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AWARD

Alternative Water Resources and Deliberation processes to renew water supply strategic planning

D5.4 - Demo case#3 Implementation progress report

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EXECUTIVE SUMMARY

Deliverable 5.4 presents the main findings of Demo Case 3 within the AWARD project, implemented in the Paralimni and Agia Napa municipalities in Cyprus. The demo case focuses on the reuse of treated urban wastewater for irrigation purposes in a region characterized by intense seasonal tourism and limited freshwater availability. The project aimed to demonstrate how existing infrastructure can be enhanced and optimized for safe, efficient, and sustainable water reuse, supporting both local and regional water resilience strategies.

The case centered on enhancing the operation of the Paralimni–Agia Napa wastewater treatment plant (WWTP) through **targeted upgrades in monitoring, energy management, and stakeholder engagement**. Key interventions included operational adjustments at the wastewater treatment plant (WWTP), a targeted monitoring upgrade plan involving new sensors for real-time tracking of key parameters (e.g. ammonia, chlorophyll, DO), to transition from periodic laboratory monitoring to real-time, predictive plant management. This shift enhances treatment reliability, ensures regulatory compliance with Class A reuse standards, and allows dynamic operational adjustments that improve energy efficiency. In addition, Governance and stakeholder engagement was promoted by establishing platforms for dialogue with municipalities, farmers, hotel operators, regulatory agencies, and local communities. This participatory approach will help in co-design solutions, inform regarding concerns around water quality, health risks, and the economic implications of reuse, leading to broader social acceptance

The main results achieved include a detailed documentation and analysis of WWTP operation over the last four years, which established a robust baseline of hydraulic, organic, and energy performance and created the necessary foundation for future operational changes and optimizations. The decision to implement an upgraded monitoring plan with new probes at critical control stages allowed for much more granular and timely supervision of the process, ensuring early detection of potential problems and enabling corrective interventions. Energy efficiency improvements, although implemented before AWARD, were systematically assessed and validated by the project, showing a 20% reduction in specific energy consumption compared to pre-upgrade levels, while the installation of additional energy meters now allows more precise profiling of energy use across treatment stages. These datasets will form the basis for further optimization, particularly in view of the upcoming EU Directive that sets ambitious requirements for energy neutrality in wastewater treatment plants. At the same time, the WWTP consistently complied with Class A reuse standards, with effluent quality suitable for irrigating crops, hotels, sports facilities, and public green areas. Risks of nutrient accumulation and algal growth in reservoirs were successfully mitigated through adaptive aeration and disinfection management, while social engagement activities with farmers, hotels, and municipal authorities significantly increased awareness and trust in reclaimed water as a safe and economically viable alternative.

Looking ahead, the next steps will focus on exploiting the new monitoring infrastructure to gradually develop digital twin applications that will support predictive maintenance, scenario testing, and optimized decision-making. The availability of high-resolution operational and energy data will enable the proposal of further energy-saving measures, reinforcing the transition towards energy-neutral WWTPs in line with forthcoming EU legislation. In parallel, efforts will be made to establish a transparent reporting and certification framework so that monitoring results are openly shared with end-users, further reinforcing trust and accountability. Economic and pricing models will also be assessed to balance affordability for farmers with cost recovery for operators, ensuring fair allocation of resources between agriculture and tourism. Finally, lessons learned in DC#3 will be transferred to other Mediterranean regions with similar conditions, providing a replicable and scalable model for integrating wastewater reuse into climate-resilient water management strategies.

RELATED DELIVERABLES AND WORKPACKAGES' CONNECTION

This section details if there are any related Deliverables (e.g. interim versions, prerequisites etc.) and highlights links with the other Work Packages:

- The work carried out was based on the inputs from WP5 (Task 5.2) and especially the results concerning subtask 5.2.3.
- The AWR regulatory of this deliverable is in line with Deliverable D2.1 "*AWR regulatory, policy framework and funding mechanisms*"
- The results presented in this deliverable have contributed to and will continue to inform the following project activities:
  - WP3 (Task 3.2): by supporting the development of the Strategic Foresight Framework for Demo Case #3;
  - WP4 (Task 4.2): by providing input on the key characteristics and operational features of the Alternative Water Resources (AWR) system in Demo Case #3;
  - WP6 (Task 6.4) by supporting the assessment of the replicability and transferability of the proposed solutions across different regional and institutional contexts.

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LIST OF ACRONYMS

BOD	**Biochemical Oxygen Demand**
COD	**Chemical Oxygen Demand**
DAF	**Dissolved Air Flotation**
DS	**Dry Solids**
EAC	**Electricity Authority of Cyprus**
EC	**European Commission**
EOAA	**Famagusta District Local Government Organization (in Greek: EOAA)**
E. coli	**Intestinal Coliforms (Escherichia coli)**
EU	**European Union**
FOG	**Fats, Oils, and Grease**
GA	**Grant Agreement**
GWBs	**Ground Water Bodies**
IPPC	**Integrated Pollution Prevention and Control**
LCAH	**Level Control Alarm High**
LWF	**Local Water Forum**
PE	**Population Equivalent**
PLC	**Programmable Logic Controller**
PSB	**Paralimni Sewerage Board**
P_tot	**Total Phosphorus**
N_tot	**Total Nitrogen**
SS	**Suspended Solids**
TS	**Total Solids**
WDD	**Water Development Department**
WFD	**Water Framework Directive**
WP	**Work Package**
WWTP	**Wastewater Treatment Plant**

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I. INTRODUCTION

The AWARD (Alternative Water Resources for Sustainable Water Management in Mediterranean Regions) project promotes sustainable, decentralized, and circular water solutions in areas facing water stress. Cyprus, a semi-arid island state with increasing climatic variability, is particularly vulnerable to prolonged droughts and overexploitation of groundwater.

The Ammochostos (Famagusta) district of Cyprus includes the areas of Paralimni and Agia Napa. The Paralimni Sewerage Board (PSB) operates the main WWTP which collects the wastewater from the two areas. The WWTP of Paralimni-Agia Napa has recently been upgraded (January 2023) and currently treats up to 31,000 m^3/d of sewage wastewater having a design treatment capacity of 190,000 PE. 30% of the reclaimed water is used to irrigate the gardens in hotels, 60% to irrigate different types of crops and the remaining 10% public green spaces and football pitches. The reclaimed water is thus provided at a certain price by the Water Development Department to farmers and to hotel business (0.07 €/m^3 for agricultural use and 0.17 €/m^3 for green area).

Demo Case 3, implemented in the municipalities of Paralimni and Agia Napa in Cyprus, focused on urban wastewater reuse for irrigation as a viable approach to reduce freshwater dependency, safeguard natural resources, and secure water availability in high-demand periods. The case study illustrates the technical feasibility, environmental benefits, and institutional pathways for mainstreaming treated wastewater as a reliable alternative water resource in Mediterranean tourist destinations. The main objective is to tackle water reuse challenges and to become a water reuse example worldwide where the water reuse standards are fully met by integrating digital technologies with conventional wastewater treatment coupled with tertiary filtration and disinfection.

The solution will consolidate data from a variety of sensors and sources to provide a continuous picture of: A) the influent sewage quality and upstream loading pinpointing the potential discharge of industrial and/or hazardous substances and the increase of water salinity; B) energy consumption of the hotspots of the WWTP (i.e. aeration of the bioreactors) in order to adjust the operation resulting in net energy saving; C) Operating characteristics of the bioreactors which will pinpoint potential problems in biomass activity and will allow the adjustment of operational parameters and ameliorate the treated water quality; and D) The water quality which is delivered by the WWTP for water reuse. This will ensure that the water reuse limits set up by the regulation are always met.

II. Description of the demo case in Cyprus

II.1 Description of the area/ region

II.1.1 Geographical Description

Cyprus is located at an average northern latitude of 35° and eastern longitude of 33°, surrounded by the eastern Mediterranean Sea. It covers an area of 9,254 square kilometers and is divided into 4 natural regions and 6 administrative districts. The Famagusta District is one of the six districts of Cyprus.

Paralimni is the largest community in the fertile plain of the Famagusta District and is located at the southeastern tip of Cyprus. Since 1986, it has been established as a Municipality and has since been the largest municipality in the free (government-controlled) area of the Famagusta District. It was named after the lake on which it is built—one of the protected habitats included in the NATURA 2000 network. Today, it has approximately 15,000 inhabitants and is divided into an urban and a tourist zone. The tourist zone includes Protaras, a seaside suburb of Paralimni with many hotel complexes.

Paralimni's neighbouring municipality is Ayia Napa, a small town in the Famagusta District that has also been an independent municipality since 1986. It is located further east from Cape Greco and Dhekelia. Due to its sandy beaches, Ayia Napa is a very popular tourist destination.

