3.5.2 Interchange Alternatives

An interchange is planned at around KM27+000 post on Lang-Hoa Lac Highway, connecting the HHTP eastern sub-gate and the provincial road on the east of NPIP with the highway. As such, it should be a four-leg interchange, and several interchange types are considered. Interchanges can be generally classified into following three groups based on the method of managing different traffic movements:

- Full grade separation group,
- Weaving group, and
- Partial grade separation group.

Types of four-leg interchanges that may be considered for this location are described under each group.

(1) Full Grade Separation Group

Full grade separation group includes the most ideal, basic interchange types. There are no at-grade crossings, and each traffic movement is provided with an independent ramp. Therefore, the construction cost is generally the highest, and land to be acquired is extensive. Careful investigation is necessary for adoption of an interchange of this group.

1) Cloverleaf Interchange

A cloverleaf interchange (Figure 3.5-6) is a two-level interchange in which left turns are handled by loop ramps. To go left, vehicles first pass either over or under the other road, then turn right onto a one-way ramp which loops 270 degrees to the right and then merges onto the intersecting road.

Advantage

- It requires only one bridge, which makes the cost low if land is plentiful.

Disadvantage

- It has considerable land consumption.
- The loop ramps have a tight radius and the weaving sections are generally short.

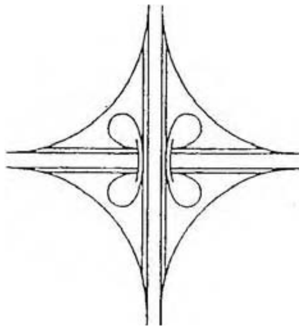


Figure 3.5-6 Cloverleaf Interchange

2) Stack Interchange

In a stack interchange (Figure 3.5-7), left turns are handled by semi-directional overpass ramps. To go left, vehicles first turn slightly right (on a "right-turn" ramp), than go left on a ramp which goes over (or under) the through traffic and connects to the "right-turn" ramp in the opposite quadrant of the interchange. Thus, a stack interchange has two pairs of left-turning ramps which can be "stacked" in various configurations above or below the two through routes.

Advantage

- It does not suffer from the problem of weaving associated with a cloverleaf interchange.

Disadvantage

- It requires massive construction works, leading to a higher cost.

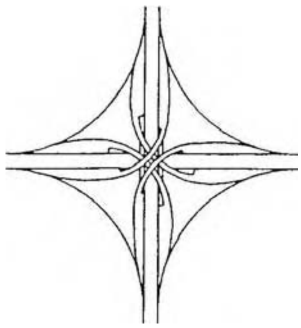


Figure 3.5-7 Stack Interchange

(2) Weaving Group

Weaving group does not involve at-grade crossings but has some weaving sections; that is, two or more traffic movement that meet in parallel share part of the roads or the ramps on the way.

1) Roundabout Interchange

A roundabout interchange (Figure 3.5-8) is an interchange between an expressway and a minor road. It can be formed either by adding an overpass to a roundabout to provide grade separation (with ramps connecting the expressway to the roundabout), or by constructing a roundabout above the expressway, straddling it on a pair of bridges.

Advantage

- It provides a relatively simple solution for rural intersections with four or more approaches where speed and volumes are not high.

Disadvantages

- It has considerable land consumption.

- Each traffic movement goes through weaving at least once; hence, the speed and capacity are limited.

- Directional signing is difficult unless the diameter of the circle is large enough.

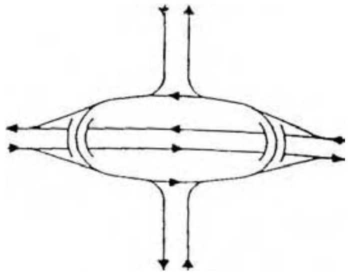


Figure 3.5-8 Roundabout Interchange

(3) Partial Grade Separation Group

Partial grade separation group has at least one location in which traffic movements cross each other at grade. It may be either a crossing of a main road and a ramp or a crossing of two ramps. This group may be suitable for interchanges between two roads of different classification standards such as an expressway and an ordinary road. While continuity and safety of traffic may not be fully achieved, the construction cost is generally lower and the land to be acquired is also smaller. There are various interchange types under this group.

1) Trumpet Interchange

A trumpet interchange is traditionally used for a three-leg interchange where one highway terminates at another expressway (Figure 3.5-9(a)). It involves at least one loop ramp connecting traffic either entering or leaving the terminating expressway with far lanes of the continuous expressway. These junctions are useful for toll roads as they concentrate all entering and leaving traffic in a single stretch of road where toll booths can be installed. For a four-leg interchange, a double trumpet interchange (Figure 3.5-9(b)) or a combination of a traditional trumpet and an at-grade crossing (Figure 3.5-9(c)) can be considered. A double trumpet interchange can usually be found when a toll road meets another toll road or expressway.

<u>Advantages</u>

- It provides a relatively high-speed, semi-direct movement for heavier turning volume of traffic, increasing the capacity.
- It involves no weaving (except in a double trumpet interchange).

<u>Disadvantages</u>

- It has a loop ramp of a tight radius for traffic off an expressway, depending on the interchange configuration.
- Length of the ramps tends to be longer, especially, in a double trumpet interchange.

(a) (b) (c)

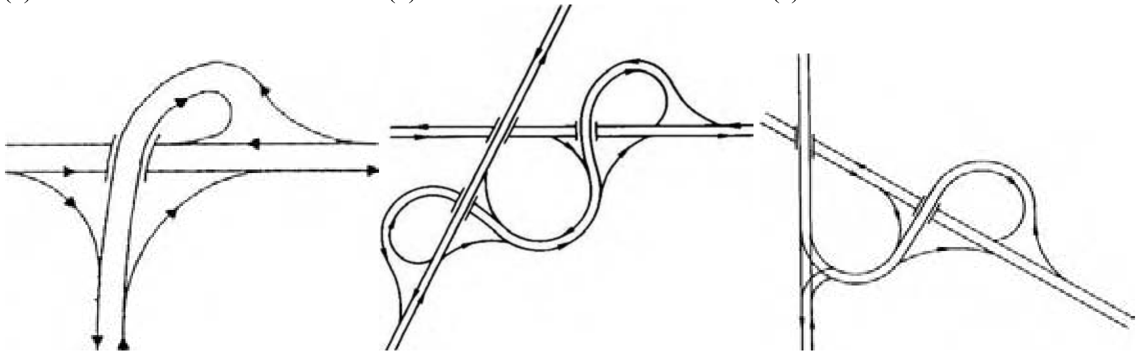


Figure 3.5-9 Trumpet Interchanges

2) Diamond Interchange

A diamond interchange (Figure 3.5-10) is used where an expressway crosses a minor road. The expressway itself will be grade-separated from the minor road, and a bridge will be provided for one or the other. Approaching the interchange from either direction, an off-ramp diverges only slightly from the expressway and runs directly across the minor road, becoming an on-ramp which returns to the expressway in a similar fashion. The two places where the ramps meet the minor road are treated as conventional intersections.

<u>Advantages</u>

- 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.

<u>Disadvantage</u>

- It involves left turning movements on the minor road and lowers the capacity, and stop signs or traffic signals are required.

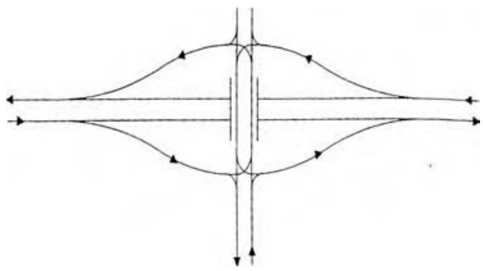


Figure 3.5-10 Diamond Interchange

3) Partial Cloverleaf Interchange

A partial cloverleaf interchange (Figure 3.5-11) has a shape transformed from a full cloverleaf interchange. Since it is usually designed with only two quadrants, it is also referred to as a folded diamond. The crossing road is often a minor road with at-grade intersections connecting with the ramps. There are various configurations of partial cloverleaf interchanges depending on the position of the two quadrants. This interchange type is often adopted to save cost on land acquisition.

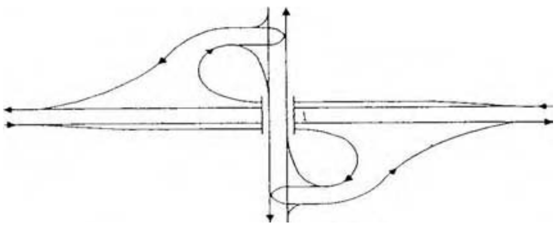
Advantages

- Single exit feature simplifies signing of expressway.
- It may be used as the first stage of a more complete cloverleaf interchange.
- It is economical in land use and makes the construction cost low.
- It involves no weaving on the expressway.

Disadvantage

- It has a loop ramp of a tight radius for traffic off an expressway, depending on the interchange configuration.
- It involves left turning movements on the minor road and lowers the capacity, and stop signs or traffic signals are required.

(a)



(b)

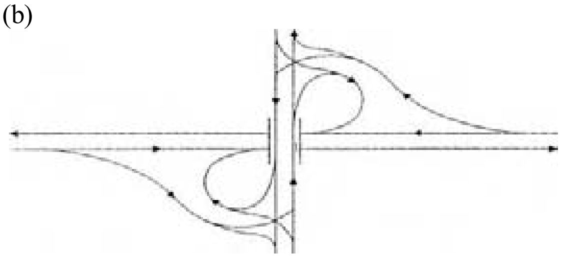


Figure 3.5-11 Partial Cloverleaf Interchanges

For the interchange connecting the HHTP eastern sub-gate and the provincial road on the east of NPIP with Lang-Hoa Lac Highway, full grade separation may not be necessary considering its high cost and vast land required. Also, too much weaving should be avoided. From the partial grade separation group, a diamond interchange may be the most recommendable for this location because of the following reasons:

- The difference in height (approximately 5 meters) between the designed Lang-Hoa Lac Highway and the crossing road will naturally make construction of a diamond interchange the most economical;
- Since Lang-Hoa Lac Highway has been designed based on the flat tariff (with a toll plaza planned around the 21-kilometer post), it is not necessary to concentrate the entering and leaving traffic for toll collection; and
- It is assumed that many commercial vehicles, especially, heavy vehicles from both HHTP and NPIP will make use of this interchange, and therefore it is better to avoid loop ramps of a tight radius.

However, further study is necessary to determine the type and design of the interchange. In particular, length and slope of the ramps should be carefully designed from a safety point of view because the crossing road is to be under Lang-Hoa Lac Highway.

3.5.3 Project Cost

The direct project construction cost is estimated based on the following conditions and assumptions; however, these are subject to change in a later stage based on the further study/design result and market price.

The construction cost of the works is estimated based on the following conditions.

(1) The quantities of the works are roughly estimated based on the preliminary design.

(2) The unit prices of the work are estimated based on the prices in the similar project and converted into 2007 current price.

(3) Exchange rate: 1 USD = 120 JPY = 16,000 VND.

(4) Value Added Tax (VAT) and Import Tax are excluded.

The estimated cost for each project is summarized in Table 3.5-2.

Table 3.5-2 Project Cost for Road

No.	Project	Specification	unit	Unit Cost (USD)	Phase-1 Quantity	Phase-1 Cost (USD)	Phase-2 Quantity	Phase-2 Cost (USD)	TOTAL Quantity	TOTAL Cost (USD)	Remarks	Conditoin
1	Construction of Internal and Zonal Roads	Pavement (asphalt)	m^2	30	312,480	9,374,400	103,660	3,109,800	416,140	12,484,200	Includes lane addition to Road A	t=600, sub-base, base, asphalt
		Sidewalk (inter-locking)	m^2	7	149,430	1,046,010	29,260	204,820	178,690	1,250,830		with sand
		Buffer Zone	m^2	1	46,260	46,260	3,250	3,250	49,510	49,510		sodding
		Median Strip	m^2	1	22,180	22,180	7,590	7,590	29,770	29,770		sodding
		Concrete Curbs	m	15	62,450	936,750	22,890	343,350	85,340	1,280,100	Includes lane addition to Road A	with inlet, base
		Lighting Pole	unit	970	1,050	1,018,500	270	261,900	1,320	1,280,400	Intervals of 35m	with pole,cable
		Plants	unit	12	4,900	58,800	1,340	16,080	6,240	74,880	Intervals of 7.5m	H=1m
		Total				**12,502,900**		**3,946,790**		**16,449,690**		
2	Construction of Bridges and Culverts	Bridges (PC, I-beam)	m^2	1,100	7,860	8,646,000	2,550	2,805,000	10,410	11,451,000	phase-1:9 bridges (No. 5-11, 13, 14)	L=20m
		Bridge (PC, Arch)	m^2	1,600	2,600	4,160,000		0	2,600	4,160,000	phase-1:1 bridge (No. 15)	L=20m
		Culverts (2@2mx2m)	m	1,110	100	111,000		0	100	111,000	phase-1:3 road sections (No. 16-18)	including earth work
		Total				**12,917,000**		**2,805,000**		**15,722,000**		
3	Construction of Interchanges and Grade Separation	Grae Separation	LS	8,107,000	1	8107000		0	1	8,107,000	Lang-Hoa Lac Hwy (KM28+971)	L=700m with frontage road
		Interchange (underpass)	LS	8,107,000	1	8107000		0	1	8,107,000	Lang-Hoa Lac Hwy (KM27+000)	L=700m with frontage road
		Total				**16,214,000**		**0**		**16,214,000**		
GRAND TOTAL						**41,633,900**		**6,751,790**		**48,385,690**		

Source: JICA Study Team

4. WATER SUPPLY SYSTEM

4.1 Outline of Original Sector Plan

(1) Water Supply Area

In the original Master Plan in 1998, the water supply system for HHTP was planned to be used in common for the HHTP area and the Vietnam National University (VNUH) area from the view point of economical infrastructural development, because both areas are close to each other.

(2) Water Demand

Water demand for HHTP was projected to be 37,000 m^3/day at the final phase (Year of 2020). The total water demand for both the HHTP area and VNUH area was projected to attain 68,000 m^3/day as stated below.

Table 4.1-1 Water Demand Projection for HHTP and VNUH in the Original M/P

Area	Water Demand (m^3/day)		
	2005	2010	2020
HHTP Area	13,000	17,000	37,000
VNUH *1	10,000	25,000	31,000
Total (Daily Average Water Demand)	23,000	42,000	68,000

*1: The water demand for VNUH was quoted from "The Tentative Plan of the Hanoi National University" prepared by MOET on April 30, 1996

Table 4.1-2 Daily and Hourly Maximum Water Consumption in the Original M/P

Area	Quantity	Remarks
Daily Average Water Demand	68,000 m^3/day	-
Daily Average Water Consumption	81,600 m^3/day	Unaccounted for Water Ratio:20 %
Daily Maximum Water Consumption	97,920 m^3/day	Daily Peak Factor:1.2
Hourly Maximum Water Consumption	10,200 m^3/hour	Hourly Peak factor:2.5

(3) Outline of Water Supply System

In the original M/P, a new water purification plant was to be constructed in Da Chong, which was located 27 km from HHTP and adjacent to Da River. The water supply system consisted of a water intake system, water purification plant, water conveyance system, conveyance pipes to be laid between Da River and HHTP, water reservoirs and water distribution pipe inside HHTP.

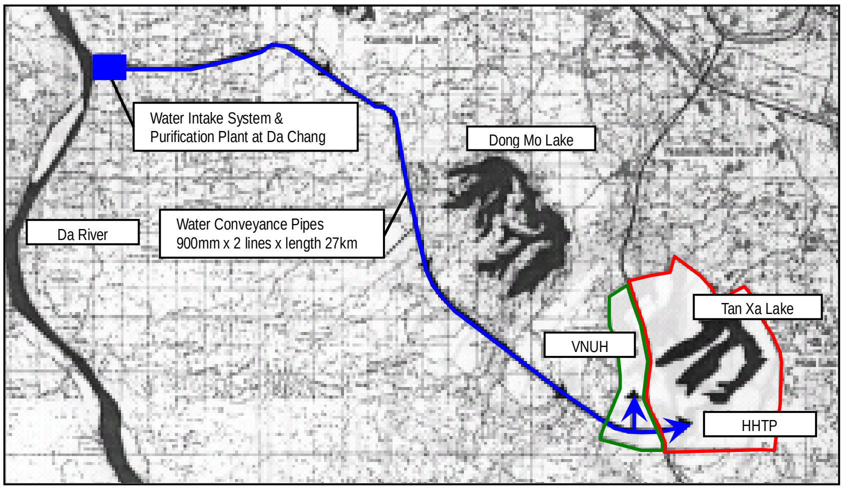
Water purified in the water purification plant was to be transferred to VNUH and reservoirs in HHTP. After that, the water was to be distributed via pump stations, distribution pipes and elevated tanks.

Main specifications of the water supply facilities are shown in Table 4.1-3. Location of the water purification plant and route of the pipeline are shown in Figure 4.1-1.

