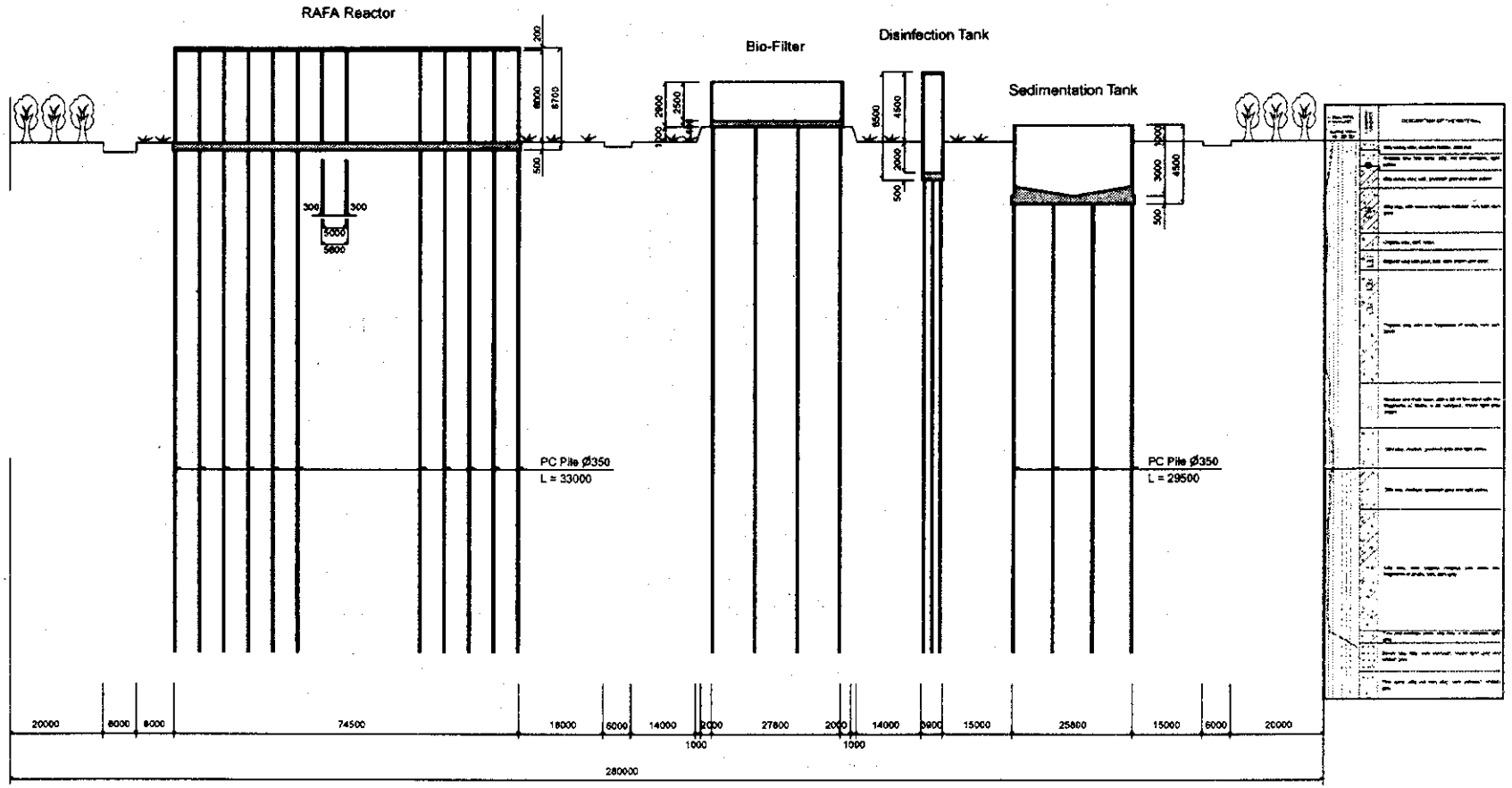


Fig. B.6-22	Cordeiro Sewage Treatment Facilities Cross Section (Section A - A)
THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR	

SECTION B-B

(H = 1/1000, V = 1/300)

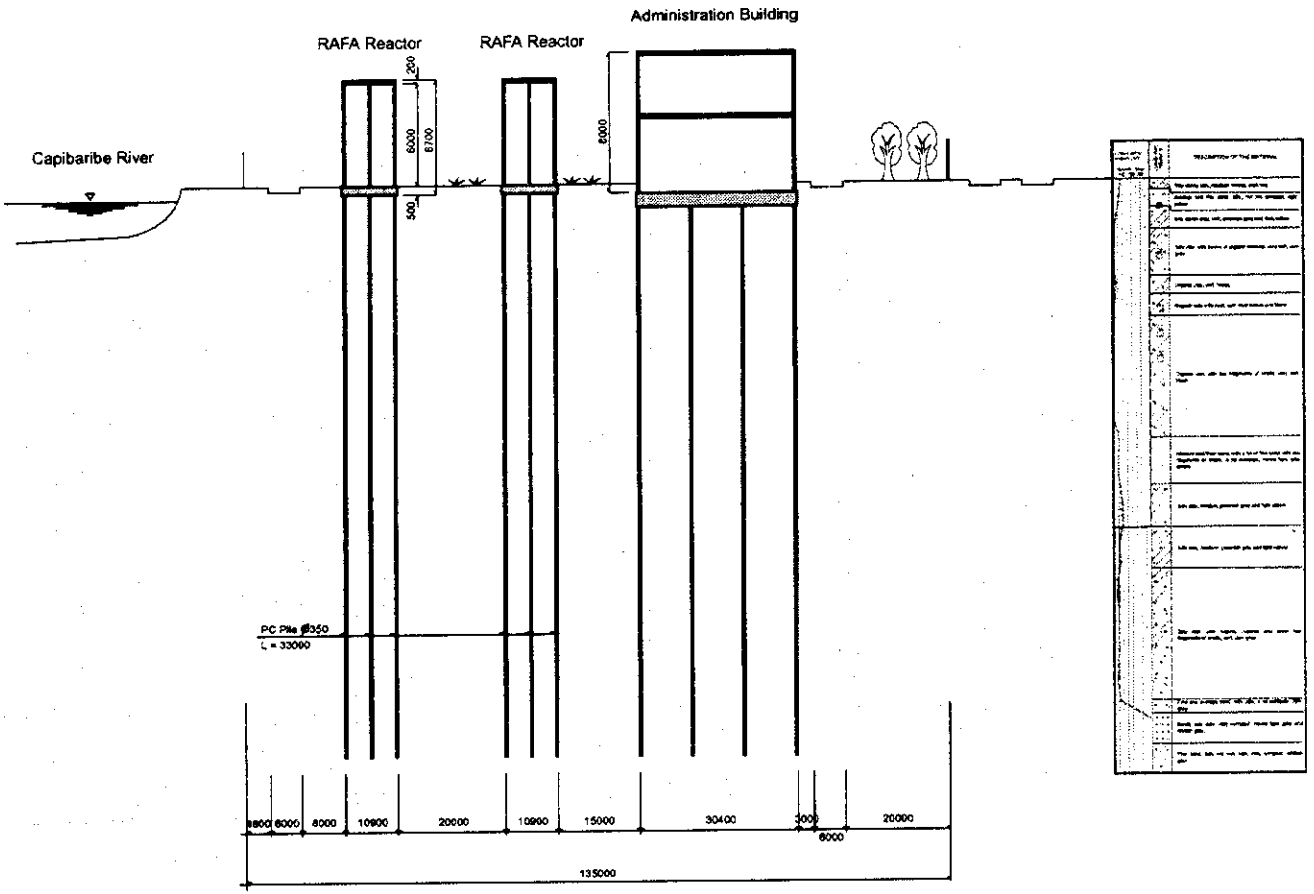


Fig. B.6-23	Cordeiro Sewage Treatment Facilities Cross Section (Section B - B)