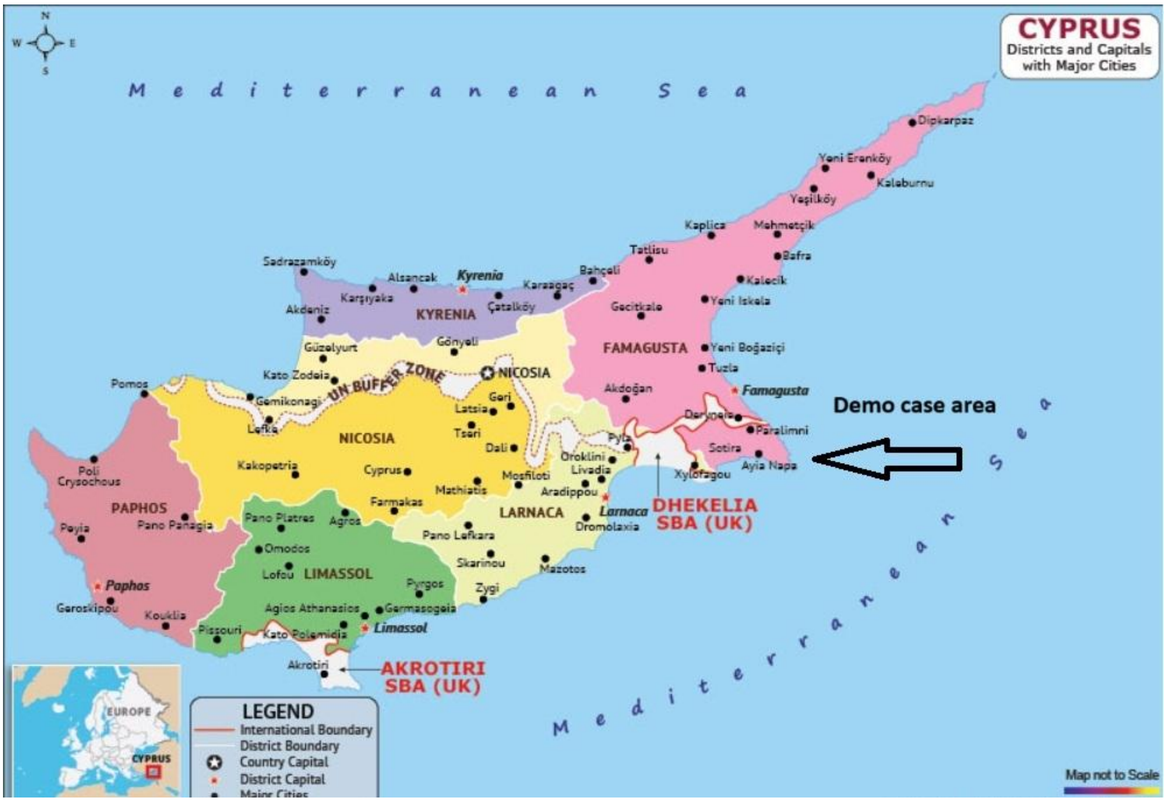

Figure 1: Cyprus map with Demo case area

II.1.2 Climatic Conditions

Cyprus owes its Mediterranean climate to the influence of the sea. The main characteristics of its Mediterranean climate are: hot and dry summers from mid-May to mid-September, rainy yet mild winters from mid-November to mid-March, and two transitional seasons—autumn and spring. During the summer, Cyprus and the eastern Mediterranean in general are under the influence of the seasonal low-pressure system centered in southwestern Asia. This results in high temperatures and clear skies. Rainfall during summer is very low, with an average that does not exceed 5% of the total annual precipitation. In winter, Cyprus is affected by the frequent passage of small depressions and weather fronts moving across the Mediterranean from west to east. These weather systems usually last from one to three days at a time and account for the largest share of rainfall. The total average rainfall during December, January, and February corresponds to about 60% of the annual precipitation.

The average annual rainfall across Cyprus is approximately 450 millimetres. On the leeward slopes, rainfall steadily decreases toward the north and east, reaching values between 300 and 350 millimetres in the central plain and the southeastern lowlands. All regions of Cyprus enjoy a high duration of sunshine compared to many other countries. In the lowland areas, the average number of sunshine hours throughout the year amounts to 75% of the total possible sunshine hours. During the summer, sunshine lasts on average 11.5 hours per day, while in the cloudiest months—December and January—sunshine duration decreases to just 5.5 hours per day. The maximum possible duration of sunshine (i.e., from sunrise to sunset) in Cyprus ranges from 9.8 hours per day in December to 14.5 hours per day in June.

II.2 Challenges

II.2.1 Water Scarcity and Demand Pressures

Water scarcity in Cyprus is a structural issue intensified by climate change, limited rainfall, and poor natural water storage capacity. Cyprus is one of the "water poor" countries of Europe with Semi-arid climate, unevenly distributed rainfall, frequent occurrence of droughts and limited water resources. According to IPCC, Cyprus is highly vulnerable to the impact of climate change and classified as one of the "global hotspots".

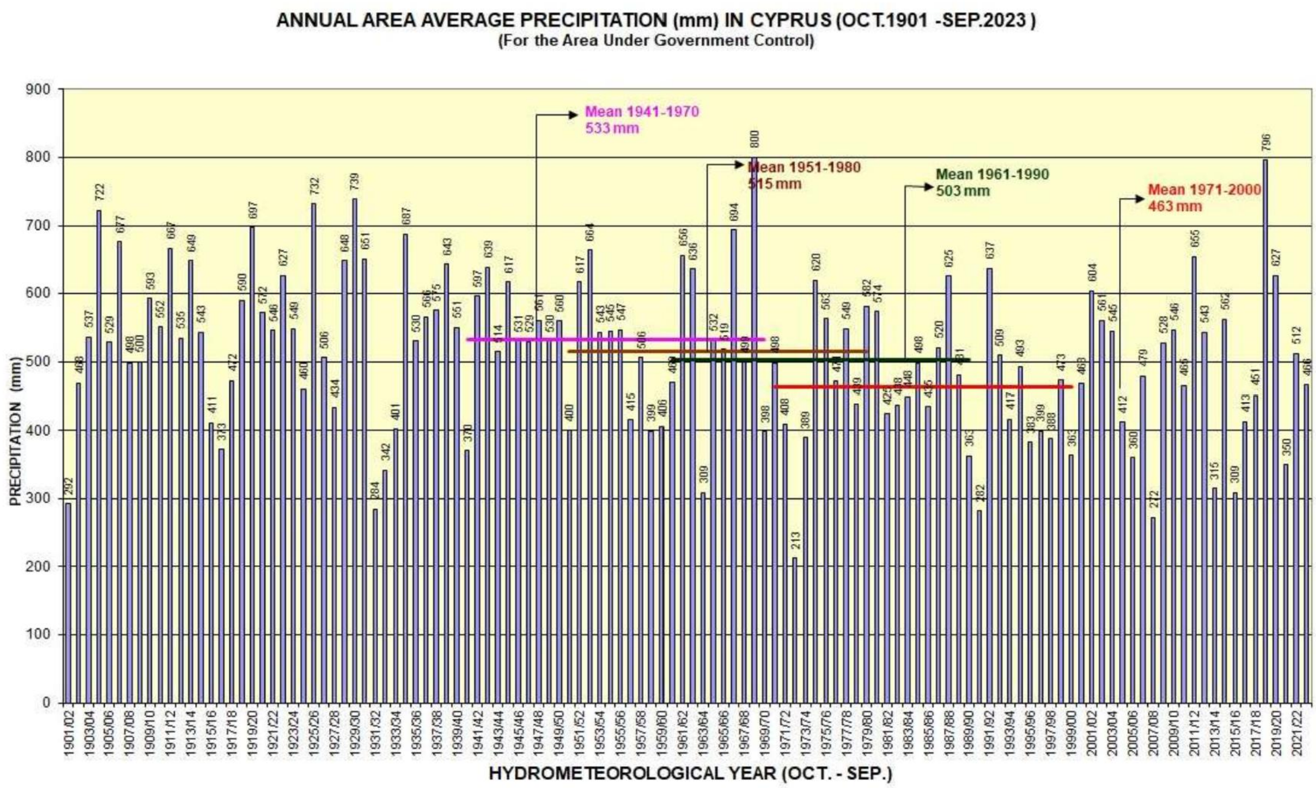

Figure 2: Cyprus annual average precipitation

Climate models predict for the next years rise in temperature and increase in the intensity and frequency of extreme drought events. These conditions, coupled with increased water demands are worsening the water scarcity problem in Cyprus. This year, the country is experiencing its third consecutive year of drought. At the beginning of June 2025, the country's 18 main reservoirs were only 21.7% full. Five years ago, the figure was 97%. Climate change is expected to worsen water availability.

Groundwater resources have been, at first, the most obvious & easily accessible sources of water for many years. In the attempt to meet the increasing water demand or to mitigate drought effects, they have been heavily over-pumped and this led to seawater intrusion into coastal aquifers and the deterioration of both quality and quantity of groundwater.

