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PILOT PROGRAM FOR UNACCOUNTED FOR WATER, LUXOR

EGYPT WATER AND WASTEWATER SECTOR SUPPORT PROGRAM
Funded by the United States Agency for International Development (USAID)

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EXECUTIVE SUMMARY

Background

Egyptian water utilities are confronted on the one hand with limited financial resources, and on the other with an obligation to provide clean drinking water to consumers. No utilities have been able to recover total expenses based on customer payments; only a few are able to recover operation and maintenance expenditures. Unaccounted for water (UFW), referring to all losses from the system, illegal or otherwise, frequently exceed 40% of all water produced. This represents a major strain on utility operations and budgets.

In order to address this situation, the USAID-funded Water and Wastewater Sector Support (WWSS) program, administered by Chemonics International, developed a methodology for utilities to reduce UFW rates. The multi-stage systematic process involves measuring water flow, leak detection, installing and fixing meters, reducing illegal connections, and increasing billing and collections.

Utilities, making use of this methodology, will be able to reduce illegal connections and lower network losses, thus reducing expenditures, and increase the number of paying customers, thus raising revenue. Preliminary results in Luxor indicate that 54% of water produced is lost, either through physical losses through leakages, or commercial losses through inaccurate meters or illegal connections. This rate, well above the national average of 20-35%, represents a significant strain on utility operations. Physical losses account for 46% of total losses, and commercial losses 54%. The methodology is currently being finalized within a pilot area of Luxor, after which it will be rolled out more broadly elsewhere in Luxor, Assiut and Sohag. By empowering these utilities to reduce levels of unaccounted for water, impressive savings have been generated, and a significant step has been made on the pathway toward sustainability and self-sufficiency.

Methodology

The following steps are the approach of the study implementation:

- Review of similar activities in this field
- Field visits for follow up
- Conduct meetings and presentations
- Establishment of departments and teams for implementation under the guidance of the project advisors
- Maintenance of the water valves in the network and construction of measuring manholes.
- Provide on-the-job training on the use of leak detection equipment
- Preparation of the time line schedule
- Selection of a pilot area according to certain criteria.
- Field survey and database preparation with maps for the pilot area by a team composed of GIS staff, meter readers, collectors, and water network maintenance staff
- Measuring of water flows and pressures in the pilot area to identify the water consumed.
- Compete leak detection survey in given area
- Encourage fixing of leaks by utility
- Measuring of water flows and pressures in the pilot area to identify the physical leakage
- Fix and install meters discovered by the database
- Replacement of the malfunctioning meters
- Reduce illegal connections by disconnection or creating billing identity
- Combine billing and leakage data under GIS system in order to track trends and monitor performance against baseline
- Orientation of meter readers to get the accurate reading
- Analyze and compare end-line results in comparison with baseline.

- Reporting and final results.

Pilot Program Experience

This study started in February 2009, and was completed in May 2010. During the project cycle, all methodology steps mentioned above were undertaken.

Pilot Area and Team

The study was conducted in a pilot area of Luxor city, located on the west side of town, over an area 0.2km^2 in size. The area was demarcated by the following boundaries: Karnak Street to the north, Railway Street to the south, Wheat Mill Street from the east, and Yossif Hassan Street from the west. The pilot location was selected based on the following criteria:

- Location within Luxor old city, site of many leaks.
- Location easily identifiable with clear boundaries.
- Low traffic flow and simplicity of leak repair.
- Presence of a qualified network department, and
- Low number of connections without meters.

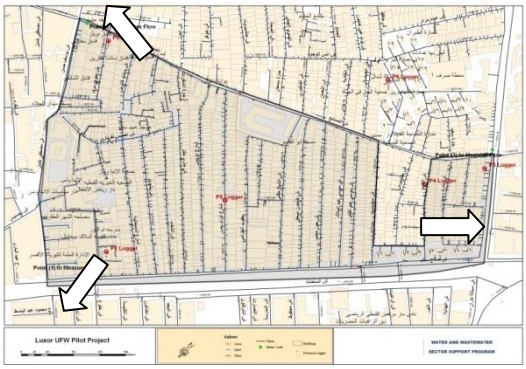

Figure 1: Map of the Pilot Area

Pilot activities were carried out by a series of task related teams. To prepare them for carrying out the study, each team received training on: meter calibration and repair, leak detection and loss reduction, geographic information systems, meter replacement, surveying non-readable meters, and illegal connections.

