- increase the capacity of the reservoirs
- separation of the transmission and distribution pipelines
- construction of new reservoirs in new supply areas

3.5.4 Booster Pumping Stations

There are three booster pumping stations at Km6, Km12, and Nongteng, and one lifting pump station at Dongdok in the Vientiane water supply system, as shown in Figure 35-3. The specifications of each pumping station are listed in Table 35-4.

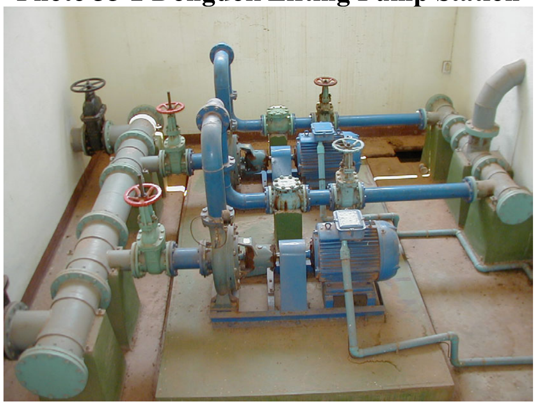
Table 35-4 Details of Booster Pumping Stations

Name of Station	Description	Pump Units	Remarks
Dongdok Lifting Pump Station	Diameter 125, Power 45kw	2	- to lift water from the ground reservoir to the elevated reservoir - Operation hours are 10 hours per day maximum, 5 hours in the morning and 5 hours in the evening - no indication of the pump's specifications
KM6 Booster Pump Station	Diameter150×125, Power 22kw, Head 25m, Capacity 3.6m3/min	2	- Repair and maintenance of motor occurs twice a year - Pumps were manufactured in 1978 - There are no problems with the pumps
KM12 Booster Pump Station	Diameter 40, Power 5.5kw, Head 50m, Capacity 220 l/min	2	- There is a pump well with a capacity of about 10 m3 - no problems with equipment
Nongteng Booster Pump Station	Diameter 100, Power 23kw, Head 60m, Capacity 100m3/h	2	- The station was constructed in 1990 but the pumps were manufactured in 1979 - Repairs of equipment have only happened once, for replacement of pump shaft, so far. - Average pressure at the station is only 0.8 kg/cm2.

The booster pumps do not work all day, because the water pressure in the pipeline upstream from the pump is not high enough and the water can not reach up to the booster pump stations. The Dongdok lifting pump and the Km12 Booster Pumping Station in particular are facing this serious problem. The Dongdok lifting pump operates for only about 10 hours per day maximum, 5 hours in the morning and 5 hours in the evening. It relies on the conditions at Km6, because the water to the Dongdok ground reservoir is transmitted through Km6 Booster Pumping Station. The operation of the Km12 booster pump only occurs during the daytime and sometimes this booster pump cannot be operated for a full day, depending on the available pressure. The operating times of the Nongteng booster pump is also only for 10 hours, from 8:00 p.m. to 6:00 a.m. Although most of the equipment at booster pump stations such as pumps, motors, valves, pipes and panels are not too deteriorated, the problems for the booster pump stations generally, is a lack of pressure at the station.

