WATER RESCUE

Water resources efficiency and conservative use in drinking water supply systems

WP	**5 Pilot Actions**
Deliverable *Tool*	**5.2.2 Pilot Actions Implementation** *Joint Deliverable*
Sub-Deliverables integrated	**D.5.1.2, D.5.2.2., D.5.3.2, D.5.4.2, D.5.5.2, D.5.6.2**
Project Beneficiary	**PB2, PB3**
Beneficiary Institution	**Municipal Water Supply and Sewerage Company of Thermi** **University of Thessaly-Special Account Funds for Research-Department of Civil Engineering**

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Table of Contents

Chapter 1. Introduction: The WATER RESCUE project in brief

1.1 The Project in brief

WATER RESCUE project's concept is based on the common cross-border (CB) water management problems in the two international river basin districts (RBDs) shared between Greece & Bulgaria (Struma-Strymonas; Maritsa-Evros). The common CB problems include water resources quality & quantity being at risk due to natural and human activities and climate change conditions. The consequence is that water bodies fail to meet the good ecological status (GES) (recorded in the river basin management plans-RBMP). In particular, drinking water faces significant risks due to the deteriorated water resources quality while at the same time significant water volume is lost in the water distribution networks (WDNs). The project aims at the sustainable and efficient management of drinking water supply by increasing drinking water use efficiency in WDNs and improving water quality in the whole water supply cycle (from the source and back to the environment). Good Ecological Status can be achieved by improving water quality and reducing water abstraction and can be maintained by taking climate change adaptation measures. The project focuses in drinking water supply management suffering from high Non-Revenue Water (NRW) levels and deteriorated water quality jeopardizing the drinking water consumers' safety and health and their quality of life. Urban water volumes end up to the sewerage networks while wastewater treatment plants are a pressure to water resources quality. Surface water bodies are both used for drinking water abstraction and are the final recipient of treated effluents. Thus, their ecological status is affected by both water quantities abstracted and water quality in the whole water supply cycle (from the resource to the water supply and the wastewater treatment plant and back to the environment).

1.2 Theme of the Project

WATER RESCUE project is expected to achieve Non-Revenue Water/water losses reduction by upgrading and adapting already developed methodologies, technologies and tools including Water Balance assessment and Performance Indicators, hydraulic simulation models, decision support systems and GIS tools. Additionally, WATER RESCUE is expected to achieve water quality improvement across the entire water supply chain (from the water intake point and the raw water treatment plant, back to the environment after the waste water treatment plant) through constant monitoring of water quality parameters in real time, water quality simulation models (including water age) and automatic chlorination systems on line and in line. Climate change impacts will be assessed to finally propose and adopt measures for climate change adaptation. WATER RESCUE has a clear innovative character since the methodologies and tools are integrated and do not tackle individual problems. It is the first time that integrated methodologies will be adapted to include the entire drinking water supply cycle. These methodologies/tools will serve as Early - Warning Systems both for water quantity and quality. WATER RESCUE results will improve drinking water management. At the same time as drinking water is involved, the consumers' safety and health are safeguarded and their quality of life is improved. Non-Revenue Water reduction will increase water resources efficiency, since less water will be abstracted from surface and groundwater bodies and reduce energy consumption as water and energy are interconnected in water supply systems (water-energy nexus). Drinking water quality will be improved through real time monitoring of water quality parameters across the entire water supply chain, from the water intake points, to the water treatment plant and the water distribution network, back to the environment through the wastewater treatment plant. Thus, drinking water quality will be safeguarded from its source up to the consumer's tap. As wastewater effluents return to water resources, their quality monitoring prevents water resources degradation due to this pressure. Water and energy resources efficiency will be promoted and the ability of the cross-border area to adapt to climate change conditions will be improved as all possible natural and man-made pressures will be evaluated, including climate change

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conditions. Water saving will be accomplished through water losses reduction and increase of the environmental awareness of the public. The quality of life is expected to be upgraded with special emphasis to the protection of the natural environment. Joint policy recommendation guidelines and papers will be developed. Good governance, transparency and participation of all stakeholders in the design, implementation and monitoring of these policies is expected. Know-how and technology transfer will take place not only among the beneficiaries but also in the stakeholders' network that will be developed.

1.3 Project Objectives

The project's main objective is the sustainable cross –border drinking water supply management aiming at water resources efficiency and conservative use through:

1. Adaptation of a joint methodological framework for water resources management (qualitatively and quantitatively) in relation to the climate change and the natural and human activities and reduction of the water resources vulnerability;

2. Increase water use efficiency through the reduction of Non-Revenue Water and water losses in the water supply networks by implementing measures tackling NRW causes;

3. Improve water quality and safety in the whole drinking water supply cycle, from the water resources to the water distribution network and back to the environment through the continuous monitoring of water quality parameters in real time and the in-line disinfection to reduce the risk of low chlorine residuals and excessive concentrations of THMs (toxic substances causing cancer);

4. Increase innovative technologies use through the integrated management of water resources including GIS-based applications; hydraulic simulation models & decision support systems;

5. Development of "green behavior", increase water saving & reduce water consumption through public awareness campaigns.

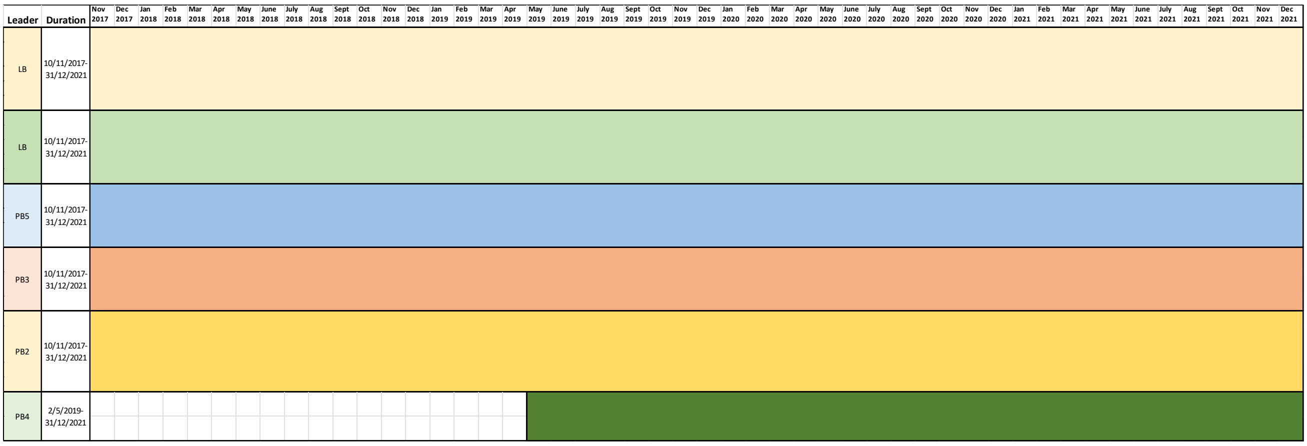

Figure 1.1. WATER RESCUE timetable

1.4 The Project structure and timetable

The project consists of six work packages:

- WP1: Project Management and Coordination
- WP2: Project Communication and Dissemination
- WP3: Current Status Analysis & Assessment
- WP4: Common Methodology and Tools
- WP5: Pilot Actions

- WP6: Policy Recommendation

The initial total project duration was 24 months but extensions were given (mainly due to covid-19 oandemic) and the final total duration is 50 months, from 10/11/2017 to 31/12/2021 (Figure 1.1).

1.5 Project Beneficiaries

Lead Beneficiary is the Municipal Water and Sewerage Company of Komotini (Greece); Beneficiary 2 is the Municipal Water and Sewerage Company of Thermi (Greece); Beneficiary 3 is the University of Thessaly-Special Account Funds for Research-Department of Civil Engineering (Greece); Beneficiary 4 is the Municipality of Kardzhali (Bulgaria); Beneficiary 5 is the Municipality of Gotse Delchev (Bulgaria); and Beneficiary 6 is the Municipal Water and Sewerage Company of Thermaikos (Greece).

Table 1.1. WATER RESCUE beneficiaries

PB #	PP name	City	Country
PB1	Municipal Water Supply and Sewerage Company of Komotini	Komotini	Greece
PB2	Municipal Water Supply and Sewerage Company of Thermi	Thermi	Greece
PB3	University of Thessaly-Special Account Funds for Research-Department of Civil Engineering	Volos	Greece
PB4	Municipality of Kardzhali	Karddzhali	Bulgaria
PB5	Municipality of Gotse Delchev	Gotse Delchev	Bulgaria
PB6	Municipal Water Supply and Sewerage Company of Thermaikos	Neoi Epivates	Greece

1.6 The present deliverable

1.6.1 The subject of the present deliverable

The present deliverable refers to WP5.2., and specifically pilot actions implementation. This deliverable includes the description of all pilot actions implemented by the project beneficiaries. Initially general data are given for the pilot area. Then the pilot action is described by providing information on the equipment installed and some photos are presented. Then the results from the pilot action are presented in comparison to the status of the pilot area before the pilot action implementation. The cost of the pilot action is given, and a comparison is made regarding the benefits and the costs. Finally, the problems encountered, and the lessons learnt are presented.

1.6.2 The approach applied developing the present deliverable

As the topics the WATER RESCUE project is dealing with, need precise knowledge of the way water supply and distribution systems operate, it was made clear, even during the kick-off meeting of the project, held in Komotini in January 2018 that WATER RESCUE beneficiaries, beyond their common agreement to work closely together, should be guided by the scientific beneficiary, University of Thessaly, to ensure the prompt delivery of what was expected by the WATER RESCUE project. Thus, the University of Thessaly, prepared the methodology and the questionnaires for this task. Municipal Water Supply and Sewerage Company of Thermi (PB2) as the WP Leader took over the responsibility to prepare the joint deliverable of Phase 5.2. PB3 contributed to this task.

Regarding the implementation of Phase 5.2., the beneficiaries reported their pilot actions implementation preocess. University of Thessaly (PB3) provided a questionnaire every four months from the beginning of the project to monitor the implementation progress of the pilot actions. All beneficiaries provided their deliverables to the WP leader, who properly elaborated the data in order to prepare the joint deliverable. The WP leader together with the University of Thessaly (PB3) prepared the respective deliverable D5.2.

Chapter 2. Pilot Actions General Description

2.1 The Pilot Actions

Each beneficiary selected the pilot action to address water use efficiency or water quality or both. The final selection of the pilot action was based on the problems of each water distribution network.

The beneficiaries that selected water use efficiency are: Municipal Water Supply and Sewerage company of Komotini (LB), Municipal Water Supply and Sewerage company of Thermi (PB2), Municipality of Kardzhali (PB4), Municipality of Gotse Delchev (PB5) and Municipal Water Supply and Sewerage company of Thermaikos (PB6) (Figure 3). The beneficiaries that selected water quality are: Municipal Water Supply and Sewerage company of Thermi (PB2) and Municipality of Kardzhali (PB4) (Figure 2.1).

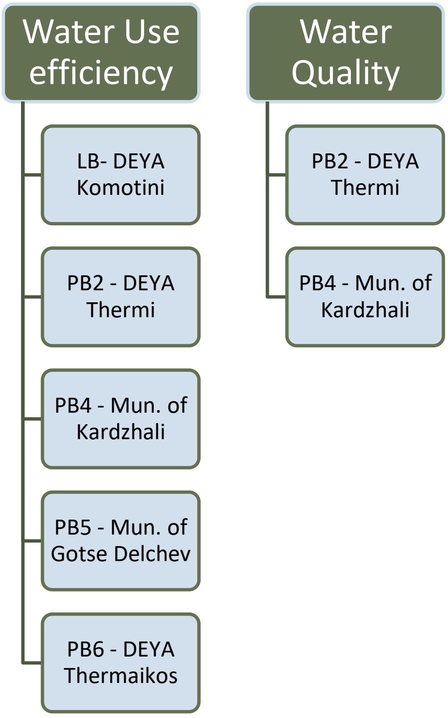

Figure 2.1. Beneficiaries implementing pilot actions related to water use efficiency or water quality

Table 2.1 summarizes the pilot actions of each beneficiary and provides a brief description. Pilot actions related to water use efficiency targeted real losses (Table 2.1).

Table 2.1. Brief description of the pilot actions

Beneficiary		Pilot action	Equipment	Water Use Efficiency	Water Quality
LB	DEYA Komotini (Greece)	Development of IT applications to directly support the water utility operations and indirectly contribute to the water use efficiency (by reducing NRW). The applications will provide: • Failure history mapping. • Field applications. • Applications for the public.	IT applications	√	
PB2	DEYA Thermi (Greece)	- Installation of flow meters in the water abstraction points - installation of automatic chlorination devices in	45 electromagnetic flow meters; 6 automatic chlorination	√	√

		the utility's water tanks. - hydraulic model development from the University of Thessaly (PB3)	systems; full unlimited licence of an hydraulic simulation model.		
PB4	Municipality of Kardzhali (Bulgaria)	- installation of flow meters in the water abstraction points - supply and installation of Inductively coupled plasma mass spectrometry (ICP-MS).	4 electromagnetic flow meters; 1 ICP-MS equipment.	√	√
PB5	Municipality of Gotse Delchev (Bulgaria)	• supply and installation of electromagnetic flowmeters and pressure meters in the DMA in "Danube" area in Gotse Delchev water supply network. • replacement of pipes F90 and F110 in DMA "Danube" area as pilot measure	Electromagnetic flowmeters with data loggers; pipes	√	
PB6	DEYA Thermaikos (Greece)	Development of IT applications aiming at supporting the operations of the water utility and indirectly the water use efficiency (reduction of NRW). The applications will be: • Water distribution networks management application. • Mapping of the failures' history.	IT applications; GIS software license	√	

2.2 Pilot Actions Assessment

To monitor and evaluate each step during the pilot actions elaboration, UTH (PB3) prepared a 4-monthly questionnaire. The questionnaire would gather the implementation status of the pilot actions. This questionnaire was initially completed in July 2018 and the last intermediate report was gathered until February 2020.

The report requested information on the pilot action (brief description), description of the activities for the 4-month period, obtained results and encountered difficulties and applied solutions.

Table 2.2 presents the implementation process of the pilot actions based on the above-mentioned questionnaire.

Table 2.2. Pilot action implementation process gathered from the 4-monthly reports

Beneficiary	Pilot action	Equipment	July-Oct 2018	Nov18 -Feb19	Mar -Jun2019	July-Oct19	Nov19-Feb20
LB	Development of IT applications to provide: • Failure history mapping. • Field applications. • Applications for the public.	IT applications	Tender launched in 25/9/2018 Evaluation process on-going	Evaluation is over. Contract to be signed	Contract signed on 9/5/2019. The deadline for the conclusion of the contracted services is 6/11/2019. The contracted amount is 88.000,00€ (plus VAT). Contractor has already started providing the services identified in the contract.	The contractor concluded the development of the IT applications. Personnel is trained by the contractor	IT applications are in place and working. LB personnel enters the necessary data.
PB2	- Installation of flow meters in the water abstraction points installation of automatic chlorination devices in the utility's water tanks. hydraulic model development from the University of Thessaly (PB3)	45 electromagnetic flow meters; 6 automatic chlorination systems; full unlimited licence of an hydraulic simulation model.	Software has been supplied Tender for the equipment is almost ready and will be launched by the end of the year	Tender launched on 3/1/19 and offers are submitted. The evaluation process is almost over. Contract will be signed in June 2019	Evaluation of offers is almost done – the contract will be signed in August 2019. PB3 collects data for the development of the simulation model of the water distribution network	Contract signed on 6/8/2019. The deadline for the supply and installation of the equipment is 6/1/2020. The contracted amount is €94.290,00. PB3 collects data for the development of the simulation model.	Equipment installed. The first data are gathered from the flow meters.
PB4	- installation of flow meters in the water abstraction points supply and installation of Inductively coupled plasma mass spectrometry (ICP-MS).	4 electromagnetic flow meters; 1 ICP-MS equipment.	Preparation of tender procedures	Announcement of tenders for contractor selection	Tenders will be examined by a committee appointed by the contracting authority in accordance with the Public Procurement Law on 26.09.2019.	Tenders have been reviewed by a committee and a contract with a contractor is pending.	
PB5	• supply and installation of electromagnetic flowmeters and pressure meters in the DMA in "Danube" area in Gotse Delchev water supply network. • replacement of pipes F90 and F110 in DMA "Danube" area as pilot measure	Electromagnetic flowmeters with data loggers; pipes' replacement	DMA selected and preliminary works are done	All actions performed for setting up DMA Dunav with measuring and telemetry equipment for data collection at the entrance; data analysis and calculation of performance in indicator.			Main focus in current period was physical replacement of main pipeline in DMA for which it was proven that generate physical water losses.
PB6	Development of IT applications aiming at supporting the operations of the water utility and indirectly the water use efficiency (reduction of NRW). The applications will be: • Water distribution networks management application. • Mapping of the failures' history.	IT applications; GIS software license		The Tender procedure was initiated at 15/05/2019, will be completed in 25/05/2019 and will be contracted in early June			

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Chapter 3. Results – Discussion

The present chapter presents the pilot actions each beneficiary elaborated. The results from the elaboration of each pilot action are presented.

3.1 PB1 – Municipal Water Supply and Sewerage Company of Komotini, Greece

3.1.1 General data on the pilot area

Municipal Water Supply and Sewerage company of Komotini (DEYAK) supplies with water the municipality of Komotini, located in the Water District of Thrace (EL12). The people supplied with water is 65,000. The area covered is 385.3 km^2 and the average altitude is 45m. The total pipes' length is 549 km consisting of pipes from PE (with diameters 90-450mm) and from steel (with diameters 600mm). The water pipes network is old enough. The average operating pressure is 4 atm and the total number of water meters is 48,500. The number of service connections is about 17,000. The billing period is 2 months for the city of Komotini and 4 months for the municipal districts. The river basin where water is taken from is the river basin of Komotini – Loutro Evrou stream (area 1,958.3Km^2). Water is taken from Vosvozis river (EL1209R0000010085N) and the groundwater system of Rodopi (EL1200120). All the information is given in Table 3.1.1.

Table 3.1.1. General data on the water supply system of DEYA Komotinis

Data (base year 2018)	
Total population served	65,000
Total area covered (km^2)	385.3
Total pipes' length (km)	549
Mean altitude (m)	45
Mean operating pressure (Atm)	4.0
Types of pipes (material, diameters)	PE (90-450mm) and steel (600mm)
No. of water meters	48,500
No. of service connections	17,000
Billing period	2 months for Komotini city; 4 months for municipal districts
River Basin where water is taken from	Komotini – Loutro Evrou stream

3.1.2 Pilot Action

The pilot action implemented by DEYA Komotini refers to water use efficiency.

The water utility faces problems related to high Non-Revenue Water (NRW) which was estimated for 2017 to be 38% of SIV. Specifically, the water supply network suffers from pipes breaks, invisible leaks, unauthorized consumption. The main cause is that the water distribution network is old in many parts of the city.

The pilot action refers to the provision of services for the supply and installation of IT applications to directly support the water utility operations and indirectly contribute to the water use efficiency (by reducing NRW). The applications are expected to provide:

• Failure history mapping. The application will present the failures history in an interactive map. It will provide the possibility of selection of filters depending on, e.g. the severity of the problem, the time period, the cost of confrontation measures etc. The data will be presented alone but also cumulatively in the form for example of cluster map or heat map. The possibility to choose the time period of reference of the problems to give the opportunity someone to be able to see their time evolution. Additionally, the application will provide a problems management environment.

• Field applications. Utilizing the water utility's background in GIS software, field applications will be developed, in tablet environment that will be used from the utility's repair teams to provide them access to the data (e.g. distribution networks) but also to inform immediately the water operators regarding the problems faced and recorded from the personnel in the field. These applications will allow a more efficient coordination and a significant reduction in the troubleshooting time, contributing to water saving.

• Applications for the public. Internet based applications for the public will be developed. The consumers will be able to report a problem and the water utility will inform the consumers for possible water interruptions or other problems.

The pilot action was elaborated in 2018. The pilot action targets the real losses pillar “speed and quality of repairs”. By using these IT applications, the water utility will be able to:

- Be informed about the failures in the water supply and distribution system and assess their spatial and temporal variability. This will act as a decision-making tool for the water utility.
- React quicker to any failure event reducing the response time and also reduce the repair time as all the data will be available to the staff. Time reduction will eventually result in real losses reduction.
- Be informed quicker as the public will be able to report any problems asap and thus reduce the reaction and repair time.

3.1.2.1. Applications for the public

The IT applications developed as pilot action in DEYAK include an internet application, through which the public will be able to inform the utility about problems in the water supply network, while the utility will be able to proceed to the examination and solution of the mentioned problems and to inform the public for scheduled water supply interruptions. The application is accessible at the address: https://komotini.getmap.gr/.

The following categories of failures are included:

- Water leak on the ground surface;
- Firefighting break;
- manhole overflow;
- turbidity;
- bad odor of water.

Also, the consumers can use this application to check their water bill.

The steps are the following:

Initially the consumer is registered at the system. Then the consumer can submit a report regarding a problem by indicating the location and the data related to the problem / failure such as kind of failure, if there is water loss, a brief description, and a photo attachment field. The date and time are automatically entered as well as the consumer’s username and the status of the report. The users will have the opportunity to get informed about the problem they have reported.

The water utility staff is the administrator of this application.

The “users” tab allows the staff user to manage all users.

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The water supply interruptions tab allows to enter the scheduled interruptions and some of the data to be visible for the public.

Figure 3.1.1. Application interface

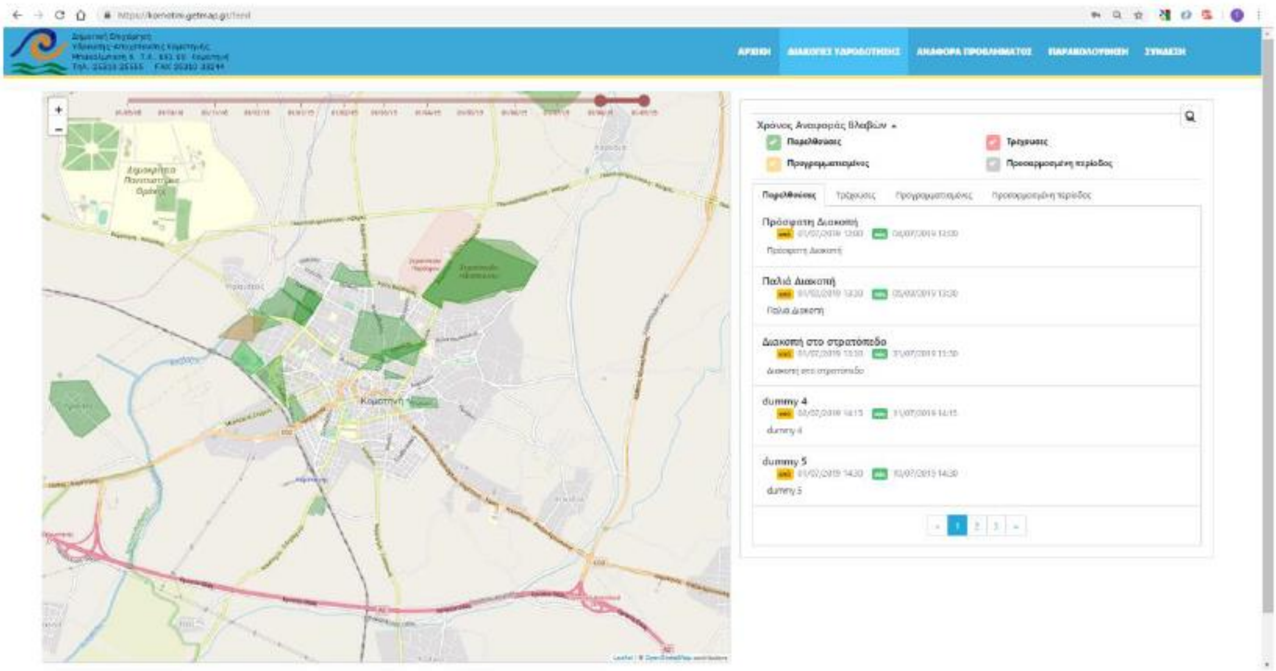

Figure 3.1.2. Water supply interruptions map

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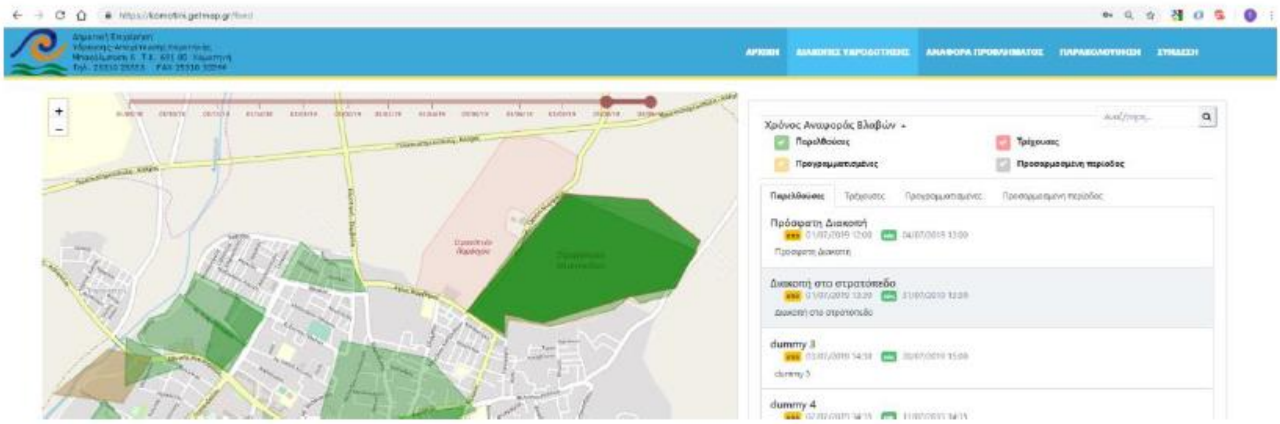

Figure 3.1.3. Spatial recording of failures

3.1.2.2. Spatial mapping of failures

This application refers to a system of spatial recording of failures. This is an online application that presents the entire history of DEYAK failures on maps and backgrounds. The application is accessible at the address: https://deyakmap.getmap.gr and the managers of the utility have full access.

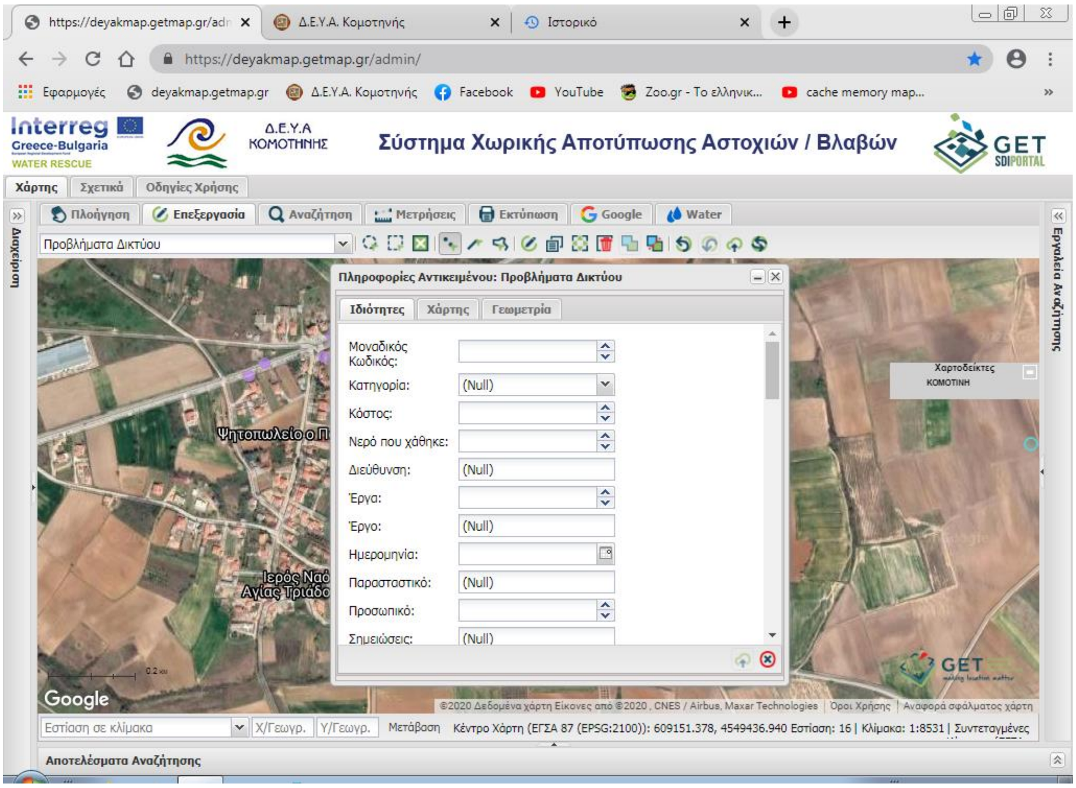

Figure 3.1.4. Inserting the failure in the application

The staff enters the information of a failure (Figure 3.1.4) and then the failure is inserted and saved in the application (Figure 3.1.5). The table showing the failures in the water supply network is available from the application (Figure 3.1.6). The data gathered from this list is the number of the incident, its description, the classification of the work, the cost and the water volume lost (Figure 6). The statists are also available (Figure 3.1.7). There are various search options, for example by category of the failure, by area, etc. (Figure 3.1.8).

There is also the option to search by code number (Figure 3.1.9). The application provides the ability to view the failure reports in the form of a map, using also Google Streets background (Figures 3.1.10 & 3.1.11).

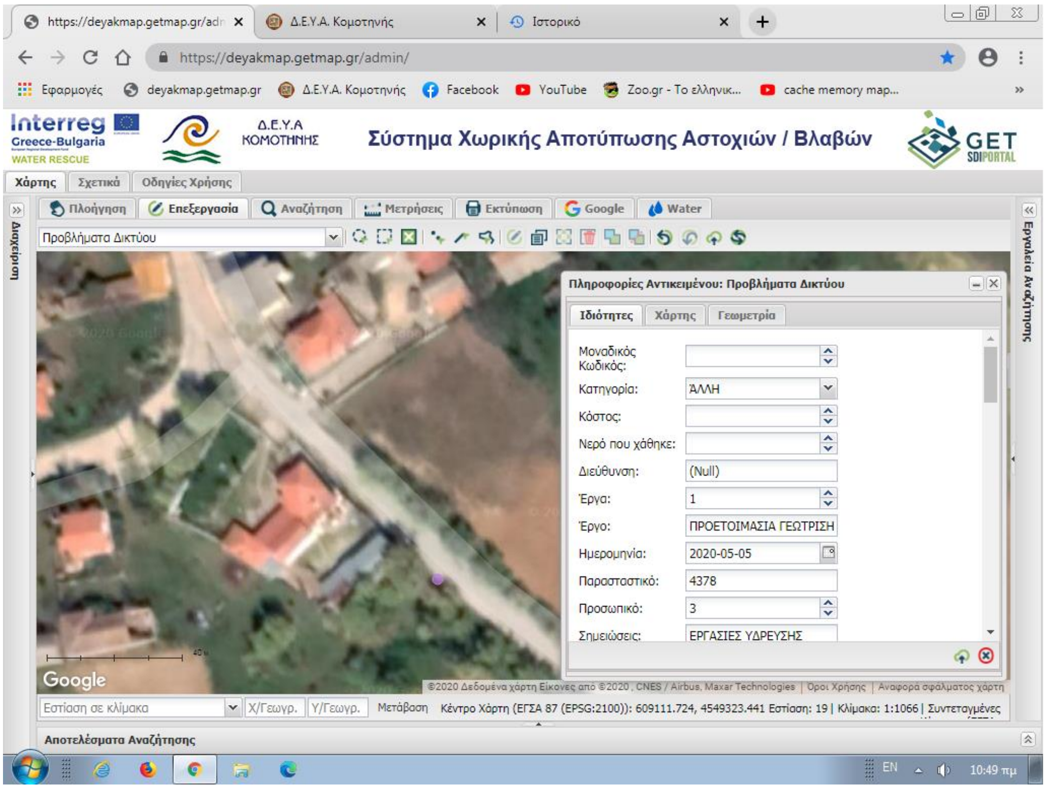

Figure 3.1.5. The failure is inserted and saved in the application.

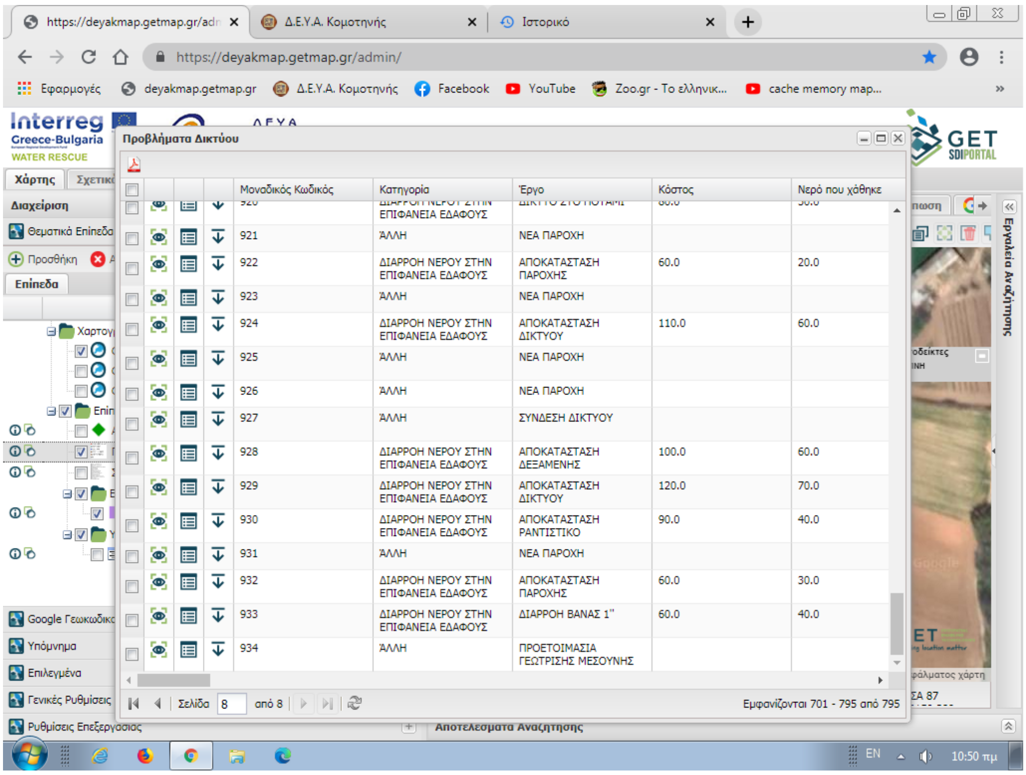

Figure 3.1.6. List of failures.

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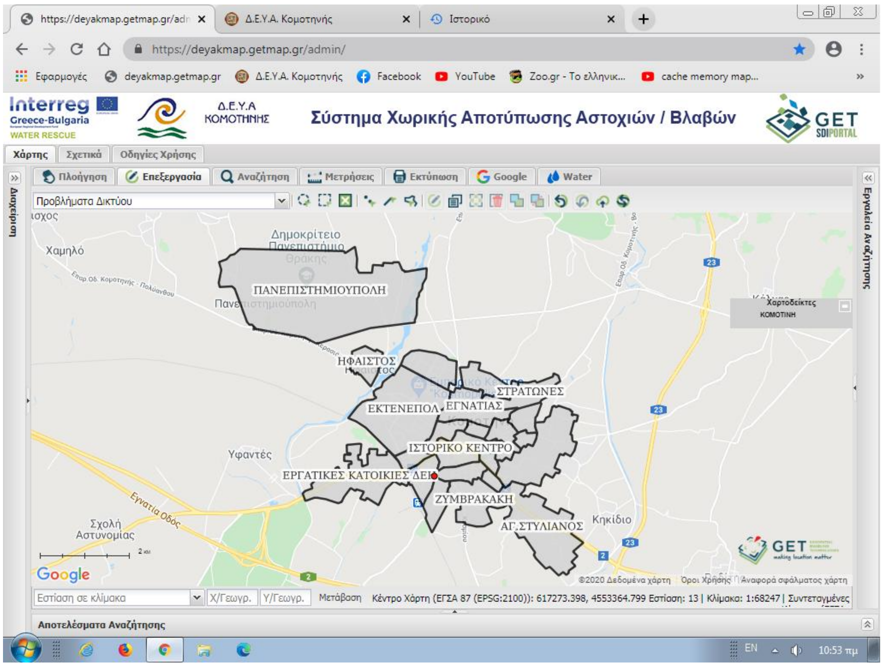

Figure 3.1.7. Statistical information on the problems of the area

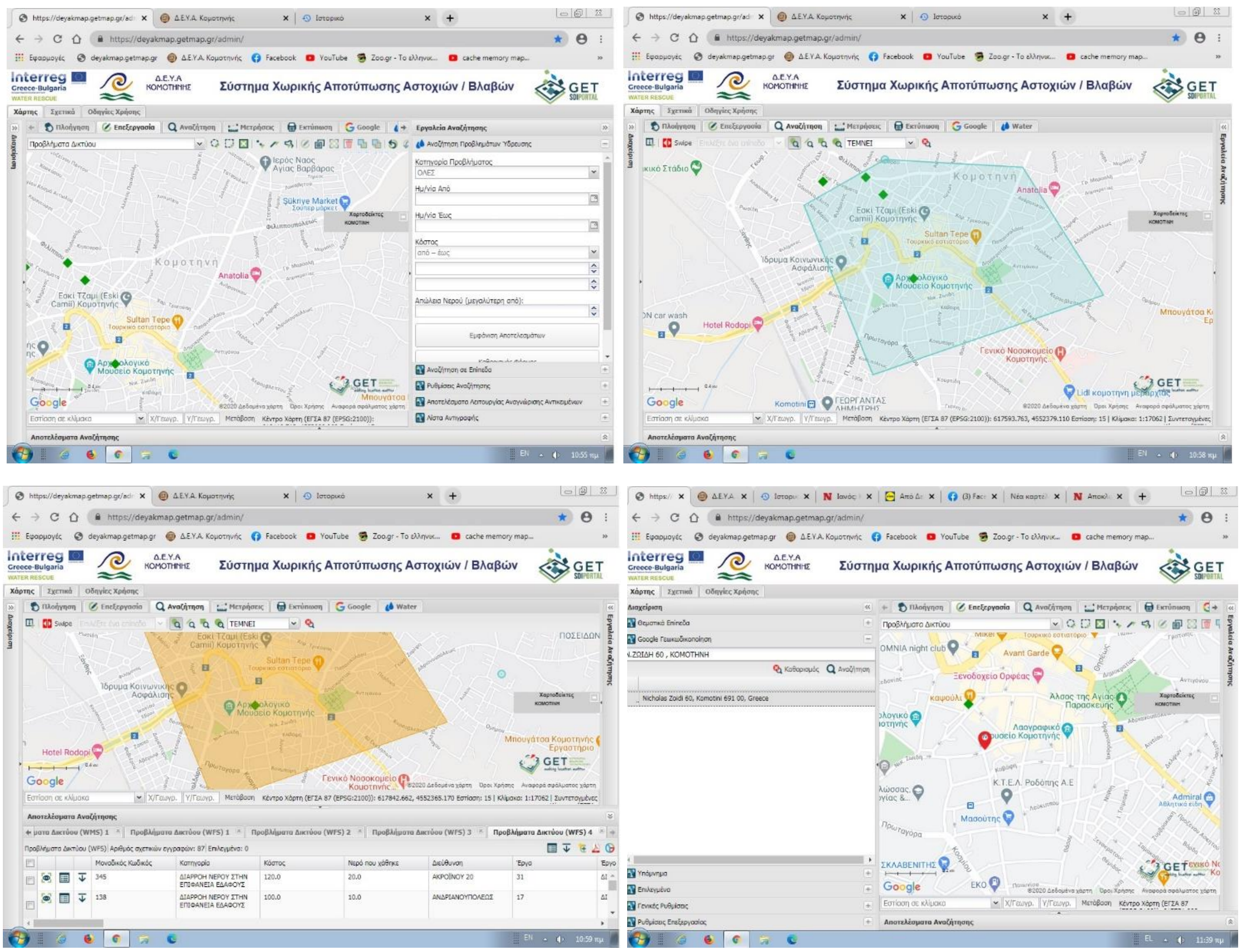

Figure 3.1.8. Search by category, by area, and other search options

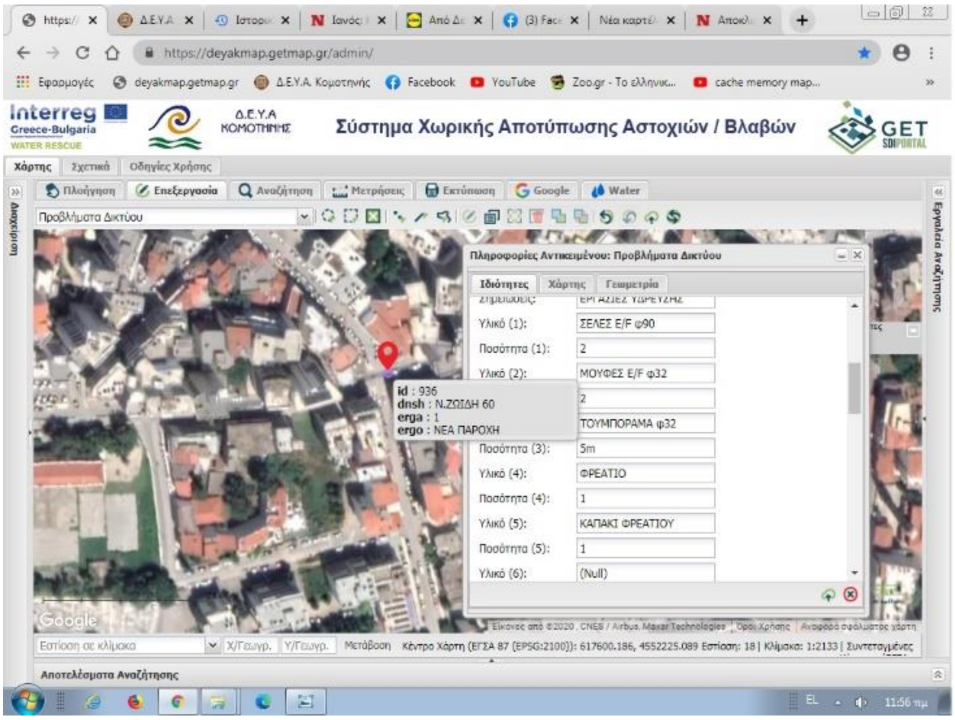

Figure 3.1.9. Search by code number

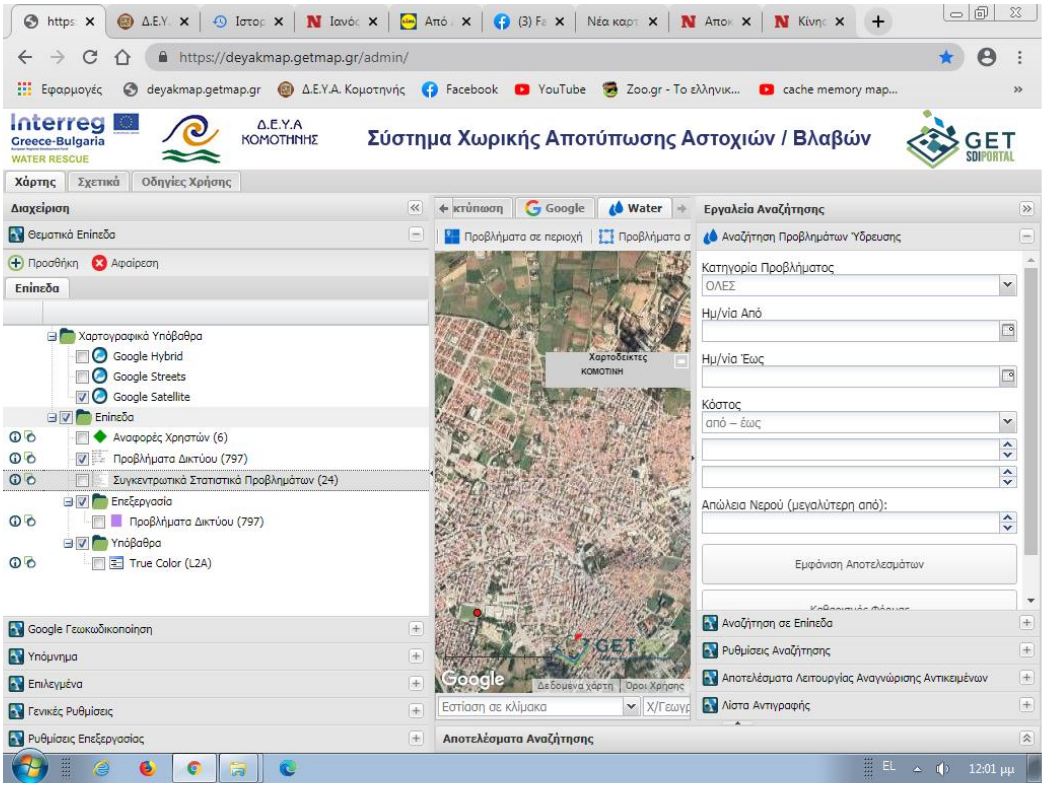

Figure 3.1.10. View options

The application includes the tab "map" including various tools for the user. The application provides the user with the base maps and the layers. The base maps are used to facilitate the orientation, display and interpretation of data, as they provide a rich and detailed representation of the natural earth surface and features. Backgrounds are "static" in comparison to layers that take their data from geospatial services.

