SUPPORTING B

TRANSPORTATION SYSTEM DEVELOPMENT PLAN

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND AND OBJECTIVE OF THE SECTOR STUDY

Based on the results of the JICA Updated Master Plan (hereafter referred to as, JICA Updated M/P), November 2007, the Vietnam Revised Master Plan (hereafter referred to as, VN Revised M/P) for the Hoa Lac High-Tech Park (hereafter referred to as, HHTP) was prepared by the Government of Vietnam (hereafter referred to as, GOV) in May 2008. The VN Revised M/P was approved by the Prime Minister of GOV as a general plan for the development of the HHTP.

The objective of the sector study is to conduct feasibility study of the roads and transportation sector for the development of the HHTP. This will carried out based on the VN Revised M/P.

1.2 SCOPE OF THE SECTOR STUDY

The Sector Study covers internal roads and transportation system in the urgent planning area of 1036ha. The some of essential external infrastructure components of the roads and transportation system plan of the HHTP such as Lan Hoa-Lack Expressway (hereafter referred to as, LHLE), the National Highway 21A (hereafter referred to as, NH21A), the Urban Mass Rapid Transit (hereafter referred to as UMRT), and urban trunk roads in Hanoi will also be examined for the development of HHTP.

Source: JICA Study Team

Figure B.1.1 Location Maps

CHAPTER 2 PRESENT CONDITIONS OF TRANSPORTATION SYSTEM

2.1 GENERAL

Based on the "JICA Hoa Lac High-Tech Park Master Plan and Feasibility Study" as conducted in March 1998, the HHTP development work under the Hoa Lac High-Tech Park Management Board (hereinafter referred to as, HHTP-MB), which was established in 1998 as an implementing body has been carried out. The development works includes the construction of some parts of the internal roads and the external roads. With this as a current planning and implementation status, this chapter reviews in detail the roads and transportation system for the development of the HHTP.

The following projects and plans that are meant for development of the roads and transportation systems will be reviewed.

External Roads and Transportation System

- The LHLE by a length of 31km (Expressway: 3.75m ×6 lanes, Frontage road: 10.5m ×2, ROW: 140m) from Hanoi to Hoa Lac, which will be constructed by MOT;
- Upgrading of the NH21A between Son Tay and Mieu Mon which was planned by MOT (Main road: 4 lanes ×2, Frontage road: 3lanes ×2, ROW: 85m);
- Development of related urban trunk roads in Hanoi; and
- The UMRT No.3 to link the Bavi tourism area and Hoa Lac with Hanoi which was planned by MOT.

Internal Roads and Transportation System

- Construction of a road network inside the HHTP and to be managed by the HHTP-MB;
- Construction of a fly-over bridge (diamond type interchange) and an underpass for crossing the LHLE which will be constructed under the LHLE project by the MOT; and
- Development of an internal transportation system in the HHTP and to be managed by the HHTP-MB.

2.2 CURRENT DEVELOPMENT PROGRESS

2.2.1 External Roads and Transportation System

The development of the external roads and transportation system will be able to provide better services to the passenger traffic and freight traffic. It is expected that this development will be able to meet the generated traffic demand in the HHTP.

Passenger Transportation System

The LHLE will be able to provide rapid access to passengers traveling between the HHTP and center of Hanoi city. It is expected that most of commuters, students, and visitors coming from center of Hanoi city to the HHTP will come through the LHLE. In addition, development of the UMRT No.3 as rail-based mass public transportation system is also planned as long term project. For this reason, development space of 20 m width has been reserved as the right of way along the LHLE road.

Freight Transportation System

High standard of road network development connecting HHTP and the major logistic bases such as major port, container depot, and airport is essential for the effective freight transportation system. According to the VN Revised M/P, Noi Bai airport, Hai Phong port, depots at inter-city railway, and Son Tay port were identified as major logistic base for the HHTP. To connect between the above logistic bases and the HHTP, development of the LHLE, south section of Hanoi City Ring Road No.3 (hereafter referred to as, RR3), road section between the RR3 and the Noi Bai airport, and the NH21A needs to be promoted.

(1) Lan Hoa-Lack Expressway Project

The LHLE will play an essential role for the passenger and freight traffic and will be the main route connecting Hanoi city center and the HHTP. The LHLE project has been developed by an implementing body that consists of MOT as Investor, Thang Long PMU as Project Manager, and VINACONEX as Construction Contractor. This project is planned to be completed by June 2010. However, considering the delays in land acquisition of approximately 2km in the vicinity of the HHTP (especially at the cloverleaf intersection site), it is anticipated that the completion of the LHLE project as compared to earlier planned schedule of June 2010, might be delayed to March, 2011 Construction duration of 30 months will be required to complete the cloverleaf intersection.

(2) National Highway 21A Plan

NH21A is currently operated as a 2-lane paved road. The VN Revised M/P identifies NH21A as a freight route connecting HHTP and Son Tay Port. It is expected that this road will be upgraded to a high standard highway so as to cater heavy vehicles. The VN Revised M/P has proposed the widening improvement plan and suggests to increase the width to 14 lanes (main road 4 lanes x2, service road 3 lanes x2, ROW 85m). Thus, it is necessary for the HHTP-MB and Ministry of Transportation (MOT) to incorporate the HHTP development plan in the NH21A development plan.

(3) Hanoi City Ring Road No.3 Project

Hanoi City Ring Road No.3 (hereafter referred to as, RR3) is located in an urban section of the main route connecting the HHTP to the logistic base of Hai Phuong Port and Kai Lan Port. The development of the RR3 has been implemented to mitigate traffic congestion, and to make freight transport more efficient in the Hanoi Metropolitan Area. Part of the southwest section between the LHLE and NH 5 initially will be constructed as a 4-lane standard expressway. As the yen loan agreement between Japan and Vietnam was exchanged in early 2008, it seems this section will going to be implemented soon in near future.

(4) UMRT No.3 Plan

The development plan for the UMRT was planned as long term (2016 and downward) project in HAIDEP with an aim to connect Hanoi city center and the HHTP. It is anticipated that this development will also lead to proper urbanization of western part of Hanoi city. The UMRT track are also planned to be incorporated in the LHLE development corridor with a width of 20 m. However, prior to planning and operation of rail-base, it has been recommended to introduce step development such as Bus Rapid Transport (hereafter, BRT). Such development will not only be able to cater initial passenger demand in the HHTP area, but will also able to provide necessary period for further planning and development of the UMRT.

2.2.2 Internal Roads and Transportation System

Based on the JICA Updated M/P, the HHTP internal roads development plan was revised by the VN Revised M/P. Later, the plan was approved by the Prime Minister of GOV. Construction of the internal roads has been implemented under the HHTP-MB. However, it is to be noted that for about 55% of planned road neither the implementation budget has been allocated nor they are scheduled for design and construction. To provide direct access between the northern HHTP area and the Phu Cat area, the VN Revised M/P has proposed the fly-over bridge (diamond type interchange) and an underpass crossing at the LHLE.

As HHTP area is quite large and may not be covered by walk, it is necessary to examine and plan for the development of internal roads system and motorized internal transportation system.

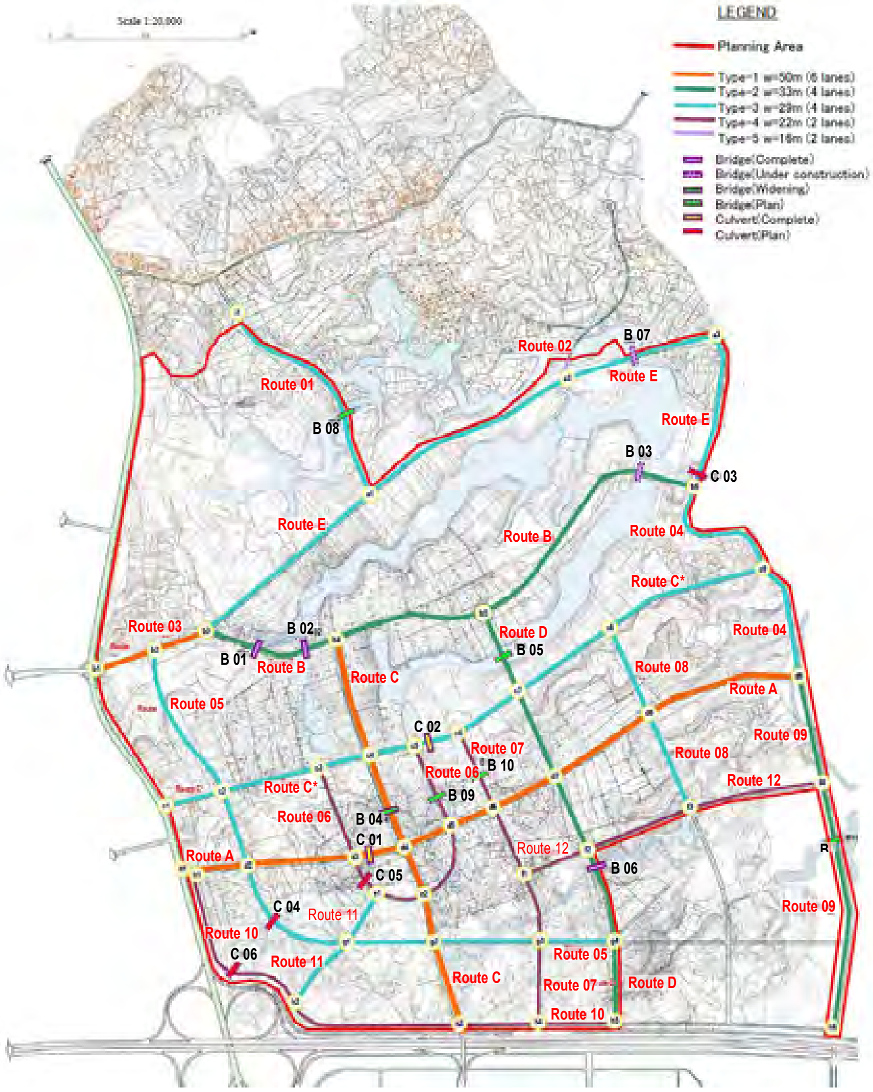
(1) HHTP Internal Roads Plan

The internal roads development plan of the HHTP is shown in Figure B.2.1 and summarized in Table B.2.1. The internal roads are classified into 5 types, and formulates hierarchical road network.

Table B.2.1 Outline of HHTP Internal Road Development Plan

Type of Road	Stage 1 (2015)			Stage 2 (2020)			Total		
	Length (m)	Width (m)	Area (m^2)	Length (m)	Width (m)	Area (m^2)	Length (m)	Width (m)	Area (m^2)
A Main Axle Road									
Type 1-1 (w=50m)	6,097	50	304,850	0	50	0	6,097	50	304,850
Type 2-2 (w=33m)	5,096	33	168,168	1,912	33	63,096	7,008	33	231,264
B Regional Road									
Type 3-3 (w=29m)	13,371	29	387,759	3,380	29	98,020	16,751	29	485,779
C Internal Road									
Type 4-4 (w=22m)	5,375	22	118,250	415	22	9,130	5,790	22	127,380
Type 5-5 (w=16m)	3,885	16	62,160	1,110	16	17,760	4,995	16	79,920
Total	33,823		1,041,187	6,817		188,006	40,641		1,229,193

Source: VN Revised M/P



Source: JICA Study Team

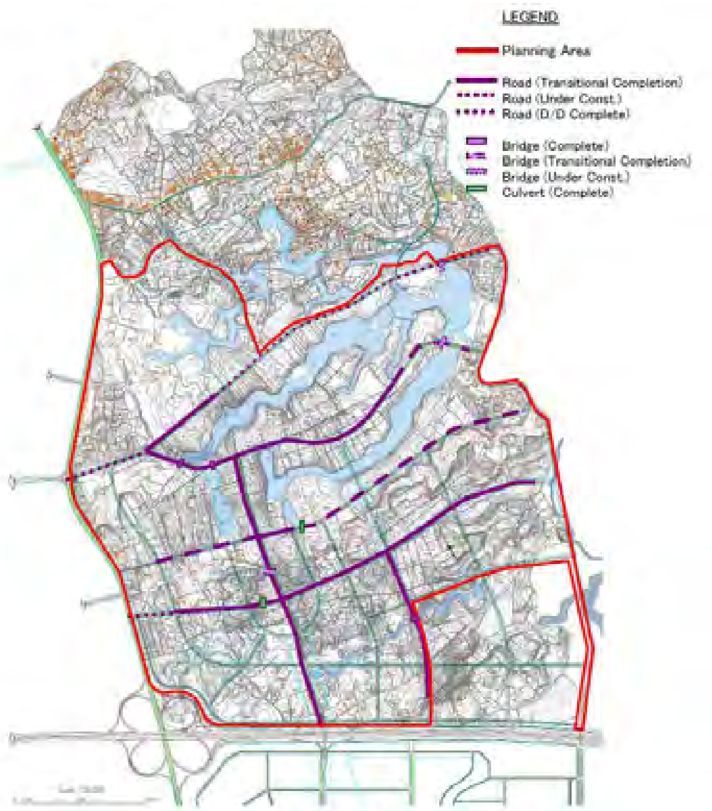
Figure B.2.1 Road Type of the HHTP Internal Roads

The status of the HHTP internal roads development is shown in Figure B.2.2 and summarized in Table B.2.2. The roads and bridges that are currently under construction are planned to be completed by the end of 2009. According to Project Management Unit of the HHTP (hereafter referred to as, HHTP PMU), the fund has been assured for the construction of the roads and bridges for which detailed design has been completed. For other roads and bridges, no funds have been assured for the preparation of detailed design and construction work. For these, the financial resources through ODA loans are expected for the preparation of design, construction, and the development purpose.

Table B.2.2 Status of Implementation

N0	Item	Length (m)	Width (m)	Area (m^2)
1	Road A	2,395	50	119,750
2	Road C	2,164	33	71,412
3	Road D	1,199	33	39,567
4	Road C*	1,072	29	31,088
5	Road B	1,028	29	29,812
6	Road E	870	29	25,230
Total		8,728		316,859

Source: VN Revised M/P



Source: JICA Study Team

Figure B.2.2 Implementation Status of HHTP Road Network

On reviewing the internal roads development plan, the following issues were found:

- Utility accommodation plan and traffic management plan are not fully examined and irrational constructions are observed at developed site (ex. Sidewalk development without utility accommodation facilities).
- Quality control is not fully performed, (ex. Defective workmanship of pre-cast and cast-in-site concrete structures) and as result there seems a necessity of repair at least in short term.

(2) Fly-Over Bridge (Diamond Type Interchange) and Underpass across the LHLE

For the connection between the HHTP internal road and the LHLE main road, the diamond type interchange including the fly-over bridge has been planned by the VN Revised M/P. Additionally, underpass at east of the diamond type interchange is also planned to connect northern part of the HHTP and Phu Cat area.

The diamond interchange design as prepared by the LHLE project implementing body Thang Long PMU), didn't considered the off ramp at outbound lane and on ramp at inbound lane as shown in Figure B.2.3. As a result the traffic coming from Hanoi corner to HHTP and traffic toward from the HHTP to Hanoi corner needs to be detoured and cloverleaf type interchange has been planned at about 1.2km west from the diamond type interchange (Hoa Lac side). This will causes low accessibility to the HHTP and compel the heavy vehicle to use general road.

In addition, the design of the fly-over bridge and the underpass as prepared by the LHLE project implementing body was not found satisfactory. The dimension of the cross section and the clearance height doesn't meet the design requirement for the HHTP.

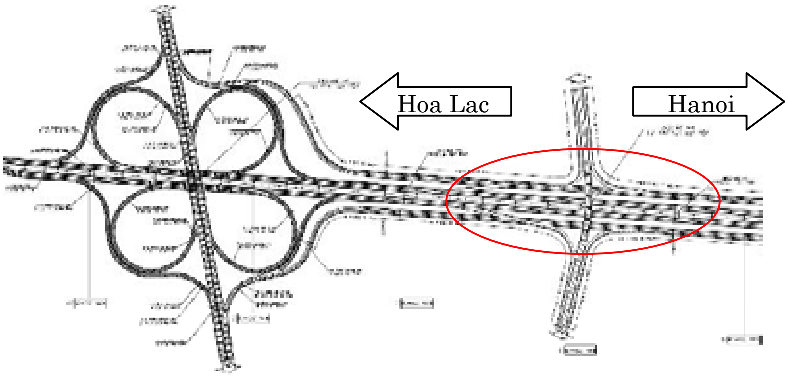


Figure B.2.3 Diamond Type Interchange Plan by MOT (Main gate of HHTP)

(3) HHTP Internal Transportation System Plan

Considering the large area of the HHTP, it is essential to develop the effective and efficient internal transportation system within the HHTP. From the view point of economic efficiency and development period, the circulation bus can be an appropriate mode of the internal transportation system.

2.2.3 Issues of the Sector Development

On reviewing the projects and plans for external and internal roads and transportation system, the following issues were found.

External Roads and Transportation System

- Planning coordination is required between the HHTP-MB and the MOT so as to incorporate the HHTP development plan in the NH21A development plan.
- Planning coordination is required between the LHLE project and the UMRT plan so as to incorporate the UMRT plan in the LHLE project.

Internal Roads and Transportation System

- Modification of the right of way for road typical cross sections is required so as to provide additional space to accommodate utilities.
- Planning coordination is required between the HHTP internal roads plan and the LHLE project specailly with refernce to diamond interchanges, the fly-over bridges, and the underpasses.
- It is recoomeneded to introduce the internal transportation system.
- Considering the revised land use and modified road right of way, traffic demand also need to be adjusted and modified.
- Vertical alignment plan needs modification in coordination with the land reclamation plan, river improvement plan, and bridge plan.

CHAPTER 3 FRAMEWORK OF TRANSPORTATION DEVELOPMENT PLAN

3.1 PLANNING BASIS

3.1.1 Missions, Strategies and Goals of the HHTP Sector Development

Missions, strategies and goals for the HHTP sector development as established in the JICA Updated M/P are shown in Table B.3.1. Based on the formulated strategies, the project formulation was examined and relevant issues for the development of the HHTP were identified.

Table B.3.1 Missions, Strategies and Goals for Road and Transportation Sector

Missions	To provide transportation functions to support various kinds of activities in the HHTP.	To provide spatial functions for other infrastructures including water, sewerage, drainage, electricity, and communications.
Strategies	To design roads and lanes leaving enough space and flexibility for later adjustment and redevelopment. To separate traffic flow of different types of users for safer, more comfortable transportation. To include some roads located outside the HHTP gates for comprehensive road development. To reinforce connectivity with external transportation infrastructure, especially, Lang-Hoa Lac Highway.	To provide enough space under the roads for utilities leaving flexibility for future development and maintenance. To develop some important zonal roads along with the internal roads for reasonable, comprehensive utility infrastructure networks.
Goals	To complete the development of road and transportation as the most basic infrastructure of the HHTP by 2015 (for Phase-1) and by 2020 (for Phase-2).	

Source: JICA Updated M/P

3.1.2 Issues for the Project Formulation

Measures for the issues listed in Chapter 2.2.3 are classified as direct measures and indirect measures as follows. As for the issues for indirect measures, examination and recommendation were made in the sector study. While, planning examinations and planning formulation were made for the issues for direct measures in the sector study.

Issues for Direct Measures

- Modification of the right of way for typical road cross sections is required due to the necessity of requirement of additional space so as to accommodate utilities;
- Recommended to introduce internal transportation system;
- Considering the revised land use and modified road right of way, traffic demand also need to be adjusted and modified; and
- Vertical alignment plan needs modification in coordination with the land reclamation plan, river improvement plan, and bridge plan.

Issues for Indirect Measures

- Planning coordination is required between the HHTP internal roads plan and the LHLE project specailly with refernce to diamond interchanges, the fly-over bridges, and the underpasses.

- Planning coordination is required between the HHTP-MB and the MOT so as to incorporate the HHTP development plan in the NH21A development plan.
- Planning coordination is required between the LHLE project and the UMRT plan so as to incorporate the UMRT plan in the LHLE project.

3.1.3 Planning Principle of the HHTP Internal Roads

Since the HHTP internal roads are categorized as urban roads, appropriate consideration should be given to the road functions along with roadside land use plan and anticipated traffic condition. Figure B.3.1 shows expected road function for urban roads.

The following principles were used to examine appropriate road functions for the HHTP internal roads and to set the planning concept:

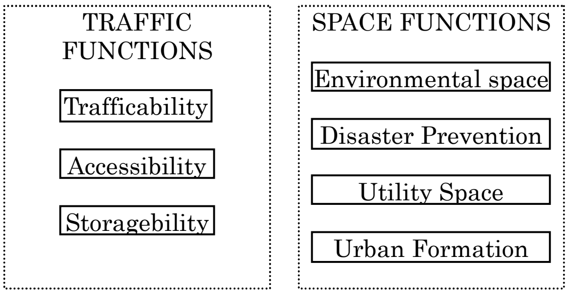


Figure B.3.1 Road Functions of Urban Roads

<u>Traffic Functions (Trafficability, Accessibility, Storability)</u>
- Adequate vehicle lane widths shall be provided for heavy vehicle passage, especially at intersections.
- Adequate additional lanes shall be provided at the intersections that connects to the circumference roads of the HHTP.
- Facilities to formulate a safe pedestrian network such as sidewalks, pedestrian crossings, and pedestrian traffic signals shall be provided.
- Roadside space shall be provided at high parking demand area and at bus stops, etc.

<u>Space Functions (Environmental Space, Disaster Prevention, Utility Space, Urban Formation)</u>
- A buffer zone shall be provided to create a hospitable roadside environment.
- Adequate utilitiy accomodation space shall be provided to support various utilities.
- Landscaping shall be considered to enhance the attractiveness of the HHTP.

The development concept for bridges and culverts are as follows:

- Maintain required opening space, based on hydrological analysis.
- Consider utilization of existing structures for widening of the B04 bridge.
- Consider landscaping for planning of the B05 Bridge.
- Plan & Design the structure height consedering the fixed condition of land reclamation and heights.

3.2 EXAMINATION OF DEVELOPMENT FRAMEWORK

3.2.1 General

To formulate the HHTP internal roads and transportation related development project, planning conditions such as demand for the facilities and relevance plan were examined.

3.2.2 Revision of Traffic Demand Projection

Considering the proposed land use plan, population projections, and traffic parameters in Hanoi Metropolitan area as set by the Comprehensive Urban Development Program in Hanoi Capital City (hereafter referred to as HAIDEP), the JICA Updated M/P estimated the traffic demand in the HHTP. However, the VN Revised M/P considering the revised the land use plan and revised basic unit of population generation ratio, and population forecast values, modified the traffic demand. Since the land use plan was slightly modified in this Study due to modification of right of way, population forecast values were also revised accordingly, as shown in Table B.3.2.

Table B.3.2 Revised Land Use Plan and Population Forecast

Name of Development Zone	Area (ha) for F/S	Area (ha)			Population Projection (persons)				Classification of Population (2015)			Classification of Population (2020)		
		Total	Stage1 (2015)	Stage2 (2020)	Total	Stage1 (2015)	Stage2 (2020)	Density (p/ha)	Day Ratio	Daytime	Nighttime	Day Ratio	Daytime	Nighttime
Hoa Lac Area														
1 Software park	64.4	64.4	43.7	20.7	12,880	8,740	4,140	200.0	1.0	8,740	0	1.0	12,880	0
2 R&D	227.9	227.9	132.7	95.2	13,674	7,962	5,712	60.0	1.0	7,962	0	1.0	13,674	0
3 Hi-tech Industrial	114.7	231.6	197.4	34.2	23,160	19,740	3,420	100.0	1.0	19,740	0	1.0	23,160	0
4 Education & Training	108.0	108.0	20.6	87.4	43,200	8,240	34,960	400.0	0.6	4,944	3,296	0.6	25,920	17,280
5 Center of hi-tech City	49.0	49.0	49.0	0.0	12,250	12,250	0	250.0	0.6	7,350	4,900	0.6	7,350	4,900
6 Mixed Use	84.5	84.5	45.2	39.3	12,675	6,780	5,895	150.0	0.4	2,712	4,068	0.4	5,070	7,605
7 Houses & Offices	41.9	41.9	41.9	0.0	34,149	34,149	0	815.0	0.0	0	34,149	0.0	0	34,149
8 Housing Complex	22.6	22.6	12.2	10.4	34,691	18,727	15,964	1,535.0	0.0	0	18,727	0.0	0	34,691
9 Amenity	0.0	110.0	110.0	0.0	220	220	0	2.0	1.0	220	0	1.0	220	0
10 Amusement	33.2	33.2	33.2	0.0	1,660	1,660	0	50.0	1.0	1,660	0	1.0	1,660	0
11 Traffic & Infrastructure	146.6	147.1	147.1	0.0	0	0	0			0	0		0	0
12 Lake & Buffer	112.4	117.0	117.0	0.0	0	0	0			0	0		0	0
13 Greeneries/Trees	30.8	30.8	30.8	0.0	0	0	0			0	0		0	0
Sub-total	1,036.0	1,268.0	980.8	287.2	188,559	118,468	70,091			53,328	65,140		89,934	98,625
Northern Phu Cat Area														
1 Software park	0.0	10.9	0.0	10.9	2,180	0	2,180	200.0	1.0	0	0	1.0	2,180	0
2 R&D	0.0	0.0	0.0	0.0	0	0	0	60.0	1.0	0	0	1.0	0	0
3 Hi-tech Industrial	0.0	289.0	0.0	289.0	28,900	0	28,900	100.0	1.0	0	0	1.0	28,900	0
4 Education & Training	0.0	0.0	0.0	0.0	0	0	0	400.0	0.6	0	0	0.6	0	0
5 Center of hi-tech City	0.0	0.0	0.0	0.0	0	0	0	250.0	0.6	0	0	0.6	0	0
6 Mixed Use	0.0	2.4	0.0	2.4	360	0	360	150.0		0	0		0	360
7 Houses & Offices	0.0	0.0	0.0	0.0	0	0	0	815.0	0.0	0	0	0.0	0	0
8 Housing Complex	0.0	2.6	0.0	2.6	3,991	0	3,991	1,535.0	0.0	0	0	0.0	0	3,991
9 Amenity	0.0	0.0	0.0	0.0	0	0	0	2.0	1.0	0	0	1.0	0	0
10 Amusement	0.0	0.0	0.0	0.0	0	0	0	50.0	1.0	0	0	1.0	0	0
11 Traffic & Infrastructure	0.0	1.9	1.9	0.0	0	0	0			0	0		0	0
12 Lake & Buffer	0.0	0.0	0.0	0.0	0	0	0			0	0		0	0
13 Greeneries/Trees	0.0	11.2	11.2	0.0	0	0	0			0	0		0	0
Sub-total	0.0	318.0	13.1	304.9	35,431	0	35,431			0	0		31,080	4,351
Total	1,036.0	1,586.0	993.9	592.1	223,990	118,468	105,522			53,328	65,140		121,014	102,976

Note: Day ratio of the population is applied to the JICA Update M/P

Source: JICA Study Team

To examine the validity of the internal roads plan as proposed by the VN Revised M/P, traffic demand for the HHTP was re-projected. This was due to the revised population generation ratio as prepared during this Study.

(1) Conditions of the Examination

Of the total 1,586ha of land which is approved by the Prime Minister of the GOV as shown in Figure B.3.2, the planning area for this Sector Study is 1,036ha. The study area doesn’t include 318ha of Phu Cat, 110ha of amenity area, and 122ha of southeast high-tech industrial zone. However, the areas such as amenity and southeast high-tech industrial zone area that are located near to the planning area were also examined. In other words, traffic demand was re-projected for an area of 1,268ha that includes 110ha of the amenity area and 122ha of southeast high-tech industrial zone.

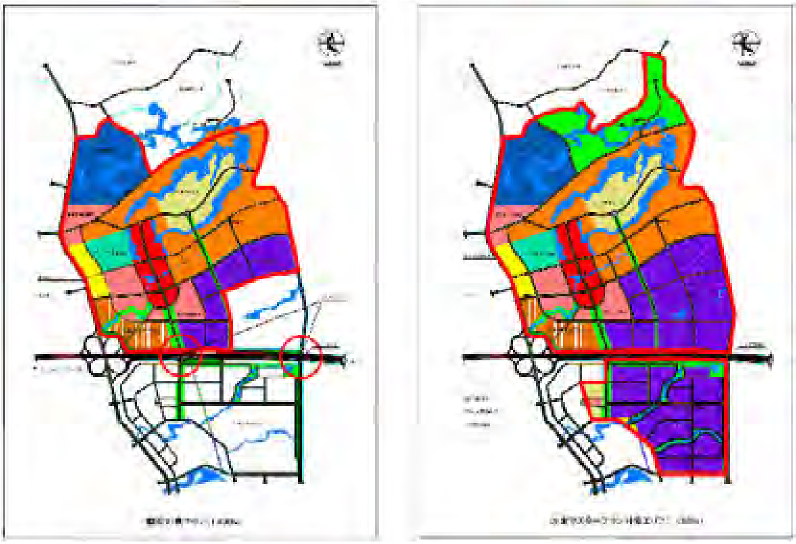


Figure B.3.2 Planning Area of HHTP (right: JICA Study, left: VN Revised M/P)

(2) Traffic Demand Projection

To examine the validity of the internal roads plan as proposed by the VN Revised M/P, the traffic demand of the HHTP was re-projected based on revision of the population generation ratio as prepared during the Study. Based on the traffic parameters for Hanoi Metropolitan Area as set by the HAIDEP and the predicted population, the re-projected traffic demand in the Stage-1(2015) and Stage-2(2020) are 27,358pcu/day and 49,123pcu/day respectively.

Table B.3.3 Revised Traffic Demand Projection

Trip Demand

	Population		Trip Rate	Daily Trips	
	2015	2020		2015	2020
Residents within HHTP	65,140	98,625	2	130,280	197,250
Daytime Population	118,468	188,559			
People from outside HHTP	53,328	89,934	2	106,656	179,868

Modal Split

Mode	Share(%)		Daily Trips (PT)	
	2012*	2020	2015	2020
Bicycle	16	3.8	17,065	6,835
Motorcycle	61.1	52.9	65,167	95,150
Car	9.7	15.8	10,346	28,419
Truck	2.3	3.5	2,453	6,295
Public Transport	10.9	24	11,626	43,168
Total	100	100	106,656	179,868

Traffic Demand Projection

Mode	Occupancy Rate		Daily Trips (VT)		PCU Factor	Daily Trips (PCU)	
	2012*	2020	2015	2020		2015	2020
Bicycle	1.13	1.13	15,102	6,049	0.2	3,020	1,210
Motorcycle	1.36	1.36	47,917	69,963	0.3	14,375	20,989
Passenger Car	2.02	2.02	5,122	14,069	1	5,122	14,069
Truck	1.7	1.7	1,443	3,703	2.5	3,607	9,258
Sub-total			69,583	93,784		26,124	45,526
Public Transport	23.56	30	493	1,439	2.5	1,234	3,597
Total			70,077	95,223		27,358	49,123

Note: Share and occupancy rate are adopted parameters in 2012 established by HAIDEP as approximation value
Source: JICA Study Team

3.2.3 Capacity Analysis of the HHTP Gates

Six gates at peripheral road of the HHTP connecting to the LHLE frontage roads and the NH21A are proposed in the VN Revised M/P. In comparison to gate plan of the JICA Update M/P, the number of the gate was increased from 4 to 6 and as a result the internal roads network was also revised so as to link the additional roads with the increased gate. As a result of these revisions, road density of the HHTP was increased in comparison to the one as suggested by

JICA Update M/P.

The LHLE and the NH21A are expected to be main access road of the HHTP. The three gates are on the LHLE and other three gates are on the NH21A. To connect with the HHTP internal roads, these gates are planned on peripheral roads of the HHTP. A total of 30 lanes of the HHTP internal roads connects to the gates. Assuming when there is inflow traffic equivalent to saturation level, these lanes will have a maximum road capacity of about 60,000pcu/h (one direction 30,000pcu/h) However, considering the traffic signal operation and high road density, the total road capacity of the HHTP internal roads will be reduced by approximately 60% of 60,000pcu/h. In other words, actual total road capacity of the HHTP internal roads becomes 36,000pcu/h (one direction 18,000pcu/h). On the other hand, considering the commuter and student travel characteristics, the in and out traffic flow of the HHTP is assumed to be concentrated during morning peak hours (7:30 to 9:30) and evening peak hours (16:30 to 18:30). And based on the re-projected traffic demand in the Stage-2(2020), the hourly traffic volume in the peak hours has been estimated about 11,380pcu. Directions of the peak hour traffic can be assumed inflow in morning peak and outflow in evening peak. Therefore, the six gates as proposed by the VN Revised M/P will be able to accommodate the projected traffic demand in the Stage-2 (2020).

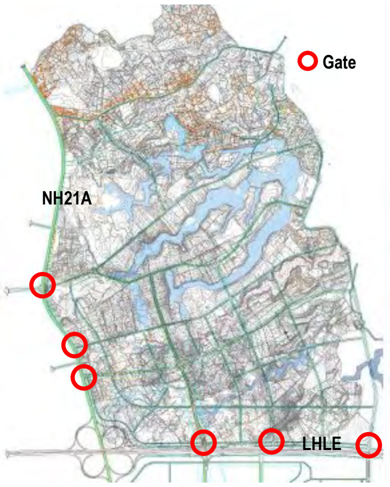


Figure B.3.3 Location of the HHTP Gates

However, if no traffic management measures such as gate usage designation, mix traffic separation, and etc. will not be made, saturated traffic flow at the gates may cause negative traffic impacts such as traffic jam and traffic accidents on the LHLE and the NH21A. Therefore, following counter measures should be introduced.

<u>Road Facilities</u>

- Channeling lane installation for in-out flow of the HHTP at the gate intersections.
- Priority signal phasing and lane arrangement for in-out flow of the HHTP at the gete intersections.

<u>Traffic Management</u>

- Introduction of dispersing gate use regulation.
- Staggered office and school hour.
- Multiple pickup.

3.2.4 Examination of the HHTP Transportation System Development Plan

Most of the HHTP visitors commuting with public transport seem to use public bus service. Along with the external transportation system, the circulation bus would be major transportation mean in the HHTP. To formulate plan of bus related facility such as bus terminal in the HHTP based on the re-projected public transport traffic demand, following study was examined.

(1) Type of Bus

Introduction of appropriate combination of large bus and middle bus is proposed as the HHTP internal transportation system. This will be able to meet the passenger demand characteristics.

Table B.3.4 Type of Bus

Bus Type	Capacity (Passengers)	Max Capacity (Passengers)	Bus Size (m)
Large bus	45	75	12×2.5
Middle bus	27	45	9×2.5

(2) Peak Hour Bus Demand

Peak hour bus demand of the HHTP internal transportation system has been estimated based on the re-projected traffic demand. Based on assumption that all visitors will transfer to the HHTP internal transportation system and with a peak hour ratio of 10%, the traffic demand was estimated for the HHTP internal transportation system.

Table B.3.5 Peak Hour Bus Demand

Type of Passengers	Total Bus Demand (trips/day)		Peak Hour Bus Demand (trips/hour)	
	2015	2020	2015	2020
Residents	14,201	47,340	1,420	4,734
Visitor	11,626	43,168	1,163	4,317
Total	25,826	90,508	2,583	9,051

(3) Necessary Number of Bus

In case that 3 circulation bus routes are set for the HHTP internal transportation system, a bus can be assumed 3 time circulation per hour, and also 2 passenger rotation in a circulation. As a result, 9 buses (2 large buses, 7 middle-sized buses) in 2015, and 30 buses (6 large buses, 24 middle-sized buses) in 2020 are estimated as listed in Table B.3.6.

Table B.3.6 Necessary Number of Bus

Bus Type	Peak Hour Bus Demand (vehicle/hour)		Bus Demand under Operation (3 circulation/bus · hour)		Average Passenger Rotation (2 passengers/circulation)		Necessary Bus Number (vehicle)	
	2015	2020	2015	2020	2015	2020	2015	2020
Large bus	35	121	12	40	6	20	2	6
Middle bus	58	202	19	67	10	34	7	24

(4) Necessary Bus Parking Area

Necessary bus parking area which includes bus parking lot, passage way, and platform has been estimated for the HHTP and is listed in Table B.3.7.

Table B.3.7 Peak Hour Bus Demand

Bus Type	Bus Size (m)	Parking Lot (m^2)	Passage Way (m^2/vehicle)	Platform (m^2)	Necessary Bus Parking Area (m^2)	
					2015	2020
Large bus	12×2.5	43 (13m×3.3m)	43 (13m×3.3m)	26	194	679
Middle bus	9×2.5	33 (10m×3.3m)	33 (10m×3.3m)	20	577	2,025
Total					771	2,704

3.2.5 Examination of Fly-Over Bridge (Diamond Type Interchange) and Underpass Plan

(1) Comparison between the VN Revised M/P and the LHLE Project

The diamond type interchange including the fly-over bridge and the underpass plan in the VN

Revised M/P as well as in the LHLE project are shown in Figure B.3.4. There are some discrepancies in the two plans specially in connection method and are discussed below:

- No off-ramp on the outbound of the diamond type interchange at the HHTP main gate has been planned in the LHLE project.
- Eastern interchange that is planned under the LHLE project is at about 500m east of the underpass.

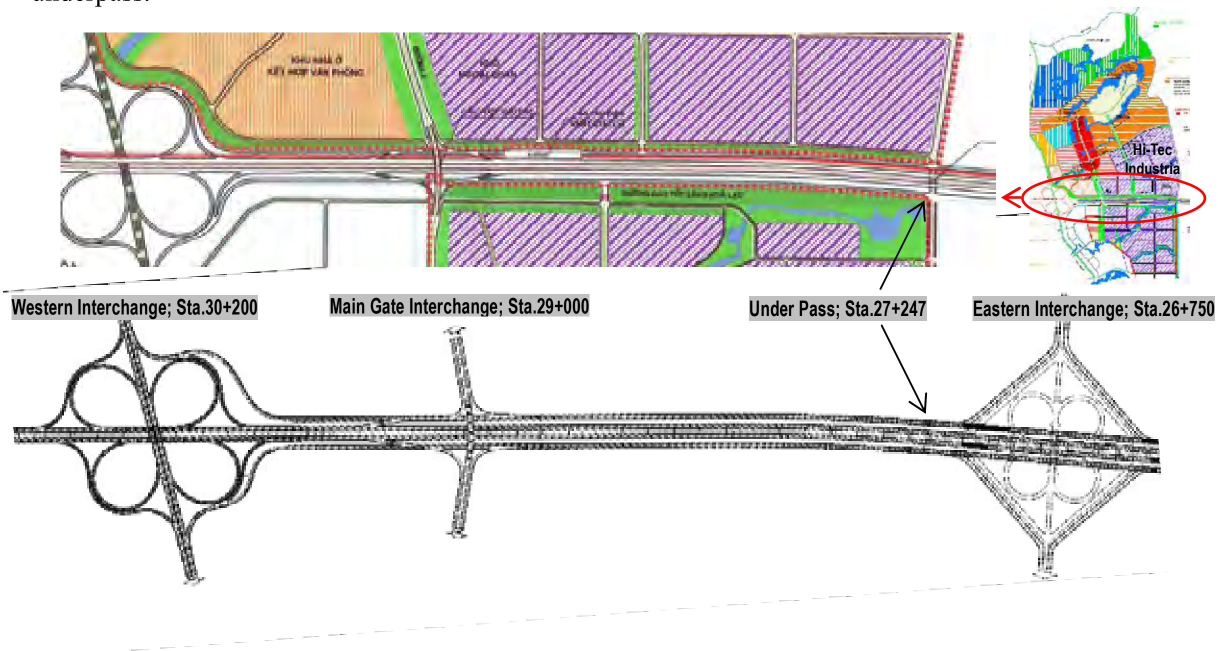


Figure B.3.4 Comparison of Linkage Plan (Upper: VN Revised M/P, Lower: LHLE Project)

(2) Issues of the MOT Linkage Plan

1) Eastern Interchange

The eastern interchange is planned as cloverleaf type interchange at Sta. 26+750 in the LHLE project. However, following particulars regarding the development are not clear:

- Objectives of development (role and functions)
- Connection plan to existing/planned roads
- Implementation schedule
- Implementation authority

Meanwhile, the eastern interchange development is expected to provide functional access to the HHTP as second major linkage between the HHTP and the LHLE, and expected advantages are as follows:

- Disperse inflow/outflow traffic to/from the HHTP through the LHLE
- Segregate heavy vehicles traffic flow from other traffic flows

From the view point of above, following issues are found for the eastern interchange plan.

