5.3 Water Leakage Detection

5.3.1 Outline of Research

(1) Purpose of Water Leakage Detection

The basic purposes of water leakage detection are as follows:

i) Ascertain the actual water leakage situation in Tashkent City. Survey the actual leakage and the frequency. Estimate the volume of leakage by comparing the water distribution volume and the actual water consumption. In Tashkent City, 740 L/capita is adopted as the daily maximum per capita water consumption but compared with standards in other countries, it is extremely large and less than reliable. The volume of water leakage shall be estimated along with an examination of the appropriateness of this figure.

ii) Enlighten the local counterparts to recognize the importance of water leakage detection through on-site activities. In Tashkent City, the steel hot water distribution pipe is installed in the concrete box together with the water pipe and thus, water leakage can seriously affect hot water distribution. Therefore, urgent improvement is needed.

iii) Technology transfer

(2) Measurement of Distribution Water Volume and Pressure

To ascertain the actual water leakage situation in Tashkent City, the following survey will be conducted:

i) Install self-recording ultrasonic flow meters on the distribution pipes from the WTPs and measure the distribution volume over 24 hours.

ii) Install self-recording water pressure meters at the major points of the distribution pipes in the city to monitor fluctuations in water pressure.

The results of actual flow measurement are to be compared with the historical water distribution records in Vodokanal.

(3) Water Leakage Detection

For efficient technology transfer, the following activities shall be carried out:

i) Detect water leakage with a counterpart by the sonic detection method or the relative sonic detection method. Let them recognize the effectiveness of this technique and teach them how to operate the equipment by conducting on-site activities.

ii) Water leakage shall be visually checked at most location.

The detailed detection process will be described later.

(4) Estimate of Water Leakage Volume

By comparing the results of the measurement of the distribution water volume and pressure with the actual water consumption research described in the previous section, the volume of the total water leakage in the city can be estimated.

5.3.2 Measurement of Water Flow and Pressure

(1) Flow Meter Installation

1) Installation Points

The major water sources of Tashkent City are the Kadirya, Boz-su, Kibray and South WTPs and so on, as shown in Table 5.3.1. The total distribution volume of these three (3) major WTPs, namely Kadirya, Boz-su and Kibray comprise more than 90% of the total production capacity of all the WTPs. Initially, flow measurement was scheduled to be performed on these three (3) WTPs, but South WTP was added at the request of Tashkent City Vodokanal. The total capacity of these four (4) WTPs represents almost 95.5% of the total capacity.

Table 5.3.1 Capacities of WTPs

Name	Capacity cu.m/day	Rate(%)	Total(%)
Kadirya	1,375,000	59.11	59.11
Boz-su	235,600	10.13	69.24
Kibray	485,200	20.86	90.10
South	113,000	4.86	94.96
Karazov	52,200	2.24	97.21
Sergeli	40,000	1.72	98.93
Bektemir	25,000	1.07	100.00

i) As shown in Figure 5.3.1(1), flow meters were installed on the existing distribution pipes at the Kibray WTP. FM1 to 3 were installed on the distribution pipes crossing the Boz-su canal which have a diameter of 1,800, 1,400 and 1,600 mm, respectively. FM4 and 5 were installed on distribution pipe with diameter of 1,000 mm, running parallel to the distribution pipe towards the Kibray WTP. FM 6 was installed on the distribution pipe with a diameter of 1,800 mm passing along the side of No.1 Intake Pump Station. As to the force main with a diameter of 600 mm, since an adequate portion for meter installation portion could not be secured, no meter was installed and the distribution volume was estimated by the pump operation records. Meters were installed the exposed portions of the pipes.

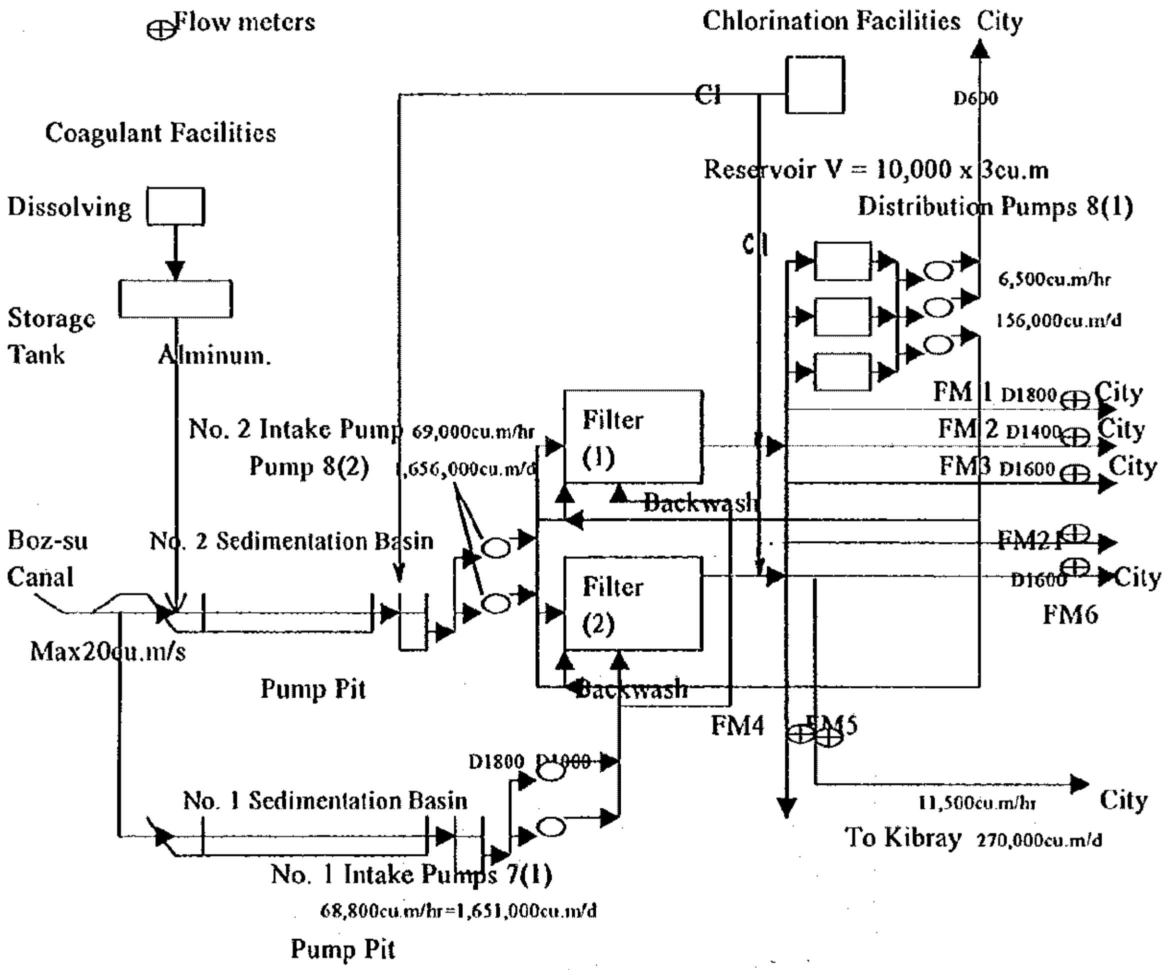


Figure 5.3.1(1) Flow Meter Installation Points at the Kadirya WTP

ii) With respect to the Boz-su WTP, FM7 and 8 were installed on the force mains with a diameter of 1,200 and 1,000 mm, respectively, as shown in Figure 5.3.1(2). Meters were installed in pits for differential pressure flow meters. Flow measurement at Kadirya and Boz-su WTPs were executed simultaneously.

iii) With respect to the Kibray WTP, flow meters were installed on the distribution lines of the Vremennaya Distribution Pump Station. FM9 and 10 were set up on pipes with a diameter of 1,200 mm and 1,400 mm, respectively. As to the No.1 distribution pump station, FM11 was set up on a pipe with a diameter of 1,800 mm, coming from Kadirya WTP and FM11 to 14 were installed on pipes with diameter of 1,800 mm, 1,200 mm, 900 mm and 700 mm, respectively.

FM15 was installed on a pipe running parallel to the pipe coming from the Kadirya WTP.

Of these, FM9 and 10 were installed on pipes which are submerged in a water cannel for one-third of their diameter. FM11 and 15 were attached on the end of the portion of the pipes which cross the rever 3 km away from the WTP and FM12 to 14 were also installed on the ends of portions which cross the cannel, 3km away from the WTP.

