APPENDIX E

WATER SUPPLY, SEWERAGE AND DRAINAGE

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E.1 Water Supply System

E.1.1 General

For development of the industrial estates in Sri Lanka, especially in the Greater Colombo area, availability of water resource is critically important due to the fact that natural water resources are rather limited in the region. It is, therefore, important to carefully study on the available water resources quantitatively and qualitatively.

Study on water resources has been mainly made on three rivers, Kelani, Maha and Deduru rivers, as well as on groundwater potential in the vicinity of each estate. Sampling and water quality tests on the river water have been executed in the course of this Study.

E.1.2 Water Resources and Their Quality

1) Water Resources

Water resources for the proposed industrial estate sites have been studied on the basis of the existing hydrological data obtained from the Irrigation Department. The results of analysis and selection of an appropriate source of water for the proposed water supply scheme in each estate are explained hereunder.

a) Atherfield Estate

The Kelani river and its tributary, the Sithawaka river which joins the Kelani river in the vicinity of the proposed site, have been selected as major sources for the water supply scheme. From the viewpoint of available discharge, evaluated through flow duration analysis as shown in Fig.E-1-1, the Kelani river has been selected as the appropriate water source. According to the analysis, at least 1 million m^3/day of water will be obtainable during the return period of 10 years.

b) Martin Estate

The Deduru river and groundwater potential around the proposed site have been studied. The Deduru river has a sufficient discharge as analyzed and shown in Fig.E-1-2. According to the analysis, at least 29,000 m^3/day of water will be obtainable during the return period of 10 years.

As for the groundwater potential, it is assumed that a couple of thousand cubic meters would be obtainable, judging from the existing water supply scheme in Chilaw. However, locations of the wells should be several kilometers far from the proposed industrial site to avoid sea water intrusion into the aquifer. Consequently, utilization of groundwater at this estate will not be found to be justifiable.

c) Sirigampola Estate

The Maha river, small streams around the proposed site and groundwater have been studied for the water supply scheme. As for the small streams, available discharge is insufficient for water supply for industrial use, judging from the hydrological estimation by means of topographical maps and site reconnaissance surveys.

As for the groundwater potential, the Water Resources Board reported that approximately 200,000 gallons per day (910 m^3/day) could be obtainable from the aquifer. However, this volume is not sufficient to meet the requirement of 2,400 m^3/day for industrial use.

The Maha river, according to the flow duration analysis as shown in Fig. E-1-3, is found to be sufficient for the probability of less than 92%, which corresponds to a water deficit for 29 days a year.

Under such circumstances, water is proposed to be taken from the Maha river, and some wells will be provided for emergency use in the draught years.

d) Ekala Estate

The Dandugam river and the Attanagalu river which run through the estate site would be utilized. However, no hydrological data has been made available. According to the preliminary estimate on the basis of topographic maps and site reconnaissance surveys, it would be difficult to obtain sufficient volume of water constantly through the year. In this context, it would be necessary to utilize both groundwater and river water at this alternative estate site.

e) Katana Estate

The Maha river will be the source of water for Katana estate. Kimbulapitiya river in the vicinity of the site is not suitable due to insufficient discharge. Potential of groundwater in and around the site is presumed to be low and sufficient quantity of groundwater will not be made available for Katana estate.

2) Water Quality

a) Kelani River

Water quality of the Kelani river was previously investigated by BOI from August 1987 to January 1990 in conjunction with the development of Biyagama EPZ. Sampling took place at about 5 km upstream of the Ambatale water intake. Results of the laboratory tests revealed comparatively high levels of biological parameters, such as maximum BOD of 55 mg/l and Fecal Coliform of 6,000 MPN/ml. Other chemical and biological parameters were in relatively good condition as water source for potable water. Contents of heavy metals were reported in a few records. The detected parameters were 1-5 ppb of cadmium, 2-22 ppb of copper and 1-20 ppb of lead and they were lower than the allowable standard limits.

Another water quality investigation was carried out at 1.5 km upstream of the Ambatale water intake by the Environment Division of National Building Research Organization, during the period from August 1990 to July 1991. All the parameters were lower than the standard as shown in Table E-1-1, and they were in relatively good condition as water source.

Water quality tests on the Kelani river at Ambatale treatment plant have been done periodically by NWSDB. This tests revealed that chemical and biological parameters were comparatively good as shown in Table E-1-2.

From late 1991 to April 1992, heavy drought brought about the worst water quality conditions at Ambatale. The maximum levels were detected in January and February 1992; high concentration of conductivity of more than 2,000 us/cm, turbidity of more than 300 degree and chloride of 1,000 mg/l.

It was reported that the operation of the treatment plant was interrupted several times due to this reason.

In the course of this Study, sampling and water quality tests were executed from March to June 1992. The sampling point was selected at a site downstream from the confluence between the Kelani river and the Sithawaka river. Water quality at this point was found to be satisfactory for the water source to Atherfield estate, as shown in Table E-1-3.

b) Deduru River

No existing data was made available with respect to water quality of the Deduru river, and sampling and tests were conducted at the the Deduru river in the vicinity of the proposed estate site from March to June 1992. A high concentration of salinity and conductivity caused by sea water intrusion was present. The results of the water quality tests are shown in Table E-1-3.

Due to the salinity contents, the Deduru water in the vicinity of the proposed estate will not be utilized for water supply scheme throughout a year. It will be necessary to set up an intake site at least 5 km upstream of the proposed estate site.

c) Maha River

No existing data was made available with respect to water quality of the Maha river and sampling and tests were conducted in the course of this study. The sampling point was selected at a site downstream from the existing Negombo treatment plant. Table E-1-3 shows the results of the water quality tests, with the implication that parameters are acceptable as water source.

E.1.3 Proposed Water Supply System

1) Planned Supply Volume

Unit water demand for each industrial estate has been computed on the basis of the data available from BOI, as well as by referring to the design criteria used internationally. The supply volume are calculated as shown in Tables E-1-4 and E-1-5.

Average hourly water supply has been computed for the supply of 10 hours, for factory operation. For the computation of the maximum hourly water supply, a coefficient of time fluctuation of 1.3 has been applied. Water supply for fire fighting has also been estimated at the volume of 1 m^3/min each for 2 hydrants.

2) Water Supply Facilities

(1) Atherfield Estate

a) Intake Facilities

Intake facilities will be located on the left bank of the Kelani river just downstream from the confluence of the Kelani river and Sithawaka river, as shown in Fig. E-1-4.

The intake volume has been determined on the basis of the maximum daily water supply and augmentation by other necessary demands, as well as the conveyance pipe loss of approximately 10%. The intake volume will be 12,300 m^3/day as shown in Table E-1-6.

The intake facilities are composed of grit chamber, box culvert, pumps and appurtenant facilities. The grit chamber will be a reinforced concrete structure with screens and stop-logs. The bulk head will be provided with concrete and masonry walls of 40 m in extension on both sides.

b) Conveyance Facilities

Steel pipe will be used for conveyance of raw water. Pumps are required to convey raw water from the intake site (EL. 35m) to the purification plant (EL. 98m). Unit discharge of pumps will be 9 m^3/min. Diameter and length of the conveyance pipe are 300 mm and 500 m, respectively.

c) Purification Facilities

In the light of the results of water quality analysis of the Kelani river, as well as in view of the successful operation of the purification plant by rapid sand-filtration method at Ambatale treatment plant, a similar type of purification method will be recommended for water treatment in Atherfield estate. The capacity of the purification plant will be 11,200 m^3/day, which corresponds to the maximum daily water supply volume.

Purification facilities as composed of coagulant chemicals feeding facilities, coagulation basin, chemical sedimentation, rapid sand filter, clear water reservoir, aeration facilities and relevant mechanical and electrical apparatuses.

d) Distribution Facilities

A distribution tank will be constructed on a mountain side as shown in Fig. E-1-4. Effective capacity of the tank will be 6,600 m^3, which corresponds to a volume of 14 hours supply. Pipe network system will be provided as shown in Fig. E-1-4.

(2) Martin Estate

a) Intake Facilities

The intake facilities will be established in the vicinity of Bangadeniya, approximately 5 km upstream of the Deduru river as shown in Fig. E-1-5.

The intake volume, including augmented water for other demands, has been determined in the same manner as Atherfield estate. The total intake volume will be 18,000 m^3/day. The structure of intake facilities will be the same as the case of Atherfield.

b) Conveyance Facilities

Steel pipe will be used for conveyance of raw water. Pump facilities will be required to convey raw water to the purification plant in Martin estate. Diameter of the conveyance pipe and its length will be 500 mm and 5,000 m, respectively.

c) Purification Facilities

According to the results of water quality analysis of the Deduru river, rapid sand-filtration method will be recommended for water purification. Capacity of the purification plant will be 16,400 m3/day. Other relevant facilities in the purification plant will be similar to the system in the case of Atherfield.

d) Distribution Facilities

Two alternatives for distribution tanks have been studied. One is a ground type distribution tank with a capacity of 9,600 m^3, and the other is a water tower type tank with a capacity of 400 m^3. The former is provided with booster pumps and the latter is provided with conventional pumps. According to the comparative study, it is recommendable to select a water tower type tank in view of the operation and maintenance cost. Pipe network system in Martin estate is shown in Fig. E-1-6.

(3) Sirigampola Estate

a) Intake Facilities

The intake facilities will be located at Kodunnawa in Maha river as shown in Fig. E-1-7. There is a rockfill type weir at Kodunnawa for water intake to the existing Negombo treatment plant. It is proposed to utilize this existing weir.

The intake volume has been determined on the basis of the maximum daily supply and other augmented demands. The maximum volume of intake will be 2,400 m^3/day. However, as described in Chapter E.1.2, the Maha river is not sufficient for stable water supply throughout a year, and some groundwater wells should be provided for emergency use in the drought years.

b) Conveyance Facility

Steel pipe will be used for conveyance of raw water. Pump facilities will be required to convey water from the intake site to the proposed estate. Diameter and length of the pipe will be 300 mm and 15 km, respectively.

c) Purification Facilities

Capacity of the purification plant will be 2,200 m^3/day, which corresponds to the maximum daily supply volume. Rapid sand-filtration method will be recommended for the purification system.

d) Distribution Facilities

Though comparative study between ground-type and tower-type distribution tank, tower-type tank with a capacity of 100 m^3 has been selected for water distribution system in the estate. Further, ground-type distribution tank will also be required to reserve pumped groundwater for draught years. The capacity of ground-type distribution tank will be 1,300 m^3. Pipe network system is shown in Fig. E-1-8.

(4) Ekala Estate

a) Intake Facilities

Water resources will be mainly dependent on groundwater and partially on river water available in the vicinity of the estate. However, further study on availability of surface water and pump tests of groundwater will be required. Intake volume has been computed to be 7,500 m^3/day.

b) Purification Facilities

Purification facilities of 6,800 m^3/day in capacity will be constructed. The treatment will be rapid-sand filtration method.

c) Distribution Facilities

The distribution tanks will be 4,000 m^3 for ground type and 300 m^3 for tower type, respectively. The pipe network system is shown in Fig. E-1-9.

(5) Katana Estate

a) Intake Facilities

Intake facilities will be located in the Maha river in the vicinity of Kodurnawa, where a rockfill weir is constructed for water intake of the existing Negombo treatment plant. The location of weir is shown in Figure E-1-7. The maximum volume of intake will be 2,800 m^3/day. In addition to intake facilities of the Maha river, development of groundwater well is recommendable in view of the water deficit of the Maha river during draught seasons.

b) Purification Facilities

Capacity of the purification plant will be 2,500 m^3/day which corresponds to the planned maximum daily supply amount. Rapid sand-filtration method will be adopted for purification system.

c) Distribution Facilities

Tower type and ground type distribution tank with the capacity of 100 m^3 and 1,300 m^3 respectively are necessary for the water distribution system in the estate. The pipe network system is shown in Fig. E-1-10.

The facilities planned for the alternative industrial estates are summarized in Table E-1-6.

Table E-1-1 ANALYSIS OF WATER SAMPLE IN KELANI RIVER 1.5 KM
UPSTREAM OF THE AMBATALE INTAKE

Date	Aug. 90	Sept. 90	Oct. 90	Nov. 90	Dec. 90	Jan. 91	Feb. 91	Mar. 91	Apr. 91	May 91	Jun. 91	Jul. 91	Standard for Source Water Convenient Treatment	Standard of Drinking Water	
														Highest Desirable Level	Maximum Permissible Level
Sample Time	12.45	12.00	12.30	-	-	12.45	11.30	-	-	-	-	-			
Temp. C	28.00	28.00	28.00	20.00	-	27.00	30.00	30.00	-	30.00	29.00	30.00	-	-	-
Conductivity µs/cm	350.00	36.00	59.00	26.00	-	141.00	41.00	450.00	-	380.00	330.00	40.00	-	750	3,500
pH	6.50	6.30	6.40	6.30	-	6.90	6.70	5.60	-	4.80	6.50	6.50	5.8 - 8.5	7.0 - 8.5	6.5 - 9.0
SS mg/lit.	3.60	1.20	13.50	-	-	2.00	6.00	3.00	25.50	8.00	-	8.50	-	-	-
Alkalinity mg/lit.	33.60	14.00	16.80	-	-	19.60	56.00	39.20	16.80	28.00	16.80	11.20	-	200	400
Ammonia mg/lit.	-	-	-	-	0.38	0.28	-	-	-	-	Nil	Nil	-	-	0.06
DO	6.90	6.60	6.80	-	-	-	6.90	-	-	5.90	6.90	7.00	-	-	-
Nitrate (N) mg/lit.	-	-	-	-	-	0.30	-	-	-	-	-	-	-	-	10
Nitrite (N) mg/lit.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01
Iron mg/lit.	<0.10	-	-	-	-	<0.10	<0.10	<0.10	-	-	-	0.10	-	0.3	1.0
Tot. Hard. mg/lit.	5.00	4.00	-	-	10.00	14.00	10.00	-	6.00	10.00	14.00	13.00	-	250	600
Ca mg/lit.	1.60	2.80	-	-	2.40	6.00	3.20	-	3.60	3.20	3.20	3.20	-	100	240
Mg mg/lit.	0.24	-	-	-	0.97	1.94	0.49	-	-	49.00	1.46	1.22	-	30 to 150	150
sulphate mg/lit.	3.71	0.42	14.40	-	-	7.00	7.82	-	33.40	4.53	27.98	20.51	400	200	400
Chloride mg/lit.	1.50	1.00	2.00	- -	- -	5.00	4.00	6.00	7.00	9.00	5.00	4.00	Desirable 200 Max. 1,200	200	1,200
Sodium mg/lit.	2.30	2.20	2.40	-	-	2.50	2.30	2.50	3.50	4.10	4.20	3.30	-	-	-
Potascium mg/lit.	1.00	1.00	0.50	-	-	0.60	0.50	2.00	1.80	0.50	-	0.50	-	-	-
Phosphate mg/lit.	-	0.03	-	-	-	-	-	-	0.05	0.02	0.03	0.02	-	-	2.0
Turbidity NTU	3.50	2.70	8.20	2.00	-	-	-	4.70	-	6.50	8.50	5.00	-	2	8
FC/100 ml	500.00	TNTC	TNTC	-	-	-	1,100.00	2,000.00	TNTC	TNTC	TNTC	TNTC	5,000	Absent	Absent
TDS mg/lit.	2.10	2.00	81.00	-	-	-	48.00	-	92.00	90.00	26.00	25.00	-	-	-
COD														-	10.00

Note: 1) COD is analysed during Jan.-Apr. '90 Varies from <10 to 13
during 1989 it varied from >10 to 17

2) TNTC - Too numerous to count.

Source: Environment Division of the National Building Research Organisation.

Table E-1-2 RAW WATER QUALITY DATA (CLOSE TO AMBATALE INTAKE)

Date	18/5/90	22/2/91	05/07/91	28/8/91	06/11/91	Standard for Source Water, Convenient Treatment	Standard for Source Water, Convenient Treatment in Japan
Appearance	Clear	Clear	Slightly turbid	Clear	Clear	-	-
Turbidity	2.3	2.5	8.5	1.5	-	-	10
pH	6.4	7.1	8	6.8	-	5.0 - 8.5	5.8 - 8.6
Electrical Conductivity (microsiemers/cm)	960	40	78	27	-	-	-
Chlorides (as C1)	316	3	8	6	10	Desirable 200 max. 1,200	200
Total Alcalinity (as CaCo3)	12	16	38	14		-	-
Total Hardness (as CaCo3)	6	16	40	12	18	-	300
Totla Dissolved Solids	640	25	50	20	35	-	500
Nitrates (as N)	0.3	trace	trace	trace	trace	-	10
Nitries (as N)	Minute trace	Minute trace	Minute trace	Minute trace	Minute trace	-	-
Free Ammonia	-	-	-	-	-	-	-
Albuminoid Ammonia	-	-	-	-	-	-	-
Iron (as Fe)	0.32	0.16	2	1.2	0.16	-	0.3
Colour (Hazen Scale)	<5	<5	-	5	5	300	-

Source: National Water Supply & Drainage Board

Table E-1-3 WATER QUALITY ANALYSIS (1/4)

March, 1992

PARAMETER	AVISSAWELLA	NEGOMBO	CHILAW
Date	30.3.92	31.3.92	31.3.92
Time - hrs.	12.10	08.40	14.30
Weather	Fair-dry	Fair-dry	Fair-dry
Seasonal Weather	Fair	Fair	Fair
pH	6.8	7.6	7.8
Depth	Surface	50 cm	50 cm
Conductivity μs/cm	31	5,300	23,600
Ambient Temp. °C	34.1	32.4	32.4
Water Temp. °C	32.6	31.8	37.5
Salinity (Nacl) %	0.00	0.28	1.45
bed		1.14	2.55
Nitrite - N mg/l	0.001	0.000	0.003
Nitrate - N mg/l	0.003	0.003	0.012
Ammonia - N mg/l	0.050	0.050	0.080
Organic - N mg/l	3.300	3.800	3.700
(Kjeldahl - N)			
Total - N mg/l	3.354	3.853	3.795
Iron mg/l	<0.1	<0.1	<0.1
Total coliform	TNC	Nil	Nil
Feacal coliform	TNC	Nil	Nil
Dilutions for coliform	-	-	-
SS mg/l	4.5	24.55	98.15
DO mg/l	6.6	7.1	4.4
BOD mg/l	1.1	1.8	0.6
COD mg/l	<10	10	10
Oil & Grease	Nil	Nil	Nil
Chlorides mg/l	Nil	1,665	10,920
Total P mg/l	0.44	0.03	0.01
Manganese mg/l	0.002	0.024	0.008
Location	Apalapitiya	Waikkala	Martin Estate

Note : TNC = Too Numerous to Count

Table E-1-3 WATER QUALITY ANALYSIS (2/4)

April, 1992

PARAMETER	AVISSAWELLA	NEGOMBO	CHILAW
Date	27.4.92	28.4.92	28.4.92
Time - hrs.	13.10	14.30	11.00
Weather	Fair	Fair	Fair
Seasonal Weather	Rainy	Rainy	Rainy
pH	6.51	6.05	6.65
Depth	50 cm	50 cm	50 cm
Conductivity μs/cm	27	56	118
Ambient Temp. °C	30.4	32.5	34.8
Water Temp. °C	28.9	30.6	33.9
Salinity (Nacl) %	0.00	0.00	0.00
Nitrite - N mg/l	0.012	0.034	0.080
Nitrate - N mg/l	0.550	0.750	0.072
Ammonia - N mg/l	0.040	0.070	0.110
Organic - N mg/l (Kjeldahl - N)	0.950	1.020	1.340
Total - N mg/l	1.552	1.874	1.602
Iron mg/l	0.2	0.3	0.4
Total coliform	TNC	TNC	TNC
Feacal coliform	TNC	TNC	TNC
Dilutions for coliform	10 times	10 times	10 times
SS mg/l	31.2	92.0	121.0
DO mg/l	7.0	6.2	5.3
BOD mg/l	1.8	2.2	3.2
COD mg/l	10	20	37
Oil & Grease	Nil	Nil	Nil
Chlorides mg/l	Nil	Nil	22.75
Total P mg/l	0.650	0.181	0.023
Manganese mg/l	0.001	0.056	0.005
Location	Galthotalanga Apalapitiya	Thambarawila Waikkala	Martin Estate (Near Lunu-Oya)

Note : TNC = Too Numerous to Count

Table E-1-3 WATER QUALITY ANALYSIS (3/4)

May, 1992

PARAMETER	AVISSAWELLA	NEGOMBO	CHILAW
Date	25.5.92	26.5.92	26.5.92
Time - hrs.	13.00	16.20	13.05
Weather	Fair	Fair	Fair
Seasonal Weather	after heavy rains	after heavy rains	after heavy rains
pH	6.6	6.64	7.82
Depth	50 cm	50 cm	50 cm
Conductivity μs/cm	25	53	306
Ambient Temp. °C	30.0	32.0	38.0
Water Temp. °C	29.2	30.3	33.4
Salinity (Nacl) %	0.00	0.00	0.01
Nitrite - N mg/l	0.003	0.012	0.000
Nitrate - N mg/l	0.240	0.370	0.000
Ammonia - N mg/l	0.010	0.030	0.030
Organic - N mg/l (Kjeldahl - N)	1.120	1.050	1.050
Total - N mg/l	1.373	1.462	1.080
Iron mg/l	0.1	0.1	<0.1
Total coliform	TNC	TNC	TNC
Feacal coliform	TNC	2500	700
Dilutions for coliform	100 times	100 times	100 times
SS mg/l	10.6	11.0	28.0
DO mg/l	7.0	6.8	7.4
BOD mg/l	0.5	1.6	2.7
COD mg/l	<10	10	18
Oil & Grease	Neglegible	Neglegible	Neglegible
Chlorides mg/l	Nil	Nil	78.7
Total P mg/l	1.254	0.028	0.028
Manganese mg/l	0.006	0.031	0.001
Location	Galthotalanga Apalapitiya	Thambarawila Waikkala	Martin Estate (Near Lunu-Oya)

Note : TNC = Too Numerous to Count

Table E-1-3 WATER QUALITY ANALYSIS (4/4)

June, 1992

PARAMETER	AVISSAWELLA	NEGOMBO	CHILAW
Date	26.6.92	30.6.92	30.6.92
Time - hrs.	13.00 hrs	16.00 hrs	11.00 hrs
Weather	Fair	Fair	Fair
Seasonal Weather	Fair	Fair	Fair
pH	6.91	7.4	8.7
Depth	50 cm	50 cm	50 cm
Conductivity µs/cm	21	49	343
Ambient Temp. °C	31.6	30.6	33.4
Water Temp. °C	27.7	31.5	30.7
Salinity (Nacl) %	0.00	0.00	0.01
Nitrite - N mg/l	0.003	0.004	0.000
Nitrate - N mg/l	0.021	0.210	0.003
Ammonia - N mg/l	0.020	0.040	0.000
Organic - N mg/l (Kjeldahl - N)	1.288	1.624	1.540
Total - N mg/l	1.332	1.878	1.543
Iron mg/l	<0.1	<0.1	<0.1
Total coliform	TNC	2000	3000
Feacal coliform	TNC	1000	1100
Dilutions for coliform	100 times	100 times	100 times
SS mg/l	5.5	13.5	5.5
DO mg/l	7.3	7.3	9.2
BOD mg/l	0.6	1.6	2.7
COD mg/l	11.3	87.9	5.7
Oil & Grease	Neglegible	Neglegible	Neglegible
Chlorides mg/l	Nil	Nil	129.6
Total P mg/l	1.026	0.184	0.054
Manganese mg/l	Nil	0.006	Nil
Location	Apalapitiya	Thambarawila Waikkala	Martin Estate (Near Lunu-Oya)