Cloverleaf type interchange is not recommended. The cloverleaf interchange is a two-level interchange in which left turns are handled by loop ramps. To go left from outbound of the LHLE (E-O), vehicles first pass over the MRTA viaduct (MRTA) and frontage road (F-O), then turn right onto a one-way ramp (RO-1) which loops 270 degrees to the right and then merges onto the intersecting road (AR-1). To go right from outbound of the LHLE (E-O), vehicles has to first pass over the MRTA viaduct (MRTA) and frontage road (F-O), then has to pass through a one-way ramp (RO-3) and then merges onto the intersecting road (AR-1). To maintain above turnings from the LHLE to intersecting road, the UMRT need to be planned at lower level, and installation of steep grade ramp viaducts are necessary. Summary of evaluation of the cloverleaf type interchange are as follows:

Advantage
- Full access control is provided to all inflow and outflow traffics to/from the LHLE, which will facilitate safe and smooth traffic.

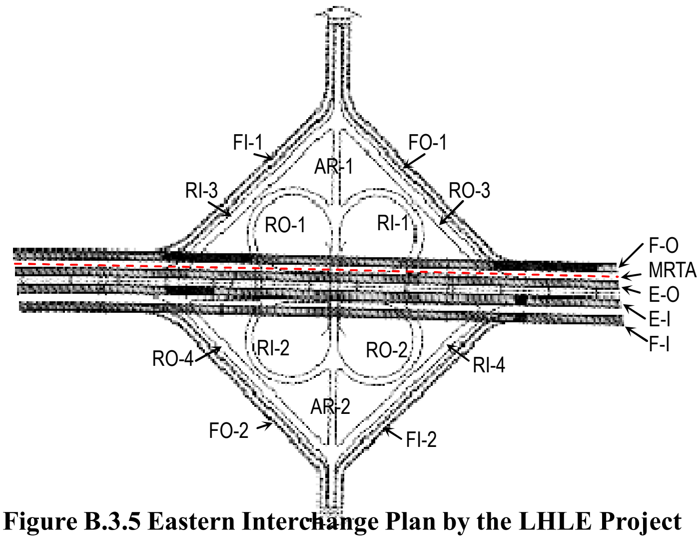


Figure B.3.5 Eastern Interchange Plan by the LHLE Project

Disadvantage
- It has considerable land consumption.
- The loop ramps have a tight radius and the weaving sections are generally short.
- Construction cost is higher than the other intersection type due to longer bridge section length at intersecting road and ramps.
- Accessibility between the frontage roads (F-O, F-I) and express way (E-O, E-I) is not efficient.

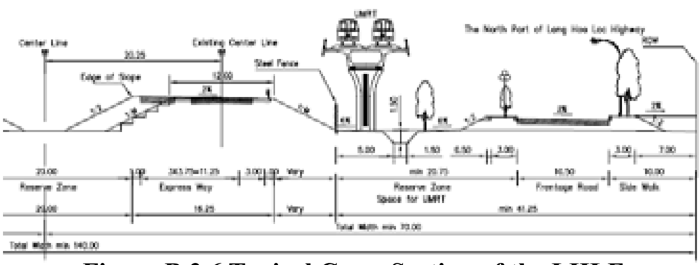


Figure B.3.6 Typical Cross Section of the LHLE

2) Main Gate Interchange

Since the LHLE will be the most crucial route for external transportation to/from the HHTP, development of a good linkage is very essential to maintain smooth and efficient traffic flow between the LHLE and the HHTP However, if the LHLE project plan is followed then the inflow and outflow traffic to/from the HHTP and from/to Hanoi Corner through the LHLE will need to be detour at the main gate interchange as shown in Figure B.3.7 and Figure B.3.8,. In addition, the following issues are anticipated:

Inflow traffic
- Traffic is likely to be concentrated at the western gate along the NH21A. This is due to the shorter route as compared to the route to the main gate.
- Traffic congestion may be observed at southern part of the main gate interchange due to diverted traffic.

Outflow traffic
- Traffic is likely to be concentrated at western gate along the NH21A. This is due to the shorter route as compared to the route to the main gate.

(3) Recommendation for the LHLE Project Linkage Plan

1) Eastern Interchange

Considering the issues found in foregoing section, expected role by the HHTP project and to ensure economic feasibility and smooth traffic functions, modifications are recommended to the eastern interchange plan of the LHLE project. By reviewing the JICA Updated M/P and the findings from updated information of the LHLE, diamond type interchange is recommended.

The comparisons between cloverleaf and diamond interchanges are shown in Table B.3.8.

Table B.3.8 Comparison of Interchange Type

Interchange Type	Advantage	Disadvantage
Cloverleaf	• FullAccess control is provided to all inflow and outflow traffics to/from the LHLE, which makes safe and smooth traffic.	• It has considerable land consumption. • The loop ramps have a tight radius and the weaving sections are generally short. • Construction cost is higher than the other intersection type due to longer bridge section length at intersecting road and ramps. • UMRT need to down planned level. • Accessibility between the frontage roads(F-O, F-I) and express way(E-O, E-I) is not efficient.
Diamond	• It has high-standard single exits and entrances before and after the structure, respectively. • It is the most economical in land use and makes the construction cost low. • It involves no weaving on the expressway. • It contributes to ensure smooth and efficient access between the HHTP and the LHLE	• It involves left turning movements on the minor road and lowers the capacity, and stop signs or traffic signals are required. • UMRT need to slightly raise planned level.

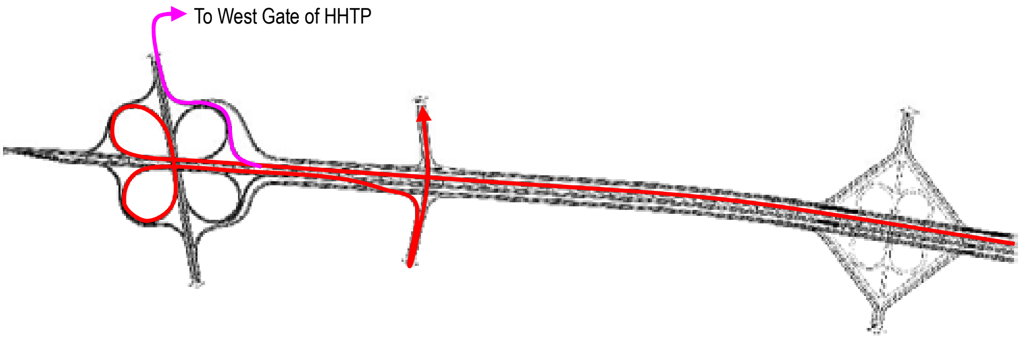


Figure B.3.7 Inflow Traffic from Hanoi Corner to the HHTP Main Gate (North)

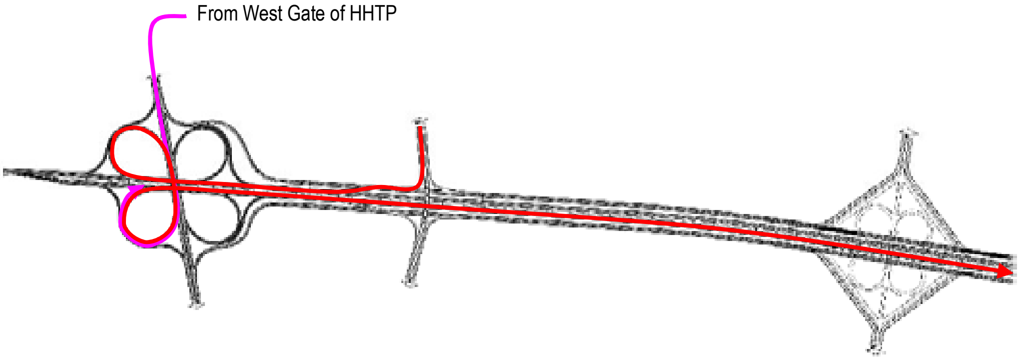


Figure B.3.8 Outflow Traffic from the HHTP Main Gate (North) to Hanoi Corner

Recommended diamond type interchange at the eastern interchange is shown in Figure B.3.9.

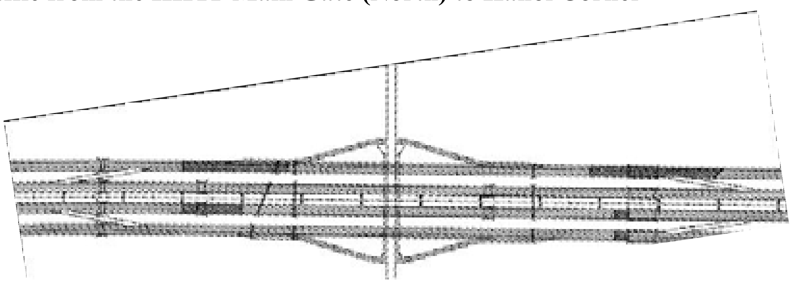


Figure B.3.9 Recommended Diamond Type Interchange

In addition to the formulation of the development plan including connection plan to existing/planned roads, implementation schedule, study team stress on to immediate formulation of implementation authority that will be responsible for the coordination with the HHTP development project.

2) Main Gate Interchange

With the likely implementation of the diamond type interchange by 2015, it is anticipated that the inflow and outflow traffic to/from the HHTP from/to Hanoi Corner through the LHLE will be smoothly dispersed. In addition, with the construction of essential additional on-ramps and off-ramps connecting the frontage roads and the expressways will further ensure the efficiency of traffic flow, as shown in Figure B.3.10 to Figure B.3.12. Installation of these additional ramps will regulate the traffic flow properly.

Two alternatives are proposed for the outflow traffic from the HHTP, as illustrated in Figure B.3.11. Alternative 1 seems to a better one as it has certain advantages over Alternative 2. Alternative 1 provides adequate U-turn space in the HHTP south area and as a result, the main volume of traffic from the HHTP south area can pass through the main gate.

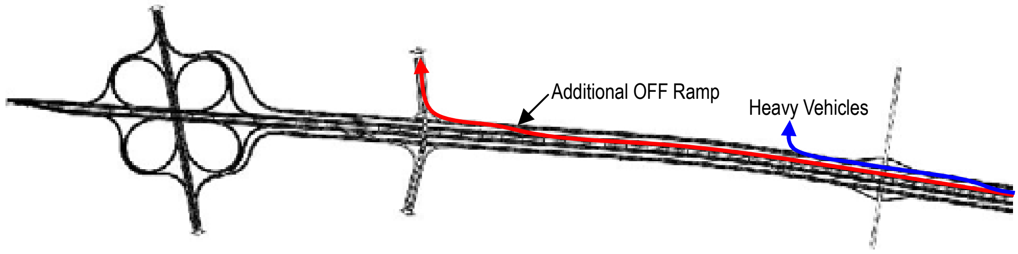


Figure B.3.10 Recommended Modification of the LHLE Connection Plan (Inflow)

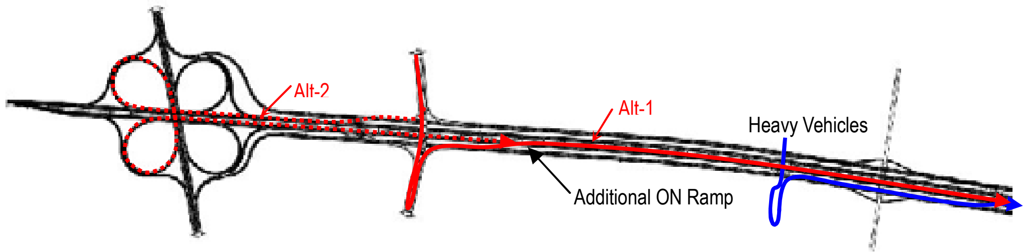


Figure B.3.11 Recommended Modification of the LHLE Connection Plan (Outflow)

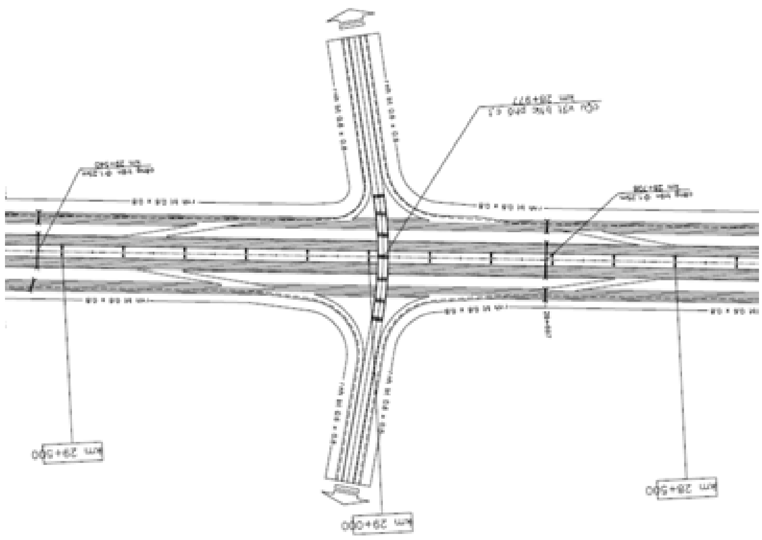


Figure B.3.12 Recommended Modification of the LHLE Connection Plan

(4) Comments for the Fly-Over Bridge and the Underpass

1) Fly-Over Bridge

The LHLE project proposed typical cross section for the main gate over bridge as shown in Figure B.13. According to the figure, total span of 17m accommodates lanes, shoulders, and median.

The HHTP internal roads are designing based on TCXDVN 104-2007 and TCVN 4054-2005. According to the standard, total width of 18m (lane 3.75m×4, shoulder 0.5m×2, median 2.0m) is necessary.

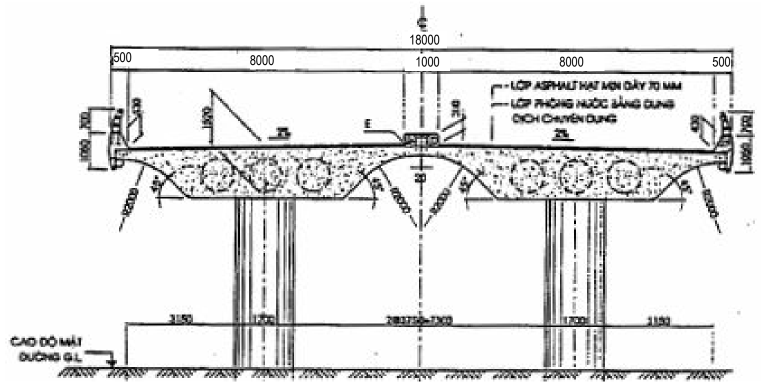


Figure B.3.13 Typical Cross Section of the Fly-Over Bridge by the LHLE Project

2) Underpass

The LHLE project proposed typical cross section for the underpass as shown in Figure B.3.14. According to the figure, total width of 6m has been provided to lanes, shoulders, and median with a clearance height of 4.925m.

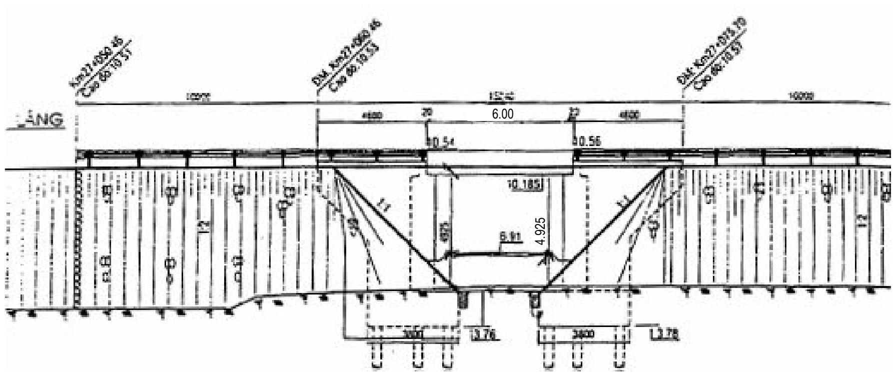


Figure B.3.14 Typical Cross Section of the Underpass by MOT

According to the TCXDVN 104-2007 and the TCVN 4054-2005, total 9.5m width (lane 3.50m×2, shoulder 0.25m×2, median 1.5m) is needed to the underpass.

The 4.925m clearance height is complied with the geometric standard. However, as the underpass is mainly intended for the passage of heavy vehicle passages, extra precaution need to be taken so as to avoid any damage to the bridge from over loaded vehicle height. Thus, considering the practical experience in Vietnam, it is recommended to increase the clearance height by another 1.0mr i.e. from 4.925m to 5.925m.

3.3 PROPOSED SECTOR DEVELOPMENT PLAN

3.3.1 HHTP Internal Roads Development Plan

The HHTP internal roads consist of 18 roads, 11 bridges, and 6 culverts, as shown in Figure B.3.16 and listed in Table B.3.9 and Table B.3.10. About 45% of roads, 5 bridges, and 2 culverts have been constructed or are in the process of preparation of the detailed design. The remaining roads, bridges, and culverts are subjected to formulate the sector development plan. Outlines of the proposed sector development plan for the HHTP internal roads are also shown in Table B.3.9 and Table B.3.10. The proposed HHTP internal roads development plan consists of 19,842m of new construction roads, 15,382m of road widening, construction of 6 bridges that includes widening of 1 bridge, and 4 box culverts.

Table B.3.9 Status of the HHTP Internal Road Development - Roads

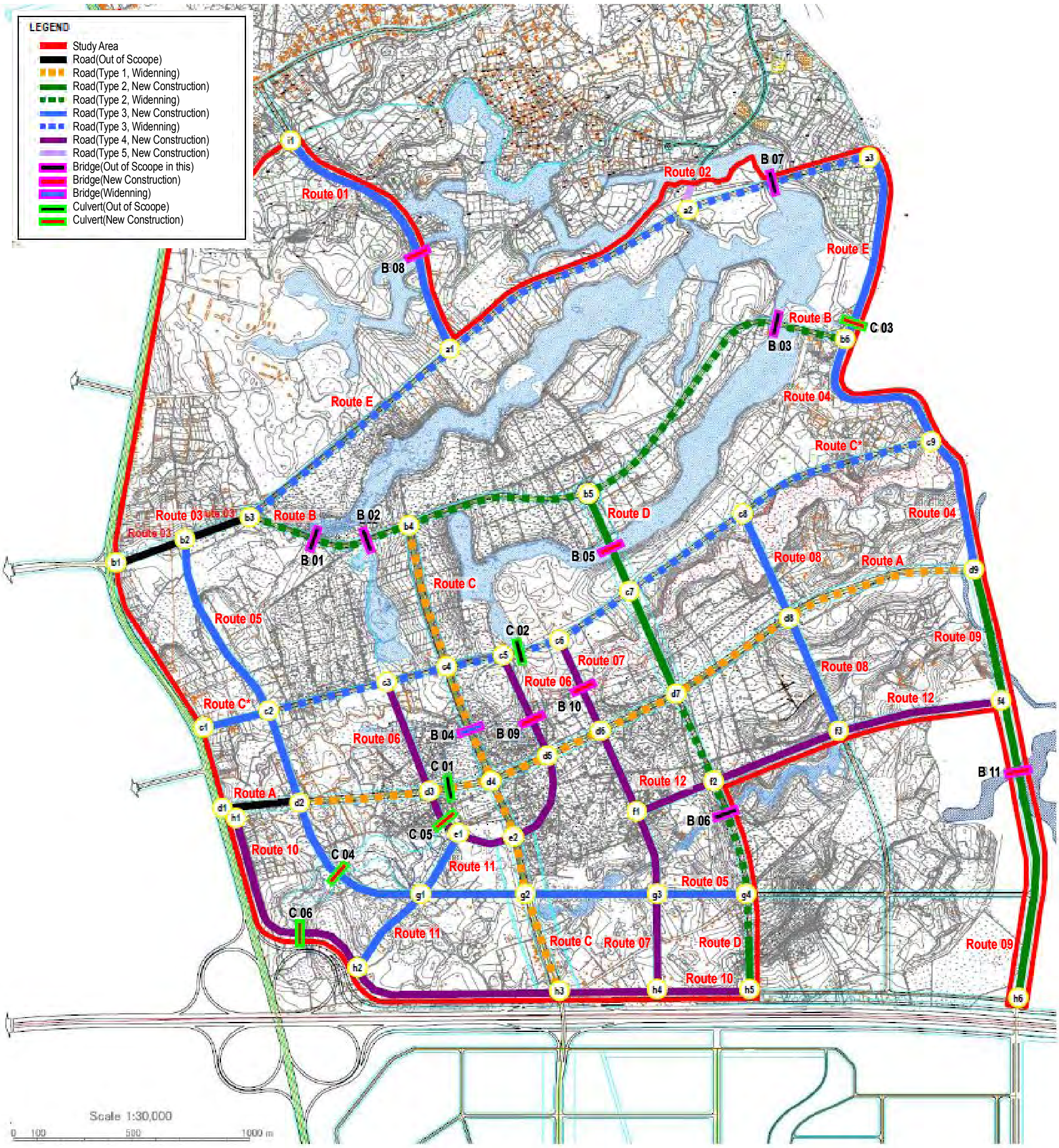
Routes	Type	Length (m)	Road Right of Way (m)	No. of lanes	Development Type and Length		Implementation Status						Remarks
					New Construction	Widening (m)	Completion (m)	Transitional Completion		Incompletion			
								length (m)	width (m)	Under Construct	D/D Complete	No Design (m)	
Route A	1	3,306	50	6	–	3,036	–	3,036	50	–	270	–	Median narrowing, lane widenning
Route B	2	2,931	38	4	–	2,931	–	2,091	33	840	–	–	Under construction section needs widenning, Replacement
Route C	1	2,125	50	6	–	2,125	–	2,125	25	–	–	–	
Route C*	3	3,430	34	4	340	3,090	–	280	29	2,810	–	340	Under construction section needs widenning
Route D	2	2,289	38	4	1,156	1,133	–	1,133	33	–	–	1,156	
Route E	3	3,940	34	4	873	3,067	–	730	29	–	2,337	873	D/D complete section needs widenning
Route 01	3	1,193	34	4	1,193	–	–	–	–	–	–	1,193	
Route 02	5	96	16	2	96	–	–	–	–	–	–	96	
Route 03	1	632	50	6	–	–	–	–	–	–	632	–	
Route 04	3	1,353	34	4	1,353	–	–	–	–	–	–	1,353	
Route 05	3	3,366	34	4	3,366	–	–	–	–	–	–	3,366	
Route 06	4	1,875	31	2	1,875	–	–	–	–	–	–	1,875	
Route 07	4	1,611	31	2	1,611	–	–	–	–	–	–	1,611	
Route 08	3	1,034	34	4	1,034	–	–	–	–	–	–	1,034	
Route 09	2	1,885	38	4	1,885	–	–	–	–	–	–	1,885	
Route 10	4	2,700	31	2	2,700	–	–	–	–	–	–	2,700	
Route 11	3	732	34	4	732	–	–	–	–	–	–	732	
Route 12	4	1,628	31	2	1,628	–	–	–	–	–	–	1,628	
Total		36,126			19,842	15,382	0	9,395		3,650	3,239	19,842	

Source: JICA Study Team

Table B.3.10 Status of the HHTP Internal Roads Development - Bridges and Culverts

Code	Plan	Route	Station			DHWL (m)	Clearance (m)	Minimum Height (Girder/Top Slab Bottom)	Structure Type	Width (m)	Length (m)
			Beginning	Center	End						
B01	Completed	Route B	—	—	—	—	—	—	—	—	—
B02	Completed	Route B	—	—	—	—	—	—	—	—	—
B03	Under Construction	Route B	—	—	—	12.63	0.5	13.13	Concrete Arch	26	0.05+52+0.05=52.1
B04	Plan (Widening)	Route C	Followed the existing condition						PC Hollow Girder	33.5	0.05+15.0+0.05=15.1
B05	Plan (New Construction)	Route D	0+241.110	0+267.160	0+293.210	12.63	0.5	13.13	Concrete Arch	26	0.05+52+0.05=52.1
B06	Completed	Route D	—	—	—	—	—	—	—	—	—
B07	Under Construction	Route E	—	—	—	—	—	—	—	—	—
B10	Plan (New Construction)	Route 07	0+169.950	0+176.000	0+182.050	12.63	0.5	13.13	PC Hollow Girder	22	0.05+12.0+0.05=12.1
B11	Plan (New Construction)	Route 09	0+867.950	0+880.000	0+892.050	9.6	0.5	10.1	PC Hollow Girder	26	0.05+24.0+0.05=24.1
C01	Completed	Route A	—	—	—	—	—	—	—	—	—
C02	Completed	Route C*	—	—	—	—	—	—	—	—	—
B08	Plan (New Construction)	Route 01	0+454.347	0+475.422	0+496.497	12.63	0.5	13.13	PC Hollow Girder	29	0.05+21+0.05+21+0.05=42.15
C03	Plan (New Construction)	Route 04	0+743.625	0+747.000	0+750.375	12.63	0.5	13.13	Box Culvert(2@3.0*2.0)	29	0.25+3.0+0.25+3.0+0.25=6.75
C04	Plan (New Construction)	Route 05	1+617.750	1+619.000	1+620.250	12.63	0.5	13.13	Box Culvert(1@2.0*2.0)	29	0.25+2.0+0.25=2.5
C05	Plan (New Construction)	Route 06	0+661.750	0+663.000	0+664.250	12.63	0.5	13.13	Box Culvert(1@2.0*2.0)	22	0.25+2.0+0.25=2.5
B09	Plan (New Construction)	Route 06	1+738.450	1+746.000	1+753.550	12.63	0.5	13.13	PC Hollow Girder	22	0.05+15.0+0.05=15.1
C06	Plan (New Construction)	Route 10	0+526.750	0+528.000	0+529.250	12.63	0.5	13.13	Box Culvert(1@2.0*2.0)	22	0.25+2.0+0.25=2.5

Source: JICA Study Team



Source: JICA Study Team

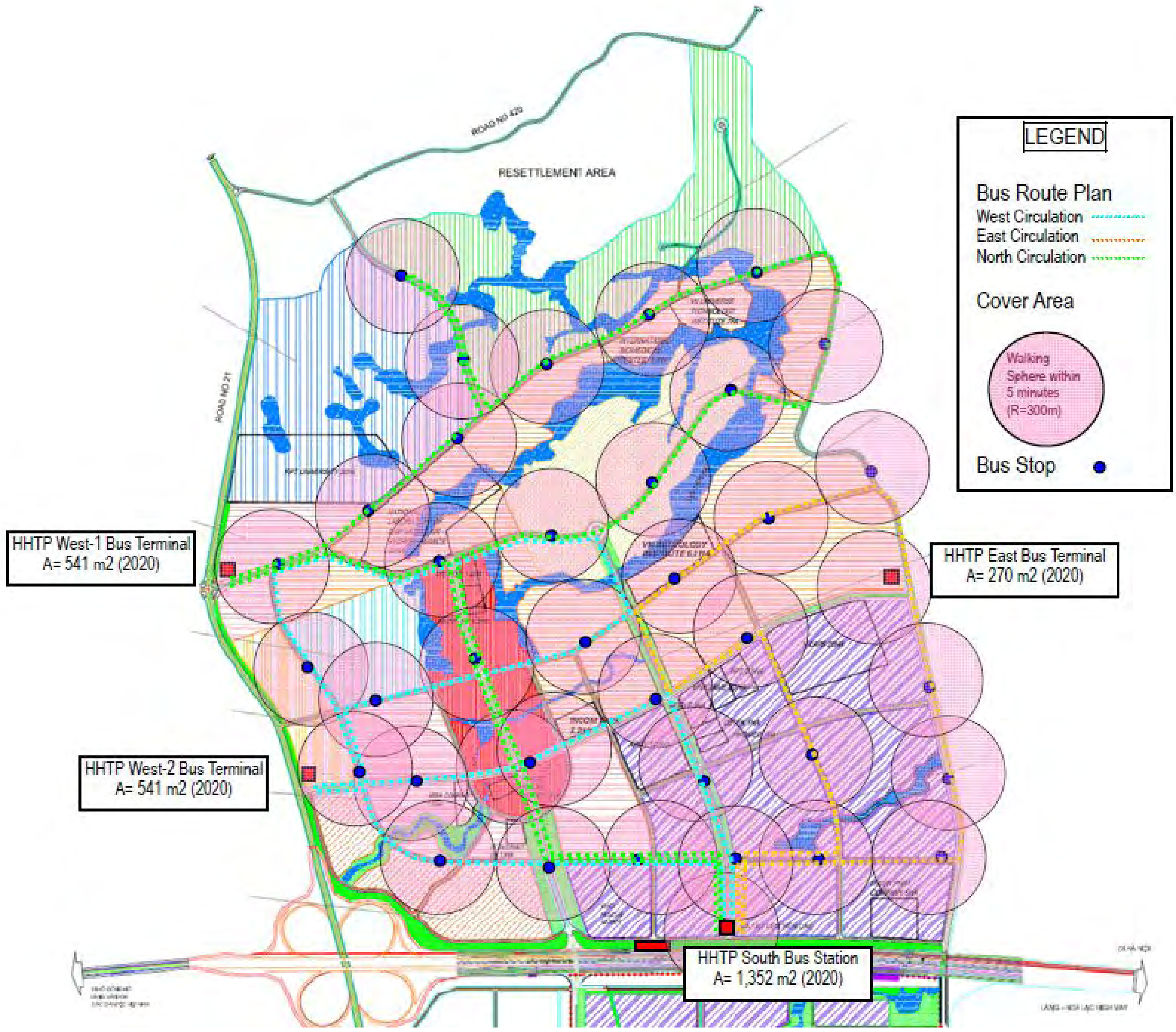
Figure B.3.15 Implementation Status of the HHTP Road Network

3.3.2 Transportation System

Circulating buses are assumed to be the mode for the internal transport system. For the introduced three (3) circulating bus routes as shown in Figure B.3.16 and considering the revised traffic demand, requirement of 9 buses (2 large buses, 7 middle-sized buses) and 30 buses (6 large buses, 24 middle-sized buses) has been estimated for 2015 and 2020 respectively. Accordingly the requirement for the bus terminal areas has been estimated as 771m^2 and 2,704m^2 in 2015 and 2020 respectively. Four bus terminals are proposed besides periphery roads of the HHTP. Based on the assumed share of the each bus terminals, the requirement of the necessary area has been estimated and listed in Table B.3.11. To emphasize the eco-friendly environment in the HHTP area, study also recommends for the introduction of electric buses.

Table B.3.11 Estimated Necessary Bus Terminal Areas

Bus Terminals	Share (%)	Necessary Area (m^2)	
		2015	2020
HHTP WEST-1	20	154	541
HHTP WEST-2	20	154	541
HHTP EAST	10	77	270
HHTP SOUTH	50	387	1352
Total		771	2,704



Source: JICA Study Team

Figure B.3.16 Proposed Circulating Bus Routes, Bus Stops, and Bus Terminals

3.3.3 Project Implementation, Operation and Maintenance of the HHTP Internal Roads and Transportation System

The organization HHTP-PMU under the HHTP-MB will be responsible for the implementation of HHTP internal roads and transportation system projects. In order to allow smooth project implementation, appropriate capacity development and empowerment exercises must be undertaken. Operation and maintenance work of the HHTP internal roads will be carried out by the Infrastructure Bureau in the HHTP-PMU.

CHAPTER 4 PROPOSED TRANSPORTATION PLAN

4.1 GENERAL

The 17 internal roads including 6 bridges and 4 box culverts are selected to conduct preliminary design as shown in Table B.4.1.

Table B.4.1 List of Roads, Bridges and Culverts for Feasibility Study

Routes	Type	Length (m)	Road Right of Way (m)	No. of lanes	Development Type						Remarks
					Road		Bridge		Box Culvert		
					New Const-ruction (m)	Widening (m)	New Const-ruction	Widening	New Const-ruction	Widening	
Route A	1	3,306	50	6		3,036					Median narrowing, lane widenning
Route B	2	2,931	38	4		2,931	(B03)				Under construction section needs widenning, Replacement
Route C	1	2,125	50	6		2,125		B04			
Route C*	3	3,430	34	4	340	3,090					Under construction section needs widenning
Route D	2	2,289	38	4	1,156	1,133	B05				
Route E	3	3,940	34	4	873	3,067			C03		D/D complete section needs widenning
Route 01	3	1,193	34	4	1,193		B08				
Route 02	5	96	16	2	96						
Route 04	3	1,353	34	4	1,353						
Route 05	3	3,366	34	4	3,366				C04		
Route 06	4	1,875	31	2	1,875		B09		C05		
Route 07	4	1,611	31	2	1,611		B10				
Route 08	3	1,034	34	4	1,034						
Route 09	2	1,885	38	4	1,885		B11				
Route 10	4	2,700	31	2	2,700				C06		
Route 11	3	732	34	4	732						
Route 12	4	1,628	31	2	1,628						
Total		36,126			19,842	15,382	5	1	4		

Source: JICA Study Team

4.2 DESIGN STANDARDS

Design standards that were followed for roads, bridges and box culverts were in confirmation to the current Vietnamese standards, and are as follows:

- Vietnamese construction specifications TCXDVN 104–2007: Urban road specifications for design
- Highway specification for design TCVN 4054 – 2005
- Pavement specification for flexible pavement design 22TCN-211-2006
- Specification of traffic sign 22TCN-237-01
- Design Standard of artificial lighting outside of civil construction 20TCN 95-83
- Vietnam Construction Standard TCXDVN 259- 2001: design standard for artificial lighting in streets, road, square
- Building code of Vietnam, Ministry of Construction
- Specification of bridge design 22TCN 272-05

Clearances for roadways and waterways were not considered as grade separation and waterway crossing points were not planned. The major design criteria for planning the bridges and box culverts are summarized in Table B.4.2.

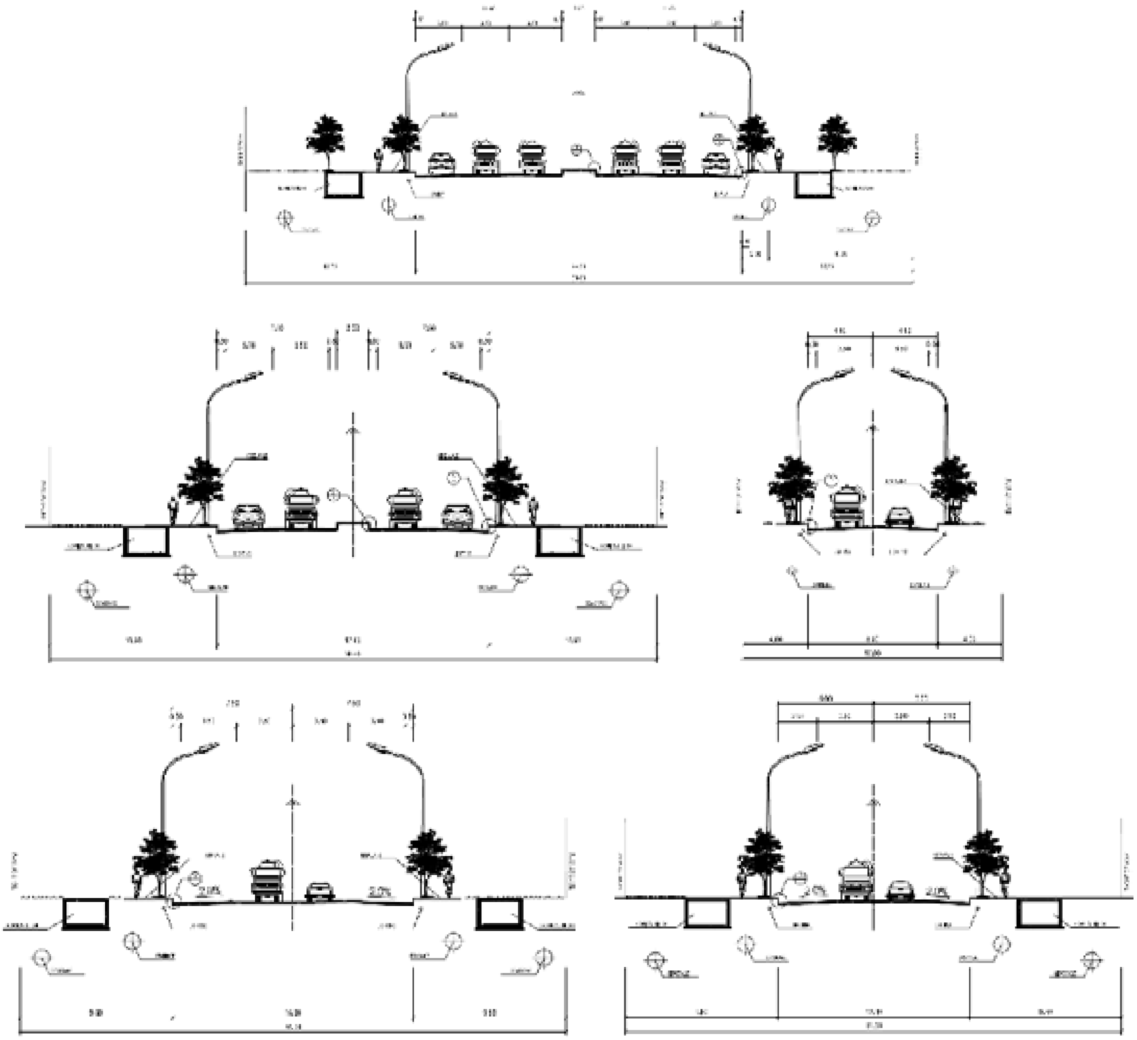
Table B.4.2 Major Design Criteria for Planning of Bridges and Box Culverts

Item	Criteria	Remark
Design high water level (DHWL)	100 years return period	Followed land reclamation plan
Vertical clearance for DHWL	Minimum 0.5m	Without driftwood condition
Navigation clearance	Not considered	No planned waterway at crossing points
Clearance for roadway	Not considered	No planned grade separation at crossing points

Source: 22TCN 272-05

4.3 EXAMINATION OF TYPICAL CROSS SECTIONS

Five types of typical cross sections were planned in the VN revised M/P. Each cross section elements of the typical cross sections were reviewed from the aspect of the design standard and the planning concept. With a review of buried utility plan, it was found that road type 2, 3 and 4 were not in accordance with the Vietnamese building code 2008 and thus, accordingly the buffer zones on road type 2, 3 and 4 were revised. The typical cross sections planned in the sector study are shown in Figure B.4.1. The planting and buffer zones were omitted in the bridge and box culvert sections.



Source: JICA Study Team

Figure B.4.1 Typical Cross Sections

4.4 ALIGNMENT STUDY AND DESIGN

4.4.1 Horizontal Alignment

Grid pattern road network is planned in the VN Revised M/P based on proposed road network as proposed by the JICA Updated M/P. The grid pattern road network is appropriate for the HHTP road network so as to maintain flexibility of land use, and to cover the entire HHTP with uniform road density. As far road densities in the VN Revised M/P are concerned, it satisfies the standard as followed in the JICA Updated M/P and are shown in Table B.4.3. As a result, the designed horizontal alignments in the VN Revised M/P were endorsed.

Table B.4.3 Standard Road Density by Land Use

Land use	Standard Road Density (km/km^2)
Software Park	2.0
Research and Development	2.0
High-tech Industrial Area	1.0
Education and Training	2.0
Center of High-tech City	5.0
Mixed Use Area	4.5
Residential Area	4.0

Source: JICA Update M/P

4.4.2 Vertical Alignment

Topography in the HHTP area is flat. Therefore, design controls to the vertical alignment were established based on the land reclamation plan and designed high water level. The maximum gradient is 2.17%, and it fairly satisfies the design criteria for the design of 70km/hr speed road.

