2.4 Result of Each Pilot Project Site (Action U6 - U14)

Result of Each Pilot Project Site （Action U6 – Action14）

1. Results of Pilot Project in Pilot Project Site-1 (Zagazig East)

1.1 Action U6 (Making field survey of distribution network)

The purpose of this action is to confirm the source of water to the area by isolating the valve at the entrance of the network and confirm that no water in the network after that. The survey also includes the confirmation of the minor valves, fire hydrants, and the governmental building in the distribution network. It was assumed that governmental building may have the largest amount of wastage during night hours after departure of employees.

Based on the GIS base maps, a draft of the water distribution network has been prepared by the UFW team. The GIS team drew the network for Zagazig East Area-1 and the pipe data was verified by the UFW team and the distribution network crew.

The team made a site survey to verify all data indicated on the GIS map. All customer data was collected from the commercial department in SHAPWASCO. The commercial department has customer information for Zagazig city and part of Zagazig markaz. The other branches are at early stages of collecting customer information and establishing a reliable database of customers.

The customer information recorded on the database was established by dividing Zagazig city into regions. Each region was divided into blocks. Each block shall be surrounded by streets. Each block was divided to buildings and each building has the customers identified with their account number. In the site survey, the customer information was verified and the customers that are not connected to the network in the area were removed from the area database and consequently their water meter shall not be read during the project activities.

Table 1-1 Network Survey Result in Zagazig East Area-1

Diameter of Asbestos pipe feeding the area	200 mm
Length of water distribution network pipes (material: Asbestos)	3,588 m
400 mm	10 m
200 mm	279 m
150 mm	698 m
100 mm	2,601 m
Number of fire hydrants in the area	6 pcs
Number of governmental building	0 pcs
Number of schools	2 pcs
Number of isolating valves	43 pcs
200 mm	5
150 mm	6
100 mm	32
Number of water meters	1,661 pcs

Source: GIS Center

1.2 Action U7 (Surveying Working conditions of water meters and conducting meter readings)

Working conditions of water meters were collected from the commercial department. Non-working meters were recorded by the meter reader of SHAAPWASCO and were verified by the UFW team.

Table 1-2 Status of the Meters inside the areas

Meter Status	Number of Meters
Total number of meters as per commercial database	1,661 pcs
Meters outside the activity area[1]	238 pcs
Total number of meters inside pilot project area	1,423 pcs
Meters registered closed by SHAPWASCO	124 pcs
Meters in closed houses[2]	126 pcs
Connection without meters (flat rate)	5 pcs
Meters lifted for maintenance by SHAPWASCO	5 pcs
Non working meters	364 pcs
Working meters	799 pcs

After confirming the status of the meters, a meter repairing team has repaired a part of the non working meters. Some of the non-working meters could not be repaired and they were replaced before the water meter reading was conducted.

1.3 Action U8 (Measuring metering error for working meters)

Meter error shall be one of the sources of the commercial UFW. A series of meter calibration for determining the accuracy of the meter has been conducted by the following method:

1. Select 20 to 30 working meters randomly in the pilot project site.
2. Close all the taps in the house.
3. Set the hands of the water meter at zero point.
4. Open one tap and close all other taps in the house. Measurement shall be done by the following three cases for the degree of tap opening:
   - Case 1 : Full opening
   - Case-2 : Half opening
   - Case-3 : Quarter opening
5. Keep running water into the measuring tank for one minute and close the tap.
6. Reopen the tap for one minute and close.
7. Repeat items 5 and 6 until water level shows 20L or other readings (10L and 15L which will be determined taking into account the work progress at site and situation of the house).
8. Close the tap and read the meter.
9. Record the time of the measurement (from item 3 to 5)
10. Repeat the procedure from item 3 to 6 for all cases.

[1] Meters has a water supply outside the concerned network

[2] Customer is outside the country and left his account open

The average meter error was recorded as 4.0 % at an average flow of 0.253 L/s (15.2 L/min.). The positive sign of the meter error indicated that the water meter read more than the actual amount of water passing through it. The positive value also indicated that the amount of UFW should be decreased by this amount of error. This value shall be taken into account during the water balance analysis.

The main source of wastage inside house is the leak in the faucet and toilets. This wastage can not be determined during day hours. To determine the leakage in house, the water usage pattern in the house should be registered including the minimum night flow.

The method to determine the wastage in houses was based on installing a flow meter on the inlet pipeline feeding the house for complete 24 hours. The recorded minimum night flow is assumed to be the value of the wastage due to leakage from faucet and toilet. The following table represents the results of the flow meter records during this activity.

Table 1-3 Wastage in Houses during

Building No.	No.1	No.2	No.3	No.4	No.5
Number of floors	5	5	5	4	15
Number of flats	11	10	10	8	130
Average number of person per flat	4	4	4	4	4
Number of water closet	11	10	10	8	130
Number of automatic laundry	3	6	6	3	NA
Number of water meters	11	9	9	6	1
Total measured flow (L/d)	5,117	7,788	2,629	2,478	123,994
Average person consumption (L/c/d)	116	195	66	77	238
Average MNF (L/s) from 1:0 to 6:0 a.m.	0.048	0.092	0.023	0.013	1.176
Minimum recorded flow at night	0.029	0.036	0.024	0.00	1.057
Calculated wastage per water meter (L/hr)	9.5	14.4	9.6	0	29.3

All the surveyed building was medium houses except the fifth building which was a huge building consists of 15 floors and inside 130 flats. The main water connection to the building is 100 mm diameter and has one bulk water meter and was not working. The building has an elevated water tank at the roof floor level. The water is pumped from a pump at the ground level to feed the elevated tank. The pump is operated by a level control which means that when the level in the tank reach a minimum level, a signal from the level switch operates the pumps until the water level in the tank reach a certain maximum level at which the pump stops.

According to the measured results, it was concluded that the minimum night flow in the houses could represent the wastage in the faucets and toilets. The wastage in houses could be estimated as 12 L/hr. The calculated value was below the minimum start flow of the water meters. The installed water meters was class (B) which has -if calibrated or new- a minimum start flow of 30 L/hr.

This value of wastage shall be taken into consideration when preparing the water balance analysis as

starting flow and metering inaccuracies in apparent losses. This amount of water was measured as a part of minimum night flow value determined by the flow meter installed at the main pipeline to the study area.

1.4 Action U9 (Conducting MNF survey)

A series of minimum night flow survey was conducted in this stage. It was assumed that the value of the minimum night flow (MNF) is an indication on the amount of leakage in the distribution network. This activity is summarized as follow:

1- A flow meter shall be installed on the water inlet(s) to register the amount of water entering the study area.

2- Two pressure recorders shall be installed as well; one of these recorders shall be installed at the inlet point and the other at the far end of the network for the same period of the flow meter recording to measure the average pressure in the network.

3- The flow meter shall be allowed to register the flow rate value for at least 24 hours.

4- The minimum registered flow shall represent the amount of leakage in the network beside the wastage in houses.

5- The equivalent leakage flow during the day could be determined by the following equation.

$$Q_1 = \sqrt{\frac{p_2}{p_1}} Q_2$$

Where;
Q1 = equivalent minimum night flow
P2 = Average pressure at minimum night flow time
P1 = Average pressure at the time of equivalent minimum night flow
Q2 = Minimum night flow at a certain pressure

6- Determine the percent of MNF which represent a comparative basis for the UFW by dividing the equivalent minimum night flow by the total flow registered by the flow meter (Q_{MNF}/Q_{TOTAL})

A series of MNF runs was conducted before leakage detection or repair takes place. The summary of these results is represented in the following table 1-4.

Table 1-4 Summary of Result

Item	Unit	Value
Average Flow	L/s	19.74
Minimum flow (MNF)	L/s	11.56
Maximum value of flow	L/s	27.92
Total flow rate (Q_{TOTAL})	m^3/day	1,705
Equivalent MNF (Q_{MNF})	m^3/day	984
Ratio	%	57.6

This ratio of equivalent MNF was considered very high and its sources shall be analyzed after the leakage detection and repair works finish.

1.5 Action U10 (Making water balance analysis before repair works)

To establish a water balance analysis, the following procedure shall be followed:

1- Determine the net amount of water entering the study pilot area which was measured as 1705 m^3/d.

2- Determine the authorized consumption, the sum of metered volume 984 m^3/d with over registration error of 4 % (38 m^3/d) so that the net volume of billed authorized consumption will be 946 m^3/d . The billed un-metered volume that was assumed to be consumed as a flat rate evaluation of 25 m^3/month/meter. The value of the billed unmetered consumption was calculated to be 126 m^3/d. This amount of water was consumed by the registered customers at SHAPWASCO. Authorized consumption may include items such as fire fighting, training, flushing of mains and sewers, street cleaning, public fountains and gardens, etc, these may be billed, unbilled, metered or unmetered. This value was neglected in this study as the area was controlled against these actions during the study period.

3- Determine the water loss which is the difference between system input volume and authorized consumption. Water losses can be considered as a total volume for the whole system, or for partial systems such as transmission or distribution schemes, or individual zones as in our case in Zagazig East Area 1. Water losses consist of real losses and apparent losses. The total volume of the water losses was calculated to be 633 m^3/d.

4- Determine apparent losses that include all types of inaccuracies associated with customer metering as well as data handling error (meter reading and billing), plus unauthorized consumption (theft or illegal use). This value shall include the wastage in houses. The value of the wastage volume was calculated as 56 m^3/d. regarding the meter error in registration, the over registration of customer meters lead to underestimation of Real Losses and under-registration of customer meters leads to over-estimation of real Losses.

5- Determine the Real Losses that indicate the physical water losses from the networks (i.e. leakage). This amount shall represent the water volume lost through all types of leaks, bursts, and overflows.

The following table represents the water balance analysis before repair works for Zagazig East Area-1

Table 1-5 Water Balance Analysis before Repair Works for Zagazig East Area-1 (m^3/day)

Water Distributed Volume **1705** m^3/day	Authorized Consumption **1072.15** m^3/day	Billed Authorized Consumption **1072.15**	Billed Metered Consumption	984	**Water Sold** 1072.15 **m^3/day**	**Revenue Water** 1072.15 **m^3/day**
			Metering error (over registration)	-38		
			Billed Unmetered Consumption(fixed amount collected)	126		
		Unbilled Authorized Consumption **0**	Unbilled Metered Consumption	0	**Commercial losses** 56 **m^3/day**	**Unaccounted for Water (UFW)** 632.85 **m^3/day**
			Unbilled Unmetered Consumption	0		
	Unauthorized Consumption **632.85** m^3/day	Apparent Losses **56**	Unauthorized Consumption	0		
			Metering Inaccuracies(start flow & under registration)	56		
		Real Losses (leakage) **576.85**	Leakage on Transmission and/or Distribution Mains		**Physical losses** 576.85 **m^3/day**	
			Leakage and Overflows at Utility's Storage Tanks			
			Leakage on Service Connections up to point of Customer metering	577		

According to the status of water meters at this stage, it was difficult to determine accurately the volume of water consumed by the customers.

It was assumed that the customer's consumption shall conform to the flat rate consumption (i.e. 25 m^3/month/water meter). The second assumption was that meter inaccuracy is over-registration of 4.0%.

1.6 Action U11 (Conducting leakage detection survey)

The leak detection went through several stages with the acoustic rod and the digital sound detector. When there was a point suspected to have a leak, the UFW team began to use a more advanced leak detection equipment such as the leak detector and/or the leak sound correlator to exactly locate the leak on the pipe.

(1) Detection of leaking sound by Acoustic Rod or Digital Sound Detector

The first attempt to detect the leakage in the pipes and the house connection was done using the acoustic rod and the digital sound detector.

When leakage occurs, leaking sound spreads through the pipe. At the point where valves are available, acoustic rod or digital sound detector was useful for detecting the sound. The method of leaking sound detection is shown on Figure 1-1.

Figure 1-1 Detecting Leakage on House Connection by Acoustic Rod

The UFW team has been trained on leak detection by the acoustic rod and the digital leak detector at Mostrod Training Center and OJT at site by assistance of JICA expert team during the activity.

(2) Detection of leaking points by Leak Detector

To detect the leakage on the distribution pipeline, the leak detector was used. The leak detection activity using the leak detector is shown in Figure 1-2. It was helpful to confirm the location of the leakage by night survey to isolate the background noise caused by traffic during daytime.

Figure 1-2 Detection Work by Leak Detector

(3) Detection by Leak Sound Correlator

Leak Sound Correlator was applied to confirm the leaking point when leak sound is detected in two points. This equipment identifies the location of leaks by intercepting leak noise that is caught by a sensor at two valves or hydrants. It measures the difference in transmission time between two points, and processes the data by computer. Thus, it exactly shows the leaking point.

The following figure shows the use of leak sound correlator in the activity area.

Figure 1-3 Leak Sound Correlator

(4) Confirmation of Leak Point by Acoustic Rod

After detecting leak point, some holes were drilled at the detected leak points and acoustic rod was inserted in the hole to confirm the exact location of the leak point. This method is very useful especially in paved roads to make the decision of excavation in paved road worth. Figure 1-4 shows the confirmation of leaks when found by acoustic rod drilled in the ground.

Figure 1-4 Method of Confirming Exact Location of Leak Point

(5) Pipe Locating Devices

In some locations, the buried electrical cables shall cause a big risk for labor to excavate beside. It was necessary to locate the position of the electrical cables before excavation. In other locations, when the buried pipes were not identified, following devices was used to locate the electrical cables and/or the buried pipes.

Pipe & Cable Locator

This device was used for locating pipes and cables under the ground.

Figure 1-5 Pipe & Cable Locator

Metal Locator

A sensor of this device detects the location of hidden iron-made structures such as valve boxes and stop valves. In some locations, the asphalt paving covered the surface box of the valves and the cover of the valve chambers. The use of metal locator has led to the detection and relocation of these iron-made structures.

Figure 1-6 Metal Locator

(6) Results of leak detection

The leak detection survey led to detect five (5) leaks in the area. All the detected leaks were on the house connections which were manufactured from lead. One of these leaks was on the connection to a public school. The reason for the leaks was due to wrong construction due to bending the lead pipe bending without using the proper facilities to bend such pipes.

The following table indicates the summary of the detected leaks and the map indicated the location of these leaks on the GIS map used during the survey.

Table 1-6 Summary of Detected Leaks Information

Leakage Record Sheet					
No.	1	2	3	4	5
Date	21-8-07	22-8-07	23-8-07	24-8-07	23-08-07
Block Number	46	51	56	48	36
House Number	335	2	39	13	School
Position	HC	HC	HC	HC	HC
Condition of leak	Crack	Packing	Unknown	Crack	Crack
Diameter of pipe	50	50	50	50	50
Material of leak pipe	Lead	Lead	Lead	Lead	Lead
Depth of pipe	70 cm	190 cm	100 cm	120 cm	70 cm
Ground conditions	Paved	Paved	Paved	Paved	Conc.
Cause of leak	Water pressure	Deterioration	Construction	Water pressure	Water pressure
Leakage size	Large	Medium	Medium	Medium	Large
Leakage quantity (measured)	3 L/s	NA	NA	NA	NA

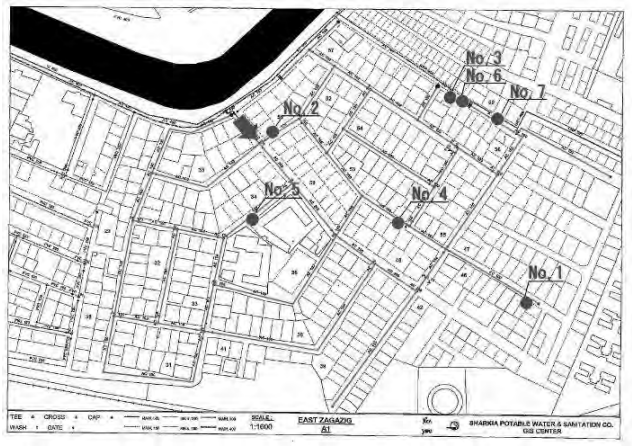


Figure 1-7 Location of Detected Leaks in Zagazig East Area-1

The common features of the detected leaks that all the leaks were on the lead pipe forming the house connection. Most of the leaks were due to cracks caused in the pipe by bending the lead pipe during construction period and then with water pressure and deterioration, the crack begins to spread. Due to asphalt pavement and the position of the crack on the side of the house connection, no water comes out the ground surface. All the leak water goes to the sewers in some case and to a ground aquifer in other cases.

1.7 Action U12 (Repairing leakage parts)

Following the leaks had been detected; the repair works takes place by SHAPWASCO equipment and facilities. All the lead pipes and house connection with detected leak has been replaced with PVC pipes with proper fittings.

1.8 Action U13 (Conducting MNF survey after repair works)

In order to confirm the effectiveness of the repairing work (or reduction percentage of leakage ratio), MNF survey was carried out after the repairing work of the leaking parts. In the mean time of the MNF survey, two rounds of meter reading were conducted in the same period (about 6 days). The purpose of collecting meter reading was to measure the billed authorized consumption to be used in the water balance analysis.

A flow meter has been installed at the main inlet pipeline and was allowed to register the flow rate for the whole 6 days. Two flow meters were used, one each two days to overcome the short lifetime of portable batteries that was used to operate the flow meter.

The following table represents the main findings during the MNF survey after leak detection and repair.

Table 1-7 Status of Water Meters after Repair

Item	unit	Status
Duration of MNF survey, days	day	6
Total amount of water registered by flow meter during measurement period	m^3	8,155 (1,359 m^3/day)
Number of read meters	nos	1,163
Number of locked meters	nos	255
Number of flat rate connection	nos	5

1.9 Action U14 (Making water balance analysis and its evaluation)

As described in item 1.5 of this report, the water balance analysis is a useful tool to evaluate the UFW ratio. The following data should be known or estimated before making the water balance analysis:

1- Quantity of water entering the study area network.
2- Quantity of water leaving the study area network and goes to another network at the boundary of it.
3- Quantity of billed authorized consumption.
4- Estimation of the unbilled authorized consumption.
5- Meter inaccuracy and error in start flow measurement (the minimum flow rate at which the water meter begin to register the flow amount).
6- In SHAPWASCO, there was no unbilled metered water. Previously, the governmental building did not pay for the water. This case is not found in Zagazig East Area-1. All building has a meter except some 5 building which are billed on a flat rate of 25m^3/month.
7- During UFW team survey for the distribution network and the status of the meters, the team did not find customers theft water (i.e. unauthorized consumption).

During the Action U8, it was found that the wastage in houses equal 12 L/hr/meter. It was assumed that this wastage shall be for a period of 3 hours (night hours). In the daytime, the use of the faucets and flush tanks in the toilet make the water meter run for a flow higher than the start flow. This shall

make the meter register the total flow passing through it including the wastage flow.

The number of meters that could have a wastage including flat rate connections is 1,423 meters.
Total amount of wastage per day = 1,423meters x 12L/hr x 3hr/1000= 51 m^3/day

The following table represents the water balance analysis after repair.

Table 1-8 Water balance analysis for Zagazig East Area-1 after repair (m^3/day)

Water Distributed Volume **1395** m^3/day	Authorized Consumption **1072.15** m^3/day	Billed Authorized Consumption **1072.15**	Billed Metered Consumption 984	**Water Sold** 1072.15 **m^3/day**	**Revenue Water** 1072.15 **m^3/day**
			Metering error (over registration) -38		
			Billed Unmetered Consumption(fixed amount collected) 126		
		Unbilled Authorized Consumption **0**	Unbilled Metered Consumption 0	**Commercial losses**	**Unaccounted for Water (UFW)** 322.85 **m^3/day**
			Unbilled Unmetered Consumption 0		
	Unauthorized Consumption **322.85** m^3/day	Apparent Losses **51**	Unauthorized Consumption 0	51 **m^3/day**	
			Metering Inaccuracies(start flow & under registration) 51		
		Real Losses (leakage) **271.85**	Leakage on Transmission and/or Distribution Mains	**Physical losses** 271.85 **m^3/day**	
			Leakage and Overflows at Utility's Storage Tanks		
			Leakage on Service Connections up to point of Customer metering 272		

The value of 4 % of meter inaccuracy is adopted as over-registration taking into consideration of the replacement of non-working meters to new meters.

Summary of UFW activity in Zagazig East A-1 before and after repair activity

Parameter	Unit	Assessment Before Repair	Assessment After Repair	Reduction
Water Distributed	m^3/day	1550		---
Customer Consumption	m^3/day	1072.15	1072.15	---
UFW (by volume)	m^3/day	632.85	322.85	310.00
UFW ratio	%	40.83%	20.83%	20.00%
Leakage (by volume)	m^3/day	576.85	271.85	305.00
Leakage ratio	%	37.22%	17.54%	19.68%

2 Results of Pilot Project in Pilot Project Site-2 (Hihya City)

2.1 Action U6 (Making field survey of distribution network)

The purpose of this action is to confirm the source of water to the area by isolating the valve at the entrance of the network and confirm that no water in the network after that. The survey also includes the confirmation of the minor valves, fire hydrants, and the governmental building in the distribution network. It was assumed that governmental building may have the largest amount of wastage during night hours after departure of employees. Based on the GIS base maps, a draft of the water distribution network has been prepared by the UFW team. The GIS team drew the network for Hihya Area-2 and the pipe data was verified by the UFW team and the distribution network crew.

The team made a site survey to verify all data indicated on the GIS map. The customer data that was available in the commercial department in SHAPWASCO was not classified as in the case of Zagazig network. All the customers were identified by address only and the account number. It was very difficult to find the customer on the GIS network map. A new identification system similar to that found in Zagazig was necessary to be established.

It was assumed that when establishing a database system for Hihya, Area-2 shall have a region number that could be different of surrounding areas. We assumed that region number of Area-2 shall not be taken into account on this identification system. The buildings in Hihya Area-2 were divided into blocks. Each block was surrounded by streets. Each block was divided into buildings. By this way, each building has a unique identification by block number/building number.

A new survey was done after that to identify the customers on the GIS map. In the site survey, the customer information was established and the customers that are not connected to the network in the area were removed from the area database and consequently their water meter shall not be read during the project activities. The study area in Hihya has a tree shape water network. The area was fed from two points. It was necessary to close one of these connections. It was decided to close the valve connecting the area to the old Hihya city. This action took place during the period of MNF measurements.

The results of the field survey for Hihya Area-2 yield the following information:

Table 2-1 Network Survey Results in Hihya Area-2

Item	Result
Diameter of PVC pipe feeding the area	300 mm
Length of water distribution network pipes (material: Asbestos(AC) and PVC)	10,480 m
300 mm	PVC:845m
200 mm	AC:986m
150 mm	AC:236m,PVC:823m
100 mm	AC:1,164m,PVC:6,430m
Number of fire hydrants in the area	5
Number of governmental building	8
Number of schools	4
Number of isolating valves	33
300 mm	2
150 mm	3
100 mm	28
Number of water meters	1,404

Source: GIS Center

2.2 Action U7 (Surveying Working conditions of water meters)

Working conditions of the water meters were collected from the commercial department. The non-working meters were recorded by the meter reader and were verified by the UFW team. Due to lack of proper database for Hihya Area-2, the status of the water meters was unknown and not confirmed.

A first attempt was conducted to collect water meters reading within a certain period (e.g. 3 to 4 days). This attempt was failed due to lack of a reliable database of water meters. However, it was expected that the number of the non-working meters shall be big as some of the meters was not enclosed inside the buildings as in the case of the governmental housing.

From the meter status survey, it was found that the percent of the non-working meters is about 50% of the total meters inside the study area. It was decided to repair the meters that could be repaired and replace the non-working meters which can not be repaired.

Table 2-2 Status of Meters inside Hihya Area-2

Item	Number of Meters
Total number of meters as per commercial database	1,404
Meters in closed houses[3]	128
Non-working meters	518
Working meters	758

After confirming the status of the meters, a meter repairing team has repaired a part of the

[3] Customer is outside the country and left his account open

non-working meters. As of the end of February 2008, 180 meters has been repaired. Some of the non-working meters could not be repaired and it should be replaced before the second water meter reading is conducted.

2.3 Action U8 (Measuring metering error for working meters)

Meter error shall be one of the sources of the commercial UFW. A series of meter calibration for determine the accuracy of the meter has been conducted by the following method.

1. Select 20 to 30 working meters randomly in the pilot project site.
2. Close all the taps in the house.
3. Set the hands of the water meter at zero point.
4. Open one tap and close all other taps in the house. Measurement shall be done by the following three cases for the degree of tap opening:
   - Case 1 : Full opening
   - Case-2 : Half opening
   - Case-3 : Quarter opening
5. Keep running water into the measuring tank for one minute and close the tap.
6. Reopen the tap for one minute and close.
7. Repeat items 5 and 6 until water level shows 20L or other readings (10L and 15L which will be determined taking into account the work progress at site and situation of the house).
8. Close the tap and read the meter.
9. Record the time of the measurement (from item 3 to 5)
10. Repeat the procedure from item 3 to 6 for all cases.

The average meter error was recorded as 4.0 %. The positive sign of the meter error indicated that the water meter read more than the actual amount of water passing through it. The positive value also indicated that the amount of commercial UFW should be decreased by this amount of error. This value shall be taken into account during the water balance analysis. The error of the meter was due to presence of some impurities in the water (silt, solids, etc.). Such impurities cause the clogging of the meter screen. As the water flow passes through the meter clogged screen, the water velocity increases. The increase in water velocity makes the rotation speed of the meter increase and the meter is over registering the actual flow passing through it.

The main source of wastage inside house is the leak in the faucet and toilets. This wastage can not be determined during day hours. To determine the leakage in house, the water usage pattern in the house should be registered including the minimum night flow.

The method to determine the wastage in houses that was followed in Zagazig East Area-1 can not be followed in Hihya Area-2 as most of the house connection was less than 2 inches which is beyond the limits of the flow meter measurements. This method to determine the wastage could be possible for some of the governmental buildings such as the hospital and the educational building. The flow meter was fixed on the inlet pipe to the hospital and the educational building to measure the wastage inside these building. The results of these measurements are shown on Table 2-3.

The recorded minimum night flow is assumed to be the value of the wastage due to leakage from faucet and toilet. The following table represents the results of the flow meter records during this activity

Table 2-3 The wastage measurements and results in Hihya Area-2

Building No.	No.1	No.2	No.3	No.4	No.5
Number of floors	1	1	1	1	1
Number of water closet	1	1	1	1	1
Number of water meters	4	5	1	1	1
Total measured flow (L/day)	9,910	3,061	8,078	3,229	1,329
Average MNF (L/s) from 1:00 to 5:00 a.m.	0.051	0.0	0.068	0.0	0.0
Average Minimum recorded flow at night	0.10	0.01	0.071	0.013	0.015

All the surveyed building was medium houses. The average minimum flow at night hours (from 12:00 am to 6:00 am) was recorded as 0.0034 L/s/meter. This value yields a wastage value of 12.3 L/hr/meter. The recorded value was very close to the value recorded in Zagazig East Area-1.

According to the measured results, it was concluded that the minimum night flow in the houses could represent the wastage in the faucets and toilets. The calculated value was below the minimum start flow of the water meters. The installed water meters was class (B) which has -if calibrated or new- a minimum start flow of 30 L/hr.

This value of wastage shall be taken into consideration when preparing the water balance analysis as unbilled un-metered water volume. This amount of water was measured as a part of minimum night flow value determined by the flow meter installed at the main pipeline to the study area.

Regarding the governmental building, there were 12 buildings. Only three buildings have a working water meters. The status of these buildings is given in the following table:

Table 2-4 Status and Diameter of Connection to Governmental Buildings in Hihya A-2

Building Name	Meter Status	Connection less than 2 inch	Measured MNF (L/s)
Central Hospital Old building	Not working	No	1.21
Central Hospital new Building	Working	No	0.41
Electricity Engineering Building	Not working	Yes	
Real Estate Taxes Building	Not working	Yes	
City Hall	No meter	Yes	
Traffic Management Building	No meter	Yes	
Fathy Moharram School	Working	No	0.46
Education Department	Working	No	0.019
Al-Azhar Girls Institute	Not working	Yes	
Agricultural Engineering Building	Not working	Yes	
Al-Azhar Elementary School	Working	Yes	
Amina Waked School	Not working	No	0.11

All connections less than 2 inches can not be measured with the flow meter. A series of flow measurement for the governmental building was conducted to determine the amount of wastage in these building during night. The buildings that could be measured were the hospital and the education department. To determine the average wastage in these buildings, it was assumed that the water usage

pattern in the hospital shall be different than the pattern in other public buildings. The average measured wastage in the remaining three buildings was 0.196 L/s. This assumption shall give a wastage value in the public buildings except the hospital of 1.96 L/s. The measured wastage value in the hospital was 1.62 L/s. Although the wastage value (0.196 L/s) in each building could be registered by the water meter, but as mentioned in the above table, 7 meters out of 10 was not working.

The value of the wastage to be considered in the water balance analysis shall be as follows:

- Building with non-working meters	:	0.196 x 7 = 1.37 L/s
- Old Hospital	:	1.21 L/s
Total	:	2.58 L/s

2.4 Action U9 (Conducting MNF survey)

A series of minimum night flow survey was conducted in this stage. It was assumed that the value of the minimum night flow (MNF) is an indication on the amount of leakage in the distribution network. This activity is summarized as follow:

1- A flow meter shall be installed on the water inlet(s) to register the amount of water entering the study area.
2- Two pressure recorders shall be installed as well; one of these recorders shall be installed at the inlet point and the other at the far end of the network for the same period of the flow meter recording to measure the average pressure in the network.
3- The flow meter shall be allowed to register the flow rate value for at least 24 hours.
4- The minimum registered flow shall represent the amount of leakage in the network beside the wastage in houses.
5- The equivalent leakage flow during the day could be determined by the equation mentioned in section 1.4.
6- Determine the percent of MNF which represent a comparative basis for the UFW by dividing the equivalent minimum night flow by the total flow registered by the flow meter (Q_{MNF}/Q_{TOTAL})

A series of MNF runs was conducted before leakage detection or repair takes place. The summary of these results is represented in the following table 2-5.

