Metropolitan Manila Development Agency
Republic of the Philippines

No.

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR
URGENT IMPROVING / UPGRADING OF
FLOOD CONTROL SYSTEM IN METRO MANILA
IN
REPUBLIC OF THE PHILIPPINES

NOVEMBER 2007

JAPAN INTERNATIONAL COOPERATION AGENCY

PACIFIC CONSULTANTS INTERNATIONAL

IDEA CONSULTANTS, INC.

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PREFACE

In response to a request from the Government of Republic of the Philippines, the Government of Japan decided to conduct a basic design study on the Project for Urgent Improving / Upgrading of Flood Control System in Metro Manila and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to the Philippines a study team from March 1, 2007 to March 24, 2007.

The team held discussions with the officials concerned of the Government of the Philippines, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to the Philippines in order to discuss a draft basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Republic of the Philippines for their close cooperation extended to the teams.

November 2007

Masafumi Kuroki
Vice-President
Japan International Cooperation Agency

November 2007

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Urgent Improving / Upgrading of Flood Control System in Metro Manila in Republic of the Philippines.

This study was conducted by the Consortium of Pacific Consultants International and Idea Consultants, Inc., under a contract to JICA, during the period from February 2007 to November 2007. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of the Philippines and formulated the most appropriate basic design for the project under Japan's Grant Aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Atsuhiko Yamamoto

Project manager,
Basic design study team on
The Project for Urgent Improving / Upgrading of Flood Control System in Metro Manila
The Consortium of Pacific Consultants International and Idea Consultants, Inc.

Summary

Summary

Republic of the Philippines (hereinafter refer to as “the Philippines”) is located in south-east Asia, west Pacific Ocean and consist of approximately 7,000 scattered islands ranges 1,850 km from east to west and 1,100 km from south to north. National land area is 299,404 km^2 and population is approximately 86,240 thousands in 2004.

Manila belongs to the tropical monsoon climate. Average annual rainfall is 2,139mm. 81% of annual rainfall falls during the Wet Season from the month of June to October. Annual average temperature is 28℃, while average monthly minimum and maximum temperatures are observed in the month of January (22℃) and April (34℃) respectively. Mean annual total pan evaporation is 1,335 mm. Maximum pan evaporation occurs in the month of April (162 mm) followed by May (148 mm) and March (147 mm). Average monthly minimum and maximum relative humidity are observed in the month of March to April (65 %) and August to September (80 %) respectively. Annual average relative humidity is calculated at 74 %.

Major industries of the Philippines are agriculture, forestry and fisheries industry, manufacturing industry and service industry and GDP growth rate is 5.4 % in 2006. GDP per capita in 2005 is 1,232 US$. Real GDP of each industry are: primary industry 14.3 %, secondary industry 32.3 % and tertiary industry in 2005 and employed populations of each industry are primary industry 35 %, secondary industry 15 % and tertiary industry. 50 %.

The Government of the Philippines prepared the “Middle-term Philippines Development Plan（MTPDP 2004-2010）” as a national development plan. Improvement of solid waste management and prevention of natural disaster are mentioned in the sector of environment and natural resources as important items. Flood control measure which is the object of the Project is pointed out as one of the most important items.

Risk of the flood disaster at Manila which is located at inundation area of the Pasig River is recently increasing year by year, together with overpopulation. Since Manila is one of most important city which is political and economic center of the country, flood control measure of Manila is most important subject in the Philippines. Flood control project such as preparation of drainage pumping stations have been implemented at metropolitan Manila for many years. However, most of the existing drainage pumping facilities have grown old and requires rehabilitation. Additionally, deterioration of all systems such as pump, engine, drainage valve, automatic trash screen, is serious due to overloading of operation caused by inflow of a large quantity of solid waste. Likewise, there is a lot of solid waste and sedimentation in the drainage canals and so the drainage capability of the canal has decreased considerably. Also, squatters in the drainage canals are hindering widening and dredging of canal as well as operation and maintenance activities.

Hence, the Government of the Philippines requested the Japan's Grant Aid to the Government of Japan for the procurement of necessary material and equipment to restore the function of the three drainage pumping stations (Quiapo, Aviles・Sampaloc, Tripa de Gallina).

After the submission of the request, JICA has carried out "The Study on Drainage System Improvement in the Core Area of Metropolitan Manila" (hereinafter refer as the Development Study) in 2004. Major drainage pumping stations and drainage canal systems at core area of metropolitan Manila have been studied in detail and a Master plan on improvement of drainage system has been drawn out in the Development Study. Likewise, priority projects have been selected in the master plan.

Under such circumstances, the Government of Japan has decided to conduct the Basic Design Study. The functional recovering of requested three drainage pumping stations are positioned as priority issues in the priority projects of the Development Study. Therefore, the basic design study shall be carried out on the basis of lesson learnt and suggestion which got in the Development Study.

JICA dispatched to the Philippines a study team for Basic Design Study during the period of March 1, 2007 to March 24, 2007 in order to confirm background, contents and scope of the Project. After the team returned to Japan, contents of request and validity of the cooperation were inspected and an appropriate draft basic design was drawn up. Then, a mission was sent to the Philippines from October 14, 2007 to October 22, 2007 in order to discuss the draft basic design.

A target year of the Plan has been set at the year 2020, based on the results of the inspection of equipment including disassembly. The target year of the Master plan of the Development study "The Study on Drainage Improvement in the Core Area of Metropolitan Manila", which is the preceding plan of this project, was also taken into account when deciding the target year. The equipment plan of the Project covers renewal and rehabilitation plan of equipment which are necessary to prevent a capacity degradation due to trouble and/or wear of the drainage pumping stations as of 2020. The basic policy of the each equipment is described below.

Name of Major Equipment	Basic Policy	General Descriptions
Main Pump	Replacement of parts which are necessary to be replaced	• Judgment either replacement or anticorrosive coat shall to be decided based on 1.5 mm which is minimum wear tolerance mentioned in the gate and iron pipe technical standard.
Main Engine	Renewal to diesel engine which satisfies the original specification	• Cheapest combination between new engine and reduction gear shall be employed as a new engine and reduction gear out of a middle speed diesel engine on the market which can be used with one stage reduction gear type. • Combination which can cope with destruction due to twisting vibration shall be employed.
Electric System	Renewal by Colgate cable and anticorrosive material	• Colgate cables shall be basically selected for the renewal of wiring. • The structure of the panel shall be able to prevent moisture getting into electric panels as much as possible.

Name of Major Equipment	Basic Policy	General Descriptions
Auxiliary	Renewal of auxiliary matching the new engine	• Design of auxiliary shall be carried out according to the existing design standard of the Ministry of Land, Infrastructure and Transport in Japan, in order to match the new-type engine.
Automatic Trash Screen	Renewal of defective parts by anticorrosive material	• Renewal of parts which are defective situation by anticorrosive material based on the results of inspections.
Flood Gate	Renewal of electric system	• Control panel and wiring of automatic hoisting system which was requested additionally shall be renewed by the same method of electric system.
Overhead Traveling Crane	Renewal of defective parts	• Defective parts, control panel and wiring shall be renewed by the same method of electric system.
Anticorrosive Coat	Anticorrosive coat by staffs of the drainage pumping stations	• For equipment that were found necessary to apply anticorrosive coating based on the results of overhaul, materials for anticorrosive coat shall be procured in the Project. Application of anticorrosive coat is not included in the Project component.
Additional Drainage Capacity	Strengthening of drainage capacity by changeover the angle of impeller	• The capacity strengthening of 3.0m^3/sec. of Aviles・Sampaloc drainage pumping station shall be carried out by changeover the angle of impeller. • An eddy flow prevention wall should be constructed to prevent obstruction caused by increased flow velocity.

The outline of the Basic Design based on the basic policy mentioned above is as follows. In addition to the list below, Paints of anticorrosive coat, spare parts for main engines and four stop logs for Quiapo, five rubbers of stop logs for Tripa de Gallina are included as target equipments.

Items	Quiapo		Aviles・Sampaloc		Tripa de Gallina	
	Items	Qnt	Items	Qnt	Items	Qnt
Main Pump	Guide Casing	4	Guide Casing	4	Submerged Bearing Sleeve	1
	Discharge Elbow	1	Discharge Elbow	1	Packing Sleeve	4
	Impeller Nut	1	Column Pipe	2	Submerged Bearing	1
	Impeller Washer	4	Oil Seal	4	Lantern Ring	5
	Oil Seal	4	Shaft Enclosing Tube	4	Packing	8
	Submerged Bearing	1	Bowl Bearing	4	Trust Bearing Radial Bearing	1
	Shaft Enclosing Tube	4				
	Bowl Bearing	4			V-Belt（for Grease Pump）	6
	Mechanical Seal	1				
	Coupling Bolt	1				
Main Engine	Main Engine	4	Main Engine	4	Main Engine	8
			Reduction Gear	4	Reduction Gear	8
Electric System	Control Center (3 faces)	1	Control Center (3 faces)	1	Control Center (6 faces)	1
	Direct Current Power Panel	1	Direct Current Power Panel	1	Direct Current Power Panel	1
	Common Control Panel	1	Common Control Panel	1	Common Control Panel	1
	Site Control Panel	4	Site Control Panel	4	Site Control Panel	8
	Trash Screen Control Panel	1	Trash Screen Control Panel	1	Trash Screen Control Panel	2
	Conveyor Control Panel	1	Conveyor, Hopper Control Panel	1	Conveyor Control Panel	1
	Wiring and Piping	1	Wiring and Piping	1	Wiring and Piping	1
Trash Screen Facilities	Renewal of Rake （6 pieces／unit）	4	Horizontal Conveyor Belt, Roller	1	Renewal of Rake （6 pieces／unit）	8
	Horizontal Conveyor	1	Inclined Conveyor Belt	1	Horizontal Conveyor	2
	Inclined Conveyor	1	Hopper	1	Inclined Conveyor	1
	Second Screen	2				

Items	Quiapo		Aviles・Sampaloc		Tripa de Gallina	
	Items	Qnt	Items	Qnt	Items	Qnt
Auxiliaries	Pure Water Pump	2	Pure Water Pump	2	Pure Water Pump	4
	Cooling Water Pump (Engine)	4	Cooling Water Pump (Engine)	4	Cooling Water Pump (Common)	4
	Cooling Water Pump (Generator)	2	Cooling Water Pump (Generator)	2	Vacuum Pump	4
	Fuel Transfer Pump	2	Fuel Transfer Pump	2	Fuel Transfer Pump	2
	Drainage Pump	2	Drainage Pump	2	Drainage Pump	2
	Air Compressor	2	Air Compressor	2	Air Compressor	4
	Cooling Tower	3	Cooling Tower	2	Cooling Tower (1)	2
	Ventilation Fan	2	Ventilation Fan	2	Cooling Tower (2)	2
	Canal and River Water Gauge	2	Canal and River Water Gauge	2	Ventilation Fan	5
	Suction Well Water Gauge	4	Suction Well Water Gauge	1	Canal and River Water Gauge	2
	Cooling Water Tank Water Gauge	1	Cooling Water Tank Water Gauge	1	Suction Well Water Gauge	8
	Cooling Water Tank Thermometer	1	Cooling Water Tank Thermometer	1	Cooling Water Tank Water Gauge	1
	Piping	1	Piping	1	Cooling Water Tank Thermometer	1
					Piping	1
Flood Gate	Gate Control Panel	2	Gate Control Panel	2	Gate Control Panel	3
Overhead Traveling Crane	Crane Power Panel	1	Crane Power Panel	1	Crane Power Panel	1
	Common Protection Panel	1	Common Protection Panel	1	Common Protection Panel	1
	Push Button Switch Box	1	Push Button Switch Box	1	Push Button Switch Box	1
	Curtain Cable	1	Curtain Cable	1	Curtain Cable	1
Concrete Works	Foundation of Engine	4	Foundation of Engine	4	Foundation of Engine	8
	Foundation of Cooling Tower	3	Foundation of Cooling Tower	2	Foundation of Cooling Tower	4
			Eddy Flow Prevention Wall	4		

In case that the Japan's Grant Aid Project shall be implemented, it takes 6.0 months for a detailed design, 1.5 months for design works for shop drawing, 14.0 months for manufacture of engines and reduction gears which come under the influence of booming economy in China and Middle-east, 6.0 months for pump parts, auxiliaries and conveyor, 4.0 months for electric devices. Conveyance period from Japan shall be assumed as 1.0 months including custom clearance. It is assumed that the Project will be a national bond project because period of installation works of the Project is limited to 6.0 months only per year because installation can only be done during dry season, and it will take several years to install all equipment. Total period of installation works shall be 15.0 months through three dry seasons. It shall take 0.5 month for initial operation guidance, O&M guidance, inspections and handover after completion of installation works. In short, it shall take 40.0 months from the contract agreement of the contractor to handover. The Project cost borne by the Philippines side is roughly estimated as 154.6 million Japanese Yen (64.02 million Pesos) excluding any other taxes such as national internal revenue taxes and import duties.

As for direct effects of the Project, it is expected that 1) breakdown of the targeted drainage pumping stations shall be prevented, 2) Flooding volume 2,740 thousands m^3, flooding area 4,493 thousands ha which may occur by breakdown of the targeted drainage pumping stations can be reduce to flooding volume 744 thousands m3, flooding area 2,013 thousands ha by prevention of breakdown,

3) Operation and maintenance will be performed with higher efficiency owing to the decrease of O&M costs by improved fuel consumption efficiency and decreased frequency of minor failures. Through such direct effects, prevention of natural disaster which is overall target shall be achieved.

Likewise, indirect effects, 1) Expansion of impassable area will be prevented as well as social and economic activity are not impeded, 2) Hemorrhage of public and private asset by the flood damage shall be prevented and deterioration of living standard shall be reduced, are expected..

The Project is expected to bear various effects as mentioned above. Furthermore, since the Project shall contribute to reduction of flood damage at Metropolitan Manila, validity of Japan's Grant Aid for the Project is confirmed. Additionally, it is confirmed that human resources and technical level of the recipient country are sufficient for O&M of the Project. However, it is considered that the Project can be implemented more smoothly and efficiently if following points are improved.

- Securing of budget based on annual O&M plan
- Improvement of pump operation rule
- Establishment and continuation of O&M structure (budget and manpower) of PSFO
- Implementation of priority project which was pointed out by the Development study

During the first day (October 15) of the discussion with MMDA on the explanation of the Draft Basic Design, Mr. Fernando (MMDA chairman) was concerned about 2 points in the contents presented by the Study Team of the Japanese side proposal for the Grant Aid Project.

a) It is planned to operate the drainage pumps in the three pump stations by engine. But, to save fuel and avoid fuel robbery by the staffs, it is better to change the system operation to a commercial electric system with a generator for the backup;

b) The proposed costs for the three pump stations is more than double of the unit costs for the plan that MMDA elaborated in the past.

The study team explained as followings:

a) The contents utilized for the design and cost estimation were based on the items agreed indicated in the last minutes signed among Mr. Nagata and Mr. Fernando;

b) The equipment will be Japanese to be in conformity with the actual equipment. That is why the cost is higher than purchasing all of them in the Philippines. There will not be necessary to stop them to make the improvements. So, these works require the pointed costs and period.

But, the chairman didn't accept the explanation and it was not possible to get his consent. So, the study team discussed again with the experts of MMDA and prepared to discuss with the chairman on October 18 at 14:00 pm.

But, in this day when the study team went to MMDA, the meeting was canceled because the chairman was called by the president. The plan to sign the M/D was also canceled by the reason that the chairman had another schedule on October 19.

The result was that after the first short discussion with the chairman, there was no chance to meet him again, not being possible to discuss even about the M/D.

Therefore, the study team explained their opinion about the chairman's comments for changing the contents and costs to the experts of MMDA, asking them to tell it to the chairman. But, considering that decision of MMDA is made all by the chairman, the study team concluded that it is difficult to have the M/D signed. The discussion with the experts of MMDA will not alter the chairman's opinion.

In this context, the study team consulted JICA Philippines office and sent a letter annexing the draft M/D to MMDA after discussing with the expert of MMDA. The following actions were left entirely to the resident representative of JICA Philippines office and the study team went back to Japan.

The opinions of the study team that explained to the experts of MMDA are presented as follow;

Opinions of the Study Team

a) Modification of the Motor Pump System

⇒ The fuel robbery by the MMDA staffs is problem of the staffs moral. So, a comprehensive training shall be done by the MMDA under instruction of the chairman. The fuel robbery problems will not be solved changing the motor system, because the backup generator will utilize fuel too;

⇒ JICA sent a team to confirm the requested contents and signed a M/D in March 14. But, its content was to improve the actual drainage pump system (engine), and no request for motor system was included in it. So, JICA will not accept additional requests at this time, when the study is almost finished. Therefore, if MMDA needs to study the motor drive pump system, MMDA shall do it by themselves or should request new technical cooperation or grant aid for the Japanese government;

⇒ The modification to a commercial electricity based motor system will result in an increase of the initial cost, including the backup generator, but the running cost will be reduced. In this case, a comparison of combined capital and operating expenses for both systems should be carried out. But, the emergency response of a commercial electricity should be discussed with MERALCO;

b) Concern About the High Project Cost

⇒ Japanese made equipment are currently installed in the existing target drainage pump station such as engines manufactures by Yammar and pumps by Ebara Co. (installed in 1976 and 1977

through a Japanese Yen loan). JICA examined the procurement of equipment from third countries (e.g. China, India, Russia, etc.) where cheaper equipment can be provided in order to improve the function of the system. But, it is a concern the new and old pumps will not match and may not fulfill their function properly. So, Japanese engines and pumps are planed here, that are more expensive than third countries equipment. But, the cost estimation was done for low prices (unreasonable low prices were not selected to avoid dumping) and it is not the case of being too much expensive;

⇒ The pump type for another MMDA project mentioned by the chairman which he compared the cost with this Project is submersible pumps. Those pumps can be installed with simple facilities by low costs and the pump itself is cheaper. But the maintenance of them is more difficult and expensive, and the life time is shorter. Moreover, the present improvement project needs budget to remove the old facility and has limited working space. So, it is not appropriate to simply compare both cases and conclude that it is expensive;

⇒ Therefore, the study team considers that the cost presented by them to improve the drainage capacity of the three pumps is not too expensive and is reasonable.

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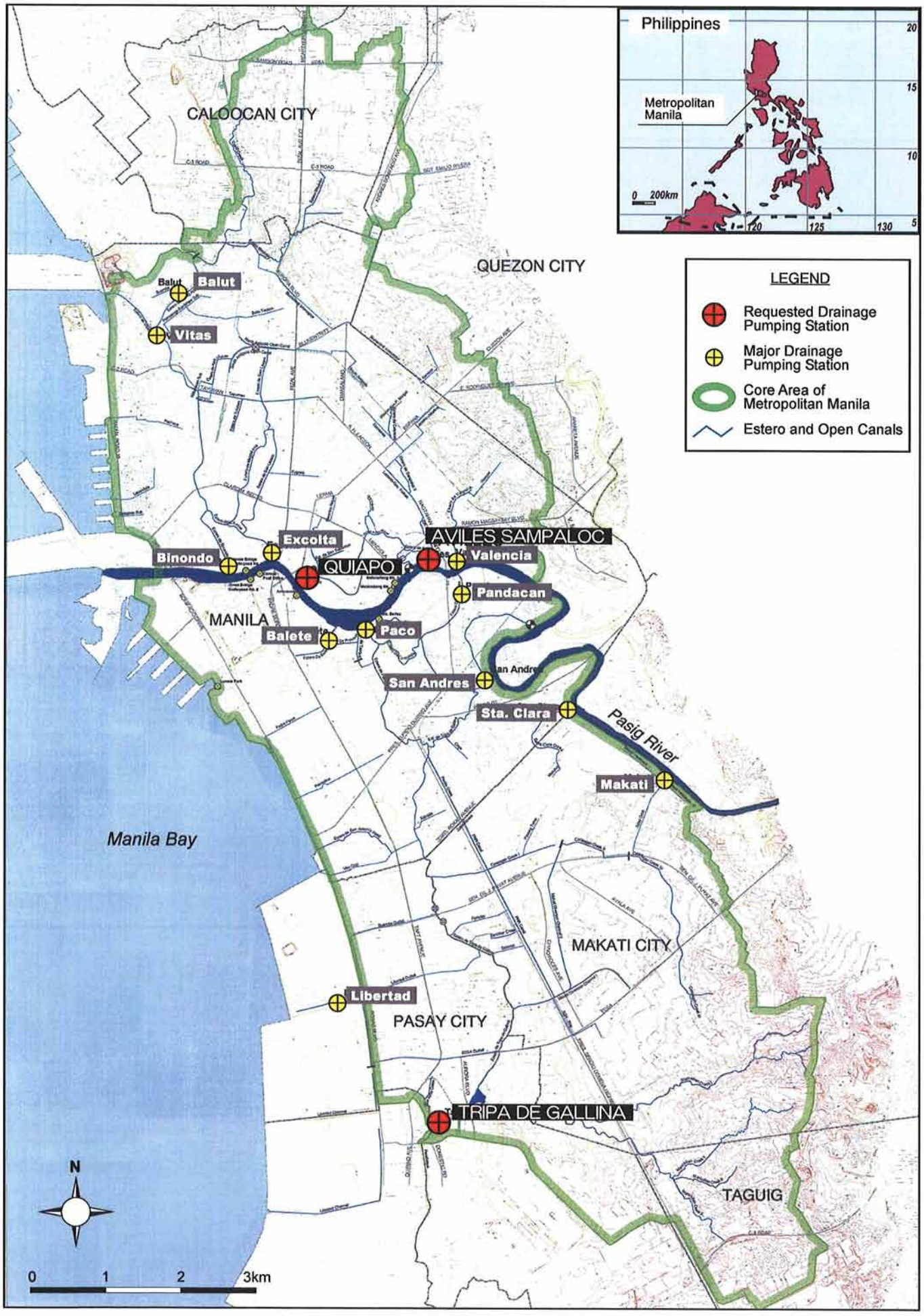


LOCATION MAP ON THE PROJECT FOR URGENT IMPROVING / UPGRADING OF FLOOD CONTROL SYSTEM IN METRO MANILA

List of Tables

Abbreviations

General

A/P	:	Authorization to Pay
ADB	:	Asian Development Bank
B/A	:	Banking Arrangement
CEC	:	Commission of the European Communities
CNC	:	Certification of Non-Coverage
DAC	:	Development Assistance Committee
DBM	:	Department of Budget and Management
DENR	:	Department of Environment and Natural Resources
DOF	:	Department of Finance
DPWH	:	Department of Public Works and Highways
DSR	:	Debt-Service Ratio
DWO	:	Drainage and Waterways Operation
ECA	:	Environmentally Critical Area
ECP	:	Environmentally Critical Project
EIS	:	Environmental Impact Statement
EMB	:	Environmental Management Bureau
E/N	:	Exchange of Notes
ECC	:	Environmental Compliance Certificate
FCMS	:	Flood Control Management Service
FCSEC	:	Flood Control and Sabo Engineering Center
FOB	:	Free on Board
GDP	:	Gross Domestic Product
GEF	:	Global Environmental Forum
GNI	:	Gross National Income
GTZ	:	Deutsche Gesellschaft fur Technishche Zusammenarbeit
H.A.F.P	:	Horizontal Axis Flow Pump
IEE	:	Initial Environmental Effects
IFAD	:	International Fund for Agricultural Development
JBIC	:	Japan Bank for International Cooperation
JICA	:	Japan International Cooperation Agency
M/D	:	Minutes of Discussion
M/M	:	Minutes of Meeting
MERALCO	:	The Manila Electric Company
MMDA	:	Metropolitan Manila Development Authority
MTPDP	:	Medium-Term Philippine Development Plan
NAIA	:	Ninoy Aquino International Airport
NEDA	:	National Economic Development Authority
NEDA	:	Netherlands Development Assistance

NTRC	:	National Tax Research Center
O&M	:	Operation and Maintenance
ODA	:	Official Development Assistance
PAGASA	:	The Philippine Atmospheric Geophysical and Astronomical Services Administration
PDM	:	Project Design Matrix
PNR	:	Philippine National Railway
PSFO	:	Pumping Stations and Flood Gates Operation
SARS	:	Severe Acute Respiratory Syndrome
SWMO	:	Solid Waste Management Office
UNDP	:	United Nations Development Program
UNFPA	:	United Nations Population Fund
UNICEF	:	United Nations Children's Fund
UNTA	:	United Nations Regular Program for Technical Assistance
USAID	:	United States Agency for International Development
VAT	:	Value-added Tax
V.A.F.P	:	Vertical Axis Flow Pump
WB	:	World Bank

Length

cm	:	centimeter
km	:	kilometer
m	:	meter
mm	:	millimeter

Area, Volume, Weight

cm^2	:	square centimeter
ha	:	hector
kg	:	kilogram
km^2	:	square kilometer
lit	:	liter
m^3	:	cubic meter
mm^2	:	square millimeter

Currency

US$	:	United States Dollar
Pesos	:	Philippines Pesoa
JY	:	Japanese Yen

Others

ϕ	:	phi
℃	:	degree centigrade
%	:	percent
C	:	core
Dia.	:	diameter
EL.	:	elevation
Hp	:	horsepower
hr	:	hour
kgf	:	kilogram foot
kw	:	kilowatt
KVA	:	kilovolt-ampere
P	:	page
PS	:	metric horsepower
sec	:	second
min	:	minute
min-1	:	per minute
mmAq	:	millimeter aqua
MPa	:	mega pascal
Nm^3	:	normal cubic meter
No.	:	number
V	:	volt

Chapter 1 Background of the Project

Chapter 1 Background of the Project

1.1 Background of the Project

Republic of the Philippines (hereinafter refer to as "the Philippines") is one of world's leading natural disaster countries: seismic hazard is No.2 and flood and volcanic disaster is No.4 in the world in occurrence frequency of natural disaster per area (number of disaster per km^2 from 1966 to 1990). As annual average, more than 700 personals have died and more than 1,500 million yen have lost. Flood and sediment disasters occur frequently since approximately 20 typhoons occur in the surround area of the Philippines and nearly half of those move inland in addition to severe rainstorm that occur due to season rain front during rainy season (June to November).

Risk of the flood disaster at urban area is increasing year by year, because urban areas are located at flood area of large rivers and there is acceleration urban congestion of recent years. The Government of the Philippines is anxious about this situation because it attaches importance to flood control and disaster prevention. However, budget and number of technical staff are not sufficient in Department of Public Works and Highways which is in charge of flood control and Sabo project of major rivers in the nation, and Department of Meteorology and Astronomy which is in charge of flood early warning project.

Flood control project such as preparation of drainage pumping stations have been implemented at metropolitan Manila for many years. However, most part of existing drainage pumping facilities are antiquated, so it is necessary to rehabilitate them. Additionally, deterioration of all systems such as pump, engine, drainage valve, automatic trash screen, is serious due to overloading of operation caused by inflow of a large quantity of solid waste. Likewise, there is a lot of solid waste and sedimentation in the drainage canals and so the drainage capability of the canal has decreased considerably. Also, squatters in the drainage canals are hindering widening and dredging of canal as well as operation and maintenance activities.

Hence, the Government of the Philippines requested the Japan's Grant Aid to the Government of Japan in order to develop the flood control system in the metropolitan Manila by developing the capacities of three drainage pumping stations (Quiapo, Aviles・Sampaloc, Tripa de Gallina) by improving and upgrading both mechanical and electrical equipment of those facilities.

After the submission of the request, JICA have carried out "The Study on Drainage System Improvement in the Core Area of Metropolitan Manila" (hereinafter refer as the Development Study) in 2004. Major drainage pumping stations and drainage canal systems at core area of metropolitan Manila have been studied and Master plan on improvement of drainage system has been drawn out in the Development Study. Likewise, priority projects have been selected in the master plan.

Functional recovering of requested three drainage pumping stations are positioned as priority issues in the priority projects of the Development Study. Therefore, the basic design study shall be carried out on the basis of lesson learnt and suggestion which got in the Development Study.

1.2 Natural Conditions

(1) Meteorological Phenomenon

Manila belongs to the topical monsoon climate. There are four rainfall stations in Metropolitan Manila. Historical variation in average monthly rainfall at Port Area, Science Garden and NAIA stations averaged over the period 1961 – 2003 and at Napindan station averaged over the period 2002 – 2003. According to observation records, average annual rainfall is 2,139mm. 81% of annual rainfall falls during the month of June to October which can be called as Wet Season. Annual average temperature is calculated at 28℃. Average monthly minimum and maximum temperatures are observed in the month of January (22℃) and April (34℃) respectively. Mean annual total pan evaporation is calculated at 1,335 mm. Maximum pan evaporation occurs in the month of April (162 mm) and then in the month of May (148 mm) and March (147 mm). Average monthly minimum and maximum relative humidity are observed in the month of March to April (65 %) and August to September (80 %) respectively. Annual average relative humidity is calculated at 74 %. Meteorological phenomenon of the study area is shown in following table;

Table 1-1 Meteorological Phenomenon of The Study Area

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Average rainfall (mm)	14	10	11	21	166	259	475	425	358	213	126	61	2,139
Average temperature (℃)	26	27	28	29	30	29	28	28	28	28	27	26	28
Monthly minimum temperature (℃)	22	23	24	25	26	25	25	25	25	25	24	23	24
Monthly maximum temperature (℃)	30	31	32	34	33	32	31	31	31	30	31	30	31
Relative humidity (%)	73	69	65	65	70	77	77	80	80	75	76	75	74
Pan evaporation (mm)	94	109	147	162	148	114	98	103	93	89	87	91	1,335

(2) Tide Level at Manila Bay

According to observation records at Manila Bay from 1999 to 2003, Mean Higher High Water is observed in the month of July (EL.11.12 m), August (EL.11.14 m) and September (EL.11.11 m). Difference between Mean Higher High Water (MHHW) and Mean Lower Low Water (MLLW) by month varies between 0.89 m to 1.05 m. Historical maximum and minimum tide level are EL. 11.91 m and EL. 9.33 m respectively which were observed in July 12, 1972 and February 3, 1913 respectively. MHHW and MLLW based on records from 1999 to 2003 are shown in following table;

Table 1-2 Average Tide Level of Manila Bay

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MHHW EL.	10.89	10.86	10.85	10.87	10.96	11.04	11.12	11.14	11.11	11.05	10.99	10.93
MLLW EL.	9.84	9.90	9.94	9.97	9.98	10.01	10.08	10.17	10.21	10.14	10.01	9.89

1.3 Social and Environmental Consideration

The Department of Environment and Natural Resources (DENR) exercises jurisdiction over the environmental administration. Its Environmental Management Bureau (EMB) is specifically tasked "to recommend rules and regulations for environmental impact assessments and provide technical assistance for their implementation and monitoring".

Presidential Decree No.1151 is the first policy issuance on Environmental Impact Statement (EIS) System in the Philippines. The Philippine EIS System was formally established in 1978 by Presidential Decree No.1586 and detailed regulations for the implementation of EIS System were laid down by the National Environmental Protection Council (NEPC). The major categories of environmentally critical project (ECP) and project within environmentally critical area (ECA) were identified through Presidential Proclamation No. 2146, series of 1981.

EIS System stated that environmental impact assessment should be carried out in accordance with project type and situation of the project site. Proponents of projects have to submit Environmental Impact Statement (EIS) or Initial Environmental Effects (IEE). In case that there is no problem for the environment, Environmental Compliance Certificate (ECC) which authorizes the project will be issued by DENR. There are four major categories in EIS System. Definitions of categories are as follows;

Category A: Environmentally Critical Project (EPC) with significant potential to cause negative environmental impacts.

Category B: Project that is not environmentally critical in nature, but which may cause negative environmental impacts because the project is located in Environmentally Critical Area (ECA).

Category C: Project intended to directly enhance environmental quality or address existing environmental problems.

Category D: Project not failing under other categories or unlikely cause adverse environmental impacts.

In general, ECC applications for projects under Category A or Category B shall be based on and EIS or IEE report, respectively. While proponents for projects classified as Category C are required to submit Project Description for issuance of Certification of Non-Coverage (CNC). Category D is considered as outside the purview of the Philippines EIS System, and shall be issued CNC.

This project is located in a flood-prone area which is categorized as ECA in the EIS System. However, the project component is rehabilitation of existing facilities without expansion of facilities. Therefore, this project shall be exempted from Category B and shall be categorized as Category C. MMDA submitted the project description and DENR already issued CNC for the project.

Chapter 2 Contents of the Project

Chapter 2 Contents of the Project

2.1 Basic Concept of the Project

(1) Overall Target and Project Target

The Metropolitan Manila area is vulnerable to floods from Pasig River, and high tides of Manila Bay, because of its low-lying topography and exposure to meteorological / hydrological conditions.

The Government of the Philippines is anxious about this situation and has carried out development of drainage channels and drainage pumping stations. However, the drainage channels have lost their original discharge capacities because of illegal dumping of solid waste into drainage channels and the encroachment by numerous informal settlers inside drainage channels, disturbing proper O&M activities and decreasing their conveyance capacities. Also the pumped solid waste flows into the drainage pumping stations and affects the lifespan of the pump facilities by overloading together with poor water quality.

Additionally, there are severe inundation areas locally in the core area, which cause heavy traffic and disturbance in the commercial activities and urban living. The severe inundation in 1999 revealed that the drainage facilities need to be reviewed and improved for their discharge capacities through various measure such as remedial and additional works to the existing drainage facilities, improvement of O&M organizations and activities, improvement of solid waste management practices, prevention of illegal activities and promotion of public participation through enhancement of public awareness for drainage improvement.

Thus, the Government of the Philippines requested the implementation of "The Study on Drainage System Improvement in the Core Area of Metropolitan Manila" (hereinafter refer as the Development Study) to the Government of Japan in order to improve conditions of social and economic activities as well as living environment in the Metropolitan Manila. Due to the request from the Government of the Philippines, the Government of Japan has carried out a Development Study from 2004 to 2005. Major drainage pumping stations and drainage canal systems in the core area of metropolitan Manila have been studied and Master plan on improvement of drainage system has been drawn up during the Development Study. The implementation schedule of measures was divided into three phases in the Master Plan. As Phase I projects that need urgent implementation, the following were suggested: improvement of drainage channels, improvement of twelve drainage pumping stations, and additional works of North and South Manila

Functional recovering of requested three drainage pumping stations are positioned as priority issues in the priority projects of the Development Study. Therefore, basic design study shall be carried out on the basis of lesson learned and suggestion in the Development Study.

(2) Examination of Requested Components

1) Modification of Requested Components through M/D (Minutes of Discussion)

Control of these drainage pumping stations were transferred from DPWH to MMDA in August 2002 by Presidential Decree. The request was drawn up by DPWH in February 2002. However, MMDA is the implementation agency of the Project because of the process at present. Since MMDA was not involved in drawing up the request and the situation of the drainage pumping stations has changed because five years have passed after drawing up the request, MMDA considers that the requested components are not enough to improve the function of the pumping stations. As the result of the M/D, the originally requested components were modified.

Additionally, since Chairman of MMDA considers that staff members of the pumping stations lack capacity for operation and maintenance, technical training using soft component scheme shall be examined in order to improve the capability of staff members for operation and maintenance of the drainage pumping stations.

2) Comparison between Requested Components and Components of Basic Design

Components of Basic Design were decided based on limitation of project budget and project effects based on above requested components. Likewise, the strengthening of operation and maintenance capability of staff through a soft-component scheme shall be excluded because of their existing technical level. Comparison between requested components and components of Basic Design are shown in the following table:

Table 2-1 Modification of Targeted Components

Items	Quiapo			Aviles・Sampaloc			Tripa de Gallina			Reasons that components were excluded by the Basic Design
	Original Request	M/D Request	Basic Design	Original Request	M/D Request	Basic Design	Original Request	M/D Request	Basic Design	
I. Main pump and engines										
1. Main pump	●	●	●	●	●	●		●	●	
2. Main diesel engine	●	●	●	●	●	●		●	●	
II. Trash screen system										
1. Auto trash screen rake	●	●	●	●	●	●	●	●	●	
2. Horizontal and inclined conveyor	●	●	●	●	●	●	●	●	●	
3. Sludge pump		●			●			●		It is not expensive and can be purchased in local market. The Philippine side can purchase by themselves.
4. Hopper	●	●		●	●	●	●	●		A hopper can not be used at Quiapo because the area is narrow. In case of Tripa de Gallina, it is more efficient that a hopper is not used.
5. Upstream gate		●			●			●		The purpose of upstream gate is to clean up the drainage canal and the drainage canal is not including target of the Project.
III. Auxiliaries										
1. Fuel supply system	●	●	●	●	●	●		●	●	
2. Electric system	●	●	●	●	●	●	●	●	●	
3. Engine cooling system	●	●	●	●	●	●		●	●	
IV. Vehicle										
1. Dump truck	●			●			●			Garbage of drainage pumping stations are taken out by trucks which are contracted by MMDA or municipalities periodically. Costs of dump trucks are paid according to volume of garbage which are carried to final disposal sites. The payment system is performing without serious problem. Therefore, these vehicles are not necessary.
2. Pick-up truck (Double cabin)		●			●			●		
3. Loader		●			●			●		
V. Overhead traveling crane		●	●		●	●		●	●	
VI. Flood Gate Rolling System		●	●		●	●		●	●	
VII. Spare parts										
1. Electrical spare parts	●	●		●	●		●	●		Most of electrical parts are local made. Therefore, the Philippines side can purchase spare parts.
2. Mechanical spare parts	●	●	●	●	●	●	●	●	●	

(3) Project Design Matrix (PDM)

General description of the Project arranged by Project Design Matrix（PDM）is shown below.

Name of the Project: The Project for Metro Manila Drainage System Urgent Improvement / Upgrading in Republic of the Philippines
Target Area: Core area of Metropolitan Manila (Target drainage block is 23.46 km^2)
Beneficiaries: Inhabitants of the target drainage block (Approximately 480 thousands)

Summary of the Project	Index	Obtaining Method of the Index Data	External Conditions
Overall Target Condition of social and economical activities as well as living condition shall be improved at Metropolitan Manila.	• Rehabilitation of the drainage canals and implementation of additional works shall be carried out. • Solid waste management along the drainage canals shall be improved. • Organization and activities for O&M shall be improved. • Urgent flood control budget and restoration budget shall be reduced	• Activity report of DWO • Collected volume of Garbage at drainage pumping stations • Activity report of SWMO • O&M activity budget and O&M report • Actual results of expenditure in the Philippines	• Precipitation pattern does not change significantly due to a large scale fluctuation of climate. • Social and economical situation of the Philippines does not become worse suddenly.
Project Target Flood control system shall be kept in good condition through improvement of function on the targeted drainage pumping stations.	• Risk of arrest of functions on the drainage pumping stations shall be reduced. • Flood area, flood time and damage losses shall be reduced.	• Hearing • Flood damage report	• Functions of the drainage pumping stations are not destroyed due to a disturbance, robbery, etc. • Engineers of the drainage pumping stations do not retire due to significant change of economic situation of the Philippines.
Output Expected Pump, engine, related auxiliary and electrical equipment of the targeted drainage pumping stations shall be renewed.	• Cutback in failure rate • Cutback in operation cost	• Operation record • Budget and actual results of O&M cost	• Political and/or economical fluctuation that disturb procurement , are not realized.
Action • Pump, electrical system, engine and automatic trash screen etc. shall be rehabilitated and/or repaired at Quiapo, Aviles・Sampaloc and Tripa de Gallina drainage pumping stations.	Invest Japan side • Basic design study • Procurement of equipment and materials • Technical transfer	Philippines side • To secure the budget and the staff • O&M of facilities after completion of the Project	Prerequisite • Security problem has not occurred at the drainage pumping stations.

Notes）DWO：Drainage Waterway Operation, SMWO：Solid Waste Management Office

2.2 Basic Design of the Requested Japanese Assistance

2.2.1 Design Policy

(1) Basic Policy (Equipment Plan)

The scope of the Project is procurement and installation works of mechanical and electrical equipment which are necessary to recover the function of the requested drainage pumping stations at Quiapo, Aviles・Sampaloc and Tripa de Gallina. A target year of the Project is 2020 which is same as the target year of the Master plan of the Development study "The Study on Drainage Improvement in the Core Area of Metropolitan Manila". The equipment plan of the Project covers renewal and rehabilitation plan of equipment which are necessary to prevent capacity degradation due to trouble and/or wear of the drainage pumping stations as of 2020, based on the results of inspections including overhauling.

Based on above stated conditions, the basic policy of the each equipment is described below.

1) Main Pump

Replacement of parts which are necessary to be replaced

Parts which are necessary to be replaced based on the result of the inspection, shall be replaced to parts of original specification. Meanwhile, since Ebara Corporation which delivered pumps, decides that detail design of parts are not open to the public, the contractor have to buy parts from Ebara corporation or the contractor needs to measure the parts after overhauling and manufacture. As for wear tolerance of parts such as discharge elbow and column pipe, since both parts are made from mild steel, judgment either replacement or anticorrosive coat shall be decided based on 1.5 mm which is minimum wear tolerance mentioned in the gate and iron pipe technical standard. As for parts for which anticorrosive coat is necessary, it shall be mentioned in item "8) Anticorrosive coat".

2) Main Engine

Renewal to a low speed diesel engine which satisfies the original specification

Main engines which are set up at Quiapo, Aviles・Sampaloc and Tripa de Gallina drainage pumping stations, are middle speed diesel engines such as 900 min-1×96 kW (130 PS), 950 min-1×169 kW (230 PS) and 950 min-1×331 kW (450 PS) which are relatively low speed respectively. Generally, it is said that low speed engines have improved endurance compared with high speed engines. On the other hand, cost of low speed engine is higher and the weight is heavier than high speed engine. Likewise, the low speed diesel engine is produced by limited companies in Japan, although the high speed diesel engine is produced by numerous companies. It is possible to consider the procurement from a third country in order to avoid being restricted to limited companies to procure the low speed engine. However, when procuring from a third country, it should be examined whether the company in the third country can cope with destruction due to

twisting vibration[1] such as taking countermeasures using high-resiliency joint or not. On the other hand, in case that main engine changes to high speed diesel engine, it is necessary to use a new large scale reduction gear in order to prevent excess load of the main pump. Existing reduction gears are one stage reduction gear type. However, when high speed engine which with more than 1,800 min-1, is employed, two stage reduction gear type should be employed because reduction rate shall be more than 6.0. In this case, the gear shall be big and maintenance shall be complicated.

As a result of judgment of above situation, cheapest combination between new engine and reduction gear shall be a middle speed diesel engine on the market which can be used with one stage reduction gear type. Likewise, supplier shall be limited to makers which can cope with destruction due to twisting vibration.

3) Electric System

Renewal by Colgate cable and anticorrosive material

Defective function of electromagnetic contactors, protection relays and rattling phenomenon of electric system were clarified during the inspection. Therefore, electric system shall be completely renewed. Existing electric lines are week and there is a lot of damage by rodents, because electric line was implemented by plastic insulated wire. Therefore, Colgate cables shall be selected for the renewal. Rodent-proof cables were considered during beginning phase of the study. However, it is identified that available period of rodent-proof effect is not clear and the cable is not used recently. Therefore, Colgate cables which are utilized for this kind of purpose recently were selected. However, in terminal material where colgate cable with the required specification is not available in the market, normal wires with application of Rodent-proof material shall used. Likewise, cable ducts and pull boxes shall be renewed by anticorrosive material Electric panels are wired through a hole at base concrete. So, damage of electric panels are occurring due to moisture from pump floor through holes. To prevent moisture getting into electric panels as much as possible, the holes shall be minimized.

4) Auxiliary

Renewal of auxiliary to new engine

Most of auxiliary shall be renewed together with new engine. Specifications of auxiliary shall be designed based on specification of new engine. Meanwhile, basic condition of new design of auxiliary are to correspond with the basic condition of primary design as much as possible, because difference between present condition and primary condition can not be clarified at present. New design shall be carried out according to the design standard of the Ministry of Land, Infrastructure and Transport (MLIT) in Japan. In case the design standard is modified compared with original design period, existing design standard shall be employed.

[1] In case that excitation frequency of engine harmonizes with characteristic frequency of axial torsion, it becomes resonant condition. Axial torsion is big and it becomes repeated stress. As the result, destruction due to twisting vibration shall be occur

The cooling system was modified during rehabilitation works in 1990s from raw water system to pure water system because of troubles caused by occurrence of slurry in the cooling system. Therefore, raw water pump and raw water heat exchanger were taken away already. In case of Quiapo and Aviles・Sampaloc drainage pumping stations, one cooling pump was installed for one main pump. Therefore, it is expected that unification of the cooling pump system will make operation and maintenance easier. However, since piping will be complex due to unification of cooling pump system, the current system of one cooling pump for one main pump shall not be changed. On the other hand, cooling pump system of Tripa de Gallina pumping station does not have one cooling pump for one main pump. However cooling pumps shall be unified because cooling pump for generators and main pumps are separated.

5) Automatic Trash Screen

Renewal of parts which are defective situation by anticorrosive material

Horizontal and inclined conveyor of Quiapo and Tripa de Gallina drainage pumping stations shall be replaced completely. Anticorrosive measures shall be applied to parts of the new conveyor. The hopper of Aviles・Sampaloc drainage pumping station shall be renewed according to existing specification. Meanwhile, hoppers of Quiapo and Tripa de Gallina drainage pumping stations shall not be installed, because garbage volume of both drainage pumping stations are not accessible from hoppers. Secondary screen of Quiapo drainage pumping station shall be renewed with anticorrosive materials, because the screen gets damaged due to a corrosive gas.

6) Flood Gate

Renewal of electric system

There were no problems identified for the requested automatic hoisting system itself. However, the control panel and wiring which is controlling the automatic hoisting system are damaged as well as the electric system of the pumping facilities. Therefore, control panel and wiring shall be completely renewed with the same method as that for the electric system.

7) Overhead Traveling Crane

Renewal of defective parts

Overhead traveling crane which shall be the main operating machine for renewal and repairing works shall be repaired by priority before renewal and repairing works of pumping station themselves. Items that were clarified during visual check and activate inspection during field study were: push button switch, control panel and electric cable. These items shall be completely renewed.

8) Anticorrosive Coat

Anticorrosive coat by staffs of the drainage pumping stations

Most equipment, which were pointed out to be in need of repair as the result of overhauling can be coped with by implementation of anticorrosive coating after descaling. IN consideration that there is only one traveling crane, the time required to implement anticorrosive coating to necessary parts of one main pump will be around two weeks for overhauling, descaling, painting anticorrosive coat and assembling. In case of Tripa de Gallina, it shall take four months for anticorrosive coat works because there are eight main pumps. Therefore, the contractor has to spend a long time for anticorrosive coat works out of the six month working period of each year. As mentioned above, in case that anticorrosive coat is included in the Project component, there is fear that implementation efficiency of the Project shall will go down because of simple labor work hours. Therefore, since staffs of the drainage pumping stations can carry out anticorrosive coat at an appropriate level, and that anticorrosive coat is not urgent work, implementation of anticorrosive coat shall be carried out by staffs of the drainage pumping stations as maintenance work during dry season after completion of the Project. Meanwhile, materials and equipment for anticorrosive coat shall be procured in the Project.

9) Additional Drainage Capacity of Aviles・Sampaloc Drainage Pumping Station

Strengthening of drainage capacity by changeover the angle of impeller

The master plan of the development study suggested that Aviles・Sampaloc drainage pumping station needed capacity strengthening of 3.0 m3/sec, because rainwater which could not be drained by Blumentritt Interceptor flows into the drainage pumping station. When the Study Team discussed this issue with MMDA during the field study, MMDA intended to apply measures to strengthen Aviles・Sampaloc drainage pumping station. Therefore, the capacity strengthening of 3.0 m3/sec of Aviles・Sampaloc drainage pumping station shall be included as the Project component. Generally, installing new pumps with competent capacity is selected to increase drainage capacity. However, the Project cost shall be expensive in this case, because structure of pumping station may have to be changed. The development study suggested strengthening of drainage capacity by changeover the angle of impeller in order to speed up the suction velocity as a method to use the existing pump. Basically, this method shall be considered in the Project. Meanwhile, an eddy flow prevention wall should be constructed because there is possibility that deterioration of pumping discharge, vortex cavitations, additional load due to increasing of pump head, ambient noise and vibration shall occur if eddy will occur around suction opening when suction velocity rises.

10) Spare Parts

Recommended spare parts by makers for one year

According to primary request, spare parts for three years was requested. However, most of spare parts which need to replace for three years, are parts that should be replaced by MMDA constantly. Therefore, self support of MMDA will be considered for the quantity of spare parts. Spare parts for one year shall be recommended, taking into regard the period required for PSFO of MMDA to prepare necessary spare parts.

11) Service Manual and Parts List, etc.

Preparation of manuals

Specification of the drainage pump will not be changed because only a part will be renewed. However, since main engine, electric system and auxiliary shall be completely renewed, the Contractor shall burden the duty of drawing up specification of equipment, operation manual and O&M manual.

(2) Policy on the Natural Conditions

Drainage capacity of each drainage pumping station was judged based on precipitation data until 2003 in the master plan of the development study. As a result of the examination, capacity strengthening of 3.0 m3/sec on Aviles・Sampaloc drainage pumping station is recommended. Need to be change the probable rainfall which was decided by the development study, was examined in the Study based on precipitation data until 2003 and obtained additional data after 2004 during the Study. As the result, it is judged that changeover the probable rainfall is not necessary. The situation of sedimentation in the drainage canals was judged by comparison between cross sections of the drainage canal which were surveyed during the development study and cross sections were surveyed during the Study at same places. As the result, increase of sedimentation in the drainage canal was not seen.

Therefore, it is concluded that situation surround the drainage pumping stations has not changed between at the development study and at present. Strengthening of the drainage capacity at the each drainage pumping station shall be only 3.0 m3/sec of Aviles・Sampaloc drainage pumping station which was pointed out by the master plan of the development study. Additionally, the Philippines is susceptible to corrosion because of high-temperature and humidity since annual average temperature is 28 degrees centigrade, and annual average related humidity is 74%. In particular, target drainage pumping stations of the Project come under the influence of the corrosive gas which occur in solid waste, etc. and flow into drainage channels. Therefore, paint for main pump and conveyor shall be designed taking anti-rust and anticorrosion into account.

(3) Policy on the Environmental and Social Condition

Since the Project component is a renewal of equipment for existing drainage pumping stations, category is ranked as C of "JICA Environmental and Social Friendliness Guideline" and "the Philippines

EIS System". MMDA agreed to complete the EIA or to get the corresponding equivalent document (e.g. Certification of Non-Coverage) and get approval before the completion of the Explanation Mission of Draft Basic Design Report at the latest according to the relevant Philippines laws, regulations and guidelines, if it is required for the Project in the Minuets of Discussion. Therefore, component that EIA report is necessary due to changeover of a Project Component caused by withdrawal of illegal building and because movement of inhabitants should not be included in the Project component.

(4) Policy on Operation and Maintenance Capacity of Implementation Agency

Since the Chairman of MMDA considers that staff members of the pumping stations are lacking in capacity for operation and maintenance, therefore, technical training using soft component scheme was examined. An operation record is kept every day at the drainage pumping stations. Hourly water levels of inside and outside of the drainage pumping stations are also recorded in the operation record. Likewise, a maintenance record which mentions beginning and ending date of the maintenance of equipment is kept too. Currently, improper rule that pump shall not be operated in case that rainfall can not be confirmed at drainage pumping stations, even though water level shall be higher than pump starting level, is employed. However, the operation and maintenance of the drainage pumping stations is carried out according to the rules by representatives of the stations under the control of the Chief engineer of PSFO. Spare parts are also managed by computer file at a warehouse which is located beside Libertad drainage pumping station. Therefore, stock of spare parts can be selected just by looking in the warehouse. Additionally, the overhauling and assembling of equipment is being carried out by staff members of drainage pumping stations during field study without any problem. Especially, staff member at Aviles・Sampaloc drainage pumping station had a satisfactory technical level that compared favorably with Japanese technicians.

It is judged that operation and maintenance capability of staff members is no problem. Therefore, it is decided that technical guidance using the soft component scheme is not necessary.

(5) Policy on Utilization of Local Contractor, Local Materials and Equipment

It is important that main pumps and engines are adjusted with existing equipment. Also, it is very important that adjustments of other equipment are performed completely in order to operate the drainage pumping stations without any problem. Therefore, it is difficult to carry out the installment works of equipment by local contractor only, and so a Japanese technician should be dispatched. Since the installment works can be carried out by local contractor if a Japanese technician supervises their performance, local contractor shall be utilized as much as possible.

As for main pumps, engines and auxiliaries, there are some branches of Japanese suppliers in Manila and they are importing all products and spare parts from Japan. It is necessary that MMDA can easily purchase necessary parts by their budget in future. Therefore, suppliers of equipment and spare parts shall be basically selected from makers which have actual branches in Manila. On the other hand, electric panels shall be procured from local suppliers because local suppliers assemble them at their factories using imported products, parts and they sell them under their original brand.

(6) Policy on the Implementation Period

Since the Project component is renewal and/or repairing of existing drainage pumping stations, function of the drainage pumping station can not be stop completely for the Project implementation from the point of view of disaster prevention. Therefore, the implementation period of the Project should be a period when need of pump operation is small. Pump operation of drainage pumping stations is carried out by rotation in order to balance the operation time of each pump. Therefore, all pumps are operated by shifts in a day. The following table shows the number of pumps that were operated during the same period from May to November (214 days) based on the operation record in 2005 which was obtained during the field study.

Table 2-2 Operation Day of Pump at Same Period

Name of Station / No. of Pump	Quiapo (Total 4 pumps)	Aviles・Sampaloc (Total 4 pumps)	Tripa de Gallina (Total 8 pumps)
3 pumps	102 days	20 days	15 days
4 pumps	6 days	12 days	5 days
5 pumps	—	—	4 days
6 pumps	—	—	7 days
7 pumps	—	—	3 days
8 pumps	—	—	3 days

All pumps were operated at the same time for several days, although 2005 was an average year without any record-breaking rainfall. Long-term rainfall prediction is impossible. Likewise, immediate restoration is difficult in case that overhauling is carried out for a piece of equipment at drainage pumping station. Based on the above indicators, it is necessary to eliminate the period from May to November from the implementation period when possibility of rainfall is high. However, since adjustment and maintenance are carried out in May before starting the permanent operation season from June, equipment of the drainage pumping station can be transferred without any problem for operation from June, and May can be included as the implementation period.

Therefore, the implementation period of the Project shall be the dry season from December to May, avoiding the rainy season. According to the precipitation data from 1990 to 2003, unexpected rainfall occurred during the above stated period. Considering abnormal climate in recent years, it is possible that necessity of pump operation will happen due to concentrated heavy rain during the implementation period. Therefore, the implementation schedule that can minimize complete stop period of the drainage pumping stations shall be considered.