Regarding drinking water, there is an increased demand due to population, tourism and lifestyle, and this places the issue as one of the main priorities for the state.

The agricultural sector is the largest consumer of water. In recent years there has been a serious deficit in irrigation and there are cuts of up to 70% in periods of drought.

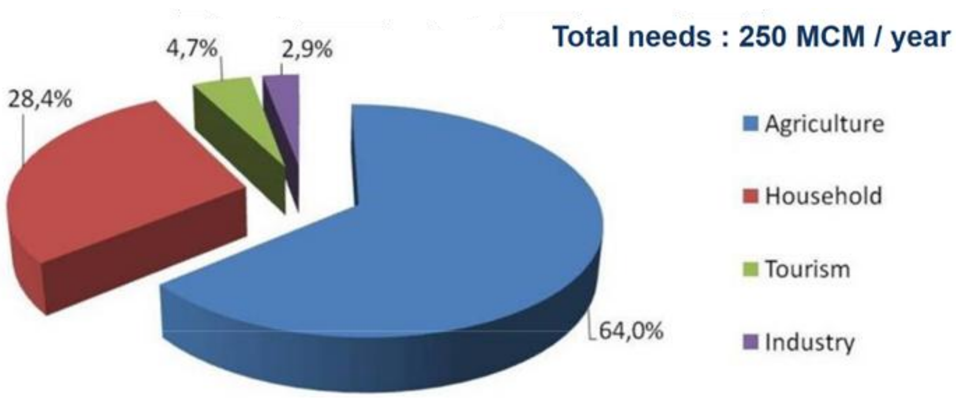

Figure 3: Different uses of water in Cyprus with approximate respective percentages

In Figure 4 the water balance of Cyprus for the years 2010 to 2022 is presented.

Year	Water demand (MCM)	Available quantity of water from conventional sources				Enrichment of the water balance from unconventional sources		Total available quantity of water (MCM) [from rainfall) + (from rainfall) + desalinized + recycled	Water balance (MCM) [= Available quantity of water- water demand]	Quantity of water given for drinking (MCM)
		Rainfall (mm)	Volume of rain (MCM)	Available quantity of water from rainfall (MCM) [Note: Around 90% of rainfall is lost due to evapotranspiration and around 0.02% from run off to the sea]	Water balance (MCM) [= available quantity of water from rainfall- Water Demand]	Quantity of desalinized water (MCM)	Quantity of recycled water (MCM)			
2010	257	429	2570	197	-60	53	12	262	5	82
2011	258	558	3348	265	7	49	14	328	70	81
2012	259	790	4737	404	145	18	17	438	179	80
2013	260	295	1770	117	-143	11	17	145	-115	78
2014	261	393	2358	173	-88	33	17	222	-39	80
2015	262	484	2904	228	-34	38	17	284	23	82
2016	**263**	430	2580	198	-65	69	19	285	22	90
2017	264	326	1956	136	-128	69	20	224	-40	94
2018	265	607	3642	300	35	70	21	391	126	95
2019	266	797	4782	405	139	55	24	484	218	94
2020	266	472	2832	221	-45	30	22	273	7	90
2021	266	454	2724	210	-56	49	22	281	15	97
2022	266	460	2760	214	-52	53	24	291	25	102

Figure 4: Water balance of Cyprus

As can be seen from the above figure, the total water demand is higher than availability and particularly irrigation needs are rarely satisfied. Furthermore, state records show that since 1996, water demand for irrigated agriculture was satisfied only once, in 2004, when all dams were full. All these create a Water Stress Index of 73%.

Another challenge that Cyprus has to address, is the deterioration of its Ground Water Bodies (GWBs) due to a number of reasons (Over-pumping of groundwater for irrigation and domestic use, poor natural recharge due to drought, intrusion of seawater into the aquifer resulting in salinization, etc.). Under the Water Framework Directive (WFD), GWBs are subdivisions of larger geographical areas of aquifers. This allows for more targeted and effective management of groundwater resources. Figure 5 shows the present status of Cyprus GWBs in terms of Quantity and Quality (salinity, nitrates, etc.). Overall, 21 GWBs (one out of the control of the Republic of CY). As it can be seen, obviously there is one more issue that must be addressed.

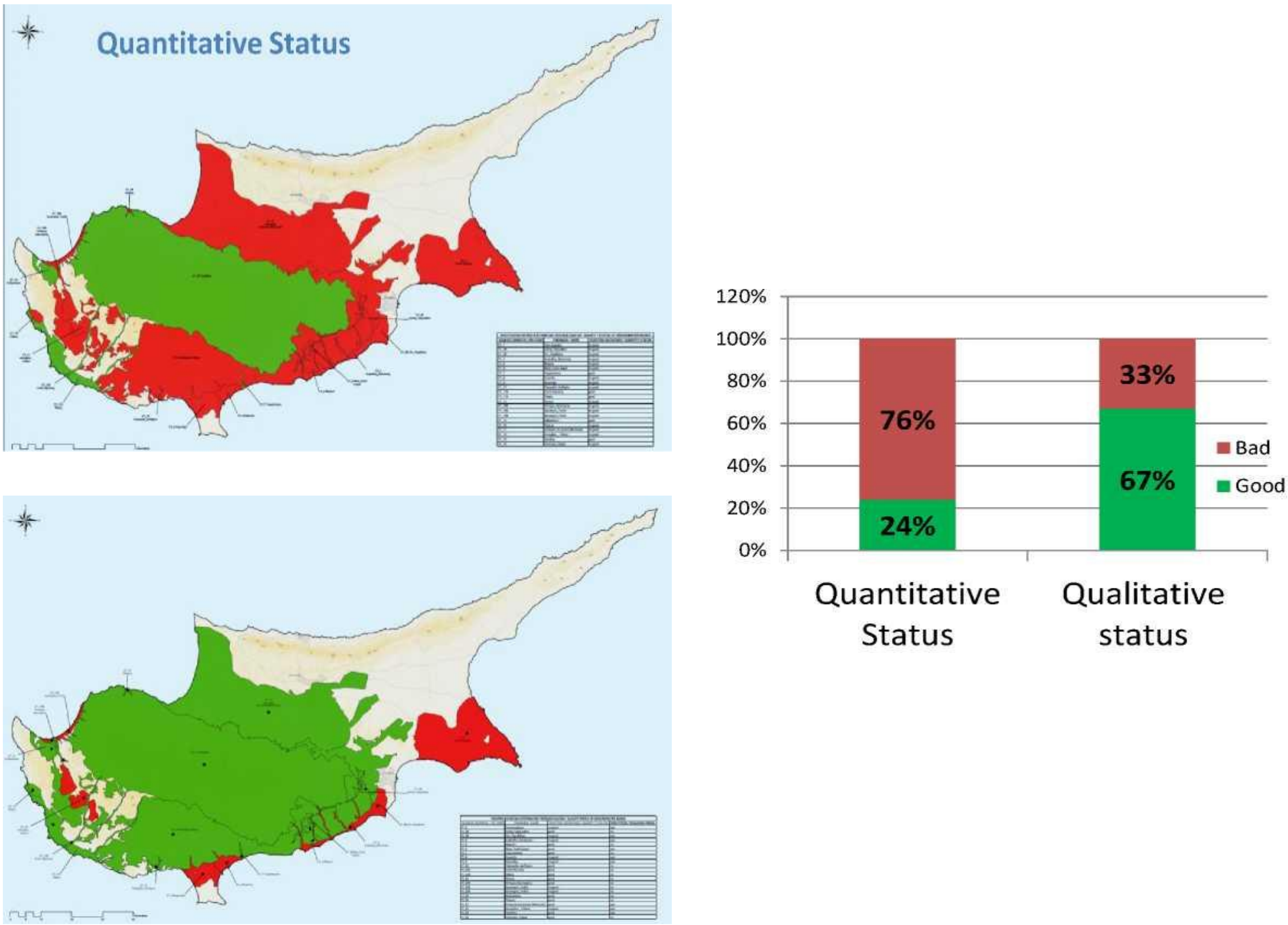

Figure 5: Quantitative and Qualitative status of Cyprus Ground Water Bodies (GWBs)

II.2.1.1 Famagusta area

The Famagusta District, where the AWARD Demo Case 3 is located, generally addresses the same challenges that the whole of Cyprus faces. However, in this District, the situation is particularly acute due to high tourism-driven demand during the dry season. Municipal water consumption triples between May and September. Additionally, landscape irrigation in public areas, resorts, and sports fields remains high year-round due to the climatic conditions and aesthetic demands of tourism.

The over-reliance on groundwater and costly desalination further constrains water security. Meanwhile, local farmers require secure water access for economically significant crops such as potatoes, citrus fruits, and vegetables. But at the same time, in these months of high tourism, the flows of wastewater are much higher than in other months. So, treated wastewater reuse offers a locally available, drought-resilient alternative that aligns with circular economy principles. However, gaps in public acceptance, infrastructure integration, and real-time quality control have hindered its widespread adoption—challenges that the AWARD project aimed to address in this demo case.