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

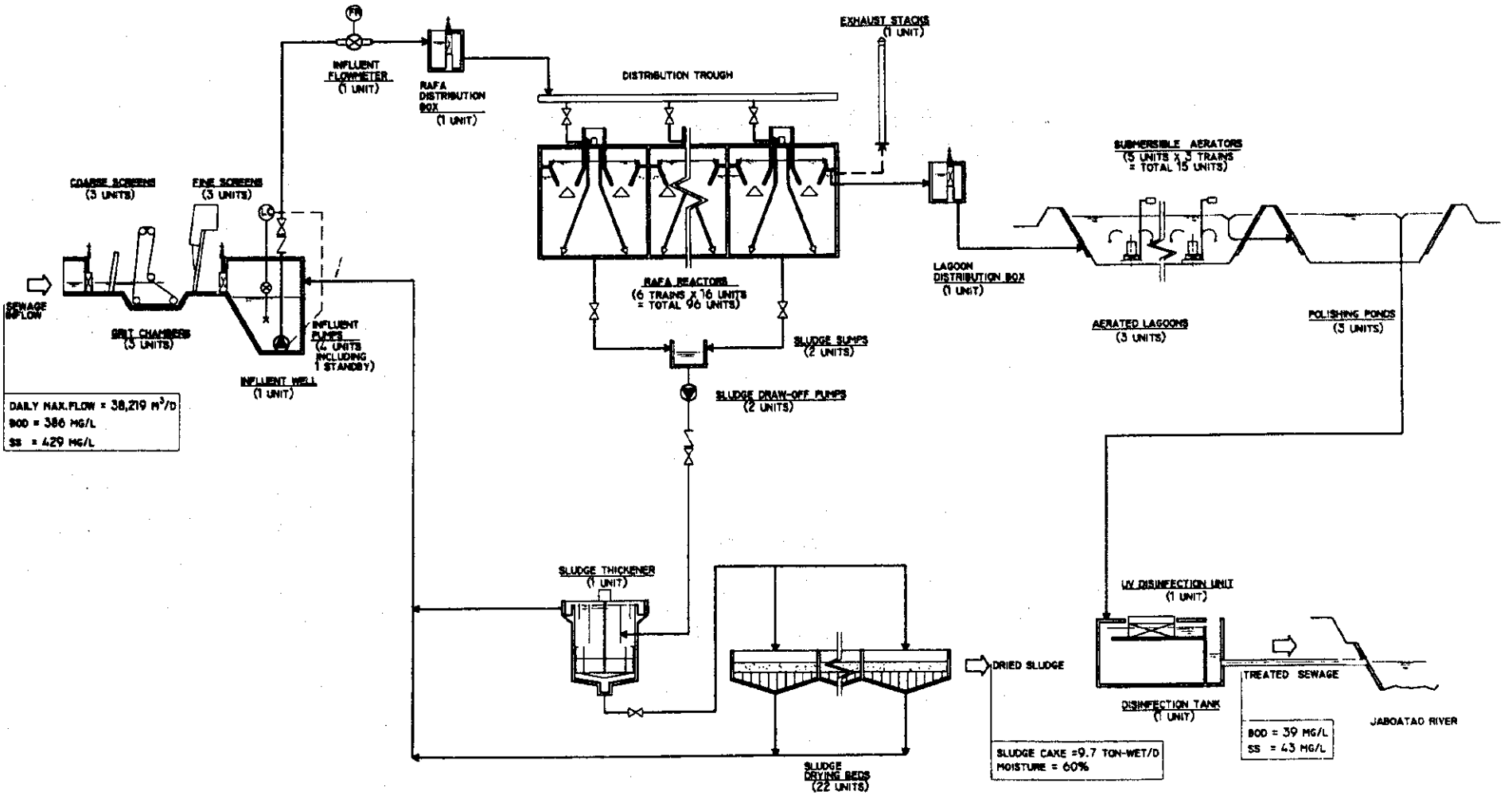
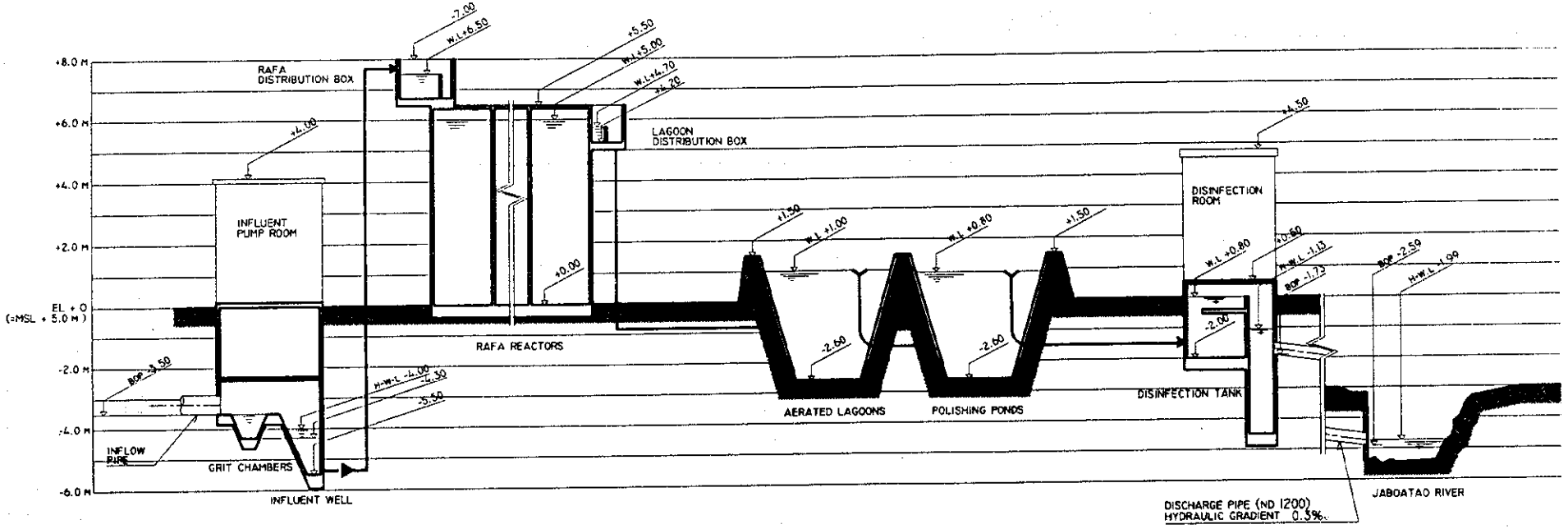


Fig. B.6-24 Prazeres SewageTreatment Facilities Flow Diagram

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR



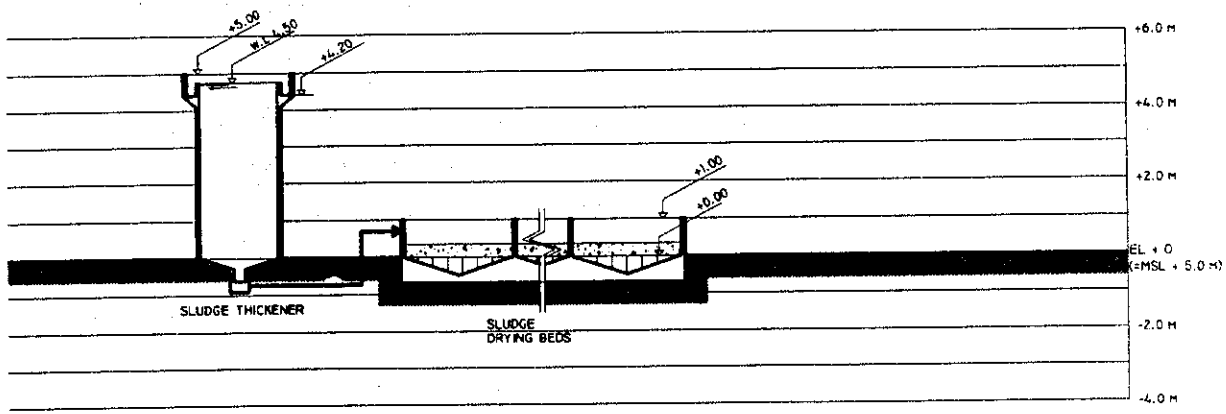
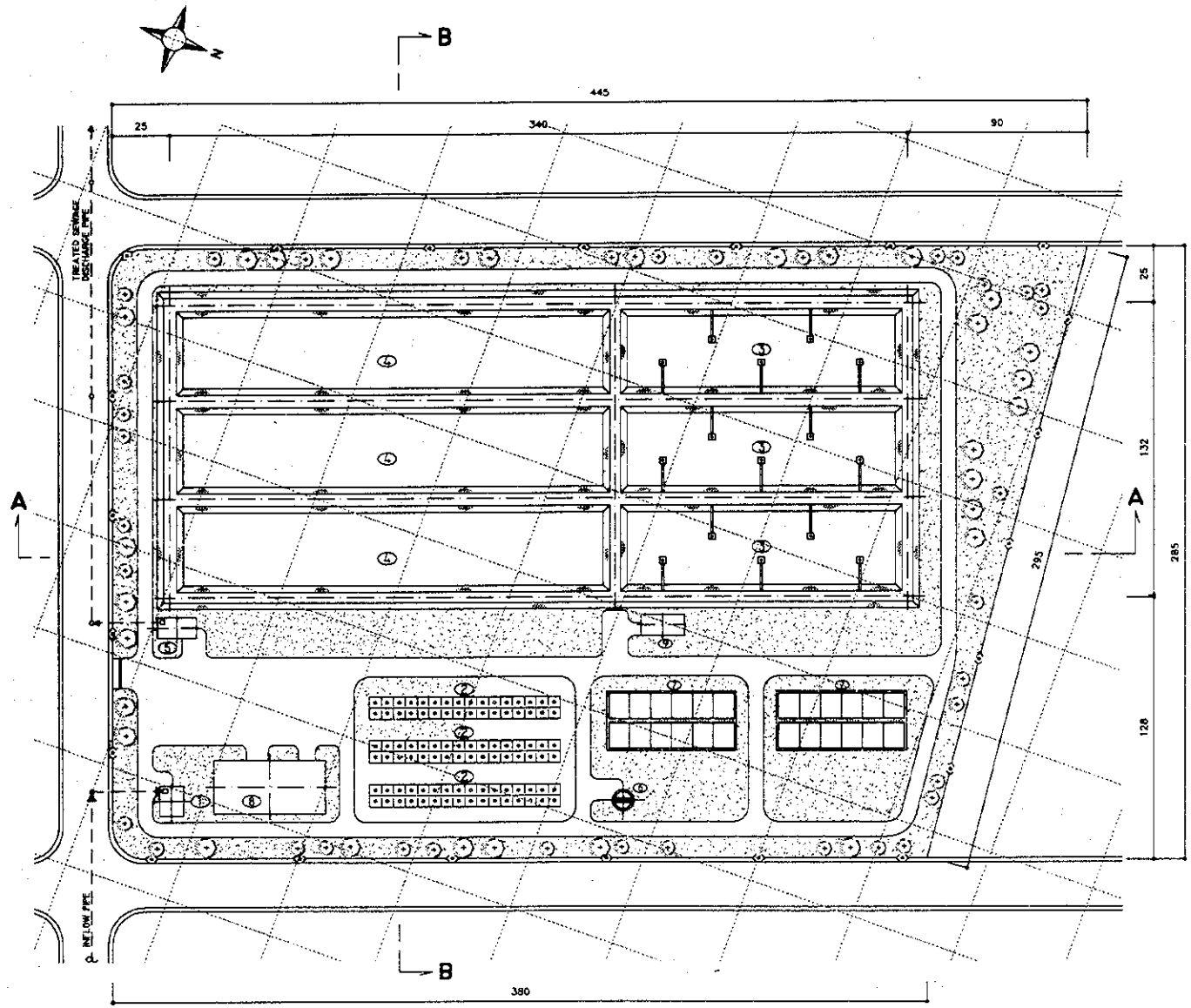
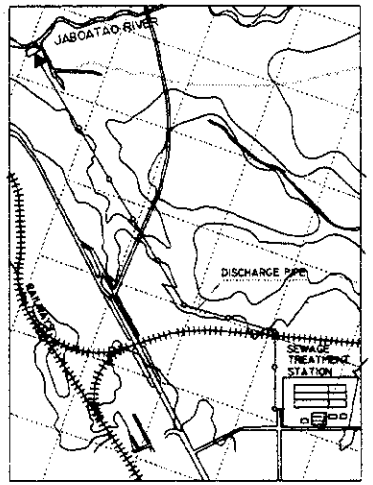