As for the examination of the implementation schedule, rainy day is not necessary to consider the rate for the implementation operation, because the implementation work shall be carried out mainly in the drainage pumping stations. Working time shall be 48 hours per week from Monday to Saturday which is the standard working time in the Philippines. However, in the case of Quiapo drainage pumping station,

since MMDA suggested that Friday should not be a working day because religious ceremonies are held in the area. Therefore, the working time of Quiapo drainage pumping station shall be 40.0 hours per week.

(7) Policy on the Bidding Method

Since the Project is a rehabilitation and/or renewal of equipment and parts, it is considered that procurement of equipment and parts can be divided into several lots. However, defect liability of installation works can not be identified in this case. Therefore, a contract which includes installment works and procurement of equipment and materials such as spare parts of main pump, engine and auxiliaries, is necessary. In short, minimum unit basis of contract shall be a drainage pumping station.

Generally, a lot of procurement and installment works should be considered based on the general rule of Japan's Grant Aid which is "The contract shall be considered to divide into several lots as much as possible in order to boost its competitiveness". When the consultant requested an estimate from the seven major Japanese pump makers for the cost estimation, only one maker submitted a complete estimate including equipment cost and cost of installment actual works. So, the cost estimation of the Project was carried out in individual prices of parts and equipment from several makers. Therefore, it is not clear whether division of lots will boost competitiveness or not. If the contract is not done as one lot, overlap of procurement pool can be prevented and effective pool plan can be proposed. As a result, it is expected that the Project cost can be minimized. Therefore, as the bidding method of the Project, the contract shall not be divided.

2.2.2 Basic Plan (Equipment Plan)

Rehabilitation and renewal plans of major equipment according to the result of inspection of equipment including overhauling are part of the basic policy. Concrete rehabilitation and renewal plans of equipment are described below.

Necessary parts of main pumps are identified by overhauling of all main pumps at three drainage pumping stations. The basic policy is that parts which are necessary to renew and parts which are necessary to have an anticorrosive coat as a corrosion countermeasure will be judged based on degree of wear and failure caused by corrosion Both types of parts will be listed up and shall be procured. The result of inspection of pump parts, parts to be renewed and parts which need anticorrosive coat, are shown in Table 2-3.

Specifications of auxiliaries shall be modified according to the result of recalculation based on new specification of engines and present design standard on pumping station facilities of the Ministry of Land, Infrastructure and Transport (MLIT) in Japan. On the other hand, raw water pump and its related equipment were removed because its system was changed in 1990s and it was not necessary. Existing specifications, specifications of new equipment, and reasons of modifications are shown in Table 2-4.

Table 2-3　List of Pump Parts and Results of Inspections at Three Drainage Pumping Stations

① Quiapo Drainage Pumping Station

Items	No. of Renewal	No. of Coat	Pump No.			
			No.1	No.2	No.3	No.4
Guide Casing	4	-	Remarkable Failure, Renewal	Remarkable Failure, Renewal	Remarkable Failure, Renewal。	Remarkable Failure, 10cm, Renewal
Discharge Elbow	1	3	△ Corrosion 1.3mm, Coat	Corrosion 1.8mm, Renewal	△ Corrosion 0.3mm, Coat	△ Corrosion 0.5mm, Coat
Column Pipe	-	4	△ Corrosion 0.5mm, Coat	△ Corrosion 0.7mm, Coat	△ Corrosion 0.4mm, Coat	△ Corrosion 0.6mm, Coat
Suction Bell Mouse	-	4	△ Coat	△ Coat	△ Coat	△ Coat
Impeller	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Impeller Hub	-	4	△ Coat	△ Coat	△ Coat	△ Coat
Upper Shaft	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Lower Shaft	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Shaft Coupling	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Submerged Bearing Case	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Impeller Nut	1	-	○ Fair	○ Fair	○ Fair	Corroded corner, Renewal
Impeller Washer	4	-	Removed parts are used. Renewal	Removed parts are used. Renewal	Removed parts are used. Renewal	Removed parts are used. Renewal
Packing Box	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Oil Seal	4	-	Durable period overrun, In duration of rubber, Renewal	Durable period overrun, In duration of rubber, Renewal	Durable period overrun, In duration of rubber, Renewal	Durable period overrun, In duration of rubber, Renewal
Submerged Bearing	1	-	Wear due to choke with garbage, Renewal	○ Fair	○ Fair	○ Fair
Shaft Enclosing Tube	4	-	Remarkable corrosion around flange, Renewal	Remarkable corrosion around flange, Renewal	Remarkable corrosion around flange, Renewal	Remarkable corrosion around flange, Renewal
Sole Plate	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Shaft Coupling	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Butterfly Valve	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Bowl Bearing	4	-	Abnormal noise, Durable period overrun, Renewal	Durable period overrun, Renewal	Abrasion, Durable period overrun, Renewal	Defective rolling, Durable period overrun, Renewal
Bearing Housing	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Bearing Pedestal	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Mechanical Seal	1	-	Adapted seal cover, Renewal	○ Fair	○ Fair	○ Fair
Oil Gauge	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Compound Gauge (Pressure Gauge)	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Coupling Bolt	1	-	○ Fair	Deformation due to hammer, Renewal	○ Fair	○ Fair

○: Fair, △: Anticorrosive coat

Consumable parts such as seal and packing which are necessary to renew above parts should be included.

② Aviles・Sampaloc Drainage Pumping Station

Items	No. of Renewal	No. of Coat	Pump No.			
			No.1	No.2	No.3	No.4
Guide Casing	4	-	Remarkable Failure, 6cm, Renewal	Wear, Renewal	Wear, Renewal	Wear, Renewal
Discharge Elbow	1	3	△ Corrosion 1.4mm, Coat	△ Corrosion 0.9mm, Coat	Corrosion 2.9mm, Renewal	△ Corrosion 0.8mm, Coat
Column Pipe	2	2	△ Coat	Corrosion 4.1mm, Failure 4.5mm, Renewal	Corrosion 4.9mm, Failure, Renewal	△ Coat
Suction Bell Mouse	-	4	△ Coat	△ Coat	△ Coat	△ Coat
Impeller	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Impeller Hub	-	4	△ Coat	△ Coat	△ Coat	△ Coat
Upper Shaft	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Lower Shaft	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Shaft Coupling	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Submerged Bearing Case	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Impeller Nut	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Impeller Washer	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Packing Box	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Oil Seal	4	-	Durable period overrun, Renewal	Durable period overrun, Renewal	Durable period overrun, Renewal	Durable period overrun, Renewal
Submerged Bearing	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Shaft Enclosing Tube	4	-	Leakage from taper welding part, Renewal	Corrosion around flange, Renewal	Failure of taper welding, Renewal	Corrosion around flange, Renewal
Sole Plate	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Shaft Coupling	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Butterfly Valve	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Bowl Bearing	4	-	Abnormal noise, Durable period overrun, Renewal	Abrasion, Durable period overrun, Renewal	Abrasion, Abnormal noise, Durable period overrun, Renewal	Abrasion, Abnormal noise, Durable period overrun, Renewal
Bearing Housing	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Bearing Pedestal	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Mechanical Seal	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Oil Gauge	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Compound Gauge (Pressure Gauge)	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Coupling Bolt	-	-	○ Fair	○ Fair	○ Fair	○ Fair

○: Fair, △: Anticorrosive coat

Consumable parts such as seal and packing which are necessary to renew above parts should be included.

③ Tripa de Gallina Drainage Pumping Station

Items	No. of Renewal	No. of Coat	Pump No.			
			No.1	No.2	No.3	No.4
Impeller	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Impeller Hub	-	8	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat
Impeller Nut	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Shaft	-	8	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat
Bearing (Submerged Bearing) Sleeve	1	-	○ Fair	Wear caused by wear of submerged bearing, Renewal	○ Fair	○ Fair
Packing Sleeve	4	-	Wear, Renewal	Wear, Renewal	○ Fair	Wear, Renewal
Bearing Casing	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Submerged Bearing	1	-	○ Fair	○ Fair	○ Fair	Secondhand is used, There is no spare parts, Renewal
Oil Seal Protector	-	8	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat
Casing Liner	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Lantern Ring	5	-	Deformation, Renewal	Deformation, Renewal	Deformation, Renewal	Deformation, Renewal
Grand	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Packing	8	-	Rather wear, Renewal	Rather wear, Renewal	Rather wear, Renewal	Rather wear, Renewal
Trust Bearing Radial Bearing	1	-	○ Fair	One-sided wear, Renewal	○ Fair	○ Fair
Coupling	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Grease Pump	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Grease Piping	-	-	○ Fair	○ Fair	○ Fair	○ Fair
Upper Casing	-	8	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat
Lower Casing	-	8	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat
Suction Casing	-	8	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat
V-Belt (for Grease Pump)	6	-	Deterioration of rubber, Loss of regular clasp, Renewal	Deterioration of rubber, Loss of regular clasp, Renewal	Deterioration of rubber, Loss of regular clasp, Renewal	Deterioration of rubber, Loss of regular clasp, Renewal

○: Fair, △: Anticorrosive coat

Consumable parts such as seal and packing which are necessary to renew above parts should be included.

Items	Pump No.			
	No.5	No.6	No.7	No.8
Impeller	○ Fair	○ Fair	○ Fair	○ Fair
Impeller Hub	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat	△ Removal of coat partly, Coat	△ Removal of coat partly, Coat
Impeller Nut	○ Fair	○ Fair	○ Fair	○ Fair
Shaft	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat	△ Removal of coat partly, Coat	△ Removal of coat partly, Coat
Bearing (Submerged Bearing) Sleeve	○ Fair	○ Fair	○ Fair	○ Fair
Packing Sleeve	Wear, Renewal	○ Fair	○ Fair	○ Fair
Bearing Casing	○ Fair	○ Fair	○ Fair	○ Fair
Submerged Bearing	○ Fair	○ Fair	○ Fair	○ Fair
Oil Seal Protector	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat	△ Removal of coat partly, Coat	△ Removal of coat partly, Coat
Casing Liner	○ Fair	○ Fair	○ Fair	○ Fair
Lantern Ring	Deformation, Renewal	○ Fair	○ Fair	○ Fair
Grand	○ Fair	○ Fair	○ Fair	○ Fair
Packing	Rather wear, Renewal	Rather wear, Renewal	Rather wear, Renewal	Rather wear, Renewal
Trust Bearing Radial Bearing	○ Fair	○ Fair	○ Fair	○ Fair
Coupling	○ Fair	○ Fair	○ Fair	○ Fair
Grease Pump	○ Fair	○ Fair	○ Fair	○ Fair
Grease Piping	○ Fair	○ Fair	○ Fair	○ Fair
Upper Casing	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat	△ Removal of coat partly, Coat	△ Removal of coat partly, Coat
Lower Casing	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat	△ Removal of coat partly, Coat	△ Removal of coat partly, Coat
Suction Casing	△ Abrasion caused by rust, Coat	△ Abrasion caused by rust, Coat	△ Removal of coat partly, Coat	△ Removal of coat partly, Coat
V-Belt (for Grease Pump)	Deterioration of rubber, Loss of regular clasp, Renewal	Deterioration of rubber, Loss of regular clasp, Renewal	○ Fair	○ Fair

○: Fair, △: Anticorrosive coat

Consumable parts such as seal and packing which are necessary to renew above parts should be included.

Table 2-4 Existing and New Specifications of Each Drainage Pumping Station

① Quiapo Drainage Pumping Station

Name of Equipment		Contents of Works	Existing Equipment		New Equipment		Remarks
			Specification	Quantity	Specification	Quantity	
Main Pump	Main Pump	C, M, I	Ebara Pump 1000VSGE 2.375m^3/s x 2.5 m x 96 kW(130 PS) x 300 min^{-1}	4	Same as on the Left	4 4	
Main Engine	Engine Main Body	C, M, I	900min^{-1} x 96 kW (130 PS)	4	900 min^{-1} to less than 1,800 min^{-1} x 96 kW	4	
	Reduction Gear	C, M, I	900 min^{-1}→300min^{-1}	4	Same as on the Left	4	
Electric System	Control Center	C, M, I	Indoor Closing Self-support Type	3	Same as on the Left	3	
	Battery and Charger Panel	C, M, I	Indoor Closing Self-support Type	1	Same as on the Left	1	
	Common Control Panel	C, M, I	Indoor Closing Self-support Type	1	Same as on the Left	1	
	Local Control Panel	C, M, I	Indoor Closing Self-support Type	4	Same as on the Left	4	
	Trash Screen Control Panel	C, M, I	Indoor Closing Self-support Type	1	Same as on the Left	1	
	Conveyor Control Panel	C, M, I	Indoor Closing Self-support Type	1	Same as on the Left	1	
	Wiring and Piping	C, M, I		1		1	
Trash Screen Facilities	Automatic Trash Screen	Renewal of Rake	3,400 mm x 4,800 mm(H) Rake 300mm	4	Same as on the Left	4	
	Horizontal Conveyor	C, M, I	750 mm x 22 m 1.5 kW	1	Same as on the Left	1	
	Inclined Conveyor	C, M, I	750 mm x 8 m 2.2 kW	1	Same as on the Left	1	
	Second Screen	C, M, I	3,400 mm x 4,800 mm	2	Same as on the Left	2	
Auxiliaries	Raw Water Pump		—	3	—	0	Pure Water is used.
	Raw Water Heat Exchanger		Shell and Tube Type	4	—	0	Due to modify the cooling system
	Clear Water Pump	C, M, I	Φ50 mm, Total Head 12 m, 250 Lit/min, 1.5 kW	2	Same as on the Left	2	
	Cooling Water Pump (Engine)	C, M, I	Φ50 mm, Total Head 12 m, 250 Lit/min, 2.2 kW	4	Φ40 mm, Total Head 15 m, 130 Lit/min, 1.5 kW	4	Due to modify the cooling system
	Cooling Water Pump (Generator)	C, M, I	Φ50 mm, Total Head 12 m, 250 Lit/min, 2.2 kW	2	Φ32 mm, Total Head 15 m, 90 Lit/min, 0.75 kW	2	Due to modify the cooling system
	Fuel Transfer Pump	C, M, I	Φ20 mm, 3 kg/cm^2, 21 Lit/min, 0.4 kW	2	Φ20 mm, 0.3 MPa, 24 Lit/min, 0.4 kW	2	Almost same specification
	Drainage Pump	C, M, I	Φ50 mm, Total Head 12 m, 250 Lit/min, 1.5 kW	2	Same as on the Left	2	
	Air Compressor	C, M, I		2	Φ15 mm, 2.94 MPa, 9 m^3/h, 3.7 kW	2	Design Standard of the MLIT
	Cooling Tower	C, M, I	0.4 kW	3	Circular Opening Type, 50℃→35℃ 203 Lit/min, 0.75 kW	3	Due to modify the cooling system
	Ventilation Fan	C, M, I	300 Nm^3/m x 98.07 Pa (10 mm Aq) x 2.2 kW	2	340 Nm^3/m x 100 Pa x 2.2 kW	2	The result of recalculation
	Canal and River Water Gauge	C, I		2	Pressure Type Water Gauge less than 10 m,+-0.5%	2	
	Suction Well Water Gauge	C, I		4	Electrode Type Water Gauge	4	
	Cooling Water Tank Water Gauge	C, I		1	Electrode Type Water Gauge	1	
	Cooling Water Tank Thermometer	C, I		1	Dial Thermometer with Points of Contact	1	
	Piping	C, M, I					
Flood Gate	Flood Gate Control Panel	C, M, I	Indoor Closing Self-support Type	2	Same as on the Left	2	
Overhead Traveling Crane	Crane Power Panel	C, M, I	Indoor Closing Wall Hanging Type 3-Phase 220V	1	Same as on the Left	1	
	Common Protection Panel	C, M, I	Indoor Closing Self-support Type	1	Same as on the Left	1	
	Push Button Switch Box	C, I	Indoor Closing Type	1	Same as on the Left	1	
	Curtain Cable	C, I	8 mm^2 x 3C x 20 m	1	Same as on the Left	1	
Concrete Works		C, I		1		1	

Remarks; C: Clearance, M: Manufacture, I: Installation

② Aviles・Sampaloc Drainage Pumping Station

Name of Equipment		Contents of Works	Existing Equipment		New Equipment		Remarks
			Specification	Quantity	Specification	Quantity	
Main Pump	Main Pump	C, M, I and Capacity Strengthening	Ebara Pump 1200VSGE 3.525 m^3/s x 3.1 m x 230 PS x 300 min^{-1}	4	4.27 5m^3/s x 3.5 m x 240 kW x 300 min^{-1}	4 4	Angle of impeller shall be modified for capacity strengthening
Main Engine	Engine Main Body	C, M, I	950 min^{-1} x 169 kW (230 PS)	4	950 min^{-1} to less than 1,800 min^{-1} x 240 kW	4	Output of engine shall be risen because of modification of impeller angle
	Reduction Gear	C, M, I	950 min^{-1}→300 min^{-1}	4	950 min^{-1} to less than 1,800 min^{-1} →300 min^{-1}	4	ditto
Electric System	Control Center	C, M, I	Indoor Closing Self-support Type	3	Same as on the Left	3	
	Battery and Charger Panel	C, M, I	Indoor Closing Self-support Type	1	Same as on the Left	1	
	Common Control Panel	C, M, I	Indoor Closing Self-support Type	1	Same as on the Left	1	
	Local Control Panel	C, M, I	Indoor Closing Self-support Type	4	Same as on the Left	4	
	Trash Screen Control Panel	C, M, I	Indoor Closing Self-support Type	1	Same as on the Left	1	
	Conveyor Hopper Control Panel	C, M, I	Indoor Closing Self-support Type	1	Same as on the Left	1	
	Water Level Observation Panel	C		1	—	0	Unification to common control panel
	Wiring and Piping	C, M, I		1		1	
Trash Screen Facilities	Horizontal Conveyor	Renewal of Belt, roller	750 mm x16.5 m x 1.5 kW	1	Same as on the Left	1	
	Inclined Conveyor	Renewal of Belt	750 mm x 13 m x 3.7 kW	1	Same as on the Left	1	
	Hopper	C, M, I	0.75 kW x 2	1	6 m^3 x 0.75kW x 2	1	
Auxiliaries	Raw Water Pump		—		—		
	Raw Water Heat Exchanger		Shell and Tube Type	4	—	0	Due to modify the cooling system
	Clear Water Pump	C, M, I	Φ50 mm, Total Head 12 m, 250 Lit/min, 1.5 kW	2	Same as on the Left	2	
	Cooling Water Pump (Engine)	C, M, I	Φ50 mm, Total Head 12 m, 250 Lit/min, 2.2 kW	4	Φ 40mm, Total Head 15 m, 240 Lit/min, 1.5 kW	4	Due to modify the cooling system
	Cooling Water Pump (Generator)	C, M, I	Φ50 mm, Total Head 12 m, 250 Lit/min, 2.2 kW	2	Φ32 mm, Total Head 15 m, 90 Lit/min, 0.75 kW	2	Due to modify the cooling system
	Fuel Transfer Pump	C, M, I	Φ20 mm, 3 kg/cm^2, 21 Lit/min, 0.4 kW	2	Φ20 mm, 0.3 MPa, 24 Lit/min, 0.4 kW	2	Almost same specification
	Drainage Pump	C, M, I	Φ50 mm, Total Head 12 m, 250 Lit/min, 1.5 kW	2	Same as on the Left	2	
	Air Compressor	C, M, I		2	Φ15 mm, 2.94 MPa, 9 m^3/h, 3.7 kW	2	Design Standard of the MLIT
	Cooling Tower	C, M, I	Circular Opening Type, 50℃→35℃, 1.5 kW	3	Circular Opening Type, 50℃→35℃, 525 Lit/min, 1.8 kW	2	Due to modify the cooling system
	Ventilation Fan	C, M, I	300 Nm^3/min x 98.07 Pa (10 mm Aq) x 2.2 kW	2	500 Nm^3/min x 100 Pa x 2.2 kW	2	The result of recalculation
	Canal and River Water Gauge	C, I		2	Pressure Type Water Gauge less than 10 m,+-0.5%	2	
	Suction Well Water Gauge	C, I		1	Electrode Type Water Gauge	1	
	Cooling Water Tank Water Gauge	C, I		1	Electrode Type Water Gauge	1	
	Cooling Water Tank Thermometer	C, I		1	Dial Thermometer with Points of Contact	1	
	Piping	C, M, I					
Flood Gate	Flood Gate Control Panel	C, M, I	Indoor Closing Self-support Type	2	Same as on the Left	2	
Overhead Traveling Crane	Crane Power Panel	C, M, I	Indoor Closing Wall Hanging Type 3-Phase 220V	1	Same as on the Left	1	
	Common Protection Panel	C, M, I	Indoor Closing Self-support Type	1	Same as on the Left	1	
	Push Button Switch Box	C, I	Indoor Closing Type	1	Same as on the Left	1	
	Curtain Cable	C, I	8 mm^2 x 3C x 20 m	1	Same as on the Left	1	
Concrete Works		C, I		1		1	

Remarks; C: Clearance, M: Manufacture, I: Installation

③ Tripa de Gallina Drainage Pumping Station

ame of Equipment		ntents of Works	isting Equipment		ew Equipment		marks
			ecification	antity	ecification	antity	
ain Pump	ain Pump	M, I	ara Pump 1650HSGE 0 m^3/s x 3.2 m x 450 PS x 210 min^{-1}	8	me as on the Left	8 8	
ain Engine	gine Main Body	M, I	0 min^{-1} x 330.75 kW (450 PS)	8	0 min^{-1} to less than 1,800min^{-1} x 330.75 kW	8	
	eduction Gear		0.75 kW x 950 min^{-1}→210 min^{-1}	8	0.75 kW x 950 min^{-1} to less than 1,800 min^{-1}→210 n^{-1}		
ectric System	ontrol Center	M, I	loor Closing Self-support Type	6	me as on the Left	6	
	ttery and Charger Panel	M, I	loor Closing Self-support Type	1	me as on the Left	1	
	ommon Control Panel	M, I	loor Closing Self-support Type	1	me as on the Left	1	
	ocal Control Panel	M, I	loor Closing Self-support Type	8	me as on the Left	8	
	ash Screen Control Panel	M, I	loor Closing Self-support Type	2	me as on the Left	2	
	onveyor Hopper Control Panel	M, I	loor Closing Self-support Type	1	me as on the Left	1	
	iring and Piping	M, I		1		1	
ash Screen cilities	tomatic Trash Screen	newal of Rake	450 mm x 5,400 mm (H) x 5, 5,350 mm x 5,400 mm (H) x 300 mm	8	me as on the Left	8	
	orizontal Conveyor	M, I	0 mm x 39.2 m x 2.2 kW, 750 mm x 15 m x 1.5 kW	1	me as on the Left	1	
	clined Conveyor	M, I	0 mm x 15.9 m x 3.7 kW	1	me as on the Left	1	
	opper		m^3	1		0	necessary
xiliaries	ear Water Pump	M, I	80 mm, Total Head 15 m, 900 Lit/min, 5.5 kW	4	me as on the Left	4	
	ooling, Sealing Water Pump		40 mm, Total Head 15 m, 110 Lit/min, 1.5 kW	4	40 mm, Total Head 15 m, 150 Lit/min, 1.5 kW	4	e to modify the cooling system
	ooling Water Pump (Generator)	M, I	40 mm, Total Head 15 m, 110 Lit/min, 1.5 kW	2		0	e to modify the cooling system
	cuum Pump	M, I	m^3/m x－78.4 kPa (-8 mAq) x 7.5 kW	4	65 mm, 4.5 m^3/m x -93 kPa, 7.5 kW	4	
	el Transfer Pump	M, I	25 mm, 3 kg/cm^2, 65 Lit/min, 1.5 kW	2	me as on the Left	2	
	ainage Pump	M, I	50 mm, Total Head 12 m, 250 Lit/min, 1.5 kW	2	me as on the Left	2	
	r Compressor	M, I	0 Nm^3/min x 2.94 MPa (30 kgf/cm^2), 3.7 kW	4	15 mm, 2.94 MPa, 9 m^3/h, 3.7 kW	4	sign Standard of the MLIT
	ooling Tower (1)	M, I	rcular Opening Type, 50℃→35℃, 0 Lit/min, 1.5 kW	4	rcular Opening Type, 50℃→35℃, 5 Lit/min, 1.5 kW	2	e to modify the cooling system
	ooling Tower (2)	M, I	rcular Opening Type, 50℃→35℃, 0 Lit/min, 1.5 kW	1	rcular Opening Type, 50℃→35℃, 0 Lit/min, 1.5 kW	2	e to modify the cooling system
	ntilation Fan	M, I	0 Nm^3/min x 98.07 Pa (10 mmAq) x 2.2 kW	5	0 Nm^3/min x 100 Pa x 2.2 kW	5	
	nal and River Water Gauge	I		2	essure Type Water Gauge less than 10 m,+-0.5%	2	
	ction Well Water Gauge	I		8	ectrode Type Water Gauge	8	
	ooling Water Tank Water Gauge	I		1	ectrode Type Water Gauge	1	
	ooling Water Tank Thermometer	I		1	al Thermometer with Points of Contact	1	
	ping	M, I		1		1	
ood Gate	ood Gate Control Panel	M, I	loor Closing Self-support Type	3	me as on the Left	3	
erhead Traveling ane	ane Power Panel	M, I	loor Closing Wall Hanging Type 3-Phase 220V	1	me as on the Left	1	
	ommon Protection Panel	I	loor Closing Self-support Type	1	me as on the Left	1	
	sh Button Switch Box	I	loor Closing Type	1	me as on the Left	1	
	rtain Cable	I	5 mm^2 x 3C x 20 m	1	me as on the Left	1	
ncrete Works		I		1		1	

Remarks; C: Clearance, M: Manufacture, I: Installation

The target components of the Project based on the above mentioned results were adjusted as shown below. Paints of anticorrosive coat, spare parts for engines and four stop logs for Quiapo, five rubbers of stop logs for Tripa de Gallina are excluded in the list. However, they are included as targeted equipment.

Table 2-5 Targeted Equipment

Items	Quiapo		Aviles・Sampaloc		Tripa de Gallina	
	Items	Qty.	Items	Qty.	Items	Qty.
Main Pump	Guide Casing	4	Guide Casing	4	Submerged Bearing Sleeve	1
	Discharge Elbow	1	Discharge Elbow	1	Packing Sleeve	4
	Impeller Nut	1	Column Pipe	2	Submerged Bearing	1
	Impeller Washer	4	Oil Seal	4	Lantern Ring	5
	Oil Seal	4	Shaft Enclosing Tube	4	Packing	8
	Submerged Bearing	1	Bowl Bearing	4	Trust Bearing Radial Bearing	1
	Shaft Enclosing Tube	4				
	Bowl Bearing	4			V-Belt（for Grease Pump）	6
	Mechanical Seal	1				
	Coupling Bolt	1				
Main Engine	Main Engine	4	Main Engine	4	Main Engine	8
			Reduction Gear	4	Reduction Gear	8
Electric System	Control Center (3 faces)	1	Control Center (3 faces)	1	Control Center (6 faces)	1
	Battery and Charger Panel	1	Battery and Charger Panel	1	Battery and Charger Panel	1
	Common Control Panel	1	Common Control Panel	1	Common Control Panel	1
	Local Control Panel	4	Local Control Panel	4	Local Control Panel	8
	Trash Screen Control Panel	1	Trash Screen Control Panel	1	Trash Screen Control Panel	2
	Conveyor Control Panel	1	Conveyor, Hopper Control Panel	1	Conveyor Control Panel	1
	Wiring and Piping	1	Wiring and Piping	1	Wiring and Piping	1
Trash Screen Facilities	Renewal of Rake （6 pieces／unit）	4	Horizontal Conveyor Belt, Roller	1	Renewal of Rake （6 pieces／unit）	8
	Horizontal Conveyor	1	Inclined Conveyor Belt	1	Horizontal Conveyor	2
	Inclined Conveyor	1	Hopper	1	Inclined Conveyor	1
	Second Screen	2				
Auxiliaries	Clear Water Pump	2	Clear Water Pump	2	Clear Water Pump	4
	Cooling Water Pump (Engine)	4	Cooling Water Pump (Engine)	4	Cooling Water Pump (Common)	4
	Cooling Water Pump (Generator)	2	Cooling Water Pump (Generator)	2	Vacuum Pump	4
	Fuel Transfer Pump	2	Fuel Transfer Pump	2	Fuel Transfer Pump	2
	Drainage Pump	2	Drainage Pump	2	Drainage Pump	2
	Air Compressor	2	Air Compressor	2	Air Compressor	4
	Cooling Tower	3	Cooling Tower	2	Cooling Tower (1)	2
	Ventilation Fan	2	Ventilation Fan	2	Cooling Tower (2)	2
	Canal and River Water Gauge	2	Canal and River Water Gauge	2	Ventilation Fan	5
	Suction Well Water Gauge	4	Suction Well Water Gauge	1	Canal and River Water Gauge	2
	Cooling Water Tank Water Gauge	1	Cooling Water Tank Water Gauge	1	Suction Well Water Gauge	8
	Cooling Water Tank Thermometer	1	Cooling Water Tank Thermometer	1	Cooling Water Tank Water Gauge	1
	Piping	1	Piping	1	Cooling Water Tank Thermometer	1
					Piping	1
Flood Gate	Flood Gate Control Panel	2	Flood Gate Control Panel	2	Flood Gate Control Panel	3
Overhead Traveling Crane	Crane Power Panel	1	Crane Power Panel	1	Crane Power Panel	1
	Common Protection Panel	1	Common Protection Panel	1	Common Protection Panel	1
	Push Button Switch Box	1	Push Button Switch Box	1	Push Button Switch Box	1
	Curtain Cable	1	Curtain Cable	1	Curtain Cable	1
Concrete Works	Foundation of Engine	4	Foundation of Engine	4	Foundation of Engine	8
	Foundation of Cooling Tower	3	Foundation of Cooling Tower	2	Foundation of Cooling Tower	4
			Eddy Flow Prevention Wall	4		

2.2.3 Basic Design Drawing

Design drawings of the Project consist of layout of equipment, piping and wiring, etc., of drainage pumping stations. List of design drawings is shown in following table;

Table 2-6 List of Design Drawing

Drawing No.	Name of Drawings	Qnt.
1	Quiapo Drainage Pumping Station Proposed General Layout	1
2	Quiapo Drainage Pumping Station Proposed Elevation Plan	1
3	Quiapo Drainage Pumping Station Proposed Piping Flow Sheet	1
4	Quiapo Drainage Pumping Station Proposed Oil and Air Flow Sheet	1
5	Quiapo Drainage Pumping Station Proposed Engine Floor Small Piping Plan	1
6	Quiapo Drainage Pumping Station Proposed Pump Floor Small Piping Plan	1
7	Quiapo Drainage Pumping Station Proposed Small Piping Elevation Plan	1
8	Quiapo Drainage Pumping Station Proposed Engine Floor Foundation Plan	1
9	Quiapo Drainage Pumping Station Proposed Pump Floor Foundation Plan	1
10	Quiapo Drainage Pumping Station Proposed Cooling Tower Foundation Plan	1
11	Quiapo Drainage Pumping Station Proposed Wiring Plan	1
12	Quiapo Drainage Pumping Station Proposed Wiring Table	3
13	Quiapo Drainage Pumping Station Proposed Single Line Diagram	1
14	Quiapo Drainage Pumping Station Reference Drawings of Panels	1
15	Quiapo Drainage Pumping Station Existing General Layout	1
16	Quiapo Drainage Pumping Station Existing Elevation View	1
17	Quiapo Drainage Pumping Station Existing Piping Flow Sheet	1
18	Quiapo Drainage Pumping Station Existing Oil and Air Flow Sheet	1
19	Quiapo Drainage Pumping Station Existing Engine Floor Small Piping Layout	1
20	Quiapo Drainage Pumping Station Existing Pump Floor Small Piping Layout	1
21	Quiapo Drainage Pumping Station Existing Small Piping Elevation View	1
22	Quiapo Drainage Pumping Station Existing Engine Floor Foundation	1
23	Quiapo Drainage Pumping Station Existing Pump Floor Foundation	1
24	Quiapo Drainage Pumping Station Existing Cooling Tower Foundation	1
25	Quiapo Drainage Pumping Station Existing Wiring Layout	1
26	Quiapo Drainage Pumping Station Existing Wiring Table	3
27	Quiapo Drainage Pumping Station Existing Single Line Diagram	1
Sub-Total		31

Drawing No.	Name of Drawings	Qnt.
28	Aviles・Sampaloc Drainage Pumping Station Proposed Engine Floor General Layout	1
29	Aviles・Sampaloc Drainage Pumping Station Proposed Pump Floor General Layout	1
30	Aviles・Sampaloc Drainage Pumping Station Proposed Elevation Plan	1
31	Aviles・Sampaloc Drainage Pumping Station Proposed Piping Flow Sheet	1
32	Aviles・Sampaloc Drainage Pumping Station Proposed Oil and Air Flow Sheet	1
33	Aviles・Sampaloc Drainage Pumping Station Proposed Engine Floor Small Piping Plan	1
34	Aviles・Sampaloc Drainage Pumping Station Proposed Pump Floor Small Piping Plan	1
35	Aviles・Sampaloc Drainage Pumping Station Proposed Small Piping Elevation Plan	1
36	Aviles・Sampaloc Drainage Pumping Station Proposed Engine Floor Foundation Plan	1
37	Aviles・Sampaloc Drainage Pumping Station Proposed Pump Floor Foundation Plan	1
38	Aviles・Sampaloc Drainage Pumping Station Proposed Cooling Tower Foundation Plan	1
39	Aviles・Sampaloc Drainage Pumping Station Proposed Wiring Plan	2
40	Aviles・Sampaloc Drainage Pumping Station Proposed Wiring Table	3
41	Aviles・Sampaloc Drainage Pumping Station Proposed Single Line Diagram	1
42	Aviles・Sampaloc Drainage Pumping Station Reference Drawings of Panels	1
43	Aviles・Sampaloc Drainage Pumping Station Existing Engine Floor General Layout	1
44	Aviles・Sampaloc Drainage Pumping Station Existing Pump Floor General Layout	1
45	Aviles・Sampaloc Drainage Pumping Station Existing Elevation View	1
46	Aviles・Sampaloc Drainage Pumping Station Existing Piping Flow Sheet	1
47	Aviles・Sampaloc Drainage Pumping Station Existing Oil and Air Flow Sheet	1
48	Aviles・Sampaloc Drainage Pumping Station Existing Engine Floor Small Piping	1
49	Aviles・Sampaloc Drainage Pumping Station Existing Pump Floor Small Piping	1
50	Aviles・Sampaloc Drainage Pumping Station Existing Small Piping Elevation View	1
51	Aviles・Sampaloc Drainage Pumping Station Existing Engine Floor Foundation	1
52	Aviles・Sampaloc Drainage Pumping Station Existing Pump Floor Foundation	1
53	Aviles・Sampaloc Drainage Pumping Station Existing Cooling Tower Foundation	1
54	Aviles・Sampaloc Drainage Pumping Station Existing Wiring Layout	2
55	Aviles・Sampaloc Drainage Pumping Station Existing Wiring Table	3
56	Aviles・Sampaloc Drainage Pumping Station Existing Single Line Diagram	1
57	Tripa de Gallina Drainage Pumping Station Proposed General Layout	1
58	Tripa de Gallina Drainage Pumping Station Proposed Elevation Plan	1
59	Tripa de Gallina Drainage Pumping Station Proposed Piping Flow Sheet	1
60	Tripa de Gallina Drainage Pumping Station Proposed Oil and Air Flow Sheet	1
61	Tripa de Gallina Drainage Pumping Station Proposed Small Piping Plan	3
Sub-Total		42

Drawing No.	Name of Drawings	Qnt.
62	Tripa de Gallina Drainage Pumping Station Proposed Cooling Tower Small Piping Plan	1
63	Tripa de Gallina Drainage Pumping Station Proposed Foundation Plan	1
64	Tripa de Gallina Drainage Pumping Station Proposed Foundation Detail Plan	2
65	Tripa de Gallina Drainage Pumping Station Proposed Cooling Tower Foundation Plan	1
66	Tripa de Gallina Drainage Pumping Station Proposed Wiring Plan	2
67	Tripa de Gallina Drainage Pumping Station Proposed Wiring Table	4
68	Tripa de Gallina Drainage Pumping Station Proposed Single Line Diagram	1
69	Tripa de Gallina Drainage Pumping Station Reference Drawings of Panels	1
70	Tripa de Gallina Drainage Pumping Station Existing General Layout	1
71	Tripa de Gallina Drainage Pumping Station Existing Elevation View	1
72	Tripa de Gallina Drainage Pumping Station Existing Piping Flow Sheet	1
73	Tripa de Gallina Drainage Pumping Station Existing Oil and Air Flow Sheet	1
74	Tripa de Gallina Drainage Pumping Station Existing Small Piping	4
75	Tripa de Gallina Drainage Pumping Station Existing Cooling Tower Small Piping	1
76	Tripa de Gallina Drainage Pumping Station Existing Foundation	1
77	Tripa de Gallina Drainage Pumping Station Existing Foundation Detail Drawings	2
78	Tripa de Gallina Drainage Pumping Station Existing Cooling Tower Foundation	1
79	Tripa de Gallina Drainage Pumping Station Existing Wiring Layout	2
80	Tripa de Gallina Drainage Pumping Station Existing Wiring Table	4
81	Tripa de Gallina Drainage Pumping Station Existing Single Line Diagram	1
Sub-Total		33
Total		106

The above listed drawings are part of a separate volume named “Basic Design Drawings”.

2.2.4 Procurement Plan

2.2.4.1 Procurement Policy

Japanese contractors who undertake a contract of procurement of equipment and installation works have to complete such works within a limited time period. Especially, installation works of the Project have to be completed during the dry season when necessity of pump operation is small and operating conditions have to be arranged before the rainy season starts. Therefore, the contractor has to have an intimate knowledge of local procurement conditions such as being a branch and subcontractor, etc. Actually, installation works shall be carried out under the control of on-site procurement manager and technician who are dispatched from Japan and commissioning (acceptance inspection, initial run, handover, etc.) of procured equipment and materials shall be carried out by an engineer to be dispatched from Japan. Related parties of the Project should stay in close contact in order to handover target equipment smoothly.

The following policies shall be planned out for procurement and installation works of equipment and materials;

- Since some equipment have a long manufacturing period, installation works plan has to ensure consistency with the manufacturing period.
- Since installation period is limited to the dry season and operating conditions have to be arranged before the rainy season starts, constraints which shall lead to delay of the implementation schedule should be included so that the Japanese contractor can carry out schedule control.
- As for the selection of equipment and materials, availability of spare parts and consumable supplies shall be considered.
- As for the procurement of equipment and materials, optimum products for use in the Philippines shall be selected from local products, Japanese made products, and products of third countries in line with technical level of the site, situation of operation and maintenance, mastery of equipment by local staff, etc.

2.2.4.2 Procurement Conditions

(1) Conditions on Procurement of Equipment and Materials

For the procurement of equipment and materials, an implementation schedule shall be drawn up paying attention to following items in order to prevent delay in transportation, installation, and handover.

- Since delay in arrival of equipment and materials will cause of delay in the implementation schedule of installation works, smooth implementation of tax benefits, import permit, custom clearance, other related procedures by the Philippines side shall be paid attention.
- Japanese contractor shall confirm situation for transportation of equipment and materials and pay enough attention to smooth implementation of custom clearance and receiving.

(2) Conditions for Installation Works

It is necessary to carry out installation works and moving of equipment and materials taking working space and road conditions in and around drainage pumping stations into account. Actual conditions of drainage pumping stations are described below and the implementation schedule of installation works should take these things into account.

1) Quiapo Drainage Pumping Station

Space of the drainage pumping station is narrow. So, it is impossible to move in heavy machinery. The following items shall be taken into account for works of Quiapo drainage pumping station.

- Garbage which is stacked at entrance of the drainage pumping station and an inclined conveyor have to be taken away, otherwise, equipment and/or materials for rehabilitation and renewal of trash screen, flood gate rolling system can not be carried in.
- Since heavy machinery can not enter to working space, it is necessary to consider conveyance by a small carrying machinery or by manpower for material handling operation in the drainage pumping station.
- It is assumed that equipment and materials shall be delivered disassembled and shall be assembled at site.
- In case equipment and materials shall be carried in from a temporary stockyard to the site by middle size truck, it will be necessary to remove vehicles which are parked and temporary shops, etc. around the pumping station.
- The drainage pumping station is located in a poor area where not only petty crimes but also homicide using guns frequently occur. Therefore, it is necessary to pay enough attention to security measurement during the implementation period.
- There was information that stop logs are used sharing with other two drainage pumping stations. However, the information could not be confirmed during field study. Therefore, it is necessary to procure stop logs for recording maintenance in the future.

2) Aviles・Sampaloc Drainage Pumping Station

The inside of the drainage pumping station is arranged well. It is possible to use middle and small machinery for repairing of conveyor, clearance and installation of hopper in the neighborhood of the site. However, it is necessary to use floating crane for installation works of cooling tower and control panels of flood gate because entrance is closed by fuel tanks. Other items to be considered are not confirmed.

3) Tripa de Gallina Drainage Pumping Station

Space of the drainage pumping station is sufficient and passageway for equipment and materials is also wide enough. There are five stop logs in the drainage pumping station at present. Waterproofing using existing stop logs was carried out in order to confirm damage of automatic trash screen during field study. However, waterproof could not be performed sufficiently because of damage and deterioration of rubber packing of stop logs. Therefore, it is necessary to procure rubber packing for stop logs for future maintenance. Other items to be considered are not confirmed.

2.2.4.3 Scope of Works

Scope of works of the Project can be divided into (1) procurement of equipment and materials, and (2) installation works. Division of responsibility for the Project works between the Philippines side and Japan side is shown in following table.

Table 2-7 Division of Responsibility for the Project Works

Items	Japan Side	Philippines Side	Remarks
1. Procurement of Equipment and Materials			
Procurement of Equipment and Materials	●		
Packing of Equipment and Materials	●		
Marine Transport of Equipment and Materials	●		
Inland Transportation of Equipment and Materials	●		
Carrying in and Installation of Equipment and Materials	●		
Alignment / Initial Run of Equipment and Materials	●		
Initial Operation Guidance of Equipment	●		
O&M Guidance of Equipment	●		
Electric and Water Charge	●		
Permission of Implementation		●	
Securing of Storage Yards of Equipment and Materials		●	
Coat of Parts which necessary to be carried out Anticorrosion Measures		●	
Clearance and Relocation of Existing Facilities	●	●	Items related to schedule management shall be the responsibility of Japan side
Final Disposal of Cleared Equipment and materials		●	
2. Tax Benefit		●	
3. Custom Clearance and Customs Charge		●	
4. Security Measures		●	

Procurement of equipment and materials in Japan and the Philippines, packing, marine transport, inland transportation from the port to drainage pumping stations, carrying in, installation, clearance of

existing facilities related to schedule management, electric and water charge during implementation period, adjustment and initial operation guidance, O&M guidance shall be carried out by Japanese contractor. Especially since clearance of existing facilities should be carried out while maintaining function of drainage pumping stations as much as possible into account, facilities that should be removed according to implementation schedule shall be the responsibility of Japan side.

Ensuring storage yard, permission of implementation at drainage pumping stations, clearance or relocation of circumjacent facilities related to the Project, clearance of existing facilities not related to implementation schedule, security measures, cost of Philippines staff related to supervision of the implementation and presence of inspection, tax benefit and final disposal of existing facilities shall be the responsibility of the Philippines side.

2.2.4.4 Procurement Management Plan

Consultant and contractor shall perform following procurement management for smooth implementation of procurement of equipment and materials from the bidding to installation and handover.

(1) Consultant

Procurement management by the consultant shall be divided into bidding support and procurement management. Major contents of consulting services at each step are shown in following table.

Table 2-8 Contents of Procurement Management by the Consultant

Steps	Contents of Services
Bidding support	・ Drawing up Bid Documents ・ Calculation of Estimation Cost ・ Bidding Support ・ Selection of Contractor
Procurement Management	・ Inspection and Approval of Shop Drawing of Equipment ・ Production (Shop) Inspection ・ Inspection before Shipping ・ Supervision of Installation Works ・ Confirmation of Initial Run and Handover ・ Support of A/P and Related Procedure ・ Confirmation of Progress of the Project for both Governments and Related Organizations

(2) Contractor

The contractor shall have a procurement manager in Japan and dispatch a site procurement manager and technician meet to arrival of procured equipment and materials to the Philippines. Japanese engineer shall be dispatched for combined initial run and alignment. These people shall carry out the following affairs in Japan and at the site.

- Presence at Production (Shop) Inspection in Japan
- Presence at Inspection before Handling and Shipping
- Presence at Production (Shop) Inspection of Local Products in the Philippines
- Installation Works of Equipment and Materials
- Individual Test of Equipment
- Initial Run and Alignment
- Initial Operation Guidance and O&M Guidance
- Contact and coordination with Client and Consultant
- Administrative management of the Project

2.2.4.5 Quality Control Plan

(1) Quality Control of Equipment and Materials

For the quality control of equipment and materials, the following inspections are planned.

1) Checking and Approval of Fabrication Drawings and Specifications

Fabrication drawings, working drawings, specifications, structural calculation sheet, process planning and execution scheme plan which are submitted by contractor shall be checked and approved.

2) Production (Shop) inspection

Conformity to specification of each equipment and part, performance test of each device, number (items, quantity) shall be confirmed before handling products. Equipment and materials which are procured in Japan shall be confirmed at factories of each manufacturer. As for procured products in the Philippines, the control center, common control panel, local control panel, trash screen control panel, overhead traveling crane power panel shall be inspected after fabrication at factories in the Philippines.

3) Inspection before Shipping

Inspection before shipping shall be entrusted a task to third-party organization. Contents of the inspection shall be as follows: ①checking between list of equipment and materials in contract document and shipping document, ②checking of quantity between shipping document and equipment and materials, ③checking of packing condition and confirmation of shipping mark.

Inspection before shipping shall be carried out two times because manufacturing lead time of pumps, electrical products, auxiliaries and engines are different. Place of the inspection shall be warehouse for packing of each manufacturer.

(2) Quality Control of Installation Works

Quality control of installation works shall be carried out taking the following items into account.

1) Schedule Control

Implementation process, process planning, schedule control plan, procurement plan of major equipment and materials on the implementation plan which shall be submitted by the contractor after the contract shall be examined carefully and it shall be confirmed whether all installation works which are mentioned in the specification can be finished within the fixed implementation period or not. Progress of implementation shall be supervised based on the implementation schedule and actual progress of the implementation after approval of the implementation plan. In case of progress delay, site manager shall be offered proper measures for recovery of delay.

2) Supervision of Installation Works

Conclusive confirmation as a drainage pumping station shall be inspected by combined loading test after completion of installation works of each equipment. Supervision of works on major equipment and materials shall be carried out taking the following items into account during implementation period.

Table 2-9 Points of Concern during Installation Works

Name of Equipment	Points of Concern
Common	・ Measure of Installation ・ Damage or Rusting of Equipment ・ Looseness of Bolt, etc. ・ Leakage of Oil and damage of Coating
Main Pump	・ Error of Installation Accuracy (Error of Shaft Center, Clearance between Impeller and Casing)
Main Engine	・ Levelness of Installation ・ Height of Shaft Center ・ Distortion and Bias
Reduction Gear etc.	・ Levelness of Installation ・ Distance between Flanges ・ Error of Shaft Center ・ Height of Shaft Center
Piping and Wiring	・ Location of Piping and Wiring ・ Installation Condition of Support Metallic Materials ・ Condition of Junctions ・ Under Cut of Welding Point, Crack

3) Supervision on Placing of Concrete and Reinforced Bar

For the placing of concrete for foundations of engines and cooling towers, trial mix shall be carried out in order to confirm water-cement ratio and concrete strength and decide a job-mix. Six test pieces of concrete which are used to place concrete shall be made to check compressive strength of 7 days and 28 days when concrete foundation is placed. More than three test pieces shall be used for the compressive strength test and strength shall be checked by average value.

Reinforced bar shall be checked by mill sheet whether quality satisfies specification or not. Distorted reinforced bar for transportation shall be prohibited to stretch and use. Bar arrangement and protective covering of the reinforced bar shall be checked based on bar scheduling before placing the concrete.

4) Safety Management

Safety management shall be supervised based on a safety management plan in the implementation plan which is submitted by contractor and approved.

Safety precaution on conveyance of heavy load and works in narrow space, protection from falling from any opening and height, safety of machinery and electricity should be checked order to prevent disaster. Attenuator or fence should be placed in order to prevent the intrusion of persons who are not authorized personnel for implementation into the site and measures to ensure that inhabitants are not involved in accidents should be taken.

As for the approval of safety management plan which shall be submitted by contractor, the above mentioned points of concern and environmental assessment shall be verified and whether the contractor can take proper measures by the plan and implementation structure or not. In case that the safety management plan cannot be executed, safety management plan has to be modified and submitted again. Likewise, in case that proper measures were not taken during implementation, site manager shall be warned to take them.

On the other hand, in case that robbery of equipment and materials is occurred, most of equipment and materials can not be procured and be manufactured immediately. Therefore, measure such as place of fence should be taken around temporary storing yards.

(3) Combined Alignment and Handover

For the combined alignment and handover, the following inspections shall be carried out.

1) Individual Test of Equipment

In case of the Project, function of the drainage pumping station should be maintained as much as possible in preparation for unexpected storms, and operating conditions have to be arranged before the rainy season starts. Therefore, renewal equipment should be connected to existing or new equipment electrically and mechanically so that individual test of equipment can be carried out for alignment and initial run.

Individual test of equipment shall be carried out according to implementation management standards for mechanical works of MLIT. The consultant shall witness individual test of equipment. Major contents of the test shall be as follows.

Table 2-10 Major Contents of Individual Test of Equipment

Name of Equipment	Individual Test of Equipment
Main Pump	① Revolutions ② Function of Vacuum Break ③ Actuation of Limit Switch of Discharge Valve ④ Power Distribution of Discharge Valve
Main Engine	① Revolutions ② Start up Revolution ③ Oil Pressure, Oil Temperature ④ Cooling Water Temperature ⑤ Exhaust Sound, Exhaust Color, Exhaust Temperature ⑥ Power Continual Condition of Reduction Gear Clutch
Electrical Equipment, Wiring of Gate	① Lamp Test ② Each Activity Test ③ Insulated resistance, Earthing Resistance
Auxiliaries	① Flow Direction of Liquid ② Electrical Current
Trash Screen	① Electrical Current ② Conveyor Speed
Overhead Traveling Crane	① Operation Check
Small Piping	① Pressure Proof Test or Confirmation of Leakage

2) Combined Loading Test, Initial Run and Alignment

Combined loading test, initial run and alignment shall be carried out after completion of connection and installation works. Combined loading test, initial run and alignment shall be carried out by Japanese engineer to be dispatched. The consultant and the client shall witness final inspection and final confirmation of all systems carried out.

Table 2-11 Major Contents of Combined Loading Test

Name of Test	Major Contents of Test	Abstract
Combined Operation Test	Equipment shall be operated after connected electrically and mechanically. Abnormal vibration, abnormal noise and abnormal increase in temperature caused by sympathetic vibration and sympathetic resonance etc. shall be confirmed.	
Start and Stop Condition Test	Whether start and stop condition is interlocked exactly or not shall be confirmed. As for major equipment, time from start to stop shall be confirmed.	Mimic line shall be used if necessary.
Protector Test	Whether protector is interlocked exactly or not shall be confirmed. As for major lines, time from formation of protect line to stop or alarm shall be confirmed.	

3) Hand Over

The result of combined loading test shall be examined with MMDA and the certification of completion shall be issued to the contractor after confirmation of perfection of all equipment or systems according to requested specification. These are procedures of handover of equipment and materials.

Date and place of the completion ceremony shall be regulated and decided with related organization of the Japanese Government (Embassy, JICA etc.) and the client.

2.2.4.6 Procurement Plan

Equipment and materials which are procured by the Project shall have a policy of procurement in the Philippines taking ease of procurement and operation and maintenance into account. However, equipment and materials which can not be procured in the Philippines shall be procured in Japan. Likewise, since the counterpart organization requested that procurement from third country should be considered if it has economical advantage, procurement from third country shall consider many factors such as economic efficiency, after service, etc.. However, third countries shall be limited to DAC member countries from the viewpoint of good supplying practice. It can not be said that procurement from DAC member country excepted Japan is more cost efficient than Japan taking transport into account because of geographic condition of Japan and the Philippines. Therefore, procurement from third country shall be considered if there is another benefit.

(1) Parts of Main Pump

Large size pumps which are set up at three drainage pumping stations are not manufactured in the Philippines. Since existing pumps are made in Japan, renewal parts of main pumps shall be made in Japan.

(2) Main Engine

In case that excitation frequency of engine harmonizes with characteristic frequency of axial torsion, it becomes a resonant condition. Axial torsion is big and it becomes repeated stress. As a result, destruction due to twisting vibration can occur. To prevent this situation, pump maker and engine maker should present vibration properties of each equipment and have measures to cope with destruction due to twisting vibration such as using high-resiliency joint. However, it is not confirmed that Japanese pump maker can take measures generally with engine makers of third country. Therefore, main engine shall be procured in Japan.

(3) Electric System

Control panels and electric panels shall be procured from local suppliers because local suppliers assemble electric panels at their factories using imported products, parts and they sell it as their original

brand. Since Japanese contractors may procure these equipment in Japan because of ease of fabrication management, etc., control center and electric panels shall be procured in the Philippines or Japan.

Battery and Charger Panel which exchange alternating-current power to direct current, is not manufactured in the Philippines. Since battery can be acquired at local market and control panels are manufactured in the Philippines, possibility of local production can not be denied. However, Battery and Charger Panel shall be procured in Japan from viewpoint of reliability of products.

(4) Trash Screen Facilities

Rake, conveyor and hopper, etc. which are procured by the Project can be manufactured and procured in the Philippines. Since Japanese contractor may procure these equipment in Japan because of ease of fabrication management, etc., trash screen facilities shall be procured in the Philippines or Japan.

(5) Auxiliaries

Pumps, cooling tower, ventilation fan auxiliaries are not manufactured in the Philippines. Therefore, these shall be procured in Japan taking reliability of products into account.

Small piping can be procured in the Philippines. However, valves and expansion joints, etc. are difficult to acquire easily at local market and lack durability. On the other hand, in case that small pipes are procured and processed in Japan, pipes and valves, joints are easily jointed and the implementation period can be minimized. Therefore, small pipes shall be procured in Japan.

Canal and river water gauges are not manufactured in the Philippines. Therefore, these shall be procured in Japan. As for the canal and river water gauge, since made in Germany is sold in Japan constantly, there is a possibility that procurement from third country may be cheaper than procurement in Japan. Therefore, canal and river water gauges shall be procured in Japan or third country.