Vertical design controls at the planned bridge and culvert were established based on the DHWL, and required clearance and structure heights.

Table B.4.4 Design Controls at Bridge and Culvert Section

Route	Structure Code	Station			DHWL (m)	Min. Clearance (m)	Structure Height (m)	Min. Surface Level (m)
		Beginning (km)	Center (km)	End (km)	a	b	C	d=a+b+c
B	B03	—	—	—	Replacement			
C	B04	0+902.614	0+910.164	0+917.714	Followed the existing surface level			
D	B05	0+241.110	0+267.160	0+293.210	12.63	0.50	5.435	18.565
E	C03	0+743.625	0+747.000	0+750.375	12.63	0.50	0.890	14.020
01	B08	0+454.347	0+475.422	0+496.497	12.63	0.50	1.494	14.624
05	C04	1+617.750	1+619.000	1+620.250	12.63	0.50	0.890	14.020
06	C05	0+661.750	0+663.000	0+664.250	12.63	0.50	0.870	14.000
	B09	1+736.950	1+746.000	1+755.050	12.63	0.50	1.374	14.504
07	B10	0+169.950	0+176.000	0+182.050	12.63	0.50	1.374	14.504
09	B11	0+867.950	0+880.000	0+892.050	9.60 1)	0.50	1.614	11.714
10	C06	0+526.750	0+528.000	0+529.250	12.63	0.50	0.870	14.000

Note: 1) Historical high water level confirmed by hearing survey in this study

4.5 INTERSECTION PLAN AND DESIGN

Intersection of the HHTP internal roads are at-grade type of intersections and consist of roundabout, cross junction, and T junctions. Traffic signal are planned to be installed at intersections where high volume of traffic will pass through.

4.5.1 Present Conditions

Three (3) roundabouts exist on the completed roads. The other existing intersections are crossing intersections with one stop operation, tentatively. As per VN Revised M/P, all other intersections that are not yet constructed will also be planned as crossing intersections.

4.5.2 Intersection Design

(1) Intersection Type

As roundabout requires an extensive land space, and may have affected the current land use plan, the crossing intersections were preferred and planned. However, two roundabouts were adopted mainly due to the good landscapes. One roundabout has a small angle of crossing. The designs were found acceptable, and reconstruction of the roundabouts is not planned in this study.

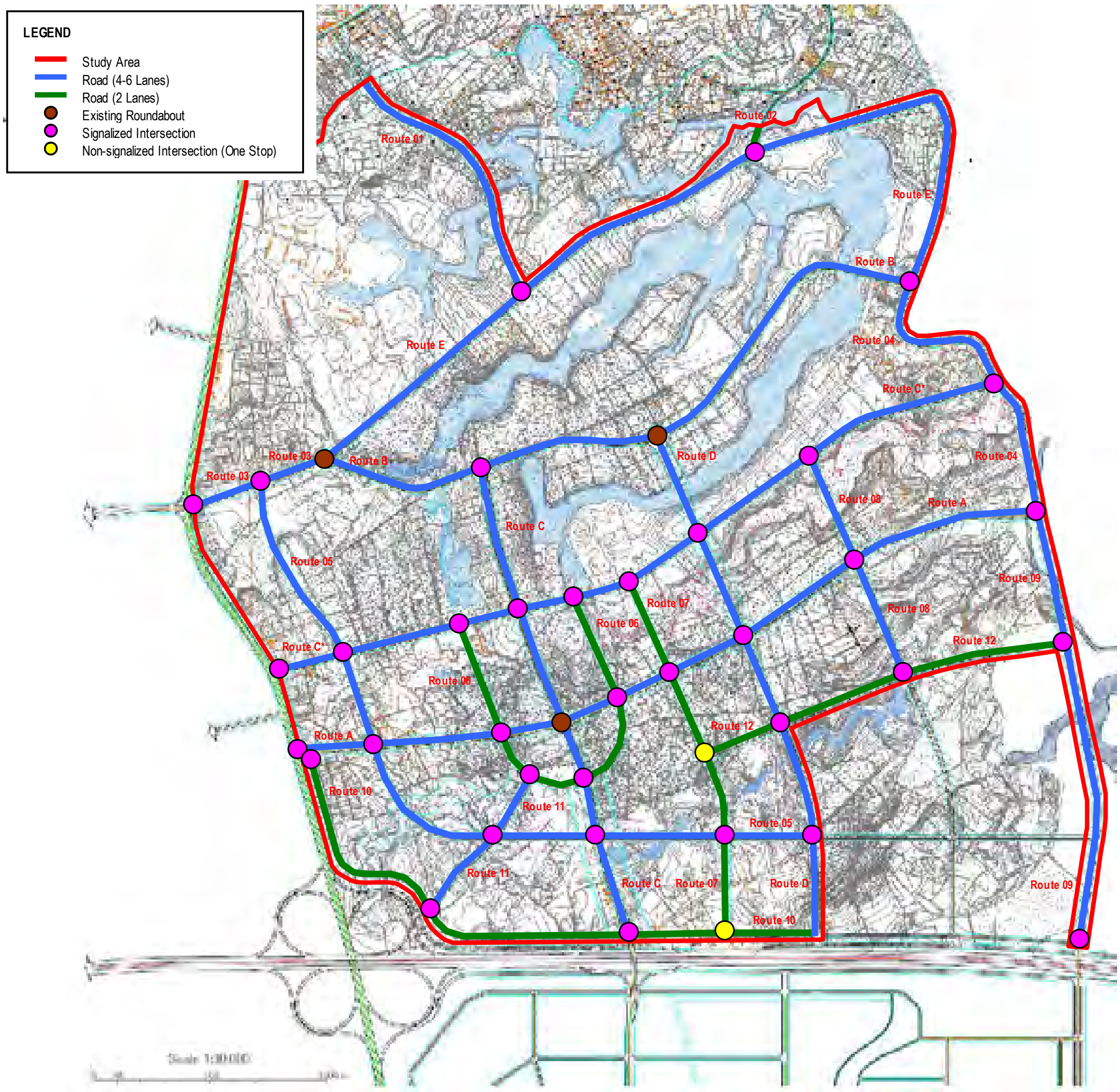
(2) Traffic Control System

Traffic control system was planned at the crossing intersections. Considering the safety of pedestrians and cyclists, all the intersections which would be crossed with 4-6 lanes road, are planned to be equipped with signalized system. In addition, those intersections which would be connected with the external roads will also be signalized. This will reduce the effect of the heavy external traffic flow during morning and evening hours. The signal lamps with 3 signal patterns were planned for installation at vehicles and pedestrian crossing. The signal control will be the planned synchronized system, and it could be procured in Vietnam.

Table B.4.5 Traffic Control System at Crossing Intersection

Road	Nos. of Lane	Internal			External
		2 Lanes	4 Lanes	6 Lanes	All
Internal	2 Lanes	Non-signalized	Signalized	Signalized	Signalized
	4 Lanes	Signalized	Signalized	Signalized	Signalized
	6 Lanes	Signalized	Signalized	Signalized	Signalized
External	All	Signalized	Signalized	Signalized	Signalized

Source: JICA Study Team



Source: JICA Study Team

Figure B.4.2 Intersection Plan

4.6 PAVEMENT DESIGN

Flexible pavement was designed for the HHTP internal roads due to cost efficiency. Pavement structure design was made in accordance with the 22TCN-211. As for the design condition of Sub-grade, more than 6 in CBR value will be maintained during the installation of 30cm thickness of stable capping layer in Sub-grade layer. As for the traffic condition, due to lack of detailed traffic demand forecast, the study recommends for the use of standard ESAL values in accordance with the TCXDVN 104–2007 for each road classifications.

4.7 DRAINAGE SYSTEM DESIGN

Drainage pipe network under sidewalk has been planned to discharge rain water within road right of way and road side area. Capacity and dimension of the drainage pipe has been designed based on design peak discharge volume, calculated rainfall intensity and catchment area of the HHTP (see Appendix C, Drainage Plan).

As for the drainage facility for carriage way and sidewalk, catch pits were designed on both side of the carriage way at an interval of every 20m.

4.8 BRIDGE DESIGN

4.8.1 Design Concepts

(1) B04 Bridge

B04 Bridge is an existing bridge on Route C, and the construction is required to widen the bridge and road section of Route C. Design concepts considered for the bridge widening are as follows:

- Follow the existing road centerline and heights.
- Widen on both sides of the existing bridge.
- Apply pretension hollow girders same as the existing superstructure type.

(2) B05 Bridge

As the planned location of B05 Bridge is at entrance of the software park, it needs to be aesthetically good too. Therefore, the type of bridge design will consider the landscape view and landscape bridge will be selected. The bridge will consist of the concrete arches for the following reasons.

- B03 and B07 Bridges which are under construction on landscape locations, those structure types are applied concrete arch.
- Construction works are easier than other type of landscape bridges.
- Construction cost is lower than other type of landscape bridges.

(3) Other Bridges

As per the VN Revised M/P, Land reclamation heights are fixed, and these heights are higher than DHWL. However, the differences are slight. In consideration of saving the superstructure heights, pretension hollow girder was planned to the other bridges. By saving the superstructure heights, embankment heights and slope lengths on the approach roads can be minimized.

4.8.2 Bridge Plan

The planned bridges are summarized below.

Table B.4.6 Bridge Plan

Road		Bridge Plan						Remark
Route	Type	Code	Station (km)	Structure Type	Width (m)	Length (m)	Arrangement (m)	
B	2	B03	─	Concrete Arch	26.0	52.10	1@52.0	Replacement
C	1	B04	0+910.164	Pretension Hollow Girder	33.5	15.10	1@15.0	Widening
D	2	B05	0+267.160	Concrete Arch	26.0	52.10	1@52.0	
01	3	B08	0+475.422	Pretension Hollow Girder	29.0	42.15	2@21.0	
06	4	B09	1+746.000	Pretension Hollow Girder	22.0	18.10	1@18.0	
07	4	B10	0+176.000	Pretension Hollow Girder	22.0	12.10	1@12.0	
09	2	B11	0+880.000	Pretension Hollow Girder	26.0	24.10	1@24.0	

4.9 OTHER MAJOR STRUCTURES

4.9.1 Road Facilities Plan

(1) Street lighting

Street lighting was planned in accordance with the TCXD 259-01. Considering the easy maintenance, the sodium type lamp has been planned for. By calculating the brightness of lamps, it is planned to install the sodium lamps at an interval of 35m each.

For other routes, Street lighting was planned in accordance with the TCXD 259-01. Considering the easy maintenance, the sodium type lamp has been applied. By calculating the brightness of lamps, it is planned to install the sodium lamps at an interval of 35m each.

Table B.4.7 Street Lighting Plan

Road Type	Pole	Lamp	Arrangement	Distance
Type 1 Type 2 Type 3 Type 4 Type 5	Single Arm Type	Sodium Type (High Pressured, 1*150W)	Both Side (Staggered Arrangement)	35m

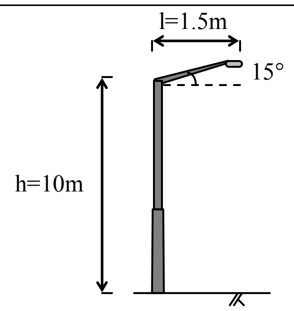


Figure B.4.3 Size of Lighting Pole

(2) Traffic Lights

Traffic lights were planned for pedestrian's safety at intersections. The signal lamps with 3 signal patterns were planned for installation at vehicles and pedestrian crossing. The signal control will be the planned synchronized system, and it could be procured in Vietnam.

4.9.2 Culvert plan

Box culverts design and opening size were planned in accordance with the design criteria and hydrological analysis.

Table B.4.8 Box Culverts Plan

Code	Road		Station	Width	Required Opening Size	Planned Opening Size	Length
	Route	Type	(km)	(m)	(m)	(m)	(m)
C03	04	3	0+747.000	29.0	6.0*1.5	2@3.0*2.0	L=6.75 (0.25+3.0+0.25+3.0+0.25)
C04	05	3	1+619.000	29.0	2.0*1.5	1@2.0*2.0	L=2.50 (0.25+2.0+0.25)
C05	06	4	0+663.000	22.0	2.0*1.5	1@2.0*2.0	L=2.50 (0.25+2.0+0.25)
C06	10	4	0+528.000	22.0	2.0*1.5	1@2.0*2.0	L=2.50 (0.25+2.0+0.25)

4.9.3 Utilities Accommodation Facilities

Road provides spaces for utilities installation such as electric system, telecommunication system, and water supply system as shown in Figure B.4.4.

Technical tunnels were planned at each intersection. Minimum separation distances among the utility lines were in accordance with the Vietnamese building code 2008. For O&M of technical tunnels, common regulations are necessary among the utility suppliers. Therefore, HHTP MB should coordinate among the suppliers.

(1) Road Section

Accommodation spaces were planned to install the drainage, electric, communication, water supply and sewage pipes/cables in the entire road sections. Minimum separation distances among the utility lines were in accordance with the Vietnamese building code 2008. However, for communication purpose in the HHTP, all optic fiber cable will be used. Due to the usage of optic fiber cable there won't be any impact of electromagnetic induction and as a result, the separation distance between communication and electrical cables can be minimized.

Table B.4.9 Minimum Separation Distance of Utility Lines

Utilities	Drainage Pipe	Electrical Cable	Communication Cable	Water Supply Pipe	Sewage Pipe
Horizontal Distance					
Drainage Pipe	0.4	0.5	0.5	0.5	0.4
Electrical Cable	0.5	0.1	- (0.5)	0.5	0.5
Communication Cable	0.5	- (0.5)	-	0.5	0.5
Water Supply Pipe	0.5	0.5	0.5	0.5	1.0
Sewage Pipe	0.4	0.5	0.5	1.0	0.4
Vertical Distance					
Drainage Pipe	-	0.5	0.5	0.5	0.4
Electrical Cable	0.5	0.1	- (0.5)	0.5	0.5
Communication Cable	0.5	- (0.5)	-	0.5	0.5
Water Supply Pipe	0.5	0.5	0.5	-	1.0
Sewage Pipe	0.4	0.5	0.5	1.0	-

Source: Vietnamese building code 2008

Distances in the parentheses above are requirements in the Vietnamese building code, but not applied in this study

(2) Bridge and Box Culvert Section

In bridge and box culvert sections, the utility lines were planned to install on structure and riverbed. The minimum separation distances that will be applied are listed in Table B.4.10.

Table B.4.10 Location of Installation of Utility Lines in Bridge and Box Culvert Section

Utilities	Bridge Section	Box Culvert Section
Electrical Cable	In Sidewalk	In Sidewalk
Communication Cable	In Sidewalk	In Sidewalk
Water Supply Pipe	On Exterior Girder	On Riverbed
Sewage Pipe	On Riverbed	On Riverbed

(3) At Intersection

a) Advantage and Disadvantage of Technical Tunnel

Table B.4.11 Comparison between Advantage and Disadvantage of Technical Tunnel

Stage	Advantage	Disadvantage
Planning & Design	• Secure of safety of trunk line for lifeline • Counter measure against earthquake for lifeline • Suitable for quake-prone country • Suitable for highly urbanized area, such as old city and highly density area of buildings	• Extensive increment of installation depth of trunk line • Necessity of large open space under the traffic road • Required firefighting facility • Required humidity control, air ventilation and drainage facilities • Required lighting facility • Not suitable for newly developed area with enough space, such as HHTP and industrial estates • In Vietnam, specification of technical tunnel is not concretely established • Increment of financial burden in case of appliance of Japanese standard for technical tunnel
Construction	• None	• High construction cost • Extension of construction period • Required high degree of accuracy for construction quality control such as tunnel joint work • Partially constructed trunk roads without technical tunnel in HHTP
Operation & Maintenance (O&M)	• Reduction of repetition of road demolition and patching works • Prompt recovery work of lifeline affected by earthquake	• Extremely O&M cost, such as air ventilation and drainage pump operation • Uncertain locus of responsibility for management of several utilities, especially in case of accident and damage of utilities

Source: JICA Study Team

b) Results

JICA F/S applies the following concepts on technical tunnel issues:

- Adoption of the technical tunnel method to be installed along trunk roads is not suitable for the Hoa Lac Area judging from results of comparing between advantage and disadvantage of technical tunnel.
- Installation of the technical tunnel at intersections of the trunk roads is reasonable from a viewpoint of decrement of the trunk road restoration works for repairing the underground facilities.
- Technical ditch method for installation along trunk roads that is proposed by HHTP-MB is adopted instead of technical tunnel according to the Decree No.41/2007/ND-CP.

- Water distribution pipes, telecommunication cables and power cables are placed in technical ditch along trunk roads in order to secure easy access for O&M and reduce repetition of road demolition and patching works for repairing work of infrastructures.

c) Typical sections of technical tunnel and technical ditch
Typical section of technical ditch and technical tunnel are presented below:

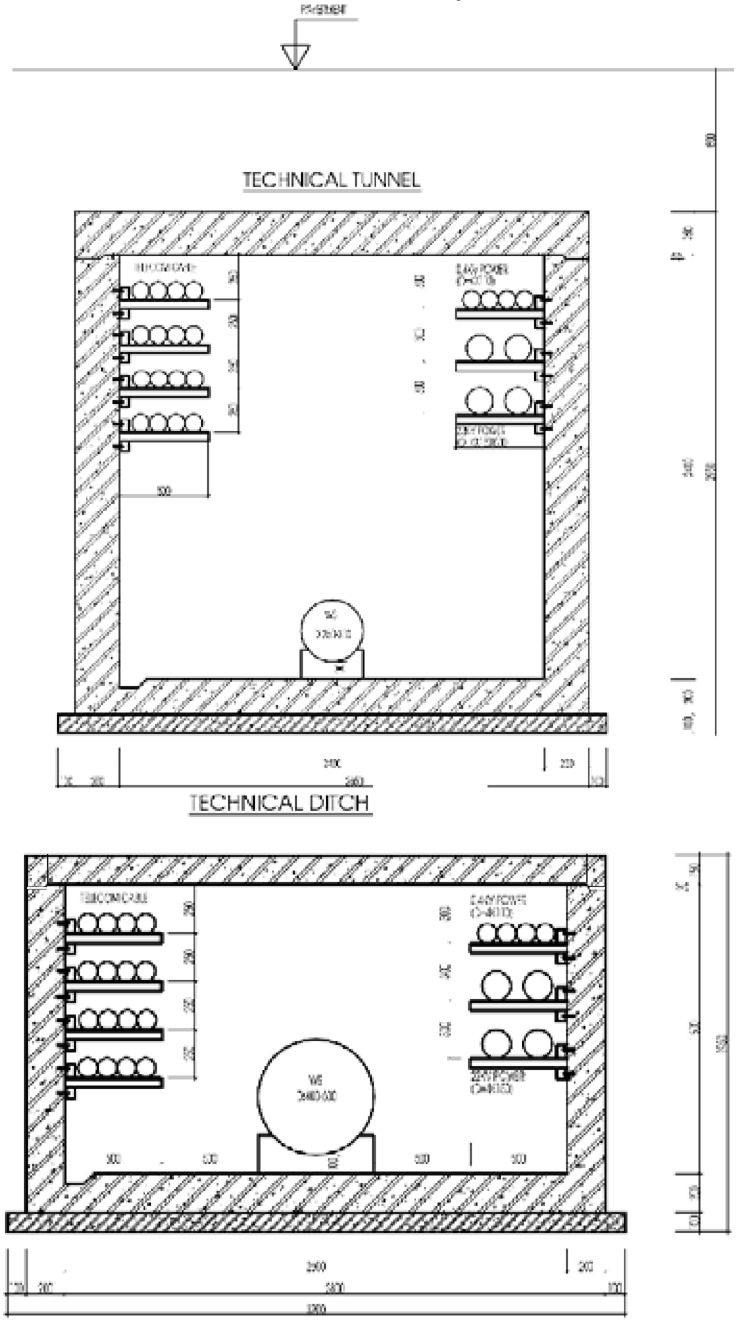


Figure B.4.4 Typical Cross Section of Technical Tunnel Technical Ditch

The minimum separation distance values that will be applied are listed in Table B.4.5. At each intersection, pumping facilities are planned to discharge stagnant water inside the tunnels. Based on our site survey, some of the technical tunnels were already constructed at intersections. However, this tunnel does not satisfy the required size. For securing the minimum separation distances, these tunnels need reconstruction.

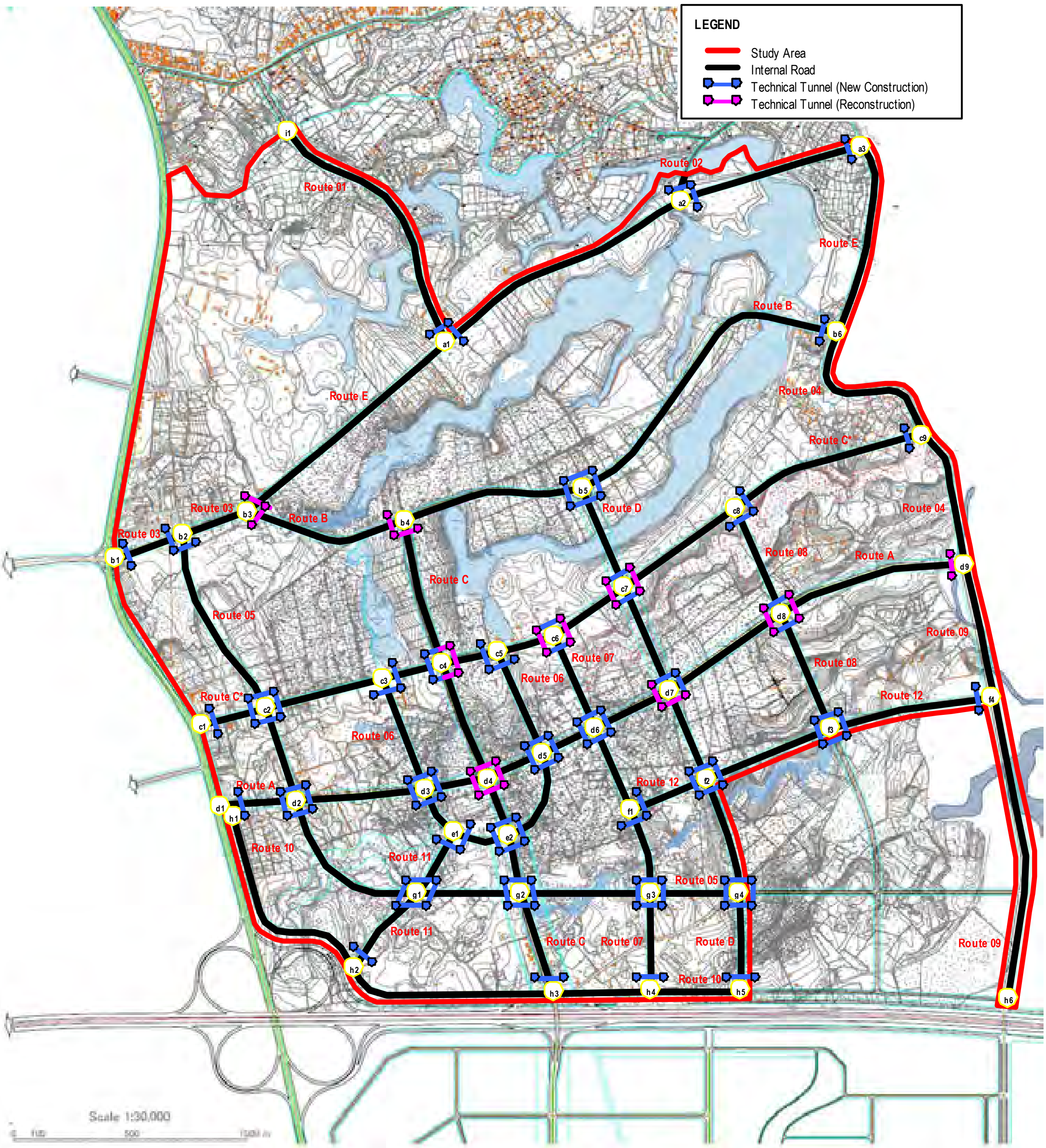
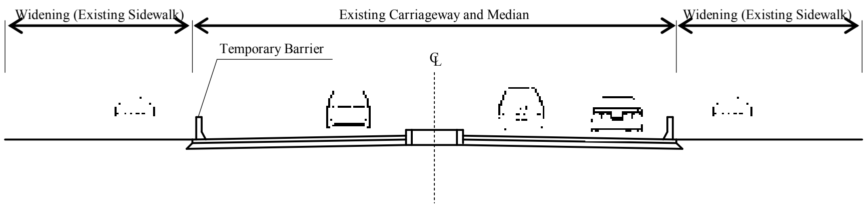


Figure B.4.5 Plan of Technical Tunnels

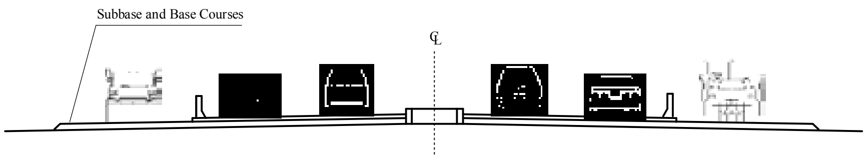
4.10 CONSTRUCTION PLAN

Construction sequence for road section was examined based on the preliminary design. No complicated work were involved in the design, however, it must be ensured that the current traffic should not be obstructed during the widening works. Therefore, following sequence for the widening of the road should be followed.

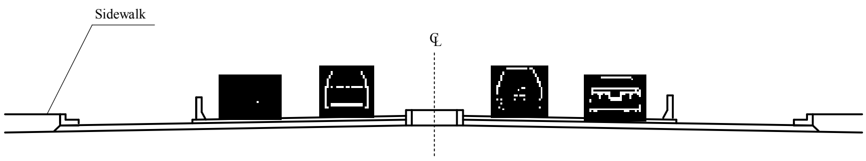
Step 1: Removal of Existing Sidewalk



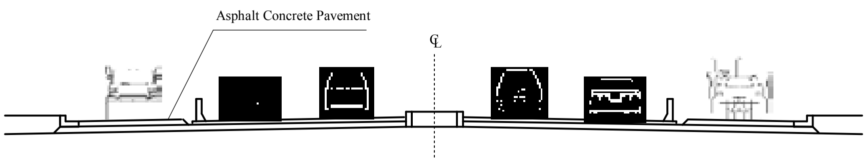
Step 2: Subbase and Base Courses



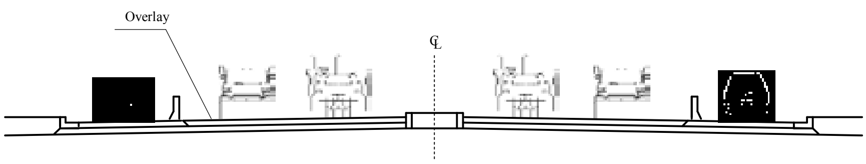
Step 3: Sidewalk



Step 4: Asphalt Concrete Pavement



Step 5: Overlay on Existing Asphalt Pavement



Step 6: Completion

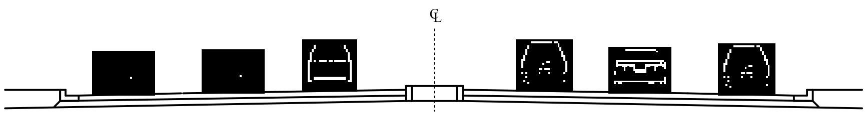


Figure B.4.6 Construction Sequence for Widening on Outsides

4.11 OPERATION AND MAINTENANCE PLAN

4.11.1 Operation and Maintenance System

Operation and maintenance for the road facilities were planned shown as below:

- Traffic lights will be operated/maintained by Hanoi People's Committee.
- Signal patterns will be managed by traffic police.
- Other road and bridge facilities will be operated by HHTP MB.
- Maintenance works for road facility will be outsourced by HHTP MB.

4.11.2 Maintenance Works

Maintenance works are classified into routine and periodic works. Routine works includes the daily inspections of the condition of pavement, slopes, drainages, bridge and other structures, and monitoring of the facilities and defects. As results of the inspection, defects can bring into notice; and accordingly the maintenance works can be undertaken.

In addition, periodic works and inspection also need be conducted such as checking and testing of performances of facilities at certain specified interval of time. This interval will depend on the structure and facility types. With this detail inspection, damages can be confirmed and accordingly repairing works can bee undertaken. In addition to the above, clearing and renewal works also need to be conducted based on the typical routine maintenance plan.

Table B.4.12 Typical Maintenance Activities

Category	Activities
Routine Maintenance	Inspection and patrol
	Clearing of road surface and ditches
	Vegetation control
	Patching of potholes, and crack sealing
	Repairing of slopes
	Repairing of traffic management facilities
	Repairing of lighting device and equipments
Periodic Maintenance	Inspection and test
	Renewal of traffic safety and management facilities
	Renewal of devices and equipments
	Overlay and re-pavement
	Replacement of expansion joints and bearing for bridges
	Repair of ditched, culverts and bridges

4.12 CONCLUSIONS

4.12.1 Revision of Traffic Demand Projection

The traffic demand of the HHTP was re-projected based on revision of the population generation ratio prepared by this Study. Based on the traffic parameters for Hanoi Metropolitan Area as set by the HAIDEP and the predicted population, the re-projected traffic demand in the Stage-1(2015) and Stage-2(2020) are 27,358pcu/day and 49,123pcu/day respectively.

4.12.2 HHTP Internal Roads Development

HHTP internal roads development plan were formulated in the sector study. The plan consists of of 19,842m of new construction roads, 15,382m of road widening, construction of 6 bridges that includes widening of 1 bridge, and 4 box culverts.

Grid pattern road network with 6 gates on the LHLE and the NH21A are justified by the demand-capacity analysis. The vertical alignments were established based on the land reclamation plan and designed high water level. The maximum gradient is 2.17%, and it fairly satisfies the design criteria for the design of 70km/hr speed road.

The typical cross sections were reviewed from the aspect of the design standard and the planning concept. With a review of buried utility plan, it was found that road type 2, 3 and 4 were not in accordance with the Vietnamese building code 2008 and thus, accordingly the buffer zones on road type 2, 3 and 4 were revised.

4.12.3 HHTP Internal Transportation System Development

Circulating buses are proposed as the HHTP internal transportation system. Considering the revised traffic demand, requirement of 9 buses (2 large buses, 7 middle-sized buses) and 30 buses (6 large buses, 24 middle-sized buses) has been estimated for 2015 and 2020 respectively. Accordingly the requirement for the bus terminal areas has been estimated as 771m^2 and 2,704m^2 in 2015 and 2020 respectively. In addition, 4 bus terminals are also proposed.

4.13 RECOMMENDATIONS

4.13.1 LHLE Project

Modification from cloverleaf type to diamond type is recommended to the eastern interchange plan of the LHLE project so as to ensure economic feasibility and traffic functions as well as to provide better access efficiency to the HHTP. Installation of additional on-ramps and off-ramps connecting the frontage roads and the LHLE are proposed to ensure efficiency of traffic flow in the HHTP.

As for the fly-over bridge and the underpass, total width of 18m (lane 3.75m×4, shoulder 0.5m×2, median 2.0m) and total width of 9.5m width (lane 3.50m×2, shoulder 0.25m×2, median 1.5m) are proposed to the MOT.

4.13.2 HHTP External Roads and Transportation Plan

Planning coordination is recommended between the HHTP-MB and Ministry of Transportation to incorporate the HHTP development plan in the NH21A development plan.

Introduction of step development such as Bus Rapid Transport is recommended to the UMRT plan. This will be not only be able to cater initial passenger demand in the HHTP area, but will also be able form a synergy with long term UMRT planned (2016-) project in HAIDEP.

4.13.3 Recommendation

(1) Structural Measures

1. To minimize the investment cost and operation management work’s cost as this will directly affect the tariff rate and tenants, the water supply facilities will be designed as simple as possible.
2. The supply water condition from DRWSP will be utilized effectively, such as reservoir/back-up system, water pressure and water quality.
3. Water supply pipeline network is designed with loop system. This will ensure the security of the water supply from any accidents and keep the clean water running inside the pipeline (will not make a dead-water).

4. Fire hydrant is designed following Vietnamese standard. However, in future as fire department will operate and utilize the hydrant services and facilities, it is suggested to consult them prior to the preparation of detail design.

(2) Non-Structural Measures

1. For the early implementation, water supply system shall be installed under the responsibility of HHTP-MB.
2. To ensure effective and efficient operation, it is recommended to out-source the management works to the professional body.

SUPPORTING C

DRAINAGE PLAN

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 PRESENT CONDITION OF DRAINAGE SYSTEM

1.1 REVIEW OF VIETNAM REVISED MASTER PLAN

The Hoa Lac High-Tech Park (HHTP) consists of two areas: the Hoa Lac Area is located to north of the Lang Hoa Lac Express (LHLE) and the Northern Phu Cat Area located to the south of LHLE. The entire area within HHTP is divided into six (6) drainage basins. Storm water is discharged into the Tich River, located to the east of the HHTP. The drainage basins are as follows:

- Hoa Lac Area (north of the LHLE): 4 basins comprising Tan Xa Lake, Dua Gai Stream, Vuc Giang Stream and a newly-built retention pond; and
- Northern Phu Cat Area (south of the LHLE): 2 basins for 2 internal streams.

The major components of drainage system in the HHTP are listed in Table C.1.1 below.

Table C.1.1 Drainage Facilities in the HHTP

Item		Stage1 (2015)		Stage2 (2020)		Total	
		Length (m)	Number	Length (m)	Number	Length (m)	Number
1	Open Canal						
	600x800	2,993		0		2,993	
	800x1000	1,183		0		1,183	
2	Sewer						
	D600	8,383		1,624		10,007	
	D800	7,863		0		7,863	
	D1000	5,021		940		5,961	
	D1250	5,122		830		5,952	
	D1500	2,329		0		2,329	
	D2000	5,300		763		6,063	
	D2500	1,790		0		1,790	
	D3000	124		0		124	
3	Road Crossing						
	D1500		8		1		9
	D2000		2		0		2
	Box Culvert	195		0		195	
	Discharge Mouth		16		2		18
4	Embankment of Lake and Stream	33,466		2,315		35,781	
Total		73,769		6,472		80,241	

Source: VN Revised M/P

1.2 PRESENT CONDITIONS OF DRAINAGE DEVELOPMENT

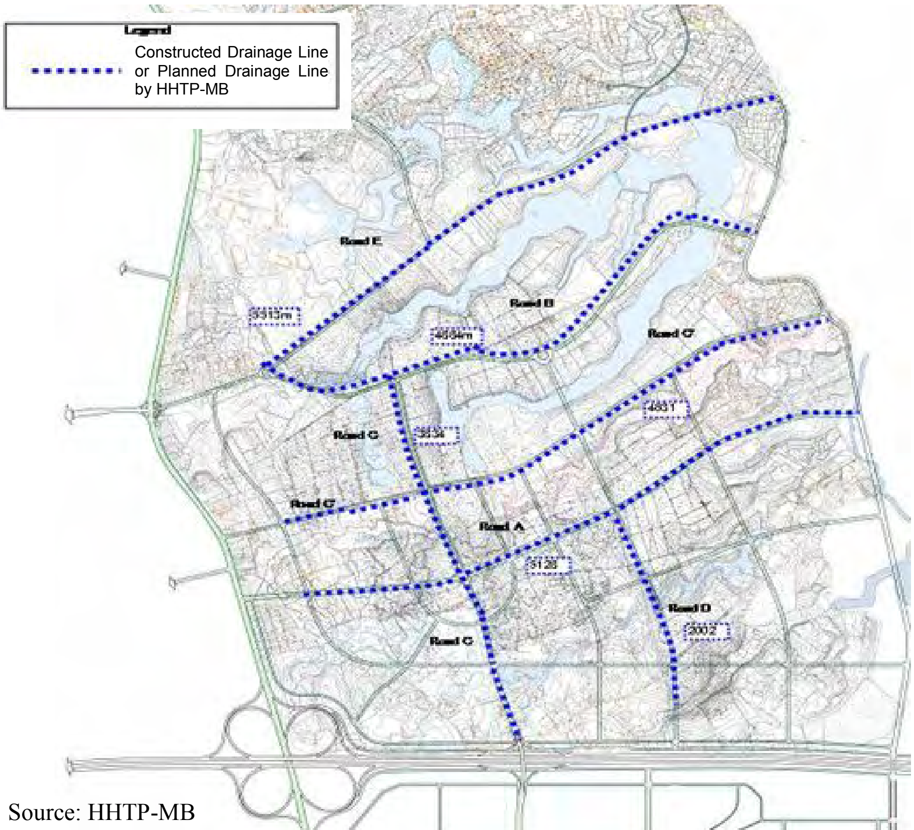
1.2.1 Drainage System

For the drainage design, the return period of three (3) years for the High-Tech Industrial Zone and one (1) year for the other zones has been adopted. Accordingly, the total length of 44.2km of drain has been estimated. This consist a length of 40km of culverts (D600mm to D3,000mm) and 4.2km of open channels. The material for drains will be Concrete Hume Pipe. It is planned that thirty (30) box culverts will be constructed at the intersections within the HHTP. During the early stage of Stage-1(2015) in the Hoa Lac Area (north of the LHLE), at present, HHTP-MB has installed the length of about 26km of drain as shown in Figure C 1.1. The details of the existing and planned drain for various identified routes are shown in Table C.1.2.

Table C.1.2 Hoa Lac Area Installed and Installing Drainage

Diameter of Drain (mm)	No. of Line	Length (m)	Total (m)
Route E			5,430
D600	2	679	1,358
D800	2	1,690	3,380
D1000	2	346	692
Route B			4,884
D600	2	741	1,482
D800	2	1,243	2,486
D1000	1	44	44
D1500	2	436	872
Route C			3,834
D800	2	1,917	3,834
Route C'			4,631
D600	2	823	1,646
D800	2	816	1,632
D800	1	478	478
D2000	1	875	875
Route A			5,128
D600	2	378	756
D800	2	620	1,240
D1000	2	1,211	2,422
D1250	2	355	710
Route D			2,002
D600	2	750	1,500
D800	2	251	502
Total			25,909

Source: HHTP-MB



Source: HHTP-MB

Figure C.1.1 Present Condition of Development for Storm Water Drainage System

1.2.2 Water Bodies of HHTP

As, the hydraulic design report of the drainage system has not yet been prepared for the HHTP, the hydrological calculations for the drainage system were not available for review purpose. In addition, the flood control function within the HHTP has also not been mentioned in the VN Revised M/P. However, based on the JICA Updated M/P, it has been estimated that a length of about 35.8km of embankment works will be required for the Tan Xa Lake, the Dua Gai Stream and the Vuc Giang Stream. These embankments will function as retention ponds to mitigate any flooding within and outside of the HHTP. The hydraulic characteristics of the water bodies in HHTP are presented in Table C.1.3.

Table C.1.3 Hydraulic Characteristics of Water Bodies

Season	Elevation of Bank	Highest Water Level: HWL	Mean Water Level: MWL	Lowest Water Level: LWL
Tan Xa Lake				
a) Dry Season	MSL+12.5m	MSL+10.5m	MSL+09.5m	MSL+07.5m
b) Rainy Season	MSL+12.5m	MSL+12.0m	MSL+11.0m	
Dua Gai Stream	-	MSL+12.0m	-	MSL+07.5m
Vuc Giang Stream	-	MSL+09.6m	-	MSL+07.5m

Source: VN Revised M/P

It can be concluded from the above table that during dry season, the Tan Xa Lake attains the lowest water level i.e. MSL+07.5. Annually the highest water level of MSL+10.5m and MSL+12.0m is attained during dry season and rainy season respectively. Construction of the embankment work for water bodies has not yet been commenced.