Mapping and GIS Interface

Figure 1 above was developed by program GIS staff for the pilot area from an AutoCAD map and converted to Arc-GIS map including the required information. During this process, data was obtained from AutoCAD and satellite images and converted into GIS data, then integrated using the same coordinates and projection. Geometric corrections and geo-referencing of satellite image were made by applying the appropriate geometric corrections procedure, utilizing ground control points from topographic maps.

Data was verified visually on screen. Revisions were made to discover errors, locate missing data, and check for proper features & layer presentation. Digital data was topologically built and prepared in the appropriate GIS format. Next, we built and implemented the data modeling database design for the UFW study by dividing the pilot area into grids with unique identification numbers, and preparing maps & sheets to collect data from the field survey.

Figure 2: Training on measuring flow with an ultrasonic flow meter

Digital maps were visually checked in the field and required attribute data was collected after coding all spatial features in the GIS database in order to ensure proper spatial links. With the database designed and implemented, next the data model was

developed. Various tables were built, drawing upon different fields with the appropriate formats, including all required attribute data.

Quality Control/ Quality Assurance (QC/QA) procedures were applied to ensure that proper digital spatial data were developed, attribute data successfully entered and coded, with correct spatial relationships. Data quality measurement and assessment was carried out according to the following criteria: Data Quality, Accuracy, Consistency, and Completeness. A statistical approach was applied in order to derive outputs based on database analyses.

Data Gathering: Baseline System Data

The pilot area was not isolated from the overall Luxor water network, and there were no bulk meters available to measure the supplied water. Three locations were identified to measure the water quantity; two for water in, and one for water out. Three ultrasonic flow meters were installed in these locations. It was found that the water supplied to the pilot area during a 48 hour period was 7295m^3 before conducting the leak detection process. The average pressure in the network during the flow measurements was between 0.77 – 1.9 bars. The estimated population in the pilot area is 13,233, resulting in a daily per capita water consumed figure of 276 liters. This figure is considered to be high for equivalent the rural governorates, implying many sources of physical and commercial leakage.

Leak Detection

A leak detection survey was implemented in the pilot area to discover the location of system leaks. This was preceded by on-the-job-training for the leak detection team. 108 leaks were discovered in the area. This figure is considered high for such a small area, 0.2 km^2, reflecting the poor state of the water network. The discovered leaks were identified and marked to facilitate the work of the network team which would come to repair the leaks. As an aside, the widespread nature of system leaks in the pilot area may argue for outright replacement, rather than piece by piece fixing, of the system.

Figure 3: Leak detection activities in Luxor City

Customer Database

A team including GIS engineers, network technicians, meter readers, and billing center employees carried out a survey of customers in the pilot area. The resultant database contains a variety of data fields, including: customer name, owner name, number flats in the building, address, length of water connections, meter type, meter diameter, meter status, water consumption, etc. The number of customers in the pilot area was 1,727 customers.

Status of Meters in the Pilot Area

The current status of meters in the pilot area was found to be as follows:

Meter status	In operation	Out of order	Less accuracy	Illegal connection	Removed	Total
Number of meters	1205	287	230	4	1	1727

The total number of malfunctioning or inaccurate meters is 508 (i.e. “out of order” plus “less accuracy”), and these were replaced with new meters. Luxor commercial sector billed those 508 households with deficient meters at a flat rate of 60 m^3 per period, i.e. two months.