Other water gauges and thermometers are not manufactured in the Philippines. Therefore, these shall be procured in Japan taking reliability of products into account.

(6) Overhead Traveling Crane

Power panel of the overhead traveling crane can be manufactured in the Philippines as control panels. Since Japanese contractor may procure these equipment in Japan because of ease of fabrication management etc., power panel of the overhead traveling crane shall be procured in the Philippines or Japan.

Other renewal equipment of the overhead traveling crane are not manufactured in the Philippines. Since existing overhead traveling crane is made in Japan, renewal equipment has to match with existing equipment. Therefore, other renewal equipment of the overhead shall be procured in Japan.

(7) Electric Cable

Colgate cable which shall be used as countermeasures to rodents and disconnection is not manufactured in the Philippines and is difficult to acquire constantly. Therefore, electric cable shall be procured in Japan taking reliability of products and assuredness of procurement into account.

Equipment which shall be procured by the Project, suppliers and its reason is shown in the following table.

Table 2-12 Division on Procurement of Major Equipment

Items	Major Equipment	Supplier			Reasons
		Japan	Philippines	Third Country	
Main Pump	Parts of Main Body	○			Existing pump is made in Japan.
Main Engine	Main Body	○			Alignments with existing pumps which are made in Japan are necessary.
	Reduction Gear	○			
Electric System	Control Center	○	○		Local products are available.
	Battery and Charger Panel	○			It is not manufactured in the Philippines.
	Common Control Panel	○	○		Local products are available.
	Local Control Panel	○	○		
	Trash Screen Control Panel	○	○		
	Conveyor Hopper Control Panel	○	○		
Trash Screen Facilities	Trash Screen	○	○		Local products are available.
	Horizontal Conveyor	○	○		
	Inclined Conveyor	○	○		
	Hopper	○	○		
Auxiliaries	Clear Water Pump	○			They are not manufactured in the Philippines.
	Cooling Water Pump	○			
	Vacuum Pump	○			
	Fuel Transfer Pump	○			
	Drainage Pump	○			
	Air Compressor	○			
	Cooling Tower	○			
	Ventilation Fan	○			
	Small Piping	○			Guarantee of products cannot be confirmed.
	Canal and River Water Gauge	○		○	Products of DAC member country are sold in Japan constantly.
	Suction Well Water Gauge	○			It is not manufactured in the Philippines.
	Cooling Water Tank Thermometer	○			It is not manufactured in the Philippines.
Flood Gate	Flood Gate Control Panel	○	○		Local products are available.
Overhead Traveling Crane	Crane Power Panel	○	○		Local products are available.
	Common Protection Panel	○			Alignments with existing cranes which is made in Japan are necessary.
	Push Button Switch Box	○			
	Curtain Cable	○			
Electric Cable	Wiring	○			Colgate pipe can not be acquired constantly at local market.

2.2.4.7 Initial Operation Guidance and O&M Guidance Plan

Drainage pumping stations which are targets of the Project have been utilized for 30 years. Therefore, it is not necessary to carry out long operation and O&M guidance. Operation and O&M guidance for newly installed equipment such as engines and auxiliaries shall be carried out. Additionally, points of concern for implementation of anticorrosive coat shall be explained.

Initial operation and O&M guidance shall be carried out by Japanese engineer to be dispatched based on operation manuals and maintenance manuals which shall be supplied by the contractor further to combined loading test, initial run and alignment. Duration of the guidance shall be one day for each drainage pumping station respectively. General description of initial operation guidance and O&M guidance shall be as follows.

(1) Initial Operation Guidance

- Explanation of maintenance manuals
- Explanation and on-the-job guidance of point to be checked before the operation
- Explanation and on-the-job guidance of starting procedure
- Explanation and on-the-job guidance of point to be checked during operation
- Explanation and on-the-job guidance of point to be checked after the operation

(2) O&M Guidance

- Explanation of maintenance manuals
- Explanation on need and frequency of periodic inspections
- Explanation on general description of monthly inspections and annual inspection
- Explanation on general description and purpose of periodic maintenances
- Explanation of trouble which tend to be happened and its causes

(3) Point of Concern on Implementation of Anticorrosive Coat

- Explanation of target equipment and materials of anticorrosive coat
- Explanation on implementation procedure of anticorrosive coat
- Explanation of standard thicknesses of preliminary prime coat, first layer and second layer
- Explanation on point of concern on implementation of anticorrosive coat

2.2.4.8 Soft Component (Technical Assistance) Plan

As mentioned in item “2.2.1 (4) Policy on Operation and Maintenance Capacity of Implementation Agency”, technical assistance using soft component scheme is not planned in the Project.

2.2.4.9 Implementation Schedule

(1) Procurement of Equipment and Materials

Equipment and materials of Pumps, engines and electrical equipment are mainly built-to-order manufacturing. Therefore, the contractor shall ship through design, manufacturing, and inspection after acceptance of order. It takes 1.5 months for design works and 14.0 months for manufacture of engines and reduction gears which come under the influence of booming economy in China and Middle-East, 6.0 months for pump parts, auxiliaries and conveyor, 4.0 months for electric devices. Most equipment and materials except electric panels shall be procured in Japan. Conveyance period from Japan shall be assumed as 1.0 month including custom clearance.

(2) Installation Works

It is assumed that the Project is national bond project because period of installation works of the Project is limited to 6.0 months only per year, so it will take several years to install all equipment. Since dry season during which implementation is to take place is set from December to May, installation works shall take 15.0 months through three dry seasons. It shall take 0.5 month for initial operation guidance, O&M guidance, inspections and handover after completion of installation works. In short, it shall take 40.0 months from the contract agreement of the contractor to handover.

(3) Implementation Schedule

Implementation schedule of the Project is shown in Table 2-13 based on procurement and installation works plan.

Table 2-13 Implementation Schedule of the Project

	Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Seasons / Work Items		Dry Season			Rainy Season					Dry Season						Rainy Season						Dry Season						Rainy Season						Dry Season						Rainy Season						Dry Season			
Contract	Cabinet Council Approval	▲																																															
	Conclusion of Exchange Note		▲																																														
	Contract of Consultant			▼																																													
Detail Design	Final Confirmation of the Project Components			▬																																													
	Drawing up of Bid Documents				▭	▭																																											
	Approval of Bid Documents					▬																																											
	Bid Announcement					▼																																											
	One-Site Orientation and Distribution of Bid Documents						▭																																										
	Bid							▼																																										
	Evaluation of Bid							▬	▬																																									
	Contract with a Contractor								▼																																								
	(Certification by the Ministry of Foreign Affair)								(▼)																																								
Procurement Supervision	Drawing up Shop Drawings and Manufacturing of Equipments									▭	▭	▭	▭	▭	▭	▭	▭	▭	▭	▭	▭	▭																													
	Transportation of Equipments																				▨	▨												▨	▨															
	Removal and Installation																						▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬
	Alignment/ Guidance of Operation/ Hand over																																															▬

2.3 Obligations of Recipient Country

For the smooth implementation of the Project, obligations of the Philippines which are necessary to implement the Project are as follows.

(1) Items on Installation Works

1) Securing of Storage Space at Libertad Warehouse

Equipment and materials which are procured by the Project shall be carried into opening of Libertad warehouse and equipment and materials shall be classified for each drainage pumping station from containers. Classified equipment and materials for each drainage pumping station shall be conveyed from Livertad warehouse to each drainage pumping station or temporary storage yards which are secured adjacent of target drainage pumping stations. On the other hand, equipment and materials which are taken away shall be conveyed from drainage pumping stations to opening of Libertad warehouse and final disposal shall be responsibility of MMDA. Therefore, sufficient space such as the temporary storage yard should be secured at opening of Libertad warehouse.

2) Securing of Temporary Storage Yards for Quiapo and Aviles・Sampaloc Drainage Pumping Stations

Area of Quiapo and Aviles・Sampaloc drainage pumping station are narrow and it is difficult to secure a space to store equipment and material which are carried into it. Therefore, it is necessary to secure temporary storage yards near the drainage pumping station and necessary equipment and materials shall be carried into the drainage pumping station meet to progress of the implementation. Equipment and materials which are taken away shall also follow the same condition. In case that robbery of equipment or materials occurs, most of equipment and materials can not be procured immediately. Therefore, countermeasures such as placing of fence should be taken to prevent such incidents.

3) Removal of Wall and Telegraph Pole near the Entrance of Quiapo Drainage Pumping Station

Wall and a telegraph pole which are on the right side of the entrance at Quiapo drainage pumping station should be taken away, otherwise, equipment and materials can not be carried in because entrance of the drainage pumping station is extremely narrow. Therefore, telegraph pole should be moved before the implementation of the Project. The wall should be taken away before the implementation of the Project and should be rebuilt after the implementation.

4) Securing of Proper Traffic Line to Quiapo Drainage Pumping Station

Width of passageway from main road to Quiapo drainage pumping station is 7.0 to 8.0 m and length is approximately 300 m. Stands and vehicles are always located along the road. Common cars can pass at present. However, trucks which shall convey equipment and materials shall have some problem to pass the road. Therefore, when equipment and materials are taken in and out, sufficient traffic lane for trucks should be secured.

(2) Items for Other Procedures

- Donation of office space for Japanese consultant and contractor
- Donation of counterparts for Japanese consultant
- Approval on certification of implementation to Japanese contractor
- Payment of charge for Bank Arrangement (B/A) and Authorization to Pay (A/P)
- Custom clearance and speedy loading and unloading of equipment and materials which are procured by the Project in the Philippines
- Value-added tax and customs duty concerning Japanese who shall supply procured equipment and materials and services based on the approved contract shall be burden of the Philippines side
- Proper utilization and operation and maintenance of equipment and materials, facilities which are procured by the Project
- Responsibility for payment that can not be covered by the Japan's Grant Aid Project
- Proper safety and security measures for Japanese who are related to the Project

Obligations of the Philippines side were explained during the basic design study and some of items are mentioned in the Minuets of Discussion (M/D). Therefore, it is judged that obligation of the Philippine side is reasonable and implementation of obligations shall be available.

2.4 Project Operation Plan

2.4.1 Operation and Maintenance of Drainage Pumping Stations

Operation and maintenance of each drainage pumping station shall be carried out by PSFO under FCMS of MMDA after completion of the Project. PSFO has jurisdiction over small and large drainage pumping stations and flood gates located in Metropolitan Manila. They cover 15 large drainage pumping stations which were constructed by financial assistance of foreign country, 8 small drainage pumping stations which were constructed by local fund, 24 relief drainage pumping stations, one flood gate, 2 automatic trash screen facilities and other related facilities on flood control in Metropolitan Manila area. Target drainage pumping stations of the Project include 15 large drainage pumping stations which were constructed by financial assistance of foreign country. Operation and Maintenance of drainage pumping stations are carried out by plant engineers, operators who are stationed to each drainage pumping station under the instruction of PSFO headquarters. As for the staff pools of target drainage pumping stations, Quiapo has 18 members,

Aviles・Sampaloc has 17 members and Tripa de Gallina has 30 members. Three shift system per day such as 0:00 to 8:00, 8:00 to 16:00 and 16:00～0:00 is employed at drainage pumping stations. It is understood that proper operation and maintenance is carried out, even though technical level are little bit different for each drainage pumping station. Therefore, existing organization structure has no problem to operate and maintain target drainage pumping stations after completion of the Project.

Spare parts supplied by the Project shall be kept in Libertad warehouse as a common rule. Minor repairing shall be carried out by staff of each drainage pumping station and repairing that can not be done by staff of each drainage pumping station shall be carried out at Libertad workshop.

2.4.2 Organization Structure on Operation and Maintenance of Drainage Pumping Stations

Operation and Maintenance of drainage pumping stations are carried out by staff who are stationed at each drainage pumping station under the instruction of PSFO headquarters. Staff in charge of each drainage pumping station are used to carry out all activities concerning operation and maintenance of drainage pumping station. Safekeeping of spare parts and repairing that can not be done by staff of each drainage pumping station is done by warehouse and workshop located beside Libertad drainage pumping station at present.

In case trouble occurs or spare parts are necessary at a drainage pumping station, the plant engineer of each drainage pumping station informs the chief engineer in PSFO headquarters. Chief engineer or other engineer who is instructed by chief engineer shall go to the site to check, and actual action of warehouse and workshop shall be taken after the instruction of headquarters. Information of drainage pumping stations is unified already and organization structure which reports problems such as failure of equipment because of misjudgment of each drainage pumping station is already established. Additionally, plant engineers of each drainage pumping station hold weekly meetings as FCMS every Monday at MMDA headquarters with responsible officials of each unit of DWO in attendance. Organization structure for unification of the information and also sharing of the information is also established at present. Therefore, proper operation and maintenance after completion of the Project can be carried out by existing organization structure.

Personnel assignment of each drainage pumping station mentioned in the previous subsection, and workforce configuration of each drainage pumping station are shown in the following table.

Table 2-14 Personnel Assignment of Each Drainage Pumping Station

	Quiapo	Aviles・Sampaloc	Tripa de Gallina
Plant Engineer	1	1	1
Asis. Plant Engineer	1	1	1
Engineer	3	3	5
Mechanical and Electrical Operator	4	1	8
Electrical Foreman	0	1	0
Mechanical Foreman	0	1	0
Electrician	0	1	0
Mechanic	0	0	2
Utility Worker	2	6	3
Laborers	7	2	10
Total	18	17	30

Person in charge of operations as an operator are engineer, mechanical and electrical operators. Number of operators at each drainage pumping station are Quiapo 7 members, Aviles・Sampaloc 4 members and Tripa de Gallina 13 members. They work under the three-shift per day system. Working hours of other staffs is 8:00 to 16:00 only. Therefore, if problem occurs from 16:00 to 8:00 at drainage pumping stations, only staffs who are stationed for night shift can cope with the problem. It is considered that some trouble which occurs during the night may be left unsolved until the next morning.

Since flooding occurs during the night, it is difficult to be noticed to inhabitants, and the damage is subject to expansion. Organization structure which can solve problems occurring during the night should be established in order to carry out proper flood control around the clock, especially from June to November. Proposed personnel assignment which can carry out flood control around clock is shown in the following table.

Table 2-15 Proposed Personnel Assignment

	Quiapo	Aviles・Sampaloc	Tripa de Gallina
Plant Engineer	1	1	1
Asis. Plant Engineer	1	1	1
Operator	4	4	8
Electrician	4	4	4
Mechanic	4	4	4
Utility Worker	4	4	4
Laborers	8	8	8
Total	26	26	30

2.5 Project Cost Estimation

2.5.1 Initial Const Estimation

Initial expense of the Philippines side for the Project is estimated as 155 million Japanese Yen (64.02 million Pesos) according to estimation conditions that are mentioned below in item (2).

(1) Cost Borne by Philippine Side 64.02 million Pesos (Approx. 154.6 million JY)

① Rental Const on Temporary Storage Yards	800,000 Pesos (Approx. 1.9 million JY)
② Removal and Relocation Cost of Existing Facilities	60,000 Pesos (Approx. 0.1 million JY)
③ Security Measures Cost	1.800 million Pesos (Approx. 4.4 million JY)
④ Banking Arrangement Charge	490,000 Pesos (Approx. 1.2 million JY)
⑤ VAT and Custom Clearance Fee	60.87 million Pesos (Approx. 147.0 million JY)

Note: Any other taxes such as national interval revenue taxes and import duties are not included.

(2) Estimation Conditions

① Conditions	:	As of March in 2007
② Exchange Rate	:	1US$＝ 119.60 JY
	:	1US$＝ 49.18 Peso
	:	1Peso＝ 2.42 JY
③ Procurement Period	:	Period of bidding, procurement of equipment and materials, installation works is shown in the implementation schedule
④ Others	:	Estimation is carried out based on Japan's Grant Aid system

2.5.2 Operation and Maintenance Cost

Drainage pumping stations which shall carry out procurement and installation works by the Project shall be operated and maintained by PSFO as mentioned in "2.4 Project Operation Plan". Annual operation and maintenance cost is estimated as 24.995 million Peso (Approx. 60.513 million JY) (Refer to Table 2-16). Operation and maintenance cost is divided into management cost such as personnel expense, fuel cost, electrical and water fee, etc., and O&M cost. Budget should be secured taking escalation in personnel expense and prices into account in order to be operated without any problem in 2020 which is the target year.

Table 2-16　O&M Cost of Targeted Drainage Pumping Stations (Annual)

Expense Item		Amount （Pesos）
Management Cost	Quiapo Drainage Pumping Station	3,617,000
	Aviles・Sampaloc Drainage Pumping Station	4,420,000
	Tripa de Gallina Drainage Pumping Station	6,545,000
	Sub-total	14,582,000
O&M Cost	Quiapo Drainage Pumping Station	2,056,000
	Aviles・Sampaloc Drainage Pumping Station	2,461,000
	Tripa de Gallina Drainage Pumping Station	5,896,000
	Sub-total	10,413,000
Total		24,995,000

2.6 Other Relevant Issues

For the smooth implementation of the Project, following items should be paid attention;

Securing of Temporary Storage Yards near Target Drainage Pumping Stations

Equipment and materials shall be carried into opening of Libertad warehouse after the custom clearance and equipment and materials shall be classified for each drainage pumping station from containers. Classified equipment and materials for each drainage pumping station shall be conveyed from Libertad warehouse to each drainage pumping station. However, target drainage pumping stations are narrow excepted Tripa de Gallina drainage pumping station and it is difficult to secure a space to store equipment and materials in the site directly. Therefore, it is necessary to secure temporary storage yards near the drainage pumping station and necessary equipment and materials shall be carried into the drainage pumping station meet to progress of the implementation. Since most of equipment and materials shall be procured in Japan and these are expensive, temporary storage yards should be located at a safety place. In case that robbery of equipment or materials occurs, most of equipment and materials can not be procured immediately. Therefore, countermeasure such as placing of fence or stationing of security guard should be taken to prevent such incidents.

Implementation of Anticorrosive Coat as Maintenance Work during Dry Season

As the result of overhauling, most equipment that are pointed out as having parts which necessary to repair, can be given an anticorrosive coat. If anticorrosive coat is not carried out for these equipment, there is a possibility that these equipment should be replaced. It is important that anticorrosive coat should be carried out step by step based on proper maintenance plan after completion of the Project in order to use equipment until 2020 under well condition.

Fulfillment of Certain Tax Burden

It is fundamental rule that tax concerning Japan's Grant Aid Project shall be burden of the recipient countries. Tax concerning provision of equipment and materials and customs duty concerning Japanese who shall supply services based on the approved contract should be paid by the Philippines side. In particularly, import tax, value-added tax and taxes concerning habitation and supplying services by Japanese should be burden of the Philippines side. Procedure of tax exemption shall be different between central governmental organization and local government organization in the Philippines as follows;

- In case that the implementation agency is central government organization

  The implementation agency shall submit an application form of tax exemption to custom office based on application form prepared by Japanese contractor. Custom office shall issue a notice of allowance of tax exemption to the implementation agency. Japanese contractor shall receive the notice of allowance of tax exemption from the implementation agency and receive tax benefit.

- In case that the implementation agency is local government organization

  The implementation agency shall submit a certification that this project is Japan's Grant Aid Project and a list of equipment and materials which shall be imported to Office of Executive Secretary of Malacañang. After the approval of the office, procedure shall be same as the case of central government organization.

The implementation agency of the Project is MMDA and MMDA is classified as neither local government organization nor central government organization. Therefore, necessary procedure for MMDA is not clear. For exact tax exemption, MMDA should confirm a procedure with custom office and Office of Executive Secretary of Malacañang before the implementation of the Project.

Smooth Shipping and Discharging and Custom Clearance of Procured Equipment and Materials in the Philippines

Direct problem that the Project shall be delayed shall be smooth shipping and discharging and custom clearance of procured equipment and materials in the Philippines. Therefore, it is important that procedure shall be confirmed before the implementation of the Project in order to carry out the smooth shipping and discharging and custom clearance at the port of Manila

Exact Implementation of Security Measure

Quiapo drainage pumping station is located in a poor area where not only petty crimes but also homicide frequently occur. Therefore, it is concerned over the possibility that the Project shall be delayed or stopped by deteriorating condition of public safety. Likewise, there is a possibility that an incident or crimes shall occur during transportation of equipment and materials because they are relatively expensive. As mentioned in the M/D, security measure should be responsibility of the Philippines. It is necessary that concrete security measure should be confirmed and necessary structure should be developed before the implementation of the Project.

Chapter 3 Project Evaluation and Recommendations

Chapter 3 Project Evaluation and Recommendations

3.1 Project Effect

The current situation/problems, direct and indirect effects of the Project shall be shown in Table 3-1.

Table 3-1 Effects and Improvement in the Current Situation by the Project

Current situation/ problems	Measurement by the Project	Effects of the Project
Direct effects		
Deterioration of all system of targeted drainage pumping stations is remarkable and situation is serious due to overloading of operation caused by inflow of a large quantity of solid waste.	Improvement and upgrading of deteriorated equipment shall be carried out.	1. Breakdown of the targeted drainage pumping stations shall be prevented. 2. Flooding volume 2,740 thousands m^3, flooding area 4,493 thousands ha which are occurred by breakdown of the targeted drainage pumping stations can be reduce to flooding volume 744 thousands m^3, flooding area 2,013 thousands ha. 3. Fuel consumption efficiency shall be improved and O&M cost shall be reduced.
Indirect effects		
Breakdown of the targeted drainage pumping stations will be occurred and prolonged flooding damage will be occurred at the basin.	Function of the targeted pumping stations shall be recovered.	1. Expansion of impassable area will be prevented as well as social and economic activities are not impeded. 2. Hemorrhage of public and private asset by the flood damage shall be prevented and deterioration of living standard shall be reduced.

3.2 Recommendations

3.2.1 Recommendations that the Recipient Country should address

Following items should be respected in order to continue the effects of the Project which shall be improved and upgraded the faction of the targeted drainage pumping stations;

(1) Securement of Budget based on Annual Operation and Maintenance Plan

Routine inspection such as daily check, monthly check and 5 years maintenance, 10 years maintenance as well as maintenance of trouble and failure which is clarified by routine inspection should be carried out in order to keep up the condition which the drainage pumping station behave well. In short, it is necessary to find out signs of failure on equipment exactly. It is said that implementation of these inspection and maintenance according to concept of preventive upkeep shall lead to following good

results; 1) This method will be economical compared to measurement after trouble considering long-term expenditure. 2) Life of equipment can be extended. Implementing the preventive upkeep, ensuring of the budget and system which can be implemented effectively based on annual operation and maintenance plan according to long-term maintenance plan are important. Therefore, present system which can not be clarified the annual budget at beginning of the fiscal year should be improved and the necessary budget for implementation of annual operation and maintenance plan should be allocated. At least, annual budget should be clarified at beginning of fiscal year and proper system which can modify the annual operation and maintenance plan based on annual budget and deliberate operation and maintenance can be implemented should be established.

(2) Operation of the Drainage Pumping Stations based on Proper Pump Operation Rule

Present operation rule is not previous rule according to commencement water level of commercial operation of pump and stop water level which was decided during previous design period. Therefore, pump operation is not started unless staff finds out rainfall even through water level of drainage canal rise up more than commencement water level of commercial operation of pump. However, in case that pump operation is started, they keep stop water level. There are four rainfall observation stations in and around Metropolitan Manila. Local storm often occur in Metropolitan Manila because of characteristic of rainfall. Therefore, it is very difficult that these rainfall observation stations can grapes micrometeorological situation. Incase that the drainage pumping stations are operated on present rule and local storm occur under the situation of high water level, it is clear that serious damage will be gained compared to previous operation rule. Since global climate change is noticed, it is very important that operation rule should be employed previous rule which the pump shall be started at commencement water level of commercial operation of pump.

3.2.2 Technical Cooperation, Cooperation with other donor

There are 15 large scale drainage pumping stations which pay a role of flood control in Metropolitan Manila. 12 drainage pumping stations out of 15 drainage pumping stations including 3 drainage pumping station that are target of this Project are suggested that similar measures with this Project are necessary. Likewise, following items are recommended as the priority projects in the development study excepted measurements of 12 drainage pumping stations;

Table 3-2 Components of Priority Project (Master Plan)

1. Rehabilitation Works of Drainage Channels Dredging of Esteros / Creeks: 139,000 m^3 - Estero de Sunog Apog / Maypajo (partially) - Estero de Tripa de Gallina (partially) - PNR Canal (partially) - Calatagan Creek I Declogging of Culvert: 20,000 m^3 - Blumentritt Interceptor - Buendia Outfall - Zobel Roxas Culvert - Faraday Culvert - Pasong Tamo Culvert Related Works: - -Relocation of Informal Settlers: 825 families
2. Additional Works for North and South Manila North Manila - Additional works of Blumentritt Interceptor - Improvement works of Blumentritt Interceptor - Construction of additional Interceptor South Manila - Additional Box Culvert along Zobel Roxas Culvert - Additional Box Culvert along Faraday Culvert
3. Supporting Measures Improvement of Operation and Maintenance Organization and Activities and Promotion of Community-Involved Activities - Improvement of the existing O&M organization and activities including establishment of Community-Involved O&M - Community-Involved Solid Waste Management Installation of Additional Hydrological Equipment Introduction of Emergency Operation and Maintenance Equipment Preparation of Guideline for Resettlement

MMDA have been carrying out a part of above stated activities focus on rehabilitation of drainage channels. However, significant progress is not resulted because of limitation of their budget. Improvement activity of the drainage pumping station is kept intact as present. Since improvement of Metropolitan Manila drainage system can be achieved by implementing above stated measures comprehensively, technical and financial assistance by foreign donor is necessity considering present economic condition of the Philippines. Especially, Japan's assistance that paid a important role in flood control project in Metropolitan Manila since 1972 and have a lot of experience on flood control of Metropolitan Manila shall be greatly expected.

It is unavoidable fact that problem on relocation of illegal settlers must surface when above measurement is implemented. Several measurements such as relocation of illegal settlers as well as generation of job opportunity, formal education and securing of healthcare facilities must be carried out in order to solve the problem. Since Asian Development Bank (ADB) has actual performance in development of relocation destination and World Bank (WB) is seeking cooperation with Japan on a long-term basis, some international agency should make a feasible relocation plan of illegal settlers under the initiative of the government of the Philippines.

【Appendices】

1. Member List of the Study Team

［Field Survey］

Name	Specialized Field in charge	Organization
Kenji NAGATA	Team Leader	Senior Adviser, Institute for International Cooperation, JICA
Norihito YONEBAYASHI	Coordinator	Water Resources Development and Environmental Management Team, Project Management Group III, Grant Aid Management Department, JICA
Atsuhiko YAMAMOTO	Chief Engineer / Drainage Plan / Operation and Maintenance	Pacific Consultants International
Toshikatsu IMAI	Drainage Canal Plan / Hydrologic Analysis	IDEA Consultants, Inc.
Motoji TOKIWA	Drainage Facility Plan 1 (Machinery)	Pacific Consultants International
Yoshisuke FUNABA	Drainage Facility Plan 1 (Electricity)	IDEA Consultants, Inc.
Gunjiro OZAWA	Procurement Plan / Cost Estimation	Pacific Consultants International

［Explanation of Draft Final Report］

Name	Specialized Field in charge	Organization
Kenji NAGATA	Team Leader	Senior Adviser, Institute for International Cooperation, JICA
Hiromu INOUE	Coordinator	Water Resources Development and Environmental Management Team, Project Management Group III, Grant Aid Management Department, JICA
Atsuhiko YAMAMOTO	Chief Engineer / Drainage Plan / Operation and Maintenance	Pacific Consultants International
Gunjiro OZAWA	Procurement Plan / Cost Estimation	Pacific Consultants International

2. Study Schedule

［Field Survey］

Date	Team Leader (JICA)	Coordinator (JICA)	Chief Engineer / Drainage Plan / O&M (Atsuhiko YAMAMOTO)	Drainage Canal Plan / Hydrologic Analysis (Toshikatsu IMAI)	Drainage Facility Plan 1 (Genji TOKIWA)	Drainage Facility Plan 2 (Yoshisuke FUNABA)	Procurement Plan / Cost Estimation (Gunjiro OZAWA)
Mar. 1 (Thu.)			Travel (Narita→Manila)				
Mar. 2 (Fri.)			Courtesy call to Embassy of Japan, JICA Office, DPWH, MMDA and relevant organizations (Submission of Inception Report)				
Mar. 3 (Sat.)			Field Survey (Identification of items to be surveyed)				
Mar. 4 (Sun.)			Field Survey (Identification of items to be surveyed)				
Mar. 5 (Mon.)			● Explanation of Inception report, Discussion and confirmation of contents ● Explanation of Japan's Grant Aid Procedures, Discussion and confirmation of points of concern to carry out the survey and cooperation as well as division of roles, etc.,		● Study on targeted pumping stations ● Study on operation and maintenance		● Collection of data on cost estimation ● Collection of data on procurement
Mar. 6 (Tue.)			● Study on background, objectives and contents of the Project ● Confirmation of overall development plan, Relation with trend of other donors and organizations etc., Characterization of the Project ● Study on execution capacity and implementing structure of the Project ● Arrangement of existing data and confirmation of present conditions ● Confirmation of natural conditions ● Analysis of drainage situations				
Mar. 7 (Wed.)							
Mar. 8 (Thu.)							
Mar. 9 (Fri.)			● Meeting with MMDA (Confirmation of overall development plan, relation with trend of other donors and organizations etc., characterization of the Project) ● Study on implementing structure and execution capacity				
Mar. 10 (Sat.)			Field Survey Team meeting (Identification of problems for the Study, Identification on contents requested by MMDA and DPWH)				
Mar. 11 (Sun.)	AM: Travel (Narita→Manila) PM: Team meeting		Team meeting (Meeting with Team leader and Coordinator)				
Mar. 12 (Mon.)	AM: Courtesy call to MMDA and DPWH, Authority for assistance PM: Discussion with MMDA/DPWH			● Collection of data on overall development plan of the Project ● Collection of hydrologic data	● Grasp of problems and check of machinery, electric parts in targeted pumping stations ● Grasp of problems on operation and maintenance		● Study on procurement conditions ● Study on cost estimation conditions
Mar. 13 (Tue.)	AM: Discussion on Minutes PM: Visitation of sites			● Arrangement of hydrologic condition ● Arrangement of items concerning project effects			
Mar. 14 (Wed.)	AM: Discussion on Minutes PM: Signature of Minutes, Report to Embassy of Japan and JICA Office						
Mar. 15 (Thu.)	AM: Occasional date PM: Travel (Manila→Narita)		● Study on background, objectives and contents of the Project ● Confirmation of overall development plan, Relation with trend of other donors and organizations etc., Characterization of the Project ● Study on execution capacity and implementing structure of the Project ● Arrangement of existing data and confirmation of present conditions ● Confirmation of natural conditions ● Analysis of drainage situations				
Mar. 16 (Fri.)		Other survey					
Mar. 17 (Sat.)			Field Survey Team meeting (Report on results of the Study, Arrangement of necessary countermeasure items, Adjustment of Field Study Report)				
Mar. 18 (Sun.)							
Mar. 19 (Mon.)			● Arrangement of O&M Plan, project effects and vitality of the Project ● Arrangement of suggestion on obligation of the recipient country ● Evaluation on effects of Japan's Grant Aid, ● Arrangement of suggestion on problems and cooperation Arrangement of other relevant items	● Arrangement of hydrologic condition ● Arrangement of items concerning project effects	● Arrangement of necessary parts for machinery (Pump, Engine, Valve, Automatic trash screen, Auxiliary equipment and Spare parts)	● Arrangement of necessary parts for electricity (Electric system, Spare parts)	● Arrangement of data concerning cost estimation and procurement
Mar. 20 (Tue.)							
Mar. 21 (Wed.)							
Mar. 22 (Thu.)			Preparation of outline of Field Survey				
Mar. 23 (Fri.)			Explanation of outline on results of Field Survey, Confirmation and discussion on basic concept of the Project Report to Embassy of Japan, JICA Office and relevant organizations				
Mar. 24 (Sat.)			Travel (Manila→Narita)				

［Explanation of Draft Final Report］

Date	Team Leader (JICA)	Coordinator (JICA)	Chief Engineer / Drainage Plan / O&M	Procurement Plan / Cost Estimation
Oct.14 (Sun.)	AM: Narita (09：35) →Manila (13：05) JL741 PM: Team Meeting			
Oct.15 (Mon.)	09:00 Meeting with JICA Philippines Office 10:30 Courtesy Call to Embassy of Japan 14:00 Courtesy Call to MMDA 16:00 Courtesy Call to NEDA			
Oct.16 (Tue.)	10:00 Meeting with JBIC	9:00 Meeting with MMDA 14:00 Discussion with Department of Budget and Management (DBM) 16:00 Visitation of Sites		
Oct.17 (Wed.)	Visitation of Sites 16:00 Discussion with Department of Finance (DOF)			
Oct.18 (Thu.)	09:30 Discussion on Minutes 16:00 Discussion with Chairman (Canceled) 18:00 Discussion with JICA Philippines Office			
Oct.19 (Fri.)	09:00 Discussion on Minutes (Canceled) 14:00 Report to JICA Philippines Office 16:00 Report to Embassy of Japan			
Oct.20 (Sat.)	Manila (14：25) →Narita (19：50) JL742		Field Supplementary Survey	
Oct.21 (Sun.)			Field Supplementary Survey	
Oct.22 (Mon.)			Manila (09:00) →Narita (14:25) JL746	

3. List of Parties Concerned in the Recipient Country

［Field Survey］

1) Metropolitan Manila Development Authority (MMDA)

Bayani F. FERNANDO	Chairman
Cesar S. LACUNA	Vice Chairman
Robert C. NACIANCENO	General Manager
Martin Louis C. ONGPIN	Private Consultant under the direct control of Chairman
Baltazar N. MELGAR	Drainage and Waterways Division Chief, Flood Control Management Service
Michael D. DOCE	Pumping Stations and Flood Gate Division Chief, Flood Control Management Service
Elsie I. ENCARNACION	Head, Solid Waste Management Office
Patrocenio A. RANCAPERO Jr.	Plant Engineer, Aviles Sampaloc Pumping Station
Daniel O. LAGUNILLA III	Plant Engineer, Quiapo Pumping Station
Delfin D. FELICILDA	Plant Engineer, Tripa de Gallina Pumping Station
Seiki Nozaki	JICA Expert (Urban Development and Administration Adviser)

2) Department of Public Works and Highways (DPWH)

Rebecca T. GARSUTA	Chief, Development Planning Division
Syunta DOUZONO	JICA Expert (Policy Adviser (Flood Control Policy))

3) The Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA)

Susan R. ESPINUEVA	Chief, Dam Operation Unit, Flood Forecasting Branch

4) Department of Environment and Natural Resources (DENR)

Eugenia L. LAGMAY	Assistant Director, Environmental Management Bureau

5) National Economic Development Authority (NEDA)

Joseph CAPISTRANO	JICA Desk Officer, Public Investment

6) Department of Finance (DOF)

Lina D. ISORENA	Executive Director, National Tax Research Center (NTRC)
Aida SIMBURIO	Assistant Commissioner, Tax Information Division

7) The World Bank (WB)

Christopher R. ANCHETA	Operations Officer

8) United Nation Development Program (UNDP)

Edgardo A. POLICARPIO	Program Assistant, Environment

9) USAID

Dainel C. Moore	Chief, Office of Energy and Environment
Gil R.DY-LIACCO	Deputy Chief, Program Resources Management Office

10) Embassy of Japan

Kouichi SAKAI	Second Secretary

11) JBIC Manila Office

Takashi BABA	Resident Officer

12) JICA Philippines Office

Kenzou IWAKAMI	Deputy Resident Representative
Takeshi KANOME	Assistant Resident Representative

［Explanation of Draft Final Report］

1) Metropolitan Manila Development Authority (MMDA)

Bayani F. FERNANDO	Chairman
Martin Louis C. ONGPIN	Private Consultant under the direct control of Chairman
Baltazar N. MELGAR	Drainage and Waterways Division Chief, Flood Control Management Service
Michael D. DOCE	Pumping Stations and Flood Gate Division Chief, Flood Control Management Service
Patrocenio A. RANCAPERO Jr.	Plant Engineer, Aviles Sampaloc Pumping Station
Daniel O. LAGUNILLA III	Plant Engineer, Quiapo Pumping Station
Delfin D. FELICILDA	Plant Engineer, Tripa de Gallina Pumping Station

2) National Economic Development Authority (NEDA)

Florante G. Igtiben	Chief, Asia & Pacific Division
Robert I. Domingo	Infrastructure Staff
Amy Dem Bemjamin	PIS

3) Department of Budget and Management (DBM)

Ruby Estrban	Director

4) Department of Finance (DOF)

Rommel S. Herrera	Assistant Director, Environmental Management Bureau

5) Embassy of Japan

Kouichi SAKAI	Second Secretary

6) JBIC Manila Office

Takashi BABA	Resident Officer

7) JICA Philippines Office

Norio MATSUDA	Resident Representative
Kenzou IWAKAMI	Deputy Resident Representative
Takeshi KANOME	Assistant Resident Representative

4. Minutes of Discussions

4.1 Field Survey

MINUTES OF DISCUSSIONS
ON BASIC DESIGN STUDY
ON "THE PROJECT FOR METRO MANILA DRAINAGE SYSTEM URGENT IMPROVEMENT/UPGRADING"
IN REPUBLIC OF THE PHILIPPINES

In response to a request from the Government of Republic of the Philippines (hereinafter referred to as "the Government of the Philippines"), the Government of Japan decided to conduct a Basic Design Study (hereinafter referred to as "the Study") on the Project for Metro Manila Drainage System Urgent Improvement/Upgrading (hereinafter referred to as "the Project") and entrusted the study to the Japan International Cooperation Agency (hereinafter referred to as "JICA").

JICA sent to the Philippines the Basic Design Study Team (hereinafter referred to as "the Team"), which is headed by Mr. Kenji NAGATA, Senior Advisor, Institute for International Cooperation, JICA, and is scheduled to stay in the country from March 1 to 24, 2007.

The Team has held discussions with the officials concerned of the Government of the Philippines and is conducting a field survey in the study area.

In the course of the discussions and field survey, both sides confirmed the main items described in the attached sheets. The Team will proceed to further works and prepare the Basic Design Study Report.

Manila, March 14, 2007

Kenji NAGATA
Leader
Basic Design Study Team

Japan International Cooperation Agency

Bayani F. Fernando
Chairman
Metropolitan Manila Development Authority (MMDA)
Republic of the Philippines

ATTACHMENT

1. Name of the Project:

The Government of the Philippines requested to change the name of the Project to "THE PROJECT FOR URGENT IMPROVING / UPGRADING OF FLOOD CONTROL SYSTEM IN THE METORO MANILA".

2. Objective of the Project:

The objective of the Project is to reduce the losses of life and property of people through developing the capacities and functions of the existing pumping stations by improving and upgrading facilities of the stations.

3. Project Sites and Area Covered by the Project:

The requested sites of the Project are pumping stations located at "QUIAPO", "AVILES SAMPALOC" and "TRIPA DE GALLINA".

4. Responsible and Implementing Organization:

4-1) The responsible and implementing organization is "Metropolitan Manila Development Authority" (hereinafter referred to as "MMDA").

4-2) The implementing department in MMDA is "Flood Control Management Service".

4-3) Organization chart of MMDA is shown in Annex-1.

5. Items requested by the Government of the Philippines:

The Government of the Philippines requested components described in Annex-2 for the proposed Project including the project components in the original request. Regarding additional items, both sides understood that the Team would study them as much as possible. However some of them may not be able to be studied because of the Study schedule.

After discussions with the Team, the Government of the Philippines agreed that the Team would assess the contents of the components. Both sides agreed that based on results of the study, JICA would evaluate and finalize the components, then recommend it to the Government of Japan.

6. Prioritization and Selection for the Project:

The Team explained that the budget for the Project would be considered by the Government of Japan by evaluating the result of the study.

Both sides agreed that the contents of the Project, which are described in Annex-2, would be prioritized and selected from the technical consideration as well as in accordance with the budget allocated for the Project.

7. Japan's Grant Aid Scheme:

7-1) The Government of the Philippines understood the Japan's Grant Aid Scheme explained by the Team, as described in Annex 3-1.

7-2) The Government of the Philippines will take the necessary measures and allocate necessary budget properly, as described in Annex 3-2, for smooth implementation of the Project, as a condition for the Japanese Grant Aid to be implemented.

7-3) The Team will clarify the necessary measures and budget to be taken by the Government of the Philippines, in addition to the general measures described in Annex 3-2, by further studies.

8. Schedule of the Study:

8-1) The consultant members of the Team will conduct further studies in the Philippines until March 24, 2007.

8-2) JICA will prepare the draft final report in English and dispatch a mission in order to explain its contents around August 2007 at the earliest if some measures described in this document such as VAT issue and EIA would be executed properly by the Government of the Philippines.

8-3) In the case that the contents of the report are accepted in principle by the Government of the Philippines, JICA will complete the final report and send it to the Government of the Philippines in around September 2007 at the earliest.

8-4) The Government of the Philippines understood that the implementation of the Study does not imply nor commit the implementation of the Project.

9. Tax and Value Added Tax (VAT) :

The Team explained the reason of suspension of the Grant Aid and strongly requested that the Government of the Philippines shall take necessary measures to pay the Value Added Tax (VAT), custom duties and any other taxes and fiscal levy charges in the Philippines arising from the Project activities and these taxes and charges would be borne by beneficiary agency in accordance with the implementation schedule.

The Government of the Philippines understood the background of suspension and promised to start necessary procedures for securing budgets for the refund of these taxes. The budgets will be arranged exclusively for the Project in accordance with the Project cost and scale.

The Government of the Philippines will inform the result or progress to the Team through JICA Philippine Office.

10. Other Relevant Issues:

10-1) Current Problems of the Pumping Stations and Flood Control System and Solution:

Both sides agreed that the Study is implemented with counterpart engineers of the Government of the Philippines to find out and confirm the current problems mutually.

The Government of the Philippines promised to solve the problem by themselves if the Project would not cover these problems and areas.

10-2) Operation and Maintenance of Facilities and Equipment:

The Team explained that improving the capability of operation and maintenance is important for the Project. The Team will evaluate the present capability of the system and propose measures, such as allocation of additional budget and qualified personnel required for the proper and effective utilization of facilities and equipment, if necessary.

The Government of the Philippines agreed to abide with the proposal of the Team as results of the Study, in accordance with the implementation schedule of the Project.

The Government of the Philippines explained the effort and progress in terms of operation and maintenance of the facilities and equipment such as rehabilitation of facilities.

The Government of the Philippines promised to keep on allocating the budget continuously for the operation and maintenance.

10-3) Technical Assistance:

The Government of the Philippines requested the technical assistance on improving the capability of operation and maintenance system for sustainable development such as capacity of observation and monitoring of equipment and facility.

The Team agreed to study its necessity and if it is confirmed, the implementation of the technical assistance as soft component program or training ~~in Japan~~ would be considered in the Project.

10-4) Activities by the Government of the Philippines related to the "Master Plan":

The Government of the Philippines explained activities and future plans to realize suggestions proposed in the "Master Plan of the Development Study on Drainage Improvement in the Core Area of Metropolitan Manila (2005)" such as dredging, resettlement of peoples and public education for cleaning the drain channel.

As examples of activities, the Government of the Philippines started opening pumping stations to the public to show how they function and how they should be taken care of in order for the public to appreciate the value of them.
The Government of the Philippines also explained they made 100 small boats to clean the drain channel that are inaccessible by larger dredgers and equipments.

10-5) Environmental Impact Assessment (EIA):

The Government of the Philippines agreed to complete the EIA or to get the corresponding equivalent document (e.g. Certificate of Non-Coverage) and get approval before the completion of the Explanation Mission of Draft Basic Design Report at the latest according to the relevant Philippines laws, regulations and guidelines, if it is required for the Project.

The Government of the Philippines also agreed to submit the official letter which shows the completion of EIA or equivalent documents.

10-6) Relevant Permission for the Project:

The Government of the Philippines will expedite necessary procedure before the Explanation Mission of Draft Basic Design Report, if the official approval or permission is required for the components of the Project. The Government of the Philippines also agreed to submit the official letter which shows the approval.

10-7) Arrangements for the Study:

As a response to the request by the Team, the Government of the Philippines agreed to arrange counterpart personnel for the Study, necessary arrangements such as working space for the Team and to provide promptly all the data and information relevant to the Project for the smooth implementation of the Study.

10-8) Safety and Security:

The Team explained that security measures are indispensable for effective study. The Government of the Philippines agreed to take necessary measures to secure the safety of the members of the Team.

The Team strongly requested that Counterpart personnel should accompany the Team especially for the field study and the Government of the Philippines agreed with this.

10-9) Lesson Learnt by the Past Cooperation by Japanese Official Development Assistance:

The Team requested to the Government of the Philippines that the outcome of technical transfer and the cooperation implemented by the Japanese government in the past should be utilized to improve the living condition of the Philippines people.

The Government of the Philippines agreed and promised to utilize the lesson learnt from the past cooperation.

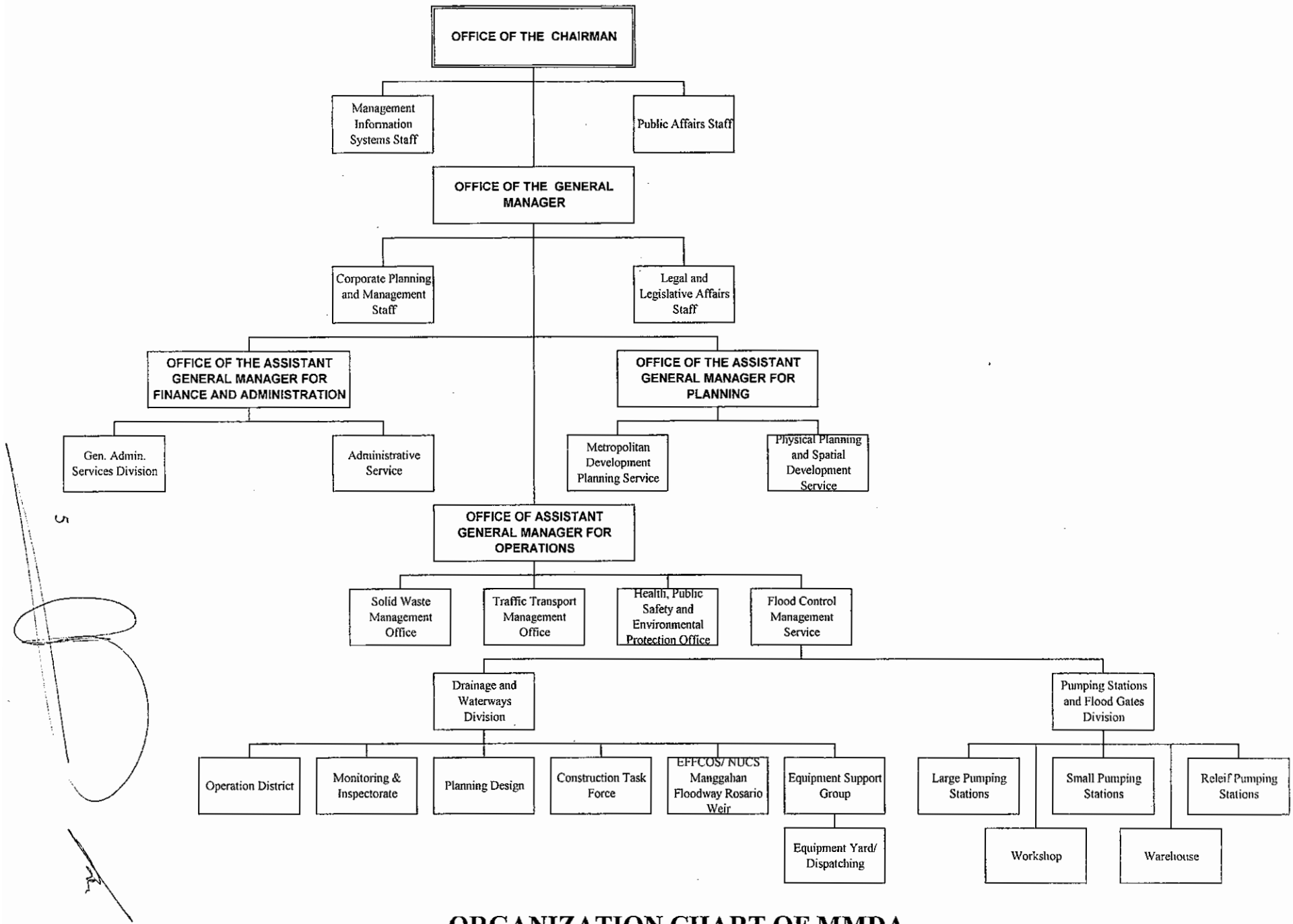
End

Annex 1 : Organization Chart of MMDA

Annex 2 : Items Requested by the Government of the Philippines

Annex 3 : 3-1 The Japan's Grant Aid Scheme

3-2 Major Undertakings to be taken by Each Government



ORGANIZATION CHART OF MMDA

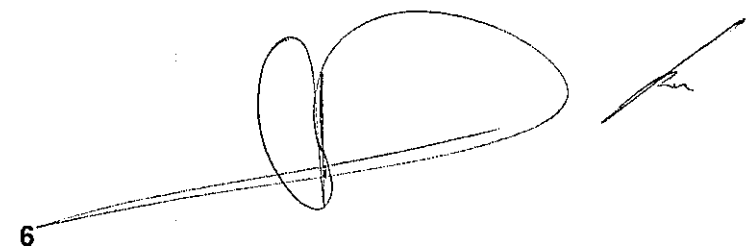
ANNEX 1

Items Requested by the Government of the Philippines

IMPROVEMENT OF MECHANIC AL AND ELECTRICAL EQUIPMENT IN THREE PUMPING STATIONS

ITEMS	QUIAPO	AVILES·SAMPALOC	TRIPA DE GALLINA
I. PUMP HOUSE			
1. Main Drainage Pump	○	○	●
2. Main Diesel Engine	○	○	●
3. Engine Cooling System	○	○	●
4. Overhead Crane	●	●	●
5. Electrical System	○	○	○
II. FLOODGATE			
Motorized Lifting System	●	●	●
III. TRASH COLLECTION SYSTEM			
1. Automatic Trash rakes	○	○	○
2. Horizontal/Inclined Conveyors	○	○	○
3. Sludge Pump	●	●	●
4. Hopper	○	○	○
5. Upstream Gate	●	●	●
IV. AUXILIARY SYSTEM			
1. Fire Detection and Control System	●	●	●
2. Security System	●	●	●
3. Fuel Supply System	○	○	○
4. Loader	●	●	●
V. Pickup Truck and Double Cab	○	○	○
VI. SPARE PARTS			
For Electrical and Mechanical Equipment/Devices	○	○	○

Notes; The symbol "○"indicates the components and items in the original request.
The symbol "●"indicates the components and items additionally requested.



Japan's Grant Aid Scheme

1. Japan's Grant Aid Scheme

The Grant Aid scheme provides a recipient country with non-reimbursable funds to procure the facilities, equipment and services (engineering services and transportation of the products, etc.) for economic and social development of the country under principles in accordance with the relevant laws and regulations of Japan. The Grant Aid is not supplied through the donation of materials as such.

2. Grant Aid Procedures

Japan's Grant Aid scheme is executed through the following procedures.

- Application	(Request made by a recipient country)
- Study	(Basic Design Study conducted by JICA)
- Appraisal & Approval	(Appraisal by the Government of Japan and Approval by Cabinet)
- Determination of Implementation	(The Notes exchanged between the Governments of Japan and the recipient country)

Firstly, the application or request for a Grant Aid project submitted by a recipient country is examined by the Government of Japan (the Ministry of Foreign Affairs) to determine whether or not it is eligible for the Grant Aid. If the request is deemed appropriate, the Government of Japan assigns JICA (Japan International Cooperation Agency) to conduct a study on the request.

Secondly, JICA conducts the study (Basic Design Study), using (a) Japanese consulting firm (s).

Thirdly, the Government of Japan appraises the project to see whether or not it is suitable for Japan's Grant Aid Scheme, based on the Basic Design Study report prepared by JICA, and the results are then submitted to the Cabinet for approval.

Fourthly, the project, once approved by the Cabinet, becomes official with the Exchange of Notes (E/N) signed by the Governments of Japan and the recipient country.

Finally, for the smooth implementation of the project, JICA assists the recipient country in such matters as preparing tenders, contracts and so on.

3. Basic Design Study

1) Contents of the Study

The aim of the Basic Design Study (hereafter referred to as "the Study"), conducted by JICA on a requested project (hereafter referred to as "the Project") is to provide a basic document necessary for the appraisal of the Project by the Government of Japan. The contents of the Study are as follows:

- Confirmation of the background, objectives, and benefits of the requested project and also institutional capacity of agencies concerned of the recipient country necessary for the Project's implementation.
- Evaluation of the appropriateness of the Project to be implemented under the Grant Aid Scheme from a technical, social and economic point of view.

- Confirmation of items agreed upon by both parties concerning the basic concept of the Project.
- Preparation of a Basic Design of the Project.
- Estimation of cost of the Project.

The contents of the original request are not necessarily approved in their initial form as the contents of the Grant Aid project. The Basic Design of the Project is confirmed considering the guidelines of Japan's Grant Aid Scheme.

The Government of Japan requests the Government of the recipient country to take whatever measures are necessary to ensure its self-reliance in the implementation of the Project. Such measures must be guaranteed even through they may fall outsides of the jurisdiction of the organization in the recipient country actually implementing the Project. Therefore, the implementation of the Project is confirmed by all relevant organizations of the recipient country through the Minutes of Discussions.

2) Selection of Consultants

For smooth implementation of the Study, JICA uses (a) registered consulting firm (s). JICA selects (a) firm (s) based on proposals submitted by interested firms. The firm (s) selected carry (ies) out a Basic Design Study and write (s) a report, based upon terms of reference set by JICA.

The consulting firm (s) used for the Study is (are) recommended by JICA to the recipient country to also work on the Project's implementation after the Exchange of Notes, in order to maintain technical consistency.

4. Japan's Grant Aid Scheme

1) Exchange pf Notes (E/N)

Japan's Grant Aid is extended in accordance with the Notes exchanged by the two Governments concerned, in which the objectives of the Project, period of execution, conditions and amount of the Grant Aid, etc., are confirmed.

2) Period of the Grant Aid

"The period of the Grant Aid" means the one fiscal year which the Cabinet approves the Project for. Within the fiscal year, all procedures such as exchanging of the Notes, concluding contracts with (a) consulting firm (s) and (a) contractor (s) and final payment to them must be completed.

However, in case of delays in delivery, installation or construction due to unforeseen factors such as natural disaster, the period of the Grant Aid can be further extended for a maximum of one fiscal year at most by mutual agreement between the two Governments.