Table 4.1-3 Main Specifications of Facilities in the Original M/P

Component System	Facilities and Specifications
1. Water Intake System	Total intake capacity: 110,000 m^3/day -Intake channel with screens and sand chambers -Intake pumps
2. Water Purification Plant	Total production capacity: 100,000 m^3/day -Grit chambers with bar screens -Flash mixing and coagulation tanks -Sedimentation tanks -Rapid sand filters -Purified water reservoirs -Power substation -Administration and chemical handing room
3. Water Conveyance System	Total conveyance capacity: 100,000 m^3/day -Transfer pumps -Pipes outside HHTP (DIP 900mm x length 27km x 2 lines) -Pipes inside HHTP (in HHTP, DIP 400-800mm x length 17 km)
4. Water Reservoirs	-5,500 m^3 x 1 unit -2,200 m^3 x 1 unit -1,700 m^3 x 1 unit
5. Distribution System *1	-Distribution pipes (DIP: 100-500mm x length 24,910m, VP: 50-75mm x 7,560m) -Distribution pump stations (3 stations) -Elevated tanks (50-120 m^3, 3 tanks)

*1 Distribution system was planned only for Phase-1 area as Feasibility Study



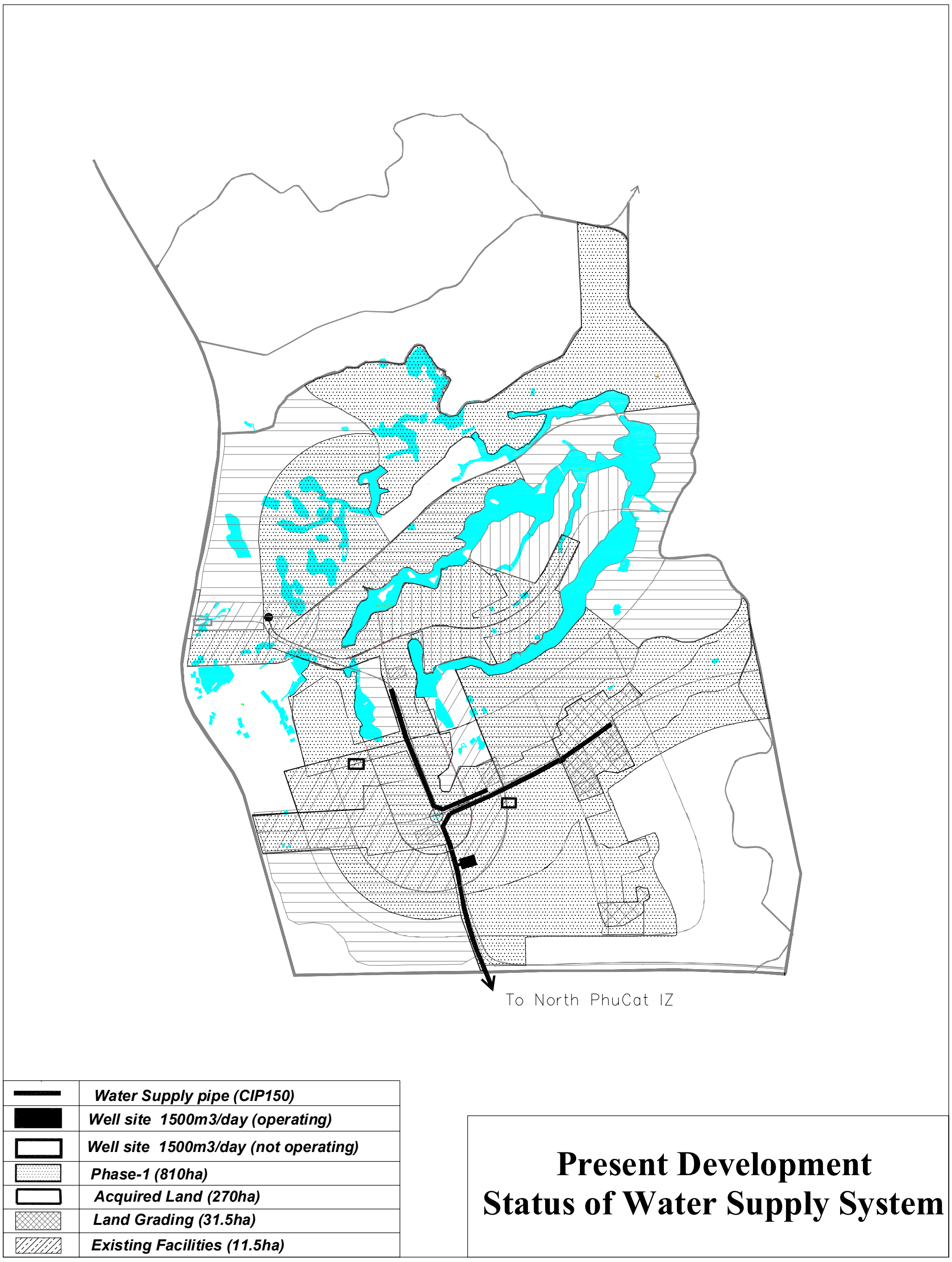
Source: JICA Study Team

Figure 4.1-1 Location of Water Purification Plant in the Original M/P

4.2 Present Condition

4.2.1 Current Development Progress

Three groundwater wells (capacity of 1,500m^3/day/well) have been developed in HHTP. One of them is equipped with a chlorination plant and supplies water to existing facilities except for the Start-Up Center which has its own well. A pipeline has been installed along the internal road network. Since the present water demand in HHTP is small, HHTP is supplying water to Phu Cat Industrial Zone. Location of the wells and present development status of the water supply pipeline are shown in figure 4.2-1.



Source: JICA Study Team

Figure 4.2-1 Location of Wells and Present Water Supply Network

4.2.2 Related Project

<u>Da River Water Supply Project</u>

Da River Water Supply Project (DWSP) will supply water to the Son Tay - Hoa Lac - Xuan Mai - Mieu Mon - Hanoi - Ha Dong urban chain and areas along the Lang - Hoa Lac Highway, of which VINACONEX is the investor under the Building-Operation-Owning (BOO) scheme. From a water purification plant which is located in Hoa Binh, purified water will be supplied to Hanoi City by gravity flow through a pipeline installed along the Lang- Hoa Lac Highway with a total length of about 47 km.

Most of the construction works for the 1st phase with a capacity of 300,000m^3/day have been completed, except for a 3km pipeline including the section in front of HHTP due to land acquisition problems. However, it is scheduled to be commissioned by the end of 2007. A total of 12,000m^3/day water will be distributed to HHTP and Phu Cat Industrial Zone (PCIZ).

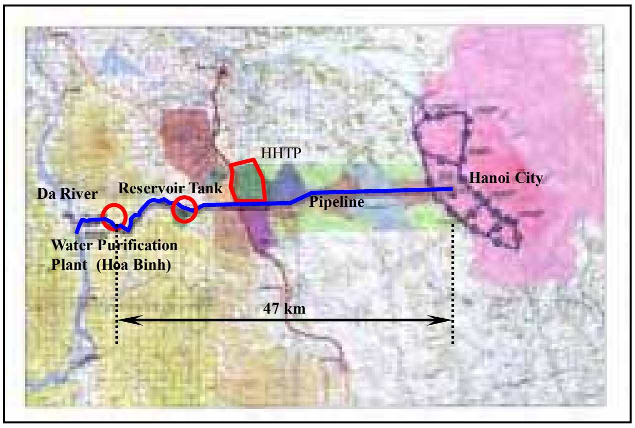
Subsequently, 2nd phase works with capacity of 600,000 m^3/day are planned to be commenced with target completion in 2010. If the water demand grows steadily, future expansion plans for up to 1,200,000 m^3/day capacity are also envisaged as a 3rd phase development.

In the 2nd phase and 3rd phase, additional pipelines are to be installed in parallel with pipeline installed under the 1st phase and the pipelines will be connected to back up each other.

Table 4.2-1 Capacity of Da River Water Supply Project

Phase	Capacity (Accumulating Total)	Construction Schedule
1st Phase	300,000m^3/day	by 2007
2nd Phase	600,000m^3/day	by 2010
3rd Phase	1,200,000m^3/day	Not yet determined

Source: JICA Study Team



Source: VINACONEX HP, JICA Study Team

Figure 4.2-2 Da River Water Supply Project

Water Purification Plant

Pipeline

Source: JICA Study Team

Facilities of Da River Water Supply Project

4.3 Update of Sector Plan

4.3.1 Sector Development Missions, Strategies and Goals

Missions, strategy and goals for water supply system sector are stated as below.

Table 4.3-1 Missions, Strategies and Goals for Water Supply Sector

Missions	To maintain excellent water quality, which is meets the Vietnamese standards. To supply sufficient quantity, which is meets the demands of end users. To provide adequate water pressure, which is meets the demands of end users.
Strategies	To plan a flexible system, which is can continue to supply water in case of internal (inside HHTP) and external (outside HHTP) accidents in order to realize sufficient water quantity even in case of accident. To plan a strong and durable system, which is can secure excellent water quality and sufficient water quantity. To plan a hydraulically effective system, which is can utilize the water pressure of DWSP in order to provide adequate water pressure. To plan a simple system, which is can facilitate the operation and minimize the maintenance work in order to secure the stability of water quantity and pressure.
Goals	To complete the development of water supply system of the HHTP by 2012 (for Phase-1) and by 2020 (for Phase-2).

In the Original M/P, a new purification plant for HHTP and VNUH was to be constructed at Da Chung. In this M/P, however, the water to HHTP will be supplied from the Da River Water Supply Project (DWSP, 300,000m^3/day as the 1st Phase and an additional 300,000m3/day as the 2nd Phase), because it is more economical, quicker and more rational to take water from a reliable external water supply system than for HHTP to construct their own water purification and conveyance system and maintain the facilities in order to develop the water supply system to realize the development mission.

4.3.2 Planning Framework

(1) Water Supply Area

In the Original M/P, the water supply system, including a water purification plant and water conveyance system, was planned to be used for both the HHTP area and VNUH area from the view point of economical infrastructural development. However, in this M/P, there is no advantage in sharing the system due to the fact that the water will be taken from DWSP. Therefore, the water supply area in this M/P is confined to the HHTP area.

(2) Water Demand and Consumption

1) Unit Water Demand

Unit water demand is estimated as shown in Table 4.3-2. Unit demands were primarily determined from TCXDVN-33-2006, which is the latest Vietnamese standard for water supply works. However, unit demands not indicated in TCXDVN-33-2006 were determined referring to TCVN-4513-1988 and Japanese standards.

Table 4.3-2 Unit Water Demand in HHTP

Category		TCXDVN-33-2006				Unit Demand for Hoa Lac				
		Urban Grade	II & III		IV	III			Source	Application
		Target Year	2010	2020	2010	2010	2012(phase-1)	2020(phase-2)		
1.	Domestic	l/cp/d	120	150	60	120	125	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	85	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	64	76	Refering to Japanese Standrad	Software Park, Center of Hi-Tech City
6.	Commercial *3	l/m^2	-	-	-	10.5	10.9	13.1		Amusement
7.	School *4	l/cp/d	-	-	-	19.2	20.0	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 (Restaurant, Shower)	l/cp/d	-	-	-	36.0	38.0	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	1.4	1.3	1.2		all

R&D: Water demand is assumed to be not so large as production manufacture. Therefore, 22m^3/day is applied.
*1: 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) Water Demand and Daily Maximum Water Consumption

Water demand and consumption by area in Phase-1 and Phase-2 are shown in Table 4.3-3. And the calculation table for each area is shown in Table 4.3-3. Daily maximum water consumption for Phase-1 (19,300 m^3/day) is larger than the amount planned for HHTP (12,000m^3/day) in the 1st phase of DWSP as indicated in 4.2.2. The countermeasure for this issue is discussed in section 4.3.4.

Table 4.3-3 Water Demand of HHTP

No.	Land Use	Phase-1(2012)		Phase-2 (2020)	
		Daily Average (m^3/day)	Daily Maximum (m^3/day)	Daily Average (m^3/day)	Daily Maximum (m^3/day)
1.	Software Park	140	220	290	420
2.	Research and development (R&D Zone)	1,540	2,400	2,860	4,120
3.	High-Tech Industrial Zone	6,300	9,830	15,300	22,030
4.	Education and Training Zone	440	690	6,040	8,700
5.	Center of Hgh-Tech City	640	1,000	2,530	3,640
6.	Mixed Use Zone	1,910	2,980	3,600	5,180
7.	High Class Residential (R&D Zone, Amenity Zone)	0	0	450	650
8.	Residential Zone	570	890	2,700	3,890
9.	Housing Complex	0	0	1,440	2,070
10.	Reserved Area	0	0	8,100	11,660
11.	Golf Course (Amenity Zone)	10	16	10	10
12.	Amusement Zone	790	1,230	1,500	2,160
Total		12,300	19,300	44,800	64,500

Source: JICA Study Team

1. Software Park

Phase-1 (2012)

Demand		
Daytime Population	Unit Demand	Demand
(capita)	(lit/cp/d)	(m^3/d)
2,250	64	140

Phase-2 (2020)

Demand		
Daytime Population	Unit Demand	Demand
(capita)	(lit/cp/d)	(m^3/d)
3,750	76	290

2. Research and Development (R&D Zone)

Phase-1 (2012)

Demand		
Area	Unit Demand	Demand
(ha)	(m^3/ha/d)	(m^3/d)
70	22	1540

Phase-2 (2020)

Demand		
Area	Unit Demand	Demand
(ha)	(m^3/ha/d)	(m^3/d)
130	22	2860

3. High-Tech Industrial Zone

Phase-1 (2012)

Demand		
Area	Unit Demand	Demand
(ha)	(m^3/ha/d)	(m^3/d)
140	45	6300

Phase-2 (2020)

Demand		
Total Floor Area	Unit Rater	Demand
(ha)	(lit/m^2/d)	(m^3/d)
340	45	15300

4. Education and Training Zone

Phase-1 (2012)

School Demand			Domestic Demand				Public Demand		Service & Commercial Demand		Total Demand
Daytime Population	Unit Demand	Demand	Living Population	Unit Rate	Service Ratio	Demand	Ratio	Demand	Ratio	Demand	
(capita)	(lit/cp/d)	(m^3/d)	(capita)	(lit/cap/d)	(%)	(m^3/d)	(%)	(m^3/d)	(%)	(m^3/d)	(m^3/d)
22,000	20	440	0	125	85	0	10	0	10	0	440

Phase-2 (2020)

School Demand			Domestic Demand				Public Demand		Service & Commercial Demand		Total Demand
Daytime Population	Unit Demand	Demand	Living Population	Unit Rate	Service Ratio	Demand	Ratio	Demand	Ratio	Demand	
(capita)	(lit/cp/d)	(m^3/d)	(capita)	(lit/cap/d)	(%)	(m^3/d)	(%)	(m^3/d)	(%)	(m^3/d)	(m^3/d)
38,000	24	912	28,500	150	100	4275	10	427.5	10	427.5	6040

5. Center of Hi-Tech City

Phase-1 (2012)

Office Demand			Domestic Demand				Public Demand		Service & Commercial Demand		Total Demand
Daytime Population	Unit Demand	Demand	Living Population	Unit Demand	Service Ratio	Demand	Ratio	Demand	Ratio	Demand	
(capita)	(lit/cp/d)	(m^3/d)	(capita)	(lit/cap/d)	(%)	(m^3/d)	(%)	(m^3/d)	(%)	(m^3/d)	(m^3/d)
10,000	64	640	0	125	85	0	10	0	10	0	640

Phase-2 (2020)

Office Demand			Domestic Demand				Public Demand		Service & Commercial Demand		Total Demand
Daytime Population	Unit Demand	Demand	Living Population	Unit Demand	Service Ratio	Demand	Ratio	Demand	Ratio	Demand	
(capita)	(lit/cp/d)	(m^3/d)	(capita)	(lit/cap/d)	(%)	(m^3/d)	(%)	(m^3/d)	(%)	(m^3/d)	(m^3/d)
12,500	76	950	8,750	150	100	1313	10	131	10	131	2530

6. Mixed Use Zone

Phase-1 (2012)

Domestic Demand *1				Public Demand		Service & Commercial Demand		Total Demand
Living Population	Unit Demand	Service Ratio	Demand	Ratio	Demand	Ratio	Demand	
(capita)	(lit/cap/d)	(%)	(m^3/d)	(%)	(m^3/d)	(%)	(m^3/d)	(m^3/d)
15,000	125	85	1594	10	159	10	159	1910

Phase-2 (2020)

Domestic Demand *1				Public Demand		Service & Commercial Demand		Total Demand
Living Population	Unit Demand	Service Ratio	Demand	Ratio	Demand	Ratio	Demand	
(capita)	(lit/cap/d)	(%)	(m^3/d)	(%)	(m^3/d)	(%)	(m^3/d)	(m^3/d)
20,000	150	100	3000	10	300	10	300	3600

*1: Although there exists commercial facilities or office in Mixed Use Area, only domestic water demand is considered, because living population is larger than daytime population.

7. High Class Residential (R&D Zone + Amenity Zone: 1,500 capita (Phase-1), 4,000 capita (Phase-2))

Phase-1 (2012)

Domestic Demand				Public Demand		Service & Commercial Demand		Total Demand
Living Population	Unit Demand	Service Ratio	Demand	Ratio	Demand	Ratio	Demand	
(capita)	(lit/cap/d)	(%)	(m^3/d)	(%)	(m^3/d)	(%)	(m^3/d)	(m^3/d)
0	125	85	0	10	0	10	0	0

Phase-2 (2020)

Domestic Demand				Public Demand		Service & Commercial Demand		Total Demand
Living Population	Unit Demand	Service Ratio	Demand	Ratio	Demand	Ratio	Demand	
(capita)	(lit/cap/d)	(%)	(m^3/d)	(%)	(m^3/d)	(%)	(m^3/d)	(m^3/d)
2,500	150	100	375	10	38	10	38	450

Source: JICA Study Team

Table 4.3-4 (1) Water Demand Projection Sheet of HHTP (1)

8. Residential Zone

Phase-1 (2012)

Domestic Demand				Public Demand		Service & Commercial Demand		Total Demand
Living Population	Unit Demand	Service Ratio	Demand	Ratio	Demand	Ratio	Demand	
(capita)	(lit/cap/d)	(%)	(m^3/d)	(%)	(m^3/d)	(%)	(m^3/d)	(m^3/d)
4,500	125	85	478.125	10	48	10	48	570

Phase-2 (2020)

Domestic Demand				Public Demand		Service & Commercial Demand		Total Demand
Living Population	Unit Demand	Service Ratio	Demand	Ratio	Demand	Ratio	Demand	
(capita)	(lit/cap/d)	(%)	(m^3/d)	(%)	(m^3/d)	(%)	(m^3/d)	(m^3/d)
15,000	150	100	2250	10	225	10	225	2700

9. Housing Copmlex

Phase-1 (2012)

Domestic Demand				Public Demand		Service & Commercial Demand		Total Demand
Living Population	Unit Demand	Service Ratio	Demand	Ratio	Demand	Ratio	Demand	
(capita)	(lit/cap/d)	(%)	(m^3/d)	(%)	(m^3/d)	(%)	(m^3/d)	(m^3/d)
0	125	85	0	10	0	10	0	0

Phase-2 (2020)

Domestic Demand				Public Demand		Service & Commercial Demand		Total Demand
Living Population	Unit Demand	Service Ratio	Demand	Ratio	Demand	Ratio	Demand	
(capita)	(lit/cap/d)	(%)	(m^3/d)	(%)	(m^3/d)	(%)	(m^3/d)	(m^3/d)
8,000	150	100	1200	10	120	10	120	1440

10. Reserved Area (High-Tech Industrial)

Phase-1 (2012)

Demand *2		
Area	Unit Demand	Demand
(ha)	(m^3/ha/d)	(m^3/d)
0	45	0

Phase-2 (2020)

Demand *2		
Area	Unit Demand	Demand
(ha)	(m^3/ha/d)	(m^3/d)
180	45	8100

*2: Assumed land use is Industrial Area

11. Golf Course (Amenity Zone)

Phase-1 (2012)

Club House *3		
Daytime population	Unit Demand	Demand
(capita)	(l/capita/d)	(m^3/d)
200	38	10

Club House *3		
Daytime population	Unit Demand	Demand
(capita)	(l/capita/d)	(m^3/d)
200	45	10

*3: Water resource for watering is to be lakes or ponds around the golf course

12. Amusement Zone

Phase-1 (2012)

Watering Demand for Park, Trees			Swimming Pool			Club House (Stadium, Swimming Pool)			Amusement Facilities			Total Demand
Area	Unit Demand	Demand	Pool Volume	Over Flow Ratio	Demand	Athletes *4	Unit Rater	Demand	Floor Area *5	Unit Rater	Demand	
(ha)	(l/m^2/d)	(m^3/d)	(m^3/d)	(l/capita/d)	(m^3/d)	(capita)	(l/capita/d)	(m^3/d)	(m^2)	(l/m^2/d)	(m^3/d)	(m^3/d)
20	1.5	300	412	10	453	800	38	30	980	10.9	10	790

Phase-2 (2020)

Watering Demand for Park, Trees			Swimming Pool			Club House (Stadium, Swimming Pool)			Amusement Facilities			Total Demand
Area	Unit Demand	Demand	Pool Volume	Unit Ratio	Demand	Athletes *4	Unit Rater	Demand	Floor Area *5	Unit Rater	Demand	
(ha)	(l/m^2/d)	(m^3/d)	(capita)	(l/capita/d)	(m^3/d)	(capita)	(l/capita/d)	(m^3/d)	(m^2)	(l/m^2/d)	(m^3/d)	(m^3/d)
60	1.5	900	412	10	453	2,400	45	110	2,940	13.1	40	1500

*4: 40% of the daytime population for Park, Sports, Amusement Area
*5: 70% of the total floor area in Park, Sports, Amusement Area

Source: JICA Study Team

Table 4.3-4 (2) Water Demand Projection Sheet of HHTP (2)

3) Hourly Maximum Factor

Hourly maximum factor is a coefficient used for calculating hourly maximum water consumption, which is used for design of distribution pipelines and elevated tanks. Hourly maximum water consumption is calculated by the following formula.

$$q_{hour.max} = K_{hour.max} \times Q_{day.max}/24$$
$$K_{hour.max} = \alpha_{max} \times \beta_{max}$$

Where,
- $q_{hour.max}$: Hourly maximum water consumption
- $K_{hour.max}$: Hourly maximum factor
- $Q_{day.max}$: Daily maximum water consumption
- α_{max} : Urbanization Coefficient (1.2 – 1.5)
- β_{max} : Population Coefficient (Table 4.3-5)

Table 4.3-5 Standard for β_{max} (Coefficient)

Population (1000 persons)	0.1	0.15	0.20	0.30	0.50	0.75	1	2
β_{max}	4.5	4.0	3.5	3.0	2.5	2.2	2.0	1.8
Population (1000 persons)	4	6	10	20	50	100	300	>1000
β_{max}	1.6	1.4	1.3	1.2	1.15	1.1	1.05	1.0

Source: TCXDVN-33-2006

In this M/P, hourly maximum factor is determined as follows.