Fig. B.6-25	Prazeres SewageTreatment Facilities Hydraulic Profile
THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR	





TREATED SEWAGE DISCHARGE PIPE

SCALE: 1/30,000

TABLE OF FACILITIES

NUMBER	NAME
1	GRIT CHAMBERS AND INFLUENT WELL
2	RAFA REACTORS
3	AERATED LAGOONS
4	POLISHING PONDS
5	DISINFECTION TANK
6	SLUDGE THICKENER
7	SLUDGE DRYING BEDS
8	ADMINISTRATION BUILDING
9	ELECTRICAL ROOM

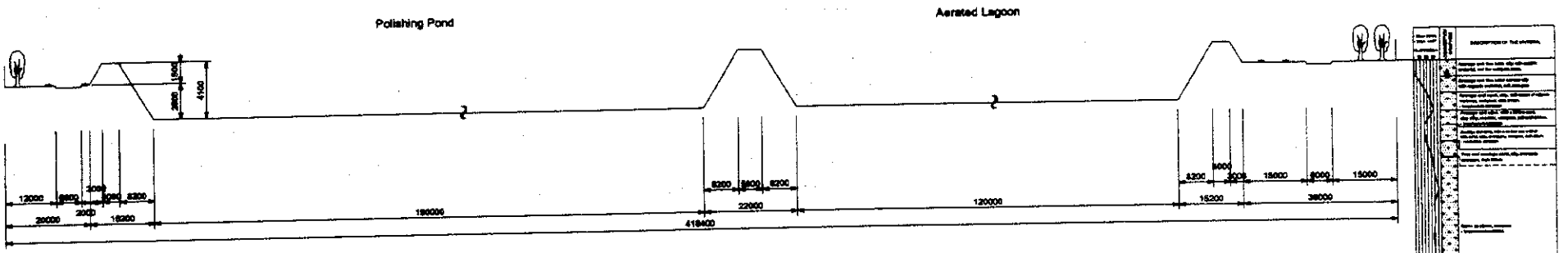
REMARKS:
(1) THE UNIT OF COORDINATE IS 50M.
(2) THE UNIT OF DIMENSIONS IS "METER".

SCALE: 1/2,000

Fig, B,6-26 **Prazeres Sewage Treatment Facilities Layout Plan**

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

Section A-A (H=1/1000,V=1/300)



Prageres (B)

Section B-B (H=1/1000,V=1/300)

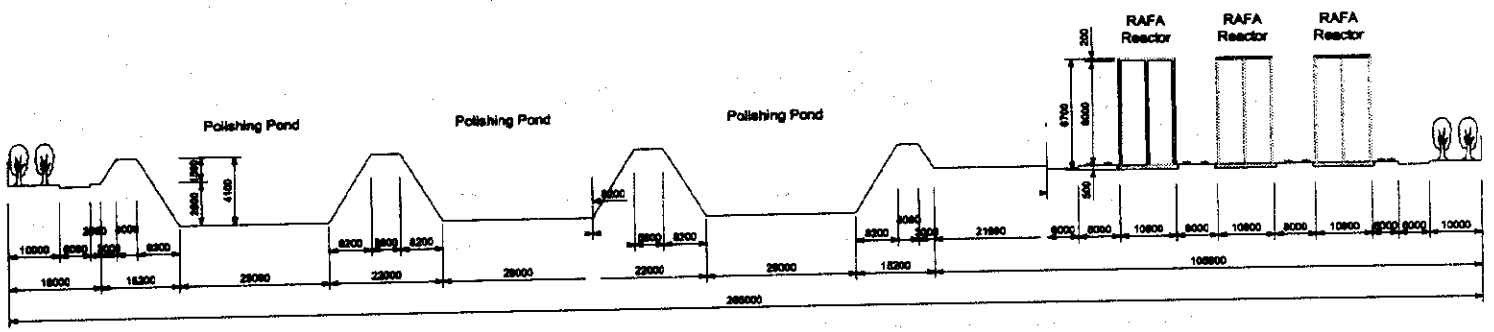


Fig. B.6-27	Prazeres Sewage Treatment Facilities Cross Section (Section A-A,B-B)
THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR	