Photo 35-1 Km6 Booster Pump Station

Photo 35-2 Dongdok Lifting Pump Station



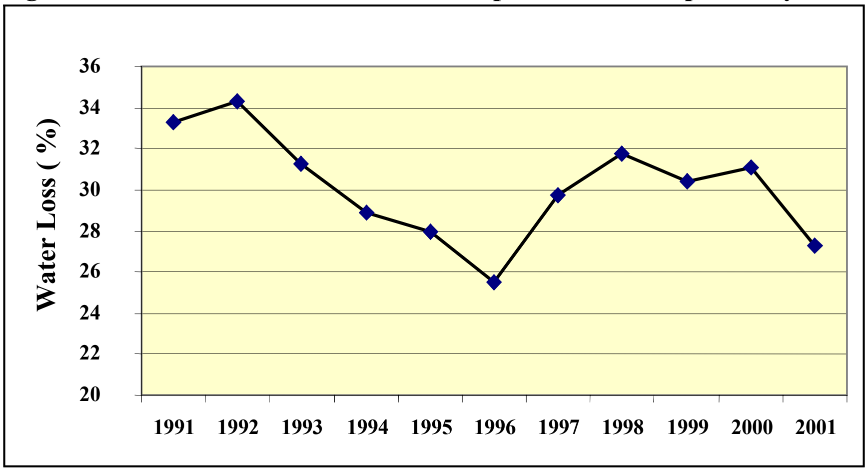
3.5.5 Unaccounted-for Water

(1) Water Loss in Nam Papa Vientiane Capital City

According to the report on Leak Detection Campaign and Reduction Unaccounted-for Water by the Nam Papa Vientiane Capital City (NPVC), losses in terms of volume of unaccounted-for water represents about 30% of the water transmitted through the distribution network. Figure 35-4 shows the water loss statistics since 1991.

The report mentioned that these statistics showed a decrease in the rate of water loss from 1997, which might be a result of the commissioning of the second phase of the Chinaimo Water Treatment Plant. The NPVC continues to repair reported leakages.

Figure 35-4 Water Loss in Nam Papa Vientiane Capital City



Source: Final Report, Leak Detection Campaign and Reduction Unaccounted-for Water

(2) Leak Detection Campaign and Reduction of Unaccounted-for Water by the French Development Agency (AFD)

In 2002, the government of the Lao PDR and the French Development Agency concluded a project for extension of potable water supply network in Vientiane. This 5-month project had two main objectives:

- To reduce the unaccounted-for water ratio from 30% to 25% in one or more pilot areas
- To establish a two-year action plan for reducing the unaccounted-for water ratio in the whole of Vientiane

Execution of the project was scheduled for the following 4 phases

- Phase 1 (January 2002): Mission establishment, preliminary review and assessment, commencement of field activities.
- Phase 2 (February 2002): Preliminary field surveys and laboratory tests for completing the preliminary diagnostic and assessment, breakdown of losses by type, purchase of devices, staff training.
- Phase 3 (March, April and May 2002): Actions to reduce unaccounted-for water in the pilot zones. Newly purchased devices such as an acoustic correlator to be used during this stage.
- Phase 4 (May 2002): Assessment of the results and elaboration of a two-year action plan for the reduction of unaccounted-for water in the whole Vientiane.

The following are the major points achieved through the project, and points to be considered in preparation of the Master Plan by the JICA study.

1) Zoning for the experiment (Pilot Zones)

Five pilot zones were chosen representing the overall situation in various districts of the city. The main features of zones are summarized as follows:

Table 35-5 Pilot Zones

Zone	Branch Office concerned	General conditions and pressure	Length of the pipelines in zone
I	Sisattanak	Close to Phonethane Reservoir (Pressure of 0.11 to 0.25 MPa)	22,3 km
II	Sisattanak	Relatively close to Phonethane reservoir. Partially supplied from the main of 800 mm from Chinaimo. Very low pressure in the day. (Pressure of 0 to 0.12 MPa)	21,2 km
III	Sikhottabong	Very close to the station of Kaolieo. (Pressure of 0 to 0.25 MPa)	20,2 km
IV	Xaisettha - Xaithani	Very close to Phonekheng reservoir. (Pressure of 0.05 to 0.21 MPa)	34,50 km
Sidamdouane	Chanthabuli	Relatively close to Phonekheng reservoir. (Pressure of 0.05 to 0.1 MPa)	26,40km
Total for 5 zones			125 km, 25% of the total length of pipelines in the network

Source: Final Report, Leak Detection Campaign and Reduction Unaccounted-for Water