Table 2-5 MNF Results before Repair in Hihya A-2

Item	Unit	2 Dec '07	3 Dec '07	4 Dec '07	6 Dec '07	7 Dec '07
Minimum flow (MNF)	L/s	9.51	16.07	15.82	10.46	10.84
Average Flow	L/s	23.22	25.22	25.47	23.55	23.70
Total flow rate (Q_{TOTAL})	m^3/day	2,007	2,180	2,202	2,036	2,048
Equivalent MNF (Q_{MNF})	m^3/day	882	1,210	1,198	941	970
Ratio	%	44.0	55.5	54.4	46.2	47.4
MNF Time		3:13	3:34	3:27	3:13	2:10

This ratio of equivalent MNF was considered very high and its sources shall be analyzed after the leakage detection and repair works finish.

2.5 Action U10 (Making water balance analysis before repair works)

To establish a water balance analysis, the following procedure shall be followed:

1- Determine the net amount of water entering the study pilot area which was measured as 2094 m^3/d.
2- Determine the authorized consumption, the sum of metered volume 979 m^3/d with over registration error of 4 % (38 m^3/d) so that the net volume of billed authorized consumption will be 941 m^3/d . The billed un-metered volume that was assumed to be consumed as a flat rate evaluation of 25 m^3/month/meter. The value of the billed unmetered consumption was calculated to be 593 m^3/d. This amount of water was consumed by the registered customers at SHAPWASCO. Authorized consumption may include items such as fire fighting, training, flushing of mains and sewers, street cleaning, public fountains and gardens, etc, these may be billed, unbilled, metered or unmetered. This value was neglected in this study as the area was controlled against these actions during the study period.
3- Determine the water loss which is the difference between system input volume and authorized consumption. Water losses can be considered as a total volume for the whole system, or for partial systems such as transmission or distribution schemes, or individual zones as in our case in Hihya Markz Area 2. Water losses consist of real losses and apparent losses. The total volume of the water losses was calculated to be 560 m^3/d.
4- Determine apparent losses that include all types of inaccuracies associated with customer metering as well as data handling error (meter reading and billing), plus unauthorized consumption (theft or illegal use). This value shall include the wastage in houses. The value of the wastage volume was calculated as 65 m^3/d. regarding the meter error in registration, the over registration of customer meters lead to underestimation of Real Losses and under-registration of customer meters leads to over-estimation of real Losses.
5- Determine the Real Losses that indicate the physical water losses from the networks (i.e. leakage). This amount shall represent the water volume lost through all types of leaks, bursts, and overflows.

The following table represents the water balance analysis before repair works for Hihya Markz Area-2

Table 2-6 Water Balance Analysis in Hihya A-2 before Repair (m^3/day)

Water Distributed Volume **2094** m^3/day	Authorized Consumption **1534.35** m^3/day	Billed Authorized Consumption **1534.35**	Billed Metered Consumption	979	**Water Sold** 1534.35 m^3/day	**Revenue Water** 1534.35 m^3/day
			Metering error (over registration)	-37.65		
			Billed Unmetered Consumption(fixed amount collected)	593		
		Unbilled Authorized Consumption **0**	Unbilled Metered Consumption	0		
			Unbilled Unmetered Consumption	0		
	Unauthorized Consumption **559.65** m^3/day	Apparent Losses **65**	Unauthorized Consumption	0	**Commercial losses** 65 m^3/day	**Unaccounted for Water (UFW)** 559.65 m^3/day
			Metering Inaccuracies(start flow & under registration)	65		
		Real Losses (leakage) **494.65**	Leakage on Transmission and/or Distribution Mains		**Physical losses** 494.65 m^3/day	
			Leakage and Overflows at Utility's Storage Tanks			
			Leakage on Service Connections up to point of Customer metering	494.65		

2.6 Action U11 (Conducting leakage detection survey)

The leak detection went through several stages with the acoustic rod and the digital sound detector. When there was a point suspected to have a leak, the UFW team began to use a more advanced leak detection equipment such as the leak detector and/or the leak sound correlator to exactly locate the leak on the pipe.

(1) Detection of leaking sound by Acoustic Rod or Digital Sound Detector

The first attempt to detect the leakage in the pipes and the house connection was done using the acoustic rod and the digital sound detector.

When leakage occurs, leaking sound spreads through the pipe. At the point where valves are available, acoustic rod or digital sound detector was useful for detecting the sound. The method of leaking sound detection is shown on Figure 2-1.

Figure 2-1 Detecting Leakage on House Connection by Acoustic Rod in Hihya A-2

The UFW team has been trained on leak detection by the acoustic rod and the digital leak detector at Mostrod Training Center and OJT at site by assistance of JICA expert team during the activity.

(2) Detection of leaking points by Leak Detector

To detect the leakage on the distribution pipeline, the leak detector was used. The leak detection activity using the leak detector is shown in Figure 2-2. It was helpful to confirm the location of the leakage by night survey to isolate the background noise caused by traffic during daylight.

Figure 2-2 Detection Work by Leak Detector in Hihya A-2

(3) Detection by Leak Sound Correlator

Leak Sound Correlator was applied to confirm the leaking point when leak sound is detected in two points. This equipment identifies the location of leaks by intercepting leak noise that is caught by a sensor at two valves or hydrants. It measures the difference in transmission time between two points, and processes the data by computer. Thus, it exactly shows the leaking point.

(4) Confirmation of Leak Point by Acoustic Rod

After detecting leak point, some holes were drilled at the detected leak points and acoustic rod was inserted in the hole to confirm the exact location of the leak point. This method is very useful especially in paved roads to make the decision of excavation in paved road worth.

(5) Pipe Locating Devices

In some locations, the buried electrical cables shall cause a big risk for labor to excavate beside. It was necessary to locate the position of the electrical cables before excavation. In other locations, when the buried pipes were not identified, following devices was used to locate the electrical cables and/or the buried pipes.

Pipe & Cable Locator

This device was used for locating pipes and cables under the ground.

Metal Locator

A sensor of this device detects the location of hidden iron-made structures such as valve boxes and stop valves. In some locations, the asphalt paving covered the surface box of the valves and the cover of the valve chambers. The use of metal locator has led to the detection and relocation of these iron-made structures.

(6) Results of leak detection

The leak detection survey led to detect 19 leaks in the area. All the detected leaks were on the house connections which were manufactured from lead. The reason for the leaks was due to wrong construction due to bending the lead pipe bending without using the proper facilities to bend such pipes.

The following Table indicates the summary of the detected leaks and the map indicated the location of these leaks on the GIS map used during the survey.

Table 2-7 Summary of Detected Leaks Information

Leakage Record Sheet

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Date	21-11	24-11	25-11	26-11	26-11	2-12	26-11	27-11	27-11	1-12	2-12	2-12	13-12	15-12	15-12	10-12	10-12	10-12	13-12
Area	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2
Position	HC	HC	HC	HC	HC	HC	HC	HC	HC	HC	V	V	V	HC	HC	HC	HC	HC	HC
Condition of leak	pack	pack	Pack	Pack	Pack	pack	pack	pack	pack	pack	pack	pack	pack	pack	pack	pack	pack	pack	pack
Diameter of pipe	25	25	25	25	25	25	25	25	25	25	150	150	100	25	25	25	25	25	25
Material of leak pipe	lead	lead	Lead	Lead	Lead	lead	lead	lead	lead	lead	Pvc	Pvc	Pvc	lead	lead	lead	lead	lead	lead
Depth of pipe	70	100	110	80	70	90	120	90	110	120	200	200	200	80	120	110	110	120	80
Ground conditions	Gra	Gra	Gra	Gra	Gra	Gra	Gra	Gra	Gra	Gra	Pav	Pav	Gra	Gra	Gra	Gra	Gra	Gra	Gra
Cause of leak	Det.	Det..	Det.	Det.	Det	Det	Det.	Det.	Det	Det	pack	pack	Pack	pack	Det	Det	Det	Det	Det
Leakage size	M	M	M	M	M	M	M	M	M	M	S	S	M	M	M	M	M	M	M
Leakage quantity	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes: Gra: Gravel, HC: House connection, V : Valves, Pack : Packing, Det : Deterioration, M : Medium, S : Small, NA : Not Applicable

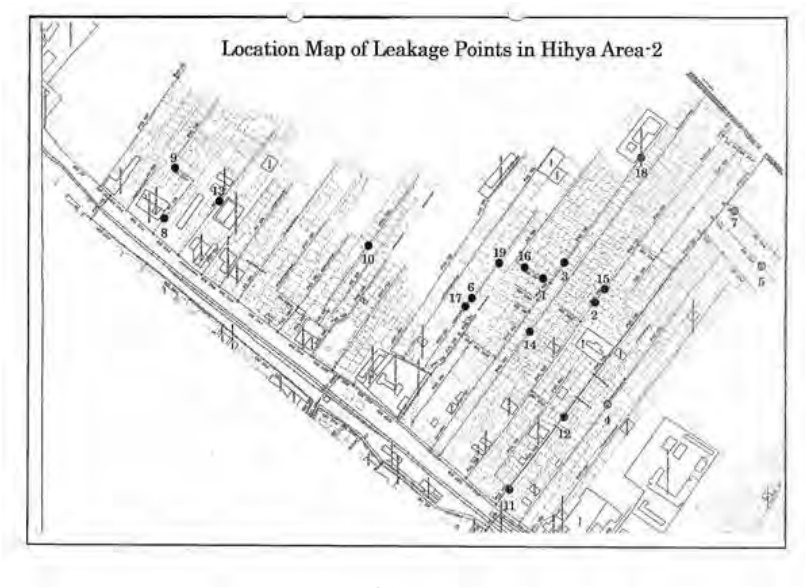


Figure 2-3 Location of detected leaks in Hihya Area-2

Except three position of the leaks on the valves of the distribution pipelines, the remaining detected leaks was on the lead pipe that form the house connection and most of the leaks was due to cracks found in the pipe due to deterioration and bending the lead pipe during construction period and then due to water pressure, the crack begins to spread. Most of the leaks were visible as the ground surface is gravel.

2.7 Action U12 (Repairing leakage parts)

Following the leaks had been detected; the repair works takes place by SHAPWASCO equipment and facilities. All the detected leak lead pipes and house connection has been replaced with PVC pipes with proper fittings.

2.8 Action U13 (Conducting MNF survey after repair works)

Although the pipe repair works has been completed, the extended MNF survey after repair works can not be done unless all non-working water meter is replaced or repaired. However, MNF measurement has been conducted for one day and was not accompanied with water meter reading. The recorded minimum night flow was 9.38L/s. The calculated MNF ratio in this case was 42% with a reduction of about 6 to 10% from the calculated MNF before leakage repair.

2.9 Action U14 (Making water balance analysis and its evaluation)

As described in item 2-5 of this report, the water balance analysis is a useful tool to evaluate the UFW ratio. The following data should be known or estimated before making the water balance analysis.

1- Quantity of water entering the study area network 1,979 m^3/d.
2- Quantity of water leaving the study area network and goes to another network at the boundary of it (Nil).
3- Quantity of billed authorized consumption. This value could be assumed as measured before as the water meter status is the same as the time of measuring the water meters. 736 m^3/d. The volume of billed unmetered water shall be considered as the same value before repair (905 m^3/d)
4- Estimation of the unbilled authorized consumption. (Nil)
5- Meter inaccuracy and error in start flow measurement (the minimum flow rate at which the water meter begin to register the flow amount). This shall be estimated as before the leakage repair (+4.0 %)
6- In SHAPWASCO, there was no unbilled metered water. Previously, the governmental building did not pay for the water. All building has a meter except the two governmental buildings (traffic department and the city hall).
7- During UFW team survey for the distribution network and the status of the meters, the team did not find customers theft water (i.e. unauthorized consumption).

The water balance analysis shall be completed after water meter repair and replacement.

Table 2-8 Water balance analysis for Hihya Markaz Area-2 after repair (m^3/day)

Water Distributed Volume **1979** m^3/day	Authorized Consumption **1641.54** m^3/day	Billed Authorized Consumption **1641.54**	Billed Metered Consumption	766	**Water Sold** 1641.54 m^3/day	**Revenue Water** 1641.54 m^3/day
			Metering error (over registration)	-29.46		
			Billed Unmetered Consumption(fixed anmount collected)	905		
		Unbilled Authorized Consumption **0**	Unbilled Metered Consumption	0	**Commercial losses** 65 m^3/day	**Unaccounted for Water (UFW)** 337.46 m^3/day
			Unbilled Unmetered Consumption	0		
	Unauthorized Consumption **337.46** m^3/day	Apparent Losses **65**	Unauthorized Consumption	0		
			Metering Inaccuracies(start flow & under registration)	65		
		Real Losses (leakage) **272.46**	Leakage on Transmission and/or Distribution Mains		**Physical losses** 272.46 m^3/day	
			Leakage and Overflows at Utility's Storage Tanks			
			Leakage on Service Connections up to point of Customer metering	272.5		

Summary of UFW activity in Hihya A-2 before and after repair activity

Parameter	Unit	Assessment Before Repair	Assessment After Repair	Reduction
Water Distributed	m^3/day	2036.5		---
Customer Consumption	m^3/day	1534.35	1641.54	---
UFW (by volume)	m^3/day	559.65	337.46	222.19
UFW ratio	%	27.48%	16.57%	10.91%
Leakage (by volume)	m^3/day	494.65	272.46	222.19
Leakage ratio	%	24.29%	13.38%	10.91%

3 Results of Pilot Project in Pilot Project Site-3 (Zagazig West)

3.1 Action U6 (Making field survey of distribution network)

The purpose of this action is to confirm the source of water to the area by isolating the valve at the entrance of the network and confirm that no water in the network after that. The survey also includes the confirmation of the minor valves, fire hydrants, and the governmental building in the distribution network.

Based on the GIS base maps, a draft of the water distribution network has been prepared by the UFW team. The GIS team drew the network for Zagazig West Area-3 and the pipe data was verified by the UFW team and the distribution network crew.

The team made a site survey to verify all data indicated on the GIS map. All customer data was collected from the commercial department in SHAPWASCO. In the site survey, the customer information was verified as follows:

Table 3-1 Network Survey Result in Zagazig West Area-3

Diameter of Asbestos pipe feeding the area	100 mm
Length of water distribution network pipes (material: Asbestos(AC) and PVC)	5,463m
200 mm	AC:1,206m
100 mm	AC:103m,PVC:4,154m
Number of isolating valves	24
200 mm	1
100 mm	23
Number of water meters	1,200

Source: GIS Center

3.2 Action U7 (Surveying Working conditions of water meters and conducting meter readings)

Working conditions of the water meters were collected from the commercial department. The non-working meters were recorded by the meter reader and were verified by the UFW team.

The status of the meters inside the area was as follows:

Table 3-2 Status of Meters inside the Area

Meter Status	Number of Meters
Total number of meters as per commercial database	1,200
Working meters	780
Non working meters	420
1) Meters repaired	120
2) Meters need to replace	300

After confirming the status of the meters, a meter repairing team will repair a part of the non working meters. Some of the non working meters can not be repaired and it will be replaced before the water meter reading will be conducted.

3.3 Action U8 (Measuring metering error for working meters)

Meter error shall be one of the sources of the commercial UFW. A series of meter calibration for determine the accuracy of the meter has been conducted by the following method.

1 Select 20 to 30 working meters randomly in the pilot project site.
2 Close all the taps in the house.
3 Set the hands of the water meter at zero point.
4 Open one tap and close all other taps in the house. Measurement shall be done by the following three cases for the degree of tap opening:
   - Case 1 : Full opening
   - Case-2 : Half opening
   - Case-3 : Quarter opening
4. Keep running water into the measuring tank for one minute and close the tap.
5. Reopen the tap for one minute and close.
6. Repeat items 5 and 6 until water level shows 20L or other readings (10L and 15L which will be determined taking into account the work progress at site and situation of the house).
7. Close the tap and read the meter.
8. Record the time of the measurement (from item 3 to 5)
9. Repeat the procedure from item 3 to 6 for all cases.

The average meter error was recorded as 4.0 %. The positive sign of the meter error indicated that the water meter read more than the actual amount of water passing through it. The positive value also indicated that the amount of commercial UFW should be decreased by this amount of error. This value shall be taken into account during the water balance analysis. The error of the meter was due to presence of some impurities in the water (silt, solids, etc.). Such impurities cause the clogging of the meter screen. As the water flow passes through the meter clogged screen, the water velocity increases. The increase in water velocity makes the rotation speed of the meter increase and the meter is over registering the actual flow passing through it.

The main source of wastage inside house is the leak in the faucet and toilets. This wastage can not be determined during day hours. To determine the leakage in house, the water usage pattern in the house should be registered including the minimum night flow.

This method to determine the wastage in houses can not be followed in Zagazig West Area-3 as most of the house connection was less than 2 inches which is beyond the limits of the flow meter measurements so that the recorded value 12 L/hr/meter in Zagazig East and Hihya City will be used when calculating wastage value in houses in Zagazig West.

3.4 Action U9 (Conducting MNF survey)

A series of minimum night flow survey was conducted in this stage. It was assumed that the value of the minimum night flow (MNF) is an indication on the amount of leakage in the distribution network. This activity is summarized as follow:

1- A flow meter shall be installed on the water inlet(s) to register the amount of water entering the study area.
2- Two pressure recorders shall be installed as well; one of these recorders shall be installed at the inlet point and the other at the far end of the network for the same period of the flow meter recording to measure the average pressure in the network.
3- The flow meter shall be allowed to register the flow rate value for at least 24 hours.
4- The minimum registered flow shall represent the amount of leakage in the network beside the wastage in houses.
5- The equivalent leakage flow during the day could be determined by the equation mentioned in section 1.4.
6- Determine the percent of MNF which represent a comparative basis for the UFW by dividing the equivalent minimum night flow by the total flow registered by the flow meter (Q_{MNF}/Q_{TOTAL}).

A series of MNF runs was conducted before leakage detection or repair takes place. The summary of these results is represented in the following table:

Table 3-3 Summary of Results for MNF Survey before Leakage Repair

Item	Unit	Value
Average Flow	L/s	8.54
Minimum flow (MNF)	L/s	4.48
Maximum value of flow	L/s	12.08
Total flow rate (Q_{TOTAL})	m^3/day	738
Equivalent MNF (Q_{MNF})	m^3/day	360
Ratio	%	48.8

This ratio of equivalent MNF was considered very high and its sources shall be analyzed after the leakage detection and repair works finish.

3.5 Action U10 (Making water balance analysis before repair works)

To establish a water balance analysis, the following procedure shall be followed:

1- Determine the net amount of water entering the study pilot area which was measured as 852 m^3/d.
2- Determine the authorized consumption, the sum of metered volume 399 m^3/d with over registration error of 4 % (15 m^3/d) so that the net volume of billed authorized consumption will be 384 m^3/d. The billed un-metered volume that was assumed to be consumed as a flat rate evaluation of 25 m^3/month/meter. The value of the billed unmetered consumption was calculated to be 175 m^3/d. This amount of water was consumed by the registered customers at SHAPWASCO. Authorized consumption may include items such as fire fighting, training, flushing of mains and sewers, street cleaning, public fountains and gardens, etc, these may be billed, unbilled, metered or unmetered. This value was neglected in this study as the area was controlled against these actions during the study period.

3- Determine the water loss which is the difference between system input volume and authorized consumption. Water losses can be considered as a total volume for the whole system, or for partial systems such as transmission or distribution schemes, or individual zones as in our case in Zagazig west Area 3. Water losses consist of real losses and apparent losses. The total volume of the water losses was calculated to be 293 m^3/d.

4- Determine apparent losses that include all types of inaccuracies associated with customer metering as well as data handling error (meter reading and billing), plus unauthorized consumption (theft or illegal use). This value shall include the wastage in houses. The value of the wastage volume was calculated as 39 m^3/d. regarding the meter error in registration, the over registration of customer meters lead to underestimation of Real Losses and under-registration of customer meters leads to over-estimation of real Losses.

5- Determine the Real Losses that indicate the physical water losses from the networks (i.e. leakage). This amount shall represent the water volume lost through all types of leaks, bursts, and overflows.

The following table represents the water balance analysis before repair works for Zagazig west Area-3

Table 3-4 Water Balance Analysis in Zagazig west A-3 before Repair (m^3/day)

Water Distributed Volume **852** m^3/day	Authorized Consumption **558.65** m^3/day	Billed Authorized Consumption **558.65**	Billed Metered Consumption	399	**Water Sold** 558.65 **m^3/day**	**Revenue Water** 558.65 **m^3/day**
			Metering error (over registration)	-15.35		
			Billed Unmetered Consumption(fixed amount collected)	175		
		Unbilled Authorized Consumption **0**	Unbilled Metered Consumption	0	**Commercial losses**	**Unaccounted for Water (UFW)** 293.35 **m^3/day**
			Unbilled Unmetered Consumption	0		
	Unauthorized Consumption **293.35** m^3/day	Apparent Losses **39**	Unauthorized Consumption	0	39 **m^3/day**	
			Metering Inaccuracies(start flow & under registration)	39		
		Real Losses (leakage) **254.35**	Leakage on Transmission and/or Distribution Mains		**Physical losses** 254.35 **m^3/day**	
			Leakage and Overflows at Utility's Storage Tanks			
			Leakage on Service Connections up to point of Customer metering	254.35		

3.6 Action U11 (Conducting leakage detection survey)

The leak detection survey is currently under way with using the acoustic rod and the digital sound detector. As the result of survey, several doubtful places for leakage were found and five (5) leakage places were detected on the lead pipe in house connection after excavation.

(1) Detection of leaking sound by Acoustic Rod or Digital Sound Detector

The first attempt to detect the leakage in the pipes and the house connection was done using the acoustic rod and the digital sound detector.

When leakage occurs, leaking sound spreads through the pipe. At the point where valves are available, acoustic rod or digital sound detector was useful for detecting the sound. The method of leaking sound detection is shown on Figure 3-1.

Figure 3-1 Detecting Leakage on House Connection by Acoustic Rod in Zagazig west A-3

The UFW team has been trained on leak detection by the acoustic rod and the digital leak detector at Mostrod Training Center and OJT at site by assistance of JICA expert team during the activity.

(2) Detection of leaking points by Leak Detector

To detect the leakage on the distribution pipeline, the leak detector was used. The leak detection activity using the leak detector is shown in Figure 3-2. It was helpful to confirm the location of the leakage by night survey to isolate the background noise caused by traffic during daylight.

Figure 3-2 Detection Work by Leak Detector in Zagazig west A-3

(3) Results of leak detection

The leak detection survey led to detect 5 leaks in the area. All the detected leaks were on the house connections which were manufactured from lead. The reason for the leaks was due to wrong construction due to bending the lead pipe bending without using the proper facilities to bend such

pipes.

The following Table indicates the summary of the detected leaks and the map indicated the location of these leaks on the GIS map used during the survey.

Table 3-5 Summary of Detected Leaks Information

Leakage Record Sheet					
No.	1	2	3	4	5
Date	27-5	27-5	27-5	27-5	27-5
Area	A3	A3	A3	A3	A3
Position	Pipe	Pipe	Pipe	Pipe	Pipe
Condition of leak	Crack	Crack	Crack	Crack	Crack
Diameter of pipe	50	50	50	50	50
Material of leak pipe	lead	lead	lead	lead	lead
Depth of pipe	70	70	70	70	70
Ground conditions	Soil	Soil	Soil	Soil	Soil
Cause of leak	Det.	Det.	Det.	Det.	Det.
Leakage size	M	M	M	M	M
Leakage quantity	NA	NA	NA	NA	NA

Notes: Det: Deterioration, M: Medium, S: Small, NA: Not Applicable

The detected leaks was on the lead pipe that form the house connection and most of the leaks was due to cracks found in the pipe due to deterioration and bending the lead pipe during construction period and then due to water pressure, the crack begins to spread. Most of the leaks were invisible as the ground surface is soil.

The location of detected leaks is shown as following figure.

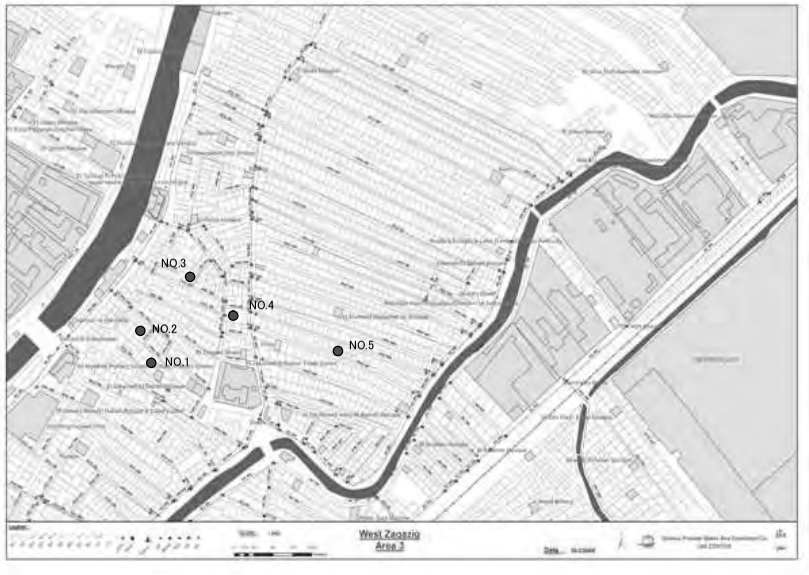


Figure 3-3 Location of detected leaks in Zagazig west Area-3

3.7 Action U12 (Repairing leakage parts)

Following the leaks had been detected; the repair works takes place by SHAPWASCO equipment and facilities. All the detected leak pipes and house connection has been replaced with PVC pipes with proper fittings.

3.8 Action U13 (Conducting MNF survey after repair works)

In order to confirm the effectiveness of the repairing work (or reduction percentage of leakage ratio), MNF survey was carried out after the repairing work of the leaking parts. In the mean time of the MNF survey, two rounds of meter reading were conducted in the same period. The purpose of collecting meter reading was to measure the billed authorized consumption to be used in the water balance analysis.

A flow meter has been installed at the main inlet pipeline and was allowed to register the flow rate for the whole 5 days. Two flow meters were used, one each two days to overcome the short lifetime of portable batteries that was used to operate the flow meter.

The following table represents the main findings during the MNF survey after leak detection and repair.

Table 3-6 Status of Water Meters after Repair

Item	unit	Status
Duration of MNF survey, days	day	5
Total amount of water registered by flow meter during measurement period	m^3	4,890 (807.5 m^3/day)
Number of read meters	nos	955
Number of locked meters	nos	274
Number of flat rate connection	nos	--

3.9 Action U14 (Making water balance analysis and its evaluation)

The water balance analysis is a useful tool to evaluate the UFW ratio. The following data should be known or estimated before making the water balance analysis.

1- Quantity of water entering the study area network 807 m^3/d.
2- Quantity of water leaving the study area network and goes to another network at the boundary of it (Nil).
3- Quantity of billed authorized consumption. This value could be assumed as measured before as the water meter status is the same as the time of measuring the water meters. 539 m^3/d. The volume of billed unmetered water shall be considered as (108 m^3/d)
4- Estimation of the unbilled authorized consumption. (Nil)
5- Meter inaccuracy and error in start flow measurement (the minimum flow rate at which the water meter begin to register the flow amount). This shall be estimated as before the leakage repair.
6- During UFW team survey for the distribution network and the status of the meters, the team did not find customers theft water (i.e. unauthorized consumption).

During the Action U8, it was found that the wastage in houses equal 12 L/hr/meter. It was assumed that this wastage shall be for a period of 3 hours (three hours). In the daytime, the use of the faucets and flush tanks in the toilet make the water meter run for a flow higher than the start flow. This shall make the meter register the total flow passing through it including the wastage flow.

The number of meters that could have a wastage including flat rate connections is 1064 meters.
Total amount of wastage per day = 1064meters x 12L/hr x 3hr/1000= 38 m^3/day
The value of 10% of meter inaccuracy is adopted as over-registration taking into consideration of the replacement of non-working meters to new meters.

The following table represents the water balance analysis after repair.

Table 3-7 Water balance analysis for Zagazig west Area-3 after repair (m^3/day)

Water Distributed Volume **807** m^3/day	Authorized Consumption **646.46** m^3/day	Billed Authorized Consumption **646.46**	Billed Metered Consumption	560	**Water Sold** 646.46 **m^3/day**	**Revenue Water** 646.46 **m^3/day**
			Metering error (over registration)	-21.54		
			Billed Unmetered Consumption(fixed amount collected)	108		
		Unbilled Authorized Consumption **0**	Unbilled Metered Consumption	0	**Commercial losses** 38 **m^3/day**	**Unaccounted for Water (UFW)** 160.54 **m^3/day**
			Unbilled Unmetered Consumption	0		
	Unauthorized Consumption **160.54** m^3/day	Apparent Losses **38**	Unauthorized Consumption	0		
			Metering Inaccuracies(start flow & under registration)	38		
		Real Losses (leakage) **122.54**	Leakage on Transmission and/or Distribution Mains		**Physical losses** 122.54 **m^3/day**	
			Leakage and Overflows at Utility's Storage Tanks			
			Leakage on Service Connections up to point of Customer metering	122.5		

Summary of UFW activity in Zagazig west A-3 before and after repair activity

Parameter	Unit	Assessment Before Repair	Assessment After Repair	Reduction
Water Distributed	m^3/day	829.5		---
Customer Consumption	m^3/day	558.65	646.46	---
UFW (by volume)	m^3/day	293.35	160.54	132.81
UFW ratio	%	35.36%	19.35%	16.01%
Leakage (by volume)	m^3/day	254.35	122.54	131.81
Leakage ratio	%	30.66%	14.77%	15.89%

4 Results of Pilot Project in Pilot Project Site-4 (Zagazig Markaz)

4.1 Action U6 (Making field survey of distribution network)

The purpose of this action is to confirm the source of water to the area by isolating the valve at the entrance of the network and confirm that no water in the network after that. The survey also includes the confirmation of the minor valves, fire hydrants, and the governmental building in the distribution network.

