N-W-1-EG1

STRENGTHEN THE WATER UTILITIES CAPACITIES TO MANAGE/REDUCE NRW AND DETECT LEAKAGE

Synthesis Report

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WATER AND ENVIRONMENT SUPPORT IN THE ENI SOUTHERN NEIGHBOURHOOD REGION

The "Water and Environment Support (WES) in the ENI Neighbourhood South Region" project is a regional technical support project funded by the European Neighbourhood Instrument (ENI South). WES aims to protect the natural resources in the Mediterranean context and to improve the management of scarce water resources in the region. WES mainly aims to solve the problems linked to the pollution prevention and the rational use of water.

WES builds on previous similar regional projects funded by the European Union (Horizon 2020 CB/MEP, SWIM SM, SWIM-H2020 SM) and strives to create a supportive environment and increase capacity all stakeholders in the partner countries (PCs).

The WES Project Countries are Algeria, Egypt, Israel, Jordan, Lebanon, Morocco, Libya, Palestine, Syria and Tunisia. However, in order to ensure the coherence and effectiveness of EU funding or to promote regional cooperation, the eligibility of specific actions can be extended to neighbouring countries in the Southern Neighbourhood region.

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ABBREVIATIONS

AOD	Above Ordnance Datum, Used to specify heights above mean sea level
AOI	Area of Interest
AWWC	Asyut Water and Wastewater Company
CARL	Current Annual Real Losses
DB	Database
DMA	District Metering Area
DMZ	District Metering Zone
DN	Diamètre Nominal (Nominal Diameter)
EPSG	European Petroleum Survey Group. It is a public registry of geodetic datum, spatial reference systems, Earth ellipsoids, coordinate transformations and related units of measurements.
ESRI	Environmental Systems Research Institute
GIS	Geographic Information System
HCWW	Holding Company for Water and Wastewater
HP	Horsepower
ILI	Infrastructure Leakage Index
IWA	International Water Association
kVA	kilovolt-Ampere
Kw	Kilowatt
lps	litre per second
m	metre
m^3/day	cubic metre per day
m^3/hour	cubic metre per hour
m^3/year	cubic metre per year
MLD	Million Litres per day
mm	millimetre
NOS	Normal Operating Status
NRW	Non-revenue Water
POI	Point of Interest
PRV	Pressure Reducing Valve
PS	Pump Station
SMS	Short Message Service
TP	Treatment Plant

UARL	Unavoidable Annual Real Losses
WDS	Water Distribution System
WGS	World Geodetic System
WKID	Well-Known ID
WSS	Water Supply System
WTP	Water Treatment Plant
WTS	Water Transmission System

1 CONTEXT OF THE ACTIVITY

Egypt has asked the WES Project to implement a national activity entitled "[Strengthen the water utilities capacities to manage/reduce NRW and detect leakage]". The activity **supports the Real Loss Reduction Strategy (2017)** prepared with the support of the second phase of the European Union's (EU) Water Sector Reform Program, which promotes an integrated nonrevenue water reduction strategy and its alignment with the real Loss Reduction Strategy.

The overall objective of this activity is "to assist a selected water utility to target the reduction of Non-Revenue Water (NRW) and to continue its efforts to improve NRW management".