The layers include various possibilities. The application is able to search for failures based on various criteria such as type of failure, time frame, cost and amount of water losses (Figures 3.1.8 & 3.1.9).

The applications are connected to QGIS software providing geospatial data.

During the pilot action the concessionaire provided educational activities to the utility’s staff in order to be trained to these applications.

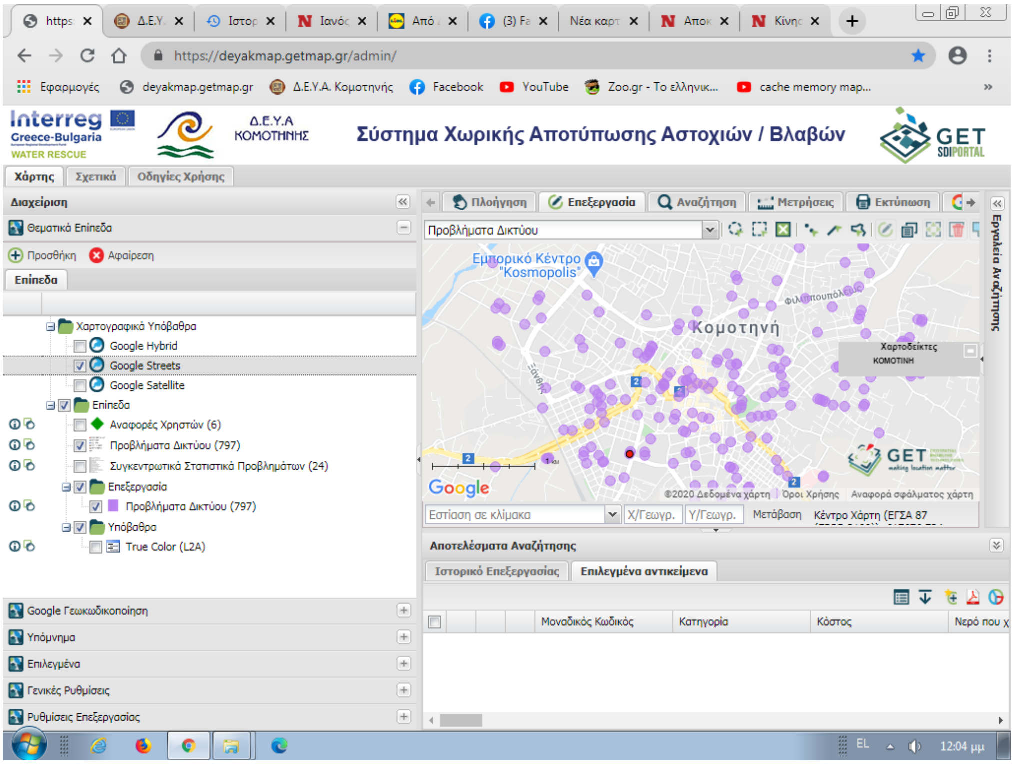

Figure 3.1.11. View options using google streets

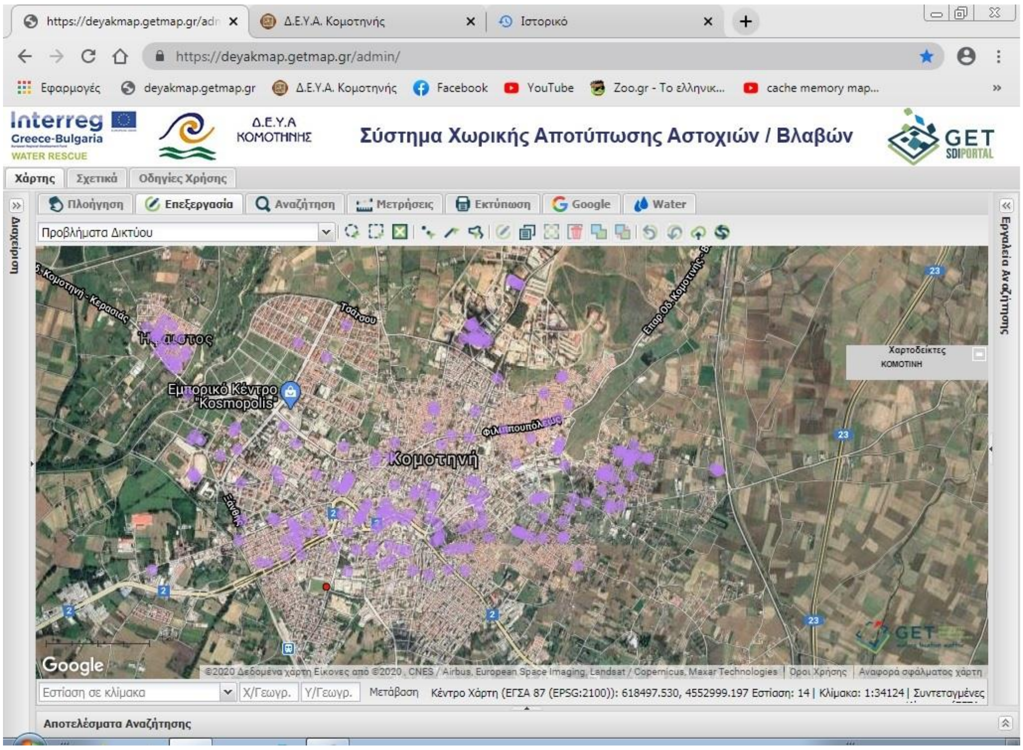

Figure 3.1.12. The central screen showing the failures

3.1.3 Results

The water utility staff was trained in order to use the developed applications. In particular, the water utility staff inserted the reported failures for 2018 and 2019 in the application. Specifically, in 2018 66 failures related to pipes' leaks and breaks were reported while in the first 9 months of 2019 135 failures were reported and inserted in the application. The main failures are pipes' leaks and breaks, followed by network repair and connections' leaks in 2019 (Figure 3.1.13).

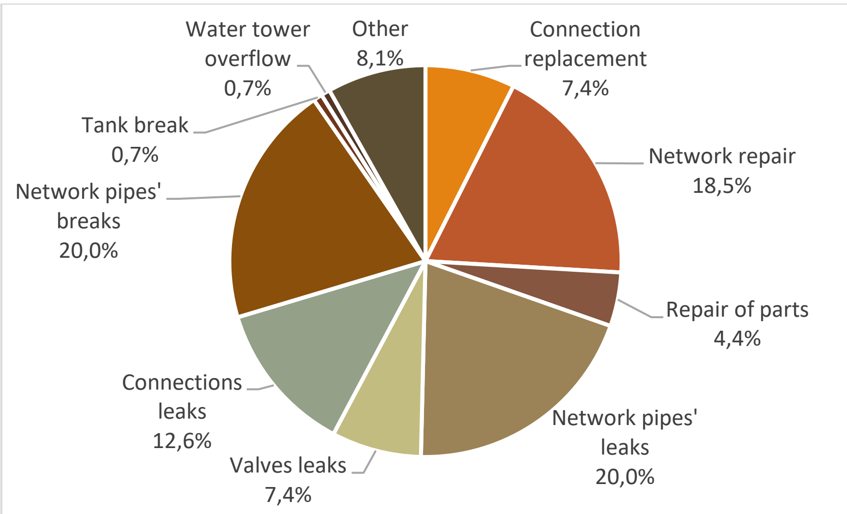

Figure 3.113. The main failure types in 2019

The use of the developed applications aims at targeting the speed of repairs, being a real losses reduction pillar. Additionally, the applications aim at improving the quality of services to the consumers. The total cost of the pilot action is 88,000.00€.

The benefits of the pilot action are the time reduction for the repair of failures by the online information from the public and the provision of all data regarding a failure online, informing the customers for any emergency situation, better analysis of the failures of the water supply network in order to schedule and organize any actions, etc. By reducing the time to repair, less water volume is lost and the costs are reduced. Also the water utility managers can use these IT applications as decision-making tools. The data gathered from the application regarding failures provide a good insight on the main problems of the water supply network and their spatial allocation, allowing the water utility managers to prepare the tenders for the necessary works. Finally, the water utility provides improved water services to its customers.

3.1.4 Problems encountered and applied solutions

There are not any specific problems encountered during the pilot action implementation. The only problem faced was the delay of the tender procedures due to bureaucratic reasons.

DEYAK suggests that other water utilities can apply this solution as it is a useful decision-making tool.

3.1.5 Lessons learnt

The pilot action has proven to be a useful decision-making tool and DEYAK suggests other utilities to implement such applications. IT applications that can be connected to other IT tools (e.g. GIS, SCADA, etc.) are useful to the utility managers.

3.2 PB2: Municipal Enterprise for Water Supply and Sewerage of Thermi, Greece

3.2.1 General data on the pilot area

Municipal Water Supply and Sewerage Company of Thermi (DEYA Thermis) is the water utility supplying with water the area of Thermi including several municipal districts: Thermi, Mikra, N. Redestos, Tagarades, N. Risio, Vasilika, Souroti, Agia Paraskevi, Agios Antonios, Lakkia, Peristera and Livadi. The area covered by DEYA Thermis is 1,559.34 Km^2. The area's altitude ranges from 0-200m. The water meters (active) are 25,786 supplying with water a population of 53,070 people (2011 census). The total pipes' length is about 700Km and the pipes are made of PE (60%) and PVC (40%). The pipes are installed since 1970 until now. The average operating pressure is about 5 atm (Table 3.2.1).

DEYA Thermis is supplying the municipal district of Thermi with water from groundwater boreholes from three groundwater subsystems: down flow of Antemountas; Thermi – N. Risio; and Cholomontas – Oreokastro (Chalkidiki river basin). DEYA Thermis water abstraction is allocated in the groundwater systems as shown in Table 3.2.1. The major water volume (97.8%) comes from the subsystems of Anthemountas down flow and Thermi – N. Risio. The first subsystem is assessed in bad quantitative and chemical status, while the second is assessed in good quantitative and chemical status. Only 2.1% of water volume comes from the Cholomontas - Oreokastro subsystem which is found to be in good chemical and quantitative status.

Table 3.2.1. General data of the water supply network of DEYA Thermis (base year 2019)

General data	
Total population served	53,070
Total area covered (Km^2)	1,559.34
Total pipes' length (Km)	700

Mean altitude (m)	0-200
Mean operating pressure (atm)	5
Types of pipes (material, diameters, lengths)	PE (60%); PVC (40%)
Age of pipes (per material, diameter)	Since 1970
No. of water meters	25,786
Billing Period	Every 3 months
River Basin where water is taken from	Chalkidiki river basin

3.2.2 Pilot Action

The pilot action of DEYA Thermis refers both to water efficiency and water quality.

3.2.2.1 Water Efficiency

DEYA Thermi uses 54 boreholes for water abstraction. However, the water volume abstracted is not actually recorded, resulting in assumptions on the estimation of these water volumes. The fact that the water volume entering the water distribution network is estimated based on the pumping stations data, does not allow the water utility to do the water balance based on actual data. The consequences are that the water balance could not show the actual Non-Revenue water (NRW) values and the actual causes of NRW. Additionally, based on national legislation the Water Directorate issued water use permits for the boreholes used and the water utility is obliged to install flowmeters for the monitoring and recording of the water abstraction. During the pilot action, flowmeters are supplied and installed in 45 boreholes (Table 3.2.2; Figures 3.2.1 & 3.2.2). The installation took place from 27/11/2019 until 16/12/2019. The flowmeters conform with the European Directive MID 2004/22/EC or the later MID 2014/32/EC.

Table 3.2.2. The locations of the installed flowmeters

a/a	Location / Borehole	Name of the location	Supplying water to the municipal districts
1	Thermi	Aeroporias	Thermi – 16.000 people
2	Thermi	Firos Sideras	
3	Thermi	Kosmidis	
4	Thermi	Emporiki	
5	Thermi	Ergotaxio	
6	Thermi	Thermokipio	
7	Thermi	Interbeton	
8	Thermi	Lida Maria	
9	Thermi	Parsourakou-2	
10	Thermi	Patsourakoy-new-3	
11	Thermi	Toumpas B	
12	Triadi	Triadi	
13	Thermi	Hayat	
14	Thermi	Eurotech	
15	N. Redestos	Kanavou	Vasilika – 4.030 people
16	Filothei	Filotheis -1 (Redestos)	
17	Filothei	Filotheis -2 (new)	
18	Filothei	Filotheis -3 (old)	
19	N. Redestos	Hempe	
20	N. Redestos	Christoforou	
21	Tagarades	Tagaradon -1	Tagarades – 2.100 people
22	Tagarades	Tagaradon-3 (Livadi) new	

23	N. Risio	Zampetoglou	N. Risio – 3.000 people
24	N. Risio	N. Risiou - C3	
25	N. Risio	N. Risioy – C4	
26	Vasilika	Ai Gianni (BA3)	Agios Antonios (Vasilika) – 880 people
27	Lakkia	North Oikismos LA1	Lakkia – 45 people
28	Lakkia	Inverter 1	
29	Lakkia	East Oikismos LA2	
30	Ag. Paraskevi	Anthemounta P. (ACP1)	Agia Paraskevi (Vasilika) – 2.300 people
31	Souroti	Koukos (S1)	Souroti – 1.600 people
32	Livadi	Entos Oikismou(L1)	Livadi – 260 people (850 in the summer)
33	Livadi	Ektos Oikismou (L2)	
34	Kardia	Christodoulidis	Plagiari, Kardia, Kato Sholari, Trilofos, Lakkoma – 18.500 people and 212 connections to businesses
35	Kardia	Kloni	
36	Kardia	Kakarimou	
37	Epanomi	Apostolou	
38	Plagiari	Rema	
39	Plagiari	A1.3-Osia Xeni (Garou)	
40	Plagiari	A2.1	
41	Plagiari	A2.2	
42	Plagiari	New A2	
43	Plagiari	A1.2-Trigonou	
44	Plagiari	A1.1	
45	Ag. Paraskevi	S1(Ag. Paraskevi)	

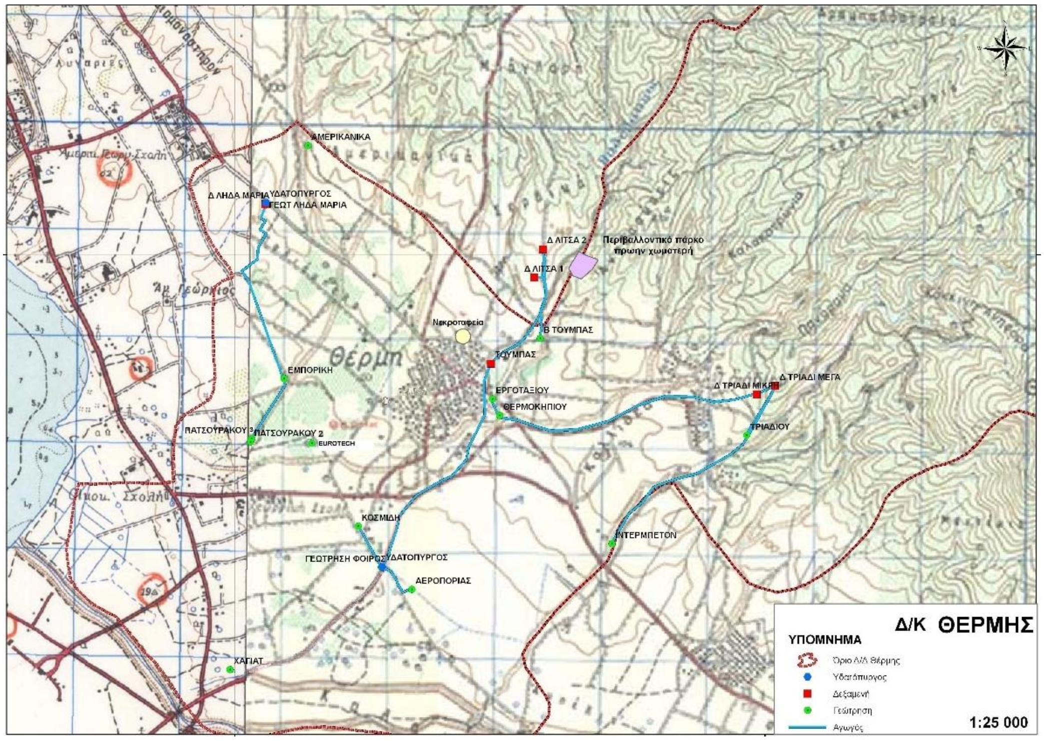

Figure 3.2.1. The location of boreholes and tanks in the municipal district of Thermi

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

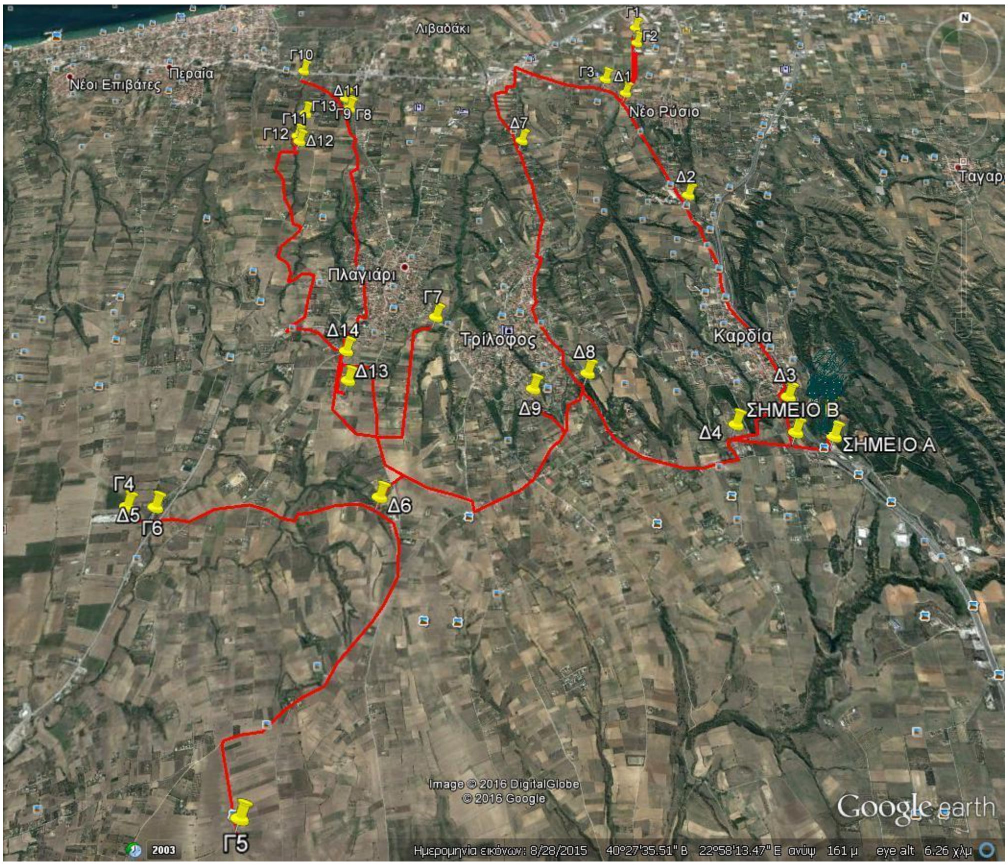

Figure 3.2.2. The location of boreholes and tanks in the municipal district of Mikra

3.2.2.2 Water Quality

DEYA Thermis uses chlorination for the disinfection of water in water tanks. There are 29 chlorination points to cover the whole water supply network of DEYA of Thermi. The major problem faced regarding water quality is the increased value of some physical-chemical parameters that sometimes is near the allowable maximum values of the legislation. The cause of this problem is the groundwater geological background. Another problem is the excessive increase of turbidity which is due to the excessive abstraction of the groundwater. The tanks did not have automated chlorination systems.

The pilot action is the supply and installation of automated chlorination systems in 6 water tanks (out of the 29 chlorination points, that is 20.7%) (Table 3.2.3). The installation was concluded in 6/12/2019. The automated chlorination systems provide assurance that water quality parameters are within the limits set by legislation and regulations (Figure 3.2.3).

Table 3.2.3. The locations of the installed automated chlorination systems, their capacity and consumption

a/a	Settlement name	Tank	Capacity (m^3)	Consumption (m^3/year)
1	Kardia	Sterna (Δ1)	40	290,000
2	Plagiari	Central tank (Δ14)	240	400,000
3	N. Redestos	Pefkakia (small – Δ1)	75	45,000
4	Ag. Paraskevi	Upper tank (Δ1)	400	295,000
5	Souroti	Upper tank (Δ1)	200	205,000
6	Peristera	D2	200	50,000

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Figure 3.2.3. Chlorination devices installed

3.2.2.3 Hydraulic Simulation model

PB3, University of Thessaly, Civil Engineering department, developed the hydraulic simulation model for the water distribution system of Thermi. WaterGems software is used.

The water utility provided the necessary data to the University of Thessaly, Civil Engineering dept. and specifically pdf files with the geoprofile of the external and internal aqueduct (Figure 3.2.4), consumption data per water meter of 2018, data about the tanks and the boreholes.

Figure 3.2.4. Geoprofile of the internal aqueduct

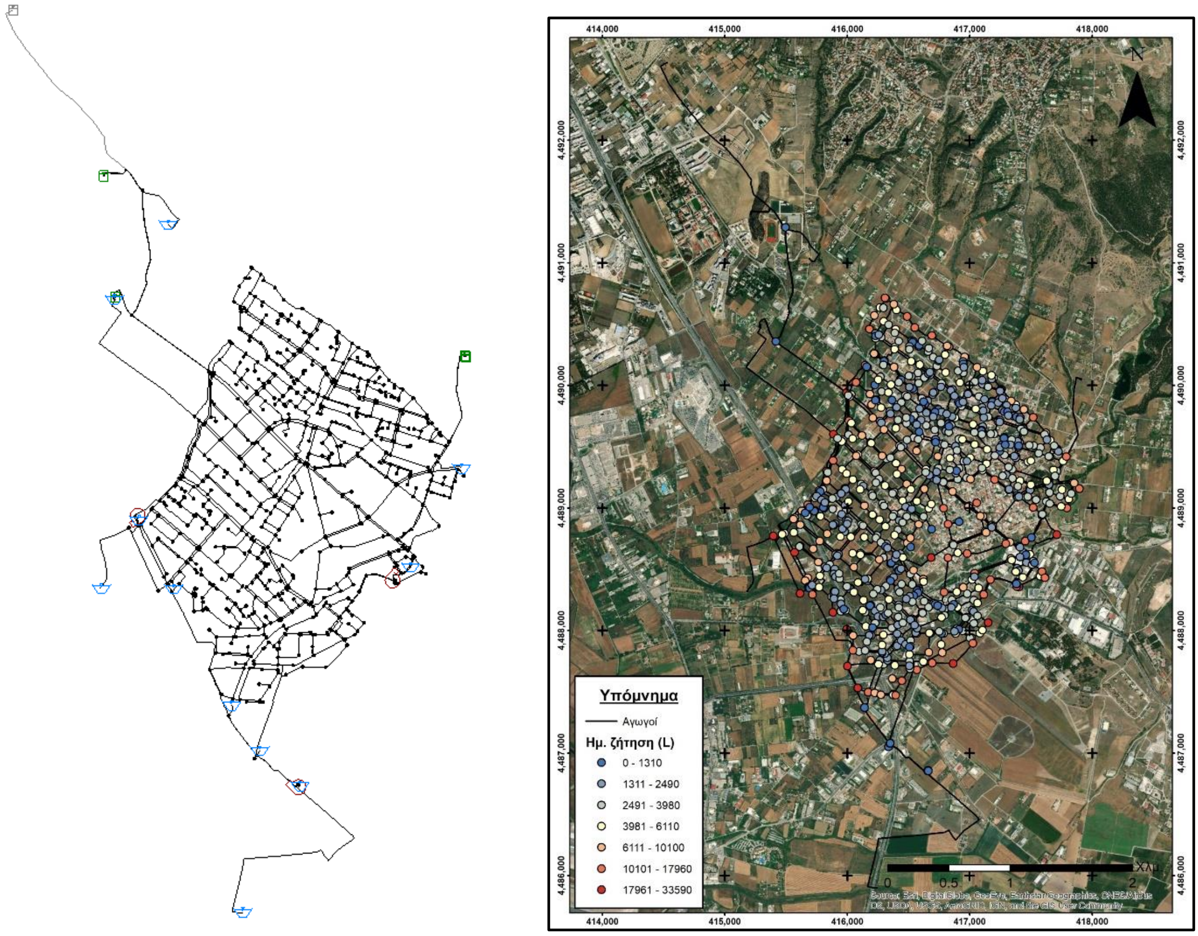

Figure 3.2.5. (a) The water distribution network of Thermi; (b) the average daily nodes' consumption

The internal network is mainly looped in shape and is gravitational, while the external aqueduct operates gravitationally and in parallel with pumping stations. There are eleven sources of water entering the network. Water from four boreholes goes to the Aeroporia tank from where the water is transferred to two pumping stations. Water from one of the pumping stations with water from another borehole goes to the Litsa Tank 2, and from there to Litsa tank 1. Then water is transported to the distribution network by gravity. Water from the other pumping stations along with water from three other boreholes is transferred to the new tank of Thermi. Water enters the distribution network by gravity. The water network is showed in Figure 3.2.5a.

The consumption pattern is established for the model using data from the water utility. The consumption is equally distributed using Thiesen triangles at the network's nodes. However, it is noted that there are many types of users such as domestic, agricultural, industrial and the use from the airport of Thessaloniki. Figure 3.2.5b shows the average daily nodes' consumption.

Figure 3.2.6a shows the external pipes' diameter and figure 3.2.6b shows the pipes' material.

The hydraulic model of the network is developed. The results (Figure 3.2.7a) show that the smaller / local pipes show the lowest flow rates, while the main water distribution pipes show the highest average daily flow. Given that pressure is not regulated through pressure reduction valves, the results showed that the nodes at the highest altitudes of the network have low pressure, while as altitude decreases pressure increases to quite high pressures (Figure 3.2.7b).

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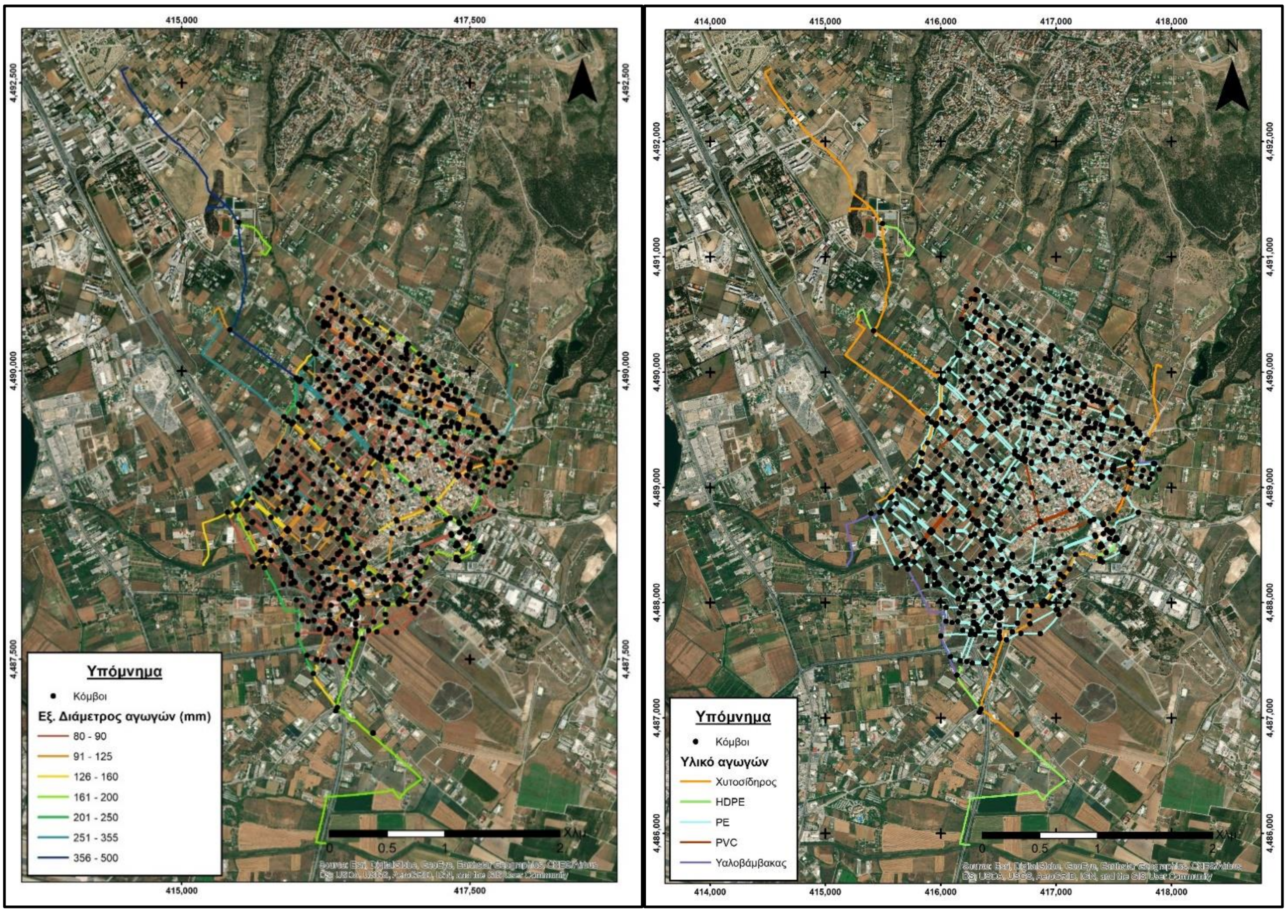

Figure 3.2.6. (a) External pipes' diameter; (b) pipes' material

Three pressure zones are developed (virtually) using the hydraulic model using combinations of altitude and pressure (Figure 3.2.8). For the creation of the three zones some of the isolation valves are closed and some other are added (Table 3.2.4). To regulate the pressure, three pressure reduction valves are installed at the entrance of each zone in order to achieve minimum pressure of 2 atm in every node. The critical nodes are identified: (a) zone A, higher altitude node J-327 and lower altitude node J-33; (b) zone B, higher altitude J-417 and lower altitude node J-196; and (c) zone C, higher altitude node J-749 and lower altitude node J-587.

It is noted that there is a reduction in pressure in all zones, with the maximum reduction up to 58% while the minimum reduction is 4% (Table 3.2.5). In addition, there is a stabilization of pressure during zoning, where the average pressure per zone remains constant regardless of time, in contrast to the time before the zones' creation where a strong fluctuation in pressure is noted. The model showed that if zoning takes place the water volume entering the network is reduced by 3.44%.

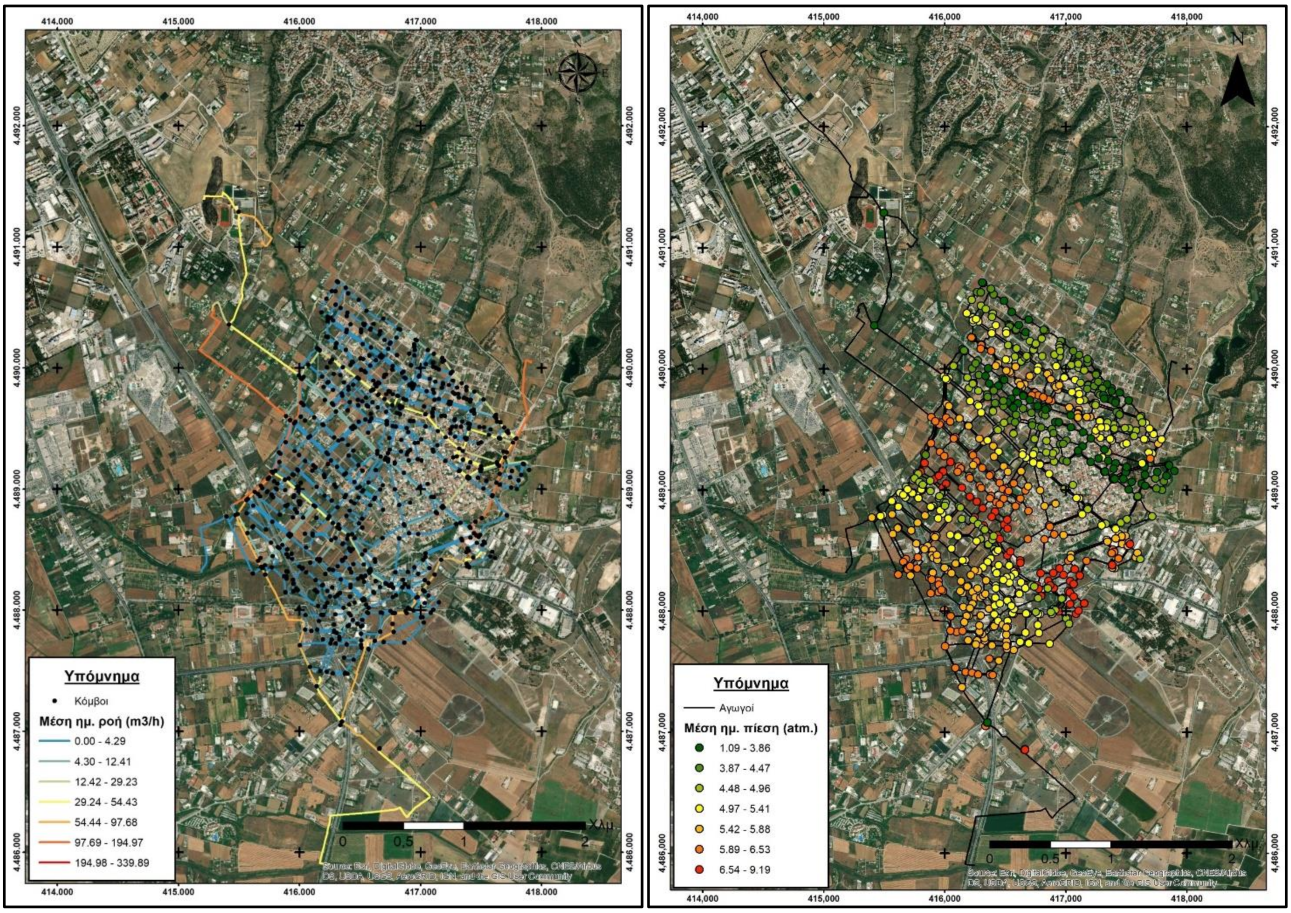

Figure 3.2.7. (a) Average water flow; (b) average water pressure

Table 3.2.4. Old and new isolation valves and pressure reduction valves

Isolation valves			
Name	Diameter (mm)	Altitude (m)	Pipe id
Existing			
ISO-107	160	64,34	P-198
ISO-113	400	61,25	P-202
New ones			
ISO-186	315	60,60	P-294
ISO-187	225	66,35	P-317
ISO-188	160	66,50	P-472
ISO-189	225	57,67	P-347
ISO-190	225	66,50	P-345
Pressure reduction valves			
Name	Diameter (mm)	Altitude (m)	Pressure set (atm)
PRV-1	300	86,28	4,15
PRV-2	350	42,04	2,10
PRV-3	160	61,75	2,50

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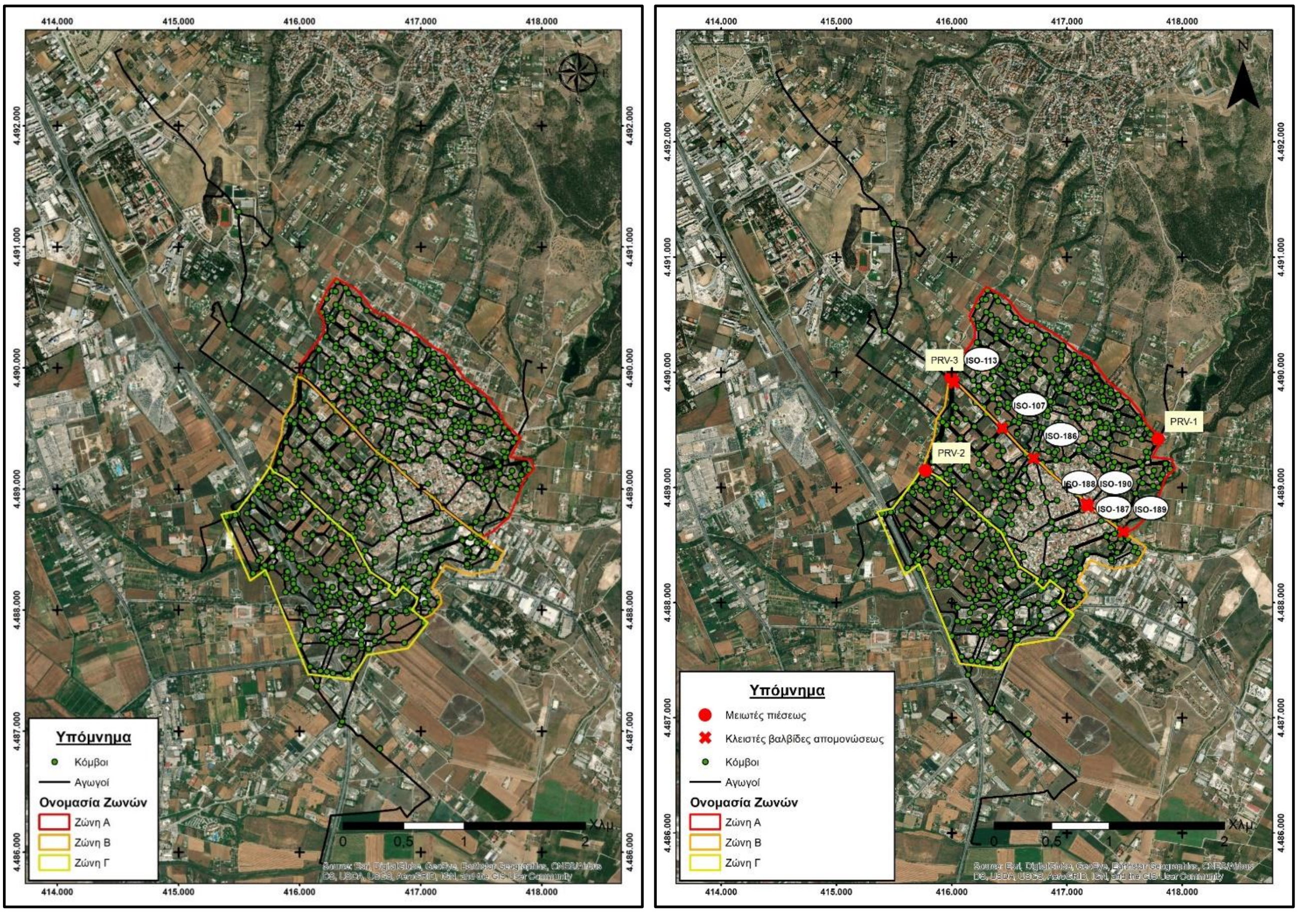

Figure 3.2.8. (a) Three pressure zones suggested; (b) PRVs and isolation valves

Table 3.2.5. Average pressure before and after the creation of the zones and the difference in percentage

Time (hours)	Before zoning			During zoning			Difference (%)		
	Zone A	Zone B	Zone C	Zone A	Zone B	Zone C	Zone A	Zone B	Zone C
0	4,53	6,48	5,41	4,00	3,60	2,85	-11,73%	-44,49%	-47,33%
1	4,56	6,49	5,43	4,00	3,60	2,85	-12,24%	-44,61%	-47,52%
2	5,42	8,53	5,42	4,02	3,60	2,85	-25,92%	-57,82%	-47,46%
3	5,39	8,49	5,42	4,45	3,60	2,85	-17,41%	-57,64%	-47,42%
4	5,39	8,49	5,41	4,45	3,60	2,85	-17,50%	-57,62%	-47,38%
5	5,38	8,46	5,41	4,01	3,60	2,85	-25,44%	-57,49%	-47,33%
6	4,54	6,49	5,43	4,36	3,59	2,85	-3,88%	-44,64%	-47,54%
7	5,00	7,68	5,41	4,14	3,59	2,84	-17,14%	-53,26%	-47,42%
8	4,50	6,49	5,40	4,00	3,57	2,84	-11,07%	-44,95%	-47,45%
9	4,52	6,46	5,38	3,99	3,56	2,83	-11,84%	-44,86%	-47,35%
10	4,48	6,41	5,39	3,98	3,56	2,83	-11,21%	-44,46%	-47,48%
11	4,48	6,43	5,38	3,98	3,57	2,83	-11,06%	-44,56%	-47,34%
12	4,47	6,42	5,40	3,98	3,57	2,84	-10,92%	-44,37%	-47,49%
13	4,48	6,44	5,39	3,98	3,57	2,84	-11,09%	-44,58%	-47,38%
14	4,50	6,44	5,38	3,97	3,57	2,84	-11,68%	-44,56%	-47,28%
15	4,48	6,42	5,40	3,98	3,57	2,84	-11,23%	-44,39%	-47,47%

16	4,48	6,44	5,39	3,98	3,57	2,83	-11,13%	-44,66%	-47,38%
17	4,49	6,44	5,37	3,97	3,56	2,83	-11,64%	-44,72%	-47,24%
18	4,49	6,43	5,37	3,98	3,55	2,83	-11,38%	-44,86%	-47,34%
19	4,48	6,43	5,37	3,98	3,55	2,83	-11,27%	-44,80%	-47,39%
20	4,48	6,41	5,38	3,98	3,55	2,83	-11,16%	-44,54%	-47,43%
21	4,49	6,44	5,37	3,97	3,56	2,83	-11,66%	-44,65%	-47,23%
22	4,49	6,43	5,39	3,98	3,57	2,84	-11,28%	-44,41%	-47,37%
23	4,50	6,45	5,40	3,98	3,59	2,84	-11,58%	-44,36%	-47,32%
24	4,50	6,47	5,41	4,00	3,60	2,85	-11,03%	-44,42%	-47,38%

3.2.3 Results

The expected results from the pilot action include:

- Accurate estimation of the water volumes abstracted and entered the water supply system of DEYA of Thermi;
- Better estimation of the water balance and the NRW levels;
- Design of the strategies to reduce NRW levels based on accurate data;
- Adequate chlorination for the water supplying the municipal districts of Thermi municipality;
- Safe water for the consumers.