Results:

1. Reduction in the UFW Percentage in the pilot area due to leakage reduction

A second round of measurements was carried in the pilot area in the same three locations during a comparable 48 hour period to determine the effect of repairing the discovered leaks. The consumption of water inside the pilot area was found to be 4,947 cubic meters during 48 hours, and the mean effective pressure was 1.1 – 2.2 bars. So the mean per capita water consumed was 187 liters/day, i.e. a reduction of 32.2%. Since no activities were performed to reduce commercial losses during the same period, this reduction is attributable singly to leak detection and repair.

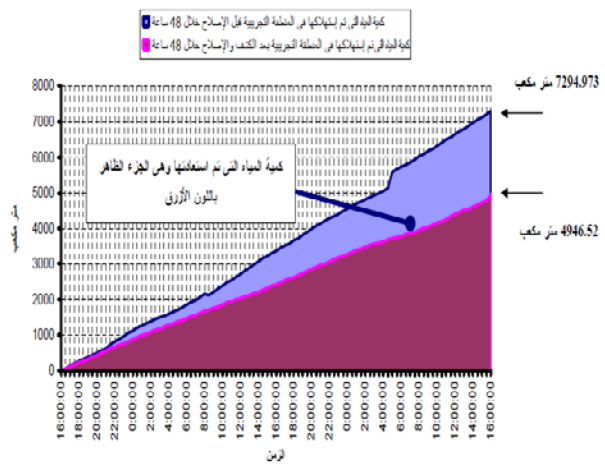

Figure 4: The consumption (inflow minus outflow) in the pilot area before (blue + purple) and after (purple) leak detection and repair.

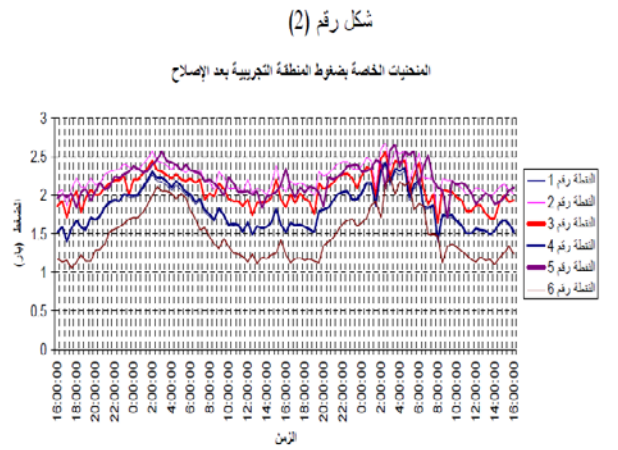

Figure 5: The pressure in the pilot area network before and after leak repair

The following table presents the conclusion of measurements before and after repairing the leaks discovered in the pilot area.

Item	Before repair	After repair
Quantity of water consumed in 48 hours (m^3)	7,295	4,947
Consumption / person / day (liters)	275	187
Mean effective pressure (bars)	1.9	2.2
Lowest pressure (bars)	0.77	1.1
Percentage of UFW	50.18	18

Thus, the percentage of UFW in the pilot area was reduced from 50% to 18% after fixing leaks in the pilot area.

2. Reduction in the UFW percentage in the pilot area due to commercial activities

Staff from the Luxor commercial sector formed teams which addressed metering issues. This team was involved in meter replacement, repair, calibration, addressing illegal connections, and ongoing follow up. Activities undertaken by this team included:

- Simplifying the work of meter readers by identifying the most efficient route for each reader and redistributing readers among districts and branches.

- Discovering the illegal connections, and offering to cut the service if the customer did not sign a contract with the company, or connecting to an adjacent customer and arranging for them to pay the bill together.