2 SCOPE OF WORK

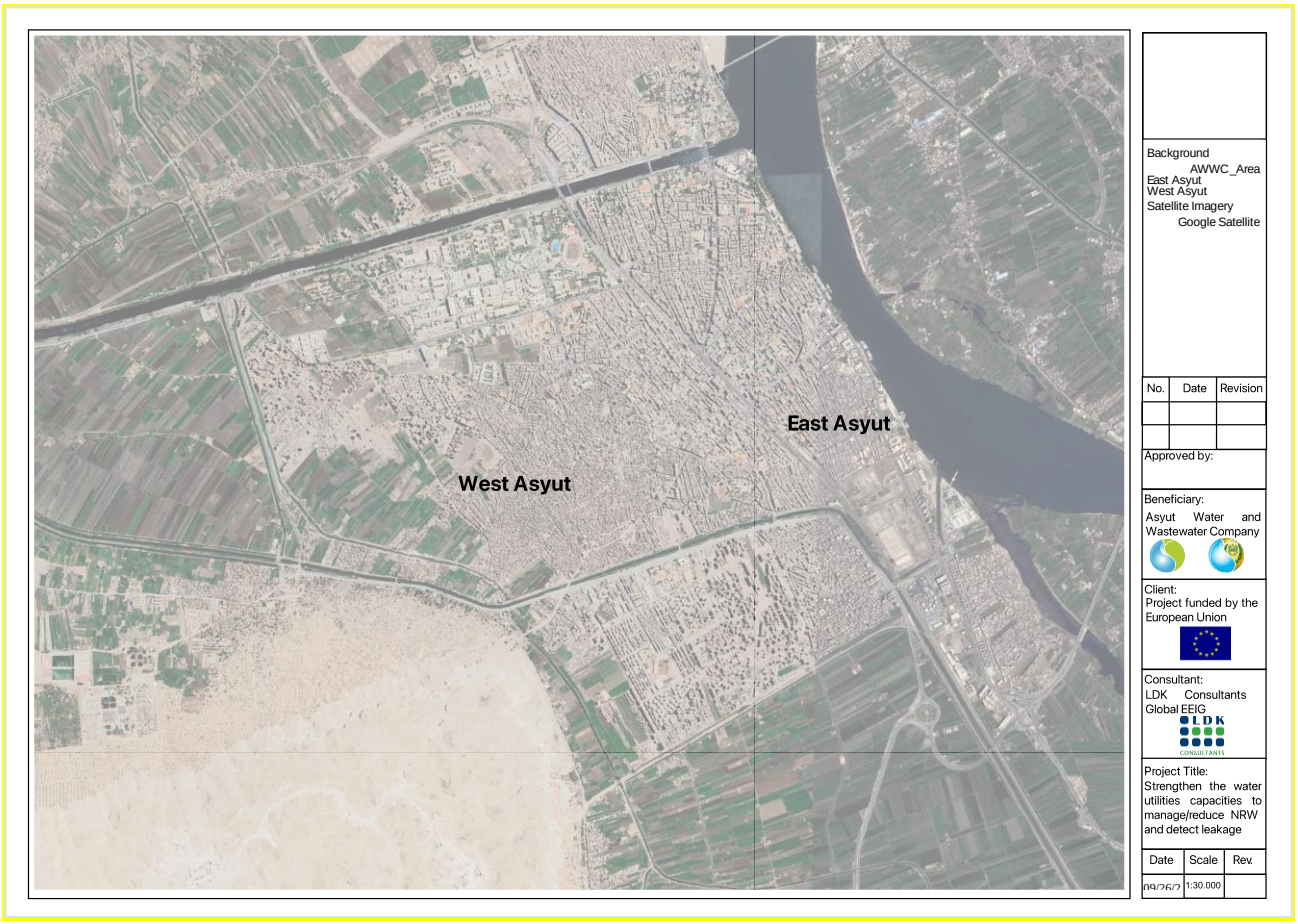
The specific objectives of the activity are to:

- Investigate the situation of non-revenue water management in a pilot city served by Asyut Drinking Water and Sewerage Company and prepare its network, as part of rational planning aimed at NRW reduction, to the next stage of implementation of distribution zones/sectors and their subsequent division into District Metered Areas (DMAs).
- Implement and calibrate a hydraulic model for the network of the pilot city as a tool to provide valid support to move into the design stage and establishment of DMAs
- Introduce internationally recognised best practices for improving NRW (including the design of Distribution Zones and the use of GIS to enable an analysis of the geographical distribution of leakage).
- Build the capacity of the utility staff involved in the pilot area on the implementation of best practices for the management of non-revenue water through on-the-job training and direct involvement in the implementation of the tasks with the support of non-key experts (field data analysis, water balancing, model calibration, and fixing anomalies between the results of the model calculations and the field data).
- Develop a manual documenting the proposed procedures for reducing NRW in Asyut city water network.

3 THE STUDY AREA

The activity has been implemented for the Asyut city water network; an extended water supply system of more than 200 km and multiple water sources served by the Asyut Drinking Water and Sewerage Company. Asyut City is customarily divided into two sub-zones: West Asyut (AlGharb) and East Asyut (AlSharq); the two zones constitute the study area of this project.

Figure 1: of Asyut city



4 SUMMARY OF TASKS PERFORMED

The WES team conducted the following tasks during the project:

1. Task 1: Inception phase
2. Task 2: Verification of GIS Maps and Customer Database
3. Task 3: Calibration of the hydraulic model
4. Task 4: Preliminary division of the network into distribution zones and design of the zones
5. Task 5: Elaboration of procedures to reduce NRW and prepare the synthesis report

4.1 TASK 1: INCEPTION PHASE

The task included an initial data assessment (background, network, infrastructure, customer), an evaluation of the availability and reliability of network and customers' data and the establishment of the partner teams (NRW and GIS) who will be involved in the activity throughout its implementation to ensure the transfer of know-how, training and learning by doing. During this phase, the sequence of actions necessary to carry out the activity was also determined.