3.2.3.1 Water efficiency

The results from the pilot action implementation include the exact recordings of the flowmeters in the boreholes (Table 3.2.6). Data are gathered on 28/1/2020, 30/6/2020 and 9/2/201. The data from the last registration are taken into consideration to estimate the total water volume entering the network. The time the flowmeters were metering is from 27/11/2019 – 9/2/2020 (440 days average). The total water volume recorded during this time period is 8,212,705m^3. Given that this amount of water is abstracted from 45 out of the 54 boreholes, the total amount abstracted from all the boreholes for the same period of 440 days is estimated to be 9,855,246m^3. That means that in a year time the total water volume abstracted is estimated to be 8,175,375m^3. The water utility estimates that during one year the total water volume abstracted is about 4,100,000m^3. The water volume abstracted is highly underestimated (almost 100%)! Given that the water volume consumed is recorded in the water consumers, the NRW levels are very high!

The total cost for the supply and installation of the flowmeters is 66,150.00€ (no VAT included).

The exact recordings of the water volume will allow the water utility to estimate accurately the NRW level and design strategies and measures to reduce it.

Table 3.2.6. Flowmeters' recordings

a/a	Location / Borehole	Name of the location	Water volume abstracted until 28/1/2020 (m^3)	Water volume abstracted until 30/6/2020 (m^3)	Water volume abstracted until 9/2/2021 (m^3)
1	Thermi	Aeroporias	96,077	245,488	688,420
2	Thermi	Firos Sideras	42,715	153,549	268,160
3	Thermi	Kosmidis	36,302	120,550	212,420
4	Thermi	Emporiki	27,115	76,399	202,170
5	Thermi	Ergotaxio	10,503	26,050	81,175
6	Thermi	Thermokipio	44,357	104,618	273,270
7	Thermi	Interbeton	62,123	141,866	381,123

8	Thermi	Lida Maria	32,841	32,888	32,902
9	Thermi	Parsourakou-2	0	0	0
10	Thermi	Patsourakoy-new-3	19,313	59,228	201,621
11	Thermi	Toumpas B	0	0	0
12	Triadi	Triadi	15,068	49,881	155,208
13	Thermi	Hayat	12,990	60,609	235,725
14	Thermi	Eurotech	71,527	154,946	337,422
15	N. Redestos	Kanavou	479	588	604
16	Filothei	Filotheis -1 (Redestos)	88,569	204,357	472,930
17	Filothei	Filotheis -2 (new)	56,174	106,247	284,100
18	Filothei	Filotheis -3 (old)	626	5,537	50,028
19	N. Redestos	Hempe	4,067	14,518	50,768
20	N. Redestos	Christoforou	20,027	69,821	249,489
21	Tagarades	Tagaradon -1	21,091	110,913	224,675
22	Tagarades	Tagaradon-3 (Livadi) new	68,251	118,745	142,070
23	N. Risio	Zampetoglou	0	0	0
24	N. Risio	N. Risiou - C3	24,806	68,839	191,750
25	N. Risio	N. Risioy – C4	40,929	106,682	294,600
26	Vasilika	Ai Gianni (BA3)	19,698	116,948	196,370
27	Lakkia	North Oikismo LA1	20,935	42,855	97,633
28	Lakkia	Inverter 1	2,184	0	39,356
29	Lakkia	East Oikismos LA2	0	1,544	19,345
30	Ag. Paraskevi	Anthemounta P. (ACP1)	58,786	147,245	444,500
31	Souroti	Koukos (S1)	2,501	3,094	162,078
32	Livadi	Entos Oikismou(L1)	0	0	0
33	Livadi	Ektos Oikismou (L2)	6,003	17,651	1,316
34	Kardia	Christodoulidis	44,996	130,682	389,000
35	Kardia	Kloni	27,732	86,712	236,934
36	Kardia	Kakarimou	925	19203	82,903
37	Epanomi	Apostolou	0	0	0
38	Plagiari	Rema	0	0	0
39	Plagiari	A1.3-Osia Xeni (Garou)	35,614	53,488	132,394
40	Plagiari	A2.1	0	0	0
41	Plagiari	A2.2	3,997	70,188	275,177
42	Plagiari	New A2	25,914	61,811	100,900
43	Plagiari	A1.2-Trigonou	11,177	0	46,341
44	Plagiari	A1.1	28,218	55,515	159,956
45	Ag. Paraskevi	S1(Ag. Paraskevi)	157,176	411,569	797,872

3.2.3.2 Water quality

The results from the installation of the automated chlorination systems are:

- More efficient chlorination since the automated system allows for the correct dose after measuring the level of the free chlorine in water;
- Better water quality.

The total cost for the supply and installation of the six automated chlorination systems is 28,140.00€.

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

3.2.3.3 Hydraulic simulation model

The development of the hydraulic simulation model provided to the water utility a useful tool for decision-making. The network is imprinted providing information of the water flows and pressures. As the water distribution network is not divided in zones, three pressure zones are developed virtually using the model. To divide the distribution network, isolation valves are closed and new ones are installed (virtually). Based on the data and using the hydraulic simulation model, PRVs are installed at the entrance of each zone (virtually). The PRVs are used to regulate water pressure. The results showed that average pressure is reduced from 4 to 58% depending on the time of the day. The highest pressure reduction is met in the morning hours (2-5 am) as it is well-known that as consumption is low at this time, pressure gets its higher values. This results in high leakage rates. Such an application of PRVs results in the reduction of water volume entering the network by 3.44% or 37,970 m^3 per year.

3.2.4 Problems encountered and applied solutions

There were not specific problems met during the implementation of the pilot action. The tendering process took some time to conclude due to bureaucratic conditions in public procurement.

3.2.5 Lessons learnt

3.2.5.1 Water efficiency

The pilot action implementation revealed that the estimation of water volume abstracted from the boreholes was highly underestimated. This fact made the water utility operators to underestimate the NRW level and they could not be able to design the correct NRW reduction strategies. The water utility will implement this measure to the 9 remaining boreholes.

It is very important to know the water volume entering the network and the water consumed in order to correctly and reliably estimate the NRW level. In general, the correct measurements of water volumes consumed or lost will provide the water operators data in order to design the correct strategies for the confrontation of NRW. The water utility proposes the implementation of similar activities to all water utilities at regional and national level.

The development of the hydraulic model of the water distribution network is a useful tool for water operators as it can be used for the development of scenarios, the segmentation of the network in DMAs for more efficient management, etc.

3.2.5.2 Water quality

The supply and installation of automated chlorination systems provided to the water utility a more efficient chlorination in the water tanks, providing safe water to the consumers. Chlorination is used for the disinfection of water and the controlling of bacteria and viruses in drinking water. However, the amount of free chlorine should not exceed the limits set by the legislation. Automated chlorination systems allow for efficient chlorination and the control of the free chlorine concentration.

The water utility proposes this measure to other water utilities at regional and national level. The water utility will implement this measure to the remaining water tanks.

3.3 PB3: University of Thessaly, Special Account Funds for Research, Civil Engineering Department, Greece

PB3 developed the hydraulic simulation model of PB2 and provided guidelines for the update of the hydraulic model of LB. PB3 prepared all questionnaires for WP5 and monitored the pilot actions implementation.

3.4 PB4: Municipality of Kardzhali, Bulgaria

3.4.1 General data on the pilot area

The water supply and distribution system of Kardzhali supplies with water 55,019 people, through 19,854 service connections. The mean operating pressure is 4-5 atm (Table 3.4.1). The average age of the pipes are 35 years. The billing period is monthly. Water is taken from Borovitsa river, the dam of Borovitsa and Perpereshka river. Data for the pipes are given in Table 3.4.2.

Table 3.4.1. General data of the water supply network of Kardzhali (base year 2017)

General data	
Total population served	55,019
Mean operating pressure (atm)	4-5
No. of service connections	19,854
Billing Period	monthly
River Basin where water is taken from	Borovitsa river, dam of Borovitsa, Perpereshka river.

Table 3.4.2. Pipes data for water supply network of Kardzhali

MUNICIPALITY	length of the water supply network			
	in the settlements		out of populated areas	
	Φ ≤300 мм	Φ > 300 мм	Φ ≤ 300 мм	с Φ > 300 мм
	км	км	км	км
MUNICIPALITY KARDZHALI	171171	7608	143539	33380
Incl.				
ethericity	97668	7608	122202	33380
steel	11975		12811	
PEPP and PVC	61528		8526	

3.4.2 Pilot Action

With respect to the monitoring and requirements for drinking water quality, it is necessary that the laboratory equipment used by the operator operating the water supply system be able to carry out as many analyzes as required by the relevant regulations (Ordinance 9 on drinking water quality) and be accurate as a research method. Current laboratory equipment limits the number of indicators tested and requires much of the research to be outsourced, which involves a long time for sample analysis and high costs.

Flowmeters are installed to record water volume accurately.

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

3.4.3 Results

The flowmeters included in the project will help to locate sections of the water supply system where there is a suspected loss or theft of water, and after their installation very accurately and quickly it will be possible to identify possible accidents in those sections.

Delivery and installation of four electromagnetic flow meters

Contractor SONICS Ltd

Four ultrasonic flowmeters were installed under the project - 3. in the town of Kardzhali and 1 pc. on the border of Kardzhali municipality and Momchilgrad municipality (Figure 3.4.1).

The places are as follows:

1. On Bulgaria Blvd. at the roundabout at the exit of the city to bl. Coca-Cola - measures the water quantities at the entrance to the Baikal district. It is mounted on an F 600 pipe.
2. At the crossroads of Struma Street and Osmi Oktomvri Street - measures water quantities for the central part of the city.
It is mounted on an F 400 pipe.
3. To PS PETLINO after a pressure tank of 5000 m3 - measures water quantities for Gledka and Gorna Gledka districts.
It is mounted on an F 300 pipe.
4. On the border of the municipality of Kardzhali and the municipality of Momchilgrad to the village of Pepelishte - measures water quantities for the municipality of Momchilgrad by the "Dam. Borovitsa "
It is mounted on an F 500 pipe.

Ultrasonic flow meters are of the frequency pulse type in which the speed of movement of the fluid / water / is determined by measuring the time for the passage of ultrasonic pulses against and in the direction of movement of the fluid. The ultrasonic flow meters installed under the project measure the passed water quantities every minute. The data reported by the device are in l / sec for instantaneous consumption, accumulated volume for the hour, for the day, for the month and for the year.

All appliances are software installed on a computer of a dispatcher who monitors the readings of flow meters 24 hours a day, 7 days a week. The same software through remote access to the computer of the dispatcher can be monitored by an unlimited number of employees / manager, ch. engineer, DWTP technologist, technical managers, etc./ for timely action in case of events.

Data and graphs for the past period / hour, day, week and month / can be extracted from the software. Comparing them with the collected water in the area of operation of the flow meter, analyzes are made for the condition and losses of the network. The dispatcher, who is on duty on a shift, monitors the readings and in case of deviation from the normal ones signals the emergency teams for possible accidents and leaks in the network.

The system allows to display data and graphs from which the minimum night consumption of the system can be determined at the lowest consumption by users, the amount of water loss from hidden leaks. After locating the area by stopping cranes from end to nearby streets and monitoring the cost, the street with the problem area is located. To more accurately determine the hidden leak, our company has portable terrestrial noise microphones, point correlators and point noise bearings. In addition to these devices under the project, the company has installed 9 more. ultrasonic flow meters for measuring water quantities and two level meters, which are included in the same software. Attached we present screenshots with data and graphs from the readings of the devices installed under the project.

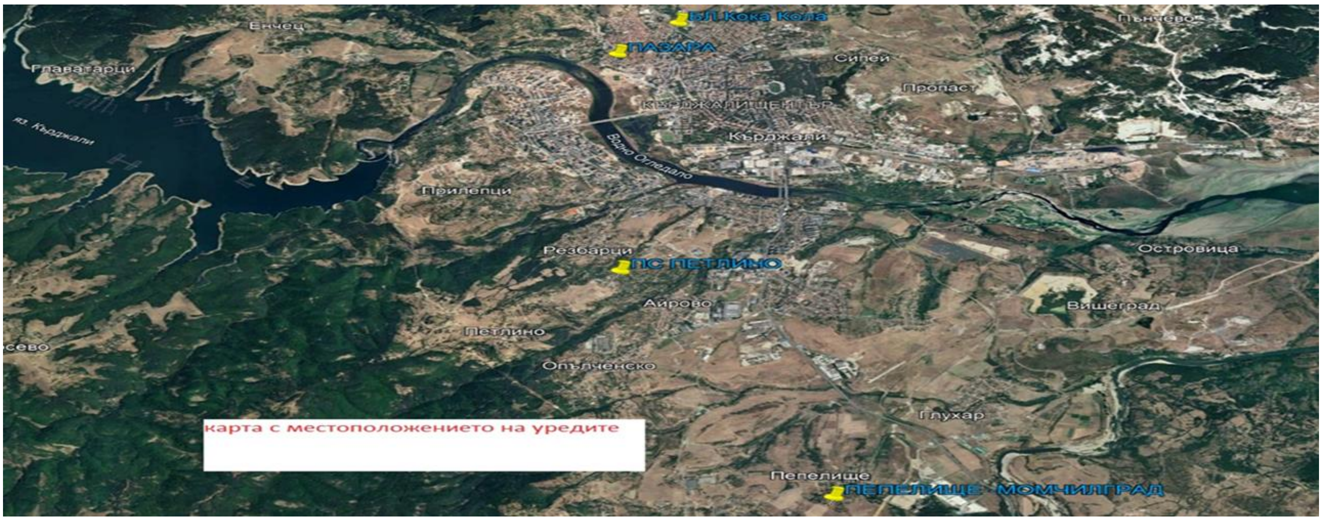

Figure 3.4.1. Locations where the flowmeters are installed

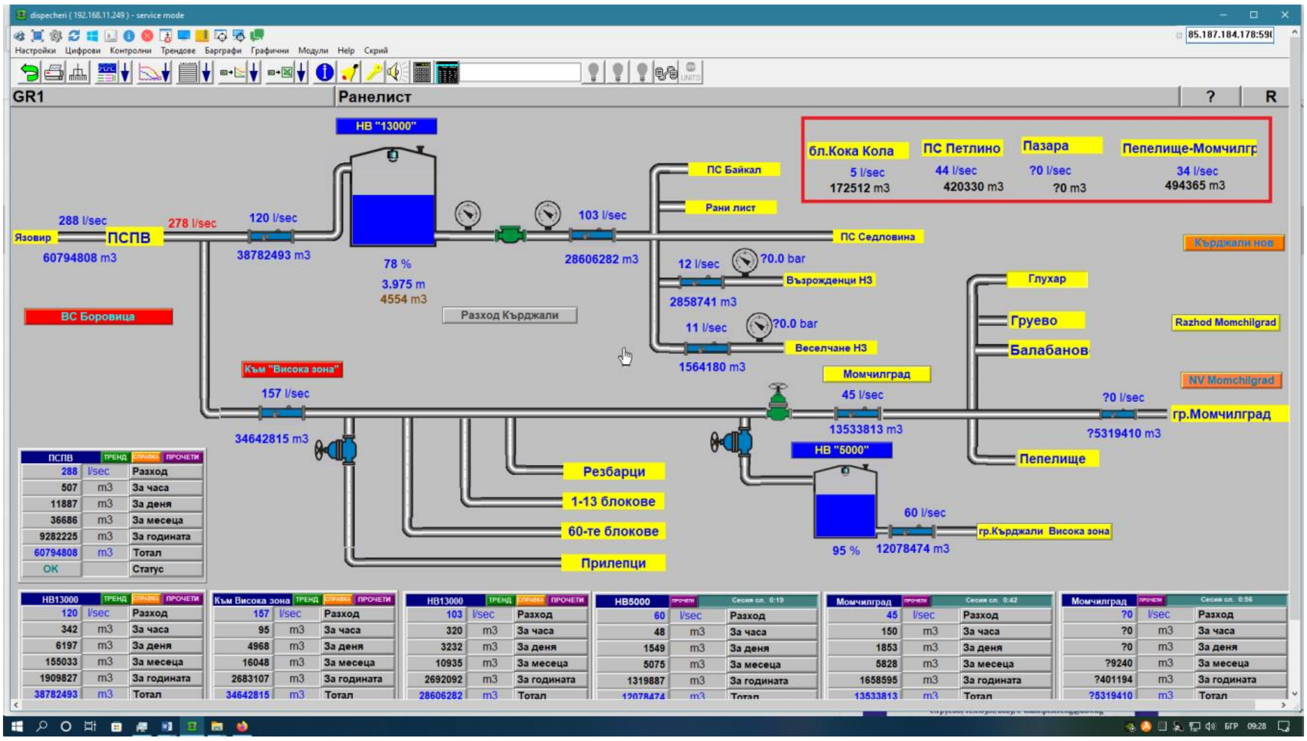

Figure 3.4.2. The 4 flowmeters as they appear at the SCADA

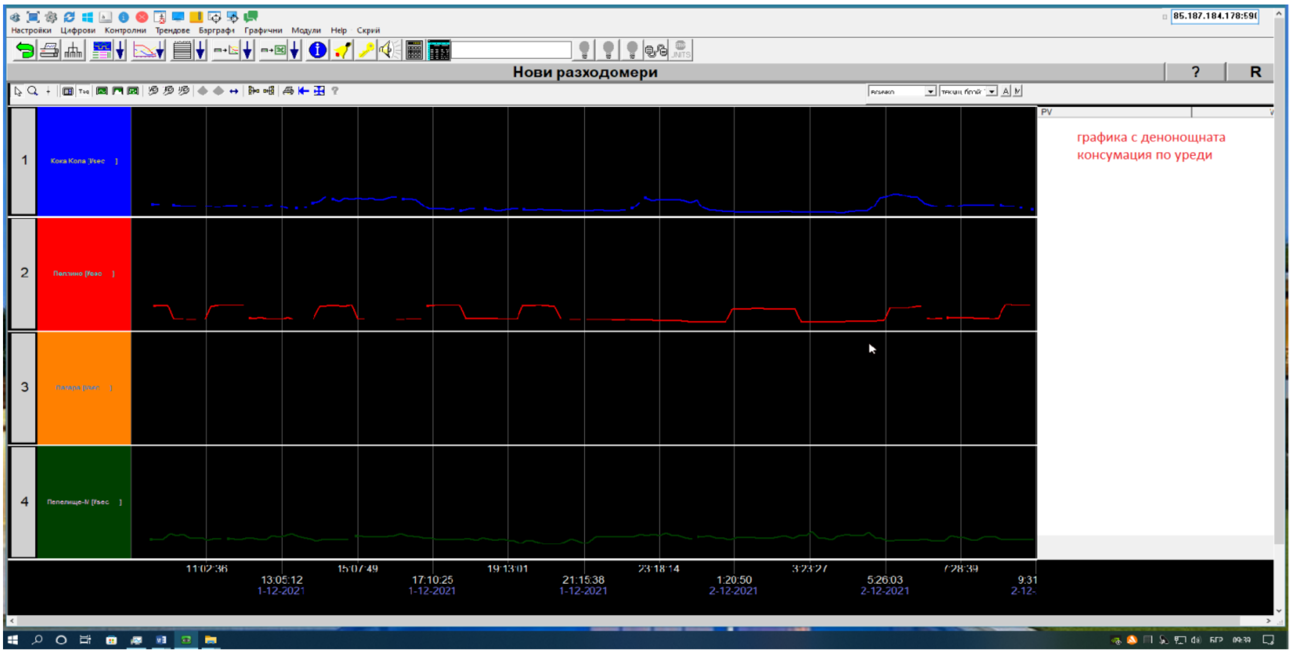

Figure 3.4.3. Water flow at the 4 flowmeters for 24 hours

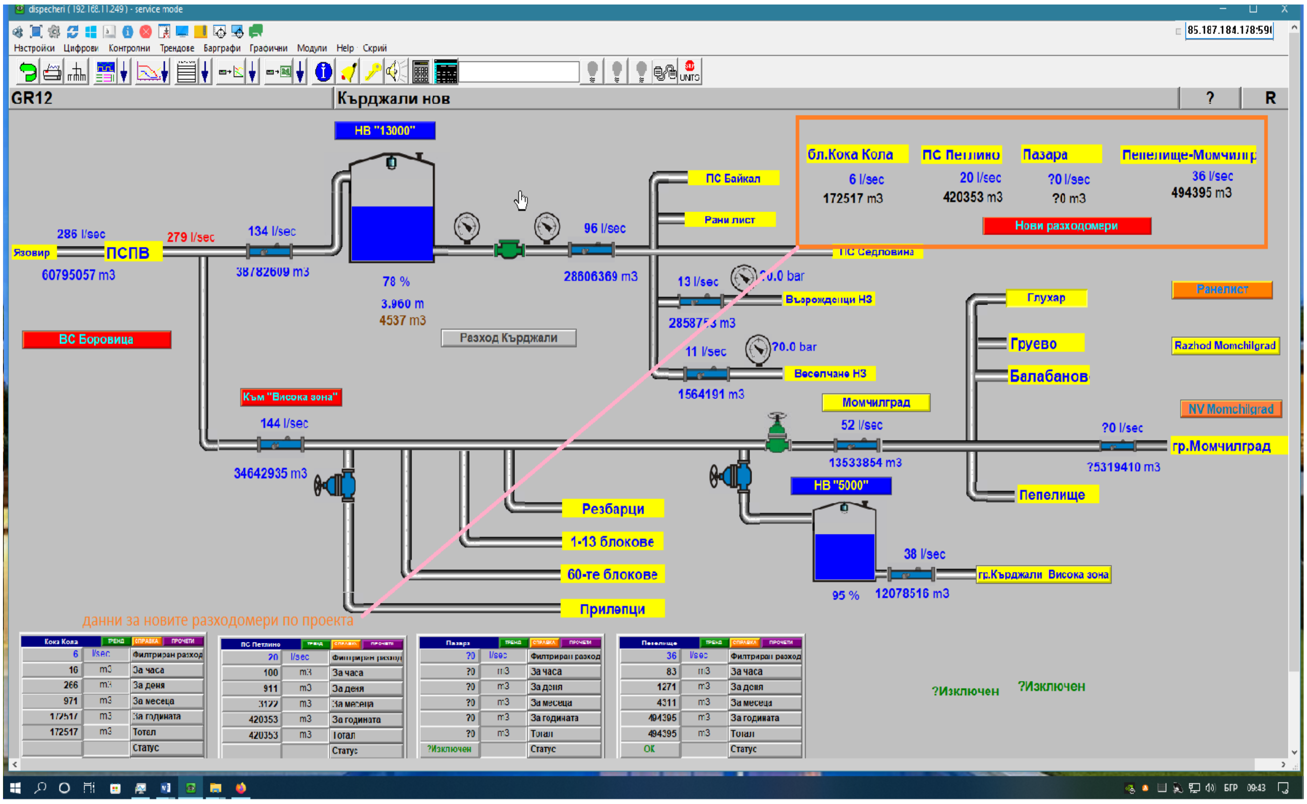

Figure 3.4.3. Data from the new flow meters

Figure 3.4.4. Installation of the flowmeters

From the presented data the following volume of water has passed through the flow meters: 1,087,265 m3.

The laboratory equipment provided in the project will enable the investigation of a large number of indicators required by the relevant drinking water quality regulations, will enable the rapid and timely analysis of the samples, as well as the measurement with high accuracy and correctness.

<u>Delivery and installation of mass spectrometer with inductively connected plasma Plasma ICP - MS.</u>

Contractor "ASM2" Ltd

On December 22, 2021, the mass spectrometer was installed, configured, tested and ready for operation. During the functional tests of the system, the following standard procedures were performed to check the qualification of the installation, operational readiness and verification of the equipment for operation.

the equipment has no obvious transport defects **yes**

The supply voltage of the system corresponds to the Bulgarian standards **yes**

The configuration of the system corresponds to that ordered by the customer yes

When the system is turned on, the displays light up and the keys function normally yes

When each of the modules of the system is switched on, it successfully passes its initial testing and initialization procedure yes

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

The software product is configured to work with the specific system yes

There is normal two-way communication between the system and the control software, the status of the device is available in real time on the computer screen yes

Each of the modules of the device reaches its set parameters and goes into the status "ready for analysis" yes

All operating parameters of the system / hardware and software / fully comply with the technical specifications of the manufacturer yes

The start signal works normally and the system modules are in full sync yes

The software automatically processes information and generates a correct result yes

In analysis and standard sample, the results meet the requirements yes

The manufacturer's standard operating procedure for checking the qualification of the installation, operational readiness and verification of the equipment for operation has been completed successfully yes

The mass spectrometer with inductively connected plasma Plasma ICP – MS can analyze drinking water. In particular, it can determine the following elements: arsenic, chromium, selenium, copper, lead, cadmium, boron, nickel, zinc, sodium, aluminum, manganese, iron, antimony, barium, mercury, uranium, strontium and others.

Figure 3.4.5. The mass spectometer

3.4.4 Problems encountered and applied solutions

No problems encountered.

3.4.5 Lessons learnt

Effective management of the entire drinking water supply cycle, both in terms of quality and quantity, by reducing water losses and improving water quality.

3.5 PB5: Municipality of Gotse Delchev, Bulgaria

3.5.1 General data on the pilot area

Pilot actions will take place in sub DMA called Dunav. Due to specificity of the areas covered mainly from 4-5 floors blocks, DMA has high level of non-revenue water with relatively short main pipeline and small number of service connections. The population served is 1,650 people through 1.14 Km of pipes and 49 service connections. The area covered is 0.20Km^2. The area's mean altitude is 525m. The pipes' length is 1,141m of steel pipes of 200mm diameter and 539m of brass pipes (service connections) of 32mm diameter. The pipes are installed more than 30 years ago (Table 3.5.1). The mean operating pressure is 4.5 atm.

Table 3.5.1. General data of the water distribution network of Dunav DMA (base year 2018)

General data	
Total population served	1,650
Total area covered (Km^2)	0.20
Total pipes' length (Km)	1.14
Mean altitude (m)	525
Mean operating pressure (atm)	4.5
Types of pipes (material, diameters, lengths)	Steel with diameter 200mm=1,141m; brass with diameter 32mm=539m
Age of pipes (per material, diameter)	>30 years
No. of service connections	49
Billing Period	monthly
River Basin where water is taken from	Mest river basin

3.5.2 Pilot Action

Pilot actions implemented as a part of current project are dedicated to improvement of water efficiency in terms of physical water loss reduction and quality of service water supply provided by local water Operator.

The specific pilot action was chosen due to following two reasons:

- unacceptably high level of physical water losses – as a part of current project it was calculated and proven that all indicators which are related with water losses are higher than maximum permissible values:
  - real losses – 50.54%
  - real water losses per service connection – 6,042.63
  - real water losses per mains length – 259,499.33
  - ILI – 94
- Age of pipeline – apart from high level of physical water losses another problem is related with age of pipelines which is more than 30 years. Taking into account that 10% from population of the city in concentrated in areas served by relatively short pipelines and in addition to high level of physical water losses those pipe sections generate it was decided that it would be better to replace some of them.

As a part of overall project following actions were performed:

- Design of DMA, construction of a manhole, installation of measuring equipment and data analysis – as a part of that part of pilot actions insertion flow meter with autonomous power supply was supplied and installed. In addition data was implemented in specialized software for data management and water loss calculation.

Figure 3.5.1 – manhole with insertion flow meter at the entrance of DMA Dunav

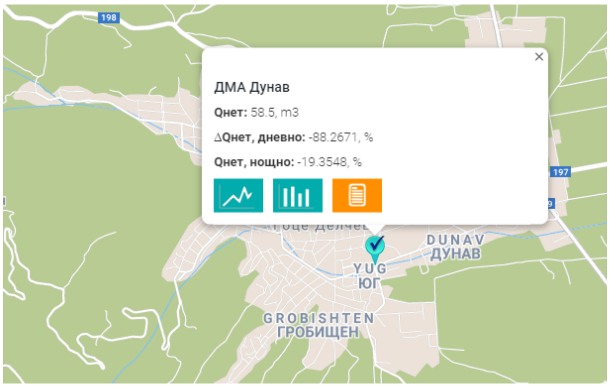

Figure 3.5.2 – View from system for data management and water loss reduction

- Rehabilitation of water main in DMA Dunav – final stage of the project was related with rehabilitation of certain pipe sections with following sizes and length:
    - Ф110 – 601 m
    - Ф90 – 552 m
    - Ф63 – 294 m

Figure 3.5.3 – Reconstruction of pipeline

Figure 3.5.4 – Reconstruction of pipeline

3.5.3 Results

Expected result from the pilot action implementation is the direct impact expected after implementation of pilot actions related to the reduction of real water losses in DMA Dunav.

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

Real losses are estimated to be reduced from 50% to 30%.

As a part of the project, the first action implemented was to set up of constant flow measurement of DMA inlet. Data analysis for the level of water losses are based on 1 year constant measurements. Thanks to those data effect from rehabilitation of pipeline can be easily assessed as follow:

- <u>Reduction in net flow delivered at entrance of DMA.</u>

The water supplied in the DMA is reduced after the pilot action implementation. Specifically, the reduction ranges from 25% (July) to 38% (April).

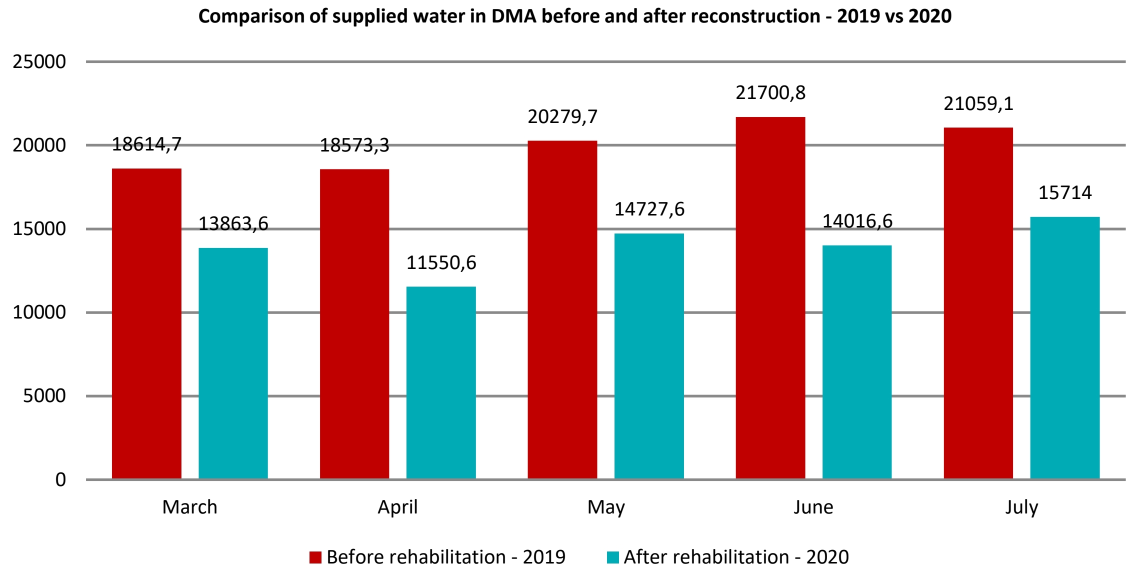

Figure 3.5.5. Water supplied in DMA before and after the implementation of the pilot action

Table 3.5.2. Water supplied before and after rehabilitation and the related reduction in %

Time period	Before rehabilitation - 2019	After rehabilitation - 2020	Reduction in supplied water in DMA
March	18,614.7	13,863.6	26%
April	18,573.3	11,550.6	38%
May	20,279.7	14,727.6	27%
June	21,700.8	14,016.6	35%
July	21,059.1	15,714.0	25%

- <u>Reduction of net night flow which is directly related with level of real losses</u>

Average night flow is reduced after the pilot action implementation. The reduction percentage ranges from 43% to 57.9%. The highest reduction percentage is met in June.

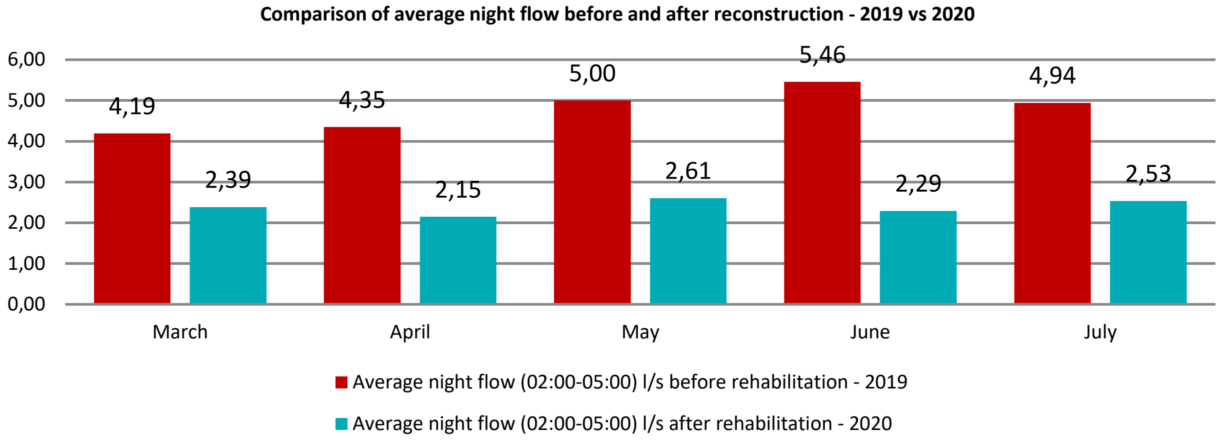

Figure 3.5.6. Average night flow in DMA before and after the implementation of the pilot action

Table 3.5.3. Average night flow before and after rehabilitation and the related reduction in %

Time	Average night flow (02:00-05:00) L/s before rehabilitation - 2019	Average night flow (02:00-05:00) L/s after rehabilitation - 2020	Reduction
March	4,19	2,39	43,0%
April	4,35	2,15	50,6%
May	5,00	2,61	47,8%
June	5,46	2,29	57,9%
July	4,94	2,53	48,7%

- Reduction of ILI index which measures level of real losses

ILI index is reduced radically. The reduction ranges from 44% to 59%. ILI values after the implementation of the pilot action range from 46.98 to 57.73 compared to 94.65 to 124.14 before the pilot action implementation.

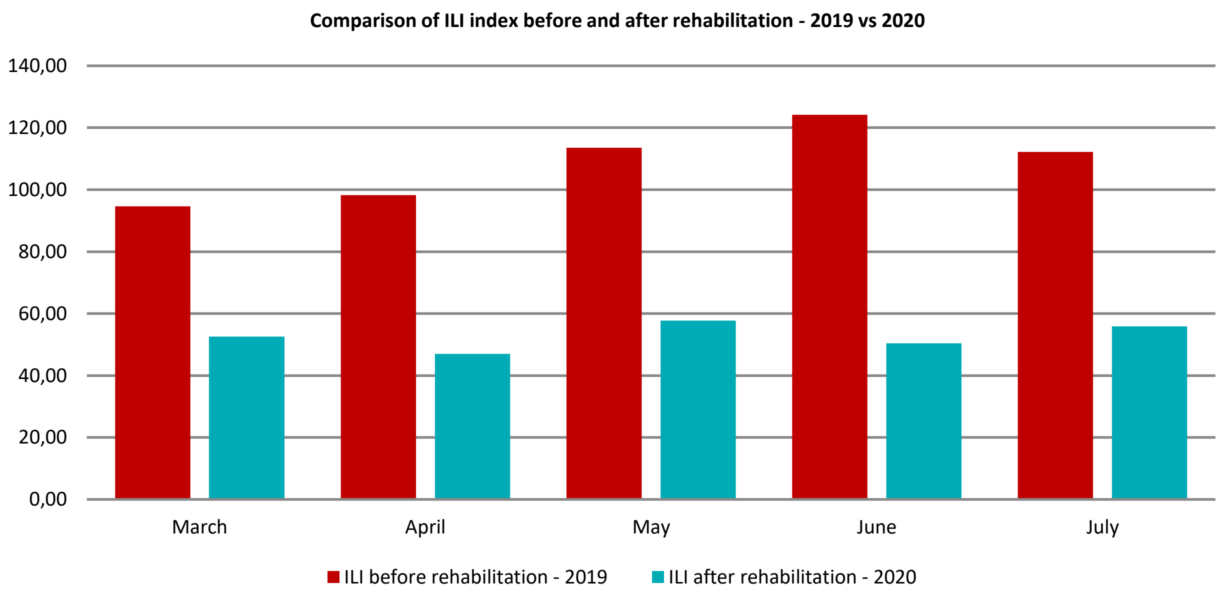

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Figure 3.5.7. ILI index values in DMA before and after the implementation of the pilot action

Table 3.5.4. ILI index values before and after rehabilitation and the related reduction in %

Time	ILI before rehabilitation - 2019	ILI after rehabilitation - 2020	Reduction
March	94,65	52,59	44%
April	98,29	46,98	52%
May	113,52	57,73	49%
June	124,14	50,43	59%
July	112,20	55,84	50%

The cost of the pilot action is: reconstruction of pipeline is 96,550.36€ and the DMA set up is 10,000.00€. The water volume saved ranges from 13,974 m^3 to 20,045 m^3 per month.

