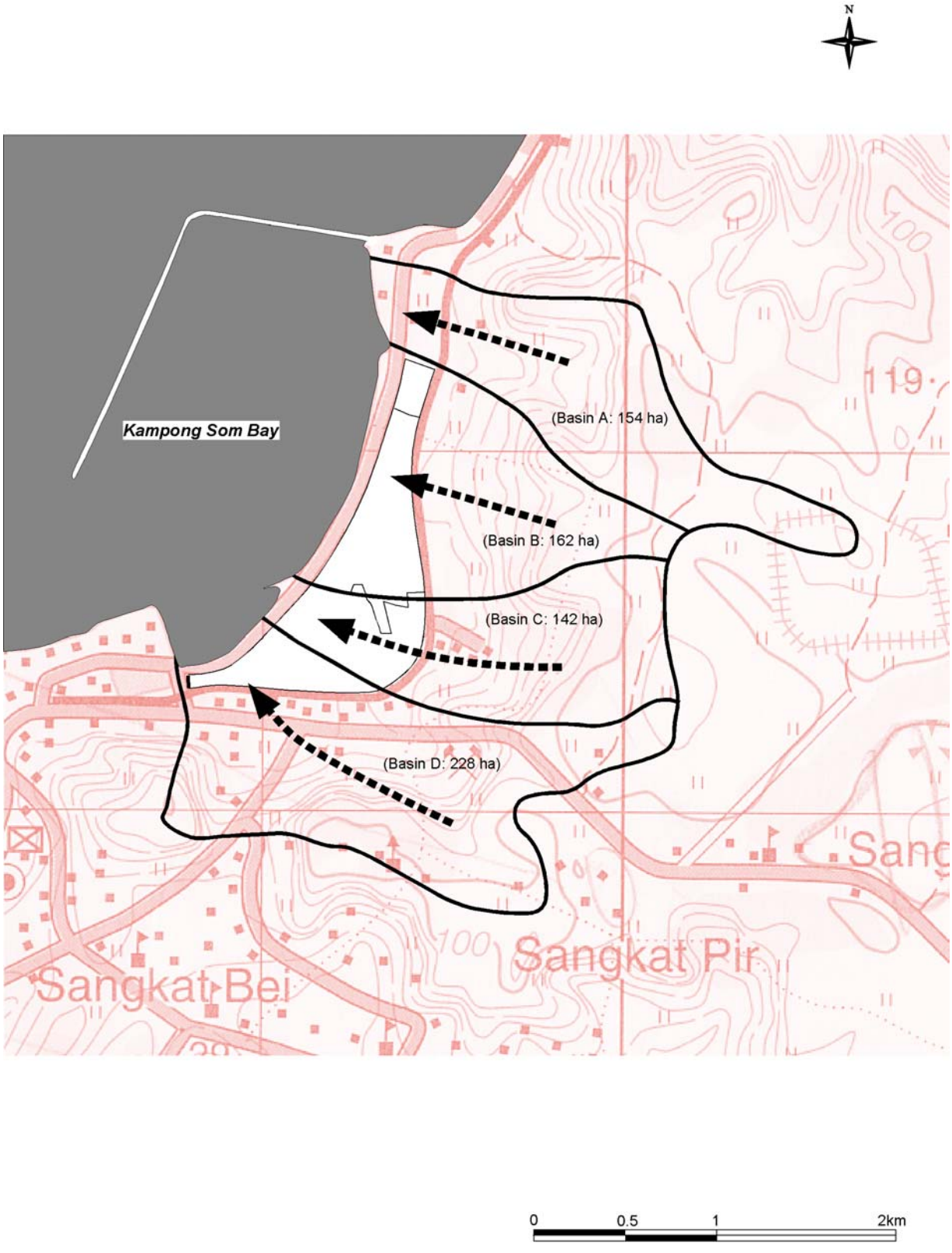
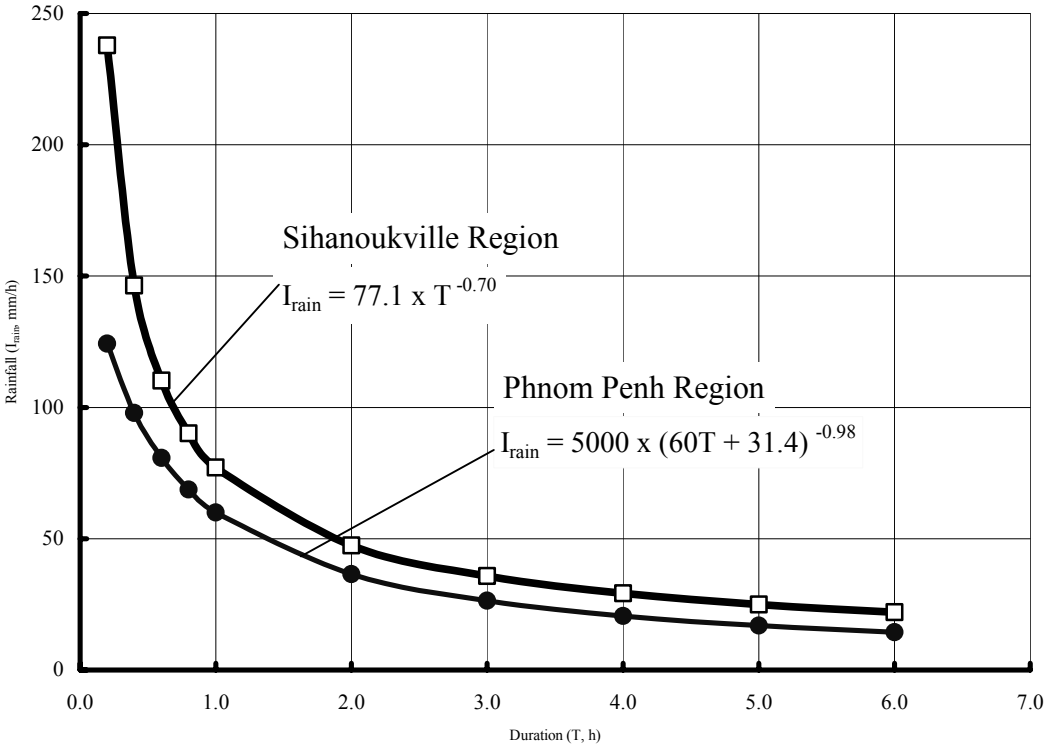