Based on the GIS base maps, a draft of the water distribution network has been prepared by the UFW team. The GIS team drew the network for Zagazig Markaz Area-1 and the pipe data was verified by the UFW team and the distribution network crew.

The team made a site survey to verify all data indicated on the GIS map. All customer data was collected from the commercial department in SHAPWASCO. In the site survey, the customer information was verified as follows:

Table 4-1 Network Survey Result in Zagazig Markaz Area-1

Diameter of pipe feeding the area	150 mm (PVC)
Length of water distribution network pipes (material: PVC)	PVC:9,391m
200 mm	PVC:6,121m
150 mm	PVC:2,214m
100 mm	PVC:1,056m

Source: GIS Center

4.2 Action U7 (Surveying Working conditions of water meters and conducting meter readings)

Working conditions of the water meters were collected from the commercial department. The non-working meters were recorded by the meter reader and were verified by the UFW team.

The status of the meters inside the area was as follows:

Table 4-2 Status of Meters inside the Area

Meter Status	Number of Meters
Total number of meters as per commercial database	1,604
Working meters	1224
Non working meters	380
1) Meters repaired	224
2) Meters need to replace	156

After confirming the status of the meters, a meter repairing team will repair a part of the non working meters. Some of the non working meters can not be repaired and it will be replaced before the water meter reading will be conducted.

4.3 Action U8 (Measuring metering error for working meters)

Meter error shall be one of the sources of the commercial UFW. A series of meter calibration for determine the accuracy of the meter has been conducted by the following method.

1. Select 20 to 30 working meters randomly in the pilot project site.
2. Close all the taps in the house.
3. Set the hands of the water meter at zero point.
4. Open one tap and close all other taps in the house. Measurement shall be done by the following three cases for the degree of tap opening:
   - Case 1 : Full opening
   - Case-2 : Half opening
   - Case-3 : Quarter opening
5. Keep running water into the measuring tank for one minute and close the tap.
6. Reopen the tap for one minute and close.
7. Repeat items 5 and 6 until water level shows 20L or other readings (10L and 15L which will be determined taking into account the work progress at site and situation of the house).
8. Close the tap and read the meter.
9. Record the time of the measurement (from item 3 to 5)
10. Repeat the procedure from item 3 to 6 for all cases.

The average meter error was recorded as 4.0 %. The positive sign of the meter error indicated that the water meter read more than the actual amount of water passing through it. The positive value also indicated that the amount of commercial UFW should be decreased by this amount of error. This value shall be taken into account during the water balance analysis. The error of the meter was due to presence of some impurities in the water (silt, solids, etc.). Such impurities cause the clogging of the meter screen. As the water flow passes through the meter clogged screen, the water velocity increases. The increase in water velocity makes the rotation speed of the meter increase and the meter is over registering the actual flow passing through it.

The main source of wastage inside house is the leak in the faucet and toilets. This wastage can not be determined during day hours. To determine the leakage in house, the water usage pattern in the house should be registered including the minimum night flow.

This method to determine the wastage in houses can not be followed in Zagazig Markaz Area-1 as most of the house connection was less than 2 inches which is beyond the limits of the flow meter measurements so that the recorded value 12 L/hr/meter in Zagazig East and Hihya City will be used when calculating wastage value in houses in Zagazig Markaz.

This value of wastage shall be taken into consideration when preparing the water balance analysis as unauthorized consumption. This amount of water was measured as a part of minimum night flow value determined by the flow meter installed at the main pipeline to the study area.

4.4 Action U9 (Conducting MNF survey)

A series of minimum night flow survey was conducted in this stage. It was assumed that the value of the minimum night flow (MNF) is an indication on the amount of leakage in the distribution network. This activity is summarized as follow:

1- A flow meter shall be installed on the water inlet(s) to register the amount of water entering the study area.
2- Two pressure recorders shall be installed as well; one of these recorders shall be installed at the inlet point and the other at the far end of the network for the same period of the flow meter recording to measure the average pressure in the network.
3- The flow meter shall be allowed to register the flow rate value for at least 24 hours.
4- The minimum registered flow shall represent the amount of leakage in the network beside the wastage in houses.
5- The equivalent leakage flow during the day could be determined by the equation mentioned in section 1.4.
6- Determine the percent of MNF which represent a comparative basis for the UFW by dividing the equivalent minimum night flow by the total flow registered by the flow meter (Q_{MNF}/Q_{TOTAL}).

A series of MNF runs was conducted before leakage detection or repair takes place. The summary of these results is represented in the following table:

Table 4-3 Summary of Result for MNF Survey before Leakage Repair

Item	Unit	Value
Average Flow	L/s	26.37
Minimum flow (MNF)	L/s	11.48
Maximum value of flow	L/s	37.51
Total flow rate (Q_{TOTAL})	m^3/day	2279
Equivalent MNF (Q_{MNF})	m^3/day	886
Ratio	%	38.88

This ratio of equivalent MNF was considered very high and its sources shall be analyzed after the leakage detection and repair works finish.

4.5 Action U10 (Making water balance analysis before repair works)

To establish a water balance analysis, the following procedure shall be followed:

1- Determine the net amount of water entering the study pilot area which was measured as 1759 m^3/d.
2- Determine the authorized consumption, the sum of metered volume 556 m^3/d with over registration error of 4 % (21 m^3/d) so that the net volume of billed authorized consumption will be 535 m^3/d. The billed un-metered volume that was assumed to be consumed as a flat rate evaluation of 25 m^3/month/meter. The value of the billed unmetered consumption was calculated to be 583 m^3/d. This amount of water was consumed by the registered customers at SHAPWASCO. Authorized consumption may include items such as fire fighting, training, flushing of mains and sewers, street cleaning, public fountains and gardens, etc, these may be billed, unbilled, metered or unmetered. This value was neglected in this study as the area was controlled against these actions during the study period.
3- Determine the water loss which is the difference between system input volume and authorized consumption. Water losses can be considered as a total volume for the whole system, or for partial systems such as transmission or distribution schemes, or individual zones as in our case in Zagazig Markz Area 1. Water losses consist of real losses and apparent losses. The total volume of the water losses was calculated to be 641 m^3/d.
4- Determine apparent losses that include all types of inaccuracies associated with customer metering as well as data handling error (meter reading and billing), plus unauthorized consumption (theft or illegal use). This value shall include the wastage in houses. The value of the wastage volume was calculated as 58 m^3/d. regarding the meter error in registration, the over registration of customer meters lead to underestimation of Real Losses and under-registration of customer meters leads to over-estimation of real Losses.
5- Determine the Real Losses that indicate the physical water losses from the networks (i.e. leakage). This amount shall represent the water volume lost through all types of leaks, bursts, and overflows.

The following table represents the water balance analysis before repair works for Zagazig Markz Area-1

Table 4-4 Water Balance Analysis in Zagazig Markaz A-1 before Repair

(m^3/day)

Water Distributed Volume **1759** m^3/day	Authorized Consumption **1117.62** m^3/day	Billed Authorized Consumption **1117.62**	Billed Metered Consumption	556	**Water Sold** 1117.62 **m^3/day**	**Revenue Water** 1117.62 **m^3/day**
			Metering error (over registration)	-21.38		
			Billed Unmetered Consumption(fixed amount collected)	583		
		Unbilled Authorized Consumption **0**	Unbilled Metered Consumption	0	**Commercial losses** 58 **m^3/day**	**Unaccounted for Water (UFW)** 641.38 **m^3/day**
			Unbilled Unmetered Consumption	0		
	Unauthorized Consumption **641.38** m^3/day	Apparent Losses **58**	Unauthorized Consumption	0		
			Metering Inaccuracies(start flow & under registration)	58		
		Real Losses (leakage) **583.38**	Leakage on Transmission and/or Distribution Mains		**Physical losses** 583.38 **m^3/day**	
			Leakage and Overflows at Utility's Storage Tanks			
			Leakage on Service Connections up to point of Customer metering	583.38		

4.6 Action U11 (Conducting leakage detection survey)

The leak detection went through several stages with the acoustic rod and the digital sound detector. When there was a point suspected to have a leak, the UFW team began to use more advanced leak detection equipment such as the leak detector and/or the leak sound correlator to exactly locate the leak on the pipe.

(1) Detection of leaking sound by Acoustic Rod or Digital Sound Detector

The first attempt to detect the leakage in the pipes and the house connection was done using the acoustic rod and the digital sound detector.

When leakage occurs, leaking sound spreads through the pipe. At the point where valves are available, acoustic rod or digital sound detector was useful for detecting the sound. The method of leaking sound detection is shown on Figure 4-1.

Figure 4-1 Detecting Leakage on House Connection by Acoustic Rod

The UFW team has been trained on leak detection by the acoustic rod and the digital leak detector at Mostrod Training Center and OJT at site by assistance of JICA expert team during the activity.

(2) Results of leak detection

The leak detection survey led to detect 9 leaks in the area. All the detected leaks were on the house connections which were manufactured from PVC. The reason for the leaks was due to wrong construction due to bending the pipe bending without using the proper facilities to bend such pipes.

The following Table indicates the summary of the detected leaks and the map indicated the location of these leaks on the GIS map used during the survey

Table 4-5 Summary of Detected Leaks Information

Leakage Recorded Sheet									
No.	1	2	3	4	5	6	7	8	9
Date	27-5-08	27-5-08	27-5-08	27-5-08	27-5-08	28-5-08	27-5-08	27-5-08	9−6-08
Area	A_1	A_1	A_1	A_1	A_1	A_1	A_1	A_1	A_1
Position	Pipe	Pipe	Pipe	Pipe	Pipe	Pipe	Pipe	Pipe	Pipe
Condition of Leak	Crack	Crack	Crack	Crack	Crack	Crack	Crack	Crack	Crack
Diameter of Leak Pipe	25	25	25	25	25	25	25	25	25
Material of Leak Pipe	Lead	Lead	Lead	PVC	Lead	PVC	PVC	PVC	PVC
Depth of Pipe	70	70	70	70	70	70	70	70	70
Ground Condition	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Cause of Leak	Det	Cor	Cor	Det	Cor	Det	Det	Det	Det
Leakage Size	M	M	M	M	M	M	M	M	M
Quantity of Leakage	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes: Det: Deterioration, Cor: Corrosion, M: Medium, S: Small, NA: Not Applicable

The detected leaks was on the PVC and lead pipes that form the house connection and most of the leaks was due to cracks found in the pipe due to deterioration and bending during construction period and then due to water pressure, the crack begins to spread. Most of the leaks were invisible as the ground surface is soil.

The location of detected leaks is shown as following figure.

Figure 4-2 Location of detected leaks in Zagazig Markaz Area-1

4.7 Action U12 (Repairing leakage parts)

Following the leaks had been detected; the repair works takes place by SHAPWASCO equipment and facilities. All the detected leak pipes and house connection has been replaced with PVC pipes with proper fittings.

4.8 Action U13 (Conducting MNF survey after repair works)

In order to confirm the effectiveness of the repairing work (or reduction percentage of leakage ratio), MNF survey was carried out after the repairing work of the leaking parts. In the mean time of the MNF survey, two rounds of meter reading were conducted in the same period (about 3 days). The purpose of collecting meter reading was to measure the billed authorized consumption to be used in the water balance analysis.

A flow meter has been installed at the main inlet pipeline and was allowed to register the flow rate for the whole 3 days. Two flow meters were used, one each two days to overcome the short lifetime of portable batteries that was used to operate the flow meter.

The following table represents the main findings during the MNF survey after leak detection and repair.

Table 4-6 Status of Water Meters after Repair

Item	unit	Status
Duration of MNF survey, days	day	3
Total amount of water registered by flow meter during measurement period	m^3	4,185 (1,508 m^3/day)
Number of read meters	nos	1,604
Number of locked meters	nos	368
Number of flat rate connection	nos	2

4.9 Action U14 (Making water balance analysis and its evaluation)

The water balance analysis is a useful tool to evaluate the UFW ratio. The following data should be known or estimated before making the water balance analysis.

1- Quantity of water entering the study area network 1,508 m^3/d.
2- Quantity of water leaving the study area network and goes to another network at the boundary of it (Nil).
3- Quantity of billed authorized consumption. This value could be assumed as measured before as the water meter status is the same as the time of measuring the water meters. 1147 m^3/d. The volume of billed unmetered water shall be considered as (131 m^3/d)
4- Estimation of the unbilled authorized consumption. (Nil)
5- Meter inaccuracy and error in start flow measurement (the minimum flow rate at which the water meter begin to register the flow amount). This shall be estimated as before the leakage repair.
6- During UFW team survey for the distribution network and the status of the meters, the team did not find customers theft water (i.e. unauthorized consumption).

During the Action U8, it was found that the wastage in houses equal 12 L/hr/meter. It was assumed that this wastage shall be for a period of 3 hours (night hours). In the daytime, the use of the faucets and flush tanks in the toilet make the water meter run for a flow higher than the start flow. This shall make the meter register the total flow passing through it including the wastage flow.

The value of 4% of meter inaccuracy is adopted as over-registration taking into consideration of the replacement of non-working meters to new meters.

The following table represents the water balance analysis after repair.

Table 4-7 Water balance analysis for Zagazig Markaz Area-1 after repair

(m^3/day)

Water Distributed Volume **1508** m^3/day	Authorized Consumption **1278.12** m^3/day	Billed Authorized Consumption **1278.12**	Billed Metered Consumption	1193	**Water Sold** 1278.12 **m^3/day**	**Revenue Water** 1278.12 **m^3/day**
			Metering error (over registration)	-45.88		
			Billed Unmetered Consumption(fixed amount collected)	131		
		Unbilled Authorized Consumption **0**	Unbilled Metered Consumption	0		
			Unbilled Unmetered Consumption	0		
	Unauthorized Consumption **229.88** m^3/day	Apparent Losses **45**	Unauthorized Consumption	0	**Commercial losses** 45 **m^3/day**	**Unaccounted for Water (UFW)** 229.88 **m^3/day**
			Metering Inaccuracies(start flow & under registration)	45		
		Real Losses (leakage) **184.88**	Leakage on Transmission and/or Distribution Mains		**Physical losses** 184.88 **m^3/day**	
			Leakage and Overflows at Utility's Storage Tanks			
			Leakage on Service Connections up to point of Customer metering	184.9		

Summary of UFW activity in Zagazig Markaz A-1 before and after repair activity

Parameter	Unit	Assessement Before Repair	Assessement After Repair	Reduction
Water Distributed	m^3/day	1633.5		---
Customer Consumption	m^3/day	1117.62	1278.12	---
UFW (by volume)	m^3/day	641.38	229.88	411.50
UFW ratio	%	39.26%	14.07%	25.19%
Leakage (by volume)	m^3/day	583.38	184.88	398.50
Leakage ratio	%	35.71%	11.32%	24.40%

5 Results of Pilot Project in Pilot Project Site-5 (Ibrahimiya Markaz)

5.1 Action U6 (Making field survey of distribution network)

The purpose of this action is to confirm the source of water to the area by isolating the valve at the entrance of the network and confirm that no water in the network after that. The survey also includes the confirmation of the minor valves, fire hydrants, and the governmental building in the distribution network.

Based on the GIS base maps, a draft of the water distribution network has been prepared by the UFW team. The GIS team drew the network for Ibrahimiya Markaz Area-1 and the pipe data was verified by the UFW team and the distribution network crew.

The team made a site survey to verify all data indicated on the GIS map. All customer data was collected from the commercial department in SHAPWASCO. In the site survey, the customer information was verified as follows:

Table 5-1 Network Survey Result in Ibrahimiya Markaz Area-1

Diameter of PVC pipe feeding the area	250 mm
Length of water distribution network pipes (material: Asbestos(AC) and PVC)	6,387m
400 mm	PVC:75m
250 mm	PVC:1,207m
200 mm	AC:82m
150 mm	PVC:170m
100 mm	PVC:4,853m

Source: GIS Center

5.2 Action U7 (Surveying Working conditions of water meters and conducting meter readings)

Working conditions of the water meters were collected from the commercial department. The non-working meters were recorded by the meter reader and were verified by the UFW team.

The status of the meters inside the area was as follows:

Table 5-2 Status of Meters inside the Area

Meter Status	Number of Meters
Total number of meters as per commercial database	1,125
Working meters	1,048
Non working meters	77
1) Meters repaired	4
2) Meters need to replace	73

After confirming the status of the meters, a meter repairing team will repair a part of the non working meters. Some of the non working meters can not be repaired and it will be replaced before the water meter reading will be conducted.

5.3 Action U8 (Measuring metering error for working meters)

Meter error shall be one of the sources of the commercial UFW. A series of meter calibration for determine the accuracy of the meter has been conducted by the following method.

1. Select 20 to 30 working meters randomly in the pilot project site.
2. Close all the taps in the house.
3. Set the hands of the water meter at zero point.
4. Open one tap and close all other taps in the house. Measurement shall be done by the following three cases for the degree of tap opening:
   - Case 1 : Full opening
   - Case-2 : Half opening
   - Case-3 : Quarter opening
5. Keep running water into the measuring tank for one minute and close the tap.
6. Reopen the tap for one minute and close.
7. Repeat items 5 and 6 until water level shows 20L or other readings (10L and 15L which will be determined taking into account the work progress at site and situation of the house).
8. Close the tap and read the meter.
9. Record the time of the measurement (from item 3 to 5)
10. Repeat the procedure from item 3 to 6 for all cases.

The average meter error was recorded as 4.0 %. The positive sign of the meter error indicated that the water meter read more than the actual amount of water passing through it. The positive value also indicated that the amount of commercial UFW should be decreased by this amount of error. This value shall be taken into account during the water balance analysis. The error of the meter was due to presence of some impurities in the water (silt, solids, etc.). Such impurities cause the clogging of the meter screen. As the water flow passes through the meter clogged screen, the water velocity increases. The increase in water velocity makes the rotation speed of the meter increase and the meter is over registering the actual flow passing through it.

The main source of wastage inside house is the leak in the faucet and toilets. This wastage can not be determined during day hours. To determine the leakage in house, the water usage pattern in the house should be registered including the minimum night flow.

This method to determine the wastage in houses can not be followed in Ibrahimiya Markaz Area-1 as most of the house connection was less than 2 inches which is beyond the limits of the flow meter measurements so that the recorded value 12 L/hr/meter in Zagazig East and Hihya City will be used when calculating wastage value in houses in Ibrahimiya Markaz.

This method to determine the wastage could be possible for some of the governmental buildings such as the hospital and the educational building. The flow meter was fixed on the inlet pipe to the hospital and the educational building to measure the wastage inside these building. The results of these measurements are shown on Table 5-2.

Table 5-3 Status and Diameter of Connection to Governmental Buildings in Ibrahimiya Markaz A-1

Building Name	Meter Status	Connection less than 2 inch	Measured MNF (L/s)
Moubarak Elementary School	No meter	No	0.000
Ibrahimiya Experimental Language School	Working	No	0.120
Ibrahimiya Medical Center	Working	No	0.085
El Shaab Elementary School	No meter	No	0.000
Division of El Ibrahimiya Electricity	Working	No	0.000
The Veterinary Unit	Working	No	0.000
Chicken Farm	Working	No	0.400

According to the measured results, it was concluded that the minimum night flow could represent the wastage in the faucets and toilets. The calculated value was above the minimum start flow of the water meters. The installed water meters was class (B) which has -if calibrated or new- a minimum start flow of 30 L/hr so that the recorded value for wastage for governmental building in Ibrahimiya Markaz A-1 was registered in meter reading .

This value of wastage shall be taken into consideration when preparing the water balance analysis as unauthorized consumption. This amount of water was measured as a part of minimum night flow value determined by the flow meter installed at the main pipeline to the study area.

5.4 Action U9 (Conducting MNF survey)

A series of minimum night flow survey was conducted in this stage. It was assumed that the value of the minimum night flow (MNF) is an indication on the amount of leakage in the distribution network. This activity is summarized as follow:

1- A flow meter shall be installed on the water inlet(s) to register the amount of water entering the study area.
2- Two pressure recorders shall be installed as well; one of these recorders shall be installed at the inlet point and the other at the far end of the network for the same period of the flow meter recording to measure the average pressure in the network.
3- The flow meter shall be allowed to register the flow rate value for at least 24 hours.
4- The minimum registered flow shall represent the amount of leakage in the network beside the wastage in houses.
5- The equivalent leakage flow during the day could be determined by the equation mentioned in

section 1.4.

6- Determine the percent of MNF which represent a comparative basis for the UFW by dividing the equivalent minimum night flow by the total flow registered by the flow meter (Q_{MNF}/Q_{TOTAL}).

A series of MNF runs was conducted before leakage detection or repair takes place. The summary of these results is represented in the following table:

Table 5-4 Summary of Results for MNF Survey before Leakage Repair

Item	Unit	Value
Average Flow	L/s	15.42
Minimum flow (MNF)	L/s	5.24
Maximum value of flow	L/s	28.85
Total flow rate (Q_{TOTAL})	m^3/day	1333
Equivalent MNF (Q_{MNF})	m^3/day	484
Ratio	%	36.29

This ratio of equivalent MNF was considered very high and its sources shall be analyzed after the leakage detection and repair works finish.

5.5 Action U10 (Making water balance analysis before repair works)

To establish a water balance analysis, the following procedure shall be followed:

1- Determine the net amount of water entering the study pilot area which was measured as 1248 m^3/d.

2- Determine the authorized consumption, the sum of metered volume 842 m^3/d with over registration error of 4 % (32 m^3/d) so that the net volume of billed authorized consumption will be 810 m^3/d. The billed un-metered volume that was assumed to be consumed as a flat rate evaluation of 25 m^3/month/meter. The value of the billed unmetered consumption was calculated to be 98 m^3/d. This amount of water was consumed by the registered customers at SHAPWASCO. Authorized consumption may include items such as fire fighting, training, flushing of mains and sewers, street cleaning, public fountains and gardens, etc, these may be billed, unbilled, metered or unmetered. This value was neglected in this study as the area was controlled against these actions during the study period.

3- Determine the water loss which is the difference between system input volume and authorized consumption. Water losses can be considered as a total volume for the whole system, or for partial systems such as transmission or distribution schemes, or individual zones as in our case in Ibrahimia Markz Area 1. Water losses consist of real losses and apparent losses. The total volume of the water losses was calculated to be 340 m^3/d.

4- Determine apparent losses that include all types of inaccuracies associated with customer metering as well as data handling error (meter reading and billing), plus unauthorized consumption (theft or illegal use). This value shall include the wastage in houses. The value of

the wastage volume was calculated as 36 m^3/d. regarding the meter error in registration, the over registration of customer meters lead to underestimation of Real Losses and under-registration of customer meters leads to over-estimation of real Losses.

5- Determine the Real Losses that indicate the physical water losses from the networks (i.e. leakage). This amount shall represent the water volume lost through all types of leaks, bursts, and overflows.

The following table represents the water balance analysis before repair works for Ibrahimia Markz Area-1

Table 5-5 Water Balance Analysis in Ibrahimiya Markaz A-1 before Repair

(m^3/day)

Water Distributed Volume **1248** m^3/day	Authorized Consumption **907.62** m^3/day	Billed Authorized Consumption **907.62**	Billed Metered Consumption	842	**Water Sold** 907.62 m^3/day	**Revenue Water** 907.62 m^3/day
			Metering error (over registration)	-32		
			Billed Unmetered Consumption(fixed amount collected)	98		
		Unbilled Authorized Consumption **0**	Unbilled Metered Consumption	0	**Commercial losses**	**Unaccounted for Water (UFW)** 340.38 m^3/day
			Unbilled Unmetered Consumption	0		
	Unauthorized Consumption **340.38** m^3/day	Apparent Losses **36**	Unauthorized Consumption	0	36 m^3/day	
			Metering Inaccuracies(start flow & under registration)	36		
		Real Losses (leakage) **304.38**	Leakage on Transmission and/or Distribution Mains		**Physical losses** 304.38 m^3/day	
			Leakage and Overflows at Utility's Storage Tanks			
			Leakage on Service Connections up to point of Customer metering	304		

5.6 Action U11 (Conducting leakage detection survey)

The leak detection went through several stages with the acoustic rod and the digital sound detector. When there was a point suspected to have a leak, the UFW team began to use more advanced leak detection equipment such as the leak detector and/or the leak sound correlator to exactly locate the leak on the pipe.

(1) Detection of leaking sound by Acoustic Rod or Digital Sound Detector

The first attempt to detect the leakage in the pipes and the house connection was done using the acoustic rod and the digital sound detector.

When leakage occurs, leaking sound spreads through the pipe. At the point where valves are available, acoustic rod or digital sound detector was useful for detecting the sound. The method of leaking sound detection is shown on Figure 5-1.

Figure 5-1 Detecting Leakage on House Connection by Acoustic Rod

The UFW team has been trained on leak detection by the acoustic rod and the digital leak detector at Mostrod Training Center and OJT at site by assistance of JICA expert team during the activity.

(2) Detection of leaking points by Leak Detector

To detect the leakage on the distribution pipeline, the leak detector was used. The leak detection activity using the leak detector is shown in Figure 5-2. It was helpful to confirm the location of the leakage by night survey to isolate the background noise caused by traffic during daytime.

Figure 5-2 Detection Work by Leak Detector

(3) Detection by Leak Sound Correlator

Leak Sound Correlator was applied to confirm the leaking point when leak sound is detected in two points. This equipment identifies the location of leaks by intercepting leak noise that is caught by a sensor at two valves or hydrants. It measures the difference in transmission time between two points, and processes the data by computer. Thus, it exactly shows the leaking point.

The following figure shows the use of leak sound correlator in the activity area.

Figure 5-3 Leak Sound Correlator

(4) Confirmation of Leak Point by Acoustic Rod

After detecting leak point, some holes were drilled at the detected leak points and acoustic rod was inserted in the hole to confirm the exact location of the leak point. This method is very useful especially in paved roads to make the decision of excavation in paved road worth. Figure 5-4 shows the confirmation of leaks when found by acoustic rod drilled in the ground.

Figure 5-4 Method of Confirming Exact Location of Leak Point

(5) Pipe Locating Devices

In some locations, the buried electrical cables shall cause a big risk for labor to excavate beside. It was necessary to locate the position of the electrical cables before excavation. In other locations, when the buried pipes were not identified, following devices was used to locate the electrical cables and/or the buried pipes.

Pipe & Cable Locator

This device was used for locating pipes and cables under the ground.

Figure 5-5 Pipe & Cable Locator

Metal Locator

A sensor of this device detects the location of hidden iron-made structures such as valve boxes and stop valves. In some locations, the asphalt paving covered the surface box of the valves and the cover of the valve chambers. The use of metal locator has led to the detection and relocation of these iron-made structures.

(6) Results of leak detection

The leak detection survey led to detect 8 leaks in the area. All the detected leaks were on the house connections which were manufactured from PVC. The reason for the leaks was due to wrong construction due to bending the pipe bending without using the proper facilities to bend such pipes.

The following Table indicates the summary of the detected leaks and the map indicated the location of these leaks on the GIS map used during the survey.

2.4-26

Table 5-6 Summary of Detected Leaks Information

Leakage Recorded Sheet								
No.	1	2	3	4	5	6	7	8
Date	24-7-08	24-7-08	24-7-08	24-7-08	28-7-08	29-7-08	29-7-08	22-7-08
Area	A_1	A_1	A_1	A_1	A_1	A_1	A_1	A_1
Position	Joint	Joint	Joint	Joint	Joint	Joint	Valve	Joint
Condition of Leak	Breakage	Crack	Crack	Crack	Crack	Crack	Pack kin	Crack
Diameter of Leak Pipe	25	25	25	25	25	25	25	25
Material of Leak Pipe	PVC	PVC	PVC	PVC	PVC	PVC	PVC	PVC
Depth of Pipe	60	60	90	90	150	60	60	100
Ground Condition	Gravel	Gravel	Gravel	Gravel	Gravel	Gravel	Gravel	Asphalt
Cause of Leak	Det	Det	Det	Det	Det	Det	Det	Det
Leakage Size	L	M	M	M	M	M	S	M
Quantity of Leakage	NA	NA	NA	NA	NA	NA	NA	NA

Notes: Det: Deterioration, L: Large, M: Medium, S: Small, NA: Not Applicable

The detected leaks was on the PVC pipe that form the house connection and most of the leaks was due to cracks found in the pipe due to deterioration and bending during construction period and then due to water pressure, the crack begins to spread. Most of the leaks were invisible as the ground surface is soil.

The location of detected leaks is shown as following figure.