3) Procurement of Products and Services

Under the Grant Aid, in principle, Japanese products and services including transport or those of the recipient country are to be purchased.

When the two Governments deem it necessary, the Grant Aid may be used for the purchase of the products or services of a third country.

However, the prime contractors, namely, consulting constructing and procurement firms, are limited to "Japanese nationals". (The term "Japanese nationals" means persons of Japanese nationality or Japanese corporations controlled by persons of Japanese nationality.)

4) Necessity of "Verification"

The Government of recipient country or its designated authority will conclude contracts denominated in Japanese yen with Japanese nationals. Those contracts shall be verified by the Government of Japan. This "Verification" is deemed necessary to secure accountability to Japanese taxpayers.

5) Undertakings required to the Government of the Recipient Country

In the implementation of the Grant Aid project, the recipient country is required to undertake such necessary measures as the following:

① To secure land necessary for the sites of the Project and to clear, level and reclaim the land prior to commencement of the construction,
② To provide facilities for the distribution of electricity, water supply and drainage and other incidental facilities in and around the sites,
③ To secure buildings prior to the procurement in case the installation of the equipment,
④ To ensure all the expenses and prompt execution for unloading, customs clearance at the port of disembarkation and internal transportation of the products purchased under the Grant Aid,
⑤ To exempt Japanese nationals from customs duties, internal taxes and other fiscal levies which will be imposed in the recipient country with respect to the supply of the products and services under the Verified Contracts,
⑥ To Accord Japanese nationals, whose services may be required in connection with the supply of the products and services under the Verified contracts, such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work.

6) "Proper Use"

The recipient country is required to operate and maintain the facilities constructed and equipment purchased under the Grant Aid properly and effectively and to assign staff necessary for this operation and maintenance as well as to bear all the expenses other than those covered by the Grant Aid.

7) "Re-export"

The products purchased under the Grant Aid should not be re-exported from the recipient country.

8) Banking Arrangements (B/A)

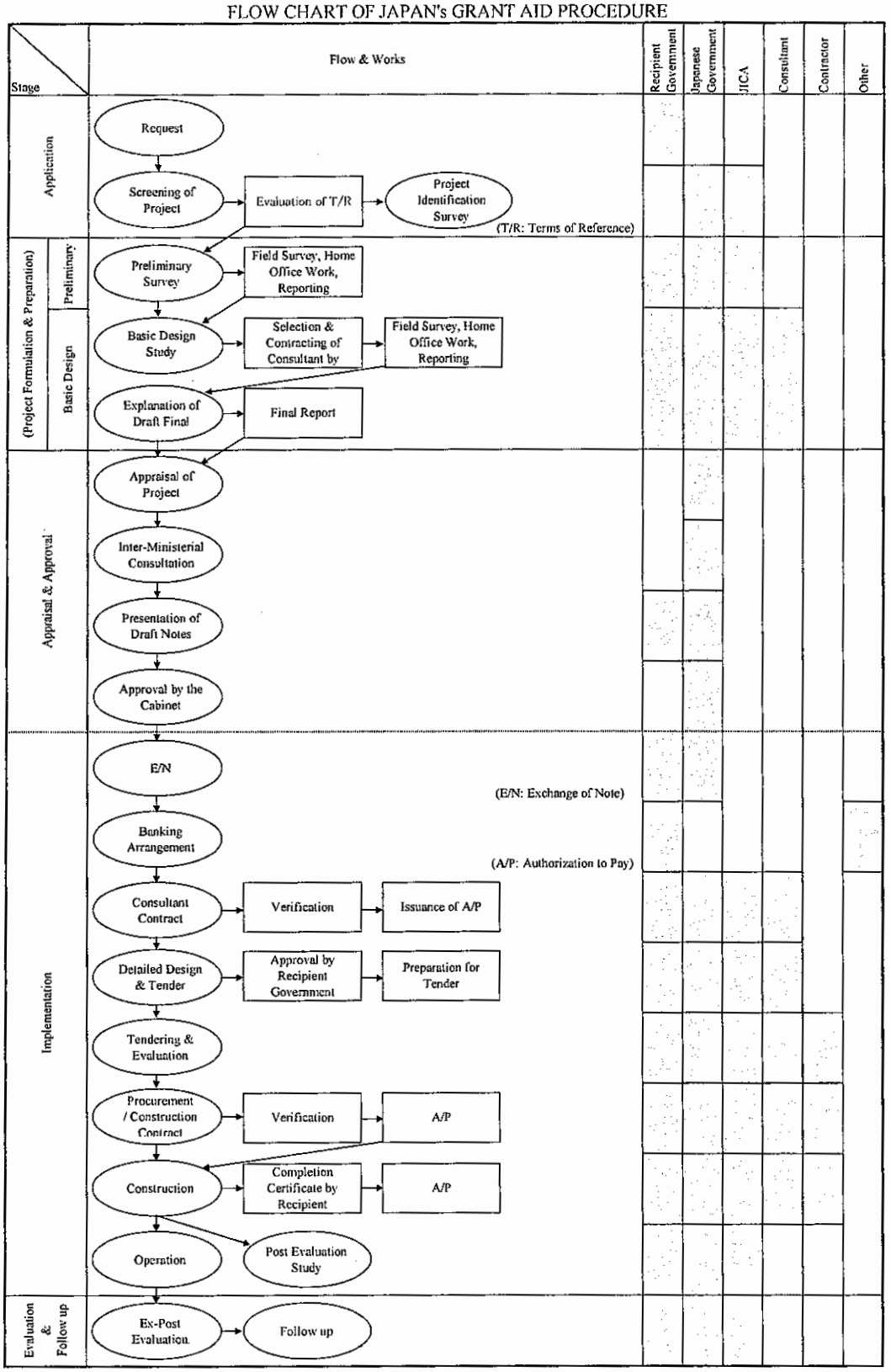
a) The Government of the recipient country or its designated authority should open an account in the name of the Government of the recipient country in a bank of Japan (hereinafter referred to as "the Bank"). The Government of Japan will execute the Grant Aid by making payments in Japanese yen to cover the obligations incurred by the Government of the recipient country or its designated authority under the Verified Contracts.

b) The payments will be made when payment requests are presented by the Bank to the Government of Japan under an Authorization to Pay (A/P) issued by the Government of the recipient country or its designated authority.

9) Authorization to Pay (A/P)

The Government of the recipient country should bear an advising commission of an Authorization to Pay and payment commissions to the Bank.

FLOW CHART OF JAPAN's GRANT AID PROCEDURE



Major Undertaking to be taken by Each Government

REFFERENCE

No.	Items	To be covered by Grant Aid	To be covered by Recipient Side
1	To bear the following commissions to the Japanese bank for banking services based upon the B/A		
	1) Advising commission of A/P		●
	2) Payment commission		●
2	To ensure unloading and customs clearance at port of disembarkation in recipient country		
	1) Marine (Air) transportation of the products from Japan the recipient	●	
	2) Tax exemption and custom clearance of the products at the port of disembarkation		●
	3) Internal transportation from the port of disembarkation to the project site	(●)	(●)
3	To accord Japanese nationals, whose service may be required in connection with the supply of the products and the services under the verified contract, such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work		●
4	To exempt Japanese nationals from customs duties, internal taxes and other fiscal levies which may be imposed in the recipient country with respect to the supply of the products and services under the verified contracts		●
5	To maintain and use properly and effectively the facilities contracted and equipment provided under the Grant Aid		●
6	To bear all the expenses, other than those to be borne by the Grant Aid, necessary for the transportation and installation of the equipment		●

(B/A: Banking Arrangement, A/P: Authorization to pay)

4.2 Explanation of Draft Final Report

For a better tomorrow for all.
Japan International Cooperation Agency
PHILIPPINE OFFICE

19 October 2007

CHAIR BAYANI F. FERNANDO
Metropolitan Manila Development Authority
MMDA Building, Orense St., EDSA
Makati City

Dear Chair Fernando,

We are pleased to forward herewith, a copy of the Draft Final Report of the Basic Design Study on the "Project for Urgent Improving/Upgrading of Flood Control System in Metro Manila". The Project is being proposed by the MMDA for possible Japan's Grant Aid.

As you may note in the Report, the contents of the Basic Design Study were based on the agreements during the discussions of the Basic Design Study Team and the MMDA representatives in March 2007. Said agreements are likewise stipulated in the Minutes of Discussion which the Chair and Mr. Kenji Nagata, leader of the Basic Design Study Team signed on 14 March 2007 (Appendix of Draft Final Report.)

As Mr. Nagata has already informed the Chair, JICA intends to implement the Project soonest time possible. Attached, for your further consideration, is the Minutes covering the discussions between the MMDA and the Explanation Team for the Basic Design Study of the subject Project from 15-19 October 2007.

Should you find the Minutes of Discussions in order, please inform our office as soon as possible, so we could initiate the project implementation.

Thank you and we look forward to your usual cooperation on the matter.

40th Floor, Yuchengco Tower, RCBC Plaza, 6819 Ayala Avenue, Makati City 1200 Philippines
P.O. Box 1026, Makati Central Post Office
Tel. No.: (+632) 889-7119 Fax. No.: (+632) 889-6850
JICA Homepage: http://www.jica.go.jp/philippines

Best regards.

Very truly yours,

NORIO MATSUDA
Resident Representative

And

KENJI NAGATA
Leader, Explanation Team
for the Basic Design Study

cc: Director Jonathan L. Uy, NEDA Public Investment Staff
Minister Akira Sugiyama, Embassy of Japan

MINUTES OF DISCUSSIONS
ON BASIC DESIGN STUDY
ON "THE PROJECT FOR URGENT IMPROVING/UPGRADING OF
FLOOD CONTROL SYSTEM IN METRO MANILA"
IN REPUBLIC OF THE PHILIPPINES
(EXPLANATION OF DRAFT FINAL REPORT)

In March 2007, the Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched the Basic Design Study Team on the Project for Urgent Improving/Upgrading of Flood Control System in Metro Manila (hereinafter referred to as "the Project") to Republic of the Philippines (hereinafter referred to as "the Philippines"), and through discussions, field survey, and results of technical examination in Japan, JICA prepared a draft final report on this study.

In order to explain and consult with the Government of the Philippines on the contents of the draft final report, JICA dispatched the Draft Report Explanation Team (hereinafter referred to as "the Team"), which is headed by Mr. Kenji NAGATA, Senior Advisor, Institute for International Cooperation, The Team is scheduled to stay in the country from October 14 to 22, 2007.

In the course of discussions and field survey, the Team and Metropolitan Manila Development Authority (hereinafter referred to as "both sides") confirmed the main items described in the attached sheets.

Manila, October 19, 2007

Kenji NAGATA	Bayani F. Fernando
Leader	Chairman
Draft Report Explanation Team	Metropolitan Manila Development Authority (MMDA)
Japan International Cooperation Agency	Republic of the Philippines

ATTACHMENT

1. Title of the Project

Both sides agreed to rename the title of the Project as "The Project for Urgent Improving/Upgrading of Flood Control System in Metro Manila", in compliance with the request made by the Philippine side. Final decision on the title will be made when both Governments sign the Exchange of Notes for the Project.

2. Components of the project

The Philippine side agreed and accepted in principle the components of the draft final report.

3. Japan's Grant Aid Scheme

3-1) The Philippine side understood the Japan's Grant Aid Scheme and will take the necessary measures and allocate necessary budget properly for smooth implementation of the Project, as a condition for the Japan's Grant Aid to be implemented. The Grant Aid Scheme and necessary measures were described in the Annex of the Minutes of Meeting agreed by both sides on March 14, 2007 (hereinafter referred to as "the Previous M/M").

3-2) Measures for "Other Relevant Issues" in this document, should be timely and properly undertaken by the Philippine side since these are indispensable to the whole Project Design. The Team explained that if the measures will not be taken properly, the approval of the Project would be reconsidered including cancellation by the Government of Japan.

4. Schedule of the Study

JICA will complete the final report in accordance with the items and confirmed by both sides and send it to the Government of the Philippines in December 2007 at the earliest.

5. Cost Estimation

Both sides agreed that the Project Cost Estimation as attached in Annex-1 should never be duplicated or released to any outside parties before the signing of all the Contract(s) for the Project.

Regarding the cost to be borne by the Philippine side, the Team requested the Philippine side to secure the appropriate and necessary amount of budget.

6. Other Relevant Issues:

The Team requested the Philippines side to carry out following matters;

(1)Taxes Arising from the Project

The Team explained again the background of suspension of the Grant Aid for the Philippine as written in the previous M/M.

The Team explained the rough cost estimate of the VAT and custom clearance fee to be borne by the Philippine side. However, other taxes such as national internal revenue taxes and import duties are not clear for the Japanese side. The Team requested to secure the appropriate and necessary amount of budget to pay the Value Added Tax (VAT), custom clearance fee and any other taxes and in the Philippines.

The Team also requested the Philippine side to report following matters in writing by the end of February in 2008.

- The result of budget allocation for VAT and custom clearance fee to be borne by the Philippine side.
- Estimation and breakdown of any other taxes.
- Information and schedule of reimbursement procedure for Japanese Consultant and Contractor.

The Philippine side committed to arrange the budget for the Philippine fiscal year 2009-12 in accordance with the Project cost and schedule, and submit the reports on the subject above mentioned.

(2)Operation rules of the pumping stations

The Team found that currently "no rainfall no operation" policy has been employed. It means pumps are operated simultaneously only when there is a possibility of rainfall even though water level is higher than pump starting level.

The Team pointed out that the current rule of operation is very risky and flooding at upstream might not be avoided. Therefore the Philippines side should apply appropriate operation rules of pumping stations in accordance with water levels.

The Philippine side agreed to the Japanese proposal and promised to take necessary measures.

(3)Proper implementation of custom clearance and safekeeping of equipment and materials

The Team explained that the shipping of equipment and materials will be done twice during implementation period of the Project and requested the Philippine side to properly carry out smooth custom clearance.

The Team also requested the Philippine side to properly secure the storage space at the Libertad warehouse because the equipment and materials will be brought to the Libertad warehouse and will be classified for each drainage pumping station from containers.

(4)Anticorrosive coat

The Team requested the Philippine side to carry out the application of anticorrosive coat of parts which have been identified needing such application after completion of the Project, even though parts are not to be replaced or renewed.

(5)Clearance of existing equipment and materials

Both sides confirmed again that the replaced equipment and materials to be replaced in the Project should be re-used or cleared out by the Philippine side.

(6)Fair Implementation of the Project

The Team explained that some information in both the draft and the final reports of the Study should be dealt with confidentially until the tender is closed, since disclosure of the information will affect fairness of tender procedure when the project proceeds to actual implementation stage.

The Philippine side understood and agreed on careful handling of the reports and achieving fair tendering.

END

5. References

A Rainfall Analysis

A Rainfall Analysis

1. General

The objective of rainfall analysis here conducted is to check if it is necessary or not to update the rainfall-intensity-duration-frequency curve established in 2004 for JICA Development study on "Drainage Improvement in the Core Area of Metropolitan Manila in the Republic of the Philippines" for runoff analysis in the drainage basin of the objective area of the Project.

2. Rainfall Station

Though data on hourly rainfall was available for several stations, the data used for this analysis was that of "Science garden" station because this was the only station duplicating with the stations used for the Development Study mentioned above.

3. Rainfall Data

Hourly rainfall data newly collected for the analysis is the data since 2004 because the data up to 2003 was used for the said Development Study These data are shown in Table 3-1 to 3-36.

4. Rainfall-intensity-duration-frequency curve

The 10 year return period curve, which is the rainfall-intensity-duration-frequency curve established in the Development study and was used for the drainage plan is as follows for 10-year return period. The return period of 10-year is used for the runoff analysis and drainage planning.

$$I = \frac{1216}{(t+11)^{0.63}}$$

Here,

I : rainfall intensity (mm/hr)

t : duration of rainfall (min)

The maximum short duration rainfall used for the preparation of the rainfall-intensity-duration-frequency curve in the Development Study is shown in Table 1-2.

5. Additional data since 2004

The annual maximum short duration rainfalls for various durations (1 hour, 2 hours, 3 hours, 6 hours, 12 hours, 24 hours) calculated from the data since 2004 and shown in Table 5-1.

6. Probability Curve

The probability analysis for the short duration annual maximum rainfall has been conducted by use of the data before 2004 and the data since 2004. The curves are shown in Figure 6-1 to 6-6 for various durations. As shown in the figures, it could be judged that there is no need to update the rainfall-intensity-duration frequency curve previously established in the Development study.

Table 3-1 Hourly Rainfall at Science Garden in 2004

2004 Unit : mm

January	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 - 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 - 13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 - 14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 - 15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 - 16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 - 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 - 18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 - 19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 - 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 - 21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 - 22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 - 23	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01 - 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02 - 03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03 - 04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04 - 05	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
05 - 06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06 - 07	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* DAILY	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3

Table 3-2 Hourly Rainfall at Science Garden in 2004

Unit : mm

2004																													
February	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 - 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2
12 - 13	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
13 - 14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
14 - 15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
15 - 16	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2
16 - 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	12	0	0	0	0	0	0	13
17 - 18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 - 19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 - 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 - 21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 - 22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 - 23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2
01 - 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	4
02 - 03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2
03 - 04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04 - 05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05 - 06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06 - 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* DAILY	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	24	2	1	1	0	0	0	31

Table 3-2 Hourly Rainfall at Science Garden in 2004

Unit : mm

2004																															
March	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 - 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 - 13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 - 14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 - 15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 - 16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 - 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 - 18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 - 19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 - 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 - 21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 - 22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 - 23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01 - 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02 - 03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03 - 04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04 - 05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05 - 06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06 - 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* DAILY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3-4 Hourly Rainfall at Science Garden in 2004

Unit : mm

2004																														
April	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 - 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 - 13	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
13 - 14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	10
14 - 15	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	18
15 - 16	0	0	0	0	0	0	0	18	6	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	25
16 - 17	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
17 - 18	0	0	0	0	0	0	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 - 19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 - 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 - 21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 - 22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 - 23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01 - 02	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
02 - 03	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
03 - 04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04 - 05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05 - 06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06 - 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* DAILY	0	0	0	0	2	0	29	35	7	0	3	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	88

Table 3-5 Hourly Rainfall at Science Garden in 2004

Unit : mm

2004																															
May	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 - 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 - 13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	4
13 - 14	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	8	0	0	6	7	0	0	0	0	0	0	0	0	0	0	22
14 - 15	0	0	0	0	0	0	0	0	42	0	0	0	0	0	0	0	2	0	0	1	3	0	0	0	0	0	0	0	0	0	0	48
15 - 16	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	5	0	0	7	1	13	0	0	0	0	0	0	0	0	0	33
16 - 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	5	0	0	0	0	0	0	0	0	0	7
17 - 18	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 - 19	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	3	0	0	1	0	0	0	0	0	0	0	0	0	6
19 - 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	5	0	0	3	0	0	0	0	0	0	0	0	0	9
20 - 21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	1	0	0	0	0	0	0	0	0	0	5
21 - 22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 - 23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	2	0	0	0	0	0	0	0	0	0	12
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	4	0	0	0	0	0	0	0	0	0	5
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
01 - 02	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	28
02 - 03	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	1	0	0	5	0	0	0	0	0	0	0	0	0	12
03 - 04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	4
04 - 05	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	6
05 - 06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06 - 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
* DAILY	0	0	0	0	0	0	14	3	50	1	0	0	0	1	0	0	20	1	23	15	16	62	0	0	0	0	0	0	0	0	0	206

Table 3-6 Hourly Rainfall at Science Garden in 2004

Unit : mm

2004																														
June	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	TOTAL
08 - 09	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	9
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	10	0	0	0	0	15
10 - 11	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	13	0	0	0	0	17
11 - 12	3	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	7
12 - 13	1	0	0	0	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
13 - 14	0	0	1	0	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	8
14 - 15	0	0	0	0	0	1	1	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	12
15 - 16	0	1	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	5
16 - 17	0	2	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
17 - 18	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0
18 - 19	0	1	0	0	1	1	0	0	0	0	0	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
19 - 20	0	0	1	0	0	2	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
20 - 21	0	0	0	0	0	4	0	0	0	0	0	0	12	1	0	0	0	0	0	0	15	0	0	1	0	0	0	0	0	0	33
21 - 22	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	5
22 - 23	0	0	1	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	1	0	0	0	0	24
23 - 24	0	0	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	7
00 - 01	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3
01 - 02	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
02 - 03	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
03 - 04	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	6
04 - 05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	2
05 - 06	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	6
06 - 07	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	3
07 - 08	2	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
* DAILY	7	6	4	9	14	22	5	2	0	1	0	11	13	5	0	2	0	0	0	23	19	3	7	9	8	24	0	0	5	3	202

Table 3-7 Hourly Rainfall at Science Garden in 2004

Unit : mm

2004																															
July	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 - 11	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	11
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	2
12 - 13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	0	0	13	0	0	19
13 - 14	0	0	0	0	0	0	0	0	0	0	0	0	0	5	16	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	24
14 - 15	0	0	0	0	0	10	0	0	8	0	0	5	16	11	1	0	0	1	9	0	1	36	0	0	0	1	0	0	1	0	0	100
15 - 16	0	1	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0	1	0	0	0	0	19	0	2	0	0	0	0	0	0	41
16 - 17	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	14	0	3	3	0	0	0	0	0	37
17 - 18	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
18 - 19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	2	1	1	1	1	14	0	0	0	5	0	29
19 - 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	6	1	1	1	1	1	0	28	0	5	0	46
20 - 21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	0	0	0	0	0	5
21 - 22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	2
22 - 23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01 - 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7
02 - 03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03 - 04	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	6
04 - 05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05 - 06	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
06 - 07	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0	4
* DAILY	6	1	0	0	0	10	0	0	26	17	0	6	16	16	17	0	6	3	10	2	12	40	40	14	10	24	0	28	17	13	9	343

Table 3-8 Hourly Rainfall at Science Garden in 2004

Unit : mm

2004																															
August	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	27
09 - 10	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	11
10 - 11	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	3	0	0	0	0	0	0	11
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	7	0	0	0	0	0	0	8
12 - 13	0	1	0	1	0	0	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	9
13 - 14	0	0	0	10	0	0	0	1	0	0	0	0	6	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	18
14 - 15	0	0	0	18	0	0	0	0	1	0	0	0	16	0	0	0	1	1	0	0	0	1	0	0	3	0	0	0	0	0	10	51
15 - 16	0	0	0	0	0	0	0	4	1	0	0	0	4	0	2	0	1	0	0	0	0	1	0	0	5	31	0	0	0	0	11	60
16 - 17	0	0	0	3	0	0	0	2	0	0	0	0	0	0	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	7	18
17 - 18	0	0	0	28	0	0	0	0	0	0	0	0	0	0	1	2	2	0	0	0	0	0	0	0	2	0	0	0	0	0	1	36
18 - 19	2	0	0	16	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	23
19 - 20	0	0	0	0	0	0	0	0	0	0	0	23	2	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	28
20 - 21	0	0	0	2	0	0	0	0	0	0	0	30	0	7	1	0	0	0	0	1	0	0	0	0	3	11	0	0	0	0	0	55
21 - 22	0	0	0	3	0	0	0	0	0	0	0	0	0	25	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	31
22 - 23	0	8	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	1	0	0	0	4	2	0	0	0	0	0	20
23 - 24	0	8	0	0	0	0	0	0	0	0	0	0	0	4	7	0	0	0	0	1	0	0	0	0	5	0	0	0	0	0	0	25
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	2	17	0	0	0	0	1	0	0	0	0	2	6	0	0	0	0	0	28
01 - 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3
02 - 03	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	11
03 - 04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37	12	1	0	0	0	0	0	50
04 - 05	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	10	0	0	0	0	0	0	41
05 - 06	0	0	5	0	10	0	0	0	0	0	0	2	0	0	0	0	5	0	0	0	0	0	0	9	2	2	0	0	0	0	0	35
06 - 07	0	0	1	0	7	0	0	1	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	49	5	0	0	0	0	0	0	66
07 - 08	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	33	2	0	0	0	0	0	0	38
* DAILY	2	17	6	82	28	1	6	14	5	0	0	58	31	43	36	4	18	1	0	3	1	3	0	158	103	54	0	0	0	0	29	703

Table 3-9 Hourly Rainfall at Science Garden in 2004

Unit : mm

2004																														
September	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09 - 10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	3
10 - 11	43	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	47
11 - 12	17	0	0	0	0	0	0	0	0	0	0	0	0	13	0	1	0	0	0	0	9	0	0	0	0	0	0	0	0	0	40
12 - 13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	0	0	0	4	0	0	0	0	0	0	0	0	0	0	25
13 - 14	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
14 - 15	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	19
15 - 16	1	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	27	0	1	0	0	0	0	4	0	37
16 - 17	0	0	0	0	0	0	2	0	0	0	0	0	*	0	16	0	0	0	0	0	0	0	18	0	0	0	0	0	5	0	41
17 - 18	0	0	0	18	0	0	0	0	0	0	0	0	*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 - 19	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
19 - 20	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
20 - 21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	3
21 - 22	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3
22 - 23	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	15
23 - 24	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
01 - 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
02 - 03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
03 - 04	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
04 - 05	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
05 - 06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
06 - 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* DAILY	80	0	1	19	0	6	2	0	0	0	0	0	5	17	16	35	1	0	0	4	10	27	18	1	3	0	0	18	10	5	278

Table 3-10 Hourly Rainfall at Science Garden in 2004

2004																															Unit : mm
October	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 - 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0
12 - 13	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	7
13 - 14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0
14 - 15	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
15 - 16	0	0	0	0	0	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	*	0	0	0	0	0	0	0	0	0	4
16 - 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0
17 - 18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0
18 - 19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 - 20	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
20 - 21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 - 22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 - 23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	3
23 - 24	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	8
00 - 01	23	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	31
01 - 02	5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
02 - 03	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
03 - 04	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
04 - 05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05 - 06	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
06 - 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* DAILY	32	1	7	0	0	20	2	8	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	83

Table 3-11 Hourly Rainfall at Science Garden in 2004

Unit : mm

2004 November	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	TOTAL
08 - 09	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	*	0	0	0	0	0	0	0	2
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	*	0	0	0	0	0	0	0	1
10 - 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0	0	1	0	1
11 - 12	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0	0	0	0	3
12 - 13	0	0	0	0	2	0	0	5	0	0	1	0	0	0	0	0	0	0	0	1	0	0	*	0	0	0	0	0	2	0	11
13 - 14	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	*	0	0	0	0	0	4	0	7
14 - 15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	5
15 - 16	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	7	0	10
16 - 17	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	5	0	11
17 - 18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	8	1	15
18 - 19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	11	0	13
19 - 20	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	16	0	18
20 - 21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	0	29
21 - 22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31	0	31
22 - 23	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	9
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3
00 - 01	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	4
01 - 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
02 - 03	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03 - 04	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
04 - 05	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
05 - 06	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
06 - 07	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	5
07 - 08	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	3
* DAILY	0	0	2	0	4	1	0	6	0	0	5	2	0	0	0	0	2	0	9	18	2	1	0	0	0	0	0	0	132	2	186

Table 3-12 Hourly Rainfall at Science Garden in 2004

Unit : mm

2004																															
December	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL
08 - 09	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
09 - 10	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
10 - 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 - 13	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
13 - 14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 - 15	0	2	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
15 - 16	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
16 - 17	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
17 - 18	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
18 - 19	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
19 - 20	0	2	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
20 - 21	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
21 - 22	0	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
22 - 23	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
23 - 24	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01 - 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02 - 03	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
03 - 04	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
04 - 05	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
05 - 06	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
06 - 07	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
07 - 08	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
* DAILY	0	43	1	0	9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	54

Table 3-13 Hourly Rainfall at Science Garden in 2005

2005 Unit : mm

January	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 - 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 - 13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
13 - 14	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
14 - 15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	4
15 - 16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 - 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 - 18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 - 19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 - 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 - 21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 - 22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 - 23	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01 - 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02 - 03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03 - 04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04 - 05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05 - 06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06 - 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* DAILY	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	5	1	0	0	0	0	0	0	0	0	0	0	8

Table 3-14 Hourly Rainfall at Science Garden in 2005

Unit : mm

2005 February	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28		TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
10 - 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
12 - 13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
13 - 14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
14 - 15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
15 - 16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
16 - 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
17 - 18	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		2
18 - 19	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		1
19 - 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
20 - 21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
21 - 22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
22 - 23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
23 - 24	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		1
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
01 - 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
02 - 03	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		5
03 - 04	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		1
04 - 05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
05 - 06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
06 - 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
* DAILY	0	0	0	0	0	0	0	0	6	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		10

Table 3-15 Hourly Rainfall at Science Garden in 2005

Unit : mm

2005																															
March	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 - 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
12 - 13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
13 - 14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 - 15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	6
15 - 16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
16 - 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 - 18	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 - 19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 - 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 - 21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 - 22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 - 23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01 - 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02 - 03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03 - 04	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
04 - 05	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
05 - 06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
06 - 07	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* DAILY	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0	0	0	14

Table 3-16 Hourly Rainfall at Science Garden in 2005

Unit : mm

2005																														
April	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 - 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 - 13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 - 14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 - 15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	0	0	12	0	0	0	0	0	0	0	0	0	0	0	12
15 - 16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 - 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 - 18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 - 19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 - 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 - 21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 - 22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 - 23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01 - 02	0	0	2	0	0	0	0	0	0	0	0	0	0	0	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
02 - 03	0	0	2	0	0	0	0	0	0	0	0	0	0	0	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
03 - 04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04 - 05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	0	0	0	0	0	0	0	0	16	0	0	0	0	0	16
05 - 06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06 - 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* DAILY	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	16	0	0	0	0	0	32

Table 3-17 Hourly Rainfall at Science Garden in 2005

Unit : mm

2005																															
May	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 - 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	14
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 - 13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
13 - 14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 - 15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
15 - 16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 - 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 - 18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	16	0	0	0	0
18 - 19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	12	0	0	0	26	0	0	0	40
19 - 20	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	1	0	0	0	0	0	0	23	0	0	0	0	0	0	0	29
20 - 21	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	3
21 - 22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	8
22 - 23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	2
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
01 - 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
02 - 03	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	7
03 - 04	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
04 - 05	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
05 - 06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06 - 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* DAILY	0	0	0	0	0	0	0	2	5	0	0	6	0	0	0	0	3	0	0	0	0	2	0	36	1	1	1	66	0	2	4	129

Table 3-18 Hourly Rainfall at Science Garden in 2005

Unit : mm

2005																														
June	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	TOTAL
08 - 09	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 - 11	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
11 - 12	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
12 - 13	0	0	0	0	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
13 - 14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 - 15	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
15 - 16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
16 - 17	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	18
17 - 18	0	0	0	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0	0	2	0	0	0	0	0	0	0	0	0
18 - 19	0	0	0	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0	1	19	0	0	0	0	0	83
19 - 20	0	1	0	9	11	9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	12	0	8	13	0	0	0	0	0	64
20 - 21	0	0	0	1	4	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	25	1	0	0	0	0	1	0	45
21 - 22	0	0	0	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	10
22 - 23	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	13	0	0	0	29
23 - 24	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	5	0	0	0	14
00 - 01	0	0	0	0	3	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	21
01 - 02	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	0	0	7
02 - 03	0	0	0	0	1	0	1	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	20
03 - 04	0	10	0	0	1	0	7	0	23	0	0	0	0	0	s	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	42
04 - 05	0	3	0	0	0	6	0	7	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	18
05 - 06	0	1	0	0	0	0	10	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
06 - 07	0	1	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* DAILY	4	17	0	83	24	45	23	20	54	1	0	0	0	0	1	0	0	0	25	16	0	39	28	11	32	30	20	0	1	0	474

Table 3-19 Hourly Rainfall at Science Garden in 2005

Unit : mm

2005																															
July	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL
08 - 09	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	2	0	5	0	0	0	0	0	0	0	0	0	0	0	12
09 - 10	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
10 - 11	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	10
11 - 12	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	11
12 - 13	0	0	0	2	8	0	0	0	6	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	27
13 - 14	0	0	0	0	2	0	0	0	4	0	0	7	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37
14 - 15	0	0	0	0	2	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
15 - 16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	14
16 - 17	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	9
17 - 18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 - 19	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	12
19 - 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
20 - 21	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	5
21 - 22	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	10	0	0	0	0	0	0	0	14
22 - 23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
23 - 24	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	4
00 - 01	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
01 - 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
02 - 03	0	1	0	4	6	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
03 - 04	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	5
04 - 05	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4
05 - 06	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
06 - 07	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	5
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
* DAILY	0	2	0	20	57	1	0	0	13	1	0	8	0	26	1	1	1	17	3	9	0	7	0	11	0	1	0	1	0	0	22	202

Table 3-20 Hourly Rainfall at Science Garden in 2005

Unit : mm

2005 August	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL
08 - 09	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
09 - 10	0	0	0	0	5	1	1	1	0	1	0	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13
10 - 11	0	0	0	0	0	1	0	6	0	0	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	15
11 - 12	0	0	0	0	1	0	0	2	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	10
12 - 13	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3
13 - 14	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
14 - 15	0	0	0	0	0	0	0	0	0	0	3	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
15 - 16	0	0	0	0	0	0	0	1	0	0	2	4	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	12
16 - 17	0	0	0	1	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	14	0	0	0	0	1	0	0	0	0	20
17 - 18	22	0	0	0	0	1	0	0	0	0	1	5	0	0	0	0	0	0	0	0	0	12	0	0	0	0	1	0	0	0	0	42
18 - 19	30	0	0	0	0	0	0	1	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	10	0	15	0	0	0	0	70
19 - 20	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	5
20 - 21	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	0	0	0	0	1	4	0	0	0	21
21 - 22	0	0	0	0	4	0	0	0	0	0	6	0	0	0	0	0	0	0	2	0	0	0	0	3	0	3	1	1	0	0	0	20
22 - 23	0	0	0	1	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	6
23 - 24	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
01 - 02	0	0	0	3	1	1	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	12
02 - 03	0	0	0	0	0	3	0	1	0	0	1	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11
03 - 04	0	0	0	6	0	13	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
04 - 05	0	0	0	1	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
05 - 06	0	0	0	0	3	0	0	1	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
06 - 07	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
07 - 08	0	0	0	0	1	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
* DAILY	52	0	0	12	31	22	1	15	0	1	38	53	1	1	0	0	0	0	5	1	0	27	6	3	12	13	21	5	0	0	2	322

Table 3-21 Hourly Rainfall at Science Garden in 2005

Unit : mm

2005																														
September	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	*	*	0	0	0	0	0	0	1	0	0	0	0	0	0	5
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	0	0	0	0	0	0	3	0	0	0	0	0	0	3
10 - 11	6	0	0	0	0	0	21	0	0	0	0	0	0	0	0	*	*	0	0	0	0	0	0	3	0	0	0	0	0	0	30
11 - 12	1	0	0	0	0	0	5	0	0	0	0	0	0	0	4	*	*	0	0	0	0	0	1	0	0	0	0	0	0	0	11
12 - 13	0	0	0	0	0	0	1	0	0	0	0	0	0	0	4	*	0	0	1	0	0	0	0	8	0	0	0	0	0	0	14
13 - 14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	*	0	0	1	0	0	0	0	2	0	0	0	0	0	0	4
14 - 15	0	0	0	0	0	0	0	0	0	1	0	0	0	0	4	*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	6
15 - 16	0	0	1	0	0	0	0	0	0	0	0	0	1	0	8	*	0	1	0	0	0	0	0	1	0	0	0	0	0	0	12
16 - 17	0	0	9	0	0	0	0	0	0	0	0	0	0	24	2	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35
17 - 18	0	0	3	0	1	0	0	0	0	0	0	0	0	2	19	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 - 19	0	0	3	1	0	0	0	0	0	0	0	22	0	4	16	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	46
19 - 20	0	0	3	4	0	0	0	0	0	0	7	17	0	1	3	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35
20 - 21	0	0	2	3	0	0	0	0	0	0	0	0	0	5	1	*	0	0	0	1	0	0	0	0	0	0	4	0	0	3	19
21 - 22	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3
22 - 23	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	*	0	0	0	0	0	0	1	0	0	0	0	0	0	9	12
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
00 - 01	0	0	0	0	0	0	0	0	0	0	0	3	0	0	*	*	0	0	0	0	0	0	1	0	0	0	0	0	0	4	8
01 - 02	0	1	0	0	26	0	0	0	0	0	0	2	0	0	*	*	0	0	0	0	0	0	0	0	0	0	0	2	0	0	31
02 - 03	0	19	1	0	3	0	0	0	0	0	0	3	0	0	*	*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	27
03 - 04	0	2	0	0	0	0	0	0	0	0	0	0	0	4	*	*	0	0	1	0	0	0	1	0	0	0	0	0	0	0	8
04 - 05	0	0	0	0	0	0	0	0	0	0	0	0	0	7	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
05 - 06	0	0	0	0	0	0	0	0	0	0	0	1	0	2	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4
06 - 07	0	0	0	0	0	0	0	0	0	0	0	1	0	1	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3
07 - 08	0	0	0	0	1	0	0	0	0	0	0	1	0	1	*	*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	4
* DAILY	7	22	22	9	31	0	27	0	0	1	9	50	1	53	66	0	0	1	3	2	0	0	6	18	0	0	4	2	0	20	354

Table 3-22 Hourly Rainfall at Science Garden in 2005

Unit : mm

2005																															
October	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL
08 - 09	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	5
09 - 10	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	4
10 - 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	4
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	4
12 - 13	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	9	0	2	0	0	0	0	24
13 - 14	0	0	0	0	0	0	0	6	0	0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	14	0	2	0	0	25	0	69
14 - 15	0	0	31	0	0	0	0	6	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	0	0	13	0	57
15 - 16	0	0	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	12	0	0	0	0	0	0	1	0	0	4	0	21
16 - 17	0	0	1	0	0	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	39
17 - 18	0	0	0	0	0	5	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	17
18 - 19	0	0	0	0	0	0	6	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	10	0	26
19 - 20	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	1	0	8
20 - 21	0	27	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28
21 - 22	0	11	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
22 - 23	0	0	0	0	0	0	36	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	3	0	0	1	0	41
23 - 24	0	0	0	0	0	0	4	0	0	12	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	28
00 - 01	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	16
01 - 02	0	1	0	0	0	4	0	0	0	1	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	18
02 - 03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
03 - 04	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	10
04 - 05	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	9	0	0	0	0	11
05 - 06	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	7	0	0	0	0	9
06 - 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	4	5	0	0	0	0	10
07 - 08	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	2	2	0	0	0	8
* DAILY	2	40	34	4	0	51	52	17	1	13	4	39	1	0	0	10	0	2	1	12	0	0	1	0	24	5	97	6	0	55	0	471

Table 3-23 Hourly Rainfall at Science Garden in 2005

Unit : mm

2005 November	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 - 11	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
11 - 12	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
12 - 13	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
13 - 14	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	0	29
14 - 15	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
15 - 16	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
16 - 17	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
17 - 18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 - 19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 - 20	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
20 - 21	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	5
21 - 22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
22 - 23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01 - 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02 - 03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03 - 04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04 - 05	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
05 - 06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06 - 07	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	3
07 - 08	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	6
* DAILY	6	0	1	0	10	1	0	1	0	7	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	5	0	34	2	68

Table 3-24 Hourly Rainfall at Science Garden in 2005

Unit : mm

2005																															
December	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 - 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 - 12	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
12 - 13	0	0	0	0	0	0	0	0	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
13 - 14	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
14 - 15	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
15 - 16	0	0	0	0	0	0	0	3	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
16 - 17	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
17 - 18	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
18 - 19	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3
19 - 20	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	11
20 - 21	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2
21 - 22	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
22 - 23	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
00 - 01	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
01 - 02	0	0	5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
02 - 03	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
03 - 04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04 - 05	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
05 - 06	0	0	0	0	0	0	0	0	0	0	0	1	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
06 - 07	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
07 - 08	0	0	0	0	0	0	0	1	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
* DAILY	0	0	5	0	0	0	0	11	10	9	1	2	9	10	0	0	2	0	0	0	0	0	0	0	0	0	11	0	0	0	0	70

Table 3-25 Hourly Rainfall at Science Garden in 2006

2006 Unit : mm

January	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	2
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 - 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 - 12	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	6
12 - 13	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2
13 - 14	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2
14 - 15	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	7
15 - 16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	6
16 - 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
17 - 18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 - 19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
19 - 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 - 21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
21 - 22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	0	0	0	0	0	0	8
22 - 23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	4
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01 - 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02 - 03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03 - 04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04 - 05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05 - 06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	2
06 - 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	3
* DAILY	2	1	0	0	0	0	0	0	0	0	0	0	6	1	0	0	0	0	0	0	0	0	0	11	22	4	2	1	0	0	0	50

Table 3-26 Hourly Rainfall at Science Garden in 2006

Unit : mm

2006																												
February	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 - 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 - 13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 - 14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 - 15	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
15 - 16	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
16 - 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
17 - 18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 - 19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 - 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 - 21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 - 22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 - 23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01 - 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02 - 03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03 - 04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04 - 05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05 - 06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06 - 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* DAILY	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3

Table 3-27 Hourly Rainfall at Science Garden in 2006

Unit : mm

2006																															
March	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
10 - 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2
12 - 13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
13 - 14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 - 15	0	0	0	0	0	0	0	0	0	0	0	0	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	31
15 - 16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 - 17	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
17 - 18	0	0	0	3	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
18 - 19	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
19 - 20	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
20 - 21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 - 22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 - 23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	5
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	1	0	9
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
01 - 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02 - 03	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
03 - 04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
04 - 05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05 - 06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06 - 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* DAILY	3	0	0	3	0	0	0	0	0	0	0	4	29	1	0	0	0	0	0	0	0	0	0	0	0	0	0	13	2	9	8	72

Table 3-28 Hourly Rainfall at Science Garden in 2006

Unit : mm

2006																														
April	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 - 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 - 13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 - 14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 - 15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 - 16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 - 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 - 18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 - 19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 - 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 - 21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 - 22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 - 23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01 - 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02 - 03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03 - 04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04 - 05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05 - 06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06 - 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* DAILY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3-29 Hourly Rainfall at Science Garden in 2006

Unit : mm

2006																															
May	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0		2
10 - 11	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		2
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
12 - 13	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	4	0	0	2	52	0	0	0	0	0	0		59
13 - 14	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	3	0	0	8	2	0	0	0	0	0	0		15
14 - 15	0	0	0	0	0	0	0	0	0	6	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1		9
15 - 16	0	0	0	0	0	0	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		4
16 - 17	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		4
17 - 18	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
18 - 19	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		2
19 - 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0		2
20 - 21	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	39	0	0	0		40
21 - 22	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		5
22 - 23	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		1
23 - 24	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0		8
00 - 01	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		2
01 - 02	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0		5
02 - 03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
03 - 04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
04 - 05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
05 - 06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
06 - 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
* DAILY	0	0	0	0	0	0	0	0	0	9	12	14	5	0	0	10	1	0	0	7	0	0	11	54	0	0	40	0	0	1	0	164

Table 3-30 Hourly Rainfall at Science Garden in 2006

Unit : mm

2006																														
June	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	**TOTAL**
08 - 09	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
10 - 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 - 13	0	0	0	0	0	0	0	0	0	0	0	0	37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37
13 - 14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	1	0	0	0	0	0	12
14 - 15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	3	0	0	0	0	0	13
15 - 16	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	26	0	0	0	0	0	0	5	0	1	0	0	2	0	0	38
16 - 17	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	8	0	0	0	0	0	0	0	31
17 - 18	0	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
18 - 19	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	14
19 - 20	0	0	36	0	0	0	0	0	0	0	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	69
20 - 21	0	0	20	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21
21 - 22	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	4
22 - 23	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	1	6
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
01 - 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
02 - 03	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
03 - 04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04 - 05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05 - 06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06 - 07	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* DAILY	0	69	61	0	0	0	0	0	0	1	36	0	37	3	24	27	1	0	0	0	10	0	13	11	12	0	6	5	0	1	317

Table 3-31 Hourly Rainfall at Science Garden in 2006

Unit : mm

2006																															
July	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL
08 - 09	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	2	1	0	0	0	0	0	5	13
09 - 10	0	0	0	0	0	0	0	2	0	0	0	0	0	3	0	0	0	0	1	0	0	0	0	6	0	0	0	0	0	0	1	13
10 - 11	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	1	0	0	0	0	22	5	1	0	0	0	0	0	0	33
11 - 12	0	0	0	1	0	0	0	0	0	0	0	0	2	1	0	0	0	1	0	0	0	0	4	7	0	0	0	0	0	0	1	17
12 - 13	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	1	0	0	0	0	0	2	1	1	0	0	0	0	1	1	11
13 - 14	0	0	0	0	0	4	0	2	0	0	0	3	1	0	0	0	0	0	0	0	0	0	4	1	7	0	0	0	4	2	6	34
14 - 15	0	0	0	0	0	0	0	1	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	5	34	0	0	0	51	3	1	102
15 - 16	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	2	8	4	15	0	0	0	3	4	0	56
16 - 17	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	14	0	3	4	0	0	0	2	1	30
17 - 18	0	0	0	0	0	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	14	0	5	0	0	0	0	1	0	0
18 - 19	0	0	0	0	0	3	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	5	12	0	2	1	0	1	0	0	0	28
19 - 20	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	3	8	5	1	0	2	0	0	0	21
20 - 21	0	0	0	0	0	2	0	1	0	0	0	1	3	0	0	0	0	0	0	0	0	0	1	3	1	0	0	3	0	0	0	15
21 - 22	0	0	0	0	0	4	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	2	6	1	0	0	1	0	0	2	22
22 - 23	0	0	0	0	0	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	11	0	1	0	0	3	0	0	19
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	2	0	20	0	0	12	0	0	39
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	3	0	2	0	0	6	0	1	17
01 - 02	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2	5	0	1	0	0	0	0	0	10
02 - 03	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	6	1	0	0	0	0	0	0	0	0	10
03 - 04	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	12	7	3	0	0	0	0	4	0	0	29
04 - 05	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	5	4	14	0	0	0	0	1	0	0	27
05 - 06	0	0	0	0	0	0	0	0	0	0	4	0	9	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	15
06 - 07	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	4	3	0	0	1	0	0	1	2	1	26
07 - 08	0	0	0	0	0	0	0	0	1	0	6	0	7	0	0	0	0	0	0	0	1	6	2	15	0	0	0	0	0	4	0	42
* DAILY	0	0	0	3	0	20	0	10	1	0	58	13	40	14	0	0	1	4	1	0	1	40	108	101	76	31	0	7	85	19	20	653

Table 3-32 Hourly Rainfall at Science Garden in 2006

Unit : mm

2006 August	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	3	0	0	2	0	1	0	0	0	0	0	0	0	1	0	0							7
09 - 10	0	0	0	0	0	0	0	1	1	0	0	0	1	3	2	0	0	0	0	0	0	0	0	0	0							8
10 - 11	0	0	0	14	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	2	0	0							19
11 - 12	1	0	0	2	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0							8
12 - 13	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0							5
13 - 14	0	0	0	0	0	0	0	1	0	2	0	0	0	0	1	3	0	1	0	0	0	0	0	0	0							8
14 - 15	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	2	0	1	2	0	1							9
15 - 16	0	0	0	0	0	0	0	0	0	0	0	14	1	8	0	0	0	0	0	0	0	0	1	0	0				0	0		24
16 - 17	0	0	0	0	1	0	0	0	0	0	0	20	0	1	0	0	0	0	0	0	0	0	0	0	1				0	0		23
17 - 18	1	0	0	0	2	9	0	0	0	0	8	4	0	1	0	0	0	0	0	0	0	0	0	0	0				0	0	6	31
18 - 19	0	0	0	0	1	3	0	1	0	0	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0				0	0		32
19 - 20	0	0	0	0	1	1	1	1	0	0	26	0	0	0	0	0	0	0	0	1	3	7	1	0	0				0	0		42
20 - 21	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	1	1	0	5	0	2	0	0	0				0	0		16
21 - 22	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	1	0	2	0	0	0	0	0				0	0		6
22 - 23	0	0	0	0	2	0	0	0	0	0	0	0	9	0	0	0	0	0	0	1	0	0	0	0	0				0	0		12
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	0	0	0	0	2	0	0	0	0	0				0	0		7
00 - 01	0	0	0	0	0	0	2	0	0	0	1	0	9	0	0	0	0	1	0	1	0	0	0	0	0							14
01 - 02	0	0	0	0	0	0	1	1	0	0	0	2	6	0	0	0	1	5	0	0	0	0	0	0	0							16
02 - 03	0	0	0	0	0	0	0	2	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0							6
03 - 04	0	0	0	0	0	0	0	0	0	4	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0							6
04 - 05	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	4	0	2	0	0	0	0	0	0							10
05 - 06	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							1
06 - 07	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0							3
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0							1
* DAILY	2	0	0	16	11	18	4	8	1	9	71	42	33	21	7	7	7	9	3	15	4	11	7	0	2	0	0	0	0	0	6	314

Table 3-33 Hourly Rainfall at Science Garden in 2006

Unit : mm

2006																															
September	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	TOTAL
08 - 09	0	0	0	0	0	27	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	29
09 - 10	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	17
10 - 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	1	8	0	0	14
12 - 13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	3	18	0	0	26
13 - 14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 - 15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	16	1	8	0	0	26
15 - 16	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	1	0	3	1	0	0	14
16 - 17	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	8	0	0	0	0	5	0	7	4	0	0	31
17 - 18	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	2	2	0	0	0	1	0	0	0	0	3	1	0	0	0
18 - 19	0	0	3	11	0	0	1	0	0	0	0	0	0	0	0	0	1	32	0	10	0	0	0	0	0	1	0	0	0	0	59
19 - 20	0	0	1	0	0	0	1	59	48	0	0	0	0	0	0	0	0	1	0	2	0	0	0	4	0	14	0	0	0	0	130
20 - 21	0	0	0	0	0	0	0	1	86	0	0	0	0	0	0	0	0	0	3	1	0	0	0	5	0	0	0	0	0	0	96
21 - 22	0	0	0	0	6	0	0	0	14	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	24
22 - 23	0	0	0	1	19	0	0	0	3	1	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	1	0	0	0	29
23 - 24	0	0	0	1	4	0	0	0	4	3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	13
00 - 01	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3
01 - 02	0	0	0	0	4	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	13
02 - 03	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	2	0	0	0	29
03 - 04	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	3	0	0	0	11
04 - 05	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	4
05 - 06	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	10
06 - 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	16
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
* DAILY	0	0	4	20	33	43	6	60	156	27	1	0	0	0	0	0	5	35	6	21	0	14	5	37	11	31	52	43	0	0	610

Table 3-34 Hourly Rainfall at Science Garden in 2006

Unit : mm

2006																															
October	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	4
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3
10 - 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	6
12 - 13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	1	0	7
13 - 14	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
14 - 15	0	0	0	1	0	0	0	0	1	0	0	3	24	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	32
15 - 16	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	8	0	0	0	0	0	0	0	2	0	0	0	0	0	0	12
16 - 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
17 - 18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 - 19	0	0	0	0	0	0	0	0	15	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
19 - 20	0	0	0	0	0	0	0	0	7	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	10
20 - 21	0	0	0	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	19
21 - 22	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
22 - 23	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01 - 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
02 - 03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5
03 - 04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5
04 - 05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	6
05 - 06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3
06 - 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	6
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	6
* DAILY	0	0	0	9	19	0	0	0	23	1	2	5	25	0	0	0	14	0	0	0	0	0	0	0	11	0	1	0	34	17	0	161

Table 3-35 Hourly Rainfall at Science Garden in 2006

Unit : mm

2006																														
November	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09 - 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 - 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 - 13	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
13 - 14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
14 - 15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
15 - 16	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	6
16 - 17	0	0	1	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
17 - 18	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
18 - 19	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
19 - 20	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
20 - 21	8	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
21 - 22	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
22 - 23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23 - 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	11
00 - 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
01 - 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5
02 - 03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	16
03 - 04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04 - 05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
05 - 06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06 - 07	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
07 - 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* DAILY	18	0	1	4	1	17	0	2	0	1	0	0	0	0	0	1	0	0	6	0	0	0	0	0	0	0	0	0	0	35	86

Table 3-36 Hourly Rainfall at Science Garden in 2006

Unit : mm

2006																															
December	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL
08 - 09	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
09 - 10	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
10 - 11	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
11 - 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
12 - 13	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	8
13 - 14	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
14 - 15	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
15 - 16	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
16 - 17	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2
17 - 18	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
18 - 19	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
19 - 20	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
20 - 21	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
21 - 22	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
22 - 23	0	0	0	0	0	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
23 - 24	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
00 - 01	0	0	0	0	0	0	1	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
01 - 02	0	0	0	0	0	0	0	0	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
02 - 03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03 - 04	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
04 - 05	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
05 - 06	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
06 - 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07 - 08	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
* DAILY	0	0	0	0	0	0	2	0	3	46	4	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	64

Table 4-1 Annual Maximum Rainfall at Science Garden Station

Unit: mm

Year	1 hour	2-hour	3-hour	6-hour	12-hour	24-hour	48-hour
1961	-	-	-	177.8	213.1	251.0	280.2
1962	-	-	-	135.6	173.7	205.0	327.9
1963	-	-	-	71.6	125.0	167.1	178.3
1964	-	-	-	99.1	104.1	198.3	259.5
1965	50.8	73.3	88.2	115.3	140.8	159.8	239.3
1966	60.0	85.1	100.7	125.1	153.9	169.9	274.3
1967	102.4	149.6	181.0	239.7	292.8	334.5	350.0
1968	45.6	66.1	79.6	104.7	127.9	145.5	205.0
1969	38.9	56.4	67.8	88.4	108.6	122.8	397.3
1970	83.7	122.4	148.4	197.7	241.0	276.5	-
1971	46.2	54.7	57.9	74.4	80.5	84.6	103.7
1972	72.5	122.5	143.5	158.5	159.8	218.0	435.2
1973	130.3	130.8	131.3	131.3	131.3	131.3	298.1
1974	42.2	77.5	102.6	149.4	180.8	214.3	366.3
1975	31.7	48.9	68.0	104.9	170.1	209.3	247.7
1976	128.0	186.3	224.7	294.5	361.2	410.1	-
1977	39.3	58.5	71.5	90.3	116.3	135.7	-
1978	47.2	68.1	81.3	103.8	148.2	174.4	255.5
1979	67.1	86.9	130.3	179.3	191.7	223.0	297.9
1980	46.0	70.4	77.4	102.7	123.6	133.8	147.5
1981	37.5	50.0	52.4	73.0	115.7	161.0	230.9
1982	42.2	60.1	71.2	89.1	109.8	121.6	144.2
1983	35.2	51.3	62.0	82.0	100.2	114.4	131.2
1984	35.4	50.9	60.8	77.4	95.4	106.6	-
1985	41.8	60.3	72.6	95.1	116.0	131.0	-
1986	72.2	122.7	150.7	176.1	184.9	190.4	367.5
1987	42.4	62.0	74.7	99.0	120.1	137.6	142.0
1988	38.5	55.6	67.2	88.9	107.7	123.1	240.5
1989	32.4	45.8	54.5	70.4	85.2	96.4	175.4
1990	63.7	91.9	110.4	143.8	176.0	199.4	233.6
1991	-	-	-	157.8	194.2	253.5	295.5
1992	-	-	-	81.2	101.0	145.2	177.6
1993	-	-	-	112.6	138.6	151.9	209.4
1994	-	-	-	106.6	145.8	169.8	196.4
1995	-	-	-	72.0	106.0	163.6	169.8
1996	-	-	-	81.2	94.2	120.2	155.0
1997	-	-	-	104.2	191.8	223.8	301.2
1998	-	-	-	89.8	108.7	172.7	241.5
1999	-	-	-	191.7	204.8	280.7	431.3
2000	-	-	-	181.4	260.2	267.0	319.2
2001	-	-	-	88.0	105.0	129.4	209.7
2002	-	-	-	80.6	152.4	216.3	417.9
2003	-	-	-	73.2	99.0	156.0	278.6
2004	49.0	82.0	106.0	172.0	201.0	230.0	312.0
2005	39.0	65.0	74.0	82.0	83.0	100.0	119.0
2006	86.0	134.0	148.0	155.0	156.0	156.0	226.0