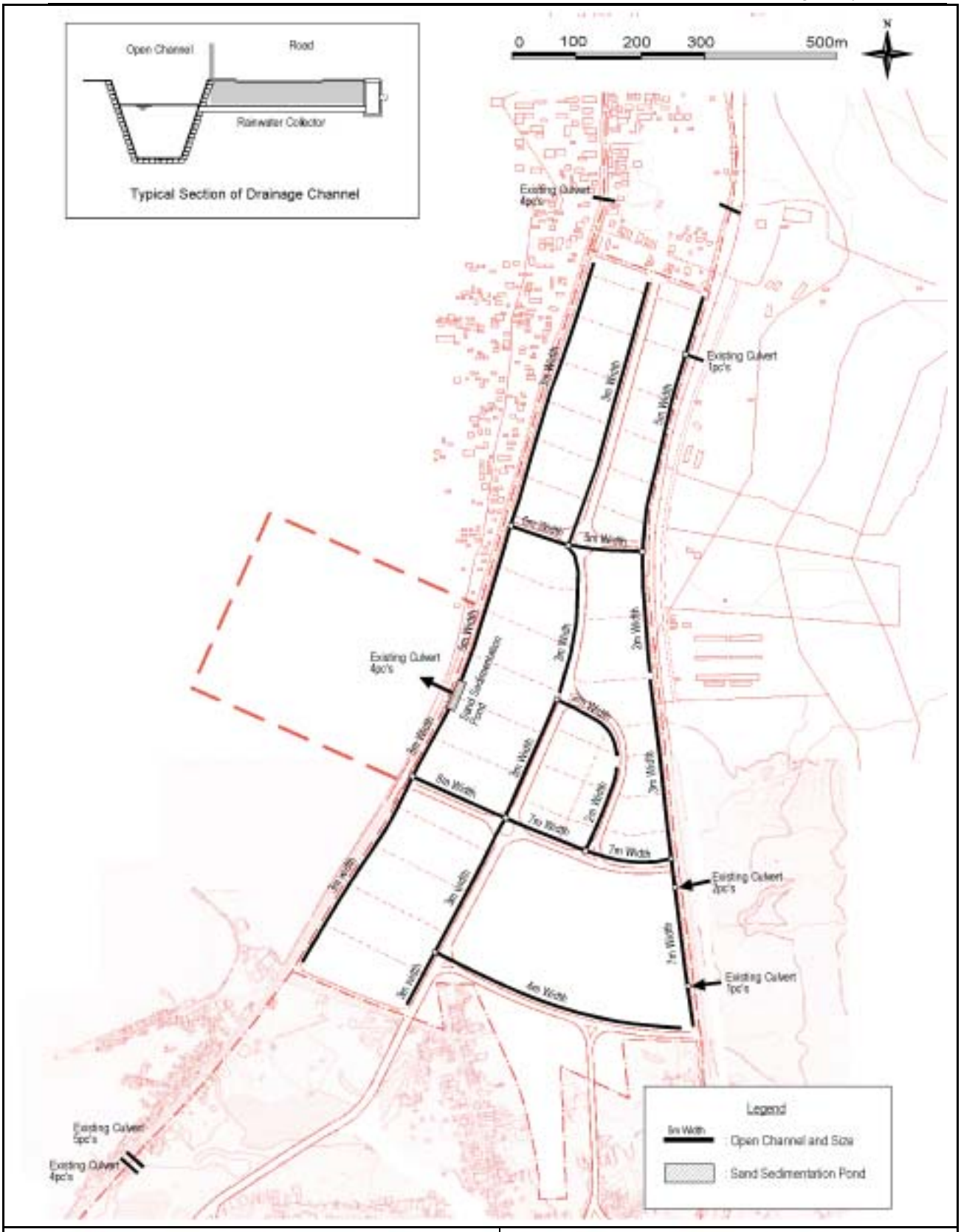
The Study on Regional Development of The Phnom Penh-Sihanoukville Growth Corridor in The Kingdom of Cambodia	**Figure 7.2-13**
Japan International Cooperation Agency (JICA)	**Drainage Basins of the Sihanoukville Port Free Zone (SPFZ)**