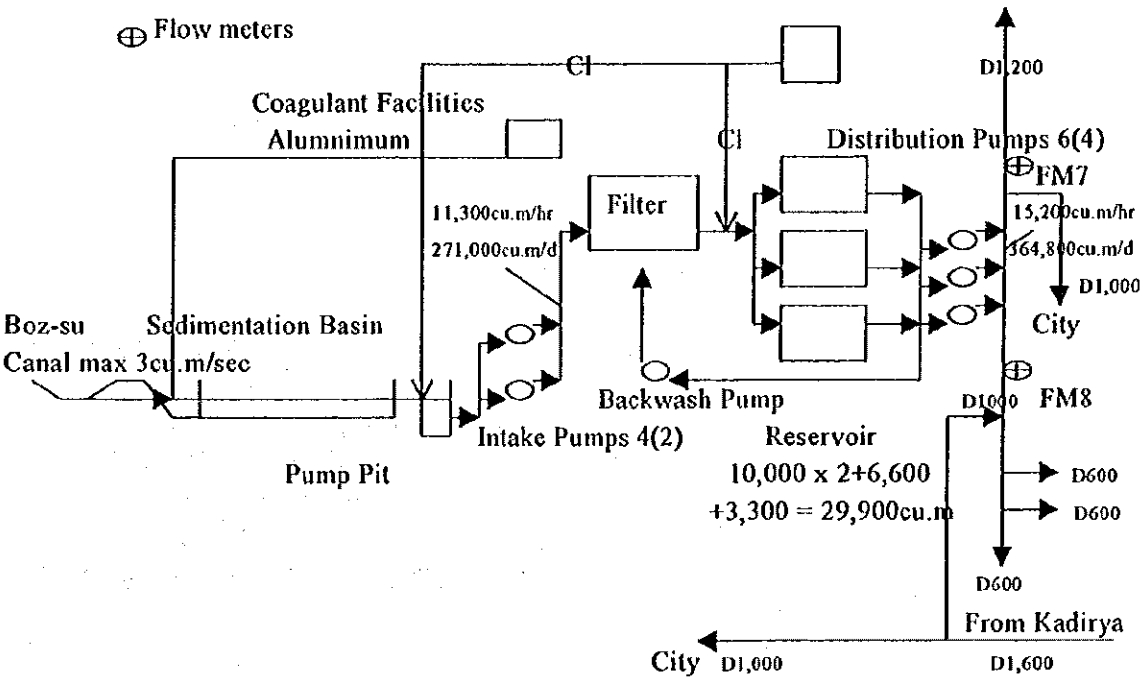


Figure 5.3.1(2) Flow Meter Installation Points at the Boz-su WTP

iv) With respect to the South WTP, Flow meters were installed on the distribution pipes to the Chiranzar District. FM16 to 18 were placeded on pipes with a diameter of 1,000 mm, 700 mm and 600 mm, respectively. Further, based on a request from Tashkent City Vodokanal, FM19 and 20 were installed on the well intake pipes with 800 mm and 700 mm. All the meters were installed in pits.

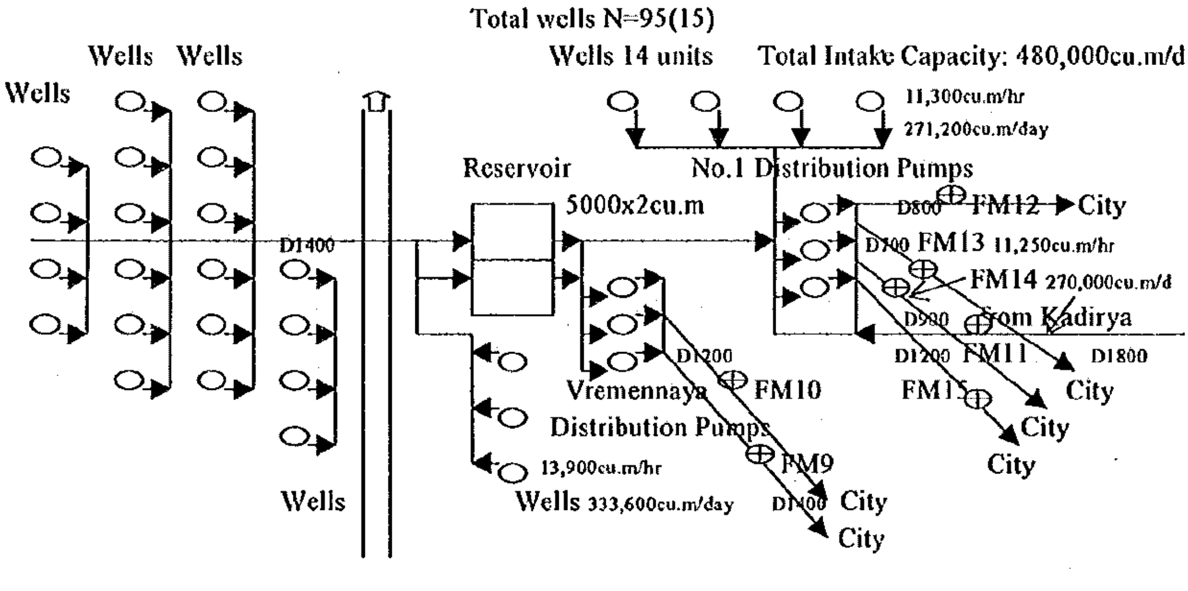


Figure 5.3.1(3) Flow Meter Installation Points at the Kibray WTP

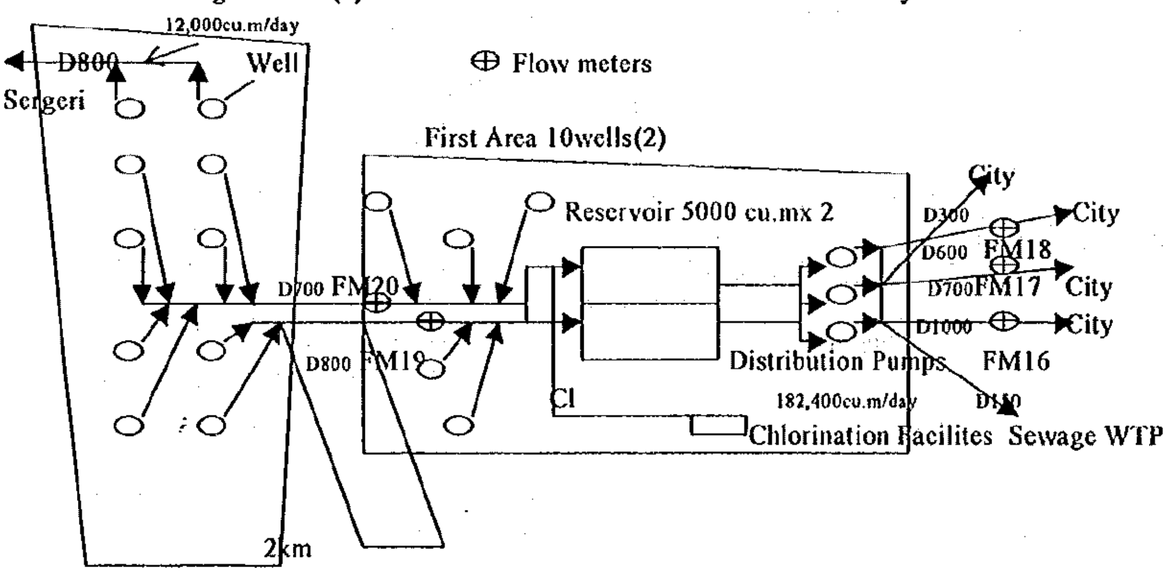


Figure 5.3.1(4) Flow Meter Installation Points at the South WTP

The installed flow meters installed are summarized in Table 5.3.2.

Table 5.3.2 Measuring Points

Name of WTP	No. of Flow Meter	Diameter (mm)	Location	Date Attached	Date Measured
Kadirya	FM1	1,800	On the ground	Aug.7	Aug.7 to 10
	FM2	1,400	On the ground	Aug.7	Aug.7 to 10
	FM3	1,600	On the ground	Aug.7	Aug.7 to 10
	FM4	1,800	On the ground	Aug.7	Aug.7 to 10
	FM5	1,000	On the ground	Aug.7	Aug.7 to 10
	FM6	1,800	On the ground	Aug.7	Aug.7 to 10
	FM21	1,000	On the ground	Aug.7	Aug.16 to 17
Boz-su	FM7	1,200	In a pit	Aug.6	Aug.8 to 10
	FM8	1,000	In a pit	Aug.6	Aug.8 to 10
Kibray	FM9	1,400	On the canal	Aug.11	Aug.11 to 13
	FM10	1,200	On the canal	Aug.11	Aug.11 to 13
	FM11	1,800	On the River	Aug.12	Aug.12 to 13
	FM12	1,000	On the canal	Aug.12	Aug.12 to 13
	FM13	700	On the canal	Aug.11	Aug.11 to 13
	FM14	900	On the canal	Aug.11	Aug.11 to 13
	FM15	1,200	On the River	Aug.12	Aug.12 to 13
South	FM16	1,000	In a pit	Aug.19	Aug.19 to 20
	FM17	700	In a pit	Aug.19	Aug.19 to 20
	FM18	600	In a pit	Aug.19	Aug.19 to 20
	FM19	800	In a pit	Aug.19	Aug.19 to 20
	FM20	700	In a pit	Aug.19	Aug.19 to 20

2) Attaching the Flow Meters

Table D.5.3.1 shows the specifications for flow meters installed. As shown in the table, these meters are attachable ultrasonic flow meters which require certain length of straight pipes for measurement. Careful adjustment is needed during the installation of the meters. However, they also have many advantages such as flexibility of application and a compact disign.

Photo 5.3.1 shows the meter installation work. Table 5.3.2 also shows the meter installation dates, the locations and the measurement dates.

(2) Pressure Gage Installation

1) Installation Points

Pressure gages shall be installed in areas which are prone low water pressure in the water supply network. Pressure and flow measurements shall be executed simultaneously.