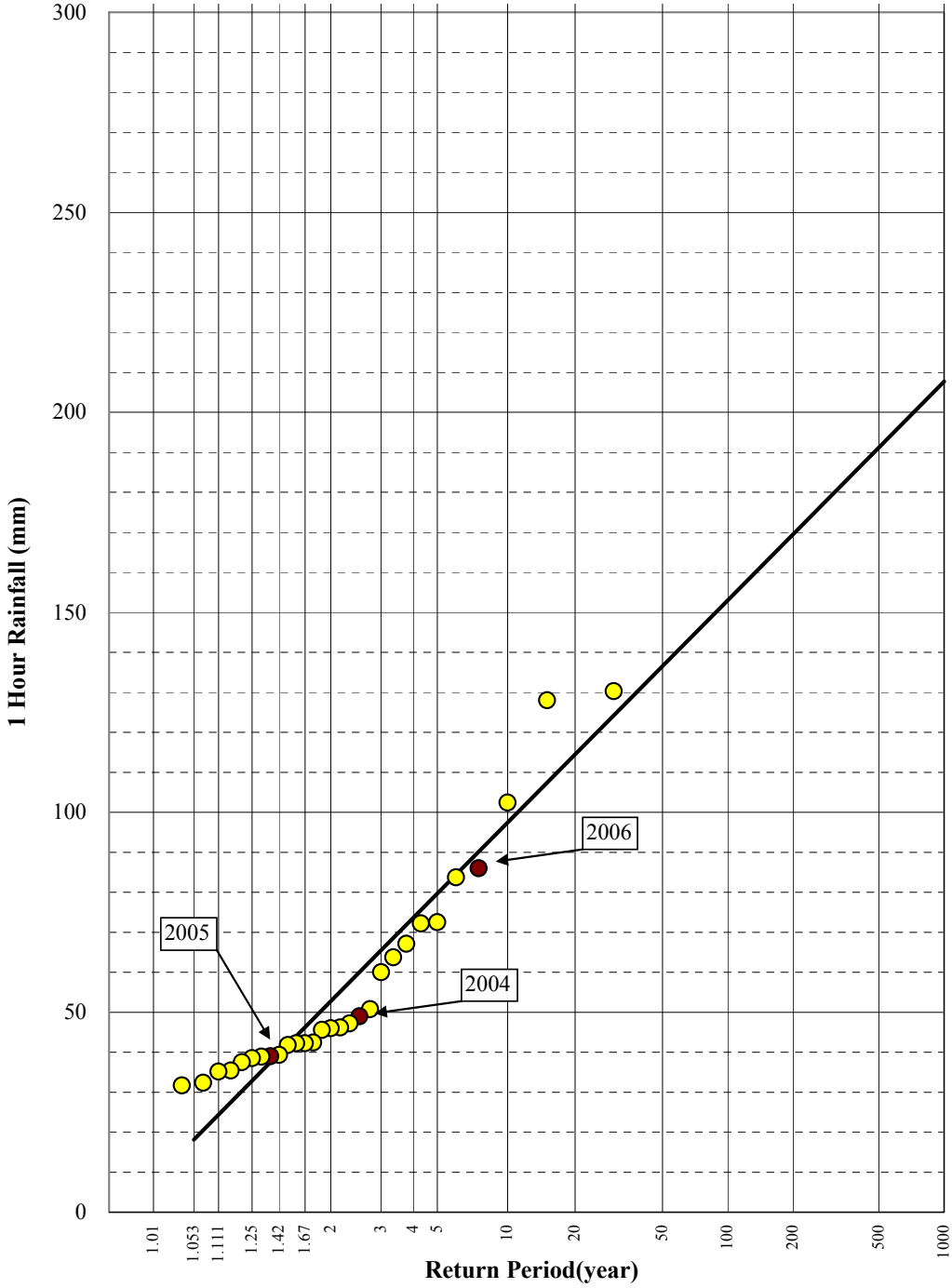


Figure 6-1 Probability Analysis of 1-Hour Rainfall at Science Garden

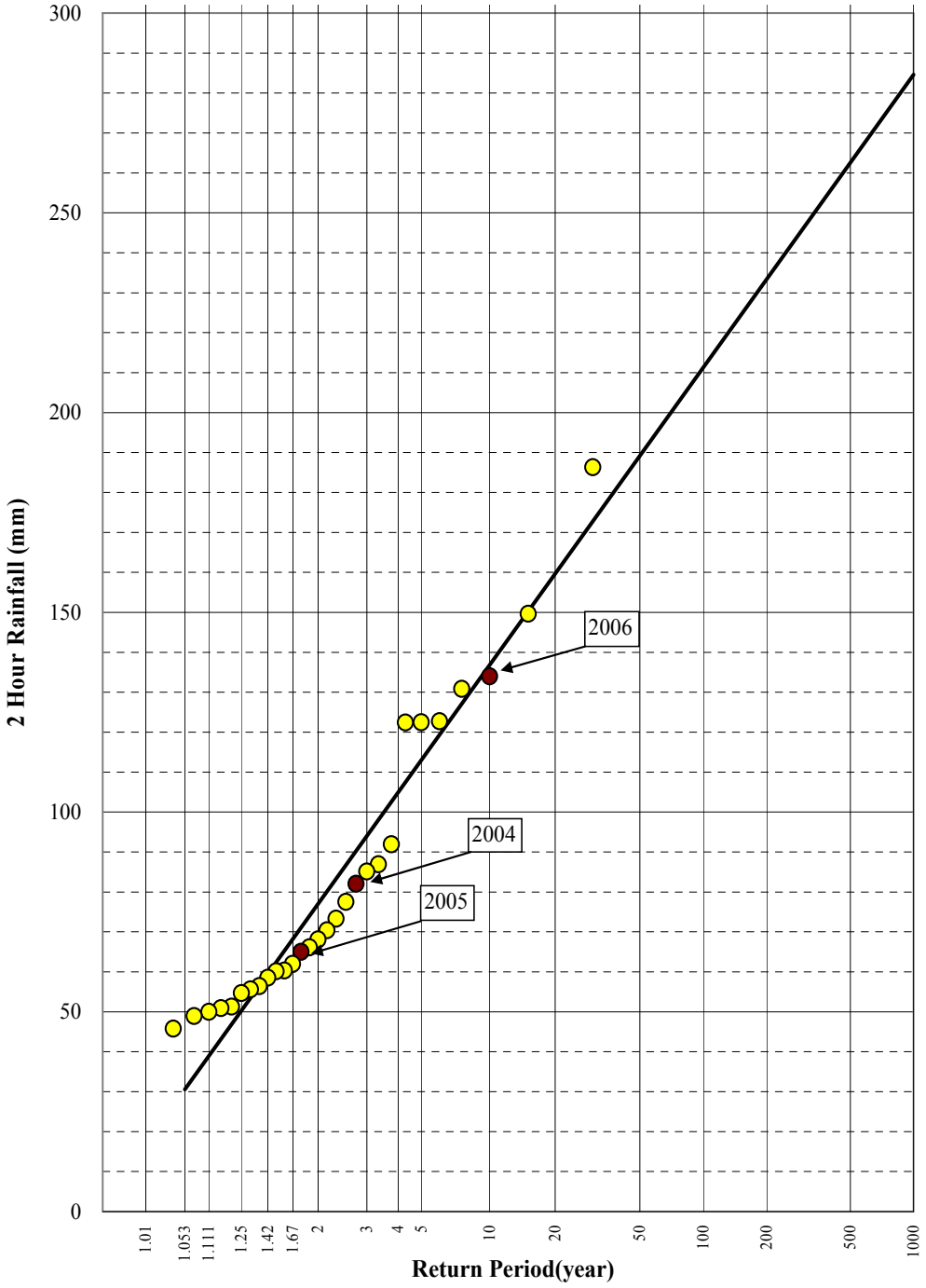


Figure 6-2 Probability Analysis of 2-Hour Rainfall at Science Garden

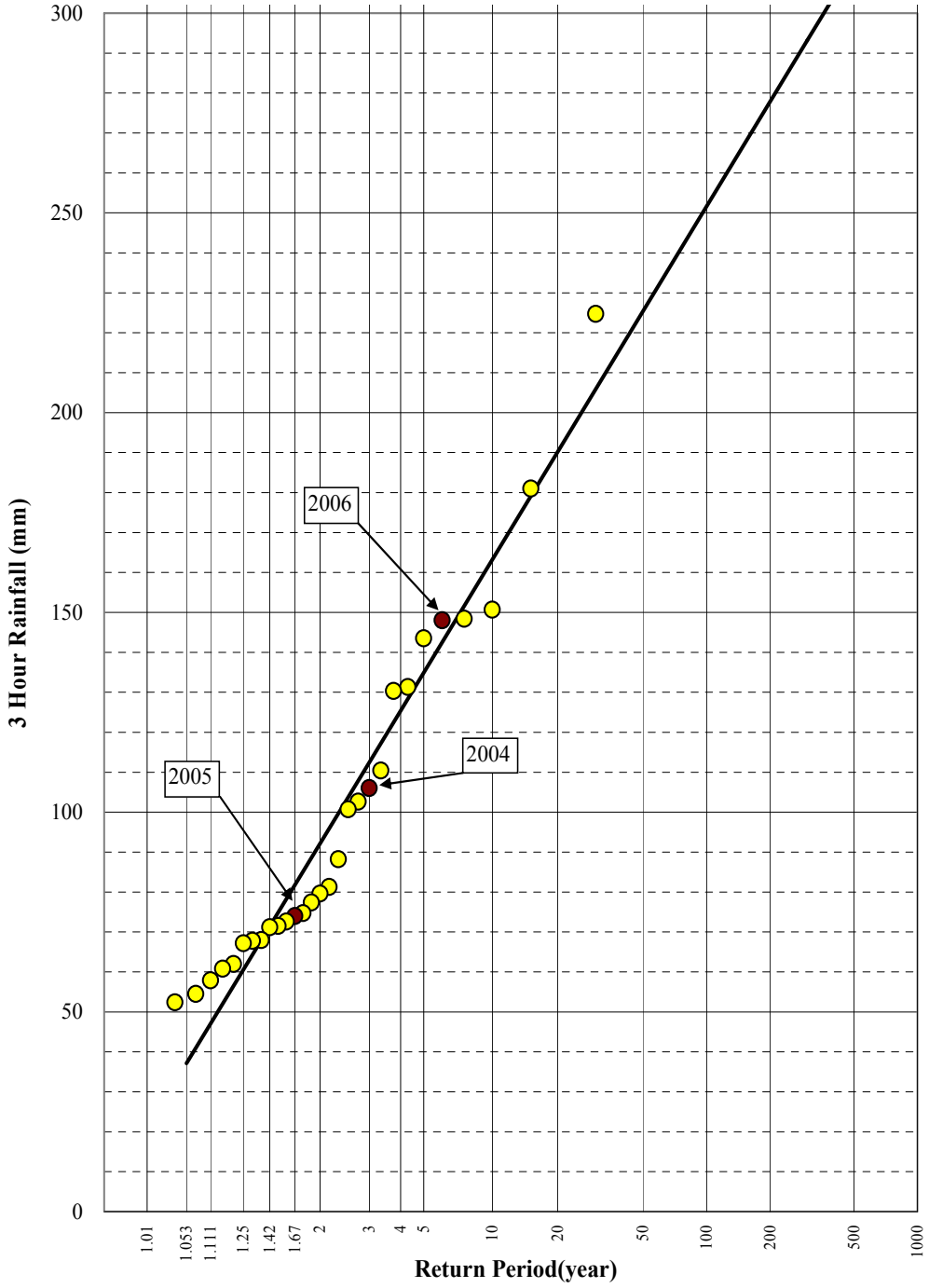


Figure 6-3 Probability Analysis of 3-Hour Rainfall at Science Garden

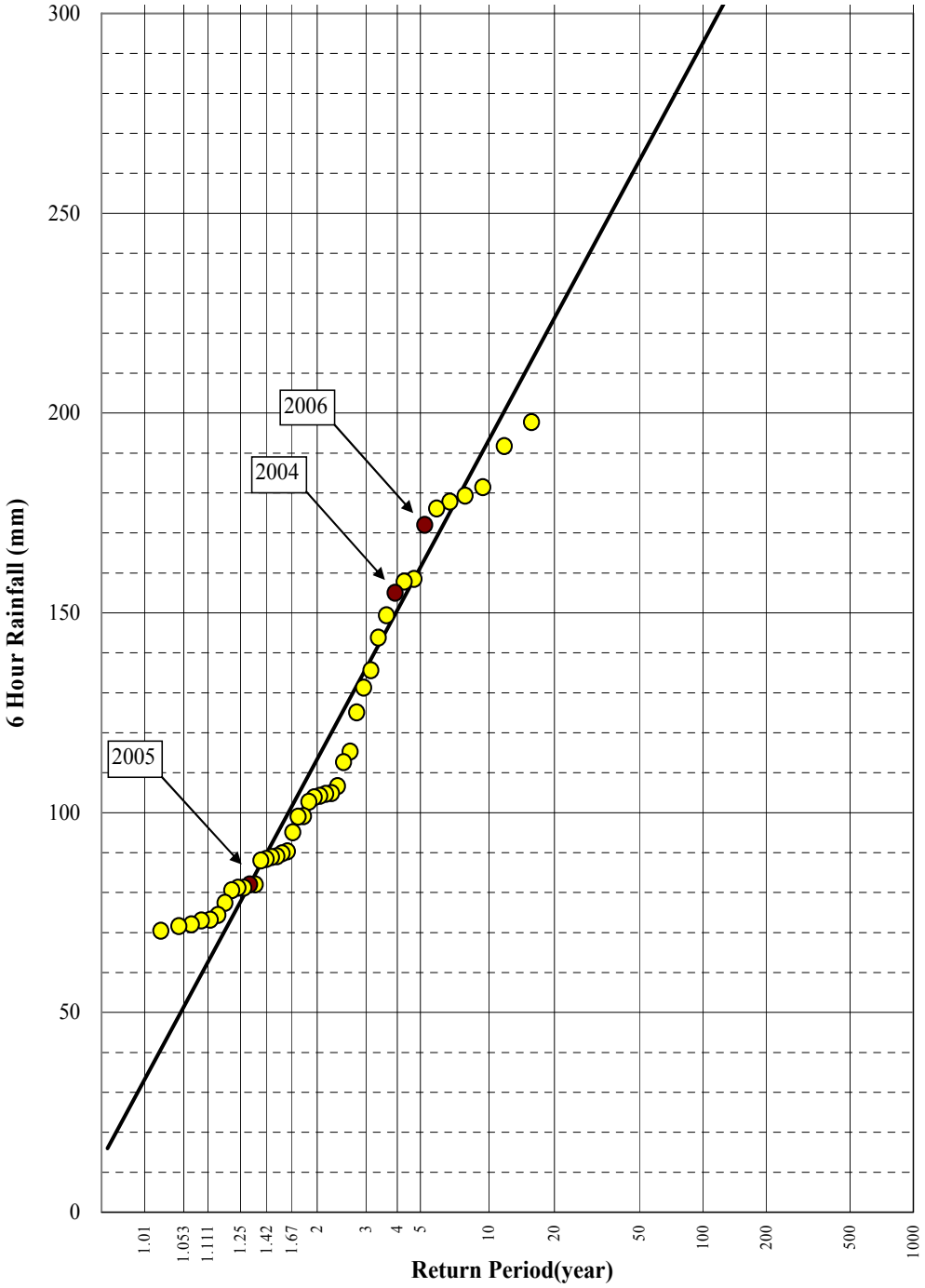


Figure 6-4 Probability Analysis of 6-Hour Rainfall at Science Garden

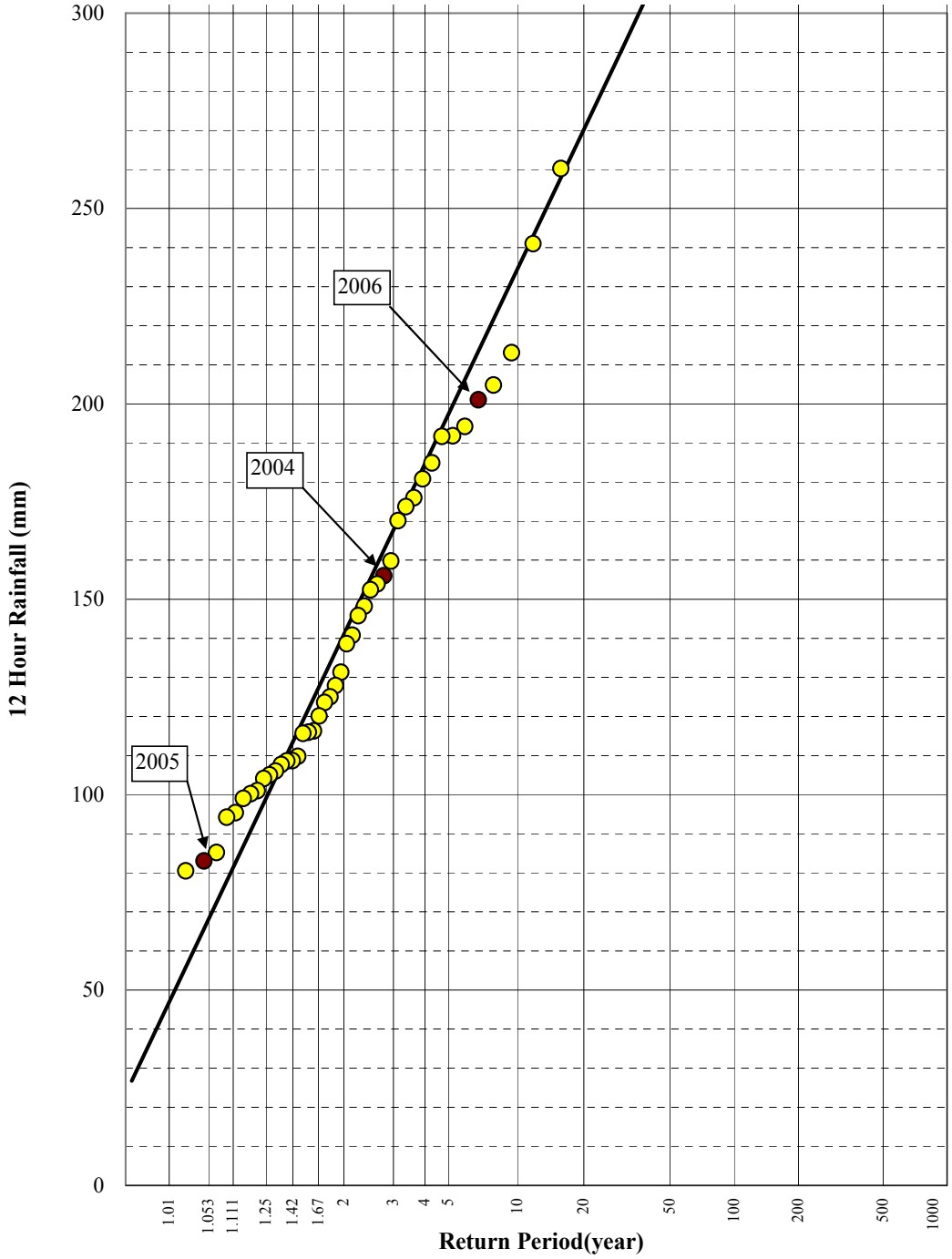


Figure 6-5 Probability Analysis of 12-Hour Rainfall at Science Garden

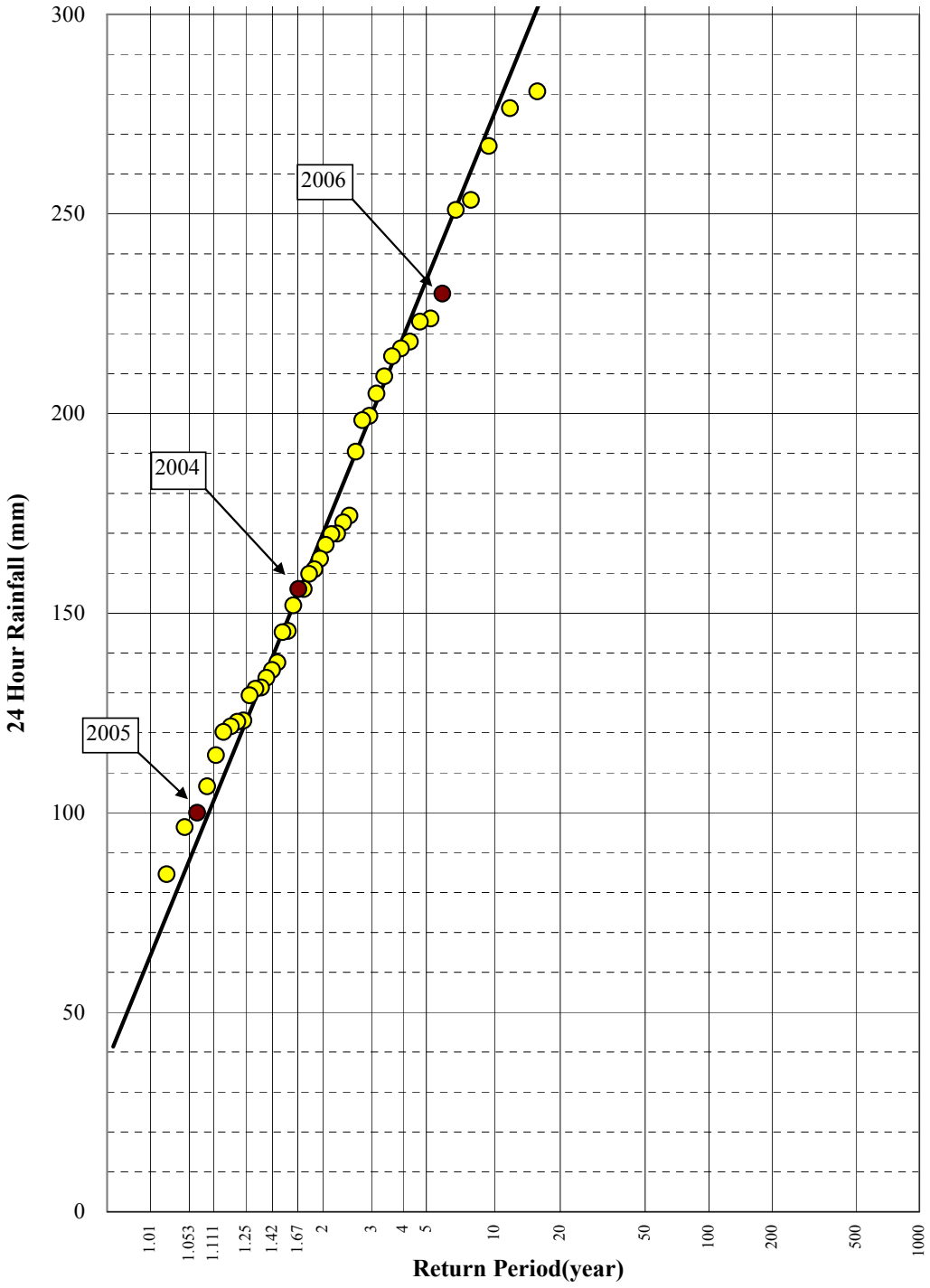


Figure 6-6 Probability Analysis of 24-Hour Rainfall at Science Garden

B Existing Conditions of Drainage Canals

B Existing Conditions of Drainage Canals

1. General

The targeted drainage pumping stations for this Basic Design Study are Quiapo, Aviles・Sampaloc and Tripa de Gallina. The locations of are shown in Figure 1-1. Locations of major drainage canals are shown in Figure 1-2.

2. Existing Conditions

2.1 Quiapo Drainage Pumping Station

Inlet canal to the Quiapo drainage pumping station is full of garbage and the water hyacinth as shown in the following photo:

Inlet Canal to Quiapo Drainage Pumping Station (as of March 3, 2007)

As can be seen in the photo, houses are densely built up on both sides of the canal, but the houses are not the obstructions of the flow. Though details should be further examined, It is expected that a suitable flow width for the scale of the Drainage Pumping Station is secured.

The drainage canal on the downstream side of the Drainage Pumping Station is rather clean with almost no garbage and no illegal houses constructed along the canal as seen in the following photo:

Downstream Canal of Quiapo Drainage Pumping Station as of March 3, 2007

One of the major drainage canals is Estero de San Miguel. The canal is connected to Aviles Sampaloc Drainage Pumping Station. The present conditions of the canal are as shown in the following photo:

Estero de San Miguel as of March 8, 2007

Some garbage is seen in the canal but no illegal houses are constructed in the canal

The other major drainage canal is Estero de Quiapo and its situation is as shown in the following photo;

Estero de Quiapo as of March 8, 2007

As seen in the photo, a considerable number of illegal houses are constructed in the area of the drainage canal of Estero de Quiapo. These houses are deemed to have foundation piles in the canal, and depending on the conditions, may lead to disturbance of the flow.. There are also a considerable amount of garbage I the canal. However, the width of the canal itself is expected to be sufficient.

One of the secondary canals joining the Estero de Quiapo is called as NE13 in the Development Study and the present conditions of the canal are as shown in the following photo;

Secondary Canal to Estero de Quiapo as of March 8, 2007

On the other hand, present conditions of one of the secondary canal to Estero de San Miguel called as NE15 in the Development Study are shown in the following photo;

NE15 (Secondary Canal to Estero de San Miguel) as of March 8, 2007

As seen in the photo, the canal is fully filled up and the function as the drainage canal is completely lost. According to the neighboring people, the adjacent road becomes as a drainage canal in the rainy season and depending on the year, sometimes the flow depth comes up to the knee or waist height.

2.2 Aviles Sampaloc Drainage Pumping Station

Inlet Canal to Aviles Sampaloc Drainage Pumping Station as of March 3, 2007

The inlet canal to Aviles Sampaloc drainage pumping station is shown in the following photo. As seen in the photo, the inlet canal is clean without any garbage and no illegal houses are constructed along the canal. The canal remains the same as when it was built.

The major drainage canal flowing into the Aviles Sampaloc drainage system is Estero de Sampaloc and the present situation of the canal at the crossing point with J.P. Laurel Road is as shown in the following photo;

Estero de Sampaloc as of March 8, 2007

As seen in the photo, neither garbage nor illegal houses are seen along the canal.

On the other hand, the situation of the drainage canal called as NE18 in the Developent Plan is as shown in the following photo:

Estero de Sampaloc as of March 8, 2007

As seen in the photo, the canal entering the tunnel is full of garbage just in the upstream reaches of the road. But in the further upstream reaches, the canal is not full of garbage but some illegal houses are constructed in the canal as shown in the following photo.

2.3 Tripa de Gallina Drainage Pumping Station

Inlet of Tripa de Gallina Drainage Pumping Station as of March 3, 2007

As seen in the photo, no garbage can be seen in the canal. Just before the drainage system. But some garbage is accumulated at the garbage screen site as seen in the following photo;

Tripa de Gallina Drainage Pumping Stationas of March 3, 2007

The canal downstream of the pumping station is the Parafiaque River and the canal upstream of the pumping station is Estero de Tripa de Gallina. A small regulating pond is provided around 500 m upstream of the pumping station. As shown in the following photo, many illegal houses are constructed around the pond, but the garbage are not so much widely accumulated.

Regulating Pond of Estero de Tripa de Gallina as of March 9, 2007

The Estero de Tripa de Gallina is connected to drainage blocks flowing to the far Pasig River. The drainage basin boundary with the Libertad drainage system is located at around 3 km upstream of the pumping station, at the crossing place with the Antonio S Araniz Avenue. The situation of this area is as shown in the following photo;

Estero de Tripa de Gallina at Antonio S Aranaiz Avenue as of March 9, 2007

As seen in the photo, the flow width is secured but houses are overhanging over the canal and garbage is accumulated at this place.

Zanzibar Creek is a secondary drainage canal flowings into the Estero de Tripa de Gallina at the east of this place. The present situation is as shown in the following photo;

Zainzibar Creek as of March 9, 2007

Here, no illegal houses are seen but a considerable amount of garbage is accumulated. Furthermore, there is a highway running above the road seen in this photo, and its pier is completely blocking the drainage canal. Thus the drainage canal here has also completely lost its function.

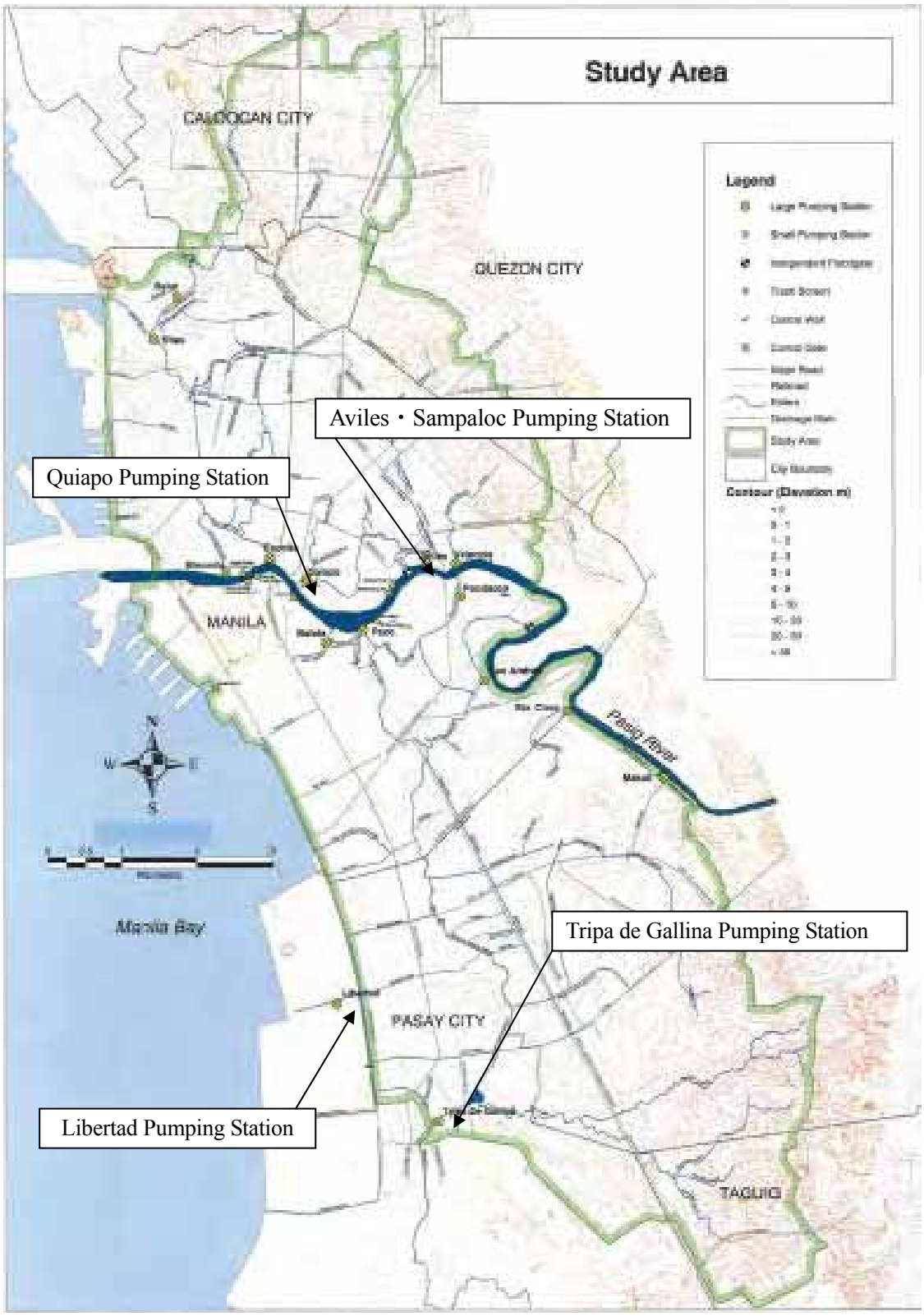


Figure 1-1 Location of Drainage Pumping Stations

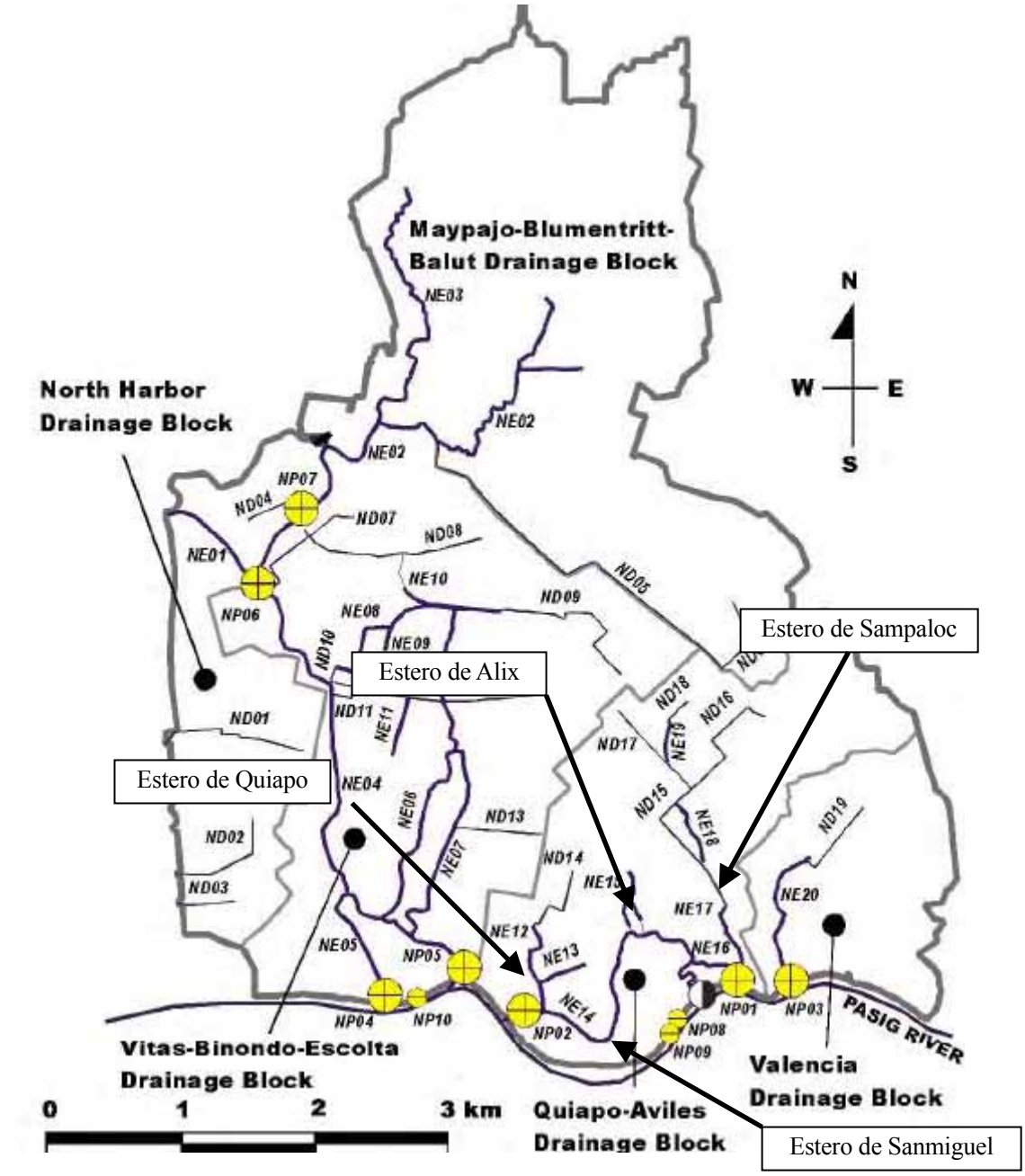


Figure 1-2 (1) Locations of Major Drainage Canals of Quiapo and Aviles Sampaloc

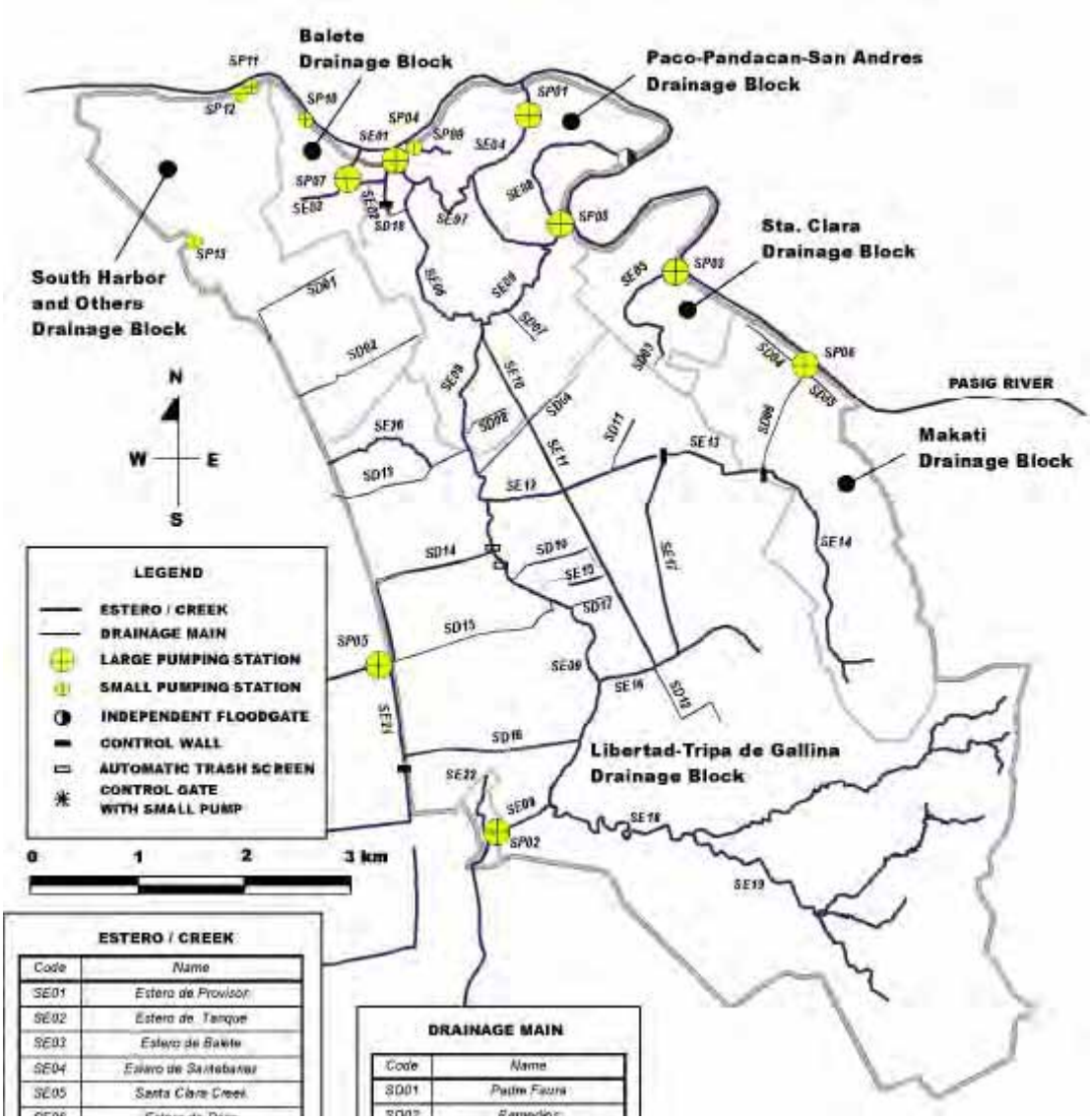


Figure 1-2 (2) Locations of Major Drainage Canals of Tripa de Gallina

C Flow Capacity of Drainage Canal

C Flow Capacity of Drainage Canal

1. Comparison of Cross-sectional Profile of Drainage Canal

1.1 General

The Development study was conducted in 2004 to 2005 and cross-sectional survey of drainage canals were conducted at the following locations. In this study, evaluation of change of cross-sectional area of flow was carried out at the same location which ahs been surveyed in the Development study.

Drainage Block	Drainage Canal	No. of Location
Quiapo	Estero de Alix	2
Aviles・Sampaloc	Estero de Sampaloc	2
Tripa de Gallina	Estero de Tripa de Gallina	8
“do“	Zanzibar Creek	2

In the study, brief cross-sectional survey of drainage canals at the same locations was originally planed but due to the reasons that some canals were not functioning as drainage canal or due to fences or some other facilities the survey was impossible to conduct, the survey has been conducted at the locations with some modifications as follows:

Drainage Block	Drainage Canal	No. of Location
Quiapo	Estero de San Miguel, etc.	2
Aviles・Sampaloc	Estero de Sampaloc	4
Tripa de Gallina	Estero de Tripa de Gallina	8

The survey has been conducted without any traverse survey or leveling survey due to limited budget and time frame.

1.2 Comparison of Cross Sections

The locations of cross-sectional survey of drainage canal in the present study are shown in Figure 1-2-1 and the comparison of cross-sectional profiles between the cross-sectional profiles in the master plan study and the present study are shown in Figure 1-2-2.

As shown in the figures, some cross-sectional profiles seem to have decreased in its flow area to certain extent, but generally it can be concluded that decrease of flow area since the master plan study time is negligible.

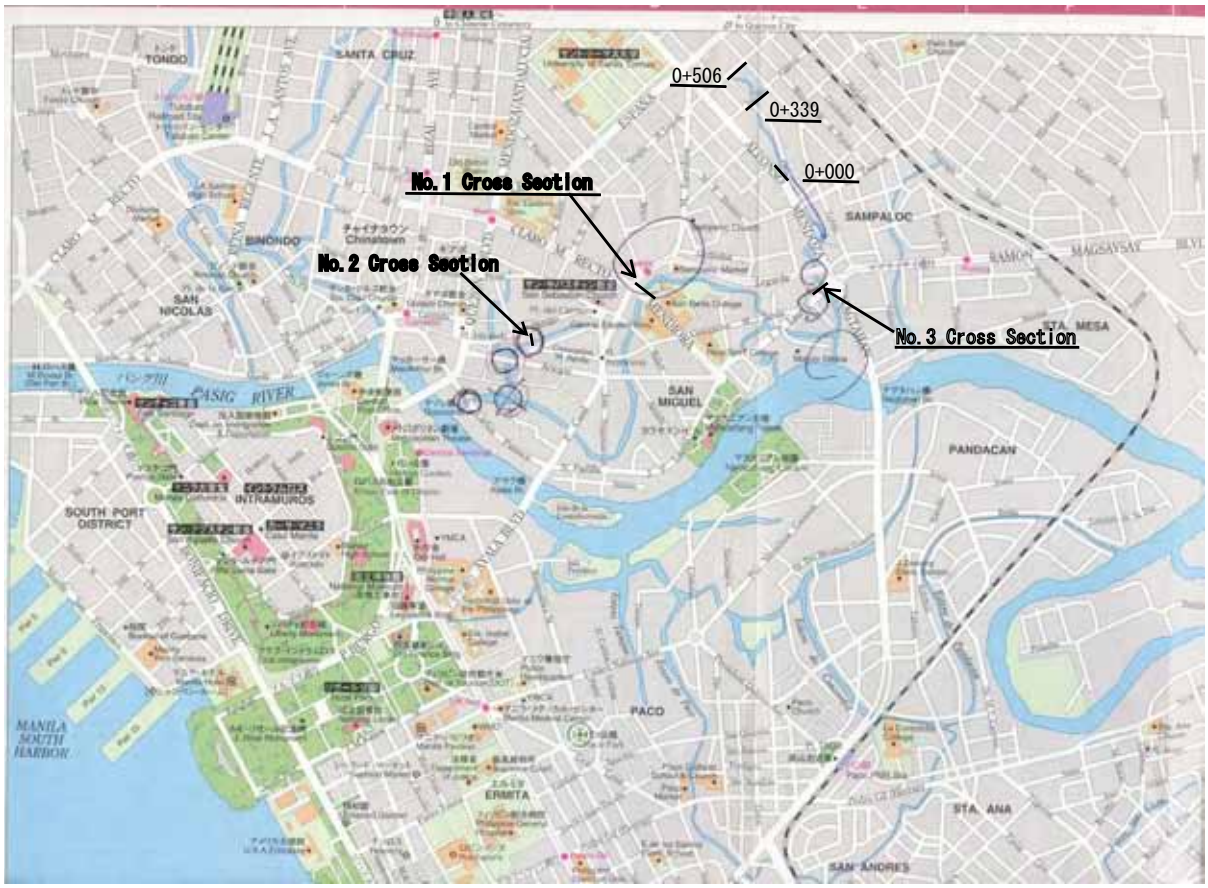


Fig 1-2-1 (1) Location of Cross-sectional Survey in Quiapo/ Aviles・Sampaloc Drainage Area

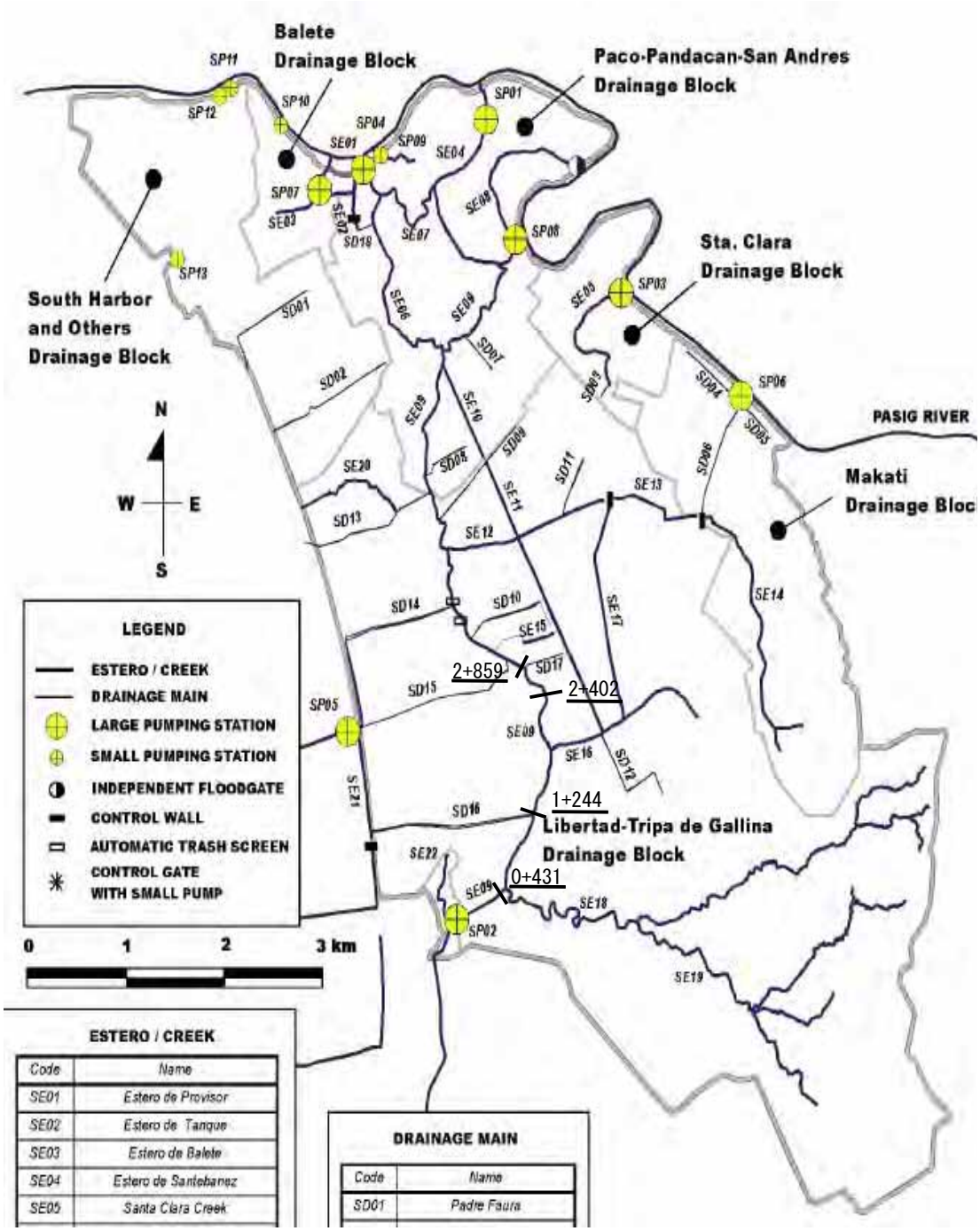
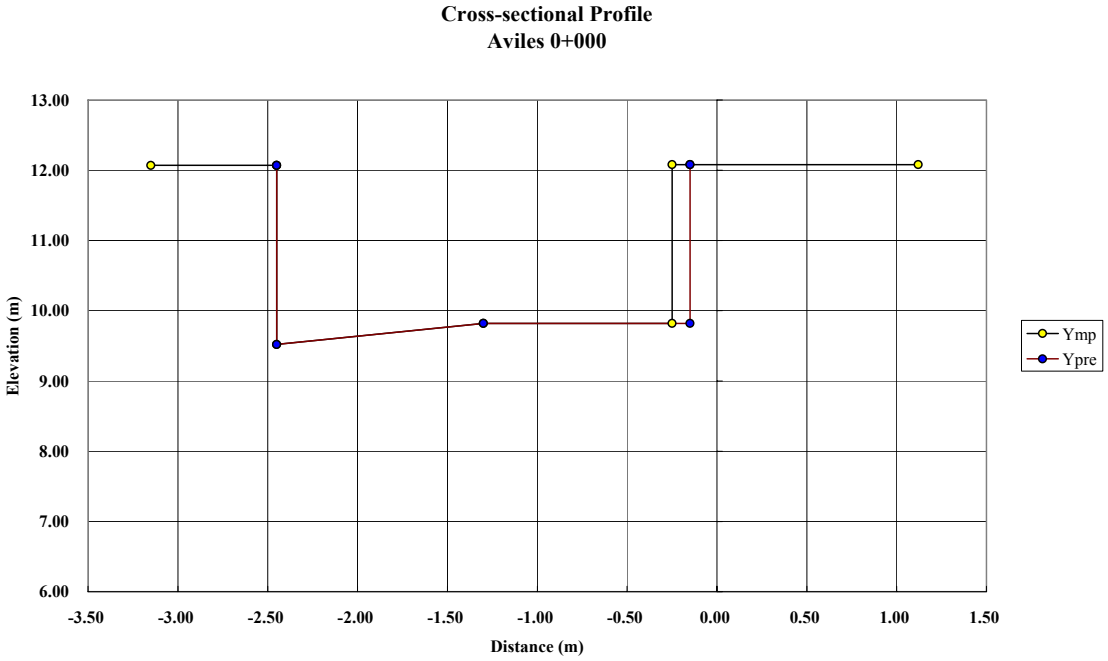
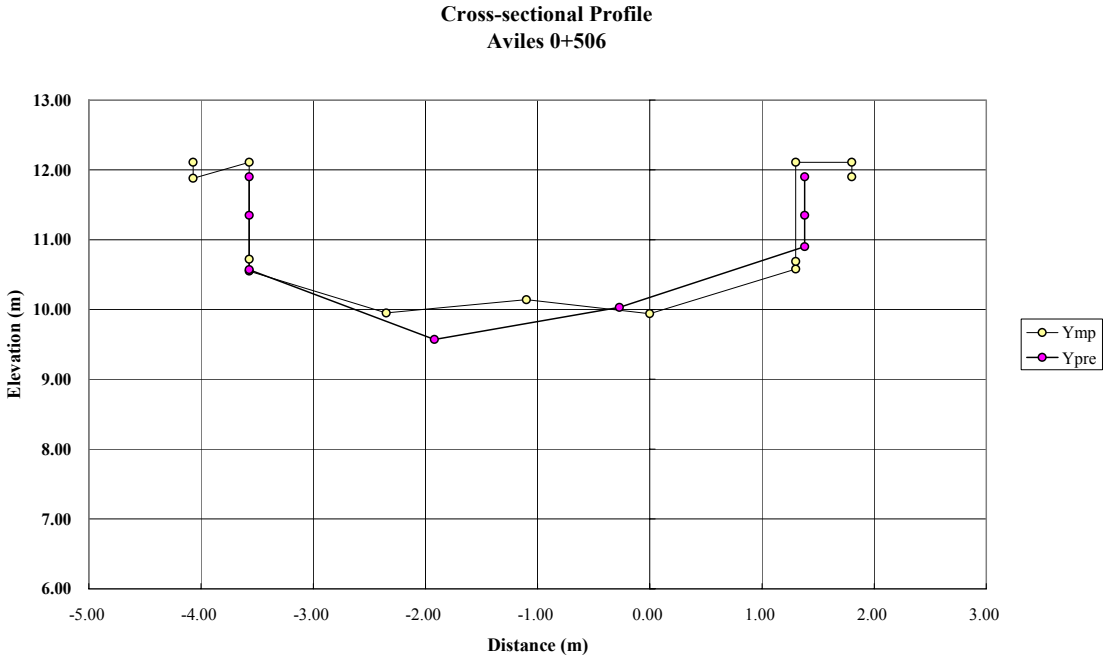


Fig 1-2-1 (2) Location of Cross-sectional Survey in Tripa de Gallina Drainage Area

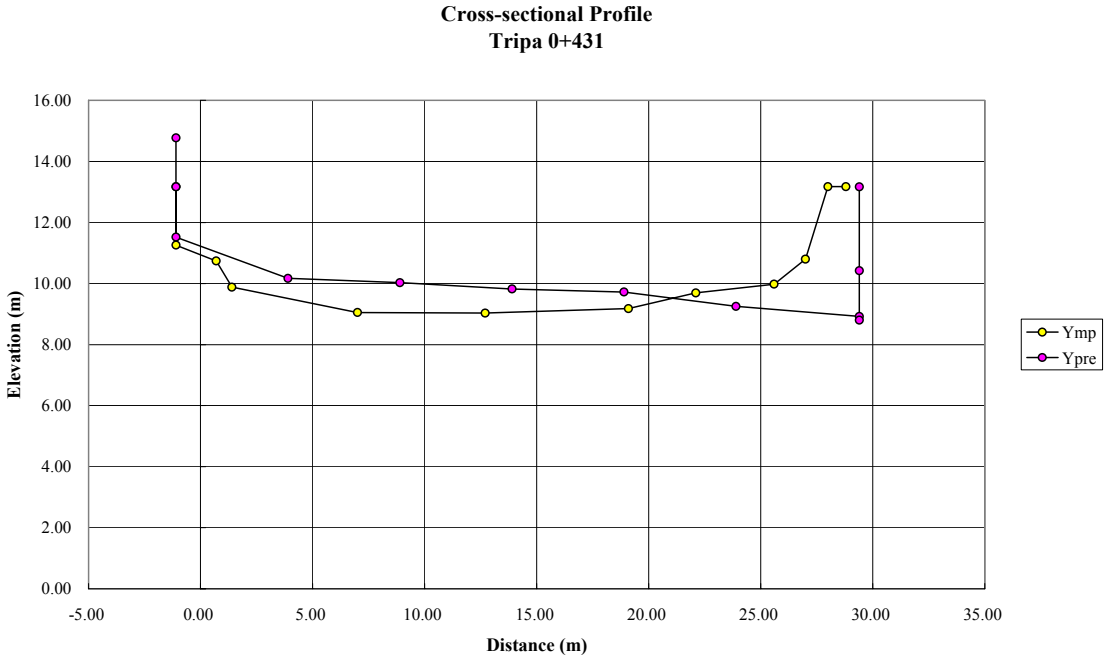


Note: Ymp shows the cross-section in the Development stage and Ypres shows the cross-section in the present study.