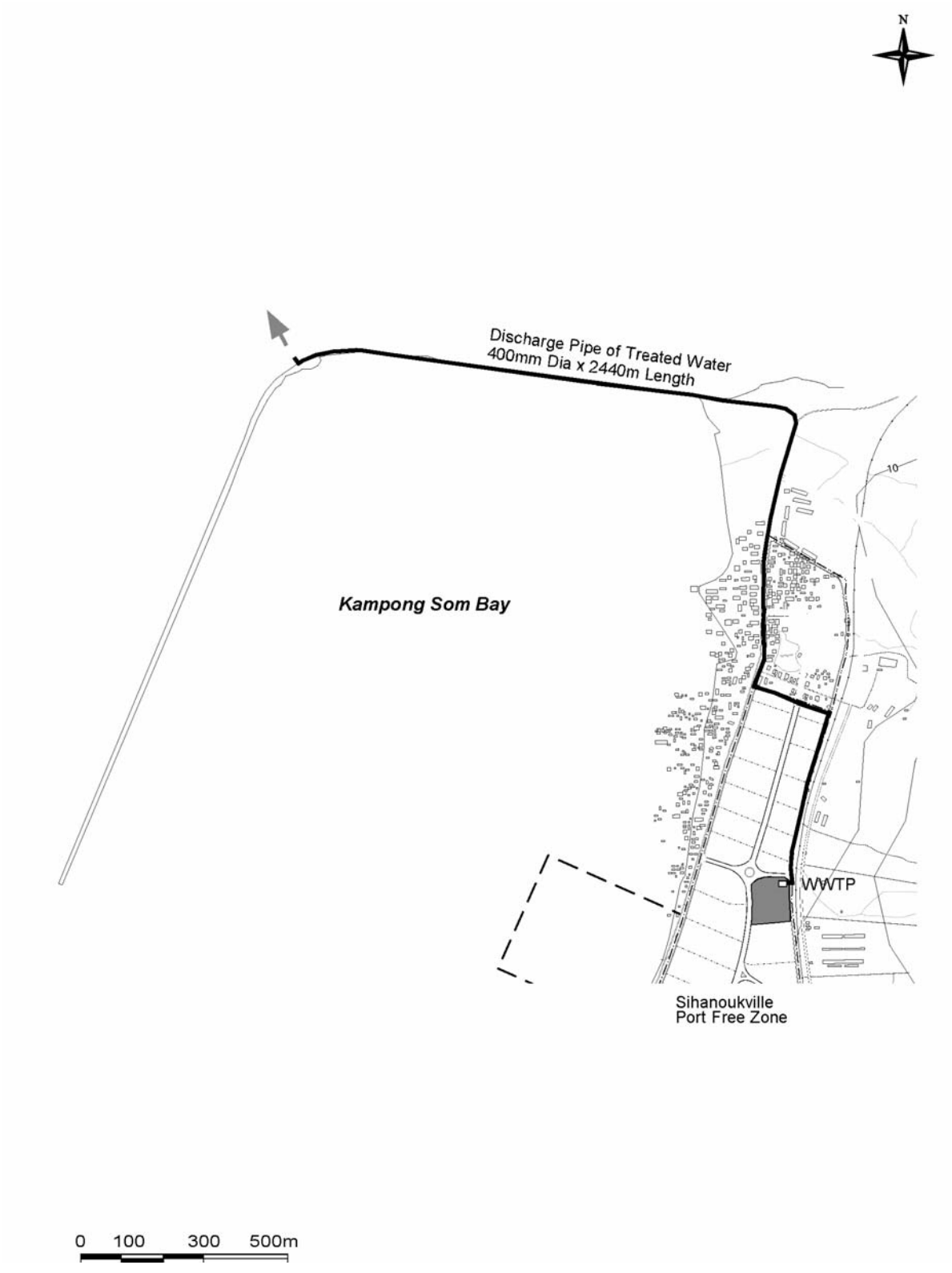
Source:
1) As for Sihanoukville region, the formula has been established by the JICA Study Team.

2) As for Phnom Penh region, the formula was established in the "Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh (JICA, 1999)".