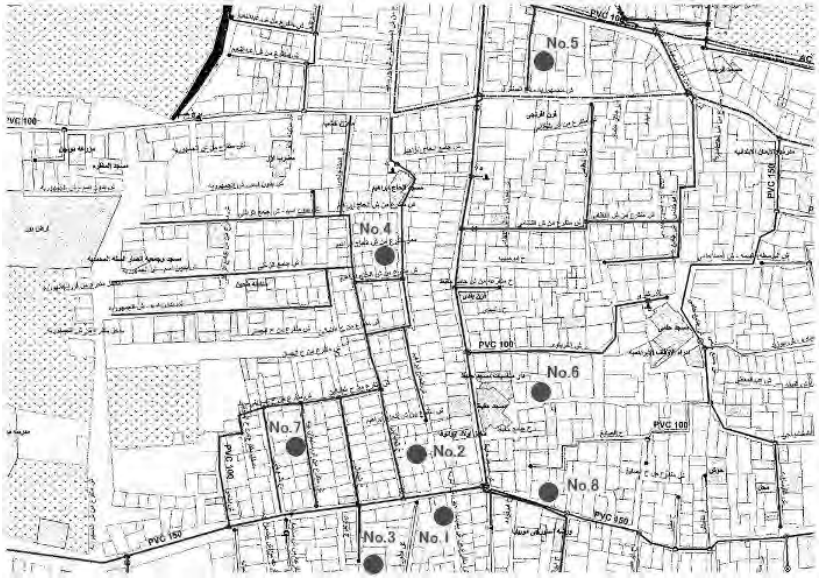


Figure 5-6 Location of detected leaks in Ibrahimiya Markaz Area-1

5.7 Action U12 (Repairing leakage parts)

Following the leaks had been detected; the repair works takes place by SHAPWASCO equipment and facilities. All the detected leak pipes and house connection has been replaced with PVC pipes with proper fittings.

5.8 Action U13 (Conducting MNF survey after repair works)

In order to confirm the effectiveness of the repairing work (or reduction percentage of leakage ratio), MNF survey was carried out after the repairing work of the leaking parts. In the mean time of the MNF survey, two rounds of meter reading were conducted in the same period (about 5 days). The purpose of collecting meter reading was to measure the billed authorized consumption to be used in the water balance analysis.

A flow meter has been installed at the main inlet pipeline and was allowed to register the flow rate for the whole 6 days. Two flow meters were used, one each two days to overcome the short lifetime of portable batteries that was used to operate the flow meter.

The following table represents the main findings during the MNF survey after leak detection and repair.

Table 5-7 Status of Water Meters after Repair

Item	unit	Status
Duration of MNF survey, days	day	5
Total amount of water registered by flow meter during measurement period	m^3	5,110 (1,022 m^3/day)
Number of read meters	nos	1,006
Number of locked meters	nos	101
Number of flat rate connection	nos	23

5.9 Action U14 (Making water balance analysis and its evaluation)

The water balance analysis is a useful tool to evaluate the UFW ratio. The following data should be known or estimated before making the water balance analysis.

1- Quantity of water entering the study area network 1,022 m^3/d.
2- Quantity of water leaving the study area network and goes to another network at the boundary of it (Nil).
3- Quantity of billed authorized consumption. This value could be assumed as measured before as the water meter status is the same as the time of measuring the water meters. 830 m^3/d. The volume of billed unmetered water shall be considered as (33 m^3/d)
4- Estimation of the unbilled authorized consumption. (Nil)
5- Meter inaccuracy and error in start flow measurement (the minimum flow rate at which the water meter begin to register the flow amount). This shall be estimated as before the leakage repair.
6- During UFW team survey for the distribution network and the status of the meters, the team did not find customers theft water (i.e. unauthorized consumption).

During the Action U8, it was found that the wastage in houses equal 12 L/hr/meter. It was assumed that this wastage shall be for a period of 3 hours (night hours). In the daytime, the use of the faucets and flush tanks in the toilet make the water meter run for a flow higher than the start flow. This shall make the meter register the total flow passing through it including the wastage flow.

The value of 4% of meter inaccuracy is adopted as over-registration taking into consideration of the replacement of non-working meters to new meters.

The following table represents the water balance analysis after repair.

Table 5-8 Water balance analysis for Ibrahimiya Markaz Area-1 after repair

(m^3/day)

Water Distributed Volume **1022** m^3/day	Authorized Consumption **862.81** m^3/day	Billed Authorized Consumption **862.81**	Billed Metered Consumption	863	**Water Sold** 862.81 m^3/day	**Revenue Water** 862.81 m^3/day
			Metering error (over registration)	-33		
			Billed Unmetered Consumption(fixed amount collected)	33		
		Unbilled Authorized Consumption **0**	Unbilled Metered Consumption	0	**Commercial losses**	**Unaccounted for Water (UFW)** 159.19 m^3/day
			Unbilled Unmetered Consumption	0		
	Unauthorized Consumption **159.19** m^3/day	Apparent Losses **36**	Unauthorized Consumption	0	36 m^3/day	
			Metering Inaccuracies(start flow & under registration)	36		
		Real Losses (leakage) **123.19**	Leakage on Transmission and/or Distribution Mains		**Physical losses** 123.19 m^3/day	
			Leakage and Overflows at Utility's Storage Tanks			
			Leakage on Service Connections up to point of Customer metering	123		

Summary of UFW activity in Ibrahimia Marakz A-1 before and after repair activity

Parameter	Unit	Assessment Before Repair	Assessment After Repair	Reduction
Water Distributed	m^3/day	1135		---
Customer Consumption	m^3/day	907.62	862.8076923	---
UFW (by volume)	m^3/day	340.38	159.1923077	181.19
UFW ratio	%	29.99%	14.03%	15.96%
Leakage (by volume)	m^3/day	304.38	123.1923077	181.19
Leakage ratio	%	26.82%	10.85%	15.96%

6 Results of Pilot Project in Pilot Project Site-6 (Diarb Nigm)

6.1 Action U6 (Making field survey of distribution network)

The purpose of this action is to confirm the source of water to the area by isolating the valve at the entrance of the network and confirm that no water in the network after that. The survey also includes the confirmation of the minor valves, fire hydrants, and the governmental building in the distribution network.

Based on the GIS base maps, a draft of the water distribution network has been prepared by the UFW team. The GIS team drew the network for Diarb Nigm Area-2 and the pipe data was verified by the UFW team and the distribution network crew.

The team made a site survey to verify all data indicated on the GIS map. All customer data was collected from the commercial department in SHAPWASCO. In the site survey, the customer information was verified as follows:

Table 6-1 Network Survey Result in Diarb Nigm Markaz Area-2

Diameter of PVC pipe feeding the area	150 mm
Total length of water distribution network pipes (material: PVC)	14,498 m
150 mm	10,884 m
100 mm	3,614 m

Source: GIS Center

6.2 Action U7 (Surveying Working conditions of water meters and conducting meter readings)

Working conditions of the water meters were collected from the commercial department. The non-working meters were recorded by the meter reader and were verified by the UFW team.

The status of the meters inside the area was as follows:

Table 6-2 Status of Meters inside the Area

Meter Status	Number of Meters
Total number of meters as per commercial database	1,800
Working meters	1600
Non working meters	200
1) Meters repaired	-
2) Meters need to replace	-

After confirming the status of the meters, a meter repairing team will repair a part of the non working

meters. Some of the non working meters can not be repaired and it will be replaced before the water meter reading will be conducted.

6.3 Action U8 (Measuring metering error for working meters)

Meter error shall be one of the sources of the commercial UFW. A series of meter calibration for determine the accuracy of the meter has been conducted by the following method.

1. Select 20 to 30 working meters randomly in the pilot project site.
2. Close all the taps in the house.
3. Set the hands of the water meter at zero point.
4. Open one tap and close all other taps in the house. Measurement shall be done by the following three cases for the degree of tap opening:
   - Case 1 : Full opening
   - Case-2 : Half opening
   - Case-3 : Quarter opening
5. Keep running water into the measuring tank for one minute and close the tap.
6. Reopen the tap for one minute and close.
7. Repeat items 5 and 6 until water level shows 20L or other readings (10L and 15L which will be determined taking into account the work progress at site and situation of the house).
8. Close the tap and read the meter.
9. Record the time of the measurement (from item 3 to 5)
10. Repeat the procedure from item 3 to 6 for all cases.

The average meter error was recorded as 4.0 %. The positive sign of the meter error indicated that the water meter read more than the actual amount of water passing through it. The positive value also indicated that the amount of commercial UFW should be decreased by this amount of error. This value shall be taken into account during the water balance analysis. The error of the meter was due to presence of some impurities in the water (silt, solids, etc.). Such impurities cause the clogging of the meter screen. As the water flow passes through the meter clogged screen, the water velocity increases. The increase in water velocity makes the rotation speed of the meter increase and the meter is over registering the actual flow passing through it.

The main source of wastage inside house is the leak in the faucet and toilets. This wastage can not be determined during day hours. To determine the leakage in house, the water usage pattern in the house should be registered including the minimum night flow.

This method to determine the wastage in houses can not be followed in Diarb Nigm Area-2 as most of the house connection was less than 2 inches which is beyond the limits of the flow meter measurements so that the recorded value 12 L/hr/meter in Zagazig East and Hihya City will be used when calculating wastage value in houses in Diarb Nigm.

6.4 Action U9 (Conducting MNF survey)

A series of minimum night flow survey was conducted in this stage. It was assumed that the value of the minimum night flow (MNF) is an indication on the amount of leakage in the distribution network. This activity is summarized as follow:

1- A flow meter shall be installed on the water inlet(s) to register the amount of water entering the study area.

2- Two pressure recorders shall be installed as well; one of these recorders shall be installed at the inlet point and the other at the far end of the network for the same period of the flow meter recording to measure the average pressure in the network.

3- The flow meter shall be allowed to register the flow rate value for at least 24 hours.

4- The minimum registered flow shall represent the amount of leakage in the network beside the wastage in houses.

5- The equivalent leakage flow during the day could be determined by the equation mentioned in section 1.4.

6- Determine the percent of MNF which represent a comparative basis for the UFW by dividing the equivalent minimum night flow by the total flow registered by the flow meter (Q_{MNF}/Q_{TOTAL}).

A series of MNF runs was conducted before leakage detection or repair takes place. The summary of these results is represented in the following table:

Table 6-5 Summary of Results for MNF Survey before Leakage Repair

Item	Unit	Value
Average Flow	L/s	21.37
Minimum flow (MNF)	L/s	8.18
Maximum value of flow	L/s	47.11
Total flow rate (Q_{TOTAL})	m^3/day	1847
Equivalent MNF (Q_{MNF})	m^3/day	750
Ratio	%	40.60

This ratio of equivalent MNF was considered very high and its sources shall be analyzed after the leakage detection and repair works finish.

6.5 Action U10 (Making water balance analysis before repair works)

To establish a water balance analysis, the following procedure shall be followed:

1- Determine the net amount of water entering the study pilot area which was measured as 1478 m^3/d.

2- Determine the authorized consumption, the sum of metered volume 942 m^3/d with over registration error of 4 % (36 m^3/d) so that the net volume of billed authorized consumption will be 906 m^3/d . The billed un-metered volume that was assumed to be consumed as a flat rate evaluation of 25 m^3/month/meter. The value of the billed unmetered consumption was calculated to be 191 m^3/d. This amount of water was consumed by the registered customers at SHAPWASCO. Authorized consumption may include items such as fire fighting, training, flushing of mains and sewers, street cleaning, public fountains and gardens, etc, these may be billed, unbilled, metered or unmetered. This value was neglected in this study as the area was controlled against these actions during the study period.

3- Determine the water loss which is the difference between system input volume and authorized consumption. Water losses can be considered as a total volume for the whole system, or for partial systems such as transmission or distribution schemes, or individual zones as in our case in Diarb Nigm Markz Area 2. Water losses consist of real losses and apparent losses. The total volume of the water losses was calculated to be 381 m^3/d.

4- Determine apparent losses that include all types of inaccuracies associated with customer metering as well as data handling error (meter reading and billing), plus unauthorized consumption (theft or illegal use). This value shall include the wastage in houses. The value of the wastage volume was calculated as 66 m^3/d. regarding the meter error in registration, the over registration of customer meters lead to underestimation of Real Losses and under-registration of customer meters leads to over-estimation of real Losses.

5- Determine the Real Losses that indicate the physical water losses from the networks (i.e. leakage). This amount shall represent the water volume lost through all types of leaks, bursts, and overflows.

The following table represents the water balance analysis before repair works for Diarb Nigm Markz Area-2

Table 6-6 Water Balance Analysis in Diarb Nigm Markz A-2 before Repair (m^3/day)

Water Distributed Volume **1478** m^3/day	Authorized Consumption **1096.77** m^3/day	Billed Authorized Consumption **1096.77**	Billed Metered Consumption	942	**Water Sold** 1096.77 m^3/day	**Revenue Water** 1096.77 m^3/day
			Metering error (over registration)	-36		
			Billed Unmetered Consumption(fixed amount collected)	191		
		Unbilled Authorized Consumption **0**	Unbilled Metered Consumption	0		
			Unbilled Unmetered Consumption	0		
	Unauthorized Consumption **381.23** m^3/day	Apparent Losses **66**	Unauthorized Consumption	0	**Commercial losses** 66 m^3/day	**Unaccounted for Water (UFW)** 381.23 m^3/day
			Metering Inaccuracies(start flow & under registration)	66		
		Real Losses (leakage) **315.23**	Leakage on Transmission and/or Distribution Mains		**Physical losses** 315.23 m^3/day	
			Leakage and Overflows at Utility's Storage Tanks			
			Leakage on Service Connections up to point of Customer metering	315		

6.6 Action U11 (Conducting leakage detection survey)

The leak detection went through several stages with the acoustic rod and the digital sound detector.

When there was a point suspected to have a leak, the UFW team began to use more advanced leak detection equipment such as the leak detector and/or the leak sound correlator to exactly locate the leak on the pipe.

(1) Detection of leaking sound by Acoustic Rod or Digital Sound Detector

The first attempt to detect the leakage in the pipes and the house connection was done using the acoustic rod and the digital sound detector.

When leakage occurs, leaking sound spreads through the pipe. At the point where valves are available, acoustic rod or digital sound detector was useful for detecting the sound. The method of leaking sound detection is shown on Figure 6-1.

Figure 6-1 Detecting Leakage on House Connection by Acoustic Rod

The UFW team has been trained on leak detection by the acoustic rod and the digital leak detector at Mostrod Training Center and OJT at site by assistance of JICA expert team during the activity.

(2) Detection of leaking points by Leak Detector

To detect the leakage on the distribution pipeline, the leak detector was used. The leak detection activity using the leak detector is shown in Figure 6-2. It was helpful to confirm the location of the leakage by night survey to isolate the background noise caused by traffic during daytime.

Figure 6-2 Detection Work by Leak Detector

(3) Results of leak detection

The leak detection survey led to detect 2 leak points in the area. All the detected leaks were on the house connections which were manufactured from PVC. The reason for the leaks was due to wrong construction due to bending the pipe bending without using the proper facilities to bend such pipes.

The following Table indicates the summary of the detected leaks and the map indicated the location of these leaks on the GIS map used during the survey

Table 6-7 Summary of Detected Leaks Information

Leakage Record Sheet		
No.	1	2
Date	15-2	15-2
Area	A2	A2
Position	Pipe	Pipe
Condition of leak	Crack	Crack
Diameter of pipe	50	50
Material of leak pipe	lead	Lead
Depth of pipe	70	70
Ground conditions	Soil	Soil
Cause of leak	Det.	Det.
Leakage size	M	M
Leakage quantity	NA	NA

The detected leaks was on the lead pipe that form the house connection and most of the leaks was due to cracks found in the pipe due to deterioration and bending during construction period and then due to water pressure, the crack begins to spread. Most of the leaks were invisible as the ground surface is soil.
The location of detected leaks is shown as following figure.

Figure 6-3 Location of detected leaks in Diarb Nigm Markz Area-2

6.7 Action U12 (Repairing leakage parts)

Following the leaks had been detected; the repair works takes place by SHAPWASCO equipment and facilities. All the detected leak pipes and house connection has been replaced with PVC pipes with proper fittings.

6.8 Action U13 (Conducting MNF survey after repair works)

In order to confirm the effectiveness of the repairing work (or reduction percentage of leakage ratio), MNF survey was carried out after the repairing work of the leaking parts. In the mean time of the MNF survey, two rounds of meter reading were conducted in the same period (about 9 days). The purpose of collecting meter reading was to measure the billed authorized consumption to be used in the water balance analysis.

A flow meter has been installed at the main inlet pipeline and was allowed to register the flow rate for the whole 6 days. Two flow meters were used, one each two days to overcome the short lifetime of portable batteries that was used to operate the flow meter.

The following table represents the main findings during the MNF survey after leak detection and repair.

Table 6-8 Status of Water Meters after Repair

Item	unit	Status
Duration of MNF survey, days	day	9
Total amount of water registered by flow meter during measurement period	m^3	12,900 (1,425 m^3/day)
Number of read meters	nos	1,608
Number of locked meters	nos	195
Number of flat rate connection	nos	200

6.9 Action U14 (Making water balance analysis and its evaluation)

As described in item 6-5 of this report, the water balance analysis is a useful tool to evaluate the UFW ratio. The following data should be known or estimated before making the water balance analysis.

1- Quantity of water entering the study area network 1,425 m^3/d.
2- Quantity of water leaving the study area network and goes to another network at the boundary of it (Nil).
3- Quantity of billed authorized consumption. This value could be assumed as measured before as the water meter status is the same as the time of measuring the water meters. 988 m^3/d. The volume of billed unmetered water shall be considered as (166 m^3/d)
4- Estimation of the unbilled authorized consumption. (Nil)
5- Meter inaccuracy and error in start flow measurement (the minimum flow rate at which the water meter begin to register the flow amount). This shall be estimated as before the leakage repair.
6- During UFW team survey for the distribution network and the status of the meters, the team did not find customers theft water (i.e. unauthorized consumption).

During the Action U8, it was found that the wastage in houses equal 12 L/hr/meter. It was assumed that this wastage shall be for a period of 3 hours (night hours). In the daytime, the use of the faucets and flush tanks in the toilet make the water meter run for a flow higher than the start flow. This shall make the meter register the total flow passing through it including the wastage flow.

The number of meters that could have a wastage including flat rate connections is 1,006 meters.
Total amount of wastage per day = 1,808meters x 12L/hr x 3hr/1000= 66 m^3/day

The following table represents the water balance analysis after repair.

Table 6-9 Water balance analysis for Diarb Nigm Markz Area-2 after repair

(m^3/day)

Water Distributed Volume **1425** m^3/day	Authorized Consumption **1154.46** m^3/day	Billed Authorized Consumption **1154.46**	Billed Metered Consumption	1028	**Water Sold** 1154.46 m^3/day	**Revenue Water** 1154.46 m^3/day
			Metering error (over registration)	-40		
			Billed Unmetered Consumption(fixed amount collected)	166		
		Unbilled Authorized Consumption **0**	Unbilled Metered Consumption	0	**Commercial losses**	**Unaccounted for Water (UFW)** 270.54 m^3/day
			Unbilled Unmetered Consumption	0		
	Unauthorized Consumption **270.54** m^3/day	Apparent Losses **66**	Unauthorized Consumption	0	66 m^3/day	
			Metering Inaccuracies(start flow & under registration)	66		
		Real Losses (leakage) **204.54**	Leakage on Transmission and/or Distribution Mains		**Physical losses** 204.54 m^3/day	
			Leakage and Overflows at Utility's Storage Tanks			
			Leakage on Service Connections up to point of Customer metering	205		

Summary of UFW activity in Diarb Nigm Marakz A-2 before and after repair activity

Parameter	Unit	Assessment Before Repair	Assessment After Repair	Reduction
Water Distributed	m^3/day	1451.5		---
Customer Consumption	m^3/day	1096.77	1154.46	---
UFW (by volume)	m^3/day	381.23	270.54	110.69
UFW ratio	%	26.26%	18.64%	7.63%
Leakage (by volume)	m^3/day	315.23	204.54	110.69
Leakage ratio	%	21.72%	14.09%	7.63%

7 Results of Pilot Project in Pilot Project Site-7 (Abu-Hamad Markaz)

7.1 Action U6 (Making field survey of distribution network)

The purpose of this action is to confirm the source of water to the area by isolating the valve at the entrance of the network and confirm that no water in the network after that. The survey also includes the confirmation of the minor valves, fire hydrants, and the governmental building in the distribution network.

Based on the GIS base maps, a draft of the water distribution network has been prepared by the UFW team. The GIS team drew the network for Abu-Hamad Area-3 and the pipe data was verified by the UFW team and the distribution network crew.

The team made a site survey to verify all data indicated on the GIS map. All customer data was collected from the commercial department in SHAPWASCO. In the site survey, the customer information was verified as follows:

Table 7-1 Network Survey Result in Abu Hamad Markaz Area-3

Diameter of PVC pipe feeding the area	150 mm
Total length of water distribution network pipes (material: PVC)	11,832 m
150 mm	6,215 m
100 mm	5,617 m

Source: GIS Center

7.2 Action U7 (Surveying Working conditions of water meters and conducting meter readings)

Working conditions of the water meters were collected from the commercial department. The non-working meters were recorded by the meter reader and were verified by the UFW team.

The status of the meters inside the area was as follows:

Table 7-2 Status of Meters inside the Area

Meter Status	Number of Meters
Total number of meters as per commercial database	743
Working meters	534
Non working meters	209
1) Meters repaired	-
2) Meters need to replace	209

After confirming the status of the meters, a meter repairing team will repair a part of the non working meters. Some of the non working meters can not be repaired and it will be replaced before the water meter reading will be conducted.

7.3 Action U8 (Measuring metering error for working meters)

Meter error shall be one of the sources of the commercial UFW. A series of meter calibration for determine the accuracy of the meter has been conducted by the following method.

1. Select 20 to 30 working meters randomly in the pilot project site.
2. Close all the taps in the house.
3. Set the hands of the water meter at zero point.
4. Open one tap and close all other taps in the house. Measurement shall be done by the following three cases for the degree of tap opening:
   - Case 1 : Full opening
   - Case-2 : Half opening
   - Case-3 : Quarter opening
5. Keep running water into the measuring tank for one minute and close the tap.
6. Reopen the tap for one minute and close.
7. Repeat items 5 and 6 until water level shows 20L or other readings (10L and 15L which will be determined taking into account the work progress at site and situation of the house).
8. Close the tap and read the meter.
9. Record the time of the measurement (from item 3 to 5)
10. Repeat the procedure from item 3 to 6 for all cases.

The average meter error was recorded as 4 %. The positive sign of the meter error indicated that the water meter read more than the actual amount of water passing through it. The positive value also indicated that the amount of commercial UFW should be decreased by this amount of error. This value shall be taken into account during the water balance analysis. The error of the meter was due to presence of some impurities in the water (silt, solids, etc.). Such impurities cause the clogging of the meter screen. As the water flow passes through the meter clogged screen, the water velocity increases. The increase in water velocity makes the rotation speed of the meter increase and the meter is over registering the actual flow passing through it.

The main source of wastage inside house is the leak in the faucet and toilets. This wastage can not be determined during day hours. To determine the leakage in house, the water usage pattern in the house should be registered including the minimum night flow.

This method to determine the wastage in houses can not be followed in Abu Hamad Area-3 as most of the house connection was less than 2 inches which is beyond the limits of the flow meter measurements so that the recorded value 12 L/hr/meter in Zagazig East and Hihya City will be used when calculating wastage value in houses in Abu Hamad.

7.4 Action U9 (Conducting MNF survey)

A series of minimum night flow survey was conducted in this stage. It was assumed that the value of the minimum night flow (MNF) is an indication on the amount of leakage in the distribution network.

This activity is summarized as follow:

1- A flow meter shall be installed on the water inlet(s) to register the amount of water entering the study area.
2- Two pressure recorders shall be installed as well; one of these recorders shall be installed at the inlet point and the other at the far end of the network for the same period of the flow meter recording to measure the average pressure in the network.
3- The flow meter shall be allowed to register the flow rate value for at least 24 hours.
4- The minimum registered flow shall represent the amount of leakage in the network beside the wastage in houses.
5- The equivalent leakage flow during the day could be determined by the equation mentioned in section 1.4.
6- Determine the percent of MNF which represent a comparative basis for the UFW by dividing the equivalent minimum night flow by the total flow registered by the flow meter (Q_{MNF}/Q_{TOTAL}).

A series of MNF runs was conducted before leakage detection or repair takes place. The summary of these results is represented in the following table:

Table 7-3 Summary of Results for MNF Survey before Leakage Repair

Item	Unit	Value
Average Flow	L/s	9.85
Minimum flow (MNF)	L/s	4.24
Maximum value of flow	L/s	25.07
Total flow rate (Q_{TOTAL})	m^3/day	850
Equivalent MNF (Q_{MNF})	m^3/day	332
Ratio	%	39

This ratio of equivalent MNF was considered very high and its sources shall be analyzed after the leakage detection and repair works finish.

7.5 Action U10 (Making water balance analysis before repair works)

To establish a water balance analysis, the following procedure shall be followed:

1- Determine the net amount of water entering the study pilot area which was measured as 935 m^3/d.
2- Determine the authorized consumption, the sum of metered volume 442 m^3/d with over registration error of 4 % (17 m^3/d) so that the net volume of billed authorized consumption will be 425 m^3/d . The billed un-metered volume that was assumed to be consumed as a flat rate evaluation of 25 m^3/month/meter. The value of the billed unmetered consumption was calculated to be 160 m^3/d. This amount of water was consumed by the registered customers at SHAPWASCO. Authorized consumption may include items such as fire fighting, training, flushing of mains and sewers, street cleaning, public fountains and gardens, etc, these may be billed, unbilled, metered or unmetered. This value was neglected in this study as the area was controlled against these actions during the study period.
3- Determine the water loss which is the difference between system input volume and authorized consumption. Water losses can be considered as a total volume for the whole system, or for partial systems such as transmission or distribution schemes, or individual zones as in our case in Abu Hamad Markz Area 3. Water losses consist of real losses and apparent losses. The total volume of the water losses was calculated to be 350 m^3/d.
4- Determine apparent losses that include all types of inaccuracies associated with customer metering as well as data handling error (meter reading and billing), plus unauthorized consumption (theft or illegal use). This value shall include the wastage in houses. The value of the wastage volume was calculated as 27 m^3/d. regarding the meter error in registration, the over registration of customer meters lead to underestimation of Real Losses and under-registration of customer meters leads to over-estimation of real Losses.
5- Determine the Real Losses that indicate the physical water losses from the networks (i.e. leakage). This amount shall represent the water volume lost through all types of leaks, bursts, and overflows.

The following table represents the water balance analysis before repair works for Abu Hamad Markz Area-3

Table 7-4 Water Balance Analysis in Abu Hamad Markz A-3 before Repair (m^3/day)

Water Distributed Volume **935** m^3/day	Authorized Consumption **585.00** m^3/day	Billed Authorized Consumption **585.00**	Billed Metered Consumption	442	**Water Sold** 585.00 **m^3/day**	**Revenue Water** 585.00 **m3/day**
			Metering error (over registration)	-17		
			Billed Unmetered Consumption(fixed amount collected)	160		
		Unbilled Authorized Consumption **0**	Unbilled Metered Consumption	0	**Commercial losses** 27 **m3/day**	**Unaccounted for Water (UFW)** 350.00 **m^3/day**
			Unbilled Unmetered Consumption	0		
	Unauthorized Consumption **350.00** m^3/day	Apparent Losses **27**	Unauthorized Consumption	0		
			Metering Inaccuracies(start flow & under registration)	27		
		Real Losses (leakage) **323.00**	Leakage on Transmission and/or Distribution Mains		**Physical losses** 323.00 **m^3/day**	
			Leakage and Overflows at Utility's Storage Tanks			
			Leakage on Service Connections up to point of Customer metering	323.00		

7.6 Action U11 (Conducting leakage detection survey)

The leak detection went through several stages with the acoustic rod and the digital sound detector. When there was a point suspected to have a leak, the UFW team began to use more advanced leak detection equipment such as the leak detector and/or the leak sound correlator to exactly locate the leak on the pipe.

(1) Detection of leaking sound by Acoustic Rod or Digital Sound Detector

The first attempt to detect the leakage in the pipes and the house connection was done using the acoustic rod and the digital sound detector.

When leakage occurs, leaking sound spreads through the pipe. At the point where valves are available, acoustic rod or digital sound detector was useful for detecting the sound. The method of leaking sound detection is shown on Figure 7-1.

Figure 7-1 Detecting Leakage on House Connection by Acoustic Rod

The UFW team has been trained on leak detection by the acoustic rod and the digital leak detector at Mostrod Training Center and OJT at site by assistance of JICA expert team during the activity.

(2) Detection of leaking points by Leak Detector

To detect the leakage on the distribution pipeline, the leak detector was used. The leak detection activity using the leak detector is shown in Figure 7-2. It was helpful to confirm the location of the leakage by night survey to isolate the background noise caused by traffic during daytime.

Figure 7-2 Detection Work by Leak Detector

(3) Results of leak detection

The leak detection survey led to detect 2 leak points in the area. All the detected leaks were on the house connections which were manufactured from lead. The reason for the leaks was due to wrong construction due to bending the pipe bending without using the proper facilities to bend such pipes.

The following Table indicates the summary of the detected leaks and the map indicated the location of these leaks on the GIS map used during the survey

Table 7-4 Summary of Detected Leaks Information

Leakage Record Sheet		
No.	1	2
Date	15-2	15-2
Area	A3	A3
Position	Pipe	Pipe
Condition of leak	Crack	Crack
Diameter of pipe	50	50
Material of leak pipe	lead	Lead
Depth of pipe	70	70
Ground conditions	Soil	Soil
Cause of leak	Det.	Det.
Leakage size	M	M
Leakage quantity	NA	NA

The detected leaks was on the lead pipe that form the house connection and most of the leaks was due to cracks found in the pipe due to deterioration and bending during construction period and then due to water pressure, the crack begins to spread. Most of the leaks were invisible as the ground surface is soil.