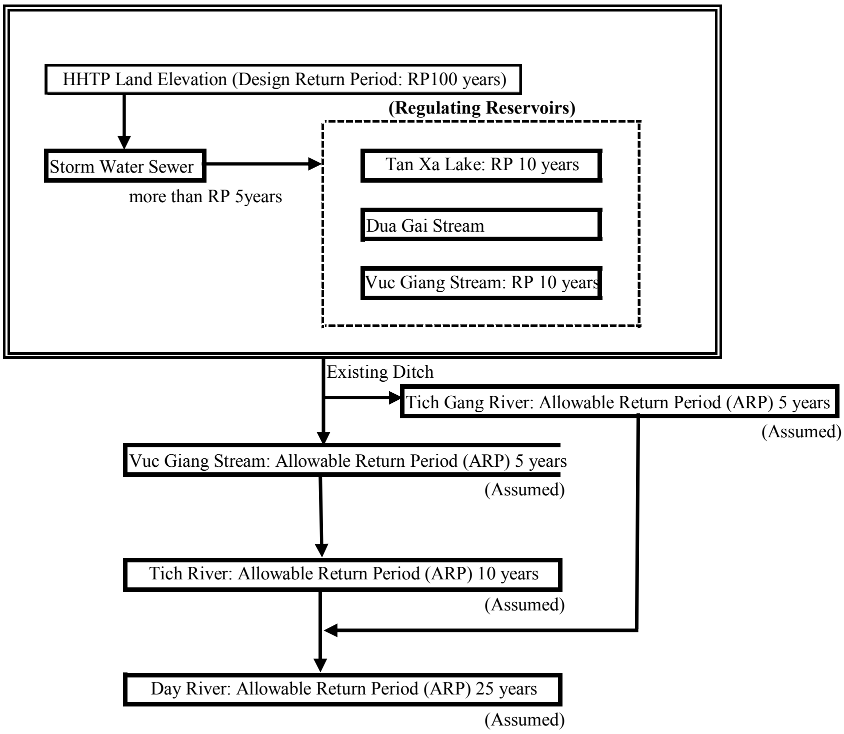
1.2.3 Issues and Strategy

In the Hoa Lac area (north of LHLH), the feasibility study for the drainage system was hindered by certain problems and constraints, mentioned hereinafter. It is to be noted that the hydraulic analysis of drainage system is based on the preliminary examination. This is mainly because of the following conditions, issues and risks that came across during the hydraulic study:

1) Although the VN Revised M/P presented the drainage plan with the drainage and layout map, but it is still exactly not known that how the storm water flow was calculated and how the sizes of culverts were determined.
2) The allocation of discharge of storm water flow from each zone is also not clear.
3) In general, the collection of data and information for the Tich River was the most formidable experience. The lack of available information and unsatisfactory responses from HHTP-MB resulted in the deficit of important data and information that would be required for conducting the feasibility study.
4) For the design of storm water drainage, return period of three (3) has been adopted by the VN Revised M/P for the High-Tech Industrial Zone and one (1) year for the other zones. However, considering the impotence of HHTP, it seems that the return periods for design of storm water drainage is low.
5) It is of major concern that the flood protection measures for downstream area of HHTP, such as retention pond and external drainage canal were not considered by the VN Revised M/P.
6) Considering that Vuc Giang Stream, the Tich River and the Day River will be the final receiving end of the discharged storm water from HHTP, the allowable return periods of these rivers and streams is not clear.
7) The operation and maintenance (O&M) of the drainage facilities will be conducted by HHTP-MB, but institutional structure for the O&M including fare collection system has not been examined by the VN Revised M/P.

It is to be noted that even though HHTP-MB recognizes the necessity of the flood protection measures for downstream area of HHTP, the flood protection measures were not planned by the VN Revised M/P. For conducting the feasibility study in the Hoa Lac area (north of LHLE), the following policy and strategy were adopted:

1) Present drainage system in HHTP as assumed is mentioned below;



(source: JICA Study Team)

It was assumed that the Tich River and the Day River belong to the National drainage system in Vietnam.

2) The design return period of storm water drainage in HHTP has been proposed to be more than five (5) years.
3) The allowable return periods of the Tich River and the Day River shall be determined by Vietnamese side, such as DARD, MONRE or MOC. The allowable return periods of the Vuc Giang Stream outside of HHTP shall be determined based on results of the river survey and discussion with HHTP-MB, DARD, MONRE and MOC.
4) The drainage system plan of the VN Revised M/P shall be reviewed and revised.
5) Increment of discharge storm water after development of HHTP shall be stored within the HHTP area.
6) Three (3) basins consisting of the Tan Xa Lake, the Dua Gai Stream and the Vuc Giang Stream in HHTP shall function as the flood protection measures for downstream area of HHTP.
7) Retention pond or regulating reservoir shall be constructed by a developer of the High-Tech Industrial Zone (VINACONEX/FPT).
8) It is proposed that the proper structure for the O&M of drainage and sewer facilities including wastewater treatment plant should be established.

CHAPTER 2 FRAMEWORK OF DRAINAGE DEVELOPMENT PLAN

2.1 BASIC CONCEPTS

The basic concepts for the drainage development plan in the Hoa Lac Area are briefly described below:

2.1.1 Target Year

The drainage development plan will be formulated on the basis of the VN revised M/P of HHTP for the year 2020. In May 2008, this has already been approved by the Prime Minister of Vietnam as a general plan for the development of the national project.

2.1.2 Project Area

The project area determined by the VN Revised M/P is the Hoa Lac area (north of LHLE) covering about 1,268ha. However, total area for the F/S has been estimated about 1,036ha of the Hoa Lac area. This excludes the Amenity zone and Stage-2 (2020) of High-Tech Industrial Zone.

2.1.3 Drainage Basin

At present, the drainage basin of the Hoa Lac Area consists of three (3) sub-basins i.e. Tan Xa Lake, the Dua Gai Stream and the Vuc Giang Stream. However, after development, the basin will be divided into four (4) sub-basins of the Tan Xa Lake (C1), the Dua Gai Stream (C2), Vuc Giang Newly Built Reservoir (C3) and the Vuc Giang Stream (C4) as shown in Table C.2.1.

Table C.2.1 Drainage Basin

I	CATCHMENT	AREA (ha)
1	TAN XA LAKE: C1	575.3
2	DUA GAI STREAM: C2	275.3
3	VUC GIANG NEWLY-BUILT RESERVOIR: C3	244.1
4	VUC GIANG STREAM: C4	56.3
	SUB-TOTAL	1,151.0
II	**WATER SURFACE AREA**	
1	TAN XA LAKE	107.0
2	DUA GAI STREAM	5.4
3	VUC GIANG NEWLY-BUILT RESERVOIR	4.6
	SUB-TOTAL	117.0
III	**TOLAL**	1268.0
IV	**OUTSIDE BASIN C0 (inflow to Tan Xa Lake)**	74.8

Source: JICA Study Team

According to the VN Revised M/P, the northern area that lies outside of the Hoa Lac Area can still discharge its storm water to the Tan Xa Lake. However, the flow of storm water and wastewater from the western part of the Hoa Lac Area should be blocked at the national road No.21.

2.1.4 Storm Water Collection System

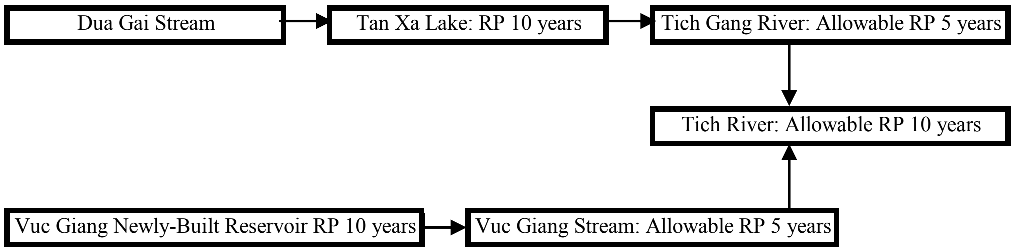
Separate Stream system will be adopted for collection of storm water in the Hoa Lac Area.

2.1.5 Retention Functions for Flood Control

The three water bodies i.e. the Tan Xa Lake, the Dua Gai stream and the Vuc Giang stream will function for retention and/or regulating the flood.

2.1.6 Receiving Water Body of Storm Water

After development of drainage system, the storm water from the Hoa Lac Area will be discharged to the Tick River through the Tich Gang River and the Vuc Giang Stream as shown in the Figure C.2.1.



RP: Return Period

Source: JICA Study Team

Figure C.2.1 Storm Water Discharge Flow

2.2 DESIGN STORM WATER FLOW

The drainage development plan was carried out for the above three (3) sub-basins. The design for storm water flow was determined as described below:

2.2.1 Rainfall Intensity

A rainfall intensity formula for Hanoi was developed by MOC as follows:

1) MOC

$$\mathbf{I = 0.36 \cdot [5416 \cdot (1+0.25 \cdot \log P \cdot t^{0.13})]/(t+19)^{0.82}}$$

where, I: Rainfall intensity (mm/hour) (36 mm/hour = 100 l/sec/ha)
P: Return period (year)
t: Concentration time (minute)

In addition, the other formulas that were developed by the Hanoi Civil Engineering College and the Vietnam Meteorological and Hydrological Center for Hanoi are mentioned below:

2) Hanoi Civil Engineering College **proposed standard** TCXD 51-2008

$$\mathbf{I = 0.36 \cdot [5890 \cdot (1+0.65 \cdot \log P)]/(t+20 \cdot P^{0.18})^{0.84}}$$

where, I: Rainfall intensity (mm/hour) (36 mm/hour = 100 l/sec/ha)
P: Return period (year)
t: Concentration time (minute)

3) Vietnam Meteorological and Hydrological Center

$$\mathbf{q = [(20+11.61)^{0.7951} \cdot q_{20} \cdot (1+0.2458 \cdot \lg P)]/(t+11.61)^{0.7951}}$$

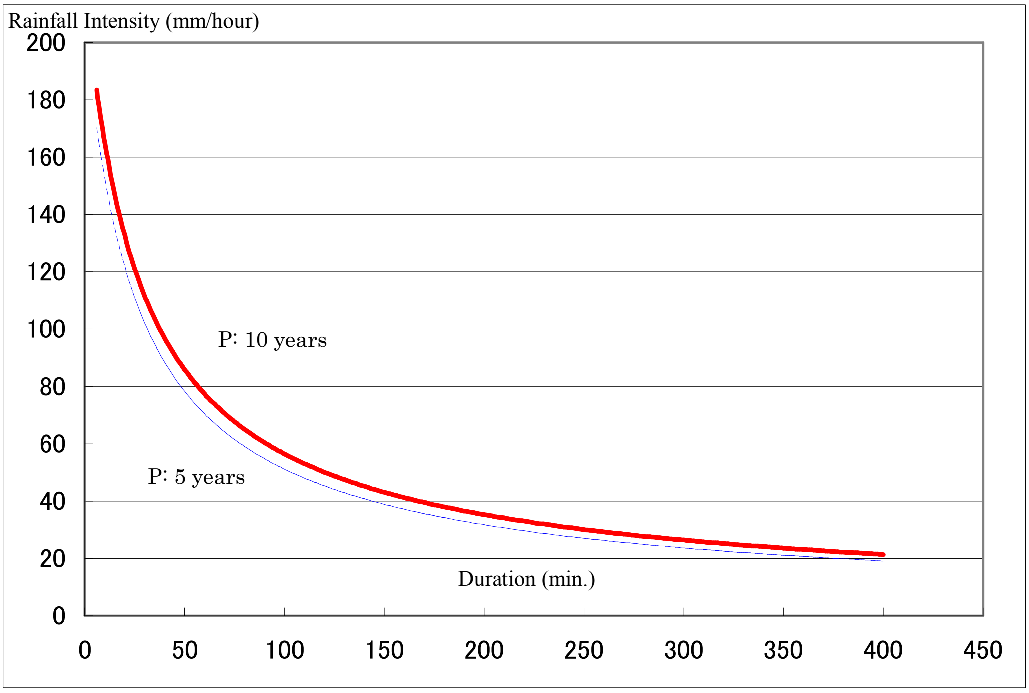
where, q: Rainfall intensity (l/sec/ha)
P: Return period (year)
t: Concentration time (minute)
q_{20}: Rainfall intensity in 20 minutes

The formula as developed by MOC was adopted for the storm water drainage system for the Hoa Lac Area. This was adopted due to the following reason:

i) This formula as developed by MOC has already been widely used in the earlier projects for planning purpose in Hanoi. Some noticeable examples are the Study on Urban Drainage and Wastewater Disposal System in Hanoi City (JICA), Hanoi City Drainage and Environmental Improvement Project (JBIC), Master Plan and Feasibility Study on the Hoa Lac High-Tech Park Project (JICA), JICA Updated M/P on the Hoa Lac High-Tech Park Project (JICA), etc.

ii) There is only a slight difference among the three rainfall intensity curves.

Rainfall intensity curves for 5 years and 10 years are shown in Figure C.2.2.



Source: JICA Study Team

Figure C.2.2 Rainfall Intensity Curves

2.2.2 Design Storm Water Flow

The design storm water flow shall be calculated by using the rational formula, and the rainfall intensity formula that has been developed by the Ministry of Construction in Vietnam and is given below:

$$Q = C \cdot q \cdot A$$

Where,
- Q: Design storm water flow (m^3/second)
- C: Runoff coefficient
- q: Rainfall intensity (mm/second/ha)
- A: Drainage area (ha)

$$q = 0.36 \cdot [5416 \cdot (1+0.25 \cdot \log P \cdot t^{0.13})]/(t+19)^{0.82}$$

where,
- q: Rainfall intensity (mm/hour)
- P: Return period (year)
- t: Concentration time (minute)

2.2.3 Runoff Coefficient

The runoff coefficient should be the overall runoff coefficient of drainage basin which has been calculated by considering the runoff coefficients of each area with individual surface characteristics as shown in Table C.2.2.

Table C.2.2 Overall Runoff Coefficient

Land Use Type		Hoa Lac Area Before development				Hoa Lac Area After Development			
		Classification of Area		Runoff Coefficient		Classification of Area		Runoff Coefficient	
		Area (ha)	Proportion	Base	Average	Area (ha)	Proportion	Base	Average
1	Residential Area	236.22	18.62%	0.95	0.18	184.20	14.53%	0.95	0.14
2	Newly Industrial Area	11.50	0.91%	0.85	0.01	712.40	56.18%	0.85	0.48
3	Specialized Use Area	187.89	14.81%	0.80	0.12	113.60	8.96%	0.80	0.07
3.1	Public Utility	20.68	1.63%			113.60	8.96%		
3.2	Transportation	80.73	6.36%				-		
3.3	Irrigation	12.15	0.96%				-		
3.4	Cultural Assets	0.28	0.02%				-		
3.5	Security & Defense	68.13	5.37%				-		
3.6	Cemetery	5.92	0.47%				-		
4	Agricultural Area	636.00	50.14%	0.30	0.15		0.00%	0.30	0.00
5	Water Surface	139.00	10.96%	1.00	0.11	117.00	9.23%	1.00	0.09
6	Forestry Area	51.51	4.06%	0.30	0.01	30.80	2.43%	0.30	0.01
7	Existing Industrial Area		0.00%	0.85	0.00		0.00%	0.85	0.00
8	Open Space	6.39	0.50%	0.40	0.00	110.00	8.68%	0.40	0.03
Total		1,268.51	100.00%	Overall	0.58	1,268.00	100.00%	Overall	0.82

Source: JICA Study Team

Thus, the overall runoff coefficient prior to and after the development of HHTP has been estimated as 0.58 and 0.82 respectively.

2.3 HYDROLOGICAL ANALYSIS OF TAN XA LAKE

2.3.1 Rainfall Data

Daily measurement record of water levels of the Tan Xa Lake was provided by the Phu Sa Company. Annual water levels of the Tan Xa Lake from 1993 to 2008 are summarized in Table C.2.3.

The maximum water level (H max) of EL. 12.40m was recorded in 2008 and the lowest water level (H min) of EL. 7.50m was recorded in 2002. Average H max and H min for the last 10 yeas are EL. 11.61m and 9.03m respectively.

Table C.2.3 Annual Water Levels of Tan Xa Lake

Unit: m, MSL

Year	H max	H min
1993	11.70	11.01
1994	12.08	7.73
1995	11.65	9.20
1996	11.40	9.30
2000	11.35	10.33
2001	12.03	8.25
2002	11.41	7.50
2006	11.25	10.87
2007	10.87	8.20
2008	12.40	7.95
Average	11.61	9.03

Source: Daily record of Phu Sa Company

2.3.2 Return Periods and Maximum Water Levels

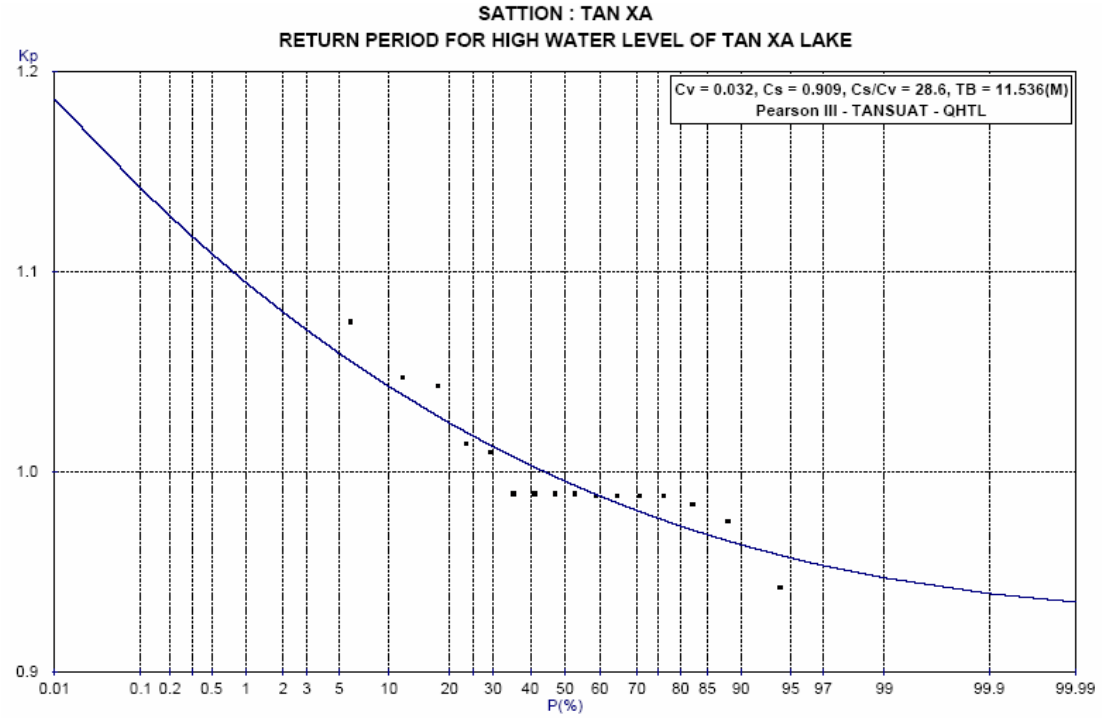
The feasibility study on overhaul of Tan Xa Lake irrigation system (February 1996) was conducted by the Hanoi Water Resources University. This study reports the result of hydrological analysis for correlation between maximum water levels and return periods. The maximum water levels were estimated by the Pearson III (PIII) method as follows:

$$H_{tb} = \frac{\sum_{i=1}^{n} H_i}{n} \qquad C_v = \sqrt{\frac{\sum_{i=1}^{n}(K_i - 1)^2}{n-1}} \qquad K_i = \frac{H_i}{H_{tb}}$$

$$C_s = \frac{\sum_{i=1}^{n}(K_i - 1)^3}{(n-3)C_v^3}$$

Where:
H_i: High water level of year i, (meter);
n: year recorded
C_v: Distribution ratio estimate by Momen method
K_i: Moduyn ratio
C_s: Deviation ratio

Result of hydrological analysis is presented in Figure C.2.3.



Source: Hanoi Water Resources University

Figure C.2.3 Return Period and High Water Level

2.3.3 Design Maximum Water Level of Tan Xa Lake

From the above hydrological analysis, maximum water levels of Tan Xa Lake were calculated and the results are presented in Table C.2.4. The maximum water level with 50 years of return period was estimated to be EL.12.63m above mean see level. It is also recommended by the feasibility study on overhaul of Tan Xa Lake irrigation system that the maximum water level with EL.12.63m should be secured considering the environmental conservation of the Tan Xa Lake, control of floods and facilitating irrigation.

The hydraulic characteristics of the Tan Xa Lake are recommended below:

Elevation of Bank	: MSL+13.13m	For water environmental protection
Maximum Water Level	: MSL+12.63m	For flood control to 50 years of return period and water environmental conservation (estimated)
High Water Level	: MSL+12.00m	For annual high water level during rainy season
Mean Water Level	: MSL+10.50m	For water level to be kept even during dry season
Low Water Level	: MSL+7.50m	For the past lowest water level by drought

Table C.2.4 Summary Sheet of Tan Xa Lake Hydrological Analysis

Data	: HIGH WATER LEVEL OF TAN XA LAKE, STATION: TAN XA
Number of record	: 16
Cv	: 0.032
Cs	: 0.909
Cs/Cv	: 28.561
Average	: 11.536 (m)

P%	Xp
0.010	13.682
0.100	13.167
0.200	13.008
0.333	12.890
0.500	12.794
1.000	12.627
2.000	12.455
3.000	12.352
5.000	12.218
10.000	12.026
20,000	11.816
25.000	11,743
30,000	11.680
40.000	11.573
50,000	11,481
60,000	11,396
70,000	11,312
75,000	11,269
80,000	11,223
85,000	11,173
90,000	11,115
95,000	11,039
97,000	10,995
99,000	10,924
99,900	10,834
99,990	10,785

DATA SET

X	T	Xgiam	T
11.700	1993	12,400	2008
12,080	1994	12,080	1994
11,650	1995	12,030	2001
11,400	1996	11,700	1993
11,400	1997	11,650	1995
11,400	1998	11,410	2005
11,400	1999	11,410	2004
11,350	2000	11,410	2003
12,030	2001	11,410	2002
11,410	2002	11,400	1999
11,410	2003	11,400	1998
11,410	2004	11,400	1997
11,410	2005	11,400	1996
11,250	2006	11,350	2000
10,870	2007	11,250	2006
12,400	2008	10,870	2007

CHAPTER 3 PROPOSED STORM WATER DRAINAGE PLAN

3.1 DESIGN CONCEPT AND CRITERIA

3.1.1 Design Concept

The proposed design concept for storm water drainage system within the Study area is as follows:

1) To apply the following regulations and standards corresponding to the;

- VN Revised M/P for the Hoa Lac High-Tech Park (HHTP);
- Design Standard for Works of Sewerage and Drainage System in Vietnam (1989);
- Environment Protection Law in Vietnam (1994);
- Guidance for Environmental Impact Assessment (1993);
- Environmental Quality Standard for River's Water (TCVN 5942-2005);
- Decree of the Government on Urban Underground Construction (No. 41/2007/ND-CP, 2003);
- Building Code of Vietnam (Decision No. 682/BXD-CSXD, 1996);
- Sewerage Law in Japan (1983); and
- Japan Sewerage Works Association Standards (1984).

2) To harmonize with the existing infrastructures as constructed by HHTP-MB.

3) To adopt a separate system for collection of storm water.

4) To take adequate measures in line with the local conditions so as to protect the landscape, water environment, and protect the site from the natural disaster such as floods.

3.1.2 Design Criteria

(1) Design Flow

Design flow for the designed storm water flow (DSF) has been calculated by the rational formula as described in the subsection 2.2.

(2) Hydraulic Design for Drain

The hydraulic design of drain is based on Manning's formula, which is given below:

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

Where,
- Q: Storm water discharge (m^3/sec)
- A: Sectional area of pipe (m^2)
- V: Mean velocity (m/sec)
- n : Roughness coefficient
- R: Hydraulic radius (m)
- I : Hydraulic gradient

For the hydraulic design of drains the following criteria were adopted:

a) Roughness Coefficient: 0.013
Reinforce concrete pipes is to be used for the drain. Considering the long term operation, the roughness coefficient of 0.013 has been adopted for reinforced concrete pipes.

b) Allowable Flow Velocity: 0.8–3.0m/sec
The minimum velocity shall not be less than 0.8m/sec in order to avoid any sedimentation and keep consistency with the onsite road gradient as much as possible. In addition, to prevent the pipe from eroding, the maximum velocity shall be limited to 3.0m/sec.

c) Allowance of Drainage System Capacity
The allowance of the storm water drain capacity is to be 10% to 20% of the design flow. The allowance is generally applied while selecting the drain pipes. This is done to accommodate any unexpected flow fluctuations or to prevent the pipes against the putrefaction of drainage.

d) Minimum Size of Drain: 250mm
The minimum size of pipe to be selected will be 250mm so as to secure the workability of maintenance and operation (O&M).

e) Depth of Earth Covering: 0.6–3.0m
To prevent any damage or collapse of the pipes, the minimum earth covering is determined as 0.6 along the sidewall m and 1.0m on the traffic road. However, in order to minimize construction cost, the maximum depth of earth covering is limited to 3.0m.

f) Maximum Manhole Interval
Manhole shall be located at the places where there is occurrence of change in flow direction or pipe gradient or diameter. In addition, manholes will also occur at the originating point of drain pipeline and junction points of pipes. The maximum manhole interval for each size of drain is proposed as follows:

Drain Diameter (mm)	Maximum Interval (m)
≦ D300	50
≦ D600	75
≦ D 1000	100
≦ D1500	150
≦ D1650	200

g) Connection of Pipes: Pipe bottom connection or Water surface connection.
A pipe bottom connection is recommended in view of the depth of the pipe laying and construction cost. However, water surface connection is proposed in case of a difference of diameters between connecting drains. This will prevent backwater at the drain pipeline.

h) Hydraulic Gradient: recommended below.

Diameter of pipe	≦ 500mm	: 2.0‰
	≦1,000mm	: 1.0‰
	≦1,500mm	: 0.7‰
	> 1,500mm	: 0.6‰

(3) Grit Chamber with Screen

The design criteria of the grit chamber are recommended below:

- Number of grit chambers : ≧2 units
- Bottom slop of grit chamber : 1/100 – 2/100
- Mean velocity : 0.3m/sec
- Retention period : 30 – 60sec
- Depth of sand pit : 30cm
- Surface loading : $3600m^3/m^2$・day

The screen for storm water will be located after the grit chamber.

(4) Retention Functions

Retention functions for the Tan Xa Lake, and the Vuc Giang Stream shall be designed to cope with 10 years of flood return period. An allowable return period of the Tich River via the Vuc Giang and Tich Gang River is assumed to be 10 years. Such design will not only protect the Hoa Lac Area against flood but will also protect the downstream area of HHTP. Capacity of retention functions has been estimated by the following formula:

$$Q = [Q_{10} - Q_a/2] \cdot T \cdot 60$$

Where, Q: Design capacity of retention pond (m^3)
Q_{10}: Design storm water flow (m^3/second)
Q_a: Allowable discharge flow (m^3/second)
T: Concentration time (minute)

For volume of sedimentation, estimated by 1.5m^3/ha/year and 10 years period.

As per the results of the river survey conducted by the JICA Study Team, the Vuc Giang stream shall be improved by MOC and/or MARD so as to link it with the national drainage system of Vietnam.

(5) Tan Xa Lake Regulating Gate

Sluice Gate will be adopted for the Tan Xa Lake regulating gate. Design of sluice gate is calculated by the following formula:

$$Q_0 = C \cdot B \cdot d \cdot [2 \cdot g \cdot H_1]^{0.5}$$

Where, Q_0: Discharge flow (m^3/second)
C : Coefficient of correlation between H_1/d and H_2/d
B : Width of gate (m)
d : Opening height of gate (m)
g : Gravitational constant (9.8 m/sec^2)
H_1: Upstream water height (m)
H_2: Downstream water height (m)

(6) Tan Xa Lake Overflow Weir

Overflow weir for the Tan Xa Lake has been designed based on the formula as mentioned below. This will secure the annual mean water height of the Tan Xa Lake and will able to keep the maintenance flow of rivers and pond downstream, such as the Tich Gang River and irrigation ponds.

$$Q_c = C \cdot L \cdot h^{0.5}$$

Where, Q_c: Overflow (m^3/second)
C : Overflow coefficient
L : Width of trough (m)
h: Water height of trough (m)

(7) Vuc Giang New Reservoir with Regulating Orifice

A Vuc Giang new reservoir with retention function shall be constructed at the High-Tech Industrial zone that is to be developed by FPT. The Vuc Giang new reservoir is proposed to be a multiple type retention pond with a regulating orifice. The orifice is designed by the following formula:

In case of H□1.2·D

$$Q_o = 1.8 \cdot B \cdot H^{1.5}$$

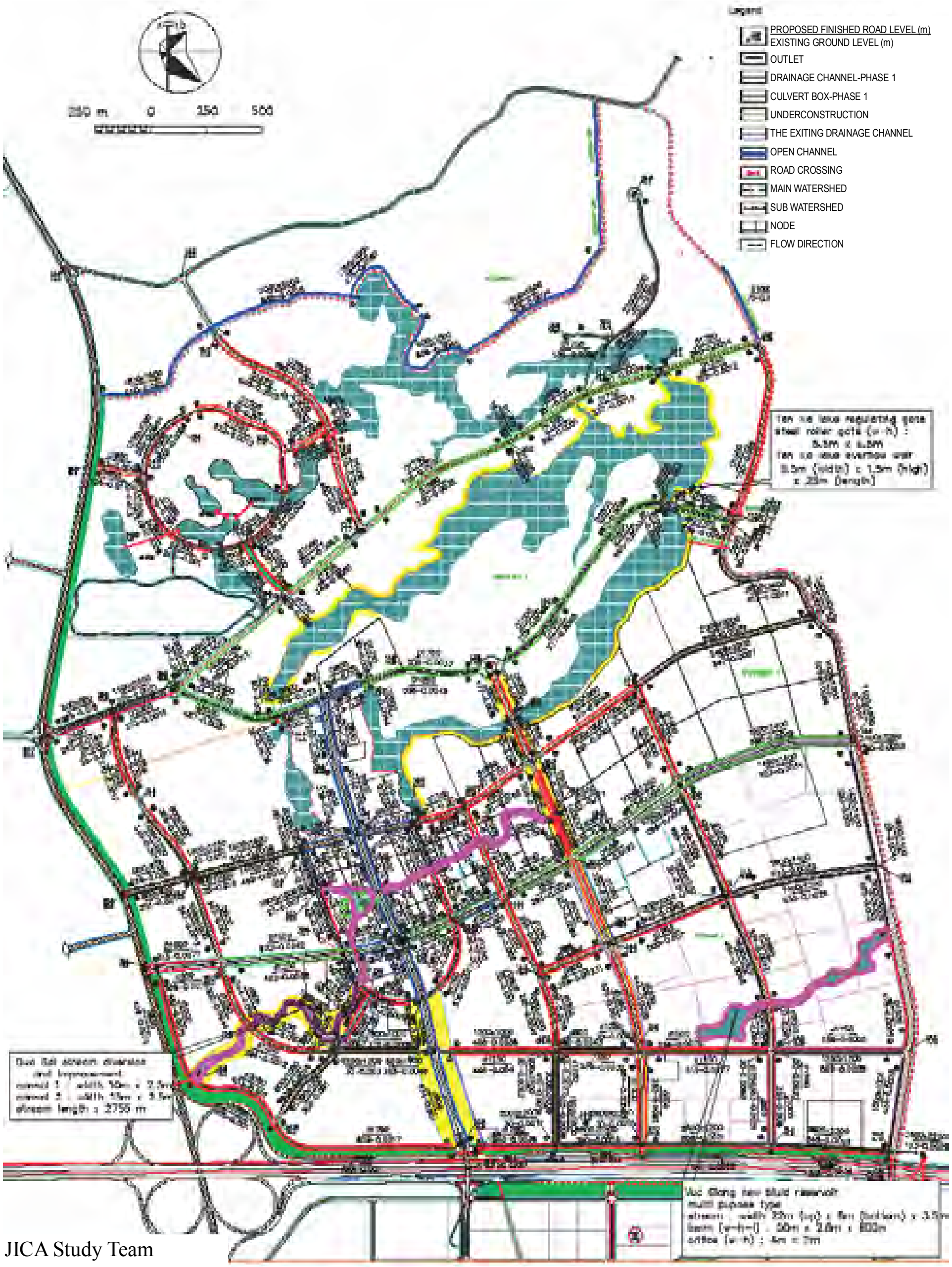
In case of H□1.8·D

$$Q_o = C \cdot B \cdot D \cdot [2 \cdot g \cdot (H - D/2)]^{0.5}$$

Where, Q_o: Discharge flow (m^3/second)
H: Height between water level of pond and bottom of orifice
C : Discharge coefficient
B : Width of trough (m)
D : Height of orifice (m)
g : Gravitational constant (9.8 m/sec^2)

3.2 DEFINITION OF PROPOSE STORM WATER DRAINAGE PLAN

The proposed storm water drainage plan should be able to cope well with the variety of public facilities and services, functional zones and environmental requirements particularly in HHTP. On the basis of the design concept and criteria as has been discussed earlier, this chapter proposed the storm water drainage plan for the Hoa Lac Area. The overall storm water drainage plan in the Hoa Lac Area is shown in Figure C.3.1.



Source: JICA Study Team

Figure C.3.1 Overall Drainage Plan

3.2.1 Storm Water Collection System

(1) Summary of Concept and Criteria for Storm Water Drainage

The design concept and criteria adopted for the storm water drainage system in the Hoa Lac area (north of LHLE) are summarized below:

a) Concept of storm water drainage system plan

Design period	: The year of 2020
Planning area	: 1268 ha of Hoa Lac area (north of LHLE)
Design population	: 193,326
Drainage basin	: Four basins of Tan Xa Lake, Dua Gai Stream, Vuc Giang Newly Built Reservoir and Vuc Giang Stream
Collection system	: Separate system
Design storm water flow (DSF)	: 5 years of return period for drain
Storm water reservoir for flood control	: Tan Xa Lake and Vuc Giang stream
Receiving water bodies	: Tich River through Vuc Giang stream and Tich Gang River

b) Design criteria for storm water collection drainage
The hydraulic design has been based on the following criteria:

Design storm water flow (DSF)	: Rational formula $Q = C \cdot q \cdot A$ Where, Q: Design storm water flow (m^3/second) C: runoff coefficient q: Rainfall intensity (mm/second/ha) A: Drainage area (ha)
Rainfall intensity	: Intensity formulation of MOC $q = 0.36 \cdot [5416 \cdot (1+0.25 \cdot \log P \cdot t^{0.13})]/(t+19)^{0.82}$ where, q: Rainfall intensity (mm/hour) P: Return period (year) t: Concentration time (minute)
Return period	: 5 years for drain
Overall runoff coefficient	: 0.6 before development, 0.8 after development
Hydraulic design of drain	: Manning's formula $Q = A \cdot V$, $V = (1/n) \cdot R^{2/3} \cdot I^{1/2}$ Where, Q: Storm water discharge (m^3/sec) A: Sectional area of pipe (m^2) V: Mean velocity (m/sec) n : Roughness coefficient R: Hydraulic radius (m) I : Hydraulic gradient
Allowable flow velocity	: 0.8 - 3.0 m/s
Minimum size of drain	: 250mm
Allowance of drain capacity	: 10%-20% of design storm water flow
Minimum earth covering	: 1.0m
Maximum manhole interval	: 50m for less than D300mm, 75m for less than D600mm 100m for D1000mm, 150m for less than D1500mm 200m for less than D1650mm
Pipe connection method	: Pipe bottom connection or water surface connection
Material of drain	: Hume concrete pipe
Roughness coefficient	: 0.013
Hydraulic gradient	: 2.0‰for less than D500mm, 1.0‰for less than D1000mm 0.7‰for less than D1500mm, 0.6‰for less than D1500mm

(2) Proposed Storm Water Collection System

Four discharge basins that consist of the Tan Xa Lake (C1), the Dua Gai Stream (C2), Vuc Giang Newly Built Reservoir (C3) and the Vuc Giang Stream (C4) were planned by the VN Revised M/P for storm water collection system. For the drainage design, the VN Revised M/P adopted the return period of 3 years for Industrial zone and 1 year for other zones. However, for the drainage design in the Hoa Lac Area, the JICA Study proposed the application of the 5 years of return period.

The result of the hydraulic design of the storm water collection system is given in Tables C.3.1 (1/5) to (5/5). It gives the details like the designated pipe number, commanding area of pipe, pipe length, diameter, design discharge, velocity, etc. In addition, the Figure C.3.2 shows the diameter, gradient and length of proposed wastewater collection pipes.