Table 4.3-6 Hourly Maximum Factor by Phase

Phase	α_{max}	β_{max}	$K_{hour.max}$	Remarks
Phase-1	1.2	1.1	1.32	Population: 85,400
Phase-2	1.2	1.05	1.26	Population: 218,000

Source: JICA Study Team

4) Water Quality

Actual water quality which will be supplied from DWSP can not be confirmed at present because the water purification plant has not been operated. However, the water quality must follow TCXDVN-33-2006, which is the Vietnamese water supply standard. As shown below, the Vietnamese standard meets the WTO Guideline for Drinking Water Quality and the water supplied to HHTP will be adequate quality for drinking purposes.

Table 4.3-7 Water Quality for Urban Water Supply Systems

[Chemicals]

No.	Parameter	Unit	Vietnamese Standard (TCXDVN-33-2006)	WTO Guideline For Drinking Water Quality *1
1	Turbidity	NTU	≤ 2	Average ≤ 1 Maximum ≤ 5
2	Color	TCU	≤ 15	≤ 15
3	Odor	-	No strange smell	Acceptable
4	pH	-	6.5 - 8.5	6.5 – 8.5
5	Hardness	-	≤ 12	No Standard
6	Oxidisability ($KMnO_4^{2+}$)	mg/l	≤ 2	No Standard
7	Hydrogen sulfide, H_2S	mg/l	≤ 0.05	≤ 0.05
8	Chloride, Cl-	mg/l	≤ 250	≤ 250
9	Nitrate, NO_2^-	mg/l	≤ 50	≤ 50
10	Nitrite, NO_3^-	mg/l	≤ 3	≤ 3
11	Sulfate, SO_4^{2-}	mg/l	≤ 250	≤ 250
12	Phosphate, PO_4^{2-}	mg/l	≤ 2.5	No Standard -
13	Fluoride, F	mg/l	0.7 – 1.5	≤ 1.5
14	Iodine, I	mg/l	0.005 – 0.007	No Standard
15	Ammonia, NH_4^+	mg/l	≤ 1.5	≤ 1.5
16	Calcium, Ca	mg/l	≤ 100	No Standard
17	Iron, Fe	mg/l	≤ 0.3	≤ 0.3
18	Manganese, Mn	mg/l	≤ 0.2	≤ 0.4
19	Copper, Cu	mg/l	≤ 2	≤ 2
20	Zinc, Zn	mg/l	≤ 3	≤ 3
21	Aluminum, Al	mg/l	≤ 0.2	≤ 0.2
22	Lead, Pb	mg/l	≤ 0.01	≤ 0.01
23	Arsenic, As	mg/l	≤ 0.01	≤ 0.01
24	Cadmium, Cd	mg/l	≤ 0.003	≤ 0.003
25	Mercury, Hg	mg/l	≤ 0.01	≤ 0.001
26	Chromium, Cr	mg/l	≤ 0.001	≤ 0.005
27	Cyanide, CN	-	≤ 0.07	≤ 0.07
28	Chlorine concentration at the treatment plant or at pump station	mg/l	> 0.5 mg/l but not so much as to be offensive	> 0.5 mg/l
29	Chlorine concentration at the end of the network	mg/l	> 0.5 mg/l but not so much as to be offensive	> 0.5 mg/l

[Microorganism]

No.	Parameter	Vietnamese Standard (TCXDVN-33-2006)	WTO Guideline For Drinking Water Quality*
1	Creatures	No visible creatures and no worm's eggs, parasites or intestinal flat worms	-
2	Total coliform	Non detectable in 100 ml	Non detectable in 100 ml
3	E. coliform or fecal coliform	Non detectable in 100 ml	Non detectable in 100 ml

*: In this table, parameters in WHO Guideline are confined to the items regulated in TCXDVN-33-2006
Source: JICA Study Team

4.3.3 Sector Development Plan

(1) Verification of Water Pressure of DWSP

For the planning of the water supply system, water pressure of DWSP at the branch for HHTP is an important factor. Figure 4.3-1, the drawing of the pipeline prepared by VINACONEX, indicates that the water pressure at the branch point for HHTP will be about 4.5 kgf/cm^2. However, due to the importance of the pressure, the pressure should be verified in this study. Verification procedure of the water pressure in the pipeline of the DWSP is described below. Water pressure will be about 3.98 kgf/cm^2, which is a little lower than the VINACONEX plan but it will be sufficient pressure to deliver the water to the reservoirs which will be constructed in HHTP.

[Calculation of Head Loss]

$H_f = I \times L$
$= 15.81$ m
$I = 10.666 \times C^{1.85} \times D^{-4.85} \times Q^{1.85}$ (Hazen-Williams' Formula)

Where,
- H_f : Head loss (m)
- L : Length of pipeline = 7,410m (Reservoir – HHTP)
- I : Hydraulic gradient
- C : Roughness coefficient of pipes = 110 (Includes local pressure loss)
- D : Pipe diameter = 1.60 m
- Q : Water flow quantity = 3.797 m^3/sec *1

*1: Although the capacity of 1st phase of the water system is projected to be 300,000m^3/day, maximum flow from the Reservoir is indicated as 3.797m^3/s in the VINACONEX drawing, which is equivalent to 328,000m^3/day. There are some water users between the Reservoir and HHTP, which means that the flow quantity will be smaller than 3.797m^3/s. However, considering that head loss becomes larger if the flow quantity is larger, in order to prevent overestimation of water head, head loss is calculated on the condition that water flow quantity is 3.797 m^3/s.

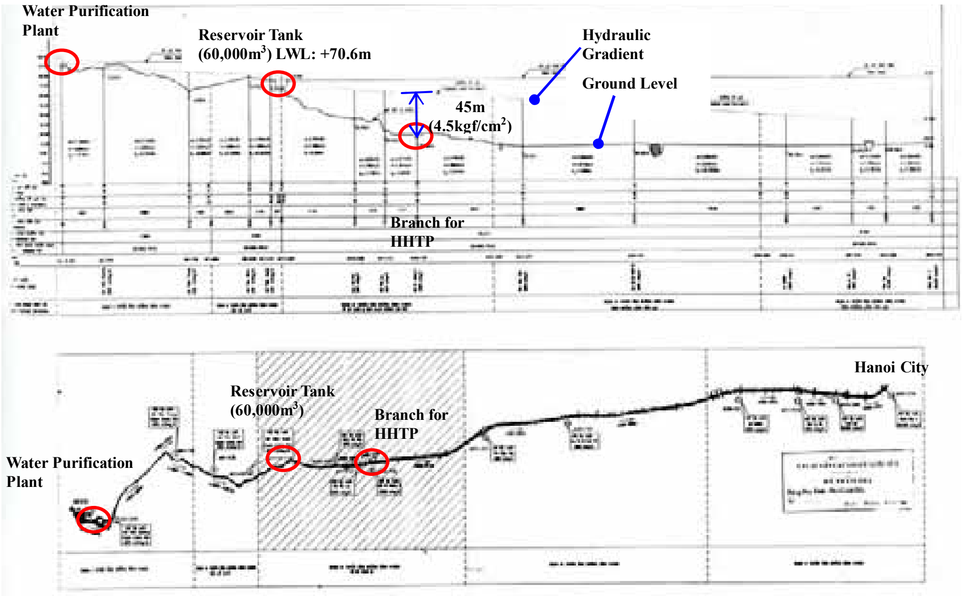
[Calculation of Water Pressure at HHTP]

Based on the fact that the lowest water level (L.W.L) of the reservoir is indicated as 70.6 m in the VINACONEX drawing, the water head at the branch point for HHTP will be as follows.

$H = H_1 - H_f - H_2$

$= \underline{\mathbf{39.8\ m}}$

Where, H : Water Head at HHTP (m)
H1 : L.W.L of the Reservoir = 70.6m
H_f : Head loss = 15.8 m
H2 : Ground Level at HTP = approximately 15m



Source: VINACONEX, JICA Study Team

Figure 4.3-1 Plan and Longitudinal Section of Pipeline of Da River Water Supply Project

(2) Basic Water Supply System

1) System Options

Water supply system options in HHTP are as below.

<u>- Plan-1</u>

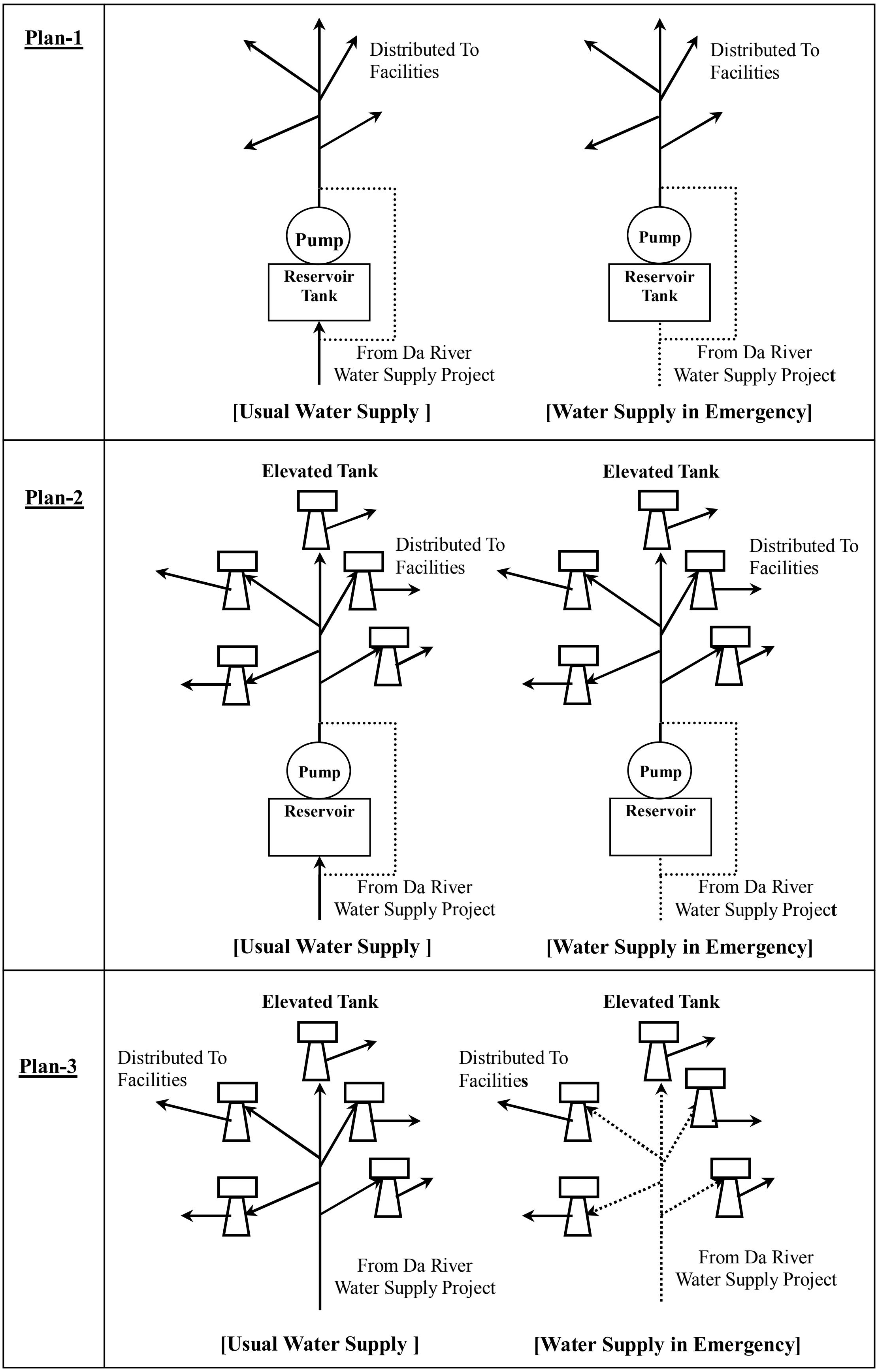
In this system, water from DWSP will usually be distributed via the reservoirs and pump stations. If DWSP fails to supply water, water will be supplied from the reservoirs. And if there are some troubles with the reservoirs or pump stations, direct water supply from DWSP is possible.

<u>- Plan-2</u>

In this system, water from DWSP will usually be distributed via the reservoirs, pump stations and elevated tanks. If DWSP fails to supply water, water will be supplied from the reservoirs. And if there are some troubles with the reservoir or pump stations, direct water supply from DWSP is possible.

<u>- Plan-3</u>

In this system, water from DWSP will usually be distributed via an elevated tank constructed in each water supply block. If DWSP fails to supply water, water will be supplied only from the elevated tank and reservoir on each building.



Source: JICA Study Team

Figure 4.3-2 Image of Basic Water Supply System Options

2) Selection of Basic Water supply System

Among these three systems, plan-2 is the most recommendable. Although plan-2 is the most expensive, safety against accidents should count in consideration of the importance of the activities in HHTP, especially in High-Tech Industrial Zone and Research and Development Zone.

Comparison of water supply systems is summarized in Table 4.3-8.

Elevated tanks should be designed so as not to spoil the scenery. With careful study of their shape and material they are expected to be a kind of landmark to suit the scenery of each area.

Table 4.3-8 Comparison of Basic Water Supply Systems

	Plan-1	Plan-2	Plan-3
Cost	More expensive than plan-3.	Most expensive.	Most inexpensive because there is no reservoir or pump station.
	Point: 2	Point: 1	Point: 3
Safeness	Water supply is possible even in case of loss of external water supply. However, this is inferior to Plan-2 in terms of safety against internal accident because there is no tank after the reservoir.	Safety against external and internal accidents is most excellent.	Capacity of back-up is smaller than other plans.
	Points: 2	Points: 3	Points: 1
Stability of Water Pressure	Water pressure can be relatively unstable because change in water consumption rates affects the water pressure in the pipeline directly.	Most stable due to existence of pump stations and elevated tanks.	Water pressure will be stable.
	Points: 1	Points: 3	Points: 2
Maintenance	Maintenance of pump facilities is necessary.	Same as plan-1.	Most easy because there is no large reservoir or pump station.
	Points: 2	Points: 2	Points: 3
Others	-	-	Some booster pumps will be necessary at the water supply blocks far from the connection point with DWSP
Evaluation	-	Safety and stability are most excellent. **Selected**	Overall point rating is equal to plan-2. However, safety against accident is inferior.
	Total Points: 8	Total Points: 9	Total Points: 9

Source: JICA Study Team

(3) Water Supply Network

1) Water Supply Network

The water Supply network for HHTP is shown in Figure 4.3-3. The entire water supply area is divided into 10 water supply blocks. Water from DWSP will flow into the reservoirs (No.1 – No.3) and be delivered to the elevated tanks by the pumps installed in pump stations beside the reservoirs.

Elevated tanks function to adjust the water pressure and to secure some back-up in case of accidents.

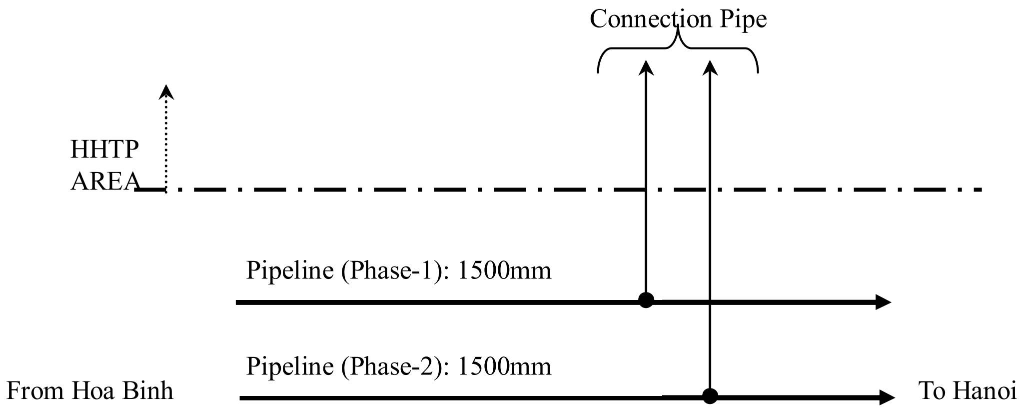
A looped pipeline is necessary to provide a flexible water supply system which can improve safety against accidents and for preventing accumulation at the end of the pipeline which causes water quality degradation. Therefore, the pipeline should be installed along with the road development even if the adjacent area belongs to Phase-2 in order to realize development goals indicated in 4.3.1.