Note : TNC = Too Numerous to Count

Table E-1-4 Planned Supply Amount

Planning Item		Atherfield	Martin	Sirigampola	Ekala	Katana
(1) Maximum Daily Water Supply	m^3/day	11,200	16,400	2,200	6,800	2,500
(2) Average Hourly Water Supply	m^3/hr	1,100	1,600	200	600	250
(3) Maximum Hourly Water Supply	m^3/hr	1,430	2,100	250	790	330
(4) Water Supply for Fire Fighting	m^3/hr	120	120	120	120	120
(5) Planned volume of Water Supply at the Time of Fire	m^3/hr	1,550	2,220	370	910	450
	l/sec	430	620	110	260	125

Table E-1-5 Assumption of Unit Water Demand

Artherfield Site (71.6 ha)

Type of Factory	Unit Water Demand (m^3/ha/day)	Factory Area Required (ha)	Daily Water Demand (m^3/day)
Food	250	1.5	375
Textile, Apparel	108	15.0	1,620
Paper products	50	1.0	50
Rubber products	300	10.25	3,075
Non metal mineral products	80	1.0	80
Gems	120	8.0	960
Others (Toy, etc)	50	6.0	300
Total	-	42.75	6,460
Average Daily Water Demand per hectare (m^3/ha/day)			151

151 m^3/ha/day x 71.6 ha = 10,812 m^3/day
100 l/day/cap. x 3,800 cap. = 380 m^3/day
11,192 m^3/day

Martin Site (83.9 ha)

Type of Factory	Unit Water Demand (m^3/ha/day)	Factory Area Required (ha)	Daily Water Demand (m^3/day)
Food	150	10.0	1,500
Textile, Apparel	108	6.0	648
Leather, Footwear	200	1.0	200
Chemical products	28	23.5	658
Rubber products	106	4.0	424
Non metal mineral products	80	0.25	20
Fabricated metal products	80	10.5	840
Tannery *	900	10.5	9,450
Leather *	60	13.5	810
Total	-	79.25	14,550
Average Daily Water Demand per hectare (m^3/ha/day)			189

* UNIDO Project

189 m^3/ha/day x 83.9 ha = 15,857 m^3/day   189 m^3/ha/day x (83.9 - 10.5 - 13.5) ha = 11,321 m^3/day
100 l/day/cap. x 5,300 cap. = 530 m^3/day
16,387 m^3/day

Sirigampola Site (35 ha)

Type of Factory	Unit Water Demand (m^3/ha/day)	Factory Area Required (ha)	Daily Water Demand (m^3/day)
Machinery	50	23.0	1,150
Total	-	23.0	1,150
Average Daily Water Demand per hectare (m^3/ha/day)			50

50 m^3/ha/day x 35 ha = 1,750 m^3/day
100 l/day/cap. x 4,100 cap. = 410 m^3/day
2,160 m^3/day

Ekala Site (93.4 ha)

Type of Factory	Unit Water Demand (m^3/ha/day)	Factory Area Required (ha)	Daily Water Demand (m^3/day)
Fabricated metal products	80	2.5	200
Machinery	50	28.0	1,400
Gems	120	8.0	960
Others (Toy, etc)	50	22.0	1,100
Total	-	60.5	3,660
Average Daily Water Demand per hectare (m^3/ha/day)			59

59 m^3/ha/day x 93.4 ha = 5,511 m^3/day
100 l/day/cap. x 13,000 cap. = 1,300 m^3/day
6,811 m^3/day

Katana Site (44.0ha)

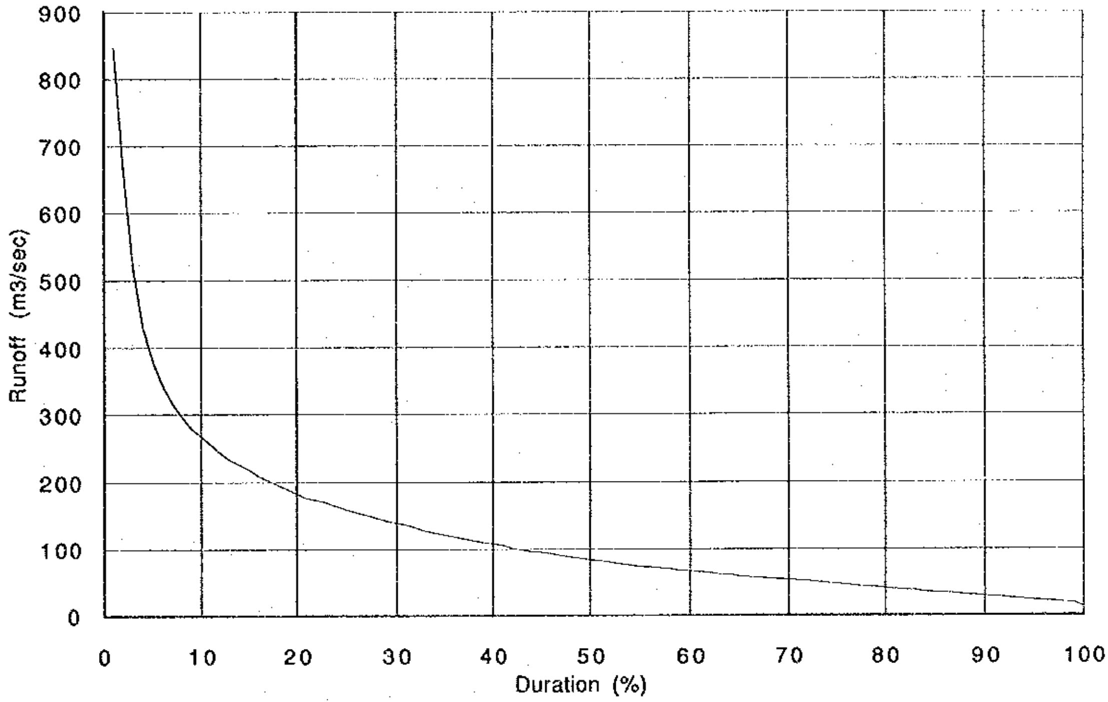
Type of Factory	Unit Water Demand (m^3/ha/day)	Factory Area Required (ha)	Daily Water Demand (m^3/day)
Fabricated metal products	80	10.0	800
Machinery	50	34.0	1,700
Total	-	44.0	2,500
Average Daily Water Demand per hectare (m^3/ha/day)			57

57 m^3/ha/day x 44.0 ha = 2,500 m^3/day

Table E-1-6 WATER SUPPLY FACILITIES IN THE PROPOSED ESTATES

	Unit	Atherfield	Martin		Sirigampola	Ekala	Katana
1. Intake							
1) Intake Capacity	m^3/day	12,300		18,000	2,400	7,500	2,800
2) Protection Bulk Head							
a. Excavation	m^3			600			
b. Concrete	m^3			30			
c. Masonry	m^2			120			
2. Conveyance							
1) Pump Head	m	60		30	30	20	30
2) Couveyance Pipe, Steel, Ø	mm	300		500	300	300	300
3) Pipe Length	m	500		5,000	15,000	1,000	10,000
4) Pump Capacity	m^3/min	9		13	2	6	2
3. Purification Plant							
1) Plant Capacity	m^3/day	11,200		16,400	2,200	6,800	2,500
2) Treatment Method			Rapid Sand Filter				
4. Transmission							
1) Pump Head	m	50		30	30	30	30
2) Transmission Pipe, Steel, Ø	mm	300		600	200	250	200
3) Pipe Length	m	1,360		770	400	800	30
4) Pump Capacity	m^3/min	8		12	2	5	2
5. Distribution							
1) Tank Ground	m^3	6,600	-		1,300	4,000	1,300
Tower	m^3	-		400	100	300	100
2) Pipe (Ductile Iron)							
a. Ø 100	m	290	-	200	-	-	100
b. Ø 150	m	220	-	-	-	70	-
c. Ø 200	m	900	120	-	-	1,000	1,400
d. Ø 250	m	1,510	270	460	-	800	1,010
e. Ø 300	m	2,220	1,230	1,580	1,930	3,060	220
f. Ø 350	m	320	160	210	-	-	-
g. Ø 400	m	1,660	120	-	-	950	230
h. Ø 450	m	200	210	310	-	-	-
i. Ø 500	m	-	-	710	985	1,200	-
j. Ø 600	m	-	110	-	700	800	-
k. Ø 700	m	-	-	440	140	560	-
l. Ø 800	m	-	-	-	-	30	-
Total		7,320	2,220	3,910	3,755	8,470	2,960

Fig. E-1-1 Flow Duration of Kelani river



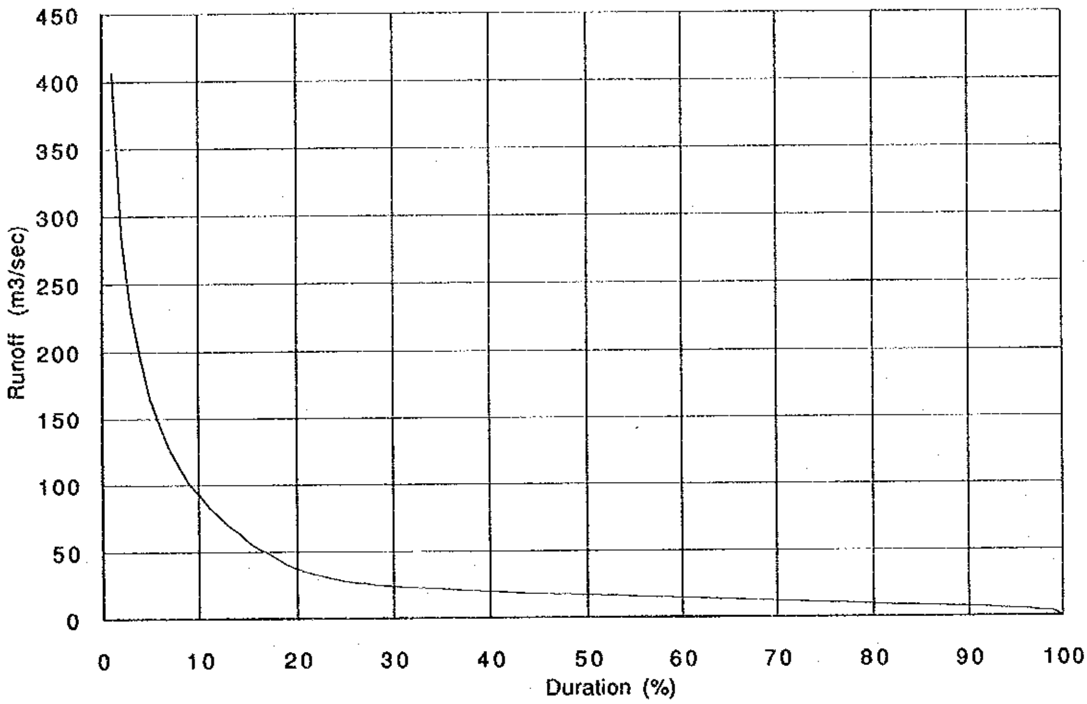
FLOW DURATION AT THE KELANI BY THE SERIES METHOD

YEAR : 1981 - 1991 MAX. : 6175.64 m3/s
TOTAL : 3013 Days MIN. : 12.75 m3/s
AVE. : 137.34 m3/s

Duration (%)	Runoff (m3/s)	Duration (%)	Runoff (m3/s)	Duration (%)	Runoff (m3/s)	Duration (%)	Runoff (m3/s)
1 -	846.71	26 -	154.39	51 -	82.15	76 -	46.00
2 -	663.29	27 -	151.02	52 -	80.03	77 -	44.33
3 -	518.56	28 -	146.46	53 -	77.90	78 -	42.55
4 -	429.89	29 -	141.90	54 -	75.78	79 -	42.49
5 -	379.00	30 -	138.81	55 -	73.65	80 -	40.79
6 -	342.72	31 -	135.84	56 -	72.66	81 -	39.09
7 -	315.98	32 -	131.27	57 -	71.53	82 -	38.24
8 -	296.60	33 -	126.91	58 -	69.41	83 -	37.39
9 -	279.32	34 -	123.94	59 -	68.00	84 -	35.69
10 -	268.41	35 -	120.96	60 -	67.00	85 -	34.84
11 -	255.52	36 -	117.99	61 -	65.16	86 -	33.99
12 -	243.18	37 -	115.01	62 -	64.00	87 -	32.58
13 -	233.26	38 -	112.04	63 -	62.00	88 -	31.30
14 -	226.37	39 -	109.07	64 -	60.91	89 -	30.59
15 -	219.55	40 -	107.82	65 -	59.07	90 -	29.00
16 -	209.04	41 -	105.10	66 -	57.22	91 -	28.41
17 -	202.55	42 -	100.99	67 -	57.00	92 -	26.91
18 -	196.03	43 -	98.30	68 -	55.38	93 -	25.50
19 -	189.52	44 -	96.26	69 -	54.53	94 -	24.08
20 -	183.00	45 -	95.61	70 -	53.54	95 -	22.66
21 -	176.49	46 -	92.92	71 -	52.00	96 -	21.95
22 -	173.00	47 -	90.23	72 -	51.56	97 -	21.25
23 -	169.97	48 -	88.00	73 -	49.86	98 -	19.83
24 -	163.74	49 -	85.78	74 -	49.00	99 -	18.41
25 -	158.41	50 -	83.57	75 -	47.03	100 -	12.75

Source: Irrigation Dept.
Remarks: Minimum potential is 12.75 m^3/sec (1,101,600 m^3/day)

Fig. E-1-2 Flow Duration of Deduru river



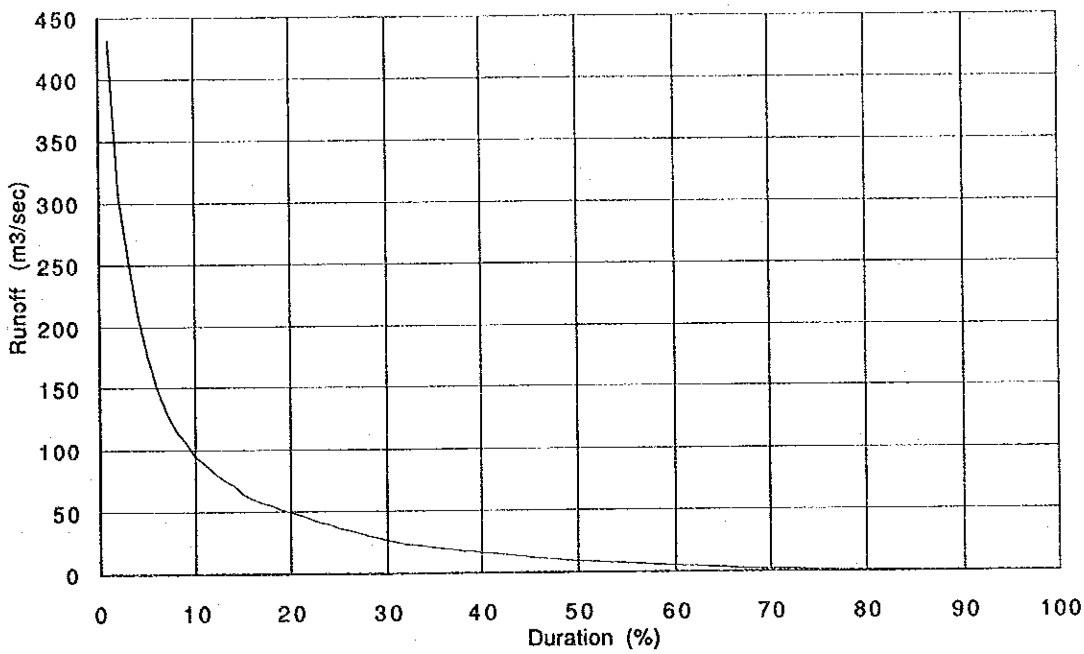
FLOW DURATION AT THE DEDURU BY THE SERIES METHOD

YEAR : 1966 - 1979 MAX. : 1000.45 m3/s
TOTAL : 4258 DAYS MIN. : 0.34 m3/s
AVE. : 39.94 m3/s

Duration (%)	Runoff (m3/s)	Duration (%)	Runoff (m3/s)	Duration (%)	Runoff (m3/s)	Duration (%)	Runoff (m3/s)
1 -	407.22	26 -	26.74	51 -	16.69	76 -	10.71
2 -	285.52	27 -	26.15	52 -	16.49	77 -	10.68
3 -	229.09	28 -	25.21	53 -	16.49	78 -	10.31
4 -	195.16	29 -	24.36	54 -	16.12	79 -	9.97
5 -	164.99	30 -	23.97	55 -	15.86	80 -	9.75
6 -	144.62	31 -	23.37	56 -	15.52	81 -	9.35
7 -	127.20	32 -	22.97	57 -	15.35	82 -	8.98
8 -	113.71	33 -	22.52	58 -	15.13	83 -	8.78
9 -	101.16	34 -	22.35	59 -	14.90	84 -	8.78
10 -	92.72	35 -	21.78	60 -	14.56	85 -	8.56
11 -	83.68	36 -	21.39	61 -	14.56	86 -	8.39
12 -	76.49	37 -	20.99	62 -	14.22	87 -	8.05
13 -	69.69	38 -	20.40	63 -	13.99	88 -	7.93
14 -	64.65	39 -	20.23	64 -	13.60	89 -	7.68
15 -	58.02	40 -	19.60	65 -	13.43	90 -	7.37
16 -	52.41	41 -	19.41	66 -	13.17	91 -	7.20
17 -	49.09	42 -	19.01	67 -	12.83	92 -	6.86
18 -	44.76	43 -	18.61	68 -	12.63	93 -	6.40
19 -	40.17	44 -	18.41	69 -	12.63	94 -	6.09
20 -	37.39	45 -	18.41	70 -	12.24	95 -	5.61
21 -	34.70	46 -	17.96	71 -	11.90	96 -	5.61
22 -	32.63	47 -	17.51	72 -	11.67	97 -	4.93
23 -	31.05	48 -	17.45	73 -	11.39	98 -	4.28
24 -	29.24	49 -	17.25	74 -	11.10	99 -	3.63
25 -	27.93	50 -	17.00	75 -	10.91	100 -	0.34

Source: Irrigation Dept.
Remarks: Minimum potential is 0.34 m^3/sec (29,376 m^3/day)

Fig. E-1-3 Flow Duration of Maha river



FLOW DURATION AT THE MAHA BY THE SERIES METHOD

YEAR : 1981 - 1991
TOTAL : 2916 Days

MAX. : 844.19 m3/s
MIN. : 0.01 m3/s
AVE. : 38.01 m3/s

Duration (%)	Runoff (m3/s)	Duration (%)	Runoff (m3/s)	Duration (%)	Runoff (m3/s)	Duration (%)	Runoff (m3/s)
1 -	432.27	26 -	34.79	51 -	8.92	76 -	0.93
2 -	306.35	27 -	32.83	52 -	8.41	77 -	0.74
3 -	255.48	28 -	30.79	53 -	8.22	78 -	0.57
4 -	210.28	29 -	28.95	54 -	7.79	79 -	0.57
5 -	176.18	30 -	27.14	55 -	7.37	80 -	0.57
6 -	149.58	31 -	25.38	56 -	6.94	81 -	0.57
7 -	129.55	32 -	23.68	57 -	6.52	82 -	0.54
8 -	115.30	33 -	23.00	58 -	6.29	83 -	0.54
9 -	105.89	34 -	22.10	59 -	5.67	84 -	0.51
10 -	93.99	35 -	20.74	60 -	5.33	85 -	0.51
11 -	88.35	36 -	19.97	61 -	4.99	86 -	0.48
12 -	80.74	37 -	19.26	62 -	4.90	87 -	0.48
13 -	75.07	38 -	17.96	63 -	4.31	88 -	0.48
14 -	70.79	39 -	17.83	64 -	3.97	89 -	0.45
15 -	64.02	40 -	16.43	65 -	3.63	90 -	0.45
16 -	60.06	41 -	15.95	66 -	2.96	91 -	0.42
17 -	57.14	42 -	15.13	67 -	2.76	92 -	0.36
18 -	55.16	43 -	14.48	68 -	2.38	93 -	0.30
19 -	51.56	44 -	13.82	69 -	2.26	94 -	0.23
20 -	49.29	45 -	12.52	70 -	1.98	95 -	0.19
21 -	47.03	46 -	11.90	71 -	1.95	96 -	0.13
22 -	44.53	47 -	11.22	72 -	1.84	97 -	0.06
23 -	41.34	48 -	10.37	73 -	1.70	98 -	0.03
24 -	39.52	49 -	9.92	74 -	1.39	99 -	0.02
25 -	36.54	50 -	9.21	75 -	1.05	100 -	0.01

Source: Irrigation Dept.

Remarks: Existing water intake at Negonbo Water Works is 25,000 m^3/day and Required waters proposed industrial site is 2,200 m^3/day.