2) District Metering, Waste Metering, Step Test

The AFD project will apply the methods widely used for the detection of water loss. Those methods are District Metering, Waste Metering, and the Step Test. District metering has been applied in the selected pilot area for a 5 months intensive period. District metering was proposed in the action plan for 2 years, 2003 and 2004. Waste metering and the Step Test will be applied in future. The zone is to be isolated from pipe networks and the inflow to the zone is to be measured continuously by an installed water meter. This measurement is referred to as "District Metering". District metering profiles the inflow of water to the zone and measures peak flow, minimum flow, and total volume of water to the zone. If an abnormal flow is measured, the pipelines in the zone should be investigated. The volume of unaccounted-for water is defined as the difference between the total inflow to the zone and the sum of water volume measured by individual water meters in the zones. The pipeline networks in the zones are to be divided into several sub-zones which are also temporarily isolated from others. The inflow to the sub-zone is to be measured by water meters, usually portable meters. This measurement is referred to as "Waste Metering". The difference of flow between the minimum flow measured and the flow known to be consumed at the time of measuring will be principally due to a physical loss of water from the pipes. The minimum flow is usually measured at midnight. The pipelines in the sub-zones are to be divided into several sections by isolation valves referred to as step valves. If further investigation on pipelines of certain sub-zones is required as a result of waste metering, waste metering with the operation of step valves to detect leakage in each section will be conducted. This measuring is referred to as "Step Test". Among the above methods, only District metering will relate to planning for transmission mains.

3) Leak Detection and Repair

Intensive leak detection was conducted in each zone. The result is summarized below:

Table 35-6 Leakage Detection Summary (1)

Pilot Zone	Pipeline Length (km)	Connection (nos)	Leakage Detected (no. of location)			Leakage Flow Rate		Leakage Repaired	
			Total	Street	Connection	Small	Large		(%)
Customer		1,600	116		116	116		109	94
Sisamdouane	26.4	2,453	104	24	80	95	9	104	100
Zone 1	22.3	2,073	105	24	81	86	19	61	58
Zone 2	21.2	1,967	80	10	70	67	13	38	48
Zone 3	20.3	1,882	82	2	80	74	8	81	99
Zone 4	34.5	3,206	137	14	123	126	11	66	48
Total for Zone	124.7	11,581	508	74	434	448	60	350	69
Total	124.7	11581	624	74	550	564	60	459	74

Source: Final Report, Leak Detection Campaign and Reduction Unaccounted-for Water

Detected leakage per pipeline length is summarized in Table 35-7.

Table 35-7 Leakage Detection Summary (2)

Pilot Zone	Leakages detected per km		
	Small	Large	Total
Sisamdouane	0.3	3.6	3.9
Zone 1	0.9	3.9	4.7
Zone 2	0.6	3.2	3.8
Zone 3	0.4	3.7	4.1
Zone 4	0.3	3.7	4.0
For all zones	0.5	3.6	4.1

Source: Final Report, Leak Detection Campaign and Reduction Unaccounted-for Water

The leakage points tabulated in the above were visible to the human eye. Detection of invisible leakage by specialised equipment such as acoustic correlaters and microphones etc, will be conducted after all of the visible leakage is repaired because the specialised equipment is designed to detect noise from leaking pipes, however the noise levels were low due to low water pressure in the pipelines.

4) Water Meter Investigation

Water meter investigation in each zone was also conducted by testing on site. Some meters were calibrated on site, and others were calibrated on a test bench in the NPVC workshop. In addition, the consumption profile with a datalogger was used to measure both small and large meters. The results of the investigations are summarized below:

Table 35-8 Water Meter Investigation Summary

Pilot Zone	Meters Inves-tigated	Anomalies of Meters Detected			Corrected Anomalies		Anomalies per 1000 Connections		
		Total	Re-placed	Rein-stalled	Number	(%)	Re-placed	Rein-stalled	Total
Customer	1600	202	62	140	184	91	39	88	126
Sisamdouane	2453	130	96	34	130	100	39	14	53
Zone 1	2073	100	61	39	19	19	29	19	48
Zone 2	1967	252	177	75	40	16	90	38	128
Zone 3	1882	140	54	86	140	100	29	46	75
Zone 4	3206	235	165	70	128	54	51	22	73
Total	11581	1059	615	444	641	61	53	38	91

Source: Final Report, Leak Detection Campaign and Reduction Unaccounted-for Water

Investigation of water meters for large consumers, more than 2,000 m^3/month, concluded that (i) meters were not properly installed; (ii) there was a lack of accessories and fittings for the meter: (iii) leakage from service pipes for large consumers of water, especially governmental authorities was excessive.