II.3 Water resources and management

In Cyprus the Objective at national level is to ensure availability of water for all uses to the maximum extent possible. All houses are connected to public water supply with excellent quality of drinking water and improved sanitation facilities.

Cyprus has adopted an Integrated & sustainable approach to water management including: a) Strategic planning, b) Long term actions to meet future demands under scarcity conditions, and c) Short term actions to face a particular drought event within the existing framework as is illustrated in figure 6.

Figure 6: Cyprus general concept of water management

Cyprus used three ways to deal with water shortages:

1. Water collection and reservation in Dams. In the 80's, Cyprus developed a system of dams that aimed to save rainwater. Cyprus dams have a capacity of 315 million tons of water which is sufficient for water supply for the population, the 3 million tourists visiting Cyprus yearly and the needs for agriculture.

Figure 7: Dam in Cyprus

2. Waste water purification. Cyprus is a pioneer in reuse on wastewater. In Cyprus around 97% of the treated waste water is reused in accordance with Art. 12 (1) of the UWWTD. The effluent is mainly reused directly for irrigation or indirectly via replenishment of aquifers. In 2023, 28.2 million cubic meters of treated effluent were reused in agriculture.

Figure 8: Wastewater treatment plant

3. Seawater desalination. Five Desalination Plants are in operation in Cyprus, at Dhekelia, Limassol (Episkopi), EAC Vassilikos, Larnaca and Paphos delivering each from 15.000 m^3/d to 62.000 m^3/d, fresh potable water.

Figure 9: Desalination plant

In order to address the challenge of domestic water demand, Cyprus constructed major water works infrastructure. Figure 10 presents the Cyprus government water works that serve as sources for domestic use, in terms of percentages of million cubic meters. It includes the use of Dams, Boreholes, Desalination plans and in some difficult periods, water transfer from Greece.

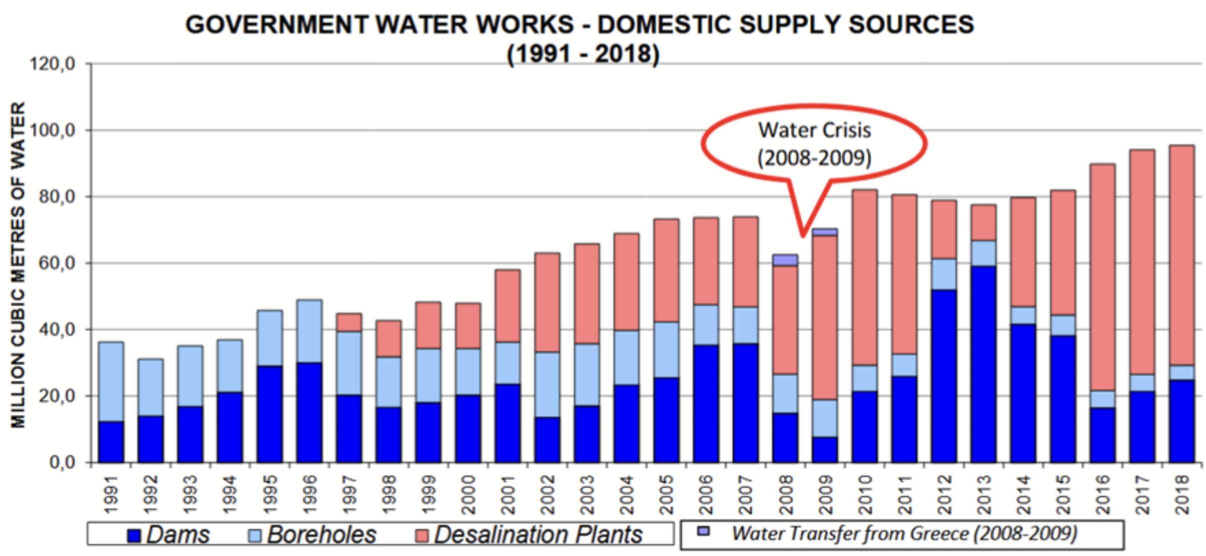

Figure 10: Water works in Cyprus as domestic supply sources

Accordingly, in order to address the challenge of irrigation water demand, Cyprus implemented an integrated management plan with the corresponding hydraulic infrastructure works. Figure 11, presents the water works that serve as sources for irrigation purposes. It includes the use of Dams, Wells and recycled water from WWTPs.

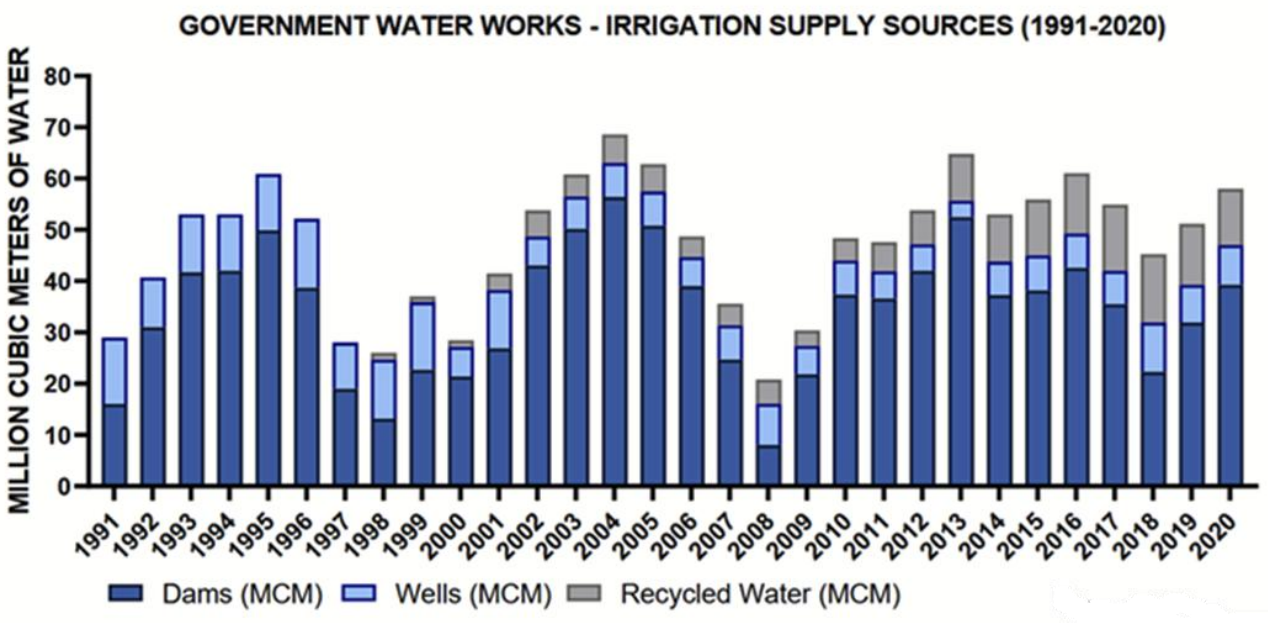

Figure 11: Water works in Cyprus as irrigation supply sources

<u>Demand Management Measures</u>

Effective water demand management is also one of Cyprus priorities and a complementary measure to the three ways mentioned above, as it is a fundamental condition for the exercise and application of a sustainable water policy. In fact, it consists of a set of measures and actions, including:

- **Legislation**
  –Integrated Water Management Law
- **Incentive water pricing**
  - Metering is applied to all users

- Volumetric pricing and rising block tariffs
- **Leakage reduction in distribution networks**
- **Improve irrigation efficiency**
  - On farm advanced irrigation systems and techniques (95% of irrigated area)
- **Addressing illegal abstraction**
  - Introduction of a more stringent procedure regarding borehole drilling and abstraction permits through the *Integrated Water Management Law*
- **Cultivation of a water consciousness culture**

II.3.1 Treated wastewater for reuse is a growing resource in Cyprus

In 2023, 28.2 million cubic meters (MCM) of recycled water was produced. In Cyprus, the treated effluent from the urban wastewater treatment plants is reused for the following purposes:

- **Direct Irrigation** (under the Code of Good Agricultural Practice): Crops, green areas → **~ 77%**
- **Indirect irrigation**: Enrichment of underground water (Aquifer recharge) → **~ 20%**
- **Discharge** into dams (for irrigation purposes only) or to the sea → **~ 3%**

In figure 12, the Cyprus water reuse master plan is presented.