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	Figure E-1-4 Plan of Water Supply Facilities in Atherfield Estate
	Nippon Koei Co., Ltd. in association with Unico International Corporation and Japan External Trade Organization (JETRO)

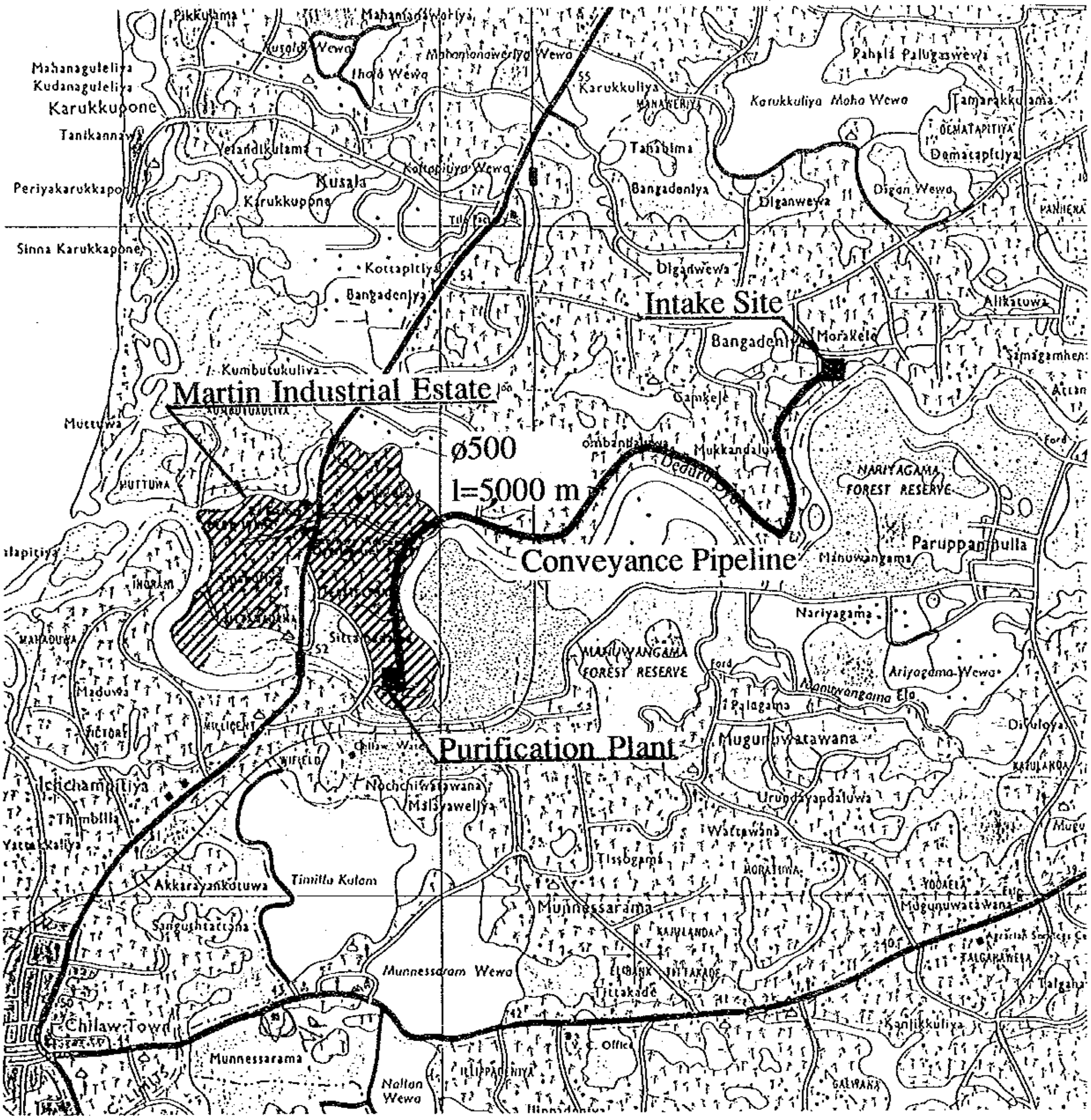

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Figure E-1-5 Location Map of Intake Site for Martin Estate

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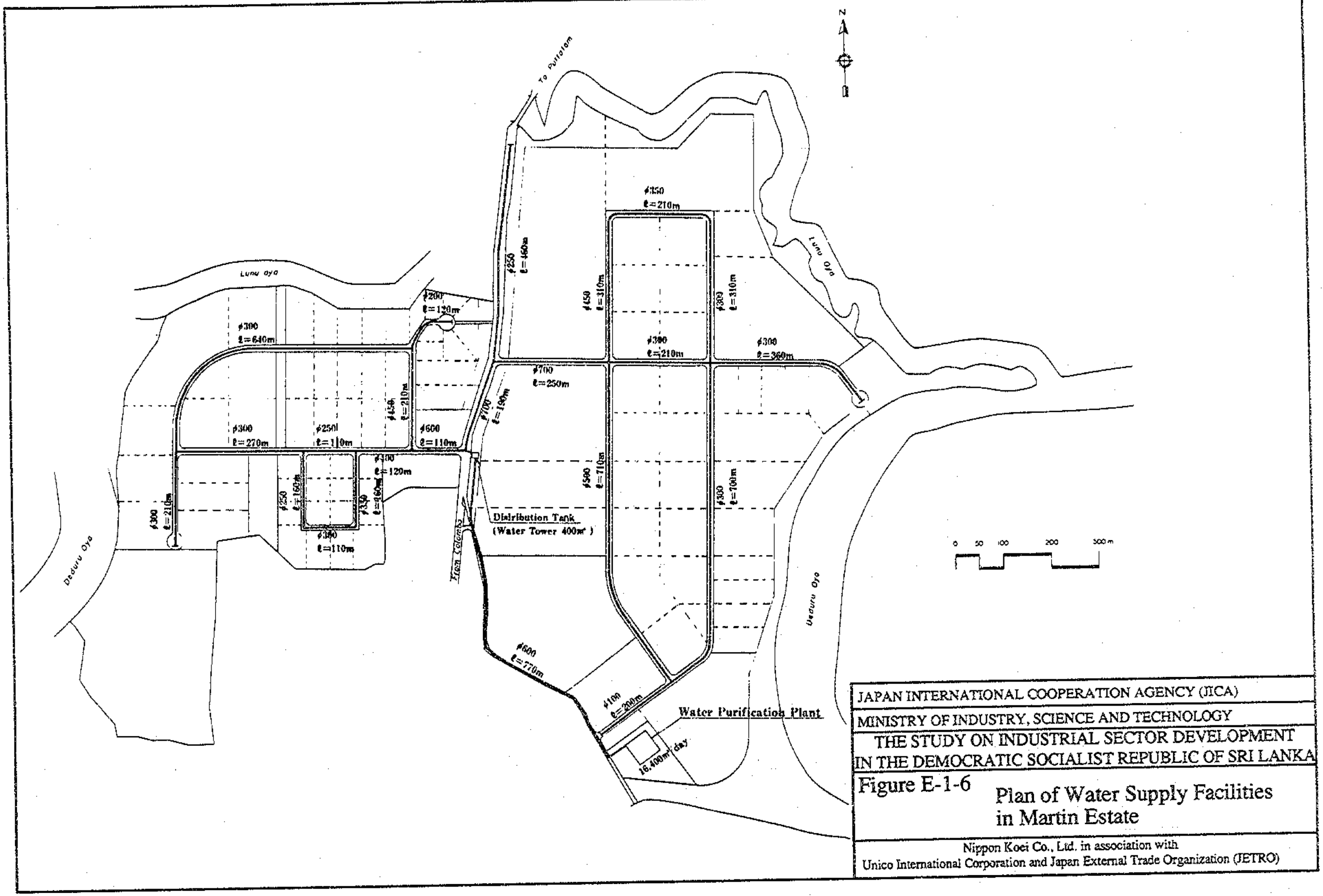

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Figure E-1-6 Plan of Water Supply Facilities in Martin Estate

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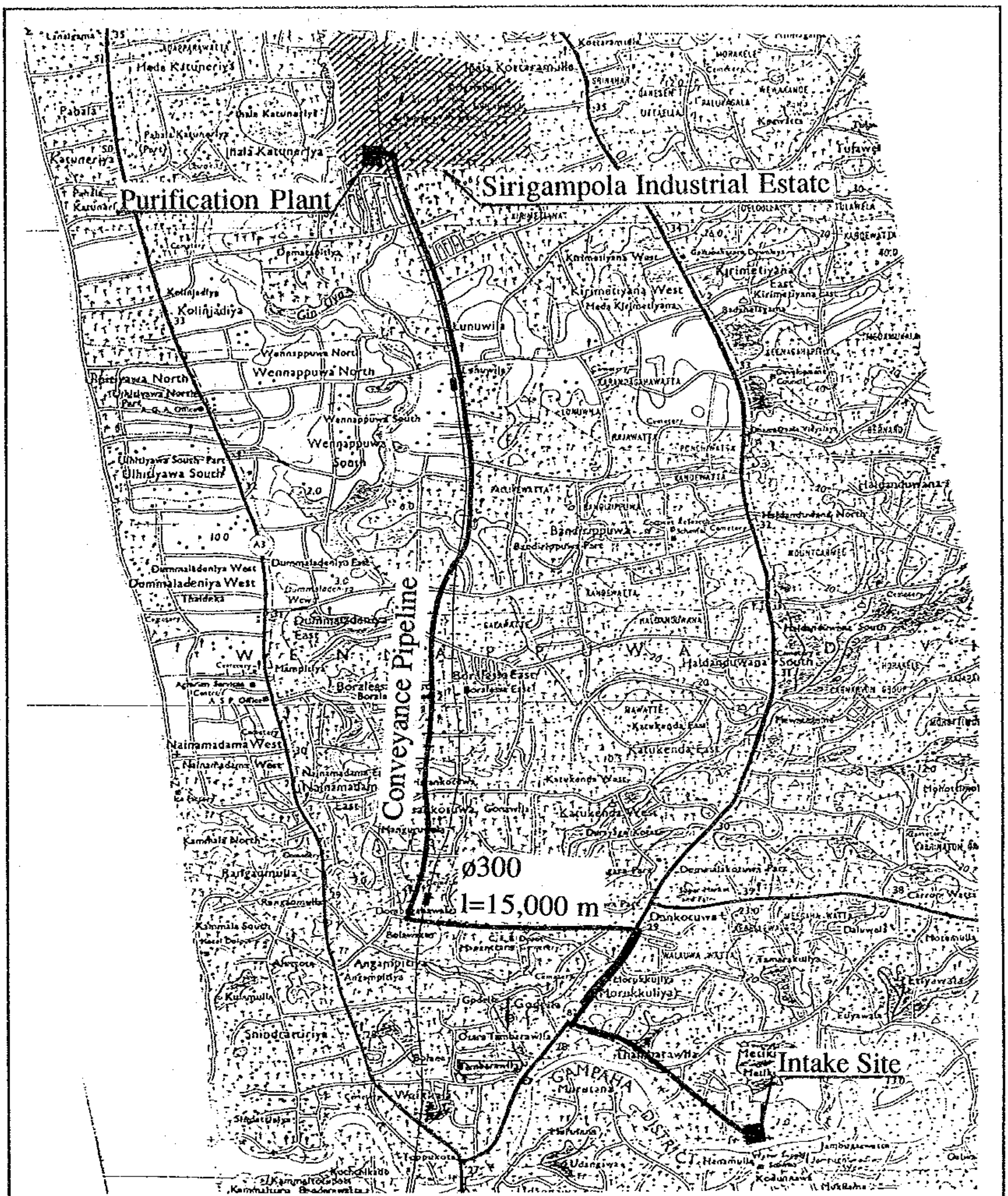

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	Figure E-1-7 Location Map of Intake Site for Sirigampola Estate
	Nippon Koei Co., Ltd. in association with Unico International Corporation and Japan External Trade Organization (JETRO)

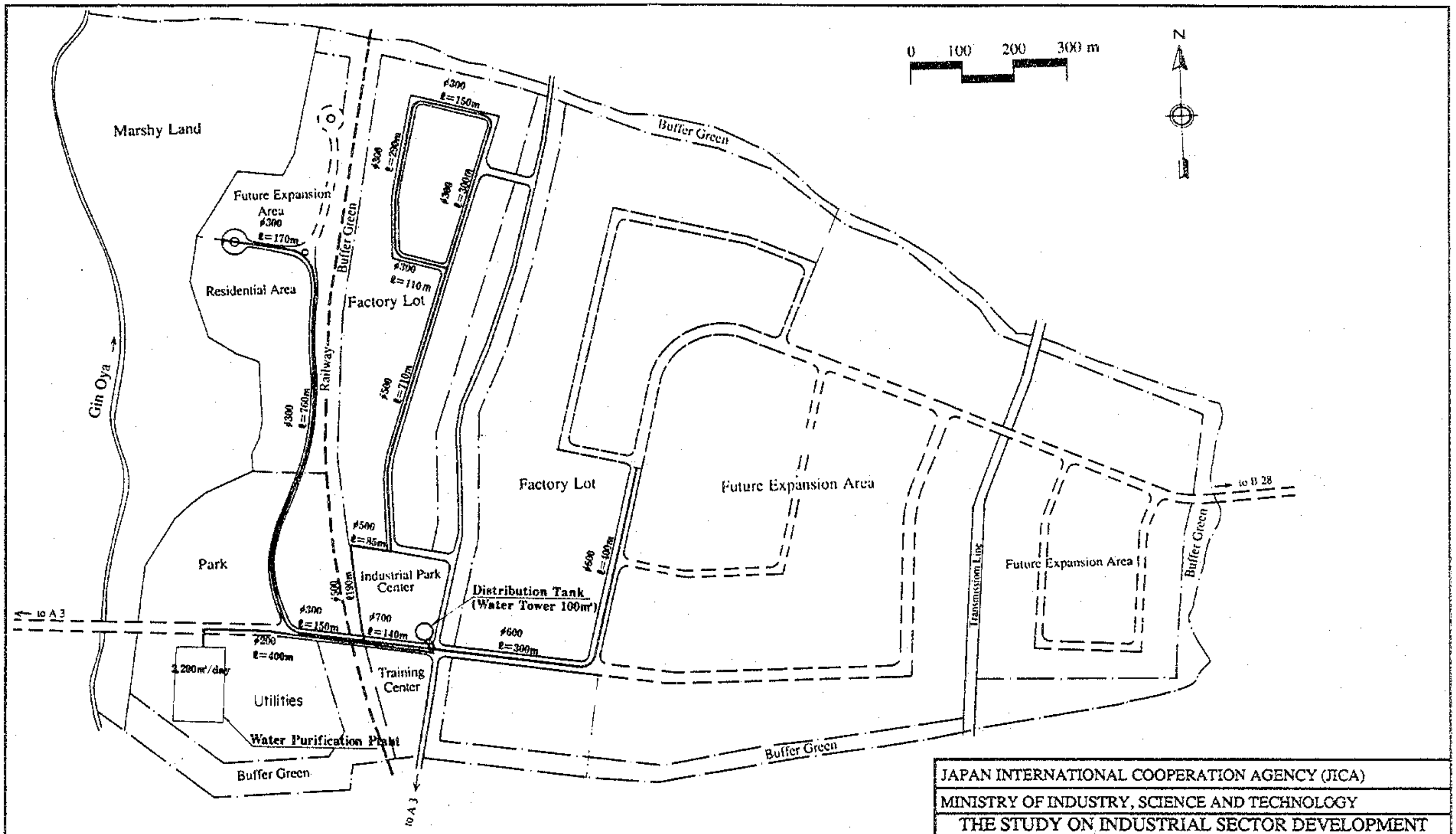

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Figure E-1-8 Plan of Water Supply Facilities in Sirigampola Estate

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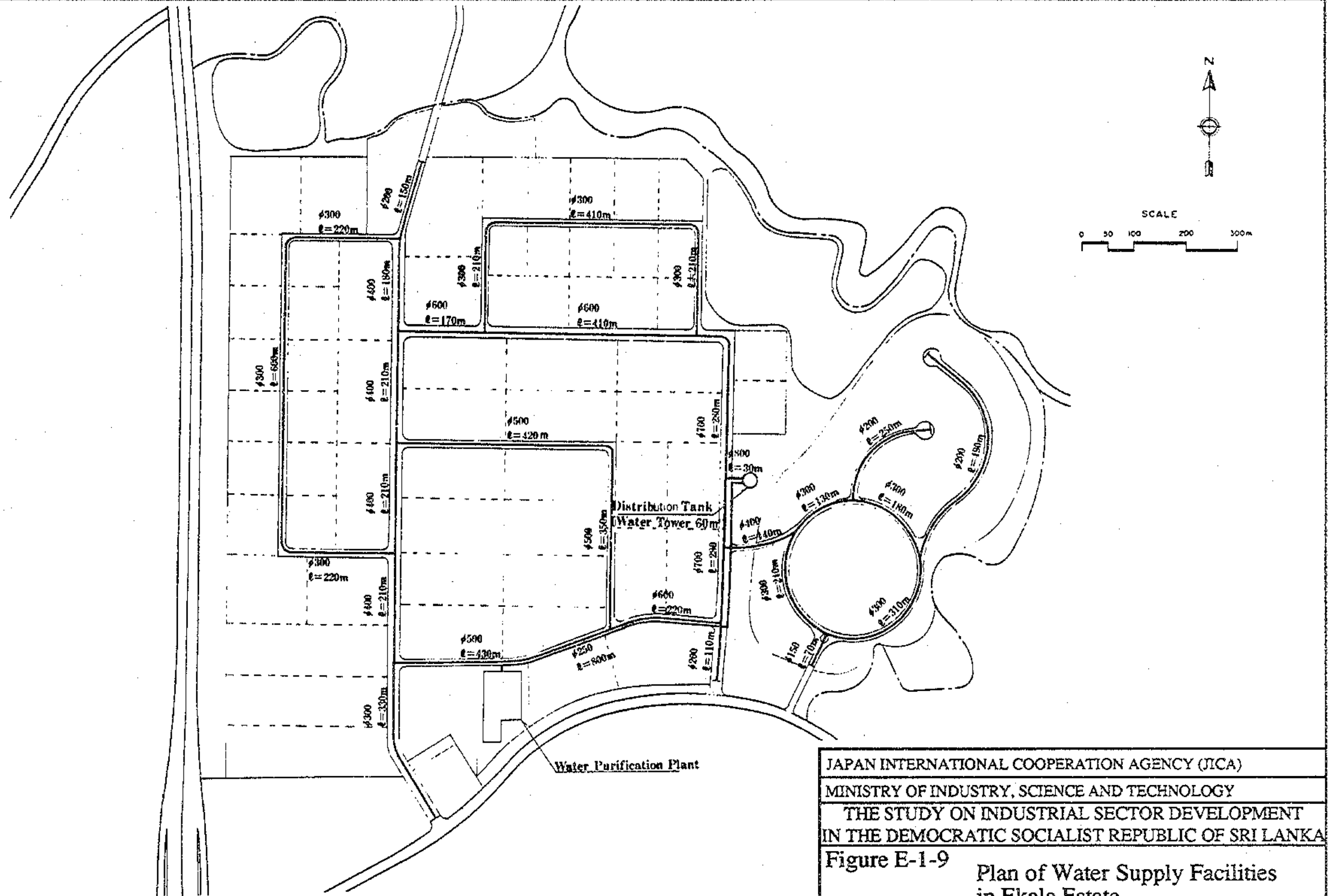

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Figure E-1-9 Plan of Water Supply Facilities in Ekala Estate

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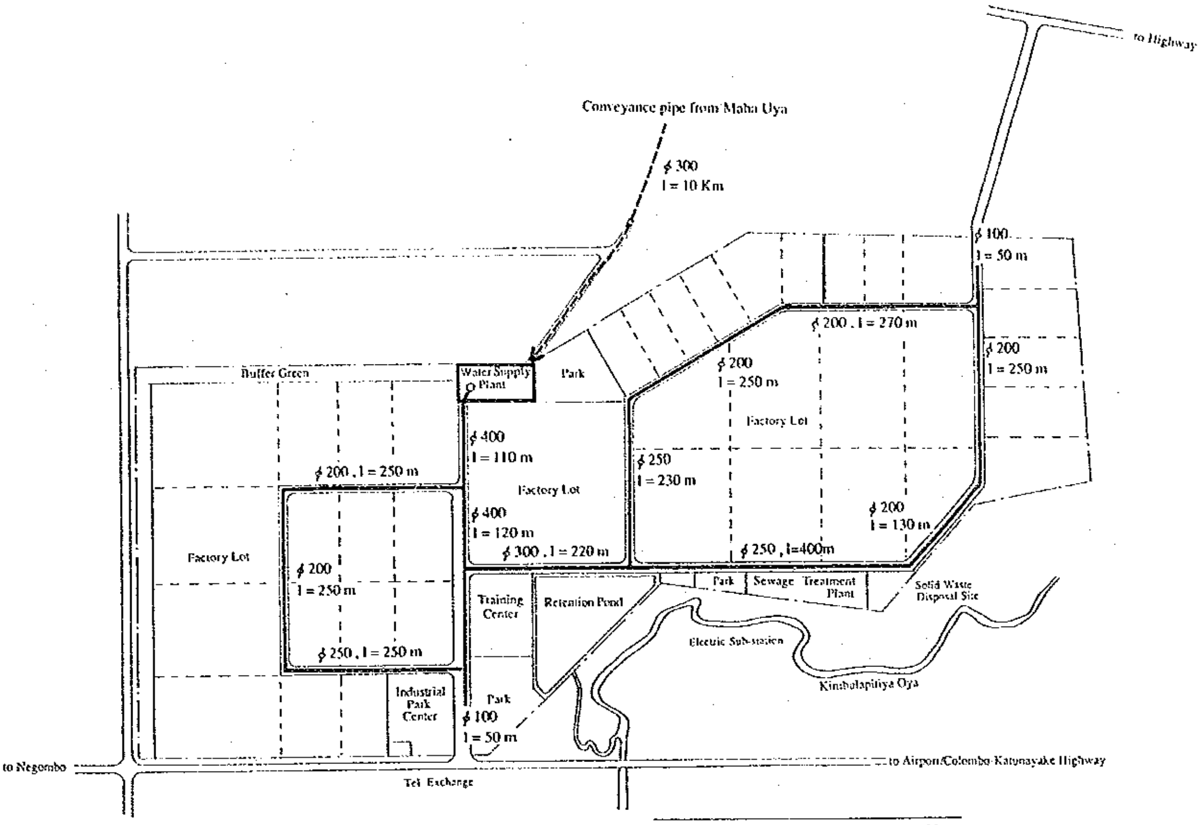

∮100	50+50	= 100 m
∮200	250+250+250+270+250+130	= 1,400 m
∮250	400+130+250+230	= 1,010 m
∮300	220	= 220 m
∮400	110+120	= 230 m

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Figure E-1-10 Plan of Water Supply Facilities in Katana Estate

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E.2 Sewerage System

E.2.1 General

The key points for the study on sewerage systems for the proposed industrial estates are to define the wastewater quantity and quality in accordance with the type and scale of industries in the estates and to formulate design of appropriate treatment facilities.

The treatment methods have been determined on the basis of the wastewater characteristics in each industrial estate, such as quality of influents, time fluctuation of quantity, and removal efficiency of pollution load.

Disposal of effluents has been determined in the light of possible future contamination of the receiving water. In principal, environmental protection measures for the receiving water have been taken to satisfy national standards in Sri Lanka.

E.2.2 Basic Design Conditions

1) National Standards

Development of a sewerage system in the proposed industrial estates will basically follow the "National Environmental Act and Regulations" gazetted in 1990.

The tolerance limits for industrial effluents to be discharged into the wastewater treatment plant are shown in Table E-2-1. The effluents which exceed the said limits should be treated at an inhouse treatment plant prior to discharge them into the sewer line.

Table E-2-2 shows the norms for the effluent from common wastewater treatment plant operated by BOI. The tolerance limits for industrial effluents to be discharged into inland surface waters after treatment are defined as shown in Table E-2-3.

2) Design Criteria

a) Sewerage System

For design of a sewerage system to be installed in the industrial estates, the separate system will be adopted from the economic point of view.

b) Sewer Lines

The minimum diameter of the sewer line will be 250 mm. The pipe will be PVC for 250 and 300 mm and reinforced concrete for 300 mm and above. Minimum velocity will be 0.6 m/sec. In Atherfield, steel pipe will be adopted for the line from the manhole located at the lowest portion in the estate to the treatment plant, in view of the topographic conditions.

c) Treatment Method

In view of the successful experience in the existing treatment plants in Sri Lanka, as well as in the light of physical conditions in the industrial estates, the oxidation sludge method will be adopted.

E.2.3 Proposed Sewerage System

1) Sewage Volume

The volume of sewage water will be equal to the volume of water supply, as generally accepted in NWSDB and BOI design criteria and in other developed countries. The volume of sewage water in the proposed industrial estates is summarized as follows:

Atherfield	11,200 m3/day
Martin	11,300 m3/day (only eastern part)
Sirigampola	2,200 m3/day
Ekala	6,800 m3/day
Katana	2,500 m3/day

2) Quality of Influent

Influent quality has been determined on the basis of the type and scale of the industries to be located in each site, as summarized hereunder (Refer to Table E-2-4).

	BOD(mg/l)		SS(mg/l)	
	(mg/l)	(kg/day)	(mg/l)	(kg/day)
Atherfield	305	3,417	620	6,942
Martin	510	5,778	716	8,110
Sirigampola	57	100	147	257
Ekala	58	321	189	1,043
Katana	13	33	388	970

3) Proposed Sewerage System

(1) Atherfield Estate

a) Sewer Pipes

Sewer lines will be basically designed by assuming a gravity system. However, more than a half of the wastewater should be conveyed to the treatment plant by pumps due to the topographic conditions in the estate, as shown in Fig. E-2-1.

b) Sewage Treatment Plant

The oxidation ditch will be designed, using the oxidation sludge methods, because oxidation ditches have flexibility against daily fluctuation of pollution load and volume of influent. Capacity of the treatment plant will be 11,200 m^3/day. Treated water will be discharged into the Kelani river.

(2) Martin Estate

a) Sewer Pipes

Pipe reticulations system at this estate will be divided into two groups, i.e. western part and eastern part, as shown in Fig.E-2-2. Whole reticulation has been designed in this study, but the treatment plants will be constructed in two stages as described below.

b) Sewage Treatment Plants

The treatment plant for the western part, with a capacity of 5,100 m^3/day, will be handled by the "UNIDO Scheme". On the other hand, the treatment plant for the eastern part with a capacity of 11,300 m^3/day will be designed as an oxidation ditch type. The treated water will be discharged into the Deduru river.

(3) Sirigampola Estate

a) Sewage Pipes

Pipe reticulations for this estate are shown in Fig. E-2-3. Diameter of the pipes ranges from 250 mm to 700 mm.

b) Sewage Treatment Plant

The sewage treatment will be an oxidation ditch type. Treated water will be discharged into the Gin river located in the vicinity of the estate.

(4) Ekala Estate

a) Sewage Pipes

The pipe diameter will range from 250 mm to 800 mm, as shown in Fig. E-2-4.

b) Sewage Treatment Plant

The treatment will be an oxidation ditch type. Treated water will be discharged into the Dandugam river.

(5) Katana Estate

a) Sewage Pipes

Pipe reticulations for the estate are shown in Fig. E-2-5. Diameter of the pipes ranges from 250 mm to 450 m.

b) Sewage Treatment Plant

The treatment will be an oxidation ditch type. Treated water will be discharged into the Kimbulapitiya river.