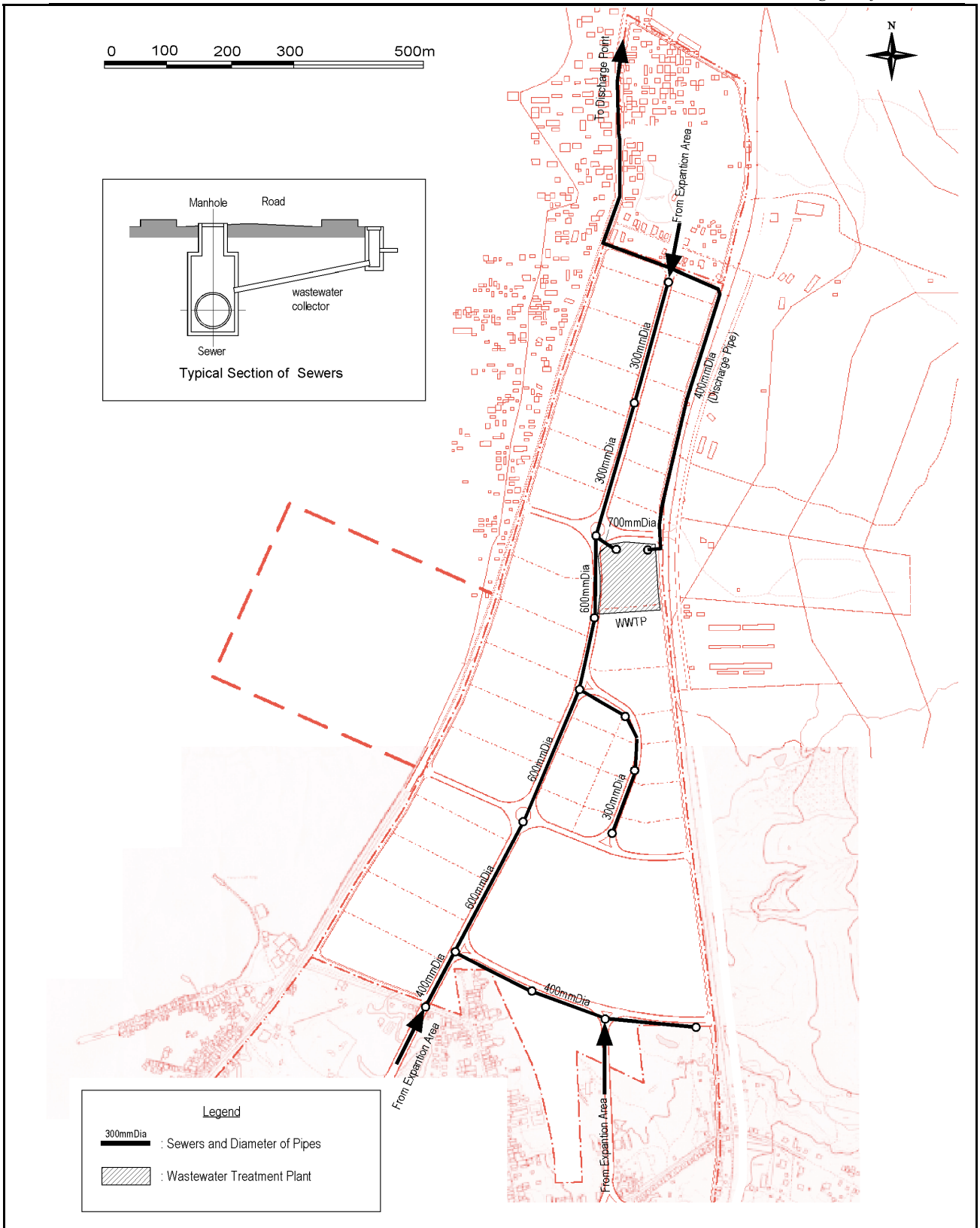
The Study on Regional Development of The Phnom Penh-Sihanoukville Growth Corridor in The Kingdom of Cambodia	**Figure 7.2-14**
Japan International Cooperation Agency (JICA)	**Hourly Rainfall in the Study Area**



The Study on Regional Development of The Phnom Penh-Sihanoukville Growth Corridor in The Kingdom of Cambodia Japan International Cooperation Agency (JICA)	**Figure 7.2-15** **Layout of Drainage for the Sihanoukville Port Free Zone (SPFZ)**



The Study on Regional Development of The Phnom Penh-Sihanoukville Growth Corridor in The Kingdom of Cambodia Japan International Cooperation Agency (JICA)	**Figure 7.2-16** **Treated Wastewater Discharge Pipe for the Sihanoukville Port Free Zone (SPFZ)**



The Study on Regional Development of The Phnom Penh-Sihanoukville Growth Corridor in The Kingdom of Cambodia Japan International Cooperation Agency (JICA)	**Figure 7.2-17** **Layout of Sewerage for the Sihanoukville Port Free Zone (SPFZ)**