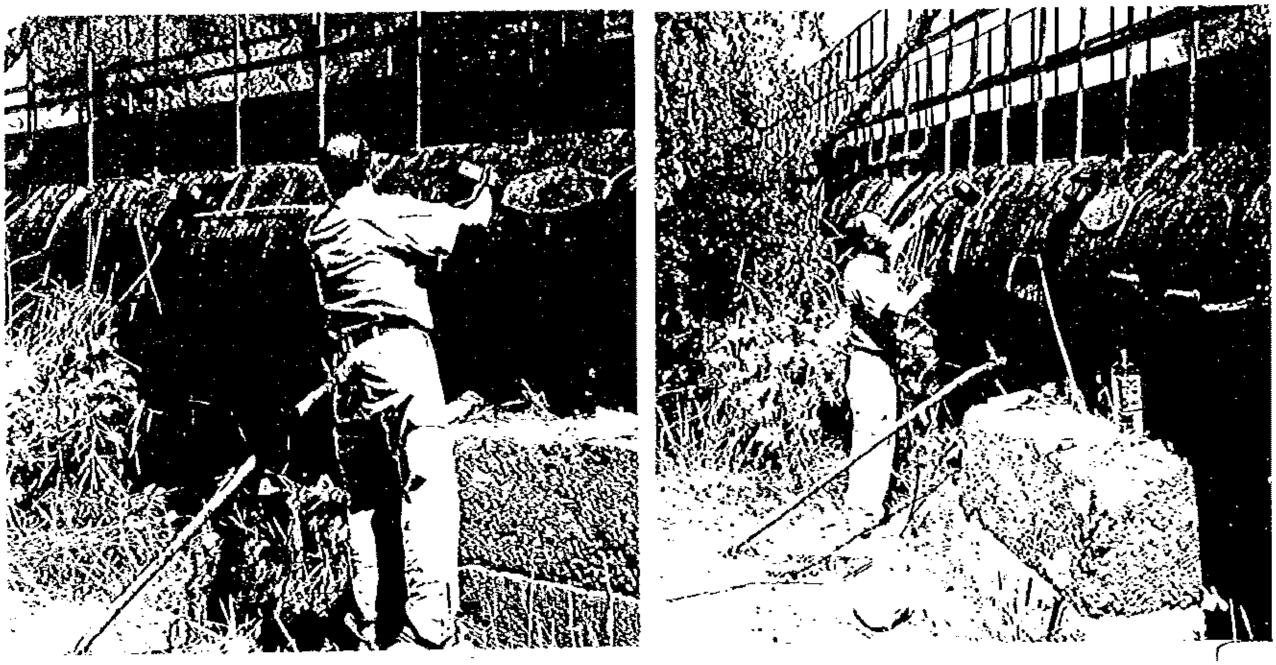


Photo 5.3.1 Installed FM1

However, since the only available installation points were the pump stations, the meters were installed at the points shown in Figure D.5.3.1(1), D.5.3.1(2) and the location and date are of the installation are shown Table5.3.3. Tashkent City Vodokanal also wants to monitor the water pressure fluctuation. The daily pressure fluctuation was minimal. Other 24-hours pressure measurements were carried out disregarding the flow measurement.

Table 5.3.3 Location and Date

Mark	Location	Date	Days of the Week
P-1	Vodokanal Office	Aug.10 to 11	Wed.to Thu.
P-2	Akamal-Ikrom Dist. Office	Aug.13 to 14	Fri.to Sat.
P-3	South Distribution Center	Aug.17 to 18	Wed.to Thu.
P-4	Boz-su Pipe 6 (low)	Aug.19 to 20	Fri.to Sat.
P-5	Boz-su Pipe 1,2,4 (high)	Aug.19 to 20	Fri.to Sat.
P-6	South WTP	Aug.19 to 20	Fri.to Sat.
P-7	Vodokanal Office	Aug.29 to 30	Mon.to Tue.

2) Installed Pressure Gage

The specification of the pressure gages installed are presented in Table D.5.3.2. 24-hour recording paper was used. The meter installation work is shown in Photo 5.3.2.

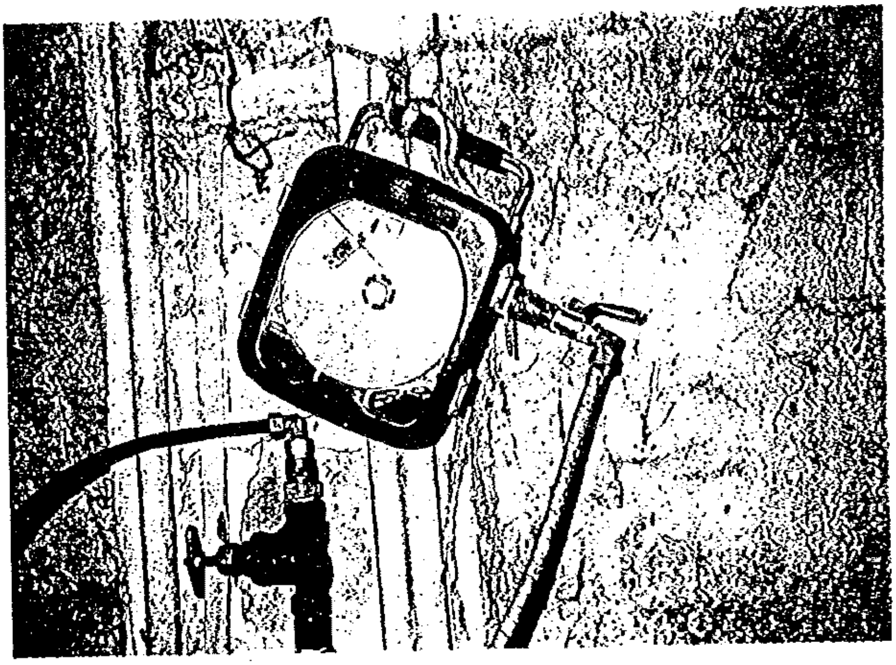


Photo 5.3.2 Pressure Gage Installed

(3) Measured Flow Data

1) Measured Results

Figure D.5.3.2 presents the flow measurement results as of of August 8 and 9, 1999 at the Boz-su and Kadirya WTPs and the total flow is presented in Figure D.5.3.3.

Figure D.5.3.4 presents these as of 12 and 13 of August 1999 in Kibray WTP and total flow is presented in figure D.5.3.5 .

More-over South WTP's Flow data is presented in Figure D.5.3.6 as of 19 and 20 of August 1999 and total flow is also pesented in figure D.5.3.7.

2) Estimation of Flow Data

Figure 5.3.2 shows the composed flow data of all and major WTPs in Tashkent City. This flow pattern was presented huge water leakage or waste tendency because flow pattern was almost flat. Total flow of four WTPs was approximately 2,707,000 cu.m/day, 1,830,000 cu.m/day in Kadirya WTP, 258,000 cu.m /day in Boz-su WTP, 478,000 cu.m/day in Kibray WTP and 141,000 cu.m/day in South WTP.

Figure 5.3.3 shows the record of the operation of each WTP, (the Kadirya, the Boz-su, the Kibray and the South) on the days when the water flow was measured.

Figure 5.3.2 Composed Flow Data for the WTPs in Tashkent City

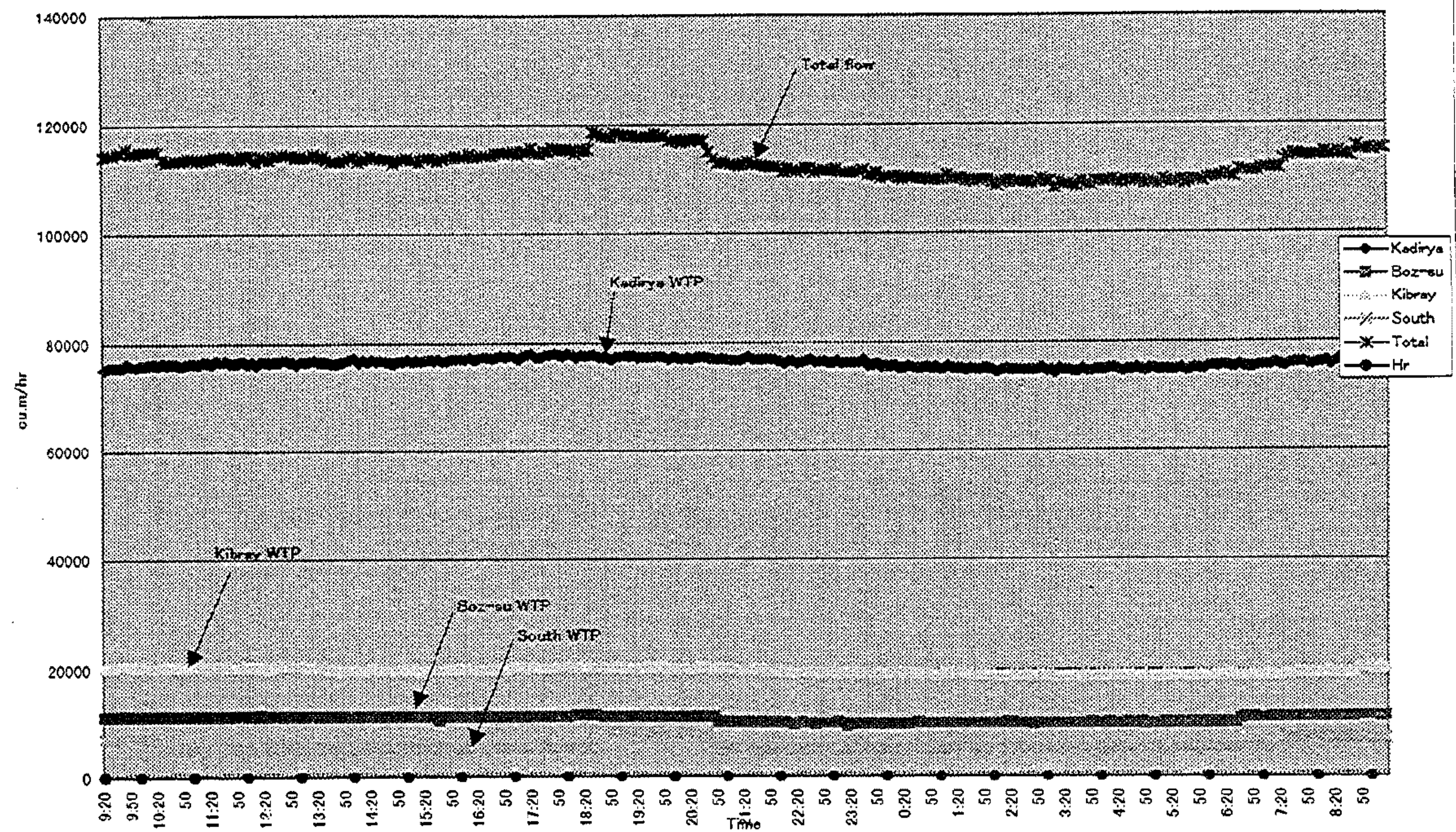


Figure 5.3.3 Working Record of Pumps

Name	P.No.	Capacity	8															9								
	or		9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	0	1	2	3	4	5	6	7	8
Kadirya WTP	1-1	208.3x5																								
	1-2	105																								
	2-1	208.3																								
	2-2	108.3																								
	Total		1463.1																							
Boz-su WTP	1	105																								
	2	53.3																								
	3	41.7																								
	Total		200												158.3										200	
	Pressure1 kgf/sq.cm		3.8												3.6										3.8	
	Pressure2 kgf/sq.cm		1.8												1.7										1.8	

Name	P.No.	Capacity	12											13												
	or		13	14	15	16	17	18	19	20	21	22	23	0	1	2	3	4	5	6	7	8	9	10	11	12
Kibray WTP	1-1	86.7x2																								
	1-2	60																								
	2-1	86.7																								
	Total		320.1																							
South WTP	1	60x2																								
	2	60																								
	3	33.3																								
	Total		120						180					120					153.3			120				

Pump working

The flows of the Kadirya and the Boz-su WTPs were measured on August 8 and 9, and the flow of the Kibray WTP was measured on August 19 and 20. Supplemental measurements by the FM21 were conducted at the Kadirya WTP on August 17 and 18.