2) Pipeline at the river/lake-crossing point

The pipeline at the river/lake-crossing point will be put on bridges. However, at the point of existing bridges, aqueduct bridges should be considered because the existing bridges may not be able to endure the load of the pipes and water.

3) Plan for Connection with DWSP

Pipes will be installed to connect to each DWSP pipeline as shown in Figure 4.3-4.



Source: JICA STUDY TEAM

Figure 4.3-4 Image of Connection with Da River Water Supply Project

(4) Plan of Reservoirs and Pump Stations

1) Capacity of Reservoirs

Total capacities of the reservoirs are planned to be equivalent to 12 hours of daily maximum water consumption in order to secure safety against accidents. The total of 12 hours is based on the Japanese standard for water supply. Capacities of reservoirs by phase are shown in Table 4.3-9.

Table 4.3-9 Capacity of the Reservoirs

No	Phase-1		Phase-2		Total		Service Area
	Water Consumption*	Capacity	Water Consumption*	Capacity	Water Consumption*	Capacity	
	(m^3/day)	(m^3)	(m^3/day)	(m^3)	(m^3/day)	(m^3)	
1	19,300	10,000	28,480	14,500	47,780	24,500	Main Area
2	0	0	5,060	2,600	5,060	2,600	East part of High-Tech IZ and Housing Complex
3	0	0	11,660	6,000	11,660	6,000	Reserved Area
Total	19,300	10,000	45,200	23,100	64,500	33,100	

*: Daily Maximum Water Consumption
Source: JICA Study Team

2) Capacity of Pump Stations

Capacities of pump stations which are based on hourly maximum water consumption are shown below.

Table 4.3-10 Necessary Capacities of the Pump Stations

No	Phase-1			Phase-2 (Total)			Service Area
	Water Consumption*1	$K_{hour.max}$	Necessary Capacity*2	Water Consumption*1	$K_{hour.max}$	Necessary Capacity*2	
	(m^3/day)	-	(l/s)	(m^3/day)	-	(l/s)	
1	19,300	1.32	294.9	47,780	1.26	696.8	Main Area
2	0	1.32	0	5,060	1.26	73.8	East part of High-Tech IZ and Housing Complex
3	0	1.32	0	11,660	1.26	170.1	Reserved Area
Total	19,300	-	294.9	64,500	-	895.6	

*1: Daily Maximum Water Consumption
*2: Hourly Maximum Water Consumption
Source: JICA Study Team

3) Plan of Reservoirs and Pump Stations

Based on Table 4.3-9 and Table 4.3-10, configuration of the reservoirs and the quantity of each pump station are determined. Outline of the reservoirs and pump stations are as follows.

Table 4.3-11 Outline of the Reservoirs and Pump Facilities

No.	Facility	Outline (Rough Configuration of the Reservoirs and Capacity of the Pumps)	Phase	Area
1	Reservoir	40m x 25m x 5mH x 2 tanks (10,000m^3)	1	1.8 ha
		50m x 30m x 5mH x 2 tanks (14,500 m^3)	2	
	Pump Station	100 l/s x 45mH x 4 sets (300 l/s, 1 Stand-by)	1	
		100 l/s x 45mH x 8 sets (700 l/s in total, 1 Stand-by)	2	
2	Reservoir	13m x 20m x 5mH x 2 tanks (2,600m^3)	2	0.5 ha
	Pump Station	45 l/s x 35mH x 3 sets (90 l/s, 1 Stand-by)	2	
3	Reservoir	30m x 20m x 5mH x 2 tanks (6,000m^3)	2	0.5 ha
	Pump Station	45 l/s x 35mH x 5 sets (180 l/s, 1 Stand-by)	2	

Source: JICA Study Team

(5) Capacity of Elevated Tanks

Capacity of elevated tanks is planned to be about 30 minutes' volume of hourly maximum water consumption based on the Japanese Standard for the elevated tanks for pressure adjustment. Capacity of the elevated tanks in each water supply block is shown in Table 4.3-12.

Table 4.3-12 Capacities of Elevated Tanks

No.	Land Use	Area	Daily Maximum Water Consumption	Hourly Maximum Water Consumption *	30 minute Volume of Hourly Maximum Water Consumption	Capacity of Tank	Phase
		ha	m^3/day	m^3/hour	m^3	m^3	
1	High-Tech Industrial Zone 1	147	9,520	499.8	250	250	1
2	Residential Zone	50	3,890	204.2	103	120	1
3	Center of Hi-Tech City	50	3,640	191.1	96		1
	Mixed Use Zone 1	57	3,370	176.9	89		
	Amusement Zone	60	2,160	113.4	57		
	Tank No.3 Total	167	9,170	481	242	250	
4	Research & Development (R&D Zone)	130	4,120	216.3	109	120	1
5	Education & Training Zone	95	8,700	456.8	229		1
	Mixed Use Zone 2	60	1,810	95.0	48		
	Tank No.5 Total	155	10,510	552	277	250	
6	Software Park	75	420	22.1	12	40	1
7	High Class Residential (R&D Zone, Zmenity Zone)	25	650	34.1	18		1
	Golf Course (Amenity Zone)	100	10	0.5	1		
	Tank No.6 Total	125	660	35	19	40	
8	High-Tech Industrial Zone 2	147	9,520	499.8	250	250	2
9	High-Tech Industrial Zone 3	46	2,990	157.0	79		2
	Housing Complex	20	2,070	108.7	55		
	Tank No.9 Total	66	5,060	266	134	120	
10	Reserved Area	180	11,660	612.2	307	250	2
	Total		64,600	3,391.5	1,703	1690	-

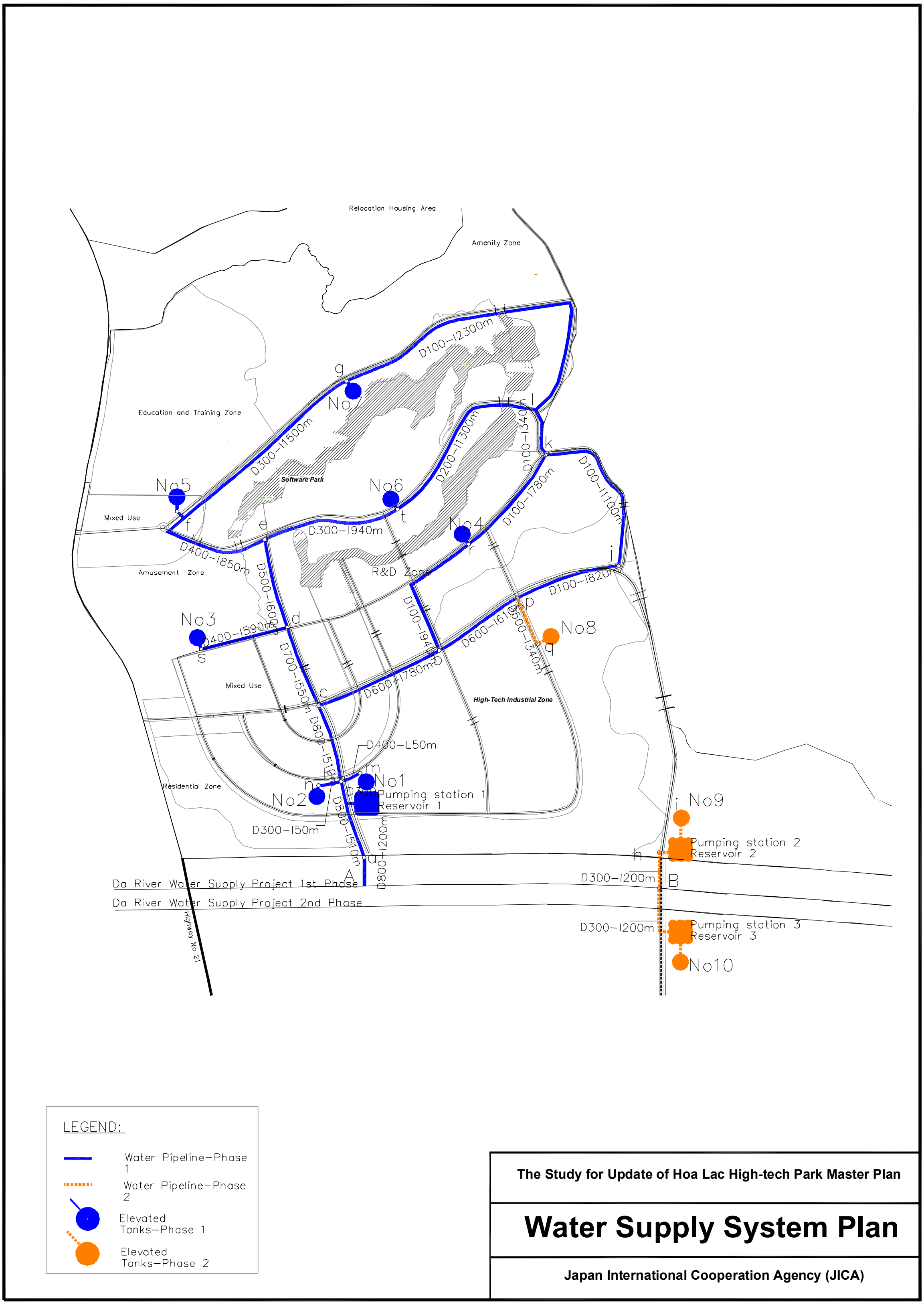
Source: JICA Study Team

(6) Material of Pipelines

Usually, cast-iron pipes (CIP), polyvinyl chloride pipes (PVC) and steel pipes (SP) are used for water supply pipelines. Among these materials, CIP is selected from the view point of economic advantage and strength.

(7) Utilization of Existing Wells

The water from the existing wells, which amounts to 7,000 m^3/day in maximum, should be utilized for back-up or emergency use.



Source: JICA Study Team

Figure 4.3-3 Plan of Water Supply Network

4.3.4 Development Issues

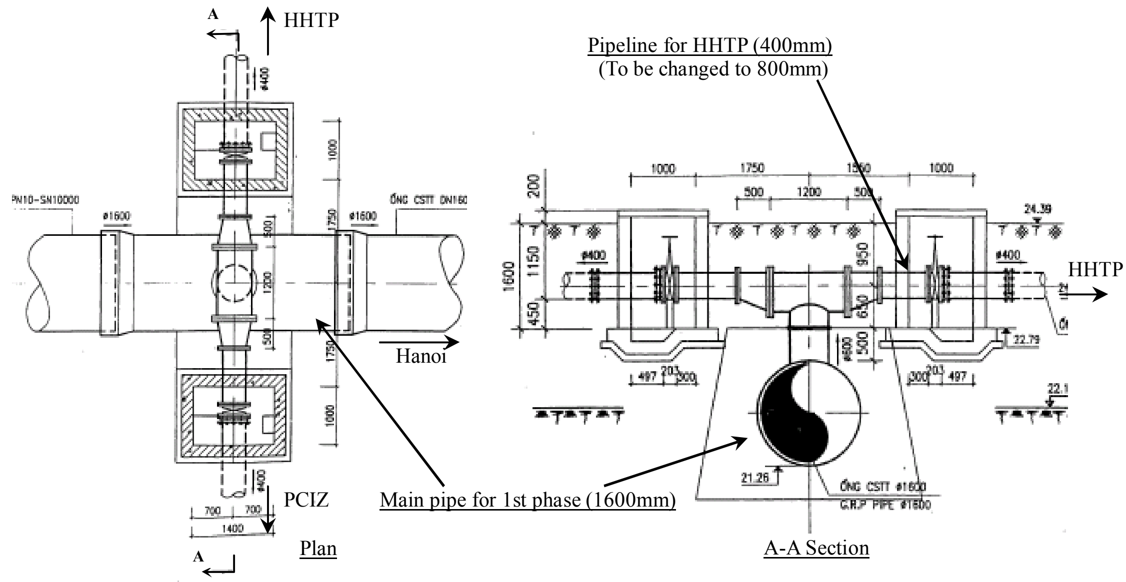
(1) Difference between Water Demand and Planned Supply Quantity in Phase-1

Although daily maximum water consumption of HHTP in Phase-1 is 19,300m^3/day as shown in Table 4.3-1, planned water supply quantity at the branch for HHTP is only 12,000m^3/day. Moreover, because the branch is shared with Phu Cat Industrial Zone (PCIZ), available water quantity for HHTP is less than 12,000m^3/day, which is much smaller than the water demand. It is necessary to submit a request to the executive agency of DWSP for a revision of water the distribution plan.

(2) Necessity of Changing the Specification of the Branch for HHTP

In the DWSP, the branch for HHTP is 1,600mm x 600mm and the diameter of the pipeline for HHTP is reduced to 400mm, which is too small to distribute the water to the whole area of HHTP. It is necessary to change the structure of the branch so that the diameter meets the water demand of HHTP, which is 800mm. Moreover, it is recommended that the branches be installed for HHTP and PCIZ separately to prevent adverse hydraulic effects caused by unbalanced water consumption between HHTP and PCIZ.

Present plan of the branch for HHTP and PCIZ is shown Figure 4.3-4.



Source: VINACONEX, JICA Study Team

Figure 4.3-5 Present Plan of the Branch for HHTP and PCIZ

4.4 Proposed Project List

Projects in the water supply sector that are necessary for developing HHTP are shown in Table 4.4-1. The projects can be categorized into those to be implemented in Phase-1, which are prioritized projects, and those to be implemented in Phase-2.

Table 4.4-1 Project List for Water Supply

No.	Project	General description	Specification	Phase
1	Installation of Pipeline for Phase-1	To install pipelines to take water from Da River Water Supply Project (DWSP) 1st Phase and develop water supply network to send water to each water supply block	CIP 800mm x 2,220m CIP 700mm x 550m CIP 600mm x 600m CIP 400mm x 3,220m CIP 300mm x 990m CIP 200mm x 3,620m CIP 100mm x 5,460m	1
2	Installation of Pipeline for Phase-2	To install pipelines to take water from DWSP 2nd Phase and other remained pipelines to complete the water supply network in HHTP	CIP 400mm x 200m CIP 300mm x 650m	2
3	Construction of Reservoir and Pump Station for Phase-1	To Construct the reservoir to secure water supply in case of accident for phase-1 area	No.1 Reservoir (10,000 m^3) No.1 Pump Station (100 l/s x 45 mH x 3 sets, 1 Stand-by)	1
4	Construction of Reservoirs and Pump Stations for Phase-2	To Construct the reservoirs to secure water supply in case of accident for phase-2 area (No.1: Expansion, No.2 and No.3: New construction)	No.1 Reservoir (Additional 14,500 m^3) No.1 Pump Station (100 l/s x 45 mH x 8 sets in total, 1 Stand-by) No.2 Reservoir (2,600 m^3) No.2 Pump Station (45 l/s x 35 mH x 3 sets, 1 Stand-by) No.3 Reservoir (6,000 m^3) No.3 Pump Station (45 l/s x 35 mH x 5 sets, 1 Stand-by)	2
5	Construction of Elevated Tanks for Phase-1	To construct elevated tanks for the areas which will be developed in phase-1	No.1 Capacity of 250m^3 x 28mH (H.W.L) No.2 Capacity of 120m^3 x 28mH (H.W.L) No.3 Capacity of 250m^3 x 28mH (H.W.L) No.4 Capacity of 40m^3 x 28mH (H.W.L) No.5 Capacity of 250m^3 x 28mH (H.W.L) No.6 Capacity of 120m^3 x 28mH (H.W.L) No.7 Capacity of 40m^3 x 28mH (H.W.L)	1
6	Construction of Elevated Tanks for Phase-2	To construct elevated tanks for the areas which will be newly developed in phase-2	No.8 Capacity of 250m^3 x 28mH (H.W.L) No.9 Capacity of 120m^3 x 28mH (H.W.L) No.10 Capacity of 250m^3 x 28mH (H.W.L)	2

Source: JICA Study Team

4.5 Technical Study for Phase-1 Development

4.5.1 Projects to Be Implemented in Phase-1

The projects to be implemented in Phase-1 are shown in Table 4.5-1 and Figure 4.3-1. The projects are to install pipelines to take water from Da River Water Supply Project (DWSP) 1st Phase and develop a water supply network to deliver water to each water supply block and to secure a stable water supply for HHTP Phase-1 area.