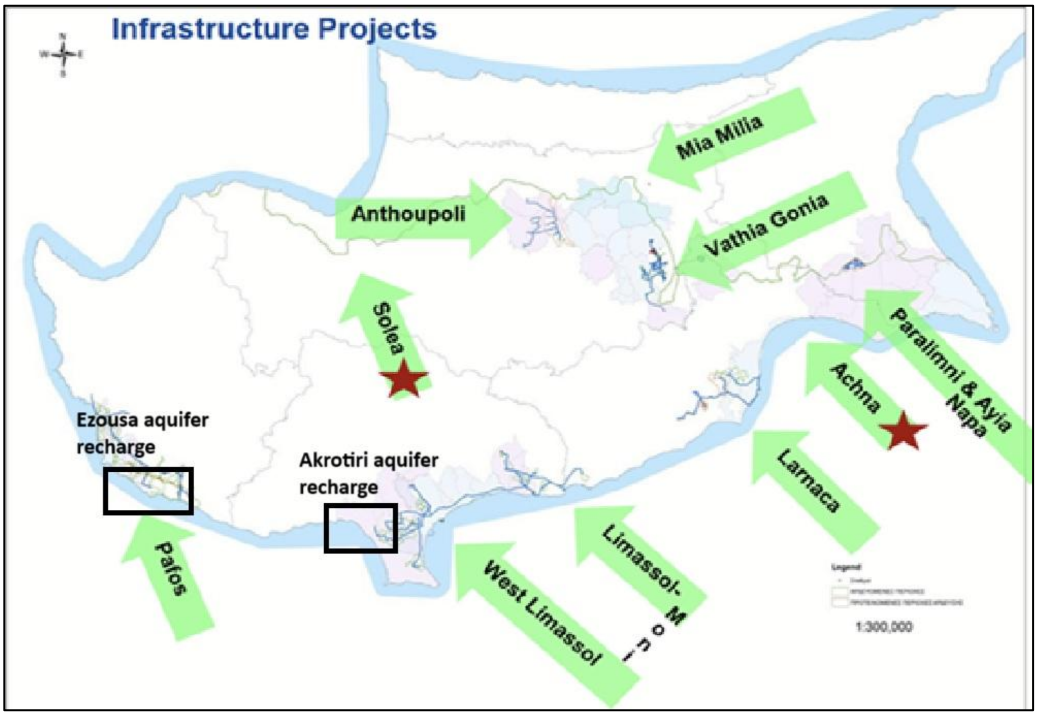

Figure 12: Water reuse master plan in Cyprus

Water reuse in Cyprus is regulated by:

- The Water Pollution Control Laws (106(I)/2002 to 2013)
- The Water Pollution Control (Sensitive Areas for Disposal of Urban Wastewater) Ministerial Decree of 2013 (No. 280/2013)

- The Code of Good Agricultural Practice Decree (No. 283/2023)
- The Ministerial Decree for small-scale wastewater treatment plants < 2000 p.e. (No. 379/2015)
- The Environmental Impact Assessment Law (No. 127(I)/2018) for discharge to water bodies and for the management of the effluent for new UWWTPs
- Regulation (EU) 2020/741 of the European Parliament and of the council on minimum requirements for water reuse

II.3.2 District of Famagusta water management

The municipalities of Paralimni and Agia Napa currently source water from a mix of groundwater, desalinated water and partially treated effluent reuse. While groundwater historically served as the main source, its declining levels have triggered ecological and regulatory concerns. Desalinated water, while abundant, is energy-intensive and expensive. For now, desalinated water is used only for drinking purposes, while groundwater and reclaimed water from wastewater, are used for irrigation. Reclaimed water is also used for aquifer recharge. Hence, increasing the reuse of treated urban wastewater—for non-potable uses—has become a strategic objective of the Water Development Department.

The existing WWTP, jointly operated by the two municipalities, is a critical asset for local water management. The treated effluent from the plant can be safely reused, offering an opportunity to close the water cycle while reducing operational costs and improving water balance. Through AWARD, a systemic approach was taken to support this reuse scheme through technical reinforcement and engagement with regulatory and user stakeholders.

II.4 Existing infrastructure in the demo case of Paralimni-Agia Napa (Cyprus) of relevance

The Paralimni–Agia Napa area is located in the southeastern coastal zone of Cyprus, part of the administrative Famagusta District. Paralimni is the largest municipality in the government-controlled area of the district and has seen rapid urban development since the 1980s. Adjacent to it, Agia Napa is one of the island’s most visited tourist towns, especially during summer months, drawing thousands of international visitors. The area consists of residential zones, extensive hotel infrastructure, agricultural land, and protected environmental sites including wetlands and coastal ecosystems.

The Paralimni–Agia Napa WWTP (location in Fig. 13) operates since 2002 under the supervision of the Famagusta District Local Government Organization (in Greek: EOAA) and treats domestic sewage of PARALIMNI and AGIA NAPA areas. It delivers Class A reclaimed water, suitable for agricultural use to two these areas (Paralimni and Agia Napa). The reclaimed water is used to irrigate different types of crops, gardens in hotels, public green spaces and football pitches (Figure 14). The Number of Reclaimed water users is 1500 users in Paralimni and 600 users in Ayia Napa. The selling Prices of reclaimed water are 0.07 €/m^3 for agricultural use and 0.17 €/m^3 for green area

Figure 13: Location of the Famagusta district WWTP

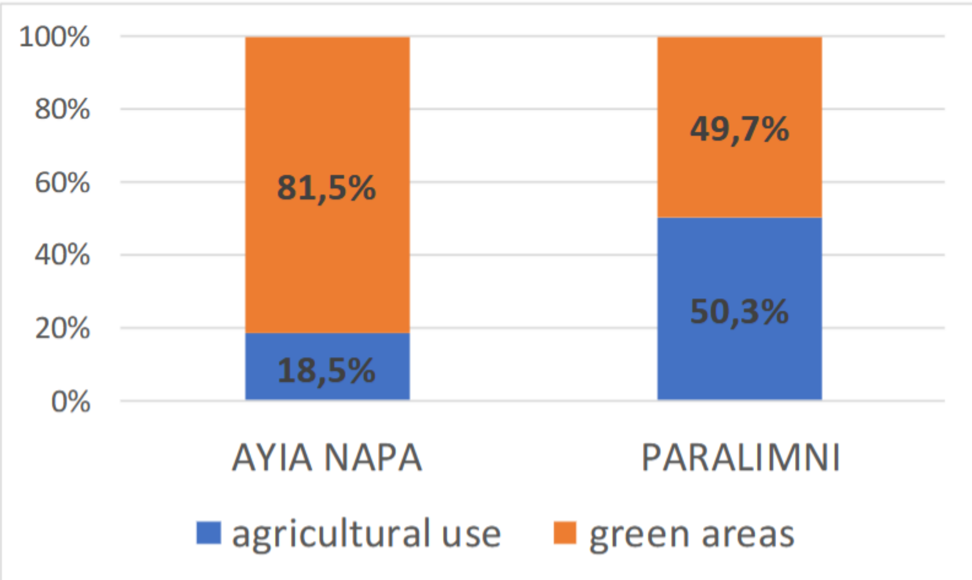

Figure 14: Reclaimed water uses in Agia Napa and Paralimni

In general, the sewage flows from the two areas are joined in a common collector - well and enter the WWTP. At a glance, the stages of treatment in the WWTP are:

1.Mechanical pretreatment (removes solids above 3mm, grid and fats – oils)

2.Secondary treatment, extended aeration system with settling basins (removes BOD, COD, Nitrogen and Phosphorous)

3. The secondary treated wastewater is stored in 4 storage (to twins) basins for each area of Agia Napa and Paralimni (total volume of ~ 400000m^3)

4.Tertiary Treatment removes fine particles and disinfects effluent (Filtration and chlorination)

5. After Tertiary treatment the reclaimed water is stored in two separate tanks located in different locations (nearby the secondary storage tanks) and corresponding to each area of Paralimni and Agia Napa.

The Hydraulic load is 31.600 m^3/d and the Organic load is 12.500 kg BOD_5/d and correspond to an Equivalent population (PE) of 208.000.
The WWTP general layout and general view is presented in Figures 15 and 16.