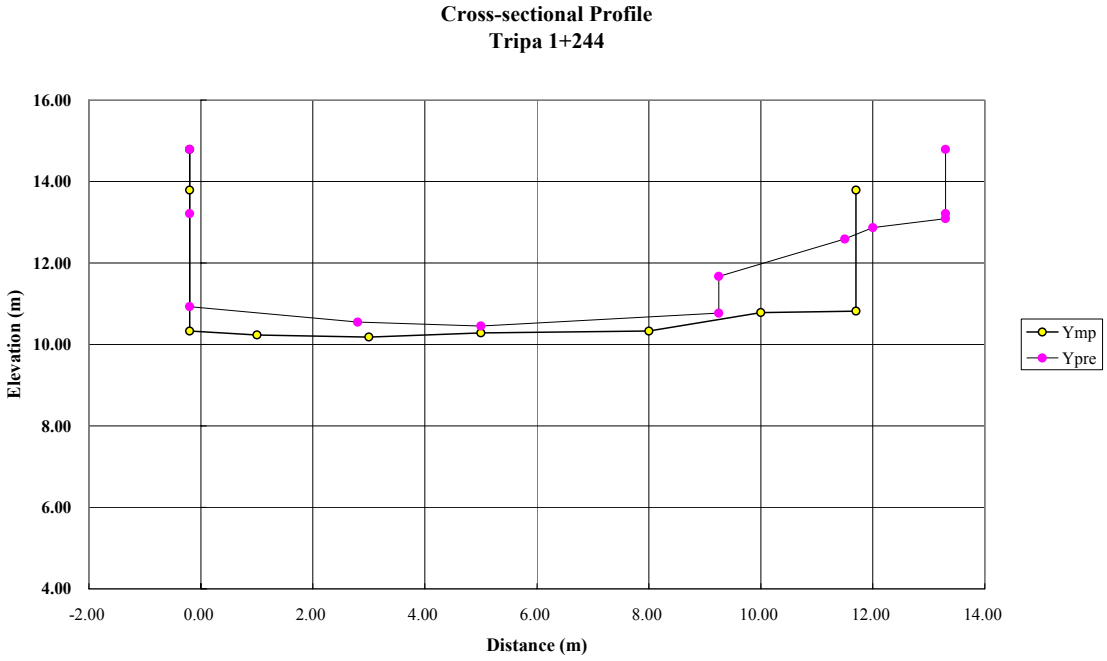


Note: Ymp shows the cross-section in the Development stage and Ypres shows the cross-section in the present study.

Figure 1-2-2 (1) Comparison of Cross-sectional Profile of Drainage Canal



Note: Ymp shows the cross-section in the Development study and Ypres shows the cross-section in the present study.



Note: Ymp shows the cross-section in the Development study and Ypres shows the cross-section in the present study.

Figure 1-2-2 (2) Comparison of Cross-sectional Profile of Drainage Canal

2. Evaluation of Flow Capacity of Drainage Canal

2.1 General

According to the results of evaluation of flow capacity of drainage canals which were conducted by the Development study from 2004 to 2005, flow capacity of both Aviles・Sampaloc and Tripa de Gallina were evaluated as less than 2 years return period mostly. Since cross section of drainage canals are not changed, evaluation results should be same. However, according to the results of field survey of each drainage pumping station and drainage canals, it is seen that scale of drainage pumping stations correspond to capacity of drainage canals, even though there are lot of garbage flowing in the drainage canals. Therefore, simple examination on flow capacity of drainage canals was carried out in the study.

2.2 Method of Evaluation

Basin are of each drainage pumping station and cross section survey sites are estimated based on the results of the Development study. Assumed flow volume of cross section survey site is estimated by a ratio of basin area based on drainage capacity of each drainage pumping station. Flow capacities of each cross section are examined by varied flow calculation or uniform flow calculation. Flow capacities of each drainage canal are evaluated whether flow capacity of drainage canal correspond to drainage capacity of each drainage pumping station or not.

2.3 Evaluation Results

2.3.1 Drainage Canal of Quiapo Drainage Pumping Station

The locations of the cross-sections used for the evaluation of flow capacity are No. 1 and No. 2 locations shown in Figure 1-2-1 (1). No. 1 location is located just upstream of the Mendiora bridge over the Estero de San Miguel and No. 2 location is located over the secondary canal flowing to Estero de Quiapo. But since these cross-sections are not the cross-sections of the master plan study,

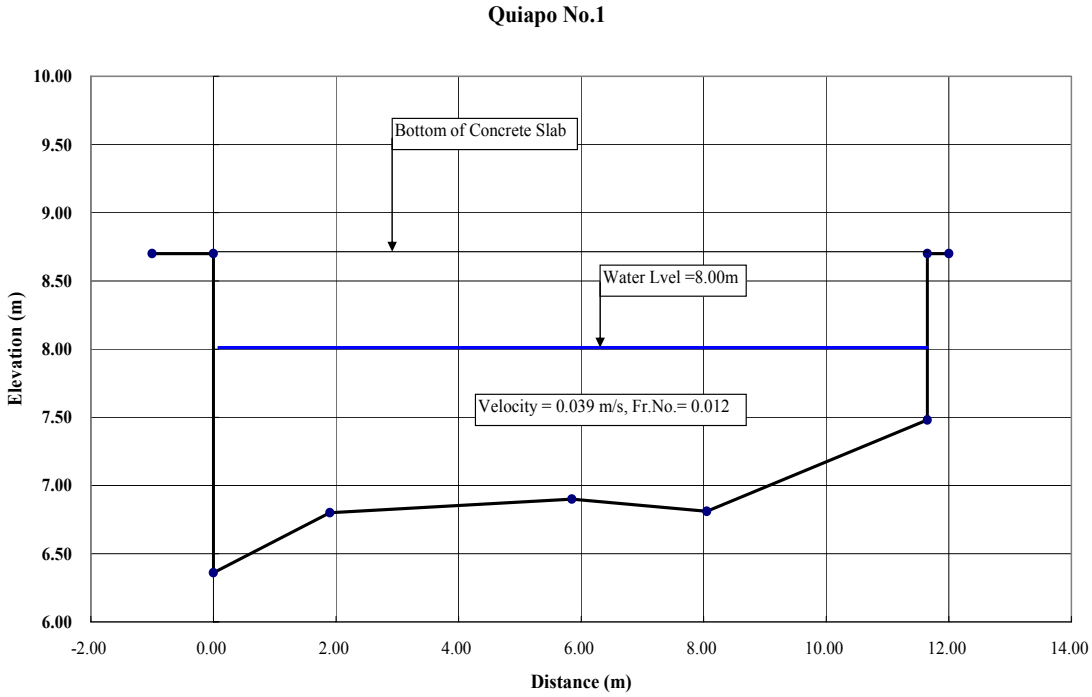
Since the longitudinal profile of the canal is not available, the flow velocity and the water depth necessary to discharge the assumed flow corresponding to the drainage capacity of the drainage pumping station and thus calculated flow velocity and the water depth have been evaluated from a comprehensive viewpoint.

The Estero de Alix has, as mentioned in the previous section, already lost its drainage function since the canal is completely blocked in the downstream reaches.

1) No. 1 location (Estero de San Miguel)

Location	Drainage Area (km^2)	Q10(m^3/s)	Remarks
Pumping Station	2.293	10.8	Master Plan
No.1	0.100	0.5	Area Ratio Calculation

The necessary flow at No. 1 location is calculated proportional to the drainage capacity of the Qiapo drainage pumping station in the drainage area. With that condition, the flow velocity and the water depth at No. 1 location has been calculated and shown in the following figure;



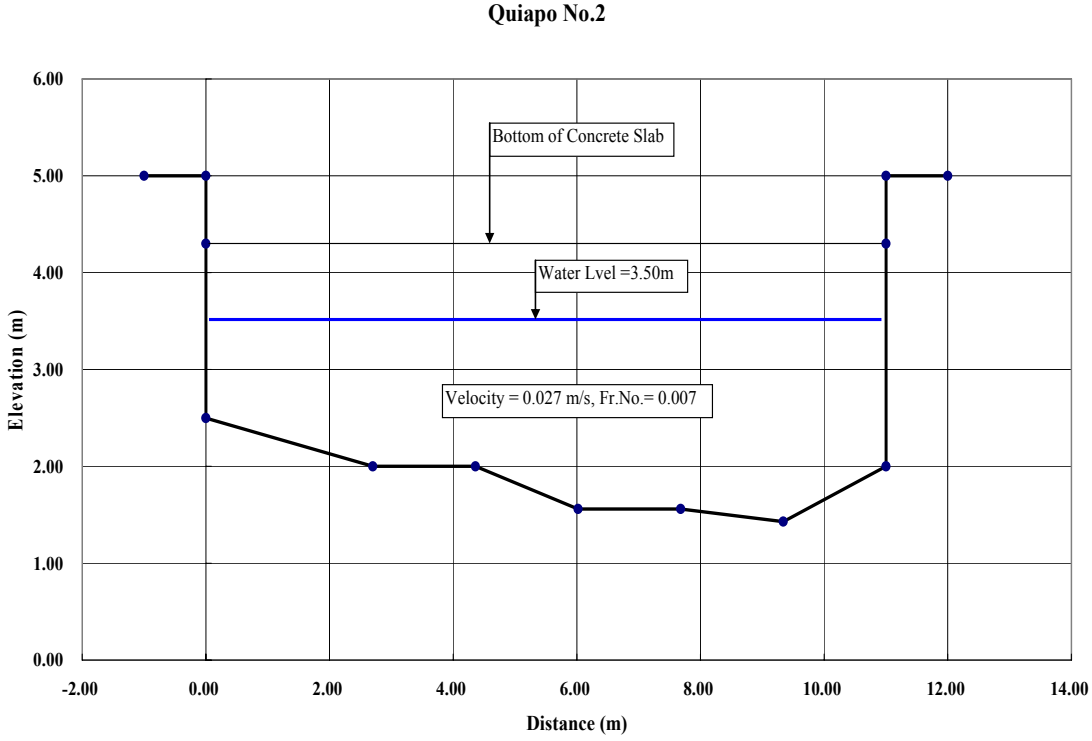
In the above figure, the elevation is neither the elevation above the mean sea level nor the elevation above certain datum line. The elevation here is just assumed one for comparison purpose.

In the above figure, when the water surface elevation is assumed to be 8.0 m with the elevation of the bottom of the bridge girder slab of 8.70 m, the necessary flow velocity for the necessary discharge capacity corresponding to the drainage pumping capacity becomes just 0.039 m/sec and the Froude Number is 0.012. Accordingly the Estero de San Miguel at this location can be said to have the enough flow capacity for drainage.

2) No. 2 location (secondary canal to Estero de Quiapo)

Location	Drainage Area (km^2)	Q10(m^3/s)	Remarks
Pumping Station	2.293	10.8	Master Plan
No.2	0.100	0.5	Area Ratio Calculation

The necessary flow at No. 2 location is calculated proportional to the drainage capacity of the Quiapo drainage pumping station in the drainage area. With that condition, the flow velocity and the water depth at No. 2 location has been calculated and shown in the following figure;



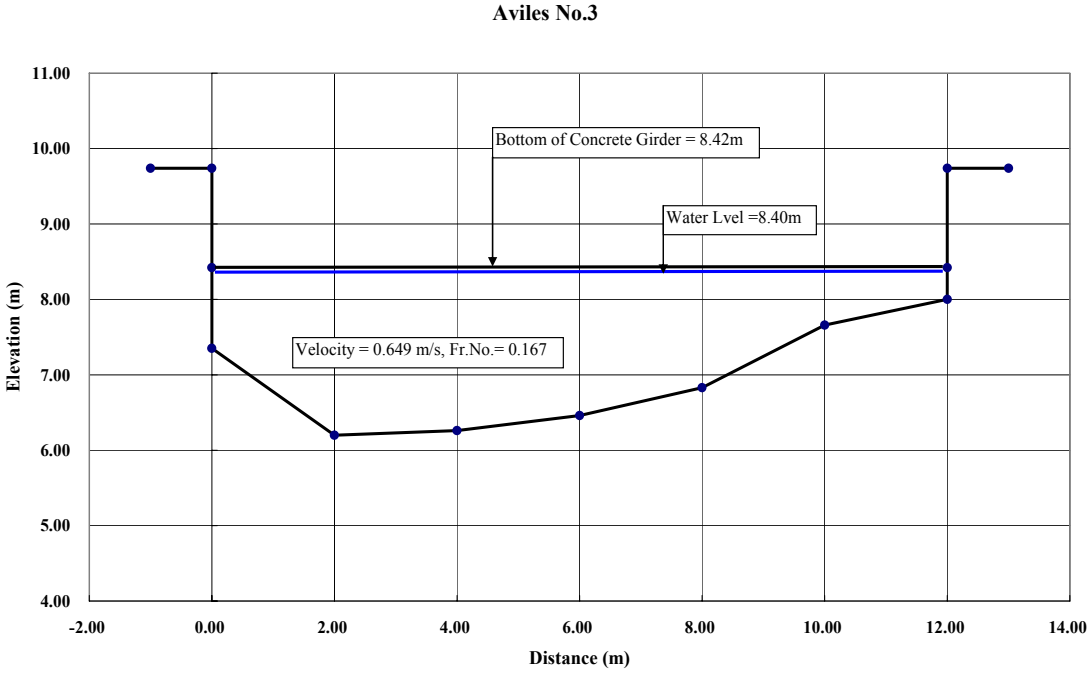
In the above figure, the elevation of the bottom of the bridge girder slab is 4.20 m and with the assumed water surface elevation of 3.50 m, the necessary flow velocity become just 0.027 m/sec for the necessary discharge corresponding to the drainage capacity of the pumping station and the Froude Number is 0.007. Accordingly the secondary drainage canal to the Estero de Quiapo at this location can be said to have the enough flow capacity for drainage.

2.3.2 Drainage Canal of Aviles・Sampaloc Drainage System

The locations of the cross-sections used for the evaluation of flow capacity are No. 3 and 0+000, 0+339, and 0+506 locations of Estero de Sampaloc shown in Figure 1-2-1 (1). Cross-sectional profile at No. 3 location is not available in the master plan study but cross-sectional profiles at other three locations are available in the master plan study and accordingly the evaluation of flow capacity at No. 3 location has been conducted in the same manner with the way mentioned in the previous section on Quiapo drainage system and the evaluation of flow capacity at other three locations has been conducted by use of non-uniform flow calculation since the longitudinal profile is available on this drainage canal.

1) No. 3 location (Estero de Sampaloc)

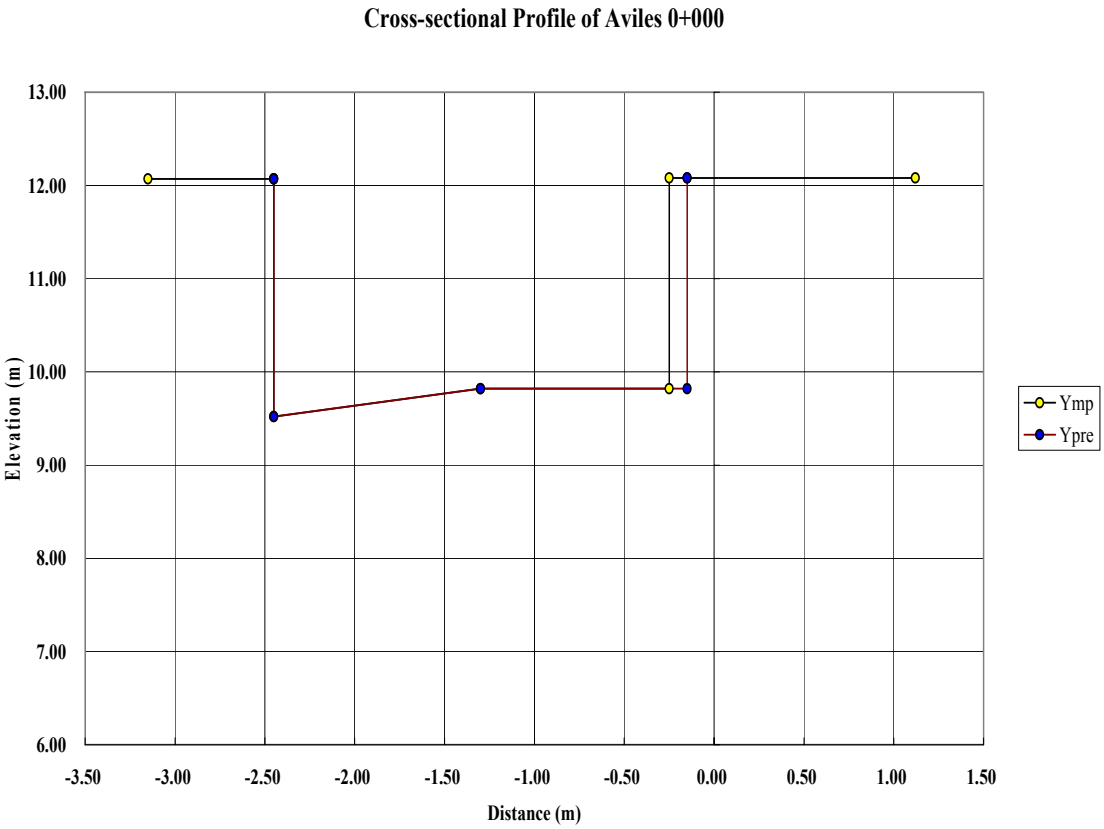
Location	Drainage Area (km^2)	Q10(m^3/s)	Remarks
Pumping Station	3.284	15.6	Master Plan
No. 3	2.550	12.1	Area Ration Calculation



In the above figure, the elevation of the bottom of the bridge girder slab is 8.42 m and with the assumed water surface elevation of 8.40 m, the flow velocity becomes 0.649 m/sec for the necessary discharge corresponding to the drainage capacity of the pumping station and the Froude Number is 0.167. In consideration of these hydraulic conditions and the situation around here as shown in the photo in the chapter of present situation of drainage canal, it can be concluded that there is enough flow capacity at this location.

2) 0+000、0+339、0+506 locations（Estero de Sampaloc）

Location	Drainage Area (km^2)	Q10(m^3/s)	Remarks
Pumping Station	3.284	15.6	Master Plan
Aviles 0+000	1.931	9.2	Area Ration Calculation
Aviles 0+339	1.516	7.2	Area Ration Calculation
Aviles 0+506	1.312	6.2	Area Ration Calculation



The Estero de Sampaloc is an open canal in the reaches of 0+339 and 0+506 but before reaching the location of 0+000 it goes under the Lacson Street and becomes the drainage conduit.

The necessary velocity for the necessary discharge at the 0+000 location that is the downstream end of the reaches becomes over 1.7 m/sec even with the water surface elevation of 12.00 m that is nearly the same level with the bottom elevation of bridge girder. The flow velocity in the open canal reaches at the locations of 0+339 and 0+506 becomes only about 0.3 m/sec ~ 0.5 m/sec for the necessary discharge. Accordingly the flow capacity at the open canal reaches seems to have enough capacity but since the canal becomes the drainage conduit with so much accumulated garbage in the downstream and it does not seem that the canal has enough flow capacity corresponding to the drainage capacity of the Aviles・Sampaloc drainage pumping capacity.

2.3.3 Drainage Canal of Tripa de Gallina Drainage System

The locations of the cross-sections used for the evaluation of flow capacity are 0+431, 1＋244、2+402 and 2+859 locations of Estero de Tripa de Gallina shown in Figure 1-2-1 (2). The 2+859 location is the drainage basin boundary place as mentioned in the previous chapter.

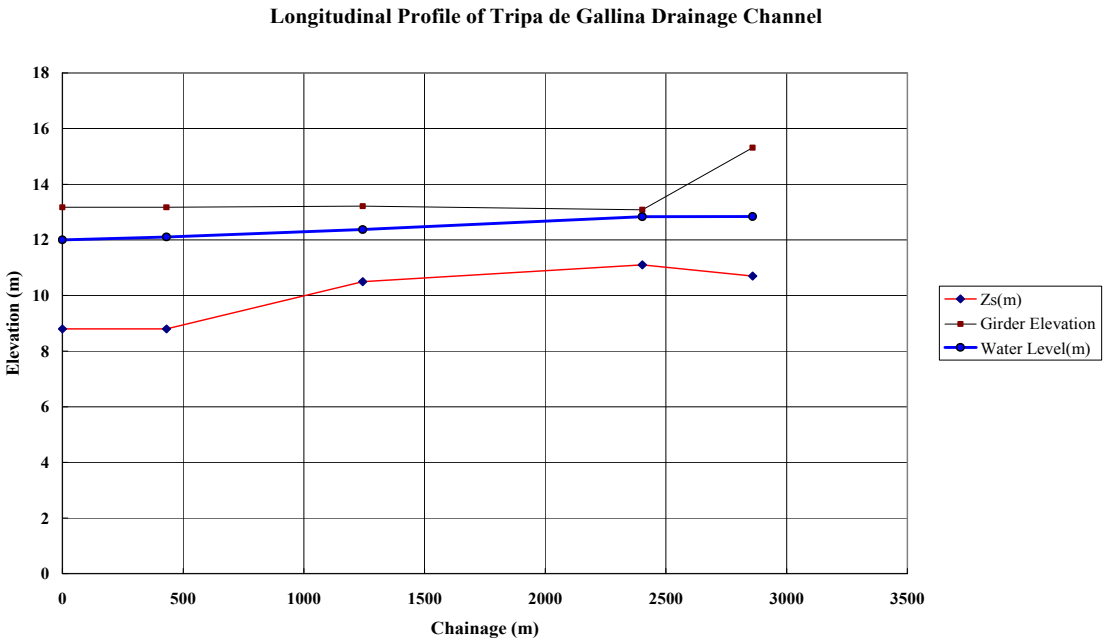
Since the longitudinal profile of the Estero de Tripa de Gallina is available in the master plan study, the flow capacity has been evaluated by use of non-uniform flow calculation. Here the non-uniform flow calculation has been conducted starting from the drainage pumping station of Tripa de Gallina, but since

the cross-sectional profile of the canal at the pumping station is not available, the cross-sectional profile at 0+439 location that is located just upstream of the pumping station has been substituted as the cross-sectional profile of the pumping station for the non-uniform flow calculation.

1) Estero de Tripa de Gallina

Location	Drainage Area (km^2)	Q10(m^3/s)	Remarks
Pumping Station	17.05	57.0	Master Plan
0+431	10.84	36.2	Area Ration Calculation
1+244	5.49	18.4	Area Ration Calculation
2+402	0.35	1.2	Area Ration Calculation
2+859	0.35	1.2	Area Ration Calculation

The non-uniform flow calculation has been conducted with the boundary conditions in the above table and the results are shown in the following figure;



Here Zs means the lowest river-bed elevation. The above figure shows that this drainage canal has enough flow capacity when the water level at the pumping station is kept at 12.0 m corresponding to the drainage pumping capacity of 57 m^3/sec. Here the situation of the 2+402 location where the water surface elevation and the elevation of the bottom of the bridge girder slab are nearly the same is shown in the following photo;

2+402 Location of Estero de Tripa de Gallina 2+402 as of March 9, 2007

As can be seen in the photo, the bottom elevation of the bridge girder slab is pretty lower than the road surface nearby. Accordingly in consideration of the upstream and downstream canals with rather higher road surface, it can be concluded that the canal has enough flow capacity.

D Impact of Drainage Pumping Stations Failure

D Impact of Drainage Pumping Stations Failure

1. General

It has become clear that the failure of drainage pumping equipment of Quiapo, Aviles・Sampaloc and Tripa de Gallina might occur at any time since the equipment have been used for 20~30 years that is over the life time of the equipment. Here the study has been conducted to investigate the impact due to the failure of pumping equipment from the hydraulic viewpoint.

2. Hydrologic and Hydraulic Dimensions of Drainage Pumping Stations

Hydraulic dimensions of drainage pumping stations are as follows;

Pumping Station	Drainage Basin (km^2)	Pumping Capacity (m^3/s)
Quiapo	2.29	10.8
Aviles・Sampaloc	3.28	15.6
Tripa de Gallina	11.56	57.0

The above pumping capacities are decided so that the 10-year return period rainfall in the basin could be drained within 12 hours and the allowable inundation depth should be 20 cm.

The rainfall-intensity-duration-frequency curve used for drainage planning in 1974 was as follows;

$$I = \frac{510.6}{(t+1)^{0.46}}$$

Here, *I : rainfall intensity (mm/hr)*
t : rainfall duration (min)

3. Impact Study due to Failure of Drainage Pumping Stations

The above-mentioned rainfall-intensity-duration-frequency curve was updated when the master plan study was conducted in 2004 to 2005. The updated rainfall-intensity-duration-frequency curve was as follows;

$$I = \frac{1216}{(t+11)^{0.63}}$$

This formula has been used for the present study. The necessity to update this formula has been studied in the present study as mentioned in a previous chapter, and it has been concluded that there is no need to update this formula.

4. Runoff Hydrograph

Runoff hydrographs to Quiapo, Aviles・Sampaloc and Tripa de Gallina drainage pumping stations have been calculated by use of the above rainfall-intensity-duration-frequency curve. The runoff calculation has been conducted with synthetic rational formula method.

0.5 行 In the calculation, traveling time of flood and the runoff coefficient in the master plan report have been used for the calculation as shown below;

Drainage Basin	Traveling Time (hour)	Runoff Coefficient
Quiapo	1.00	0.737
Aviles・Sampaloc	1.39	0.715
Tripa de Gallina	1.39	0.619

Here the runoff coefficients are the values of future runoff coefficients determined in the master plan report. In the calculation, the forward concentrated rainfall pattern is adopted for generating the design hyetograph in reference to 1974 drainage planning report.

Calculated runoff hydrographs are shown in Tables 4-1-1 to 4-1-4 and Figures 4-1-1 to 4-1-4.

5. Drainage Calculation

Since Quiapo and Aviles・Sampaloc drainage basins are practically the same areas, even though the basins have been handled as the independent basins in the previous studies, the runoffs from these basins are handled as one basin runoff in this section for easy comparison of impacts of pump failure.

With the runoff hydrograph thus calculated in the Quiapo and Aviles・Sampaloc drainage basin, and with the runoff hydrograph in the Tripa de Gallina drainage basin, the drainage calculations have been conducted for the case of ordinary operation of drainage pumping equipment and for the case of pumping equipment failure.

The summary of calculation results are shown below:

The case of pump failure

Pumping Station	Flooding Volume (m^3)	Flooding Level (m)	Flooding Area (m^2)
Quiapo + Aviles・Sampaloc	906,390	1.61	1,804,091
Tripa de Gallina	1,626,804	2.21	2,349,484

The case of pump operation

Pumping Station	Flooding Volume (m^3)	Flooding Level (m)	Flooding Area (m^2)
Quiapo	476,128	1.50	1,014,,662
Aviles・Sampaloc	372,534	1.42	854,257
Quiapo + Aviles・Sampaloc	247,757	1.32	661,053
Tripa de Gallina	387,169	1.88	1,182,492

In the above table, the calculation case when the Aviles・Sampaloc fails in operation corresponds to the case of operation of only Quiapo, and the calculation case when the Quiapo fails in operation corresponds to the case of operation of only Aviles・Sampaloc. Change of situation on inundation and drainage by time passage are shown in Figure 5-1 to -5-4.

The above dimensions are calculated based on the contour line maps prepared in the master plan report conducted in 2004 to 2005. The area-volume curves of the those drainage basins are prepared in the present study based on the contour line maps and the area-volume curves are shown in Figure 5-5 for Quiapo Aviles・Sampaloc drainage basin and in Figure 5-6 for Tripa de Gallina drainage basin.

The flooding depths due to the failure of pumping facilities are estimated based on the contour line map as follows;

Pumping Station	Flooding Depth (m)	Flooding Level (m)	Lowest Ground Level (m)
Quiapo	0.42	1.42	1.00
Aviles・Sampaloc	0.50	1.50	1.00
Quiapo + Aviles・Sampaloc	0.61	1.61	1.00
Tripa de Gallina	0.21	2.21	2.00

Here, the flooding depth is estimated as the difference between the flooding level and the lowest ground level (outside of the estero area) in the drainage basin based on the contour map.

Housing condition in the drainage basin of Quiapo and Aviles・Sampaloc near the pumping stations is shown in Figure 5-7 and the contour line map is shown in Figure 5-8.

The inundation area due to the failure of pumping station is shown in Figure5-9 for the case of Quiapo and Aviles・Sampaloc simultaneous failure. Blue area shows the inundation area in the case of pump failure and the light blue area shows the inundation area in the case of ordinary operation of pumping facilities and the yellow area shows the area not inundated in both cases. Inundation area includes the area of estero that is the area approximately below the elevation of 1.0 m.

Housing condition of Tripa de Gallina drainage basin near the pumping station is shown in Figure 5-10 and the contour line map is shown in Figure 5-11. The inundation area due to the failure of Tripa de Gallina pumping station is shown in Figure 5-12.

It is estimated that the inundation area under the case of normal operation of pumping station of Tripa de Gallina is below the elevation of 1.88 m and this is nearly the same area of estero, the drainage channel area and there would be no damage due to the inundation in this case.

Table 4-1 Runoff, Drainage & Flooding Calculation in Case of Operation of only Quiapo

time(mn)	runoff (m^3/s)	pump (m^3/s)	step volume with pump (m^3)	sum-volume with pump (m^3)	step volume without pump (m^3)	sum-volume without pump (m3)
0.0	0	0	0	0	0	0
60.0	71.40	10.8	109,086	109086	128,526	128,526
83.4	74.35	10.8	87,152	196238	102,315	230,841
120.0	46.11	10.8	108,544	304782	132,260	363,102
166.8	26.07	10.8	71,020	375801	101,346	464,448
180.0	24.38	10.8	11,424	387226	19,978	484,426
240.0	18.98	10.8	39,160	426386	78,040	562,466
300.0	15.90	10.8	23,908	450294	62,788	625,254
360.0	13.78	10.8	14,552	464846	53,432	678,686
420.0	12.26	10.8	7,996	472842	46,876	725,562
480.0	11.17	10.8	3,286	476128	42,166	767,728
540.0	10.27	10.8	-290	475838	38,590	806,318
600.0	9.54	10.8	-3,223	472615	35,657	841,975
660.0	8.92	10.8	-5,664	466951	33,216	875,191
720.0	8.42	10.8	-7,681	459270	31,199	906,390

Table 4-2 Runoff, Drainage & Flooding Calculation in Case of Operation of Only Aviles・Sampaloc

time(mn)	runoff (m^3/s)	pump (m^3/s)	step volume with pump (m^3)	sum-volume with pump (m^3)	step volume without pump (m^3)	sum-volume without pump (m3)
0.0	0	0	0	0	0	0
60.0	71.40	15.6	100,446	100446	128,526	128,526
83.4	74.35	15.6	80,413	180859	102,315	230,841
120.0	46.11	15.6	98,003	278862	132,260	363,102
166.8	26.07	15.6	57,541	336403	101,346	464,448
180.0	24.38	15.6	7,623	344026	19,978	484,426
240.0	18.98	15.6	21,880	365906	78,040	562,466
300.0	15.90	15.6	6,628	372534	62,788	625,254
360.0	13.78	15.6	-2,728	369806	53,432	678,686
420.0	12.26	15.6	-9,284	360522	46,876	725,562
480.0	11.17	15.6	-13,994	346528	42,166	767,728
540.0	10.27	15.6	-17,570	328958	38,590	806,318
600.0	9.54	15.6	-20,503	308455	35,657	841,975
660.0	8.92	15.6	-22,944	285511	33,216	875,191
720.0	8.42	15.6	-24,961	260550	31,199	906,390

Table 4-3 Runoff, Drainage & Flooding Calculation in Case of Operation Both Quiapo and Aviles・Sampaloc

time(mm)	runoff of Aviles+Quiapo (m^3/s)	pump (m^3/s)	step volume with pump (m^3)	sum-volume with pump (m^3)	step volume without pump (m^3)	sum-volume without pump (m^3)
0.0	0.00	0	0	0	0	0
60.0	84.14	26.4	103,924	103,924	151,444	151,444
83.4	92.05	26.4	86,618	190,542	123,683	275,128
120.0	58.70	26.4	107,554	298,097	165,529	440,657
166.8	32.13	26.4	53,400	351,496	127,531	568,187
180.0	30.14	26.4	3,752	355,248	24,660	592,848
240.0	23.42	26.4	1,376	356,624	96,416	689,264
300.0	19.59	26.4	-17,615	339,009	77,425	766,689
360.0	16.97	26.4	-29,226	309,783	65,814	832,503
420.0	15.09	26.4	-37,340	272,443	57,700	890,203
480.0	13.74	26.4	-43,163	229,281	51,877	942,081
540.0	12.63	26.4	-47,585	181,695	47,455	989,535
600.0	11.72	26.4	-51,207	130,489	43,833	1,033,369
660.0	10.97	26.4	-54,190	76,299	40,850	1,074,219
720.0	10.35	26.4	-56,671	19,628	38,369	1,112,588

Table 4-4 Runoff, Drainage & Flooding Calculation in Case of Operation of Tripa de Gallina

time(mn)	rainfall Intensity (mm/hr)	sum-rainfall (mm)	step rainfall (mm)	step rainfall intensity at time (mm)	runoff (m^3/s)	pump (m^3/s)	step volume with pump (m^3)	sum-volume with pump (m^3)	step volume without pump (m^3)	sum-volume without pump (m^3)
0.0	0	0	0		0	0.0	0	0	0	0
74.4	73.8	91.52	91.52	73.81	146.72	57.0	200,262	200262	327,486	327,486
148.8	49.7	123.35	31.82	25.66	51.02	57.0	186,907	387169	441,355	768,841
223.2	39.1	145.42	22.08	17.80	35.39	57.0	-61,587	325582	192,861	961,702
297.6	32.9	162.97	17.54	14.15	28.12	57.0	-112,691	212891	141,757	1,103,459
372.0	28.7	177.79	14.83	11.96	23.77	57.0	-138,635	74255	115,813	1,219,271
446.4	25.6	190.77	12.98	10.47	20.81	57.0	-154,945	-80689	99,503	1,318,775
520.8	23.3	202.41	11.64	9.38	18.65	57.0	-166,359	-247048	88,089	1,406,864
595.2	21.5	213.01	10.60	8.55	16.99	57.0	-174,891	-421939	79,557	1,486,421
669.6	20.0	222.78	9.77	7.88	15.66	57.0	-181,562	-603500	72,886	1,559,308
744.0	18.7	231.87	9.09	7.33	14.58	57.0	-186,952	-790452	67,496	1,626,804