Table C.3.1 Hydraulic Design (1/5)

Project: Hoa Lac Hi-Tech Park
Location: Hà Nội
Drainage Basin: Tan Xa Lake (TXL)-CATCHMENT 1
TOTAL AREA = 575.3HA

Formula		$Q=1/360xCxIxA$; $I= 0.36 \times 5416 \times (1+ 0.25 \times lgP \times t^{0.13})/(t+19)^{0.82}$; $Q=A \times 1/Mn \times R^{2/3} \times S^{1/2}$ (Manning)	
Lo (m):	100	P 5	Runoff Coefficient 0.8
To (min):	5-10		

From Node	To Node	Length	Catchment Self	Catchment Pass	Catchment Total	Runoff co-efficient	Concentration time Self	Concentration time Pass	Concentration time Total	Rainfall intensity	Peak Flow	Pipe Diameter	Box Cuvert Width	Box Cuvert Height	Sectional Area	Wet perimeter	Hydraulic Radius	Manning	Hydraulic Gradient	Velocity	Flow Capacity	Sewer Ground elevation Up	Ground elevation Down	Top Level Up	Top Level Down	Invert Level Up	Invert Level Down	Soil Coverage depth Up	Soil Coverage depth Down
		L			A	C	T1	T2	Tt	I	Q	D	B	H	S	S	R	n	i	V									
		(m)	(ha)	(ha)	(ha)		(min)	(min)	(min)		(l/s)	(m)	(m)	(m)	(m2)	(m2)	(m)			(m/s)	(l/s)	m	m	m	m	m	m	m	m
120	121	267	2.21		2.21	0.8	2.00	7.00	9.00	434.349	768		0.600	0.800	0.432	2.04	0.21	0.013	0.0266	4.46	1926	22.60	15.50	21.96	14.86	21.16	14.06	0.64	0.64
125	121	345	7.84		7.84	0.8	6.83	7.00	13.83	385.294	2417		1.400	1.200	1.512	3.56	0.42	0.013	0.0015	1.68	2545	16.00	15.50	15.78	15.26	14.58	14.06	0.22	0.24
121	122	30		10.05	10.05	0.8	0.21	13.83	14.04	383.433	3083		1.400	1.200	1.512	3.56	0.42	0.013	0.0120	4.76	7199	15.50	15.50	15.26	14.90	14.06	13.70	0.24	0.60
126	122	355	3.58		3.58	0.8	6.50	7.00	13.50	388.245	1112		0.800	1.000	0.720	2.60	0.28	0.013	0.0031	1.82	1310	16.00	15.50	15.80	14.70	14.80	13.70	0.20	0.80
122	123	504	22.17	13.63	35.80	0.8	4.22	14.04	18.26	349.86	10020		1.800	1.600	2.592	4.68	0.55	0.013	0.0059	3.98	10329	15.50	13.00	15.30	12.33	13.70	10.73	0.20	0.67
128	127	331	4.09		4.09	0.8	4.00	7.00	11.00	412.481	1350	0.800			0.502	2.51	0.20	0.013	0.0110	2.76	1386	20.60	17.40	19.60	15.96	18.80	15.16	1.00	1.44
127	123	246	1.18	4.09	5.27	0.8	2.32	11.00	13.32	389.893	1644	0.800			0.502	2.51	0.20	0.013	0.0180	3.53	1773	17.40	13.00	15.96	11.53	15.16	10.73	1.44	1.47
123	124	80		41.07	41.07	0.8	0.75	13.32	14.07	383.207	12591		2.000	2.000	3.600	5.60	0.64	0.013	0.0039	3.58	12882	13.00	13.00	12.73	12.42	10.73	10.42	0.27	0.58
105	107	263	4.45		4.45	0.8	2.60	7.00	9.60	427.48	1522	0.800			0.502	2.51	0.20	0.013	0.0164	3.37	1693	19.00	15.50	17.98	13.67	17.18	12.87	1.02	1.83
106	107	370	11.63		9.49	0.8	7.48	7.00	14.48	379.631	2882	1.500			1.766	4.71	0.38	0.013	0.0017	1.65	2913	16.00	15.50	15.00	14.37	13.50	12.87	1.00	1.13
107	109	35		13.94	13.94	0.8	0.28	14.48	14.76	377.194	4206	1.500			1.766	4.71	0.38	0.013	0.0105	4.10	7240	15.50	15.50	14.37	14.00	12.87	12.50	1.13	1.50
108	109	365	4.97		4.97	0.8	5.89	7.00	12.89	393.885	1566	1.250			1.227	3.93	0.31	0.013	0.0034	2.07	2533	16.00	15.50	14.99	13.75	13.74	12.50	1.01	1.75
109	110	273	3.74	18.91	22.65	0.8	4.43	14.76	19.19	343.302	6221	2.000			3.140	6.28	0.50	0.013	0.0018	2.06	6456	15.50	15.00	14.50	14.01	12.50	12.01	1.00	0.99
110	111	487	14.43	22.65	37.08	0.8	5.51	19.19	24.70	309.491	9181	2.000			3.140	6.28	0.50	0.013	0.0037	2.95	9256	15.00	14.50	14.00	12.20	12.00	10.20	1.00	2.30
111	112	30		37.08	37.08	0.8	0.30	24.70	24.99	307.88	9133	2.500			4.906	7.85	0.63	0.013	0.0036	3.37	16553	14.50	13.00	12.70	12.59	10.20	10.09	1.80	0.41
113	114	285	6.39		6.39	0.8	2.49	7.00	9.49	428.787	2192		0.800	0.800	0.576	2.24	0.26	0.013	0.0151	3.82	2202	19.00	15.50	18.78	14.48	17.98	13.68	0.22	1.02
114	116	320	9.00	6.39	15.39	0.8	4.85	9.49	14.33	380.883	4689		1.500	1.600	2.160	4.38	0.49	0.013	0.0021	2.20	4753	15.50	15.00	15.28	14.61	13.68	13.01	0.22	0.39
115	116	580	8.63		8.63	0.8	11.87	7.00	18.87	345.512	2385		1.400	1.400	1.764	3.92	0.45	0.013	0.0013	1.63	2873	15.40	15.00	15.16	14.41	13.76	13.01	0.24	0.59
116	118	30		24.02	24.02	0.8	0.23	18.87	19.10	343.892	6608		1.500	1.600	2.160	4.38	0.49	0.013	0.0080	4.29	9276	15.00	15.00	14.61	14.37	13.01	12.77	0.39	0.63
117	118	586	9.41		9.41	0.8	10.49	7.00	17.49	355.497	2676		1.400	1.400	1.764	3.92	0.45	0.013	0.0017	1.86	3285	15.40	15.00	15.17	14.17	13.77	12.77	0.23	0.83
118	119	454	5.64	33.43	39.07	0.8	4.43	17.49	21.92	325.575	10176		1.800	2.000	3.240	5.40	0.60	0.013	0.0039	3.42	11072	15.00	14.50	14.77	13.00	12.77	11.00	0.23	1.50
120	119	159	3.03		3.03	0.8	1.27	7.00	8.27	442.856	1073	0.800			0.502	2.51	0.20	0.013	0.0250	4.16	2090	17.80	14.50	15.77	11.80	14.97	11.00	2.03	2.71
119	121	60		42.10	42.10	0.8	0.50	21.92	22.42	322.527	10863	2.500			4.906	7.85	0.63	0.013	0.0050	3.98	19508	14.50	13.00	13.50	13.20	11.00	10.70	1.00	-0.20
											0																		
122	123	390	5.30		5.30	0.8	3.68	7.00	10.68	415.771	1763	0.800			0.502	2.51	0.20	0.013	0.0180	3.53	1773	20.60	14.50	19.60	12.58	18.80	11.78	1.00	1.92
											0																		
1	3	350	8.70		8.70	0.8	4.52	15.00	19.52	341.047	2374		1.200	1.000	1.080	3.00	0.36	0.013	0.0044	2.58	2789	14.00	14.00	13.80	12.26	12.80	11.26	0.20	1.74
2	3	193	2.05		2.05	0.8	2.58	8.00	10.58	416.883	684	0.800			0.502	2.51	0.20	0.013	0.0090	2.50	1254	14.80	14.00	13.80	12.06	13.00	11.26	1.00	1.94
3	5	20		10.75	10.75	0.8	0.15	19.52	19.67	340.029	2924		1.200	1.000	1.080	3.00	0.36	0.013	0.0130	4.44	4794	14.00	14.00	12.26	12.00	11.26	11.00	1.74	2.00
4	5	198	2.50		2.50	0.8	2.51	8.00	10.51	417.614	835	0.800			0.502	2.51	0.20	0.013	0.0100	2.63	1322	14.80	14.00	13.78	11.80	12.98	11.00	1.02	2.20
5	6	248	4.47	13.25	17.72	0.8	6.03	19.67	25.70	304.111	4311	2.000			3.140	6.28	0.50	0.013	0.0008	1.37	4304	14.00	14.00	13.00	12.80	11.00	10.80	1.00	1.20
6	7	260	5.77	17.72	23.49	0.8	5.66	25.70	31.36	277.327	5212	2.000			3.140	6.28	0.50	0.013	0.0010	1.53	4812	14.00	14.00	12.80	12.54	10.80	10.54	1.20	1.46
											0																		
8	20	332	5.40		5.40	0.8	11.29	7.00	18.29	349.596	1510	1.500			1.766	4.71	0.38	0.013	0.0006	0.98	1731	14.00	14.00	13.00	12.80	11.50	11.30	1.00	1.20
20	21	479	5.00	5.40	10.40	0.8	11.52	18.29	29.82	284.075	2364	1.500			1.766	4.71	0.38	0.013	0.0012	1.39	2447	14.00	14.00	12.80	12.23	11.30	10.73	1.20	1.77
											0																		
11	12	348	9.48		9.48	0.8	4.59	7.00	11.59	406.513	3083	1.250			1.227	3.93	0.31	0.013	0.0051	2.53	3103	17.10	15.40	16.10	14.33	14.85	13.08	1.00	1.07
12	14	20		10.78	10.78	0.8	0.20	11.59	11.78	404.536	3489	1.250			1.227	3.93	0.31	0.013	0.0090	3.36	4122	15.40	15.40	14.33	14.15	13.08	12.90	1.07	1.25
13	14	354	4.00		4.00	0.8	4.91	6.00	10.91	413.411	1323	1.000			0.785	3.14	0.25	0.013	0.0062	2.40	1887	17.10	15.40	16.09	13.90	15.09	12.90	1.01	1.50
14	16	281	2.25	14.78	17.03	0.8	3.22	11.78	15.00	375.185	5112	1.500			1.766	4.71	0.38	0.013	0.0053	2.91	5144	15.40	14.00	14.40	12.91	12.90	11.41	1.00	1.09
15	16	194	3.07		3.07	0.8	3.87	7.00	10.87	413.843	1016	1.000			0.785	3.14	0.25	0.013	0.0030	1.67	1313	14.00	14.00	12.99	12.41	11.99	11.41	1.01	1.59
16	10	30		20.10	20.10	0.8	0.19	15.00	15.19	373.562	6007	1.500			1.766	4.71	0.38	0.013	0.0166	5.15	9103	14.00	14.00	12.91	12.41	11.41	10.91	1.09	1.59
9	10	253	1.30		1.30	0.8	3.38	5.00	8.38	441.599	459	0.800			0.502	2.51	0.20	0.013	0.0090	2.50	1254	15.00	14.00	13.99	11.71	13.19	10.91	1.01	2.29
10	17	93	0.50	21.40	21.90	0.8	1.17	5.00	6.17	469.71	8229	2.000			3.140	6.28	0.50	0.013	0.0030	2.65	8334	14.00	14.00	12.91	12.63	10.91	10.63	1.09	1.37
18	19	298	4.46		4.46	0.8	5.02	4.00	9.02	434.07	1549	1.000			0.785	3.14	0.25	0.013	0.0042	1.98	1553	14.00	14.00	13.00	11.75	12.00	10.75	1.00	2.25
25	26	632	9.31		9.31	0.8	15.20	7.00	22.20	323.83	2412	1.500			1.766	4.71	0.38	0.013	0.0012	1.39	2447	14.00	14.00	13.00	12.24	11.50	10.74	1.00	1.76
27	28	678	10.45		10.45	0.8	15.10	9.00	24.10	312.79	2615	1.500			1.766	4.71	0.38	0.013	0.0014	1.50	2644	14.00	14.00	13.00	12.05	11.50	10.55	1.00	1.95
29	31	640	6.44		6.44	0.8	15.55	7.00	22.55	321.746	1658	1.250			1.227	3.93	0.31	0.013	0.0015	1.37	1683	14.50	13.60	13.31	12.35	12.06	11.10	1.19	1.25
30	31	177	1.87		1.87	0.8	2.85	6.00	8.85	436.069	652	0.800			0.502	2.51	0.20	0.013	0.0062	2.07	1041	14.00	13.60	13.00	11.90	12.20	11.10	1.00	1.70
31	33	30		8.31	8.31	0.8	0.83	22.55	23.38	316.86	2106	1.500			1.766	4.71	0.38	0.013	0.0009	1.20	2120	13.60	13.60	12.60	12.57	11.10	11.07	1.00	1.03
32	33	177	1.00		1.00	0.8	2.80	5.00	7.80	448.587	359	0.800			0.502	2.51	0.20	0.013	0.0064	2.10	1057	14.00	13.60	13.00	11.87	12.20	11.07	1.00	1.73
33	87	35		9.31	9.31	0.8	0.54	23.38	23.92	313.773	2337	1.500			1.766	4.71	0.38	0.013	0.0029	2.15	3805	13.60	13.50	12.57	12.47	11.07	10.97	1.03	1.03
34	23	692	24.32		24.32	0.8	12.29	15.00	27.29	296.002	5759	2.000			3.140	6.28	0.50	0.013	0.0015	1.88	5893	14.50	13.50	13.50	12.46	11.50	10.46	1.00	1.04
86	87	400	6.03		6.03	0.8	4.37	7.00	11.37	408.706	1972	1.000			0.785	3.14	0.25	0.013	0.0100	3.05	2396	17.50	13.50	16.50	12.50	15.50	11.50	1.00	1.00
24	85	410	5.14		5.14	0.8	4.52	6.00	10.52	417.47	1717	1.000			0.785	3.14	0.25	0.013	0.0098	3.02	2372	17.50	13.50	16.50	12.48	15.50	11.48	1.00	1.02
											0																		
34	35	720	15.04		15.04	0.8	10.19	10.00	20.19	336.58	4050	1.500			1.766	4.71	0.38	0.013	0.0035	2.36	4162	17.50	15.00	16.50	14.00	15.00	12.50	1.00	1.00
35	37	30		15.04	15.04	0.8	0.27	20.19	20.46	334.801	4028	1.500			1.766	4.71	0.38	0.013	0.0085	3.69	6514	15.00	15.00	14.00	13.75	12.50	12.25	1.00	1.26
36	37	726	18.27		18.27	0.8	9.36	10.00	19.36	342.112	5000	1.750			2.404	5.50	0.44	0.013	0.0034	2.58	6214	17.50	15.00	16.47	14.00	14.72	12.25	1.03	1.00
37	38	15		33.31	33.31	0.8	0.13	20.46	20.59	333.925	8898	1.750			2.404	5.50	0.44	0.013	0.0070	3.71	8917	15.00	15.00	14.00	13.90	12.25	12.15	1.00	1.11
											0																		
39	40	351	2.70		2.70	0.8	6.49	7.00	13.49	388.39	839	0.800			0.502	2.51	0.20	0.013	0.0047	1.80	906	14.80	13.50	13.80	12.15	13.00	11.35	1.00	1.35
40	88	327	2.48	2.70	5.18	0.8	5.72	13.49	19.20	343.191	1422	1.000			0.785	3.14	0.25	0.013	0.0039	1.91	1497	13.50	13.50	12.35	11.07	11.35	10.07	1.15	2.43
											0																		
41	42	351	6.46		6.46	0.8	4.62	7.00	11.62	406.117	2099	1.250			1.227	3.93	0.31	0.013	0.0051	2.53	3103	14.80	13.50	13.79	12.00	12.54	10.75	1.01	1.50
42	89	337	7.20	6.46	13.66	0.8	7.03	11.62	18.65	347.042	3792	1.750			2.404	5.50	0.44	0.013	0.0013	1.60	3843	13.50	13.50	12.50	12.06	10.75	10.31	1.00	1.44
43	90	390	5.49		5.49	0.8	9.81	7.00	16.81	360.646	1584	1.250			1.227	3.93	0.31	0.013	0.0014	1.33	1626	13.50	13.50	12.50	11.95	11.25	10.70	1.00	1.55
											0																		
44	91	398	5.21		5.21	0.8	10.81	7.00	17.81	353.104	1472	1.250			1.227	3.93	0.31	0.013	0.0012	1.23	1505	13.50	13.50	12.50	12.02	11.25	10.77	1.00	1.48
											0																		
46	94	236	2.01		2.01	0.8	10.52	7.00	17.52	355.255	571	1.000			0.785	3.14	0.25	0.013	0.0006	0.75	587	13.50	13.50	12.50	12.36	11.50	11.36	1.00	1.14
94	95	30		2.01	2.01	0.8	0.53	17.52	18.05	351.348	565	1.000			0.785	3.14	0.25	0.013	0.0038	1.88	1477	13.50	13.50	12.36	12.25	11.36	11.25	1.14	1.25
45	95	236	2.00		2.00	0.8	7.95	5.00	12.95	393.303	629	1.000			0.785	3.14	0.25	0.013	0.0011	0.99	777	13.50	13.50	12.50	12.25	11.50	11.25	1.00	1.25
95	93	32		4.01	4.01	0.8	0.67	10.00	10.67	415.875	1334	1.250			1.227	3.93	0.31	0.013	0.0020	1.58	1943	13.50	13.50	12.50	12.44	11.25	11.19	1.00	1.06
											0																		
92	93	730	12.37		12.37	0.8	13.60	10.00	23.60	315.603	3123	1.500			1.766	4.71	0.38	0.013	0.0020	1.79	3160	13.50	13.50	12.50	11.04	11.00	9.54	1.00	2.46
47	48	339	18.40		18.40	0.8	3.48	10.00	13.48	388.481	5718	1.500			1.766	4.71	0.38	0.013	0.0066	3.25	5740	17.40	15.70	16.40	14.16	14.90	12.66	1.00	1.54
48	49	692	16.20	18.40	34.60	0.8	7.96	13.48	21.43	328.567	9095	2.000			3.140	6.28	0.50	0.013	0.0036	2.90	9104	15.70	13.50	14.66	12.18	12.66	10.18	1.04	1.32
49	50	20		34.60	34.60	0.8	0.22	21.43	21.65	327.213	9057	2.000			3.140	6.28	0.50	0.013	0.0040	3.06	9623	13.50	13.10	12.18	12.10	10.18	10.10	1.32	1.00
51	52	377	5.30		5.30	0.8	5.19	7.00	12.19	400.589	1698	1.000			0.785	3.14	0.25	0.013	0.0063	2.42	1902	17.60	15.70	16.58	14.20	15.58	13.20	1.02	1.50
52	53	660	7.70	5.30	13.00	0.8	9.52	12.19	21.70	326.888	3400	1.500			1.766	4.71	0.38	0.013	0.0033	2.31	4083	15.70	13.50	14.70	12.50	13.20	11.00	1.00	1.00
53	54	20		13.00	13.00	0.8	0.29	21.70	21.99	325.106	3381	1.500			1.766	4.71	0.38	0.013	0.0033	2.30	4059	13.50	13.10	12.50	12.43	11.00	10.93	1.00	1.00
56	58	158	3.75		3.75	0.8	1.62	8.00	9.62	427.239	1282	0.800			0.502	2.51	0.20	0.013	0.0152	3.24	1629	18.40	16.00	16.45	14.05	15.65	13.25	1.95	1.95
57	58	539	19.20		19.20	0.8	7.01	10.00	17.01	359.079	5515	1.750			2.404	5.50	0.44	0.013	0.0033	2.56	6159	17.80	16.00	16.80	15.00	15.05	13.25	1.00	1.00
58	59	30		22.95	22.95	0.8	0.25	17.01	17.26	357.203	6558	1.750			2.404	5.50	0.44	0.013	0.0083	4.04	9709	16.00	16.00	15.00	14.75	13.25	13.00	1.00	1.25
22	60	246	1.00		1.00	0.8	3.30	8.00	11.30	409.409	328	0.800			0.502	2.51	0.20	0.013	0.0089	2.49	1249	20.60	18.40	19.60	17.40	18.80	16.60	1.00	1.00
60	59	173	2.60		2.60	0.8	1.52	8.00	9.52	428.4	891	0.800			0.502	2.51	0.20	0.013	0.0208	3.79	1906	18.40	16.00	17.40	13.80	16.60	13.00	1.00	2.20
61	59	536	9.77		9.77	0.8	7.32	9.00	16.32	364.461	2849	1.250			1.227	3.93	0.31	0.013	0.0048	2.44	2995	17.80	16.00	16.80	14.25	15.55	13.00	1.00	1.75
59	62	30		35.32	35.32	0.8	0.31	17.26	17.57	354.876	10027	2.000			3.140	6.28	0.50	0.013	0.0044	3.21	10093	16.00	16.00	15.00	14.87	13.00	12.87	1.00	1.13
63	64	177	3.47		3.47	0.8	2.51	8.00	10.51	417.628	1159	0.800			0.502	2.51	0.20	0.013	0.0080	2.35	1182	17.10	16.00	16.10	14.68	15.30	13.88	1.00	1.32
65	66	175	4.40		4.40	0.8	2.41	8.00	10.41	418.692	1474	1.000			0.785	3.14	0.25	0.013	0.0063	2.42	1902	17.10	16.00	16.10	15.00	15.10	14.00	1.00	1.00
67	68	110	2.00		2.00	0.8	1.39	9.00	10.39	418.838	670	0.800			0.502	2.51	0.20	0.013	0.0100	2.63	1322	17.10	16.00	16.10	15.00	15.30	14.20	1.00	1.00
69	70	110	2.00		2.00	0.8	1.39	9.00	10.39	418.838	670	0.800			0.502	2.51	0.20	0.013	0.0100	2.63	1322	17.10	16.00	16.10	15.00	15.30	14.20	1.00	1.00
71	73	731	42.90		42.90	0.8	8.92	10.00	18.92	345.139	11845		2.200	2.200	4.356	6.16	0.71	0.013	0.0020	2.73	11894	14.00	13.50	13.66	12.20	11.46	10.00	0.34	1.30
72	73	135	19.80		19.80	0.8	1.37	10.00	11.37	408.707	6474	1.750			2.404	5.50	0.44	0.013	0.0055	3.29	7910	13.50	13.50	12.49	11.75	10.74	10.00	1.01	1.75
73	74	50		62.70	62.70	0.8	0.47	18.92	19.40	341.862	17148	2.500			4.906	7.85	0.63	0.013	0.0039	3.51	17229	13.50	13.00	12.50	12.31	10.00	9.81	1.00	0.70
76	77	491	10.05		10.05	0.8	4.66	10.00	14.66	378.067	3040		1.200	1.000	1.080	3.00	0.36	0.013	0.0081	3.51	3793	17.60	13.60	17.40	13.40	16.40	12.40	0.20	0.20
75	77	422	3.66		3.66	0.8	6.74	6.00	12.74	395.284	1157		0.800	0.800	0.576	2.24	0.26	0.013	0.0045	2.09	1202	15.30	13.60	15.10	13.20	14.30	12.40	0.20	0.40
77	79	30		13.71	13.71	0.8	0.30	14.66	14.96	375.544	4119		1.200	1.200	1.296	3.36	0.39	0.013	0.0068	3.36	4356	13.60	13.60	13.60	13.40	12.40	12.20	0.00	0.20
78	79	425	4.21		4.21	0.8	5.33	8.00	13.33	389.817	1313		0.800	0.800	0.576	2.24	0.26	0.013	0.0073	2.66	1531	15.30	13.60	15.10	12.00	14.30	11.20	0.20	1.60
79	80	847	17.58	17.92	35.50	0.8	17.22	14.96	32.18	273.863	7778		2.400	2.200	4.752	6.36	0.75	0.013	0.0007	1.64	7791	13.60	13.50	13.40	12.83	11.20	10.63	0.20	0.67
80	83	30		35.50	35.50	0.8	0.67	32.18	32.85	271.108	7699		2.400	2.400	5.184	6.72	0.77	0.013	0.0005	1.49	7722	13.50	13.50	13.03	13.01	10.63	10.61	0.47	0.49
81	82	510	7.78		7.78	0.8	5.25	10.00	15.25	373.061	2322		0.800	1.000	0.720	2.60	0.28	0.013	0.0098	3.24	2329	17.60	13.60	17.40	12.40	16.40	11.40	0.20	1.20
82	83	858	17.37	7.78	25.15	0.8	16.46	15.25	31.71	275.817	5549		2.000	2.000	3.600	5.60	0.64	0.013	0.0009	1.74	6256	13.60	13.50	13.40	12.61	11.40	10.61	0.20	0.89
83	84	613	9.86	60.65	70.51	0.8	8.93	32.85	41.78	239.619	13516		2.800	2.400	6.048	7.12	0.85	0.013	0.0011	2.29	13839	13.50	13.50	13.01	12.34	10.61	9.94	0.49	1.16

Source: JICA Study Team

Table C.3.1 Hydraulic Design (2/5)

Project Hoa Lac Hi-Tech Park
Location Hanoi
Drainage Basin: Dua Gai -CATCHMENT 2
TOTAL AREA = 275.3 HA

Formula	$Q=1/360xCxIxA$; $I= 0.36 \times 5416 \times (1+ 0.25 \times lgP \times t^{0.13})/(t+19)^{0.82}$; $Q=A \times 1/Mn \times R^{2/3} \times S^{1/2}$ (Manning)	
Lo (m): 100	P 5	Runoff Coefficient 0.8
To (min): 5-10		

From Node	To Node	Length	Catchment Self	Catchment Pass	Catchment Total	Runoff co-efficient	Concentration time Self	Concentration time Pass	Concentration time Total	Rainfall intensity	Peak Flow	Pipe Diameter	Box Cuvert Width	Box Cuvert Height	Sectional Area	Wet perimeter	Hydraulic Radius	Manning	Hydraulic Gradient	Velocity	Flow Capacity	Ground elevation Up	Ground elevation Down	Top Level Up	Top Level Down	Invert Level Up	Invert Level Down	Soil Coverage depth Up	Soil Coverage depth Down
		L			A	C	T1	T2	Tt	I	Q	D	B	H	S	S	R	n	I	V		Up	Down	Up	Down	Up	Down	Up	Down
		(m)	(ha)	(ha)	(ha)		(min)	(min)	(min)		(l/s)	(m)	(m)	(m)	(m2)	(m2)	(m)			(m/s)	(l/s)	m	m	m	m	m	m	m	m
96	98	288	4.03		4.03	0.8	1.94	7.00	8.94	435.001	1402		0.800	0.800	0.576	2.24	0.26	0.013	0.0253	4.95	2850	22.60	15.50	22.38	15.09	21.58	14.29	0.22	0.41
97	98	345	3.48		3.48	0.8	9.20	7.00	16.20	365.417	1017		1.000	1.000	0.900	2.80	0.32	0.013	0.0012	1.25	1125	15.90	15.50	15.70	15.29	14.70	14.29	0.20	0.21
98	100	30		7.51	7.51	0.8	0.24	16.20	16.44	363.502	2184		1.000	1.000	0.900	2.80	0.32	0.013	0.0130	4.12	3704	15.50	15.50	15.29	14.90	14.29	13.90	0.21	0.60
99	100	350	3.31		3.31	0.8	7.44	5.00	12.44	398.111	1054		0.800	1.000	0.720	2.60	0.28	0.013	0.0023	1.57	1128	15.90	15.50	15.70	14.90	14.70	13.90	0.20	0.60
100	101	488	7.57	10.82	18.39	0.8	4.86	16.44	21.30	329.424	4846		1.400	1.400	1.764	3.92	0.45	0.013	0.0055	3.35	5909	15.50	13.20	15.28	12.60	13.88	11.20	0.22	0.60
101	102	184	1.64	18.39	20.03	0.8	3.46	21.30	24.76	309.15	4954		1.800	1.800	2.916	5.04	0.58	0.013	0.0011	1.77	5165	13.20	13.20	13.00	12.80	11.20	11.00	0.20	0.40
103	102	246	2.63		2.63	0.8	3.62	7.00	10.62	416.42	876		0.800	1.000	0.720	2.60	0.28	0.013	0.0048	2.26	1630	13.40	13.20	13.18	12.00	12.18	11.00	0.22	1.20
102	107	35		22.66	22.66	0.8	0.61	24.76	25.36	305.886	5545		1.800	1.800	2.916	5.04	0.58	0.013	0.0013	1.93	5615	13.20	13.20	12.80	12.75	11.00	10.95	0.40	0.45
1	2	830	13.01		13.01	0.8	22.06	10.00	32.06	274.334	2855	1.750			2.404	5.50	0.44	0.013	0.0008	1.25	3014	14.500	14.200	13.50	12.84	11.75	11.09	1.00	1.36
2	3	453	3.80	13.01	16.81	0.8	15.58	32.06	47.65	223.029	2999	2.000			3.140	6.28	0.50	0.013	0.0004	0.97	3043	14.200	14.000	13.11	12.93	11.11	10.93	1.09	1.07
											0																		
4	3	482	3.43		3.43	0.8	7.05	7.00	14.05	383.341	1052	0.800			0.502	2.51	0.20	0.013	0.0075	2.28	1145	17.600	14.000	16.60	12.99	15.80	12.19	1.00	1.02
											0																		
5	7	251	5.39		5.39	0.8	3.54	7.00	10.54	417.301	1799	1.000			0.785	3.14	0.25	0.013	0.0060	2.36	1856	15.500	14.000	14.50	12.99	13.50	11.99	1.00	1.01
											0																		
6	7	392	5.07		5.07	0.8	11.12	7.00	18.12	350.84	1423	1.250			1.227	3.93	0.31	0.013	0.0011	1.17	1441	14.000	14.000	13.00	12.57	11.75	11.32	1.00	1.43
											0																		
8	10	244	3.50		3.50	0.8	3.48	7.00	10.48	417.937	1170	0.800			0.502	2.51	0.20	0.013	0.0079	2.34	1175	15.500	14.000	14.50	12.57	13.70	11.77	1.00	1.43
											0																		
9	10	363	4.19		4.19	0.8	12.91	7.00	19.91	338.403	1134	1.250			1.227	3.93	0.31	0.013	0.0007	0.94	1150	14.000	14.000	13.00	12.75	11.75	11.50	1.00	1.25
											0																		
11	13	360	4.19		4.19	0.8	12.02	7.00	19.02	344.476	1155		1.200	1.200	1.296	3.36	0.39	0.013	0.0006	1.00	1294	14.200	14.000	14.00	13.78	12.80	12.58	0.20	0.22
12	13	365	7.07		7.07	0.8	5.21	7.00	12.21	400.369	2264		1.200	1.000	1.080	3.00	0.36	0.013	0.0036	2.34	2523	15.300	14.000	15.10	13.79	14.10	12.79	0.20	0.21
13	15	35	0.00	11.26	11.26	0.8	0.49	19.02	19.51	341.102	3073		1.200	1.200	1.296	3.36	0.39	0.013	0.0034	2.38	3080	14.000	14.000	13.80	13.68	12.60	12.48	0.20	0.32
14	15	340	2.27		2.27	0.8	12.82	7.00	19.82	339.019	616		1.000	1.000	0.900	2.80	0.32	0.013	0.0006	0.88	796	14.200	14.000	14.00	13.80	13.00	12.80	0.20	0.20
15	17	34		13.53	13.53	0.8	0.40	19.51	19.91	338.426	3663		1.200	1.200	1.296	3.36	0.39	0.013	0.0049	2.85	3698	14.000	14.000	13.80	13.63	12.60	12.43	0.20	0.37
16	17	375	3.18		3.18	0.8	6.79	7.00	13.79	385.643	981		0.800	0.800	0.576	2.24	0.26	0.013	0.0035	1.84	1060	15.300	14.000	15.10	13.79	14.30	12.99	0.20	0.21
17	18	40	0.00	16.71	16.71	0.8	0.37	19.91	20.27	336.002	4492		1.200	1.200	1.296	3.36	0.39	0.013	0.0080	3.65	4725	14.000	13.500	13.80	13.48	12.60	12.28	0.20	0.02
18	19	20		16.71	16.71	0.8	0.18	19.91	20.09	337.209	4508		1.200	1.200	1.296	3.36	0.39	0.013	0.0080	3.65	4725	13.500	13.500	13.30	13.14	12.10	11.94	0.20	0.36
										484.285	0																		
20	22	90	1.00		1.00	0.8	1.47	7.00	8.47	440.49	352	0.800			0.502	2.51	0.20	0.013	0.0060	2.04	1024	14.000	14.000	13.00	12.46	12.20	11.66	1.00	1.54
21	22	246	1.00		1.00	0.8	3.65	7.00	10.65	416.14	333	0.800			0.502	2.51	0.20	0.013	0.0073	2.25	1129	15.800	14.000	14.80	13.00	14.00	12.20	1.00	1.00
										484.285	0																		
23	25	178	2.26		2.26	0.8	2.64	7.00	9.64	427.061	772	0.800			0.502	2.51	0.20	0.013	0.0073	2.25	1129	15.300	14.000	14.30	13.00	13.50	12.20	1.00	1.00
24	25	234	1.34		1.34	0.8	9.88	7.00	16.88	360.07	386	0.800			0.502	2.51	0.20	0.013	0.0009	0.79	397	14.000	14.000	13.00	12.79	12.20	11.99	1.00	1.21
25	27	30		3.60	3.60	0.8	0.75	16.88	17.63	354.407	1021	1.000			0.785	3.14	0.25	0.013	0.0019	1.33	1045	14.000	14.000	12.99	12.93	11.99	11.93	1.01	1.07
26	27	193	0.30		0.30	0.8	8.15	7.00	15.15	373.918	90	0.800			0.502	2.51	0.20	0.013	0.0009	0.79	397	14.000	14.000	13.00	12.83	12.20	12.03	1.00	1.17
27	28	60	0.20	3.90	4.10	0.8	1.37	17.63	19.00	344.603	1130	1.000			0.785	3.14	0.25	0.013	0.0023	1.46	1149	14.000	14.000	12.93	12.79	11.93	11.79	1.07	1.21
										484.285																			
29	32	306	3.13		3.13	0.8	5.01	7.00	12.01	402.353	1007	0.800			0.502	2.51	0.20	0.013	0.0060	2.04	1024	15.000	13.400	14.00	12.16	13.20	11.36	1.00	1.24
31	32	215	1.25	3.13	4.38	0.8	3.63	7.00	10.63	416.347	1459	1.000			0.785	3.14	0.25	0.013	0.0042	1.98	1550	14.300	13.400	13.30	12.40	12.30	11.40	1.00	1.00
32	34	40		4.38	4.38	0.8	0.72	10.63	11.35	408.92	1433	1.000			0.785	3.14	0.25	0.013	0.0037	1.86	1458	13.400	13.400	12.40	12.25	11.40	11.25	1.00	1.15
33	34	215	1.72		1.72	0.8	4.21	7.00	11.21	410.305	565	0.800			0.502	2.51	0.20	0.013	0.0042	1.70	855	14.300	13.400	13.30	12.40	12.50	11.60	1.00	1.00
34	35	230	3.23	6.10	9.33	0.8	3.30	11.35	14.65	378.178	2823	1.250			1.227	3.93	0.31	0.013	0.0043	2.32	2849	13.400	13.200	12.40	11.41	11.15	10.16	1.00	1.79
										484.285	0																		
36	38	338	6.73		6.73	0.8	4.63	7.00	11.63	406.072	2186	1.250			1.227	3.93	0.31	0.013	0.0047	2.43	2985	15.000	13.400	14.00	12.40	12.75	11.15	1.00	1.00
37	38	187	2.43		2.43	0.8	2.56	7.00	9.56	428.007	832	0.800			0.502	2.51	0.20	0.013	0.0086	2.44	1226	15.000	13.400	14.00	12.39	13.20	11.59	1.00	1.01
38	40	40		9.16	9.16	0.8	0.79	11.63	12.42	398.384	2919	1.500			1.766	4.71	0.38	0.013	0.0018	1.70	2998	13.400	13.400	12.40	12.33	10.90	10.83	1.00	1.07
39	40	172	1.90		1.90	0.8	4.36	7.00	11.36	408.797	621	0.800			0.502	2.51	0.20	0.013	0.0025	1.32	661	13.400	13.200	12.40	11.97	11.60	11.17	1.00	1.23
40	41	230	2.27	11.06	13.33	0.8	4.80	12.42	17.21	357.57	3813	1.750			2.404	5.50	0.44	0.013	0.0013	1.60	3843	13.400	13.200	12.40	12.10	10.65	10.35	1.00	1.10
										484.285																			
42	43	305	5.20		5.20	0.8	6.42	7.00	13.42	389.022	1618	1.250			1.227	3.93	0.31	0.013	0.0020	1.58	1943	13.700	13.100	12.70	12.09	11.45	10.84	1.00	1.01
43	44	280	1.84	5.20	7.04	0.8	5.89	13.42	19.31	342.473	1929	1.250			1.227	3.93	0.31	0.013	0.0020	1.58	1943	13.100	13.000	12.09	11.53	10.84	10.28	1.01	1.47
44'	44	126	1.00		1.00	0.8	6.52	7.00	13.52	388.113	310	0.800			0.502	2.51	0.20	0.013	0.0006	0.64	324	13.000	13.000	12.00	11.92	11.20	11.12	1.00	1.08
											0																		
49	51	370	4.70		4.70	0.8	5.77	7.00	12.77	394.999	1485	1.000			0.785	3.14	0.25	0.013	0.0049	2.14	1677	14.900	13.100	13.90	12.09	12.90	11.09	1.00	1.01
50	51	280	3.85		3.85	0.8	3.09	7.00	10.09	422.15	1300	0.800			0.502	2.51	0.20	0.013	0.0132	3.02	1519	16.800	13.100	15.80	12.10	15.00	11.30	1.00	1.00
51	57	40		8.55	8.55	0.8	0.61	12.77	13.38	389.344	2663	1.250			1.227	3.93	0.31	0.013	0.0038	2.18	2678	13.100	13.100	12.10	11.95	10.85	10.70	1.00	1.15
55	57	204	3.17		3.17	0.8	1.92	7.00	8.92	435.244	1104	0.800			0.502	2.51	0.20	0.013	0.0181	3.54	1780	16.800	13.100	15.80	12.10	15.00	11.30	1.00	1.00
57	56	198	2.56	11.72	14.28	0.8	3.42	8.92	12.33	399.155	4560	1.750			2.404	5.50	0.44	0.013	0.0019	1.93	4645	13.100	13.100	12.10	11.72	10.35	9.97	1.00	1.38
56	58	30		14.28	14.28	0.8	0.52	12.33	12.85	394.241	4504	1.750			2.404	5.50	0.44	0.013	0.0019	1.93	4645	13.100	13.100	11.72	11.66	9.97	9.91	1.38	1.44
58	B8	30		14.28	14.28	0.8	0.52	12.85	13.37	389.457	4449	1.750			2.404	5.50	0.44	0.013	0.0019	1.93	4645	13.100	13.100	11.66	11.60	9.91	9.85	1.44	1.50
52	53	272	5.19		5.19	0.8	3.87	7.00	10.87	413.792	1718	1.000			0.785	3.14	0.25	0.013	0.0059	2.34	1838	14.700	13.100	13.70	12.10	12.70	11.10	1.00	1.00
53	59	50		13.74	13.74	0.8	0.69	13.38	14.08	383.125	4211	1.500			1.766	4.71	0.38	0.013	0.0036	2.40	4239	13.100	13.100	12.10	11.92	10.60	10.42	1.00	1.18
59	58	189	3.64	22.19	25.83	0.8	2.60	14.08	16.68	361.66	7473	2.000			3.140	6.28	0.50	0.013	0.0025	2.42	7608	13.100	13.100	12.10	11.63	10.10	9.63	1.00	1.47
58	B8	30		36.48	36.48	0.8	0.30	16.68	16.97	359.37	10488	2.000			3.140	6.28	0.50	0.013	0.0048	3.36	10542	13.100	13.100	11.63	11.49	9.63	9.49	1.47	1.61
45	46	286	1.68		1.68	0.8	6.46	7.00	13.46	388.637	522	0.800			0.502	2.51	0.20	0.013	0.0031	1.48	741	14.900	14.000	13.90	13.00	13.10	12.20	1.00	1.00
46	48	30		1.68	1.68	0.8	0.85	13.46	14.31	381.085	512	0.800			0.502	2.51	0.20	0.013	0.0020	1.18	591	14.000	14.000	13.00	12.94	12.20	12.14	1.00	1.06
47	48	286	1.60		1.60	0.8	6.46	7.00	13.46	388.637	497	0.800			0.502	2.51	0.20	0.013	0.0031	1.48	741	14.900	14.000	13.90	13.00	13.10	12.20	1.00	1.00
48	54	356	5.17	3.28	8.45	0.8	6.45	14.31	20.76	332.854	2250	1.250			1.227	3.93	0.31	0.013	0.0027	1.84	2258	14.000	13.100	13.00	12.04	11.75	10.79	1.00	1.06
53'	54	277	2.20		2.20	0.8	9.56	7.00	16.56	362.53	638	1.000			0.785	3.14	0.25	0.013	0.0010	0.97	758	13.100	13.100	12.10	11.82	11.10	10.82	1.00	1.28
54	60	40		10.65	10.65	0.8	0.53	20.76	21.29	329.467	2807	1.250			1.227	3.93	0.31	0.013	0.0050	2.50	3072	13.100	13.100	12.04	11.84	10.79	10.59	1.06	1.26
59'	60	277	2.43		2.43	0.8	10.08	7.00	17.08	358.551	697	1.000			0.785	3.14	0.25	0.013	0.0009	0.92	719	13.100	13.100	12.10	11.85	11.10	10.85	1.00	1.25
60	61	243	0.50	13.08	13.58	0.8	4.32	21.29	25.61	304.602	3309	1.500			1.766	4.71	0.38	0.013	0.0022	1.88	3314	13.100	13.100	12.09	11.56	10.59	10.06	1.01	1.54
61'	61	126	1.74		1.74	0.8	5.62	7.00	12.62	396.461	552	1.000			0.785	3.14	0.25	0.013	0.0006	0.75	587	13.000	13.000	12.00	11.92	11.00	10.92	1.00	1.08
											0																		
62	63	313	1.00		1.00	0.8	5.09	7.00	12.09	401.524	321	0.800			0.502	2.51	0.20	0.013	0.0061	2.05	1030	17.900	16.000	16.90	15.00	16.10	14.20	1.00	1.00
63	64	566	6.80	1.00	7.80	0.8	7.77	12.09	19.86	338.747	2114	1.250			1.227	3.93	0.31	0.013	0.0047	2.43	2979	16.000	13.400	15.00	12.34	13.75	11.09	1.00	1.06
64	28	105	3.70	7.80	11.50	0.8	2.06	19.86	21.92	325.543	2995	1.500			1.766	4.71	0.38	0.013	0.0018	1.70	2998	13.400	13.400	12.40	12.21	10.90	10.71	1.00	1.19
										484.285	0																		
65	66	313	4.28		4.28	0.8	4.38	7.00	11.38	408.622	1399	1.000			0.785	3.14	0.25	0.013	0.0061	2.38	1872	17.900	16.000	16.90	14.99	15.90	13.99	1.00	1.01
66	68	622	7.45	4.28	11.73	0.8	8.00	11.38	19.37	342.031	3210	1.500			1.766	4.71	0.38	0.013	0.0042	2.59	4579	16.000	13.400	15.00	12.39	13.50	10.89	1.00	1.01
										484.285	0																		
67	68	160	2.00		2.00	0.8	4.05	7.00	11.05	411.905	659	0.800			0.502	2.51	0.20	0.013	0.0025	1.32	661	14.500	14.100	13.50	13.10	12.70	12.30	1.00	1.00
										484.285	0																		
96	98	295	1.00		1.00	0.8	2.64	7.00	9.64	427.024	342	0.800			0.502	2.51	0.20	0.013	0.0200	3.72	1869	21.400	15.500	20.40	14.50	19.60	13.70	1.00	1.00
97	98	347	9.43		9.43	0.8	7.01	7.00	14.01	383.686	2895	1.500			1.766	4.71	0.38	0.013	0.0017	1.65	2913	15.900	15.500	14.90	14.31	13.40	12.81	1.00	1.19
98	100	25		10.43	10.43	0.8	0.45	14.01	14.47	379.719	3168	1.500			1.766	4.71	0.38	0.013	0.0021	1.83	3238	15.500	15.500	14.20	14.15	12.70	12.65	1.30	1.35
99	100	352	1.00		1.00	0.8	13.23		13.23	390.73	313	0.800			0.502	2.51	0.20	0.013	0.0011	0.89	446	15.900	15.500	14.90	14.50	14.10	13.70	1.00	1.00
100	101	489	4.50	11.43	15.93	0.8	5.70	14.47	20.17	336.703	4291	1.500			1.766	4.71	0.38	0.013	0.0051	2.86	5052	15.500	13.000	14.15	11.65	12.65	10.15	1.35	1.35
101	102	184	10.04	15.93	25.97	0.8	2.90	20.17	23.07	318.674	6621	2.000			3.140	6.28	0.50	0.013	0.0019	2.11	6632	13.000	13.000	12.00	11.65	10.00	9.65	1.00	1.35
103	102	248	7.44		7.44	0.8	5.17	7.00	12.17	400.783	2385	1.500			1.766	4.71	0.38	0.013	0.0016	1.60	2826	13.400	13.000	12.40	12.00	10.90	10.50	1.00	1.00
102	107	25		33.41	33.41	0.8	0.31	23.07	23.38	316.883	8470	2.000			3.140	6.28	0.50	0.013	0.0031	2.70	8472	13.000	13.000	11.65	11.57	9.65	9.57	1.35	1.43
104	107	248	2.46		2.46	0.8	6.77	7.00	13.77	385.845	759	1.000			0.785	3.14	0.25	0.013	0.0016	1.22	959	13.400	13.000	12.40	12.00	11.40	11.00	1.00	1.00
105	106	220	1.00		1.00	0.8	2.12	7.00	9.12	432.92	346	0.800			0.502	2.51	0.20	0.013	0.0173	3.46	1737	16.800	13.000	15.80	12.00	15.00	11.20	1.00	1.00
106	107	143	3.50	1.00	4.50	0.8	3.88	7.00	10.88	413.667	1489	1.250			1.227	3.93	0.31	0.013	0.0012	1.23	1505	13.000	13.000	12.00	11.83	10.75	10.58	1.00	1.17
										484.285	0																		
108	109	318	4.98		4.98	0.8	2.91	7.00	9.91	424.032	1689	1.000			0.785	3.14	0.25	0.013	0.0142	3.64	2856	17.500	13.000	16.50	11.98	15.50	10.98	1.00	1.02
109	110	217	2.90	4.98	7.88	0.8	5.22	9.91	15.13	374.065	2358	1.500			1.766	4.71	0.38	0.013	0.0012	1.39	2447	13.000	13.000	12.00	11.74	10.50	10.24	1.00	1.26
41	110	210	1.61		1.61	0.8	7.11	7.00	14.11	382.82	493	0.800			0.502	2.51	0.20	0.013	0.0014	0.98	495	13.000	13.000	11.99	11.70	11.19	10.90	1.01	1.30
111	112	240	2.50		2.50	0.8	2.36	7.00	9.36	430.25	861	0.800			0.502	2.51	0.20	0.013	0.0167	3.40	1706	17.000	13.000	16.00	12.00	15.20	11.20	1.00	1.00
35	112	230	3.10		3.10	0.8	6.09	7.00	13.09	392.018	972	1.000			0.785	3.14	0.25	0.013	0.0017	1.26	988	13.000	13.000	12.00	11.61	11.00	10.61	1.00	1.39
112	110	30		5.60	5.60	0.8	0.71	13.09	13.80	385.604	1728	1.250			1.227	3.93	0.31	0.013	0.0016	1.42	1738	13.000	13.000	11.86	11.81	10.61	10.56	1.14	1.19
110	116	30		15.09	15.09	0.8	0.38	13.80	14.18	382.235	4614	1.500			1.766	4.71	0.38	0.013	0.0043	2.62	4633	13.000	13.000	12.00	11.87	10.50	10.37	1.00	1.13
114	115	297	6.35		6.35	0.8	2.70	7.00	9.70	426.444	2166	1.000			0.785	3.14	0.25	0.013	0.0145	3.67	2883	17.300	13.000	16.30	12.00	15.30	11.00	1.00	1.00
115	116	212	7.41	6.35	13.76	0.8	3.66	7.00	10.66	416.047	4580	1.750			2.404	5.50	0.44	0.013	0.0019	1.93	4645	13.000	13.000	12.00	11.60	10.25	9.85	1.00	1.40
113	116	240	6.51		6.51	0.8	2.03	7.00	9.03	433.99	2260	1.000			0.785	3.14	0.25	0.013	0.0167	3.94	3097	17.000	13.000	16.00	11.99	15.00	10.99	1.00	1.01
										484.285																			
23	C4	331	2.00		2.00	0.8	4.64	7.00	11.64	405.931	649	0.800			0.502	2.51	0.20	0.013	0.0082	2.38	1194	20.100	17.400	19.10	16.40	18.30	15.60	1.00	1.00
C4	24	267	2.00	2.00	4.00	0.8	3.25	11.64	14.89	376.115	1204	0.800			0.502	2.51	0.20	0.013	0.0109	2.74	1377	17.400	14.500	16.40	13.50	15.60	12.70	1.00	1.00
										484.285	0																		
C4	24'	249	2.00		2.00	0.8	2.92	7.00	9.92	423.927	678	0.800			0.502	2.51	0.20	0.013	0.0116	2.84	1426	17.400	14.500	16.40	13.50	15.60	12.70	1.00	1.00
										484.285	0																		
D4	24''	180	2.00		2.00	0.8	4.56	7.00	11.56	406.753	651	0.800			0.502	2.51	0.20	0.013	0.0025	1.32	661	14.500	14.500	13.50	13.05	12.70	12.25	1.00	1.45
										484.285	0													-1.00	-1.00	-1.00	-1.00	1.00	1.00
D4	24'''	180	2.00		2.00	0.8	4.56	7.00	11.56	406.753	651	0.800			0.502	2.51	0.20	0.013	0.0025	1.32	661	14.500	14.500	13.50	13.05	12.70	12.25	1.00	1.45
										484.285	0																		
H3	G2	434	2.73		2.73	0.8	28.88	7.00	35.88	259.423	567	1.250			1.227	3.93	0.31	0.013	0.0002	0.50	614	15.600	15.600	14.60	14.51	13.35	13.26	1.00	1.09
G2	E2	236	0.50	2.73	3.23	0.8	15.70	35.88	51.58	213.273	551	1.250			1.227	3.93	0.31	0.013	0.0002	0.50	614	15.600	15.800	14.51	14.46	13.26	13.21	1.09	1.34
E2	D4	265	0.50	3.23	3.73	0.8	3.56	51.58	55.14	205.241	612	1.250			1.227	3.93	0.31	0.013	0.0049	2.48	3043	15.800	14.500	14.46	13.16	13.21	11.91	1.34	1.34
D4	D3	183		3.73	3.73	0.8	3.29	55.14	58.44	198.394	592	1.250			1.227	3.93	0.31	0.013	0.0027	1.85	2271	14.500	14.000	13.16	12.66	11.91	11.41	1.34	1.34