The location of detected leaks is shown as following figure.

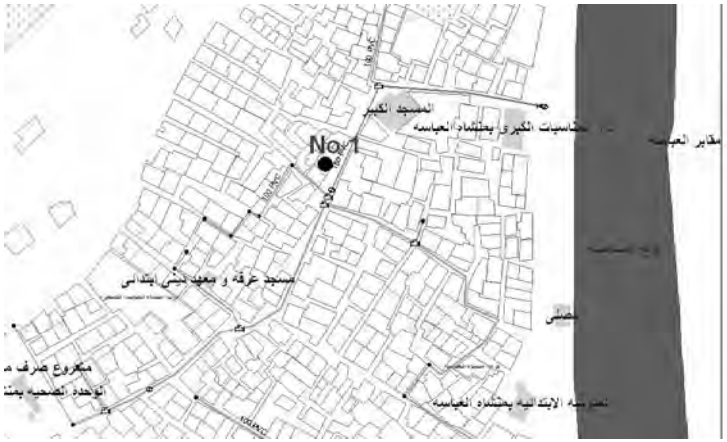


Figure7-3 Location of detected leaks in Abu Hamad Markz Area-3

7.7 Action U12 (Repairing leakage parts)

Following the leaks had been detected; the repair works takes place by SHAPWASCO equipment and facilities. All the detected leak pipes and house connection has been replaced with PVC pipes with proper fittings.

7.8 Action U13 (Conducting MNF survey after repair works)

In order to confirm the effectiveness of the repairing work (or reduction percentage of leakage ratio), MNF survey was carried out after the repairing work of the leaking parts. In the mean time of the MNF survey, two rounds of meter reading were conducted in the same period. The purpose of collecting meter reading was to measure the billed authorized consumption to be used in the water balance analysis.

A flow meter has been installed at the main inlet pipeline and was allowed to register the flow rate for the whole working days. Two flow meters were used, one each two days to overcome the short lifetime of portable batteries that was used to operate the flow meter.

The following table represents the main findings during the MNF survey after leak detection and repair.

Table 7-5 Status of Water Meters after Repair

Item	unit	Status
Average amount of water registered by flow meter during measurement period	m^3	(850 m^3/day)
Number of read meters	nos	547
Number of locked meters	nos	3
Number of flat rate connection	nos	193

7.9 Action U14 (Making water balance analysis and its evaluation)

As described in item 7-5 of this report, the water balance analysis is a useful tool to evaluate the UFW ratio. The following data should be known or estimated before making the water balance analysis.

1- Quantity of water entering the study area network 850 m^3/d.
2- Quantity of water leaving the study area network and goes to another network at the boundary of it (Nil).
3- Quantity of billed authorized consumption. This value could be assumed as measured before as the water meter status is the same as the time of measuring the water meters. 425 m^3/d. The volume of billed unmetered water shall be considered as (160 m^3/d)
4- Estimation of the unbilled authorized consumption. (Nil)
5- Meter inaccuracy and error in start flow measurement (the minimum flow rate at which the water meter begin to register the flow amount). This shall be estimated as before the leakage repair.
6- During UFW team survey for the distribution network and the status of the meters, the team did not find customers theft water (i.e. unauthorized consumption).

During the Action U8, it was found that the wastage in houses equal 12 L/hr/meter. It was assumed that this wastage shall be for a period of 3 hours (three hours). In the daytime, the use of the faucets and flush tanks in the toilet make the water meter run for a flow higher than the start flow. This shall make the meter register the total flow passing through it including the wastage flow.

The number of meters that could have a wastage including flat rate connections is 740 meters.
Total amount of wastage per day = 740 meters x 12L/hr x 3hr/1000= 27 m^3/day

The following table represents the water balance analysis after repair.

Table 7-6 Water balance analysis for Abu Hamad Area-3 after repair

(m^3/day)

Water Distributed Volume **850** m^3/day	Authorized Consumption **585.00** m^3/day	Billed Authorized Consumption **585.00**	Billed Metered Consumption	442	**Water Sold** 585.00 **m^3/day**	**Revenue Water** 585.00 **m^3/day**
			Metering error (over registration)	-17		
			Billed Unmetered Consumption(fixed anmount collected)	160		
		Unbilled Authorized Consumption **0**	Unbilled Metered Consumption	0	**Commercial losses**	**Unaccounted for Water (UFW)** 265.00 **m^3/day**
			Unbilled Unmetered Consumption	0		
	Unauthorized Consumption **265.00** m^3/day	Apparent Losses **27**	Unauthorized Consumption	0	**Physical losses** 27 **m^3/day**	
			Metering Inaccuracies(start flow & under registration)	27		
		Real Losses (leakage) **238.00**	Leakage on Transmission and/or Distribution Mains			
			Leakage and Overflows at Utility's Storage Tanks		238.00 **m^3/day**	
			Leakage on Service Connections up to point of Customer metering	238		

Summary of UFW activity in Abu Hamad Marakz A-3 before and after repair activity

Parameter	Unit	Assessment Before Repair	Assessment After Repair	Reduction
Water Distributed	m^3/day	892.5		---
Authorized Consumption	m^3/day	585.00	585.00	---
UFW (by volume)	m^3/day	350.00	265.00	85.00
UFW ratio	%	39.22%	29.69%	9.52%
Leakage (by volume)	m^3/day	323.00	238.00	85.00
Leakage ratio	%	36.19%	26.67%	9.52%

8 Results of Pilot Project in Pilot Project Site-8 (Minia -Alqamah Markaz)

8.1 Action U6 (Making field survey of distribution network)

The purpose of this action is to confirm the source of water to the area by isolating the valve at the entrance of the network and confirm that no water in the network after that. The survey also includes the confirmation of the minor valves, fire hydrants, and the governmental building in the distribution network.

Based on the GIS base maps, a draft of the water distribution network has been prepared by the UFW team. The GIS team drew the network for Minia - Alqamah Area-3 and the pipe data was verified by the UFW team and the distribution network crew.

The team made a site survey to verify all data indicated on the GIS map. All customer data was collected from the commercial department in SHAPWASCO. In the site survey, the customer information was verified as follows:

Table 8-1 Network Survey Result in Minia - Alqamah Markaz Area-3

Diameter of PVC pipe feeding the area	150 mm
Total length of water distribution network pipes (material: PVC)	15,147 m
150 mm	3,554 m
100 mm	11,479 m

Source: GIS Center

8.2 Action U7 (Surveying Working conditions of water meters and conducting meter readings)

Working conditions of the water meters were collected from the commercial department. The non-working meters were recorded by the meter reader and were verified by the UFW team.

The status of the meters inside the area was as follows:

Table 8-2 Status of Meters inside the Area

Meter Status	Number of Meters
Total number of meters as per commercial database	`1025
Working meters	1011
Non working meters	14
1) Meters repaired	13
2) Meters need to replace	1

After confirming the status of the meters, a meter repairing team will repair a part of the non working meters. Some of the non working meters can not be repaired and it will be replaced before the water meter reading will be conducted.

8.3 Action U8 (Measuring metering error for working meters)

Meter error shall be one of the sources of the commercial UFW. A series of meter calibration for determine the accuracy of the meter has been conducted by the following method.

1. Select 20 to 30 working meters randomly in the pilot project site.
2. Close all the taps in the house.
3. Set the hands of the water meter at zero point.
4. Open one tap and close all other taps in the house. Measurement shall be done by the following three cases for the degree of tap opening:
   - Case 1 : Full opening
   - Case-2 : Half opening
   - Case-3 : Quarter opening
5. Keep running water into the measuring tank for one minute and close the tap.
6. Reopen the tap for one minute and close.
7. Repeat items 5 and 6 until water level shows 20L or other readings (10L and 15L which will be determined taking into account the work progress at site and situation of the house).
8. Close the tap and read the meter.
9. Record the time of the measurement (from item 3 to 5)
10. Repeat the procedure from item 3 to 6 for all cases.

The average meter error was recorded as 4 %. The positive sign of the meter error indicated that the water meter read more than the actual amount of water passing through it. The positive value also indicated that the amount of commercial UFW should be decreased by this amount of error. This value shall be taken into account during the water balance analysis. The error of the meter was due to presence of some impurities in the water (silt, solids, etc.). Such impurities cause the clogging of the meter screen. As the water flow passes through the meter clogged screen, the water velocity increases. The increase in water velocity makes the rotation speed of the meter increase and the meter is over registering the actual flow passing through it.

The main source of wastage inside house is the leak in the faucet and toilets. This wastage can not be determined during day hours. To determine the leakage in house, the water usage pattern in the house should be registered including the minimum night flow.

This method to determine the wastage in houses can not be followed in Minia - Alqamah Area-3 as most of the house connection was less than 2 inches which is beyond the limits of the flow meter measurements so that the recorded value 12 L/hr/meter in Zagazig East and Hihya City will be used when calculating wastage value in houses in Minia – Alqamah.

8.4 Action U9 (Conducting MNF survey)

A series of minimum night flow survey was conducted in this stage. It was assumed that the value of the minimum night flow (MNF) is an indication on the amount of leakage in the distribution network. This activity is summarized as follow:

1- A flow meter shall be installed on the water inlet(s) to register the amount of water entering the study area.
2- Two pressure recorders shall be installed as well; one of these recorders shall be installed at the inlet point and the other at the far end of the network for the same period of the flow meter recording to measure the average pressure in the network.
3- The flow meter shall be allowed to register the flow rate value for at least 24 hours.
4- The minimum registered flow shall represent the amount of leakage in the network beside the wastage in houses.
5- The equivalent leakage flow during the day could be determined by the equation mentioned in section 1.4.
6- Determine the percent of MNF which represent a comparative basis for the UFW by dividing the equivalent minimum night flow by the total flow registered by the flow meter (Q_{MNF}/Q_{TOTAL}).

A series of MNF runs was conducted before leakage detection or repair takes place. The summary of these results is represented in the following table:

Table 8-3 Summary of Results for MNF Survey before Leakage Repair

Item	Unit	Value
Average Flow	L/s	11.76
Minimum flow (MNF)	L/s	5.02
Maximum value of flow	L/s	18.49
Total flow rate (Q_{TOTAL})	m^3/day	1016
Equivalent MNF (Q_{MNF})	m^3/day	448
Ratio	%	44

This ratio of equivalent MNF was considered very high and its sources shall be analyzed after the leakage detection and repair works finish.

8.5 Action U10 (Making water balance analysis before repair works)

To establish a water balance analysis, the following procedure shall be followed:

1- Determine the net amount of water entering the study pilot area which was measured as 1036 m^3/d.
2- Determine the authorized consumption, the sum of metered volume 669 m^3/d with over registration error of 4 % (25 m^3/d) so that the net volume of billed authorized consumption will be 644 m^3/d . The billed un-metered volume that was assumed to be consumed as a flat rate evaluation of 25 m^3/month/meter. The value of the billed unmetered consumption was calculated to be 58 m^3/d. This amount of water was consumed by the registered customers at SHAPWASCO. Authorized consumption may include items such as fire fighting, training, flushing of mains and sewers, street cleaning, public fountains and gardens, etc, these may be

billed, unbilled, metered or unmetered. This value was neglected in this study as the area was controlled against these actions during the study period.

3- Determine the water loss which is the difference between system input volume and authorized consumption. Water losses can be considered as a total volume for the whole system, or for partial systems such as transmission or distribution schemes, or individual zones as in our case in Minia - Alqamah Area 3. Water losses consist of real losses and apparent losses. The total volume of the water losses was calculated to be 335 m^3/d.

4- Determine apparent losses that include all types of inaccuracies associated with customer metering as well as data handling error (meter reading and billing), plus unauthorized consumption (theft or illegal use). This value shall include the wastage in houses. The value of the wastage volume was calculated as 32 m^3/d. regarding the meter error in registration, the over registration of customer meters lead to underestimation of Real Losses and under-registration of customer meters leads to over-estimation of real Losses.

5- Determine the Real Losses that indicate the physical water losses from the networks (i.e. leakage). This amount shall represent the water volume lost through all types of leaks, bursts, and overflows.

The following table represents the water balance analysis before repair works for Minia – Alqamah Markaz Area-3

Table 8-4 Water Balance Analysis in Minia - Alqamah Markz A-3 before Repair (m^3/day)

Water Distributed Volume **1036** m^3/day	Authorized Consumption **701.27** m^3/day	Billed Authorized Consumption **701.27**	Billed Metered Consumption	669	**Water Sold** 701.27 **m^3/day**	**Revenue Water** 701.27 **m^3/day**
			Metering error (over registration)	-25.73		
			Billed Unmetered Consumption(fixed amount collected)	58		
		Unbilled Authorized Consumption **0**	Unbilled Metered Consumption	0	**Commercial losses**	**Unaccounted for Water (UFW)** 334.73 **m^3/day**
			Unbilled Unmetered Consumption	0		
	Unauthorized Consumption **334.73** m^3/day	Apparent Losses **32**	Unauthorized Consumption	0	32 **m^3/day**	
			Metering Inaccuracies(start flow & under registration)	32		
		Real Losses (leakage) **302.73**	Leakage on Transmission and/or Distribution Mains		**Physical losses** 302.73 **m^3/day**	
			Leakage and Overflows at Utility's Storage Tanks			
			Leakage on Service Connections up to point of Customer metering	302.73		

8.6 Action U11 (Conducting leakage detection survey)

The leak detection went through several stages with the acoustic rod and the digital sound detector. When there was a point suspected to have a leak, the UFW team began to use more advanced leak detection equipment such as the leak detector and/or the leak sound correlator to exactly locate the leak on the pipe.

(1) Detection of leaking sound by Acoustic Rod or Digital Sound Detector

The first attempt to detect the leakage in the pipes and the house connection was done using the acoustic rod and the digital sound detector.

When leakage occurs, leaking sound spreads through the pipe. At the point where valves are available, acoustic rod or digital sound detector was useful for detecting the sound. The method of leaking sound detection is shown on Figure 8-1.

Figure 8-1 Detecting Leakage on House Connection by Acoustic Rod

The UFW team has been trained on leak detection by the acoustic rod and the digital leak detector at Mostrod Training Center and OJT at site by assistance of JICA expert team during the activity.

(2) Detection of leaking points by Leak Detector

To detect the leakage on the distribution pipeline, the leak detector was used. The leak detection activity using the leak detector is shown in Figure 8-2. It was helpful to confirm the location of the leakage by night survey to isolate the background noise caused by traffic during daytime.

Figure 8-2 Detection Work by Leak Detector

(3) Results of leak detection

The leak detection survey led to detect 2 leak points in the area. All the detected leaks were on the house connections which were manufactured from lead. The reason for the leaks was due to wrong construction due to bending the pipe bending without using the proper facilities to bend such pipes.

The following Table indicates the summary of the detected leaks and the map indicated the location of these leaks on the GIS map used during the survey

Table 8-5 Summary of Detected Leaks Information

Leakage Record Sheet		
No.	1	2
Date	15-2	15-2
Area	A3	A3
Position	Pipe	Pipe
Condition of leak	Crack	Crack
Diameter of pipe	50	50
Material of leak pipe	lead	Lead
Depth of pipe	70	70
Ground conditions	Soil	Soil
Cause of leak	Det.	Det.
Leakage size	M	M
Leakage quantity	NA	NA

The detected leaks was on the lead pipe that form the house connection and most of the leaks was due to cracks found in the pipe due to deterioration and bending during construction period and then due to water pressure, the crack begins to spread. Most of the leaks were invisible as the ground surface is soil.
The location of detected leaks is shown as following figure.

Figure 8-3 Location of detected leaks in Minia Alqamah Markz Area-3

8.7 Action U12 (Repairing leakage parts)

Following the leaks had been detected; the repair works takes place by SHAPWASCO equipment and facilities. All the detected leak pipes and house connection has been replaced with PVC pipes with proper fittings.

8.8 Action U13 (Conducting MNF survey after repair works)

In order to confirm the effectiveness of the repairing work (or reduction percentage of leakage ratio), MNF survey was carried out after the repairing work of the leaking parts. In the mean time of the MNF survey, two rounds of meter reading were conducted in the same period. The purpose of collecting meter reading was to measure the billed authorized consumption to be used in the water balance analysis.

A flow meter has been installed at the main inlet pipeline and was allowed to register the flow rate for the whole working days. Two flow meters were used, one each two days to overcome the short lifetime of portable batteries that was used to operate the flow meter.

The following table represents the main findings during the MNF survey after leak detection and repair.

Table 8-6 Status of Water Meters after Repair

Item	unit	Status
Average amount of water registered by flow meter during measurement period	m^3	(1258 m^3/day)
Number of read meters	nos	793
Number of locked meters	nos	66
Number of flat rate connection	nos	89

8.9 Action U14 (Making water balance analysis and its evaluation)

As described in item 8-6 of this report, the water balance analysis is a useful tool to evaluate the UFW ratio. The following data should be known or estimated before making the water balance analysis.

1. Quantity of water entering the study area network 1401 m^3/d.
2. Quantity of water leaving the study area network and goes to another network at the boundary of it (Nil).
3. Quantity of billed authorized consumption. This value could be assumed as measured before as the water meter status is the same as the time of measuring the water meters. 1006 m^3/d. The volume of billed unmetered water shall be considered as (74 m^3/d)
4. Estimation of the unbilled authorized consumption. (Nil)
5. Meter inaccuracy and error in start flow measurement (the minimum flow rate at which the water meter begin to register the flow amount). This shall be estimated as before the leakage repair.
6. During UFW team survey for the distribution network and the status of the meters, the team did not find customers theft water (i.e. unauthorized consumption).

During the Action U8, it was found that the wastage in houses equal 12 L/hr/meter. It was assumed that this wastage shall be for a period of 3 hours (three hours). In the daytime, the use of the faucets and flush tanks in the toilet make the water meter run for a flow higher than the start flow. This shall make the meter register the total flow passing through it including the wastage flow.

The number of meters that could have a wastage including flat rate connections is 882 meters.
Total amount of wastage per day = 882 meters x 12L/hr x 3hr/1000= 32 m^3/day

The following table represents the water balance analysis after repair.

Table 8-7 Water balance analysis for Minia – Alqamah Markz Area-3 after repair (m^3/day)

Water Distributed Volume **1258** m^3/day	Authorized Consumption **989.62** m^3/day	Billed Authorized Consumption **989.62**	Billed Metered Consumption	972	**Water Sold** 989.62 **m^3/day**	**Revenue Water** 989.62 **m^3/day**
			Metering error (over registration)	-37.38		
			Billed Unmetered Consumption(fixed amount collected)	55		
		Unbilled Authorized Consumption **0**	Unbilled Metered Consumption	0	**Commercial losses**	**Unaccounted for Water (UFW)** 268.38 **m^3/day**
			Unbilled Unmetered Consimption	0		
	Unauthorized Consumption **268.38** m^3/day	Apparent Losses **32**	Unauthorized Consumption	0	32 **m^3/day**	
			Metering Inaccuracies(start flow & under registration)	32		
		Real Losses (leakage) **236.38**	Leakage on Transmission and/or Distribution Mains		**Physical losses** 236.38 **m^3/day**	
			Leakage and Overflows at Utility's Storage Tanks			
			Leakage on Service Connections up to point of Customer metering	236.4		

Summary of UFW activity in Minia – Alqamah Markz Area_3 before and after repair activity

Parameter	Unit	Assessment Before Repair	Assessment After Repair	Reduction
Water Distributed	m^3/day	1147		---
Customer Consumption	m^3/day	701.27	989.62	---
UFW (by volume)	m^3/day	334.73	268.38	66.35
UFW ratio	%	29.18%	23.40%	5.78%
Leakage (by volume)	m^3/day	302.73	236.38	66.35
Leakage ratio	%	26.39%	20.61%	5.78%

9 Results of Pilot Project in Pilot Project Site-9 (Bilbais Markaz)

9.1 Action U6 (Making field survey of distribution network)

The purpose of this action is to confirm the source of water to the area by isolating the valve at the entrance of the network and confirm that no water in the network after that. The survey also includes the confirmation of the minor valves, fire hydrants, and the governmental building in the distribution network.

Based on the GIS base maps, a draft of the water distribution network has been prepared by the UFW team. The GIS team drew the network for Bilbais Markaz Area-4 and the pipe data was verified by the UFW team and the distribution network crew.

The team made a site survey to verify all data indicated on the GIS map. All customer data was collected from the commercial department in SHAPWASCO. In the site survey, the customer information was verified as follows:

Table 9-1 Network Survey Result in Bilbais Markaz Area-4

Diameter of PVC pipe feeding the area	150 mm
Total length of water distribution network pipes (material: PVC)	6,061 m
150 mm	1,156 m
100 mm	4,949 m

Source: GIS Center

9.2 Action U7 (Surveying Working conditions of water meters and conducting meter readings)

Working conditions of the water meters were collected from the commercial department. The non-working meters were recorded by the meter reader and were verified by the UFW team.

The status of the meters inside the area was as follows:

Table 9-2 Status of Meters inside the Area

Meter Status	Number of Meters
Total number of meters as per commercial database	977
Working meters	727
Non working meters	250
1) Meters repaired	-
2) Meters need to replace	250

After confirming the status of the meters, a meter repairing team will repair a part of the non working meters. Some of the non working meters can not be repaired and it will be replaced before the water meter reading will be conducted.

9.3 Action U8 (Measuring metering error for working meters)

Meter error shall be one of the sources of the commercial UFW. A series of meter calibration for determine the accuracy of the meter has been conducted by the following method.

1. Select 20 to 30 working meters randomly in the pilot project site.
2. Close all the taps in the house.
3. Set the hands of the water meter at zero point.
4. Open one tap and close all other taps in the house. Measurement shall be done by the following three cases for the degree of tap opening:
   - Case 1 : Full opening
   - Case-2 : Half opening
   - Case-3 : Quarter opening
5. Keep running water into the measuring tank for one minute and close the tap.
6. Reopen the tap for one minute and close.
7. Repeat items 5 and 6 until water level shows 20L or other readings (10L and 15L which will be determined taking into account the work progress at site and situation of the house).
8. Close the tap and read the meter.
9. Record the time of the measurement (from item 3 to 5)
10. Repeat the procedure from item 3 to 6 for all cases.

The average meter error was recorded as 4 %. The positive sign of the meter error indicated that the water meter read more than the actual amount of water passing through it. The positive value also indicated that the amount of commercial UFW should be decreased by this amount of error. This value shall be taken into account during the water balance analysis. The error of the meter was due to presence of some impurities in the water (silt, solids, etc.). Such impurities cause the clogging of the meter screen. As the water flow passes through the meter clogged screen, the water velocity increases. The increase in water velocity makes the rotation speed of the meter increase and the meter is over registering the actual flow passing through it.

The main source of wastage inside house is the leak in the faucet and toilets. This wastage can not be determined during day hours. To determine the leakage in house, the water usage pattern in the house should be registered including the minimum night flow.

This method to determine the wastage in houses can not be followed in Bilbais Area-4 as most of the house connection was less than 2 inches which is beyond the limits of the flow meter measurements so that the recorded value 12 L/hr/meter in Zagazig East and Hihya City will be used when calculating wastage value in houses in Bilbais Markaz.

9.4 Action U9 (Conducting MNF survey)

A series of minimum night flow survey was conducted in this stage. It was assumed that the value of the minimum night flow (MNF) is an indication on the amount of leakage in the distribution network. This activity is summarized as follow:

1- A flow meter shall be installed on the water inlet(s) to register the amount of water entering the study area.
2- Two pressure recorders shall be installed as well; one of these recorders shall be installed at the inlet point and the other at the far end of the network for the same period of the flow meter recording to measure the average pressure in the network.
3- The flow meter shall be allowed to register the flow rate value for at least 24 hours.
4- The minimum registered flow shall represent the amount of leakage in the network beside the wastage in houses.
5- The equivalent leakage flow during the day could be determined by the equation mentioned in section 1.4.
6- Determine the percent of MNF which represent a comparative basis for the UFW by dividing the equivalent minimum night flow by the total flow registered by the flow meter (Q_{MNF}/Q_{TOTAL}).

A series of MNF runs was conducted before leakage detection or repair takes place. The summary of these results is represented in the following table:

Table 9-3 Summary of Results for MNF Survey before Leakage Repair

Item	Unit	Value
Average Flow	L/s	10.31
Minimum flow (MNF)	L/s	1.43
Maximum value of flow	L/s	26.24
Total flow rate (Q_{TOTAL})	m^3/day	890
Equivalent MNF (Q_{MNF})	m^3/day	126
Ratio	%	14.18

This ratio of equivalent MNF was considered very high and its sources shall be analyzed after the leakage detection and repair works finish.

9.5 Action U10 (Making water balance analysis before repair works)

To establish a water balance analysis, the following procedure shall be followed:

1. Determine the net amount of water entering the study pilot area which was measured as 890 m^3/d.
2. Determine the authorized consumption, the sum of metered volume 491 m^3/d with over registration error of 4 % (19 m^3/d) so that the net volume of billed authorized consumption will be 472 m^3/d . The billed un-metered volume that was assumed to be consumed as a flat rate evaluation of 25 m^3/month/meter. The value of the billed unmetered consumption was calculated to be 203 m^3/d. This amount of water was consumed by the registered customers at SHAPWASCO. Authorized consumption may include items such as fire fighting, training, flushing of mains and sewers, street cleaning, public fountains and gardens, etc, these may be billed, unbilled, metered or unmetered. This value was neglected in this study as the area was controlled against these actions during the study period.
3. Determine the water loss which is the difference between system input volume and authorized consumption. Water losses can be considered as a total volume for the whole system, or for partial systems such as transmission or distribution schemes, or individual zones as in our case in Bilbais Markaz Area_4. Water losses consist of real losses and apparent losses. The total volume of the water losses was calculated to be 215 m^3/d.
4. Determine apparent losses that include all types of inaccuracies associated with customer metering as well as data handling error (meter reading and billing), plus unauthorized consumption (theft or illegal use). This value shall include the wastage in houses. The value of the wastage volume was calculated as 30 m^3/d. regarding the meter error in registration, the over registration of customer meters lead to underestimation of Real Losses and under-registration of customer meters leads to over-estimation of real Losses.
5. Determine the Real Losses that indicate the physical water losses from the networks (i.e. leakage). This amount shall represent the water volume lost through all types of leaks, bursts, and overflows.

The following table represents the water balance analysis before repair works for Bilbais Markaz Area-4

Table 9-4 Water Balance Analysis in Bilbais Markaz A-4 before Repair (m^3/day)

Water Distributed Volume 890 m^3/day	Authorized Consumption 675 m^3/day	Billed Authorized Consumption 675	Billed Metered Consumption	491	**Water Sold** 675 m^3/day	**Revenue Water** 675 m^3/day
			Metering error (over registration)	-19		
			Billed Unmetered Consumption(fixed amount collected)	203		
		Unbilled Authorized Consumption 0	Unbilled Metered Consumption	0	**Commercial losses**	**Unaccounted for Water (UFW)** 215 m^3/day
			Unbilled Unmetered Consumption	0		
	Unauthorized Consumption 215 m^3/day	Apparent Losses 30	Unauthorized Consumption	0	30 m^3/day	
			Metering Inaccuracies(start flow & under registration)	30		
		Real Losses (leakage) 185	Leakage on Transmission and/or Distribution Mains		**Physical losses** 185 m^3/day	
			Leakage and Overflows at Utility's Storage Tanks			
			Leakage on Service Connections up to point of Customer metering	185		

9.6 Action U11 (Conducting leakage detection survey)

The leak detection went through several stages with the acoustic rod and the digital sound detector. When there was a point suspected to have a leak, the UFW team began to use more advanced leak detection equipment such as the leak detector and/or the leak sound correlator to exactly locate the leak on the pipe.

(1) Detection of leaking sound by Acoustic Rod or Digital Sound Detector

The first attempt to detect the leakage in the pipes and the house connection was done using the acoustic rod and the digital sound detector.

When leakage occurs, leaking sound spreads through the pipe. At the point where valves are available, acoustic rod or digital sound detector was useful for detecting the sound. The method of leaking sound detection is shown on Figure 9-1.

Figure 9-1 Detecting Leakage on House Connection by Acoustic Rod

The UFW team has been trained on leak detection by the acoustic rod and the digital leak detector at Mostrod Training Center and OJT at site by assistance of JICA expert team during the activity.

(2) Detection of leaking points by Leak Detector

To detect the leakage on the distribution pipeline, the leak detector was used. The leak detection activity using the leak detector is shown in Figure 9-2. It was helpful to confirm the location of the leakage by night survey to isolate the background noise caused by traffic during daytime.

Figure 9-2 Detection Work by Leak Detector

(3) Results of leak detection

The leak detection survey led to detect 3 leak points in the area. All the detected leaks were on the house connections which were manufactured from lead. The reason for the leaks was due to wrong construction due to bending the pipe bending without using the proper facilities to bend such pipes.

The following Table indicates the summary of the detected leaks and the map indicated the location of these leaks on the GIS map used during the survey

Table 9-5 Summary of Detected Leaks Information

Leakage Record Sheet			
No.	1	2	3
Date	15-8	15-8	15-8
Area	A4	A4	A4
Position	Pipe	Pipe	Pipe
Condition of leak	Crack	Crack	Crack
Diameter of pipe	50	50	50
Material of leak pipe	lead	Lead	Lead
Depth of pipe	70	70	70
Ground conditions	Soil	Soil	Soil
Cause of leak	Det.	Det.	Det.
Leakage size	M	M	M
Leakage quantity	NA	NA	NA

The detected leaks was on the lead pipe that form the house connection and most of the leaks was due to cracks found in the pipe due to deterioration and bending during construction period and then due to water pressure, the crack begins to spread. Most of the leaks were invisible as the ground surface is soil.