The inception phase ended with an inception Report and with a one-day workshop, whose objective was to:

- Present the summary of the conclusions of the inception mission.
- Define the requirements and necessary resources of the partner team (NRW and GIS) and stakeholders.
- Present the job profiles proposed for the members of the partner team (NRW, and GIS)
- Agree on the targets of the intervention.
- Establish the partner teams (NRW and GIS).

4.2 TASK 2: VERIFICATION OF GIS MAPS AND CUSTOMERS DATABASE

This task included:

(1) checking information on existing background maps (aerial photography, vector cartography, etc.), existing network maps (primary, distribution, service connections) and infrastructures (water intakes, water treatment plants, tanks/reservoirs, pumping stations, etc.)
(2) verification of the existing customers' database.

AWWC provided information on the organization of the GIS and on the customer database in use in the company.

On the basis of the provided information, the WES team conducted a database design analysis in order to identify improvements to be proposed to the existing AWWC WSS DB structure.

Conclusions were presented in the WSS GIS database Design Report which was organized in the following chapters:

1. Analysis of the HCWW databases
2. Conceptual Data Model
3. Logical data Model
4. HCWW / WES databases Comparative Analysis
5. Definition of the set of attributes of each entity in the WES GIS database

AWWC also provided the consumer database, which was used for the construction of the hydraulic model. **However, the** Unfortunately the DB provided by AWWC for the geographical positions of the meters had incomplete information and could not be used for the next stage of the project but it was helpful as it included the positions of the large consumers that were used for demand allocation of the hydraulic model.

4.3 TASK 3: CALIBRATION OF THE HYDRAULIC MODEL

This task involved the implementation of the network hydraulic model for the study area, using the network and facilities data to be imported from the GIS database as well as the data to be imported from the customers' database.

The WES team provided as list of sites where monitoring points – both flowmeters and pressure gauges – were to be installed and AWWC performed the field work needed for model calibration. The next figure shows the position chosen for the installation of the monitoring points.

Data were taken from the monitoring sets from August 11th to August 20th.

Based on the monitoring data, the total amount of water fed into the water supply system was determined and calibration could be performed.

The network layout and allocated demand that were developed using data provided by AWWC, and the flow distribution resulting from the calculations were used to select the initial proposal for the overall network zoning and the corresponding identification of the locations of flowmeters to be installed and valves to be closed.

4.4 TASK 4: PRELIMINARY DIVISION OF THE NETWORK SYSTEM INTO DISTRIBUTION ZONES (DZ).

Under this task, control areas i.e., Distribution Zones (DZs) and District Metering Areas (DMAs) were identified along with the positions of the Zones' inflow sites (Q&P Monitoring sites).

The available data did not allow the water balance to be prepared with the required accuracy as (i) the demand data is only an estimate based on the volume transiting in the system and the number of nodes in each urban area, (ii) the amount of water lost is also a pure estimate based on the length of the network in the area and an estimated coefficient with no reference to the real situation, (iii) no information on pressure is available from the field.

To provide an indication of what to do in the immediate future, an exercise was carried out to compare the estimated volume entering into the WSS (domestic + commercial demand, large consumers demand and leakage) with the estimated amount of water lost, DMA by DMA.

Next

Table 1~~Table 1~~ shows the result of the exercise and indicates a possible ranking of the DMAs from which NRW activities could start. The performance indicator (KPI) adopted is defined by the ratio between the amount of water lost (in lps) and the total length of the network (in km) in each DMA.

Table 1: DMA to watch out for, according to KPI (lps/km)

DMA	Total Demand (lps)	Leak (lps)	Pipe length (km)	KPI	Rank
DMA1	55,97	17,87	19,36	0,923	2
DMA2	38,56	15,53	23,61	0,658	8
DMA3	57,04	20,50	29,58	0,693	7
DMA4	4,60	1,76	6,38	0,276	13
DMA5	1,28	0,32	1,29	0,251	14
DMA6	1,04	0,63	0,52	1,221	1
DMA7	19,20	1,67	2,12	0,787	6
DMA10	64,92	20,22	23,95	0,844	4
DMA17	217,84	80,34	101,34	0,793	5
DMA20	140,68	42,75	46,64	0,917	3
DMA-ARAB	3,36	1,70	2,73	0,622	10
DMA-FORTY	1,07	0,33	1,21	0,276	12
DMA-GERMA	4,80	1,79	3,61	0,496	11
DMA-NAZLET	7,03	2,85	16,52	0,173	16
DMA-UNI	10,08	3,68	5,74	0,641	9
INFLOW	0,74	0,22	1,10	0,198	15
OUTFLOW	1,71	0,61	3,87	0,157	17
	629,91	**212,77**	**289,58**		

The task ended with the preparation of the Hydraulic Model and Zone Design Report.