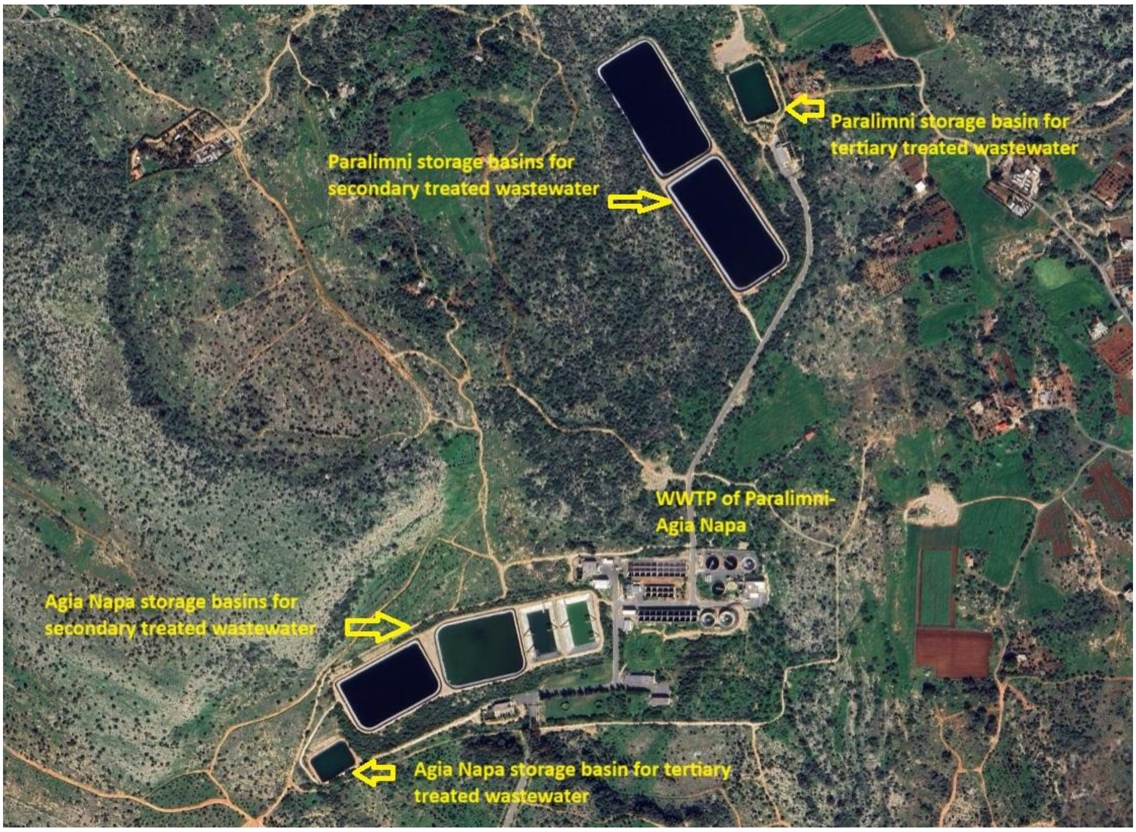

Figure 15: General layout of the WWTP Paralimni-Agia Napa

Figure 16: General view of Paralimni, Agia Napa and the WWTP

II.5 Assessment of required upgrade

To ensure the long-term sustainability and safety of reclaimed water for irrigation, the AWARD project prioritized real-time monitoring and proactive quality control. While the Paralimni–Agia Napa WWTP had consistently produced high-quality effluent, prior to AWARD the monitoring practices relied primarily on laboratory sampling and manual oversight. Recognizing the importance of timely interventions—especially in the context of open-air storage and variable seasonal demands—the demo case introduced a targeted sensor upgrade and energy monitoring system.

This sensor-based enhancement was designed to support both **water quality assurance** and **operational efficiency**. It was decided to add sensors at critical control points—mainly post-treatment and within the storage reservoirs—to detect potential risks (e.g., nutrient accumulation, turbidity spikes, algae growth) and to support more responsive system management.

Table 1 Sensor and Meter Deployment in Demo Case 3

Parameter	Instrument Type	Monitoring Purpose
Chlorophyll-a	Fluorometric sensors (2 units)	Early detection of algal blooms and eutrophication risks in open reservoirs
Residual Chlorine	Online chlorine analysers (2 units)	Continuous verification of disinfection efficiency and compliance with reuse standards
Oxidation–Reduction Potential (ORP)	ORP sensor (1 unit)	Monitor redox conditions to optimise disinfection processes and biological stability
Ammonia (NH_4^+)	Ion-selective electrode (1 unit)	Verify nitrification efficiency and biological treatment status
Energy Consumption	Inline digital energy meters (9 units)	Monitor the energy use within all operational points for optimisation and efficiency benchmarking

III. Technical Description of the demo case in Cyprus

WWTP was constructed in 2000 and started its operation on 2002. Energy consumption is a key operational consideration for this facility, as it is for wastewater treatment plants globally. In 2018, after nearly 15 years of operation, an **energy efficiency upgrade plan** was developed and implemented, which involved the replacement and modernization of critical electromechanical equipment across the plant's processes. This was done through a **holistic approach**, targeting both high and low power consumption points within the plant. The upgrade project was divided into several construction phases, giving priority to replacing energy-intensive equipment. These improvements are ongoing and now focus on smaller yet equally important systems. In 2023, in response to the significant urban development and rising tourist inflows in the area, the biological treatment capacity of the plant was increased by 50% through the construction of two modern bioreactors and the reinforcement of the existing four. This significantly expanded the overall treatment capacity of the facility.

Following the most recent upgrade in 2023, the Urban Wastewater Treatment Plant (WWTP) has reached a **maximum daily treatment capacity of 31,500 m³ of wastewater**, with a total **organic load capacity of 10,990 kg BOD_5**. Two additional upgrades are currently in the design phase:

1. An increase in filtration/disinfection capacity, and
2. Sludge management through composting processes.

As shown in the flow diagram, the WWTP includes:

- **Pre-treatment**,
- **Central secondary treatment** with six bioreactors and six secondary sedimentation tanks,
- **Two tertiary treatment units** with capacity for phosphorus chemical precipitation, **filtration (sand filters)**, and **disinfection (via sodium hypochlorite dosing)**.

To balance the volumes of produced treated water, two sealed **balancing tanks** with capacities of 6,000 m³ and 5,000 m³ have been installed. These serve the irrigation needs within the municipal boundaries of **Paralimni and Agia Napa**, respectively.

The **sludge treatment line** consists of mechanical thickeners and centrifuges, using a diluted cationic polymer solution for thickening. Additionally, two sealed emergency tanks of 50,000 m³ each are hydraulically connected to the central inlet well receiving flows from the pumping stations, serving emergency situations or buffering peak instantaneous inflows.

Finally, for the storage of reclaimed (treated) water, **four open-air storage reservoirs with a total capacity of 350,000 m³** are installed. These are hydraulically connected to the overflow chambers of the secondary sedimentation tanks and serve to store reclaimed water for later reuse in irrigation.

The treatment loop begins with mechanical screening and grit removal, followed by biological treatment through four reactors (each divided into anaerobic, anoxic, and aerobic zones). Internal recirculation ensures full nitrogen removal. From the secondary clarifiers, the clarified effluent passes through carbon filters and disinfection units (NaOCl dosing) before being stored in municipal reservoirs. The storage system is monitored for biological growth and nutrient stability. The reuse network includes pressure-controlled pumps and distribution pipelines reaching urban green areas, hotel gardens, and agricultural plots.

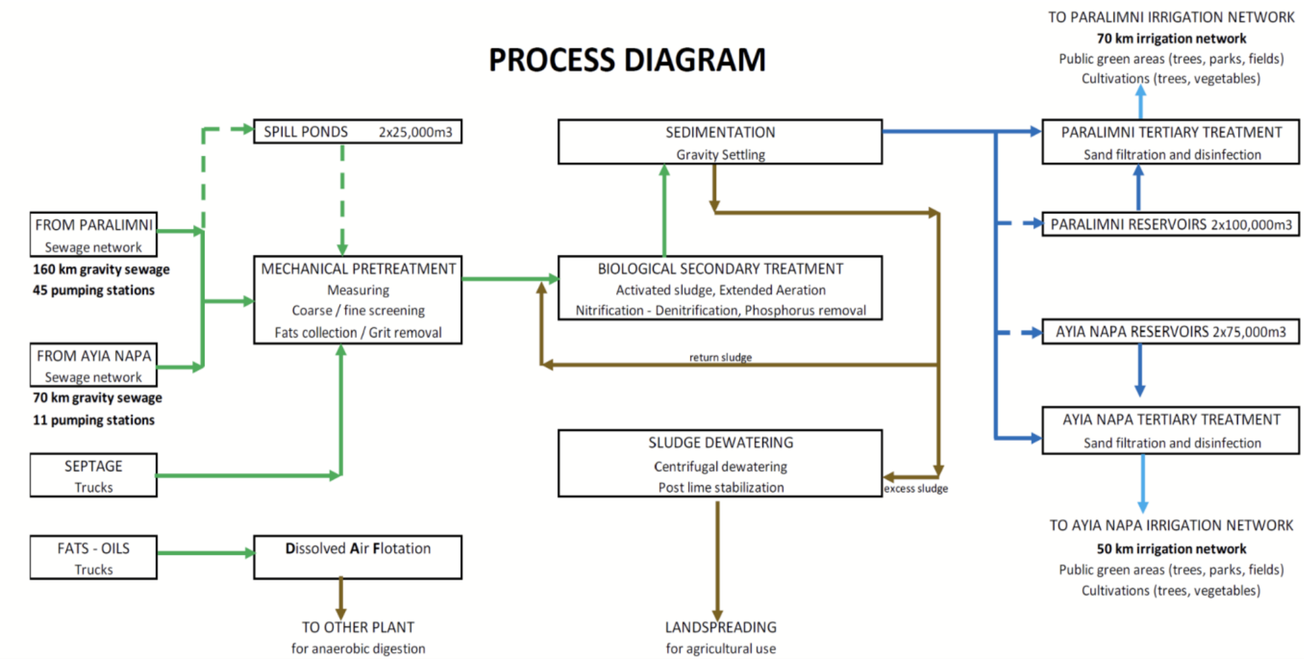

Figure 17: Flow diagram of Paralimni WWTP

The wastewater treatment plant (WWTP) has a **total hydraulic capacity of 21,600 m³/day** and can process an **organic load of up to 7,500 kg BOD_5/day**.