The findings and data are discussed below.

i) **Distribution Line at the Kadirya WTP**

The Kadirya WTP has two intake pumps, i.e. No. 1 and No. 2. Their respective capacity is more than 1.6 million cu.m/day, which exceeds the nominal capacity of 1,375,000 cu.m/day. Figure 5.3.3 indicates that the total nominal pump capacity of 1,363 cu.m/hr is obtained by operating all the No.1 intake pumps, except for the stand-by and two of the No. 2 intake pumps. However, Figures D.5.3.2 and D.5.3.3 indicate an average actual measured flow of 1,270 cu.m/min or 1.83 million cu.m/day, which is slightly lower than the nominal capacity. This result implies that a decrease of in the pump discharge occurs when the transmission quantity exceeds the nominal capacity due to the head loss from friction, piping, etc.

Incidentally, the intake amount permitted from the Boz-su canal is 21.19 cu.m/sec. or 1.83 million cu.m/day, which is almost equal to the average actual measured flow. The transmission pipe to the Kibray WTP, with a diameter of 1,800mm had the largest volume of 330 to 350 cu.m/min or 470,000 to 500,000 cu.m/day. Part of this flow is sent to Tashkent City through a diversion pipe at its mid point.

ii) **Distribution Line of at the Boz-su WTP**

Figures 5.3.3, D.5.3.2, and D.5.3.3 show that the daytime pumped volume is 195 cu.m/min against a nominal capacity of 200 cu.m/min, while the nighttime volume is 158 cu.m/min against 160cu.m/min. The daily treatment quantity is about 260,000 cu.m/day.

iii) **Distribution Line at the Kibray WTP**

The Kibray WTP receives about 250 cu.m/min (360,000 cu.m/day) of water from the Kadirya WTP, as shown in Figure D.5.3.4, and puts out 600 cu.m/min of water as presented in Figure D.5.3.5. Consequently, the water sent from the Kibray WTP is 330 cu.m/min (= 580-250) or 500,000 cu.m/day.

As presented in Figure 5.3.3, the pumping capacity is 320 cu.m/min. Therefore all the water from the Kadirya WTP is transmitted to the city by gravity.

iv) Distribution Line at the South WTP

The South WTP operates with a combination of three types of pumps as shown in Figures D.5.3.6 and D.5.3.7. The measured flow of each pump has decreased to about 70% of the nominal capacity, i.e. 90, 140 and 120 against 120, 180 and 153 cu.m/min of the nominal capacity respectively.

v) Estimate of Total Distribution Volume

Considering the above findings, the total water supply volume from the WTPs to Tashkent City is about 2.7 million cu.m/day as presented in Figure 5.3.4.

(4) Measured Pressure Data

Figure 5.3.5 presents the results of the water pressure survey in Tashkent City. P6 installed at the South WTP indicated very high pressure of 5 to 7.3 kgf/sq.cm due to the high pressure transmission to the Chianzar District.

However, P3 installed in the nearby Chilanzar District indicated very low pressure of 1 kgf/sq.cm during the peak period. Though the pipeline alignment details are not known because a map showing distribution line network is not available, it seems that the network alignment is not appropriate. P.4 is installed on the high-pressure transmission pipeline of the Boz-su WTP and indicated about 3 kgf/sq.cm, which may be considered appropriate as a source of water supply. However, P.5 installed on the low-pressure transmission pipeline of the WTP showed about 1 kgf/sq.cm, which is not sufficient as a source of water supply, and requires additional pressure by booster pumps. The pressure gauge installed at the Akamal-Ikrom District Office indicated proper pressure, i.e. 2 kgf/sq.cm in the daytime and 2 to 2.5 kgf/sq.cm at night, ever though the district is located in the north-western area of the city and is considered a low pressure area.

The monitoring center for water supply facilities is located in the office of Vodokanal. At the center, water pressure measurements are carried out twice a day.

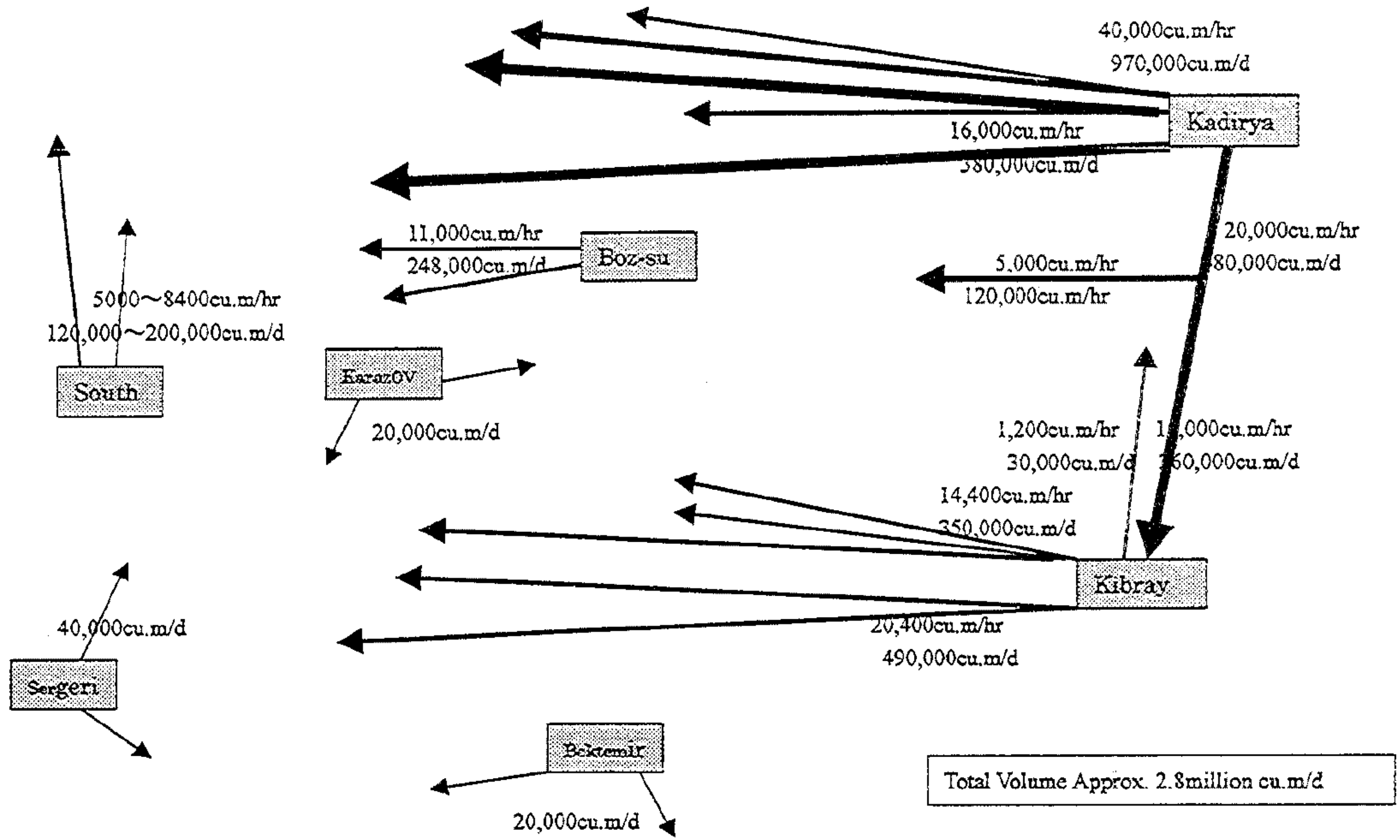
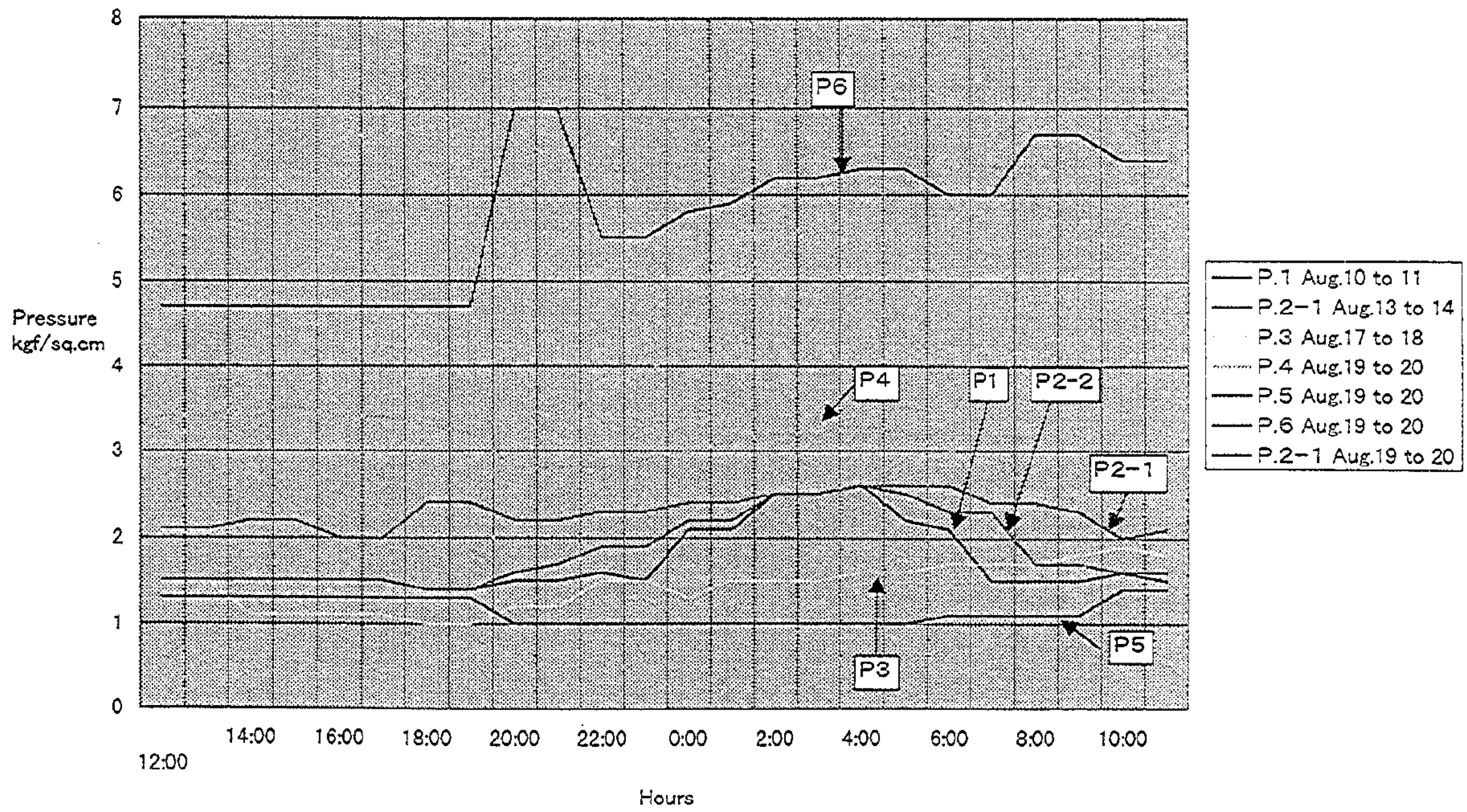