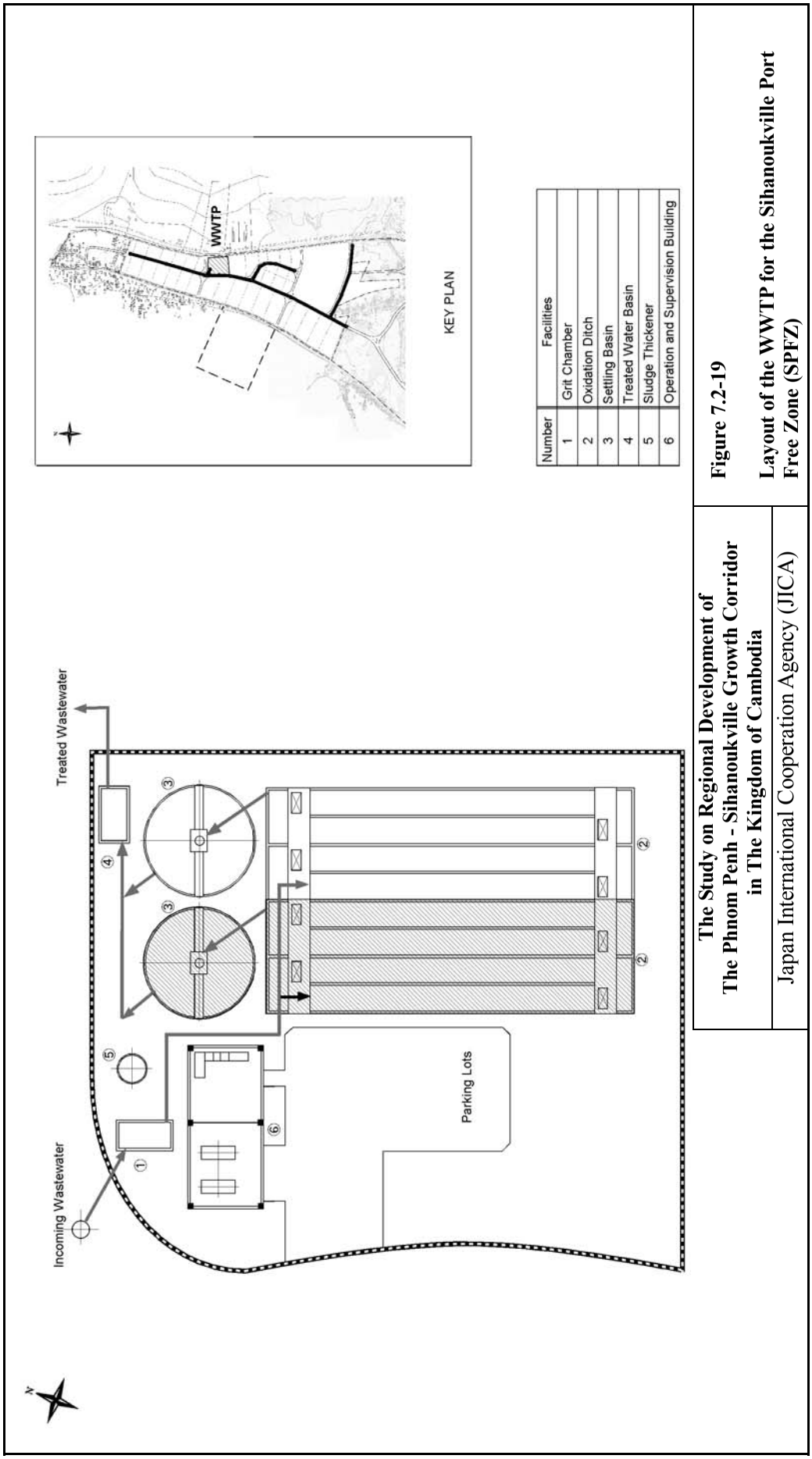


Figure 7.2-19

Layout of the WWTP for the Sihanoukville Port Free Zone (SPFZ)

7.2.7 Solid Waste Management

(1) General Considerations

1) Generation and discharge of solid waste

Solid waste generated from factories must be managed properly so as not to inflict negative influences on the environment. Solid waste may be categorized into combustible, non-combustible and toxic waste according to their physical or chemical characteristics, as follows:

- Combustible waste: Sludge, waste oil, waste plastic, waste paper, waste wood, waste textiles, animal body/plant residue, waste rubber
- Non-combustible: Ash, waste acid, waste alkali, waste metal, waste glass and ceramic, slugs, waste construction material, dust
- Toxic waste: Waste containing heavy metals, other toxic or hazardous wastes

In the projection of the generated amount of solid waste, statistical data in Japan tabulated in **Table 7.2.-17** were used.

Table 7.2-17 Generation Rate of Solid Waste

	Combustible	Non-Combustibles	Toxic	Total
Food manufacturing	1,203	44		1,247
Textiles	88	1		89
Wearing Apparel except Footwear	11	0		11
Footwear	387	23		411
Furniture and Fixtures	162	18		180
Cardboard Boxes and Containers	613	455		1,068
Drugs and Medicines	358	297	14.8	669
Soap and Cleaning Preparations, Perfumes	148	246		394
Rubber Products	149	12		161
Pottery, China and Earthenware	756	364		1,120
Electrical Machinery, Apparatus, Appliances	224	143	7.2	374
Jewelry and Related Articles	331	550		881
Sporting and Athletic Goods	387	23		411
Toys and Other Manufacturing Industries	331	550		881
Recycling Industry	63	72		135

Notes: Unit : kg/ha/day
Source: Based on the statistical data issued by the Ministry of Environment in Japan.