The influent to the plant should theoretically not exceed the following load thresholds:

- 7,500 kg BOD_5/day
- 5,415 kg/day Suspended Solids (SS)
- 1,870 kg/day Total Nitrogen
- 248 kg/day Total Phosphorus

III.1 Primary – Mechanical Treatment

The wastewater enters the treatment facility via **two separate sewer networks** and dozens of pumping stations.

- The **first network**, coming from the southwest, includes the wastewater from the **municipality of Agia Napa**, accounting for **30–50% of the total inflow**.
- The **second network**, from the northeast, includes wastewater from **Paralimni's urban core**, as well as from the tourist zones of **Kapparis, Agia Triada, Pernera, and Protaras**, accounting for **50–70% of the total inflow**.

The inflows from the two municipalities are monitored separately with two flowmeters

Upon entry to the facility, wastewater undergoes **mechanical treatment** to remove all coarse solids:

- A **20 mm coarse screen**
- **Two 3 mm fine screens**
- One **manual hand-raked screen** (non-motorized)

The motorized screens operate via **PLC timers** and are triggered by **level sensors (LCAH)** installed in the screening channels.

III.3.1. Grit and Grease Removal

Following the mechanical screening, the wastewater flows into **two pre-aerated grit and grease chambers**. These tanks are designed to separate heavier inert materials (such as sand) and fats/oils through controlled aeration.

The **mechanical pre-treatment unit is housed inside a building** and is connected to **two biofilters** (Figure 18) that effectively **reduce and minimize emissions of hydrogen sulfide (H_2S) and methane (CH_4)**, thus controlling odors and greenhouse gas emissions.

III.3.2 Dissolved Air Flotation (DAF)

The WWTP is also equipped with a **Dissolved Air Flotation (DAF) unit**, with a **maximum influent flow rate of Qmax: 14 m³/h** (Figure 19).

This unit is used primarily for the **treatment of grease and fats**, both:

- From the **central grease trap** within the facility, and
- From **external deliveries**—typically grease and oily waste collected by **tanker trucks** from food-related businesses and transported to the plant.

This upgraded DAF unit is used to **reduce the volume of fatty waste** collected from the plant's **central grease trap**, as well as **grease loads received externally**, primarily delivered to the facility via **tanker trucks**.

The DAF process effectively separates and concentrates fats, oils, and grease (FOG), improving overall plant performance and reducing the burden on downstream biological treatment processes.

Figure 18: Mechanical pretreatment

Figure 19: Dissolved air flotation Unit

III.2 Biological Treatment

The pumping and transfer needs of large volumes of liquid are handled by electric pumps, which in many cases operate on a 24-hour basis. The sludge recirculation and extraction pumping systems are considered of critical importance, and any interruption in their operation can easily cause serious problems in the treatment process.

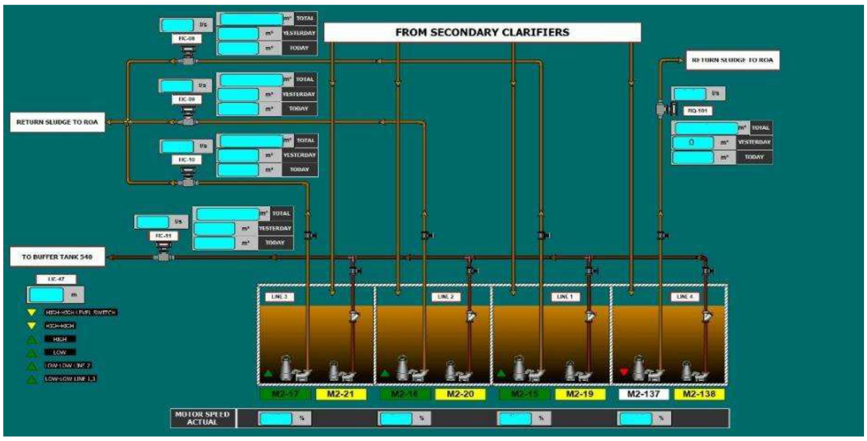

Figure 20: Flow diagram of the pumping systems for recirculation and extraction of sludge

The secondary treatment unit consists of four (4) plug-flow activated sludge bioreactors operating in extended aeration mode, with pre-denitrification and enhanced biological phosphorus removal. Each bioreactor has a total capacity of 4000 m³ and consists of ten (10) interconnected sub-tanks of 400 m³ each (Figure 21). The main treatment goals are the biological removal of organic matter, nitrogen, and phosphorus. To achieve this, anaerobic, anoxic, and aerobic conditions are applied across the sub-tanks of each operational bioreactor, facilitating the growth and activity of the respective microbial communities responsible for each biological process.

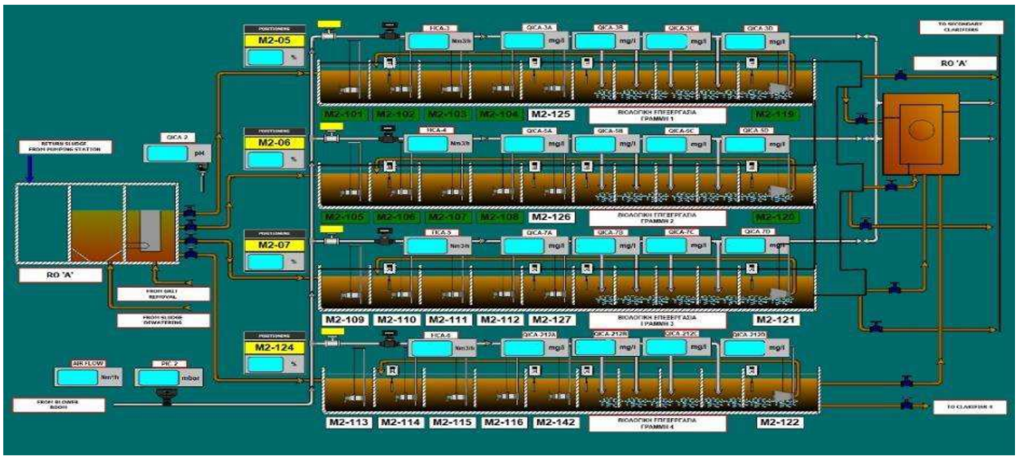

Figure 21: Flow diagram of the 4 bioreactors

The fifth sub-tank is designed as a flexible zone (swing zone) and can operate either under anoxic conditions with a mixer or under aerobic conditions with the use of aeration diffusers, in order to enhance denitrification efficiency by prolonging the residence time in the anoxic zone. From the sixth to the tenth sub-tank, **full aeration** is applied using (Figure 22). Air supply is ensured by **six blowers (**Figure 23**)**. In the tenth sub-tank, each bioreactor is equipped with an **internal nitrate recirculation propeller mixer**, which returns nitrate-rich mixed liquor to the anoxic zone through a dedicated piping system. The starting point of denitrification can be selected among the 1st, 2nd, or 3rd sub-tank, offering operational flexibility depending on the influent wastewater characteristics and secondary effluent quality. This internal recirculation strategy is managed by the operator as a control tool to optimize nitrogen removal performance.

The system was designed to allow hydraulic flexibility: each bioreactor can be connected to any of the four clarifiers. In case of mechanical or operational failure in one clarifier, the flow can be diverted to an alternative unit to maintain continuous operation.

Figure 22: Aeration tanks

Figure 23: Aeration Blowers

Each **secondary clarifier** has a diameter of 22 meters and a capacity of 1875 m³ (Figure 24). The clarified effluent is either transferred directly to the **tertiary treatment units** of Paralimni or Ayia Napa, depending on irrigation demand, or directed to four **effluent storage reservoirs**. Two of these serve Paralimni with a total capacity of 200,000 m³ , and two serve Ayia Napa with a combined capacity of 150,000 m³ (Figure 25).