3.5.4 Problems encountered and applied solutions

No problems encountered.

3.5.5 Lessons learnt

Main conclusion from current project is that real losses can be managed only by dedicated approach including right measurements and data analysis and rehabilitation of most critical sections from pipelines.

Based on achieved results in terms of reduction of water losses it is obvious that approach applied in current project is the right one when it comes for water loss reduction.

DMA approach and rehabilitation of pre-defined section in water supply network is well known approach worldwide. In Bulgaria National Water Regulator obliged Water Operators to introduced DMA zoning and this was introduced as a key quality indicator affecting price of water. Due to this DMA has become common approach for assessment of real water losses and selection of most crucial pipes sections for reconstruction.

3.6 PB6: Municipal Enterprise for Water Supply and Sewerage of Thermaikos, Greece

3.6.1 General data on the pilot area

The water utility of Thermaikos has set the whole water supply network as the pilot case. The general data of the pilot case are given in Table 3.6.1. The water utility supplies with water a population of 50,264 people through 654 Km of pipes and 32,656 service connections. The total area covered is 135.5 Km^2 and the mean altitude 55m. The mean operating pressure is 3 atm.

Table 3.6.1. General data of the water supply network of DEYA Thermaikos (base year 2017)

General data	
Total population served	50,264
Total area covered (Km^2)	135.5
Total pipes' length (Km)	654
Mean altitude (m)	55
Mean operating pressure (atm)	3
Types of pipes (material, diameters, lengths)	PVC, asbestos cement
Age of pipes (per material, diameter)	PVC: 33 years; asbestos cement: >55 years
No. of service connections	32,656
River Basin where water is taken from	Chalkidiki river basin

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

3.6.2 Pilot Action

The pilot action for the Municipal Water Supply and Sewerage Company of Thermaikos consists of the development of IT applications for: (a) Water distribution networks management allowing water operators to manage the spatial data of the water distribution networks (e.g. Identification of the areas affected by water interruptions or failures, etc.) and; (b) Mapping of the failures history in an interactive map.

Both IT applications are developed internally at the systems of DEYA Thermaikos.

The first application allows the water utility to manage the geospatial data related to the water supply and distribution network and the infrastructure. This application gives the ability to provide basic tools such as the location of areas affected by failures or interruptions in water supply. The application is GIS-based. The user can enter data using user-friendly forms (Figure 3.6.1). These forms refer to different parts of the network, such as bulk water meters, connection points, distribution points, district metered areas (DMAs), fittings, water intake points, manholes, water meters, pipelines, etc. There are forms for data entry for damages and failures, maintenance, repair, etc. The application gives various abilities: (a) topology: for any change in the water supply and distribution network; (b) combined search, for example pipe diameter and material (Figure 3.6.2); (c) reporting: the user can get printable reports (figure 3.6.3) and; (d) statistics: the user can create any form of statistics.

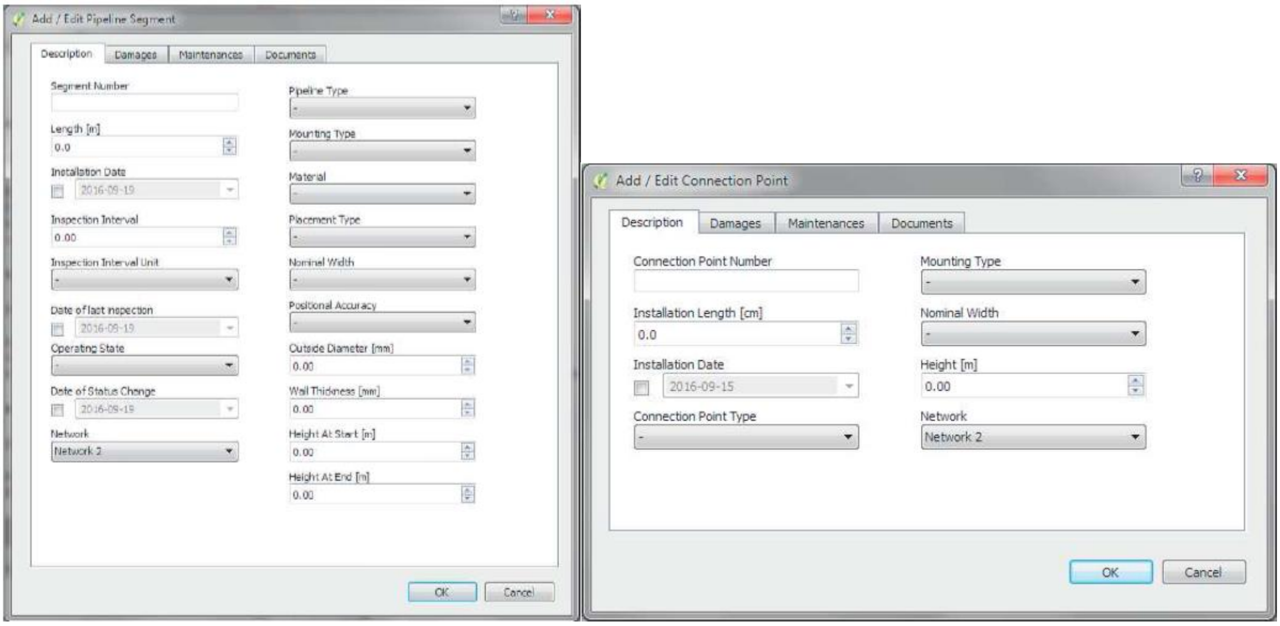

Figure 3.6.1. The forms for data entry

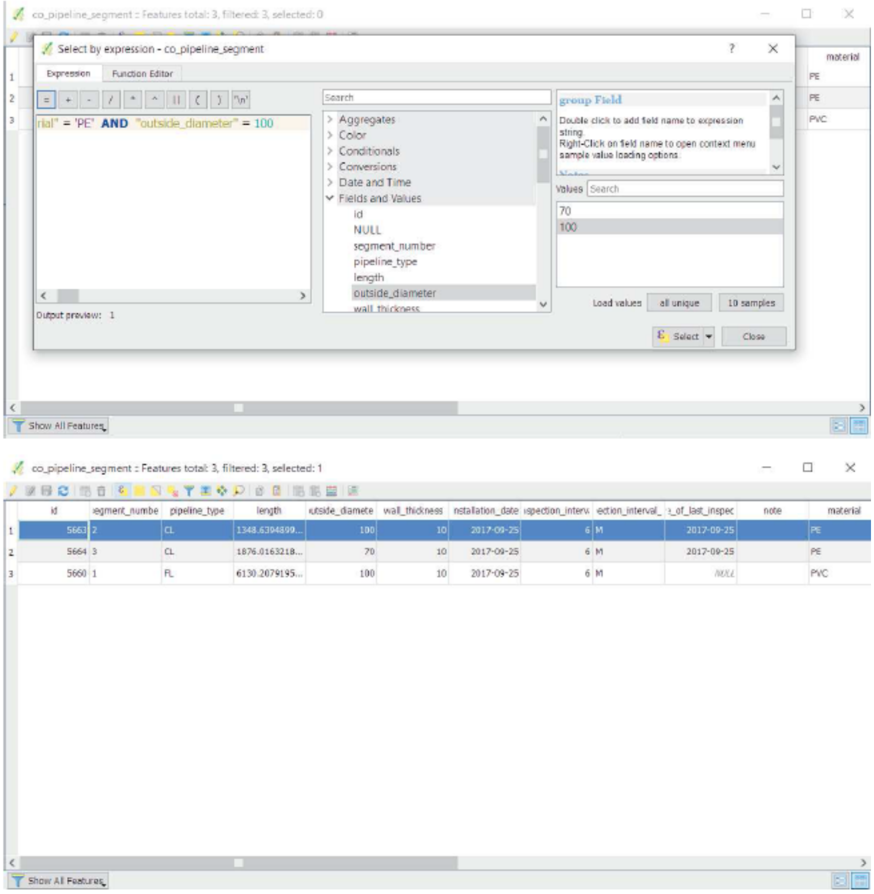

Figure 3.6.2. Combined search

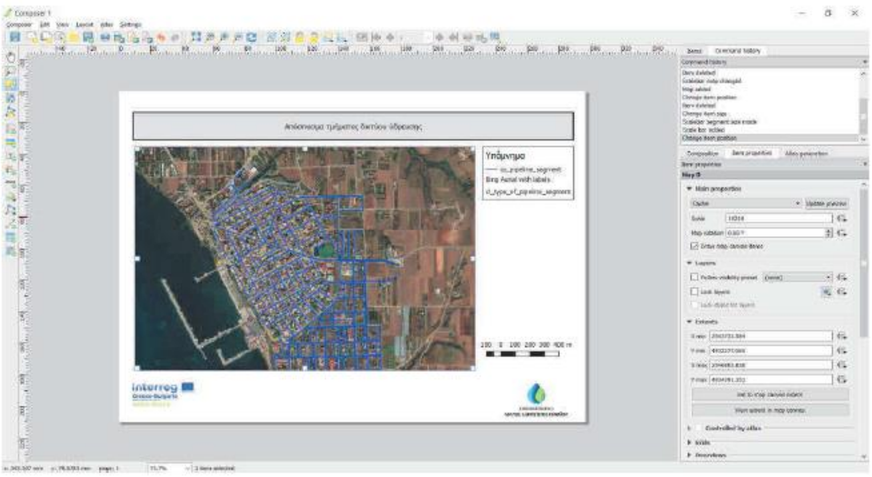

Figure 3.6.3. The preface for printable reports

The second application gives the ability to the water utility to monitor the time and spatial evolvement of failures in the water distribution network (Figure 3.6.4). Each failure and its related data (such as cost, water lost, materials used, etc.) are imprinted in a map where the user can search using the appropriate filters and perform spatial analysis. In this way the water utility can locate the areas where there are significant water losses and the repair cost is high and therefore plan the implementation of works and interventions in order to improve the operation of the water distribution network and at the same time to reduce the operational cost and the cost of the related Non-Revenue Water.

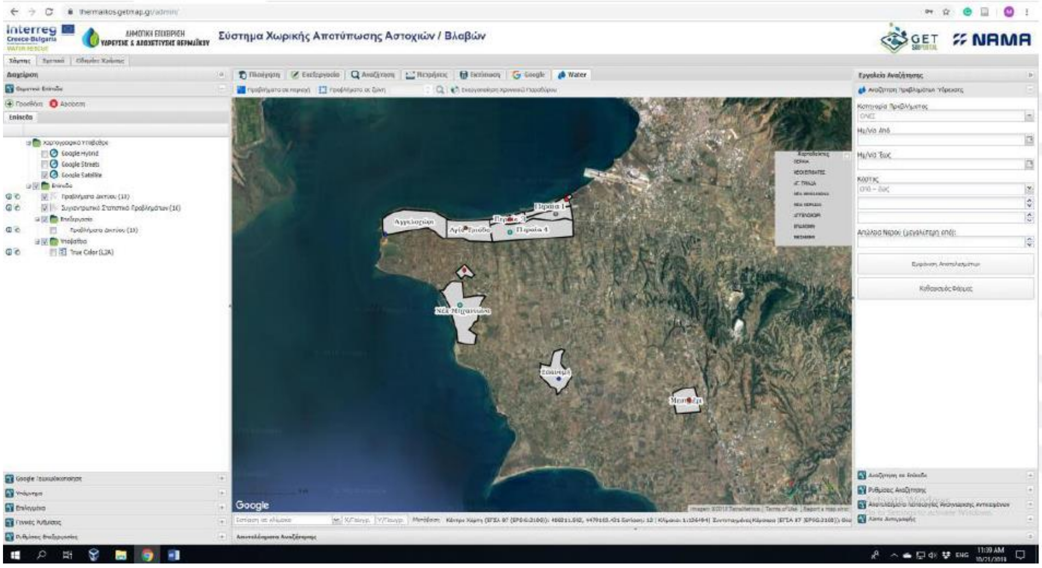

Figure 3.6.4. The application for spatial mapping of failures

3.6.3 Results

The IT applications are developed for the water supply network of DEYA of Thermaikos, both internal (Figure 3.6.5 & 3.6.6) and external (Figure 3.6.7). The user has maps with the infrastructure of the water distribution network and at the same time can get information about any failures or water interruptions.

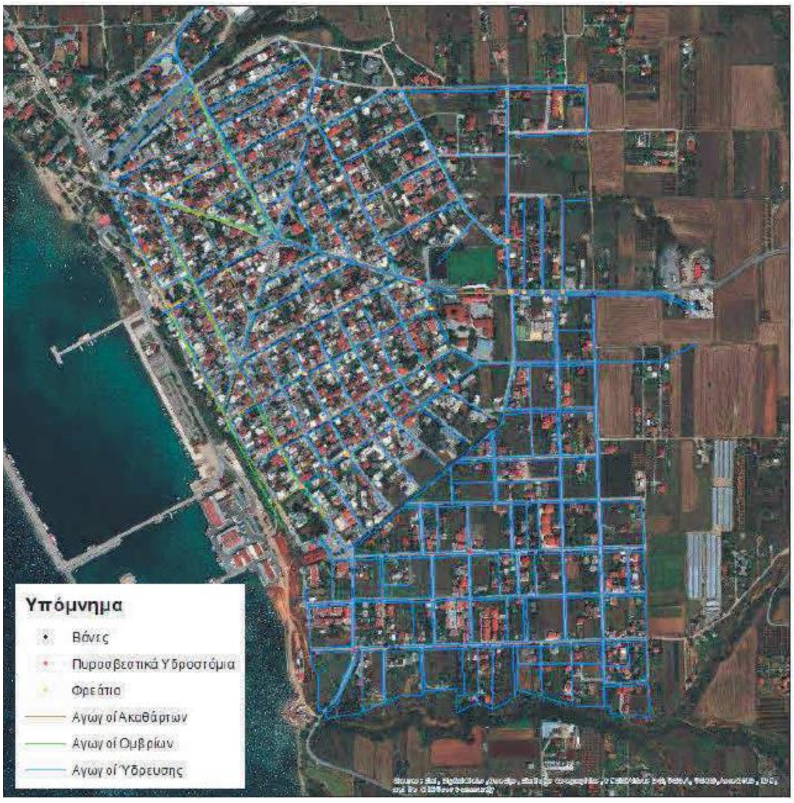

Figure 3.6.5. The water distribution network of New Mihaniona

Figure 3.6.6. The water distribution network of Ano Peraia

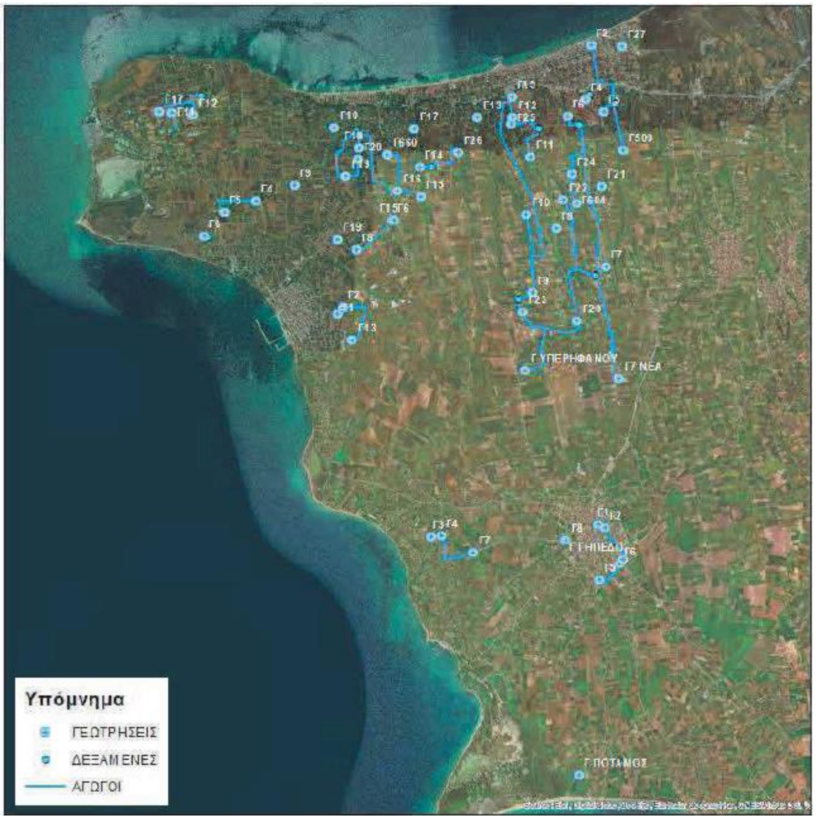

Figure 3.6.7. The external water supply network

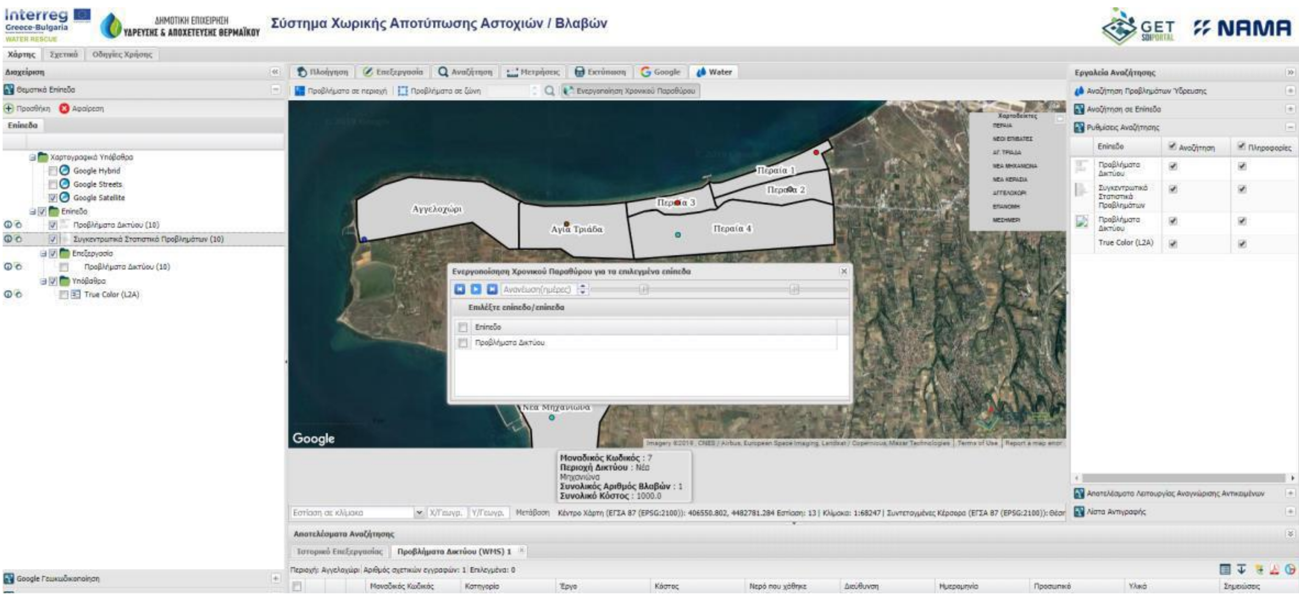

Figure 3.6.8. Failures indicated in the application

The spatial mapping application provides data about the failures in the water distribution network. The user can monitor both the time and spatial distribution of these failures. This allows the water utility managers to locate areas with high number of failures and plan the necessary actions. Also, the application gives information about the cost of the repairs of the failures. Thus, the water utility managers can set their criteria in order to prioritize their actions (Figures 3.6.8, 3.6.9, 3.6.10 and 3.6.11).

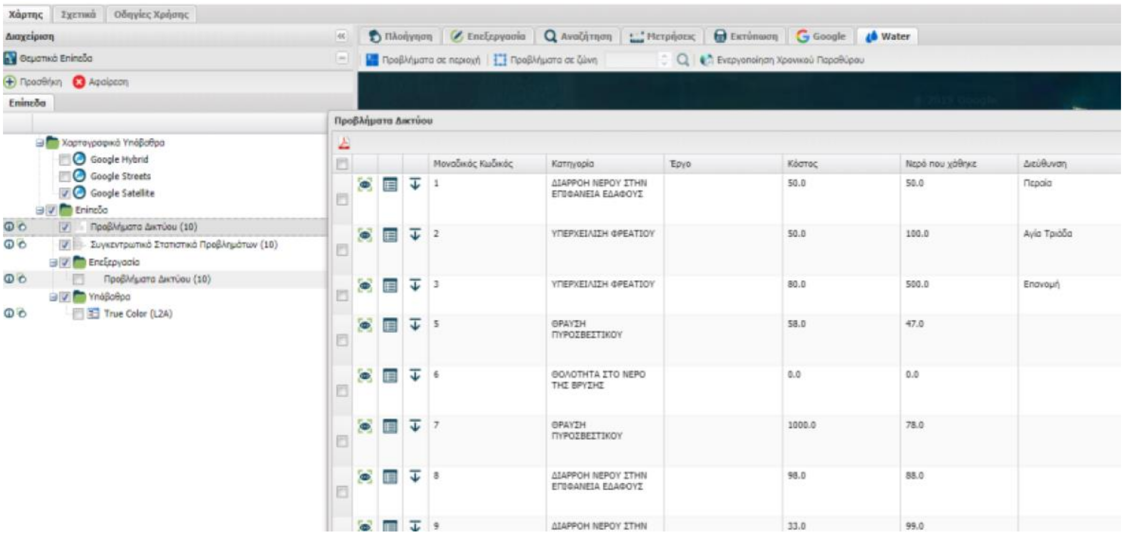

Figure 3.6.9. Information list view

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

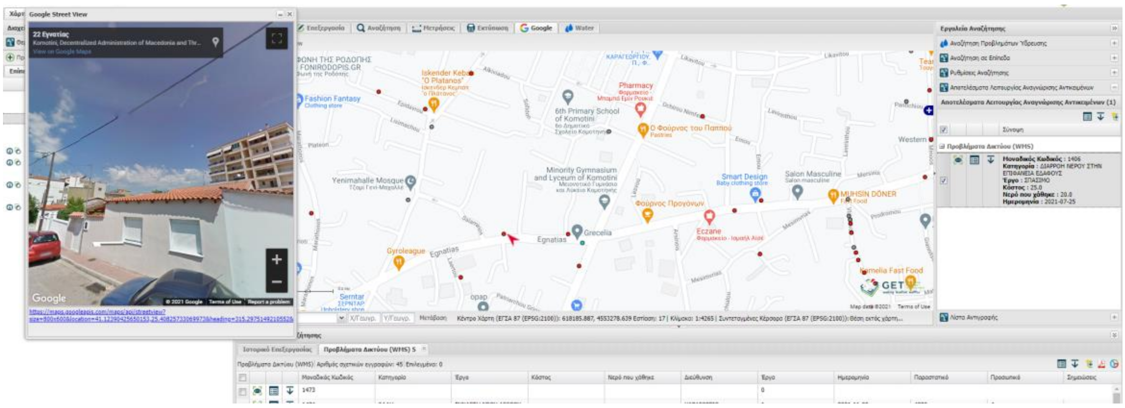

Figure 3.6.10. Street view

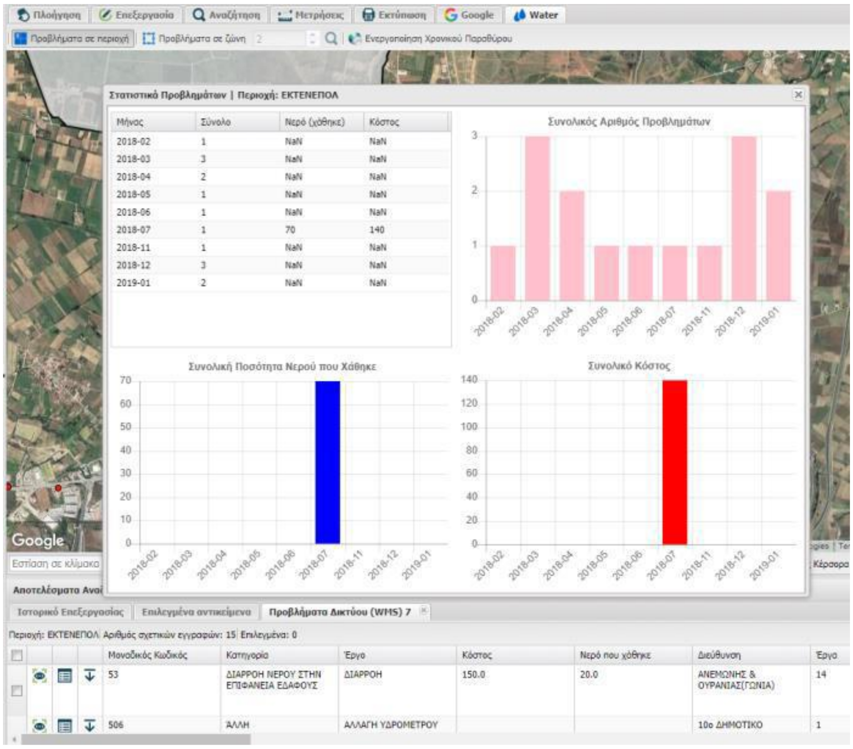

Figure 3.6.11. Statistics and reports

3.6.4 Problems encountered and applied solutions

No problems are recorded.

3.6.5 Lessons learnt

The pilot action of DEYA Thermaikos refers to water use efficiency, targeting the "speed and quality of repairs" real losses reduction pillar. The applications developed provide a useful decision-making tool that can be connected to other IT tools for a more efficient water distribution system management.

The cost of the pilot action in 57,500.00€.

Chapter 4. Discussion and Conclusions

4.1 Pilot areas description

The beneficiaries involved in pilot actions are DEYA Komotinis (PB1), DEYA Thermis (PP2), University of Thessaly (PB3), Municipality of Kardzhali (PB4), Municipality of Gotse Delchev (PB5) and DEYA Thermaikos (PB6).

The Water Utility of Komotini supplies with water the municipality of Komotini, located in the Water District of Thrace (EL12). The people supplied with water is 65,000 for Komotini city through 400 km of pipes' length. The average operating pressure is 4 atm and the total number of water meters is 48,500. Municipal Water Supply and Sewerage Company of Thermi (DEYA Thermis) is the water utility supplying with water the area of Thermi including several municipal districts of a total population of 53,070 people through 25,786 active water meters. The total pipes' length is about 700Km and the average operating pressure is about 5 atm. The University of Thessaly does not have its pilot case. However, based on the project's application form, PB3 is responsible for developing the hydraulic simulation model for the water distribution network of PB2. The water supply and distribution system of Kardzhali supplies with water 55,019 people, through 19,854 service connections. The mean operating pressure is 4-5 atm. The average age of the pipes are 35 years. Pilot actions will take place in sub DMA called Dunav, for the Municipality of Gotse Delchev. The DMA has high levels of non-revenue water. The total population of 1,650 people is supplied with water through 1,140 Km of pipes at a mean operating pressure of 4.5 atm. The number of connections are 49. The water utility of Thermaikos selected as its pilot case the total water distribution network. 50,264 people are supplied with water through 654 Km of pipes and 32,656 service connections. The mean operating pressure is 3 atm (Table 4.1).

4.2 Pilot actions

The pilot actions the beneficiaries implemented refer to water use efficiency and/or water quality. The pilot actions related to water use efficiency target to NRW components, such as Real Losses. All water utility or municipality beneficiaries implemented pilot actions related to water use efficiency and only two of them (PB2 and PB4) implemented also water quality related pilot activities. More specifically:

DEYA Komotini (LB), selected as a pilot action to develop IT applications in order to tackle real losses management pillar of speed and quality of repair. As the water distribution network of Komotini city suffers from high NRW levels (45.74% of SIV in 2017), the water utility decided to develop IT applications in order to reduce the total time for the repair of failures in the distribution network and at the same time provide a decision-making tool to the utility managers. This tool is valuable as the managers can monitor the evolution of the failures both spatially and temporally and can localize the parts of the network where interventions are needed. Additionally, the IT applications developed will improve the quality of service to the consumers as they can be informed in real time for any water interruptions and they can also report any unusual event that is due to a failure in the water distribution network.

DEYA Thermi (PB2) implemented pilot actions related to both water use efficiency and water quality. Specifically, 45 flowmeters are installed in the boreholes of the water utility in order to record with accuracy the water volumes abstracted. This activity will result in a more accurate elaboration of the water balance in order to estimate NRW and its causes and then develop a strategy to reduce them. The water utility installed also 6 automated chlorination devices in selected water tanks in order to develop an accurate chlorination system that can ensure safe water for the consumers.

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University of Thessaly, Civil Engineering Dept. (PB3) developed the hydraulic simulation model for the water distribution network of PB2 in order to monitor the operation of the network in terms of flow and pressure. PB3 also divided the water distribution network in 3 zones (virtually) using the hydraulic simulation model and installed one PRV at the entrance of each zone (virtually). The PRVs regulated pressure in such a way, that pressure at the critical points of each zone is 2 atm. Based on the model's calculations, pressure is reduced resulting in lower water losses and lower water volumes entering the network.

Municipality of Kardzhali (PB4) decided to implement 2 different activities in the context of its pilot action, one related to water use efficiency and the other to water quality. Municipality of Kardzhali installed flow meters at the water abstraction points in order to record accurately the water volumes. This will help the water utility to estimate the water balance and the NRW level reliably and then decide on the measures to reduce it. The second pilot activity refers to the supply of an inductively coupled plasma mass spectrometry (ICP-MS). Using the ICP-MS the water utility will be possible to implement permanent operational monitoring of drinking water quality and wastewater and to analyze samples of the drinking water, wastewater and sludge for elemental composition. The ICP-MS will allow the implementation of timely and prompt measures for improving the quality of water. In this way the water utility will provide safe water to its customers and make sure that the treated water effluent from the wastewater treatment plant is at the proper quality to return to the environment.

Municipality of Gotse Delchev (PB5) pilot action refer to the purchase and installation of electromagnetic flowmeters and pressure meters in the DMA in "Danube" area in Gotse Delchev water supply network and the replacement of pipes with diameter 90 and 110 in DMA "Danube" area. As real losses are extremely big in this DMA (NRW is 66.08% of SIV and ILI is 115 in 2017) and the water distribution network is very old, the municipality decided to install flowmeters and pressure meters at this DMA at the beginning to record all the necessary data. Then they decided to replace water pipes. It is expected that these actions will reduce real losses as they target on the real losses management pillar of pipeline and asset management.

DEYA of Thermaikos (PB6) implemented a pilot action to tackle real losses and specifically the pillar of speed and quality of repairs. PB6 developed IT applications for water distribution network management to localize the areas affected by water interruptions etc. and mapping failures history. Although the NRW assessment in 2017 was not very high, the water utility does not possess all the necessary data for reliable and accurate estimations of NRW and water losses. This is why the water utility decided to develop the water distribution network management application in order to gather all the necessary data for the water distribution network and at the same time to be able to use this application as a decision-making tool. The failures mapping application gives the possibility to the water utility to reduce the total repair time for failures and also act as a decision-making tool for the managers in order to decide whether a specific part of the network needs further actions.

4.3 Results

4.3.1 LB – DEYA Komotini

The water utility developed an IT application for failure mapping history and also applications to the public. In particular, the water utility staff inserted the reported failures for 2018 and 2019 in the application. Specifically, in 2018 66 failures related to pipes' leaks and breaks were reported while in the first 9 months of 2019 135 failures were reported and inserted in the application. The main failures are pipes' leaks and breaks, followed by network repair and connections' leaks in 2019. The use of the developed applications aims at targeting the speed of repairs, being a real losses reduction pillar. Additionally, the applications aim at improving the quality of services to the consumers. The total cost of the pilot action is 88,000.00€.

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Table 4.1. Pilot areas characteristics

General Data	Komotini (GR)	Thermi (GR)	Kardzhali (BG)	Gotse Delchev (BG)	Thermaikos (GR)
Total population served	65,000	53,070	55,019	1,650	50,264
Total area covered (Km^2)	385.3	1,559.34		0.20	135.5
Total pipes' length (Km)	400	700		1,140	654
Mean altitude (m)	45	0-200	4-5	525	55
Mean operating pressure (atm)	4.0	5		4.5	3
Type / age of pipes (per material, diameter)	PE (90-450mm) and steel (600mm)	PE (60%); PVC (40%); since 1970	Steel and PVC. Average 35 years	Steel (200mm): 1,141m; brass (32mm): 539m. Age >30 years	PVC: 33 years; asbestos cement: >55 years
No. of service connections	17,000		19,854	49	32,656
No. of water meters		25,786			

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Table 4.2. WB components for the pilot areas of PB1 & PB2 for 2017 and 2019 (ex ante and ex post evaluation)

	Komotini (GR)		Thermi (GR)	
	2017	2019	2017	2019
System Input Volume	5.885.000	5.300.000	4.010.739	8175375
Authorized Consumption	2.898.576	3.053.000	3.171.455	3484966
Billed Authorized Consumption	2.839.726	3.000.000	2.970.918	3279127
Billed Metered Consumption	2.839.726	3.000.000	2.970.918	3279127
Billed Unmetered Consumption	0	0	0	0
Unbilled Authorized Consumption	58.850	53.000	200.537	205839
Unbilled Metered Consumption	0	0	200.537	0
Unbilled Unmetered Consumption	58.850	53.000	0	205839
Revenue Water	2.839.726	3.000.000	2.970.918	3279127
Water Losses	2.986.424	2.247.000	839.284	4690409
Apparent Losses	484.809	503.000	337.199	409666
Unauthorized Consumption	58.850	53.000	40.107	81754
Meter and Metering Errors	425.959	450.000	297.092	327913
Real Losses	2.501.615	1.744.000	502.085	4280743
Non-Revenue Water	3.045.274	2.300.000	1.039.821	4896248

4.3.2 PB2 – DEYA Thermi

4.3.2.1 Water efficiency

The results from the pilot action implementation include the exact recordings of the flowmeters in the boreholes. The time the flowmeters were metering is from 27/11/2019 – 9/2/2020 (440 days average). The total water volume recorded during this time period is 8,212,705m^3. Given that this amount of water is abstracted from 45 out of the 54 boreholes, the total amount abstracted from all the boreholes for the same period of 440 days is estimated to be 9,855,246m^3. That means that in a year time the total water volume abstracted is estimated to be 8,175,375m^3. The water utility estimates that during one year the total water volume abstracted is about 4,100,000m^3. The water volume abstracted is highly underestimated (almost 100%)! Given that the water volume consumed is recorded in the water consumers, the NRW levels are very high! The total cost for the supply and installation of the flowmeters is 66,150.00€ (no VAT included).

The exact recordings of the water volume will allow the water utility to estimate accurately the NRW level and design strategies and measures to reduce it.

4.3.2.2 Water quality

The installation of the automated chlorination systems ensured efficient chlorination in 6 water tanks supplying 1,285,000m^3/year. The population supplied with safe water is 17,229 people.

The total cost for the supply and installation of the six automated chlorination systems is 28,140.00€.

4.3.2.3 Hydraulic simulation model

The development of the hydraulic simulation model provided to the water utility a useful tool for decision-making. The network is imprinted providing information of the water flows and pressures. As the water distribution network is not divided in zones, three pressure zones are developed virtually using the model. To divide the distribution network, isolation valves are closed and new ones are installed (virtually). Based on the data and using the hydraulic simulation model, PRVs are installed at the entrance of each zone (virtually). The PRVs are used to regulate water pressure. The results showed that average pressure is reduced from 4 to 58% depending on the time of the day. The biggest pressure reduction is met in the morning hours (2-5 am) as it is well-known that as consumption is low at this time, pressure gets its higher values. This results in high leakage rates. Such an application of PRVs results in the reduction of water volume entering the network by 3.44% or 37,970 m^3 per year.

4.3.3 PB4 – Municipality of Kardzhali

PB4 installed 4 flowmeters and is able to monitor through SCADA the water flows. Based on the data available, the water passed through these 4 flowmeters is 1,087,265 m^3. Additionally, PB4 supplied and installed a mass spectrometer which analyzed drinking water. This mass spectrometer is able to analyze the following elements: arsenic, chromium, selenium, copper, lead, cadmium, boron, nickel, zinc, sodium, aluminum, manganese, iron, antimony, barium, mercury, uranium, strontium and others.

4.3.4 PB5 – Municipality of Gotse Delchev

As a part of the project, the first action implemented was to set up of constant flow measurement of DMA inlet. Data analysis for the level of water losses are based on 1 year constant measurements. Thanks to those data effect from rehabilitation of pipeline can be easily assessed as follow:

- Reduction in net flow delivered at entrance of DMA.

The water supplied in the DMA is reduced after the pilot action implementation. Specifically, the reduction ranges from 25% (July) to 38% (April).

- Reduction of net night flow which is directly related with level of real losses

Average night flow is reduced after the pilot action implementation. The reduction percentage ranges from 43% to 57.9%. The highest reduction percentage is met in June.

- Reduction of ILI index which measures level of real losses

ILI index is reduced radically. The reduction ranges from 44% to 59%. ILI values after the implementation of the pilot action range from 46.98 to 57.73 compared to 94.65 to 124.14 before the pilot action implementation.

The cost of the pilot action (reconstruction of pipeline) is 96,550.36€.

4.3.5 PB6 – DEYA Thermaikos

The water utility developed IT applications for (a) water distribution networks management allowing water operators to manage the spatial data of the water distribution networks (e.g. Identification of the areas affected by water interruptions or failures, etc.) and; (b) mapping of the failures history in an interactive map. These applications allow the water utility managers to monitor the water supply system and plan the appropriate measures to reduce failures and finally reduce Non-Revenue Water.

4.4 Problems encountered and Lessons Learnt

4.4.1 LB – DEYA of Komotini

The only problem was the delay of the tender procedure due to bureaucratic reasons. The pilot action has proven to be a useful decision-making tool and DEYAK suggests other utilities to implement such applications. IT applications that can be connected to other IT tools (e.g. GIS, SCADA, etc.) are useful to the utility managers.

4.4.2 PB2 – DEYA of Thermi

There were not specific problems met during the implementation of the pilot action. The tendering process took some time to conclude due to bureaucratic conditions in public procurement.

4.4.2.1 Water efficiency

The pilot action implementation revealed that the estimation of water volume abstracted from the boreholes was highly underestimated. This fact made the water utility operators to underestimate the NRW level and they could not be able to design the correct NRW reduction strategies. The water utility will implement this measure to the 9 remaining boreholes.

It is very important to know the water volume entering the network and the water consumed in order to correctly and reliably estimate the NRW level. In general, the correct measurements of water volumes consumed or lost will provide the water operators data in order to design the correct strategies for the confrontation of NRW. The water utility proposes the implementation of similar activities to all water utilities at regional and national level.

The development of the hydraulic model of the water distribution network is a useful tool for water operators as it can be used for the development of scenarios, the segmentation of the network in DMAs for more efficient management, etc.

4.4.2.2 Water quality

The supply and installation of automated chlorination systems provided to the water utility a more efficient chlorination in the water tanks, providing safe water to the consumers. Chlorination is used for the disinfection of water and the controlling of bacteria and viruses in drinking water. However, the amount of free chlorine should not exceed the limits set by the legislation. Automated chlorination systems allow for efficient chlorination and the control of the free chlorine concentration.

The water utility proposes this measure to other water utilities at regional and national level. The water utility will implement this measure to the remaining water tanks.

4.4.3 PB3 – Municipality of Kardzhali

No difficulties except of delays at the procurement process.

4.4.4 PB5 – Municipality of Gotse Delchev

Main conclusion from current project is that real losses can be managed only by dedicated approach including right measurements and data analysis and rehabilitation of most critical sections from pipelines.

Based on achieved results in terms of reduction of water losses it is obvious that approach applied in current project is the right one when it comes for water loss reduction.

DMA approach and rehabilitation of pre-defined section in water supply network is well known approach worldwide. In Bulgaria National Water Regulator obliged Water Operators to introduced DMA zoning and this was introduced as a key quality indicator affecting price of water. Due to this DMA has become common approach for assessment of real water losses and selection of most crucial pipes sections for reconstruction.