In solid waste management, it is crucial that the waste generated in factories be recovered and/or reused as reclaimed resources as much as possible to reduce the volume of waste discharged outside. In this Study, the following discharge amount of solid waste was calculated, assuming that 35 % of generated waste is recovered or reused in the factories:

	Units	Solid Waste Discharged from Factories				WWTP Sludge
		Combustible	Non-Combustible	Toxic Waste	Total	
- Discharged Solid Waste:	(ton/day)	4.6	2.4	0.05	7.0	2.3

The breakdown of discharged solid waste is shown in **Table 7.2-18**, by industrial category.

2) Toxic Waste

Of the solid waste to be generated from factories, it is proposed that toxic and hazardous wastes be handled separately from other wastes. These wastes should be managed with a special care, since they may give irreversible and serious effect to the environment and human bodies. They must be adequately treated at the responsibility and expense of each factory, under the supervision and guidance of the managing authority of the Free Zone.

3) Existing Public Disposal Site

An existing public disposal site, which is used mainly for municipal garbage, is located closed to the SIA-6. Because the current disposal is carried out in the way of simple dumping, there is a concern that disposed waste containing organic or combustible components may influence the surrounding environment. In the future, this dumping site should be remodeled into an environment-friendly "Controlled Landfill". A controlled landfill is provided with necessary facilities like enclosure dikes, protection fences, leachate treatment, gas vents, etc. In this Study, it is planned that the public disposal site will be used for the solid waste from the Free Zone and the Industrial Areas, after it is renovated.

(2) Solid Waste Disposal System

1) Selection of Solid Waste Disposal Method

Until the public disposal site is renovated, a temporary disposal measure for solid waste from the site should be provided. For the selection of the most suitable measure, the following alternatives have been examined, assuming a five year operation period:

Alternative A: Direct landfill disposal of all wastes

Alternative B: Landfill disposal after incineration of combustible waste

2) Direct Landfill Disposal (Alternative A)

In this alternative, it was presumed that all wastes except toxic waste would be disposed of at a controlled landfill, which would be sited in the existing public disposal site.

The outline of the controlled landfill is shown in **Figure 7.2-20**, and its specifications are described as follows:

- Landfill site:	1 unit	Landfill capacity 15000 m^3,
		Equipped with: Enclosure dike
		Surface sealing with clay soil
		Leachate drainage
		Gas ventilation equipment
- Vehicles		Open trucks (2 ton, 4 units)
		Bulldozer (1 unit)
- Other appurtenances:		Administration and workshop building (1 unit)
		Leachate treatment plant (1 unit)
		Retention pond (1 unit)
		Power receiving and control boards (1 unit)

3) Landfill Disposal after Incineration (Alternative B)

The incineration aims at reducing the waste volume and stabilizing organic solid wastes. In this alternative, the combustible waste including WWTP sludge would be incinerated and the ashes would be disposed of at the public disposal site. The site of incineration should be located at a proper place near the existing disposal site, while non-combustible waste would be disposed of at the existing public disposal site. Total material flow of solid waste is shown in **Figure 7.2-21**.

An incinerator with high-temperature burning and rapid gas cooling was selected to prevent the generation of dioxin compounds.

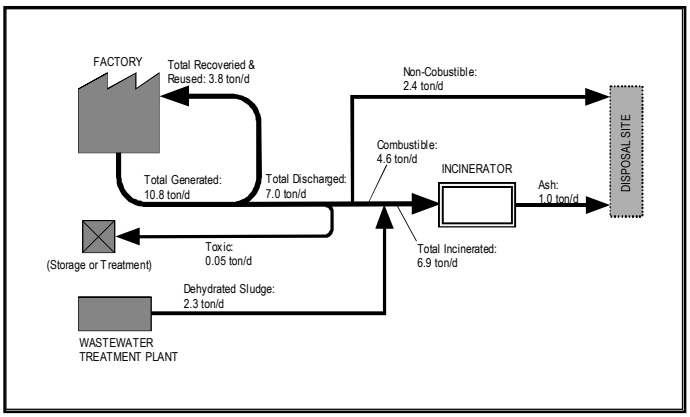


Figure 7.2-21 Flow Diagram for Solid Waste Disposal (Alternative B)

The outline of the incineration plant is shown in **Figure 7.2-22**. The specifications for the incinerator and other facilities are described as follows:

- Incinerator:	1 unit	Stoker firing type, Capacity 7.0 ton/day, Operation time 14 hours per day Equipped with: Primary combustion chamber (1 unit) Secondary combustion chamber (1 unit) Cyclone dust collector (1 unit) Exhaust stack (1 unit)
- Vehicles:		Open trucks (2 ton, 3 units) Fork lift (1 unit)
- Other appurtenances:		Workshop building Power receiving and control boards (1 unit)

4) Selected Measure

The costs (per ton of discharged waste) for the solid waste disposal and treatment in the two alternatives are compared as follows:

	Initial Cost (US$/ton)	Operation Cost (US$/ton)	Total Cost (US$/ton)
- Alternative A:	33	25	58
- Alternative B:	84	83	167

(Note: The operation period of systems is assumed to be 5 years.)