Figure 5.3.4 Water Distribution Volume in Tashkent City

Figure 5.3.5 Water Pressure in Tashkent City



The results indicate large fluctuations in pressure, i.e. 1.5 kgf/sq.cm in the daytime and 2 to 2.5 kgf/sq.cm at the night.

5.3.3 Water Leakage Detection

(1) Selection of Water Leakage Detection Methods

1) Detection Equipment

In this study, these 3 detection methods were selected:

- Sonic detection method (noise detection, general method, but a high level detection skill is required)
- Relative sonic detection method (noise detection, noise will be detected at two points and the distance to the leakage points will be calculated by the time lag in the noise transmission at the two points)
- The minimal flow method (water consumption will be minimum during the night. To detect the leakage point(s) and the volume, the flow will be measured at the target distribution main closing valves of the connections in the detached houses.)

Preparations included the following equipment: sonic detection equipment, a relative sonic detection equipment and ultrasonic flow meters (which were used for the flow measurement of the entire city) .

2) Detection Method

i) Sonic Detection Method

This detection mainly involves checking the main distribution pipes. It is important because the reported volume of leakage from pipes installed in the amount to roads are reported that will be more than 80% of the total volume of leakage in Japan. This detection is relatively difficult since a detector cannot distinguish leakage noise from other noises. A high level of and experience are required.

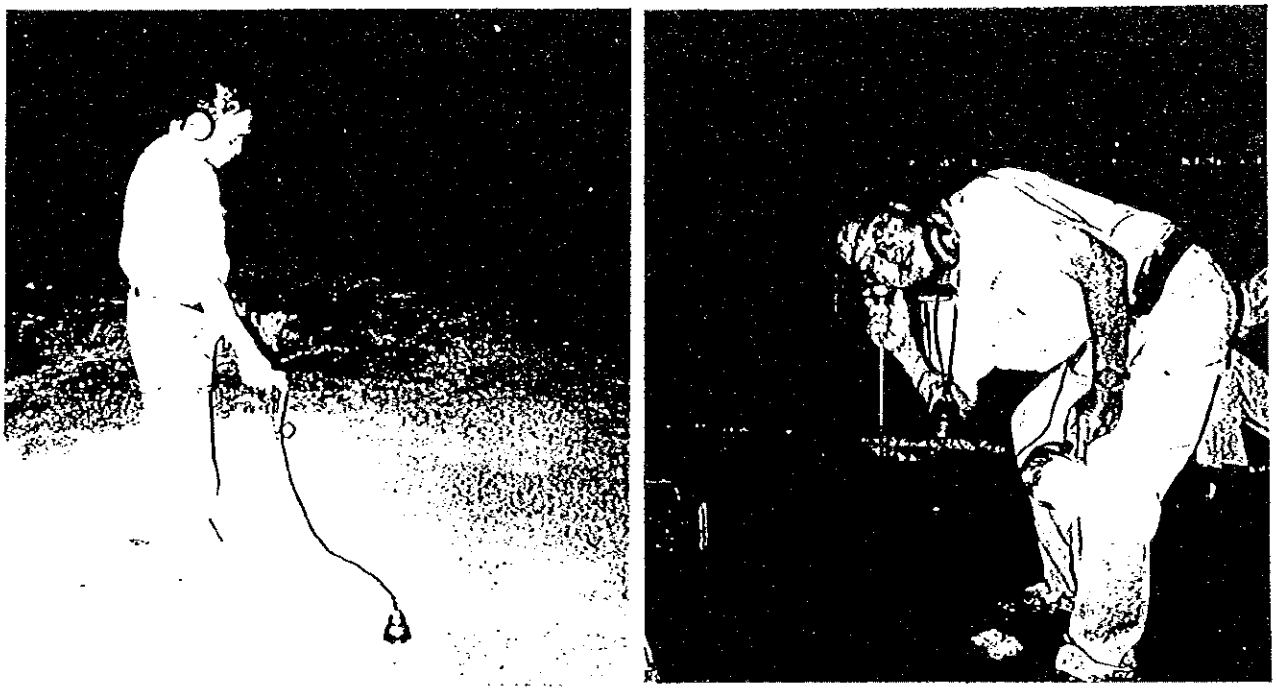


Photo 5.3.3 Road Surface Sonic Detection

The detector walks along the distribution pipes and uses a noise detector on the surface of the road. (See Photo 5.3.3)

This detection should be conducted around midnight (between P.M.10:00 and A.M 3:00), when various general noises and water flow will be minimal.

ii) Relative Sonic Detection Method

With this method, noise is detected at two points and the distance to the leakage point is calculated by the time lag of the noise transmission at these two points.

After measuring the distance between the 2 target valves, the sensors are attached to the 2 valves to determine the relative wave pattern. If a relative wave pattern is found, the distance from the leaking point is calculated by the propagation velocity and the distance between the two valves. (See Photo 5.3.4.)

Photo 5.3.4 Relative Sonic Detection

iii) Minimal Flow Method

Although the aforementioned methods can detect leakage points, they cannot measure the leakage volume. Thus the minimal flow method is necessary.

By this method, the water flow is measured at a target pipeline section during at midnight. The volume measured is primarily leakage because water consumption is minimal at that time.

One or two self-recording ultrasonic flow meters are attached the pipes after all valves downstream have been closed.

3) Selection of Water Leakage Detection Equipment

Although the necessary detection equipment for all three (3) detection methods were prepared, based on the site conditions, it was determined that the sonic detection method was the most applicable and that the relative sonic detection method was partially applicable. It was decided, however, that the minimal flow method was not applicable. The reasons are as follows:

- Due to in-house water leakage and institutional use (for example; the use of water in parks), the water flow does not stop even at night. Therefore, the minimal flow method, which operates on the premise that little water flows during the night, is not applicable.
- The relative sonic detection method is applied to specific leakage points. Accordingly target leakage area must be located by the sonic detection method in advance. When the detailed leakage points must be specified, this method is applied.

In Tashkent City, leaked water often intrudes into the culverts where hot water pips are installed because the water supply pipeline is usually installed parallel to the hot water pipes as shown in Figure 5.3.6. In such cases, the Hot Water Supply Authority makes immediate complaint because the thermal efficiency of the hot water pipes have decreased sharply. Therefore, Tashkent City Vodokanal is kept well informed of the occurrence of leakage. However, detection of a leakage point is not easy because the water intrusion into the culvert indicates only the approximate location of leak.