4.4.5 PB6 – DEYA of Thermaikos

No specific difficulties.

4.5 Conclusions

The pilot actions implemented by the project beneficiaries refer to water use efficiency and/or water quality (Table 4.3).

Table 4.3. Brief description of the pilot actions

Beneficiary		Pilot action	Equipment	Water Use Efficiency	Water Quality
LB	DEYA Komotini (Greece)	Development of IT applications to directly support the water utility operations and indirectly contribute to the water use efficiency (by reducing NRW). The applications will provide: • Failure history mapping. • Field applications. • Applications for the public.	IT applications	√	
PB2	DEYA Thermi (Greece)	- Installation of flow meters in the water abstraction points - installation of automatic chlorination devices in the utility's water tanks. - hydraulic model development from the University of Thessaly (PB3)	45 electromagnetic flow meters; 6 automatic chlorination systems; full unlimited licence of an hydraulic simulation model.	√	√
PB4	Municipality of Kardzhali (Bulgaria)	- installation of flow meters in the water abstraction points - supply and installation of Inductively coupled plasma mass spectrometry (ICP-MS).	4 electromagnetic flow meters; 1 ICP-MS equipment.	√	√
PB5	Municipality of Gotse Delchev (Bulgaria)	• supply and installation of electromagnetic flowmeters and pressure meters in the DMA in "Danube" area in Gotse Delchev water supply network. • replacement of pipes F90 and F110 in DMA "Danube" area as pilot measure	Electromagnetic flowmeters with data loggers; pipes	√	
PB6	DEYA Thermaikos (Greece)	Development of IT applications aiming at supporting the operations of the water utility and indirectly the water use efficiency (reduction of NRW). The applications will be: • Water distribution networks management application. • Mapping of the failures' history.	IT applications; GIS software license	√	

Regarding water use efficiency, the pilot actions of DEYA Komotini, DEYA Thermis, Municipality of Gotse Delchev, Municipality of Kardzhali and DEYA Thermaikos resulted in (a) the reliable recording of water flows from the water supply sources and/or at the entrance of zones; (b) the mapping of failures allowing the water utility managers to plan their actions based on specific measurable criteria; (c) exact and reliable estimation of the water balance; (d) reduction in water entering the network and in real losses (up to 59% reduction of ILI in the pilot DMA in the Municipality of Gotse Delchev.

Regarding water quality, the pilot action of DEYA Thermis and the Municipality of Kardzhali resulted in (a) the monitoring of water quality and specifically the concentrations of pollutants and heavy metals; and (b) the reliable chlorination of water.

In conclusion, the results from the pilot actions resulted in:

- Accurate estimation of the water volumes abstracted and entered the water supply system;
- Accurate estimation of the water balance and the NRW levels;
- Design of the strategies to reduce NRW levels based on accurate data;
- NRW reduction;
- Real losses reduction;
- Leak events reduction;
- Reduction of repair time;

- Better knowledge of the network;
- Better analysis of the failures and their causes;
- Adequate chlorination for the water supplied;
- Safe water for the consumers;
- Reduced operational costs;
- Improved customer service.

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Appendix: Beneficiaries' reports

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WATER RESCUE

Water resources efficiency and conservative use in drinking water supply systems

Interreg
Greece-Bulgaria
WATER RESCUE
European Regional Development Fund

EUROPEAN UNION

WP	**5 Pilot Actions**
Deliverable *Tool*	**5.1.2 Pilot Actions Implementation** *Questionnaire*
Project Beneficiary No	**LB/PB1**
Beneficiary Institution	**Municipal Water Supply and Sewerage Company of Komotini**

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The contents of this report are sole responsibility of the Municipal Water Supply & Sewerage Company of Komotini and can in no way be taken to reflect the views of the European Union, the participating countries the Managing Authority and the Joint Secretariat.

Name of the organization/institution: Municipal Water Supply and Sewerage Company of Komotini
Beneficiary number: LB/PB1

1 Introduction

Municipal Water Supply and Sewerage company of Komotini (DEYAK) supplies with water the municipality of Komotini, located in the Water District of Thrace (EL12). The people supplied with water is 65,000. The area covered is 385.3 km^2 and the average altitude is 45m. The total pipes' length is 549 km consisting of pipes from PE (with diameters 90-450mm) and from steel (with diameters 600mm). The water pipes network is old enough. The average operating pressure is 4 atm and the total number of water meters is 48,500. The number of service connections is about 17,000. The billing period is 2 months for the city of Komotini and 4 months for the municipal districts. The river basin where water is taken from is the river basin of Komotini – Loutro Evrou stream (area 1,958.3Km^2). Water is taken from Vosvozis river (EL1209R000010085N) and the groundwater system of Rodopi (EL1200120). All the information is given in Table 1.

Table 1. General data on the water supply system of DEYA Komotinis

Data (base year 2018)	
Total population served	65,000
Total area covered (km^2)	385.3
Total pipes' length (km)	549
Mean altitude (m)	45
Mean operating pressure (Atm)	4.0
Types of pipes (material, diameters)	PE (90-450mm) and steel (600mm)
No. of water meters	48,500
No. of service connections	17,000
Billing period	2 months for Komotini city; 4 months for municipal districts
River Basin where water is taken from	Komotini – Loutro Evrou stream

2 Pilot Action

The pilot action implemented by DEYA Komotini refers to water use efficiency.

The water utility faces problems related to high Non-Revenue Water (NRW) which was estimated for 2017 to be 38% of SIV. Specifically, the water supply network suffers from pipes breaks, invisible leaks, unauthorized consumption. The main cause is that the water distribution network is old in many parts of the city.

The pilot action refers to the provision of services for the supply and installation of IT applications to directly support the water utility operations and indirectly contribute to the water use efficiency (by reducing NRW). The applications are expected to provide:

• Failure history mapping. The application will present the failures history in an interactive map. It will provide the possibility of selection of filters depending on, e.g. the severity of the problem, the time period, the cost of confrontation measures etc. The data will be presented alone but also cumulatively in the form for example of cluster map or heat map. The possibility to choose the time period of reference of the problems to give the opportunity someone to be able to see their time evolution. Additionally, the application will provide a problems management environment.

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• Field applications. Utilizing the water utility's background in GIS software, field applications will be developed, in tablet environment that will be used from the utility's repair teams to provide them access to the data (e.g. distribution networks) but also to inform immediately the water operators regarding the problems faced and recorded from the personnel in the field. These applications will allow a more efficient coordination and a significant reduction in the troubleshooting time, contributing to water saving.

• Applications for the public. Internet based applications for the public will be developed. The consumers will be able to report a problem and the water utility will inform the consumers for possible water interruptions or other problems.

The pilot action was elaborated in 2018. The pilot action targets the real losses pillar "speed and quality of repairs". By using these IT applications, the water utility will be able to:

- Be informed about the failures in the water supply and distribution system and assess their spatial and temporal variability. This will act as a decision-making tool for the water utility.
- React quicker to any failure event reducing the response time and also reduce the repair time as all the data will be available to the staff. Time reduction will eventually result in real losses reduction.
- Be informed quicker as the public will be able to report any problems asap and thus reduce the reaction and repair time.

2.1. Applications for the public

The IT applications developed as pilot action in DEYAK include an internet application, through which the public will be able to inform the utility about problems in the water supply network, while the utility will be able to proceed to the examination and solution of the mentioned problems and to inform the public for scheduled water supply interruptions. The application is accessible at the address: https://komotini.getmap.gr/.

The following categories of failures are included:

- Water leak on the ground surface;
- Firefighting break;
- manhole overflow;
- turbidity;
- bad odor of water.

Also, the consumers can use this application to check their water bill.

The steps are the following:

Initially the consumer is registered at the system. Then the consumer can submit a report regarding a problem by indicating the location and the data related to the problem / failure such as kind of failure, if there is water loss, a brief description, and a photo attachment field. The date and time are automatically entered as well as the consumer's username and the status of the report. The users will have the opportunity to get informed about the problem they have reported.

The water utility staff is the administrator of this application.

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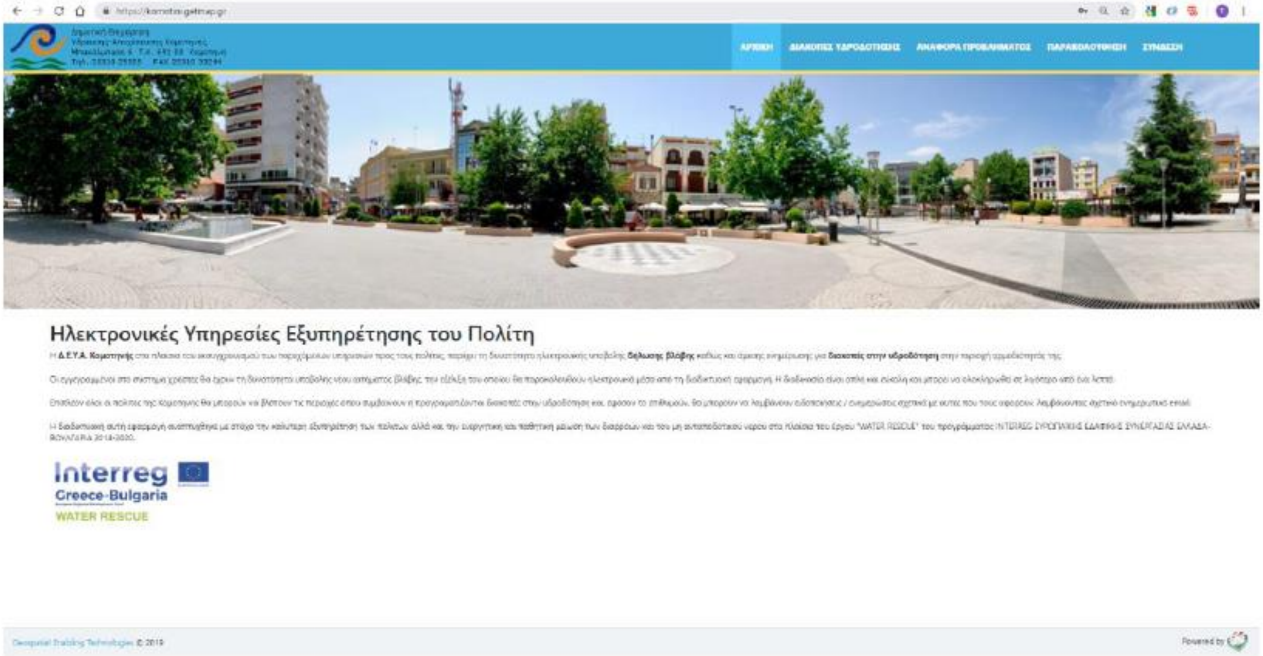

Figure 1. Application interface

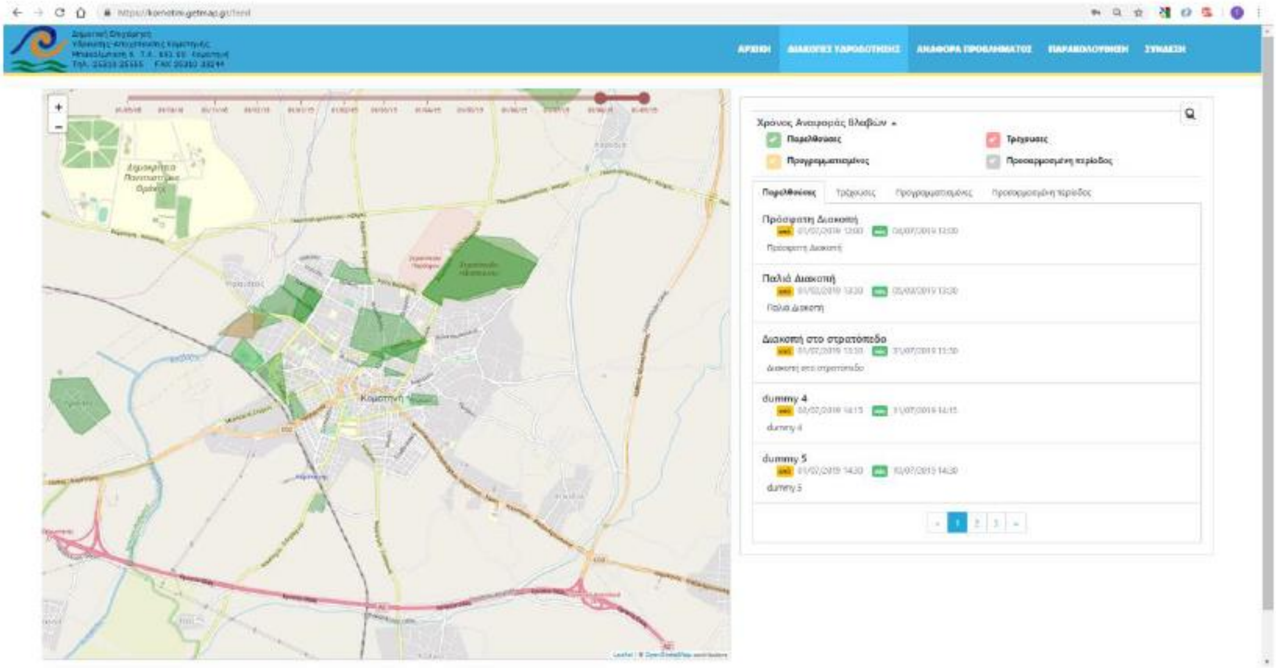

Figure 2. Water supply interruptions map

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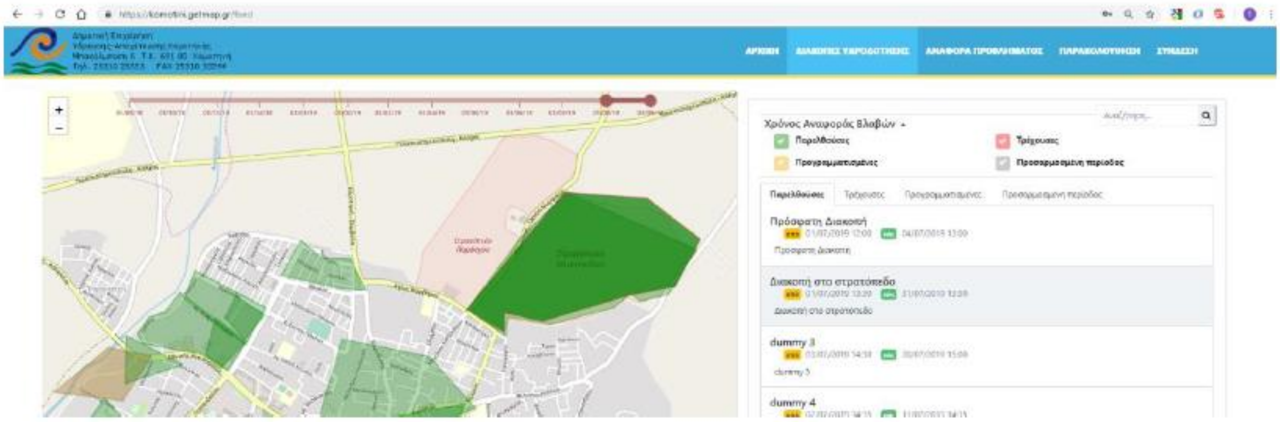

Figure 3. Spatial recording of failures

The “users” tab allows the staff user to manage all users.

The water supply interruptions tab allows to enter the scheduled interruptions and some of the data to be visible for the public.

2.2. Spatial mapping of failures

This application refers to a system of spatial recording of failures. This is an online application that presents the entire history of DEYAK failures on maps and backgrounds. The application is accessible at the address: https://deyakmap.getmap.gr and the managers of the utility have full access.

The staff enters the information of a failure (Figure 4) and then the failure is entered and saved in the application (Figure 5). The table showing the failures in the water supply network is available from the application (Figure 6). The data gathered from this list is the number of the incident, its description, the classification of the work, the cost and the water volume lost (Figure 6). The statists are also available (Figure 7). There are various search options, for example by category of the failure, by area, etc. (Figure 8). There is also the option to search by code number (Figure 9). The application provides the ability to view the failure reports in the form of a map, using also Google Streets background (Figures 10 & 11).

The application includes the tab “map” including various tools for the user. The application provides the user with the base maps and the layers. The base maps are used to facilitate the orientation, display and interpretation of data, as they provide a rich and detailed representation of the natural earth surface and features. Backgrounds are "static" in comparison to layers that take their data from geospatial services.

The layers include various possibilities. The application is able to search for failures based on various criteria such as type of failure, time frame, cost and amount of water losses (Figures 8&9).

The applications are connected to QGIS software providing geospatial data.

During the pilot action the concessionaire provided educational activities to the utility’s staff in order to be trained to these applications.

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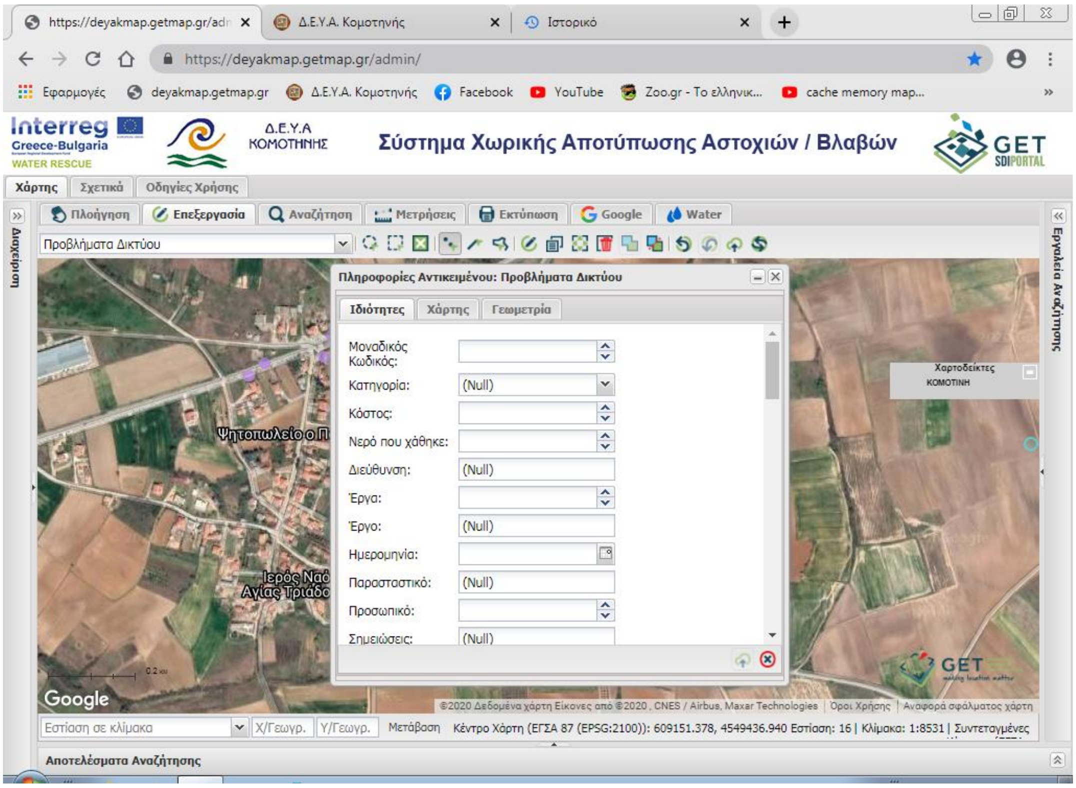

Figure 4. Inserting the failure in the application

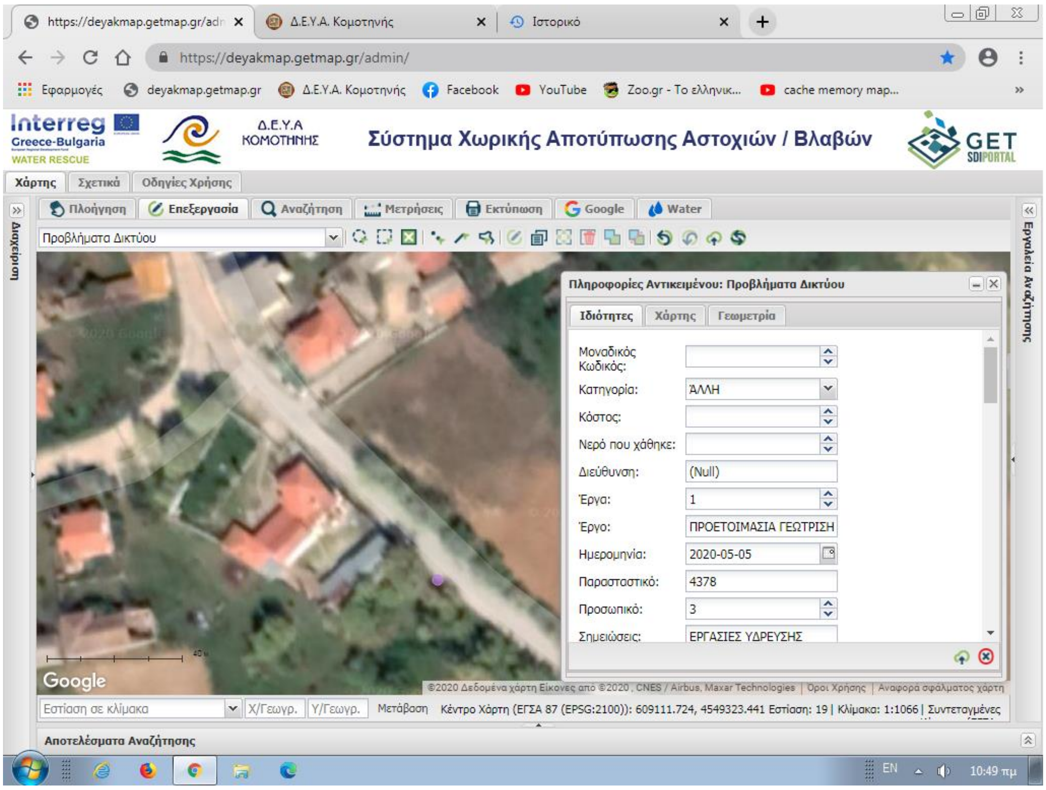

Figure 5. The failure is inserted and saved in the application.

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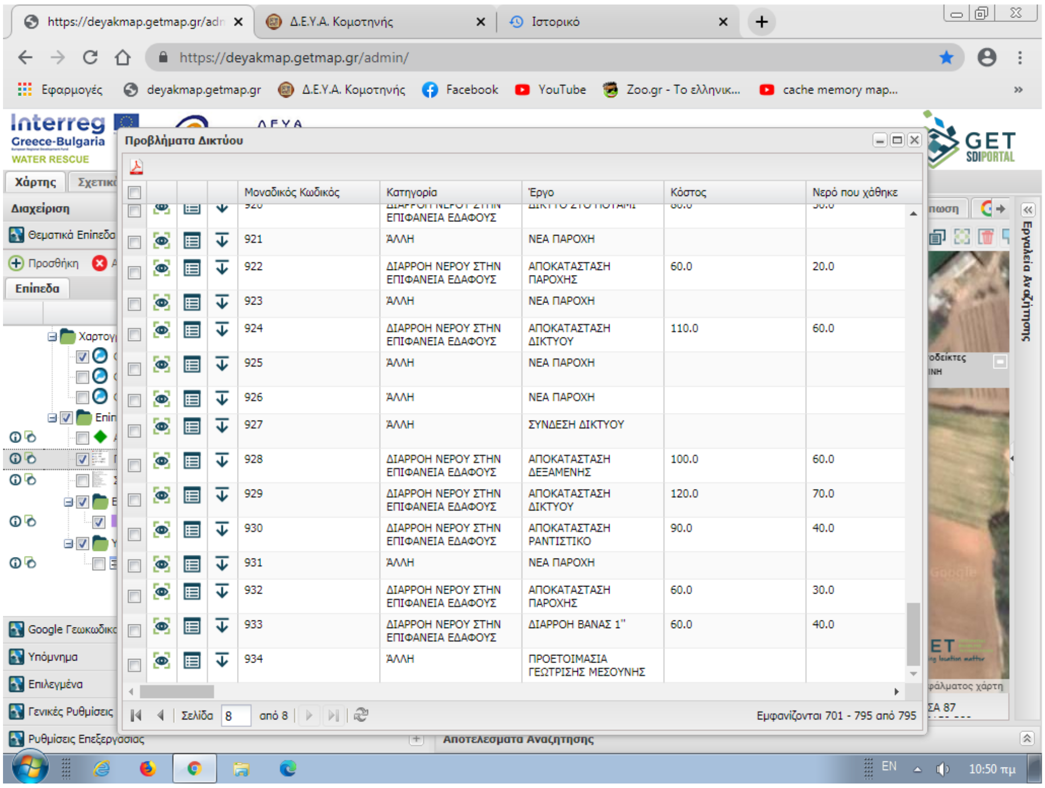

Figure 6. List of failures.

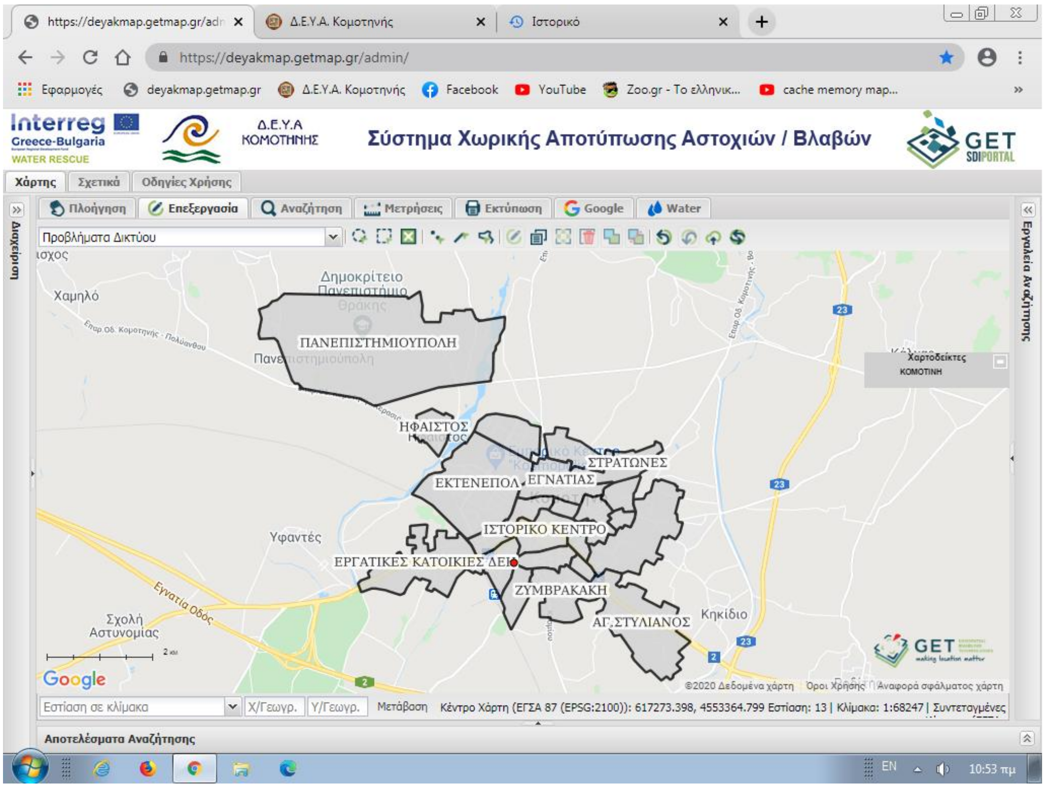

Figure 7. Statistical information on the problems of the area

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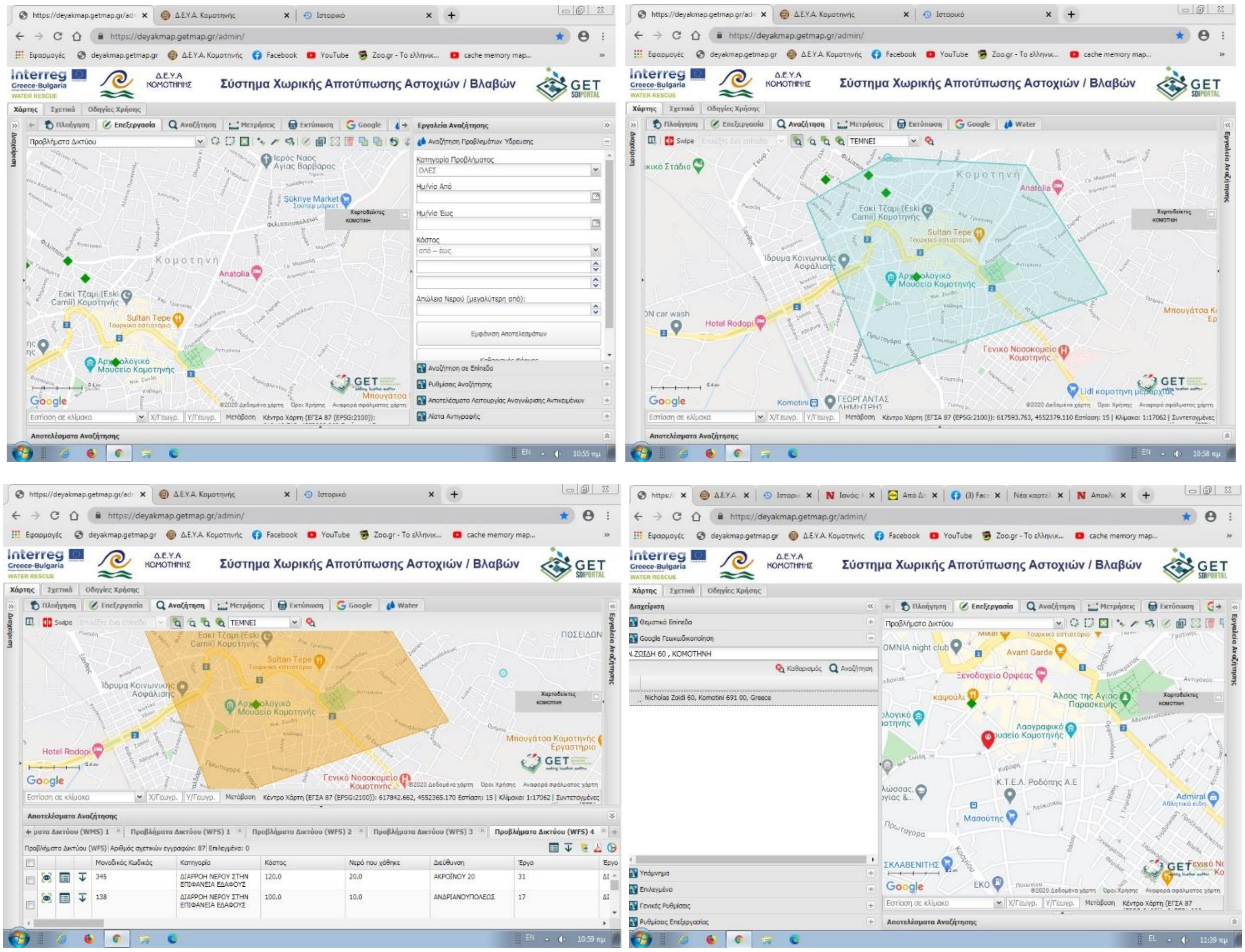

Figure 8. Search by category, by area, and other search options

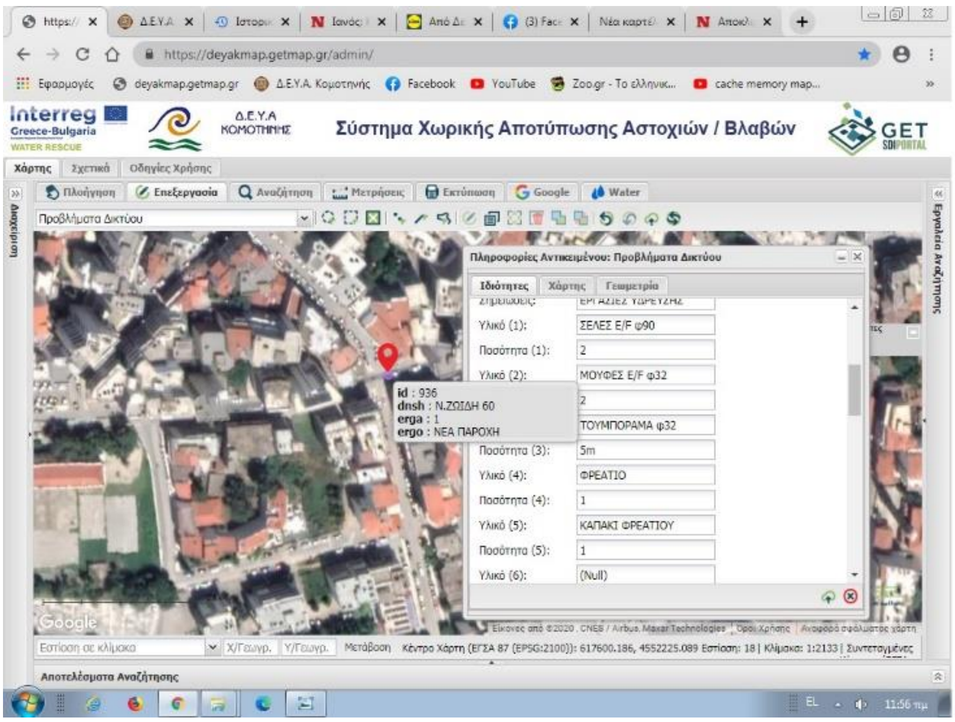

Figure 9. Search by code number

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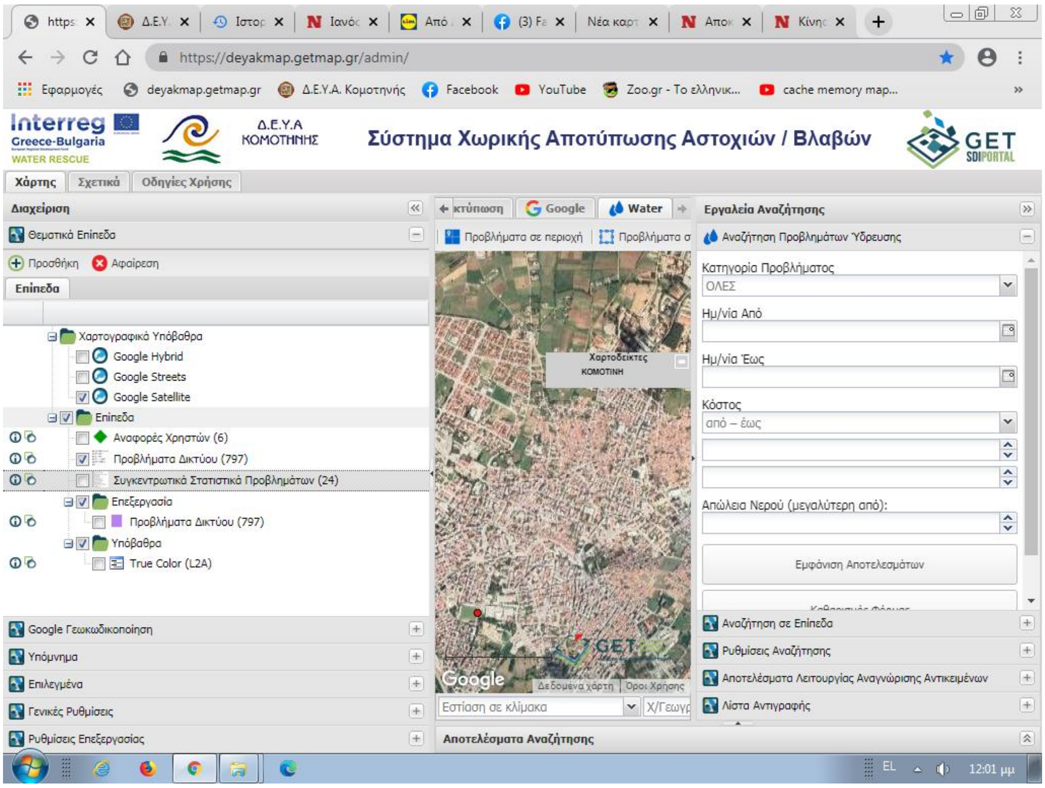

Figure 10. View options

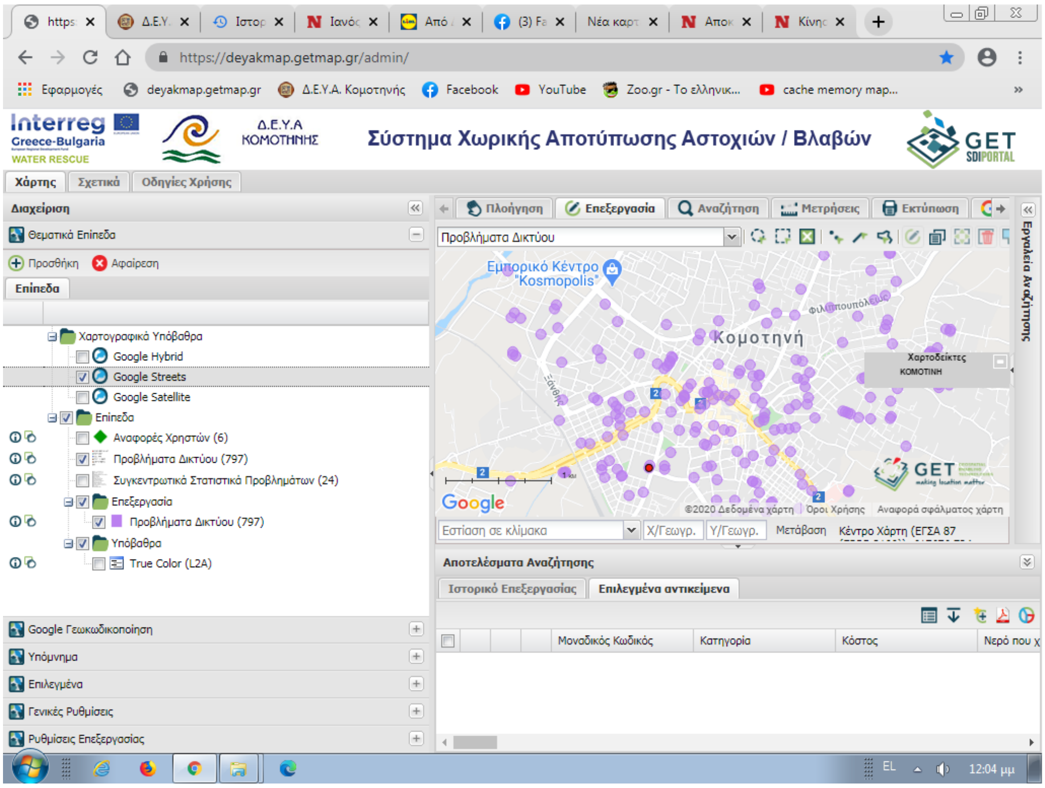

Figure 11. View options using google streets

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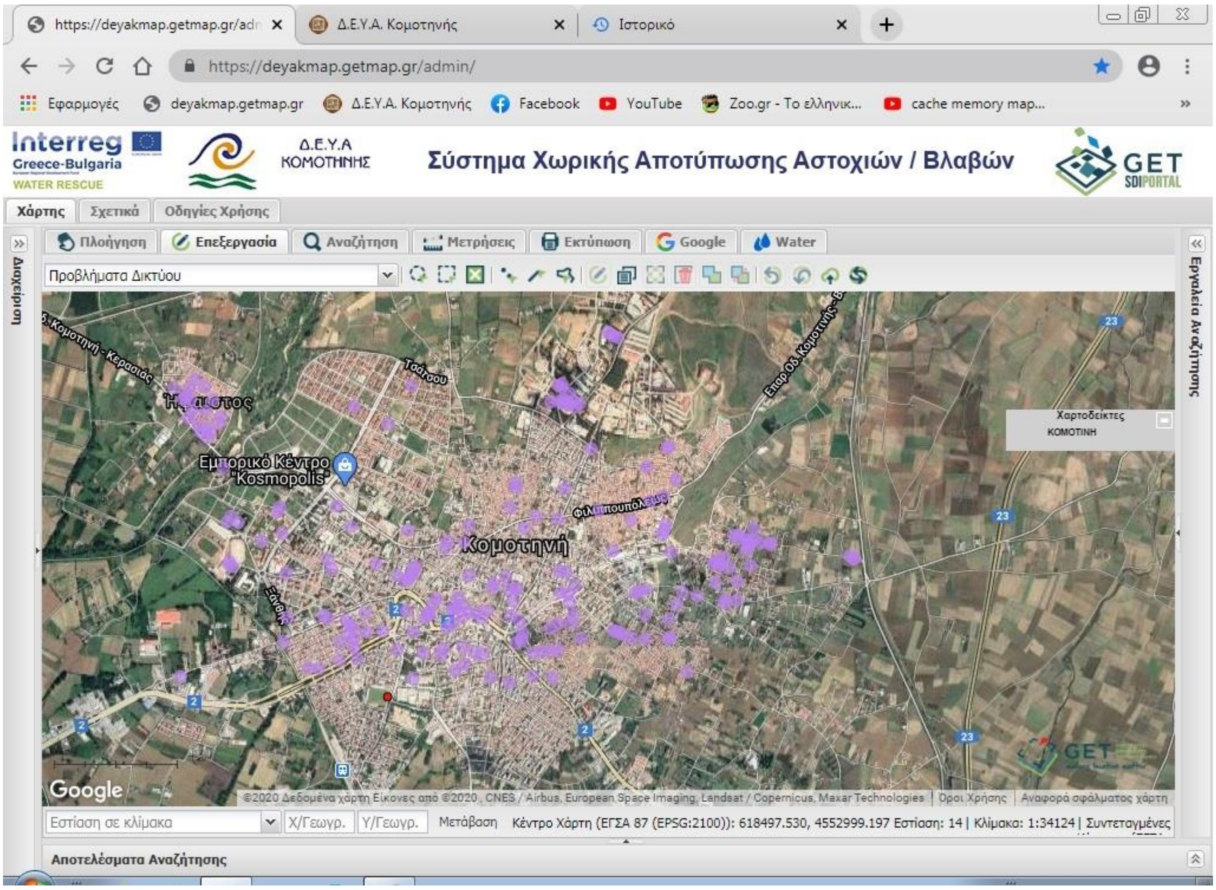

Figure 12. The central screen showing the failures

3 Results

The water utility staff was trained in order to use the developed applications. In particular, the water utility staff inserted the reported failures for 2018 and 2019 in the application. Specifically, in 2018 66 failures related to pipes' leaks and breaks were reported while in the first 9 months of 2019 135 failures were reported and inserted in the application. The main failures are pipes' leaks and breaks, followed by network repair and connections' leaks in 2019 (Figure 13).