Facilities proposed for the sewage system in each estate are summarized in Table E-2-5.

Table E-2-1 TOLERANCE LIMITS FOR INDUSTRIAL WASTE WATER (EFFLUENTS) DISCHARGED INTO THE COMMON WASTE WATER TREATMENT PLANT

PARAMETERS	MAXIMUM TOLERANCE LIMIT
BOD (5 days at 20°C) (mg/l)	200
pH	6.0 - 8.5
Suspended solids	500
Total dissolved solids (inorganic) (mg/l)	2100
Temperature (°C)	40
Phenolic compounds (as C_6H_5OH) (mg/l)	5
Oil and grease (mg/l)	30
Total Chromium (mg/l)	2 (Chromium VI 0.5)
Copper (as Cu) (mg/l)	3
Lead (as Pb) (mg/l)	1
Nickel (as Ni) (mg/l)	3
Zinc (as Zn) (mg/l)	10
Aresenic (as As) (mg/l)	0.2
Boron (as B) (mg/l)	2
Percent Sodium	60
Ammonical Nitrogen (as N) (mg/l)	50
Sulphides (as S) (mg/l)	2
Sulphates (as SO_4) (mg/l)	1000
Chlorides (as Cl) (mg/l)	900
Cyanides (as CN) (mg/l)	0.2
Radioactive Materials	
Alpha emitters (μc/ml)	10^{-7}
Beta emitters (μc/ml)	10^{-6}

Source : BOI
Remarks:
mg/l = Milligrams/litre
μc/ml = Microcuries/millilitre
BOD = Biochemical Oxygen Demand

The quality of waste waters discharged into common sewer or collection system should be such as to ensure that the waste water:

1. does not damage the sewer by physical or chemical action;
2. does not endanger the health of the workers cleaning the sewer;
3. does not upset the processes that are normally used in sewage treatment;
4. does not overload the common treatment plant;
5. does not damage the crops or affect the soil in case the effluent after treatment is used for irrigation and,
6. does not create fire and explosion hazards due to certain constituents present in the effluent.

   The industrial effluents not conforming to the specified tolerance limits or containing solids such as ash, sands, feathers, large floatables, straw, plastics, wood, lime slurry, residue, beer or distillery slops, chemical or paint residue, gross solids from cannery wastes, cinder, sand, tar, hair, rags, metal shavings, garbage and broken glass shall not be permitted to be discharged directly into the common sewer line leading to the waste water treatment plant. Such effluents have to be subjected to an inhouse treatment to bring them to be within the suggested tolerance limits and/or to free them from the undersirable material mentioned above prior to discharge into the sewer line.

Table E-2-2 NORMS FOR THE EFFLUENT FROM COMMON WASTE WATER TREATMENT PLANT (AFTER TREATMENT)

PARAMETERS	TOLERANCE LIMIT MAXIMUM
BOD in 5 days at 20°C (maximum)	30 mg/l
Suspended solids (maximum).	30 mg/l
pH	6.5 - 8.0

Source : BOI
Remarks: The Common waste water treatment plant is operated by the BOI with assistance from the National Water Supply and Drainage Board, Sri Lanka.

Table E-2-3 TOLERANCE LIMITS FOR INDUSTRIAL WASTE WATER (EFFLUENTS) DISCHARGED INTO INLAND SURFACE WATERS (AFTER TREATMENT)

PARAMETERS	MAXIMUM TOLERANCE LIMIT
pH	6.0 - 8.5
Suspended solids (mg/l)	50
Temperature (°C)	40
BOD (5 days at 20°C) (mg/l)	30
COD (mg/l)	250
Phenolic compounds (as C_6H_5OH) (mg/l)	1.0
Cyanides (mg/l)	0.2
Sulphides (mg/l)	2.0
Fluorides (mg/l)	2.0
Total residual Chlorine (mg/l)	1.0
Ammonical Nitrogen (as N) (mg/l)	50
Arsenic (as As) (mg/l)	0.2
Cadmium (as Cd) (mg/l)	0.1
Chromium (as Cr) (mg/l)	0.1
Copper (as Cu) (mg/l)	3.0
Lead (as Pb) (mg/l)	0.1
Mercury (as Hg) (mg/l)	0.0005
Nickel (as Ni) (mg/l)	3.0
Selenium (as Se) (mg/l)	0.05
Zinc (as Zn) (mg/l)	5.0
Pesticides	Nil
Oil and grease (mg/l)	10.0
Radioactive Materials	
Alpha emitters (μc/ml)	10^{-7}
Beta emitters (μc/ml)	10^{-6}

Source : BOI

Remarks:

mg/l = Milligrams/litre

μc/ml = Microcuries/millilitre

BOD = Biochemical Oxygen Demand

COD = Chemical Oxygen Demand

These values are based on a dilution of the effluents by at least 8 volumes of clean receiving water. If the dilution is below 8 times, the maximum tolerance limits shall be worked out on a proportionate basis taking into consideration the dilution factor. However no increase in the limits will be allowed as a result of increased dilution beyond 1:8.

All efforts should be made to remove colour and unpleasent odour from the effluents.

Table E-2-4 Assumption of Pollution Load (1/3)

Atherfield Site

Type of Factory	Unit Pollution Load (kg/m^3) BOD	Unit Pollution Load (kg/m^3) SS	Daily Water Demand (m^3/day)	Daily Pollution Load (kg/day) BOD	Daily Pollution Load (kg/day) SS
Food	1.0	2.0	375	375.0	750.0
Textile, Apparel	0.01	0.03	1,620	16.2	48.6
Paper Products	1.0	2.0	50	50.0	100.0
Rubber Products	0.5	1.0	3,075	1,537.5	3,075.0
Non-metal Mineral Products	0.05	0.03	80	4.0	2.4
Gems	0.01	0.1	960	9.6	96.0
Others	0.01	0.1	300	3.0	30.0
Total	-	-	6,460	1,995.3	4,102.0
Average Daily Pollution Load (kg/m^3)			BOD	0.309	
			SS	0.635	

Daily total pollution load

10,812 m^3/day x 0.309 kg/m^3 = 3,341 kg/day
380 m^3/day x 0.200 kg/m^3 = 76 kg/day
3,417 kg/day (BOD)

10,812 m^3/day x 0.635 kg/m^3 = 6,866 kg/day
380 m^3/day x 0.200 kg/m^3 = 76 kg/day
6,942 kg/day (SS)

Average pollution load

3,417 kg/day ÷ 11,192 m^3/day = 0.305 kg/m^3 = 305 mg/l (BOD)
6,942 kg/day ÷ 11,192 m^3/day = 0.620 kg/m^3 = 620 mg/l (SS)

Martin Site

Type of Factory	Unit Pollution Load (kg/m^3) BOD	Unit Pollution Load (kg/m^3) SS	Daily Water Demand (m^3/day)	Daily Pollution Load (kg/day) BOD	Daily Pollution Load (kg/day) SS
Food	1.0	1.0	1,500	1,500.0	1,500.0
Textile, Apparel	0.01	0.03	648	6.5	19.4
Leather, Footwear	1.0	1.5	200	200.0	300.0
Chemical Products	0.3	0.1	574	172.2	57.4
Rubber Products	0.5	1.0	424	212.0	424.0
Non-metal Mineral Products	0.05	0.03	20	1.0	0.6
Fabricated Metal Products	0.02	0.8	840	16.8	672.0
Total	-	-	4,206	2,108.5	2,973.4
Average Daily Pollution Load (kg/m^3)			BOD	0.501	
			SS	0.707	

Daily total pollution load

11,321 m^3/day x 0.501 kg/m^3 = 5,672 kg/day
530 m^3/day x 0.200 kg/m^3 = 106 kg/day
5,778 kg/day (BOD)

11,321 m^3/day x 0.707 kg/m^3 = 8,004 kg/day
530 m^3/day x 0.200 kg/m^3 = 106 kg/day
8,110 kg/day (SS)

Average pollution load

5,778 kg/day ÷ 11,321 m^3/day = 0.510 kg/m^3 = 510 mg/l (BOD)
8,110 kg/day ÷ 11,321 m^3/day = 0.716 kg/m^3 = 716 mg/l (SS)

Table E-2-4 Assumption of Pollution Load (2/3)

Sirigampola Site

Type of Factory	Unit Pollution Load (kg/m^3)		Daily Water Demand (m^3/day)	Daily Pollution Load (kg/day)	
	BOD	SS		BOD	SS
Machinery	0.01	0.1	1,150	11.5	115.0
Total	-	-	1,150	11.5	115.0
Average Daily Pollution Load (kg/m^3)			BOD	0.010	
			SS	0.100	

Daily total pollution load

1,750 m^3/day x 0.010 kg/m^3 = 18 kg/day
410 m^3/day x 0.200 kg/m^3 = 82 kg/day
100 kg/day (BOD)

1,750 m^3/day x 0.100 kg/m^3 = 175 kg/day
410 m^3/day x 0.200 kg/m^3 = 82 kg/day
257 kg/day (SS)

Average pollution load

100 kg/day ÷ 1,750 m^3/day = 0.057 kg/m^3 = 57 mg/l (BOD)
257 kg/day ÷ 1,750 m^3/day = 0.147 kg/m^3 = 147 mg/l (SS)

Ekala Site

Type of Factory	Unit Pollution Load (kg/m^3)		Daily Water Demand (m^3/day)	Daily Pollution Load (kg/day)	
	BOD	SS		BOD	SS
Fabricated Metal Products	0.02	0.8	200	4.0	160.0
Machinery	0.01	0.1	1,350	13.5	135.0
Gems	0.01	0.1	720	7.2	72.0
Others	0.01	0.1	1,100	11.0	110.0
Total	-	-	3,370	35.7	477.0
Average Daily Pollution Load (kg/m^3)			BOD	0.011	
			SS	0.142	

Daily total pollution load

5,511 m^3/day x 0.011 kg/m^3 = 61 kg/day
1,300 m^3/day x 0.200 kg/m^3 = 260 kg/day
321 kg/day (BOD)

5,511 m^3/day x 0.142 kg/m^3 = 783 kg/day
1,300m^3/day x 0.200 kg/m^3 = 260 kg/day
1,043 kg/day (SS)

Average pollution load

321 kg/day ÷ 5,511 m^3/day = 0.058 kg/m^3 = 58 mg/l (BOD)
1,043 kg/day ÷ 5,511 m^3/day = 0.189 kg/m^3 = 189 mg/l (SS)

Table E-2-4 Assumption of Pollution Load (3/3)

Katana Site

Type of Factory	Unit Pollution Load (kg/m^3)		Daily Water Demand (m^3/day)	Daily Pollution Load (kg/day)	
	BOD	SS		BOD	SS
Fabricated Metal Products	0.02	0.8	800	16.0	800.0
Machinery	0.01	0.1	1,700	17.0	170.0
Total			2,500	33.0	970.0
Average Daily Pollution Load (kg/m^3)			BOD	0.013	
			SS	0.388	

Daily total pollution load

2,500 m^3/day x 0.013 kg/m^3 = 33 kg/day (BOD)

2,500 m^3/day x 0.388 kg/m^3 = 970 kg/day (SS)

Average pollution load

33 kg/day ÷ 2,500 m^3/day = 0.013 kg/m^3 = 13 mg/l (BOD)

970 kg/day ÷ 2,500 m^3/day = 0.388 kg/m^3 = 388 mg/l (SS)

Table E-2-5 SEWERAGE FACILITIES

	Unit	Atherfield	Martin		Sirigampola	Ekala	Katana
1. Pipe							
a. Ø 250 (PVC)	m	4,010	1,570	2,540	2,340	5,360	1,820
b. Ø 300 (PVC)	m	1,640	410	1,340	235	1,000	390
c. Ø 400 (Concrete)	m	-	-	550	100	1,490	-
d. Ø 450 (Concrete)	m	10	210	310	1,030	210	350
e. Ø 500 (Concrete)	m	-	-	-	-	170	-
f. Ø 600 (Concrete)	m	-	-	-	150	210	-
g. Ø 700 (Concrete)	m	-	-	10	130	180	-
h. Ø 800 (Concrete)	m	-	-	-	-	200	-
i. Ø 400 (Steel)	m	350	-	-	-	-	-
Total		6,010	2,190	4,750	3,985	8,820	2,560
2. Manhole	unit	180	80	160	140	290	140
3. House Collecting Pipe PVC Ø150	m	400	600	400	300	700	380
4. Pump Facility (from Manhole to T/P)							
1) Pump Diameter	mm	400	-	-	-	-	-
2) Head	m	10	-	-	-	-	-
3) Pump Capacity	m^3/min	8	-	-	-	-	-
5. Treatment Plant							
1) Capacity	m^3/day	11,200	-	11,300	2,200	6,800	2,500
2) Treatment Method	-	Oxidation Ditch System					
6. House Inlet	unit	40	60	40	30	70	38

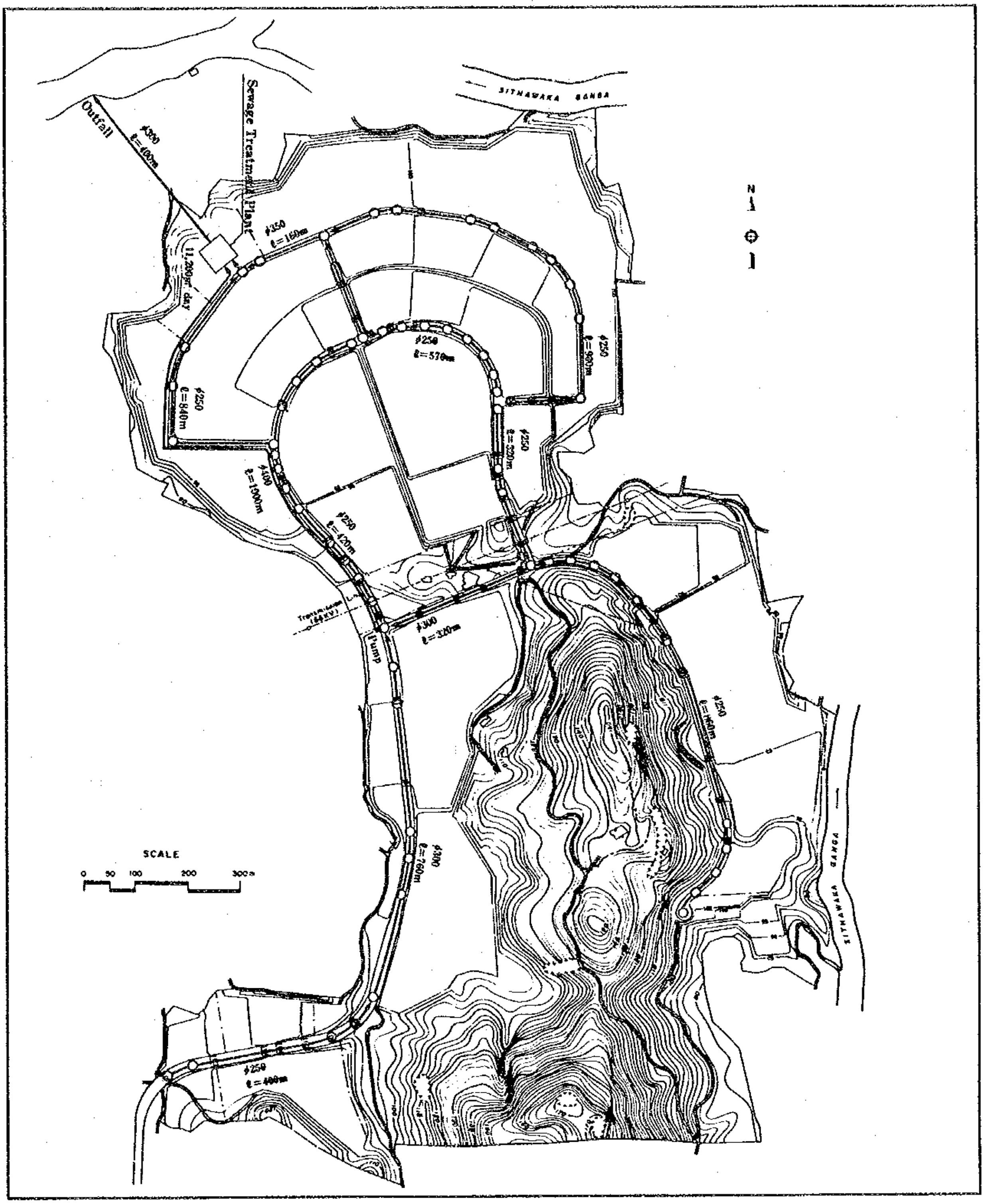

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	Figure E-2-1 Plan of Sewerage Facilities in Atherfield Estate
	Nippon Koei Co., Ltd. in association with Unico International Corporation and Japan External Trade Organization (JETRO)

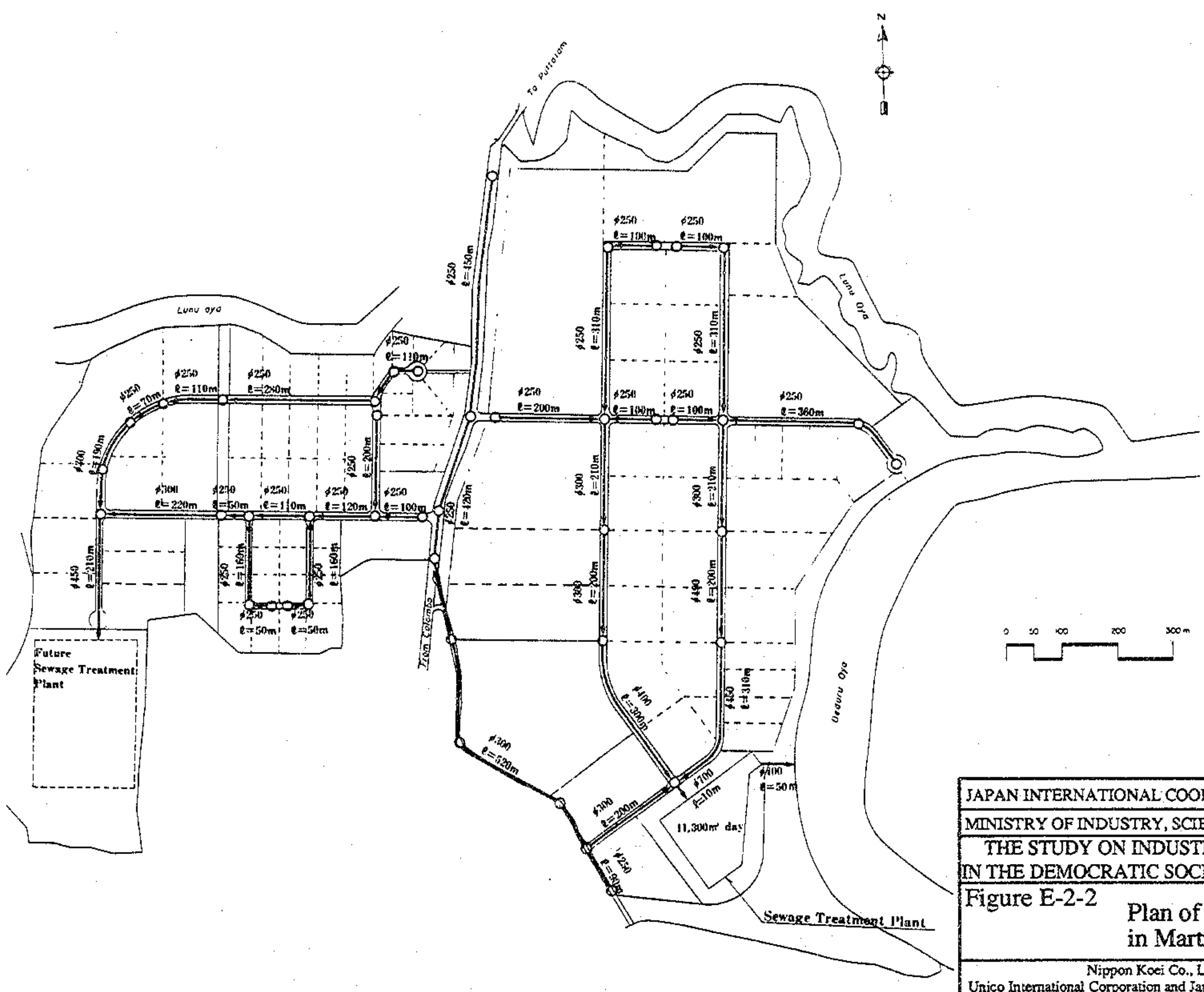

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Figure E-2-2 Plan of Sewerage Facilities in Martin Estate

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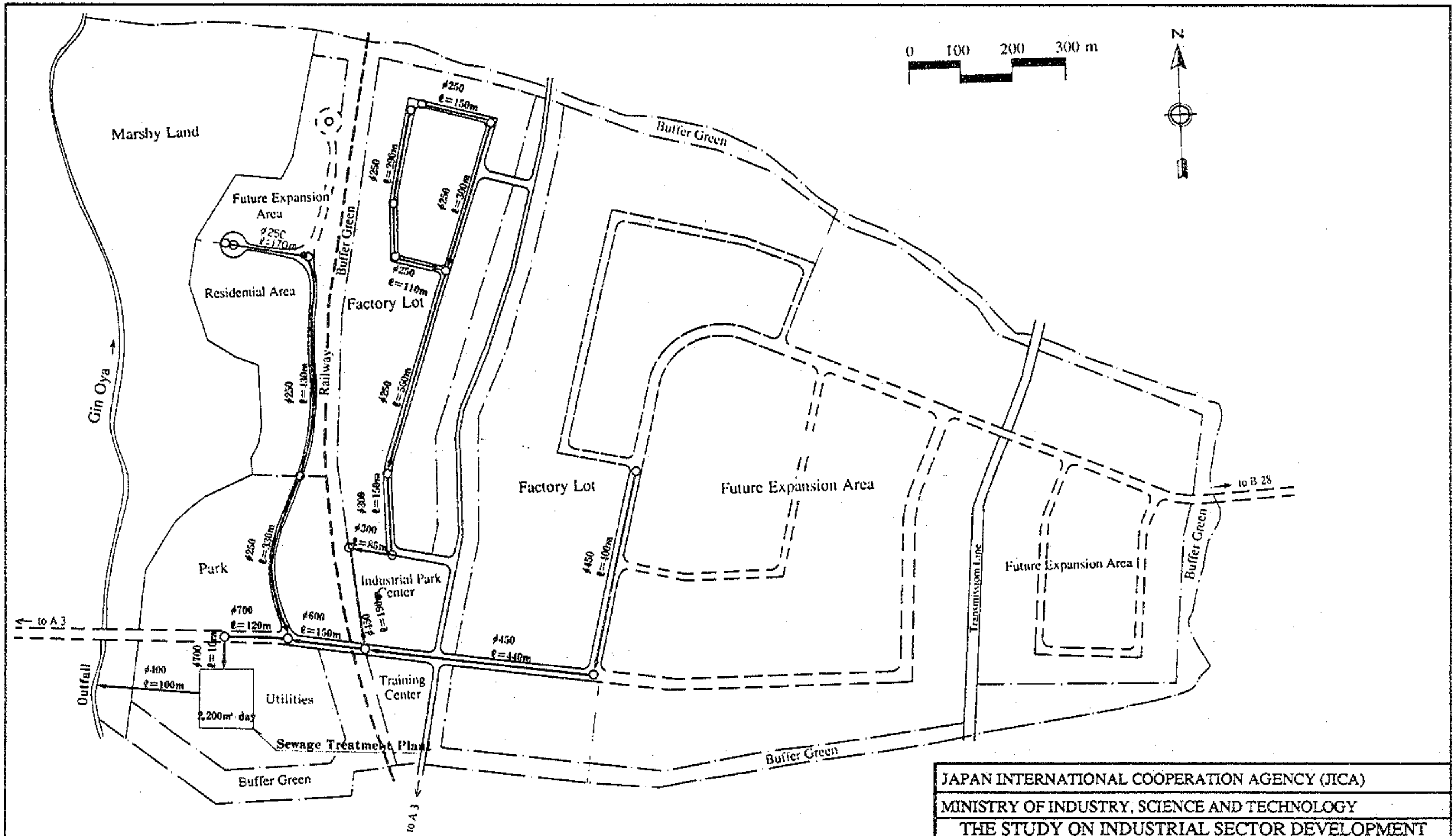