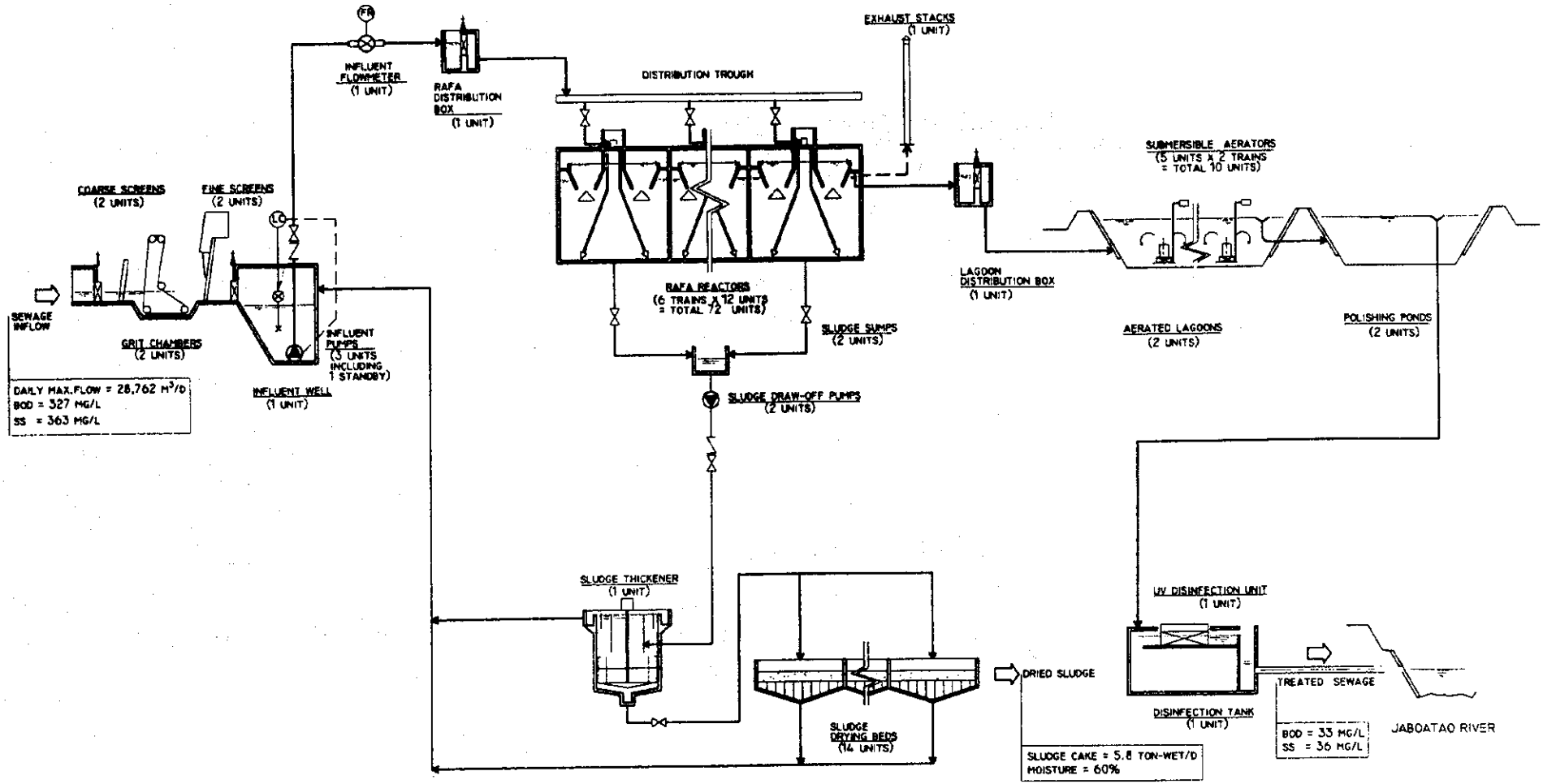


Fig. B.6-28 Curcurana SewageTreatment Facilities Flow Diagram

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

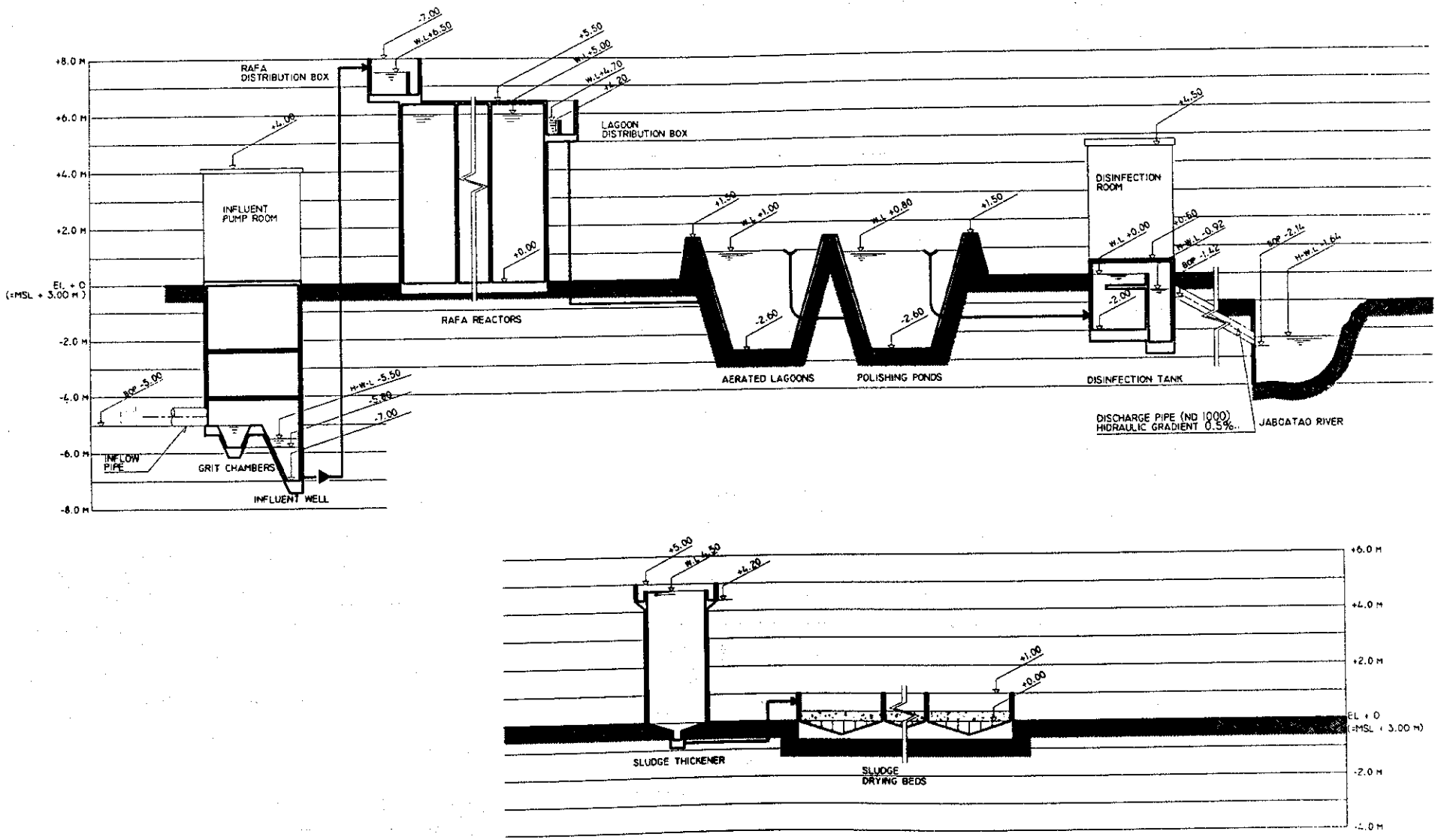


Fig. B.6-29	Curcurana SewageTreatment Facilities Hydraulic Profile
THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR	

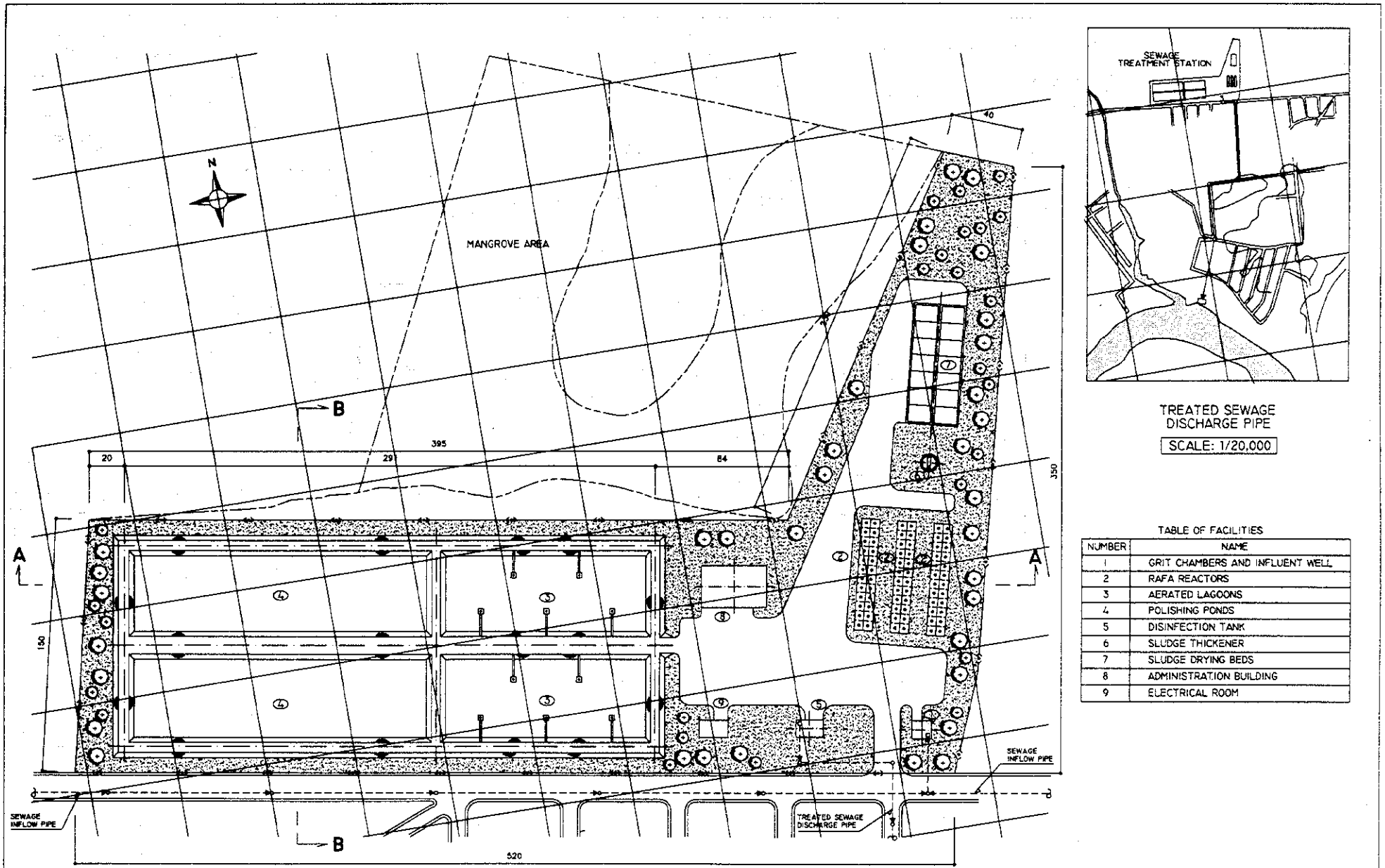


TABLE OF FACILITIES

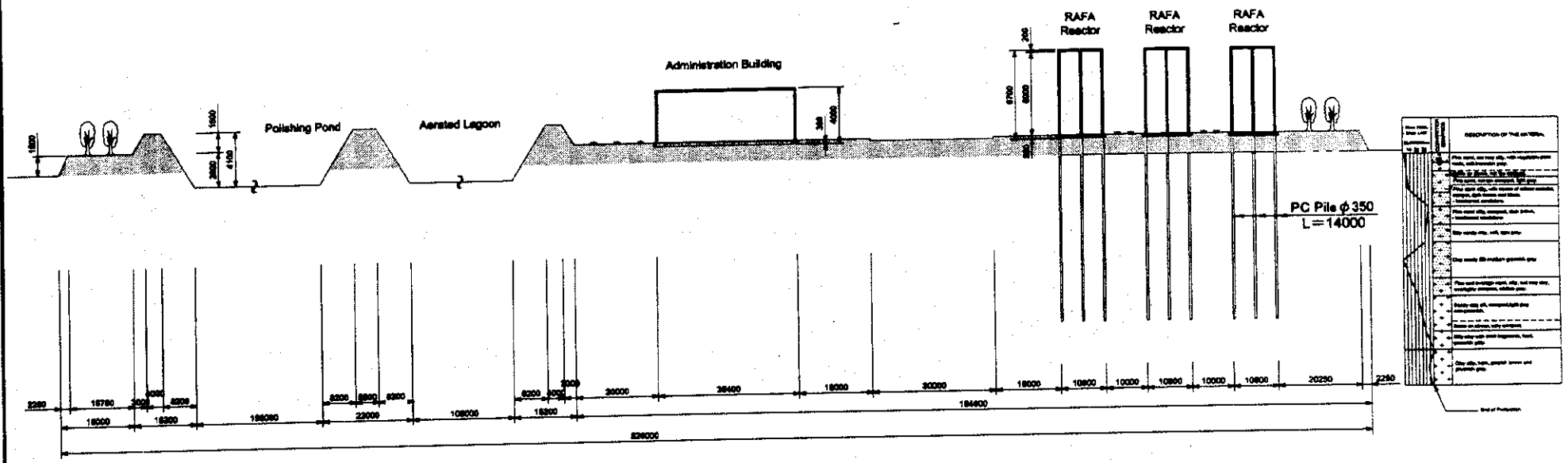
NUMBER	NAME
1	GRIT CHAMBERS AND INFLUENT WELL
2	RAFA REACTORS
3	AERATED LAGOONS
4	POLISHING PONDS
5	DISINFECTION TANK
6	SLUDGE THICKENER
7	SLUDGE DRYING BEDS
8	ADMINISTRATION BUILDING
9	ELECTRICAL ROOM