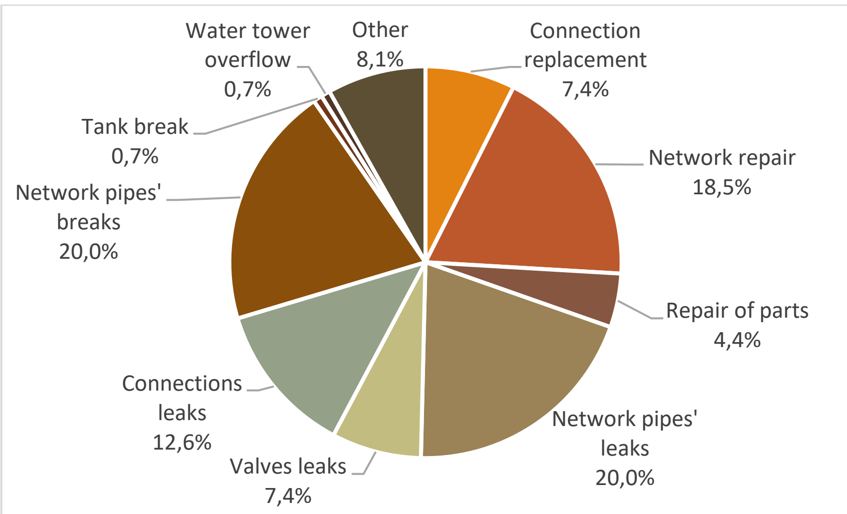

Figure 13. The main failure types in 2019

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The use of the developed applications aims at targeting the speed of repairs, being a real losses reduction pillar. Additionally, the applications aim at improving the quality of services to the consumers. The total cost of the pilot action is 88,000.00€.

The benefits of the pilot action are the time reduction for the repair of failures by the online information from the public and the provision of all data regarding a failure online, informing the customers for any emergency situation, better analysis of the failures of the water supply network in order to schedule and organize any actions, etc. By reducing the time to repair, less water volume is lost and the costs are reduced. Also the water utility managers can use these IT applications as decision-making tools. The data gathered from the application regarding failures provide a good insight on the main problems of the water supply network and their spatial allocation, allowing the water utility managers to prepare the tenders for the necessary works. Finally, the water utility provides improved water services to its customers.

4 Problems encountered and applied solutions

There are not any specific problems encountered during the pilot action implementation. The only problem faced was the delay of the tender procedures due to bureaucratic reasons.

DEYAK suggests that other water utilities can apply this solution as it is a useful decision-making tool.

5 Lessons learnt

The pilot action has proven to be a useful decision-making tool and DEYAK suggests other utilities to implement such applications. IT applications that can be connected to other IT tools (e.g. GIS, SCADA, etc.) are useful to the utility managers.

6 Comments

No comments.

WATER RESCUE

Water resources efficiency and conservative use in drinking water supply systems

Interreg
Greece-Bulgaria
WATER RESCUE
European Regional Development Fund

EUROPEAN UNION

WP	**5 Pilot Actions**
Deliverable *Tool*	**5.2.2 Pilot Actions Implementation** *Questionnaire*
Project Beneficiary No	**PB2**
Beneficiary Institution	**Municipal Water Supply and Sewerage Company of Thermi**

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

The contents of this report are sole responsibility of the Municipal Water Supply and Sewerage Company of Thermi and can in no way be taken to reflect the views of the European Union, the participating countries the Managing Authority and the Joint Secretariat.

Name of the organization/institution: Municipal Water Supply and Sewerage Company of Thermi
Beneficiary number: PB2

1 Introduction

Municipal Water Supply and Sewerage Company of Thermi (DEYA Thermis) is the water utility supplying with water the area of Thermi including several municipal districts: Thermi, Mikra, N. Redestos, Tagarades, N. Risio, Vasilika, Souroti, Agia Paraskevi, Agios Antonios, Lakkia, Peristera and Livadi. The area covered by DEYA Thermis is 1559.34 Km^2. The area's altitude ranges from 0-200m. The water meters (active) are 25,786 supplying with water a population of 53,070 people (2011 census). The total pipes' length is about 700Km and the pipes are made of PE (60%) and PVC (40%). The pipes are installed since 1970 until now. The average operating pressure is about 5 atm.

DEYA Thermis is supplying the municipal district of Thermi with water from groundwater boreholes from three groundwater subsystems: down flow of Antemountas; Thermi – N. Risio; and Cholomontas – Oreokastro (Chalkidiki river basin). DEYA Thermis water abstraction is allocated in the groundwater systems as shown in Table 2. The major water volume (97.8%) comes from the subsystems of Anthemountas down flow and Thermi – N. Risio. The first subsystem is assessed in bad quantitative and chemical status, while the second is assessed in good quantitative and chemical status. Only 2.1% of water volume comes from the Cholomontas - Oreokastro subsystem which is found to be in good chemical and quantitative status.

Table 1. General data of the water supply network of DEYA Thermis (base year 2019)

General data	
Total population served	53,070
Total area covered (Km^2)	1,559.34
Total pipes' length (Km)	700
Mean altitude (m)	0-200
Mean operating pressure (atm)	5
Types of pipes (material, diameters, lengths)	PE (60%); PVC (40%)
Age of pipes (per material, diameter)	Since 1970
No. of water meters	25,786
Billing Period	Every 3 months
River Basin where water is taken from	Chalkidiki river basin

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2 Pilot Action

The pilot action of DEYA Thermis refers both to water efficiency and water quality.

Water Efficiency

DEYA Thermis uses 54 boreholes for water abstraction. However, the water volume abstracted is not actually recorded, resulting in assumptions on the estimation of these water volumes. The fact that the water volume entering the water distribution network is estimated based on the pumping stations data, does not allow the water utility to do the water balance based on actual data. The consequences are that the water balance could not show the actual Non-Revenue water (NRW) values and the actual causes of NRW. Additionally, based on national legislation the Water Directorate issued water use permits for the boreholes used and the water utility is obliged to install flowmeters for the monitoring and recording of the water abstraction. During the pilot action, flowmeters are supplied and installed in 45 boreholes (Table 2; Figures 1 & 2). The installation took place from 27/11/2019 until 16/12/2019. The flowmeters conform with the European Directive MID 2004/22/EC or the later MID 2014/32/EC.

Table 2. The locations of the installed flowmeters

a/a	Location / Borehole	Name of the location	Supplying water to the municipal districts
1	Thermi	Aeroporias	Thermi – 16.000 people
2	Thermi	Firos Sideras	
3	Thermi	Kosmidis	
4	Thermi	Emporiki	
5	Thermi	Ergotaxio	
6	Thermi	Thermokipio	
7	Thermi	Interbeton	
8	Thermi	Lida Maria	
9	Thermi	Parsourakou-2	
10	Thermi	Patsourakoy-new-3	
11	Thermi	Toumpas B	
12	Triadi	Triadi	
13	Thermi	Hayat	
14	Thermi	Eurotech	
15	N. Redestos	Kanavou	Vasilika – 4.030 people
16	Filothei	Filotheis -1 (Redestos)	
17	Filothei	Filotheis -2 (new)	
18	Filothei	Filotheis -3 (old)	
19	N. Redestos	Hempe	
20	N. Redestos	Christoforou	
21	Tagarades	Tagaradon -1	Tagarades – 2.100 people
22	Tagarades	Tagaradon-3 (Livadi) new	
23	N. Risio	Zampetoglou	N. Risio – 3.000 people
24	N. Risio	N. Risiou - C3	
25	N. Risio	N. Risioy – C4	
26	Vasilika	Ai Gianni (BA3)	Agios Antonios (Vasilika) – 880 people
27	Lakkia	North Oikismos LA1	Lakkia – 45 people
28	Lakkia	Inverter 1	
29	Lakkia	East Oikismos LA2	

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30	Ag. Paraskevi	Anthemounta P. (ACP1)	Agia Paraskevi (Vasilika) – 2.300 people
31	Souroti	Koukos (S1)	Souroti – 1.600 people
32	Livadi	Entos Oikismou(L1)	Livadi – 260 people (850 in the summer)
33	Livadi	Ektos Oikismou (L2)	
34	Kardia	Christodoulidis	Plagiari, Kardia, Kato Sholari, Trilofos, Lakkoma – 18.500 people and 212 connections to businesses
35	Kardia	Kloni	
36	Kardia	Kakarimou	
37	Epanomi	Apostolou	
38	Plagiari	Rema	
39	Plagiari	A1.3-Osia Xeni (Garou)	
40	Plagiari	A2.1	
41	Plagiari	A2.2	
42	Plagiari	New A2	
43	Plagiari	A1.2-Trigonou	
44	Plagiari	A1.1	
45	Ag. Paraskevi	S1(Ag. Paraskevi)	

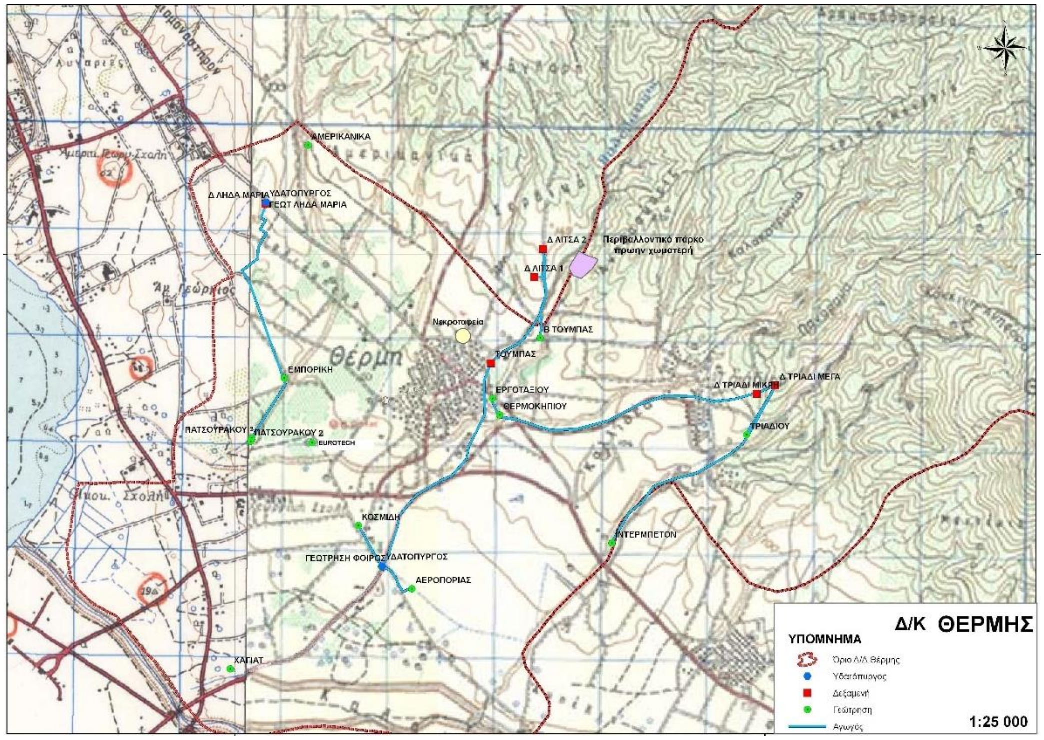

Figure 1. The location of boreholes and tanks in the municipal district of Thermi

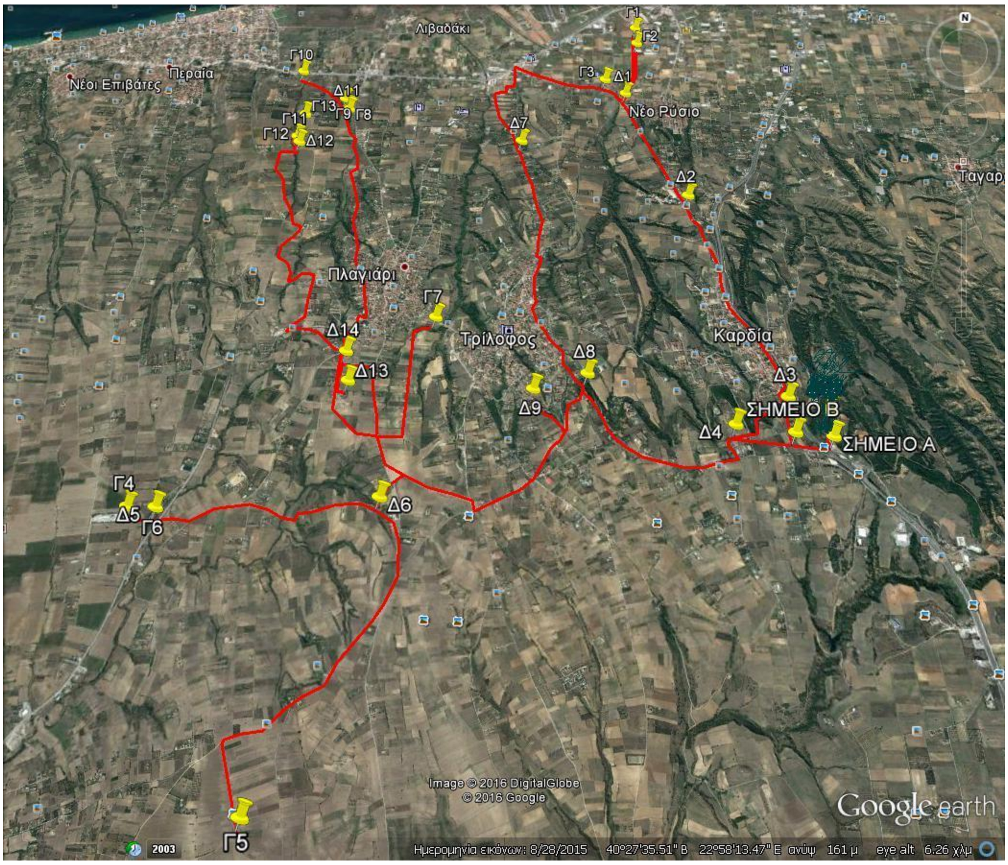

Figure 2. The location of boreholes and tanks in the municipal district of Mikra

Water Quality

DEYA Thermis uses chlorination for the disinfection of water in water tanks. There are 29 chlorination points to cover the whole water supply network of DEYA of Thermi. The major problem faced regarding water quality is the increased value of some physical-chemical parameters that sometimes is near the allowable maximum values of the legislation. The cause of this problem is the groundwater geological background. Another problem is the excessive increase of turbidity which is due to the excessive abstraction of the groundwater. The tanks did not have automated chlorination systems.

The pilot action is the supply and installation of automated chlorination systems in 6 water tanks (out of the 29 chlorination points, that is 20.7%) (Table 3). The installation was concluded in 6/12/2019. The automated chlorination systems provide assurance that water quality parameters are within the limits set by legislation and regulations (Figure 3).

Table 3. The locations of the installed automated chlorination systems, their capacity and consumption

a/a	Settlement name	Tank	Capacity (m^3)	Consumption (m^3/year)
1	Kardia	Sterna (Δ1)	40	290,000
2	Plagiari	Central tank (Δ14)	240	400,000
3	N. Redestos	Pefkakia (small – Δ1)	75	45,000
4	Ag. Paraskevi	Upper tank (Δ1)	400	295,000
5	Souroti	Upper tank (Δ1)	200	205,000
6	Peristera	D2	200	50,000

Figure 3. Chlorination devices installed

Hydraulic Simulation model

PB3, University of Thessaly, Civil Engineering department, developed the hydraulic simulation model for the water distribution system of Thermi. WaterGems software is used.

The water utility provided the necessary data to the University of Thessaly, Civil Engineering dept. and specifically pdf files with the geoprofile of the external and internal aqueduct (Figure 4), consumption data per water meter of 2018, data about the tanks and the boreholes.

Figure 4. Geoprofile of the internal aqueduct

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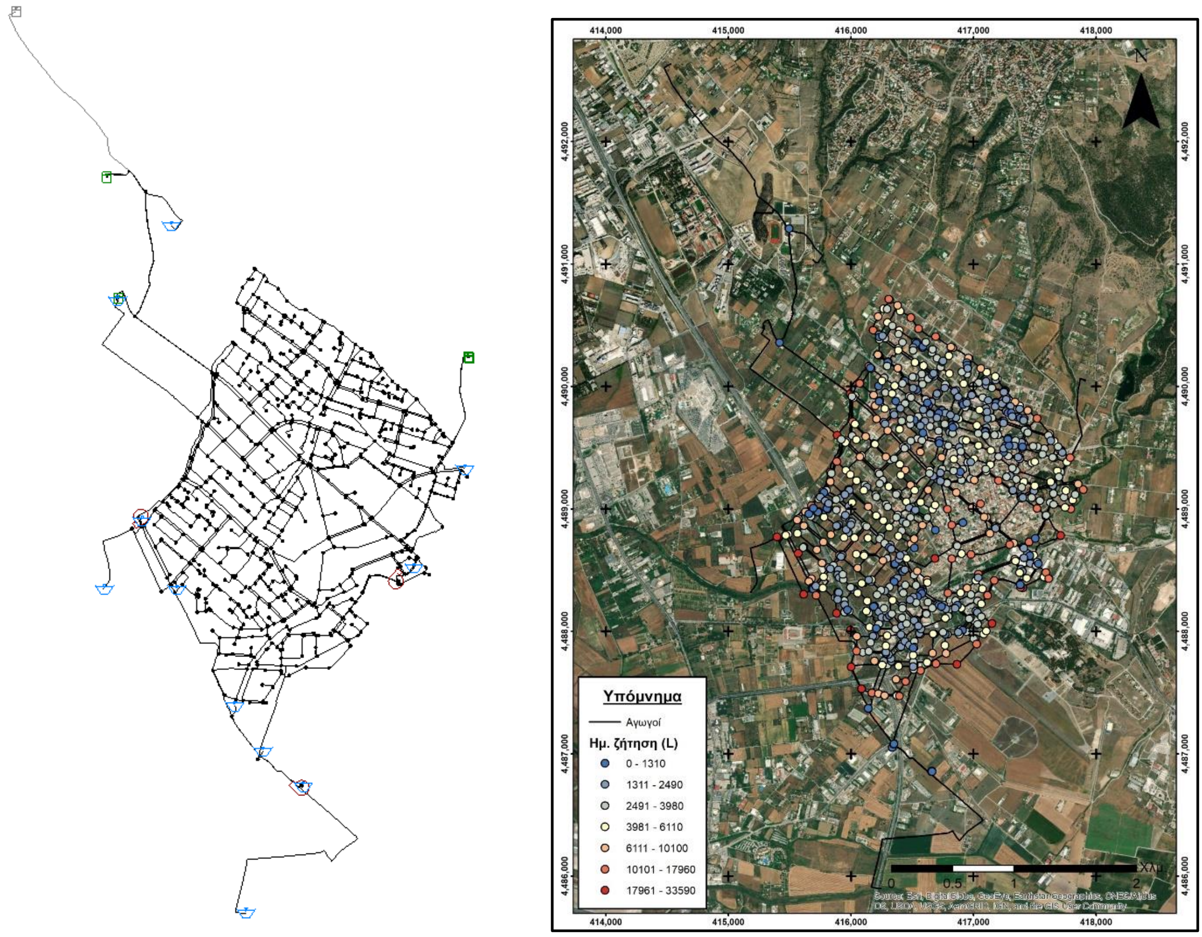

Figure 5. (a) The water distribution network of Thermi; (b) the average daily nodes' consumption

The internal network is mainly looped in shape and is gravitational, while the external aqueduct operates gravitationally and in parallel with pumping stations. There are eleven sources of water entering the network. Water from four boreholes goes to the Aeroporia tank from where the water is transferred to two pumping stations. Water from one of the pumping stations with water from another borehole goes to the Litsa Tank 2, and from there to Litsa tank 1. Then water is transported to the distribution network by gravity. Water from the other pumping stations along with water from three other boreholes is transferred to the new tank of Thermi. Water enters the distribution network by gravity. The water network is showed in Figure 5a.

The consumption pattern is established for the model using data from the water utility. The consumption is equally distributed using Thiesen triangles at the network's nodes. However, it is noted that there are many types of users such as domestic, agricultural, industrial and the use from the airport of Thessaloniki. Figure 5b shows the average daily nodes' consumption.

Figure 6a shows the external pipes' diameter and figure 6b shows the pipes' material.

The hydraulic model of the network is developed. The results (Figure 7a) show that the smaller / local pipes show the lowest flow rates, while the main water distribution pipes show the highest average daily flow. Given that pressure is not regulated through pressure reduction valves, the results showed that the nodes at the highest altitudes of the network have low pressure, while as altitude decreases pressure increases to quite high pressures (Figure 7b).

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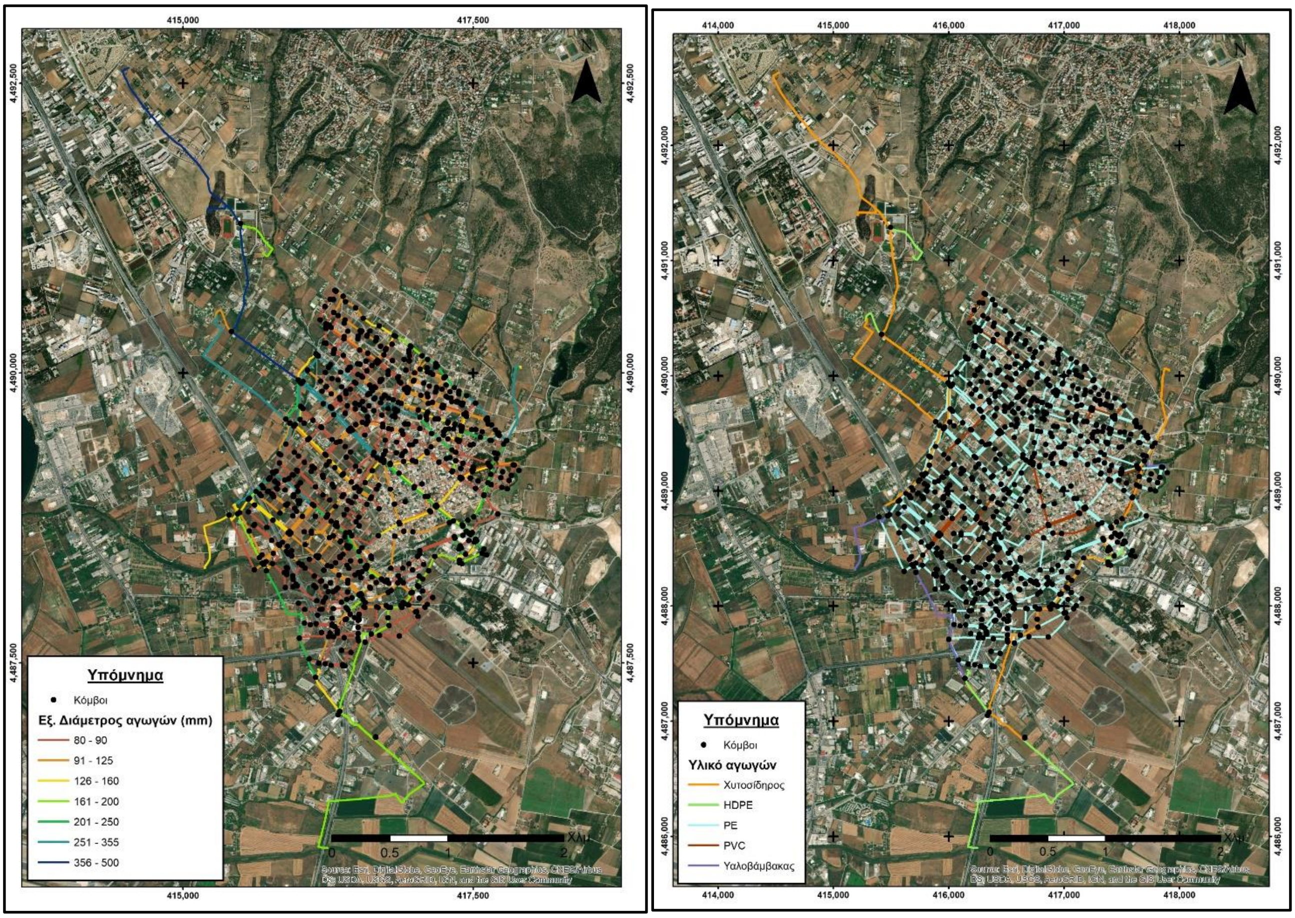

Figure 6. (a) External pipes' diameter; (b) pipes' material

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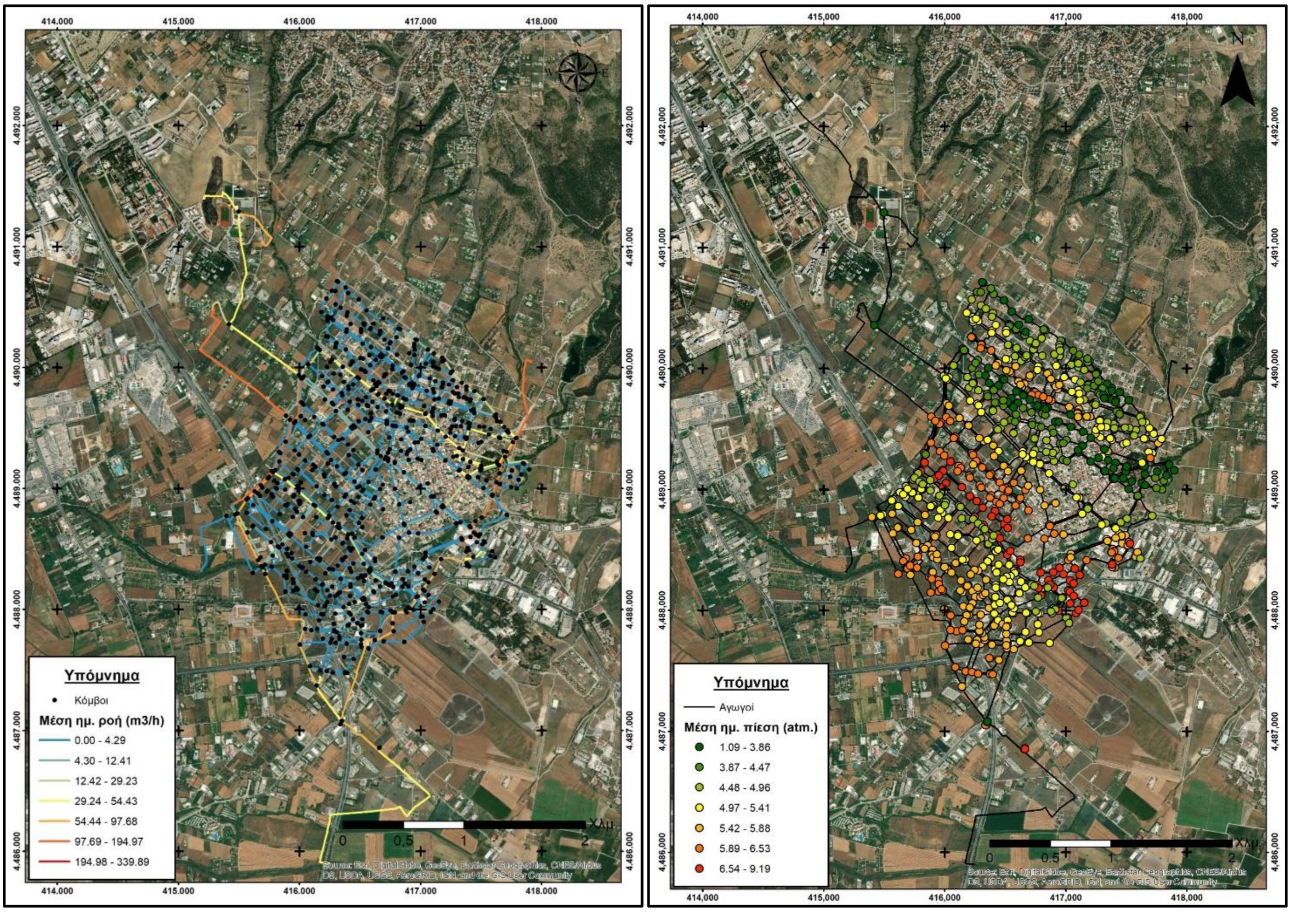

Figure 7. (a) Average water flow; (b) average water pressure

Three pressure zones are developed (virtually) using the hydraulic model using combinations of altitude and pressure (Figure 8). For the creation of the three zones some of the isolation valves are closed and some other are added. To regulate the pressure, three pressure reduction valves are installed at the entrance of each zone in order to achieve minimum pressure of 2 atm in every node. The critical nodes are identified: (a) zone A, higher altitude node J-327 and lower altitude node J-33; (b) zone B, higher altitude J-417 and lower altitude node J-196; and (c) zone C, higher altitude node J-749 and lower altitude node J-587.

Table 4. Old and new isolation valves and pressure reduction valves

Isolation valves			
Name	Diameter (mm)	Altitude (m)	Pipe id
Existing			
ISO-107	160	64,34	P-198
ISO-113	400	61,25	P-202
New ones			
ISO-186	315	60,60	P-294
ISO-187	225	66,35	P-317
ISO-188	160	66,50	P-472
ISO-189	225	57,67	P-347
ISO-190	225	66,50	P-345
Pressure reduction valves			
Name	Diameter (mm)	Altitude (m)	Pressure set (atm)

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PRV-1	300	86,28	4,15
PRV-2	350	42,04	2,10
PRV-3	160	61,75	2,50

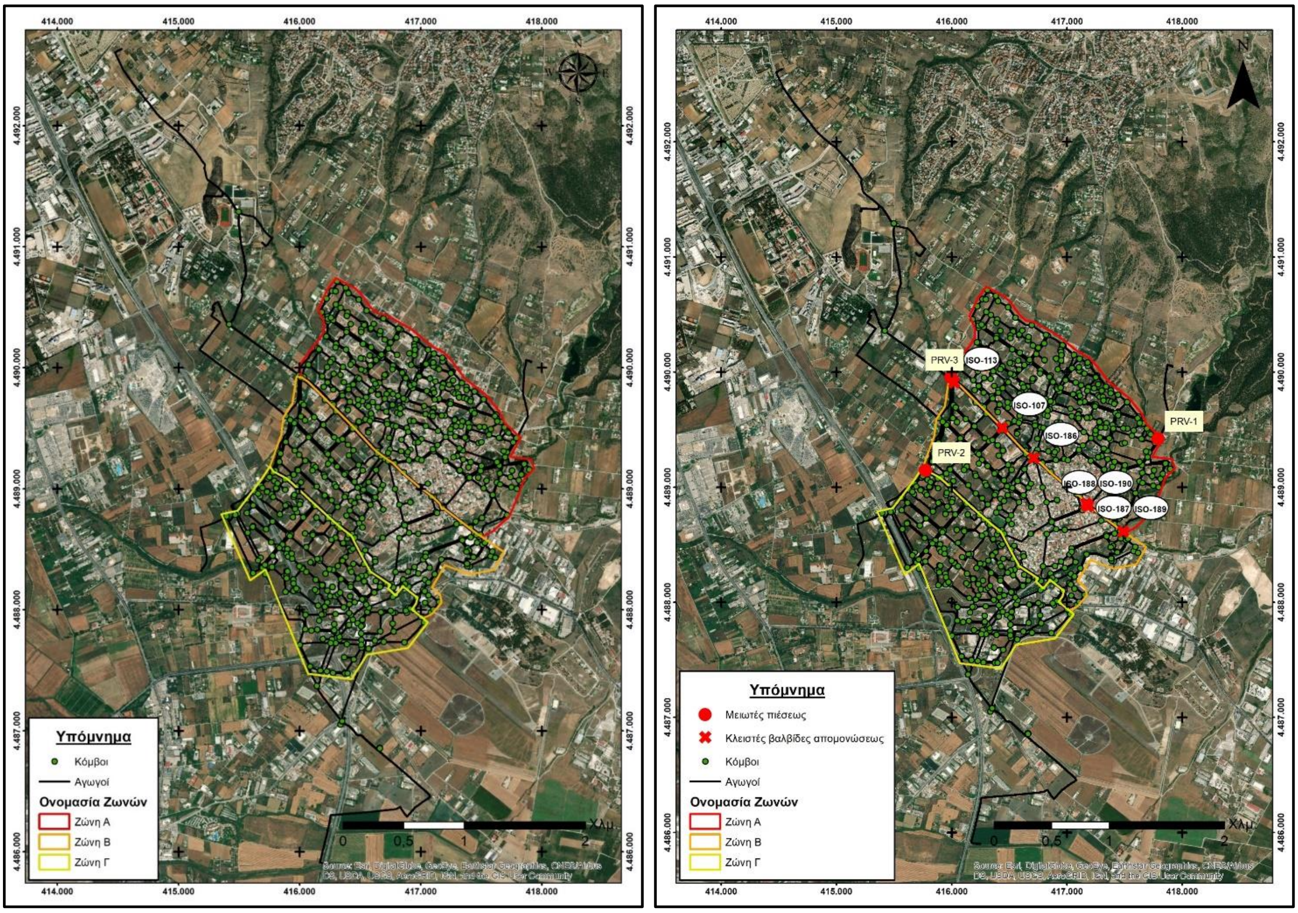

Figure 8. (a) Three pressure zones suggested; (b) PRVs and isolation valves

It is noted that there is a reduction in pressure in all zones, with the maximum reduction up to 58% while the minimum reduction is 4% (Table 5). In addition, there is a stabilization of pressure during zoning, where the average pressure per zone remains constant regardless of time, in contrast to the time before the zones' creation where a strong fluctuation in pressure is noted. The model showed that if zoning takes place the water volume entering the network is reduced by 3.44%.

Table 5. Average pressure before and after the creation of the zones and the difference in percentage

Time (hours)	Before zoning			During zoning			Difference (%)		
	Zone A	Zone B	Zone C	Zone A	Zone B	Zone C	Zone A	Zone B	Zone C
0	4,53	6,48	5,41	4,00	3,60	2,85	-11,73%	-44,49%	-47,33%
1	4,56	6,49	5,43	4,00	3,60	2,85	-12,24%	-44,61%	-47,52%
2	5,42	8,53	5,42	4,02	3,60	2,85	-25,92%	-57,82%	-47,46%
3	5,39	8,49	5,42	4,45	3,60	2,85	-17,41%	-57,64%	-47,42%
4	5,39	8,49	5,41	4,45	3,60	2,85	-17,50%	-57,62%	-47,38%
5	5,38	8,46	5,41	4,01	3,60	2,85	-25,44%	-57,49%	-47,33%
6	4,54	6,49	5,43	4,36	3,59	2,85	-3,88%	-44,64%	-47,54%

7	5,00	7,68	5,41	4,14	3,59	2,84	-17,14%	-53,26%	-47,42%
8	4,50	6,49	5,40	4,00	3,57	2,84	-11,07%	-44,95%	-47,45%
9	4,52	6,46	5,38	3,99	3,56	2,83	-11,84%	-44,86%	-47,35%
10	4,48	6,41	5,39	3,98	3,56	2,83	-11,21%	-44,46%	-47,48%
11	4,48	6,43	5,38	3,98	3,57	2,83	-11,06%	-44,56%	-47,34%
12	4,47	6,42	5,40	3,98	3,57	2,84	-10,92%	-44,37%	-47,49%
13	4,48	6,44	5,39	3,98	3,57	2,84	-11,09%	-44,58%	-47,38%
14	4,50	6,44	5,38	3,97	3,57	2,84	-11,68%	-44,56%	-47,28%
15	4,48	6,42	5,40	3,98	3,57	2,84	-11,23%	-44,39%	-47,47%
16	4,48	6,44	5,39	3,98	3,57	2,83	-11,13%	-44,66%	-47,38%
17	4,49	6,44	5,37	3,97	3,56	2,83	-11,64%	-44,72%	-47,24%
18	4,49	6,43	5,37	3,98	3,55	2,83	-11,38%	-44,86%	-47,34%
19	4,48	6,43	5,37	3,98	3,55	2,83	-11,27%	-44,80%	-47,39%
20	4,48	6,41	5,38	3,98	3,55	2,83	-11,16%	-44,54%	-47,43%
21	4,49	6,44	5,37	3,97	3,56	2,83	-11,66%	-44,65%	-47,23%
22	4,49	6,43	5,39	3,98	3,57	2,84	-11,28%	-44,41%	-47,37%
23	4,50	6,45	5,40	3,98	3,59	2,84	-11,58%	-44,36%	-47,32%
24	4,50	6,47	5,41	4,00	3,60	2,85	-11,03%	-44,42%	-47,38%

3 Results

The expected results from the pilot action include:

- Accurate estimation of the water volumes abstracted and entered the water supply system of DEYA of Thermi;
- Better estimation of the water balance and the NRW levels;
- Design of the strategies to reduce NRW levels based on accurate data;
- Adequate chlorination for the water supplying the municipal districts of Thermi municipality;
- Safe water for the consumers.

Water efficiency

The results from the pilot action implementation include the exact recordings of the flowmeters in the boreholes (Table 6). Data are gathered on 28/1/2020, 30/6/2020 and 9/2/201. The data from the last registration are taken into consideration to estimate the total water volume entering the network. The time the flowmeters were metering is from 27/11/2019 – 9/2/2020 (440 days average). The total water volume recorded during this time period is 8,212,705m^3. Given that this amount of water is abstracted from 45 out of the 54 boreholes, the total amount abstracted from all the boreholes for the same period of 440 days is estimated to be 9,855,246m^3. That means that in a year time the total water volume abstracted is estimated to be 8,175,375m^3. The water utility estimates that during one year the total water volume abstracted is about 4,100,000m^3. The water volume abstracted is highly underestimated (almost 100%)! Given that the water volume consumed is recorded in the water consumers, the NRW levels are very high!

The total cost for the supply and installation of the flowmeters is 66,150.00€ (no VAT included).

The exact recordings of the water volume will allow the water utility to estimate accurately the NRW level and design strategies and measures to reduce it.

Table 6. Flowmeters' recordings

a/a	Location / Borehole	Name of the location	Water volume abstracted until 28/1/2020 (m^3)	Water volume abstracted until 30/6/2020 (m^3)	Water volume abstracted until 9/2/2021 (m^3)
1	Thermi	Aeroporias	96,077	245,488	688,420
2	Thermi	Firos Sideras	42,715	153,549	268,160
3	Thermi	Kosmidis	36,302	120,550	212,420
4	Thermi	Emporiki	27,115	76,399	202,170
5	Thermi	Ergotaxio	10,503	26,050	81,175
6	Thermi	Thermokipio	44,357	104,618	273,270
7	Thermi	Interbeton	62,123	141,866	381,123
8	Thermi	Lida Maria	32,841	32,888	32,902
9	Thermi	Parsourakou-2	0	0	0
10	Thermi	Patsourakoy-new-3	19,313	59,228	201,621
11	Thermi	Toumpas B	0	0	0
12	Triadi	Triadi	15,068	49,881	155,208
13	Thermi	Hayat	12,990	60,609	235,725
14	Thermi	Eurotech	71,527	154,946	337,422
15	N. Redestos	Kanavou	479	588	604
16	Filothei	Filotheis -1 (Redestos)	88,569	204,357	472,930
17	Filothei	Filotheis -2 (new)	56,174	106,247	284,100
18	Filothei	Filotheis -3 (old)	626	5,537	50,028

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19	N. Redestos	Hempe	4,067	14,518	50,768
20	N. Redestos	Christoforou	20,027	69,821	249,489
21	Tagarades	Tagaradon -1	21,091	110,913	224,675
22	Tagarades	Tagaradon-3 (Livadi) new	68,251	118,745	142,070
23	N. Risio	Zampetoglou	0	0	0
24	N. Risio	N. Risiou - C3	24,806	68,839	191,750
25	N. Risio	N. Risioy – C4	40,929	106,682	294,600
26	Vasilika	Ai Gianni (BA3)	19,698	116,948	196,370
27	Lakkia	North Oikismo LA1	20,935	42,855	97,633
28	Lakkia	Inverter 1	0	0	39,356
29	Lakkia	East Oikismos LA2	0	1,544	19,345
30	Ag. Paraskevi	Anthemounta P. (ACP1)	58,786	147,245	444,500
31	Souroti	Koukos (S1)	2,501	3,094	162,078
32	Livadi	Entos Oikismou(L1)	0	0	0
33	Livadi	Ektos Oikismou (L2)	6,003	17,651	1,316
34	Kardia	Christodoulidis	44,996	130,682	389,000
35	Kardia	Kloni	27,732	86,712	236,934
36	Kardia	Kakarimou	925	19,203	82,903
37	Epanomi	Apostolou	0	0	0
38	Plagiari	Rema	0	0	0
39	Plagiari	A1.3-Osia Xeni (Garou)	35,614	53,488	132,394
40	Plagiari	A2.1	0	0	0
41	Plagiari	A2.2	3,997	70,188	275,177
42	Plagiari	New A2	25,914	61,811	100,900
43	Plagiari	A1.2-Trigonou	0	0	46,341
44	Plagiari	A1.1	28,218	55,515	159,956
45	Ag. Paraskevi	S1(Ag. Paraskevi)	157,176	411,569	797,872

Water quality

The results from the installation of the automated chlorination systems are:

- More efficient chlorination since the automated system allows for the correct dose after measuring the level of the free chlorine in water;
- Better water quality.