The investigation results for 6 water meters with a connection diameter of 15 mm also showed that the size of the water meter was larger than appropriate, because 24 % of the water consumed is below the transition flow rate (Qt). The transition flow Qt is the limit of permissible error in measurement, as specified by accepted standards for measuring. The size of many of the meters in the capital city is not the correct size for the water flow and so, the transition flow rate has a greater error that the limit of permissible error.

5) Action plan for 2003 and 2004

The 5-month project concluded that it should be possible to reduce the ratio of water leakage to 25% by the end of 2004, provided that the following conditions are effectively implemented:

a. Implementation of various sub-projects aiming for a reduction of physical and commercial losses (including metering losses)

Sub-projects are:

- Continuation of the visible leak detection and repair campaign
- Invisible leak detection campaign
- Installation of district meters
- Defective meter replacement campaign
- Large meter resizing campaign
- Old meter replacement campaign
- Replacement of old mains and house connections*
- Loss reduction in capital city and governmental premises

*: on going by Nam Papa Vientiane Capital City

b. Institutional strengthening of the NPVC, including these various components: a more adaptable organization, improvement of the management information system (including the billing system), improved monitoring, staff training and responsibility.

Institutional strengthening comprises:

- Technical assistance to implement the institutional strengthening and monitoring of the 2-Year Action Plan
- Creation of an UFW Reduction Department in charge of leakage detection and repair, meter management, customer consumption monitoring and reporting.
- Definition, purchase and installation of a new customer management system
- Purchase of equipment and tools
- Training programs

(3) Present Situation

Regarding the two-year action plan, the procurement of consulting services through bidding has been conducted by the NPVC. The implementation of the action plan has been delayed for more than 6 months.

The NPVC continues repairing leakage from pipelines when visible leakages are reported. However invisible leakage detection has not been conducted due to the difficulties presented by low water pressure in the network.

(4) Points to be considered in planning for water supply scheme in Vientiane by the JICA Study

In accordance with the scope of work between the Government of Lao PDR and JICA, the demarcation of development planning for the water supply system in Vientiane between JICA and AFD was confirmed as scope of works by the JICA study. The work to be done by the JICA study includes of development planning for the intake, purification, and transmission mains. However the following should be the points of argument for the planning of transmission mains.

1) Water demand and Zoning

The estimated flow rate of pipelines based on water demand is the most fundamental criterion for planning pipelines. The flow rate is calculated by the pipeline network analysis based on estimated water demand, the flow capacity of pipelines and/or geographical features of the service area.

The required pressures of pipelines will be decided by the capacity of pipelines which is determined by the pipe characteristics such as dimensions of pipes, conditions of internal surface of pipes, and pipe materials.

2) Definition of transmission main

The JICA Study will cover the entire water supply system in Vientiane, and planning of the facilities will include intake systems, water purification, and transmission mains. The transmission main is defined as:

- Pipelines connecting water treatment plant and reservoir(s)
- Booster pumps to facilitate the pipelines defined above

The pipelines other than above will be considered as distribution pipes which are to be studied by the AFD project.

3) District metering and Transmission Pipelines

Principally all water entering a specified zone is to flow through a district meter which will be installed at a branch from the main transmission line. The location of the branch to the zone should be a critical criterion for the hydraulic analysis of transmission pipelines in Vientiane, to be carried out by the JICA study. Information regarding zoning and the location of district meters should be consistent in both the AFD project and the JICA study.

4) Rehabilitation of the transmission main

The AFD project summarized through intensive investigation of the existing pipes in the designated zones that an average of 4.1 visible leakages were detected per 1km. Invisible leakage could not be detected by equipment because of noise disturbance from the visible leakages. In addition, low water pressure of the network also aggravated this method of detecting invisible leaks. However, the occurrence of invisible leakage will be more than that of visible leakage, even if the leakage flow rate of invisible leakage is smaller than that of visible leakage.