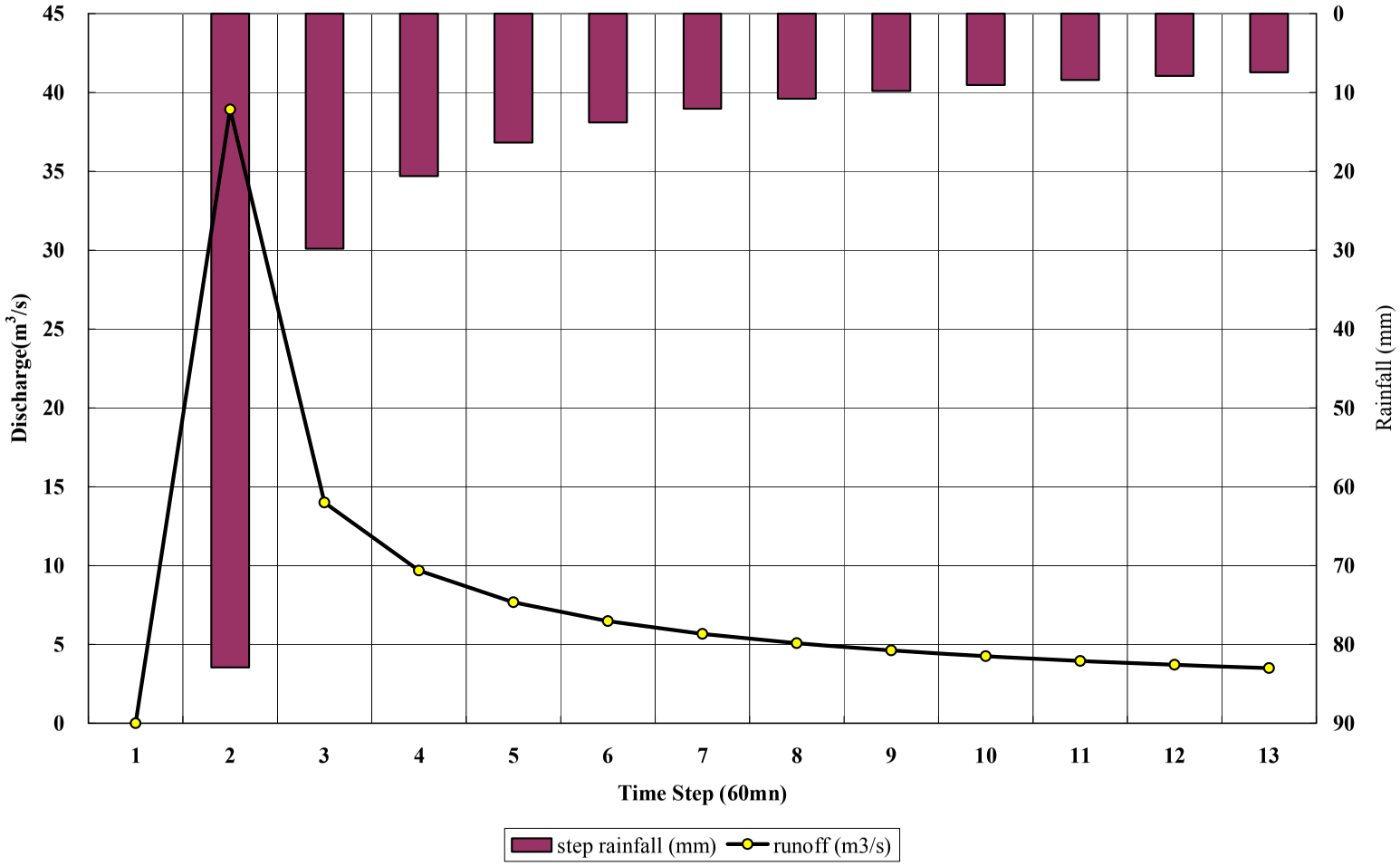


Figure 4-1 Quiapo Drainage Area Design Rainfall and Runoff

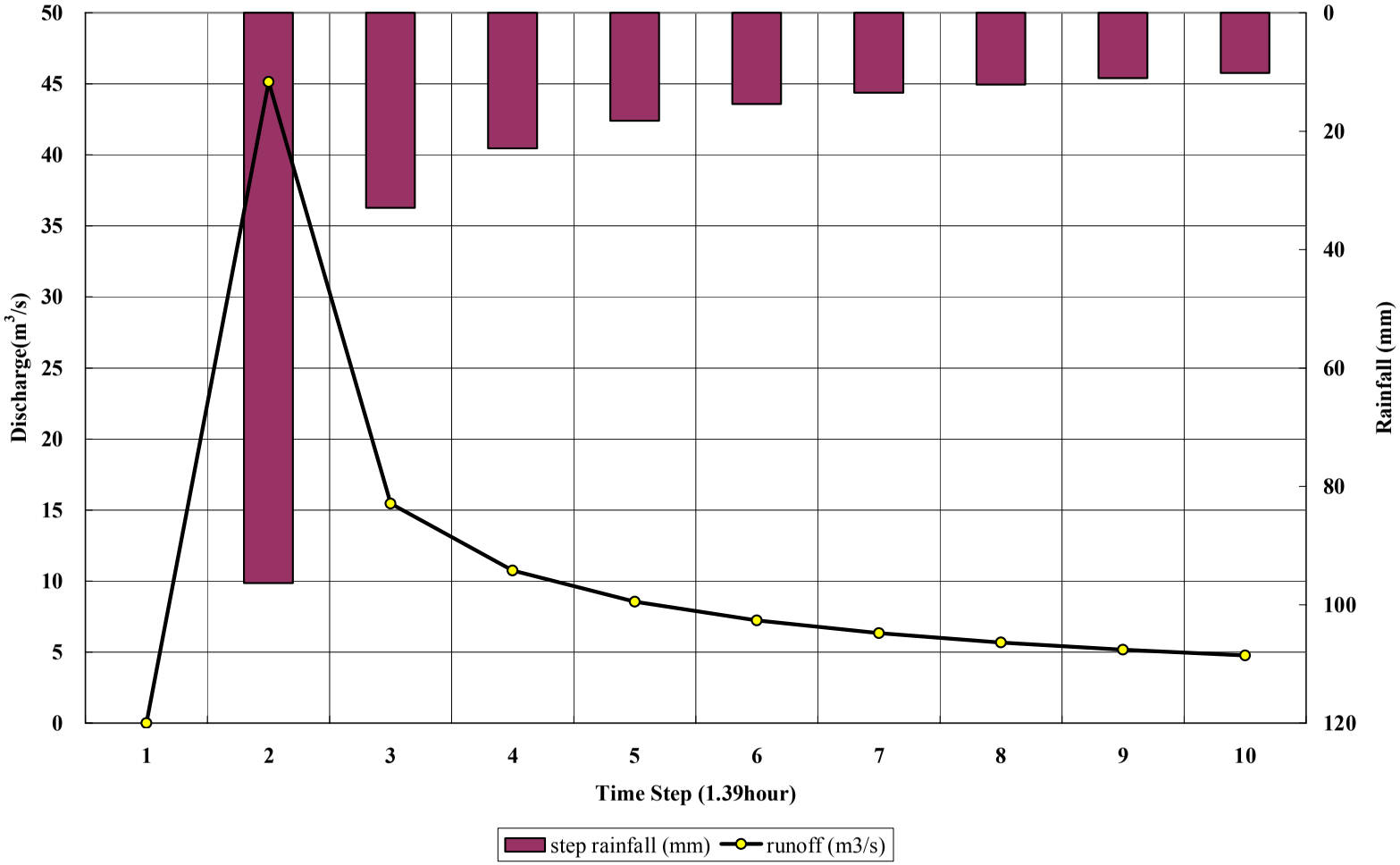


Figure 4-2　Aviles・Sampaloc Drainage Area Design Rainfall and Runoff

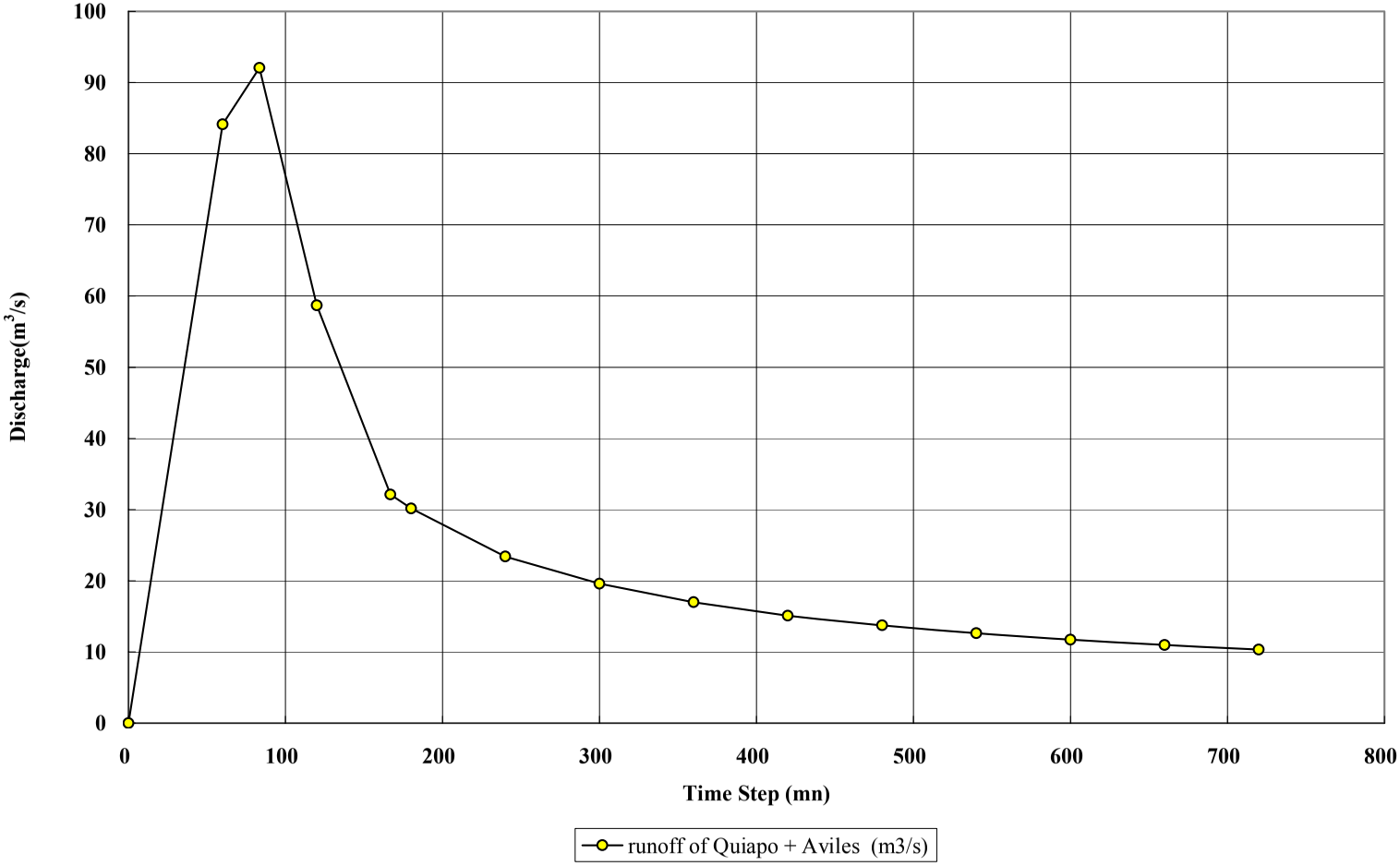


Figure 4-3　Quiapo and Aviles・Sampaloc Drainage Area Design Rainfall and Runoff

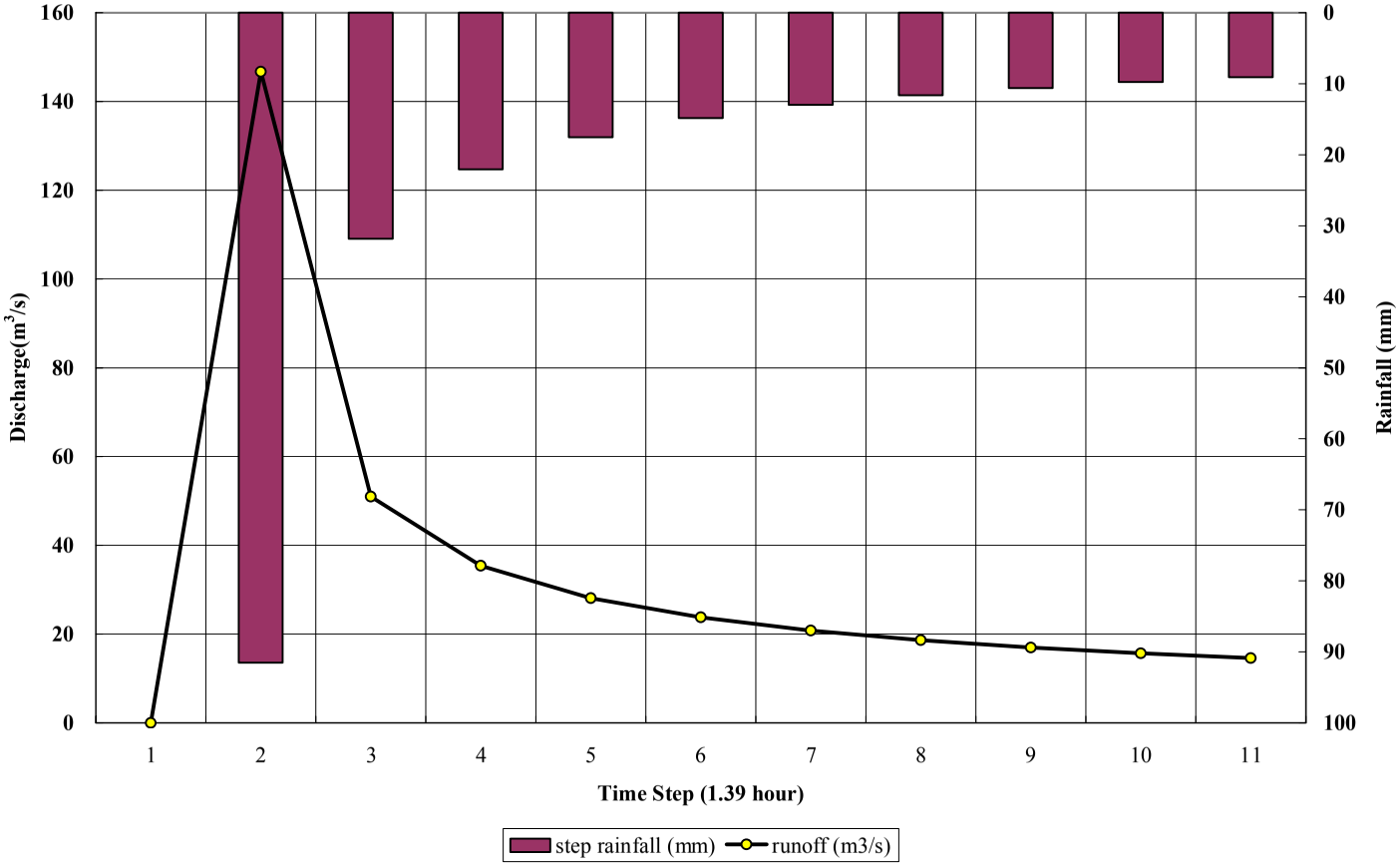


Figure 4-4 Tripa de Gallina Drainage Area Design Rainfall and Runoff Graph

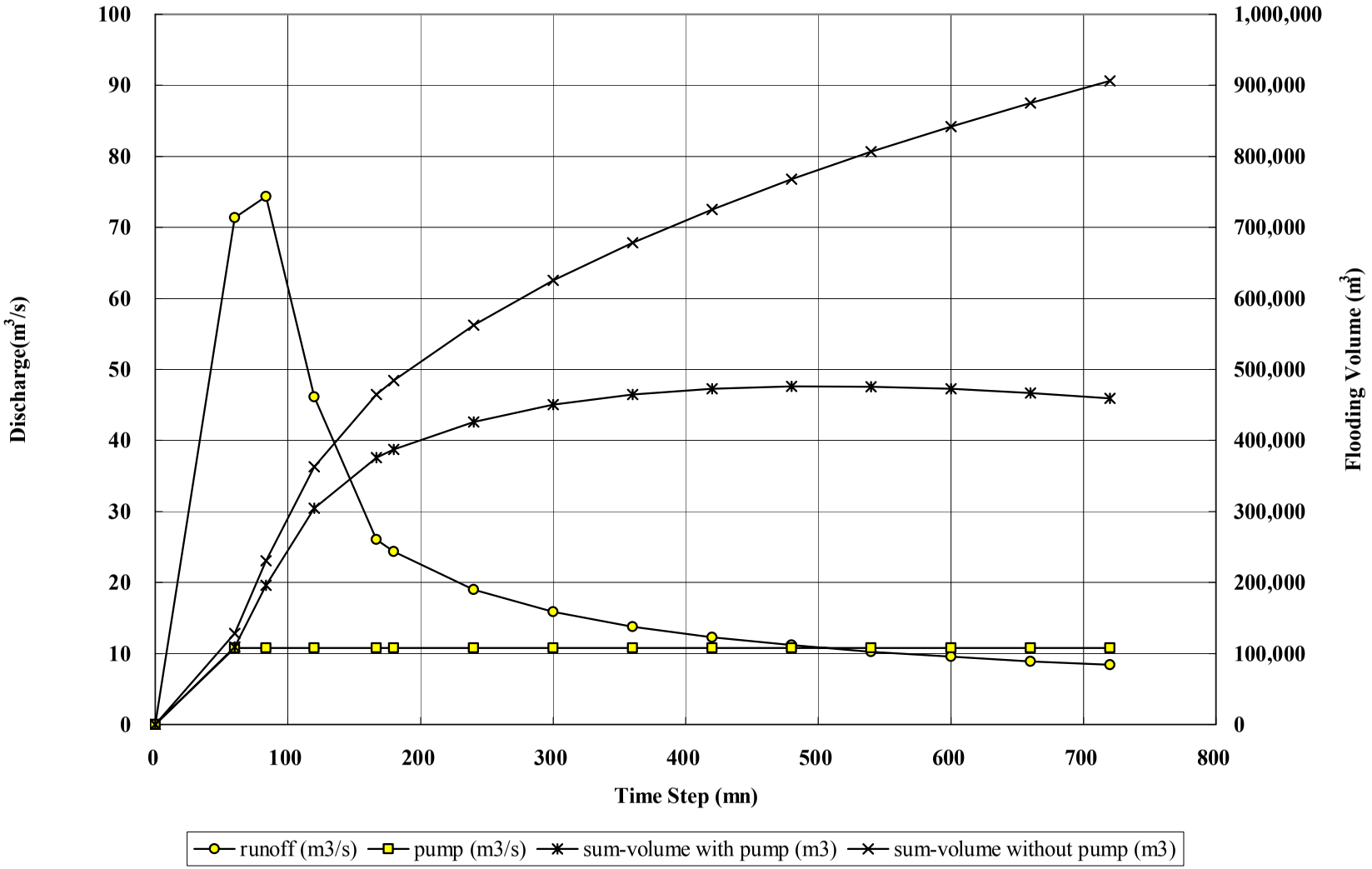


Figure 5-1 Quiapo Drainage Calculation

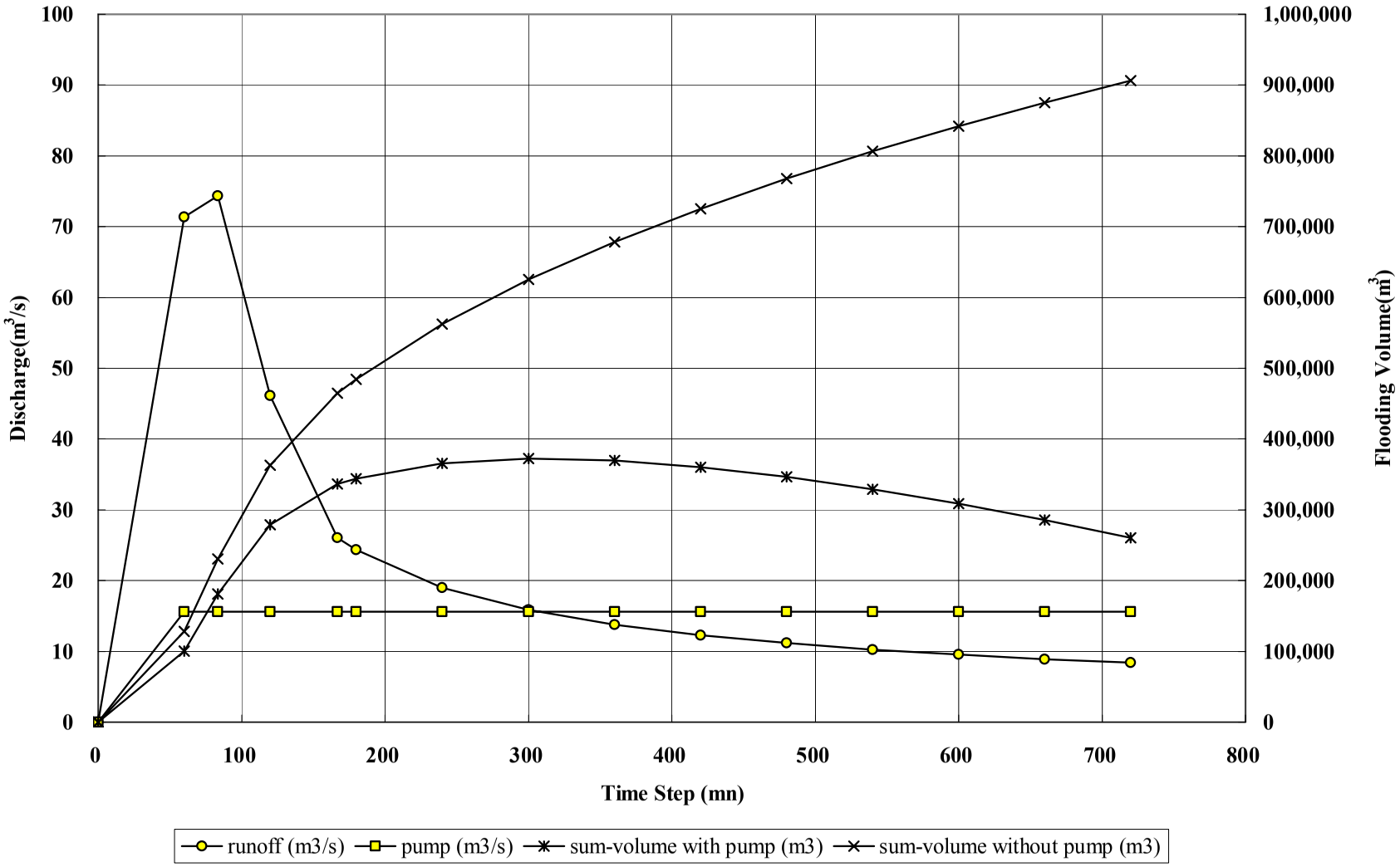


Figure 5-2　Aviles・Sampaloc Drainage Calculation

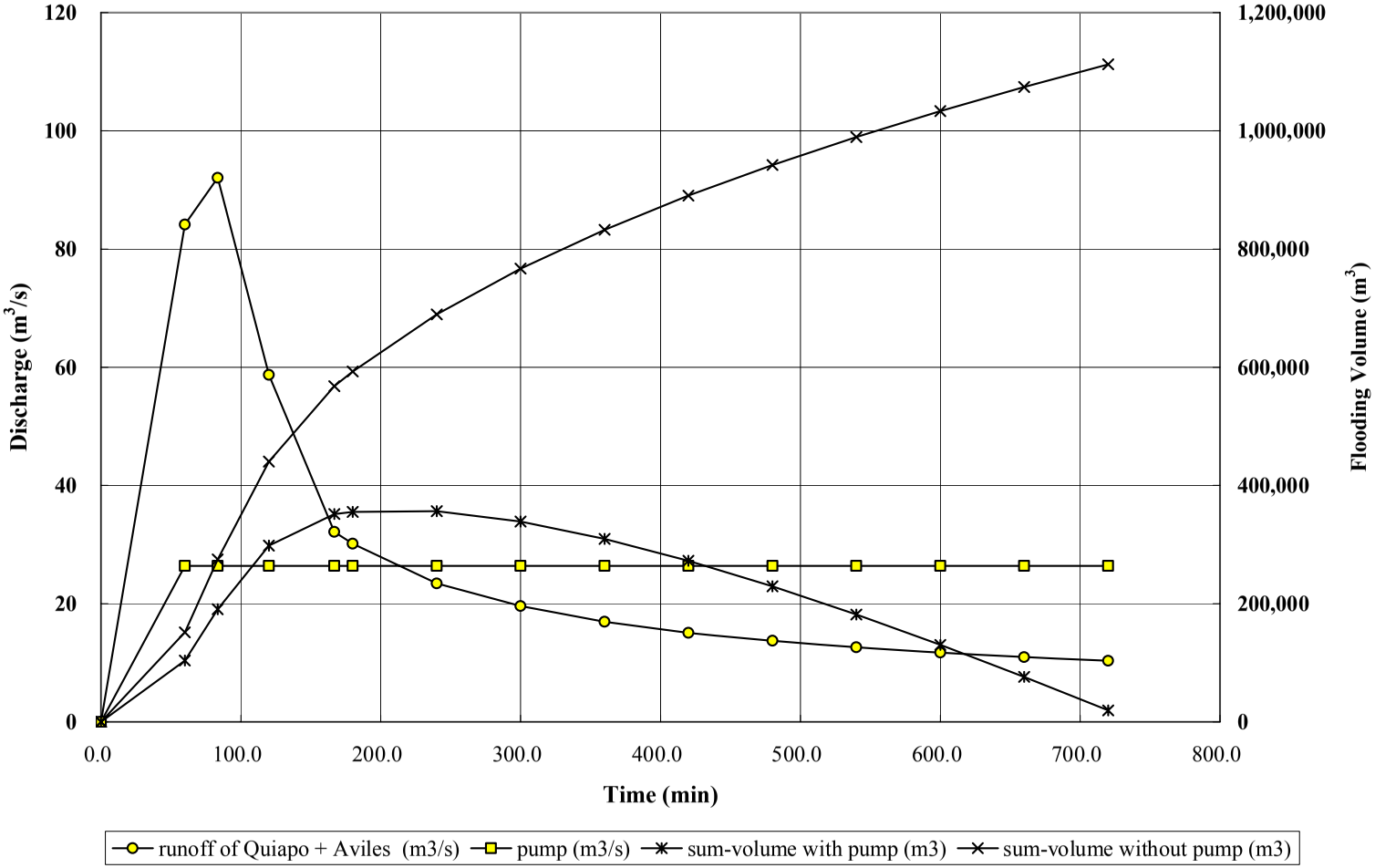


Figure 5-3 Quiapo + Aviles・Sampaloc Drainage Calculation

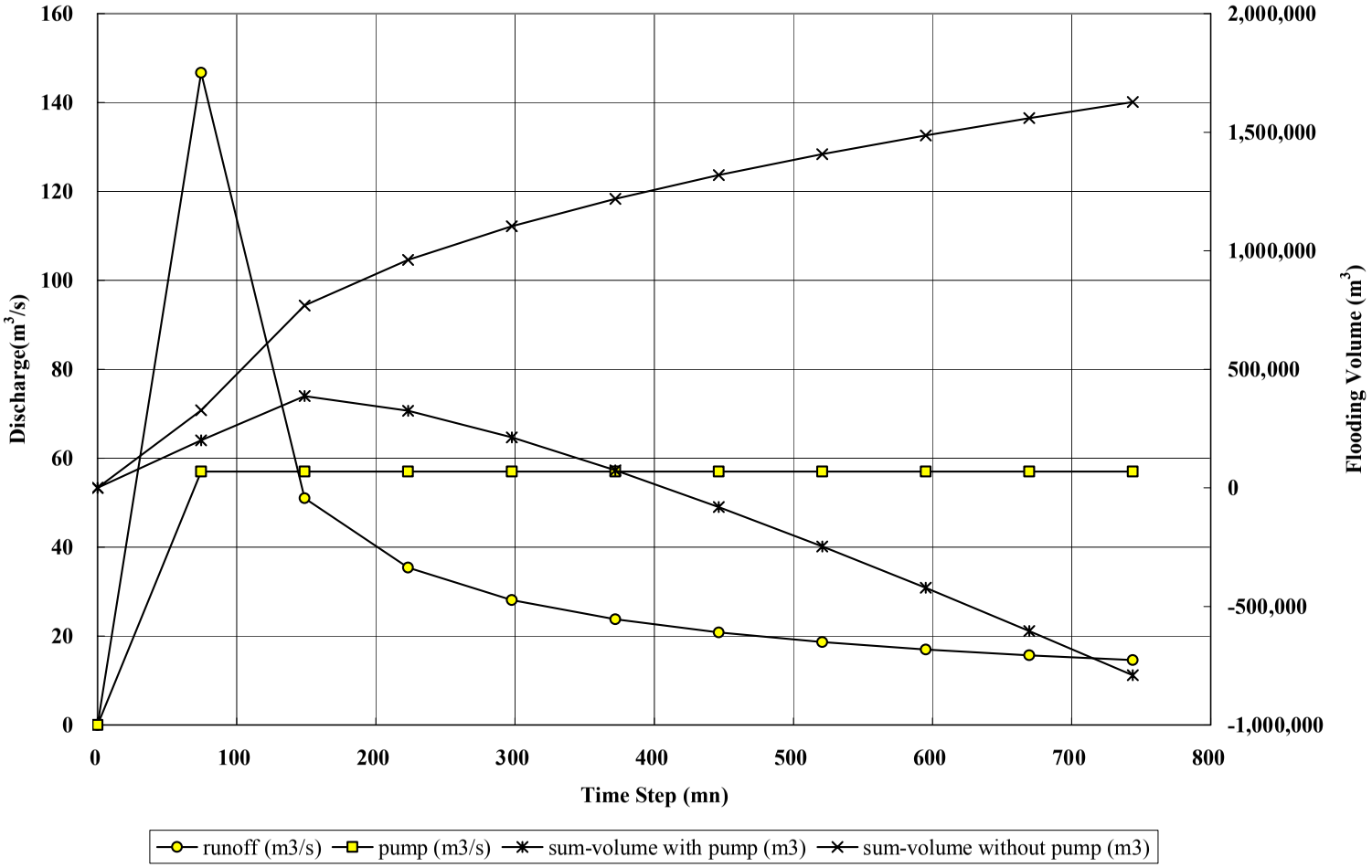


Figure 5-4 Tripa de Gallina Drainage Calculation

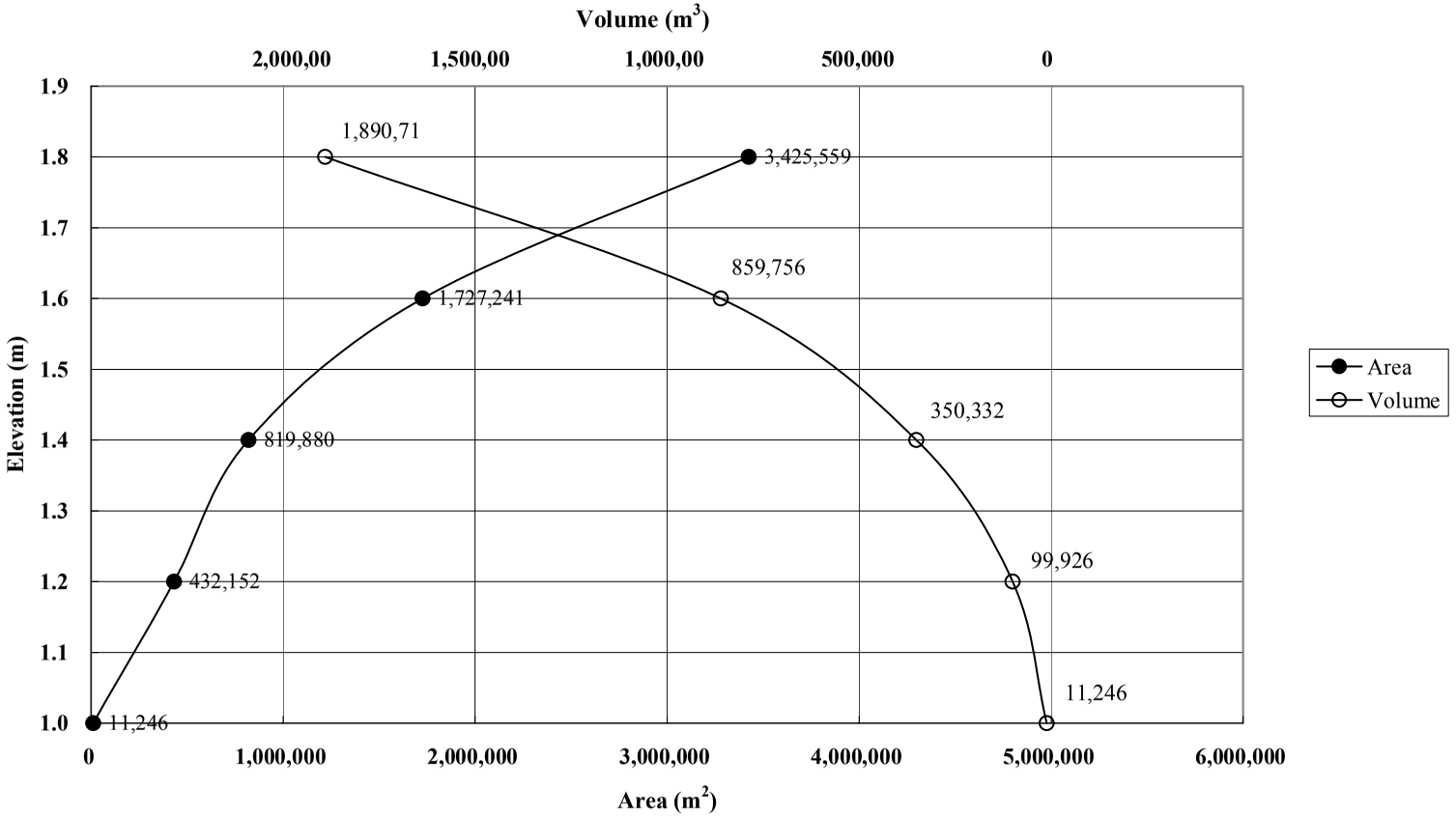


Figure 5-5 Quiapo and Aviles・Sampaloc Basin Area-Volume Curve

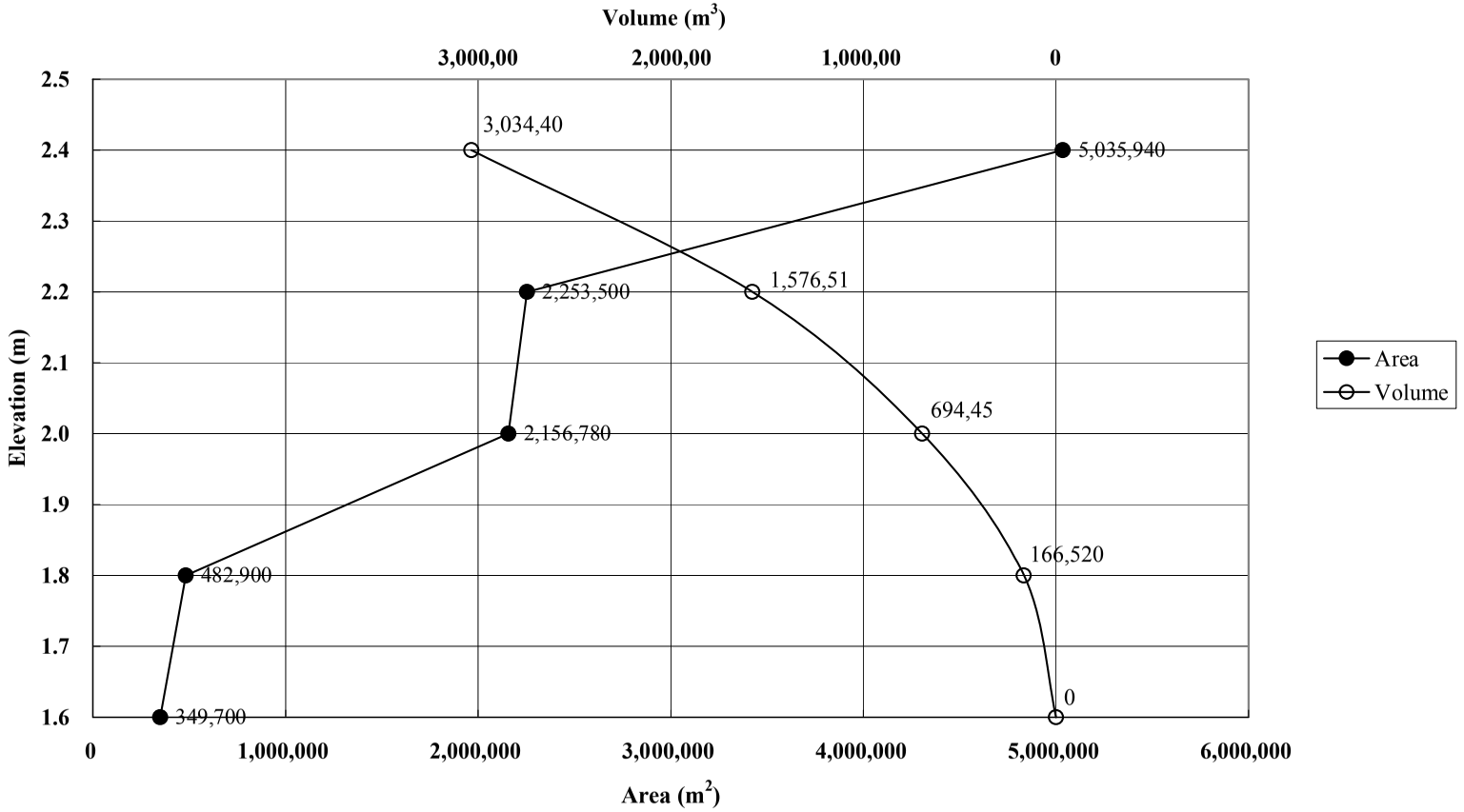


Figure 5-6 Tripa de Gallina Drainage Basin Area-Volume Curve

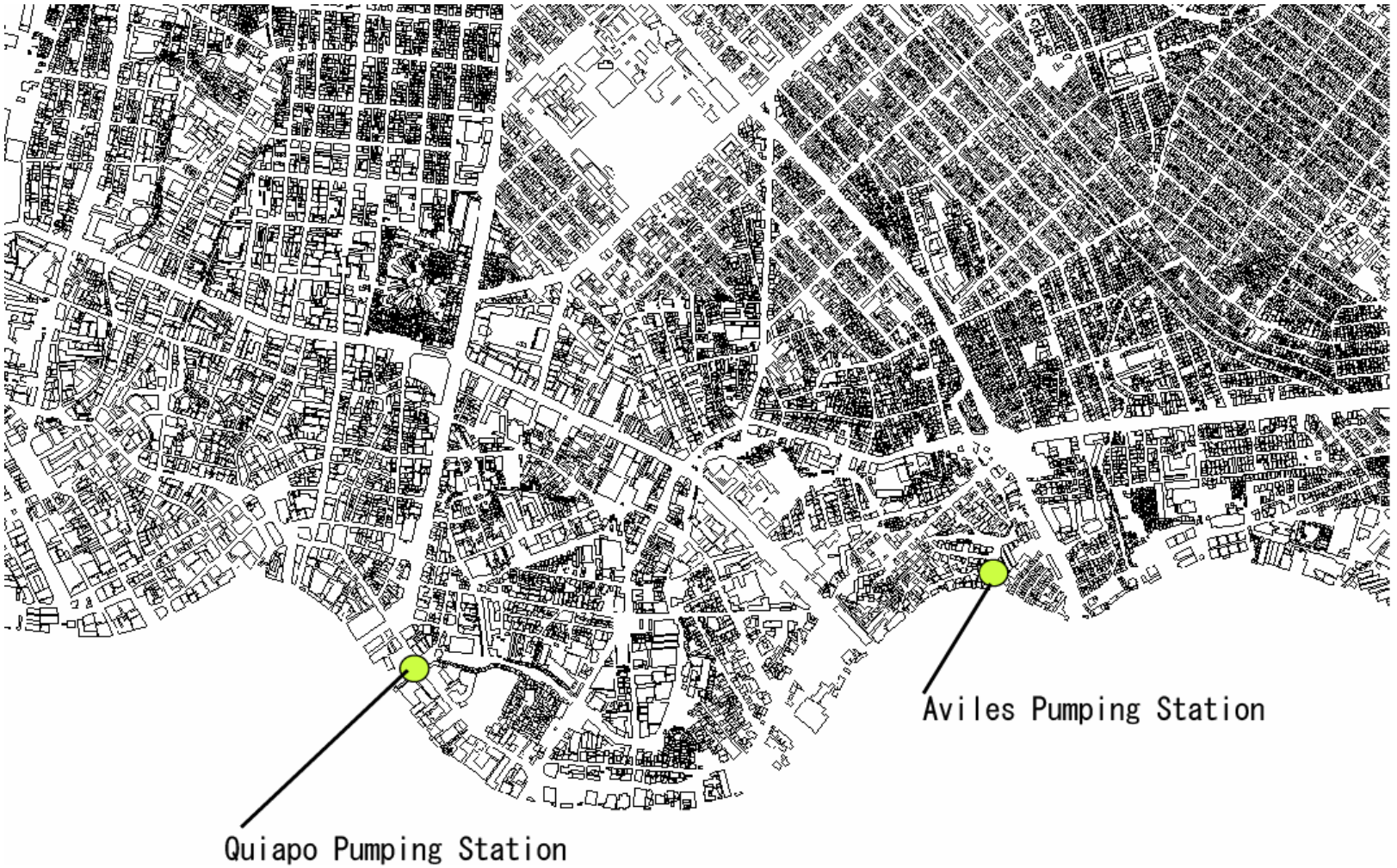


Figure 5-7　Quiapo Aviles・Sampaloc Basin Housing Situation Map

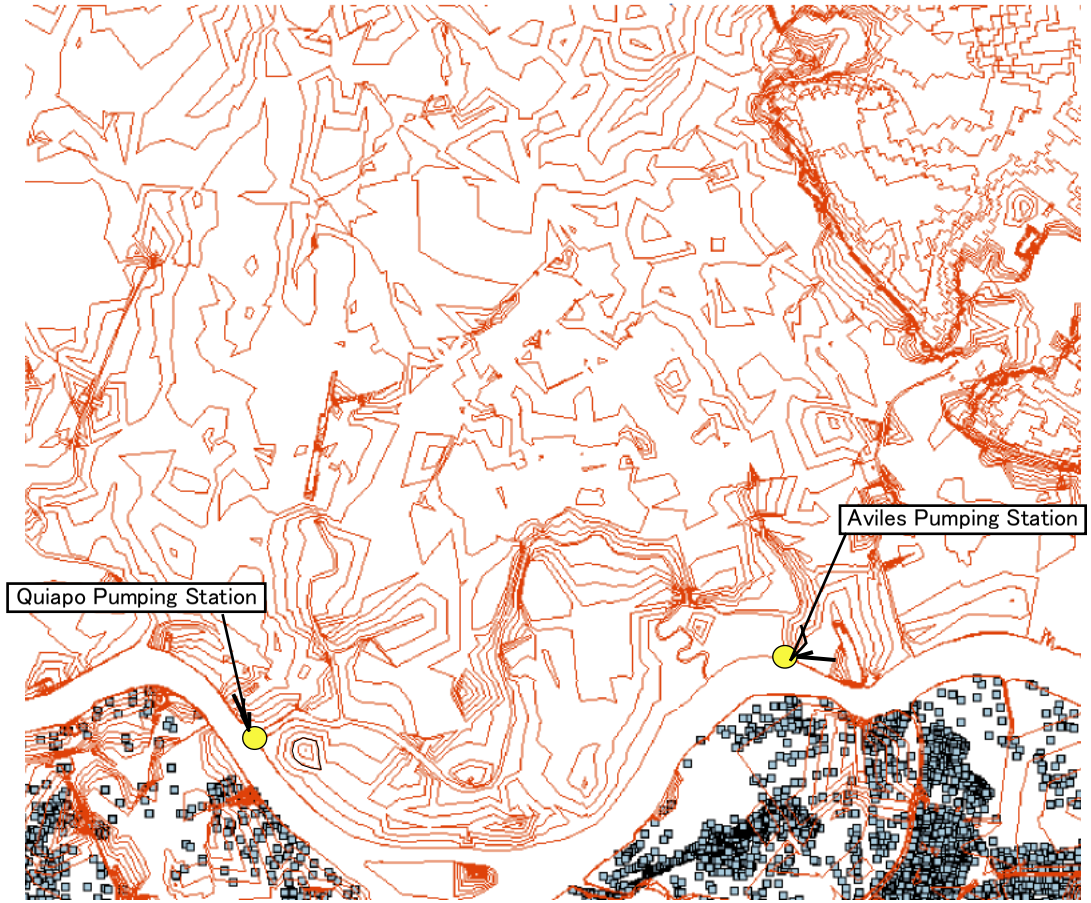


Figure 5-8　Quiapo and Aviles・Sampaloc Basin Contour Map

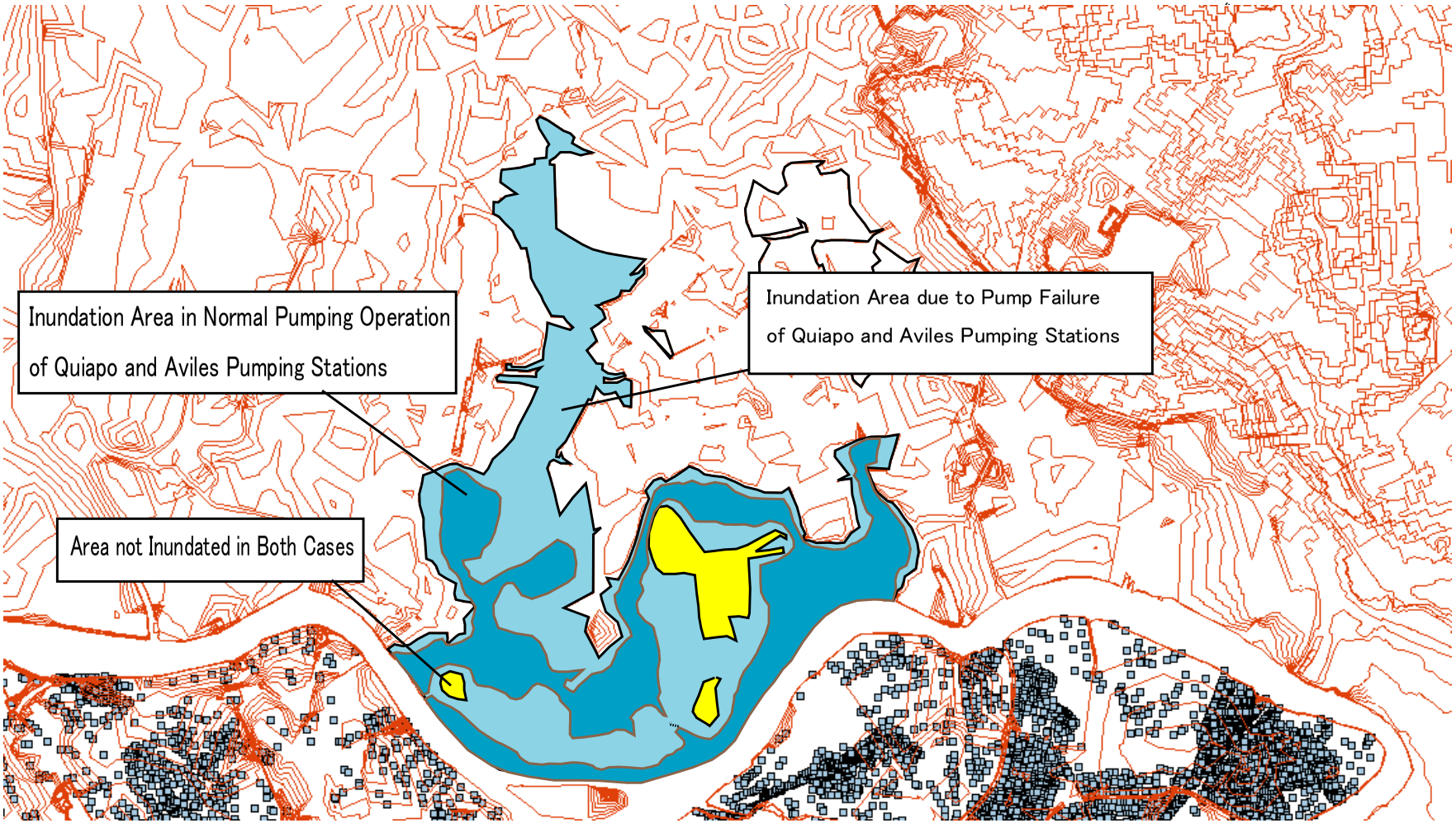


Figure 5-9　Quiapo and Aviles・Sampaloc Basin Inundation Map

Figure 5-10 Tripa de Gallina Drainage Area Housing Situation Map

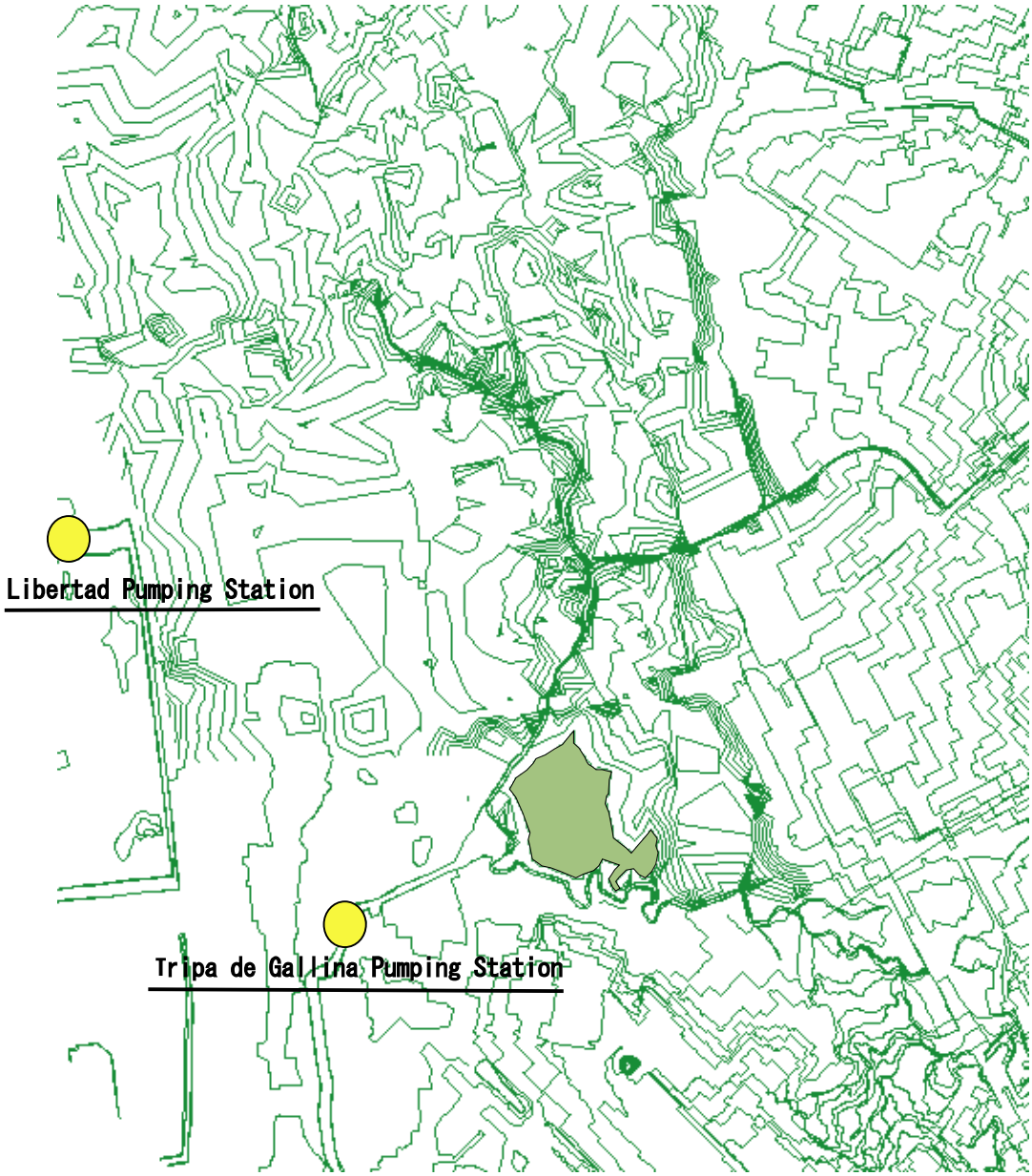


Figure 5-11 Tripa de Gallina Contour Map

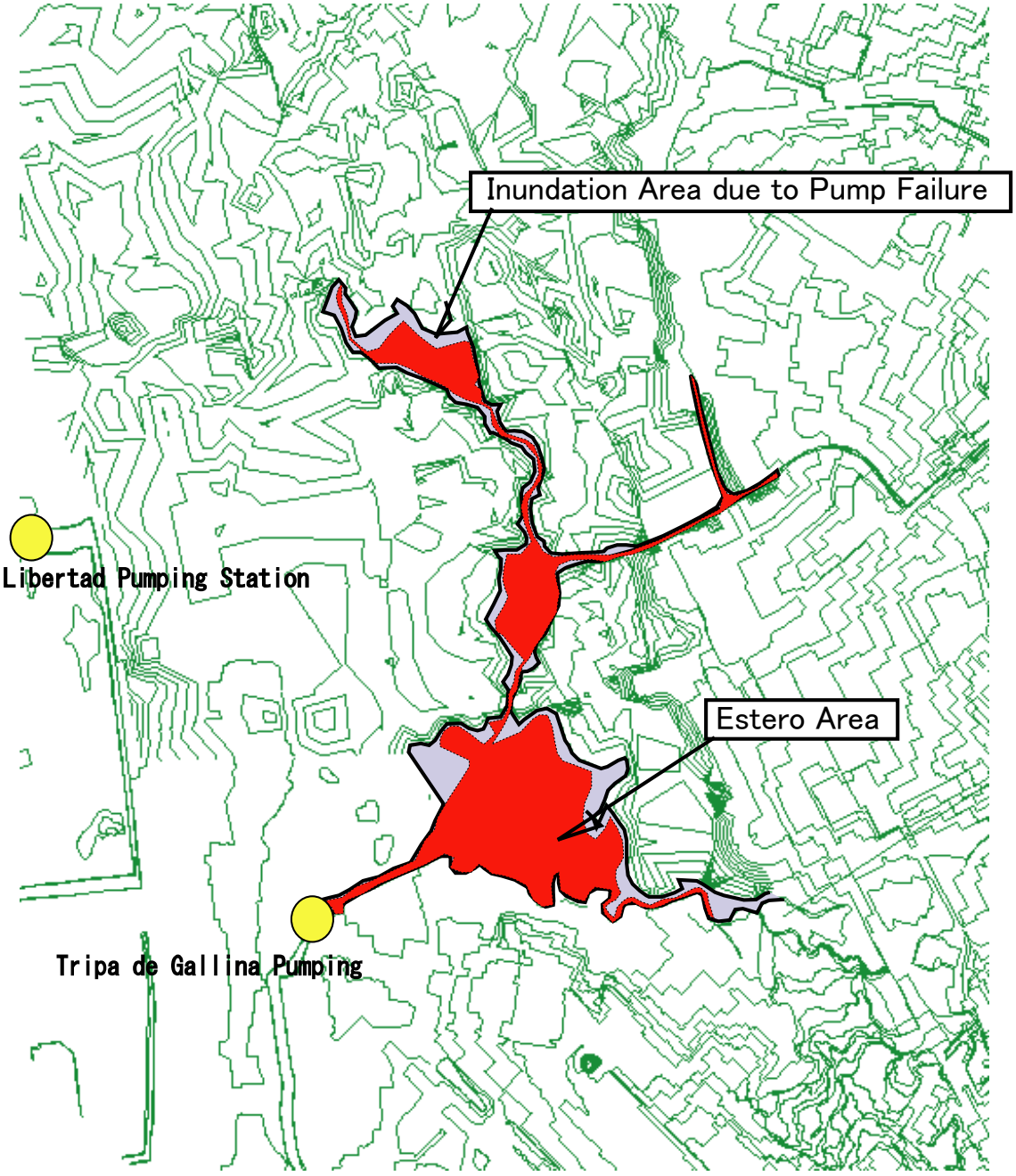


Figure 5-12 Tripa de Gallina Drainage Area Inundation Map

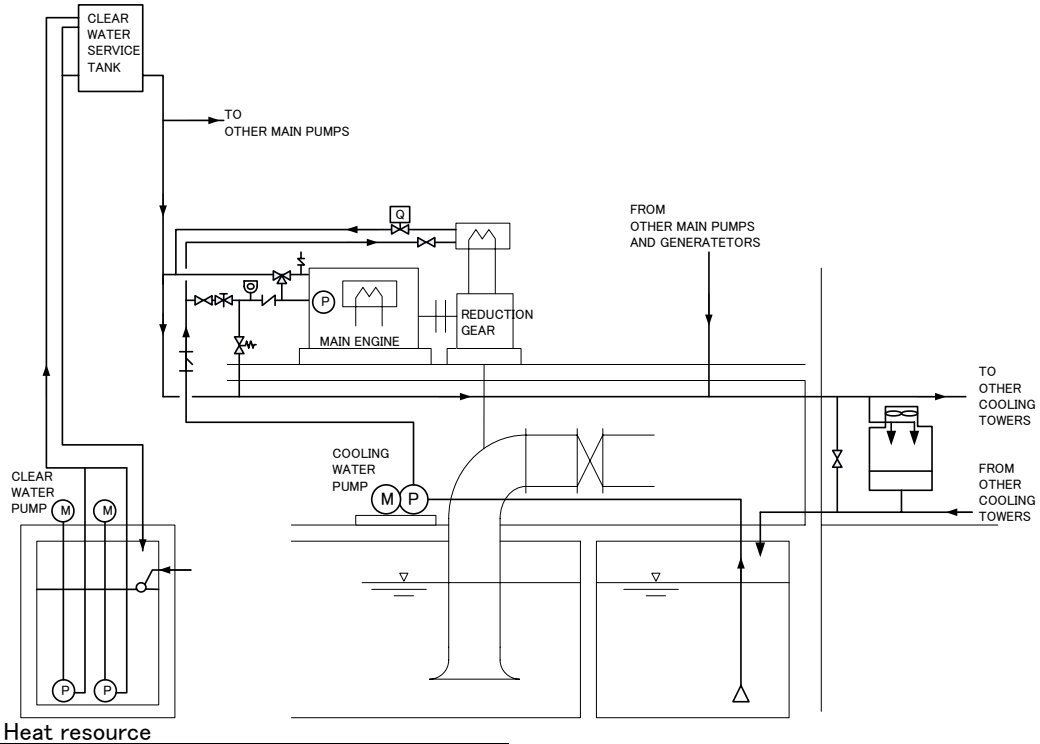
E Examinations on Specifications of Auxiliaries

1. CALCULATION ON SPECIFICATIONS OF AUXILIARIES IN QUIAPO (QUIAPO)

1.1 CALCULATION OF SPECIFICATION OF COOLING WATER EQUIPMENT

1.1.1 FLOW SHEET OF COOLING WATER EQUIPMENT

The cooling water system is composed from following equipments described in flow sheet and equipments of heat resource are shown in table.



Heat resource

	Output (kW)	Sets
Main engine	96	4
Reduction gear	96	4
Generator engine	70	2

1.1.2 REQUIRED COOLING WATER CAPACITY

Total required cooling water capacity is determined by following equation.

$$Q_{CW} = \Sigma Q$$

(1) Required cooling water capacity for Main Engine

Required water capacity is calculated below.

$$Q_{ME} = \frac{Q_c}{60 \times \Delta T \times C \times \gamma}$$

Q_{ME} : Required water capacity for main engine (L/min)

ΔT : Temperature difference of cooling water between input and output
= 15 ℃

C : Specific heat of water
= 4.19 kJ/(kg*℃) = 4.19 kW*s/(kg*℃)

γ : Mass of water = 1.0

Q_c : Quantity of heat of Main Engine (kJ/h)

$$Q_c = P_E \times B_E \times H_U \times \tau$$

P_E : Engine output 96 kW

B_E : Fuel consumption 0.34 kg/kW/h

H_U : Net calorific value of diesel oil 42700 MJ/kg

τ : Heat radiation factor 0.3

$$Q_{ME} = \frac{418{,}118}{60 \times 15 \times 4.19 \times 1.0}$$

$$= 110.9 \text{ L/min} \Rightarrow 120 \text{ L/min}$$

(2) Required cooling water capacity for Reduction Gear

Required water capacity is calculated below.

$$Q_G = \frac{60 \times P_E \times (1 - \eta)}{\Delta T \times C \times \gamma}$$

Q_G : Required water capacity for reduction gear (L/min)

P_E : Engine output 96 kW

ΔT : Temperature difference of cooling water between input and output = 15 ℃

C : Specific heat of water = 4.19 kJ/(kg*℃) = 4.19 kW*s/(kg*℃)

γ : Mass of water = 1.0

η : Efficiency of reduction gear 0.96

$$Q_G = \frac{60 \times 96 \times (1 - 0.96)}{15 \times 4.19 \times 1.0}$$

$$= 3.7 \text{ L/min} \Rightarrow 10 \text{ L/min}$$

(3) Required cooling water capacity for Generator Engine

Required water capacity is calculated below.

$$Q_{GE} = \frac{Q_c}{60 \times \Delta T \times C \times \gamma}$$

Q_{GE} : Required water capacity for generator engine (L/min)

ΔT : Temperature difference of cooling water between input and output = 15 ℃

C : Specific heat of water = 4.19 kJ/(kg*℃) = 4.19 kW*s/(kg*℃)

γ : Mass of water = 1.0

Q_c : Quantity of heat of Main Engine (kJ/h)

$$Q_c = P_E \times B_E \times H_U \times \tau$$

P_E : Engine output 70 kW

B_E : Fuel consumption 0.34 kg/kW/h

H_U : Net calorific value of diesel oil 42700 MJ/kg

τ : Heat radiation factor 0.3

$$M_E = \frac{304878}{60 \times 15 \times 4.19 \times 1.0}$$

$$= 80.8 \text{ L/min} \Rightarrow 90 \text{ L/min}$$

Therefore, total required cooling water capacity for each pump is

$$Q_{CWP} = \Sigma Q$$

$$= 120 + 10$$

$$= \underline{\underline{130 \text{ L/min}}}$$

And then, for each generator

Q_{CWG} = 90 L/min

1.1.3 REQUIRED TOTAL HEAD FOR WATER COOLING WATER

For calculation, some conditions and requirements are supposed and given that,

a) LWL of Cooling Water Reserver is 3,000mm from surface on pump floor.

b) The admissible pressure for inlet of engine is from 0m to 10m or less.

d) Required total head is divided as below
Before engine, total head is borne by cooling water pump, so
after pass the engine other total head is borne by included pump of the engine.

c) Required residual head for cooling tower is about 5m

So, total required head shall be calculated for the most farther pump from Cooling Water Reserver and Cooling Towers.

(1) For cooling water pump

(1)-1 Actual Head

Ha = 15.55 − 8.1

= 7.45 m

Has = 3.5 m Suction section

Had = 3.95 m Discharge section

LWL	8.1	m
Inlet level for engine	15.55	m
Standard level of cooling water pump	11.6	m

(1)-2 Loss Head

a) Suction section

	D1
Pipe bore m	0.05
Veracity m/s	1.103
Veracity Head m	0.062

Q = 130 L/min
= 0.00217 m^3/s

1) Friction loss of discharge straight pipe

$$h1s = \lambda \times \frac{L}{D1} \times \frac{V^2}{2g}$$

= 0.53 m

λ = (0.02 + 1 / (2000 x D1)) x 1.5
= 0.045

L = 9.5 m approx.

2) Friction loss of foot Valve

$$h2s = \zeta \times \frac{V^2}{2g}$$

= 0.136 m

ζ = 2.2

3) Minor loss

Supposed as 0.5 m

So total suction loss head is 1.166 m ⇒ hfs = 1.17 m

b) Discharge section

	D1	D2	
Pipe bore m	0.05	0.05	
Veracity m/s	1.103	1.019	
Veracity Head m	0.062	0.053	

Q1 = 130 L/min Q3
= 0.0022 m^3/s
Q2 = 120 L/min
= 0.0020 m^3/s

1) Friction loss of discharge straight pipe section D1

$$h1d = \lambda \times \frac{L}{D1} \times \frac{V^2}{2g}$$

λ = (0.02 + 1 / (2000 x D1)) x 1.5
= 0.045

= 0.067 m

L = 1.2 m approx.

2) Friction loss of discharge straight pipe section D2

$$h2d = \lambda \times \frac{L}{D2} \times \frac{V^2}{2g}$$

λ = (0.02 + 1 / (2000 x D2)) x 1.5
= 0.045

= 0.239 m

L = 5 m approx.

3) Minor loss including divided flow loss

Supposed as 3.0 m

So total suction loss head is 3.306 m ⇒ hfd = 3.31 m

(1)-3 Total Head

HT = Ha + Hfs + Hfd

= 11.93 m so, required total head of cooling water pump is determined 12m or more.

(2) For included pump of the engine

(2)-1 Actual Head

Ha = 12.95 − 15.85 + 5

= 2.1 m

Outlet level for engine	15.85	m
Inlet level for cooling tower	12.95	m
Required head at inlet for cooling tower	5	m

(2)-2 Loss Head

		D1	D2	D3
Pipe bore	m	0.05	0.1	0.08
Veracity	m/s	1.103	1.294	1.104
Veracity Head	m	0.062	0.085	0.062

Q1 = 130 L/min = 0.0022 m^3/s

Q3 = 203 # L/min = 0.0056 m^3/s

Q2 = 610 L/min = 0.0102 m^3/s

1) Friction loss of discharge straight pipe section D1

$$h1 = \lambda \times \frac{L}{D1} \times \frac{V^2}{2g}$$

λ = (0.02 + 1 / (2000 x D1)) x 1.5
= 0.045

= 0.497 m

L = 8.9 m approx.

2) Friction loss of discharge straight pipe section D2

$$h2 = \lambda \times \frac{L}{D2} \times \frac{V^2}{2g}$$

λ = (0.02 + 1 / (2000 x D2)) x 1.5
= 0.0375

= 0.956 m

L = 30 m approx.

3) Friction loss of discharge straight pipe section D3

$$h3 = \lambda \times \frac{L}{D3} \times \frac{V^2}{2g}$$

λ = (0.02 + 1 / (2000 x D2)) x 1.5
= 0.03938

= 0.092 m

L = 3 m approx.

4) Minor loss

Supposed as 2.0 m

So total discharge loss head is 3.545 m ⇒ hfd = 3.55 m

(2)-3 Total Head

HT = Ha + Hfs + Hfd

= 5.65 m ⇒ 6 m

so, required total head of included pump of the engine is determined 6m or more.

1.1.4 REQUIRED DIAMETER OF RETURN PIPE OF COOLING WATER

Actual Head is,

Ha = 10.5 − 12.8

= −2.3 m

Outlet level for cooling tower: 12.8 m

Discharge level of return pipe of cooling water on cooling water reserver: 10.5 m

Assuming that length of return pipe from cooling tower to cooling water reserver is 30 m.

Q = 610 L/min

= 0.0102 m^3/s

Diameter of return pipe of cooling water from cooling tower is determined that total loss head depending on pipe bore must be less than absolute value of actual head from cooling tower to reserver.

Pipe bore	m	0.1	0.125	0.15	
Veracity	m/s	1.294	0.828	0.575	
Veracity Head	m	0.085	0.035	0.017	
λ		0.0375	0.0360	0.0350	
Friction loss	m	0.96	0.30	0.12	
Minor loss	m	1.5	1.5	1.5	including velocity head
total loss head	m	2.46	1.80	1.62	

Therefore, required pipe bore is 125A or more.

1.2 CALCULATION ON SPECIFICATION OF VENTILATION CAPACITY (QUIAPO)

1.2.1 THE OBJECTS FOR CALCULATION OF VENTILATION CAPACITY

The equipments and points for calculation are listed below.

Equipments	Points to Check
MAIN ENGINE	Quantity heat due to radiation Amount of combustible air
REDUCTION GEAR	Quantity heat due to radiation
GENERATOR AND ENGINE	Quantity heat due to radiation Amount of combustible air
EXHAUST PIPE AND SILENCER FOR MAIN ENGINE	Quantity heat due to radiation
EXHAUST PIPE AND SILENCER FOR GENERATOR	Quantity heat due to radiation

1.2.2 CALCULATION OF VENTILATION CAPACITY

The ventilation capacity shall be depended on the sum of amount of combustible air by engines and cooling air for quantity heat due to radiation by equipments.

$V = V1 + V2$

In this case, we shall disregard heat radiations from panels. Because cubicle switchgear and DC panels are in electric electric room that has individual ventilation, and control panels shall release less amount of heat in engine room.