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Figure E-2-3 Plan of Sewerage Facilities in Sirigampola Estate

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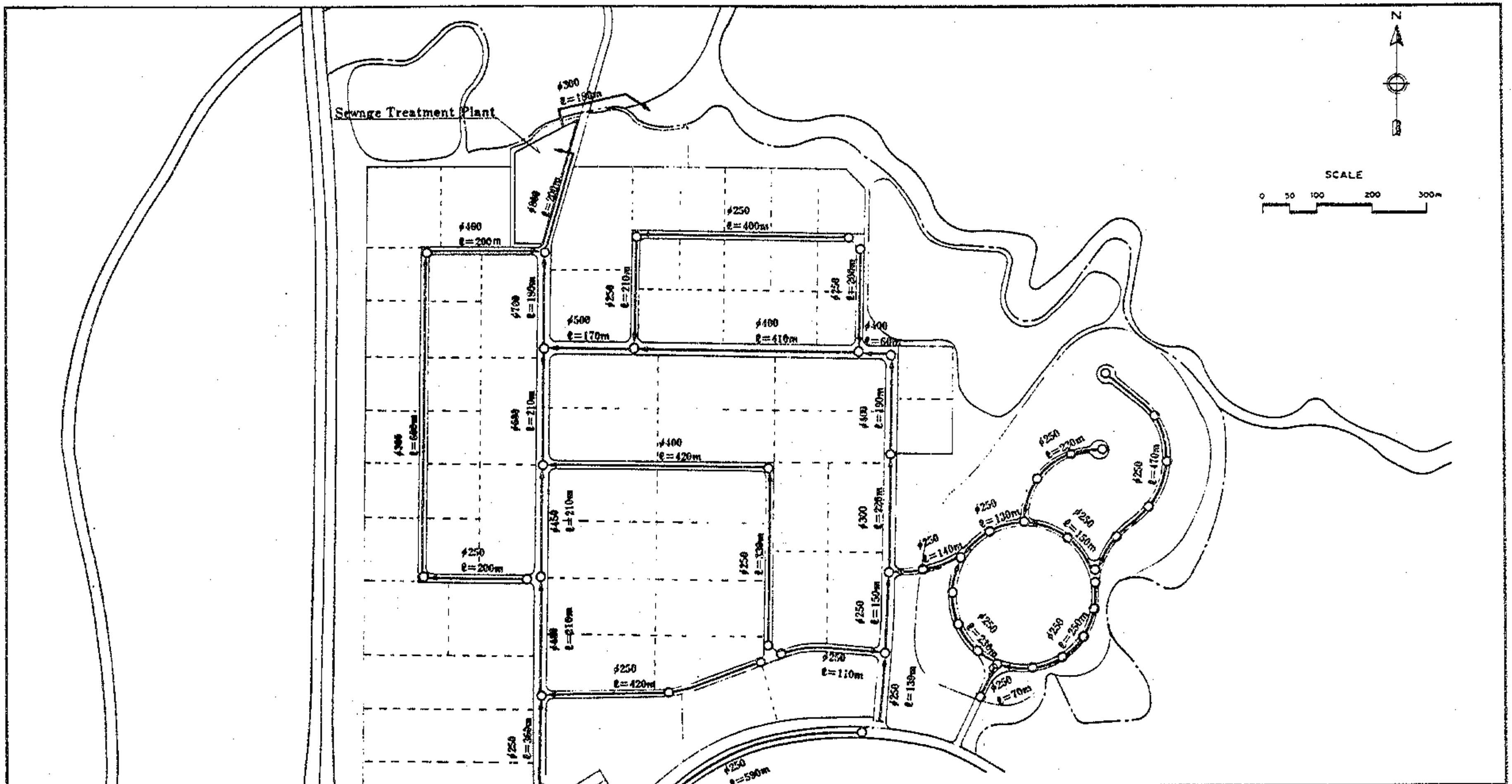

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Figure E-2-4 Plan of Sewerage Facilities in Ekala Estate

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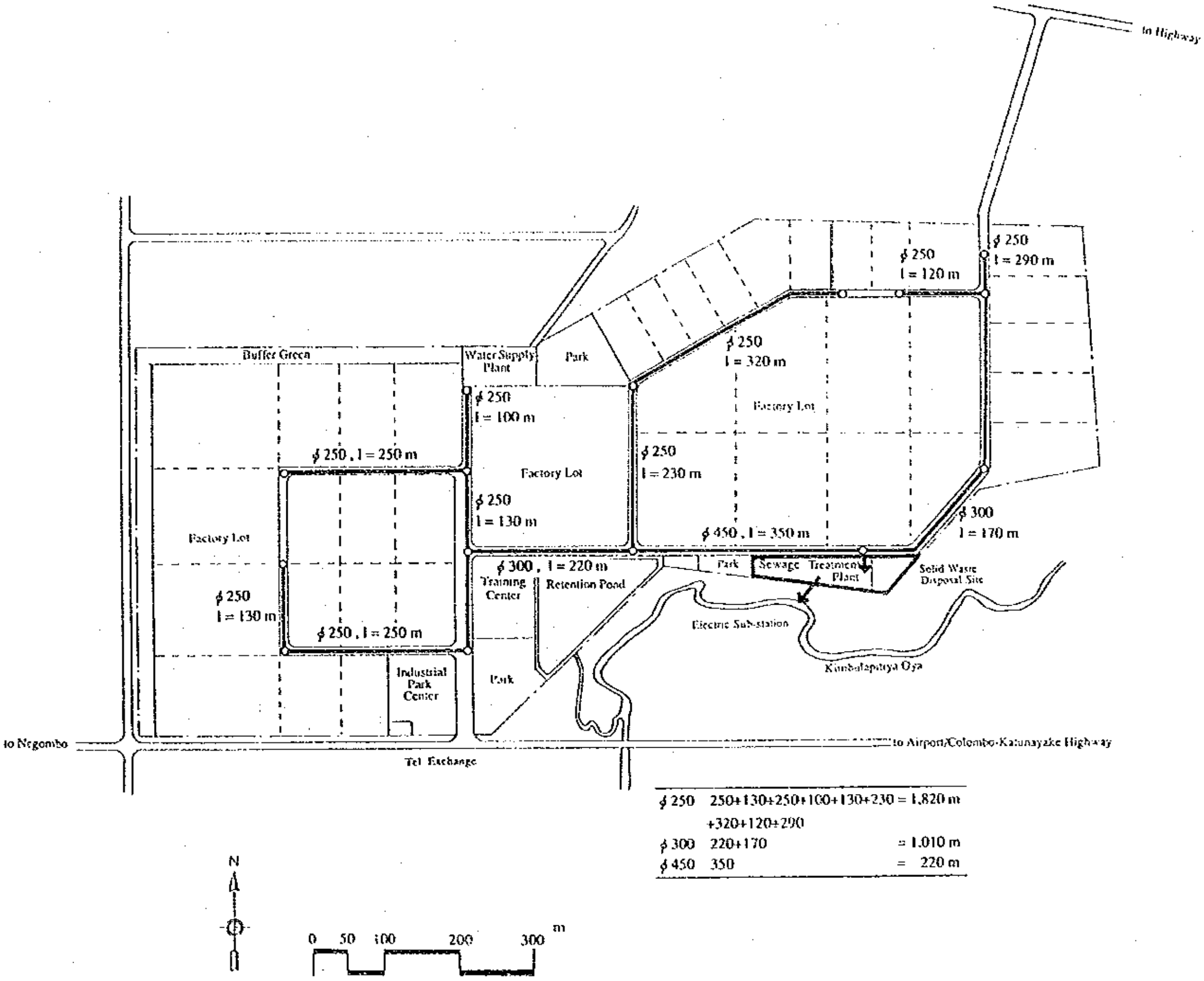

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Figure E-2-5	Plan of Sewerage Facilities in Katana Estate
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E.3 Drainage System

E.3.1 General

Drainage systems in the proposed industrial estates have been designed in the light of topographic conditions, climatic characteristics in the southwest region, and conditions of receiving water bodies, as well as by following design conditions for the drainage disposal systems authorized in Sri Lanka.

The drainage facilities in the industrial estates, as well as in the Greater Colombo area, are characterized by L-shaped gutters generally applied for the topographic and economic reasons. The drainage main pipes under the roads are less applied in Sri Lanka.

E.3.2 Design Standards and Criteria

1) Runoff Formula

Estimate of runoff discharge has been conducted by means of the rational formula as shown below:

$$Q = 1/360 * C * I * A$$

where,

C =	Coefficient of discharge	(non dimension)
	(0.7 for industrial lots, 0.5 for residential lots)	
I =	Rainfall intensity	(40 mm/hour)
A =	Area	(Hectare)
Q =	Runoff discharge	(m3/sec)

For calculation of velocity, Manning formula has been adopted, and it is estimated as follows:

$$Q = A * V$$
$$V = 1/n * R^{(2/3)} * I^{(1/2)}$$

where,

n = Coefficient of roughness (non dimension)

R = Hydraulic radius (m)

I = Gradient of water surface (= gradient of pipes)

Minimum velocity will be 0.8 m/sec for 80 % water depth.

2) Drainage Pipes

For reasons of easiness and economic construction, U-drains will be proposed. The size of U-drains will range from U-240x240 to U-600x600, and the maximum velocity will be set at 3.0 m for protecting the concrete surface. When the discharge is larger than the capacity of a U-600x600, reinforced concrete pipes will be designed.

PVC pipes with a diameter of 150 mm will be adopted for factory and street connecting pipes.

3) Manholes

Manholes will be made of concrete or reinforced concrete type, depending on their internal diameter. The intervals for installation of the manholes will be 40 m, basically.

4) Factory and Street Inlets

Factory and street inlets will be a circular or square shaped concrete structure with a diameter or internal length of 45 cm.

E.3.3 Proposed Drainage System

1) Atherfield Estate

Proposed drainage facilities in Atherfield estate is shown in Fig. E-3-1. For installation of drainage pipes, U-drains will be installed in Atherfield because topographic gradients of the proposed roads are comparatively steep. If drainage pipes are installed, manholes should be provided at shorter intervals. With the adoption of U-drain, thirteen (13) outfall structures will be provided.

2) Martin Estate

As Martin estate is topographically flat, reinforced concrete drainage pipes will be adopted as shown in Fig. E-3-2. The pipes will range from 400 mm to 1,350 mm in diameter.

For discharging rain water from the estate to the Deduru river, flap gates as outfall facilities will be installed to prevent intrusion of backwater from the river.

3) Sirigampola Estate

As the area to be developed at the initial stage is small, U-drains will be adopted at the upstream of the pipe reticulations as shown in Fig. E-3-3. The drainage pipes will be set into the Gin river at the western end of the estate.

4) Ekala Estate

U-drains will be adopted for small discharge in the upstream of the reticulations. A part of the runoff will be discharged into the river at the northern end, and the other part will be discharged into the retention ponds to be provided in the estate as shown in Fig. E-3-4.

5) Katana Estate

U-drains will be adopted in Katana site as shown in Fig. E-3-5 in consideration of the small catchment area of drainage facility. Retention pond will be constructed in order to retain the flood caused by intense rainfall in the estate.

Proposed facilities for drainage system in each estate are summarized in Table E-3-1.

Table E-3-1 DRAINAGE FACILITIES

	Unit	Atherfield	Martin		Sirigampola	Ekala	Katana
1. U-Drain							
240 x 240	m	2,120	-		-	40	940
300 x 240	m	960	-		-	280	-
300 x 300	m	200	-		-	-	-
300 x 360	m	1,320	-		-	380	1,720
360 x 360	m	2,180	-		170	910	-
360 x 300	m	500	-		-	-	-
450 x 450	m	3,380	-		640	1,080	1,700
600 x 600	m	4,150	-		640	2,290	200
1500 x 1000	m	-	-		-	-	100
1500 x 1500		-	-		-	-	1,100
Total		14,810			1,450	4,980	5,760
							-
2. Pipe (Concrete Pipe)							-
a. Ø 450	m	-	280	270	-	60	-
b. Ø 500	m	-	560	-	-	-	-
c. Ø 600	m	-	400	100	-	-	-
d. Ø 700	m	-	300	770	-	60	-
e. Ø 800	m	-	580	1,530	-	-	-
f. Ø 900	m	-	50	530	-	120	-
g. Ø 1000	m	-	-	200	350	160	-
h. Ø 1100	m	-	220	290	750	1,140	-
i. Ø 1200	m	-	-	460	430	590	-
j. Ø 1350	m	-	80	590	440	570	-
k. Ø 1500	m	-	-	-	510	210	-
l. Ø 1650	m	-	-	-	-	760	-
Total			2,470	4,740	2,480	3,670	-
3. Manhole	unit	-	60	120	60	90	-
4. House Inlet	unit	40	60	40	30	70	38
5. House Collecting Pipe (Ø150 PVC)	m	400	600	400	300	700	380
6. Street Inlet	unit	400	300	500	300	600	400
7. Street Collecting Pipe (Ø150 PVC)	m	-	1,500	2,500	1,500	300	-
8. Outfall Facility							
1) Structure	unit	14	3	1	1	5	3
2) Pipe Ø 200 PVC	m	280	-		-	-	60

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	Figure E-3-1 Plan of Drainage Facilities in Atherfield Estate
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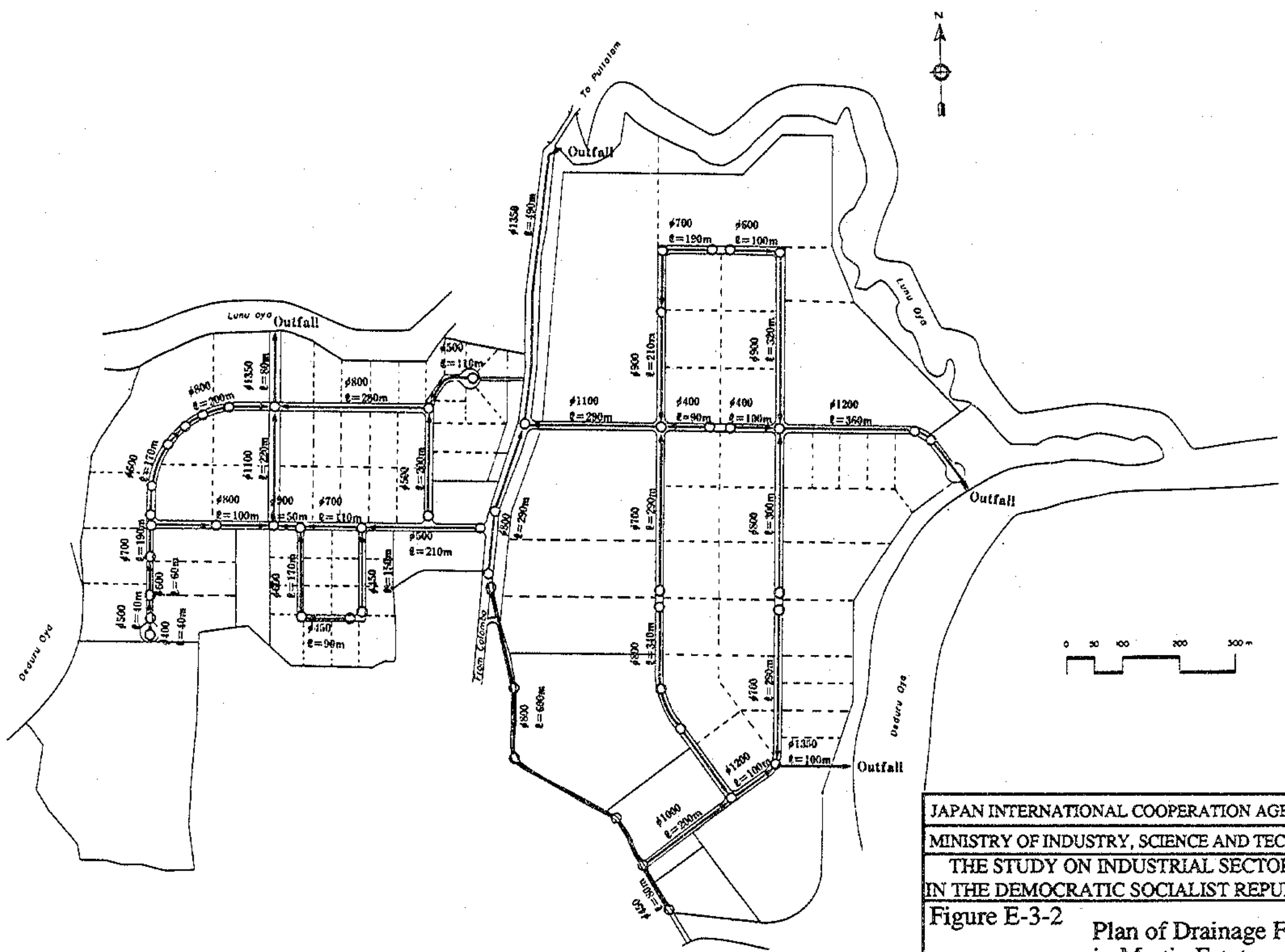

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Figure E-3-2 Plan of Drainage Facilities in Martin Estate

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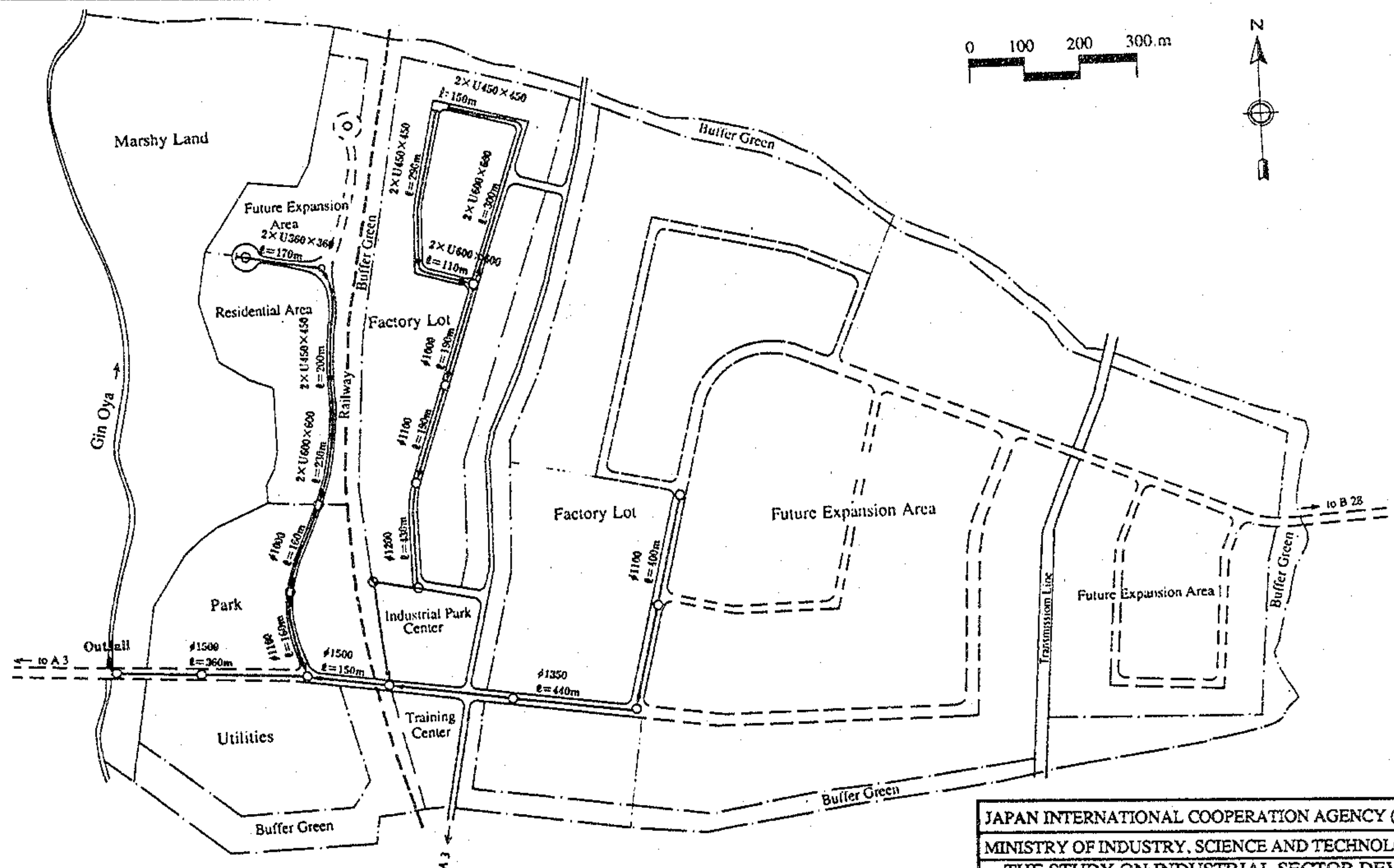

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Figure E-3-3 Plan of Drainage Facilities in Sirigampola Estate

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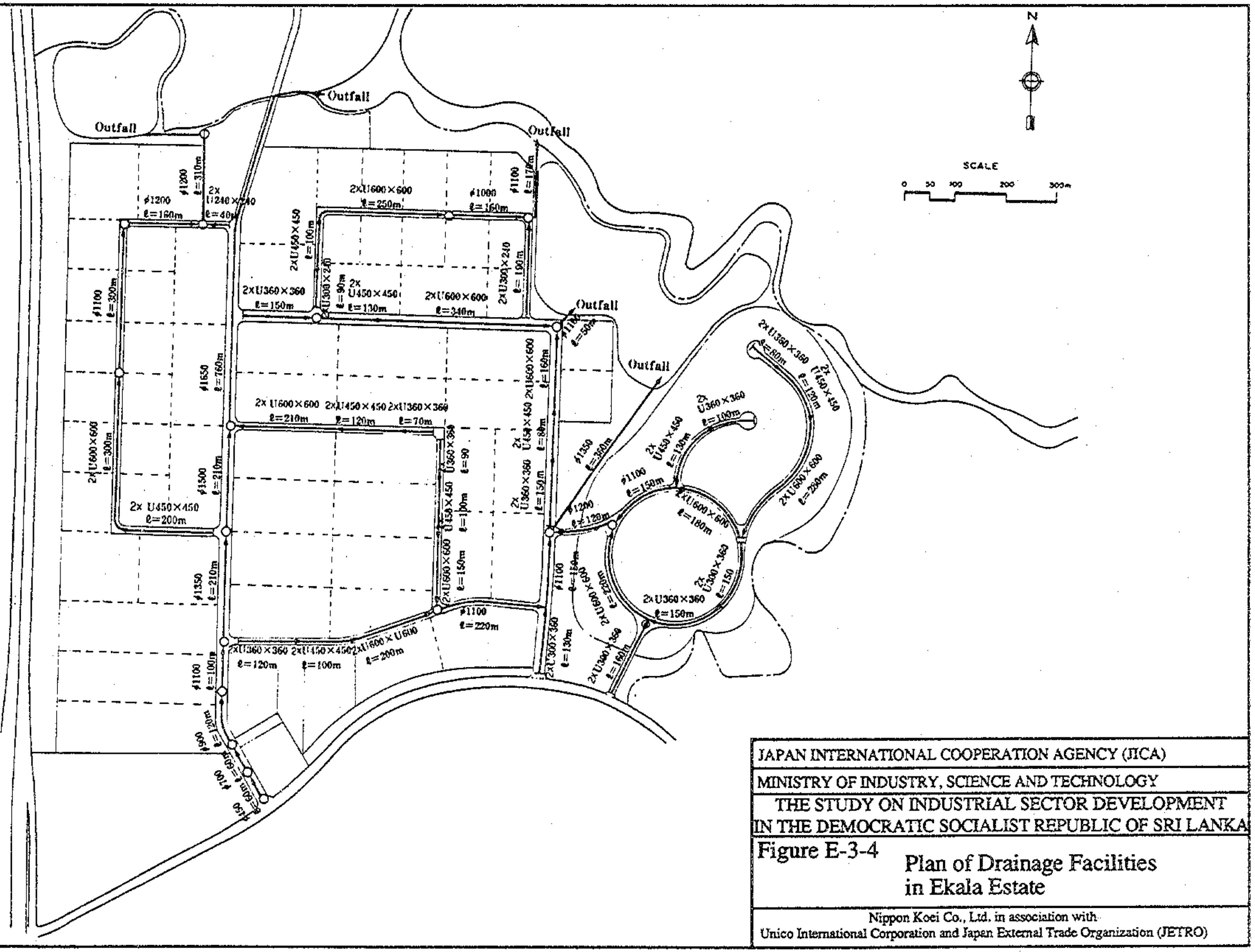