SCALE: 1/2,000

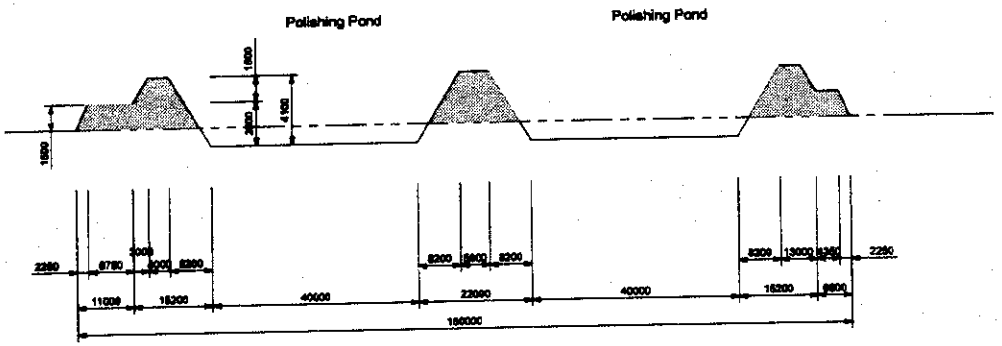
Fig. B,6-30 Curcurana Sewage Treatment Facilities Layout Plan

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

Section A-A (H=1/1000,V=1/300)



Section B-B (H=1/1000,V=1/300)



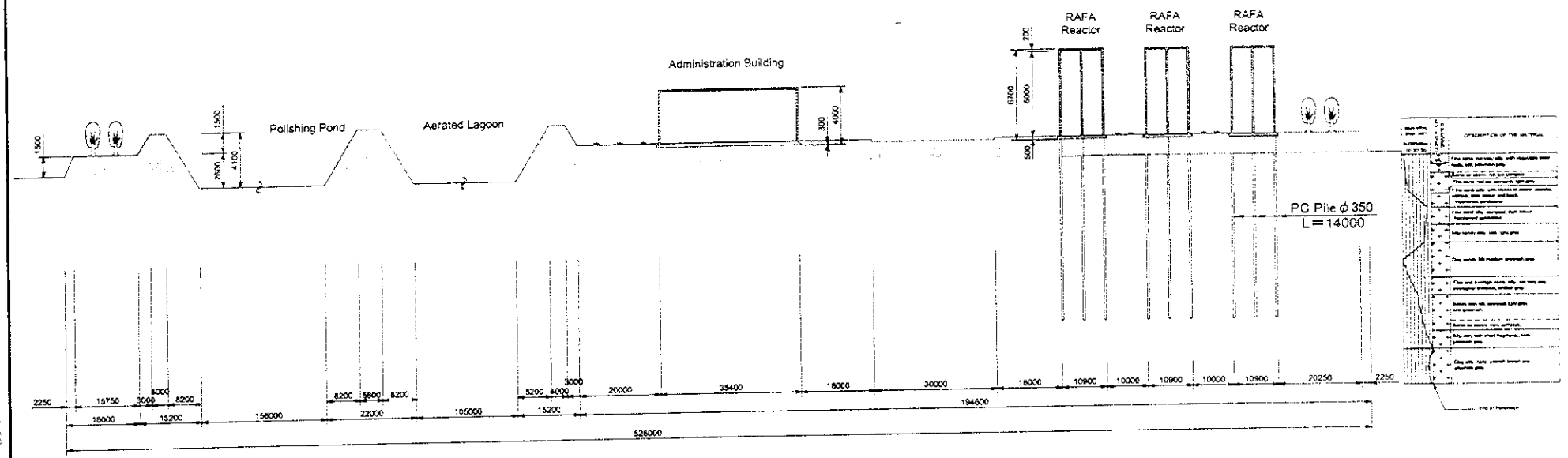
Legend

— — —	Existing Ground Level
	Embankment

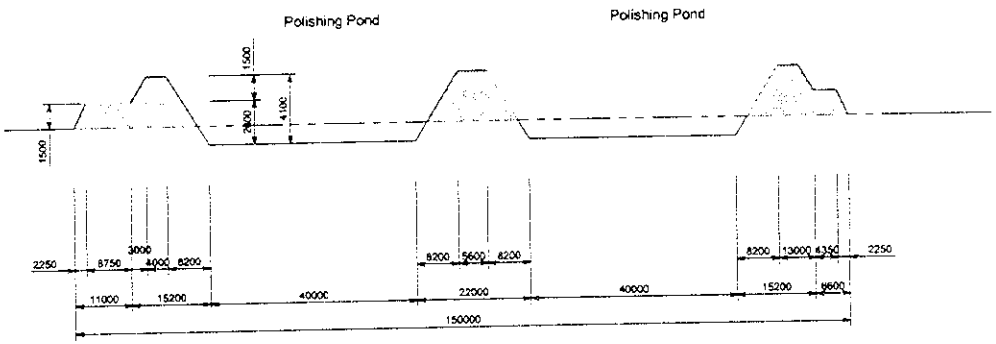
Fig. B.6-31	Curcurana Sewage Treatment Facilities Cross Section (Section A-A,B-B)

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

Section A-A (H=1/1000,V=1/300)



Section B-B (H=1/1000,V=1/300)



Legend

———	Existing Ground Level
	Embankment

Fig. B.6-31 Curcurana Sewage Treatment Facilities Cross Section (Section A-A,B-B)

THE STUDY ON STORMWATER DRAINAGE AND SEWERAGE MANAGEMENT PLAN FOR RMR

SUPPORTING REPORT C

DRAINAGE

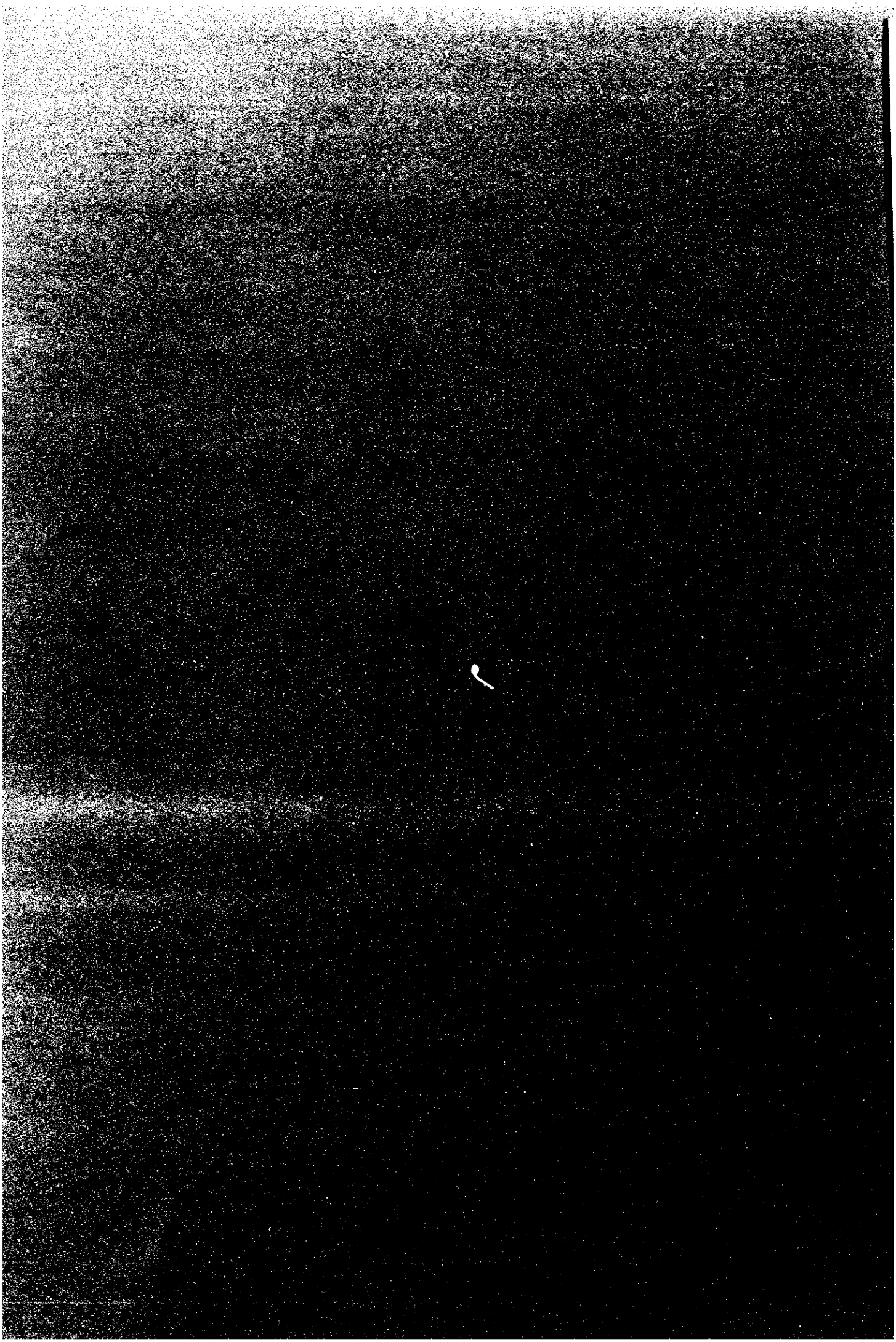


TABLE OF CONTENTS

Page

SUPPORTING REPORT C: DRAINAGE

LIST OF FIGURES

Page

SUPPORTING REPORT C: DRAINAGE

1. DRAINAGE

1.1 Flood Areas in the RMR

The delta area of the Capibaribe River underwent severe flooding until 1977. However, two dams (Carpina and Goita) were constructed and operated since 1978 for flood control and the Capibaribe River section upstream of the National Road No.101 was improved. Accordingly no significant flooding from the river has occurred for the past 22 years. Because of the large storage capacity of 395 million m^3 and the large drainage area of 6,400 km^2 for flood control by the dams, the Carpina Dam gate was opened only once in the 1990 flood. The river section downstream of the National Road No.101 has not been improved yet because it is located in a densely populated urban area.