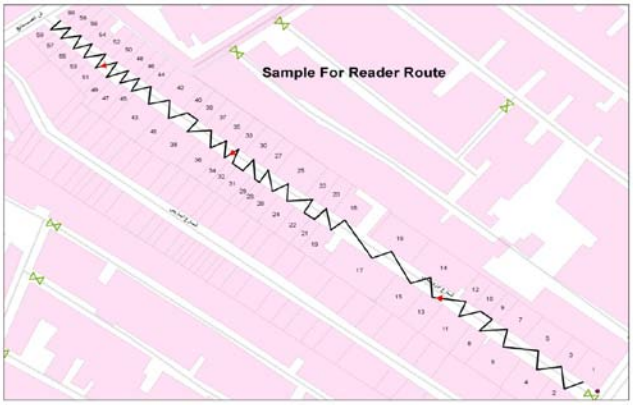

Figure 6: Route of a meter reader

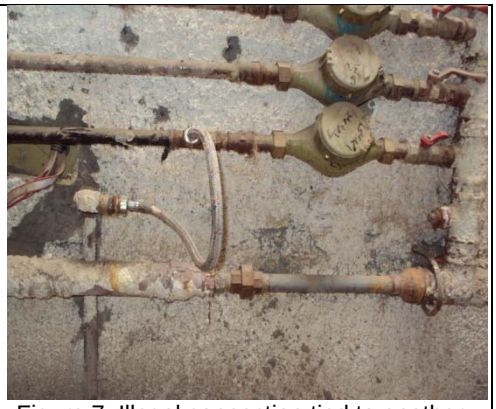

Figure 7: Illegal connection tied to another metered connection

- Installing meters in governmental buildings, or convincing them to adopt a suitable flat rate until the installation of meters.
- Surveying high-consumption customers i.e. hotels and commercial activities (car refueling stations, factories, ship feeding connections, etc.) and taking the necessary actions to install meters or accept the estimated flat rate.
- Replacing malfunctioning meters.

To identify the reduction of UFW as a result of commercial losses activity, a comparison was made between the consumption of the 1,727 customers in the pilot area between November and December 2008 with their consumption in the same two months in 2009. The results are as follows:

Item	Average consumption in the year 2008 (m^3)	Average consumption in the year 2009 (m^3)	Average Consumption increase (m^3)
For one customer	52.9	55.3	2.4
For the 1,727 customers in one period	91,358	95,503	4,145
For the 1,727 customers in one year	548,148	573,018	24,870

Hence the reduction in UFW = 24,870 / 548,148 = 4.5 %

This reduction was a result of:

- Improvements in the accuracy of meter readings through the re-distribution of meter readers among branches
- Reduction of errors in data entry by reviewing of data in the billing center
- Issuing bills for the connections which had meters but were not billed
- In cases where customers have a large accumulated debt to the company for unread meters, redistribution of that debt across the coming 6 months to encourage payment
- Repairing of meters with inaccurate readings.

It was expected that there would be a large reduction in UFW due to the replacement of malfunctioning meters. However, after replacing the meters, it was discovered that there was a *reduction* in the average consumption of each of the 508 customers with replaced meters, indicating that the flat billing rate (60 m^3

per connection per period) was higher than actual average consumption. This happened when comparing the consumption of the 508 customers in November and December 2008 with their consumption in the same period but in the year 2009. It was found that average reduction in consumption per connection is 0.913 cubic meter per period. The results are presented in the following table:

Item	Average consumption in the year 2008 m^3	Average consumption in the year 2009 m^3	Average Consumption Decrease / increase m^3
For one customer	56.225	55.342	(- 0.913)
For the 508 customer in one period	28,562	28,114	(- 448)
For the 508 customer in one year	171,372	168,684	(- 2,688)

This indicates that the reduction in commercial losses, described above, was not due to the replacement of meters, but rather to the other commercial activities described above.

3. Reduction of UFW percentage in all of Luxor City

Due to the positive results from the pilot, the change in commercial losses for all of Luxor City was assessed after commercial pilot activity implementation to assess the impact on the city as a whole. Data was gathered from Luxor water treatment plant, and reflects production during January and February, 2010; i.e., after the end of the commercial activities of the pilot UFW program described above. The plant produced 4,483,652 m3 supplied to Luxor city only. The billed water to customers for the same period was 3,129,998 m3.