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Figure E-3-4 Plan of Drainage Facilities in Ekala Estate

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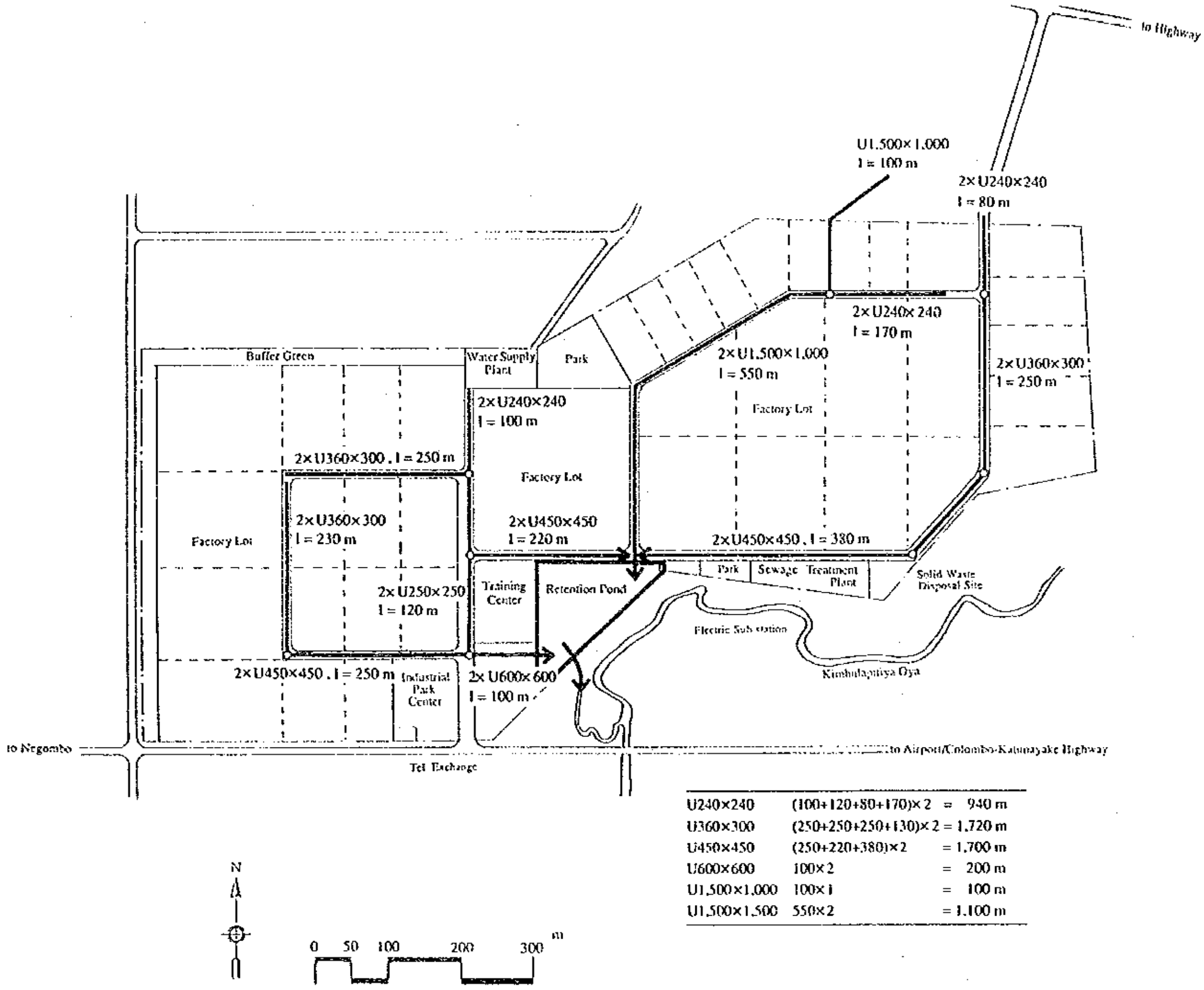

U240×240	(100+120+80+170)×2	= 940 m
U360×300	(250+250+250+130)×2	= 1,720 m
U450×450	(250+220+380)×2	= 1,700 m
U600×600	100×2	= 200 m
U1,500×1,000	100×1	= 100 m
U1,500×1,500	550×2	= 1,100 m

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Figure E-3-5 Plan of Drainage Facilities in Katana Estate

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APPENDIX F

ELECTRICITY AND TELECOMMUNICATIONS

APPENDIX F ELECTRICITY AND TELECOMMUNICATIONS

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APPENDIX F ELECTRICITY AND TELECOMMUNICATIONS

F.1 Power System

F.1.1 Organization of Power Sector

The principal Government authority in the power sector is the Ministry of Power and Energy. The Ministry has organized an Energy Coordinating Unit which is coordinating matters related to energy with other Ministries and governmental agencies.

The entire public power supply system is entrusted to the Ceylon Electricity Board (CEB) which was established in 1969 under the Ministry of Power and Energy. CEB is supplying electric power and energy all over the country, both directly and indirectly through the Lanka Electricity Company (LECO). LECO was established in 1983 to take over and improve the power supply to consumers within municipalities, which was previously managed by 218 Local Electricity Distribution Authorities.

F.1.2 CEB's Functions

CEB is a national authority for power generation, transmission and distribution. CEB is responsible for power development planning, construction of new generation, transmission and distribution facilities, operation and maintenance of power facilities, and direct or indirect sales of electric power. CEB operates island-wide 220 kV, 132 kV and 66 kV primary transmission systems for transmission of electrical energy. The generating facilities of CEB are predominantly hydropower with limited thermal generation from gas turbine and diesel generating plants.

F.2 Existing Power Facilities

F.2.1 Existing Generation Facilities

The power system network of the country is illustrated in Fig. F-1. The power network is mainly concentrated on the central and southern regions where the population is concentrated, economic activities are growing and where hydro resources are relatively abundant.

Hydropower is a valuable energy resource since coal and petroleum resources have not been discovered. Government has continuously pursued an energy development policy based on hydropower. Hydropower development was implemented in the Kehelgamu-Maskeli basin in the 1950s, while the Mahaweli development started in the late 1960s. In 1978, the government formulated the Accelerated Mahaweli Development Scheme (AMDP) to spur the development of the Mahaweli Ganga. Under AMDP, a series of large scale hydropower development schemes have been planned and implemented, together with a primary transmission line system and grid substations.

Total installed capacity of the generating facilities owned by CEB reached 1,289 MW in 1991, consisting of 1,017 MW of hydropower plants and 272 MW of thermal power plants.

Statistics of CEB power system in 1991 are summarized in Table F-1. As shown in the table, the gross power generation from both hydro and thermal power plants was 3,377 GWh, and the peak demand in the power system was 685.1 MW in 1991.

F.2.2 Existing Transmission and Distribution Lines

The transmission network is at the voltage levels of 220 kV, 132 kV and 66 kV. Voltage levels of 220 kV and 132 kV are employed for the trunk lines and voltage of 66 kV is applied for short distance lines only. The total length of transmission lines was 1,797 km at the end of 1991, consisting of 219 km of 220 kV line, 1,342 km of 132 kV line, and 236 km of 66 kV line. The transmission network is presented in Fig. F-1.

There were 28 grid substations at the end of 1991; 3 stations with a primary voltage of 220 kV, and 25 stations of 132 kV. The primary distribution line voltage is 33 kV and 11 kV, and their total length was 10,391 km and 2,518 km, respectively, in 1991.

F.2.3 Power and Energy Tariff System

CEB is regulating power tariff, though the tariff is invariably subject to the concurrence of the Government. Tariff issued in April 1991 is reproduced in Table F-2.

CEB tariff is common to the respective regions for industrial use. Average tariff per kWh for the whole categories of the consumers in April 1991 was computed to be approximately US 6 Cents. If the regular tariff are applied to the proposed industrial estates, average tariff for industrial use is approximately 5 US Cents per kWh based on the computation from the tariff system issued in April 1991.

F.3 Expansion of Power System

F.3.1 Power and Energy Demand Forecast

1) Historical trend of power market

The historical trends of generation, energy consumption and peak demand in the past 9 years are shown on Table F-3. As seen in the table, generation and demand have increased with an average annual growth rate of 6%. The relatively slow growth was caused by droughts, load shedding imposed therefrom and the insufficient capacity of thermal power plants to cover the decreased output of the hydropower plants.

Since output from the hydropower plants has been insufficient to meet the increasing demand, thermal power plants have been constructed. However, the total power supply can not meet the energy demand. In order to improve the situation, CEB envisages development of generating plants, rehabilitation of the existing network and expansion of the system.

2) Power demand forecast

The CEB forecast is updated every year, based on the latest statistics and past trends of demand growth. CEB's latest official forecast in the "Long Range Generation Expansion Plan - 1991" was prepared by applying the trend method, so called "Planning Forecast", which was formulated through the latest available data and long-term historical growth rates.

It is envisaged that the power demand in the entire power system will be annually increased at 7.5% during the period from 1991 to 1995. The energy consumption and power demand will reach 4,304 GWh and 877 MW in 1995.

F.3.2 Power System Expansion Plan

The expansion plan for power plant is prepared by CEB based on the demand forecast and the result of economic analysis. The Samanalawewa (120MW) hydropower plant is scheduled to be completed by the end of 1992. In addition, a 40 MW diesel power plant will be installed by 1994 to meet the growing power and energy demand.

In parallel with the development of new power generation, the augmentation and development of the grid substations and transmission lines are required to meet the growing system loads. Expansion of the power system to reduce the load shedding and to improve the supply reliability has been continuously executed by CEB under a series of the Transmission System Augmentation & Development Projects which involve construction of new 132kV grid substations, expansion of the existing substation and associated modification works thereof.

F.4 Proposed Power Supply System for Industrial Estates

F.4.1 Basic Design Conditions and Criteria

Power for the proposed industrial estates is available and supplied from the CEB's power grid. The basic design of power supply system for the proposed industrial estates, which is composed of primary power supply switching stations and distribution lines in the estates, will be prepared in accordance with the CEB design criteria.

From the system reliability point of view, the distribution line will be designed to enhance the quality of electricity so that the supplied voltage in the distribution system will be kept within a reasonable range.

F.4.2 Power Demand in Industrial Estates

Power demand in the proposed industrial estates has been estimated on the basis of the proposed land use plan as shown in Table F-4. Total power demand in the proposed industrial estates is summarised as follows:

Atherfield industrial estate	25.0 MW
Martin industrial estate	21.0 MW
Sirigampola industrial estate	10.5 MW
Ekala industrial estate	27.5 MW
Katana industrial estate	11.0 MW

F.4.3 Proposed Electric Power Supply System

A basic plan for installation of sub-transmission lines to be connected to the grid substation, as well as for distribution line in the industrial estates, has been formulated by referring to the power demand forecast and existing power systems in and around the area.

1) Sub-transmission Line

According to the CEB's regulation and the power demand in the proposed estates, 33 kV sub-transmission lines are planned for the power supply system. The nearest power tapping point from the CEB power grid, or the nearest grid substation, will be considered to be a power source for the industrial estates.

For power supply to Atherfield estate, CEB has a plan to construct a new sub-transmission lines with double circuits of "Lynx" conductor (175 mm^2) having 400A current capacity, between the new 132kV Avissawella grid substation to be constructed near Kosgama and Karawanella through the estate site. However, power available for the industrial estate will be limited, because this line is to be constructed to mitigate the power shortage in Avissawella area. Therefore, it is proposed to construct another double circuit sub-transmission line for exclusive use by the industrial estate, from the new Avissawella grid substation located at approximately 11 km from the industrial estate.

For Martin estate, CEB will construct a new 132 kV grid substation near Madampe and construct a new 33 kV sub-transmission line to Chilaw town. However, the capacity of this line will be insufficient to supply the required power demand in Martin estate. A new double circuit sub-transmission line is proposed to be constructed between the new Chilaw grid substation and Martin estate. The length of the proposed sub-transmission line is approximately 21km from the new grid substation.

For Sirigampola estate, a new sub-transmission line connecting Bolawatta grid substation and Chilaw through the proposed estate has been planned and part of the line is already under construction. The capacity of this line is sufficient for the required power for the estate. A power supply line to the industrial estate will be tapped from this sub-transmission line at the site.

For Ekala estate, a new 33 kV sub-transmission line will be required from Kotugoda grid substation to meet the required power demand, because the capacity of the existing distribution line is insufficient. The Kotugoda grid substation is interconnected with the 220kV transmission system.

For Katana estate, a new 33kV sub-transmission line will be required from Kotugoda grid substation. The length of the proposed sub-transmission line is 12 km from the substation.

Preliminary route selection of the sub-transmission lines for respective industrial estates are shown in Figures F- 2, F-3, and F-4.

(2) Switching station

A switching station is planned to be constructed for power distribution in the respective industrial estates. The switching station will be located in the center of the electric loads to minimize the length of distribution line and power loss.

The switching station will be provided with isolators for each power supply feeder and steel structure for 33 kV bus.

(3) Distribution Line

33 kV distribution systems are designed in each industrial estate to distribute power to consumers. The overhead line distribution system is constructed along with the road so that the consumer can tap their own lead line easily. The distribution system is basically radial type.

The preliminary distribution system for the proposed industrial estates are shown in Figures F-5, F-6, F-7, F-8, and F-9.

F.5 Telecommunications System

F.5.1 Organization of Telecommunications Sector

The overall telecommunications system is managed by the Sri Lanka Telecom (SLT). Established in 1991, SLT took over telecommunications services from the Department of Telecommunications, under supervision of the Ministry of Posts and Telecommunications (P&T).

F.5.2 Existing Telecommunications Service and System

SLT currently operates about 126,000 telephone lines over the country, with a telephone density of 1.09 set per 100 inhabitants. The telecommunications services include i) telephone services including international direct dialling services, ii) facsimile services, and iii) telex services.

The existing network structure is a two level switching hierarchy, with four tertiary centers at in Colombo, Kandy, Galle and Anuradhapura. The national network is mainly composed of a radio system (microwave and UHF/VHF) due to the topographical configurations of high mountains located in the center of the country. The existing transmission routes of microwave, UHF/VHF systems are shown in Figure F-10. Four microwave transmission routes, Colombo - Kandy, North, South and East routes, are established as the trunk radio links. The UHF and VHF transmission routes which link small cities with low capacity circuits are interconnected. SLT's telephone rates are shown in Table F-6.

F.6 Expansion of Telecommunications System

F.6.1 Expansion of Services

SLT has a long term development plan, including improvement plans for telecommunications service systems. The development is mainly for the rehabilitation of cable networks and modernization of plant and equipment.

The Greater Colombo Network Improvement Project, Phase I, was completed in 1990. The Phase II is being implemented in 1990-1994 to develop additional networks in Colombo area. In addition, the Gampaha Telecommunication Network Improvement Project and the Puttalam, Negombo and Chilaw Telecommunication Improvement Project are implemented in parallel. The overseas telecommunication services will be improved under the Second Telecommunication Project, together with earth-satellite station, trunk transmission network and management information system.

F.6.2 Expansion of System Facilities

There is much demand for subscription to telecommunications services in the country. To meet with the demand, SLT commenced an expansion and improvement project. In this development plan, expansion of telephone lines around the proposed industrial estate is incorporated. Once the subscribers telephone lines are connected, subscribers in the industrial estate, could communicate with Colombo and overseas. A data communication exchange will also be practicable at that time.

F.7 Proposed Telecommunications System for Industrial Estates

F.7.1 Basic Design Conditions

Telecommunications services for the proposed industrial estates are available through SLT. Basic design for telecommunications in the proposed industrial estates will be composed of trunk line (toll junction line) and distribution telephone line (subscriber line).

1) Toll Junction Line

The respective estate will be connected to the nearest switching center on the national network with toll junction lines in telecommunications hierarchy. Toll junction lines from the respective switching center to the estates are proposed to be optical fiber.

2) Subscriber Line

Subscriber lines are planned in the respective industrial estates. The lines are designed to be overhead metallic cable lines with branch and connection cabinet.

F.7.2 Telecommunications Demand in Industrial Estates

1) Exchange capacity

For design of the exchange capacity, total demand for telephone lines is estimated on the basis of the estimated number of employees, as shown in Table F-7. Telephone demand for the proposed industrial estates are summarized as follows:

Atherfield industrial estate	1,800 lines
Martin industrial estate	1,000 lines
Sirigampola industrial estate	600 lines
Ekala industrial estate	1,600 lines
Katana industrial estate	600 lines

2) Toll trunk line

Traffic from/to subscribers in the industrial estates will be mostly long distance calls, including international calls. The number of toll trunk lines in the proposed industrial estates is estimated as follows:

Atherfield industrial estate	330 lines
Martin industrial estate	200 lines
Sirigampola industrial estate	120 lines
Ekala industrial estate	320 lines
Katana industrial estate	120 lines

F.7.3 Proposed Telecommunications System

In view of the telecommunications demand, telecommunications system is proposed to be arranged by small switching station (PABX) in the industrial estates and it is connected to the nearest SLT telephone switching station.

The trunk line for each industrial estate will be connected to the following SLT's switching station:

Atherfield industrial estate	Awissawella switching station
Martin industrial estate	Chilaw switching station
Sirigampola industrial estate	Negombo switching station
Ekala industrial estate	Gampaha switching station
Katana industrial estate	Negombo switching station

Table F-1 SUMMARY OF POWER STATISTICS IN 1991

		Unit	Total	
(a)	Number of Power Stations	No.	19	
(b)	Instaled Capacity	MW	1,289	
(c)	Maximum Demand	MW	685.1	
(d)	Gross Generation	GWh	3,377	
(e)	Transmission & Distribution Losses	%	18.8	
(f)	Energy Sold	GWh	2,742	
(g)	Average Sale Price/Unit	Rs./kWh	2.40	1/
(h)	Revenue from Sales (Billing)	M.Rs.	5,696	
(i)	Number of Consumer Accounts	NO.	882,373	
(j)	Percentage of Households Electrified	%	33	2/
(k)	Annual Load Factor	%	56.3	
(l)	Rate of return	%	6.4	
(m)	Average Annual Electricity Consumption per Capita	kWh/person	159	

(Note) 1/ : Tariff changed from 1st April 1990
2/ : estimated
Source : Statistical Digest in 1991 published by CEB

Table F-2 ELECTRICITY TARIFF

DOMESTIC

First 10 units @Rs. 0.55 cts per unit
11-50 units @ Rs. 1.05 cts per unit
51-100 units @ Rs. 2.00 cts per unit
101-450 units @ Rs. 3.00 cts per unit
Above 450 units @ Rs. 4.00 cts per unit

MONTHLY

Fixed charge Rs. 10/- for consumption under 10 units/month
Rs. 10/- for consumption over 10 units/month

Fuel Adjustment Charge, when applicable, is on consumption over 50 units/month.

RELIGIOUS & CHARITABLE INSTRUCTIONS

First 150 units @ Rs. 0.80 cts per unit
Above 150 units @ Rs. per unit & Fuel Adjustment Charge
Fixed Charge for a month is Rs. 10/-

	General purpose	Industrial	Hotels purpose	Industrial (Time of day)	Hotels (Time of day)
Supply at 400/230V					
Contract Demand less than 50kVA				1.75 (Off-Peak)	
				+	
Unit Charge (Rs./Unit)	3.10	2.35	3.10	4.90(peak 6p.m. to 9p.m.)	-
	+	+	+	+	
Fixed Charge (upto 10kVA) (Rs.)	25.00	25.00	25.00	25.00	-
	or	or	or	or	
Fixed Charge (above 10kVA) (Rs.)	120.00	120.00	120.00	120.00	-
Supply at 400/230V					
Contract Demand 50kVA and above					
Demand Charge (Rs./kVA)	150.00	130.00	150.00	60.00	60.00
	+	+	+		
Unit Charge (Rs./Unit)	3.05	2.20	3.05	2.10 (Off-Peak)	2.15 (Off-Peak)
				+	+
				4.95(peak 6p.m. to 9p.m.)	5.00(peak 6p.m. to 9p.m.)
	+	+	+	+	+
Fixed Charge (Rs.)	240.00	240.00	240.00	240.00	240.00
H.T.supply at 11kV, 33kV and 132kV					
Demand Charge (Rs./kVA)	140.00	115.00	140.00	55.00	55.00
	+	+	+		
Unit Charge (Rs./Unit)	2.95	2.15	2.95	2.00 (Off-Peak)	2.00 (Off-Peak)
				+	+
				4.70(peak 6p.m. to 9p.m.)	4.75(peak 6p.m. to 9p.m.)
	+	+	+	+	+
Fixed Charge (Rs.)	240.00	240.00	240.00	240	240

Note :- The Fuel Adjustment Charge will be expressed as a percentage of and is applicable on the Unit Chage only.
The Fuel Adjustment Charge, when in operation, shall apply to all General Purpose, Industrial and Hotel Consumers and Time of Day Consumers

Table F-3 PEAK POWER DEMAND, ENERGY CONSUMPTION, LOSSES AND GENERATION

Year	Energy (Gwh)										Power Demand (MW)	Load Factor (%)
	Domestic & Religious	Small & Medium Industries	Heavy Industries	Commercial & Hotels	Local Authorities	Street Lighting	Total Consumption	Per Capita Sale	Losses	Total Generation		
1983	305	367	383	244	433	10	1,792	116	322	2,114	437	55.2
1984	309	404	387	308	458	11	1,877	120	374	2,250	487	52.7
1985	346	446	404	350	502	12	2,060	130	404	2,464	515	54.6
1986	369	480	445	381	543	13	2,232	139	420	2,652	540	56.1
1987	381	489	378	419	570	16	2,253	137	454	2,707	570	54.2
1988	404	521	384	443	601	17	2,371	143	428	2,799	593	53.8
1989	420	502	347	436	631	17	2,353	140	505	2,858	618	52.8
1990	514	554	356	508	657	18	2,608	153	542	3,150	639	56.2
1991	664	562	396	547	572	21	2,742	159	635	3,377	685	56.3

Source: CEB Statical Digest

Table F-4 POWER DEMAND FORECAST (1/2)

ATHERFIELD SITE

	Kind of Industries	Factory areas (ha)	Power Unit (kW/ha)	Required capacity (kW)	Demand Factor	Required Power (kW)
311	Food	3.0	500	1,500	0.55	830
321,2	Textile,Apparel	25.0	500	12,500	0.60	7,500
34	Paper products	2.0	800	1,600	0.60	960
355	Rubber products	20.5	600	12,300	0.60	7,380
36	Non metal mineral product	2.0	300	600	0.40	240
3901	Gems	16.0	500	8,000	0.55	4,400
3902-9	Others (Toy, etc..)	12.0	400	4,800	0.55	2,640
	Sub-total	80.5		41,300		23,950
	Water supply plant					270
	Sewage treatment plant					100
	Industrial park center					100
	Training center					50
	Residential house					250
	Outdoor lighting					100
	Grand total					24,820
						≈ 25 MW