Planning for transmission mains will utilize the existing transmission mains and/or distribution mains which will probably have invisible leakages. Therefore the rehabilitation and/or replacement of the existing pipes should be taken into account if the existing pipes are utilized as the transmission mains.

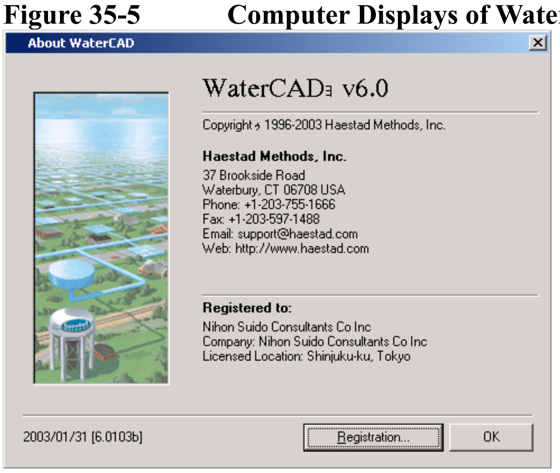
3.5.6 Analysis of Existing Pipe Network

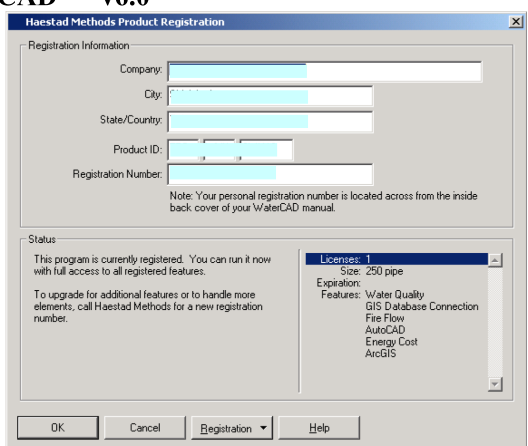
Network analysis was conducted using WaterCAD, a computer software program which runs under the AutoCAD environment, after examination of the existing transmission and distribution networks with pipe diameters larger than 100mm. Survey results of flow and pressure measurements mentioned in Annex 10 have been also taken into account for the network analysis. Results of network analysis are attached in Annex 11.

(1) Soft ware used for network analysis

Soft ware used for the network analysis is WaterCAD®v6.0 for 250 pipes, Haestad Methods Inc., purchased by the study. Although the NPVC does not use this soft ware, and nobody knows about this soft ware, during previous design work conducted by the AFD, the French consultants, (BCEOM) used this soft ware.

Figure 35-5 Computer Displays of WaterCAD ®v6.0





(2) Modelling for Analysis

For modelling of the network analysis, the following conditions have been considered.

- Junction locations were basically referred to from the network analysis carried out by BCEOM in 2001.
- The demand at each junction was calculated based on the billing data.
- The demand pattern was estimated from the results of flow measurement.
- Discharges from the Chinaimo and Kaolieo Treatment Plants were set to the same amount as the actual discharge of March 2003 as shown in Table 35-9.
- Flow rates of the 700 mm main transmission line to the Phonethane Reservoir, the 700 mm distribution main to the centre of the City and the 300 mm transmission main to Salakham Reservoir from Chinaimo Treatment Plant were adjusted, based on the results of flow measurement as shown in Table 35-10.

Table 35-9 Discharge from Chinaimo and Kaolieo WTPs

WTP	Average Discharge in March 2003	Network Analysis
Chinaimo	88,849 m3/day	85,977 m3/day
Kaolieo	25,945 m3/day	26,596 m3/day
Total	114,794 m3/day	112,573 m3/day

Table 35-10 Flow Rate of Major Pipeline

Pipeline	Flow Measurement Results	Network Analysis
700 mm Transmission to Phonethane Res.	35,700 m3/day	35,574 m3/day
700 mm Distribution to the City	36,717 m3/day	36,882 m3/day
300 mm Transmission to Salakham Res.	4,887 m3/day	4,353 m3/day