(1) Required ventilation capacity of cooling air for quantity heat due to radiations

$$V1 = \frac{\Sigma Q}{60 \times C_p \times (t_n - t_0) \times \rho}$$

V1 ;	Required ventilation capacity		m^3/min
ρ ;	Air density (at 920hPa, 37℃, 50%RH)	1.024	kg/m^3
C_p ;	Specific heat capacity at constant pressure of air	0.00028	kWh/kg/℃
t_n ;	Room air temperature	37	℃
t_o ;	Outdoor temperature	27	℃

1-1) Quantity heat due to radiation from Main Engine: Q_E

$Q_E = n \times P_E \times B_E \times H_U \times f$

n ;	Quantity	4	sets
P_E ;	Output of main engines	96	kW
B_E ;	Fuel consumption	0.34	kg/kW/h
H_U ;	Net calorific value of diesel oil	11.92	kWh/kg
f ;	Radiation ratio of diesel engine (up to 1,000min^{-1})	0.025	

$Q_E = 4 \times 96 \times 0.34 \times 11.92 \times 0.025$

$= 38.91$ kw

1-2) Quantity heat due to radiation from Reduction Gear: Q_G

$Q_E = n \times \alpha \times P_E \times (1 - \eta_G)$

n ;	Quantity	4	sets
α ;	Coefficient of radiation of reduction gear	0.15	
η_c ;	Transmission efficiency	0.96	

$Q_E = 4 \times 0 \times 96 \times (1 - 0.96)$

$= 2.30$ kw

1-3) Quantity heat due to radiation from Engine for Generator: Q_{GE}

$Q_E = n \times P_{GE} \times B_{GE} \times H_{UGE} \times f_{GE}$

n	; Quantity	2	sets
P_{GE}	; Output of engine	70	kW
B_{GE}	; Fuel consumption	0.34	kg/kW/h
H_{UGE}	; Net calorific value of diesel oil	11.92	kWh/kg
f_{GE}	; Radiation ratio of diesel engine (over 1,000min^{-1})	0.04	

$Q_E = 2 \times 70 \times 0.34 \times 11.92 \times 0.04$

$= \boxed{22.7}$ kw

1-4) Quantity heat due to radiation from Generator: Q_{Gn}

$Q_E = n \times P_{Gn} \times PF_{Gn} \times (1 - \eta_{Gn})$

n	; Quantity	2	sets
P_{Gn}	; Output of generator	75	kVA
PF_{Gn}	; Power factor of generator	0.8	
η_{Gn}	; Efficiency of generator	0.857	

$Q_E = 2 \times 75 \times 0.8 \times (1 - 0.86)$

$= \boxed{17.16}$ kw

1-5) Quantity heat due to radiation from Exhaust pipe of Main Engine : Q_{EXE}

$$Q_{EXE} = n \times \frac{2\pi \times (\theta_r - \theta_o)}{\frac{1}{\lambda} \times \ln \frac{d_1}{d_0} + \frac{2}{\alpha \times d_1}} \times L / 1000$$

n	; Quantity	4	sets
θ_r	; Exhaust gas temperature (non turbo charger)	400	℃
θ_t	; Room air temperature	37	℃
λ	; Thermal conductivity of a thermal insulation material	0.0688	W/m/℃
d_1	; Outside diameter of a thermal insulation material	0.25	m
d_0	; Inside diameter of a thermal insulation material	0.15	m
α	; Surface coefficient of heat transfer of a thermal insulation material	10	W/m^2/℃
L	; Length of a thermal insulation material	13	m

$$Q_{EXE} = 4 \times \frac{2\pi \times (400 - 37)}{\frac{1}{0.0688} \times \ln \frac{0.25}{0.15} + \frac{2}{10 \times 0.25}} \times 13 / 1000$$

$= \boxed{14.42}$ kw

1-6) Quantity heat due to radiation from Exhaust pipe of Generator Engine : Q_{EXGE}

$$Q_{EXE} = n \times \frac{2\pi \times (\theta_r - \theta_o)}{\frac{1}{\lambda} \times \ln \frac{d_1}{d_0} + \frac{2}{\alpha \times d_1}} \times L / 1000$$

n	; Quantity	2	sets
θ_r	; Exhaust gas temperature (non turbo charger)	400	℃
θ_t	; Room air temperature	37	℃
λ	; Thermal conductivity of a thermal insulation material	0.0688	W/m/℃
d_1	; Outside diameter of a thermal insulation material	0.18	m
d_0	; Inside diameter of a thermal insulation material	0.08	m

α ; Surface coefficient of heat transfer of a thermal insulation material : 10 $W/m^2/℃$

L ; Length of a thermal insulation material : 9 m

$$Q_{EXE} = 2 \times \frac{2\pi \times (400 - 37)}{\frac{1}{0.0688} \times \ln\frac{0.18}{0.08} + \frac{2}{10 \times 0.18}} \times 9 / 1000$$

$$= 3.18 \text{ kw}$$

Therefore, V1 is

$$V1 = \frac{\Sigma Q}{60 \times C_p \times (t_n - t_0)}$$

$$= \frac{38.91 + 2.30 + 22.70 + 17.16 + 14.42 + 3.18}{60 \times 0.00028 \times (37 - 27) \times 1.024}$$

$$= 573.6 \text{ m}^3/\text{min} \Rightarrow \underline{574 \text{ m}^3/\text{min}}$$

(2) Required ventilation capacity of combustible air

$$V2 = \Sigma V_S$$

2-1) Amount of combustible air of Main Engine : V_{SE}

$$V_{SE} = n \times \frac{A0 \times B_E \times P_E \times K}{60} \times \frac{P_0}{P_N} \times \frac{t_N + 273}{273}$$

n ; Quantity : 4 sets

A_0 ; Amount of theoretical combustion air for diesel oil : 11.2 m^3/kg (NTP)

B_E ; Fuel consumption : 0.34 kg/kW/h

P_E ; Output of main engine : 96 kW

K ; Excess air ratio : Diesel Engine : 2.5

P_0 ; Standard atmospheric pressure : 1013 hPa

P_N ; Atmospheric pressure at running condition : 920 hPa

t_N ; Atmospheric temperature at running condition : 37 ℃

$$V_{SE} = 4 \times \frac{11.2 \times 0.34 \times 96 \times 2.5}{60} \times \frac{1013}{920} \times \frac{37 + 273}{273}$$

$$= 76.18 \text{ m}^3/\text{min}$$

2-2) Amount of combustible air of Generator Engine : V_{SGE}

$$V_{SGE} = n \times \frac{A0 \times B_E \times P_E \times K}{60} \times \frac{P_0}{P_N} \times \frac{t_N + 273}{273}$$

n ; Quantity : 2 sets

A_0 ; Amount of theoretical combustion air for diesel oil : 11.2 m^3/kg (NTP)

B_E ; Fuel consumption : 0.34 kg/kW/h

P_E ; Output of main engine (supposed) : 70 kW

K ; Excess air ratio : Diesel Engine : 2.5

P_0 ; Standard atmospheric pressure : 1013 hPa

P_N ; Atmospheric pressure at running condition : 920 hPa

t_N ; Atmospheric temperature at running condition : 37 ℃

$$V_{SGE} = 2 \times \frac{11.2 \times 0.34 \times 70 \times 2.5}{60} \times \frac{1013}{920} \times \frac{37 + 273}{273}$$

$$= \boxed{27.77}\ m^3/min$$

Therefore, V1 is

$$V2 = V_{SE} + V_{SGE}$$

$$= 76.18 + 27.77$$

$$= 104\ m^3/min \quad \Rightarrow \quad \underline{\underline{104\ m^3/min}}$$

Thereby total ventilation capacity is fixed below,

$$V = V1 + V2$$

$$= 574 + 104$$

$$= \underline{\underline{678\ m^3/min}}$$

$$= \underline{\underline{11.3\ m^3/s}}$$

$$= \underline{\underline{40{,}680\ m^3/h}}$$

2. CALCULATION ON SPECIFICATIONS OF AUXILIARIES IN AVILES･SAMPALOC (AVILES)

2.1 CALCULATION OF SPECIFICATION OF PUMP AND REDUCTION GEAR

2.1.1 SPECIFICATIONS OF MAIN DRAINAGE PUMP in AVILES PUMPING STATION

2.1.1.1 OPERATING CONDITIONS

(1) CAPACITY

Aviles Pumping Station is expected to reinforce the total discharge capacity as $3m^3/s$ without increasing the number of installation of main drainage pumps.

a. Total Capacity Q_T = 17.1 m^3/s (The present condition is 14.1 m^3/s)

b. Unit Capacity Q = 4.275 m^3/s (The present condition is 3.525 m^3/s)

(2) Water Level

	Pasig River	Estro	Note
High Water Level	10.5	13.2	
Low Water Level	10.3	10.5	

(3) Actual Head

Design actual head is calculated following

Ha = Ham x C

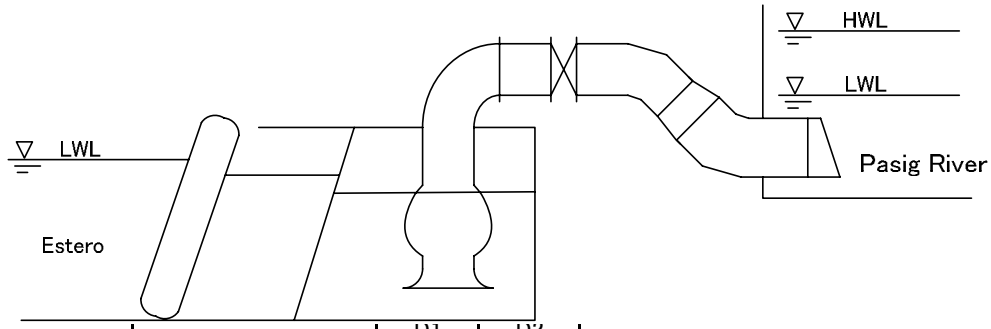
Ham : Maximum actual head = 13.2 − 10.3
= 2.9

C : Correction factor = 0.8

Ha = 2.9 x 0.8

= 2.32 m

(4) Loss Head



		D1	D2
Pipe bore	m	1.2	1.5
Verocity	m/s	3.780	2.419
Verocity Head	m	0.729	0.299

1) Friction loss of discharge straight pipe

$$h1 = \lambda \times \frac{L}{D1} \times \frac{V^2}{2g}$$

λ = (0.02 + 1 / (2000 x D1)) x 1.5
= 0.03063

= 0.124 m

L = 6.68 m

2) Friction loss of bend pipe (60 deg D=1.2m)

$$h2 = \zeta \times \frac{V^2}{2g}$$

ζ = 0.268

= 0.195 m

3) Friction loss of conical pipe (D=1.2m → D=1.5m)

$$h3 = \zeta \times \frac{V^2}{2g} \qquad \zeta = 0.19$$

$$= 0.139 \text{ m}$$

4) Friction loss of bend pipe (60 deg D=1.5m)

$$h4 = \zeta \times \frac{V^2}{2g} \qquad \zeta = 0.268$$

$$= 0.080 \text{ m}$$

5) Friction loss of discharge straight pipe

$$h5 = \lambda \times \frac{L}{D2} \times \frac{V^2}{2g} \qquad \lambda = (0.02 + 1 / (2000 \times D2)) \times 1.5$$

$$= 0.0305$$

$$= 0.023 \text{ m} \qquad L = 3.8 \text{ m}$$

6) Friction loss of flap valve

$$h6 = \zeta \times \frac{V^2}{2g} \qquad \zeta = 0.5$$

$$= 0.150 \text{ m}$$

7) Velocity head loss

$$h7 = \zeta \times \frac{V^2}{2g} \qquad \zeta = 1$$

$$= 0.299 \text{ m}$$

8) Screen loss

$$h7 = 0.300 \text{ m}$$

Therefore, total loss head is determinded below.

$$h = 0.124 + 0.195 + 0.139 + 0.080 + 0.023 + 0.150 + 0.299 + 0.300$$

$$= 1.31 \text{ m}$$

(5) Pump Head

$$H = Ha + h$$

$$= 3.63 \text{ m} \Rightarrow \underline{\mathbf{3.6\ m}}$$

2.1.1.2 Determination of diesel engine output

Diesel engin output for main pump driving is fixed below.

$$P = 0.163 \times \frac{Q \times H}{\eta_P \times \eta_G} \times \alpha$$

$$= 0.163 \times \frac{Q \times H}{\eta_P \times \eta_G} \times \alpha$$

$$= 0.163 \times \frac{256.5 \times 3.6}{0.8 \times 0.96} \times 1.25$$

$$= 245 \Rightarrow \underline{\mathbf{\mathit{240\ kW}}}$$

Q : Pump capacity (m^3/min)
H : Pump head (m)
η_P : Pump efficiency (%)
η_G : Reduction gear efficiency (%)
α : Allowance output

2.1.2 SPECIFICATIONS OF REDUCTION GEAR EQUIPMENT

Transmission capacity of reduction gear equipmt that driving main drainag pump is fixed with the following formula.

$$\text{Transmission capacity} = \frac{\text{Driver output} \times \text{Load factor}}{\text{Life factor}}$$

Load factor of reduction gear to driver and coupling type

Driver \ Input side coupling	Fulid coupling	High elastic coupring	Flexible coupring
Mortor or turbin	1.00	1.00	1.00
Diesel engine with 6 cylinders or more	1.00	1.10	1.25
Diesel engine with less than 6 cylinders	1.10	1.25	1.50

Life factor of reduction gear to running time

Total running time (h)	12,000 or less	25,000 or less	35,000 or less	50,000 or less	75,000 or less
Annual running time (h)	300 or less	600 or less	900 or less	1,200 or less	2,500 or less
Life factor	1.33	1.00	0.87	0.82	0.72
			↑ applied		

So,

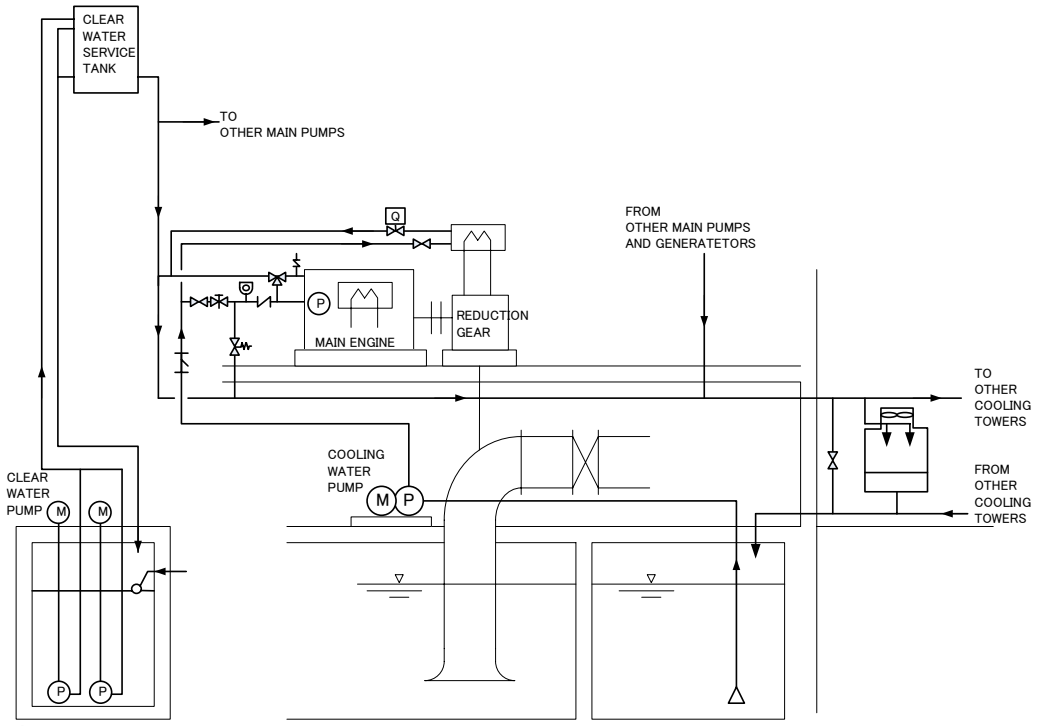
$$\text{Transmission capacity} = \frac{240 \times 1.10}{0.87}$$

$$= 303.4 \text{ kW} \Rightarrow \textbf{\textit{305 kW}}$$

2.2 CALCULATION ON SPECIFICATION OF COOLING WATER EQUIPMENT (AVILES)

2.2.1 FLOW SHEET OF COOLING WATER EQUIPMENT

The cooling water system is composed from following equipments described in flow sheet and equipments of heat resource are shown in table.



Heat resource

	Output (kW)	Sets
Main engine	240	4
Reduction gear	240	4
Generator engine	70	2

2.2.2 REQUIRED COOLING WATER CAPACITY

Total required cooling water capacity is determined by following equation.

$$Q_{CW} = \Sigma Q$$

(1) Required cooling water capacity for Main Engine

Required water capacity is calculated below.

$$Q_{ME} = \frac{Q_c}{60 \times \Delta T \times C \times \gamma}$$

Q_{ME} : Required water capacity for main engine (L/min)

ΔT : Temperature difference of cooling water between input and output
= 15 ℃

C : Specific heat of water
= 4.19 kJ/(kg*℃) = 4.19 kW*s/(kg*℃)

γ : Mass of water = 1.0

Q_c : Quantity of heat of Main Engine (kJ/h)

$$Q_c = P_E \times B_E \times H_U \times \tau$$

P_E : Engine output 240 kW

B_E : Fuel consumption 0.27 kg/kW/h

H_U : Net calorific value of diesel oil 42700 MJ/kg

τ : Heat radiation factor 0.3

$$Q_{ME} = \frac{830{,}088}{60 \times 15 \times 4.19 \times 1.0}$$

$$= 220.1 \text{ L/min} \Rightarrow 230 \text{ L/min}$$

(2) Required cooling water capacity for Reduction Gear

Required water capacity is calculated below.

$$Q_G = \frac{60 \times P_E \times (1 - \eta)}{\Delta T \times C \times \gamma}$$

Q_G : Required water capacity for reduction gear (L/min)

P_E : Engine output 240 kW

ΔT : Temperature difference of cooling water between input and output
= 15 ℃

C : Specific heat of water
= 4.19 kJ/(kg*℃) = 4.19 kW*s/(kg*℃)

γ : Mass of water = 1.0

η : Efficiency of reduction gear 0.96

$$Q_G = \frac{60 \times 240 \times (1 - 0.96)}{15 \times 4.19 \times 1.0}$$

$$= 9.2 \text{ L/min} \Rightarrow 10 \text{ L/min}$$

(3) Required cooling water capacity for Generator Engine

Required water capacity is calculated below.

$$Q_{GE} = \frac{Q_c}{60 \times \Delta T \times C \times \gamma}$$

Q_{GE} : Required water capacity for generator engine (L/min)

ΔT : Temperature difference of cooling water between input and output
= 15 ℃

C : Specific heat of water
= 4.19 kJ/(kg*℃) = 4.19 kW*s/(kg*℃)

γ : Mass of water = 1.0

Q_c : Quantity of heat of Main Engine (kJ/h)

$$Q_c = P_E \times B_E \times H_U \times \tau$$

P_E : Engine output 70 kW

B_E : Fuel consumption 0.34 kg/kW/h

H_U : Net calorific value of diesel oil 42700 MJ/kg

τ : Heat radiation factor 0.3

$$Q_{ME} = \frac{304878}{60 \times 15 \times 4.19 \times 1.0}$$

$$= 80.8 \text{ L/min} \Rightarrow 90 \text{ L/min}$$

Therefore, total required cooling water capacity for each pump is

$$Q_{CWP} = \Sigma Q$$

$$= 230 + 10$$

$$= \underline{\underline{240 \text{ L/min}}}$$

And then, for each generator

Q_{CWG} = 90 L/min

2.2.3 REQUIRED TOTAL HEAD FOR WATER COOLING WATER

For calculation, some conditions and requirements are supposed and given that,

a) LWL of Cooling Water Reserver is 3,000mm from surface on pump floor.

b) The admissible pressure at inlet of engine is from 0m to 10m or less.

d) Required total head is divided as below
Before engine, total head is borne by cooling water pump, so
after pass the engine other total head is borne by included pump of the engine.

c) Required residual head for cooling tower is about 5m

So, total required head shall be calculated for the most farther pump from Cooling Water Reserver and Cooling Towers.

(1) For cooling water pump

(1)-1 Actual Head

Ha = 15.75 − 8

= 7.75 m

Has = 3.5 m Suction section

Had = 4.25 m Discharge section

LWL	8	m
Inlet level for engine	15.75	m
Standard level of cooling water pump	11.5	m

(1)-2 Loss Head

a) Suction section

	D1
Pipe bore m	0.065
Veracity m/s	1.205
Veracity Head m	0.074

Q = 240 L/min
= 0.00400 m^3/s

1) Friction loss of discharge straight pipe

$$h1s = \lambda \times \frac{L}{D1} \times \frac{V^2}{2g}$$

= 0.591 m

λ = (0.02 + 1 / (2000 x D1)) x 1.5
= 0.04154

L = 12.5 m approx.

2) Friction loss of foot Valve

$$h2s = \zeta \times \frac{V^2}{2g}$$

= 0.163 m

ζ = 2.2

3) Minor loss

Supposed as 0.5 m

So total suction loss head is 1.254 m ⇒ hfs = 1.25 m

b) Discharge section

	D1	D2	
Pipe bore m	0.05	0.05	
Veracity m/s	2.037	1.952	
Veracity Head m	0.212	0.194	

Q1 = 240 L/min Q3
= 0.0040 m^3/s
Q2 = 230 L/min
= 0.0038 m^3/s

1) Friction loss of discharge straight pipe section D1

$$h1d = \lambda \times \frac{L}{D1} \times \frac{V^2}{2g}$$

λ = (0.02 + 1 / (2000 x D1)) x 1.5
= 0.045

= 0.229 m

L = 1.2 m approx.

2) Friction loss of discharge straight pipe section D2

$$h2d = \lambda \times \frac{L}{D2} \times \frac{V^2}{2g}$$

λ = (0.02 + 1 / (2000 x D2)) x 1.5
= 0.045

= 0.698 m

L = 4 m approx.

3) Minor loss including divided flow loss

Supposed as 2.0 m

So total suction loss head is 2.927 m ⇒ hfd = 2.93 m

(1)-3 Total Head

HT = Ha + Hfs + Hfd

= 11.93 m so, required total head of cooling water pump is determined 12m or more.

(2) For included pump of the engine

(2)-1 Actual Head

Ha = 12.85 − 15.75 + 5

= 2.095 m

Outlet level for engine	15.75	m
Inlet level for cooling tower	12.85	m
Required head at inlet for cooling tower	5	m

(2)-2 Loss Head

		D1	D2	D3
Pipe bore	m	0.065	0.125	0.1
Veracity	m/s	1.205	1.426	0.707
Veracity Head	m	0.074	0.104	0.026

Q1 = 240 L/min = 0.0040 m^3/s
Q3 = 525 L/min = 0.0056 m^3/s
Q2 = 1050 L/min = 0.0175 m^3/s

1) Friction loss of discharge straight pipe section D1

$$h1 = \lambda \times \frac{L}{D1} \times \frac{V^2}{2g}$$

λ = (0.02 + 1 / (2000 x D1)) x 1.5
= 0.04154

= 0.629 m

L = 13.3 m approx.

2) Friction loss of discharge straight pipe section D2

$$h2 = \lambda \times \frac{L}{D2} \times \frac{V^2}{2g}$$

λ = (0.02 + 1 / (2000 x D2)) x 1.5
= 0.036

= 0.785 m

L = 26.2 m approx.

3) Friction loss of discharge straight pipe section D3

$$h3 = \lambda \times \frac{L}{D3} \times \frac{V^2}{2g}$$

λ = (0.02 + 1 / (2000 x D2)) x 1.5
= 0.0375

= 0.029 m

L = 3 m approx.

4) Minor loss

Supposed as 3.0 m

So total discharge loss head is 4.443 m ⇒ hfd = 4.44 m

(2)-3 Total Head

HT = Ha + Hfs + Hfd

= 6.535 m ⇒ 7 m

so, required total head of included pump of the engine is determined 7m or more.

2.2.4 REQUIRED DIAMETER OF RETURN PIPE OF COOLING WATER

Actual Head is,

Ha = 10.5 − 12.85

= −2.35 m

Outlet level for cooling tower: 12.85 m

Discharge level of return pipe of cooling water on cooling water reserver: 10.5 m

Assuming that length of return pipe from cooling tower to cooling water reserver is 30 m.

Q = 1050 L/min

= 0.0175 m^3/s

Diameter of return pipe of cooling water from cooling tower is determined that total loss head depending on pipe bore must be less than absolute value of actual head from cooling tower to reserver.

Pipe bore	m	0.1	0.125	0.15	
Veracity	m/s	2.228	1.426	0.990	
Veracity Head	m	0.253	0.104	0.05	
λ		0.0375	0.0360	0.0350	
Friction loss	m	2.85	0.90	0.35	
Minor loss	m	1.5	1.5	1.5	including velocity head
total loss head	m	4.35	2.40	1.85	

Therefore, required pipe bore is 150A or more.

2.3 CALCULATION ON VENTILATION CAPACITY (AVILES)

2.3.1 THE OBJECTS FOR CALCULATION OF VENTILATION CAPACITY

The equipments and check points for calculation are listed below.

Equipments	Points to Check
MAIN ENGINE	Quantity heat due to radiation Amount of combustible air
REDUCTION GEAR	Quantity heat due to radiation
GENERATOR AND ENGINE	Quantity heat due to radiation Amount of combustible air
EXHAUST PIPE AND SILENCER FOR MAIN ENGINE	Quantity heat due to radiation
EXHAUST PIPE AND SILENCER FOR GENERATOR	Quantity heat due to radiation

2.3.2 CALCULATION OF VENTILATION CAPACITY

The ventilation capacity shall be depended on the sum of amount of combustible air by engines and cooling air for quantity heat due to radiation by equipments.

$V = V1 + V2$

In this case, we shall disregard heat radiations from panels. Because cubicle switchgear and DC panels are in electric electric room that has individual ventilation, and control panels shall release less amount of heat in engine room.

(1) Required ventilation capacity of cooling air for quantity heat due to radiations

$$V1 = \frac{\Sigma Q}{60 \times C_p \times (t_n - t_0) \times \rho}$$

V1	;	Required ventilation capacity		m^3/min
ρ	;	Air density (at 920hPa, 37℃, 50%RH)	1.024	kg/m^3
C_p	;	Specific heat capacity at constant pressure of air	0.00028	kWh/kg/℃
t_n	;	Room air temperature	37	℃
t_o	;	Outdoor temperature	27	℃

1-1) Quantity heat due to radiation from Main Engine: Q_E

$Q_E = n \times P_E \times B_E \times H_U \times f$

n	;	Quantity	4	sets
P_E	;	Output of main engines	240	kW
B_E	;	Fuel consumption	0.27	kg/kW/h
H_U	;	Net calorific value of diesel oil	11.92	kWh/kg
f	;	Radiation ratio of diesel engine (up to 1,000min^{-1})	0.025	

$Q_E = 4 \times 240 \times 0.27 \times 11.92 \times 0.025$

$= 77.24$ kw

1-2) Quantity heat due to radiation from Reduction Gear: Q_G

$Q_E = n \times \alpha \times P_E \times (1 - \eta_G)$

n	;	Quantity	4	sets
α	;	Coefficient of radiation of reduction gear	0.15	
η_G	;	Transmission efficiency	0.96	

$Q_E = 4 \times 0 \times 240 \times (1 - 0.96)$

$= 5.76$ kw

1-3) Quantity heat due to radiation from Engine for Generator: Q_{GE}

$$Q_E = n \times P_{GE} \times B_{GE} \times H_{UGE} \times f_{GE}$$

n	; Quantity	2	sets
P_{GE}	; Output of engine	70.8	kW
B_{GE}	; Fuel consumption	0.34	kg/kW/h
H_{UGE}	; Net calorific value of diesel oil	11.92	kWh/kg
f_{GE}	; Radiation ratio of diesel engine (over 1,000min^{-1})	0.04	

$Q_E = 2 \times 70.8 \times 0.34 \times 11.92 \times 0.04$

$= \boxed{22.96}$ kw

1-4) Quantity heat due to radiation from Generator: Q_{Gn}

$$Q_E = n \times P_{Gn} \times PF_{Gn} \times (1 - \eta_{Gn})$$

n	; Quantity	2	sets
P_{Gn}	; Output of generator	75	kVA
PF_{Gn}	; Power factor of generator	0.8	
η_{Gn}	; Efficiency of generator	0.857	

$Q_E = 2 \times 75 \times 0.8 \times (1 - 0.86)$

$= \boxed{17.16}$ kw

1-5) Quantity heat due to radiation from Exhaust pipe of Main Engine : Q_{EXE}

$$Q_{EXE} = n \times \frac{2\pi \times (\theta_r - \theta_o)}{\frac{1}{\lambda} \times \ln \frac{d_1}{d_0} + \frac{2}{\alpha \times d_1}} \times L / 1000$$

n	; Quantity	4	sets
θ_r	; Exhaust gas temperature (with turbo charger)	375	℃
θ_t	; Room air temperature	37	℃
λ	; Thermal conductivity of a thermal insulation material	0.0688	W/m/℃
d_1	; Outside diameter of a thermal insulation material	0.25	m
d_0	; Inside diameter of a thermal insulation material	0.15	m
α	; Surface coefficient of heat transfer of a thermal insulation material	10	W/m^2/℃
L	; Length of a thermal insulation material	13	m

$$Q_{EXE} = 4 \times \frac{2\pi \times (375 - 37)}{\frac{1}{0.0688} \times \ln \frac{0.25}{0.15} + \frac{2}{10 \times 0.25}} \times 13 / 1000$$

$= \boxed{13.43}$ kw

1-6) Quantity heat due to radiation from Exhaust pipe of Generator Engine : Q_{EXGE}

$$Q_{EXE} = n \times \frac{2\pi \times (\theta_r - \theta_o)}{\frac{1}{\lambda} \times \ln \frac{d_1}{d_0} + \frac{2}{\alpha \times d_1}} \times L / 1000$$

n	; Quantity	2	sets
θ_r	; Exhaust gas temperature (non turbo charger)	400	℃
θ_t	; Room air temperature	37	℃
λ	; Thermal conductivity of a thermal insulation material	0.0688	W/m/℃
d_1	; Outside diameter of a thermal insulation material	0.18	m
d_0	; Inside diameter of a thermal insulation material	0.08	m

α ; Surface coefficient of heat transfer of a thermal insulation material : 10 $W/m^2/℃$

L ; Length of a thermal insulation material : 9 m

$$Q_{EXE} = 2 \times \frac{2\pi \times (400 - 37)}{\frac{1}{0.0688} \times \ln\frac{0.18}{0.08} + \frac{2}{10 \times 0.18}} \times 9 / 1000$$

$$= 3.18 \text{ kw}$$

Therefore, V1 is

$$V1 = \frac{\Sigma Q}{60 \times C_p \times (t_n - t_0)}$$

$$= \frac{77.24 + 5.76 + 22.96 + 17.16 + 13.43 + 3.18}{60 \times 0.00028 \times (37 - 27) \times 1.024}$$

$$= 812.2 \text{ m}^3/\text{min} \Rightarrow \underline{812 \text{ m}^3/\text{min}}$$

(2) Required ventilation capacity of combustible air

$$V2 = \Sigma V_S$$

2-1) Amount of combustible air of Main Engine : V_{SE}

$$V_{SE} = n \times \frac{A0 \times B_E \times P_E \times K}{60} \times \frac{P_0}{P_N} \times \frac{t_N + 273}{273}$$

n ; Quantity : 4 sets

A_0 ; Amount of theoretical combustion air for diesel oil : 11.2 m^3/kg (NTP)

B_E ; Fuel consumption : 0.27 kg/kW/h

P_E ; Output of main engine : 240 kW

K ; Excess air ratio : Diesel Engine : 2.5

P_0 ; Standard atmospheric pressure : 1013 hPa

P_N ; Atmospheric pressure at running condition : 920 hPa

t_N ; Atmospheric temperature at running condition : 37 ℃

$$V_{SE} = 4 \times \frac{11.2 \times 0.27 \times 240 \times 2.5}{60} \times \frac{1013}{920} \times \frac{37 + 273}{273}$$

$$= 151.2 \text{ m}^3/\text{min}$$

2-2) Amount of combustible air of Generator Engine : V_{SGE}

$$V_{SGE} = n \times \frac{A0 \times B_E \times P_E \times K}{60} \times \frac{P_0}{P_N} \times \frac{t_N + 273}{273}$$

n ; Quantity : 2 sets

A_0 ; Amount of theoretical combustion air for diesel oil : 11.2 m^3/kg (NTP)

B_E ; Fuel consumption : 0.34 kg/kW/h

P_E ; Output of main engine (supposed) : 70.8 kW

K ; Excess air ratio : Diesel Engine : 2.5

P_0 ; Standard atmospheric pressure : 1013 hPa

P_N ; Atmospheric pressure at running condition : 920 hPa

t_N ; Atmospheric temperature at running condition : 37 ℃

$$V_{SGE} = 2 \times \frac{11.2 \times 0.34 \times 70.8 \times 2.5}{60} \times \frac{1013}{920} \times \frac{37 + 273}{273}$$

$$= \boxed{28.09}\ m^3/min$$

Therefore, V2 is

$$V2 = V_{SE} + V_{SGE}$$
$$= 151.2 + 28.09$$
$$= 179.3\ m^3/min \quad \Rightarrow \quad \underline{\underline{179\ m^3/min}}$$

Thereby total ventilation capacity is fixed below,

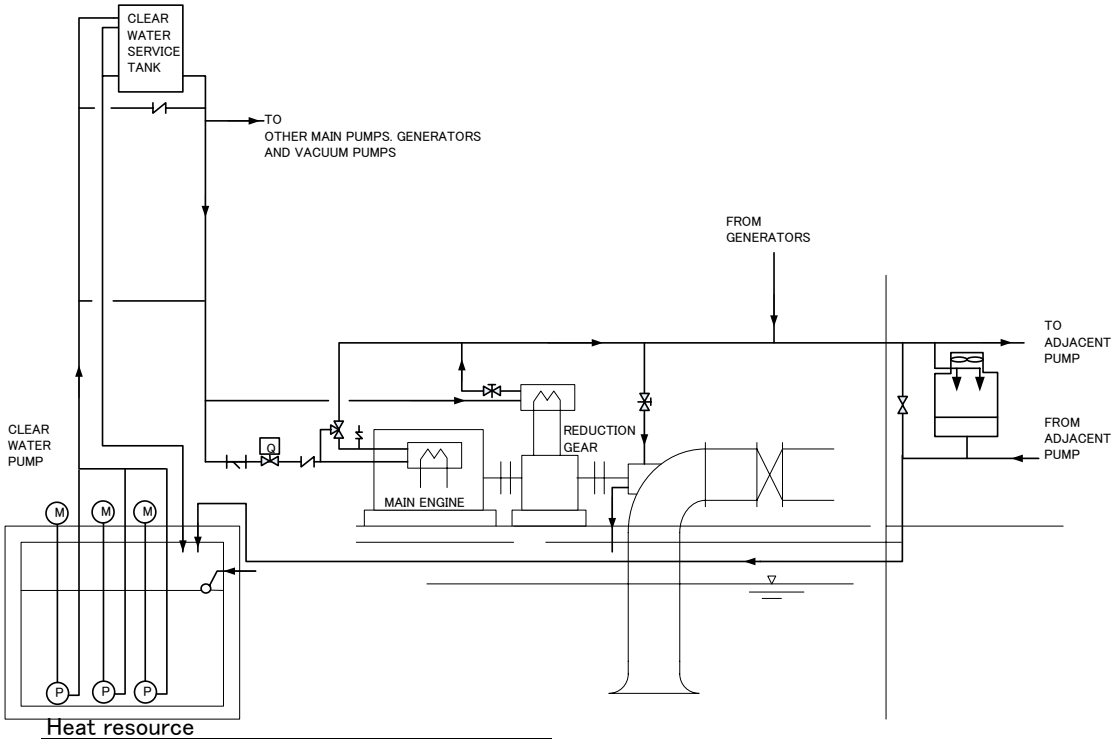
$$V = V1 + V2$$
$$= 812 + 179$$
$$= \underline{\underline{991\ m^3/min}}$$
$$= \underline{\underline{16.52\ m^3/s}}$$
$$= \underline{\underline{59{,}460\ m^3/h}}$$

3. CALCULATION ON SPECIFICATIONS OF AUXILIARIES IN TRIPA DE GALLINA (TRIPA)

3.1 CALCULATION ON COOLING WATER EQUIPMENT

3.1.1 FLOW SHEET OF COOLING WATER EQUIPMENT

The cooling water system is composed from following equipments described in flow sheet and equipments of heat resource are shown in table.



Heat resource

	Output (kW)	Sets
Main engine	331	4
Reduction gear	331	4
Generator engine	140	2

3.1.2 REQUIRED COOLING WATER CAPACITY

Total required cooling water capacity is determined by following equation.

$$Q_{CW} = \Sigma Q$$

(1) Required cooling water capacity for Main Engine

Required water capacity is calculated below.

$$Q_{ME} = \frac{Q_c}{60 \times \Delta T \times C \times \gamma}$$

Q_{ME} : Required water capacity for main engine (L/min)

ΔT : Temperature difference of cooling water between input and output
= 15 ℃

C : Specific heat of water
= 4.19 kJ/(kg*℃) = 4.19 kW*s/(kg*℃)

γ : Mass of water = 1.0

Q_c : Quantity of heat of Main Engine (kJ/h)

$$Q_c = P_E \times B_E \times H_U \times \tau$$

P_E : Engine output 331 kW

B_E : Fuel consumption 0.27 kg/kW/h

H_U : Net calorific value of diesel oil 42700 MJ/kg

τ : Heat radiation factor 0.3

$$Q_{ME} = \frac{1{,}144{,}830}{60 \times 15 \times 4.19 \times 1.0}$$

$$= 303.6 \text{ L/min} \Rightarrow 310 \text{ L/min}$$

(2) Required cooling water capacity for Reduction Gear

Required water capacity is calculated below.

$$Q_G = \frac{60 \times P_E \times (1 - \eta)}{\Delta T \times C \times \gamma}$$

Q_G : Required water capacity for reduction gear (L/min)

P_E : Engine output 331 kW

ΔT : Temperature difference of cooling water between input and output
= 15 ℃

C : Specific heat of water
= 4.19 kJ/(kg*℃) = 4.19 kW*s/(kg*℃)

γ : Mass of water = 1.0

η : Efficiency of reduction gear 0.97

$$Q_G = \frac{60 \times 331 \times (1 - 0.97)}{15 \times 4.19 \times 1.0}$$

$$= 9.5 \text{ L/min} \Rightarrow 10 \text{ L/min}$$

(3) Required cooling water capacity for Generator Engine

Required water capacity is calculated below.

$$Q_{GE} = \frac{Q_c}{60 \times \Delta T \times C \times \gamma}$$

Q_{GE} : Required water capacity for generator engine (L/min)

ΔT : Temperature difference of cooling water between input and output
= 15 ℃

C : Specific heat of water
= 4.19 kJ/(kg*℃) = 4.19 kW*s/(kg*℃)

γ : Mass of water = 1.0

Q_c : Quantity of heat of Main Engine (kJ/h)

$$Q_c = P_E \times B_E \times H_U \times \tau$$

P_E : Engine output 140 kW

B_E : Fuel consumption 0.3 kg/kW/h

H_U : Net calorific value of diesel oil 42700 MJ/kg

τ : Heat radiation factor 0.3

$$M_E = \frac{538020}{60 \times 15 \times 4.19 \times 1.0}$$

$$= 142.7 \text{ L/min} \Rightarrow 150 \text{ L/min}$$

Therefore, total required cooling water capacity for total pumps is

$$Q_{CWP} = \Sigma Q$$

$$= (310 + 10) \times 8$$

$$= 2560 \text{ L/min}$$

And then, for generator

Q_{CWG} = 150 L/min

So, total required cooling water capacity is 2710 L/min

Existing fresh water pumps are three sets, so capacity for each pump is 677.5 ⇒ 700 L/min

3.1.3 REQUIRED TOTAL HEAD FOR WATER COOLING WATER

For calculation, some conditions and requirements are supposed and given that,

a) LWL of Cooling Water Reserver is EL. 8.60 .

b) The admissible pressure for inlet of engine is from 0m to 10m or less.

d) Required total head is divided as below
Before engine, total head is borne by cooling water pump, so
after pass the engine other total head is borne by included pump of the engine.

c) Required residual head for cooling tower is about 5m

So, total required head shall be calculated for the most farther pump from Cooling Water Reserver and Cooling Towers.

(1) For cooling water pump

(1)-1 Actual Head

Ha = 14.2 − 8.6

= 5.6 m

LWL	8.6	m
Inlet level for main engine	14.2	m

(1)-2 Loss Head

a) Discharge section

	D1	D2	D3	D4	D5	D6	D7
Pipe bore m	0.15	0.15	0.15	0.125	0.125	0.125	0.065
Veracity m/s	1.952	1.811	1.509	1.738	1.304	0.869	1.607
Veracity Head m	0.194	0.167	0.116	0.154	0.087	0.039	0.1320

Q1 = 2070 L/min = 0.0345 m^3/s
Q2 = 1920 L/min = 0.0320 m^3/s
Q3 = 1600 L/min = 0.0267 m^3/s
Q4 = 1280 L/min = 0.0213 m^3/s
Q5 = 960 L/min = 0.0160 m^3/s
Q6 = 640 L/min = 0.0107 m^3/s
Q7 = 320 L/min = 0.0053 m^3/s

1) Friction loss of discharge straight pipe section D1

$$h1d = \lambda \times \frac{L}{D1} \times \frac{V^2}{2g}$$

$\lambda = (0.02 + 1 / (2000 \times D1)) \times 1.5 = 0.035$

= 0.023 m

L = 0.5 m

2) Friction loss of discharge straight pipe section D2

$$h2d = \lambda \times \frac{L}{D2} \times \frac{V^2}{2g}$$

$\lambda = (0.02 + 1 / (2000 \times D2)) \times 1.5 = 0.035$

= 0.857 m

L = 22 m

3) Friction loss of discharge straight pipe section D3

$$h3d = \lambda \times \frac{L}{D3} \times \frac{V^2}{2g}$$

$\lambda = (0.02 + 1 / (2000 \times D3)) \times 1.5 = 0.035$

= 0.162 m

L = 6 m

4) Friction loss of discharge straight pipe section D4

$$h4d = \lambda \times \frac{L}{D4} \times \frac{V^2}{2g}$$

$\lambda = (0.02 + 1 / (2000 \times D4)) \times 1.5$

$= 0.036$

$= 0.266$ m

$L = 6$ m

5) Friction loss of discharge straight pipe section D5

$$h5d = \lambda \times \frac{L}{D5} \times \frac{V^2}{2g}$$

$\lambda = (0.02 + 1 / (2000 \times D5)) \times 1.5$

$= 0.036$

$= 0.15$ m

$L = 6$ m

6) Friction loss of discharge straight pipe section D6

$$h6d = \lambda \times \frac{L}{D6} \times \frac{V^2}{2g}$$

$\lambda = (0.02 + 1 / (2000 \times D6)) \times 1.5$

$= 0.036$

$= 0.067$ m

$L = 6$ m

7) Friction loss of discharge straight pipe section D6

$$h7d = \lambda \times \frac{L}{D7} \times \frac{V^2}{2g}$$

$\lambda = (0.02 + 1 / (2000 \times D7)) \times 1.5$

$= 0.04154$

$= 0.506$ m

$L = 6$ m

3) Minor loss

Supposed as 5.0 m

So total discharge loss head is 7.031 m ⇒ hfd = 7.03 m

(1)-3 Total Head

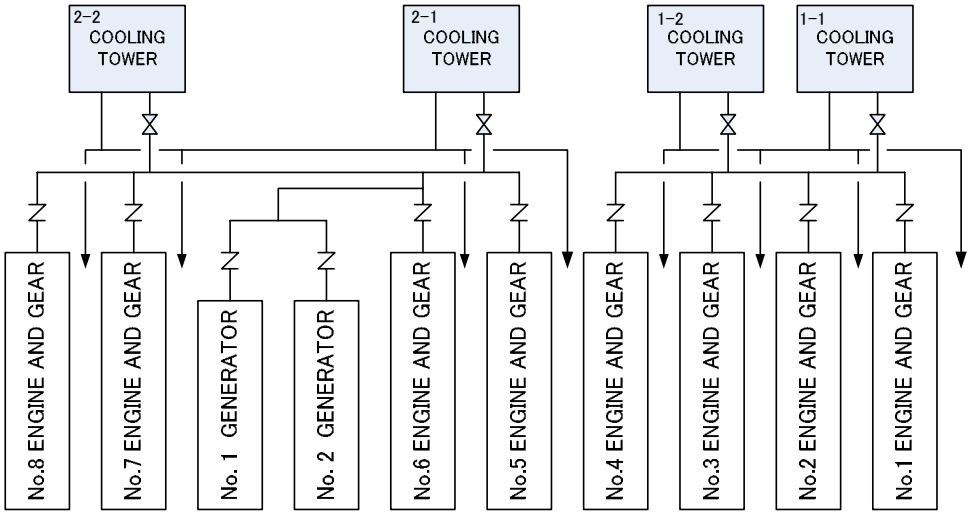
HT = Ha + Hfd

= 12.63 m

so, required total head of included pump of the engine is determined 13m or more.

(2) For included pump of the engine for No.6 pump

Total loss head is caldulated for the piping with the most water capacity.
The new group of cooling water's flow is described below.



(2)-1 Actual Head

Ha = 15.1 − 15.85 + 5

= 4.25 m

Outlet level for engine 15.85 m

Inlet level for cooling tower 15.1 m

Required head at inlet for cooling tower 5 m

(2)-2 Loss Head

		D1	D2	D3
Pipe bore	m	0.065	0.065	0.1
Veracity	m/s	1.607	2.361	0.707
Veracity Head	m	0.132	0.284	0.026

Q1 = 320 L/min = 0.0053 m^3/s

Q3 = 715 L/min = 0.0056 m^3/s

Q2 = 470 L/min = 0.0078 m^3/s

1) Friction loss of discharge straight pipe section D1

$$h1 = \lambda \times \frac{L}{D1} \times \frac{V^2}{2g}$$

= 0.759 m

λ = (0.02 + 1 / (2000 x D1)) x 1.5 = 0.04154

L = 9 m approx.

2) Friction loss of discharge straight pipe section D2

$$h2 = \lambda \times \frac{L}{D1} \times \frac{V^2}{2g}$$

= 0.907 m

λ = (0.02 + 1 / (2000 x D2)) x 1.5 = 0.04154

L = 5 m approx.

3) Friction loss of discharge straight pipe section D3

$$h3 = \lambda \times \frac{L}{D1} \times \frac{V^2}{2g}$$

= 0.244 m

λ = (0.02 + 1 / (2000 x D2)) x 1.5 = 0.0375

L = 25 m approx.

4) Minor loss

Supposed as 2.0 m

So total discharge loss head is 3.910 m ⇒ hfd = 3.91 m

(2)-3 Total Head

HT = Ha + Hfs + Hfd

= 8.16 m ⇒ 9 m

so, required total head of included pump of the engine is determined 8m or more.

3.1.4 REQUIRED DIAMETER OF RETURN PIPE OF COOLING WATER

Actual Head is,

Ha = 11 − 13.41

= −2.41 m

Outlet level for cooling tower 13.41 m

Discharge level of return pipe of cooling water on cooling water reserver 11 m

Assuming that length of return pipe from cooling tower to cooling water reserver is 16 m.

Q = 790 L/min for No.6 pump

= 0.0132 m^3/s

Diameter of return pipe of cooling water is determined that total loss head depending on pipe bore must be less than absolute value of actual head

Pipe bore	m	0.1	0.125	0.15
Veracity	m/s	1.676	1.073	0.745
Veracity Head	m	0.143	0.059	0.028
λ		0.0375	0.0360	0.0350
Friction loss	m	0.86	0.27	0.10
Minor loss	m	1.5	1.5	1.5
total loss head	m	2.36	1.77	1.60

including velocity head

Therefore, required pipe bore is 100A or more.

3.2 CALCULATION OF VENTILATION CAPACITY (TRIPA)

3.2.1 THE OBJECTS FOR CALCULATION OF VENTILATION CAPACITY

The equipments and points for calculation are listed below.

Equipments	Points to Check
MAIN ENGINE	Quantity heat due to radiation Amount of combustible air
REDUCTION GEAR	Quantity heat due to radiation
GENERATOR AND ENGINE	Quantity heat due to radiation Amount of combustible air
EXHAUST PIPE AND SILENCER FOR MAIN ENGINE	Quantity heat due to radiation
EXHAUST PIPE AND SILENCER FOR GENERATOR	Quantity heat due to radiation

3.2.2 CALCULATION OF VENTILATION CAPACITY

The ventilation capacity shall be depended on the sum of amount of combustible air by engines and cooling air for quantity heat due to radiation by equipments.

$V = V1 + V2$

In this case, we shall disregard heat radiations from panels. Because cubicle switchgear and DC panels are in electric room that has individual ventilation, and control panels shall release less amount of heat in engine room.

(1) Required ventilation capacity of cooling air for quantity heat due to radiations

$$V1 = \frac{\Sigma Q}{60 \times C_p \times (t_n - t_0) \times \rho}$$

V1	;	Required ventilation capacity		m^3/min
ρ	;	Air density (at 920hPa, 37℃, 50%RH)	1.024	kg/m^3
C_p	;	Specific heat capacity at constant pressure of air	0.00028	kWh/kg/℃
t_n	;	Room air temperature	37	℃
t_o	;	Outdoor temperature	27	℃

1-1) Quantity heat due to radiation from Main Engine: Q_E

$Q_E = n \times P_E \times B_E \times H_U \times f$

n	;	Quantity	8	sets
P_E	;	Output of main engines	324	kW
B_E	;	Fuel consumption	0.27	kg/kW/h
H_U	;	Net calorific value of diesel oil	11.92	kWh/kg
f	;	Radiation ratio of diesel engine (up to 1,000min^{-1})	0.025	

$Q_E = 8 \times 324 \times 0.27 \times 11.92 \times 0.025$

$= 208.6$ kw

1-2) Quantity heat due to radiation from Reduction Gear: Q_G

$Q_E = n \times \alpha \times P_E \times (1 - \eta_G)$

n	;	Quantity	8	sets
α	;	Coefficient of radiation of reduction gear	0.15	
η_G	;	Transmission efficiency	0.96	

$Q_E = 8 \times 0 \times 324 \times (1 - 0.96)$

$= 15.55$ kw

1-3) Quantity heat due to radiation from Engine for Generator: Q_{GE}

$$Q_E = n \times P_{GE} \times B_{GE} \times H_{UGE} \times f_{GE}$$

n	; Quantity	2	sets
P_{GE}	; Output of engine	140	kW
B_{GE}	; Fuel consumption	0.3	kg/kW/h
H_{UGE}	; Net calorific value of diesel oil	11.92	kWh/kg
f_{GE}	; Radiation ratio of diesel engine (over 1,000min^{-1})	0.04	

$Q_E = 2 \times 140 \times 0.3 \times 11.92 \times 0.04$

$= \boxed{40.05}$ kw

1-4) Quantity heat due to radiation from Generator: Q_{Gn}

$$Q_E = n \times P_{Gn} \times PF_{Gn} \times (1 - \eta_{Gn})$$

n	; Quantity	2	sets
P_{Gn}	; Output of generator	150	kVA
PF_{Gn}	; Power factor of generator	0.8	
η_{Gn}	; Efficiency of generator	0.857	

$Q_E = 2 \times 150 \times 0.8 \times (1 - 0.86)$

$= \boxed{34.32}$ kw

1-5) Quantity heat due to radiation from Exhaust pipe of Main Engine : Q_{EXE}

$$Q_{EXE} = n \times \frac{2\pi \times (\theta_r - \theta_o)}{\frac{1}{\lambda} \times \ln \frac{d_1}{d_0} + \frac{2}{\alpha \times d_1}} \times L / 1000$$

n	; Quantity	8	sets
θ_r	; Exhaust gas temperature (with turbo charger)	375	℃
θ_t	; Room air temperature	37	℃
λ	; Thermal conductivity of a thermal insulation material	0.0688	W/m/℃
d_1	; Outside diameter of a thermal insulation material	0.25	m
d_0	; Inside diameter of a thermal insulation material	0.15	m
α	; Surface coefficient of heat transfer of a thermal insulation material	10	W/m^2/℃
L	; Length of a thermal insulation material	13	m

$$Q_{EXE} = 8 \times \frac{2\pi \times (375 - 37)}{\frac{1}{0.0688} \times \ln \frac{0.25}{0.15} + \frac{2}{10 \times 0.25}} \times 13 / 1000$$

$= \boxed{26.85}$ kw

1-6) Quantity heat due to radiation from Exhaust pipe of Generator Engine : Q_{EXGE}

$$Q_{EXE} = n \times \frac{2\pi \times (\theta_r - \theta_o)}{\frac{1}{\lambda} \times \ln \frac{d_1}{d_0} + \frac{2}{\alpha \times d_1}} \times L / 1000$$

n	; Quantity	2	sets
θ_r	; Exhaust gas temperature (with turbo charger)	375	℃
θ_t	; Room air temperature	37	℃
λ	; Thermal conductivity of a thermal insulation material	0.0688	W/m/℃
d_1	; Outside diameter of a thermal insulation material	0.18	m
d_0	; Inside diameter of a thermal insulation material	0.08	m

α ; Surface coefficient of heat transfer of a thermal insulation material : 10 $W/m^2/℃$

L ; Length of a thermal insulation material : 9 m

$$Q_{EXE} = 2 \times \frac{2\pi \times (375 - 37)}{\frac{1}{0.0688} \times \ln\frac{0.18}{0.08} + \frac{2}{10 \times 0.18}} \times 9 / 1000$$

$$= 2.96 \text{ kw}$$

Therefore, V1 is

$$V1 = \frac{\Sigma Q}{60 \times C_p \times (t_n - t_0)}$$

$$= \frac{208.6 + 15.55 + 40.05 + 34.32 + 26.85 + 2.96}{60 \times 0.00028 \times (37 - 27) \times 1.024}$$

$$= 1908 \text{ m}^3/\text{min} \Rightarrow \underline{1908 \text{ m}^3/\text{min}}$$

(2) Required ventilation capacity of combustible air

$$V2 = \Sigma V_S$$

2-1) Amount of combustible air of Main Engine : V_{SE}

$$V_{SE} = n \times \frac{A0 \times B_E \times P_E \times K}{60} \times \frac{P_0}{P_N} \times \frac{t_N + 273}{273}$$

n ; Quantity : 8 sets

A_0 ; Amount of theoretical combustion air for diesel oil : 11.2 m^3/kg (NTP)

B_E ; Fuel consumption : 0.27 kg/kW/h

P_E ; Output of main engine : 324 kW

K ; Excess air ratio : Diesel Engine : 2.5

P_0 ; Standard atmospheric pressure : 1013 hPa

P_N ; Atmospheric pressure at running condition : 920 hPa

t_N ; Atmospheric temperature at running condition : 37 ℃

$$V_{SE} = 8 \times \frac{11.2 \times 0.27 \times 324 \times 2.5}{60} \times \frac{1013}{920} \times \frac{37 + 273}{273}$$

$$= 408.3 \text{ m}^3/\text{min}$$

2-2) Amount of combustible air of Generator Engine : V_{SGE}

$$V_{SGE} = n \times \frac{A0 \times B_E \times P_E \times K}{60} \times \frac{P_0}{P_N} \times \frac{t_N + 273}{273}$$

n ; Quantity : 2 sets

A_0 ; Amount of theoretical combustion air for diesel oil : 11.2 m^3/kg (NTP)

B_E ; Fuel consumption : 0.3 kg/kW/h

P_E ; Output of main engine (supposed) : 140 kW

K ; Excess air ratio : Diesel Engine : 2.5

P_0 ; Standard atmospheric pressure : 1013 hPa

P_N ; Atmospheric pressure at running condition : 920 hPa

t_N ; Atmospheric temperature at running condition : 37 ℃

$$V_{SGE} = 2 \times \frac{11.2 \times 0.3 \times 140 \times 2.5}{60} \times \frac{1013}{920} \times \frac{37 + 273}{273}$$

$$= \boxed{49.01}\ m^3/min$$

Therefore, V1 is

$$V2 = V_{SE} + V_{SGE}$$
$$= 408.3 + 49.01$$
$$= 457.4\ m^3/min \quad \Rightarrow \quad \underline{\underline{457\ m^3/min}}$$

Thereby total ventilation capacity is fixed below,

$$V = V1 + V2$$
$$= 1908 + 457$$
$$= \underline{\underline{2365\ m^3/min}}$$
$$= \underline{\underline{39.42\ m^3/s}}$$
$$= \underline{\underline{141{,}900\ m^3/h}}$$

F Basis for Calculation on Maintenance and Repairing Cost

Basis for Calculation on Maintenance and Repairing Cost

Unit of Cost : Peso

Items	Ratio on Maintenance and Repairing Cost (%)	Durable Period (year)	Annual Ratio on Maintenance and Repairing Cost (%/year)	Quiapo		Aviles・Sampaloc		Tripa de Gallina		Remarks
				Equipment Cost	Annual Maintenance and Repairing	Equipment Cost	Annual Maintenance and Repairing	Equipment Cost	Annual Maintenance and Repairing	
Main Pump	30	30	1.00	52,900,000	529,000	69,900,000	699,000	149,000,000	1,490,000	Equipment cost is a supposed cost
Main Engine and Reduction Gear	45	27	1.67	36,818,000	614,861	61,700,000	1,030,390	144,855,000	2,419,079	FOB Value
Auto Trash Screen	50	20	2.50	27,800,000	695,000	19,900,000	497,500	61,900,000	1,547,500	Equipment cost is a supposed cost
Auxiliaries	30	18	1.67	1,761,000	29,409	1,879,000	31,379	4,830,000	80,661	FOB Value
Cooling Tower	50	18	2.78	1,006,000	27,967	1,259,000	35,000	4,268,000	118,650	FOB Value
Electric Panels	45	18	2.50	6,388,000	159,700	6,704,000	167,600	9,602,000	240,050	FOB Value
Total					2,055,936		2,460,870		5,895,940	