Therefore, the UFW amount = 4,483,652 - 3,129,998 = 1,353,654 m3

The UFW percentage = 1,353,654 / 4,483,652 = 30.2 %

So the UFW percentage reduced from 50.18% to 30.2% in Luxor city including the pilot area.

Hence the reduction in UFW for all of Luxor City was = 50.18 - 30.2 = 20%

Since these measurements were taken after the commercial activities, but before the leakage repair activities, the reduction is attributed to a number of activities that occurred as a by-product of the pilot activities, including:

- Orientation of the meter readers and concentrating on the accurate meter reading, reporting for the illegal connections, and malfunctioning meters.
- Redistribution of meter readers among Luxor reasons and branches (19 branches).
- Ongoing repairing of major leaks and damage in the major water network pipes (not including the 108 leaks repaired in the pilot area, as that was after February).
- Replacement of 5,382 malfunctioning meters.
- Appling the disconnection policy for the illegal connections.
- A decision by the Luxor Company Board of Directors to give the person who reports a new illegal connection an incentive equaling 0.5% of the penalty imposed on the illegal connection owner.

This 20% reduction, due primarily to commercial activities, is significantly larger than the 4.5% commercial reduction in the pilot area. This is due primarily to the fact that Luxor City, unlike the pilot area, includes many large customers such as hotels and commercial establishments. Improving collections from those customers has a large impact on the UFW situation. On the other hand, the pilot area consists

of mostly residential customers, and an old underground network; so, the losses there were primarily due to leakage.

Pilot Conclusions and Recommendations

The overall pilot results can be summarized as follows:

- **Reduction in technical losses in the pilot area:** A high reduction in the UFW percentage in the pilot area was realized through discovering and fixing leaks. These activities reduced UFW by 32.2%. This reduction is very high because the pilot area is located in old Luxor city, which contains a very old water network. 108 leaks were discovered in an area of 0.2 km2.
- **Reduction in commercial losses in the pilot area:** The reduction in the UFW percentage in the pilot area due to the commercial activities is 4.5%. Activities in this sector included corrective actions for meter inaccuracy, broken meters, un-read meters, low flow un-registered by the meter, billing errors, customers with no records, and solving the losses due to governmental and religious buildings, illegal connections, and customers with no meters.
- **Reduction in losses in all of Luxor City:** Due primarily to corrective actions by the commercial sector inspired by the activities in the pilot area, UFW in all of Luxor City was reduced from 50.18% to 30.2%, a reduction of 20%.

Drawing on the success of the methodology in the pilot area, WWSS plans to roll out the program in other governorates. By empowering utilities to reduce levels of unaccounted for water, impressive savings have been generated, and a significant step has been made on the pathway toward sustainability and self-sufficiency.

In order to effectively roll out this methodology in other areas, our program team has made the following process recommendations:

- Using hand held devices in meter reading instead of the manual process. This will decrease errors encountered in the meter readings.
- Installing new meters for the governmental and non-governmental buildings which have connections without meters.
- Applying an incentive system for utility staff.
- Installing bulk meters at the outlet of water treatment plants to have accurate production figures.
- Provide orientation for commercial sector staff (billing, collectors, meter readers, customer service center, and meter repair and calibration workshop)
- Applying the illegal connection policy (Luxor has 12 people with the requisite legal authority).
- Increasing the number of staff working in the replication of the study within the various sectors (GIS, leak detection, network staff, and meter repair & calibration workshop).
- Expedite transportation for the staff working on the project in order to make their time more efficient.

Utilities, making use of this methodology, will be able to reduce illegal connections and lower network losses, thus reducing expenditures, and increase the number of paying customers, thus raising revenue. Preliminary results in Luxor before this pilot activity indicate that 50.18 % of water produced was lost in the year 2008, either through physical losses through leakages, or commercial losses through inaccurate meters or illegal connections. This rate, well above the national average of 20-35%, represents a significant strain on utility operations.