The location of detected leaks is shown as following figure.

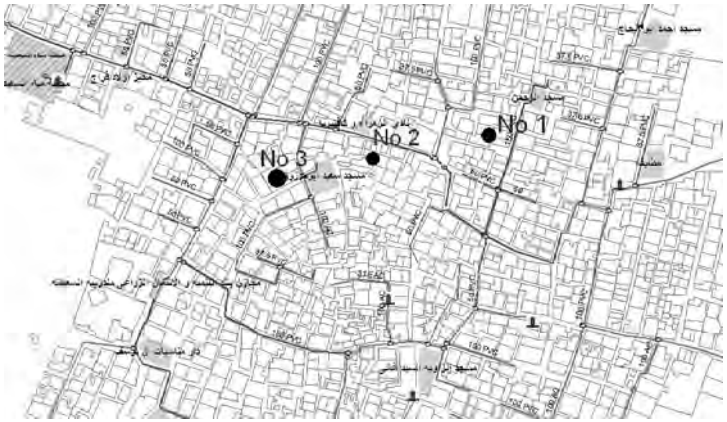


Figure 9-3 Location of detected leaks in Bilbais Markz Area-4

9.7 Action U12 (Repairing leakage parts)

Following the leaks had been detected; the repair works takes place by SHAPWASCO equipment and facilities. All the detected leak pipes and house connection has been replaced with PVC pipes with proper fittings.

9.8 Action U13 (Conducting MNF survey after repair works)

In order to confirm the effectiveness of the repairing work (or reduction percentage of leakage ratio), MNF survey was carried out after the repairing work of the leaking parts. In the mean time of the MNF survey, two rounds of meter reading were conducted in the same period. The purpose of collecting meter reading was to measure the billed authorized consumption to be used in the water balance analysis.

A flow meter has been installed at the main inlet pipeline and was allowed to register the flow rate for the whole working days. Two flow meters were used, one each two days to overcome the short lifetime of portable batteries that was used to operate the flow meter.

The following table represents the main findings during the MNF survey after leak detection and repair.

Table 9-6 Status of Water Meters after Repair

Item	unit	Status
Average amount of water registered by flow meter during measurement period	m^3	(1126 m^3/day)
Number of read meters	nos	820
Number of locked meters	nos	49
Number of flat rate connection	nos	74

9.9 Action U14 (Making water balance analysis and its evaluation)

As described in item 9-6 of this report, the water balance analysis is a useful tool to evaluate the UFW ratio. The following data should be known or estimated before making the water balance analysis.

1. Quantity of water entering the study area network 1126 m^3/d.
2. Quantity of water leaving the study area network and goes to another network at the boundary of it (Nil).
3. Quantity of billed authorized consumption. This value could be assumed as measured before as the water meter status is the same as the time of measuring the water meters. 936 m^3/d. The volume of billed unmetered water shall be considered as (61 m^3/d)
4. Estimation of the unbilled authorized consumption. (Nil)
5. Meter inaccuracy and error in start flow measurement (the minimum flow rate at which the water meter begin to register the flow amount). This shall be estimated as before the leakage repair.
6. During UFW team survey for the distribution network and the status of the meters, the team did not find customers theft water (i.e. unauthorized consumption).

During the Action U8, it was found that the wastage in houses equal 12 L/hr/meter. It was assumed that this wastage shall be for a period of 3 hours (three hours). In the daytime, the use of the faucets and flush tanks in the toilet make the water meter run for a flow higher than the start flow. This shall make the meter register the total flow passing through it including the wastage flow.

The number of meters that could have a wastage including flat rate connections is 894 meters.
Total amount of wastage per day = 894 meters x 12L/hr x 3hr/1000= 32 m^3/day

The following table represents the water balance analysis after repair.

Table 9-7 Water balance analysis for Bilbais Markz Area-4 after repair (m^3/day)

Water Distributed Volume 1126 m^3/day	Authorized Consumption 997 m^3/day	Billed Authorized Consumption 997	Billed Metered Consumption	965	**Water Sold** 997 m^3/day	**Revenue Water** 997 m^3/day
			Metering error (over registration)	-29		
			Billed Unmetered Consumption(fixed amount collected)	61		
		Unbilled Authorized Consumption 0	Unbilled Metered Consumption	0		
			Unbilled Unmetered Consumption	0		
	Unauthorized Consumption 129 m^3/day	Apparent Losses 32	Unauthorized Consumption	0	**Commercial losses** 32 m^3/day	**Unaccounted for Water (UFW)** 129 m^3/day
			Metering Inaccuracies(start flow & under registration)	32		
		Real Losses (leakage) 97	Leakage on Transmission and/or Distribution Mains		**Physical losses** 97 m^3/day	
			Leakage and Overflows at Utility's Storage Tanks			
			Leakage on Service Connections up to point of Customer metering	97		

Summary of UFW activity in Bilbais Markz Area_4 before and after repair activity

Parameter	Unit	Assessment Before Repair	Assessment After Repair	Reduction
Water Distributed	m^3/day	1008		---
Customer Consumption	m^3/day	675	997	---
UFW (by volume)	m^3/day	215	129	86
UFW ratio	%	21.33%	12.80%	8.53%
Leakage (by volume)	m^3/day	185	97	88
Leakage ratio	%	18.35%	9.62%	8.73%

10 Results of Pilot Project in Pilot Project Site-10 (Zagazig Markaz)(Expansion Area)

10.1 Action U6 (Making field survey of distribution network)

The purpose of this action is to confirm the source of water to the area by isolating the valve at the entrance of the network and confirm that no water in the network after that. The survey also includes the confirmation of the minor valves, fire hydrants, and the governmental building in the distribution network.

Based on the GIS base maps, a draft of the water distribution network has been prepared by the UFW team. The GIS team drew the network for Zagazig Markaz Area-4(Expansion Area) and the pipe data was verified by the UFW team and the distribution network crew.

The team made a site survey to verify all data indicated on the GIS map. All customer data was collected from the commercial department in SHAPWASCO. In the site survey, the customer information was verified as follows:

Table 10-1 Network Survey Result in Zagazig Markaz Area-5

Diameter of PVC pipe feeding the area	150 mm
Total length of water distribution network pipes (material: PVC)	6,267 m
150 mm	83 m
100 mm	6,184 m

Source: GIS Center

10.2 Action U7 (Surveying Working conditions of water meters and conducting meter readings)

Working conditions of the water meters were collected from the commercial department. The non-working meters were recorded by the meter reader and were verified by the UFW team.

The status of the meters inside the area was as follows:

Table 10-2 Status of Meters inside the Area

Meter Status	Number of Meters
Total number of meters as per commercial database	993
Working meters	683
Non working meters	250
1) Meters repaired	-
2) Meters need to replace	250

After confirming the status of the meters, a meter repairing team will repair a part of the non working

meters. Some of the non working meters can not be repaired and it will be replaced before the water meter reading will be conducted.

10.3 Action U8 (Measuring metering error for working meters)

Meter error shall be one of the sources of the commercial UFW. A series of meter calibration for determine the accuracy of the meter has been conducted by the following method.

1. Select 20 to 30 working meters randomly in the pilot project site.
2. Close all the taps in the house.
3. Set the hands of the water meter at zero point.
4. Open one tap and close all other taps in the house. Measurement shall be done by the following three cases for the degree of tap opening:
   - Case 1 : Full opening
   - Case-2 : Half opening
   - Case-3 : Quarter opening
5. Keep running water into the measuring tank for one minute and close the tap.
6. Reopen the tap for one minute and close.
7. Repeat items 5 and 6 until water level shows 20L or other readings (10L and 15L which will be determined taking into account the work progress at site and situation of the house).
8. Close the tap and read the meter.
9. Record the time of the measurement (from item 3 to 5)
10. Repeat the procedure from item 3 to 6 for all cases.

The average meter error was recorded as 4 %. The positive sign of the meter error indicated that the water meter read more than the actual amount of water passing through it. The positive value also indicated that the amount of commercial UFW should be decreased by this amount of error. This value shall be taken into account during the water balance analysis. The error of the meter was due to presence of some impurities in the water (silt, solids, etc.). Such impurities cause the clogging of the meter screen. As the water flow passes through the meter clogged screen, the water velocity increases. The increase in water velocity makes the rotation speed of the meter increase and the meter is over registering the actual flow passing through it.

The main source of wastage inside house is the leak in the faucet and toilets. This wastage can not be determined during day hours. To determine the leakage in house, the water usage pattern in the house should be registered including the minimum night flow.

This method to determine the wastage in houses can not be followed in Zagazig Markz Area-5 as most of the house connection was less than 2 inches which is beyond the limits of the flow meter measurements so that the recorded value 12 L/hr/meter in Zagazig East and Hihya City will be used when calculating wastage value in houses in Zagazig Markaz (Expansion Area).

10.4 Action U9 (Conducting MNF survey)

A series of minimum night flow survey was conducted in this stage. It was assumed that the value of the minimum night flow (MNF) is an indication on the amount of leakage in the distribution network. This activity is summarized as follow:

1- A flow meter shall be installed on the water inlet(s) to register the amount of water entering the study area.

2- Two pressure recorders shall be installed as well; one of these recorders shall be installed at the inlet point and the other at the far end of the network for the same period of the flow meter recording to measure the average pressure in the network.

3- The flow meter shall be allowed to register the flow rate value for at least 24 hours.

4- The minimum registered flow shall represent the amount of leakage in the network beside the wastage in houses.

5- The equivalent leakage flow during the day could be determined by the equation mentioned in section 1.4.

6- Determine the percent of MNF which represent a comparative basis for the UFW by dividing the equivalent minimum night flow by the total flow registered by the flow meter (Q_{MNF}/Q_{TOTAL}).

A series of MNF runs was conducted before leakage detection or repair takes place. The summary of these results is represented in the following table:

Table 10-3 Summary of Result for MNF Survey before Leakage Repair

Item	Unit	Value
Average Flow	L/s	9.33
Minimum flow (MNF)	L/s	1.53
Maximum value of flow	L/s	20.10
Total flow rate (Q_{TOTAL})	m^3/day	806
Equivalent MNF (Q_{MNF})	m^3/day	134
Ratio	%	16.60

This ratio of equivalent MNF was considered very high and its sources shall be analyzed after the leakage detection and repair works finish.

10.5 Action U10 (Making water balance analysis before repair works)

To establish a water balance analysis, the following procedure shall be followed:

1. Determine the net amount of water entering the study pilot area which was measured as 812 m^3/d.
2. Determine the authorized consumption, the sum of metered volume 411 m^3/d with over registration error of 4 % (15 m^3/d) so that the net volume of billed authorized consumption will be 396 m^3/d . The billed un-metered volume that was assumed to be consumed as a flat rate evaluation of 25 m^3/month/meter. The value of the billed unmetered consumption was calculated to be 146 m^3/d. This amount of water was consumed by the registered customers at SHAPWASCO. Authorized consumption may include items such as fire fighting, training, flushing of mains and sewers, street cleaning, public fountains and gardens, etc, these may be billed, unbilled, metered or unmetered. This value was neglected in this study as the area was controlled against these actions during the study period.

3. Determine the water loss which is the difference between system input volume and authorized consumption. Water losses can be considered as a total volume for the whole system, or for partial systems such as transmission or distribution schemes, or individual zones as in our case in Zagazig Markaz Area_5. Water losses consist of real losses and apparent losses. The total volume of the water losses was calculated to be 270 m^3/d.
4. Determine apparent losses that include all types of inaccuracies associated with customer metering as well as data handling error (meter reading and billing), plus unauthorized consumption (theft or illegal use). This value shall include the wastage in houses. The value of the wastage volume was calculated as 29 m^3/d. regarding the meter error in registration, the over registration of customer meters lead to underestimation of Real Losses and under-registration of customer meters leads to over-estimation of real Losses.
5. Determine the Real Losses that indicate the physical water losses from the networks (i.e. leakage). This amount shall represent the water volume lost through all types of leaks, bursts, and overflows.

The following table represents the water balance analysis before repair works for Zagazig Markaz Area-5

Table 10-4 Water Balance Analysis in Zagazig Markaz A-5 before Repair (m^3/day)

Water Distributed Volume **812** m^3/day	Authorized Consumption **541.19** m^3/day	Billed Authorized Consumption **541.19**	Billed Metered Consumption	411	**Water Sold** 541.19 **m^3/day**	**Revenue Water** 541.19 **m^3/day**
			Metering error (over registration)	-15.81		
			Billed Unmetered Consumption(fixed anmount collected)	146		
		Unbilled Authorized Consumption **0**	Unbilled Metered Consumption	0	**Commercial losses**	**Unaccounted for Water (UFW)** 270.81 **m3/day**
			Unbilled Unmetered Consumption	0		
	Unauthorized Consumption **270.81** m^3/day	Apparent Losses **29**	Unauthorized Consumption	0	29 **m^3/day**	
			Metering Inaccuracies(start flow & under registration)	29		
		Real Losses (leakage) **241.81**	Leakage on Transmission and/or Distribution Mains		**Physical losses** 241.81 **m^3/day**	
			Leakage and Overflows at Utility's Storage Tanks			
			Leakage on Service Connections up to point of Customer metering	241.81		

10.6 Action U11 (Conducting leakage detection survey)

The leak detection went through several stages with the acoustic rod and the digital sound detector.

When there was a point suspected to have a leak, the UFW team began to use more advanced leak detection equipment such as the leak detector and/or the leak sound correlator to exactly locate the leak on the pipe.

(1) Detection of leaking sound by Acoustic Rod or Digital Sound Detector

The first attempt to detect the leakage in the pipes and the house connection was done using the acoustic rod and the digital sound detector.

When leakage occurs, leaking sound spreads through the pipe. At the point where valves are available, acoustic rod or digital sound detector was useful for detecting the sound. The method of leaking sound detection is shown on Figure 10-1.

Figure 10-1 Detecting Leakage on House Connection by Acoustic Rod

The UFW team has been trained on leak detection by the acoustic rod and the digital leak detector at Mostrod Training Center and OJT at site by assistance of JICA expert team during the activity.

(2) Detection of leaking points by Leak Detector

To detect the leakage on the distribution pipeline, the leak detector was used. The leak detection activity using the leak detector is shown in Figure 10-2. It was helpful to confirm the location of the leakage by night survey to isolate the background noise caused by traffic during daytime.

Figure 10-2 Detection Work by Leak Detector

(3) Results of leak detection

The leak detection survey led to detect 2 leak points in the area. All the detected leaks were on the

house connections which were manufactured from lead. The reason for the leaks was due to wrong construction due to bending the pipe bending without using the proper facilities to bend such pipes.

The following Table indicates the summary of the detected leaks and the map indicated the location of these leaks on the GIS map used during the survey

Table 10-5 Summary of Detected Leaks Information

Leakage Record Sheet		
No.	1	2
Date	10-9	10-9
Area	A5	A5
Position	Pipe	Pipe
Condition of leak	Crack	Crack
Diameter of pipe	50	50
Material of leak pipe	lead	Lead
Depth of pipe	70	70
Ground conditions	Soil	Soil
Cause of leak	Det.	Det.
Leakage size	M	M
Leakage quantity	NA	NA

The detected leaks was on the lead pipe that form the house connection and most of the leaks was due to cracks found in the pipe due to deterioration and bending during construction period and then due to water pressure, the crack begins to spread. Most of the leaks were invisible as the ground surface is soil.

The location of detected leaks is shown as following figure.

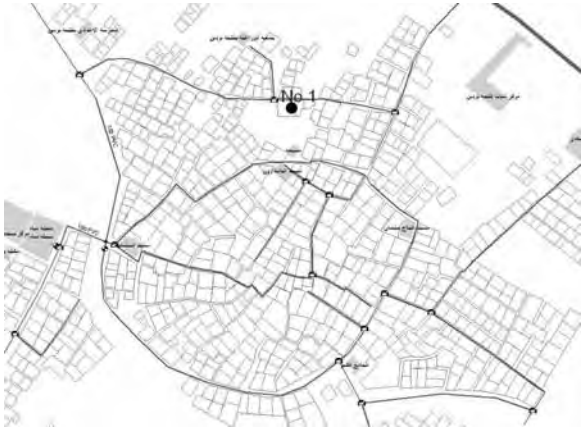


Figure 10-3 Location of detected leaks in Zagazig Markz Area-5

10.7 Action U12 (Repairing leakage parts)

Following the leaks had been detected; the repair works takes place by SHAPWASCO equipment and facilities. All the detected leak pipes and house connection has been replaced with PVC pipes with proper fittings.

10.8 Action U13 (Conducting MNF survey after repair works)

In order to confirm the effectiveness of the repairing work (or reduction percentage of leakage ratio), MNF survey was carried out after the repairing work of the leaking parts. In the mean time of the MNF survey, two rounds of meter reading were conducted in the same period. The purpose of collecting meter reading was to measure the billed authorized consumption to be used in the water balance analysis.

A flow meter has been installed at the main inlet pipeline and was allowed to register the flow rate for the whole working days. Two flow meters were used, one each two days to overcome the short lifetime of portable batteries that was used to operate the flow meter.

The following table represents the main findings during the MNF survey after leak detection and repair.

Table 10-6 Status of Water Meters after Repair

Item	unit	Status
Average amount of water registered by flow meter during measurement period	m^3	(950 m^3/day)
Number of read meters	nos	661
Number of locked meters	nos	125
Number of flat rate connection	nos	147

10.9 Action U14 (Making water balance analysis and its evaluation)

As described in item 10-6 of this report, the water balance analysis is a useful tool to evaluate the UFW ratio. The following data should be known or estimated before making the water balance analysis.

7. Quantity of water entering the study area network 950 m^3/d.
8. Quantity of water leaving the study area network and goes to another network at the boundary of it (Nil).
9. Quantity of billed authorized consumption. This value could be assumed as measured before as the water meter status is the same as the time of measuring the water meters. 625 m^3/d. The volume of billed unmetered water shall be considered as (122 m^3/d)
10. Estimation of the unbilled authorized consumption. (Nil)
11. Meter inaccuracy and error in start flow measurement (the minimum flow rate at which the water meter begin to register the flow amount). This shall be estimated as before the leakage repair.
12. During UFW team survey for the distribution network and the status of the meters, the team did not find customers theft water (i.e. unauthorized consumption).

During the Action U8, it was found that the wastage in houses equal 12 L/hr/meter. It was assumed that this wastage shall be for a period of 3 hours (three hours). In the daytime, the use of the faucets and flush tanks in the toilet make the water meter run for a flow higher than the start flow. This shall make the meter register the total flow passing through it including the wastage flow.

The number of meters that could have a wastage including flat rate connections is 808 meters.
Total amount of wastage per day = 808 meters x 12L/hr x 3hr/1000= 29 m^3/day

The following table represents the water balance analysis after repair.

Table 10-7 Water balance analysis for Zagazig Markz Area-5 after repair (m^3/day)

Water Distributed Volume **950** m^3/day	Authorized Consumption **747.00** m^3/day	Billed Authorized Consumption **747.00**	Billed Metered Consumption 650	**Water Sold** 747.00 **m^3/day**	**Revenue Water** 747.00 **m^3/day**
			Metering error (over registration) -25		
			Billed Unmetered Consumption(fixed amount collected) 122		
		Unbilled Authorized Consumption **0**	Unbilled Metered Consumption 0	**Commercial losses**	**Unaccounted for Water (UFW)** 203.00 **m^3/day**
			Unbilled Unmetered Consumption 0		
	Unauthorized Consumption **203.00** m^3/day	Apparent Losses **29**	Unauthorized Consumption 0	29 **m^3/day**	
			Metering Inaccuracies(start flow & under registration) 29		
		Real Losses (leakage) **174.00**	Leakage on Transmission and/or Distribution Mains	**Physical losses** 174.00 **m^3/day**	
			Leakage and Overflows at Utility's Storage Tanks		
			Leakage on Service Connections up to point of Customer metering 174		

Summary of UFW activity in Zagazig Markaz Area_5 before and after repair activity

Parameter	Unit	Assessment Before Repair	Assessment After Repair	Reduction
Water Distributed	m^3/day	881		---
Customer Consumption	m^3/day	541.19	747	---
UFW (by volume)	m^3/day	270.81	203	67.81
UFW ratio	%	30.74%	23.04%	7.70%
Leakage (by volume)	m^3/day	241.81	174	67.81
Leakage ratio	%	27.45%	19.75%	7.70%

11 Results of Pilot Project in Pilot Project Site-11 (Ibrahimia Markaz)(Expansion Area)

11.1 Action U6 (Making field survey of distribution network)

The purpose of this action is to confirm the source of water to the area by isolating the valve at the entrance of the network and confirm that no water in the network after that. The survey also includes the confirmation of the minor valves, fire hydrants, and the governmental building in the distribution network.

Based on the GIS base maps, a draft of the water distribution network has been prepared by the UFW team. The GIS team drew the network for Ibrahimia Markaz Area-2(Expansion Area) and the pipe data was verified by the UFW team and the distribution network crew.

The team made a site survey to verify all data indicated on the GIS map. All customer data was collected from the commercial department in SHAPWASCO. In the site survey, the customer information was verified as follows:

Table 11-1 Network Survey Result in Zagazig Markaz Area-5

Diameter of PVC pipe feeding the area	150 mm
Total length of water distribution network pipes (material: PVC)	9,168 m
150 mm	605 m
100 mm	7,468 m

Source: GIS Center

11.2 Action U7 (Surveying Working conditions of water meters and conducting meter readings)

Working conditions of the water meters were collected from the commercial department. The non-working meters were recorded by the meter reader and were verified by the UFW team.

The status of the meters inside the area was as follows:

Table 11-2 Status of Meters inside the Area

Meter Status	Number of Meters
Total number of meters as per commercial database	1234
Working meters	1164
Non working meters	70
1) Meters repaired	-
2) Meters need to replace	70

After confirming the status of the meters, a meter repairing team will repair a part of the non working meters. Some of the non working meters can not be repaired and it will be replaced before the water meter reading will be conducted.

11.3 Action U8 (Measuring metering error for working meters)

Meter error shall be one of the sources of the commercial UFW. A series of meter calibration for determine the accuracy of the meter has been conducted by the following method.

1. Select 20 to 30 working meters randomly in the pilot project site.
2. Close all the taps in the house.
3. Set the hands of the water meter at zero point.
4. Open one tap and close all other taps in the house. Measurement shall be done by the following three cases for the degree of tap opening:
   - Case 1 : Full opening
   - Case-2 : Half opening
   - Case-3 : Quarter opening
5. Keep running water into the measuring tank for one minute and close the tap.
6. Reopen the tap for one minute and close.
7. Repeat items 5 and 6 until water level shows 20L or other readings (10L and 15L which will be determined taking into account the work progress at site and situation of the house).
8. Close the tap and read the meter.
9. Record the time of the measurement (from item 3 to 5)
10. Repeat the procedure from item 3 to 6 for all cases.

The average meter error was recorded as 4 %. The positive sign of the meter error indicated that the water meter read more than the actual amount of water passing through it. The positive value also indicated that the amount of commercial UFW should be decreased by this amount of error. This value shall be taken into account during the water balance analysis. The error of the meter was due to presence of some impurities in the water (silt, solids, etc.). Such impurities cause the clogging of the meter screen. As the water flow passes through the meter clogged screen, the water velocity increases. The increase in water velocity makes the rotation speed of the meter increase and the meter is over registering the actual flow passing through it.

The main source of wastage inside house is the leak in the faucet and toilets. This wastage can not be determined during day hours. To determine the leakage in house, the water usage pattern in the house should be registered including the minimum night flow.

This method to determine the wastage in houses can not be followed in Ibrahimia Markz Area-2 as most of the house connection was less than 2 inches which is beyond the limits of the flow meter measurements so that the recorded value 12 L/hr/meter in Zagazig East and Hihya City will be used when calculating wastage value in houses in Ibrahimia Markaz (Expansion Area).

11.4 Action U9 (Conducting MNF survey)

A series of minimum night flow survey was conducted in this stage. It was assumed that the value of the minimum night flow (MNF) is an indication on the amount of leakage in the distribution network. This activity is summarized as follow:

1- A flow meter shall be installed on the water inlet(s) to register the amount of water entering the study area.
2- Two pressure recorders shall be installed as well; one of these recorders shall be installed at the inlet point and the other at the far end of the network for the same period of the flow meter recording to measure the average pressure in the network.
3- The flow meter shall be allowed to register the flow rate value for at least 24 hours.
4- The minimum registered flow shall represent the amount of leakage in the network beside the wastage in houses.
5- The equivalent leakage flow during the day could be determined by the equation mentioned in section 1.4.
6- Determine the percent of MNF which represent a comparative basis for the UFW by dividing the equivalent minimum night flow by the total flow registered by the flow meter (Q_{MNF}/Q_{TOTAL}).

A series of MNF runs was conducted before leakage detection or repair takes place. The summary of these results is represented in the following table:

Table 11-3 Summary of Result for MNF Survey before Leakage Repair

Item	Unit	Value
Average Flow	L/s	5.4
Minimum flow (MNF)	L/s	1.3
Maximum value of flow	L/s	13
Total flow rate (Q_{TOTAL})	m³/day	470
Equivalent MNF (Q_{MNF})	m³/day	143
Ratio	%	30.45

This ratio of equivalent MNF was considered very high and its sources shall be analyzed after the leakage detection and repair works finish.

11.5 Action U10 (Making water balance analysis before repair works)

To establish a water balance analysis, the following procedure shall be followed:

1. Determine the net amount of water entering the study pilot area which was measured as 473 m^3/d.
2. Determine the authorized consumption, the sum of metered volume 349 m^3/d with over registration error of 4 % (13 m^3/d) so that the net volume of billed authorized consumption will be 336 m^3/d . The billed un-metered volume that was assumed to be consumed as a flat rate evaluation of 25 m^3/month/meter. The value of the billed unmetered consumption was calculated to be 44 m^3/d. This amount of water was consumed by the registered customers at SHAPWASCO. Authorized consumption may include items such as fire fighting, training, flushing of mains and sewers, street cleaning, public fountains and gardens, etc, these may be billed, unbilled, metered or unmetered. This value was neglected in this study as the area was controlled against these actions during the study period.
3. Determine the water loss which is the difference between system input volume and authorized consumption. Water losses can be considered as a total volume for the whole system, or for partial systems such as transmission or distribution schemes, or individual zones as in our case in Ibrahimia Markaz Area_2. Water losses consist of real losses and apparent losses. The total volume of the water losses was calculated to be 94 m^3/d.
4. Determine apparent losses that include all types of inaccuracies associated with customer metering as well as data handling error (meter reading and billing), plus unauthorized consumption (theft or illegal use). This value shall include the wastage in houses. The value of the wastage volume was calculated as 41 m^3/d. regarding the meter error in registration, the over registration of customer meters lead to underestimation of Real Losses and under-registration of customer meters leads to over-estimation of real Losses.
5. Determine the Real Losses that indicate the physical water losses from the networks (i.e. leakage). This amount shall represent the water volume lost through all types of leaks, bursts, and overflows.

The following table represents the water balance analysis before repair works for Ibrahimia Markaz Area-2

Table 11-3 Water Balance Analysis in Ibrahimia Markaz A-2 before Repair (m^3/day)

Water Distributed Volume **473.6** m³/day	Authorized Consumption **379.84** m³/day	Billed Authorized Consumption **379.84**	Billed Metered Consumption	349.48	**Water Sold** 379.84 m³/day	**Revenue Water** 379.84 m³/day
			Metering error (over registration)	-13.44		
			Billed Unmetered Consumption(fixed amount collected)	43.8		
		Unbilled Authorized Consumption **0**	Unbilled Metered Consumption	0	**Commercial losses**	**Unaccounted for Water (UFW)**
			Unbilled Unmetered Consumption	0		
	Unauthorized Consumption **93.76** m³/day	Apparent Losses **41.36**	Unauthorized Consumption	0	41.36 m³/day	93.76 m³/day
			Metering Inaccuracies(start flow & under registration)	41.36		
		Real Losses (leakage) **52.40**	Leakage on Transmission and/or Distribution Mains		**Physical losses** 52.40 m³/day	
			Leakage and Overflows at Utility's Storage Tanks			
			Leakage on Service Connections up to point of Customer metering	52.4		

11.6 Action U11 (Conducting leakage detection survey)

The leak detection went through several stages with the acoustic rod and the digital sound detector. When there was a point suspected to have a leak, the UFW team began to use more advanced leak detection equipment such as the leak detector and/or the leak sound correlator to exactly locate the leak on the pipe.

(1) Detection of leaking sound by Acoustic Rod or Digital Sound Detector

The first attempt to detect the leakage in the pipes and the house connection was done using the acoustic rod and the digital sound detector.

When leakage occurs, leaking sound spreads through the pipe. At the point where valves are available, acoustic rod or digital sound detector was useful for detecting the sound. The method of leaking sound detection is shown on Figure 11-1.

Figure 11-1 Detecting Leakage on House Connection by Acoustic Rod

The UFW team has been trained on leak detection by the acoustic rod and the digital leak detector at Mostrod Training Center and OJT at site by assistance of JICA expert team during the activity.

(2) Detection of leaking points by Leak Detector

To detect the leakage on the distribution pipeline, the leak detector was used. The leak detection activity using the leak detector is shown in Figure 11-2. It was helpful to confirm the location of the leakage by night survey to isolate the background noise caused by traffic during daytime.

Figure 11-2 Detection Work by Leak Detector

(3) Results of leak detection

The leak detection survey led to detect 5 leak points in the area. All the detected leaks were on the house connections which were manufactured from lead. The reason for the leaks was due to wrong construction due to bending the pipe bending without using the proper facilities to bend such pipes.