From the above, the Alternative B would require a far higher cost. Besides, it was recognized generally that an incineration plant would require special and high-level technology for operation and maintenance.

Consequently, it is proposed that the direct landfill disposal (Alternative A) be applied for the solid waste disposal from the Sihanoukville Port Free Zone (SPFZ).

Table 7.2-18 Discharged Amount of Solid Waste in SPFZ-P

	Factory Plot (ha)	Discharged Solid Waste Amount (kg/day)			
		Combustible	Non-Combustible	Toxic & Hazardous	Total
Food manufacturing	0.8	625	23	-	648
Textiles	6.0	344	5	-	348
Wearing Apparel except Footwear	-	-	-	-	-
Footwear	-	-	-	-	-
Furniture and Fixture	-	-	-	-	-
Containers and Boxes of Paper	1.9	756	562	-	1,319
Drugs and Medicines	0.5	116	96	5	218
Soap and Cleaning Preparations, Perfumes	1.0	96	160	-	256
Rubber Products	1.5	145	12	-	157
Pottery, China and Earth Ware	1.5	737	355	-	1,092
Electrical Machinery, Apparatus, Appliance	10.0	1,454	931	47	2,431
Jewelry and Related Articles	-	-	-	-	-
Sporting and Athletic Goods	0.5	126	8	-	133
Toys and Other Manufacturing Industries	-	-	-	-	-
Recycling Industry	5.0	204	235	-	438
Total	28.7	4,603	2,386	51	7,041

Note: Estimated by the JICA Study Team by using the unit rate described in the text.