Since 1978, flooding has been caused by storm rains in the catchment downstream of the dams, and limited to the lowlands in the municipalities of Jaboatao, Recife and Olinda. The Study Team conducted a survey on flood conditions and added the survey results to the flood areas shown in the PQA-RD. Critical flood areas after 1978 are shown in Figs.C.1-1. There are many illegally built houses along the riverbanks and their occupants are to be relocated.

The situation of the critical flood areas is as follows.

(1) Jaboatao dos Guararapes

Flood areas are located around the Olho d'Agua Lagoon, which has an area of 3.75 km^2 with a drainage basin area of 33.75 km^2. The yearly maximum water level of the lagoon ranges from 0.94 m to 1.68 m (October 1990). There are two major channels, the Canal de Setubal and the Canal Corolinas, flowing into the lagoon which drain into the Jaboatao River by way of the Canal Olho D'Agua. These channels are not lined (earth channels).

The areas lower than about 2.0 m above mean sea level (m.s.l) with poor drainage are prone to flooding. However, most of the areas around the lagoon are higher than 2.0 m because of reclamation. The PQA proposed to improve parts of the Canal de Setubal and other channels. The Municipality intends to improve the canals of Setubal and Olho D'Agua and create a new channel of 40m wide, linking the two canals and bypassing the lagoon.

(2) Recife

The Municipality of Recife has conducted some drainage improvement works; thereby solving, major flood problems. The remaining flood problems are small scale and of short

duration. There are about seventy (70) locations on and around roads identified as flood prone, due mainly to poor drainage. These locations should be improved by providing road surface drainage facilities and proper municipal maintenance activities (such as cleaning).

(3) Olinda City

The critical flood areas are located along the Beberibe River and its tributary, the Canal da Malaria. The areas are lower than the surrounding areas due to the estuary topography and the existing hollows of old mining sites. The Municipality of Olinda intends to redevelop the coastal wetland by relocation and also to improve the upper part of the Rio Doce.

1.2 Further Study

Stormwater drainage problems after 1978 have been occurred in the cities of Jaboatao, Recife and Olinda. The municipalities have conducted the drainage improvement projects, which include the channels improvements, local drainage improvements, redevelopment of the swampy areas, land use regulation, etc and still continuing. The methods of those are suitable except the sizes of channels and should be implemented in early stage for improving a favorable urban function.

In order to establish an economically balanced drainage improvement plan for the urban areas in RMR, more detailed information will be required. In this section, recommendations are made on studies for the long-term, and the short-term stormwater drainage requirements of each drainage basin in the municipalities of Jaboatao, Resife and Olinda. The short-term drainage requirements are examined for the flooded areas around Olho D'Agua Lagoon, near the airport and in the Beberibe River basin.

[Study for Short-term Requirements]

This is recommendation for the stormwater drainage projects, which included in the PQA and those of the municipalities going to implement.

(1) Canal Olho D'Agua Basin (Jaboatao)

The Municipality of Jaboatao is going to improve the Canal Olho D'Agua. The improvement should study the following requirements (refer to Fig. 3.4-2):

1) The lagoon flood level rises due to small discharge capacity of the outlet canal (Canal Olho D'Agua). Present canal length can be shortened from 3.3 km to 2.4 km by moving the mouth at the Jaboatao River about 1 km downstream side. Thus

the capacity will be increased by 15 %. This will lower the lagoon flood level and flood area around it as a result.

2) The design flood levels of the canal should be approximately 1.35 m at the sea, 1.5 m at the Jaboatao River confluence, 2.0 m at the lagoon and 3.5 to 4.0 m at the Canal Setubal upstream considering the topographic conditions.

3) The lagoon should be dredged in order to store the floodwater from the area upstream. Otherwise, the Canal Olho D'Agua will need a large capacity. The canal has small hydraulic gradient (0.5/2400 or 1/3300 = 0.0002 or 0.00015).

4) It is better to provide the canal along eastern side of the lagoon for its maintenance and limit the house occupation.

5) The canal proposed by the municipality should be of compound cross section to reduce sedimentation in the channel.

6) Providing drainage channels into the lagoon can solve flooding of the areas apart from the lagoon. These areas are relatively high (3 to 4m) in general.

(2) Beberibe River Basin

1) Wet Lands along the Beberibe River and Canal Da Malaria

The flooded areas in the coastal strip and the upper Canal do Malaria basin should be reclaimed or redeveloped. Otherwise, the area lower than 2m should not be developed as regulated by the law (refer to Fig. 3.4-3).

2) Design flood levels of the Beberibe River would be about 1.35 m at the sea, 2.0 m at the Canal do Maralia confluence and 2.5 to 3m at the Canal Vasco Da Gama confluence. Width of the Beberibe River shall be kept in accordance with the laws, especially the section between Maralia and Canal Vasco Da Gama, where hydraulic gradient is small and design discharge is not small. A river width of more than 100m would be required for 20-year flood.

(3) Doce River Basin

There are low areas compared with surroundings along the lower Fragoso River and Canal do Matadouro located about 5km from the river mouth. Existing width of the Doce River is only about 30m. If the upper basin were developed, it would be difficult to drain the design discharge because of small hydraulic gradient (about 1/2000 or 0.0005). Since acquisition of the land for the Doce River improvement is not easy, these low lands (about +4 m) should be used for floodwater retarding. If developed, the lands would become flood prone or the river reaches downstream have to be widened.

(4) Canal Derby Cataruna

The Canal Derby Cataruna has tide gates on its both ends to lower the water level and store the stormwater in the cannel. Hydraulic conditions are as follows:

1) Tidal range is 1.0m to 2.5m.
2) The maximum water storage volume is about 77,000 m^3 with a maximum water level of about 1.1 m assuming that the tidal range of 2.0 m and channel length of 5.5 km.
3) The storage volume of 77,000 m^3 is equivalent to the water volume of 20mm rainfall from the channel basin of 6.46km^2 assuming runoff coefficient of 0.6. Therefore, after 20 mm storm-rain, the flood level of the channel goes up to that with no gates.
4) The tide gates can lower the water level in the channel by opening the gate during low tide and closing before high tide. Thus drainage is made efficiently up to the rainfall of 20mm.
5) The maximum daily rainfall at Resife during 30 years (1961 to1990) in August was 382 mm (1990) and in May was 235 mm (1986). The 20-year rainfall would be between 235 mm and 380 mm. The design 60-minutes rainfall for 20-year return period is 56 mm to 71mm. When a storm occur during high tide, the gates can drain effectively up to the total rainfall of 20 mm, and after that, situation is the same as that with no gate.

In conclusion,

- The gate is effective for small and frequent flood, however, it is not enough for the design flood of 20-year return period. In the area with heavy rain, the tide gate is not able to drain the design flood without a large storage volume.
- The low areas in the basin should be reclaimed in order to avoid the drainage by pumping.
- Micro drainage around the canal should be improved as proposed in the PQA for the effective use of the gate.

[Studies for Long-term Requirements]

Recommendations are made for studies for long-term stormwater drainage planning in the RMR.

(5) Planning Conditions

1) Design Rainfall

- Measurement of the rainfall for short duration at three stations in Resife, Olinda and Jaboatao,
- Analysis of probable daily rainfall for the Resife station,
- Study the relationship between daily rainfall and short duration rainfall by using the measurement data in 3 to 5 years and review the design rainfall by using the new data of the above three stations,
- Review the design rainfall (rainfall intensity – duration curves for several return periods) could be established after a long-term measurement, and
- Establish the design rainfall after a long-term measurement.

1) Design Tide for Flood Control and Drainage

The design tide of 1.35m above mean level can be used for flood control and drainage on the basis of the peak discharge. If some flood water storage or drainage by pumping is included, a design rainfall and design tide patterns should be studied.

(6) Preparation of River Improvement Plan

In order to design the stormwater drainage facilities, river improvement plans of the Beberibe, Capibaribe, Tejipio and the lower Jaboatao rivers should be prepared. The plans include longitudinal profiles, alignments and cross sections, and require the following information:

- Detailed topography in and around the flood areas and the rivers/channels,
- Cross sections and longitudinal profiles of the rivers and drainage channels,
- Rainfall measurement data daily and for short duration of storm, and
- River flood level and discharge measurement data.