Source: JICA Study Team

Project Hoa Lac Hi-Tech Park
Location Hanoi
Drainage Basin: NEWLY-BUILT RESERVOIR -CATCHMENT 3
TOTAL AREA = 244.1 HA

Formula		$Q=1/360xCxIxA$; $I= 0.36 \times 5416 \times (1+ 0.25 \times lgP \times t^{0.13})/(t+19)^{0.82}$; $Q=A \times 1/Mn \times R^{2/3} \times S^{1/2}$ (Manning)		
Lo (m):	100	P 5	Runoff Coefficient 0.8	
To (min):	5-10			

Table C.3.1 Hydraulic Design (3/5)

From Node	To Node	Length	Catchment Self	Catchment Pass	Catchment Total	Runoff co-efficient	Concentration time Self	Concentration time Pass	Concentration time Total	Rainfall intensity	Peak Flow	Pipe Diameter	Box Cuvert Width	Box Cuvert Height	Sectional Area	Wet perimeter	Hydraulic Radius	Manning	Hydraulic Gradient	Velocity	Flow Capacity	Sewer Ground elevation Up	Ground elevation Down	Top Level Up	Top Level Down	Invert Level Up	Invert Level Down	Soil Coverage depth Up	Soil Coverage depth Down
		L			A	C	T1	T2	Tt	I	Q	D	B	H	S	S	R	n	i	V		Up	Down	Up	Down	Up	Down	Up	Down
		(m)	(ha)	(ha)	(ha)		(min)	(min)	(min)		(l/s)	(m)	(m)	(m)	(m2)	(m2)	(m)			(m/s)	(l/s)	m	m	m	m	m	m	m	m
1	3	489	8.27		8.27	0.8	4.71	8.00	12.71	395.55	2617		1.000	1.000	0.900	2.80	0.32	0.013	0.0092	3.46	3113	14.9	11.0	14.70	10.21	13.70	9.21	0.20	0.79
2	3	500	12.25		12.25	0.8	4.73	10.00	14.73	377.44	3699		1.200	1.000	1.080	3.00	0.36	0.013	0.0082	3.52	3802	14.5	11.0	14.30	10.21	13.30	9.21	0.20	0.79
3	5	30		20.52	20.52	0.8	0.21	14.73	14.94	375.67	6167		1.200	1.200	1.296	3.36	0.39	0.013	0.0138	4.79	6206	11.0	11.0	10.41	10.00	9.21	8.80	0.59	1.00
4	5	500	10.26		10.26	0.8	5.66	10.00	15.66	369.7	3034	1.250			1.227	3.93	0.31	0.013	0.0069	2.94	3609	14.5	11.0	13.50	10.05	12.25	8.80	1.00	0.95
5	6	500	13.08	30.78	43.86	0.8	5.14	15.66	20.81	332.54	11668		2.000	2.000	3.600	5.60	0.64	0.013	0.0032	3.24	11668	11.0	10.0	10.80	9.20	8.80	7.20	0.20	0.80
7	8	489	6.93		6.93	0.8	5.63	7.00	12.63	396.35	2197	1.000			0.785	3.14	0.25	0.013	0.0090	2.90	2273	14.9	11.0	13.90	9.50	12.90	8.50	1.00	1.50
8	9	534	9.72	6.93	16.65	0.8	7.32	12.63	19.94	338.18	4505	1.500			1.766	4.71	0.38	0.013	0.0037	2.43	4298	11.0	10.0	10.00	8.02	8.50	6.52	1.00	1.98
10	12	635	10.83		10.83	0.8	9.64	10.00	19.64	340.19	2947		1.400	1.200	1.512	3.56	0.42	0.013	0.0026	2.19	3319	10.9	10.0	10.70	9.08	9.50	7.88	0.20	0.92
11	12	520	14.25		9.49	0.8	12.13	10.00	22.13	324.25	2462		1.400	1.400	1.764	3.92	0.45	0.013	0.0010	1.43	2520	10.0	10.0	9.80	9.28	8.40	7.88	0.20	0.72
12	14	40		20.32	20.32	0.8	0.42	22.13	22.55	321.73	5230		1.400	1.400	1.764	3.92	0.45	0.013	0.0050	3.19	5634	10.0	10.0	9.28	9.08	7.88	7.68	0.72	0.92
13	14	630	9.08		9.08	0.8	9.58	9.00	18.58	347.53	2524		1.200	1.200	1.296	3.36	0.39	0.013	0.0029	2.19	2840	10.9	10.0	10.70	8.88	9.50	7.68	0.20	1.12
14	15	290	12.12	29.40	41.52	0.8	3.44	22.55	26.00	302.57	10050		2.000	2.000	3.600	5.60	0.64	0.013	0.0024	2.81	10105	10.0	10.0	9.68	8.98	7.68	6.98	0.32	1.02
16	17	478	8.11		8.11	0.8	14.08	7.00	21.08	330.77	2146	1.500			1.766	4.71	0.38	0.013	0.0008	1.13	1998	10.00	10.00	9.00	8.62	7.50	7.12	1.00	1.38
											0																		
18	20	364	3.20		3.20	0.8	5.23	6.00	11.23	410.13	1050	1.000			0.785	3.14	0.25	0.013	0.0058	2.32	1822	11.2	10.0	10.20	8.10	9.20	7.10	1.00	1.90
19	20	566	9.66		9.66	0.8	8.43	9.00	17.43	355.91	2750		1.400	1.200	1.512	3.56	0.42	0.013	0.0027	2.24	3383	10.0	10.0	9.80	8.30	8.60	7.10	0.20	1.70
20	22	30		12.86	12.86	0.8	0.23	17.43	17.66	354.23	3644	1.750			2.404	5.50	0.44	0.013	0.0100	4.43	10657	10.0	10.0	8.85	8.55	7.10	6.80	1.15	1.45
21	22	566	12.77		12.77	0.8	15.05	10.00	25.05	307.59	3142	1.750			2.404	5.50	0.44	0.013	0.0008	1.25	3014	10.0	10.0	9.00	8.55	7.25	6.80	1.00	1.45
22	23	207	1.77	25.63	27.40	0.8	4.50	17.66	22.16	324.09	7104	2.000			3.140	6.28	0.50	0.013	0.0010	1.53	4812	10.0	10.0	8.80	8.59	6.80	6.59	1.20	1.41
24	26	295	5.31		5.31	0.8	4.42	7.00	11.42	408.17	1734		1.000	1.2	1.080	3.16	0.34	0.013	0.0035	2.22	2403	13.9	13.5	13.70	12.67	12.50	11.47	0.2	0.83
25	26	466	8.24		8.24	0.8	5.67	9.00	14.67	377.95	2491		1.000	1.2	1.080	3.16	0.34	0.013	0.0053	2.74	2956	15.4	13.5	15.20	12.73	14.00	11.53	0.2	0.77
26	28	30		13.55	13.55	0.8	0.68	14.67	15.35	372.25	4035		2.000	1.4	2.520	4.52	0.56	0.013	0.0008	1.47	3714	13.5	13.5	13.00	12.98	11.60	11.58	0.5	0.52
27	28	466	7.60		7.60	0.8	8.05	8.00	16.05	366.62	2229	1.000			0.785	3.14	0.25	0.013	0.004	1.93	1516	15.4	13.5	14.60	12.74	13.60	11.74	0.8	0.76
28	30	410	6.56	21.15	27.71	0.8	7.95	16.05	23.99	313.4	6947		2.600	1.7	3.978	5.66	0.70	0.013	0.0008	1.72	6842	13.5	13.5	13.30	12.97	11.60	11.27	0.2	0.53
29	30	340	6.57		6.57	0.8	7.58	7.00	14.58	378.77	1991	1.000			0.785	3.14	0.25	0.013	0.0024	1.50	1174	14.3	13.5	13.20	12.38	12.20	11.38	1.1	1.12
30	36	30		34.28	34.28	0.8	0.39	23.99	24.38	311.22	8535		2.000	2	3.600	5.60	0.64	0.013	0.002	2.56	9225	13.5	13.5	13.30	13.24	11.30	11.24	0.2	0.26
31	33	306	2.95		2.95	0.8	5.70	5.00	10.70	415.61	981		0.800	1	0.720	2.60	0.28	0.013	0.003	1.79	1289	13.9	13.5	13.70	12.78	12.70	11.78	0.2	0.72
32	33	330	9.63		9.63	0.8	5.39	9.00	14.39	380.39	2931		1.000	1.5	1.350	3.70	0.36	0.013	0.0027	2.04	2755	14.4	13.5	14.20	13.31	12.70	11.81	0.2	0.19
33	35	30		12.58	12.58	0.8	0.57	14.39	14.96	375.56	3780		1.800	1.5	2.430	4.50	0.54	0.013	0.0012	1.77	4294	13.5	13.5	13.30	13.26	11.80	11.76	0.2	0.24
34	35	329	1.00		1.00	0.8	8.18	5.00	13.18	391.24	313	0.800			0.502	2.51	0.20	0.013	0.0026	1.34	674	14.4	13.5	13.60	12.74	12.80	11.94	0.8	0.76
35	36	405	3.19	13.58	16.77	0.8	7.64	14.96	22.60	321.47	4313		1.800	1.5	2.430	4.50	0.54	0.013	0.0012	1.77	4294	13.5	13.5	13.30	12.81	11.80	11.31	0.2	0.69
36	38	390	10.91	51.05	61.96	0.8	5.36	24.38	29.74	284.42	14098		3.000	2	5.400	6.60	0.82	0.013	0.0013	2.43	13102	13.5	13.0	13.30	12.79	11.30	10.79	0.2	0.21
37	38	384	3.24		3.24	0.8	6.55	6.00	12.55	397.11	1029	1.000			0.785	3.14	0.25	0.013	0.0041	1.95	1534	14.5	13.0	13.50	11.93	12.50	10.93	1.0	1.07
38	40	30		65.20	65.20	0.8	0.37	29.74	30.11	282.75	14748		3.000	2	5.400	6.60	0.82	0.013	0.0016	2.69	14535	13.0	13.0	12.80	12.75	10.80	10.75	0.2	0.25
39	40	385	3.03		3.03	0.8	6.57	6.00	12.57	396.95	962	1.000			0.785	3.14	0.25	0.013	0.0041	1.95	1534	14.5	13.0	13.50	11.92	12.50	10.92	1.0	1.08
40	41	556	10.41	68.23	78.64	0.8	5.11	30.11	35.23	261.84	16473		3.000	2	5.400	6.60	0.82	0.013	0.0029	3.62	19568	13.0	11.4	12.80	11.19	10.80	9.19	0.2	0.21
41	43	403	2.79	78.64	81.43	0.8	3.16	35.23	38.38	250.58	16324		3.000	2	5.400	6.60	0.82	0.013	0.004	4.26	22982	11.4	10.0	11.20	9.59	9.20	7.59	0.2	0.41
42	43	519	10.93		10.93	0.8	5.53	9.00	14.53	379.18	3316	1.250			1.227	3.93	0.31	0.013	0.0078	3.13	3837	14.0	10.0	13.00	8.95	11.75	7.70	1.0	1.05
43	48	30		92.36	92.36	0.8	0.14	38.38	38.53	250.09	18479		3.000	2.2	5.940	6.96	0.85	0.013	0.01	6.92	41111	10.0	10.0	9.80	9.50	7.60	7.30	0.2	0.50
44	45	503	1.36		1.36	0.8	18.40	5.00	23.40	316.77	345	0.800			0.502	2.51	0.20	0.013	0.0012	0.91	458	15.1	14.5	14.10	13.50	13.30	12.70	1.0	1.00
45	47	30		1.36	1.36	0.8	0.27	23.40	23.67	315.23	343	0.800			0.502	2.51	0.20	0.013	0.02	3.72	1869	14.5	14.5	13.50	12.90	12.70	12.10	1.0	1.60
46	47	514	1.00		1.00	0.8	13.29	5.00	18.29	349.6	280	0.800			0.502	2.51	0.20	0.013	0.0024	1.29	647	15.1	14.5	14.10	12.87	13.30	12.07	1.0	1.63
47	48	566	9.86	2.36	12.22	0.8	5.88	23.67	29.55	285.29	2789	1.250			1.227	3.93	0.31	0.013	0.0082	3.21	3934	14.3	10.0	13.30	8.66	12.05	7.41	1.0	1.34
48	49	202	1.98	104.58	106.56	0.8	2.10	38.53	40.63	243.21	20734		3.000	2.5	6.750	7.50	0.90	0.013	0.002	3.21	21646	10.0	10.0	9.80	9.40	7.30	6.90	0.2	0.60

Source: JICA Study Team

Table C.3.1 Hydraulic Design (4/5) (5/5)

Project Hoa Lac Hi-Tech Park
Location Hanoi
Drainage Basin: NEWLY-BUILT RESERVOIR -CATCHMENT 4
TOTAL AREA = 56.3 HA

Formula	Q=1/360xCxIxA; I= 0.36 x 5416 x (1+ 0.25 x lgP x $t^{0.13}$)/$(t+19)^{0.82}$; Q=A x 1/Mn x $R^{2/3}$ x $S^{1/2}$ (Manning)		
Lo (m): 100	P 5	Runoff (0.8	
To (min) 5-10			

From Node	To Node	Length	Catchment Self	Catchment Pass	Catchment Total	Run off co-	Concentration time Self	Concentration time Pass	Concentration time Total	Rainfall intensity	Peak Flow	Pipe Diameter	Box Cuvert Width	Box Cuvert Height	Sectional Area	Hydraulic Radius	Manning	Hydraulic Gradient		Slope	Velocity	Flow Capacity	Sewer Ground elevation Up	Ground elevation Down	Top Level Up	Top Level Down	Invert Level Up	Invert Level Down	Soil Coverage depth Up	Soil Coverage depth Down
		L			A	C	T1	T2	Tt	I	Q	D	B	H	S	R	n	i			V		Up	Down	Up	Down	Up	Down	Up	Down
		(m)	(ha)	(ha)	(ha)		(min)	(min)	(min)		(l/s)	(m)	(m)	(m)	(m2)	(m)					(m/s)	(l/s)	m	m	m	m	m	m	m	m
5	6	275	7.57		7.57	0.8	0.25	12.00	12	399.97	2422		1.200	1.000	1.080	0.36	0.013	0.0040	1000	0.0040	2.46	2659	16.6	15.5	16.40	15.30	16.40	15.30	0.20	0.20
6	8	830	16.45	7.57	24.02	0.8	0.33	12.25	13	396.78	7625		1.600	1.400	2.016	0.49	0.013	0.0066	1400	0.0066	3.89	7839	15.5	10.0	15.30	9.80	15.30	9.80	0.20	0.20
7	8	508	7.95		7.95	0.8	0.33	10.00	10	419.49	2668		1.200	1.000	1.080	0.36	0.013	0.0057	1000	0.0057	2.94	3174	12.9	10.0	12.70	9.80	12.70	9.80	0.20	0.20
8	11	40		31.97	31.97	0.8	0.46	12.58	13	392.48	10038		1.800	1.600	2.592	0.55	0.013	0.0057	1600	0.0000	3.92	10152	10.0	10.0	9.80	9.57	9.80	9.57	0.20	0.43
9	10	266	1.00		1.00	0.8	0.42	8.00	8	441.15	353		0.800	0.800	0.576	0.26	0.013	0.0041	800	0.0041	2.00	1152	16.6	15.5	16.40	15.30	16.40	15.30	0.20	0.20
10	11	823	9.65	1.00	10.65	0.8	0.46	8.42	9	435.76	3713		1.200	1.200	1.296	0.39	0.013	0.0067	1200	0.0067	3.33	4318	15.5	10.0	15.30	9.80	15.30	9.80	0.20	0.20
11	12	60		42.62	42.62	0.8	0.50	8.88	9	430.03	14662		2.400	2.000	4.320	0.72	0.013	0.0030	2000	0.0000	3.38	14621	10.0	10.0	9.80	9.62	9.80	9.62	0.20	0.38
1	3	512	9.91		9.91	0.8	0.13	10.00	10	421.73	3343		1.400	1.200	1.512	0.42	0.013	0.0027	1200	0.0027	2.26	3415	11.4	10.0	11.20	9.82	11.20	9.82	0.20	0.18
2	3	424	3.77		3.77	0.8	0.13	8.00	8	444.66	1341		1.200	1.000	1.080	0.36	0.013	0.0006	1000	0.0000	0.95	1030	10.0	10.0	9.80	9.55	9.80	9.55	0.20	0.45
3	4	123		13.68	13.68	0.8	0.17	8.13	8	442.65	4844		1.600	1.400	2.016	0.49	0.013	0.0022	1400	0.0000	2.24	4517	10.0	10.0	9.80	9.53	9.80	9.53	0.20	0.47

Source: JICA Study Team

Project Hoa Lac Hi-Tech Park
Location Hanoi
Drainage Basin: OUTSIDE BASIN - CATCHMENT 0
TOTAL AREA = 74.8 HA

Formula	Q=1/360xCxIxA; I= 0.36 x 5416 x (1+ 0.25 x lgP x $t^{0.13}$)/$(t+19)^{0.82}$; Q=A x 1/Mn x $R^{2/3}$ x $S^{1/2}$ (Manning)	
Lo (m): 100	P	Runoff Coefficient 0.8
To (min) 5-10		

From Node	To Node	Length	Catchment Self	Catchment Pass	Catchment Total	Run off co-	Concentration time Self	Concentration time Pass	Concentration time Total	Rainfall intensity	Peak Flow	Pipe Diameter	Box Cuvert Width	Box Cuvert Height	Sectional Area	Hydraulic Radius	Manning	Hydraulic Gradient		Slope	Velocity	Flow Capacity	Sewer Ground elevation Up	Ground elevation Down	Top Level Up	Top Level Down	Invert Level Up	Invert Level Down	Soil Coverage depth Up	Soil Coverage depth Down
		L			A	C	T1	T2	Tt	I	Q	D	B	H	S	R	n	i			V		Up	Down	Up	Down	Up	Down	Up	Down
		(m)	(ha)	(ha)	(ha)		(min)	(min)	(min)		(l/s)	(m)	(m)	(m)	(m2)	(m)					(m/s)	(l/s)	m	m	m	m	m	m	m	m
1	2	640	17.2		17.2	0.8	0.08	10.00	10.08	422.18	5809		2.000	2.000	3.600	0.64	0.013	0.0015	2000	0.0014	2.22	7989	15.40	14.50	15.40	14.44	15.40	14.44	0.00	0.06
2	4	685	20.6	17.2	37.8	0.8	0.17	10.08	10.25	420.38	12712		3.000	2.000	5.400	0.82	0.013	0.0015	2000	0.0007	2.61	14073	14.50	14.00	14.50	13.47	14.50	13.47	0.00	0.53
3	4	476	8.1		8.1	0.8	0.17	8.00	8.17	444.15	2889		2.000	2.000	3.600	0.64	0.013	0.002101	2000	0.0021	2.63	9454	15.00	14.00	15.00	14.00	15.00	14.00	0.00	0.00
4		30		45.9	45.9	0.8	0.00	10.08	10.08	422.18	15513		3.000	2.000	5.400	0.82	0.013	0.03	2000	0.0333	11.66	62938	14.00	13.00	14.00	13.10	14.00	13.10	0.00	-0.10
5	7	558	5.0		5.0	0.8	0.29	7.00	7.29	454.99	1831		2.000	2.000	3.600	0.64	0.013	0.002	2000	0.0018	2.56	9225	15.00	14.00	15.00	13.88	15.00	13.88	0.00	0.12
6	7	783	23.8		23.8	0.8	0.29	10.00	10.29	419.93	7996		2.000	2.000	3.600	0.64	0.013	0.002	2000	0.0000	2.56	9225	14.00	14.00	14.00	12.43	14.00	12.43	0.00	1.57
7		20		28.8	28.8	0.8	0.00	10.29	10.29	419.93	9685		2.000	2.000	3.600	0.64	0.013	0.05	2000	0.0500	12.81	46123	14.00	13.00	14.00	13.00	14.00	13.00	0.00	0.00

Source: JICA Study Team

The total length of drain consisting of pipes and box culverts is around 64km. This includes the existing drain length of 26km. The pipe diameters vary from 600mm to 2,500mm as shown in Table C.3.2.

Table C.3.2 Storm Water Collection Drain

No	Item	Sewer Length (m)			
		JICA Design	MB Installation	Replacement	Required
1	Route E	5,513	5,430	45	45
	D600 Reinforce Concrete Pipe		1,358		0
	D800 Reinforce Concrete Pipe	351	3,380		0
	D1000 Reinforce Concrete Pipe	681	692		0
	D1250 Reinforce Concrete Pipe	1,487			0
	D1500 Reinforce Concrete Pipe	750		30	30
	D1750 Reinforce Concrete Pipe	1,078		15	15
	1400x1400	1,166			0
2	Route 03	1,141	0	0	1,141
	D800 Reinforce Concrete Pipe	263			263
	D2000 Reinforce Concrete Pipe	273			273
	800x800	285			285
	1500x1600	320			320
3	Route B	5,196	4,884	2,935	2,935
	D600 Reinforce Concrete Pipe		1,482		0
	D800 Reinforce Concrete Pipe	490	2,486		0
	D1000 Reinforce Concrete Pipe	849	44	472	472
	D1250 Reinforce Concrete Pipe	536			0
	D1500 Reinforce Concrete Pipe	999	872	680	680
	D1750 Reinforce Concrete Pipe	569		30	30
	D2000 Reinforce Concrete Pipe	1,209		1,209	1,209
	D2500 Reinforce Concrete Pipe	90		90	90
	1800x2000	454		454	454
4	Route C	3,992	3,834	3,992	3,992
	D800 Reinforce Concrete Pipe	3,992	3,834		0
5	Route C'	6,379	4,631	2,803	3,367
	D600 Reinforce Concrete Pipe	295	1,646		295
	D800 Reinforce Concrete Pipe	697	2,110		0
	D1000 Reinforce Concrete Pipe	855			0
	D1500 Reinforce Concrete Pipe	514		514	514
	D2000 Reinforce Concrete Pipe		875		0
	600x800	269			269
	800x1000	510			0
	1200x1000	491			0
	1400x1200	30			0
	1400x1500	217			0
	1600x1500	212			0
	1800x1600	504		504	504
	2000x2000	938		938	938
	2400x2200	847		847	847
6	Route A	6,231	5,128	1,855	2,481
	D600 Reinforce Concrete Pipe	683	756		313
	D800 Reinforce Concrete Pipe	791	1,240		0
	D1000 Reinforce Concrete Pipe	313	2,422		313
	D1250 Reinforce Concrete Pipe	566	710	566	566
	D1500 Reinforce Concrete Pipe	837		622	622
	D2000 Reinforce Concrete Pipe	180			0
	600x800	266			0
	1000x1200	275			0
	1200x1200	823			0
	1400x1400	830			0
	1500x1700	334		334	334
	1700x1700	333		333	333
7	Route D	3,459	2,002	0	2,027
	D600 Reinforce Concrete Pipe	344	1,500		344
	D800 Reinforce Concrete Pipe	2,284	502		1,124
	D1000 Reinforce Concrete Pipe	559			559
	D1250 Reinforce Concrete Pipe	272			
8	Route 01	2,792	0	0	2,792
	D1000 Reinforce Concrete Pipe	810			810
	D1250 Reinforce Concrete Pipe	640			640
	D1500 Reinforce Concrete Pipe	650			650
	D2000 Reinforce Concrete Pipe	692			692
9	Route 04	2,151	0	0	2,151
	D1500 Reinforce Concrete Pipe	730			730
	Box Cuvert 1000x1000	508			508
	Box Cuvert 2400x2400	300			300
	Box Cuvert 24800x2400	613			613
10	Route 05	7,656	0	0	5,110
	D800mm Reinforce Concrete Pipe	1,057			1,057
	D1000mm Reinforce Concrete Pipe	860			860
	D1250mm Reinforce Concrete Pipe	2,245			831
	D1500 Reinforce Concrete Pipe	1,541			1,541
	D1750mm Reinforce Concrete Pipe	566			
	Box Cuvert 800x1000	355			355
	Box Cuvert 1200x1000	466			466
	Box Cuvert 1400x1200	566			
11	Route 06	2,986	0	0	2,986
	D600mm Reinforce Concrete Pipe	514			514
	D800mm Reinforce Concrete Pipe	306			306
	D1500mm Reinforce Concrete Pipe	586			586
	Box Cuvert 800x800	248			248
	Box Cuvert 1200x1200	143			143
	Box Cuvert 1400x1900	230			230
	Box Cuvert 1600x1600	105			105
	Box Cuvert 1800x1900	230			230
	Box Cuvert 2000x1700	184			184
	Box Cuvert 2500x1800	440			440
12	Route 07	2,882	0	0	1,529
	D800mm Reinforce Concrete Pipe	252			252
	D1250mm Reinforce Concrete Pipe	336			336
	D1500mm Reinforce Concrete Pipe	941			941
	Box Cuvert 1000x1000	295			
	Box Cuvert 1800x1600	405			
	Box Cuvert 2000x2000	410			
	Box Cuvert 2500x2000	243			
13	Route 08	3,209	0	0	978
	D1000mm Reinforce Concrete Pipe	1,217			489
	D1500mm Reinforce Concrete Pipe	534			
	D1750mm Reinforce Concrete Pipe	30			
	D2000mm Reinforce Concrete Pipe	207			
	Box Cuvert 1000x1000	489			489
	Box Cuvert 2000x2200	500			
	Box Cuvert 2200x2400	30			
	Box Cuvert 2600x2600	202			
14	Route 09	2,320	0	0	1,418
	D1500mm Reinforce Concrete Pipe	478			
	Box Cuvert 1000x1000	932			508
	Box Cuvert 1400x1400	560			560
	Box Cuvert 2000x2200	290			290
	Box Cuvert 2500x2000	60			60
15	Route 10	3,776	0	0	1,384
	D800mm Reinforce Concrete Pipe	476			476
	D1250mm Reinforce Concrete Pipe	340			455
	D2500mm Reinforce Concrete Pipe	1,283			453
	Box Cuvert 2000x2000	30			
	Box Cuvert 2600x2200	1,647			
16	Route 11	1,181	0	0	1,181
	D600mm Reinforce Concrete Pipe	193			193
	D1250mm Reinforce Concrete Pipe	340			340
	D1500mm Reinforce Concrete Pipe	628			628
	D2000mm Reinforce Concrete Pipe	20			20
17	Route 12	2,837	0	0	2,837
	D800mm Reinforce Concrete Pipe	572			572
	D1250mm Reinforce Concrete Pipe	500			500
	Box Cuvert 1200x1000	500			500
	Box Cuvert 1200x1200	630			630
	Box Cuvert 1400x1200	635			635
	Total of Storm water Collection Sewer	63,701	25,909	11,630	38,354

Source: JICA Study Team

Although there are differences between JICA Study Team's plan and the VN Revised M/P as far the design criteria of storm water collection system is concerned but considering the existence of existing drains that has been installed by HHTP-MB, it is likely that they will be used. all The existing drain are recently constructed and satisfies the minimum requirement for drainage system Only new drains will be constructed in the newly developed area. The storm water collection facilities that will be required for the proposed project are presented in Table C.3.3.

Table C.3.3 Required Storm Water Collection Facilities

	Item	Unit	Replacement	Newly Installed	Total
1	Storm water Collection Sewer	m	11,630	26,724	38,354
	D600 Reinforce Concrete Pipe	m		1,659	1,659
	D800 Reinforce Concrete Pipe	m	3,992	4,050	8,042
	D1000 Reinforce Concrete Pipe	m	472	3,031	3,503
	D1250 Reinforce Concrete Pipe	m	566	3,102	3,668
	D1500 Reinforce Concrete Pipe	m	1,846	5,076	6,922
	D1750 Reinforce Concrete Pipe	m	45		45
	D2000 Reinforce Concrete Pipe	m	1,209	985	2,194
	D2500 Reinforce Concrete Pipe	m	90	453	543
	Box Cuvert 600x800	m		269	269
	Box Cuvert 800x800	m		533	533
	Box Cuvert 800x1000	m		355	355
	Box Cuvert 1000x1000	m		1,505	1,505
	Box Cuvert 1200x1000	m		966	966
	Box Cuvert 1200x1200	m		773	773
	Box Cuvert 1400x1200	m		635	635
	Box Cuvert 1400x1400	m		560	560
	Box Cuvert 1400x1900	m		230	230
	Box Cuvert 1500x1600	m		320	320
	Box Cuvert 1500x1700	m	334		334
	Box Cuvert 1600x1600	m		105	105
	Box Cuvert 1700x1700	m	333		333
	Box Cuvert 1800x1600	m	504		504
	Box Cuvert 1800x1900	m		230	230
	Box Cuvert 1800x2000	m	454		454
	Box Cuvert 2000x1700	m		184	184
	Box Cuvert 2000x2000	m	938		938
	Box Cuvert 2000x2200	m		290	290
	Box Cuvert 2400x2200	m	847		847
	Box Cuvert 2400x2400	m		300	300
	Box Cuvert 2500x1800	m		440	440
	Box Cuvert 2500x2000	m		60	60
	Box Cuvert 2800x2400	m		613	613
2	Manhole	Places			536
	Manhole for D600, 1.2x1.2m, H=2m	Places			38
	Manhole for D800, 1.4x1.4m, H=3m	Places			161
	Manhole for D1000, 1.6x1.6m, H=3m	Places			70
	Manhole for D1250, H=3m	Places			73
	Manhole for D1500-2000, H=3.5m	Places			183
	Manhole for D2500-3000, H=5m	Places			11
3	Connection Pipes	m			465
	D1500mm Reinforce Concrete Pipe No.1	m			160
	D1500mm Reinforce Concrete Pipe No.2	m			40
	D1500mm Reinforce Concrete Pipe No.3	m			65
	D2000mm Reinforce Concrete Pipe of NR21	m			200

Source: JICA Study Team

3.2.2 Retention Functions

(1) Summary of Concept and Criteria for Retention Functions

1) Concept of retention functions

Design period	: The year of 2020
Planning area	: 1268 ha of Hoa Lac area (north of LHLE)
Design population	: 193,326
Drainage basin	: Four basins of Tan Xa Lake, Dua Gai Stream, Vuc Giang Newly Built Reservoir and Vuc Giang Stream
Collection system	: Separate system
Design storm water flow (DSF)	: 10 years of return period for retention function
Storm water reservoir for flood control	: Tan Xa Lake and Vuc Giang Newly Built Reservoir
Receiving water bodies	: Tich River through Vuc Giang stream and Tich Gai River
Allowable discharge of Tich River	: 10 years of return period for Tich River (assumed)

2) Design criteria for retention functions

Design return period for retention functions	: 10 years (to be proposed)
Overall runoff coefficient	: 0.6 before development, 0.8 after development
Type of pond	: Natural pond with environmental conservation bank for Tan Xa Lake, and Multiple type with orifice for Vuc Giang Newly Built Reservoir
Capacity of retention function	: $Q = [Q_{10} - Q_a/2] \cdot T \cdot 60$ Where, Q: Design capacity of retention pond (m^3) Q_{10}: Design storm water flow (m^3/second) Q_a: Allowable discharge flow (m^3/second) T: Concentration time (minute)
Volume of sedimentation	: 1.5m^3/ha/yeay and 10 years period
Discharge flow of Tan Xa Lake regulating gate	: $Q_0 = C \cdot B \cdot d \cdot [2 \cdot g \cdot H_1]^{0.5}$ for emergency Where, Q_0: Discharge flow (m^3/second) C : Coefficient of correlation (0.5 assumed) B : Width of gate (m) d : Opening height of gate (m) g : Gravitational constant (9.8 m/sec^2) H_1: Upstream water height (m) H_2: Downstream water height (m)
Overflow of Tan Xa Lake weir	: $Q_c = C \cdot L \cdot h^{0.5}$ for maintenance flow Where, Q_c: Overflow (m^3/second) C : Overflow coefficient (1.8) L : Width of trough (m) h: Water height of trough (m)
Discharge flow of Vuc Giang New Reservoir orifice	: $Q_o = C \cdot B \cdot D \cdot [2 \cdot g \cdot (H - D/2)]^{0.5}$ Where, Q_o: Discharge flow (m^3/second) H: Height between water level of pond and bottom of orifice C : Discharge coefficient (0.9) B : Width of trough (m) D : Height of orifice (m) g : Gravitational constant (9.8 m/sec^2)

(2) Examination of Retention Functions

According to the VN Revised M/P, the three water bodies consisting of the Tan Xa Lake, the Dua Gai Stream and the Vuc Giang Newly Built Reservoir were planned by JICA Study Team. The earlier hydrological data maintained in the Hoa Lac Area are shown in Table C.3.4.