The following Table indicates the summary of the detected leaks and the map indicated the location of these leaks on the GIS map used during the survey

Table 11-4 Summary of Detected Leaks Information

Leakage Record Sheet					
No.	1	2	3	4	5
Date	15-8	15-8	15-8	15-8	15-8
Area	A2	A2	A2	A2	A2
Position	Pipe	Pipe	Pipe	Pipe	Pipe
Condition of leak	Crack	Crack	Crack	Crack	Crack
Diameter of pipe	50	50	50	50	50
Material of leak pipe	lead	Lead	Lead	Lead	Lead
Depth of pipe	70	70	70	70	70
Ground conditions	Soil	Soil	Soil	Soil	Soil
Cause of leak	Det.	Det.	Det.	Det.	Det.
Leakage size	M	M	M	M	M
Leakage quantity	NA	NA	NA	NA	NA

The detected leaks was on the lead pipe that form the house connection and most of the leaks was due to cracks found in the pipe due to deterioration and bending during construction period and then due to water pressure, the crack begins to spread. Most of the leaks were invisible as the ground surface is soil.

The location of detected leaks is shown as following figure.

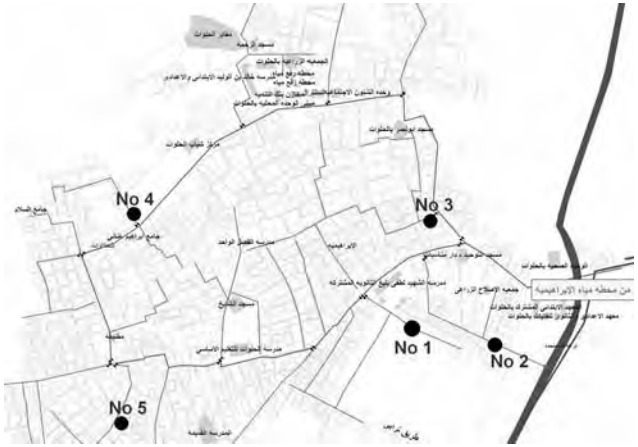


Figure 11-3 Location of detected leaks in Ibrahimia Markz Area-2

11.7 Action U12 (Repairing leakage parts)

Following the leaks had been detected; the repair works takes place by SHAPWASCO equipment and facilities. All the detected leak pipes and house connection has been replaced with PVC pipes with proper fittings.

11.8 Action U13 (Conducting MNF survey after repair works)

In order to confirm the effectiveness of the repairing work (or reduction percentage of leakage ratio), MNF survey was carried out after the repairing work of the leaking parts. In the mean time of the MNF survey, two rounds of meter reading were conducted in the same period. The purpose of collecting meter reading was to measure the billed authorized consumption to be used in the water balance analysis.

A flow meter has been installed at the main inlet pipeline and was allowed to register the flow rate for the whole working days. Two flow meters were used, one each two days to overcome the short lifetime of portable batteries that was used to operate the flow meter.

The following table represents the main findings during the MNF survey after leak detection and repair.

Table 11-5 Status of Water Meters after Repair

Item	unit	Status
Average amount of water registered by flow meter during measurement period	m^3	(470 m^3/day)
Number of read meters	nos	1091
Number of locked meters	nos	85
Number of flat rate connection	nos	58

11.9 Action U14 (Making water balance analysis and its evaluation)

As described in item 11-5 of this report, the water balance analysis is a useful tool to evaluate the UFW ratio. The following data should be known or estimated before making the water balance analysis.

1. Quantity of water entering the study area network 470 m^3/d.
2. Quantity of water leaving the study area network and goes to another network at the boundary of it (Nil).
3. Quantity of billed authorized consumption. This value could be assumed as measured before as the water meter status is the same as the time of measuring the water meters. 390 m^3/d. The volume of billed unmetered water shall be considered as (22 m^3/d)
4. Estimation of the unbilled authorized consumption. (Nil)
5. Meter inaccuracy and error in start flow measurement (the minimum flow rate at which the water meter begin to register the flow amount). This shall be estimated as before the leakage repair.
6. During UFW team survey for the distribution network and the status of the meters, the team did not find customers theft water (i.e. unauthorized consumption).

During the Action U8, it was found that the wastage in houses equal 12 L/hr/meter. It was assumed that this wastage shall be for a period of 3 hours (three hours). In the daytime, the use of the faucets and flush tanks in the toilet make the water meter run for a flow higher than the start flow. This shall make the meter register the total flow passing through it including the wastage flow.

The number of meters that could have a wastage including flat rate connections is 808 meters.
Total amount of wastage per day = 1149 meters x 12L/hr x 3hr/1000= 41 m^3/day

The following table represents the water balance analysis after repair.

Table 11-6 Water balance analysis for Ibrahimia Markz Area-2 after repair (m^3/day)

Water Distributed Volume **470.4** m^3/day	Authorized Consumption **410.23** m^3/day	Billed Authorized Consumption **410.23**	Billed Metered Consumption	404.3	**Water Sold** 410.23 m^3/day	**Revenue Water** 410.23 m^3/day
			Metering error (over registration)	-15.55		
			Billed Unmetered Consumption(fixed amount collected)	21.5		
		Unbilled Authorized Consumption **0**	Unbilled Metered Consumption	0	**Commercial losses**	**Unaccounted for Water (UFW)** 60.17 m^3/day
			Unbilled Unmetered Consumption	0		
	Unauthorized Consumption **60.17** m^3/day	Apparent Losses **41.36**	Unauthorized Consumption	0	41.36 m^3/day	
			Metering Inaccuracies(start flow & under registration)	41.36		
		Real Losses (leakage) **18.81**	Leakage on Transmission and/or Distribution Mains		**Physical losses** 18.81 m^3/day	
			Leakage and Overflows at Utility's Storage Tanks			
			Leakage on Service Connections up to point of Customer metering	18.81		

Summary of UFW activity in Ibrahimia Markaz Area_2 before and after repair activity

Parameter	Unit	Assessment Before Repair	Assessment After Repair	Reduction
Water Distributed	m^3/day	472		---
Customer Consumption	m^3/day	379.84	410.23	---
UFW (by volume)	m^3/day	93.76	60.17	33.59
UFW ratio	%	19.86%	12.75%	7.12%
Leakage (by volume)	m^3/day	52.40	18.81	33.59
Leakage ratio	%	11.10%	3.99%	7.12%

2.4-55

2.5 Formulating Plan for expanding UFW Reduction Activity to other Markaz than the Pilot Project Area

Sharkia Potable Water and Sanitation Company
(SHAPWASCO)

Plan for Expanding UFW Reduction Activity

To the Governorate Level

(Revision-0)

14th June 2009

SHAPWASCO Counterpart Team

Yachiyo Engineering Co., Ltd.
(JICA Expert Team)

2.5-1

Plan for Expanding UFW Reduction Activity to the Governorate Level (Revision-0)

Through the Project for Improvement of Management Capacity of Operation and Maintenance for SHAPWASCO (hereinafter referred to as "the Project" under the Japan technical cooperation by JICA, UFW reduction technique has been transferred to the SHAPWASCO staff by the Japanese expert team from November 2006 to October 2009.

However, in order to achieve the overall goal as "Maintenance capacity of operation and maintenance of water supply facilities is improved in Sharkia Governorate", SHAPWASCO is required to expand their activity to the Governorate level by carrying out the following:

- Establishing UFW department
- Recruiting necessary staff for UFW department
- Procuring necessary leakage survey equipment
- Setting out a practicable methodology for UFW reduction activity

JICA expert team and C/P team conducted capacity assessment survey of following 16 UFW teams (SHAPWASCO headquarters (HQ) and branch offices). The survey results are shown in **Annex-1** and **Annex-3**. As shown in **Annex-1**, more than half of the UFW team members are over 50 years old. Therefore, recruiting young staff less than 30 years old is considered one of the key issues of SHAPWASCO.

1. Headquarter
2. Zagazig East
3. Zagazig West
4. Zagazig Markaz
5. El Huseinia Markaz
6. Awlad Saqr Markaz
7. Faqus Markaz
8. Kafr Saqr Markaz
9. Abu Kabier Markaz
10. Diarb Nigm Markaz
11. Ibrahimiya Markaz
12. Hihya Markaz
13. Abu Hamad Markaz
14. Bilbais Markaz
15. Menia Alqamah Markaz
16. Mashtool El Sooq Markaz

1. Establishment of UFW Department

1-1 Organization and Tasks of UFW Department

1-1-1 Organization of UFW Department

UFW department will be composed of HQ team and 16 branch teams ant the number of employees will become 105. The organization of the department is proposed as shown in Figure-1.

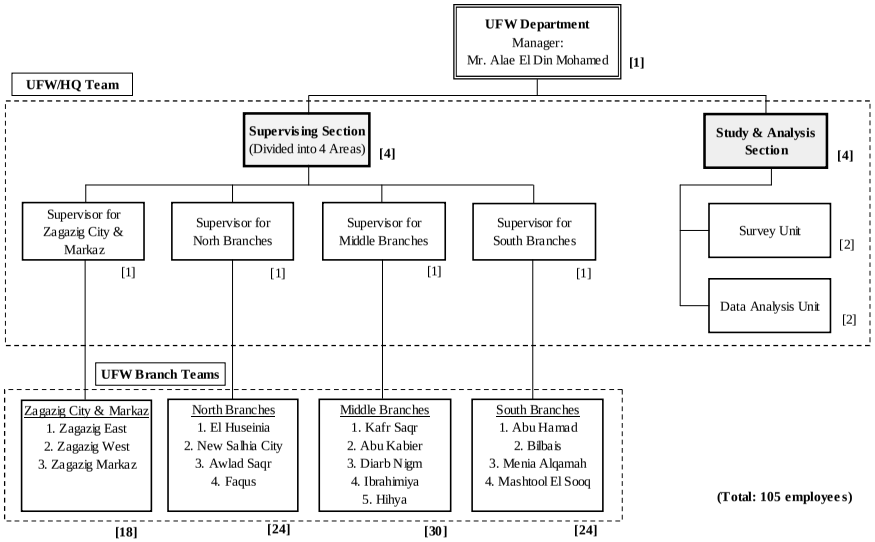


Figure-1 Proposed Organization Chart for UFW Department of SHAPWASCO

1-1-2 Organization of UFW/HQ Team

UFW/HQ team shall be composed of the following members:

- Head of UFW/HQ team: 1 (Head of UFW Department)
- Supervisor for UFW branch teams: 1 x 4 areas＝4
- Study & data analysis: 4

The organization of UFW/HQ team is proposed in Figure-2.

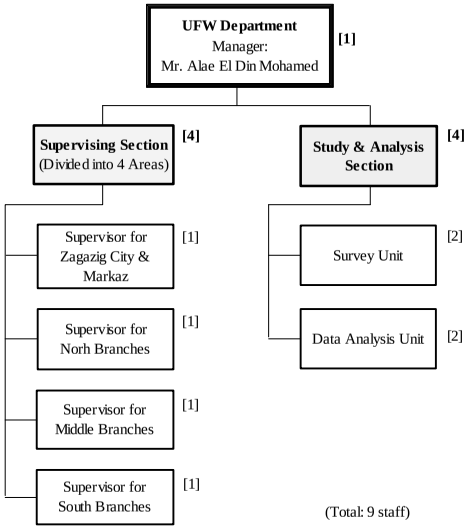


Figure-1 Proposed Organization of UFW/HQ Team of SHAPWASCO

1-1-2 Tasks for UFW/HQ Team

Tasks for UFW/HQ team are as follows:

(1) Formulating action plan for UFW reduction activity
(2) Preparing program for training UFW branch members
(3) Preparing training schedule and conducting training to UFW branch members
(4) Formulating a plan for District Metered Area (DMA) and conducting supervision of UFW reduction activity for DMAs
(5) Analyzing leakage survey results and examining countermeasures for leakage prevention
(6) Preparing a plan for recruiting UFW members
(7) Conducting procurement and maintenance of leakage survey equipment (including repairs and regular check-up)
(8) Preparing an annual budgetary plan for UFW Department (HQ team and branch teams)

For the tasks mentioned above, the roles of UFW/HQ team members are as shown in Table-1.

Table-1 Tasks and Roles of UFW/HQ Team Members

No.	Task	Head of UFW/HQ Team	Supervisor for Branch Teams	Study & Analysis Section
(1)	Formulating action plan for UFW reduction activity	○		
(2)	Preparing program for training UFW branch members	○		
(3)	Preparing training schedule and conducting training to UFW branch members	○	△	△
(4)	Formulating a plan for DMA and conducting supervision of UFW reduction activity for DMAs	△	○	△
(5)	Analyzing leakage survey results and examining countermeasures for leakage prevention	△		○
(6)	Preparing a plan for recruiting UFW members	○		
(7)	Conducting procurement and maintenance of leakage survey equipment (including repairs and regular check-up)	△	○	
(8)	Preparing an annual budgetary plan for UFW Department	○		

Note: ○: Main task, △: Assisting other staff's task

1-1-3 Job Description of UFW/HQ Team

(1) Formulating action plan for UFW reduction activity

UFW/HQ team shall formulate an annual budgetary plan for UFW reduction activity of UFW department. This plan shall include an action plan prepared by each UFW branch team. The action plan shall include at least the following items:

- Target areas
- GIS drawing of DMA for the target areas
- Leakage survey schedule for DMAs

(2) Preparing training program for UFW branch team members

The contents of the program for training are as follows:

[Class Room Training]

- Meaning of UFW reduction activity
- Leakage survey method such as Minimum Night Flow (MNF) survey, leak detection survey, etc.
- Outline of leakage survey equipment
- Evaluation of leakage survey results
- Explanation and distribution of SOP for leakage survey prepared in the project

[OJT at Hihya Training Center]

- Method of MNF survey
- Leak detection survey

(3) Preparing training schedule and conducting training of UFW branch members

UFW/HQ team shall prepare an annual training plan for UFW branch teams and conduct training according to the training plan by means of the training program

(4) Formulating a plan for DMA and conducting supervision of UFW reduction activity for DMAs

UFW/HQ team has a responsibility of the following:

- Designing DMA
- Monitoring of distributed volume at DMA
- Analyzing causes of unusual results, if any
- Giving advices to UFW branch team for leakage survey
- Supervising leakage survey by UFW branch team

(5) Analyzing leakage survey results and examining countermeasures for leakage prevention

- Analyzing results of leakage survey by preparing water balance analysis sheet
- Giving guidance for countermeasures for leakage prevention

(6) Recruit Plan for new staff of UFW Department (HQ team and branch teams)

In order to realize continuous activity for UFW reduction, two (2) new members less than 30 years old shall be employed from 2009 to 2011 for each UFW team. The recruiting plan is shown in **Annex-1**.

(7) Procurement and maintenance of leakage survey equipment

UFW/HQ team has following responsibility for leakage survey equipment:

- Conducting regular check-up for leakage survey equipment
- Conducting control for spare parts of the equipment (checking inventory stock, preparing list of the required quantity to be procured)
- Taking necessary action for repairing the equipment when it has become out of order

(8) Preparing an annual budgetary plan for UFW Department

UFW/HQ team has following responsibility for budgetary plan:

- Preparing annual budgetary plan for UFW Department including the following cost:
  - Operation cost for UFW/HQ team (personnel cost, fuel cost, training cost, maintenance cost of Hihya training center, etc.)
  - Operation cost for UFW branch teams (personnel cost, repairing leakage cost, etc.)

1-2 Organization and Tasks of UFW Branch Teams

1-2-1 Organization of UFW Branch Teams

UFW branch teams shall be composed of the following members:

- Head of UFW branch team: 1
- Engineer/technician: 3
- Worker: 2

Organization of UFW branch team is shown in Figure-2.

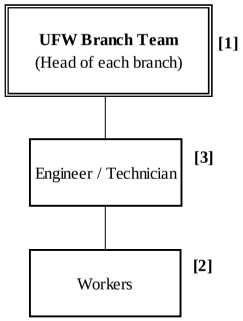


Figure-2 Organization of UFW Branch Team of SHAPWASCO

1-2-2 Tasks of UFW Branch Team

Tasks for UFW branch team are as follows:

- Determining DMAs in water distribution areas through consultation with HQ team
- Conducting leakage survey according to the action plan for UFW reduction activity for DMAs
- Conducting leakage detection survey for the DMAs where the current UFW is over the allowable level
- Repairing leaking points or replacing with new piping materials, if necessary
- Monitoring measured flow at flow meter of DMA
- Reporting the results of the above works to HQ at a regular basis

2. Recruiting Plan for UFW Department Staff

Recruiting plan for UFW department staff (HQ team and branch teams) up to 2020 is shown in **Annex-1**. In formulating the plan, following points have been taken into account:

- For the coming three (3) years from 2009 to 2011, two (2) young staff less than 30 years old shall be employed for HQ team and each branch team.
- Since more than a half of the current team members are over 50 years old, recruited young staff shall be trained within a year and these young staff shall be replaced with the aged staff.

3. Procurement Plan for Leakage Survey Equipment

Leakage survey equipments to be procured by SHAPWASCO for the coming three (3) years are shown in Annex-2. In formulating the plan, following points have been taken into account:

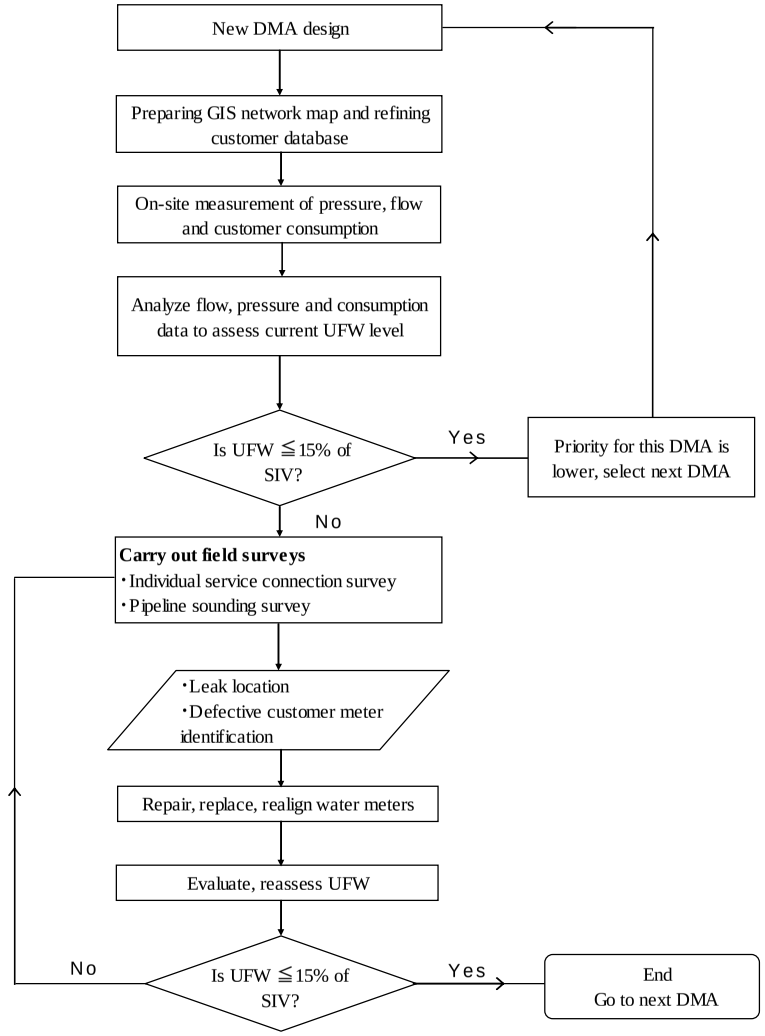
- For Zagazig East, Zagazig West and Zagazig Markaz teams, leakage survey equipments procured under the project shall be utilized.
- For the daily activity by HQ team, vehicles for operation of the team and supervision of branch teams are required and included in the plan.
- Since potable ultrasonic flow meter for large diameters are not so frequently used in the activity, only sensor shall be procured.
- For water pressure recorder, digital type shall be procured.

4. Establishment of Methodology for Practicable UFW Reduction Activity

In order to conduct UFW reduction activity efficiently and practicably, the activity shall be focused on the areas having a relatively high UFW ratio. For this purpose, District Metered Areas (DMA) shall firstly be prepared.

After determining DMAs, MNF survey shall be conducted for the selected DMAs to confirm the current situation of the leakage ratio. Then, the current UFW ratio shall be compared with the allowable level (15%) obtained from the pilot projects in the Project. If the current UFW ratio is more than the allowable level, the DMA shall be considered as the target area for conducting leakage survey.

The method mentioned above is explained by flow chart in Figure-3.



SIV = System Input Volume (or Distribution Volume)

Figure-3 Flow Chart for Practicable UFW Reduction Activity

Annex-1

Recruiting Plan for UFW Department Staff

Area	Team		No. of Staff	Age (as of Jan. 2009)					Year and Number of Recruiting Staff											Total
				<40	40-44	45-49	50-54	55-59	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
HQ	HQ	Current	3	2			1														
		Reserve*[1]	0																		
		To be recruited	1						2							1					3
Zagazig City & Markaz	Zagazig East	Current	4		2	1	1														
		Reserve	4				1	3													
		To be recruited	1						2									1			3
	Zagazig West	Current	4			2	2														
		Reserve	4			1	3														
		To be recruited	0						2												2
	Zagazig Markaz	Current	4			2	2														
		Reserve	4			4															
		To be recruited	1						2										1		3
North Branches	El Huseinia	Current	4			2	2														
		Reserve	4			1	3														
		To be recruited	2						2										2		4
	New Salhia City	Current	0																		
		Reserve	0																		
		To be recruited	0						4												4
	Awlad Saqr	Current	4			3	1														
		Reserve	4			3	1														
		To be recruited	0						2												2
	Faqus	Current	4			3	1														
		Reserve	4			4															
		To be recruited	0						2												2
Middle Branches	Kafr Saqr	Current	4			2	1	1													
		Reserve	4		1	1	2														
		To be recruited	2							2											2
	Abu Kabier	Current	4			2	2														
		Reserve	4		1	1	2														
		To be recruited	4							2									1	1	4
	Diarb Nigm	Current	4				3	1													
		Reserve	4			2	2														
		To be recruited	4							2						2					4
	Ibrahimiya	Current	4		1		1	2													
		Reserve	3			1	2														
		To be recruited	3							2			1								3
	Hihya	Current	3		1		1	1													
		Reserve	3			1	2														
		To be recruited	3							2								1			3
South Branches	Abu Hamad	Current	4			1	1	2													
		Reserve	4			3	1														
		To be recruited	3								2			1							3
	Bilbais	Current	4			2	2														
		Reserve	2			1	1														
		To be recruited	4								2								1	1	4
	Menia Alqamah	Current	4			1	1	2													
		Reserve	5			3	2														
		To be recruited	3								2								1		3
	Mashtool El Sooq	Current	4			2	2														
		Reserve	2			1	1														
		To be recruited	3								2								1		3
Total		Current	62	2	4	23	24	9													
		Reserve	55	0	2	27	23	3													
Total Number of Staff to be Recruited			52						18	10	8	0	1	1	0	3	0	2	7	2	52

Notes:
1. From 2009 to 20011, two (2) young members who are less than 30 years old shall be recruited for the UFW team of each branch.
2. Reserve members have been nominated from the current network section of each branch and they are supposed to assist UFW team in case that some of the team member can not work for the required task for any reasons.
3. Reserve members are also required to assist UFW team until recruit staff has got required skills for UFW reduction activity.
4. Staff shall be recruited when the staff becomes 59 years old that is one year before his retirement.
5. Two (2) workers are require for each UFW team and not included in this recruiting plan.

Annex-2

Equipment Purchasing Plan for UFW Teams

Area	UFW Team	Quantity and Price of Leakage Survey Equipment										Total Price (LE)	Purchasing Schedule		
		1. WLD	2. AR	3. PUM-L	4. PUM-S	5. WPR	6. PCL	7. ML	8. LD	9. CED	10. CTC		2009	2010	2011
		22,200	1,000	3,400	43,500	6,600	35,700	8,300	125,000	150,000	100,000				
HQ		1	1	1		2		1	1		1	273,100	▩		
Zagazig City & Markaz	Zagazig East	Equipment No.1 to 9 provided in the project shall be used.								1		150,000	▩		
	Zagazig West	Equipment No.1 to 9 provided in the project shall be used.													
	Zagazig Markaz	Equipment No.1 to 9 provided in the project shall be used.													
North Branches	Huseinia Markaz	1	2	1	2	2	1	1	1	1		446,800	▩		
	New Salhia	1	2	1	2	2	1	1	1			296,800	▩		
	Awlad Saqr	1	2	1	2	2	1	1	1			296,800	▩		
	Faqus	1	2	1	2	2	1	1	1			296,800	▩		
Middle Branches	Kafr Saqr	1	2	1	2	2	1	1	1	1		446,800		▩	
	Abu Kabier	1	2	1	2	2	1	1	1			296,800		▩	
	Diarb Nigm	1	2	1	2	2	1	1	1			296,800		▩	
	Ibrahimiya	1	2	1	2	2	1	1	1			296,800		▩	
	Hihya	1	2	1	2	2	1	1	1			296,800		▩	
South Branches	Abu Hamad	1	2	1	2	2	1	1	1	1		446,800			▩
	Bilbais	1	2	1	2	2	1	1	1			296,800			▩
	Menia Alqamah	1	2	1	2	2	1	1	1			296,800			▩
	Mashtool El Sooq	1	2	1	2	2	1	1	1			296,800			▩
Hihya Training Center		1	1		1		1	1	1			235,700	▩		
Total Quantity (pcs)		15	28	14	27	28	14	15	15	4	1				
Total Price (LE)		333,000	28,000	47,600	1,174,500	184,800	499,800	124,500	1,875,000	600,000	100,000	4,967,200	1,996,000	1,634,000	1,337,200

[Equipment List]

1. WLD Water leak detector
2. AR Accoustic rod
3. PUM-L Portable ultrasonic FM (sensor only for large dia.)
4. PUM-S Portable ultrasonic FM (small dia.)
5. WPR Water pressure recorder (digital type)
6. PCL Pipe and cable locator
7. ML Metal locator
8. LD Leak sound detector (Corelator)
9. CED Car for equipment delivery and supervision activity
10. CTC Car for training center (6 to 8 persons)

No.1 Headquarter

Capacity Assessment Survey for UFW Team Members of SHAPWASCO

Markaz/City: Head Quarter (No.1) Date of Survey: 12/1/2009

List of UFW Team Member

No.	Item	1	2	3	4	5
1	Name	Alae El Din Mohamed	Wala Mohamed Ali	Wala Hamdi	Tamer Kamel	
2	Age	53	24	24	27	
3	Educational background	Mechanical Engineer- Faculty of Engineering	Civil Engineer – Faculty of Engineering	Civil Engineer – Faculty of Engineering	Electrical Engineer - Faculty of Engineering	
4	Job category (eng. or technician)	Head of UFW C/P Team	Member of UFW C/P Team	Member of UFW C/P Team	Member of UFW C/P Team	
5	Working years in Water Sector	20 years	1.5 years	1.5 years	1 year	
6	Section or Department	SHAPWASCO Head Quarter	SHAPWASCO Head Quarter	SHAPWASCO Head Quarter	SHAPWASCO Head Quarter	
7	Experience of UFW activity	All Activities	All Activities	All Activities	All Activities	
8	UFW workshop or training	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	

Note:
Head of Sector: Dr. Salah Bayoumi

Annex-3 Capacity Assessment of UFW Team Members

No.2 Zagazig East

Capacity Assessment Survey for UFW Team Members of SHAPWASCO

Markaz/City: Zagazig East (No.2) Date of Survey: 6/1/2009

List of UFW Team Member

No.	Item	1	2	3	4	5
1	Name	Salama Mohamed Abd El Aal	Mohamed Mohamed Bakr	Medhat Mounir Mahmoud	Mohamed Hafez Lotfy	
2	Age	50	43	44	46	
3	Educational background	Assistant Engineer Technical High School	Assistant Engineer Technical High School	Assistant Engineer Technical High School	Assistant Engineer Technical High School	
4	Job category (eng. or technician)	Head of Zagazig City Water Networks	Supervisor of Zagazig City Water Networks	Supervisor of Zagazig City Water Networks	Head of Zagazig East Water Networks	
5	Working years in Water Sector	26 years	15 years	16 years	24 years	
6	Section or Department	Water Department	Water Department	Water Department	Water Department	
7	Experience of UFW activity	All Activities	All Activities	All Activities	All Activities	
8	UFW workshop or training	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	

Note:
Head of Sector: Mr. Ibrahim Abd El Hameed

Annex-3 Capacity Assessment of UFW Team Members

No.3 Zagazig West

Capacity Assessment Survey for UFW Team Members of SHAPWASCO

Markaz/City: Zagazig West (No.3) Date of Survey: 6/1/2009

List of UFW Team Member

No.	Item	1	2	3	4	5
1	Name	Samir Mohmoud Abd El Hameed	Mahmoud Mohamed El Hariry	Nabil Fathy El Sayed	George Abd El Maseeh	
2	Age	45	45	52	51	
3	Educational background	Assistant Engineer Technical High School	Assistant Engineer Technical High School	Assistant Engineer Technical High School	Assistant Engineer Technical High School	
4	Job category (eng. or technician)	Head of Zagazig West Water Networks	Supervisor of Zagazig City Water networks	Supervisor of Zagazig City Water networks	Supervisor of Zagazig City Water Networks	
5	Working years in Water Sector	20 years	18 years	30 years	24 years	
6	Section or Department	Zagazig City Water Networks	Zagazig City Water Networks	Zagazig City Water Networks	Zagazig City Water Networks	
7	Experience of UFW activity	All Activities	All Activities	All Activities	All Activities	
8	UFW workshop or training	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	

Note:
Head of Sector: Mr. Ibrahim Abd El Hameed

Annex-3 Capacity Assessment of UFW Team Members

No.4 Zagazig Markaz

Capacity Assessment Survey for UFW Team Members of SHAPWASCO

Markaz/City: Zagazig Markaz (No.4) Date of Survey: 6/1/2009

List of UFW Team Member

No.	Item	1	2	3	4	5
1	Name	Asma'a Mohamed Farag	Mohamed Mohamed Sabry	El Sayed Farag Ahmed	Ibrahim Bayoumi Mohamed	
2	Age	51	50	49	47	
3	Educational background	Mechanical Engineer- Faculty of Engineering	Assistant Engineer Technical High School	Assistant Engineer Technical High School	Assistant Engineer Technical High School	
4	Job category (eng. or technician)	Head of Zagazig Markaz Water Department	Head of Zagazig Markaz Water Networks	Supervisor of Zagazig Markaz Water Networks	Supervisor of Zagazig Markaz Water Networks	
5	Working years in Water Sector	22years	25 years	13 years	21 years	
6	Section or Department	Water Department	Water Networks	Water Networks	Water Networks	
7	Experience of UFW activity	All Activities	All Activities	All Activities	All Activities	
8	UFW workshop or training	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	

Note:
Head of Sector: Mr. Mohamed Hassan Attia

Annex-3 Capacity Assessment of UFW Team Members

No.5 El Huseinia

Capacity Assessment Survey for UFW Team Members of SHAPWASCO

Markaz/City: El Huseinia (No.5) Date of Survey: 21/1/2009

List of UFW Team Member

No.	Item	1	2	3	4	5
1	Name	Salah Abd El Haq	Mohamed Abd El Moneam Hashem	El Sayed Ibrahim Ali	Mohamed Abd Ala Mohamed	
2	Age	50	49	54	49	
3	Educational background	Mechanical Engineer- Faculty of Engineering	Assistant Engineer Technical High School	Assistant Engineer Technical High School	Assistant Engineer Technical High School	
4	Job category (eng. or technician)	Head of Water Department	Supervisor of Water Networks	Supervisor water Networks	Supervisor Water Networks	
5	Working years in Water Sector	19 years	17 years	29 years	22 years	
6	Section or Department	Water Department	Water Networks	Water Networks	Water Networks	
7	Experience of UFW activity	All Activities	All Activities	All Activities	All Activities	
8	UFW workshop or training	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	

Note:
Head of Sector: Mr. Abd El Hady Ghaith

Annex-3 Capacity Assessment of UFW Team Members

No.6 Awlad Saqr

Capacity Assessment Survey for UFW Team Members of SHAPWASCO

Markaz/City: Awlad Saqr Markaz (No.6) Date of Survey: December 1, 2008

List of UFW Team Member

No.	Item	1	2	3	4	5
1	Name	Mr. Emad Ahmed Abd El Kader	Mr. Bendary hassan El Adawi	Mr. Hegazy El Sayed Ali	Mr. Saeed Abd El Salam	
2	Age	48 years	47 years	47 years	52 years	
3	Educational background	Faculty of Engineering	Assistant Engineer Technical High School	Assistant Engineer Technical High School	Assistant Engineer Technical High School	
4	Job category (eng. or technician)	Manger of Water Networks	Assistant Engineer. Head of City Water Network	Assistant Engineer. Supervisor of Water Network	Assistant Engineer. Supervisor of Water Network	
5	Working years in Water Sector	17 Years	21Years	14 Years	14 Years	
6	Section or Department	Water Department	Water Department	Water Department	Water Department	
7	Experience of UFW activity	Yes, Hihya	Yes, Zagazig City & Hihya			
8	UFW workshop or training	Attend workshops held by JICA-Expert Team.	Attend workshops held by JICA-Expert Team.			