The total cost for the supply and installation of the six automated chlorination systems is 28,140.00€.

Hydraulic simulation model

The development of the hydraulic simulation model provided to the water utility a useful tool for decision-making. The network is imprinted providing information of the water flows and pressures. As the water distribution network is not divided in zones, three pressure zones are developed virtually using the model. To divide the distribution network, isolation valves are closed and new ones are installed (virtually). Based on the data and using the hydraulic simulation model, PRVs are installed at the entrance of each zone (virtually). The PRVs are used to regulate water pressure. The results showed that average pressure is reduced from 4 to 58% depending on the time of the day. The highest pressure reduction is met in the morning hours (2-5 am) as it is well-known that as consumption is low at this time, pressure gets its higher values. This results in high leakage rates. Such an application of PRVs results in the reduction of water volume entering the network by 3.44% or 37,970 m^3 per year.

4 Problems encountered and applied solutions

There were not specific problems met during the implementation of the pilot action. The tendering process took some time to conclude due to bureaucratic conditions in public procurement.

5 Lessons learnt

Water efficiency

The pilot action implementation revealed that the estimation of water volume abstracted from the boreholes was highly underestimated. This fact made the water utility operators to underestimate the NRW level and they could not be able to design the correct NRW reduction strategies. The water utility will implement this measure to the 9 remaining boreholes.

It is very important to know the water volume entering the network and the water consumed in order to correctly and reliably estimate the NRW level. In general, the correct measurements of water volumes consumed or lost will provide the water operators data in order to design the correct strategies for the confrontation of NRW. The water utility proposes the implementation of similar activities to all water utilities at regional and national level.

The development of the hydraulic model of the water distribution network is a useful tool for water operators as it can be used for the development of scenarios, the segmentation of the network in DMAs for more efficient management, etc.

Water quality

The supply and installation of automated chlorination systems provided to the water utility a more efficient chlorination in the water tanks, providing safe water to the consumers. Chlorination is used for the disinfection of water and the controlling of bacteria and viruses in drinking water. However, the amount of free chlorine should not exceed the limits set by the legislation. Automated chlorination systems allow for efficient chlorination and the control of the free chlorine concentration.

The water utility proposes this measure to other water utilities at regional and national level. The water utility will implement this measure to the remaining water tanks.

6 Comments

No comments.

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

WATER RESCUE

Water resources efficiency and conservative use in drinking water supply systems

Interreg
Greece-Bulgaria
WATER RESCUE
European Regional Development Fund

EUROPEAN UNION

WP	**5 Pilot Actions**
Deliverable *Tool*	**5.3.2 Pilot Actions Implementation** *Questionnaire*
Project Beneficiary No	**PB3**
Beneficiary Institution	**University of Thessaly-Special Account Funds for Research-Department of Civil Engineering**

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

The contents of this report are sole responsibility of the University of Thessaly-Special Account Funds for Research-Department of Civil Engineering and can in no way be taken to reflect the views of the European Union, the participating countries the Managing Authority and the Joint Secretariat.

Name of the organization/institution: University of Thessaly-Special Account Funds for Research-Department of Civil Engineering

Beneficiary number: PB3

1 Introduction

The University of Thessaly – Civil Engineering department developed the hydraulic simulation model for the water distribution system of Thermi and provided guidelines for the update of the hydraulic model of the water distribution system of Komotini, as part of its pilot activities under the context of WATER RESCUE project.

2 Pilot Action

2.1 Hydraulic simulation model of the water distribution network of Thermi

The study area is the area of Thermi municipal district. It belongs to the Region of Central Macedonia, the Regional Unit of Thessaloniki and the Municipality of Thermi (Figure 1). It should be noted that part of the water supply network extends to the Municipality of Pylaia-Hortiatis and in particular to the Municipal Unit of Panorama.

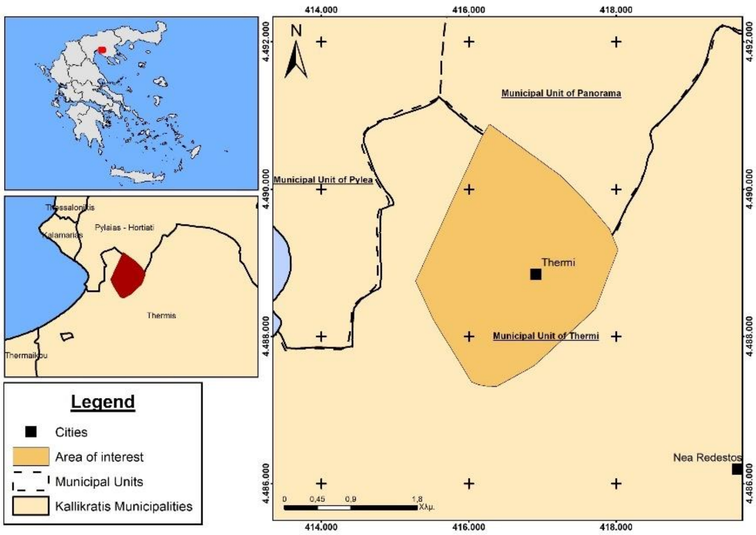

Figure 1. Study area

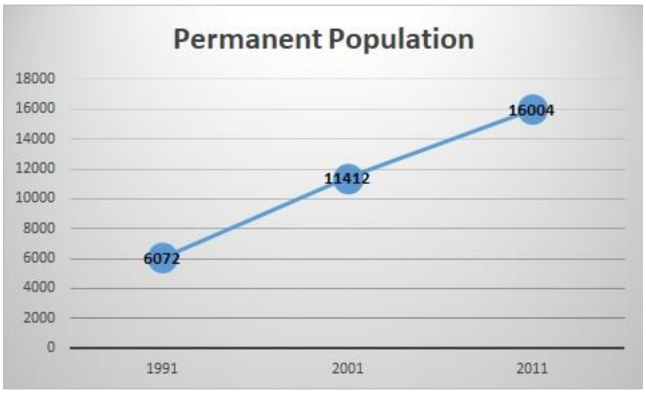

Figure 2. Population in the municipal district of Thermi (1991, 2001 and 2011)

There are 16,004 permanent residents in the area, while according to the censuses of the last three decades there is an increase in the population of the area (Figure 2).

The area, based on the average altitude, is characterized as lowland, but the geomorphology is amphitheatrical at the foothills of Chortiatis. The prevailing climate is the classic Mediterranean climate (Csa), according to the Koppen-Geiger climate classification. The average monthly maximum and minimum temperatures are 33 & -2˚C respectively, while the average annual average is 14 ˚C, with heavy rainfall during the winter and summer months, while winds are mild during the year.

The software used to develop the hydraulic simulation model is WaterGems. The water utility of Thermi provided the necessary data and specifically pdf files with the geoprofile of the external and internal aqueduct (Figure 3), consumption data per water meter of 2018, and data about the tanks and the boreholes. Water from eleven boreholes is directed to five tanks (one of them is inactive), through three pumping stations and them it is distributed to the consumers through the internal water distribution network.

Figure 3. Geoprofile of the internal aqueduct

The internal network is mainly looped in shape and is gravitational, while the external aqueduct operates gravitationally and in parallel with pumping stations. There are eleven sources of water entering the network. Water from four boreholes goes to the Aeroporia tank from where the water is transferred to two pumping stations. Water from one of the pumping stations with water from another borehole goes to the Litsa Tank 2, and from there to Litsa tank 1. Then water is transported to the distribution network by gravity. Water from the other pumping stations along with water from three other boreholes is transferred to the new tank of Thermi. Water enters the distribution network by gravity. The water network is showed in Figure 4a. The water distribution network consists of 920 pipes, 748 junctions and 185 valves.

The consumption pattern is established for the model using data from the water utility. The consumption is equally distributed using Thiesen polygons at the network’s nodes. However, it is noted that there are many types of users such as domestic, agricultural, industrial and the use from the airport of Thessaloniki. Figure 4b shows the average daily nodes’ demand.

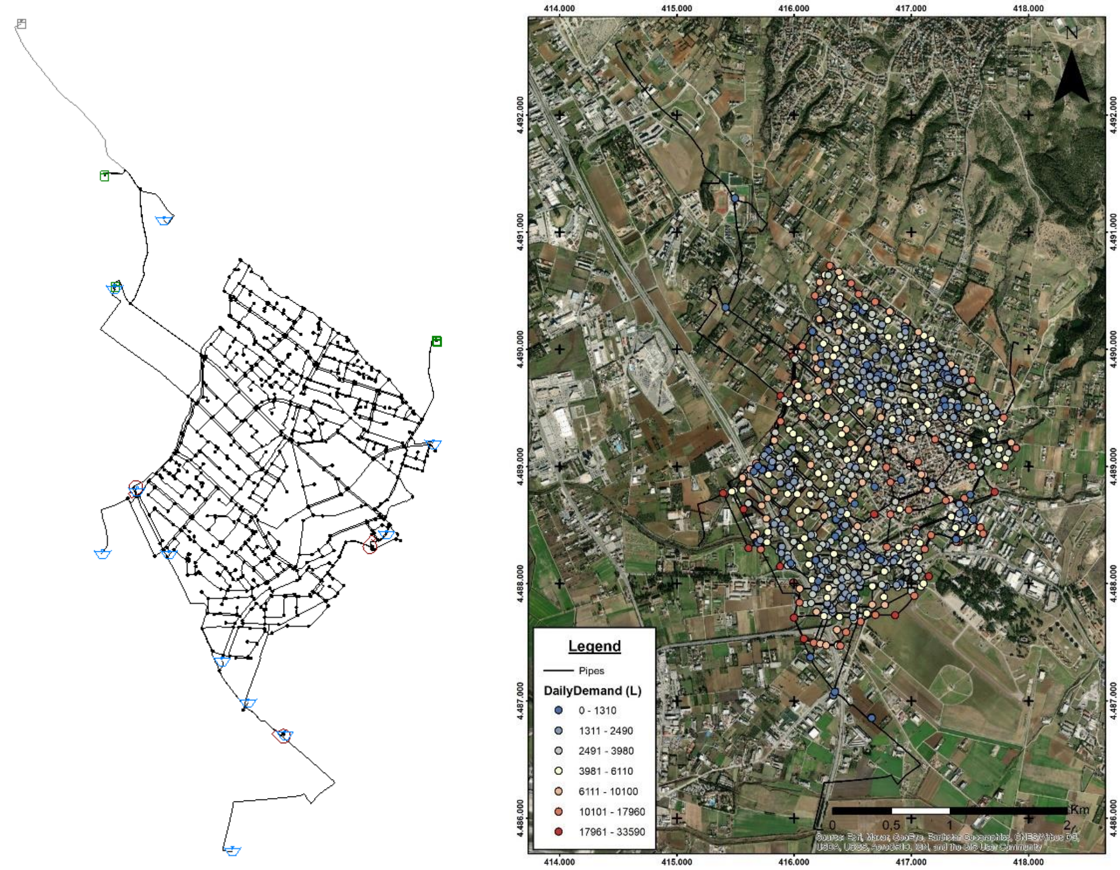

Figure 4. (a) The water distribution network of Thermi; (b) the average daily nodes' consumption

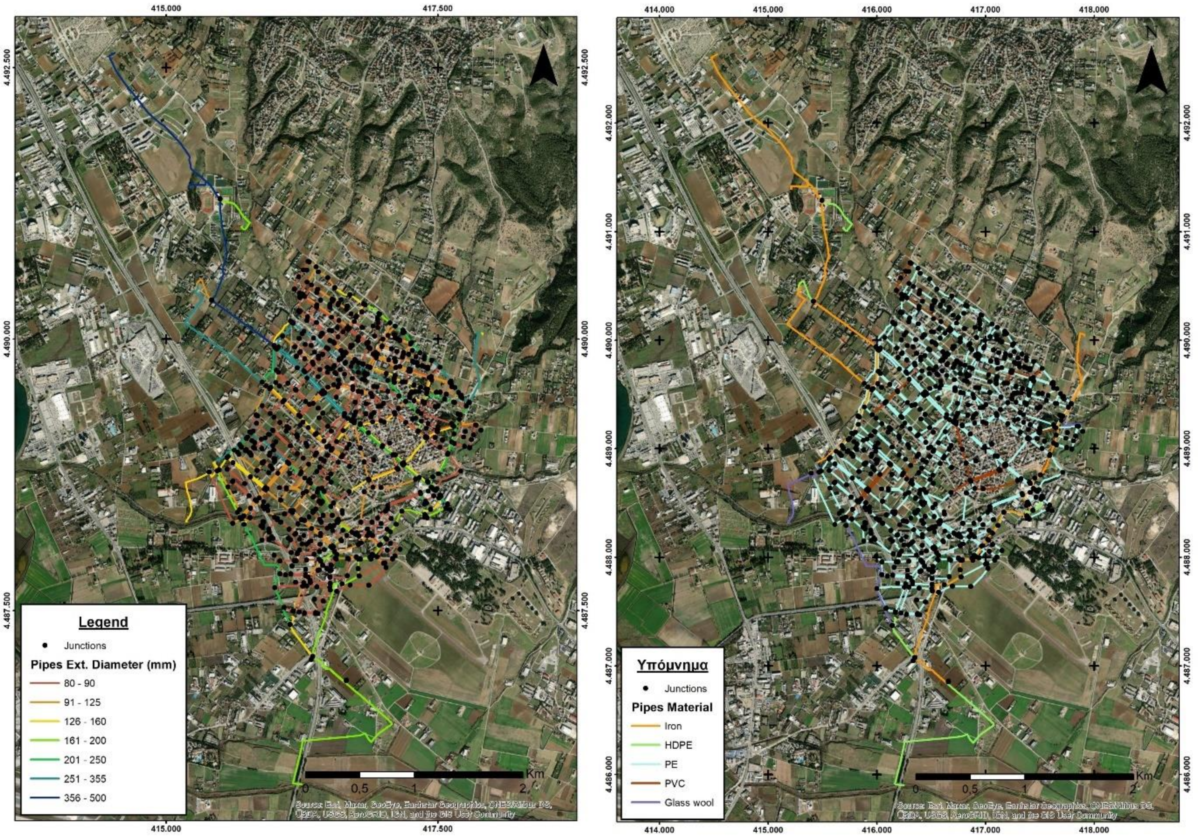

Figure 5. (a) External pipes' diameter; (b) pipes' material

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Figure 5a shows the external pipes' diameter and figure 5b shows the pipes' material. Pipes' material is ductile iron (15.5% of the total length), HDPE (4.7%), PVC (5.5%), PE (71.7%) and fiber glass (2.6%). The pipes' diameter ranges from 80 to 500mm.

The hydraulic model of the network is developed. The results (Figure 6a) show that the smaller / local pipes show the lowest flow rates, while the main water distribution pipes show the highest average daily flow. Given that pressure is not regulated through pressure reduction valves, the results showed that the nodes at the highest altitudes of the network have low pressure, while as altitude decreases pressure increases to quite high pressures (Figure 6b). Maximum pressures go up to 9 atm.

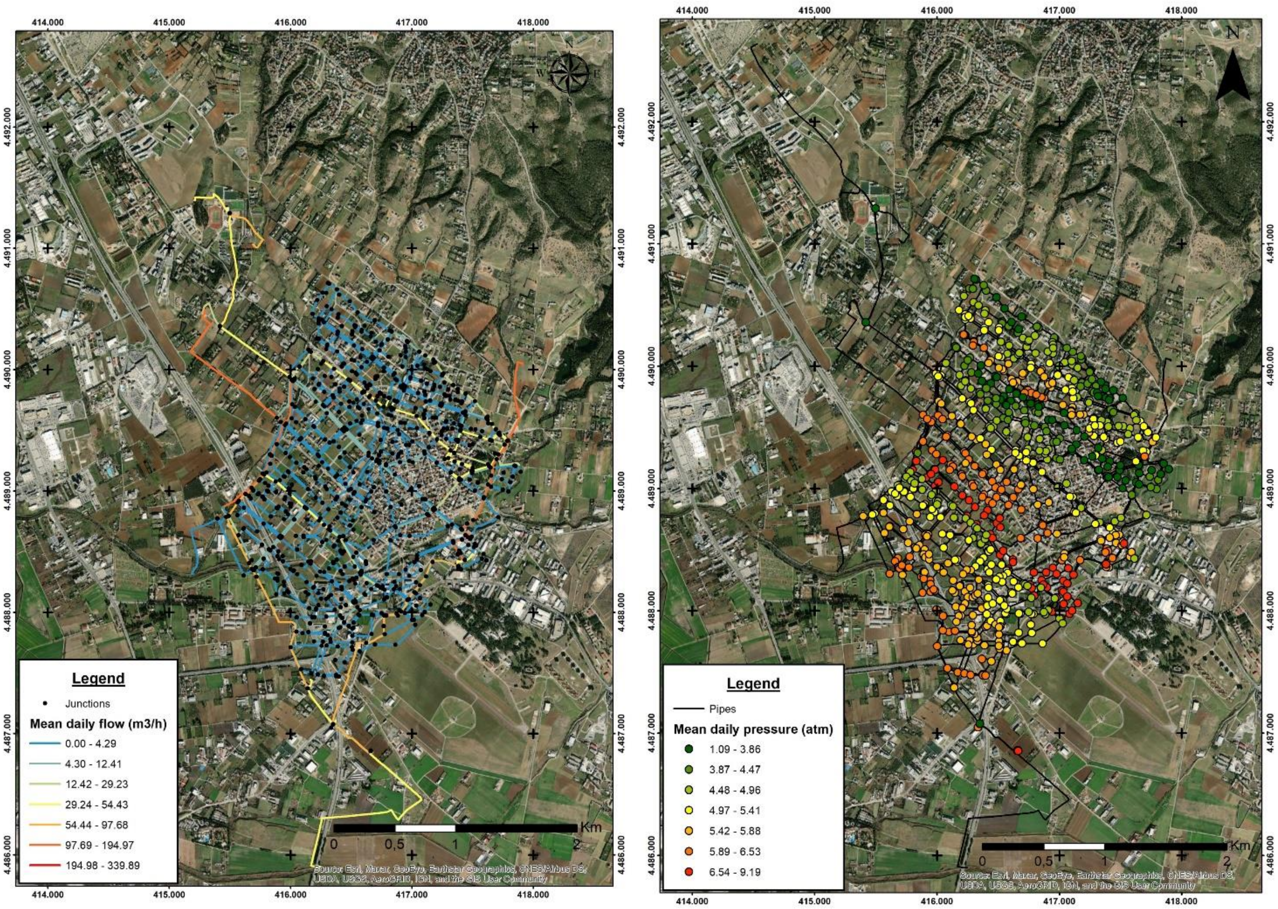


Figure 6. (a) Daily average water flow; (b) daily average water pressure

The next step was to develop (virtually) three pressure zones using the hydraulic model and using combinations of altitude and pressure (Figure 7). For the creation of the three zones some of the isolation valves are closed and some others are added (Table 1). To regulate the pressure, three pressure reduction valves are installed at the entrance of each zone in order to achieve minimum pressure of 2 atm in every node. The critical nodes are identified: (a) zone A, higher altitude node J-327 and lower altitude node J-33; (b) zone B, higher altitude J-417 and lower altitude node J-196; and (c) zone C, higher altitude node J-749 and lower altitude node J-587 (figure 8).

Table 1. Old and new isolation valves and pressure reduction valves

Isolation valves			
Name	Diameter (mm)	Altitude (m)	Pipe id
Existing			
ISO-107	160	64,34	P-198

ISO-113	400	61,25	P-202
New ones			
ISO-186	315	60,60	P-294
ISO-187	225	66,35	P-317
ISO-188	160	66,50	P-472
ISO-189	225	57,67	P-347
ISO-190	225	66,50	P-345
Pressure reduction valves			
Name	Diameter (mm)	Altitude (m)	Pressure set (atm)
PRV-1	300	86,28	4,15
PRV-2	350	42,04	2,10
PRV-3	160	61,75	2,50

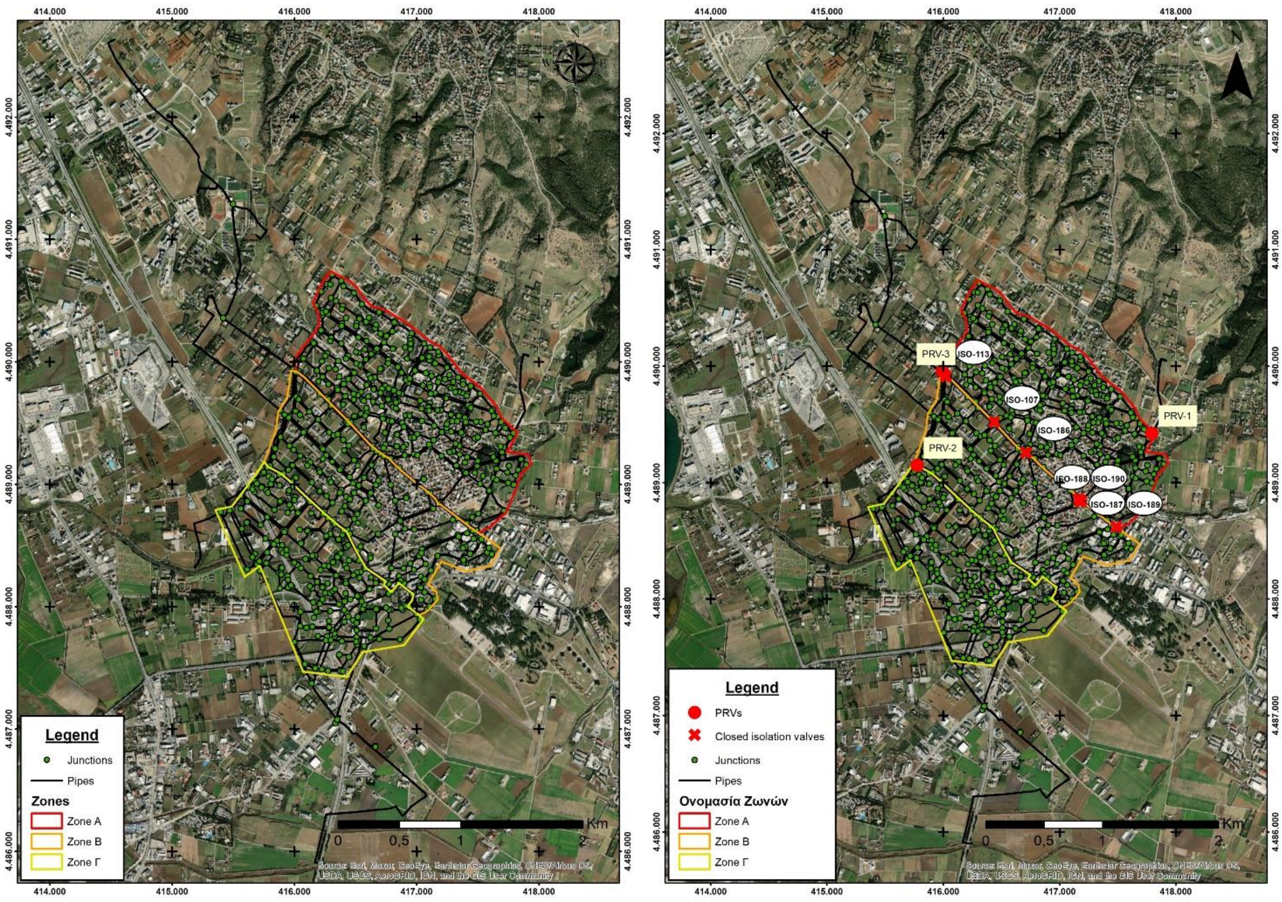


Figure 7. (a) Three pressure zones suggested; (b) PRVs and isolation valves

It is noted that there is a reduction in pressure in all zones, with the maximum reduction up to 58% while the minimum reduction is 4% (Table 2). In addition, there is a stabilization of pressure during zoning, where the average pressure per zone remains constant regardless of time, in contrast to the time before the zones' creation where a strong fluctuation in pressure is noted. The model showed that if zoning takes place the water volume entering the network is reduced by 3.44%.

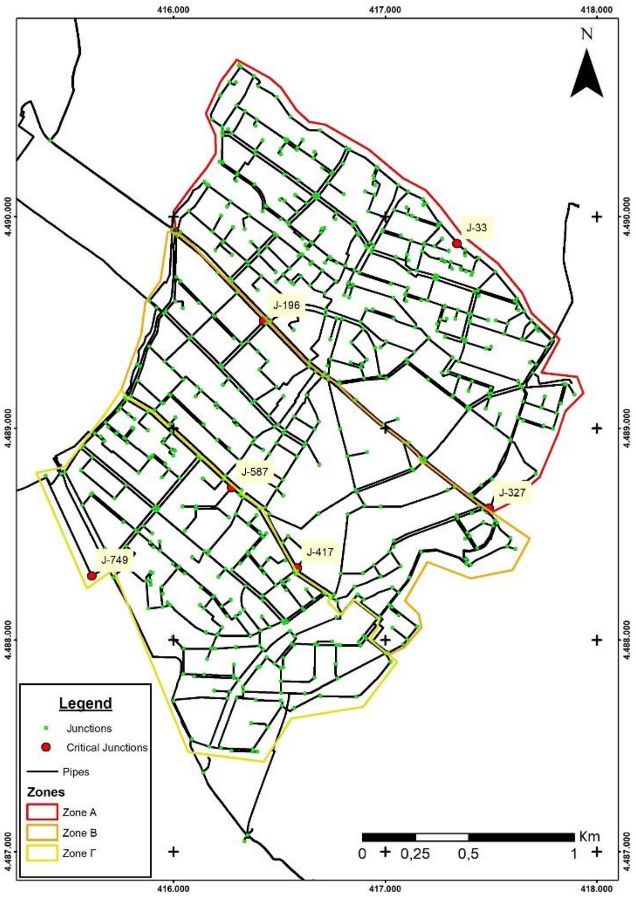


Figure 8. The critical junctions

Table 2. Average pressure before and after the creation of the zones and the difference in percentage

Time (hours)	Before zoning			During zoning			Difference (%)		
	Zone A	Zone B	Zone C	Zone A	Zone B	Zone C	Zone A	Zone B	Zone C
0	4,53	6,48	5,41	4,00	3,60	2,85	-11,73%	-44,49%	-47,33%
1	4,56	6,49	5,43	4,00	3,60	2,85	-12,24%	-44,61%	-47,52%
2	5,42	8,53	5,42	4,02	3,60	2,85	-25,92%	-57,82%	-47,46%
3	5,39	8,49	5,42	4,45	3,60	2,85	-17,41%	-57,64%	-47,42%
4	5,39	8,49	5,41	4,45	3,60	2,85	-17,50%	-57,62%	-47,38%
5	5,38	8,46	5,41	4,01	3,60	2,85	-25,44%	-57,49%	-47,33%
6	4,54	6,49	5,43	4,36	3,59	2,85	-3,88%	-44,64%	-47,54%
7	5,00	7,68	5,41	4,14	3,59	2,84	-17,14%	-53,26%	-47,42%
8	4,50	6,49	5,40	4,00	3,57	2,84	-11,07%	-44,95%	-47,45%
9	4,52	6,46	5,38	3,99	3,56	2,83	-11,84%	-44,86%	-47,35%
10	4,48	6,41	5,39	3,98	3,56	2,83	-11,21%	-44,46%	-47,48%
11	4,48	6,43	5,38	3,98	3,57	2,83	-11,06%	-44,56%	-47,34%
12	4,47	6,42	5,40	3,98	3,57	2,84	-10,92%	-44,37%	-47,49%
13	4,48	6,44	5,39	3,98	3,57	2,84	-11,09%	-44,58%	-47,38%
14	4,50	6,44	5,38	3,97	3,57	2,84	-11,68%	-44,56%	-47,28%
15	4,48	6,42	5,40	3,98	3,57	2,84	-11,23%	-44,39%	-47,47%
16	4,48	6,44	5,39	3,98	3,57	2,83	-11,13%	-44,66%	-47,38%
17	4,49	6,44	5,37	3,97	3,56	2,83	-11,64%	-44,72%	-47,24%

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

18	4,49	6,43	5,37	3,98	3,55	2,83	-11,38%	-44,86%	-47,34%
19	4,48	6,43	5,37	3,98	3,55	2,83	-11,27%	-44,80%	-47,39%
20	4,48	6,41	5,38	3,98	3,55	2,83	-11,16%	-44,54%	-47,43%
21	4,49	6,44	5,37	3,97	3,56	2,83	-11,66%	-44,65%	-47,23%
22	4,49	6,43	5,39	3,98	3,57	2,84	-11,28%	-44,41%	-47,37%
23	4,50	6,45	5,40	3,98	3,59	2,84	-11,58%	-44,36%	-47,32%
24	4,50	6,47	5,41	4,00	3,60	2,85	-11,03%	-44,42%	-47,38%

2.2 Update of the hydraulic model of the water distribution network of Komotini

PB3, University of Thessaly Civil Engineering department reviewed the hydraulic model of the water distribution network of Komotini. To develop the hydraulic model of a water supply and distribution network the following data are needed: the exact topology of the tanks, reservoirs, junctions, and pipes. Specifically, the elevation of the junctions and tanks, the area of the tanks and their diameter, each pipe's length, the pipe's material and diameter and the roughness coefficient. Then the water demand must be allocated to each node. Also, the pattern of the daily water demand should be determined.

The following data are available for the water supply system of the municipality of Komotini. The whole municipality has a water supply network of about 300 Km. The average annual water consumption is 5,200,000 m^3 and the water meters are 42,190. The water distribution network of Komotini city is radial with many dead-ends. Water is supplied through two systems: the main aqueduct including the boreholes of Komotini and the east and south system including the water abstraction of Simvola. There are six tanks supplying Komotini city with water: four cylindrical tanks of 960 m^3 each, one rectangular tank of 1,000 m^3 and one rectactugal tank of 2,000m^3. Chlorination takes place in all tanks. Water is supplied with gravity. The six tanks are used for water supply of several settlements. There are 25,240 water meters and water consumption per water meter of 272 L/day. The water demand is allocated equally to the network's nodes, which is a simplified assumption.

The exact data needed for the hydraulic model are:

- Water demand per node
- Diameter for each pipe
- Length for each pipe
- Roughness coefficient for each pipe
- Total head for each reservoir
- Elevation for each tank
- Diameter for each tank
- Initial level of water for each tank
- The minimum level of water for each tank to be operational
- The maximum level for each tank.

In case of pumps, the pump curves are needed. For the valves, their diameter and the setting of each valve are needed.

The pipes for the water distribution network of Komotini have a total length of 212,600m and they are made of PVC, PE, cast iron and asbestos cement. The pipes' diameters rang from 63 to 400mm. The roughness coefficients for each pipe were based on the pipe's material. For asbestos cement and cast iron the roughness coefficient (Hazen Williams coefficient) is 110 and for PVC pipes is 130, as defined in the data provided by the software.

The water demand pattern was developed, taking into consideration the water losses. The daily water demand pattern was developed taking data from the water utility (Figure 10).

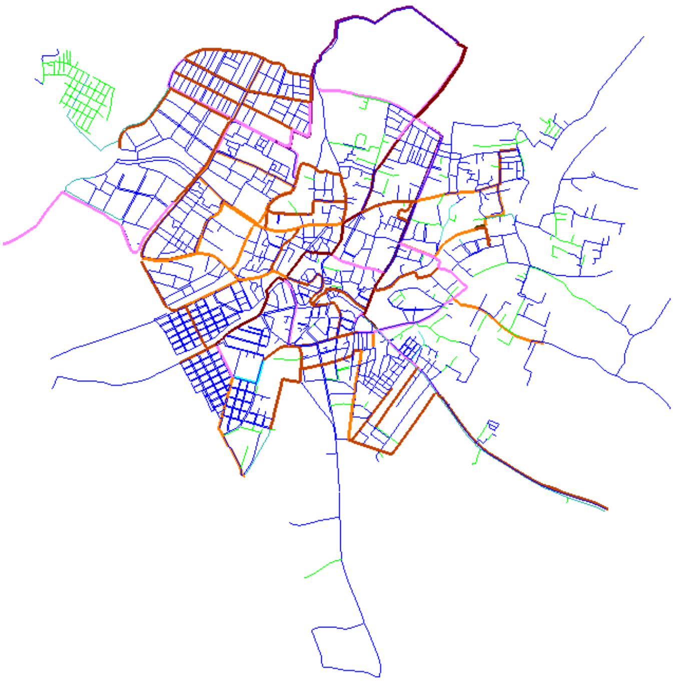


Figure 9. The water distribution network of Komotini city (based on the data provided by the water utility)

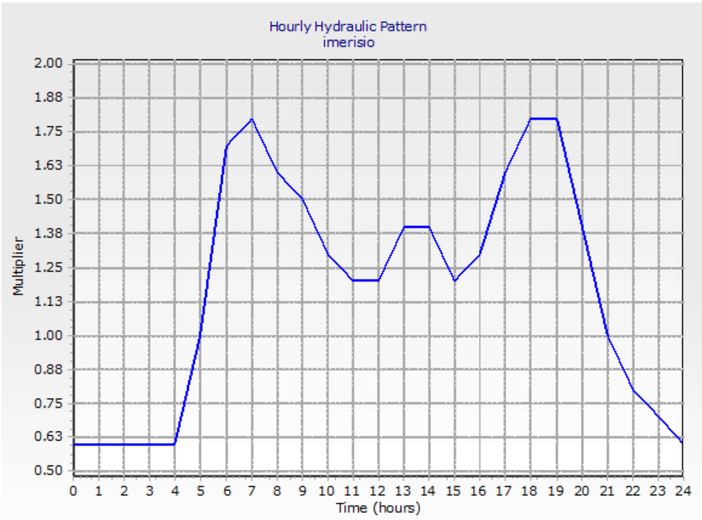


Figure 10. Daily water demand pattern for domestic use

3 Results

3.1 Hydraulic simulation model of the water distribution network of Thermi

The development of the hydraulic simulation model provided to the water utility a useful tool for decision-making. The network is imprinted providing information of the water flows and pressures. As the water distribution network is not divided in zones, three pressure zones are developed virtually using the model. To divide the distribution network, isolation valves are closed and new ones are installed (virtually). Based on the data and using the hydraulic simulation model, PRVs are installed at the entrance of each zone (virtually). The PRVs are used to regulate water pressure. The results showed that average pressure is reduced from 4 to 58% depending on the time of the day. The highest pressure reduction is met in the morning hours (2-5 am) as it is well-known that as consumption is low at this time, pressure gets its higher values. This results in high leakage rates. Such an application of PRVs results in the reduction of water volume entering the network by 3.44% or 37,970 m^3 per year.

3.2 Update of the hydraulic model of the water distribution network of Komotini

The University of Thessaly, Civil Engineering department evaluated the hydraulic simulation model of Komotini city. The following suggestions are identified:

- Although the hydraulic simulation model is developed, it has not been calibrated. In order to calibrate the model, data from the field are necessary. Data such as water flow and water pressure at specific junctions are needed for calibration. These data can be gathered from the SCADA stations.
- The allocation of water demand to the nodes is based on the simplified approach of equal allocation of water consumption. However, in order to have a model that simulates the actual operation of the water distribution network, the water demand must be allocated either by using Thiessen polygons or using the SAWDSL method at street level (Kanakoudis & Gonelas, 2015). Using SAWDSL method water demand is allocated based on the exact location of the water meter and taking into consideration its distance from the respective node.
- Non-Revenue water values should be estimated, and real and apparent losses should be allocated. Apparent losses can be added to the nodes' demand proportionally since their time distribution is similar to the domestic one. Real losses time distribution is similar to the distribution of pressure. Therefore, the allocation of real losses can be added as a separate water demand to each node with its own daily pattern, which is inversely proportional to pressure.
- The network data should be updated to include any possible changes.
- There is no distinction of the water demand to pressure dependent and volume dependent demand.
- All water meters need to be geocoded.
- In general, SCADA system data must be gathered and used in the hydraulic simulation model, such as pressure at the nodes, pipes' flow, water level at the tanks, etc.

4 Problems encountered and applied solutions

The main problem met is the difficulty to get reliable data. In general water utilities do not keep data for their water supply systems, as for example exact locations of water meters (with coordinates), digital maps of the water distribution network with all the data for the pipes (e.g. diameter, material, age) and number of customer connections. Water volumes entering the network are also not registered in a reliable way.

5 Lessons learnt

The hydraulic simulation model can assist water utilities manage their water distribution network effectively. It can provide solutions by running several scenarios. It can also be used in case of an extreme event, such as pipes' breaks in order to manage water supply so that the consumers will consume safe water. Finally, the hydraulic simulation model can be used to divide the network into district metered areas (DMAs) for an effective and efficient management. Hydraulic simulation models can be used as the basis for the development of models simulating water quality (e.g. total solids, chlorine residual, etc.).

References

Kanakoudis, V.; Gonelas, K. (2015). Properly allocating the urban waters meters' readings to the nodes of a water pipe network simulation model in a developing water utility. *Desalination and Water Treatment*, *54(8),* 2190-2203.

WATER RESCUE

Water resources efficiency and conservative use in drinking water supply systems

WP	**5 Pilot Actions**
Deliverable *Tool*	**5.4.2 Pilot Actions Implementation** *Questionnaire*
Project Beneficiary No	**PB4**
Beneficiary Institution	**Municipality of Kardzhali**

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

The contents of this report are sole responsibility of the Municipality of Kardzhali and can in no way be taken to reflect the views of the European Union, the participating countries the Managing Authority and the Joint Secretariat.

Name of the organization/institution: Municipality of Kardzhali
Beneficiary number: PB2

1 Introduction

Please describe your pilot areas

1. Въведение

Моля, опишете вашите пилотни зони

Pilot area (2018 base year)

- Total population served = 55019
- Total area covered (Km^2) =
- Total pipes' length (Km) =
- Mean altitude (m) =
- Mean operating pressure (atm) = 4-5 atm.
- Age of pipes (per material, diameter) =
- No. of service connections =19854

- **- Видове тръби (материал, диаметри, дължини) pes of pipes (material, diameters, lengths)**

MUNICIPALITY ОБЩИНА	length of the water supply network			
	in the settlements		out of populated areas	
	Ф ≤300 мм	Ф > 300 мм	Ф ≤ 300 мм	с Ф > 300 мм
	км	км	км	км
MUNICIPALITY KARDZHALI ОБЩИНА КЪРДЖАЛИ	171171	7608	143539	33380
Incl.				
Ethericity Азбестоцимент	97668	7608	122202	33380
Steel стомана	11975		12811	
PEPP and PVC	61528		8526	

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

2 Pilot Action

Пилотни действия

With respect to the monitoring and requirements for drinking water quality, it is necessary that the laboratory equipment used by the operator operating the water supply system be able to carry out as many analyzes as required by the relevant regulations (Ordinance 9 on drinking water quality) and be accurate as a research method. Current laboratory equipment limits the number of indicators tested and requires much of the research to be outsourced, which involves a long time for sample analysis and high costs.

3 Results

The flowmeters included in the project will help to locate sections of the water supply system where there is a suspected loss or theft of water, and after their installation very accurately and quickly it will be possible to identify possible accidents in those sections.

The laboratory equipment provided in the project will enable the investigation of a large number of indicators required by the relevant drinking water quality regulations, will enable the rapid and timely analysis of the samples, as well as the measurement with high accuracy and correctness.

Delivery and installation of four electromagnetic flow meters

Contractor SONICS Ltd

Four ultrasonic flowmeters were installed under the project - 3. in the town of Kardzhali and 1 pc. on the border of Kardzhali municipality and Momchilgrad municipality.

The places are as follows:

1. On Bulgaria Blvd. at the roundabout at the exit of the city to bl. Coca-Cola - measures the water quantities at the entrance to the Baikal district. It is mounted on an F 600 pipe.

2. At the crossroads of Struma Street and Osmi Oktomvri Street - measures water quantities for the central part of the city.

It is mounted on an F 400 pipe.