(3) Demand

1) Junction Demand

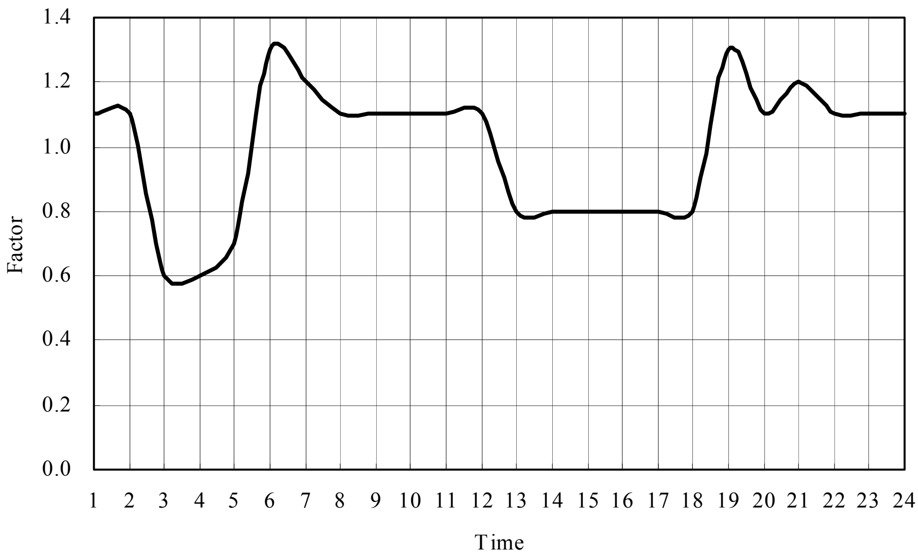
The water demand at each junction has been calculated based on the consumption data mentioned in the water bills of March 2003. Junction demand applied to the analysis is detailed in Annex 11.

2) Demand Pattern

The demand pattern applied for each junction has been estimated from the flow measurement results of the 250mm pipeline for the Nongteng area which is branched from a distribution main from the

Kaolieo WTP. This pipe covers a relatively small residential area, and it can be assumed that the flow rate through this pipe represents the demand pattern for hourly water usage. Figure 35-6 shows the demand pattern estimated and applied for the network analysis of the study. Details of the flow measurement results are attached to Annex 10.