Table C.3.4 Dimensions of Three Basins

	Tan Xa Lake	Dua Gai Stream	Vuc Giang Newly Built Reservoir
Surface area (ha)	107.0	5.4	4.6
Elevation of Bed (m)	E.L.06.54	E.L.10.81	E.L.02.89
Highest water level (m)	E.L.12.00	E.L.12.00	E.L.9.60
Average water level (m)	E.L.10.50	E.L.10.50	-
Lowest water level (m)	E.L.07.50	E.L.07.50	E.L.07.50
10 years water level (m)	E.L.12.34	E.L.12.34	E.L.08.69
Proposed Max. water level (m)	E.L. 12.63	E.L.12.63	-
Height of Bank (m)	≧E.L.13.13	≧E.L.13.13	≧E.L.10.10

Source: JICA Study Team

Increment of storm water discharge from the Hoa Lac area has been roughly estimated and is shown in Table C.3.5.

Table C.3.5 Storm Water Discharge

Return Period	Strom Water Discharge (m3/s)		
	P=10 years	P=50 years	P=100 years
Before development	181.52	218.52	234.46
After Development	258.30	310.96	333.64
Increment	76.78	92.44	99.18

Source: JICA Study Team

For the present basin in the Hoa Lac Area, the capacity and dimension of each regulating reservoir are estimated tentatively and is shown in Table C.3.6.

Table C.3.6 Examination of Regulating Reservoirs

Regulating Reservoir	Tan Xa Lake	Dua Gai Stream	Vuc Giang Stream
Surface area (ha)	107.00	5.40	4.60
Drainage area (ha)	682.27	280.70	304.99
In case of return period of 50 years			
Required capacity (m^3)	254,641	72,678	81,526
Required depth (m)	0.238	1.346	1.772
In case of return period of 10 years			
Required capacity (m^3)	195,865	56,607	63,435
Required depth (m)	0.183	1.048	1.379

Source: JICA Study Team

According to the the VN Revised M/P, flow of the Dua Gai Stream will be diverted and connected with the Tan Xa Lake ecosystem. In addition, a new reservoir will be constructed at the Vuc Giang Stream. As a result, the retention functions should be planned at the Tan Xa Lake and the Vuc Giang Stream in the Hoa Lac Area. The two regulating reservoirs are proposed as shown in Table C.3.7.

Table C.3.7 Required Regulating Reservoirs

Dimensions	Tan Xa Lake	Tan Xa Lake including Storm water of Outside Area	Vuc Giang Newly Built Reservoir
Surface area (ha)	107.0	107.0	4.6
Drainage area (ha)	963.0	1,037.7	248.7
Required capacity (m^3)	318,000	318,000	48,000
Sedimentation (m^3)	15,000	16,000	4,000
Required depth (m)	0.297	0.297	1.044
Width of Reservoir (m)	-	-	100
Length of Reservoir (m)	-	-	200
Height of Reservoir (m)	-	-	2.600
Total depth (m)	0.311	0.312	1.143
Required Volume (m^3)	333,000	334,000	52,000

Source: JICA Study Team

The plan of retention function in the Hoa Lac Area is summarized below and the following measures are required for the proper management of the drainage system and preservation of water environment.

Tan Xa Lake	• To cope with the flood return period of at least 10 years; • To secure a lake surface area of 107ha; • To secure a capacity of more than 334,000m^3 for regulating pond; • To secure the maximum water level of MSL+12.63m to meet the flood return period of 50 years; • To secure an elevation of bank MSL+13.13m; • To provide a regulating gate and overflow weir in order to control flood and supply maintenance flow for downstream rivers and ponds; • To improve the Dua Gai Stream for diversion to the Tan Xa Lake and supporting the retention function of the lake; • To improve the existing ditch and the Trung Lu Stream/Tich Gang River with enough flow capacity enabling it to receive the effluents from the Tan Xa Lake during any exigency (The improvement of these facilities will be executed by another project); and • To divert the flow of several small streams from the Tan Xa Lake ecosystem to drainage system of the National Road No.21 (This scheme will be conducted by MARD/MOT in cooperation with HHTP-MB).
Vuc Giang Newly Built Reservoir	• To cope effectively with the flood return period of at least 10 years; • To secure an average area of berm with length: 200m and width: 100m along the Vuc Giang Stream for retention function; • To be a retention pond with multipurpose; • To use the area of stream berm for multipurpose, such as a park and promenade; • To provide an orifice for flood retention; and • To improve the Vuc Giang Stream between the Newly Built Reservoir and the Tich River for reinforcing its flow capacity (The improvement work of the Vuc Giang Stream is recommended to be conducted by another project).

(2) Proposed Retention Function Facilities

The retention functions consisting of the Tan Xa Lake with the Dua Gai Stream diversion and the Vuc Giang Newly Built Reservoir that are located in the Hoa Lac Area (north of LHLE) that are proposed by JICA Study Team are shown in Figure 3.2.1.

Required facilities for retention functions are designed with the following features:

a) Tan Xa Lake regulating gate

Type of Gate	: Steel Roller Sluice Gate
Dimension	: Width 5.5m x Height 6.5m
Design discharge	: 26m^3/sec

b) Tan Xa Lake overflow weir

Type of canal	: Reinforced concrete open canal
Dimension	: Width 8.5m x Height 1.5m
Design overflow	: Only maintenance flow (Maximum flow 26m^3/sec)

c) Dua Gai Stream diversion

Type of weir	: Reinforced concrete open canal (Retained wall)
Typical section	: Width 10m x Height 2.5m, Width 15m x Height 2.5m
Design flow	: $92m^3/sec$

d) Vuc Giang newly built reservoir and orifice

Type of reservoir	: Reinforced concrete open canal (Retained wall)
Typical section	: Width $22m^{up}$ x $8m^{bottom}$ x Height 3.5m for stream
	: Width 50m to 100m x Height 2.8m for berm
Dimension of orifice	: Width 4m x Height 2m
Design overflow	: $84m^3/sec$

3.2.3 Summary of Storm water Drainage Project

The storm water drainage project is proposed as shown in Table C.3.8.

Table C.3.8 Proposed Storm Water Drainage Project

Work Item		Quantity	
1	Storm water Collection Drain		
a)	New Installation	26.7	km
	Pipes: D600 to D800	5.7	km
	Pipes: D1000 to D1250	6.1	km
	Pipes: D1500 to D2500	6.5	km
	Box Cuvert: 600x800 to 1000x1000	2.7	km
	Box Cuvert: 1200x1000 to 1700x1700	3.6	km
	Box Cuvert: 1800x1600 to 2800x2400	2.1	km
b)	Replacement	11.6	km
	Pipes: D800	4.0	km
	Pipes: D1000 to D1250	1.0	km
	Pipes: D1500 to D2500	3.2	km
	Box Cuvert: 1200x1000 to 1700x1700	0.7	km
	Box Cuvert: 1800x1600 to 2400x2200	2.7	km
c)	Manholes	536	places
d)	Connection Pipes: D1500mm & D2000mm	465	m
2	Tan Xa Lake Regulating Facilities		
a)	Regulating Gate: Width 5.5m x Height 6.5m	1	unite
b)	Overflow Weir: Width 8.5m x Height 2.0m	1	unite
c)	Spillway (canal): Width 8.5m x Height 2.0m	300	m
3	Dua Gai Stream Diversion & Improvement		
a)	Dua Gai Stream Improvement	2.3	km
b)	Dua Gai Stream Diversion	0.9	km
c)	Diversion Box Cuvert 3000x2000	180	m
4	Vuc Gaing Stream Retention Fanctions		
a)	Newly Built Reservoir (Multipurpose Type)	52,000	m^3
b)	Orifice: Box Cuvert 4000x2000	50	m
c)	Vuc Gaing Stream Improvement	500	m

Source: JICA Study Team

The outline of the storm water drainage project is summarized in Table C.3.9.

Table C.3.9 Outline of Storm Water Drainage Project

	Work Item	Quantity
1	Storm water Collection Drain	
a)	New Installation	27 km
b)	Replacement	12 km
c)	Manholes	536 units
d)	Connection Pipes: D1500mm & D2000mm	465 m
2	Tan Xa Lake Regulating Facilities	
a)	Regulating Gate: Width 5.5m x Height 6.5m	1 unit
b)	Overflow Weir: Width 8.5m x Height 2.0m	1 unit
c)	Spillway (canal): Width 8.5m x Height 2.0m	300 m
3	Dua Gai Stream Diversion & Improvement	
a)	Dua Gai Stream Improvement	2.3 km
b)	Dua Gai Stream Diversion	0.9 km
c)	Diversion Box Culvert 3000x2000	180 m
4	Vuc Gaing Stream Retention Functions	
a)	Newly Built Reservoir (Multipurpose Type)	52,000 m^3
b)	Orifice: Box Culvert 4000mm x 2000mm	50 m
c)	Vuc Gaing Stream Improvement	500 m

Source: JICA Study Team

3.3 INSTITUTIONAL ASPECTS

The following institutional aspects are taken into account to reinforce the project implementation organization and establish the operation and maintenance (O&M) mechanism for the storm water drainage system in HHTP. Figure C.3.2 shows the proposed structure for O&M organization. Main activities for operation and maintenance are;

- Operation of the relay pumping station, treatment plant, and regulating gate, and their maintenance;
- Regular patrolling of the wastewater collection, storm water collection drains, drainage canals, streams, lake and retention pond;
- Seasonal maintenance and rehabilitation of levees, revetments, etc.; and
- Measurement and monitoring of water level, flow discharge and water quality.

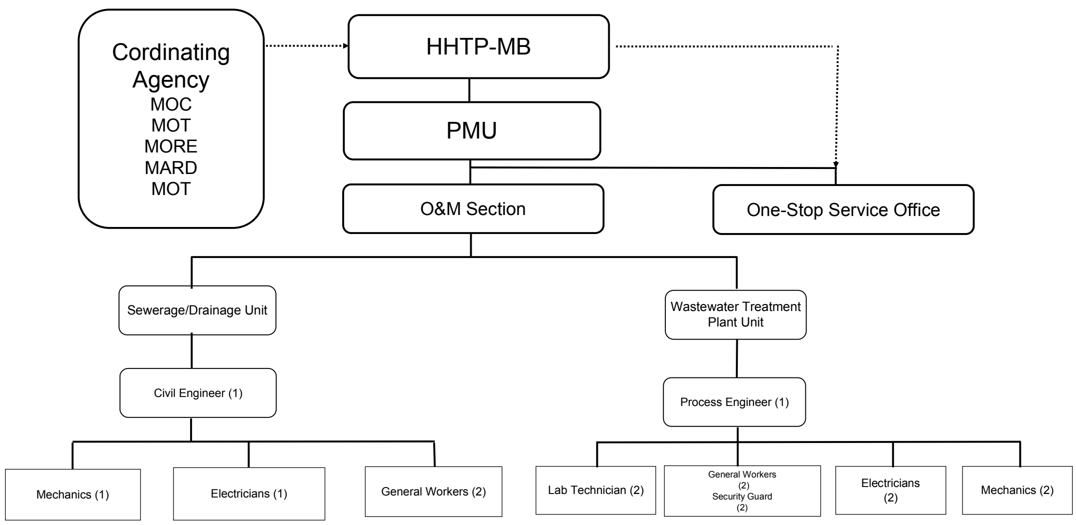


Figure C.3.2 O&M Organization

For the O&M of the all facilities related to drainage system, staff of 16 persons that includes 2 engineers, 9 technicians/operators, and 6 workers will be required. The details are shown in Table C.3.10.

Table C.3.10 Required Staff Members for O&M

Position	Treatment Plant: WWTP No.1	Drainage system	Total
	2010-2015	2015-2020	
Civil Engineer	-	1	1
Process Engineer	1	-	1
Process Operators	1	-	1
Mechanics	2	1	3
Electricians	2	1	3
Lab technicians	2	-	2
General Workers	2	2	4
Security Guard	2	-	2
Total	12	4	16

Source: JICA Study Team

Operation and maintenance (O&M) of the drainage system is recommended to be executed together with the sewerage system. For the proposed drainage and sewerage project, the ratio of annual O&M cost to the direct construction cost of sewer system and wastewater treatment plant is proposed to be 0.5% and 2% respectively. Annual O&M cost of about VND 11,000,000,000 per year (equivalent to JPY 70,000,000) has been estimated for drainage system. In general, in most of the developed countries, the O&M cost for drainage and sewerage system is recovered by beneficiaries. Thus, in order to secure the O&M cost, the sewerage levy-based system shall be established prior to implementation of the sewerage system. It is recommended that sewer charges by means of prorating the O&M cost to the development area should be collected from the developers for each functional zone.

3.4 RECOMMENDATION

3.4.1 Structural Measures

1) The drainage plan and basic design as formulated by JICA Study Team shall be reviewed and modified during the preparation of detailed design stage. This will ensure proper implementation of the project since many uncertainties still remains especially regarding lot layout at each functional zone and allowable flow of downstream water bodies.
2) Planned drainage facilities ha a tendency of excessive design and excess capacity.
3) The detailed design of drainage system should be prepared in consideration of the harmonization with the existing infrastructures as constructed by HHTP-MB.
4) To improve the Dua Gai Stream for diversion to the Tan Xa Lake and supporting the retention function of the lake.
5) To improve the existing ditch and the Trung Lu Stream/Tich Gang River with enough flow capacity so during any exigency it may able to receive the effluents from the Tan Xa Lake. (The improvement of these facilities will be executed by another project).
6) To divert the flow of several small streams from the Tan Xa Lake ecosystem to drainage

system of the National Road No.21 (This scheme will be conducted by MARD/MOT in cooperation with HHTP-MB).

7) To improve and reinforce the flow capacity of the Vuc Giang Stream between the Newly Built Reservoir and the Tich River. (The improvement work of the Vuc Giang Stream is recommended to be conducted by another project).

3.4.2 Non-Structural Measures

1) The organization of O&M for the sewerage and drainage system including the Tan Xa Lake regulating gate and the Vuc Giang new reservoir will be established as soon as possible.
2) It is important for the HHTP-MB to take quick actions to hire and train technical personnel for O&M of facilities.
3) In order to secure the O&M cost, the sewerage levy-based system, prior to the implementation of the drainage and sewerage system, should be established.

SUPPORTING D

WATER SUPPLY PLAN

TABLE OF CONTENTS

LIST OF TABLES

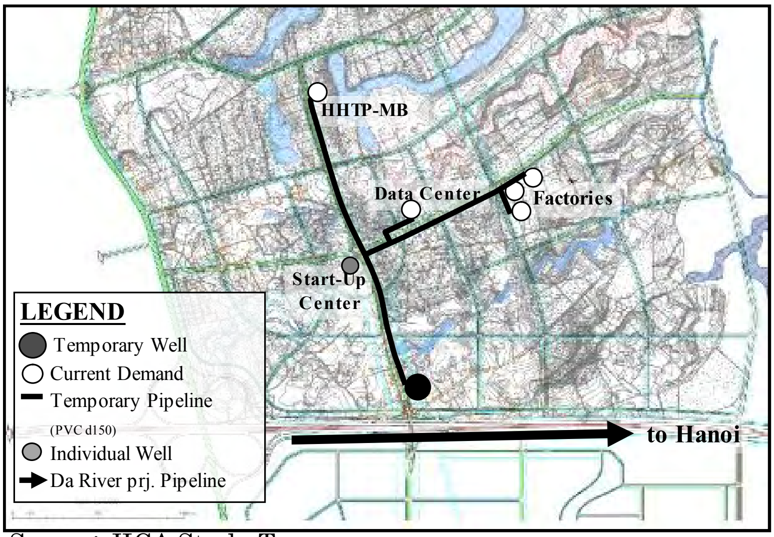
LIST OF FIGURES

CHAPTER 1 PRESENT CONDITION OF WATER SUPPLY SYSTEM

1.1 INTERNAL TENTATIVE WATER SUPPLY SYSTEM

Current water demand for existing tenants and management facilities are satisfied by the temporary water supply system, which consists of an internal well and individual wells as shown in Figure D.1.1. Currently, the internal well system with total capacity of 3,000m^3/d (consists of 2 wells) is being managed and will be managed by VINASEEN till such time the permanent supply system is being facilitated. The wells are accompanied with compact treatment facilities to purify the groundwater.

As of January 2009, only one (1) well among two (2) wells was in operation and responsible for water supply to Factories, Data Center and HHTP-MB building. In other words, it can be interpreted that from the current temporary water supply system at least 1,500m^3/d of water can still be supplied.

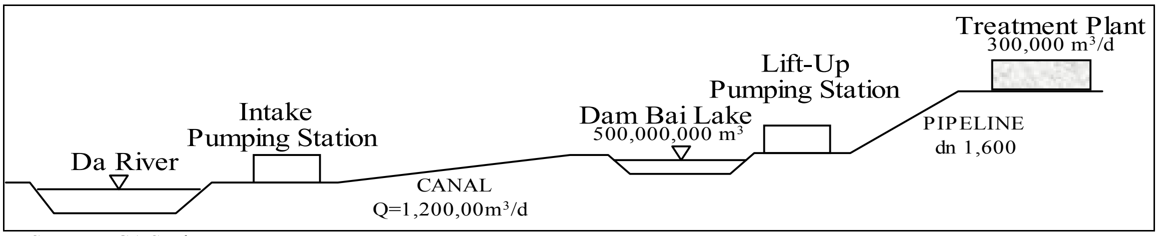


Source: JICA Study Team

Figure D.1.1 Current Water Supply System

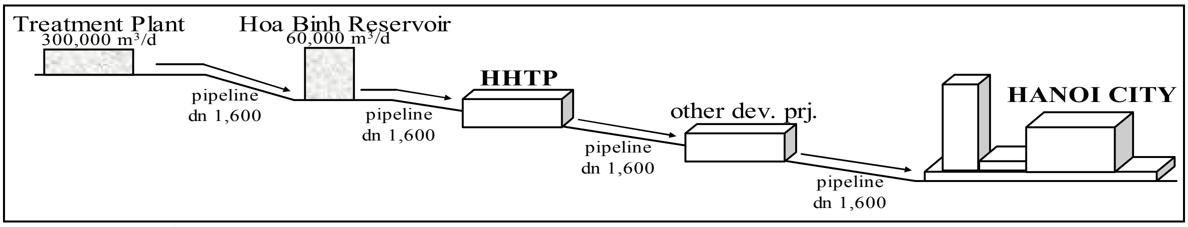
1.2 EXTERNAL SYSTEM: DA RIVER WATER SUPPLY PROJECT

Temporary water supply system will be replaced by the permanent water supply system supply from Da River Water Supply Project which is owned and operated by VINACONEX. The project outline and development status of the project is summarized below:



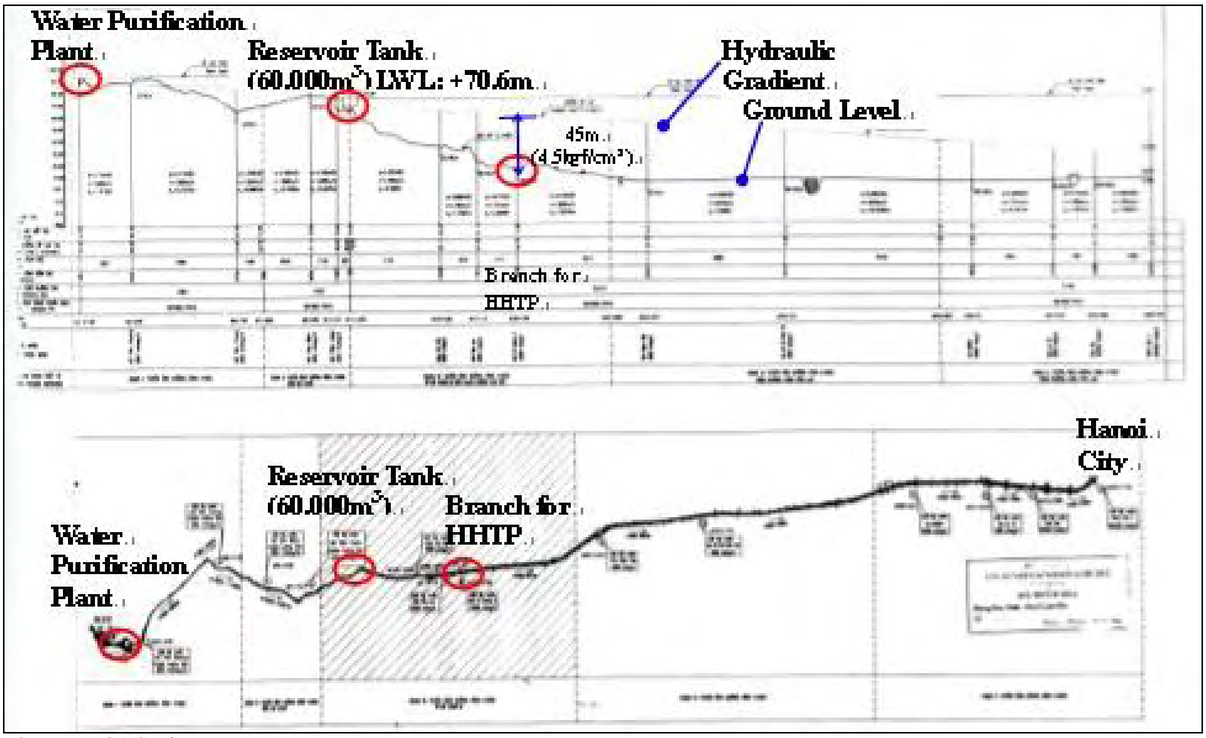
Source: JICA Study Team

Figure D.1.2 Outline of Da River Water Supply Project (Intake Side)



Source: JICA Study Team

Figure D.1.3 Outline of Da River Water Supply Project (Distribution Side)



Source: JICA Study Team

Figure D.1.4 Plan and Profile of Da River Water Supply Project's Pipeline

- Current supply capacity: 300,000m³/d (as for Stage-1 of total 2 stages with total capacity of 600,000m³/d)
- Current supplied demand: 60,000m³/d (as of January 2009), only 1 treatment line is operating among 8 lines with an average operation ratio of 3 days a week and 4 hours a day)
- System reservoir: 60,000m³/d
- Water pressure at HHTP: 5-6bar
- Water quality: meets the Vietnamese (TCVN) standard
- Future development plan: expansion of another 300,000m³/d has been planned for year 2010. However, the actual expansion capacity will be adjusted based on the required supply and demand during the period when design works for expansion are prepared

Site Photo (1/2)

Photo 1: Da River Water Supply Project
Da River as a water resource of the Project

Photo 2: Da River Water Supply Project
Intake Structure

Photo 3: Da River Water Supply Project
Intake Pumping Station

Photo 4: Da River Water Supply Project
Lake as a raw water reservoir

Photo 5: Da River Water Supply Project
Lift-Up Pumping Station from reservoir to plant

Photo 6: Da River Water Supply Project
Water Treatment Plant with capacity of 300,000m^3/d

Site Photo (2/2)

Photo 7: Da River Water Supply Project
Main Treatment Process Structure with roof for all process

Photo 8: Da River Water Supply Project
Main Control Room with all atomized system

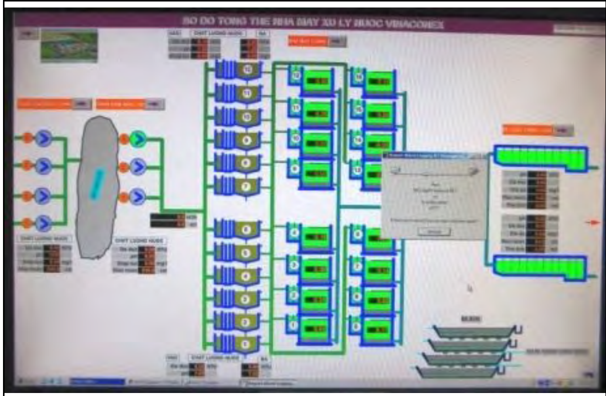


Photo 9: Da River Water Supply Project
SCADA System for all process including intake and transmission pumps

Photo 10: Da River Water Supply Project
Hoa Binh Treated Water Reservoir with capacity of 60,000m^3

Photo 11: HHTP Temporary Water Supply System
Intake Well with compact treatment system for current demands (tenants)

Photo 12: HHTP Temporary Water Supply System
Intake well with compact treatment system at Start-Up Center

1.3 ISSUES AND STRATEGIES

(1) Issues

By examining the present conditions, certain problems and constraints were identified for planning the efficient water supply system. The examination results are as follows:

1. The demolition of the current water supply system will be necessary during road improvement works.
2. To meet the current demands for existing tenants, the temporary water supply system will be required during the construction work period.
3. During the construction of the connection point (T-branch) for HHTP, it is necessary to adopt special technology so as to avoid any interruption of water supply to Hanoi City.
4. Considering the design of the water supply system, it is an immediate need to determine effective operation and management system for the permanent water supply system.

(2) Strategies

To tackle the above listed issues, the strategies as mentioned below will be adopted.

1. To delay the demolition schedule of the existing well as late as possible. The objective would be to demolish only after the connection of the permanent water supply system.
2. To include the cost of temporary piping system that connects to existing well and current tenants.
3. To adopt un-suspended method of construction for the connection point to HHTP on the VINACONEX main transmission line.
4. To establish the simplest and effective operation and maintenance structure among the related authorities.

CHAPTER 2 FRAMEWORK OF WATER SUPPLY DEVELOPMENT PLAN

2.1 DESIGN CONCEPTS

2.1.1 Plan Concept

The following concept plan will be applied for water supply to HHTP.

1. High reliability water supply system to both external (supply from Da River Water Supply Project, hereinafter called as DRWSP) and internal system.
   For external system, double supply system from current DRWSP's pipeline and future pipeline is recommended. Considering the ease for connection and maintenance, future planned pipeline shall be used as a main supply pipe. However, this can only be used if its construction can be completed prior to the completion of the HHTP water supply construction works.
   For internal system, loop network system will be provided. This will ensure the stable supply for 24 hours per day and 365 days per year.
2. Simple system for operation and management.
   With an assumption that there are not many consumers until the completion of HHTP site and considering the overall DRWSP system, the reservoir that has a capacity of 60,000m^3 can be assumed for HHTP,. This concept will not only be good for the easy maintenance but will also minimize the investment and operation cost as now the pump operation that would have been required for the own reservoir in HHTP will not be required.
3. Secure water supply plan for JICA Feasibility Study.
   Depending on the operation and management structure, the water supply piping works will also differ. Design for this feasibility study is based on the maximum number of T-branch for the future connection and maximum pipeline installation for direct supply to the tenants.
4. Installation in Technical Ditch.
   Following Vietnamese standard for the new urban development, HHTP also required to construct Technical Ditch which shall accommodate telecommunication, power supply and water supply. Therefore, piping system shall meet with the Technical Ditch requirement which shall consider the frequently comings and goings for other infrastructure maintenance works.

2.1.2 Unit Demands for Water Supply Demand Projection

The adopted unit rate demand is summarized in Table D.2.1, which basically follows the Vietnamese standards for water supply.

Table D.2.1 Demand Unit Rate for Water Supply

Category		TCXDVN-33-2006				Unit Demand for Hoa Lac				
		Urban Grade	II & III		IV	III			Source	Application
		Target Year	2010	2020	2010	2010	phase-1	phase-2		
1.	Domestic	l/cp/d	120	150	60	120	150	150	TCXDVN-33-2006	High Class Residential (R&D, Amenity), Residential Zone, Housing Complex, E&T Zone, Center of Hi-Tech City
	Service Ratio	%	85	100	75	85	100	100		
2.	Public (% to domestic)	%	10	10	0	10	10	10		High Class Residential (R&D, Amenity), Residential Zone, Housing Complex, E&T Zone, Center of Hi-Tech City
3.	Service & Commercial (% to domestic)	%	10	10	10	10	10	10		High Class Residential (R&D, Amenity), Residential Zone, Housing Complex, E&T Zone, Center of Hi-Tech City
4.	Industry *1	m^3/ha/d	22-45	22-45	-	22	22	22		R&D (R&D Zone)
						45	45	45		Hi-Tech Park, Reserved Area
5.	Office *2	l/cp/d	-	-	-	61	76	76	Refering to Japanese Standrad	Software Park, Center of Hi-Tech City
6.	Commercial *3	l/m^2	-	-	-	10.5	13.1	13.1		Amusement
7.	School *4	l/cp/d	-	-	-	19.2	24.0	24.0		E&T Zone
8.	Watering in Park, Ground	l/m^2/d	-	-	-	1.5	1.5	1.5	TCVN-4513-1988	Amusement
9.	Club House *5	l/cp/d	-	-	-	36.0	45.0	45.0	-	Stadium (Amusement), Golf Course (Amenity)
10.	Swimming Pool *6	m^3/d	-	-	-	412.0	412.0	412.0	-	Swimming Pool (Amusement)
	Over Flow Rate	%				10.0	10.0	10.0	TCVN-4513-1988	
11.	UFW	%	<25	<20	<20	25	20	20	TCXDVN-33-2006	all
12.	Daily maximum peak factor	x	1.2-1.4	1.2-1.4	1.2-1.4	1.2	1.2	1.2		all

notes:
*1: R&D: Water demand is assumed to be not so large as production manufacture. Therefore, $22m^3$/day is applied.
Hi-Tech Industrial Park: Upper limit of standard water demand ($45m^3$/day) is applied.
Reserved Area: This area is assumed to be Hi-Tech Industrial Area. Therefore, $45m^3$/day is applied.
*2: Japanese standard for office(127l/capita/d)*domestic demand in HHTP (l/capita)/Japanese standard domestic demand (250l/capita)
*3: Japanese standard for department store (21.8l/m^2/d)*domestic demand in HHTP (l/capita)/Japanese standard domestic demand (250l/capita)
*4: Japanese standard for department school (40l/capita/d)*domestic demand in HHTP (l/capita)/Japanese standard domestic demand (250l/capita)
*5: 40% of domestic water demand
*6: assumed size of swimming pool: 25m*15m*1.1mH
source: JICA Study Team

2.1.3 Design Criteria

The design criteria for water supply are based on the following.

1. TCXDVN-33-2006, latest Vietnamese standard for water supply.
2. TCVN-4513-1988, past Vietnamese standard for water supply.
3. Japanese design standard for water supply system.
4. TCVN 2622-95, Vietnamese regulation for fire fighting system.
5. Utilization of program named EPANET-2 for pipeline network analysis, which was developed by US Environmental Protection Agency and has been used to calculate many water supply systems in Vietnam.

2.1.4 Design Specification

The following design for the water supply facilities will be applied for the Hoa Lac site.

1. Pipeline
   - Water pressure at consuming points must be at least 12m (1.2kg/cm^2) in normal condition and at least 10m (1.0kg/cm^2) in the condition of fire fighting, following the proceedings of Vietnam Construction Standard, Volume VI, TCXD 33-85 (page 455).
   - Ductile iron pipe with mechanical joint will be used for water supply pipeline.
   - Steel pipe will be used as a scabbard for pipeline at river crossing point (on bridge), etc.
2. Installation
   - Out of Technical Ditch, earth covering should be at least 0.6m from the ground surface to the top of pipe.
   - No welding pipe will be utilized for connection at valves, tees or bends. Mechanical joint and/or flanges are recommended.
   - It's necessary to arrange pipe support at tees, bends outside valve pits due to the fact that pipeline in such cases will be totally placed on stable tamped ground and the pressure of the system is not high. In addition, supports will also be arranged inside the valve pits near turning points.
   - Pipeline at river crossing point can accompany along the bridge structure (beam), therefore, there is no need to construct separate pipeline along the bridge.
3. Accessories
   - T-branch with valve and end-cap will be installed in future development area at planned connection point or the future distribution system unit will be installed at the minimum distance of 100m.
   - Air release valve will be installed at high point at a convex part of pipeline.
   - Drain valve will be installed at low point at a convex part of pipeline.
   - Gate valve with water meter will be installed at necessary junctions so as to monitor and detect the water leakage in future.
4. Fire Fighting System
   - Minimum distance between 2 fire hydrant connection points (flanges) along a pipeline is 150m.
   - The diameter of fire hydrant connection socket should meet the mandatory requirement as specified by the Fire Fighting Department of Hanoi Police.
   - Fire hydrants shall not be located along radius of a curve at street intersections but shall be located along the roads at 1.6m off the fence lines. This arrangement will ensure a good view along with a convenience for fire fighting and installation of other systems.

2.2 WATER DEMAND PROJECTION

Based on the design concepts and the new proposed land use plan by VN Revised M/P, the water demand projection for the HHTP is estimated as shown below.

Table D.2.2 Estimated Water Demand in the HHTP

Name of Development Zone	Daily Average Water Supply (m3/d)					
	Classification	Unit	Unit Demand	Total	Stage1 (2015)	Stage2 (2020)
1 Software Park	Commercial	lpcd	76.0	978.9	**664.2**	314.6
2 R&D	Commercial	m3/ha	22.0	5,013.8	**2,919.4**	2,094.4
3 High-Tech Industrial	Industrial	m3/ha	45.0	10,422.0	**8,883.0**	1,539.0
4 Education & Training				3,732.5	**711.9**	3,020.5
	Domestic (Q4)	*lpcd*	*150.0*	*2,592.0*	*494.4*	*2,097.6*
	Commuter	*lpcd*	*24.0*	*622.1*	*118.7*	*503.4*
	Public	*% of Q4*	*10.0*	*259.2*	*49.4*	*209.8*
	Commercial	*% of Q4*	*10.0*	*259.2*	*49.4*	*209.8*
5 Center of High-Tech City				1,440.6	**1,440.6**	0.0
	Domestic (Q5)	*lpcd*	*150.0*	*735.0*	*735.0*	*0.0*
	Commuter	*lpcd*	*76.0*	*558.6*	*558.6*	*0.0*
	Public	*% of Q5*	*10.0*	*73.5*	*73.5*	*0.0*
	Commercial	*% of Q5*	*10.0*	*73.5*	*73.5*	*0.0*
6 Mixed Use				1,754.2	**938.4**	815.9
	Domestic (Q6)	*lpcd*	*150.0*	*1,140.8*	*610.2*	*530.6*
	Commuter	*lpcd*	*76.0*	*385.3*	*206.1*	*179.2*
	Public	*% of Q6*	*10.0*	*114.1*	*61.0*	*53.1*
	Commercial	*% of Q6*	*10.0*	*114.1*	*61.0*	*53.1*
7 Houses & Offices				6,146.7	**6,146.7**	0.0
	Domestic (Q7)	*lpcd*	*150.0*	*5,122.3*	*5,122.3*	*0.0*
	Public	*% of Q7*	*10.0*	*512.2*	*512.2*	*0.0*
	Commercial	*% of Q7*	*10.0*	*512.2*	*512.2*	*0.0*
8 Housing Complex				6,244.4	**3,370.9**	2,873.5
	Domestic (Q8)	*lpcd*	*150.0*	*5,203.7*	*2,809.1*	*2,394.6*
	Public	*% of Q8*	*10.0*	*520.4*	*280.9*	*239.5*
	Commercial	*% of Q8*	*10.0*	*520.4*	*280.9*	*239.5*
9 Amenity				9.9	**9.9**	0.0
	Domestic (Q9)	*lpcd*	*45.0*	*9.9*	*9.9*	*0.0*
	Public	*% of Q9*	*0.0*	*0.0*	*0.0*	*0.0*
	Commercial	*% of Q9*	*0.0*	*0.0*	*0.0*	*0.0*
10 Amusement				4,551.1	**4,097.9**	453.2
	Greening	*l/m2/d*	*1.5*	*498.0*	*498.0*	*0.0*
	Swimming Pool	*%*	*10.0*	*906.4*	*453.2*	*453.2*
	Domestic	*lpcd*	*45.0*	*74.7*	*74.7*	*0.0*
	Public	*l/m2/d*	*13.1*	*3,072.0*	*3,072.0*	*0.0*
TOTAL				**40,294.0**	**29,182.9**	**11,111.2**

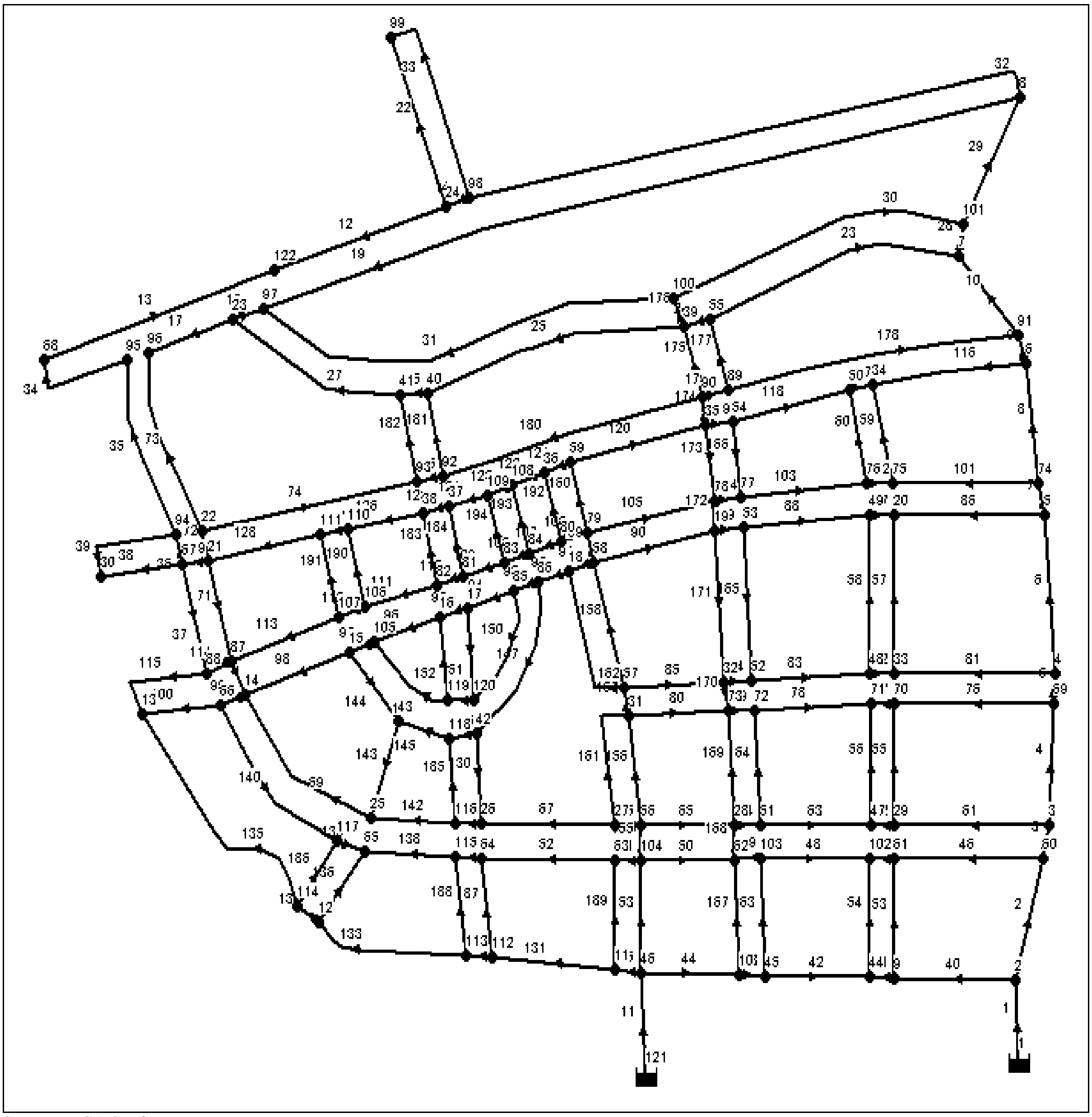
Source: JICA Study Team

CHAPTER 3 PROPOSED WATER SUPPLY PLAN

3.1 NETWORK MODELING AND ANALYSIS

3.1.1 Proposed Modeling Network

Considering the technical and operational issues, the pipeline alignment or modeling network along the major road is recommended and is summarized in the figure below. This will ensure the direct supply of water to every lot or tenant.