3. To PS PETLINO after a pressure tank of 5000 m3 - measures water quantities for Gledka and Gorna Gledka districts.

It is mounted on an F 300 pipe.

4. On the border of the municipality of Kardzhali and the municipality of Momchilgrad to the village of Pepelishte - measures water quantities for the municipality of Momchilgrad by the “Dam. Borovitsa ”

It is mounted on an F 500 pipe.

Ultrasonic flow meters are of the frequency pulse type in which the speed of movement of the fluid / water / is determined by measuring the time for the passage of ultrasonic pulses against and in the direction of movement of the fluid. The ultrasonic flow meters installed under the project measure the passed water quantities every minute. The data reported by the device are in l / sec for instantaneous consumption, accumulated volume for the hour, for the day, for the month and for the year.

All appliances are software installed on a computer of a dispatcher who monitors the readings of flow meters 24 hours a day, 7 days a week. The same software through remote access to the computer of the dispatcher can be monitored by an unlimited number of employees / manager, ch. engineer, DWTP technologist, technical managers, etc./ for timely action in case of events.

Data and graphs for the past period / hour, day, week and month / can be extracted from the software. Comparing them with the collected water in the area of operation of the flow meter, analyzes are made for the condition and losses of the network. The dispatcher, who is on duty on a shift, monitors the readings and in case of deviation from the normal ones signals the emergency teams for possible accidents and leaks in the network.

The system allows to display data and graphs from which the minimum night consumption of the system can be determined at the lowest consumption by users, the amount of water loss from hidden leaks. After locating the area by stopping cranes from end to nearby streets and monitoring the cost, the street with the problem area is located. To more accurately determine the hidden leak, our company has portable terrestrial noise microphones, point correlators and point noise bearings. In addition to these devices under the project, the company has installed 9 more. ultrasonic flow meters for measuring water quantities and two level meters, which are included in the same software. Attached we present screenshots with data and graphs from the readings of the devices installed under the project.

Map with the location of the devices

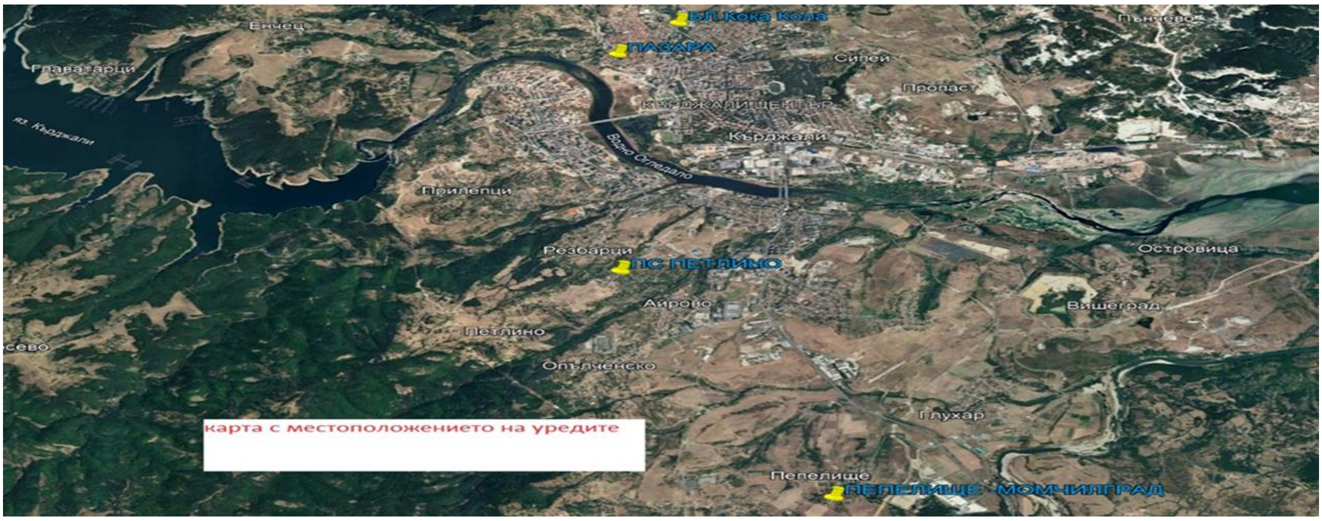
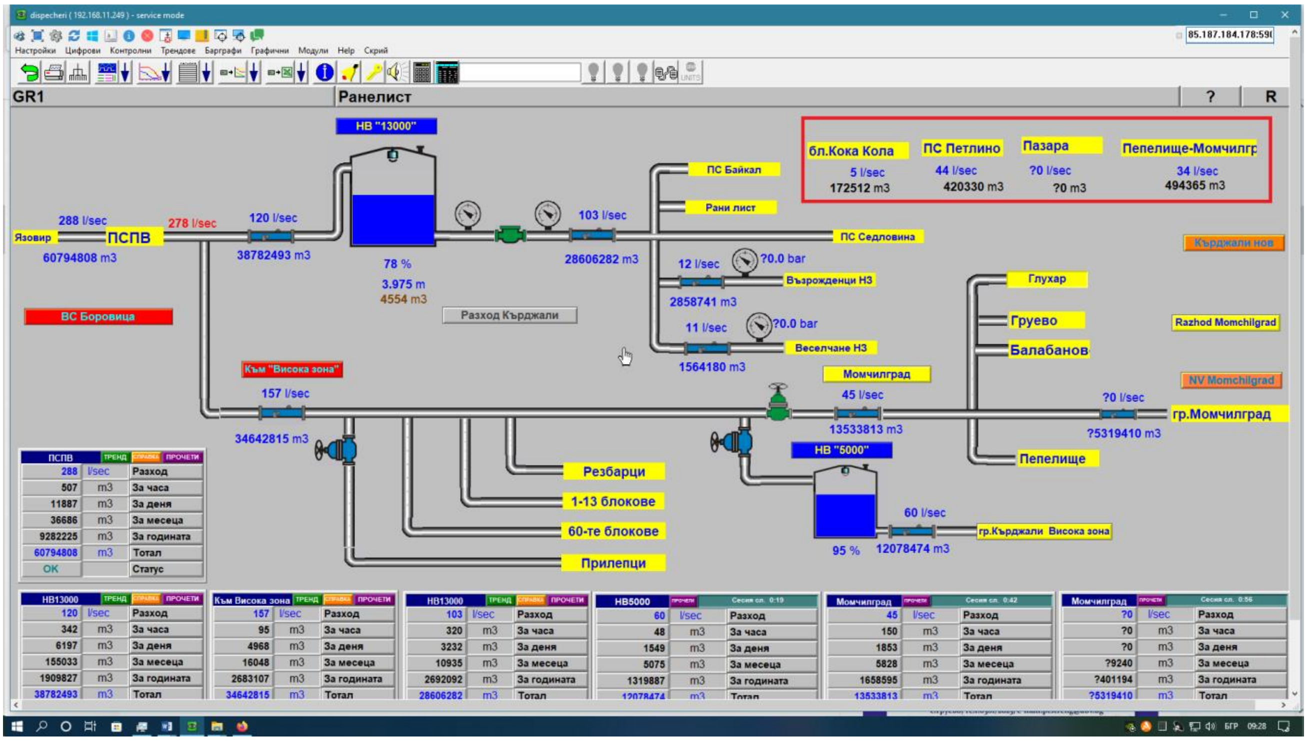
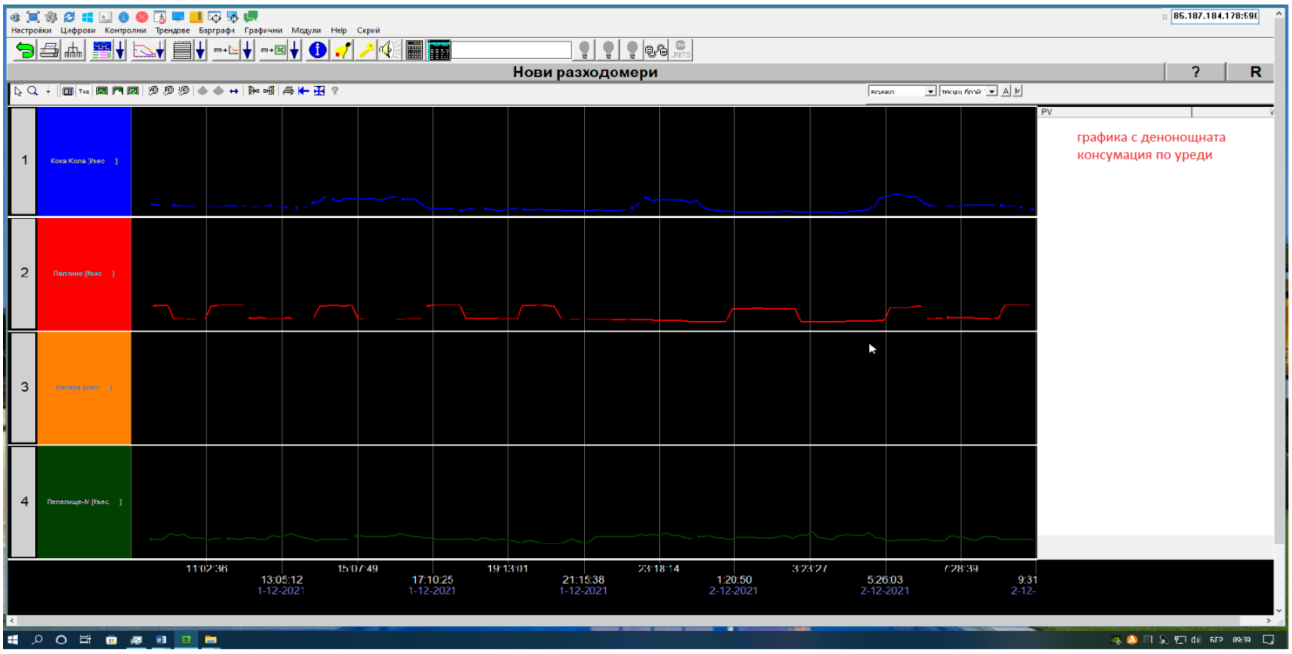


figure 1 screenshot of flowmeters



schedule with round-the-clock consumption by appliances



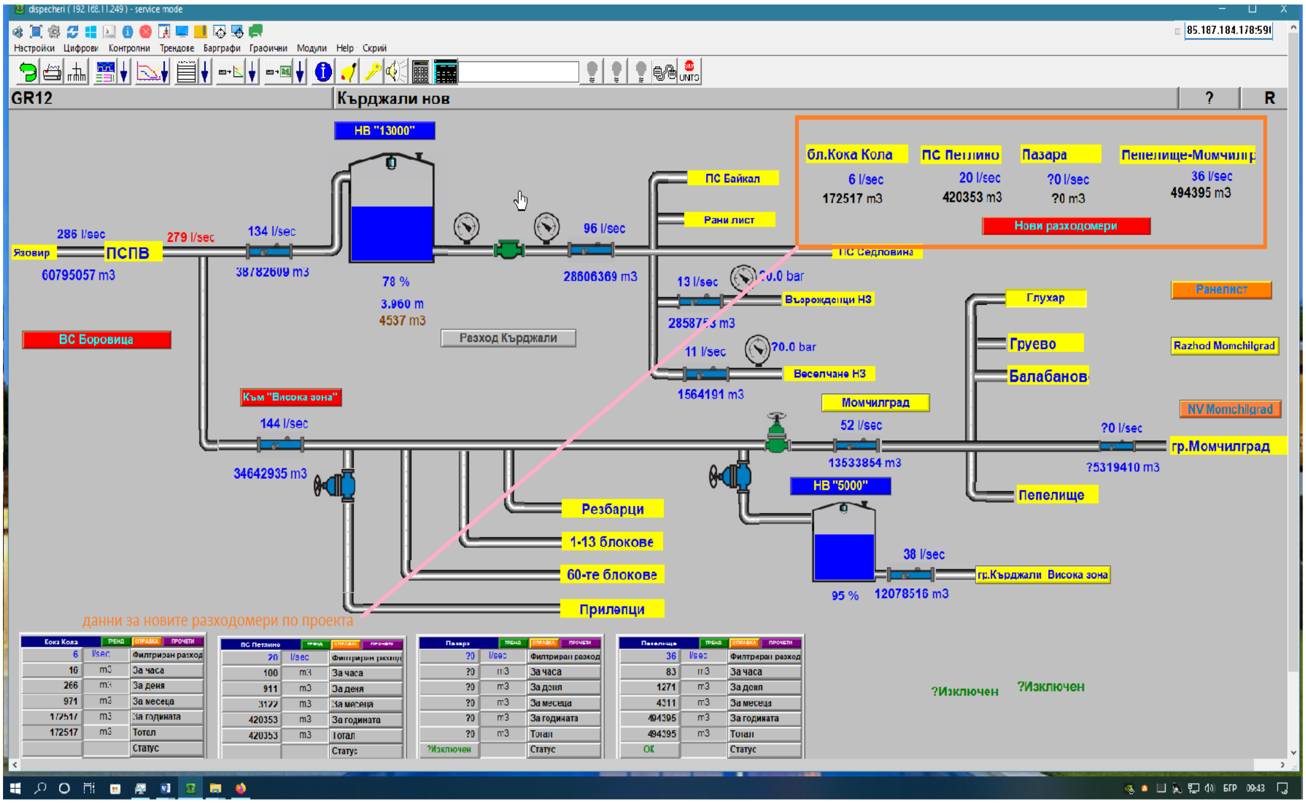


figure 2 data from the new flow meters

From the presented data the following volume of water has passed through the flow meters:1087265 m3.

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".


Delivery and installation of mass spectrometer with inductively connected plasma Plasma ICP - MS.

Contractor "ASM2" Ltd

Upcoming activities are:

1. Construction of ventilation.

2. Installation.

3. Testing the suitability of the system.

4. Commissioning.

5. Training and assistance in the development of the first analytical method for elemental analysis.

On December 22, 2021, the mass spectrometer was installed, configured, tested and ready for operation. During the functional tests of the system, the following standard procedures were performed to check the qualification of the installation, operational readiness and verification of the equipment for operation.

the equipment has no obvious transport defects **yes**

The supply voltage of the system corresponds to the Bulgarian standards **yes**

The configuration of the system corresponds to that ordered by the customer yes

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

When the system is turned on, the displays light up and the keys function normally yes

When each of the modules of the system is switched on, it successfully passes its initial testing and initialization procedure yes

The software product is configured to work with the specific system yes

There is normal two-way communication between the system and the control software, the status of the device is available in real time on the computer screen yes

Each of the modules of the device reaches its set parameters and goes into the status "ready for analysis" yes

All operating parameters of the system / hardware and software / fully comply with the technical specifications of the manufacturer yes

The start signal works normally and the system modules are in full sync yes

The software automatically processes information and generates a correct result yes

In analysis and standard sample, the results meet the requirements yes

The manufacturer's standard operating procedure for checking the qualification of the installation, operational readiness and verification of the equipment for operation has been completed successfully yes

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4 Problems encountered and applied solutions

No problems encountered so far.

5 Lessons learnt

Effective management of the entire drinking water supply cycle, both in terms of quality and quantity, by reducing water losses and improving water quality.

6 Comments

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WATER RESCUE

Water resources efficiency and conservative use in drinking water supply systems

WP	**5 Pilot Actions**
Deliverable *Tool*	**5.5.2 Pilot Actions Implementation** *Questionnaire*
Project Beneficiary No	**PB5**
Beneficiary Institution	**Municipality of Gotse Delchev**

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Name of the organization/institution: Municipality of Gotse Delchev
Beneficiary number: PB5

1 Introduction

Please describe your pilot areas

Pilot area (2018 base year)

- Total population served = 1 650
- Total area covered (Km^2) = 0,20
- Total pipes' length (Km) = 1,140
- Mean altitude (m) = 525
- Mean operating pressure (atm) = 4,5
- Types of pipes (material, diameters, lengths) =

Material	Diameter	Length
Steel (main pipeline)	200 mm	1 141 m
Brass (service connections)	32 mm	539 m

- Age of pipes (per material, diameter) =

Material	Diameter	Age
Steel (main pipeline)	200 mm	>30 years
Brass (service connections)	32 mm	>30 years

- No. of service connections = 49

2 Pilot Action

- Please identify if your pilot action refers to water efficiency or quality or both
  Pilot actions which are implemented as a part of current project are dedicated to improvement of water efficiency in terms of physical water loss reduction and quality of service water supply provided by local water Operator

- Define and present the specific problems you are facing that made you choose the specific pilot action (present as many data as you can)
  Specific pilot action was choses due to following two reasons:
  - *unacceptably high level of physical water losses – as a part of current project it was calculated and proven that all indicators which are related with water losses are higher than maximum permissible values:*
    - *real losses – 50,54%*
    - *real water losses per service connection – 6 042,63*
    - *real water losses per mains length – 259 499,33*
    - *ILI – 94*
  - *Age of pipeline – apart from high level of physical water losses another problem is related with age of pipelines which is more than 30 years. Taking into account that 10% from population of the city in concentrated in areas served by relatively short pipelines and in addition to high level of physical water losses those pipe sections generate it was decided that it would be better to replace some of them*

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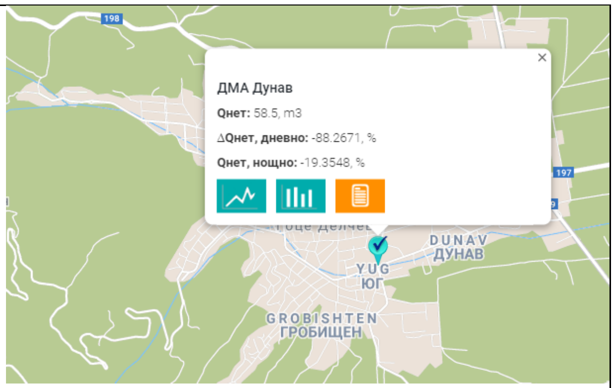
- Define and present the specific pilot action: e.g. what kind of equipment you have installed and where you installed them, etc. (please present as many photos as you can). You should provide evidence for the selection of the specific activities (why have you chosen these activities?)
  As a part of overall project following actions were performed:
  - *Design of DMA, construction of a manhole, installation of measuring equipment and data analysis – as a part of that part of pilot actions insertion flow meter with autonomous power supply was supplied and installed. In addition data was implemented in specialized software for data management and water loss calculation.*

Picture 1 – *manhole with insertion flow meter at the entrance of DMA Dunav*



Picture 2 – *View from system for data management and water loss reduction*

  - *Rehabilitation of water main in DMA Dunav – final stage of the project was related with rehabilitation of certain pipe sections with following sizes and length:*
    - *Φ110 – 601 m*
    - *Φ90 – 552 m*
    - *Φ63 – 294 m*

Picture 3 – *Reconstruction of pipeline*

Picture 4 – *Reconstruction of pipeline*

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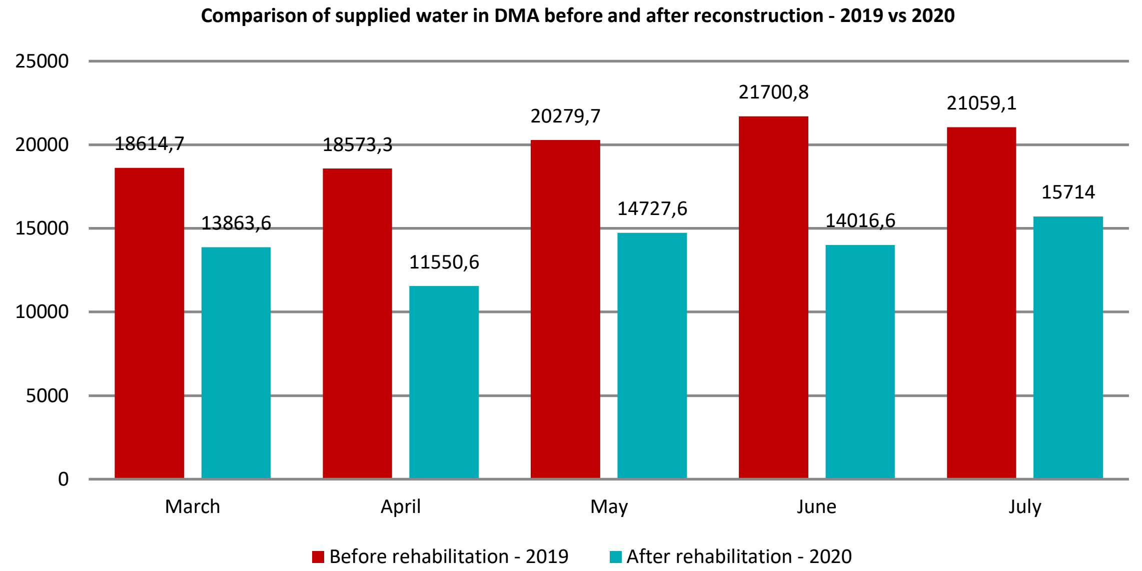
3 Results

- Present the results you expected to have from the pilot action.
  Direct impact which was expected after implementation of pilot actions is related with reduction of real water losses in DMA Dunav.

- Present the results you actually got from the pilot action implementation activities.
  Direct impact from implementation of project actions is reduction of real water losses from 50% to 30%.

- Please provide data on water savings or evidence of improved water quality from the pilot action.
  As a part of the project first action implemented was set up of constant flow measurement of DMA inlet. Data analysis for the level of water losses are based on 1 year constant measurements. Thanks to those data effect from rehabilitation of pipeline can be easily assessed as follow:
  - ➢ *Reduction in net flow delivered at entrance of DMA*



Time period	Before rehabilitation - 2019	After rehabilitation - 2020	Reduction in supplied water in DMA
March	18614,7	13863,6	26%
April	18573,3	11550,6	38%
May	20279,7	14727,6	27%
June	21700,8	14016,6	35%
July	21059,1	15714	25%

- ➢ *Reduction of net night flow which is directly related with level of real losses*

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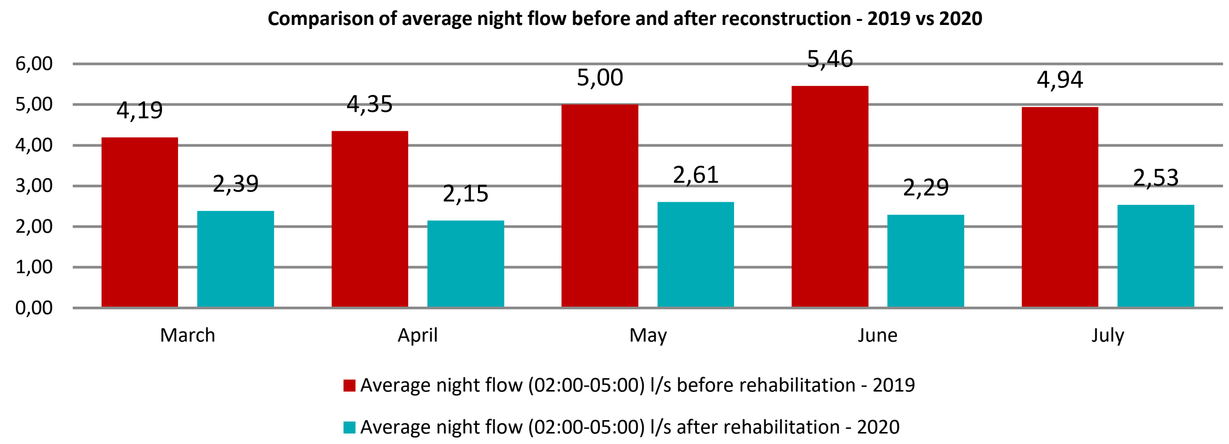
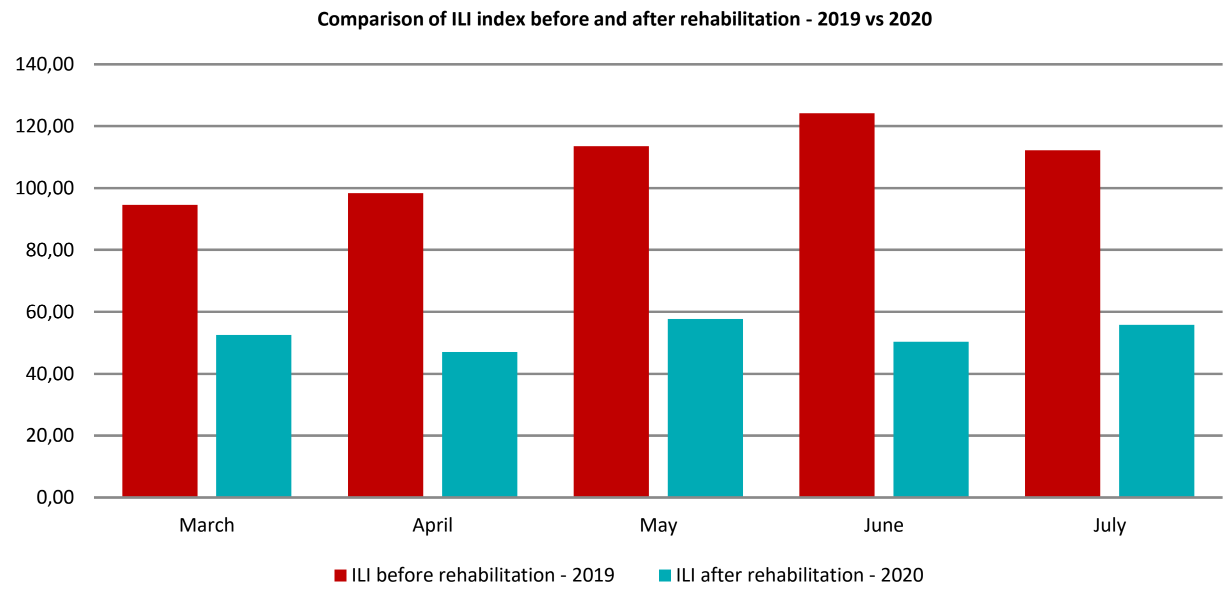


Time	Average night flow (02:00-05:00) l/s before rehabilitation - 2019	Average night flow (02:00-05:00) l/s after rehabilitation - 2020	Reduction
March	4,19	2,39	43,0%
April	4,35	2,15	50,6%
May	5,00	2,61	47,8%
June	5,46	2,29	57,9%
July	4,94	2,53	48,7%

- *Reduction of ILI index which measures level of real losses*



Time	ILI before rehabilitation - 2019	ILI after rehabilitation - 2020	Reduction
March	94,65	52,59	44%
April	98,29	46,98	52%
May	113,52	57,73	49%
June	124,14	50,43	59%
July	112,20	55,84	50%

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- Define the cost of the pilot action
  Cost of reconstruction of pipeline is 96 550,36EUR

- Define the cost related to the benefits from the pilot action.

4 Problems encountered and applied solutions

- Present any difficulties encountered during the pilot action implementation.
- How did you solve the problems? What solutions have you applied?
- Present the suggestions you might have if some other water utility wants to apply the same solution.

5 Lessons learnt

- What are the lessons learnt from the implementation of this pilot action?
  Main conclusion from current project is that real losses can be managed only by dedicated approach including right measurements and data analysis and rehabilitation of most critical sections from pipelines

- Are you proposing the implementation of these activities at the whole water supply system?
  Based on achieved results in terms of reduction of water losses it is obvious that approach applied in current project is the right one when it comes for water loss reduction

- Are you proposing the implementation of these or similar activities at other water utilities in your area / region? At national level?
  DMA approach and rehabilitation of pre-defined section in water supply network is well known approach worldwide. In Bulgaria National Water Regulator obliged Water Operators to introduced DMA zoning and this was introduced as a key quality indicator affecting price of water. Due to this DMA has become common approach for assessment of real water losses and selection of most crucial pipes sections for reconstruction.

6 Comments

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WATER RESCUE

Water resources efficiency and conservative use in drinking water supply systems

WP	**5 Pilot Actions**
Deliverable *Tool*	**5.6.2 Pilot Actions Implementation** *Questionnaire*
Project Beneficiary No	**PB6**
Beneficiary Institution	**Municipal Water Supply & Sewerage Company of Thermaikos**

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Name of the organization/institution: DEYA of Thermaikos
Beneficiary number: PB6

In order to evaluate the implementation progress of the Pilot Action, every beneficiary should prepare a report. Please reply to the following questions:

1. Identify if your pilot action refers to water efficiency or quality or both
The pilot actions refer to improving water efficiency.
2. Description of the pilot action
Information system provisioning and setup.
3. Description of performed activities regarding the pilot action
The pilot action concerned: • completion of the information system, • hardware provisioning, • in-house installation, • on-site training of the personnel
4. Obtained results
The system has been completed, set in operational mode and know-how was transferred to the organization personnel. Annex I presents an overview of the developed system
5. Encountered difficulties and applied solutions
There has been a delay in hardware acquisition. The contractor's testing and development environment has been used to test and validate the system. When the hardware finally was set up, the system was transferred to in-house installation.
6. Comments

PB6 developed IT applications for: (a) Water distribution networks management allowing water operators to manage the spatial data of the water distribution networks (e.g. Identification of the areas affected by water interruptions or failures, etc.) and; (b) Mapping of the failures history in an interactive map.
Both IT applications are developed internally at the systems of DEYA Thermaikos.

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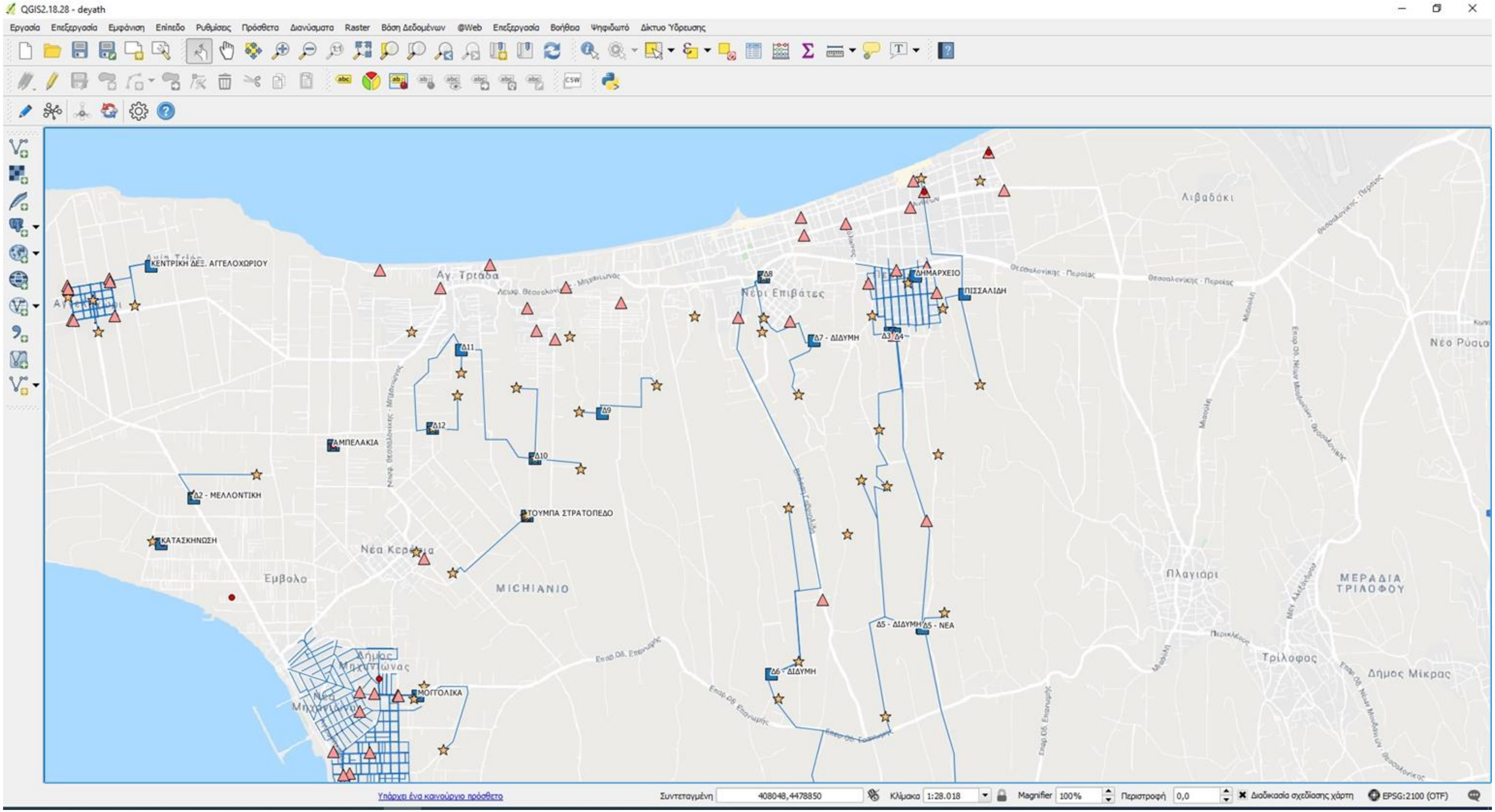
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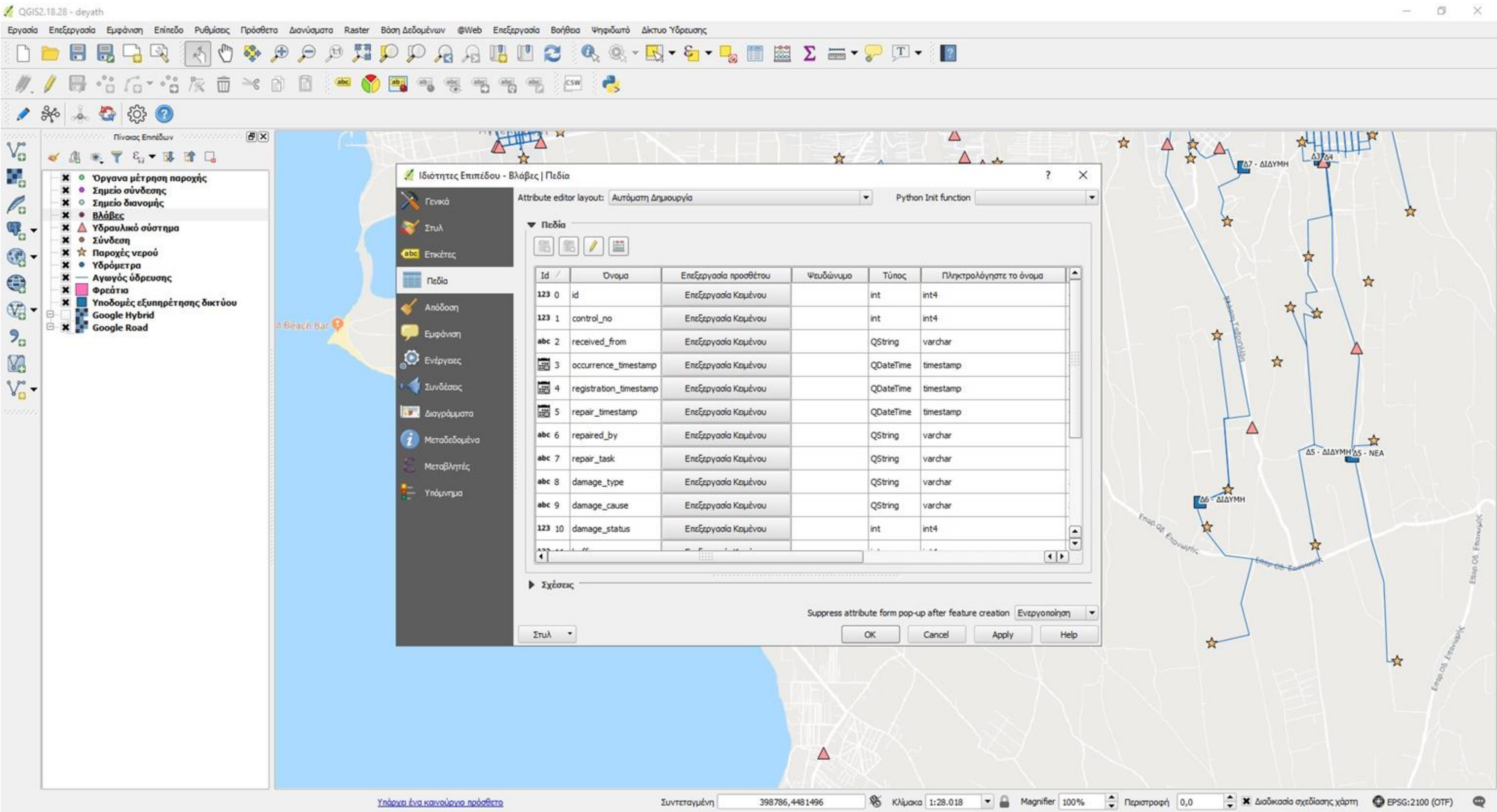
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0 | id | Επεξεργασία Κειμένου | | int | int4
1 | control_no | Επεξεργασία Κειμένου | | int | int4
2 | received_from | Επεξεργασία Κειμένου | | QString | varchar
3 | occurrence_timestamp | Επεξεργασία Κειμένου | | QDateTime | timestamp
4 | registration_timestamp | Επεξεργασία Κειμένου | | QDateTime | timestamp
5 | repair_timestamp | Επεξεργασία Κειμένου | | QDateTime | timestamp
6 | repaired_by | Επεξεργασία Κειμένου | | QString | varchar
7 | repair_task | Επεξεργασία Κειμένου | | QString | varchar
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9 | damage_cause | Επεξεργασία Κειμένου | | QString | varchar
10 | damage_status | Επεξεργασία Κειμένου | | int | int4
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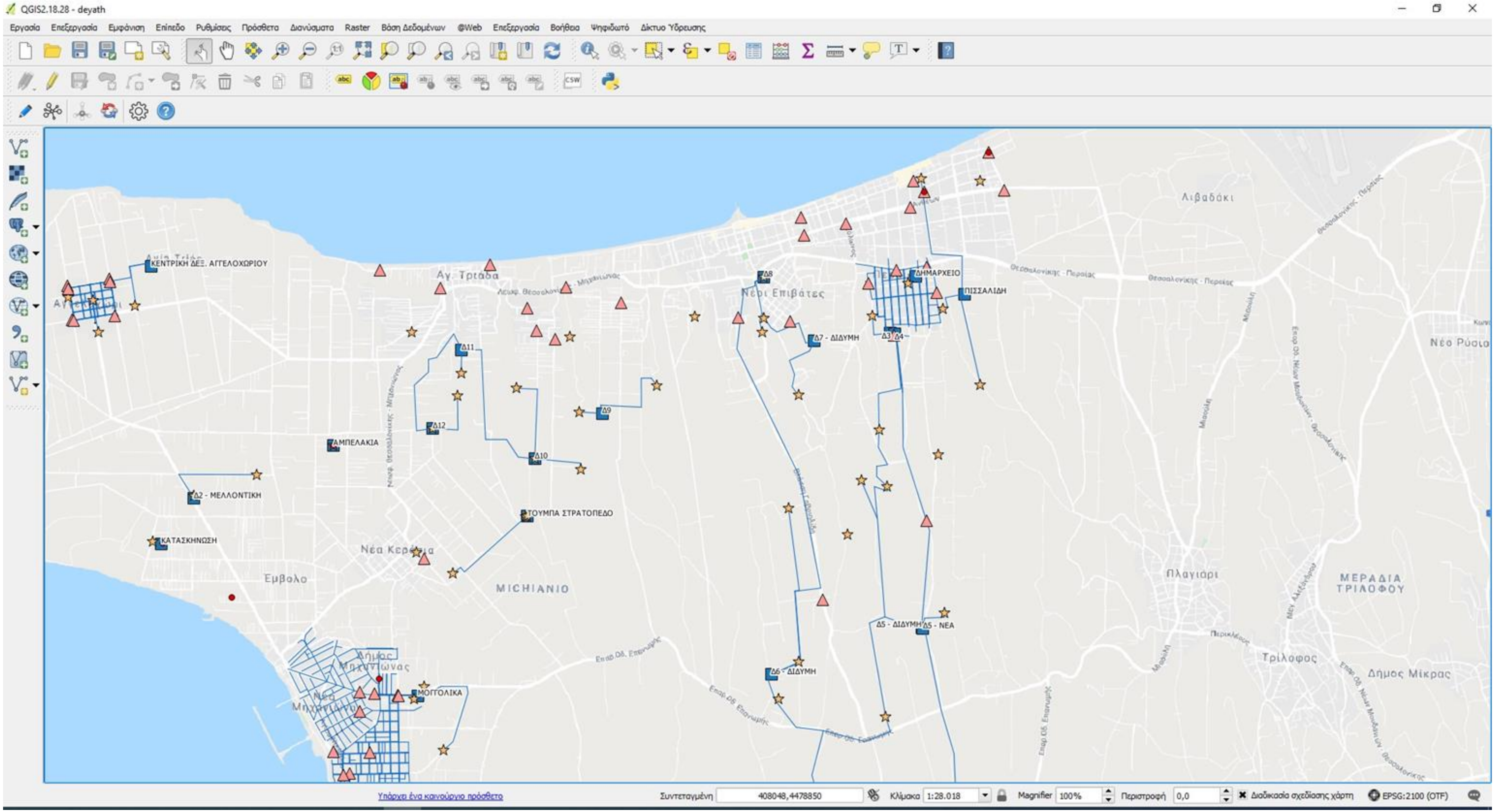
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