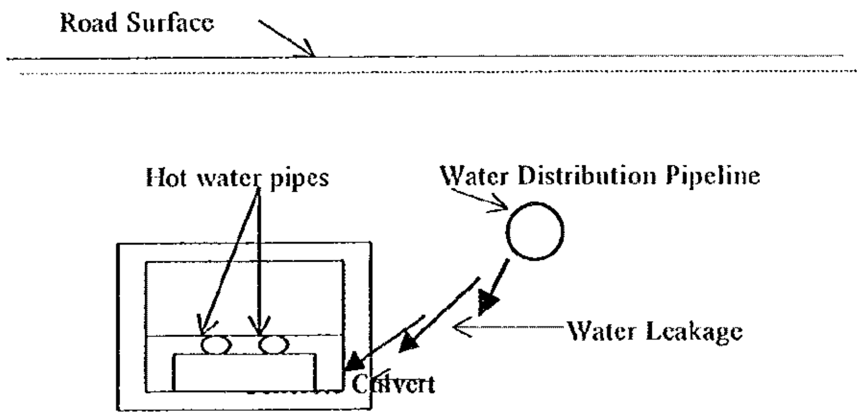


Figure 5.3.6 Water Leakage of Distribution Pipes and Hot Water Pipes

In cases where the leaked water does not intrude into the concrete culvert, the water usually spurts out of the surface of ground. In that case, it is easy to identify the leakage point. Table 5.3.4 shows the present situation of the leakage. Vodokanal received 114 reports as of May 10. During the next three months, 53 leaks were repaired, and 26 new leakage points were reported. Consequently 87 leaks were left unrepaired as of August 17.

As stated above, leakage can sometimes cause a loss to other business as and leaks must therefore be repaired immediately.

Table 5.3.4 Complaints Concerning Water Leakage and Repairs

District	Leakage Points On 10/05/99	Leaks Repaired	New Leaks Located On 17/08/99	Total
N1	12	0	5	17
N2	10	9	3	4
N3-1	19	6	1	14
N3-2	19	9	3	13
N4	12	11	0	1
N5	11	4	1	8
N6	10	0	0	10
N7	7	7	0	0
N8	4	3	2	3
N9	5	1	10	14
N10	4	2	1	3
N11	1	1	0	0
Total	114	53	26	87

In the case of water intrusion into concrete culvert, the water is pumped up in order to ascertain the approximate location of the point of leakage. Then, excavation work is carried out until the leakage point is found.

The problem with this method is the lack of efficiency because of the length of the excavation if the work is in a low traffic area such as a residential area. In the case of a main road or a deep excavation, it is difficult to apply this method.

Since leakage detection is so significant, Tashkent City Vodokanal desires to introduce effective leakage detection methods.

In the study, the acoustic detection method was applied in principle for the detection of leakage points, and correlational detection was applied as a supplementary method.

(2) Conduct of Water Leakage Detection in Tashkent City

1) Selection of Target Area

Basically, the request of Vodokanal is for us to detect leakage, following urgent complaints by the Hot Water Supply Authority. These leaks are difficulty to locate.

Although the Study Team gave serious consideration to the intentions of the Vodokanal, the detection work was conducted along the 2.5 km-long section of Umarov street, which was scheduled previously in the Preliminary Study, and along three 4.5 km-long distribution pipelines with diameters of 700, 900, and 1200 mm which supply water from the Kibray WTP to the city. The team made this decision because of time constraints and the long length requested. This position of Umarov Street involves many of the places where the Hot Water Supply Authority had complained of leakage and had requested Vodokanal to conduct a detection survey.

2) Results of Detection

The results of the detection are presented in Table 5.3.5. As shown in the table, most of the work was carried out at night.

The findings obtained through the survey are discussed Support 5.3.1:

3) Technical Transfer of Water Leakage Detection in Tashkent city

The acoustic leakage sound detection survey was conducted at 20 points, over a pipe length of 25 km in Tashkent City. During the survey, technology transfer was to the officials of Tashkent City Vodokanal who worked together with the team and were present as observers.

They were aware of the effectiveness of the technology transfer on water leakage detection (especially after September) and changed their attitude to learn this aggressively. As a result, they came to be able to distinguish between the sound caused by water leakage and general noise, particularly if the leakage sound is large and clear.

As mentioned the above, they now have the motivation to conduct water leakage detection surveys themselves. Therefore, it is certain that they can effectively use the equipment and materials for the detection of water leakage both to detect leaks and also to repair the leakage points if the equipment and materials are provided.

Photos 5.3.5(1) and (2) show the transfer of technology to the Tashkent City Vodokanal staff.

Table 5.3.5 Result of Water Leakage Detection

No.	date	Location	Detected length(km	Found leakage point number	Detection method	Diameter of pipe(sm)	Conducted Time	Others
1	19.July	Sergeri 8A apartment 24	0.9	0	Sonic	300,400,600	Night-time	Can't detect by pump noise
2	19.July	Sergeri N2 Apartment	0.5	0	Sonic	300	Night-time	No leakage
3	19.july	Amir Temur street .Aquapark	1	2	Sonic	800	Night-time	
4	31.July	Sergeri 8A apartment 24	0.9	1	Sonic	300,400,600	Night-time	After pump stop
5	31.July	Amir Temur street .Aquapark	0.5	2	Sonic	800	Night-time	Can't detect by noise
6	5.Aug.	Mannon Vigur str, Behzod Ave.	0.5	0	Sonic, Relative	150	Day-time	Can't detect by noise
7	5.Aug.	Muhano ave, N186 elementary school	0.5	0	Sonic	100	Day-time	Can't found. Sewer line?
8	6.Aug.	Mannon Vigur str, Behzod Ave.	0.5	0	Sonic	150	Night-time	Can't found by stop leakage
9	6.Aug.	Biruni Steet.	0.5	1	Sonic	800	Night-time	Leakage by Valve
10	11to12 Aug.	Kibrai district. Muso muhamedov collective farm .Katta Suv street	13.5	3	Sonic	700, 900, 1200	Day-time	Water sout up every point
11	28.08.99	Lisunova district.1block.apartement	0.5	0	Sonic	200,600	Night-time	
12	28.08.99	Birlshgan street. house 17	0.5	0	Sonic, Relative	300	Night-time	
13	2.09.99	Hamza Umarov street.aparteent No.4	2.5	1	Sonic	600	Night-time	
14	2.09.99	Crossing of Yakkasaroy street and Salomatina street	1	1	Sonic	600	Night-time	
15	7.09.99	Almazar district. Almazar street. 15/3	0.5	1	Sonic	100	Night-time	
16	7.09.99	Chilanzar district.8-block..apartment	0.2	1	Sonic	100	Night-time	
17	7.09.99	Chilanzar dist.17block..2-Qatortol str.Musical school	0.1	1	Sonic	200	Night-time	
18	9.09.99	Center 17/18.Gafur Gulom street.apartement No.45	0.5	1	Sonic	1400, 1000	Night-time	
19	9.09.99	Center 17/18.Apartement 5 and 6	2	1	Sonic	200	Night-time	
20	10.09.99	Hamza district. Birlashgan distrikt.Autoservice	0.2	1	Sonic, Relative	300	Night-time	
21	10.09.99	Crossing of Birlashgan and Kadisheva streets	0.1	1	Sonic, Relative	300	Night-time	

Photo 5.3.5 (1) Technology Transfer to the Vodokanal Staff(1)

Photo 5.3.5 (2) Technology Transfer to the Vodokanal Staff (2)

5.3.4 Estimation of Water Leakage Volume and Rate

(1) Calculation of Water Flow Balance and Unknown Water Volume

1) Condition of Calculation

From the results of the survey for water supply, both apartments and detached houses consume about 600L/capita/day in August and September as high demand period, and about 500L/capita/day in November. Table 5.3.6 shows the analysis of water consumption in Tashkent City. The analysis has been made on the following assumption:

i) Due to the fact that supplied population in 1996 was 2,160,000, the population for supply in 1999 is to be computed on the assumption of 2 % of annual increment rate which is the rate of the whole country, and the coverage of tapped water system is 98.5 %, and shown below:

$2,160,000 \times (1.02)^3 = 2,260,000$

ii) On the assumption that the sewer service rate is 85 % in number of households, that the one of apartments is 100 % and that the numbers of the apartments and detached houses and the average occupancy rate are correct in Table 5.3.6, the service rate is 25.5 %. In this case, the coverage of sewer service rate is 81.5 % in population.

iii) The distribution, sewerage volume, communal service of large consumption volume, industrial and hot and heating services (All the data are from Vodokanal) are shown in the columns of a, c, h, i and j of Table 5.3.6.

iv) Individual consumption is to be basically computed adjusting the figures of water consumption measured, to make the unknown water rate roughly same for all around year.

2) Evaluation of Calculation Result

The results are as follows:

i) Portable water distribution volume has been used for converting to the sewerage volume by using the coverage of sewer service by population. The comparison of the figure with the actual one explains the annual volume of unknown water rate by 17.7 % of the whole as an average. The unknown water is brought from leakage on distribution and sewer lines, irrigation in park connected with the portable water supply, sprinkling in the garden and leakage in heating process.