MARTIN SITE

	Kind of Industries	Factory areas (ha)	Power Unit (kW/ha)	Required capacity (kW)	Demand Factor	Required Power (kW)
311	Food	10.0	400	4,000	1	2,200
321,2	Textile,Apparel	6.0	500	3,000	1	1,800
323,4	Leather, Footwear	25.0	200	5,000	1	2,500
35	Chemical products	23.5	600	14,100	1	8,460
355	Rubber products	4.0	600	2,400	1	1,440
36	Non metal mineral products	0.3	300	75	1	40
381	Fabricated metal products	10.5	800	8,400	0	3,360
	Sub-total	79.3		36,975		19,800
	Water supply plant					200
	Sewage treatment plant					400
	Industrial park center					100
	Training center					50
	Residential house					400
	Outdoor lighting					100
	Grand total					21,050
						≈ 21 MW

SIRIGAMPOLA SITE

	Kind of Industries	Factory areas (ha)	Power Unit (kW/ha)	Required capacity (kW)	Demand Factor	Required Power (kW)
382-9	Machinery	46.0	500	23,000	0.40	9,200
	Sub-total	46.0		23,000		9,200
	Water supply plant					270
	Sewage treatment plant					100
	Industrial park center					100
	Training center					50
	Residential house					400
	Outdoor lighting					100
	Grand total					10,220
						≈ 10.5 MW

Table F-4 POWER DEMAND FORECAST (2/2)

EKALA SITE

	Kind of Industries	Factory areas (ha)	Power Unit (kW/ha)	Required capacity (kW)	Demand Factor	Required Power (kW)
381	Fabricated metal products	5.0	800	4,000	0.40	1,600
382-9	Machinery	51.0	500	25,500	0.40	10,200
3901	Gems	16.0	500	8,000	0.55	4,400
3902-9	Others (Toy, etct.)	44.0	400	17,600	0.55	9,680
	Sub-total	116.0		55,100		25,880
	Water supply plant					200
	Sewage treatment plant					100
	Industrial park cemter					100
	Training center					50
	Residential house					800
	Outdoor lighting					50
	Grand total					27,180
						≈ 27.5 MW

KATANA SITE

	Kind of Industries	Factory areas (ha)	Power Unit (kW/ha)	Required capacity (kW)	Demand Factor	Required Power (kW)
381	Fabricated metal products	10.0	800	8,000	0.40	3,200
382-9	Machinery	34.0	500	17,000	0.40	6,800
	Sub-total	44.0		25,000		10,000
	Water supply plant					200
	Sewage treatment plant					100
	Industrial park cemter					100
	Training center					50
	Residential house					0
	Outdoor lighting					100
	Grand total					10,550
						≈ 11.0 MW

Table F-5 SUMMARY OF T ELECOMUNICATION SETVICES IN 1990 AND 1991

		1990	1991*
(a)	**Inland Telephone Service**		
	1.Nos. of telephone lines	121,388	125,834
	2.New telephone lines	10,241	6,579
	3.No. of applicants in waiting list	47,495	61,313
	4.Demand for telephone	169,333	187,147
	5.Telephone density (telephone per 100 person)	1.00	1.09
(b)	**Overseas Telecommunication Services**		
	1.No. of telex connection	1,666	1,730
	2.No. of applicants in waiting list	89	84
	3.Outgoing traffic		
	Overseas telephone traffic1/	9,006,000	12,624,355
	Overseas telegrams2/	2,720,000	2,348,803
	Overseas telex traffic1/	4,472,122	4,140,000

(Note) 1/ : Figures are given in number of minutes
2/ : Figures are given in number of words
* : Provisional

Source : Central Bank of Sri Lanka Annual Report 1991

Table F-6 TELEPHONE RATES

TELEPHONE SERVICE

Telephone rate(local)

Call in STD area (including Katunayake, Biyagama , and Kogala Investment Promotion Zones) are charged at Rs. 1.00 per Unit for the first 200 unit and at 1.50 for each successive unit. A unit is 02 minutes or thereof. The "unit" for calls taken between 6.00 p.m. and 8.00 a.m. and during the full 24 hour period on a Saturday, Sunday and on a Public Holidays is 04 minutes.

Telephone rate (International)

Country	IDD Standard Rate Per minutes or Part thereof (Rs.)	Operator Assisted Minimum charge 3 minutes (Rs.) SS	Operator Assisted Minimum charge 3 minutes (Rs.) PP/CC	Operator Assisted Each add. minutes (Rs.)
U.K., France, Germany, Italy	94.00	324.00	540.00	108.00
Hong Kong, Japan, South Korea, Australia, Singapore	72.00	249.00	415.00	83.00
U.S.A., Canada	105.00	363.00	605.00	121.00

Note ; SS : Station to Station (number to number)
PP : Person to Person
CC : Collect Calls

Telex Rates

Country	Fully Automatic Per minutes or Part thereof (Rs.)	Operator Assisted Minimum charge 3 minutes (Rs.)	Operator Assisted Each additional minutes (Rs.)
U.K., Hong Kong, Singapore, Italy, Australia, Japan	73.00	219.00	73.00
France, Germany, South Korea, U.S.A., Canada	82.00	246.00	82.00
Local	2.00	-	-

Telefax Rates

Same as rates for International Telephone Services

DIRECT DIALLED (IDD) SERVICE

Standard Rates

Country	Standard Rate per Six seconds (Rs.)	Off-peak Rate per Six seconds (10 p.m.- 6 a.m.)* (Rs.)
Bangladesh, India, Maldive Islands, Nepal, Pakistan	5.00	3.00
Australia, Indonesia, Japan, Korea Rep., Malaysia, Singapore, Taiwan, Thailand	7.20	4.30
Austria, Bahrain, Djibouti, Egypt, France, Germany, Italy, Kenya, Kuwait, Netherlands, Saudi Arabia, Spain, Switzerland, United Arab Emirates, United Kingdom	9.40	5.70
Canada, United State of America	10.50	6.30

Note; * Off-peak period on weekdays is from 10 p.m. to 6 a.m. the following day. During weekends, off-peak period which commences at 10 p.m. on Saturday will continue till 6 a.m. on Monday.

Cheap Rate International Direct Dialled (IDD) service

Country	Standard Rate per Six seconds (Rs.)
Bangladesh, India, Maldive Islands, Nepal, Pakistan	5.00
Australia	7.20
Bahrain, Egypt, France, Germany, Kuwait, Saudi Arabia, United Arab Emirates, United Kingdom	9.40
Canada, United State of America	10.50

Table F-7 TELECOMMUNICATION DEMAND FORECAST (1/2)

ATHERFIELD SITE

	Kind of Industries	Factory areas (ha)	Nos. of Employee	Demand rate (W/ Empolyee)	Required Demand (No.)	Required Capacity (No.)
311	Food	3.00	450	0.10	45	50
321,2	Textile, Apparel	25.00	11,000	0.05	550	550
34	Paper products	2.00	350	0.10	35	40
355	Rubber products	20.50	1,525	0.10	153	150
36	Non metal mineral products	2.00	100	0.10	10	10
3901	Gems	16.00	6,100	0.05	305	310
3902-9	Others (Toy, etc..)	12.00	5,400	0.10	540	540
	Sub-total	80.50	24,925		1,638	1,640
	Water supply plant					1
	Sewage treatment plant					1
	Industrial park cemter					5
	Training center					5
	Residential house					80
	Grand total					1,732
					≈	1,800

MARTIN SITE

	Kind of Industries	Factory areas (ha)	Nos. of Employee	Demand rate (W/ Empolyee)	Required Demand (No.)	Required Capacity (No.)
311	Food	10.00	1,000	0.10	100	100
321,2	Textile, Apparel	6.00	1,050	0.05	53	50
323,4	Leather, Footwear	25.00	2,750	0.10	275	280
35	Chemical product	23.50	2,388	0.10	239	240
355	Rubber products	4.00	300	0.10	30	30
36	Non metal mineral product	0.25	75	0.10	8	10
381	Fabricated metal products	10.50	905	0.10	91	90
	Sub-total	79.25	8,468		794	800
	Water supply plant					1
	Sewage treatment plant					2
	Industrial park cemter					5
	Training center					5
	Residential house					120
	Grand total					933
					≈	1,000

SIRIGAMPOLA SITE

	Kind of Industries	Factory areas (ha)	Nos. of Employee	Demand rate (W/ Empolyee)	Required Demand (No.)	Required Capacity (No.)
382-9	Machinery	46.00	4,780	0.10	478	480
	Sub-total	46.00			478	480
	Water supply plant					1
	Sewage treatment plant					1
	Industrial park cemter					5
	Training center					5
	Residential house					100
	Grand total					592
					≈	600

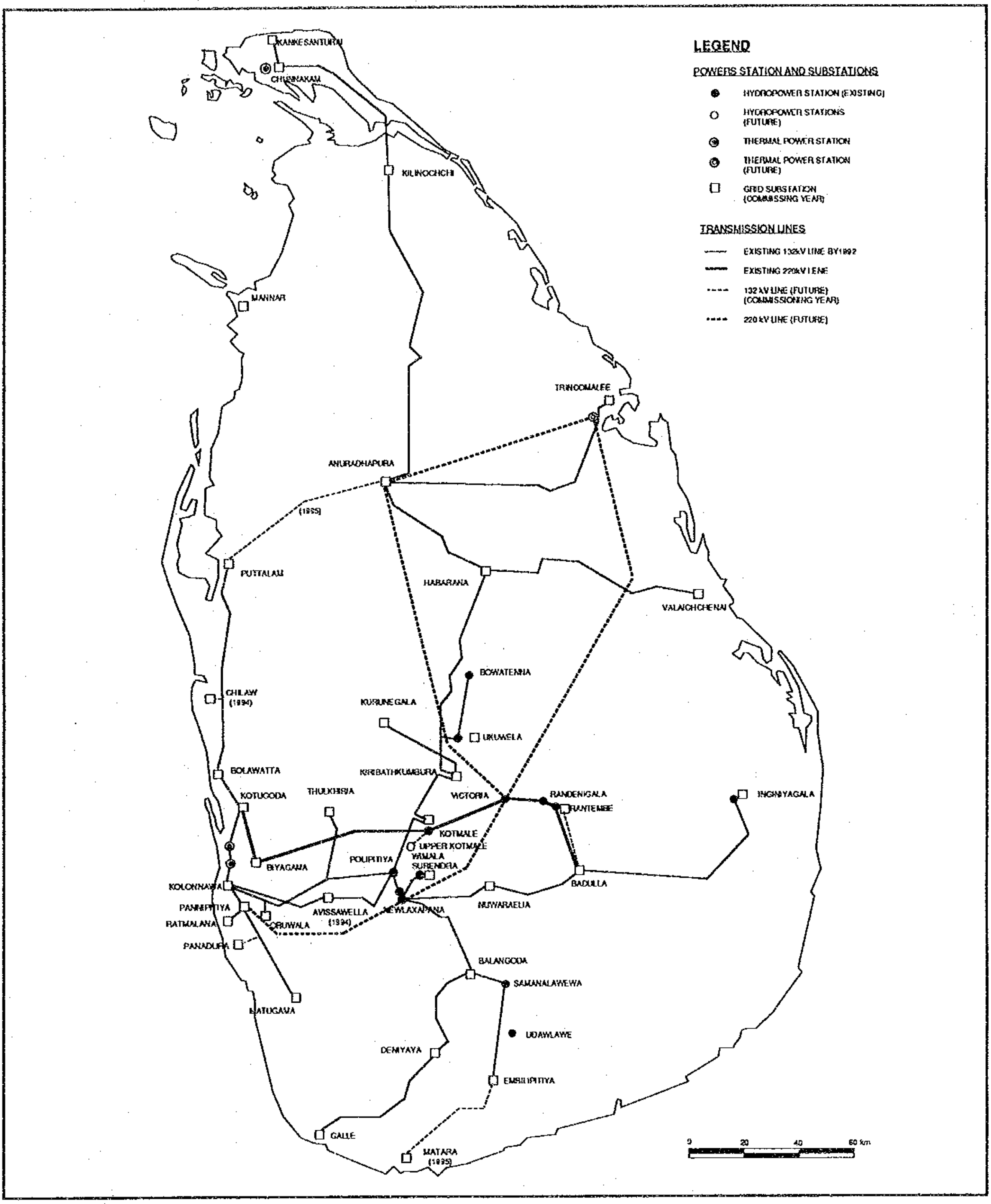
Table F-7 TELECOMMUNICATION DEMAND FORECAST (2/2)

EKALA SITE

	Kind of Industries	Factory areas (ha)	Nos. of Employee	Demand rate (W/ Empolyee)	Required Demand (No.)	Required Capacity (No.)
381	Fabricated metal products	5.00	1,000	0.10	100	100
382-9	Machinery	51.00	5,280	0.10	528	530
3901	Gems	16.00	3,600	0.05	180	180
3902-9	Others (Toy, etct.)	44.00	4,880	0.10	488	490
	Sub-total	116.00	14,760		1,296	1,300
	Water supply plant					1
	Sewage treatment plant					1
	Industrial park cemter					5
	Training center					5
	Residential house					300
	Grand total					1,612
					≈	1,600

KATANA SITE

	Kind of Industries	Factory areas (ha)	Nos. of Employee	Demand rate (W/ Empolyee)	Required Demand (No.)	Required Capacity (No.)
381	Fabricated metal products	10.00	1,200	0.10	120	150
382-9	Machinery	34.00	3,500	0.10	350	400
	Sub-total	44.00	4,700		470	550
	Water supply plant					1
	Sewage treatment plant					1
	Industrial park cemter					5
	Training center					5
	Grand total					562
					≈	600



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THE STUDY ON INDUSTIAL SECTOR DEVELOPMENT IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA
Figure F-1 **Power Transmission System**
Nippon Koei Co., Ltd. in association with Unico International Corporation and Japan External Trade Organization (JETRO)

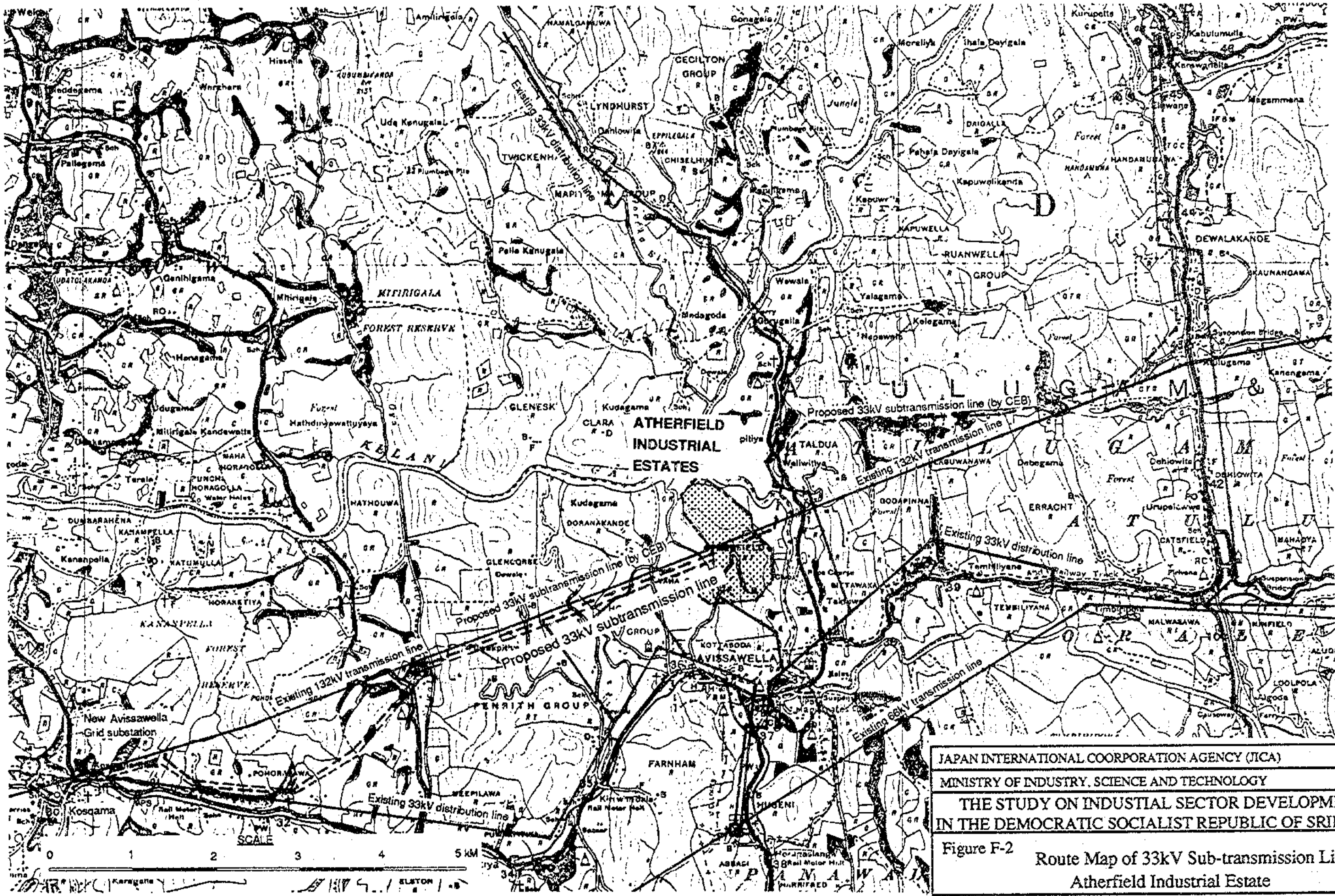

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Figure F-2 Route Map of 33kV Sub-transmission Line for Atherfield Industrial Estate

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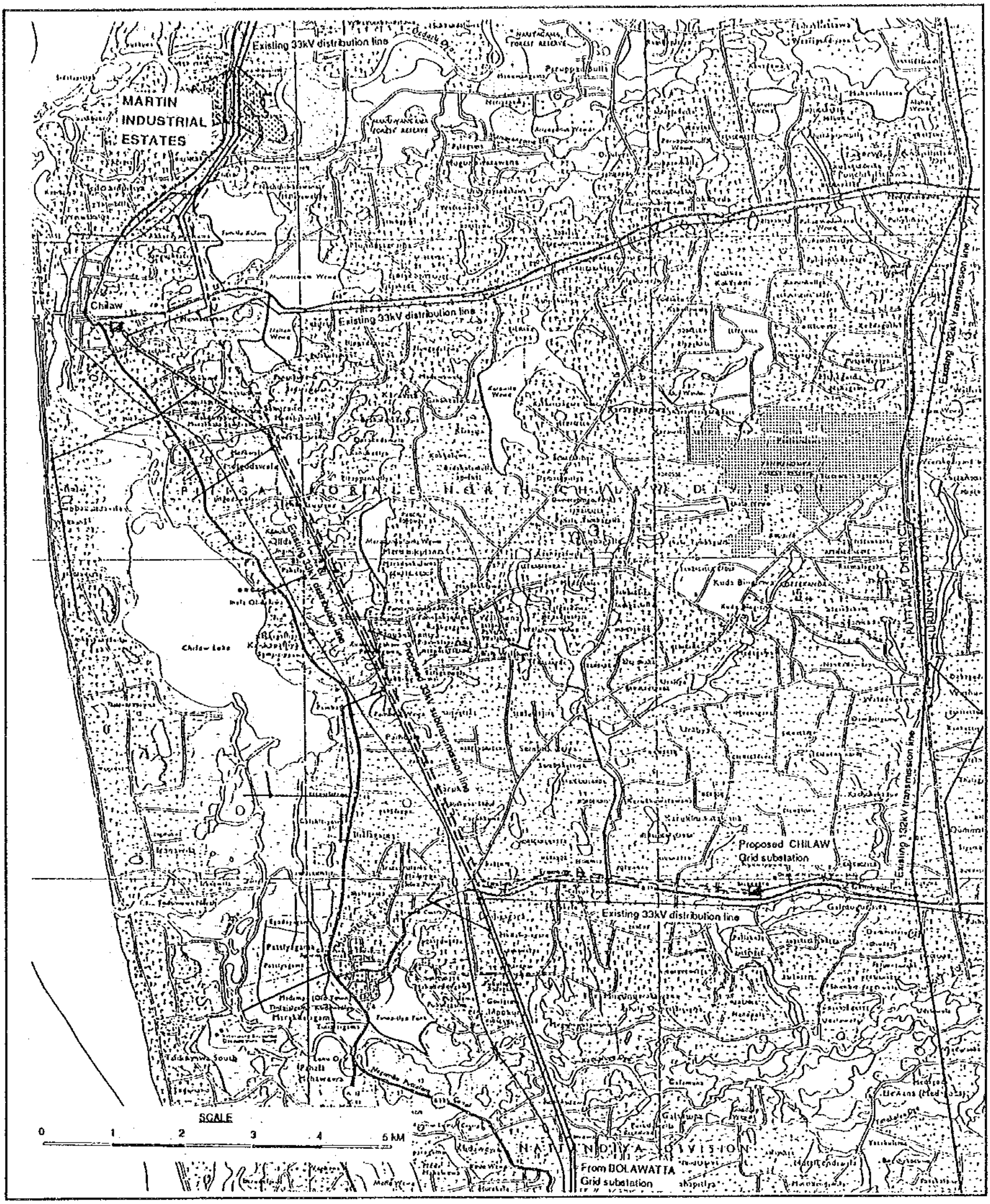

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Figure F-3 Route Map of 33kV Sub-transmission Line for Martin Industrial Estate
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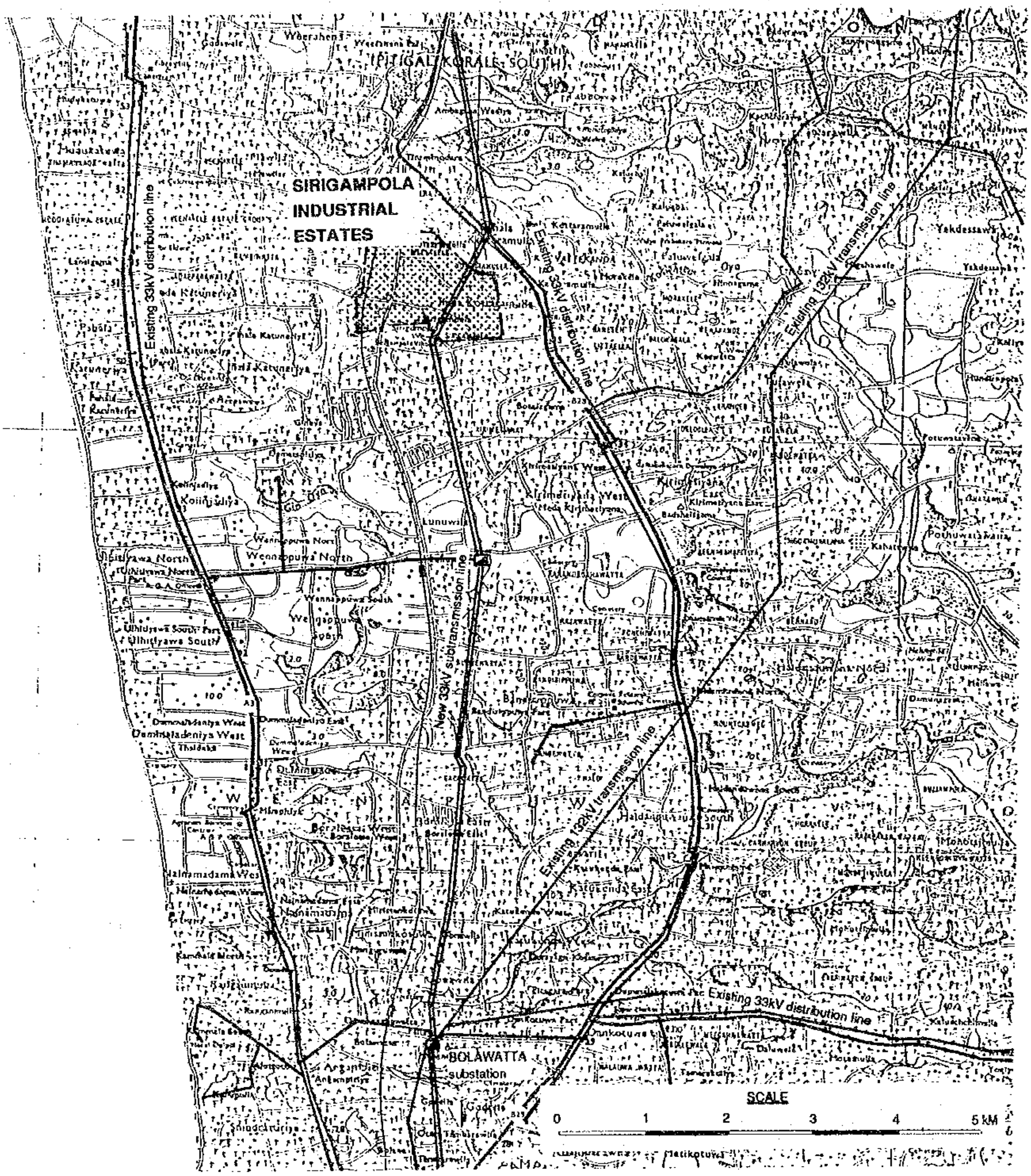