(7) Design Flood for the Drainage Channels

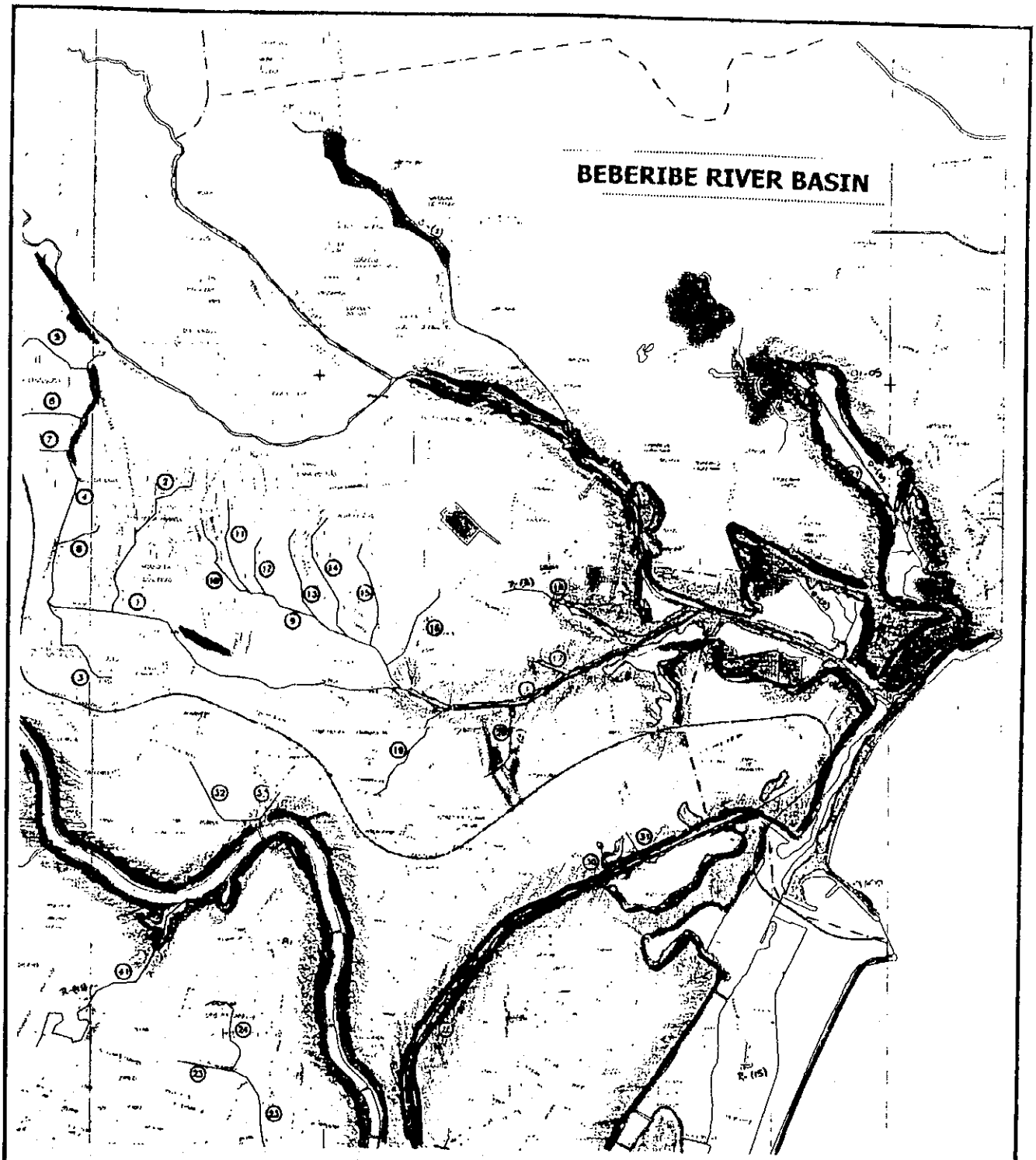
A design storm return period of 20 years was proposed in the PQA. According to the PQA evaluation of the macro drainage channel capacities (refer to Table 3.4-3), the theoretical discharge is not always larger than the 20-year flood discharge, mostly around 10-year flood or less. In addition, coefficient of roughness and slope are not practical. If the design were 20-year flood, expansion of the channels would be difficult. Therefore, the design return period of flood is recommend depending on importance of the channel as follows:

Kind of Channel	Design Flood Return Period
Rivers and Large Channels	10 to 20 years
Small Rivers and Main Open Channels	5 to 10 years
Small Channels	5 years
Road Surface Drainage	3 years

The hydraulic design of drainage channels is recommended as follows:

1) Slope of channel is decided taking, the tide level, river flood level and slope of ground level along the channel, into account.

2) Coefficients of roughness for the channel design should consider that the channels will not be always maintained well,
   - 0.03 for the rivers and wide open channels,
   - 0.02 for lined open channels
   - 0.015 to 0.02 for concrete channels and pipes