Table 5.3.6 Calculation of Water Consumption and Unknown Water in Tashekn City

Mark			a	b	c	d	e	f	h	I	j	k	l	m	n	o	p
Expression				a*0.815		b-c	d/b*100	d/0.815				h+i+j		l*2,260,000	k+m	a-n	o/a*100
Item			Distribution Volume		Sewage Volume	Difference:leakage of pipes, Gardening, Irrigation, Draind heating water		Total Difference	Large Water Consumption				Consumption of Individual		Total Consumption	Unknown Water: leakage & Irrigation	Unknown Water Rate: leakage & Irrigation
			Total	To Sewage		Volume	Rate		Communal service*1	Industry	Hot water and Heating	Total					
Units			10^3cu.m/m, cu.m/d	10^3cu.m/m, cu.m/d	10^3cu.m/m, cu.m/d	10^3cu.m/m, cu.m/d	%	10^3cu.m/m, cu.m/d	10^3cu.m/m, cu.m/d	10^3cu.m/m, cu.m/d	10^3cu.m/m, cu.m/d	10^3cu.m/m, cu.m/d	cu.m/month /capita/day	10^3cu.m/m, cu.m/d	10^3cu.m/m, cu.m/d	10^3cu.m/m, cu.m/d	%
1999	July	/month	89,495	72,938	51,648	21,290	29.2	26,123	18,726	4,078	9,251	32,055	20	45,539	77,594	11,901	
		/day	2,886,935	2,352,852	1,666,065	686,788		842,685	604,065	131,548	298,419	1,034,032	0.65	1,469,000	2,503,032	383,903	13.3
	June	/month	81,017	66,029	50,526	15,503	23.5	19,022	15,497	4,827	9,709	30,033	18	40,680	70,713	10,304	
		/day	2,700,567	2,200,962	1,684,200	516,762		634,064	516,567	160,900	323,633	1,001,100	0.60	1,356,000	2,357,100	343,467	12.7
	May	/month	73,489	59,894	50,518	9,376	15.7	11,504	14,283	5,228	10,486	29,997	17	38,533	68,530	4,959	
		/day	2,370,613	1,932,050	1,629,613	302,437		371,088	460,742	168,645	338,258	967,645	0.55	1,243,000	2,210,645	159,968	6.7
	Apl.	/month	69,077	56,298	51,061	5,237	9.3	6,425	12,655	5,430	11,765	29,850	15	33,900	63,750	5,327	
		/day	2,302,567	1,876,592	1,702,033	174,559		214,182	421,833	181,000	392,167	995,000	0.50	1,130,000	2,125,000	177,567	7.7
	Mar.	/month	70,693	57,615	45,564	12,051	20.9	14,786	11,090	4,368	16,090	31,548	16	35,030	66,578	4,115	
		/day	2,280,419	1,858,542	1,469,806	388,735		476,976	357,742	140,903	519,032	1,017,677	0.50	1,130,000	2,147,677	132,742	5.8
	Feb.	/month	66,363	54,086	49,958	4,128	7.6	5,065	13,715	4,148	14,637	32,500	13	28,476	60,976	5,387	
		/day	2,370,107	1,931,637	1,784,214	147,423		180,887	489,821	148,143	522,750	1,160,714	0.45	1,017,000	2,177,714	192,393	8.1
	Jan.	/month	71,654	58,398	50,563	7,835	13.4	9,614	10,204	4,427	16,734	31,365	16	35,030	66,395	5,259	
		/day	2,311,419	1,883,807	1,631,065	252,742		310,113	329,161	142,806	539,806	1,011,774	0.50	1,130,000	2,141,774	169,645	7.3
1998	Dec.	/month	70,140	57,164	50,598	6,566	11.5	8,057	11,849	3,904	16,323	32,076	14	31,527	63,603	6,537	
		/day	2,262,581	1,844,003	1,632,194	211,810		259,889	382,226	125,935	526,548	1,034,710	0.45	1,017,000	2,051,710	210,871	9.3
	Nov.	/month	69,382	56,546	49,970	6,576	11.6	8,069	11,314	4,982	15,404	31,700	14	30,510	62,210	7,172	
		/day	2,312,733	1,884,878	1,665,667	219,211		268,971	377,133	166,067	513,467	1,056,667	0.45	1,017,000	2,073,667	239,067	10.3
	Oct.	/month	71,571	58,330	49,800	8,530	14.6	10,467	14,887	4,657	11,626	31,170	16	35,030	66,200	5,371	
		/day	2,308,742	1,881,625	1,606,452	275,173		337,636	480,226	150,226	375,032	1,005,484	0.50	1,130,000	2,135,484	173,258	7.5
	Sep.	/month	77,239	62,950	49,499	13,451	21.4	16,504	17,929	4,470	8,262	30,661	18	40,680	71,341	5,898	
		/day	2,574,633	2,098,326	1,649,967	448,359		550,134	597,633	149,000	275,400	1,022,033	0.60	1,356,000	2,378,033	196,600	7.6
	Aug.	/month	89,592	73,017	53,512	19,505	26.7	23,933	20,644	4,367	9,558	34,569	20	45,539	80,108	9,484	
		/day	2,890,065	2,355,403	1,726,194	629,209		772,036	665,935	140,871	308,323	1,115,129	0.65	1,469,000	2,584,129	305,935	10.6
Annual Total		10^3cu.m	899,712	733,265	603,217	130,048	17.7	159,568	172,793	54,886	149,845	377,524	195	440,474	817,998	81,714	9.1
Average		cu.m/d	2,464,964	2,008,946	1,652,649	356,297		437,174	473,405	150,373	410,534	1,034,312	0.5340	1,206,778	2,241,090	223,874	9.1

Item	Number	Ave. occupant	Populatin		Sewage Service		
			Caluclated	Mended	Rate(%)	Population	Rate(%)
Detached Houses	113,471	5.1	578,702	560,139	25.5	142,684	
Units of Apartment	450,306	3.9	1,756,193	1,699,861	100.0	1,699,861	
Total	563,777				85.0		
Population	2,260,000		2,334,896	2,260,000		1,842,545	81.53
			0.97				

ii) Leakage on distribution pipe line is estimated at about 10 % on road.

iii) On the assumption of 650 L/capita/day in July and August, as a results of individual consumption survey, and in comparison of distribution volume with the consumption volume, there are observed 10 % of unknown water rate.

Taking into account the above, and applying the individual consumption of 450-650L/capita/day to each month, it shows the tendency that it consumes more in summer and less in other seasons, and the annual average consumption comes to be 534L/capita/day.

iv) In this case, the annual average unknown water rate is about 9 %. This volume responds almost to the leakage volume on distribution pipe line, which includes the volume of irrigation to the plants in parks as well.

Figure 5.3.6 shows the balance of these figures.

(2) Evaluation of Water Leakage Volume and Rate

According to the results of water supply survey, it consumes more than 500L/capita/day in the apartment and more than 600L/capita/day in the individual house without water meter.

But real water consumption per capita in Tashkent City that is shown in Chapter5.2.5 and calculated in S.5.2.1, is estimated at 300L/capita/ day as the maximum and 240L/capita/day as the average. The causes of the above seems to have derived from the following leakage in house:

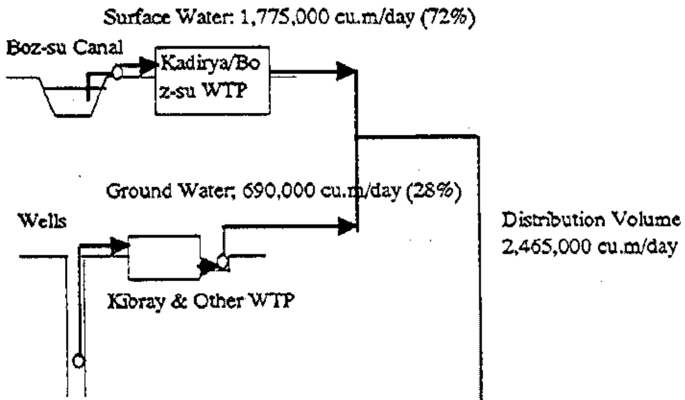
i) In apartment, there are observed many cases that ball tap of low-tank in toilet is not tightly closed. In actual measurement, the flow into low tank is more than 3 L/min. If it is totally damaged, the leakage is, 3L/min × 1440min = 4,320L/day.

The average occupants number of each unit in the apartment is 3.9, according to the survey data. Relying upon the figure, the leakage volume per head comes up to be "4,320/3.9 = 1,100L/capita/day".

ii) It might be same in the detached houses that toilet has the cause of the volume of leakage, but the low coverage of sewer service suggests that there might be other reasons.

Figure 5.3.7 Water Volume Balance of Tashekmt City

Annual average volume

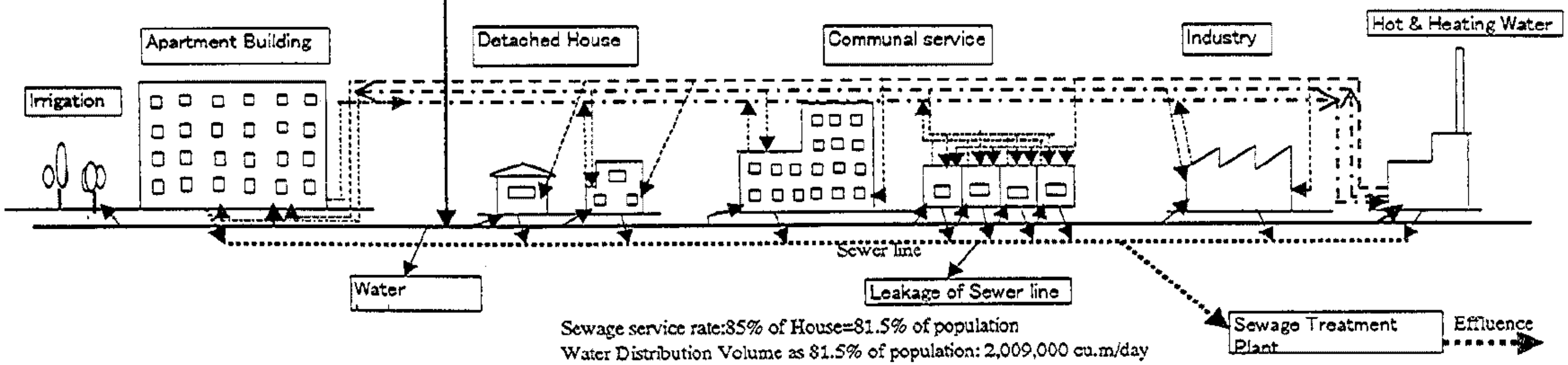


Possibile Water Reduction

Item	Apartment Building	Detached House	Communal Service	Industry	Hot & heat	Total
Distribution Volume(L/capita/day	534	534	209	66	182	—
Real Consumption(L/capita/day)	240	300	105	53	80	—
Waste or Leakage(L/capita/day)	294	234	104	13	102	—
Possible reducition(10^6cu.m/year)	182	48	86	11	84	411

Flow Balance of Water Supply

Classification	Apartment Buildings	Detached Houses	Communal Service	Industry	Hot & Heating-water	Unknown : water Leakage &	Total
House Number	450,300	113,500	—	—	—	—	563,800
Population	1,670,000	560,000	—	—	—	—	2,230,000
Consumption(m^3/day)	885,000	292,000	473,000	150,000	411,000	254,000	2,465,000
Comsumption Rate(%	36.0	11.9	19.2	6.1	16.7	10.1	100.0
Criteria(L/capita/day)	521	521	209	66	182	112	1,091
Annual Total(10^6cu.m	312.7	116.9	172.8	54.9	149.8	92.6	899.7



Sewage service rate:85% of House=81.5% of population
Water Distribution Volume as 81.5% of population: 2,009,000 cu.m/day
Sewage Volume:1,653,000cu.m/day
Difference: 356,000cu.m/day(17.7% to 2,009,000cu.m/day)
Difference: a)Water leakage of distribution and sewer pipes
b)Irrigation and gardening, c)Effeluence of heating water returning pipes

According to the interview to the plumbing companies, In Uzbekistan, since steel pipe without paint has been used for buried portion inside of house, ten years after the installation, many cases happens to start leakage due to the corrosion which causes for the holes. In such cases, big scale of remedial works seems to be required. In the same interview, it is revealed that there are plural connections in detached house.