Table 4.5-1 Projects to Be Implemented in Phase-1

Project	Specification	Remarks
Installation of Pipeline	CIP 800 mm x 2,220 m	
	CIP 700 mm x 550 m	
	CIP 600 mm x 600 m	
	CIP 400 mm x 3,220 m	
	CIP 300 mm x 990 m	
	CIP 200 mm x 3,620 m	
	CIP 100 mm x 5,460 m	
Construction of Reservoir	No.1: Reservoir (10,000 m^3) 40 m x 25 m x 5 mH x 2 tanks	Residential Zone
Construction of Pump Station	No.1: 300 l/s, 100 l/s x 40mH x 4 sets 1 stand-by	Residential Zone
Construction of Elevated Tanks	No.1: 250m^3 x 28mH (H.W.L)	High-Tech Industrial Zone
	No.2: 120m^3 x 28mH (H.W.L)	Residential Zone
	No.3: 250m^3 x 28mH (H.W.L)	Amusement Zone
	No.4: 40m^3 x 28mH (H.W.L)	Software Park
	No.5: 250m^3 x 28mH (H.W.L)	Education and Training Zone
	No.6: 120m^3 x 28mH (H.W.L)	R&D Zone
	No.7: 40m^3 x 28mH (H.W.L)	R&D Zone

Source: JICA Study Team

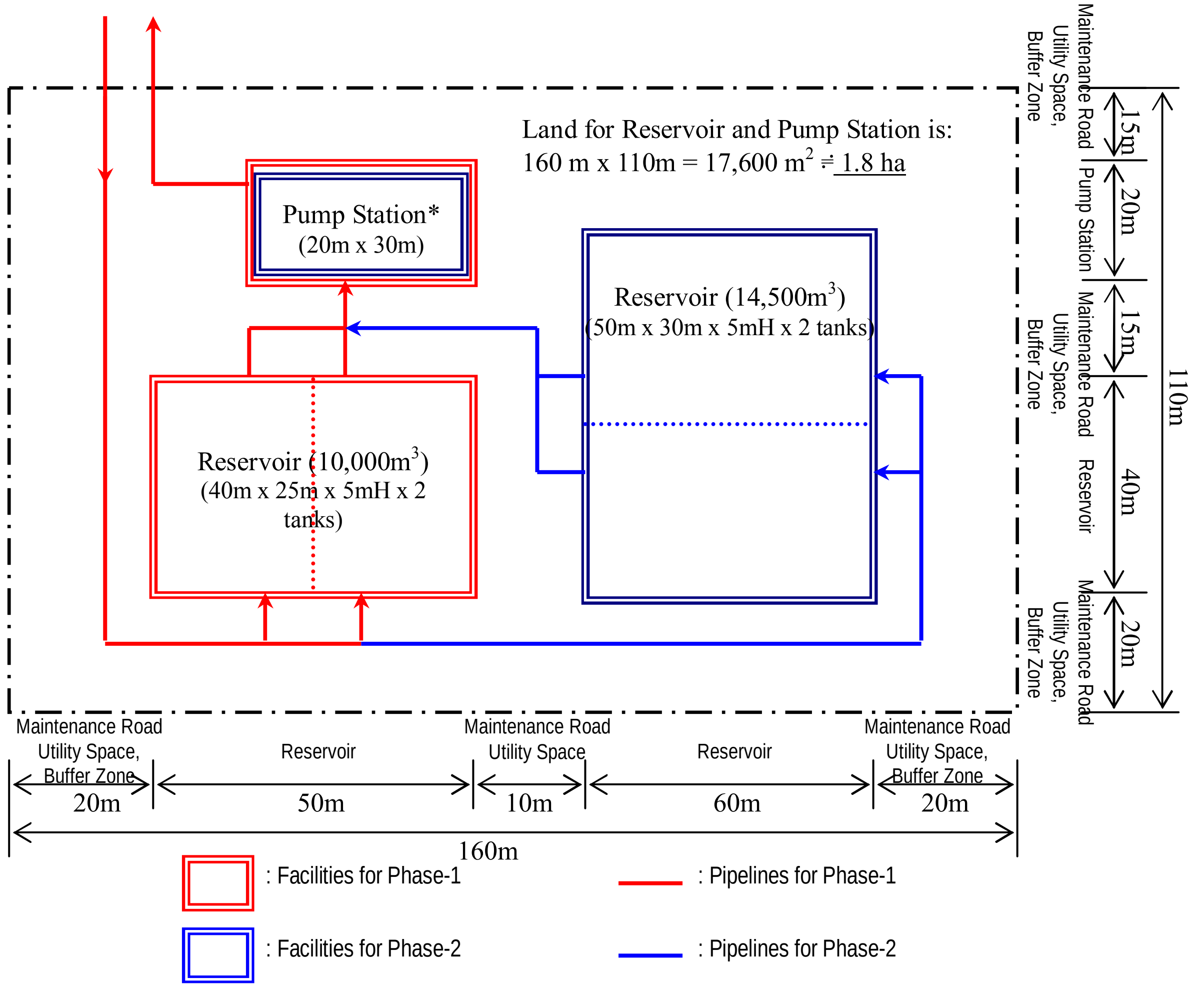
4.5.2 Reservoirs, Pump Station and Elevated Tanks in Phase-1

(1) Plan of Reservoir and Pump Station

The plan of the reservoirs and pump station is shown in Figure 4.5-1. The required area for the Phase-1 facilities will be about 0.8 ha, however, the entire 1.8 ha area should be reserved during the period of Phase-1 for future expansion in Phase-2.

(2) Plan of Elevated Tanks

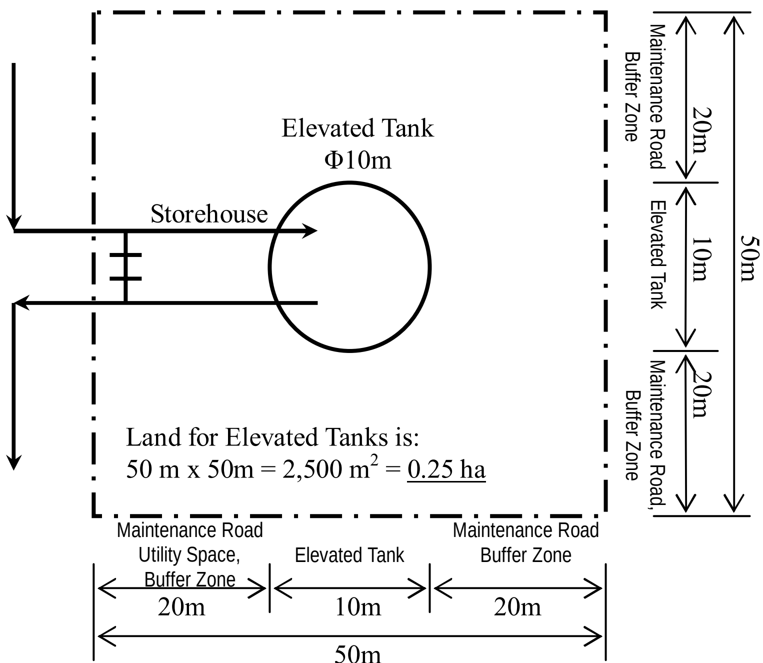
The plan of the elevated tanks is shown in Figure 4.5-2. The required area for the elevated tank facilities will be about 0.25 ha.



* Pump station will be constructed in Phase-1 so that the pump facilities for Phase-2 can be also installed in it in the future.

Source: JICA Study Team

Figure 4.5-1 Plan and Necessary Area for Reservoirs and Pump Station



Source: JICA Study Team

Figure 4.5-2 Plan and Necessary Area for Elevated Tank

(3) Design of Elevated Tanks

Elevated tanks should be designed carefully to fit with the environment surrounding them. Especially, Elevated tanks No.1 and No2, which are located near the sub-gate adjacent to Lang- Hoa Lac Highway, are expected to be symbolic structures to attract not only the HHTP users but also the general passengers on the Highway. Elevated tank No.3, which is located in the Park, Sports, and Amusement Zone is expected to be a kind of landmark in the Park with the function of a clock tower. And elevated tank No.4, which is near the lake-crossing bridge is also planned so as to create beautiful and modern scenery with the bridge.

4.5.3 Hydraulic Analysis of the Water Supply Network

(1) Target Area for the Calculations

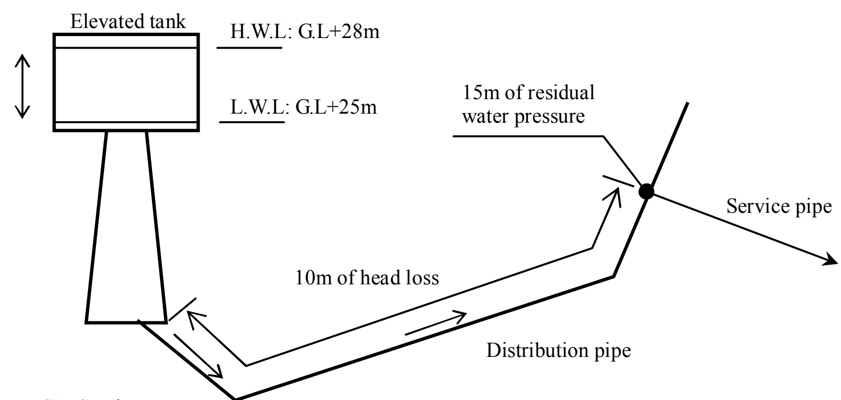
Hydraulic analysis has been conducted to determine the necessary head of the pump and diameter of the pipelines in the water supply network. Pipelines to be installed in Phase-1 are to be designed so that they will also be utilized in Phase-2, because it is not realistic to install new pipelines for the Phase-2 area beside the Phase-1 pipelines or to demolish the Phase-1 pipelines and replace them with a new network in Phase-2 construction.

Therefore, in this study, the target area for the calculations is the entire HHTP area except for the Industrial Zone and Housing Complex (No. 9 Block) and Reserved Area (No. 10 Block), for which intake pipelines will be installed in Phase-2 exclusively.

(2) Analysis Condition

1) Minimum Water Pressure

The residual water pressure of 15 m is applicable at the ground level at the branch point from the distribution pipe to the service pipe. Therefore, in this analysis, considering the 3 m water depth in the elevated tanks and the 10 m of head loss in the distribution pipes in the supply block, minimum water pressure at the elevated tanks must be G.L+28m.



Source: JICA Study Team

Figure 4.5-3 Necessary Water Pressure at the Elevated Tanks

2) Maximum Water Pressure

Maximum water pressure is determined to be 8.0 kgf/cm^2 in consideration of the ability of the pipes to withstand the water pressure.

3) Basic Formula for Analysis

Basic formula for analysis of the water supply network is the Hazen-Williams' Formula as shown in 4.3-3.

4) Hydraulic Analysis for the Looped Pipe Network

The Hardy-Cross Method is applied for the analysis of the looped pipe network. Therefore, the water flow distribution which satisfies the following equations is selected at each node point.

[Hardy-Cross Method]

$\Sigma Q_{inflow} = \Sigma Q_{outflow}$, and

$\Sigma \triangle H_{clockwise\ direction} = \Sigma \triangle H_{anti\text{-}clockwise\ direction}$

Where, Q : Water flow rate

$\triangle H$: Head loss of each pipe

5) Water Flow Quantity

Water flow quantity used for the analysis is the hourly maximum water consumption in order to respond to the water level fluctuation in the elevated tanks at peak time or water that would be supplied directly rather than via the elevated tanks in case of accidents or during maintenance work.

(4) Analysis Case

In this study, calculation was conducted for Phase-2, because Phase-2 is critical in determining the specifications of the pipelines due to that the fact that the flow quantity is larger than Phase-1.

Analysis of water supply network is as follows.

Hoa Lac - HP water supply network

Network Table - Links

Link ID	Length m	Diameter mm	Roughness	Flow LPS	Velocity m/s	Unit Headloss m/km	Friction Factor
Pipe 2	510	800	110	696.20	1.39	2.68	0.022
Pipe 3	530	800	110	500.70	1.00	1.46	0.023
Pipe 4	1000	700	110	314.76	0.82	1.18	0.024
Pipe 5	600	500	110	181.06	0.92	2.18	0.025
Pipe 6	590	400	110	133.70	1.06	3.69	0.026
Pipe 7	1500	300	110	12.62	0.18	0.19	0.035
Pipe 8	2300	100	110	2.68	0.34	2.26	0.038
Pipe 9	850	400	110	172.62	1.37	5.93	0.025
Pipe 10	940	300	110	8.44	0.12	0.09	0.037
Pipe 11	1300	200	110	1.74	0.06	0.03	0.044
Pipe 12	340	100	110	-0.94	0.12	0.32	0.044
Pipe 13	1100	100	110	1.70	0.22	0.95	0.040
Pipe 14	940	300	110	45.44	0.64	2.03	0.029
Pipe 15	780	100	110	0.76	0.10	0.17	0.037
Pipe 16	780	600	110	185.94	0.66	0.94	0.026
Pipe 17	610	600	110	140.50	0.50	0.56	0.027
Pipe 18	400	100	110	-1.70	0.22	0.95	0.040

EPANET 2 Page 1

Hoa Lac - HP water supply network

Link ID	Length m	Diameter mm	Roughness	Flow LPS	Velocity m/s	Unit Headloss m/km	Friction Factor
Pipe 26	1000	500	110	138.80	0.71	1.33	0.026
Pipe 34	50	300	110	56.70	0.80	3.06	0.028
Pipe 35	50	400	110	138.80	1.10	3.96	0.025
Pump 1	#N/A	#N/A	#N/A	696.20	0.00	-36.41	0.000
Pump 19	#N/A	#N/A	#N/A	73.80	0.00	-45.00	0.000
Pump 20	#N/A	#N/A	#N/A	170.10	0.00	-45.00	0.000

EPANET 2 Page 2

Hoa Lac - HP water supply network

Network Table - Nodes

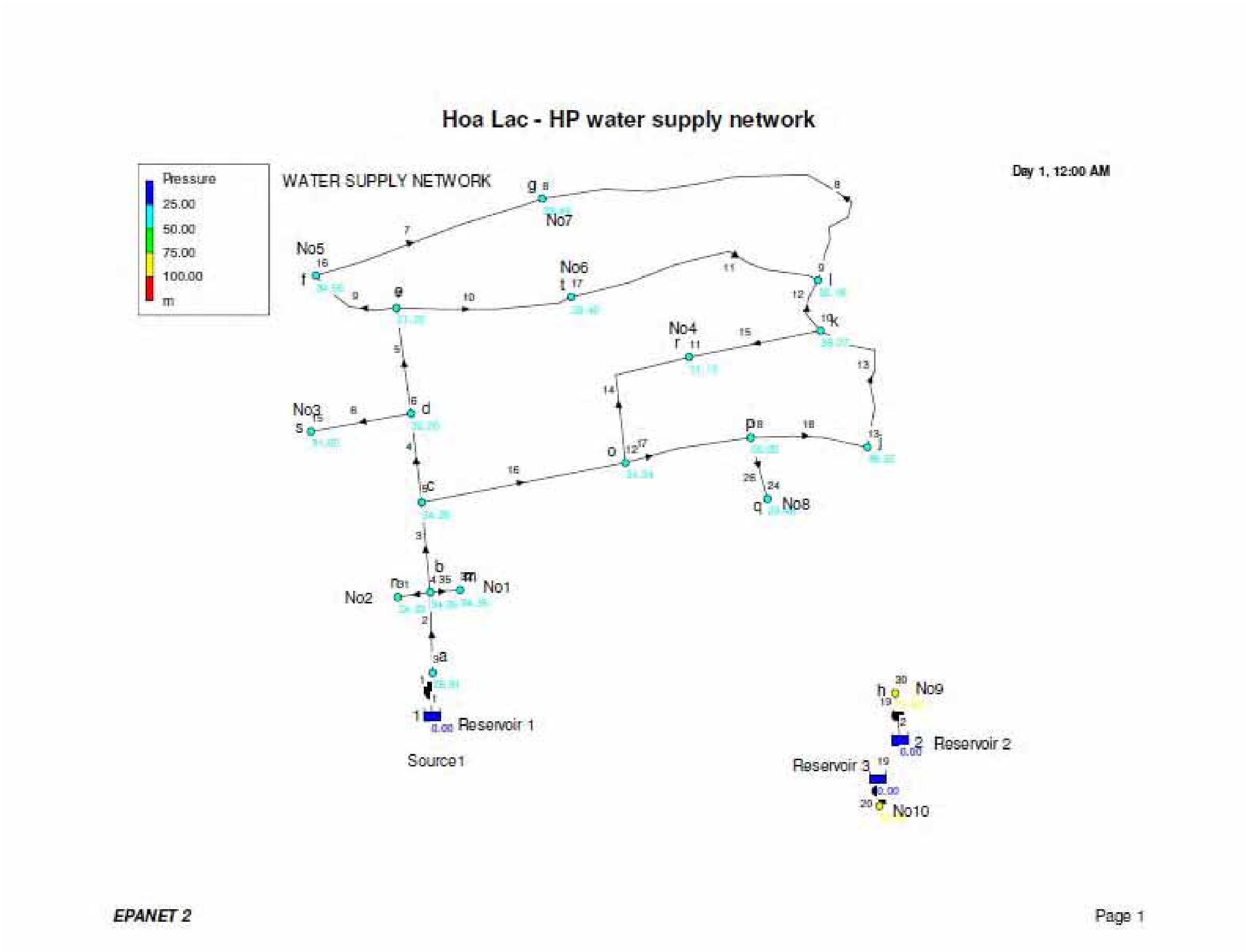
Node ID	Elevation m	Base Demand LPS	Demand LPS	Head m	Pressure m
Junc 3	15	0	0.00	50.91	35.91
Junc 4	15.2	0	0.00	49.55	34.35
Junc 5	14.5	0	0.00	48.78	34.28
Junc 6	17.4	0	0.00	47.60	30.20
Junc 7	15	0	0.00	46.29	31.29
Junc 8	12.5	15.3	15.30	40.96	28.46
Junc 9	11	0	0.00	46.16	35.16
Junc 10	11	0	0.00	46.27	35.27
Junc 11	15	46.2	46.20	46.13	31.13
Junc 12	13.1	0	0.00	48.04	34.94
Junc 13	11	0	0.00	47.32	36.32
Junc 15	13.9	133.7	133.70	45.42	31.52
Junc 16	6.7	160	160.00	41.25	34.55
Junc 17	17.8	6.7	6.70	46.20	28.40
Junc 18	16.9	0	0.00	47.70	30.80
Junc 24	16.9	138.8	138.80	46.36	29.46
Junc 30	11	73.8	73.80	90.00	79.00

EPANET 2 Page 1

Hoa Lac - HP water supply network

Node ID	Elevation m	Base Demand LPS	Demand LPS	Head m	Pressure m
Junc 31	15	56.7	56.70	49.39	34.39
Junc 32	15	138.8	138.80	49.35	34.35
Junc 14	14	170.1	170.10	90.00	76.00
Resvr 1	14.5	#N/A	-696.20	14.50	0.00
Resvr 2	45	#N/A	-73.80	45.00	0.00
Resvr 19	45	#N/A	-170.10	45.00	0.00

EPANET 2 Page 2


Hoa Lac - HP water supply network
Day 1, 12:00 AM
Pressure
25.00
50.00
75.00
100.00
m
WATER SUPPLY NETWORK
No1
No2
No3
No4
No5
No6
No7
No8
No9
No10
Reservoir 1
Reservoir 2
Reservoir 3
Source1
EPANET 2
Page 1

4.5.4 Project Cost

The direct project construction cost is estimated based on the following conditions and assumptions; however, these are subject to change in a later stage based on the further study/design result and market price.

The construction cost of the works is estimated based on the following conditions.

(1) The quantities of the works are roughly estimated based on the preliminary design.

(2) The unit prices of the work are estimated based on the prices in the similar project and converted into 2007 current price.

(3) Exchange rate: 1 USD = 120 JPY = 16,000 VND.

(4) Value Added Tax (VAT) and Import Tax are excluded.