Note:
Head of Awlad Saqr Sector: Mr. Thrwat Abd El Fatah

Annex-3 Capacity Assessment of UFW Team Members

No.7 Faqus

Capacity Assessment Survey for UFW Team Members of SHAPWASCO

Markaz/City: Faqus (No.7) Date of Survey: 13/1/2009

List of UFW Team Member

No.	Item	1	2	3	4	5
1	Name	Sebaey Mohamed Rabee	Mostafa Mohamed Mousabah	El Sayed Abd El Aziz Soliman	Salah El Dien Abbas	
2	Age	51	47	45	48	
3	Educational background	Mechanical Engineer- Faculty of Engineering	Assistant Engineer Technical High School	Assistant Engineer Technical High School	Assistant Engineer Technical High School	
4	Job category (eng. or technician)	Head of Water Networks	Supervisor of Water Networks	Supervisor water Networks	Supervisor Water Networks	
5	Working years in Water Sector	21 years	21 years	15 years	22 years	
6	Section or Department	Water Department	Water Networks	Water Networks	Water Networks	
7	Experience of UFW activity	All Activities	All Activities	All Activities	All Activities	
8	UFW workshop or training	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	

Note:
Head of Sector: Mr. Mohamed Abd El Hameed Nafe'a

Annex-3 Capacity Assessment of UFW Team Members

No.8 Kafr Saqr

Capacity Assessment Survey for UFW Team Members of SHAPWASCO

Markaz/City: Kafr Saqr (No.8) Date of Survey: 20/1/2009

List of UFW Team Member

No.	Item	1	2	3	4	5
1	Name	Fahmy Mohamed Khalf Allah	Mohamed Ibrahim Mohamed	Mohamed Awad Abd Allah	Osman Mansour Mohamed	
2	Age	55	46	47	52	
3	Educational background	Assistant Engineer Technical High School	Assistant Engineer Technical High School	Assistant Engineer Technical High School	Assistant Engineer Technical High School	
4	Job category (eng. or technician)	Head of Water Networks	Supervisor of Water Networks	Supervisor of water Networks	Supervisor of Water Networks	
5	Working years in Water Sector	25 years	22 years	19 years	25 years	
6	Section or Department	Water Department	Water Networks	Water Networks	Water Networks	
7	Experience of UFW activity	All Activities	All Activities	All Activities	No	
8	UFW workshop or training	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	No	

Note:
Head of Sector: Mr. Mohamed El Sayed Abd El Kader

Annex-3 Capacity Assessment of UFW Team Members

No.9 Abu Kabier

Capacity Assessment Survey for UFW Team Members of SHAPWASCO

Markaz/City: Abu Kabeir Markaz (No.9) Date of Survey: December 1, 2008

List of UFW Team Member

No.	Item	1	2	3	4	5
1	Name	Mr. El Sayed Abd El Raheem	Mr. Abd El Wahab Mohamed Ali	Mr. Mahrous Gergis Romees	Mr. Mahmoud Mohamed Gebaly	
2	Age	49 years	54 years	48 years	53 years	
3	Educational background	Engineer- Faculty of Engineering	Assistant Engineer Technical High School	Assistant Engineer Technical High School	Assistant Engineer Technical High School	
4	Job category (eng. or technician)	Manger of Water Networks Section	Assistant Engineer. Head of Water Network at Markaz	Assistant Engineer. Supervisor of Water Network	Assistant Engineer. Supervisor of Water Network	
5	Working years in Water Sector	16 Years	32 Years	26 Years	29 Years	
6	Section or Department	Water Department	Water Department	Water Department	Water Department	
7	Experience of UFW activity	Yes, Zagazig City	Yes, Zagazig City & Hihya	Yes, Zagazig City	Yes, Zagazig City	
8	UFW workshop or training	Attend workshops held by JICA-Expert Team.	Attend workshops held by JICA-Expert Team.	Attend workshops held by JICA-Expert Team.	Attend workshops held by JICA-Expert Team.	

Note:
Head of Abu Kabeir Sector: Mr. Ahmed El Sayed Labouta

Annex-3 Capacity Assessment of UFW Team Members

No.10 Diarb Nigm

Capacity Assessment Survey for UFW Team Members of SHAPWASCO

Markaz/City: Diarb Nigm (No.10) Date of Survey: 12/1/2009

List of UFW Team Member

No.	Item	1	2	3	4	5
1	Name	Hamdi El Sayed Abd El Fatah Sharaf	Khairy Abd El Motelb Mohamed	Mohamed El Sayed El Killany	Mohamed Megahed Abd El Aziz	
2	Age	52	52	54	57	
3	Educational background	Mechanical Engineer- Faculty of Engineering	Assistant Engineer Technical High School	Assistant Engineer Technical High School	Assistant Engineer Technical High School	
4	Job category (eng. or technician)	Manger Water Department	Head of Diarb Nigm City Water Networks	Supervisor water Networks	Supervisor of Water Networks	
5	Working years in Water Sector	30 years	31 years	31 years	36 years	
6	Section or Department	Water Department	Water Networks	Water Networks	Water Networks	
7	Experience of UFW activity	All Activities	All Activities	All Activities	All Activities	
8	UFW workshop or training	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	

Note:

Head of Sector: Mr. Adel Salah Sadek

Annex-3 Capacity Assessment of UFW Team Members

No.11 Ibrahimiya

Capacity Assessment Survey for UFW Team Members of SHAPWASCO

Markaz/City: Ibrahimuia (No.11) Date of Survey: 13/1/2009

List of UFW Team Member

No.	Item	1	2	3	4	5
1	Name	Abd Allah Abd El Mageed	Samir Mohamed Ahmed Farag	Ramadan Abd Allah Hassan	Mohamed Ragab Assar	
2	Age	58	55	40		
3	Educational background	Assistant Engineer Technical High School	Assistant Engineer Technical High School	Assistant Engineer Technical High School	Assistant Engineer Technical High School	
4	Job category (eng. or technician)	Head of Water Networks	Supervisor of Water Networks	Supervisor of water Networks	Supervisor of Water Networks	
5	Working years in Water Sector	21 years	20 years	20 years	20 years	
6	Section or Department	Water Department	Water Networks	Water Networks	Water Networks	
7	Experience of UFW activity	All Activities	All Activities	All Activities	No	
8	UFW workshop or training	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	No	

Note:

Head of Sector: Mr. Roshdy El Nagar

Annex-3 Capacity Assessment of UFW Team Members

No.12 Hihya

Capacity Assessment Survey for UFW Team Members of SHAPWASCO

Markaz/City: Hihya (No.12) Date of Survey: 5/1/2009

List of UFW Team Member

No.	Item	1	2	3	4	5
1	Name	Mahdy Fathy Ahmed	Gamal Mohamed Hussein	El Hady Fathy Ahmed		
2	Age	50	57	44		
3	Educational background	Engineer – Faculty of Engineering	Assistant Engineer Technical High School	Assistant Engineer Technical High School		
4	Job category (eng. or technician)	Manger of Water Department	Supervisor of Water Networks	Supervisor of Water Networks		
5	Working years in Water Sector	18 years	20 years	15 years		
6	Section or Department	Water Department	Water Department	Water Department		
7	Experience of UFW activity	All Activities	All Activities	All Activities		
8	UFW workshop or training	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team		

Note:
Head of Sector: Mr. El Shahat Hosny Akel

Annex-3 Capacity Assessment of UFW Team Members

No.13 Abu Hamad

Capacity Assessment Survey for UFW Team Members of SHAPWASCO

Markaz/City: Abu Hamad Markaz (No.13) Date of Survey: May 27, 2008

List of UFW Team Member

No.	Item	1	2	3	4	5
1	Name	Mr. Mostafa Abd Allah Ghanaiem	Mr. Taher Mansour Metwaly	Mr. Mohamed Mahmoud Radwan	Mr. Youssry Abd El Monem Hassan	
2	Age	57	47	55		
3	Educational background	Faculty of Engineering	Assistant Engineer Technical High School	Assistant Engineer. Technical High School	Assistant Engineer. Technical High School	
4	Job category (eng. or technician)	Manger of Water Department	Head of Water Network in Abu Hamad Markaz	Supervisor of Water Network in Abu Hamad Markaz	Supervisor of Water Network in Abu Hamad Markaz	
5	Working years in SHAPWASCO	12 Years	12 Years	12 Years	12 Years	
6	Section or Department	Water Department	Water Department	Water Department	Water Department	
7	Experience of UFW activity	No	No	No	No	
8	UFW workshop or training	Attend workshops held by JICA-Expert Team.	Attend workshops held by JICA-Expert Team.	Attend workshops held by JICA-Expert Team.	Attend workshops held by JICA-Expert Team.	

Note:
Head of Abu Hamad Sector: Mr. Farouk Basha

Annex-3 Capacity Assessment of UFW Team Members

No.14 Bilais

Capacity Assessment Survey for UFW Team Members of SHAPWASCO

Markaz/City: Bilbais Markaz (No.14) Date of Survey: May 27, 2008

List of UFW Team Member

No.	Item	1	2	3	4	5
1	Name	Mr. Bendary Abd El Kader Sharawy	Mr. Reda Abd El Hameed Abd Allah	Mr. Salah Mohamed Kamel	Mr. Mahmoud El Sayed El Killany	
2	Age	54	48	52	49	
3	Educational background	Assistant Engineer Technical High School	Assistant Engineer Technical High School	Assistant Engineer Technical High School	Assistant Engineer Technical High School	
4	Job category (eng. or technician)	Manger of Belbais Water Networks	Supervisor of Water Networks	Supervisor of Water Networks	Supervisor of Water Networks	
5	Working years in SHAPWASCO	12 Years	12 Years	12 Years	12 Years	
6	Section or Department	Water Department	Water Department	Water Department	Water Department	
7	Experience of UFW activity	No	All Activities	All Activities	All Activities	
8	UFW workshop or training	Attend workshops held by JICA-Expert Team	Attend workshops held by JICA-Expert Team	Attend workshops held by JICA-Expert Team	Attend workshops held by JICA-Expert Team	

Note:
Head of Belbais Sector: Mr. Hassan Elaiwa

Annex-3 Capacity Assessment of UFW Team Members

No.15 Menia Alqamah

Capacity Assessment Survey for UFW Team Members of SHAPWASCO

Markaz/City: Menia Alqamah Markaz (No.15) Date of Survey: May 29, 2008

List of UFW Team Member

No.	Item	1	2	3	4	5
1	Name	Mr. Mohamed Abd El Wahab	Mr. Adel Mohamed Saleh	Mr. Ibrahim Fatehy El Sadany	Mr. El Sayed Hashem El Emary	
2	Age	54	55	47	50	
3	Educational background	Engineer –Faculty of Engineering	Assistant Engineer Technical High School	Assistant Engineer Technical High School	Assistant Engineer Technical High School	
4	Job category (eng. or technician)	Manger of Menia Alqamah Water Department	Manger of Menia Al qamah City Water Networks	Manger of Melames Water Networks	Manger of Shalshlamon Water Networks	
5	Working years in SHAPWASCO	25 Years	12 Years	12 Years	12 Years	
6	Section or Department	Water Department	Water Department	Water Department	Water Department	
7	Experience of UFW activity	No	All Activities	All Activities	All Activities	
8	UFW workshop or training	No	Attend workshops held by JICA-Expert Team	Attend workshops held by JICA-Expert Team	Attend workshops held by JICA-Expert Team	

Note:
Manger of Menia Al qamah Sector: Mr. Fatehy Ameen

Annex-3 Capacity Assessment of UFW Team Members

No.16 Mashtool El Sooq

Capacity Assessment Survey for UFW Team Members of SHAPWASCO

Markaz/City: Mashtool El Sooq (No.16) Date of Survey: 13/1/2009

List of UFW Team Member

No.	Item	1	2	3	4	5
1	Name	Saeed Abd El Rahman Hefny	Mohamed Ahmed Ali Hozayen	Abd El Baset Mostafa Mohamed	Soliman Hassan Soliman	
2	Age	53	49	52	44	
3	Educational background	Mechanical Engineer- Faculty of Engineering	Assistant Engineer Technical High School	Assistant Engineer Technical High School	Assistant Engineer Technical High School	
4	Job category (eng. or technician)	Manger of Water Networks	Head of Mashtool El Sooq City Water Networks	Supervisor water Networks	Supervisor Water Networks	
5	Working years in Water Sector	23years	24 years	29 years	15 years	
6	Section or Department	Water Department	Water Networks	Water Networks	Water Networks	
7	Experience of UFW activity	All Activities	All Activities	All Activities	All Activities	
8	UFW workshop or training	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	Attend workshops held by JICA – Expert Team	

Note:
Head of Sector: Mr. Ezat El Sayed Khalil

Annex-3 Capacity Assessment of UFW Team Members

2.6 Setting of Performance Indicator for UFW Reduction Activity

Long-Term UFW Targets for SHAPWASCO

Year	UFW Team	No. of UFW Reduction Activity Site	Service Population in Activity Site	Total Service Population in Activity Site (accumulated)	Total Population in Governorate	Total Distributed Water for SHAPWASCO (m3/Year)	Water distributed per person per year (m3/cap./year)	Distributed Water in Activity Site (m3/year)	Reduction of UFW by volume (m3/year)	Accumulation of UFW Reduction (m3/year)	UFW after Activity (%)	Long Term Target (%)	Remark
2009	3	12	86,400	86,400	5,700,000	246,000,000	43.158	3,728,842	454,919	454,919	30.82		
2010	5	20	144,000	230,400	5,814,000	250,920,000	43.158	6,214,737	758,198	1,213,117	30.52		
2011	10	40	288,000	518,400	5,930,280	255,938,400	43.158	12,429,474	1,516,396	2,729,512	29.93		
2012	15	60	432,000	950,400	6,048,886	261,057,168	43.158	18,644,211	2,274,594	5,004,106	29.08		
2013	15	60	432,000	1,382,400	6,169,863	266,278,311	43.158	18,644,211	2,274,594	7,278,700	28.27		
2014	15	60	432,000	1,814,400	6,293,261	271,603,878	43.158	18,644,211	2,274,594	9,553,293	27.48		
2015	15	60	432,000	2,246,400	6,419,126	277,035,955	43.158	18,644,211	2,274,594	11,827,887	26.73	**27.0**	
2016	15	60	432,000	2,678,400	6,547,508	282,576,674	43.158	18,644,211	2,274,594	14,102,481	26.01		
2017	15	60	432,000	3,110,400	6,678,458	288,228,208	43.158	18,644,211	2,274,594	16,377,075	25.32		
2018	15	60	432,000	3,542,400	6,812,028	293,992,772	43.158	18,644,211	2,274,594	18,651,668	24.66		
2019	15	60	432,000	3,974,400	6,948,268	299,872,627	43.158	18,644,211	2,274,594	20,926,262	24.02		
2020	15	60	432,000	4,406,400	7,087,234	305,870,080	43.158	18,644,211	2,274,594	23,200,856	23.41	**23.5**	
2021	15	60	432,000	4,838,400	7,228,978	311,987,481	43.158	18,644,211	2,274,594	25,475,449	22.83		
2022	15	60	432,000	5,270,400	7,373,558	318,227,231	43.158	18,644,211	2,274,594	27,750,043	22.28		
2023	15	60	432,000	5,702,400	7,521,029	324,591,776	43.158	18,644,211	2,274,594	30,024,637	21.75		
2024	15	60	432,000	6,134,400	7,671,450	331,083,611	43.158	18,644,211	2,274,594	32,299,230	21.24		
2025	15	60	432,000	6,566,400	7,824,879	337,705,283	43.158	18,644,211	2,274,594	34,573,824	20.76	**21.0**	
2026	15	60	432,000	6,998,400	7,981,376	344,459,389	43.158	18,644,211	2,274,594	36,848,418	20.30		
2027	15	60	432,000	7,430,400	8,141,004	351,348,577	43.158	18,644,211	2,274,594	39,123,011	19.86		
2028	15	60	432,000	7,862,400	8,303,824	358,375,548	43.158	18,644,211	2,274,594	41,397,605	19.45		
2029	15	60	432,000	8,294,400	8,469,900	365,543,059	43.158	18,644,211	2,274,594	43,672,199	19.05		
2030	15	60	432,000	8,726,400	8,639,298	372,853,921	43.158	18,644,211	2,274,594	45,946,792	18.68	**19.0**	1 round activity complete
2031	15	60	432,000	9,158,400	8,812,084	380,310,999	43.158	18,644,211	2,274,594	48,221,386	18.32		2 round activity start

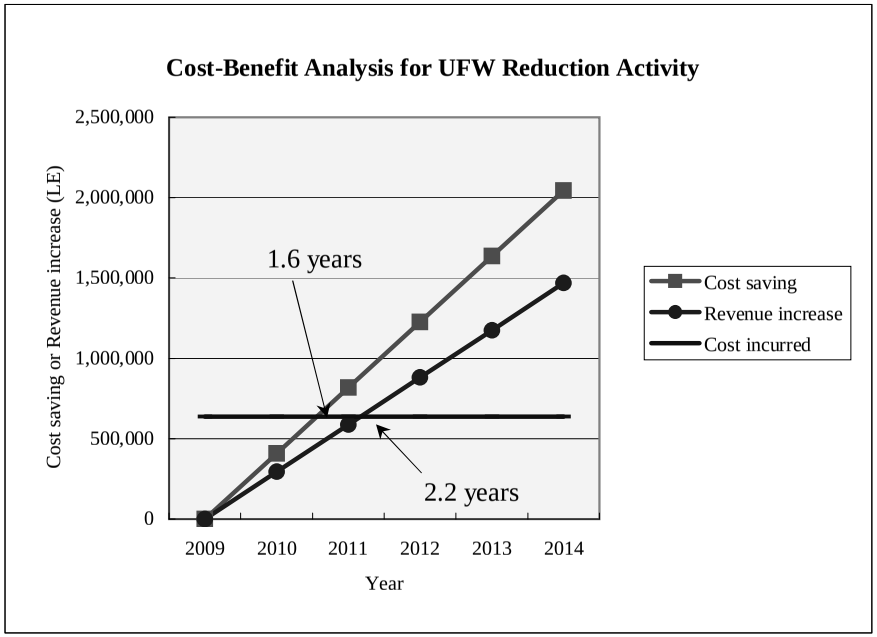
Notes:

1. Initial UFW ratio for Sharkia Governorate is assumed as 31.0% according to the results of the pilot projects in JICA technical cooperation project.
2. Reducion point after UFW reduction activities is assumed as 12.2 points according to the results of the pilot projects.
3. Taking into account of recurrence of leakage, the long-term UFW targets shall be reviewed every 3 years and revised if necessary.

2.7 Cost Effectiveness for UFW Reduction Activity

Cost-Benefit Analysis for UFW Reduction Activity

Parameters	Unit	Quantity
Water saving	m^3/day	1,705
	m^3/year	622,325
Money saving		
- At production cost (@0.657LE/m^3)	LE/year	408,868
- At selling price (@0.472LE/m^3)	LE/year	293,737
Cost incurred*[1]	LE	636,825
Benefit after 5 years of activity		
(Recurring years of leakage: Assumed as 5 years)		
- Cost reduction (at production cost)*[2]	LE	2,044,338
- Revenue increase (at selling price)*[3]	LE	1,468,687
Cost recovery period		
- At production cost (@0.657LE/m^3)	Year	1.6
- At selling price (@0.472LE/m^3)	Year	2.2



Notes:

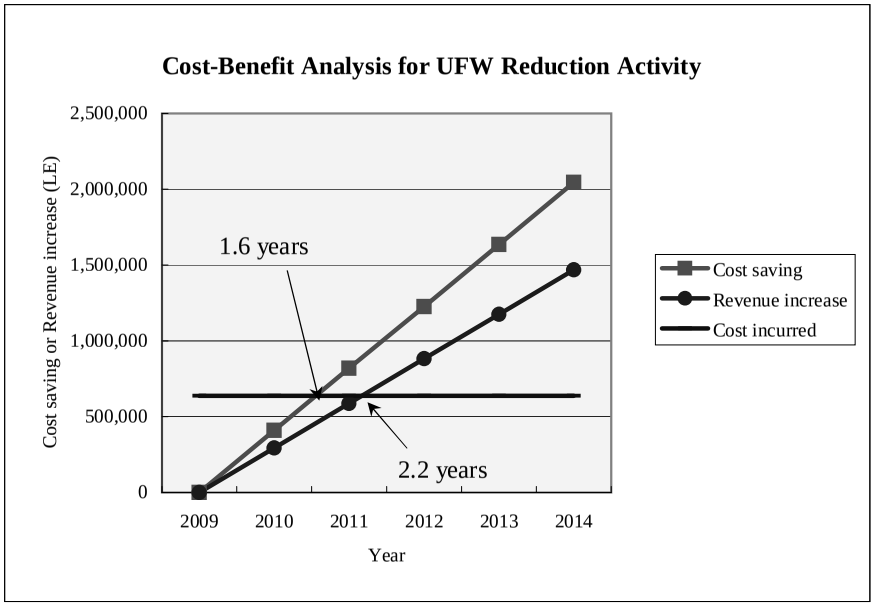
1. Cost incurred includes the following:
   - Personnel cost for staff
   - Repairing cost for leakage points
   - Preparation of GIS maps
   - Construction cost of chambers
   - Depreciation of leakage survey equipment
2. Cost reduction when distribution volume is deducted by the saved water amount.
3. Revenue increase when the saved water is sold to the customers.

Cost-Benefit Analysis for UFW Reduction Activity

Parameters	Unit	Quantity	Pilot Project Sites (Project Scope)									Expansion	
			Zagazig City East	Hihya M.	Zagazig City West	Zagazig M.	Ibrahimiya M.	Diarb Nigm M.	Menia Alqamah M.	Abu Hamad M.	Bilbais M.	Zagazig M.	Ibrahimiya M.
Water saving	m^3/day	1,705	310	222	132	411	181	110	66	85	86	68	34
	m^3/year	622,325	113,150	81,030	48,180	150,015	66,065	40,150	24,090	31,025	31,390	24,820	12,410
Money saving													
- At production cost (@0.657LE/m^3)	LE/year	408,868	74,340	53,237	31,654	98,560	43,405	26,379	15,827	20,383	20,623	16,307	8,153
- At selling price (@0.472LE/m^3)	LE/year	293,737	53,407	38,246	22,741	70,807	31,183	18,951	11,370	14,644	14,816	11,715	5,858
Cost incurred*[1]	LE	636,825	63,683	63,683	63,683	63,683	63,683	63,683	63,683	63,683	63,683	63,683	63,683
Benefit after 5 years of activity													
(Recurring years of leakage: Assumed as 5 years)													
- Cost reduction (at production cost)*[2]	LE	2,044,338	371,698	266,184	158,271	492,799	217,024	131,893	79,136	101,917	103,116	81,534	40,767
- Revenue increase (at selling price)*[3]	LE	1,468,687	267,034	191,231	113,705	354,035	155,913	94,754	56,852	73,219	74,080	58,575	29,288
Cost recovery period													
- At production cost (@0.657LE/m^3)	Year	1.6	0.9	1.2	2.0	0.6	1.5	2.4	4.0	3.1	3.1	3.9	7.8
- At selling price (@0.472LE/m^3)	Year	2.2	1.2	1.7	2.8	0.9	2.0	3.4	5.6	4.3	4.3	5.4	10.9

Notes:

1. Cost incurred includes the following:
   - Personnel cost for staff
   - Repairing cost for leakage points
   - Preparation of GIS maps
   - Construction cost of chambers
   - Depreciation of leakage survey equipment
2. Cost reduction when distribution volume is deducted by the saved water amount.
3. Revenue increase when the saved water is sold to the customers.
4. UFW reduction activity is not beneficial for the colored sites.



Cost performance

A- UFW Cost

1 Staff cost
2 Cost of fixing leakage points
3 GIS maps
4 Construction of F/M chamber

1-Staff cost	**Total**	
a Eng.Alaa		
3 (years) x 3 (hr/day) x 10 (LE/hr)	**32,850**	**L.E.**
b Assistant engineers		
2 (engineer) x 3 (years) x 7 (hr/day) x 5 (LE/hr)	**76,650**	**L.E.**
c Driver		
3 (years) x 7 (hr/day) x 5 (LE/hr)	**38,325**	**L.E.**
d Cost of Branches		
12 (branch) x 4 (engineers) x 1 (month) x 2000 (LE/month)	**96,000**	**L.E.**
Total Staff Cost	**243,825**	**L.E.**

2- Cost of fixing leakage point		
a Digging workers		
2 (workers) x 50 (LE/worker)	**100**	**L.E.**
b Supervision Team		
2 (engineer) x 50 (LE/engineer)	**100**	**L.E.**
c Fixing material	**200**	**L.E.**
Cost of fixing a leakage point	**400**	**L.E.**
Total cost of fixing leakage pionts (62 point)	**24,800**	**L.E.**

3- GIS Maps		
a Base Maps		
46 (map) x 200 (LE/map)	**9,200**	**L.E.**
b Data entry to base Map		
46 (map) x 250 (LE/map)	**11,500**	**L.E.**
Total cost of GIS maps	**20,700**	**L.E.**

3- Construction cost of chambers		
a construction cost of F/M chamber	**4,000**	**L.E.**
No. of constructed chambers 40 chambers		
Total cost of construction of chambers	**160,000**	**L.E.**

4- Depreciation of equipment		
a Total price of procured equipment	**1,250,000**	**L.E.**
No. of Depreciation Years	**20**	**Year**
Total Depreciation cost	**187,500**	**L.E.**

Total cost of UFW activity	**636,825**	**L.E.**

B- UFW Revenue

a Total saved volume of water 1,642 m^3/day
Cost of producing 1 m3 0.75 LE
Duratoin of revenue of water 5 years

Total revenue of UFW activity	**1,968,799**	**L.E.**