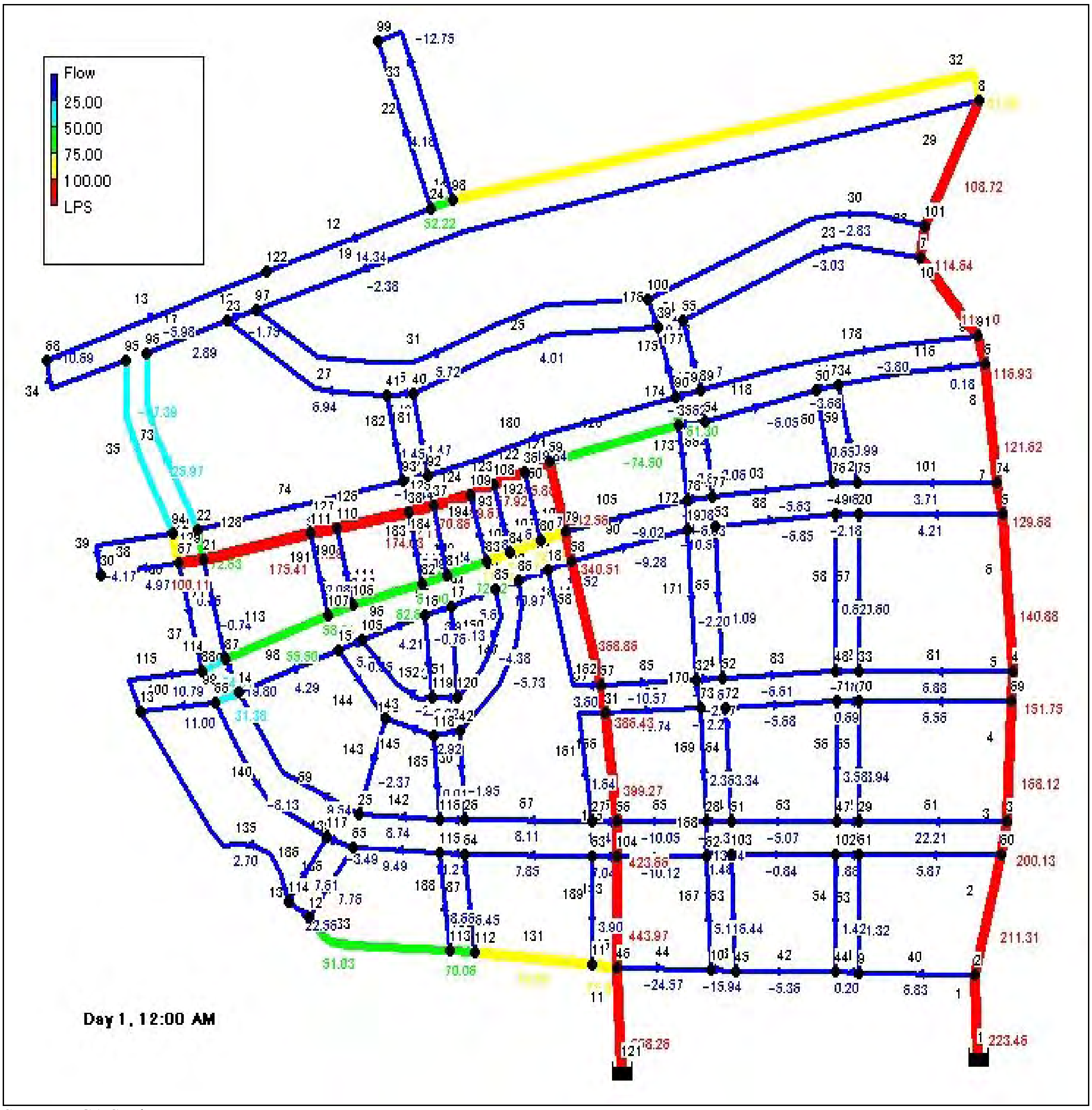
Source: JICA Study Team

Figure D.3.1 Proposed Pipeline Network with Node and Link Numbers

3.1.2 Pipeline Network Analysis

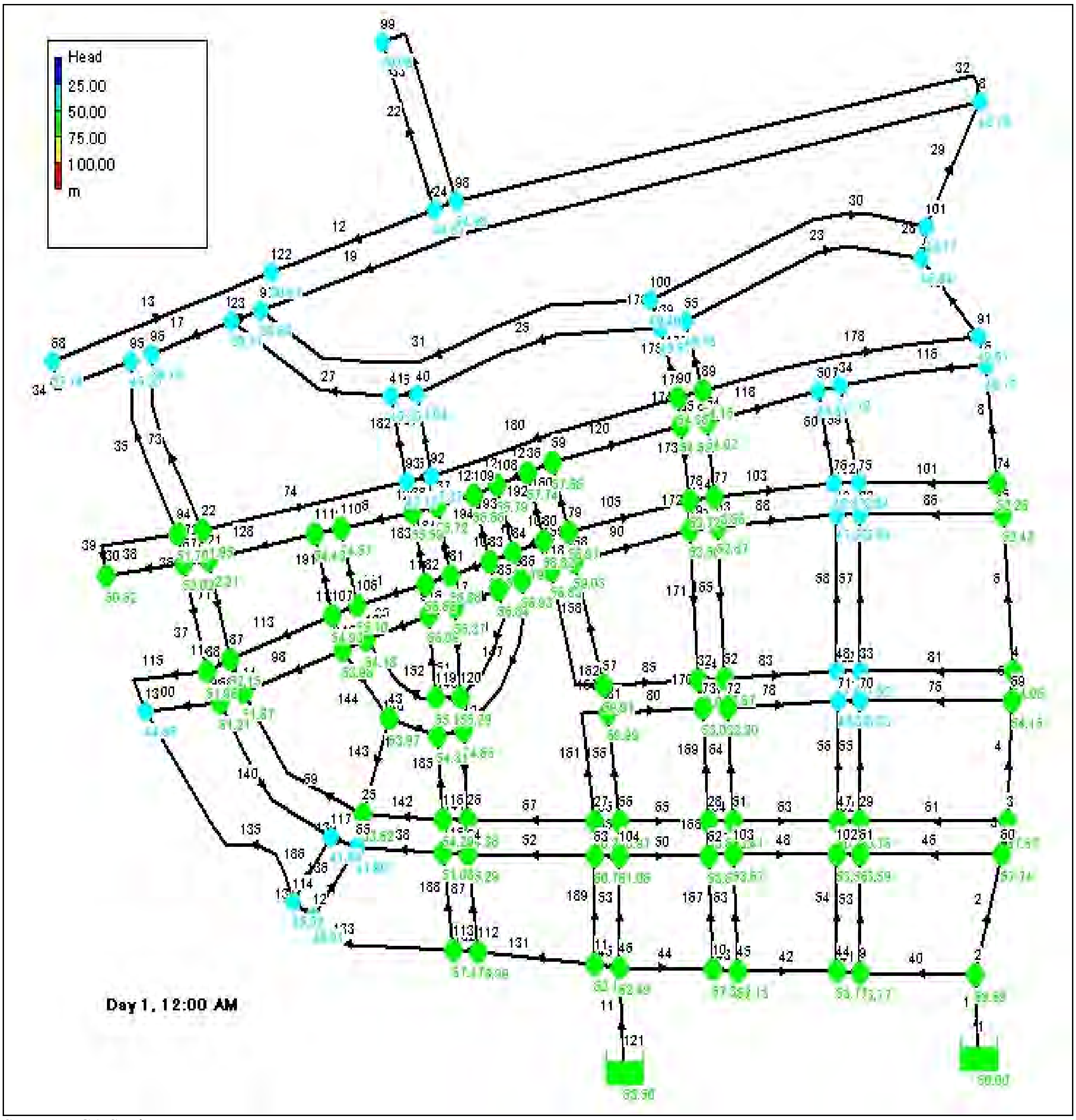
Based on the water demand, design concept and pipeline network described above, the network analysis was conducted by the software named EPANET-2. EPANET-2 is the common software used in Vietnam for the water supply pipeline network analysis.

The result of the analysis is summarized in the figures and tables below. The figures in minus as mentioned for flow describes the flow direction, which is opposite from the ordinary (clock-wise) flow.



Source: JICA Study Team

Figure D.3.2 Analyzed Water Flow (liter per second)



Source: JICA Study Team

Figure D.3.3 Analyzed Water Pressure/Head (m)

Table D.3.1 Summary of Analysis Result (1/3)

Link ID	Length (m)	Diameter	Flow (LPS)	Velocity (m/s)	Unit Headloss (m/km)
Pipe 1	187	400	223.46	1.78	7.02
Pipe 2	445	500	211.31	1.08	2.13
Pipe 3	30	400	200.13	1.59	5.72
Pipe 4	823	400	168.12	1.34	4.14
Pipe 5	30	400	151.75	1.21	3.43
Pipe 6	546	400	140.88	1.12	2.99
Pipe 7	30	350	129.68	1.35	4.91
Pipe 8	584	350	121.62	1.26	4.36
Pipe 9	30	350	116.93	1.22	4.05
Pipe 10	725	350	113.30	1.18	3.82
Pipe 14	30	200	52.22	1.66	13.90
Pipe 16	30	100	-1.75	0.22	0.75
Pipe 17	276	100	2.89	0.37	1.91
Pipe 19	3,073	100	-2.38	0.30	1.34
Pipe 22	1,183	100	4.18	0.53	3.80
Pipe 23	1,404	100	-3.00	0.39	2.09
Pipe 24	30	100	4.04	0.51	3.56
Pipe 25	749	100	4.01	0.51	3.51
Pipe 26	30	100	5.49	0.70	6.27
Pipe 27	738	100	6.94	0.88	9.68
Pipe 28	30	350	114.64	1.19	3.91
Pipe 29	828	350	108.72	1.13	3.54
Pipe 30	1,450	100	-2.83	0.36	1.84
Pipe 31	1,433	100	5.72	0.73	6.78
Pipe 32	1,986	300	81.86	1.16	4.44
Pipe 33	1,183	150	-12.75	0.72	4.15
Pipe 34	240	100	-10.69	1.36	35.05
Pipe 35	820	200	-37.39	1.19	7.49
Pipe 36	30	250	-81.51	1.66	10.70
Pipe 37	379	100	0.75	0.10	0.16
Pipe 38	268	100	4.97	0.63	5.21
Pipe 39	285	100	-4.17	0.53	3.78
Pipe 40	522	100	6.83	0.87	9.42
Pipe 41	30	100	0.20	0.03	0.01
Pipe 42	560	100	-5.36	0.68	6.00
Pipe 43	30	150	-15.94	0.90	6.27
Pipe 44	370	150	-24.57	1.39	13.97
Pipe 45	30	250	86.56	1.76	11.96
Pipe 46	585	100	5.87	0.75	7.10
Pipe 47	30	100	1.88	0.24	0.86
Pipe 48	567	100	-0.84	0.11	0.20
Pipe 49	30	100	1.46	0.19	0.54
Pipe 50	380	100	-10.12	1.29	19.49
Pipe 51	30	100	7.04	0.90	9.94
Pipe 52	450	100	7.85	1.00	12.16
Pipe 53	412	100	1.32	0.17	0.45
Pipe 54	412	100	1.42	0.18	0.51

Link ID	Length (m)	Diameter	Flow (LPS)	Velocity (m/s)	Unit Headloss (m/km)
Pipe 55	716	100	3.94	0.50	3.39
Pipe 56	706	100	3.58	0.46	2.85
Pipe 57	512	100	0.60	0.08	0.17
Pipe 58	505	100	0.62	0.08	0.11
Pipe 59	450	100	0.99	0.13	0.26
Pipe 60	457	100	0.65	0.08	0.12
Pipe 61	588	150	22.21	1.26	11.59
Pipe 62	30	100	8.46	1.08	13.98
Pipe 63	567	100	-5.07	0.65	5.42
Pipe 64	30	150	-18.36	1.04	8.14
Pipe 65	380	100	-10.05	1.28	19.25
Pipe 66	30	100	11.46	1.46	24.52
Pipe 67	452	100	8.11	1.03	12.93
Pipe 69	721	150	9.54	0.54	2.42
Pipe 70	30	150	-19.80	1.12	9.37
Pipe 71	383	100	-0.74	0.09	0.15
Pipe 72	30	250	72.63	1.48	8.64
Pipe 73	825	150	25.97	1.47	15.48
Pipe 74	743	100	5.56	0.71	6.43
Pipe 75	30	150	-16.44	0.93	6.64
Pipe 76	668	100	6.56	0.84	8.73
Pipe 77	30	100	0.69	0.09	0.13
Pipe 78	579	100	-5.68	0.72	6.68
Pipe 79	30	100	-12.29	1.57	27.93
Pipe 80	320	100	-10.74	1.37	21.74
Pipe 81	674	100	6.88	0.88	9.54
Pipe 82	30	100	-0.70	0.09	0.14
Pipe 83	570	100	-6.61	0.84	8.84
Pipe 84	30	100	-8.16	1.04	13.07
Pipe 85	324	100	-10.57	1.35	21.13
Pipe 86	783	100	4.21	0.54	6.24
Pipe 87	30	100	-2.18	0.28	1.14
Pipe 88	560	100	-6.85	0.87	9.45
Pipe 89	30	100	-10.58	1.35	21.15
Pipe 90	333	100	-9.28	1.18	16.61
Pipe 91	30	150	16.52	0.93	6.70
Pipe 92	232	150	18.41	1.04	8.19
Pipe 93	30	150	10.97	0.62	3.14
Pipe 94	225	100	5.61	0.71	6.52
Pipe 95	80	100	3.98	0.51	3.46
Pipe 96	237	100	4.21	0.54	3.83
Pipe 97	30	100	5.77	0.73	6.88
Pipe 98	529	100	4.29	0.55	3.98
Pipe 99	30	150	31.38	1.78	21.98
Pipe 100	275	100	11.00	1.40	22.75
Pipe 101	802	100	3.71	0.47	3.04
Pipe 102	30	100	-1.96	0.25	0.93

Source: JICA Study Team

Table D.3.1 Summary of Analysis Result (2/3)

Link ID	Length (m)	Diameter	Flow (LPS)	Velocity (m/s)	Unit Headloss (m/km)
Pipe 103	561	100	-5.63	0.72	6.58
Pipe 104	30	100	-5.08	0.65	5.44
Pipe 105	333	100	-9.02	1.15	15.74
Pipe 106	30	300	86.75	1.23	4.94
Pipe 107	232	300	81.87	1.16	4.44
Pipe 108	30	300	77.29	1.09	3.99
Pipe 109	225	300	72.12	1.02	3.51
Pipe 110	30	250	66.90	1.36	7.42
Pipe 111	237	250	62.63	1.28	6.57
Pipe 112	30	250	58.54	1.19	5.79
Pipe 113	529	250	55.50	1.13	5.25
Pipe 114	30	200	34.51	1.10	6.45
Pipe 115	319	100	10.79	1.37	21.95
Pipe 116	843	100	0.18	0.02	0.01
Pipe 117	30	100	-3.68	0.47	3.00
Pipe 118	560	100	-6.05	0.77	7.51
Pipe 119	30	100	-9.62	1.22	17.73
Pipe 120	365	250	-74.50	1.52	9.05
Pipe 121	30	400	165.86	1.32	4.04
Pipe 122	229	400	167.92	1.34	4.13
Pipe 123	30	400	169.67	1.35	4.21
Pipe 124	220	400	170.86	1.36	4.27
Pipe 125	30	400	172.11	1.37	4.33
Pipe 126	233	400	174.03	1.38	4.42
Pipe 127	30	400	174.29	1.39	4.43
Pipe 128	496	400	175.41	1.40	4.48
Pipe 129	30	300	100.11	1.42	6.44
Pipe 130	1,000	100	-1.95	0.25	0.27
Pipe 131	307	250	79.59	1.62	10.23
Pipe 132	188	250	70.06	1.43	8.08
Pipe 133	793	200	51.03	1.62	13.32
Pipe 134	30	150	22.56	1.28	11.93
Pipe 135	945	100	2.70	0.34	1.69
Pipe 136	420	100	7.76	0.99	11.92
Pipe 137	179	100	11.21	1.43	23.53
Pipe 138	326	100	9.49	1.21	28.14
Pipe 139	30	100	-3.49	0.44	2.71
Pipe 140	711	100	-8.13	1.03	12.97
Pipe 141	176	200	9.21	0.29	0.56
Pipe 142	326	150	8.74	0.49	2.05
Pipe 143	292	100	-2.37	0.30	1.20
Pipe 144	230	100	0.35	0.04	0.03
Pipe 145	253	100	-2.48	0.32	1.34
Pipe 146	178	100	-2.92	0.37	1.95
Pipe 147	335	100	-5.73	0.73	6.79
Pipe 148	415	100	-3.18	0.40	2.28
Pipe 149	30	100	-5.02	0.64	5.31

Link ID	Length (m)	Diameter	Flow (LPS)	Velocity (m/s)	Unit Headloss (m/km)
Pipe 150	375	100	-4.38	0.56	4.13
Pipe 151	235	100	1.13	0.14	0.34
Pipe 152	236	100	-0.76	0.10	0.16
Pipe 153	412	600	443.97	1.57	3.47
Pipe 155	30	600	423.66	1.50	3.18
Pipe 156	342	600	399.27	1.41	2.85
Pipe 157	30	600	386.43	1.37	2.68
Pipe 158	357	600	368.86	1.30	2.46
Pipe 159	30	600	340.51	1.20	2.12
Pipe 160	403	500	242.56	1.24	2.75
Pipe 161	360	100	1.64	0.21	0.67
Pipe 162	376	100	3.60	0.46	2.87
Pipe 163	410	100	6.44	0.82	8.44
Pipe 164	486	100	3.34	0.42	2.49
Pipe 165	379	100	-1.09	0.14	0.51
Pipe 166	450	100	-2.06	0.26	1.02
Pipe 167	410	100	5.11	0.65	8.94
Pipe 168	30	300	13.54	0.19	0.16
Pipe 169	471	100	2.36	0.30	1.31
Pipe 170	30	100	-2.07	0.26	1.03
Pipe 171	379	100	-2.20	0.28	1.15
Pipe 172	30	100	-6.03	0.77	7.47
Pipe 173	450	100	-2.83	0.36	1.84
Pipe 174	30	250	61.30	1.25	6.31
Pipe 175	442	150	21.19	1.20	10.62
Pipe 176	30	150	19.48	1.10	9.09
Pipe 177	437	100	7.07	0.90	10.03
Pipe 178	1,430	100	-3.80	0.48	3.18
Pipe 179	30	150	-16.62	0.94	6.77
Pipe 180	743	150	19.84	1.12	9.41
Pipe 181	613	100	1.47	0.19	0.55
Pipe 182	613	100	1.45	0.18	0.53
Pipe 183	490	100	3.09	0.39	2.17
Pipe 184	490	100	3.24	0.41	2.36
Pipe 185	207	100	0.01	0.00	0.10
Pipe 186	397	100	7.61	0.97	11.50
Pipe 187	438	100	6.45	0.82	8.45
Pipe 188	438	100	8.66	1.10	14.60
Pipe 189	412	100	3.90	0.50	3.32
Pipe 190	475	100	2.17	0.28	1.13
Pipe 191	475	100	2.08	0.27	1.04
Pipe 192	403	100	3.47	0.44	2.69
Pipe 193	442	100	3.16	0.40	2.26
Pipe 194	442	100	3.18	0.40	2.28
Pipe 12	756	150	14.34	0.81	5.15
Pipe 13	880	100	-5.98	0.76	7.36
Pipe 11	190	600	558.26	1.97	5.31

Source: JICA Study Team

Table D.3.1 Summary of Analysis Result (3/3)

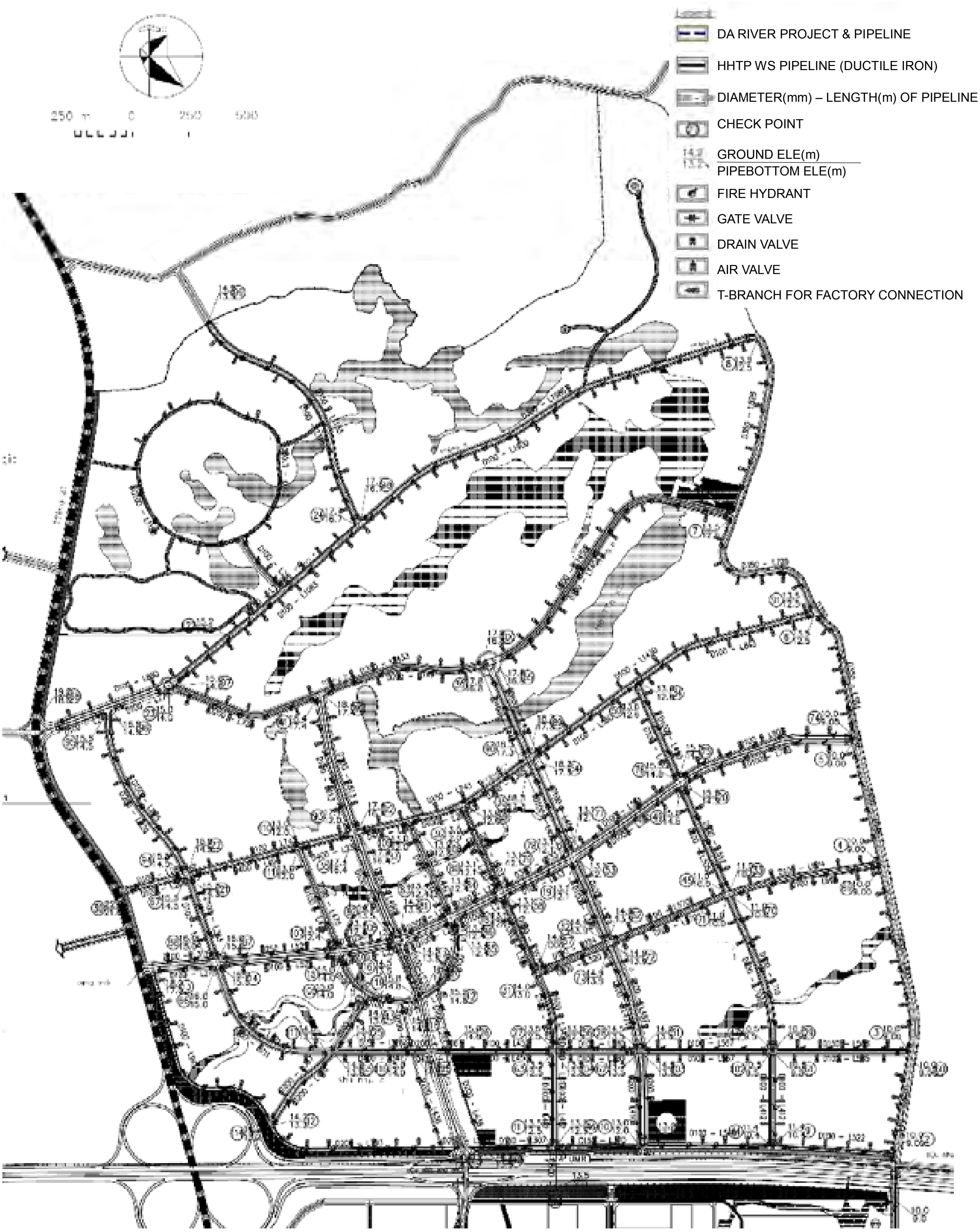
Node ID	Elevation (m)	Demand (LPS)	Head (m)	Pressure (m)
Junc 2	10.0	5.31	58.69	48.69
Junc 3	11.0	9.81	57.57	46.57
Junc 4	11.0	3.99	54.06	43.06
Junc 5	10.0	6.99	52.43	42.43
Junc 6	13.5	4.51	49.73	36.23
Junc 7	13.5	1.69	46.84	33.34
Junc 8	13.5	24.48	43.79	30.29
Junc 9	11.4	5.31	53.77	42.37
Junc 10	13.0	3.51	57.32	44.32
Junc 11	13.5	3.08	62.13	48.63
Junc 12	14.2	20.70	46.91	32.71
Junc 13	18.0	24.50	44.96	26.96
Junc 14	16.0	2.25	51.87	35.87
Junc 15	15.0	1.13	53.98	38.98
Junc 16	14.5	0.54	55.09	40.59
Junc 17	14.5	0.49	55.37	40.87
Junc 18	13.1	1.71	58.83	45.73
Junc 19	13.1	2.54	53.50	40.40
Junc 20	15.5	6.99	47.54	32.04
Junc 21	15.5	1.93	52.21	36.71
Junc 22	15.0	41.10	51.95	36.95
Junc 23	15.0	2.30	39.71	24.71
Junc 24	17.7	33.70	34.57	16.87
Junc 25	14.0	1.58	53.62	39.62
Junc 26	15.6	0.86	54.38	38.78
Junc 27	13.5	1.71	60.23	46.73
Junc 28	14.5	2.88	53.65	39.15
Junc 29	10.5	9.81	50.76	40.26
Junc 30	22.5	9.14	50.62	28.12
Junc 31	14.0	3.74	59.99	45.99
Junc 32	14.9	2.54	53.06	38.16
Junc 33	11.0	6.99	47.63	36.63
Junc 34	13.6	4.85	49.72	36.12
Junc 35	18.3	0.75	54.55	36.25
Junc 36	13.0	1.41	57.74	44.74
Junc 37	17.4	1.99	55.72	38.32
Junc 38	17.4	1.17	55.59	38.19
Junc 39	17.8	1.73	49.67	31.87
Junc 40	18.4	0.00	47.04	28.64
Junc 41	18.4	0.00	46.85	28.45
Junc 42	15.5	0.86	54.65	39.15
Junc 43	14.0	0.45	53.97	39.97
Junc 44	11.4	4.14	53.77	42.37
Junc 45	13.0	4.14	57.13	44.13
Junc 46	13.5	3.15	62.49	48.99
Junc 47	10.5	9.95	50.34	39.84
Junc 48	11.0	5.28	47.63	36.63
Junc 49	15.5	5.28	47.58	32.08
Junc 50	13.6	3.02	49.81	36.21
Junc 51	14.5	9.95	53.41	38.91
Junc 52	14.9	2.64	52.67	37.77
Junc 53	13.1	2.64	52.87	39.77
Junc 54	18.3	1.51	54.02	35.72
Junc 55	17.8	0.00	49.78	31.98
Junc 56	13.5	2.88	60.97	47.47
Junc 57	14.0	3.39	59.91	45.91
Junc 58	13.1	2.54	59.03	45.93
Junc 59	13.0	2.20	57.86	44.86
Junc 60	10.0	5.31	57.74	47.74
Junc 61	10.5	5.31	53.59	43.09
Junc 62	14.5	3.15	53.66	39.16

Node ID	Elevation (m)	Demand (LPS)	Head (m)	Pressure (m)
Junc 63	13.5	3.08	60.76	47.26
Junc 64	15.0	3.08	55.29	40.29
Junc 65	14.0	20.75	41.90	27.90
Junc 66	16.0	12.25	51.21	35.21
Junc 67	15.5	12.88	52.02	36.52
Junc 68	19.0	4.71	37.14	18.14
Junc 69	10.0	9.81	54.16	44.16
Junc 70	11.0	9.81	48.33	37.33
Junc 71	11.0	9.95	48.33	37.33
Junc 72	14.9	9.95	52.20	37.30
Junc 73	14.9	2.88	53.03	38.13
Junc 74	10.0	4.35	52.28	42.28
Junc 75	15.0	4.69	49.84	34.84
Junc 76	15.5	3.02	49.87	34.37
Junc 77	13.1	1.51	53.56	40.46
Junc 78	13.1	0.73	53.72	40.62
Junc 79	13.1	2.18	58.97	45.87
Junc 80	13.1	1.41	58.82	45.72
Junc 81	14.5	1.99	56.88	42.38
Junc 82	14.5	1.17	56.66	42.16
Junc 83	13.4	1.99	57.67	44.27
Junc 84	13.4	1.41	57.79	44.39
Junc 85	13.4	0.99	56.84	43.44
Junc 86	13.4	1.71	56.93	43.53
Junc 87	16.0	1.93	52.15	36.15
Junc 88	16.0	24.46	51.96	35.96
Junc 89	18.3	5.74	54.16	35.86
Junc 90	18.3	3.66	54.36	36.06
Junc 91	13.5	7.43	49.61	36.11
Junc 92	17.4	1.93	47.37	29.97
Junc 93	17.4	20.56	47.17	29.77
Junc 94	15.5	39.95	51.70	36.20
Junc 95	15.5	26.70	45.56	30.06
Junc 96	15.5	28.86	39.18	23.68
Junc 97	15.0	9.85	39.68	24.68
Junc 98	17.0	16.88	34.98	17.98
Junc 99	14.5	16.94	30.08	15.58
Junc 100	17.8	10.92	49.40	31.60
Junc 101	13.5	8.76	46.72	33.22
Junc 102	10.5	4.14	53.56	43.06
Junc 103	14.5	4.14	53.67	39.17
Junc 104	13.5	3.15	61.06	47.56
Junc 105	15.0	1.62	54.18	39.18
Junc 106	13.4	1.92	55.10	41.70
Junc 107	13.4	0.97	54.93	41.53
Junc 108	13.0	1.41	56.79	43.79
Junc 109	13.0	1.99	56.66	43.66
Junc 110	13.0	1.92	54.57	41.57
Junc 111	13.0	0.97	54.43	41.43
Junc 112	14.5	3.08	58.99	44.49
Junc 113	14.5	10.37	57.47	42.97
Junc 114	14.2	12.25	46.55	32.35
Junc 115	15.0	10.37	51.08	36.08
Junc 116	15.0	0.45	54.29	39.29
Junc 117	14.0	12.25	41.99	27.99
Junc 118	15.5	0.45	54.31	38.81
Junc 119	15.8	1.07	55.13	39.33
Junc 120	15.8	0.49	55.29	39.49
Junc 122	15.2	20.32	30.67	15.47
Resvr 1	60.0	223.46	60.00	0.00
Resvr 121	63.5	558.26	63.50	0.00

Source: JICA Study Team

3.2 PROPOSED PIPELINE NETWORK

Based on the result of the above analysis, the diameters of the pipes were determined and accordingly the pipeline network was designed and is shown in the figure below.



Source: JICA Study Team

Figure D.3.4 Proposed Water Supply Pipeline Network

Table D.3.2 Component of Water Supply System (1/2)

No	Item	Unit	Quantity
I. Water Supply System along the Major Road			
A.	Water supply pipeline		
1	DN600 Ductile pipeline	m	1,331
2	DN500 Ductile pipeline	m	403
3	DN400 Ductile pipeline	m	3,855
4	DN350 Ductile pipeline	m	2,168
5	DN300 Ductile pipeline	m	3,182
6	DN250 Ductile pipeline	m	1,409
7	DN200 Ductile pipeline	m	8,737
8	DN150 Ductile pipeline	m	5,996
9	DN100 Ductile pipeline	m	36,898
B.	T-branch		
1	Manhole 1.8 m x 1.8 m , H = 2.4 m (for DN250=<)	unit	81
2	Handhole 1.2 m x 1.2 m, H = 1.5 m (for DN250>)	unit	356
3	DN600 T-branch with Butterfly valve and pipe blind	unit	9
4	DN500 T-branch with Butterfly valve and pipe blind	unit	3
5	DN400 T-branch with Butterfly valve and pipe blind	unit	28
6	DN350 T-branch with Butterfly valve and pipe blind	unit	17
7	DN300 T-branch with Butterfly valve and pipe blind	unit	14
8	DN250 T-branch with Butterfly valve and pipe blind	unit	10
9	DN200 T-branch with Butterfly valve and pipe blind	unit	57
10	DN150 T-branch with Butterfly valve and pipe blind	unit	36
11	DN100 T-branch with Butterfly valve and pipe blind	unit	263
C.	Air valve		
1	Air valve	unit	30
D.	Drain valve		
1	Manhole 1.8 m x 1.8 m , H = 2.4 m (for DN250=<)	unit	5
2	Handhole 1.2 m x 1.2 m, H = 1.5 m (for DN250>)	unit	3
3	DN600 Drain valve	unit	1
4	DN400 Drain valve	unit	2
5	DN350 Drain valve	unit	1
6	DN250 Drain valve	unit	1
7	DN150 Drain valve	unit	1
8	DN100 Drain valve	unit	2
E.	Gate valve and Water meter		
1	Manhole 1.8 m x 1.8 m , H = 2.4 m (for DN250=<)	unit	29
2	Handhole 1.2 m x 1.2 m, H = 1.5 m (for DN250>)	unit	94
3	DN600 Gate valve and Water meter	unit	3
4	DN500 Gate valve and Water meter	unit	1
5	DN400 Gate valve and Water meter	unit	13
6	DN350 Gate valve and Water meter	unit	3
7	DN300 Gate valve and Water meter	unit	5
8	DN250 Gate valve and Water meter	unit	4
9	DN200 Gate valve and Water meter	unit	15
10	DN150 Gate valve and Water meter	unit	10
11	DN100 Gate valve and Water meter	unit	69
F.	Fire hydrant		
1	Fire hydrant	unit	312

Source: JICA Study Team

Table D.3.2 Component of Water Supply System (2/2)

No	Item	Unit	Quantity
II. Water Supply System for Education and Training Center			
A.	Water supply pipeline		
1	DN100 Ductile pipeline	m	2,350
B.	Accessories		
1	Handhole 1.2 m x 1.2 m, H = 1.5 m (for DN250>)	unit	88
2	DN200 T-branch with Butterfly valve and pipe blind	unit	44
3	DN150 T-branch with Butterfly valve and pipe blind	unit	30
4	DN100 T-branch with Butterfly valve and pipe blind	unit	10
5	DN100 Air valve	unit	1
6	DN100 Gate valve with Water meter	unit	3
C.	Fire hydrant		
1	Fire hydrant	unit	16

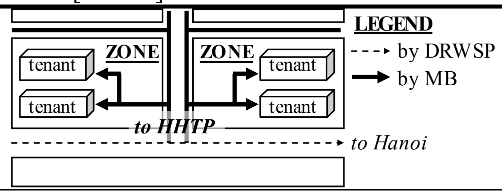
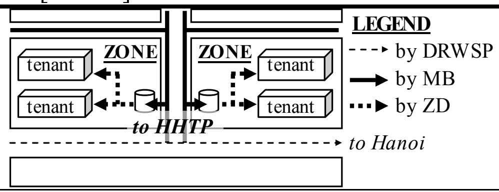
Source: JICA Study Team

3.3 INSTITUTIONAL ASPECTS

Since the water will be supplied by the supplier (DRWSP, VINACONEX), the operation and maintenance will be limited to the distribution system inside the HHTP, the operation and management, including the tenant's contract procedures, water distribution management and maintenance work, need to be as simple as possible. Some of important aspect are i) make clear responsibility, ii) minimize necessary cost, iii) fastest implementation schedule, and iv) secure sufficient customer services.

Considering objective above, the two (2) alternatives for operation and management structure was proposed. Case-1: DRWSP – MB – Tenants was found to be the better one and is recommended with some conditions.

Table D.3.3 Operation and Management (O&M) Structures

[Case-1] DRWSP – MB – Tenants	[Case-2] DRWSP – MB – ZD – Tenants
	
[Project Component] 1. Transmission Pipeline (from DRWSP connection point to each zone entrance). 2. Distribution Pipeline (from zone entrance to each tenant). 3. Necessary distribution system by ZD, such as reservoir and pump facilities.	
[Project Component for MB] - Both Transmission and Distribution Pipelines, starting from HHTP entrance (connection point from DRWSP) to every tenant. - Water Meter for every tenant (connection point to tenants).	**[Project Component for MB]** - Transmission Pipeline, starting from HHTP entrance (connection point from DRWSP) to Zone entrance. - Water Meter for every Zone (connection point to ZDs).
[Technical Consideration] - Necessary temporary water supply system so as to supply continuous water supply to the current tenants..	**[Technical Consideration]** - Necessary to adjust immediately the water supply system based on the detailed plan of every zone. - Necessary temporary water supply system so as to supply continuous water supply to the current tenants.
[Operation & Maintenance Consideration] - Clear responsibility. - Currently no organization including the staff of MB can operate and maintain water supply system.	**[Operation & Maintenance Consideration]** - Sequenced operation with zone development and sales strategy can be achieved. - Not all ZD was determined; therefore water supply system and its O&M structure can not be fixed. - Normally, the contract for water supply is done between Supplier and Tenant, however in this case, MB and ZD should also be involved as it requires more over-head cost for O&M.
[General Evaluation] More Sufficient - Considering the limited capability of MB, it is suggested to out-source the O&M works to private or public water supply company.	**[General Evaluation]** Not Sufficient - The Project can not proceed as the detailed plan and sales strategy has nit yet been decided for each zone.

Source: JICA Study Team

For the establishment of organization for better operation and management, the following important aspects as mentioned below need to be considered.

(1) Clear Responsibility

The supply of the treated bulk water to meet the overall demands of HHTP will be responsibility of the Supplier (VINACONEX, PMU for DRWSP). Distribution to the Zone can only be conducted by HHTP-MB and distribution to the Tenant can be conducted by HHTP-MB and ZD.

The responsibility should be clearly laid out to the tenants for the maintenance work especially when any problem occurs in relation to water supply and its distribution. In such situation and operations, it is always preferable to minimize the involvement of number of organization. Considering this, Case-1 structure is recommended.

(2) Minimum Management Cost

Considering the competition among the tenants and attract investors, water tariff for the tenants in no case should exceed the market price or the water tariff rate at peripheral industrial parks. Therefore, the simple management structure (Case-1) which reduces the over-head cost and can supply water with minimum facilities is appropriate and is suggested.

(3) Fastest Implementation Schedule

In case of Case-2 as discussed above, involvement of ZD becomes necessary for the determination of the water supply system and facilities in HHTP. However, considering that currently not all ZD for all zones in HHTP are yet designated, Case-1 structure seems to be better choice which can also provide faster implementation mechanism than Case-2 structure.

(4) Sufficient Customer Services

In both the above cases, especially for Case-1, currently HHTP-MB has no organization/staff and experience on management of water supply system; therefore it becomes big challenge for MB to take care of all necessary administrative and technical management works as mentioned below and keep the customer satisfactory service level high.

a. Administrative management; such as billing, financial controls, customer services and public relations.
b. Technical management; such as engineering services, water quality control, operation and maintenance works.

Therefore, it is suggested to out-source the management works for all water supply system owned by MB to the professional organization such as private sector or public water supply company with a competitive fee.

3.4 RECOMMENDATION

3.4.1 Structural Measures

1. To minimize the investment cost and operation management work's cost as this will directly affect the tariff rate and tenants, the water supply facilities will be designed as simple as possible.
2. The supply water condition from DRWSP will be utilized effectively, such as reservoir/back-up system, water pressure and water quality.
3. Water supply pipeline network is designed with loop system. This will ensure the security of the water supply from any accidents and keep the clean water running inside the pipeline (will not make a dead-water).

4. Fire hydrant is designed following Vietnamese standard. However, in future as fire department will operate and utilize the hydrant services and facilities, it is suggested to consult them prior to the preparation of detail design.

3.4.2 Non-Structural Measures

1. For the early implementation, water supply system shall be installed under the responsibility of HHTP-MB.
2. To ensure effective and efficient operation, it is recommended to out-source the management works to the professional body