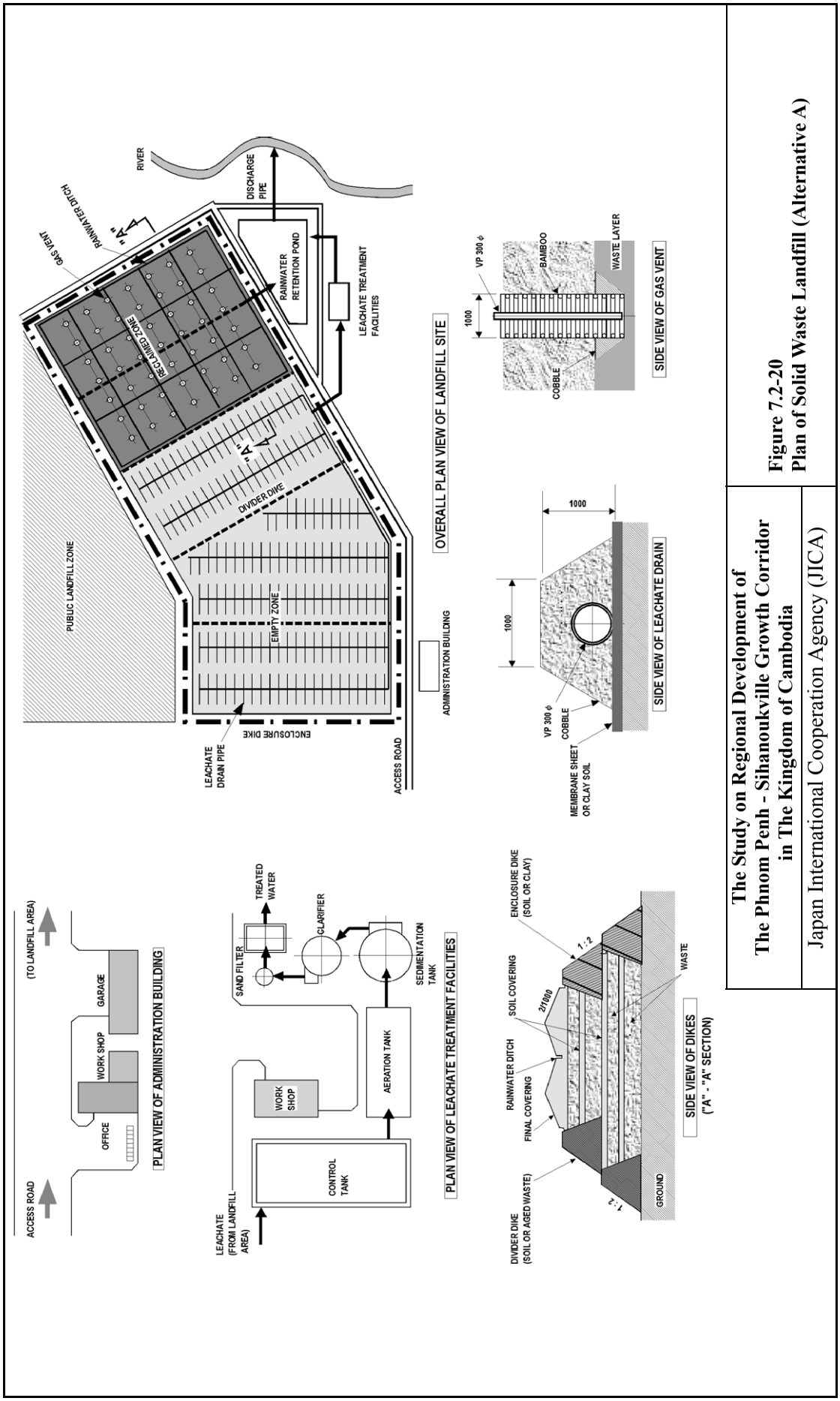


Figure 7.2-20
Plan of Solid Waste Landfill (Alternative A)

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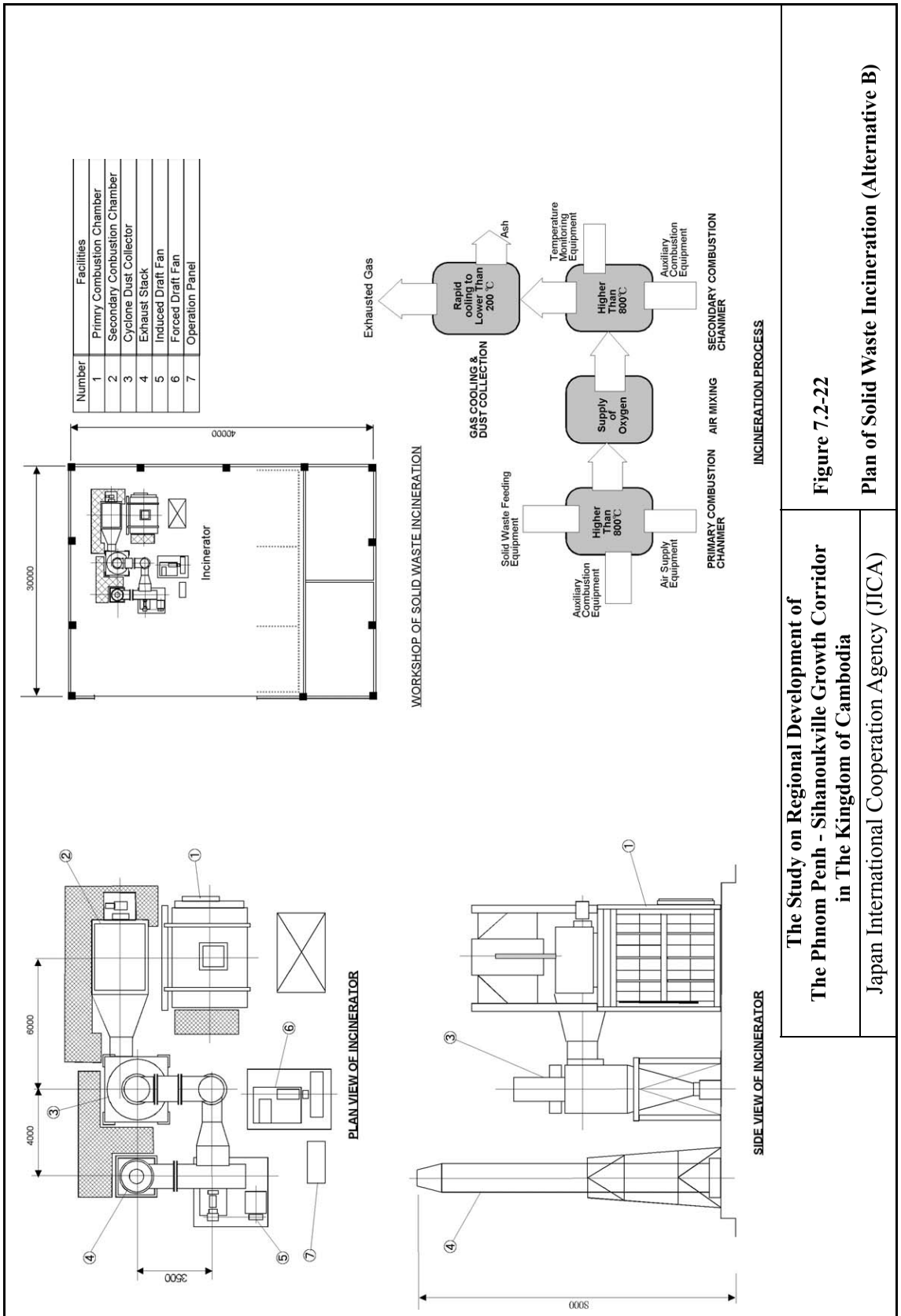

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Figure 7.2-22

Plan of Solid Waste Incineration (Alternative B)