Upon the results of water supply survey, only a few houses which consumes extremely share a great part of total consumption and the existence of such leakage increases the supply volume significantly.

iii) As for large consumer, it is apparent that the cause of leakage exists in toilet in communal service such as municipalities, schools and retail shops, and the leakage is estimated at about 50 %. In factories, there are all meters installed, so the leakage is estimated at 50 %.

Hot water and heated water of heating system is distributed 70 % to the individuals and 30 % to the large consumers. As for heating system, big leakage is reported, and for individual houses, as described in chapter 7.7.1, the required volume is estimated at 50 % of the total consumption of kitchen and bath uses, and 50 % of the whole is adopted for the leakage of large consumption.

Based upon the above, summarized is the rate of leakage which is shown in Table 5.3.7.

As mentioned in the table, in Tashkent, the leakage is estimated at 55 %, including the leakage inside of building. The leakage of distribution pipes on road shares rather small, but the volume itself is very big in comparison with the one in Japan.

For the individual uses, it seems to be reasonable to assume that the consumption over Japanese consumption standard volume is being wasted and the consumption can be reduced to the same level, adopting the pricing system by volume wasted. It should be possible to reduce the water consumption by about 60 % in all.

Table 5.3.7 Assumption of Water Leakage and Waste in Tashkent City Population 2,260,000

Item	Units	Individual Consumption			Large Consumption			Water Leakage of Pipeline	Total	Rate(%)
		Apartment	Detached house	Hot/heating Water	Communal service	Industry	Hot/heating Water			
Population	%	75.2	24.8							
Hot/heating Water Rate	%			70.0			30.0			
Distribution Volume	L/capita/d	**534**	**534**	**127**	**209**	**66**	**55**	**100**	**1091**	**100.0**
	cu.m/day	907,544	299,296	287,020	472,340	149,160	124,300	226,000	**2,465,660**	
	L/capita/d	**661**			**330**			100	1091	
	%	60.6			30.2			9.2	100.0	
Real Water consumption	L/capita/d	**230**	**270**	**65**	**104**	**46**	**27**	**0**	**482**	**44.2**
(Including Waste Water)	cu.m/day	390,890	151,330	146,900	235,040	103,960	61,020	0	1,089,139	
	L/capita/d	305			177			0	482	
	%	**63.3**			**36.7**			**0.0**	**100.0**	
Water Leakage Volume	L/capita/d	304	264	62	105	20	28	100	883	
	cu.m/day	516,654	147,967	140,120	237,300	45,200	63,280	226,000	**1,376,521**	
	L/capita/d	**356**			**153**			**100**	**609**	**55.8**
	%	**58.5**			**25.1**			**16.4**	**100.0**	
Water Waste Volume	L/capita/d	27			30			0	57	5.2
To Japan Level	cu.m/day	61,020			67,800			0	128,820	
	%	47.4			52.6				100.0	
Possible Deduction	L/capita/d	383			183			80	646	59.2
Volume (Water reakage in	cu.m/day	865,761			413,580			180,800	1,460,141	
Housings)	%	59.3			28.3				100.0	
Water Consumption in Japan	L/capita/d	278			93			20	391	
	%	**71.1**			**23.8**			**5.1**	**100.0**	

5.4 Analysis of Field Survey

5.4.1 Summary of Questionnaire Survey on User Awareness

We conducted questionnaire surveys in August and November 1999. The objective of the questionnaire survey is to evaluate the resident users' awareness or the corporate users' awareness in Tashkent regarding the following key issues:

(1) Water conservation

(2) User participation

(3) Willingness and Ability to pay the present water tariff systems and the future tariff system on the future improvement program

(4) Water Leakage

(5) Need for the possible improvement in the service areas

We summarize conclusions of the key issues on the survey as follows.

(1) Awareness on Water Conservation

1) Resident Users

Resident users' awareness on water conservation is evaluated to be adequate so that they may understand the need of water conservation and will take practical actions for reducing the expense, even in case of implementation of new water tariff collection system by meter reading. However most users probably consume much water or waste much water for their daily life on the present fixed tariff system.

2) Corporate Users

Corporate users, as a whole, have understood the need of the Water Conservation and are much concerned about water conservation. Their awareness on water conservation is higher than individual users' because they need a keener sense of water cost for better management under the tariff collection system with meter reading.

(2) Awareness on User participation

1) Resident Users

The individual users have positive awareness and much concern about the public interest issues, including the cost of water tariff or the management performance of Vodokanal from the users' point of view. In addition to this point, the lack of good communication with Vodokanal may make users willing to communicate with the Vodokanal. Therefore, their awareness and willingness for user participation is evaluated to be positive.

2) Corporate Users

The corporate users also have positive awareness and much more concern about the cost of water tariff or the management performance of Vodokanal from the management's point of view. In addition to this point, the lack of good communication with Vodokanal may make users willing to communicate with the Vodokanal. Therefore, their awareness and willingness for user participation is evaluated to be positive.

(3) Awareness on Willingness and Ability to Pay the Present Water Tariff

1) Resident Users

Resident users' awareness on the affordability to pay the water tariff is evaluated to be at a level to accept, in some degree, the increase of water tariff. If the tariff increases too much, it will not be easy for the users to agree with the policy because apart from the satisfaction of the present tariff, users show their discontent with the Vodokanal service, such as the quality of water and the water interruption

2) **Corporate Users**

Corporate users' awareness, as a whole, on the ability to pay the water tariff is evaluated to be at a level to accept, in some degree, the increase of water tariff. 51% manufacturing industry, however, show that the present tariff is expensive under the tariff system by meter reading.

(4) Awareness on Willingness and Ability to Pay the Future Water Tariff

1) **Individual Users**

71% resident users consider that it is a fair tariff concept that water tariff should be calculated and charged based on consumed volume of water. More than half (58%) interviewed resident users agree to a tariff system to pay for the water tariff according to their actual consumed volume of water by reading meter. It turned out that most opponents of the system need a safety net for the poor and the pensioner on the system.

64% of interviewed resident users prefer to pay for the installation cost of the meter divided into the monthly tariff. 30% of interviewed people would like to pay for meter installation at once after installation.

2) **Corporate Users**

Results show that most corporate users understand and support the current tariff system based on actual consumption by reading meter. 79% corporate users consider that it is a fair tariff concept, and that water tariff should be calculated and charged based on consumed volume of water. 76% corporate users agree to a tariff system to pay for the water tariff according to their actual consumed volume of water by reading meter.

55% of interviewed companies would like to pay for the installation cost of the meter divided into the monthly tariff. 41% of interviewed companies would like to pay for the meter installation cost at once. 4% of companies prefer other ways.

(5) Awareness on Water Leakage

1) Resident User

Their awareness on water leakage is evaluated to be a highly potential issue for the resident users after the implementation of the water tariff collection system charged by meter reading. 43% of the individual users answered that they had noticed water leakage from water distribution pipes inside their house. In general, 61% of them are discontent with the repair service for water leakage. 60% of interviewed resident users feel the need for improvement of the quality of the repairers' services that they are served. It is noted that for the apartment resident users only 29.1% of the apartment resident users are content with the service of JEK.

2) Corporate User

43% of interviewed corporate users answered that they had noticed water leakage from water distribution pipes inside their companies. It is found that the corporate users have much concern about the water leakage. 65% of interviewed companies need more improvement in the quality of the repairing service for the water leakage. In addition, 13% corporate users show that they need information provided by the Vodokanal on how to prevent the water leakage.

(6) Areas to Improve on Vodokanal in Near Future

1) Resident Users

The highest priority area to improve from the resident users' point of view is the issue of the safety of water quality for health reasons. 44% of interviewed users chose the item of safety of water quality for health. The following priority area to improve is the issue of stability of water supply. It includes the water interruption and low pressure of water issues. 28% chose the item of stability of water supply. The third priority area to improve is the current water tariff including the price. 18% wish to decrease or improve the current water tariff. 5% of people accordingly answered that they would like to have a better tariff collection system. 5% need more communication with Vodokanal.

2) Corporate Users

The highest priority area to improve from the corporate users' point of views is also the issue of the safety of water quality for health. 45% of interviewed companies wish to improve water quality. The following priority area to improve is the issue of the stability of water supply. 32% of them would like to have more a stable water supply. It includes the water interruption and low pressure of water issues. The third priority area to improve is the current water tariff including the price. 14% of companies wish to decrease or improve tariff system. 5% and 4% of interviewed companies answered, respectively, that they prefer to have more communication with Vodokanal and better tariff collection system.