LEGEND

Flooded Area

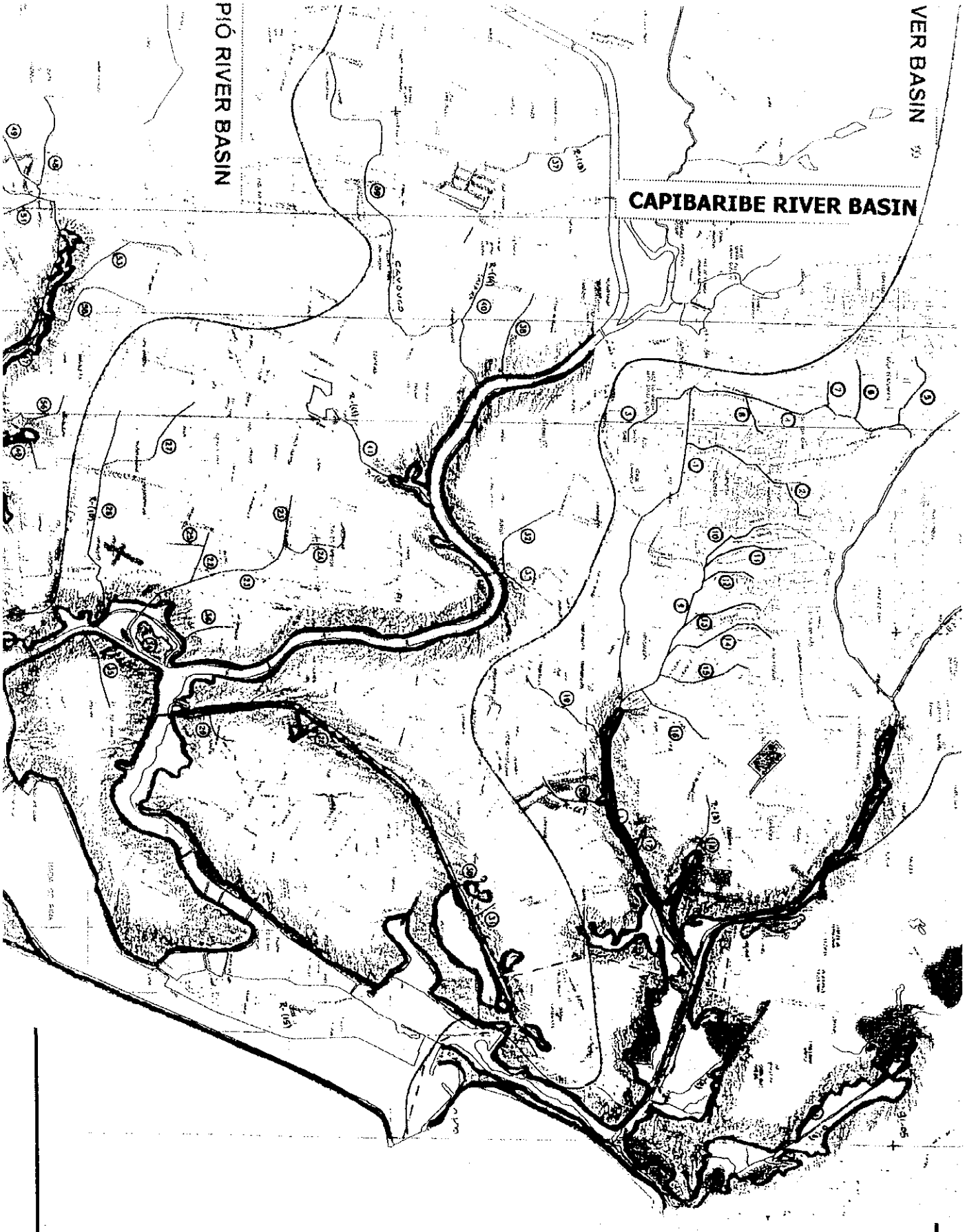
Ground Hight Less than 2.0 m

scale : 1 / 50,000

0 1 2 2,5Km

Fig.C.1-1(1/4)	Flooded Areas(After 1978) - Beberibe River Basin

THE STUDY ON STORM WATER DRAINAGE AND SEWERAGE MANEGEMENT PLAN FOR RMR



LEGEND

Flooded Area

Ground Hight Less than 2.0 m

scale : 1 / 50,000

0 1 2 2,5Km

Fig.C.1-1(2/4)	Flooded Areas(After 1978) - Capibaribe River Basin

THE STUDY ON STORM WATER DRAINAGE AND SEWERAGE MANEGEMENT PLAN FOR RMR

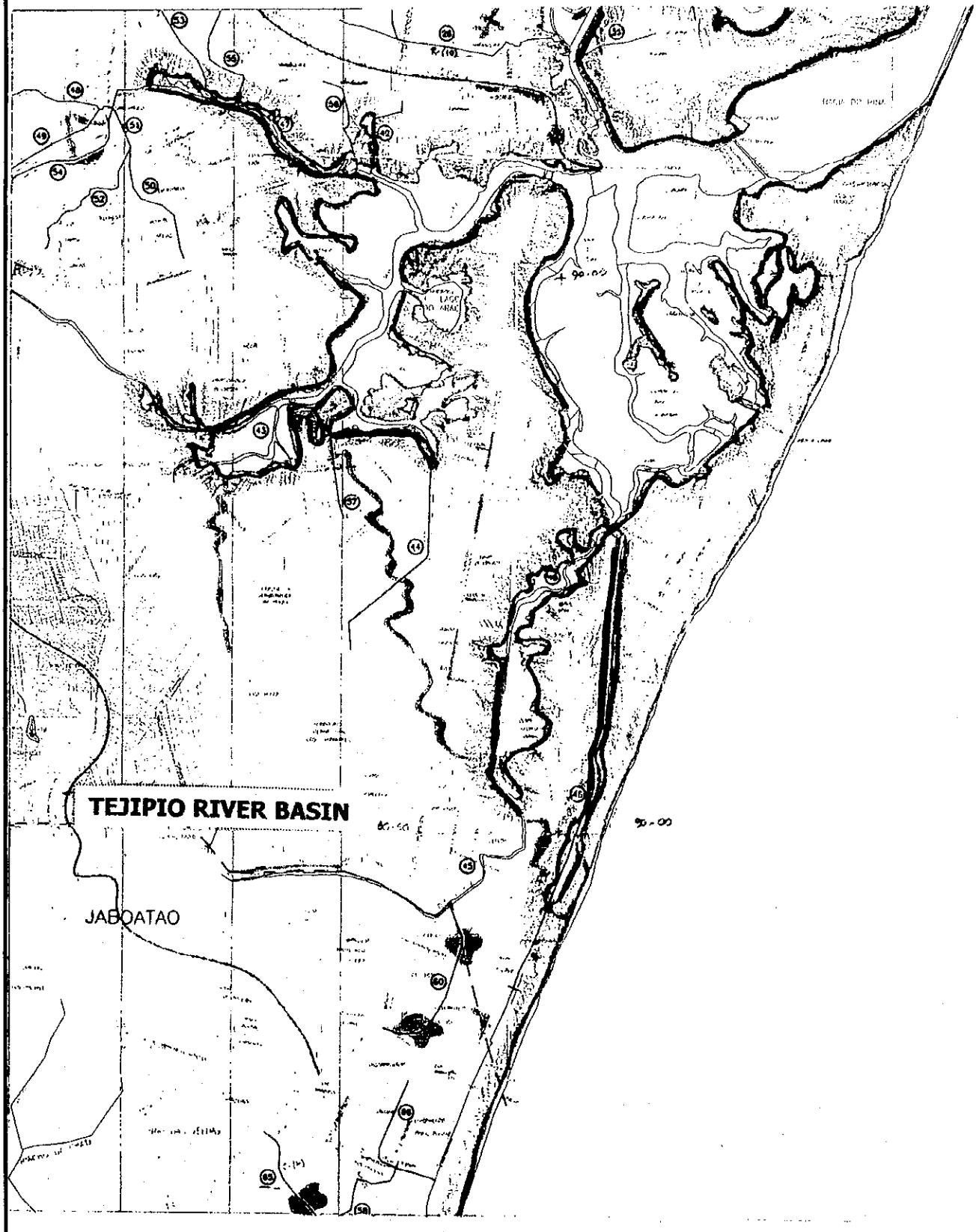


Fig.C.1-1(3/4) Flooded Areas(After 1978) - Tejipio River Basin

THE STUDY ON STORM WATER DRAINAGE AND SEWERAGE MANEGEMENT PLAN FOR RMR

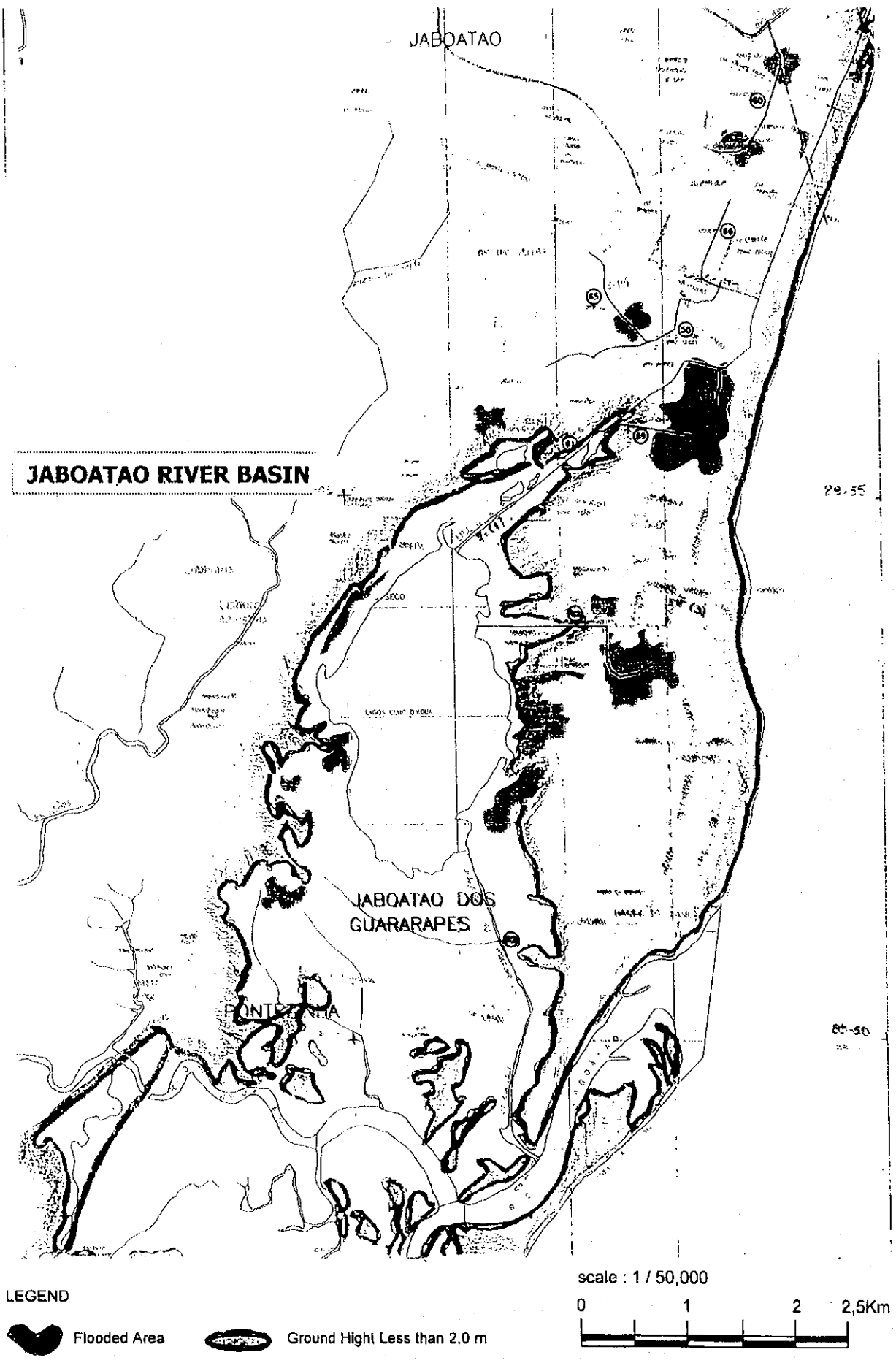


Fig.C.1-1(4/4) Flooded Areas(After 1978) - Jaboatao River Basin

THE STUDY ON STORM WATER DRAINAGE AND SEWERAGE MANEGEMENT PLAN FOR RMR

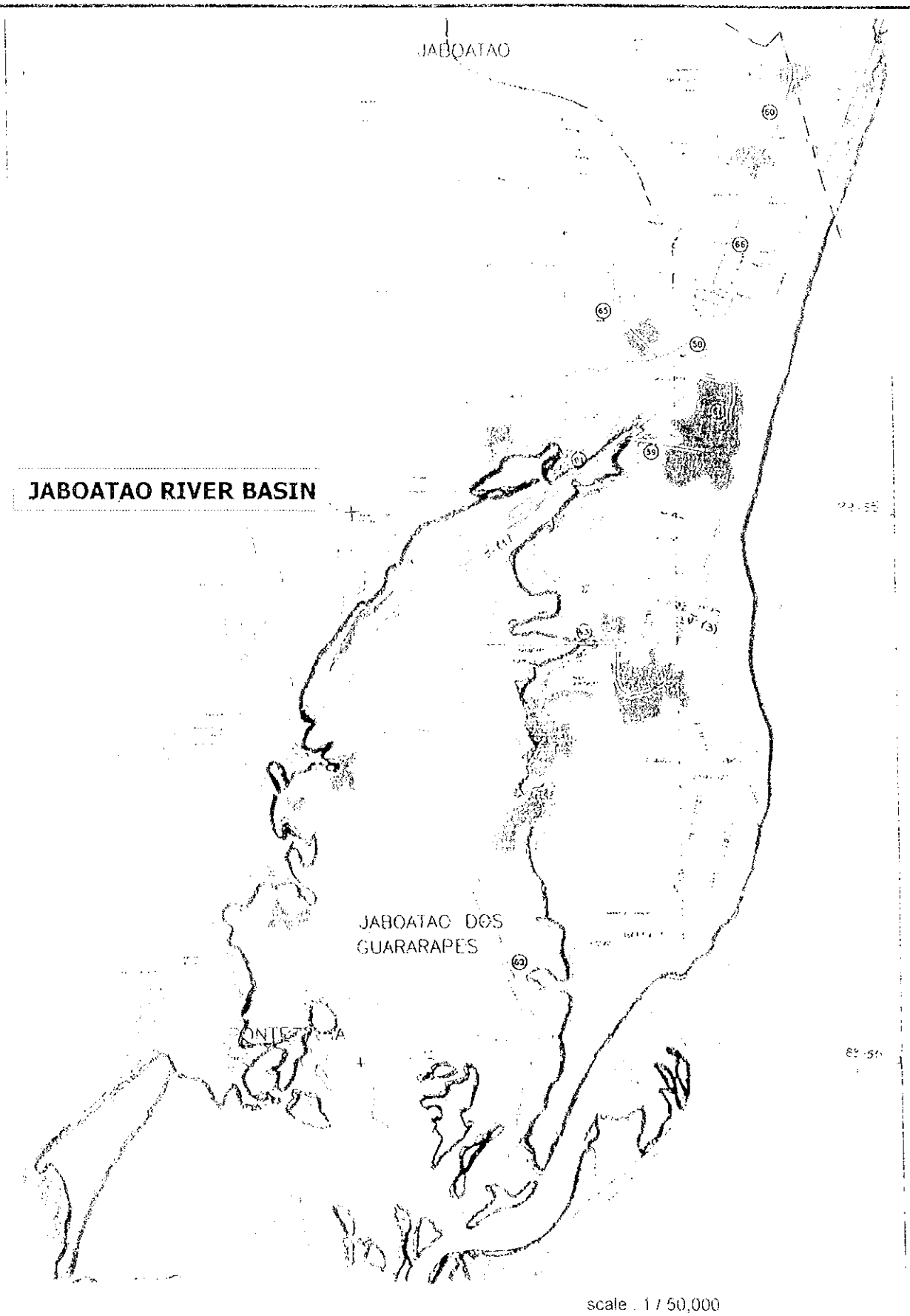


Fig.C.1-1(4/4) Flooded Areas(After 1978) - Jaboatao River Basin

THE STUDY ON STORM WATER DRAINAGE AND SEWERAGE MANEGEMENT PLAN FOR RMR