4.5 TASK 5: ELABORATION OF PROCEDURES TO REDUCE NRW

This task involves the preparation of a manual with the required set of procedures to reduce NRW that are tailored to Asyut city water network and covering the following areas:

1. GIS data upload and maintenance.
2. Hydraulic Model data upload and maintenance.
3. Distribution Zone operation and maintenance, including Q-P monitoring procedures.
4. Water Balance calculation procedure.
5. Guidance on how to divide the Distribution zones further into District Metered Areas (DMAs).

1. The project ended with a three-day training involving managers responsible for operation and maintenance (O&M), local non-revenue water staff, GIS specialists and the Commercial Department. The objective of the training was to build the capacity of Asyut Water and Wastewater Company (AWWC) in:
    i. Setting up the water supply zones and the District Metered Areas within the AWWC network and ensuring its tightness
    ii. Calculation of the water balance
    iii. Implementation of the proposed NRW reduction procedures in AWWC elaborated in the manual of procedures to reduce NRW.

5 MAIN RESULTS, DELIVERABLES, AND IMPACTS

During **Task 1** stakeholders (particularly HCWW) were involved in the project, and a data assessment was performed although initially the WES team was not allowed to use the required data directly. At the end of the task, an Inception Report was presented in which the plan of action necessary to carry out the activities were included and further agreed upon.

With **Task 2**, the WES team checked the existing background maps, the existing WSS network data (analogue and digital from the AWWC GIS department and Design department.) and the customer database. The existing database was analyzed and at the direction of the WES team, the information was improved by AWWC staff who geolocated around 85% of the customers. The WES team at the end of the task prepared the GIS Database Design and Customer's DB Report, which includes the GIS DB Conceptual Model and the GIS DB Logical data model. The GIS DB Logical data model has been implemented using the available data and it was used to create the AWWC GIS DB which is part of the deliverables of this project.

The WES team proposed to make several changes to the current AWWC WSS GIS DB in order to improve its ability to be an effective tool for the construction of the hydraulic model.

During **Task 3**, AWWC staff carried out the monitoring activities that, together with the WSS network data, were used by the WES team to implement and calibrate the WSS network hydraulic model. The two tasks were carried out after the WES team and AWWC staff agreed on the area to perform the analysis and identified the flow (Q) and pressure (P) monitoring sites.

In the subsequent **Task 4**, the WES team used the developed hydraulic model to segment the entire study area initially into zones and then proposed provisional segregation into DMAs. The delivered network analysis and zone design report, listed the necessary equipment to be purchased for the implementation of these zones and DMAs and a preliminary prioritized list of areas in which to address the first nonrevenue water reduction measures, concluded the two tasks.

In the last **Task 5,** the WES team prepared a manual with a set of procedures to reduce NRW, tailored to the Asyut city water network and provided a three-day training which summarized all the results of the project.

All deliverables can be downloaded from the WES website.

6 FUTURE ACTIONS TO BE UNDERTAKEN

The WES team recommends AWWC staff initiate the following actions:

1. Integrate the existing AWWC WSS GIS DB structure with the attributes and entities necessary to make it suitable as a tool for an NRW reduction analysis. The Logical data model and the conceptual analysis delivered under task 2 will help in this job.
2. Upgrade and update the existing AWWC WSS GIS DB in the new structure and make the AWWC GIS department the "official" repository of the AWWC WSS GIS DB.

3. It is important to conduct a monitoring campaign to determine the real characteristics of the pumps at all the pump stations in the WTPs. It is necessary to monitor for each pump the real head and flow.
4. Once the real data of the pumps will be determined, it is necessary to carry out a second field test monitoring Q and P data, which will be used for a second run of the hydraulic model.
5. the AWWC teams need to finish the localization of the customers and update their data in the GIS DB for further analysis. this data will be used to re-elaborate the demand allocation necessary for the second run of the hydraulic model.
6. The hydraulic model developed by the WES team can be used to compare the field data and the calculated data. Alternatively, the AWWC team can develop their own hydraulic model on Water GEMS using the AWWC WSS GIS DB data.
7. if the hydraulic model will confirm the assumptions made to size and locate the flowmeters to segregate the overall WSS network in Zones and DMAs, the AWWC team can proceed with the phase of acquisition of the equipment. The procedures and the reports provided will help organize and implement the DMAs.