Table 4.5-2 Project Cost for Water Supply

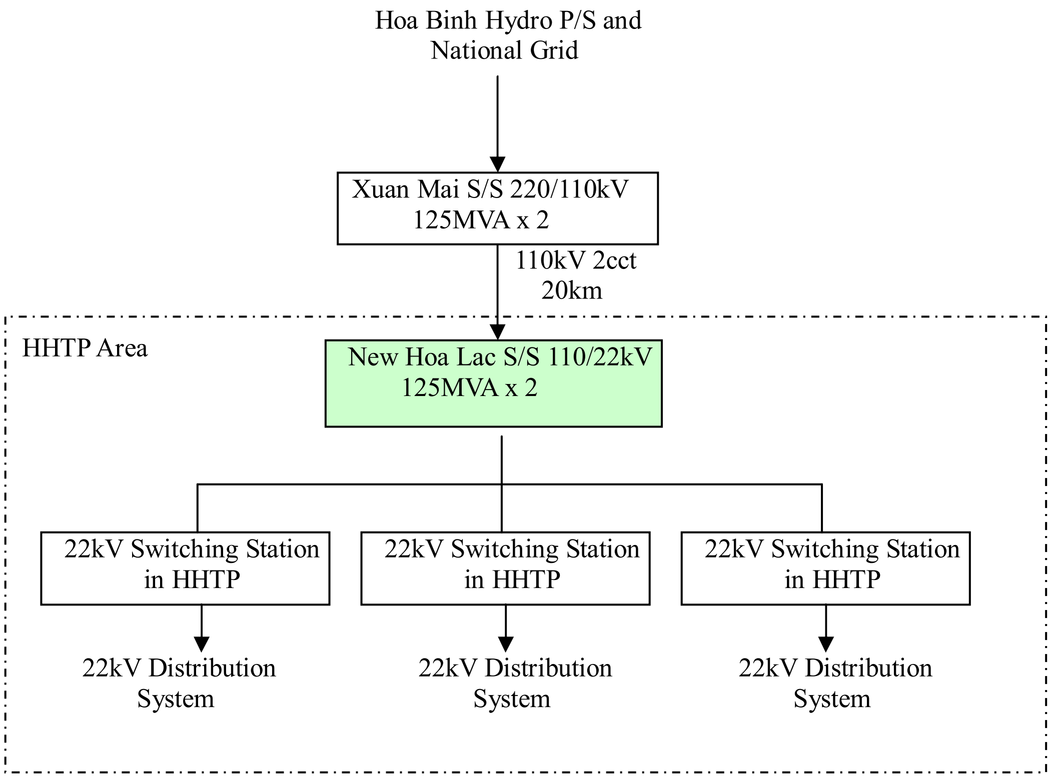
No.	Project	Specification	unit	Unit Cost (USD)	Phase-1		Phase-2		TOTAL		Remarks
					Quantity	Cost (USD)	Quantity	Cost (USD)	Quantity	Cost (USD)	
1	Construction of Reservoir Tank	Capacity of 10,000 m^3 (5,000 m^3 x 2 tanks)	set	823,300	1	823,300		0	1	823,300	
		Capacity of 14,500 m^3 (7,250 m^3 x 2 tanks)	set	1,299,900		0	1	1,299,900	1	1,299,900	
		Capacity of 2,600 m^3 (1,300 m^3 x 2 tanks)	set	225,300		0	1	225,300	1	225,300	
		Capacity of 6,000 m^3 (3,000 m^3 x 2 tanks)	set	520,000		0	1	520,000	1	520,000	
		Total				**823,300**		**2,045,200**		**2,868,500**	
2	Construction of Pump Station	19,300m3/day	set	339,800	1	339,800		0	1	339,800	
		28,480m3/day	set	533,100		0	1	533,100	1	533,100	
		5,060m3/day	set	92,500		0	1	92,500	1	92,500	
		11,660m3/day	set	213,100		0	1	213,100	1	213,100	
		Total				**339,800**		**838,700**		**1,178,500**	
3	Installation of Pipeline	DCIP 700mm - 800mm	m	1,210	2,770	3,351,700		0	2,770	3,351,700	
		DCIP 500mm - 600mm	m	610	600	366,000		0	600	366,000	
		DCIP 300mm - 400mm	m	310	4,210	1,305,100	850	263,500	5,060	1,568,600	
		DCIP 100mm - 200mm	m	125	9,080	1,135,000		0	9,080	1,135,000	
		Accessorie(valve, meter, etc)	lot	605,000	1	605,000		0	1	605,000	
		Total				**6,762,800**		**263,500**		**7,026,300**	
4	Construction of Elevated Tanks	Capacity of 250m^3, 28m height)	set	348,800	3	1,046,400	2	697,600	5	1,744,000	
		Capacity of 120m^3, 28m height	set	261,300	2	522,600	1	261,300	3	783,900	
		Capacity of 40m^3, 28m height	set	174,400	2	348,800		0	2	348,800	
		Total				**1,917,800**		**958,900**		**2,876,700**	
5	Demolition of Existing Pipeline	DCIP 150mm	m	6	2,350	**14,100**		**0**	2,350	**14,100**	
GRAND TOTAL						**9,857,800**		**4,106,300**		**13,964,100**	

Source: JICA Study Team

5. POWER SUPPLY SYSTEM

5.1 Outline of Previous Sector Plan

The electric power supply system for HHTP was planned in the Feasibility Study in 1998 as described hereunder.



Source: JICA Study Team

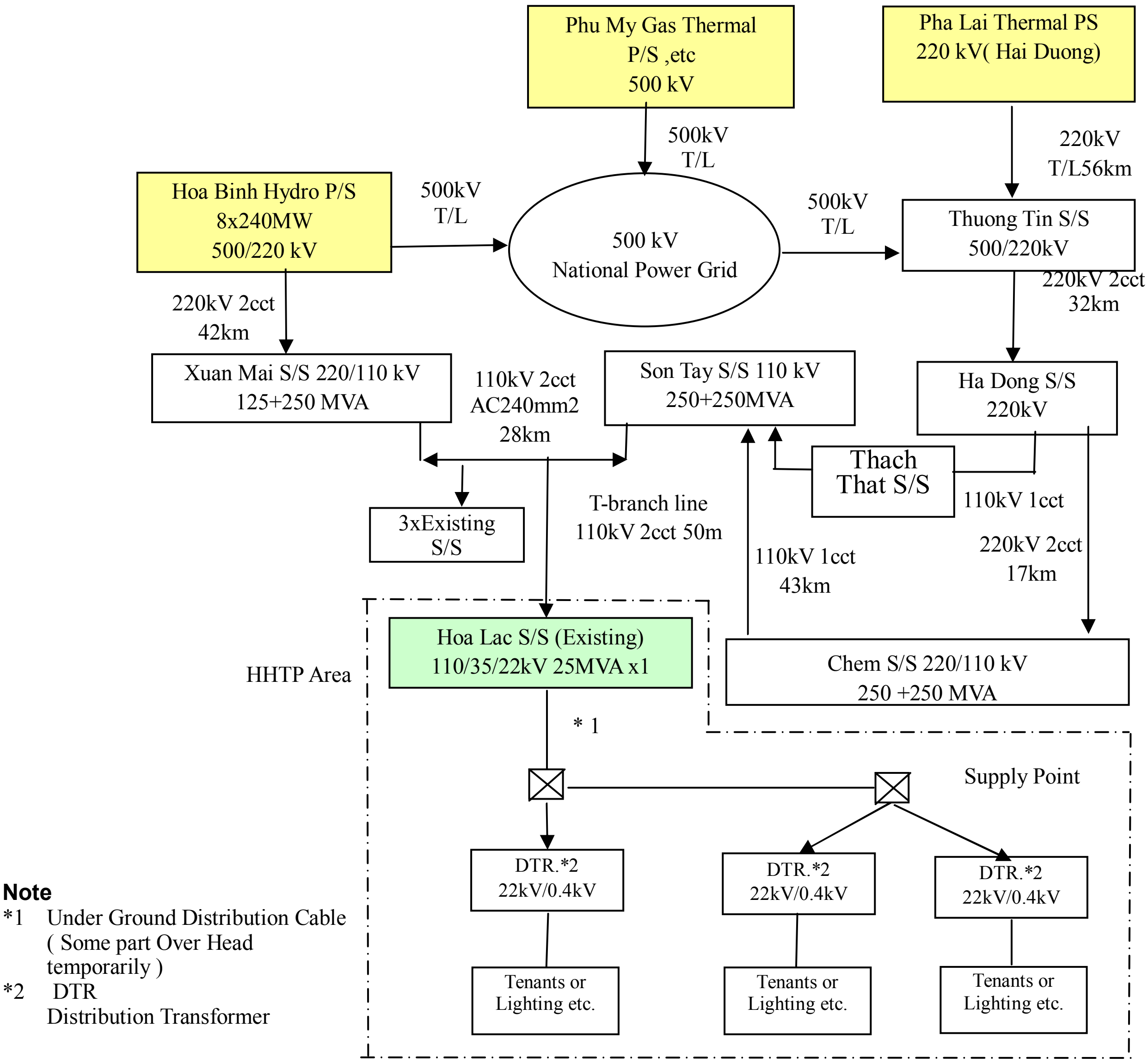
Figure 5.1-1 22kV Power Supply System for HHTP

As shown in Figure 5.1-1, a new 110/22kV substation (New Hoa Lac S/S) was to be constructed near HHTP. The 22kV distribution system inside of HHTP area consists of an advanced 22kV double circuit open ring formation using automatic line sectionalizer, monitoring and control facilities to minimize long term power interruption of the 22kV line. Telecommunication cables are to be also laid in parallel with the 22kV underground cables.

Overhead power distribution lines are proposed only for low voltage distribution by using colored concrete poles for easy tapping in view of environmental harmony.

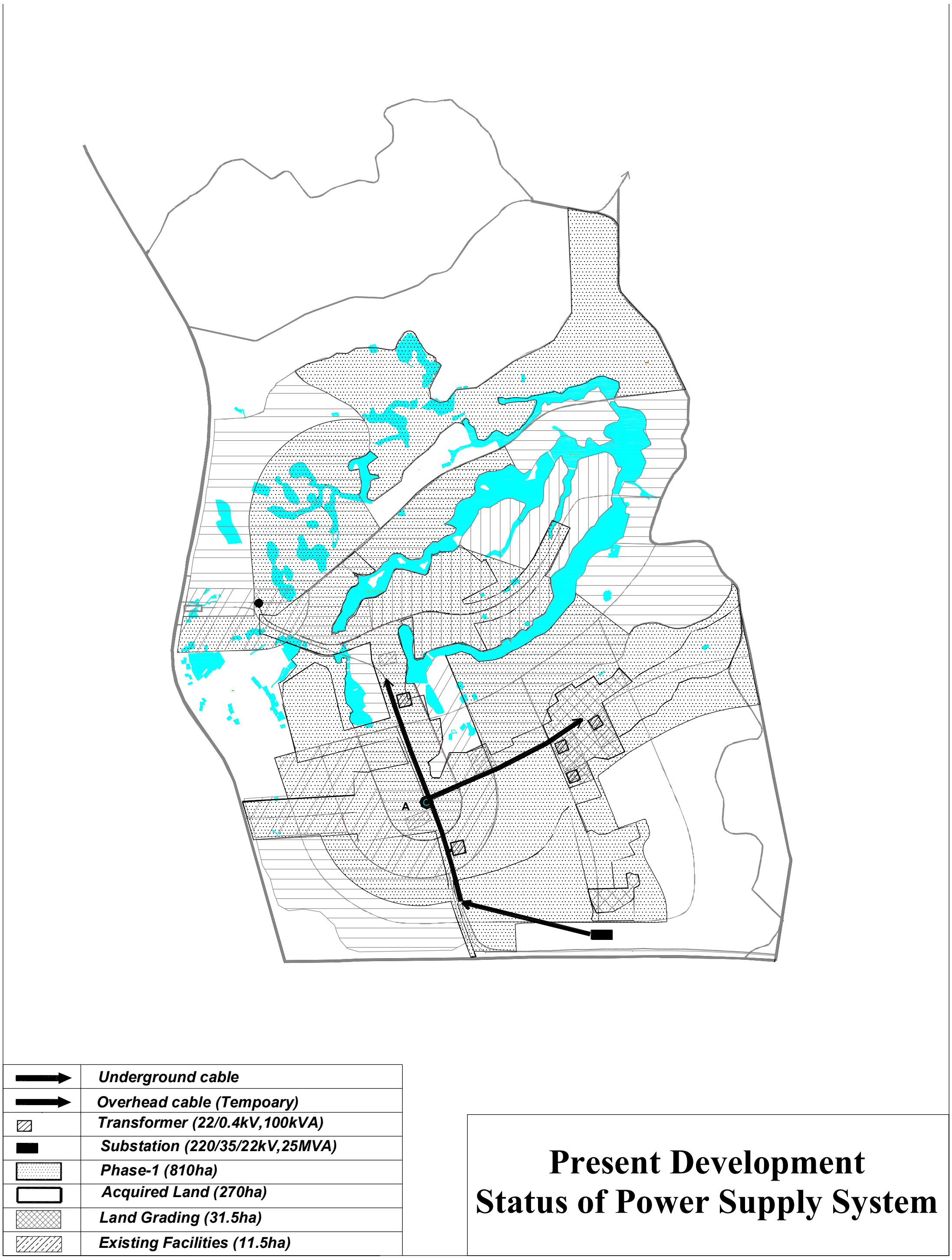
5.2 Present Condition

At present, a substation (S/S) (110/35/22kV, 25MVA) has already been constructed in the HHTP compound and a power supply network to existing facilities has been developed to cope with initial demand of the present tenants. The present regional power supply system including power plants is shown in Figure 5.2-1. Locations of the substations, transformers and the present power distribution network are shown in Figure 5.2-2.



Source: JICA Study Team

Figure 5.2-1 Present Regional Power Supply Network System for HHTP



Source: JICA Study Team

Figure 5.2-2 Location of the Substation, Transformers and Present Power Distribution Network

The photograph below shows the existing transformers installed in the HHTP substation.

Source: JICA Study Team

HHTP S/S Temporary Transformers (25MVA)

5.3 Update of Sector Plan

5.3.1 Sector Development Missions, Strategies and Goals

Missions, strategies and goals for power supply sector are shown below.

Table 5.3-1 Missions, Strategies and Goals for Power Supply Sector

Missions	To enable the tenants to fully utilize computers and other sensitive electrical equipment. To provide a non-interrupted power supply.
Strategies	To establish a reliable power supply network including whole system from power station to distribution line. To request 220kV Transmission Line as a power source for HHTP power supply to EVN. To request the direct power supply from power plant to EVN.
Goals	To complete the development of power supply system for the HHTP by 2012 (for Phase-1) and by 2020 (for Phase-2).

(1) Development Missions (Required Quality)

In these days, computer systems are taking an important role in human lives. The computer systems are essential production tools for high-tech industries. A high quality power supply, i.e., power supply without power interruption or voltage fluctuation is expected in HHTP to enable the tenants to fully utilize computers and other sensitive electrical equipment. Quality of power supply is one of the key factors to attract investors to HHTP. It is much desired to provide a non-interrupted power supply with less than a 0.3 second non-voltage time period in HHTP. In order to achieve this performance, the existing 110kV transmission line (T/L) feeding Hoa Lac substation (S/S) must be improved.

Available data show frequencies of permanent and temporary failures on 220kV and 110kV T/Ls of Vietnam in the year 2005 and 2006 as recorded in Table 5.3-2.

Table 5.3-2 Frequency of Failures on T/L Operated by PC-1

Voltage of T/L	Type of Failure	Frequency of Failure (times/100km/year)	
		2005	2006
110kV	Permanent	0	0.521
	Temporary	1.146	1.146
220kV	Permanent	0.077	0.081
	Temporary	0.590	0.636

Source: JICA Study Team

There is remarkable difference in reliability between 110kV and 220kV T/Ls in Vietnam. In the year 2006, frequency of power failure in 110kV T/L was two times higher for Temporary Failures, and six times higher for Permanent Failures than in 220kV lines.

The 110kV T/Ls tend to have more branches and to be connected to more substations, meanwhile 220kV T/Ls normally connect one substation to another with long distance in between. The 110kV lines contain more substations and branch lines in their systems than 220kV lines and this fact makes 110kV lines less reliable.

(2) Development Strategies

The power supply systems are a combination of;

(a) Power stations connected to the national power grid,
(b) 110kV, 220kV and 500kV power networks consisting of transmission lines, and step up and step down substations,
(c) Regional substations which supply power to the distribution networks, and
(d) Distribution systems including distribution lines and distribution transformers.

Hence, the reliability of the power supply system does not only depend on each one of the components listed above but also depends on whole systems. A failure in any of the components may cause the failure of whole system. Because of its simple configuration, reliability of the 220kV systems is higher than that of the 110kV systems. In order to achieve high reliability in the power system, employing 220kV T/L as a power source is recommended. A 110kV T/L for exclusive use of HHTP is also a possible solution because if the 110kV T/L is for exclusive use the reliability will become as high as that of a 220kV. However, EVN has a plan to construct a 220kV T/L in this area in the future, and therefore, construction of another 110kV T/L does not seem to comply with EVN policy. Construction of transmissions lines is the scope of EVN, so that close coordination with EVN's system planning is necessary.

These are the development strategies for the power supply system for HHTP.

(3) The goals of Power Supply System

The development goal is to develop a power supply system for HHTP by 2020 to meet the demand. The targeted desirable power supply system includes a 220kV T/L system.

5.3.2 Planning Framework

(1) Power demand forecast

Based on the nature of various categories of demands in the High-Tech Park, power demands of HHTP are estimated as shown in Table 5.3-3.

In this table, the following abbreviations are employed.

- VA/1p : VA (demand) per one person
- MVA/1ha : MVA (10^3 VA) per one hectare
- P : Population
- DF : Load Factor
- ID : Maximum demand for each category = VA/1p x P or MVA/1ha x Net Area
- DMD : Average demand for each category = DF x ID

The maximum demands are estimated to be 60 MVA for Phase-1 and 197 MVA for Phase-2.