Figure 35-6 Hourly Demand Pattern



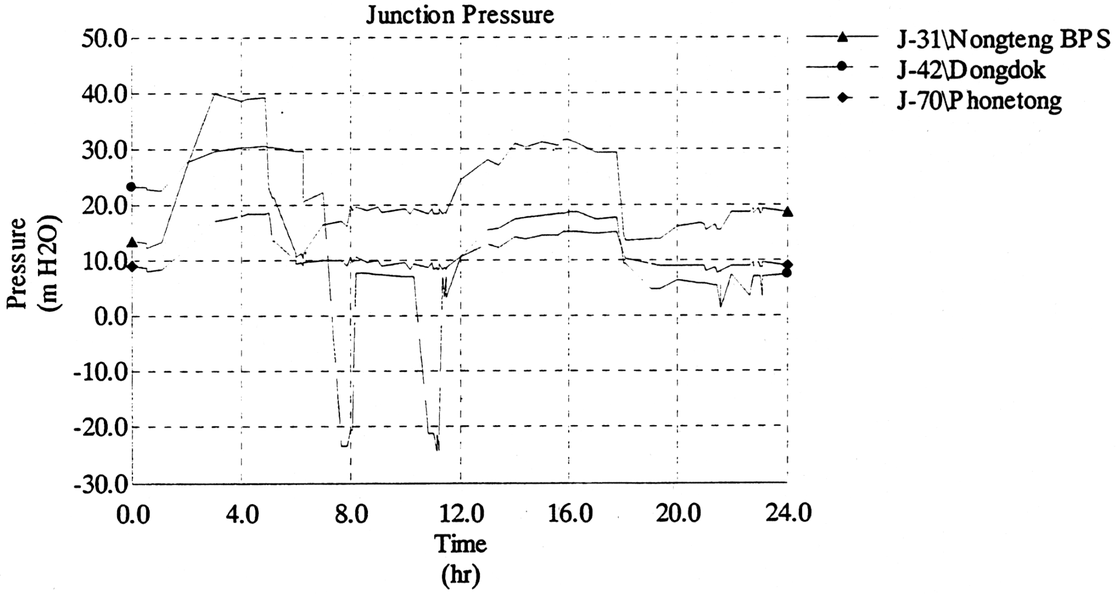
(4) Results of Analysis

1) Junction Pressure

As the results show, the water pressures of areas around the Phonetong Reservoir, Dongdok area and the Nongteng area are relatively low, as shown in Figure 35-7. The reasons for this are considered to be as follows:

- lack of production capacity of the treatment plant
- lack of total reservoir storage volume
- lack of flow capacity of the main distribution pipeline
- inadequate separation of transmission and distribution systems
- leakage

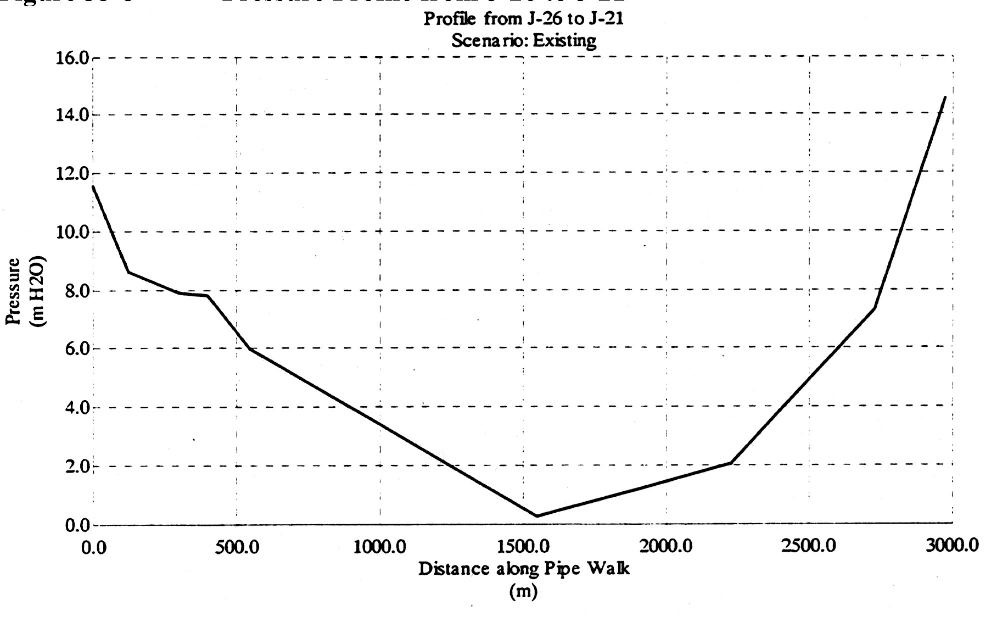
Figure 35-7 Pressures of Three Junctions



2) Pipeline Loss

Pipeline losses of the main distribution line from the Phonetong Reservoir, the distribution pipeline from the Phonekheng Reservoir to the southwest, and the pipeline leading to the center of the city are very large. Figure 35-8 shows a pressure profile from J-26 which runs beside the Mekong River to the Phonekheng Reservoir. A sharp profile means large losses of water from the pipeline.

Figure 35-8 Pressure Profile from J-26 to J-21



3) Reservoir Behaviour

As the results of the extended period are a simulation of a 24 hour period,, reservoir behaviours are summarized as shown in Figure 35-9. Almost all reservoirs can not be filled, especially the Dongdok Elevated Reservoir, the Dongdok Ground Reservoir, the Phonethane Reservoir, and the Phonetong Reservoir, which are nearly always empty all day. This corresponds with the present situation of the reservoirs.

Figure 35-9 Water Level of Reservoirs