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Figure F-4 Route Map of 33kV Sub-transmission Line for Sirigampola Industrial Estate

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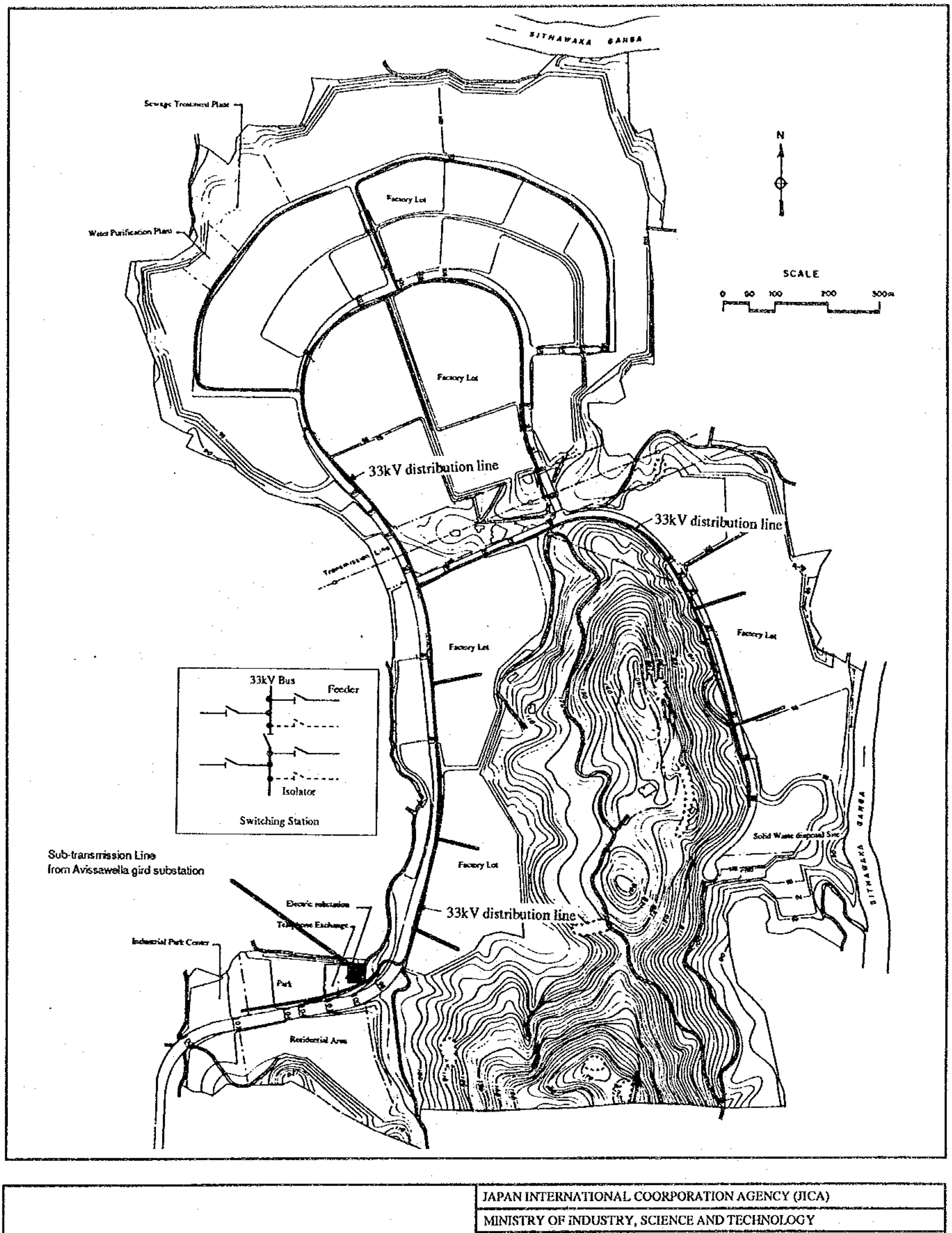

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Figure F-5 Route Map of 33kV Distiribution Line
Atherfield Industrial Estate

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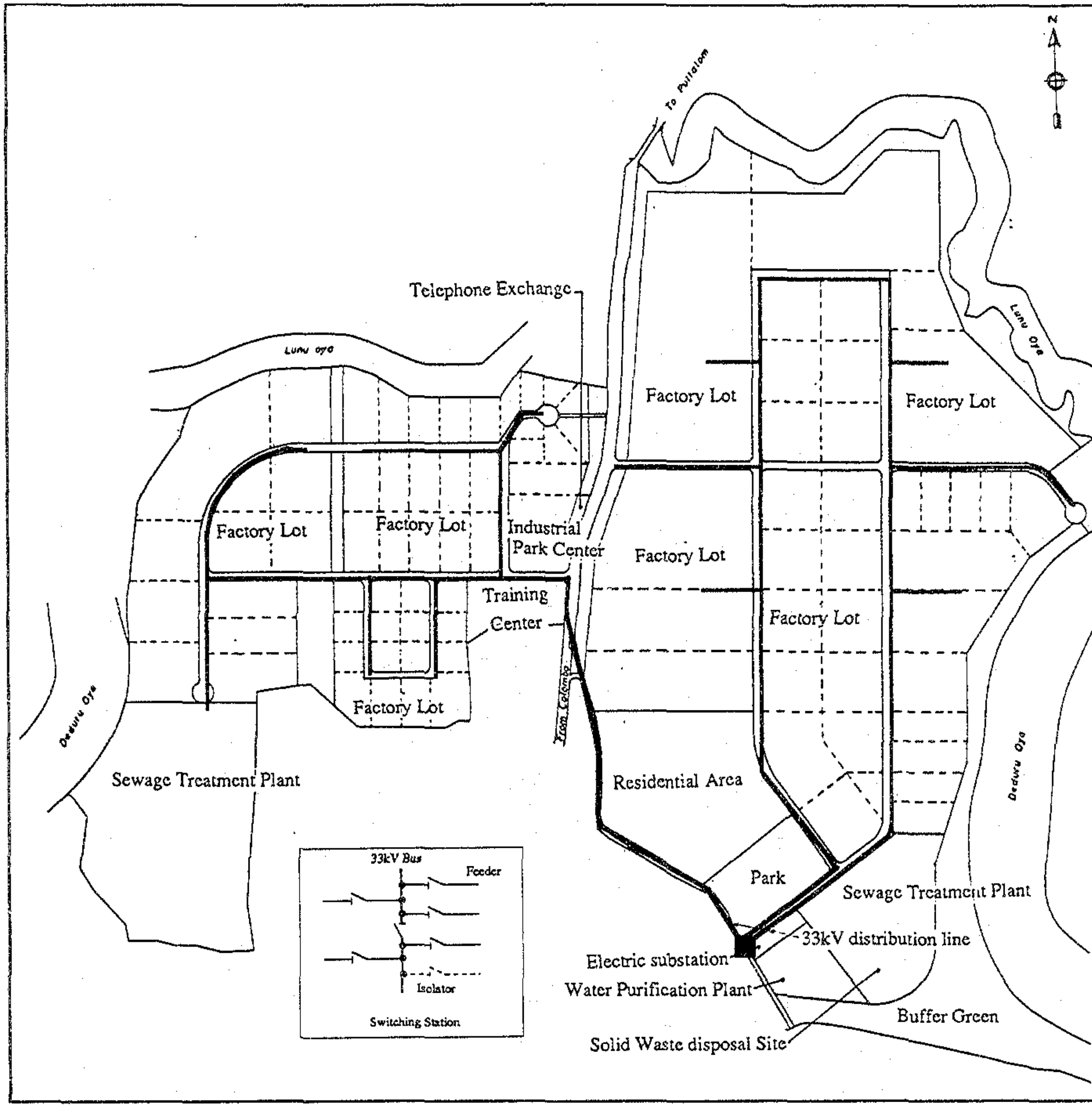

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Figure F-6 Route Map of 33kV Distribution Line
Martin Industrial Estate

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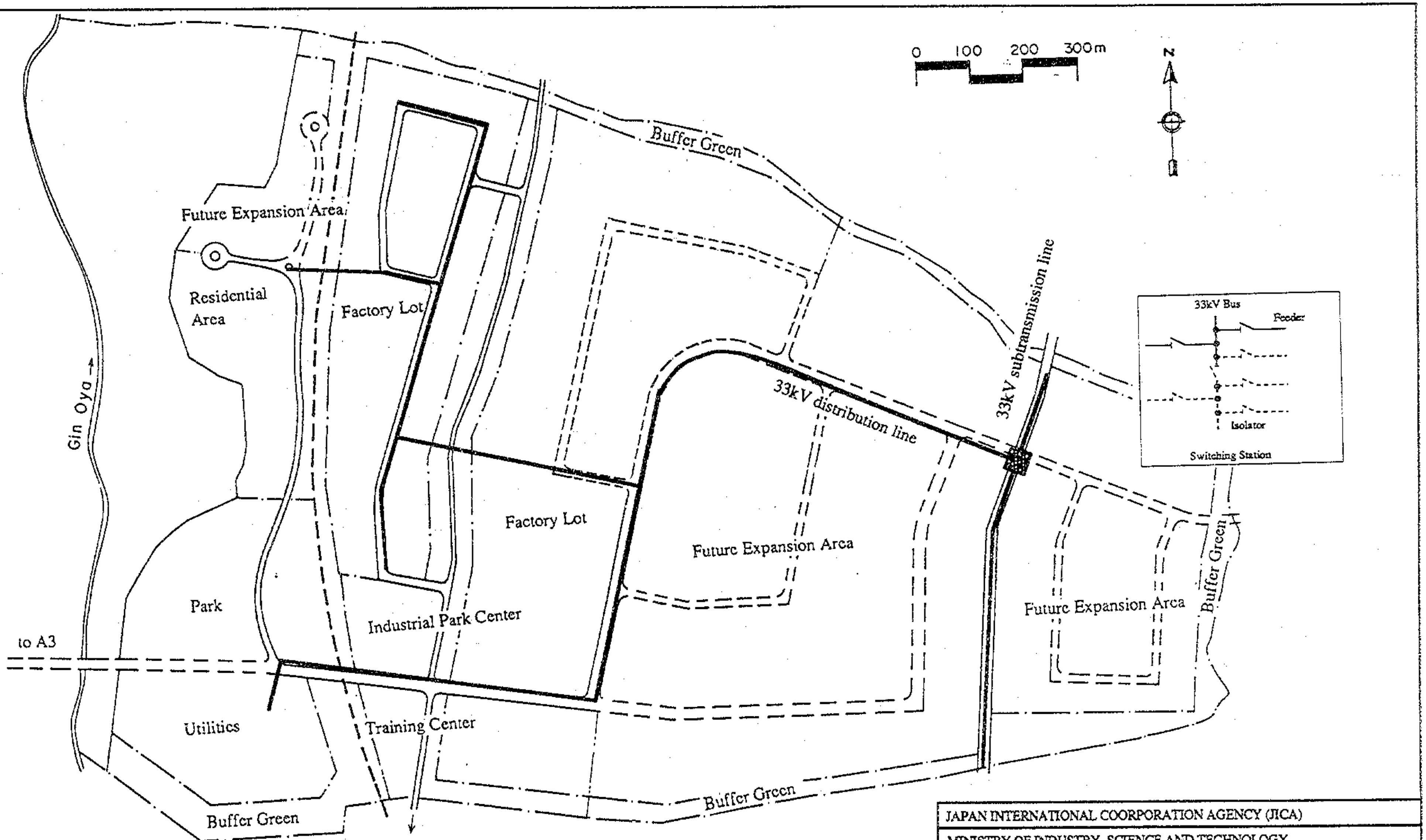

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Figure F-7 Route Map of 33kV Distribution Line Sirigampola Industrial Estate

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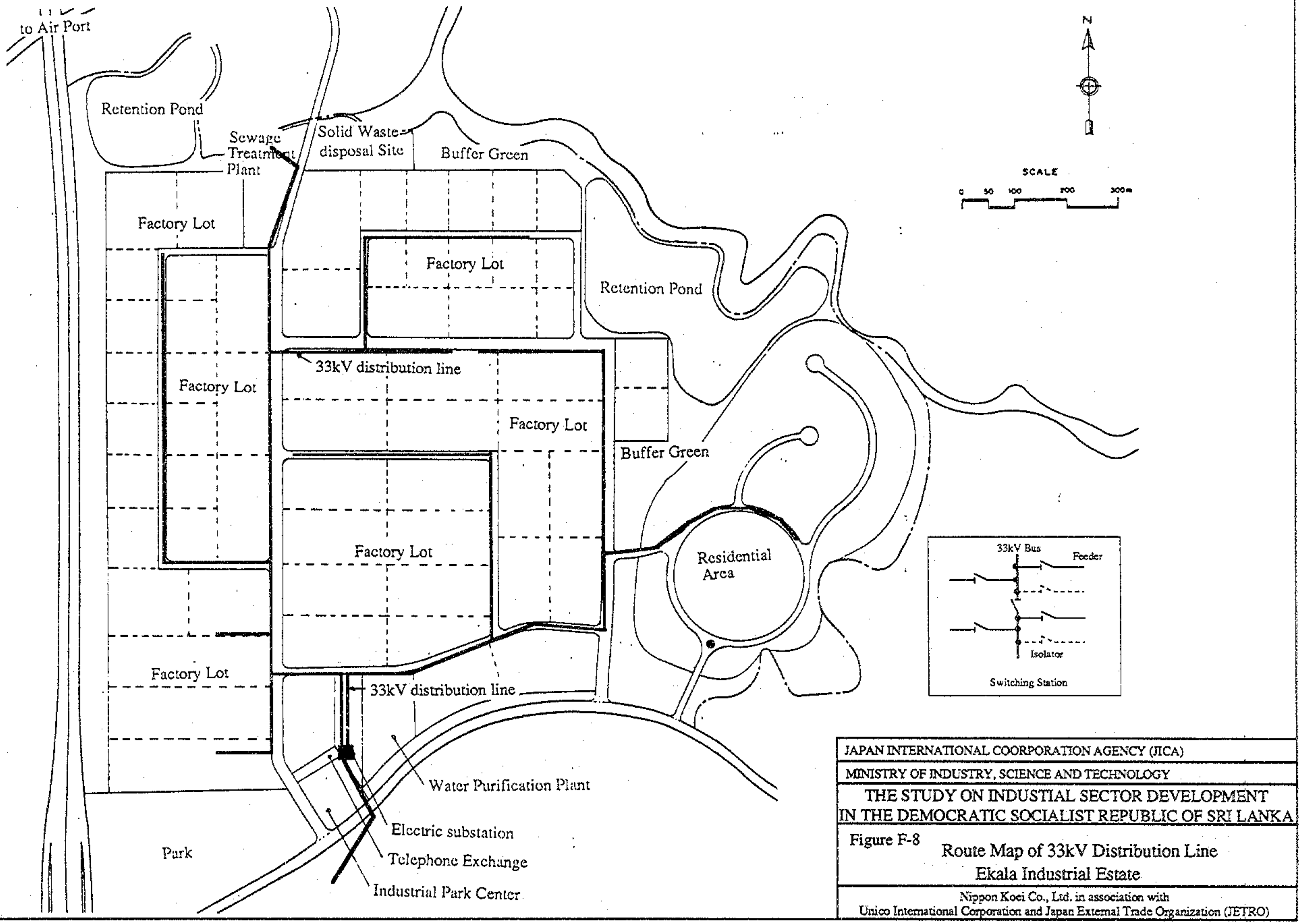

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Figure F-8 Route Map of 33kV Distribution Line Ekala Industrial Estate

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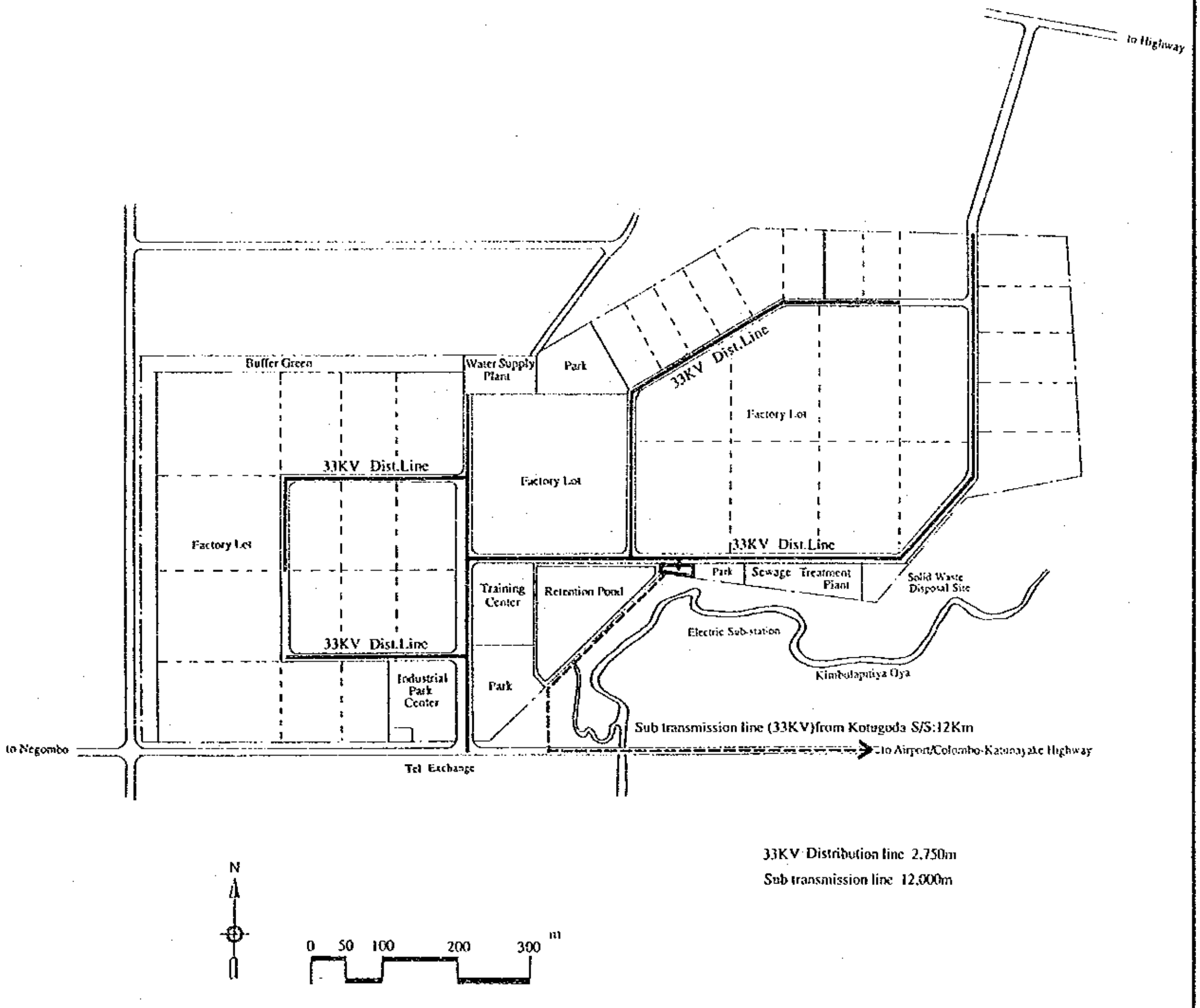

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	Figure F-9 Route Map of 33kV Distribution Line Katana Industrial Estate
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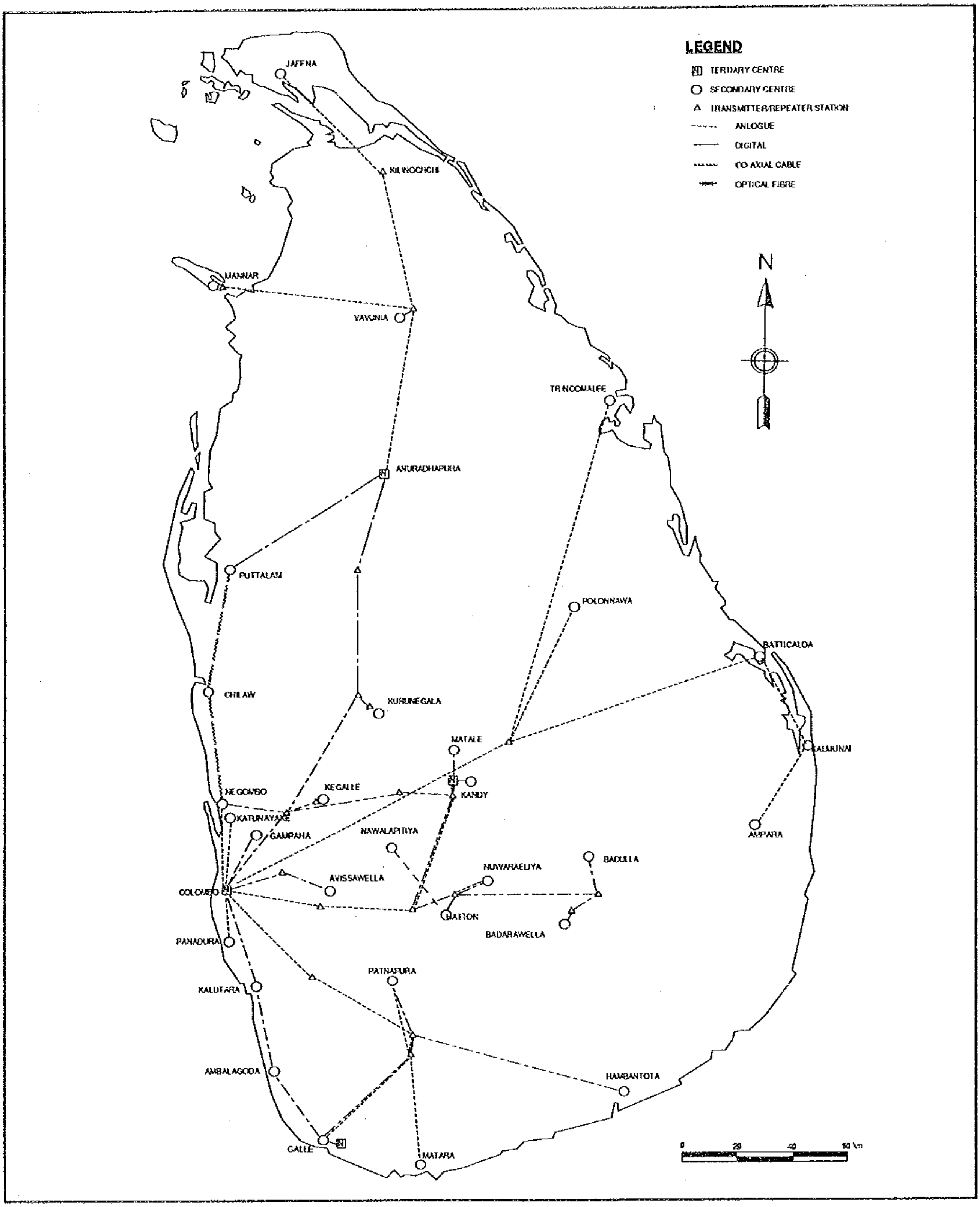

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	Figure F-10 Communication Network System
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