Table 5.3-3 Power Demand Calculation for each Zone

	Land Use Category	Unit rate Demand		Phase-1					Phase-2				
		Rate	Unit	Net Area	P	DF	ID	DMD Phase 1	Net Area	P	DF	ID	DMD Phase 2
				(ha)	Total		MVA	MVA	(ha)	Total		MVA	MVA
1	Software Park	500	VA/1p	45	2,250	0.6	1.1250	0.675	75	3,750	0.63	1.875	1.18
2	Research and Development Zone												
	a. Research and Development	500	VA/1p	70	4,200	0.6	2.1000	1.260	130	7,800	0.63	3.9	2.46
	b. High-Class Residential	300	VA/1p	0	0	0.7	0.0000	0.000	15	1,500	0.7	0.4500	0.315
3	High-Tech Industrial Zone	0.4	MVA/1ha	140	14,000	0.7	56.0000	39.200	340	34,000	0.75	136	102.00
4	Education and Training Zone	200	VA/1p	55	22,000	0.35	4.4000	1.540	95	38,000	0.4	7.6	3.04
5	Center of High-Tech City	800	VA/1p	40	10,000	0.45	8.0000	3.600	50	21,250	0.5	17	8.50
6	Mixed Use Zone	800	VA/1p	75	26,250	0.45	21.0000	9.450	100	35,000	0.5	28	14.00
7	Residential Zone	250	VA/1p	15	4,500	0.7	1.1250	0.788	50	15,000	0.72	3.75	2.70
8	Housing Complex	200	VA/1p	0	0	0.7	0.0000	0.000	20	8,000	0.72	1.6	1.15
9	Reserved Area (H-T Industry)	0.4	MVA/1ha	0	0			0.000	180	18,000	0.75	72	54.00
10	Amenity Zone												
	a. Golf Course	0.001	MVA/1ha	100	200	1	0.1000	0.100	100	200	1	0.1	0.1
	b. High-Class Residential	300	VA/1p	0	0	0.7		0.000	10	1,000	0.72	0.3	0.22
11	Amusement Zone	0.0005	MVA/1ha	20	2,000	0.55	0.0100	0.240	60	6,000	0.6	0.03	1.26
12	Infrastructure	0.03	MVA/1ha	110		0.7	3.3000	2.310	245		0.8	7.35	5.88
13	Lake and Buffer Zone	0		140					140			0	0.00
	Total			810	85,400		97.160	59.163	1,610	218,000		279.955	196.81
	Required Capacity of Transformer (33% margin)	0.75						78.88					262.41

Source: JICA Study Team

(2) External Conditions

The nearest power source for HHTP is Hoa Binh Hydro Power Station. At present, Hoa Binh Hydro Power Station has been supplying power to HHTP through newly constructed 110kV T/L from Xuan Mai S/S. This hydro P/S, however, cannot supply its full capacity during the dry season. This power shortage can be covered by the power supply from the national power grid through the same 110kV T/L of which the other end is connected to Son Tay S/S as shown in Figure 5.2-1. Son Tay S/S is supplied from Pha Lai Coal Thermal P/S and other thermal power plants connected to the national power grid. The reliability of those power supply systems from Pha Lai Thermal P/S to Son Tay S/S is not bad even though the "non-interrupted power supply with less than a 0.3 second non-voltage time period" can not be guaranteed.

5.3.3 Sector Development Plan

(1) Recommendations about Existing Hoa Lac S/S (25MVA)

Compared with the maximum power demand at the final stage (Phase-2) of 197MVA shown in Table 5.3-2, only a small amount of power is being consumed by the high-tech factories inside HHTP at this moment. The power demand of these factories is covered by the existing dedicated Hoa Lac substation which is equipped with one set of 110/22kV, 25MVA transformers. The reliability of the 110kV power source to this substation is estimated as being at the same level as the existing 110kV T/Ls as was mentioned in the foregoing Sections. This substation will be able to supply power to HHTP only for the short period until the power demands increase up to Phase-1 level indicated in Table 5.3-2.

The total capacity of the transformers in the existing Hoa Lac S/S is relatively small at 25MVA and there is no change over bus (no double bus or transfer bus system) even if another transformer were to be installed. Therefore, it is recommended that the existing Hoa Lac Substation with 25MVA transformer should be used as it is without any expansion or up-grading as long as the power demand can be covered with this transformer.

(2) Alternative-1: Phase-1 with existing 110 kV T/L

In Alternative-1, the power supply facilities are to be up-graded step-wise as the demand increases. This procedure will minimize the initial cost of the Project. However, the reliability of the power supply cannot be high at the Phase-1 stage.

1) Phase-1

The estimated demand for Phase-1 is 60MVA as mentioned in Table 5.3-2. Based on the practical method of transformer load sharing in Vietnam, two (2) 63MVA 110kV transformers will be installed according to EVN recommendations at Hoa Lac No.1 S/S. One transformer can be a stand-by. This S/S is supplied through an existing 110kV 2cct T/L from Xuan Mai S/S and Son Tai S/S. From this line, a new 110kV branch line will be constructed to Hoa Lac No.1 S/S. The substation should be equipped with double BUS-BARs for the 110kV and 22kV systems for changing over for maintenance work.

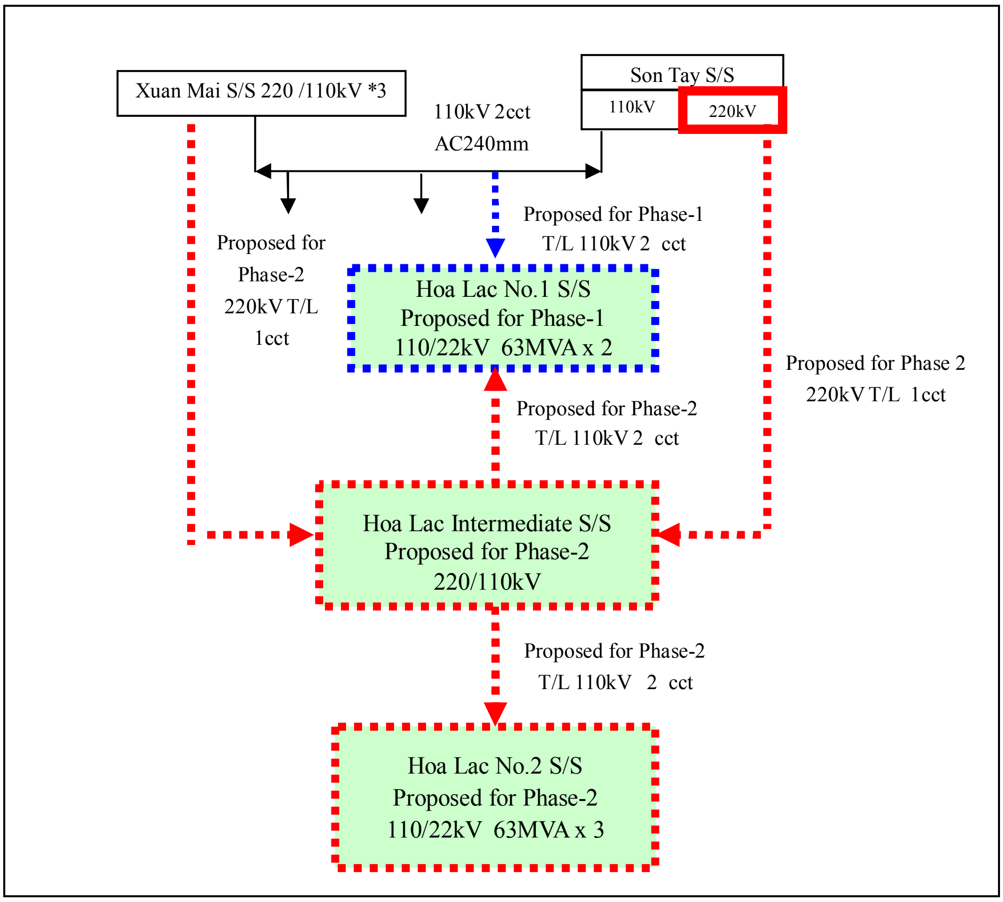
The whole load can be taken over by one transformer if the other transformer would be out of service. It is proposed that these transformers will be installed in a separate place from the existing Hoa Lac S/S. The reason why existing Hoa Lac Substation cannot be upgraded is because there is no space for two bays of 110kV T/Ls, and no space for 110kV and 22kV double BUS-BAR systems either.

2) Phase-2

The estimated demand for Phase-2 is 197MVA as per Table 5.3-2. To accommodate this huge demand, Hoa Lac No.2 S/S of 110/22kV is to be constructed together with a regional substation of 220/110kV. Estimated increase of 137MVA after Phase-1 is shared with three 63MVA transformers in Hoa Lac No.2 S/S. The entire load can be taken over with two transformers, if one transformer in this substation would be out of service.

A new 220/110kV intermediate substation for regional power supply together with a 220kV T/L to Xuan Mai S/S and Son Tai S/S are also to be constructed. The existing Phu Cat industrial estate and VNUH to be relocated in the adjacent area will receive electric power from this intermediate substation as well. The 110kV T/L which is connected to Hoa Lac No.1 S/S may be changed over to this regional substation and will function as a back-up for the 220kV lines to the regional substation.

Figure 5.3-1 shows the power supply network scheme for Alternative-1. The blue colored lines show facilities of Phase-1 and red colored lines show facilities of Phase-2.



Source : JICA Study Team

Figure 5.3-1 HHTP Power Supply Network Scheme Excluding National Power Grid (Alternative-1)

(3) Alternative-2: Phase-1 with new 220 kV T/L

Another alternative is proposed as Alternative-2. In this alternative, all the necessary power supply facilities of the 220kV T/L system are to be constructed in Phase-1 so that the reliability of the power supply will be high enough to attract the investors to HHTP from the beginning. Realization of this Alternative-2 would be subject to the Vietnamese rules and budget.

1) Phase-1

The following facilities are to be constructed in Phase-1.

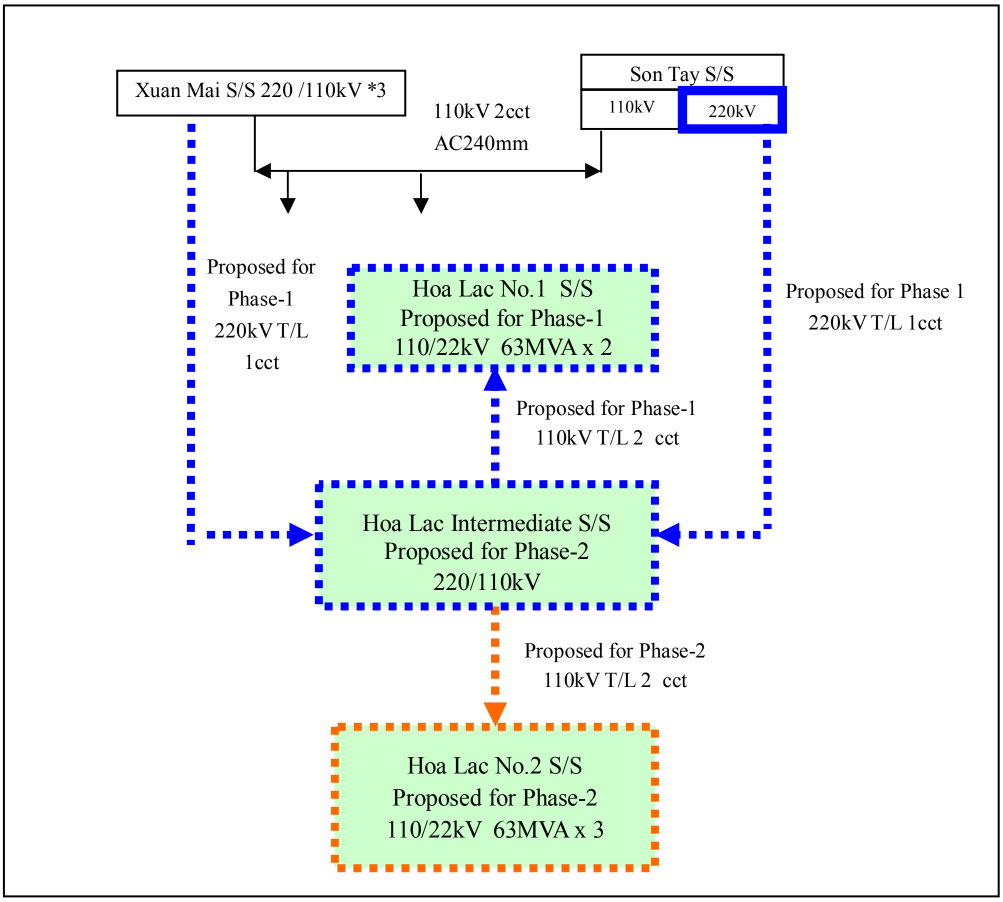
- Hoa Lac No.1 S/S
- 110kV T/L from Hoa Lac Intermediate S/S to Hoa Lac No.1 S/S
- 220kV T/L from Xuan Mai S/S to Hoa Lac Intermediate S/S
- 220kV T/L from Son Tay S/S to Hoa Lac Intermediate S/S
- Hoa Lac Intermediate S/S
- 220kV T/L bay in Xuan Mai S/S
- 220kV Upgrading Facilities of Son Tay S/S

2) Phase-2

The following facilities are to be constructed in Phase-2 to cope with the increased power demand.

- Hoa Lac No.2 S/S
- 110kV T/L from Hoa Lac Intermediate S/S to Hoa Lac No.2 S/S

Figure 5.3-2 shows the power supply network scheme for Alternative-2. The blue colored lines show facilities of Phase-1 and red colored lines show facilities of Phase-2.

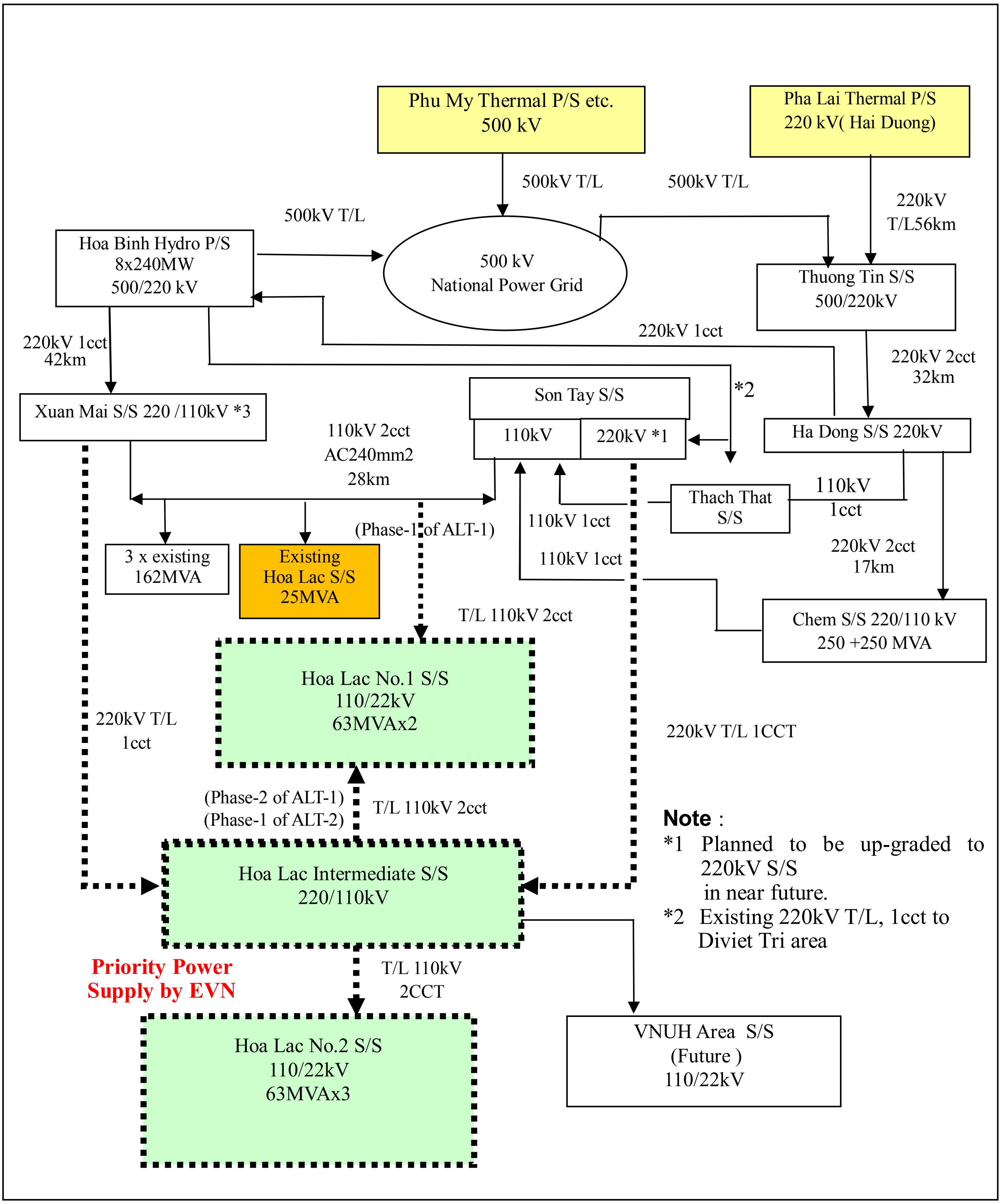


Source : JICA Study Team

Figure 5.3-2 HHTP Power Supply Network Scheme Excluding National Power Grid (Alternative-2)

(4) The Whole System

Figure 5.3-3 shows the power supply network scheme relating to HHTP.



Source: JICA Study Team

Figure 5.3-3 HHTP Power Supply Network Scheme
Including National Power Grid

5.3.4 Internal Power Sector Development Plan

The internal power supply system in the projected area consists of 22kV switching stations named the "Ring-Main Units" and 22kV cables connected to 110/22kV Hoa Lac substations No.1 and No.2.

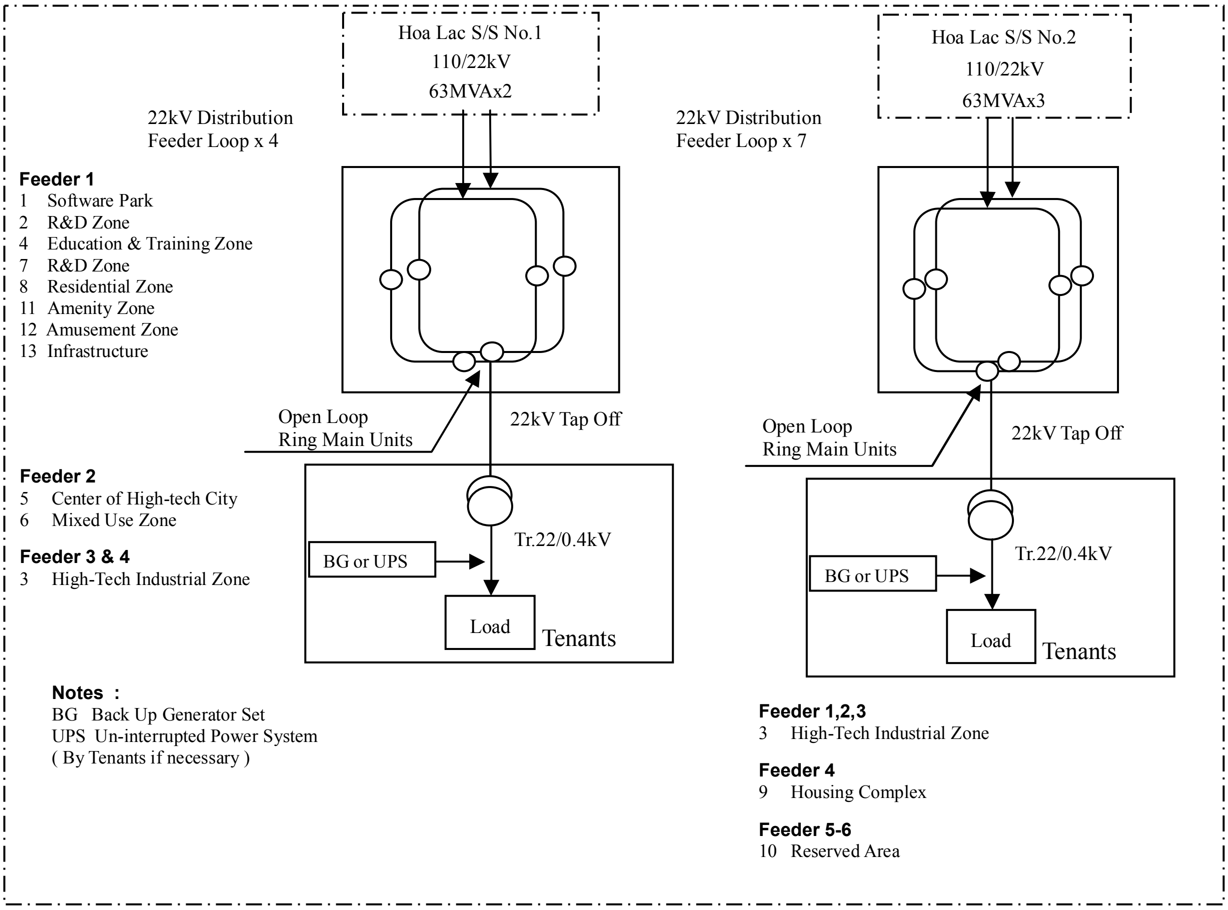
The Ring-Main Units are installed in small buildings to permit easy tapping off of the 22kV incoming line to each tenant. The Ring-Main Units and 22kV line form a loop shape and are connected to the 22kV distribution circuit breaker units in the substations. In case of some electrical failure in the distribution system including the 22kV distribution line, the loop shaped distribution system is useful for un-interrupted power supply to the tenants because of its redundant configuration.

Underground cables are recommended for the 22kV distribution system, because many electric poles and large sized 22kV overhead cables spoil the image of the High-Tech Park.

In view of security and environmental protection, steel wire armored and polyethylene sheathed (non-flammable) cables are recommended for the 22kV underground cables. Recent technology has developed such cable materials so that when the cables are scrapped after their lifetime is used up, no poisonous refuse will remain.

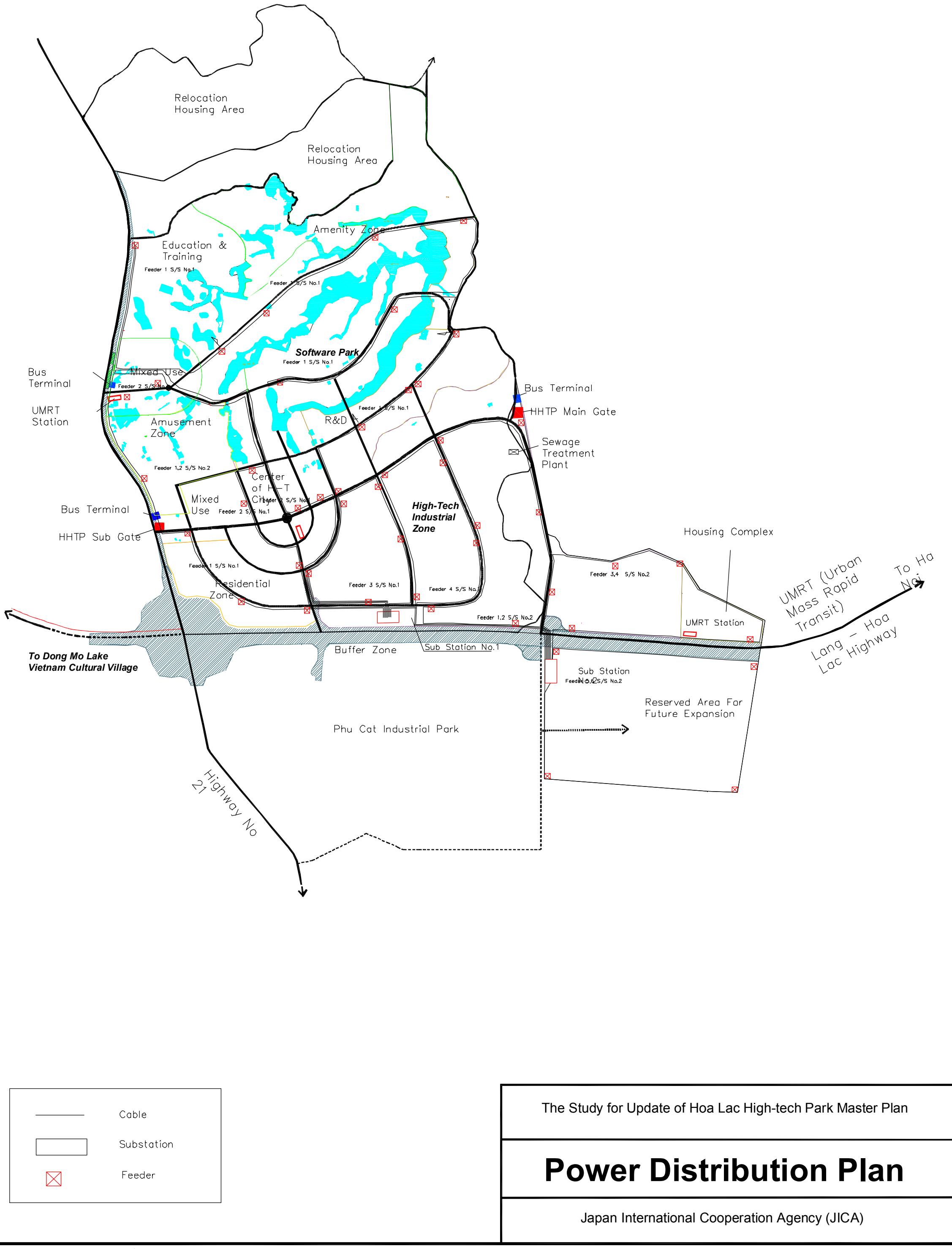
For the low voltage distribution lines in the High Class Residential Zone (R & D Zone), Residential Zone, and Housing Complex, overhead cables are recommended for easy tapping for the small consumers. Use of colored concrete poles is recommended for such low voltage lines in view of environmental harmony.

Figure 5.3-4 illustrates the system configuration of the internal power distribution system in HHTP and Figure 5.3-5 shows the plan of the internal power distribution network.



Source: JICA Study Team

Figure 5.3-4 Internal Power Supply System Configuration



The Study for Update of Hoa Lac High-tech Park Master Plan
Power Distribution Plan
Japan International Cooperation Agency (JICA)

Source: JICA Study Team

Figure 5.3-5 Plan of Power Distribution Network

5.3.5 Development Issues

Reliability of Power Supply for Phase-1

According to the internal rule of the power authority of Vietnam, it can be said that the power demand in the Hoa Lac area from the initial stage to the completion of Phase-1 would be too small to justify constructing a 220/110kV intermediate substation and 220kV T/L. Alternative-1 must be chosen if the 220kV facilities are not allowed to be constructed due to the above rule or other restrictions. In such case, the existing 110kV T/Ls will supply electric power to the existing Hoa Lac S/S and Hoa Lac No.1 S/S.

Three additional substations other than the existing Hoa Lac S/S are connected to this 110kV T/L from Xuan Mai S/S and Son Tay S/S at present, and this line is not dedicated for HHTP. This fact raises the possibilities of power failures affecting the entire 110kV system as explained in sub-clause 5.3.1-(2). Under the present situation, the power supply quality through the existing 110kV Hoa Lac S/S does not reach the level that is required by high-tech industries and adoption of Alternative-2 is strongly recommended. Adoption of Alternative-2 by the Government of Vietnam will motivate investment of potential tenants in HHTP.

Assessment of Construction of a New Power Plant for HHTP

Construction of a new power plant for exclusive use of HHTP is one of the possible options to ensure a stable electric power supply for HHTP under the present electric power shortage situation in Vietnam. The required capacity of the plant is estimated at about 250 MW at the maximum in Phase 2, assuming that all of the reserved area of 180 ha would be used as High-Tech industrial Zone. If the plant only supplies electric power to the High-Tech Industrial Zone, excluding the other functional zones, the required installed capacity could be reduced to 180 MW. The purpose of this power plant is to provide a continuous regular service to HHTP, not to be operated on stand-by basis during power failure. Regarding type of fuel, gas, oil or coal will be considered, but coal would be the likeliest option for HHTP, because of limited availability of gas and oil in Northern Vietnam and their high transportation cost.

This new power plant will bring a considerable benefit to HHTP; however, the following disadvantages and problems are conceived.

1) The optimum scale for coal fired power plants is much larger than what is required for HHTP, so the project would not be financially viable.
2) Location of a plant near HHTP would not be realistic for the following reasons;
    - Transportation of a large volume of coal is required.
    - Disposal of a large volume of ash is required.
    - An adequate quantity of cooling water must be secured for the plant operation.

As a consequence, construction of a new power plant for HHTP is deemed to be impracticable.

Instead, the construction of a new power plant in another location must be planned in view of the national level power development program in order to more effectively improve the present power shortage situation in the whole country. This new power plant is recommended to have a dedicated power transmission line to directly connect to HHTP. Meanwhile, it is indispensable that EVN continues to provide a priority to HHTP for stable supply of electric power.

5.4 List of Proposed Projects

Necessary project components in the power supply sector for HHTP, excluding the 22kV distribution system inside HHTP, are shown in Table 5.4-1 and Table 5.4-2 for Alternative-1 and Alternative-2, respectively.

Table 5.4-1 Proposed Power Supply Project (Alternative-1)

	Current Status	Phase-1	Phase-2
110/22kV S/S	25MVA Tr.	Hoa Loc No.1 S/S 2 x 63MVA Tr.	Hoa Lac No.2 S/S 3 x 63MVA Tr.
220/110 kV Intermediate S/S	N/A	N/A	Hoa Lac Intermediate S/S 2 x 125MVA Tr. (Estimated minimum)
110kV T/L	Existing incoming branch from Xuan Mai - Son Tay Line	Additional incoming branch from Xuan Mai-Son Tay Line	Hoa Lac intermediate S/S – Hoa Lac No.1 S/S Hoa Lac intermediate S/S – Hoa Lac No.2 S/S
220kV T/L	N/A	N/A	Xuan Mai S/S – Hoa Lac Intermediate S/S Son Tay – Hoa Lac Intermediate S/S
Additional 220kV T/L Bay	N/A	N/A	110/220kV Tr. and Bay in Son Tay 220kV Bay in Xuan Mai

Source: JICA Study Team

Table 5.4-2 Proposed Power Supply Project (Alternative-2)

	Current Status	Phase-1	Phase-2
110/22kV S/S	25MVA Tr.	Hoa Loc No.1 S/S 2 x 63MVA Tr.	Hoa Lac No.2 S/S 3 x 63MVA Tr.
220/110 kV Intermediate S/S	N/A	Hoa Lac Intermediate S/S 2 x 125MVA Tr. (Estimated minimum)	N/A
110kV T/L	Existing incoming branch from Xuan Mai - Son Tay Line	Hoa Lac intermediate S/S – Hoa Lac No.1 S/S	Hoa Lac intermediate S/S – Hoa Lac No.2 S/S
220kV T/L	N/A	Xuan Mai S/S – Hoa Lac Intermediate S/S Son Tay S/S – Hoa Lac Intermediate S/S	N/A
Additional 220kV T/L Bay	N/A	110/220kV Tr. and Bay in Son Tay 220kV Bay in Xuan Mai	N/A

Source: JICA Study Team

5.5 Technical Study for Phase-1 Development

5.5.1 Details of Each Project Component

Details of each project component shown in Table 5.4-1 and Table 5.4-2 are described below.

(1) 110kV Incoming T/L (to be required for Alternative-1 only)

A short 110kV T/L 1km in length is to be constructed branching from the existing 110kV line between Xuan Mai S/S and Son Tay S/S. This line will feed necessary energy to Hoa Loc S/S No.1. The length of 1km is tentatively determined because the route for the line is not exactly fixed yet.

(2) Hoa Lac S/S No.1

The function of 110kV Hoa Lac S/S No.1 is to distribute 22kV power to HHTP from the high voltage of 110kV from Xuan Mai S/S and Son Tay S/S. It contains 2 sets of 63MVA transformers and related switchgear and control system etc. to cope with the demand of Phase-1.

(3) Hoa Lac S/S No.2

The function of 110kV Hoa Lac S/S No.2 is to distribute 22kV power to HHTP from the high voltage of 110kV from Xuan Mai S/S and Son Tay S/S. It contains 3 sets of 63MVA transformers and related switchgear and control system etc. to cope with the demand of Phase-2.

(4) Hoa Lac Intermediate S/S

The function of 220kV Hoa Lac Intermediate S/S is to step down the 220kV power both from Xuan Mai S/S and Son Tay S/S to 110kV and to distribute the energy to the adjacent areas, not limited to HHTP.

(5) 110kV T/L From Hoa Lac Intermediate S/S

110kV T/L from ;

- Hoa Lac Intermediate S/S to 110kV Hoa Lac S/S No.1, and
- Hoa Lac Intermediate S/S to 110kV Hoa Lac S/S No.2

are necessary to distribute the 110kV power to 110kV Hoa Lac S/S No.1 and No.2.

(6) 220kV T/L to Hoa Lac Intermediate S/S

220kV T/L from ;

- 220kV Xuan Mai S/S to Hoa Lac Intermediate S/S of 25km length, and
- 220kV Son Tay S/S to Hoa Lac Intermediate S/S of 30km length

are necessary to feed the 220kV power to 220kV Hoa Lac Intermediate S/S.

(7) 220kV Upgrading of Son Tay S/S

The existing Son Tay S/S is a 110kV substation. Hence, a 220kV substation is to be constructed in the premises of this station to feed 220kV power to Hoa Lac Intermediate S/S. It is roughly estimated that 220/110kV transformers of minimum 2 x 125MVA shall be installed with necessary switchgear and control equipment etc.

(8) 220kV T/L Bay in Xuan Mai S/S

The existing Xuan Mai S/S does not have the necessary 220kV T/L bay. A 220kV T/L bay is to be constructed to connect the new 220kV T/L to this station with necessary switchgear and control system etc.

5.5.2 Project Cost

The direct project construction cost is estimated based on the following conditions and assumptions; however, these are subject to change in a later stage based on the further study/design result and market price.

The construction cost of the works is estimated based on the following conditions.

(1) The quantities of the works are roughly estimated based on the preliminary design.

(2) The unit prices of the work are estimated based on the prices in the similar project and converted into 2007 current price.

(3) Exchange rate: 1 USD = 120 JPY = 16,000 VND.

(4) Value Added Tax (VAT) and Import Tax are excluded.

Table 5.5-1 Cost Estimate for Phase-1 Development of Power Supply System

No.	Project	Specification	unit	Unit Cost (USD)	Quantity	Cost (USD)	Remarks
1	Hoa Lac No.1S/S and Distribution materials for Phase-1	110kV T/L Incoming for Hoa Lac No.1 S/S from 220kV Intermediate	km	150,000	5	750,000	including Civil Work and Installation
		Hoa Lac No.1 S/S (110/22 kV, 2 x 63 MVA)	lot	12,000,000	1	12,000,000	
		Sub-Total				**12,750,000**	
		Distribution Cable CE (3c x 300mm2 wire armoured)	m	310	82,600	25,606,000	including Civil Work and Installation
		Control Cable (CEE 10c x 2.5mm2 wire armoured)	m	15	44,100	661,500	
		Ring Main Unit (50A)	nos	48,400	16	774,400	
		Ring Main Unit (100A)	nos	60,500	14	847,000	
		Sub-Total				**27,888,900**	
		Total				**40,638,900**	

Source: JICA Study Team

Table 5.5-2 Cost Estimate for Phase-2 Development of Power Supply System

No.	Project	Specification	unit	Unit Cost (USD)	Quantity	Cost (USD)	Remarks
2	Hoa Lac S/S No.2 and Distribution materials for Phase-2	110kV T/L Incoming for Hoa Lac No.2 S/S from 220kV Intermediate	km	150,000	5	750,000	including Civil Work and Installation
		Hoa Lac No.2 S/S (110/22 kV, 3 x 63 MVA)	lot	14,000,000	1	14,000,000	
		Sub-Total				**14,750,000**	
		Distribution Cable CE (3c x 300mm2 wire armoured)	m	310	105,000	32,550,000	including Civil Work and Installation
		Control Cable (CEE 10c x 2.5mm2	m	15	47,600	714,000	
		Ring Main Unit (200A)	nos	72,000	12	864,000	
		Ring Main Unit (300A)	nos	84,000	6	504,000	
		Sub-Total				**34,632,000**	
		Total				**49,382,000**	

In addition, the cost of the 220 kV transmission lines and 220/110 kV substation is estimated separately as shown in Table 5.5-3. These costs were estimated separately because these facilities are not exclusively used by HHTP, but also used by other projects including Phu Cat industrial estates and VNUH as a regional facilities.

Table 5.5-3 Cost Estimate for 220 kV Transmission Line and 220/110 kV Substation

No.	Project	Specification	unit	Unit Cost (USD)	Quantity	Cost (USD)	Remarks
1	220 kV Transmission Line and 220/110 kV Substation	220kV T/L Incoming for Intermediate S/S from Xuan Mai	km	250,000	25	6,250,000	
		220kV T/L Incoming for Intermediate S/S from Son Tay	km	250,000	30	7,500,000	
		Hoa Lac Intermediate S/S (220/110/22kV, 2x125MVA)	lot	25,000,000	1	25,000,000	
		220kV T/L bay in Xuan Mai	lot	5,000,000	1	5,000,000	
		220kV Upgrading of Son Tay S/S	lot	15,000,000	1	15,000,000	
		Total				**58,750,000**	

Source: JICA Study Team

5.5.3 Recommendations

Early construction of the 220 kV transmission lines and 220/110 kV substation in Phase-

1 stage, i.e. selection of Alternative-2, will surely attract potential tenants to HHTP. Meanwhile, selection of Alternative-1 may deter such investment, because such tenants really need a reliable power supply.

Moreover, construction of these facilities will become necessary sooner or later, although these facilities have capacity in excess of Phase-1 demand. The time required for land acquisition for the facilities is also remarkable. Suspending construction of these facilities will offer any large advantage.

Hence, employing Alternative-2 is highly recommended. The Government of Vietnam is recommended to coordinate with EVN and to obtain support to construct the T/L and S/S facilities as soon as possible.