Figure 24: Sedimentation tanks

Figure 25: Reservoirs of Agia Napa (left) and Paralimni (right)

The **secondary treatment unit** (bioreactors and clarifiers) forms the **core of the WWTP**. To ensure compliance with the reuse quality requirements and guarantee treatment efficiency, the joint board of the two municipalities has set internal effluent quality standards for the secondary treated effluent, listed in:

Table 2: Quality standards of the secondary treated effluent (set by the WWTP operators in order to reach the tertiary legislation limits in the final stage)

Effluent Parameter	Discharge Limits
pH	6.5 – 8.5
BOD_5 (mg/L)	< 15 mg/L (Max deviation +10%)
Suspended Solids – SS (mg/L)	< 25 mg/L (Max deviation +10%)
Total Nitrogen (mg/L)	< 10 mg/L (Max deviation +10%)
Total Phosphorus (mg/L)	< 2 mg/L (Max deviation +10%)

Most of the activated sludge is returned to the start of the biological treatment via pumps, where it mixes with the incoming wastewater. It is then evenly distributed among the bioreactors via the inlet distributor to maintain a uniform concentration of microorganisms throughout the reactor volume and the residence time of each process.
The excess sludge (WAS) is removed from the system via excess pumps and transferred to the aerated buffer tank for storage. This buffer tank can also serve as a sludge thickener, as it is equipped with an overflow channel. From the tank's bottom, the sludge is transferred to the dewatering unit by means of screw pumps.

III.3 Sludge dewatering

Given the importance and cost of sludge management (especially due to polymer consumption), **two of the old thickening/dewatering lines** were replaced with a **modern, energy-efficient system** which includes civil works, mechanical installations, new **pumps**, and a **new drum thickener and decanter centrifuge**.

The **new thickener** produces **a minimum of 20 m³/h** of thickened sludge at **40 kgTS/m³**, while the **new centrifuge** can process **up to 28 m³/h** of thickened sludge (4% DS) and deliver at least **4 m³/h of dewatered sludge** with **20% DS** (Figure 26-27).

Figure 26: Mechanical thickener and Centrifuge

Figure 27 Dewatered sludge and Slaked lime silo

III.4 Tertiary Treatment

The facility includes **two tertiary treatment lines** (Figure 28), serving separately the **municipal irrigation networks** of Paralimni and Agia Napa.

Each tertiary unit has a **dedicated treated water storage tank—6000 m³** for Paralimni (Figure 29) and **5000 m³** for Agia Napa.

- **Paralimni line capacity**: 160 L/s, distributed across **4 sand filters** at **40 L/s per filter** .
- **Agia Napa line capacity**: 120 L/s, with **4 sand filters at 30 L/s each**.

Secondary effluent passes through sand filters for **suspended solids removal**. When filters become clogged, **backwashing** is triggered, using **chlorinated water from the contact tank** (Figure 30). The backwash water (~70 m³ per cycle) is collected and **pumped back to the plant's headworks** for re-treatment.

Disinfection is done via sodium hypochlorite dosing, while **chemical phosphorus precipitation** (using coagulants and flocculants) is applied when needed to meet effluent phosphorus limits (Figure 31).

Figure 28: Tetriary treatment of Paralimni and Agia Napa


Figure 29: Balancing Tanks of Paralimni (6000m3) and Agia Napa (5000m3)

Figure 30: Disinfection tank


Figure 31: Phosphorus Chemical Precipitation Units

III.5 Emergency Storage Tanks

The plant has **two concrete emergency storage tanks** with a **total capacity of 50,000 m³** (Figure 32).Located adjacent to the mechanical pre-treatment area, they can **receive all incoming wastewater in case of malfunction**, or **balance fluctuating inflows**.

Each tank is equipped with **2 jet aerators** and **pumps** that return stored wastewater to the headworks once flow stabilizes.

Due to the **seasonal tourist inflows**, wastewater volume varies greatly:

- **Winter (e.g., Jan 2019)**: 3,500–4,500 m³/day
- **Summer (e.g., Aug 2019)**: over 21,500 m³/day

As a result, the **number of active bioreactors varies throughout the year**, as shown in Table 3: Maximum Hourly Inflow Rate per Bioreactor:

Table 3: Maximum Hourly Inflow Rate per Bioreactor

Bioreactors in Operation	Max Hourly Inflow (m^3/h)
1	225
2	450
3	675
4	900

Figure 32: SPILL PONDS

III.6 Automation and SCADA System

The entire operation is managed via a **central control center** and **local PLC stations**, transmitting all operational signals to the SCADA system.

Structure of the Tele-Control and Monitoring System:

- **The Central Control Station (CCS)** includes:
  - Computers running SCADA software
  - GSM modems for remote alerts and controls
  - Full automated control of electromechanical systems
- **Local Control Stations**:
  - Handle **analog and digital signal processing**
  - Run embedded control algorithms for each treatment zone
- **User Interface**:
  - Offers a **realistic representation of the facility**
  - Allows operators to **monitor real-time measurements**
  - Supports **manual and remote process intervention** (Figure 33)

Figure 33: Scada room

III.7 Storage of Secondary Treated Water

At described above, **four open-type secondary treated water reservoirs** operate in the WWTP, with a **total capacity of approximately 400,000 m³**. Two are used for the needs of Paralimni municipality and the other two for Ayia Napa. During winter months, when water demand slightly decreases due to occasional rainfall, but daily production still averages around **4,500–5,000 m³/day**, the surplus is stored. **Treated water is never discharged into a natural receptor.** Stored water begins to be used again as demand increases.
This idle period doesn't last long, as the favorable climate supports multiple crop cycles per field per year. For instance, potatoes are already planted in February, a crop that demands a lot of water. After harvesting, watermelons and melons are planted, and by mid-July, vegetable crops follow. In September, another crop may be planted, such as tomatoes. Essentially, the fields are productive year-round. Water demand is mainly influenced by rainfall levels rather than agricultural activity itself.
The proper practice of storing surplus water and using it during high-demand periods, which is followed at the facility, also leads to **nutrient accumulation (eutrophication)**. This creates challenges for filtering before final reuse and increases the **chlorine demand** for effective disinfection—significantly higher than usual.
Even though nutrients in the daily treated water remain at very low concentrations, during the start of summer and the increase in temperature, there is a **noticeable bloom of phytoplankton biomass**.

III.8 Water Reuse – Quality Characteristics and Types of Crops

The treated wastewater is filtered through carbon filters and disinfected with sodium hypochlorite to eliminate pathogenic microorganisms before being stored in a balancing tank. At the WWTP facilities, two such treatment lines and two corresponding final treated water storage tanks are installed. Each tank separately supplies the needs of the respective municipality. From the storage tank, and depending on demand, each municipality autonomously manages the use of treated water.

The treated water must meet certain quality standards, which are described in detail below. The Ministry of Agriculture conducts 20 scheduled samplings per year per municipality, and the Water Development Department (WDD) conducts 4 samplings per year. There are also occasional unscheduled samplings.

Irrigation is usually done through **root-level watering** (drip irrigation), although **sprinkler and mist irrigation** systems are also observed—particularly for potatoes—and **spray systems** (e.g., lawn irrigation) are used in green spaces.

The types of irrigated crops and general water uses include:

- Public green spaces (lawns, ornamental trees, shrubs, flowers, etc.)

- Football fields and other sports facilities
- Hotel facilities (lawns, ornamental plants, flowers, etc.)
- Permanent agricultural crops (e.g., olives, oranges, lemons, figs, pomegranates)
- Seasonal crops (e.g., potatoes, taro, zucchini, eggplants, tomatoes, watermelon, melon, corn, and possibly others listed in the Ministry of Agriculture's crop code)

Figure 34: Vertical crops of cucumber (left), Crops protected from their roots and direct contact with the water(right), Agia Napa 2025, *Source: Sofia Perez, ESE Laboratory, Paris Saclay University, 2025.*

III.9 Legislative Framework – Operational Limits

At the European level, the main legislative framework covering all environmental sectors is the **Water Framework Directive 2000/60/EC** (2000_60_EK, 2000), which establishes a basis for **sustainable water management** across the EU. Together with **Directive 91/271/EEC** (91_271_EOK, 1991) on **urban wastewater treatment**, these represent the **key legal instruments for the protection of water resources**. Their goals are further reinforced by **Directive 96/61/EC** (96_61_EK, 1996) concerning **Integrated Pollution Prevention and Control (IPPC)**.

In the Republic of Cyprus, the main EU directive applied is 91/271/EEC, which governs the treatment and discharge of urban wastewater. In order to protect the broader environment, the competent Ministry of Agriculture, Natural Resources and Environment developed an implementation program based on the 19 articles of the Directive. The Water Development Department (WDD) executed and applied the European Directive through national planning, conducting relevant studies and promoting the construction and implementation of sewerage systems in small communities and municipalities with an equivalent population of more than 2,000 inhabitants.Cyprus' harmonisation with **Directive 91/271/EEC** on urban wastewater treatment was achieved through the ratification and transposition of the directive into national law via relevant legislative acts and regulations.

Specifically, the main law governing the treatment of urban wastewater in Cyprus, in line with the directive's requirements, is:

- The **Sewerage Systems and Wastewater Treatment Law of 2002** (Law No. 106(I)/2002), which regulates urban wastewater treatment, licensing of treatment plants, and the technical specifications such facilities must meet.

This primary law has been **amended** by seceral times the latest by the following act: 2013 (Law No. 181(I)/2013)

In addition, other legal acts supporting the implementation of the directive include:

- The **Water Pollution Control (Urban Wastewater Discharges) Regulations of 2003** (Regulatory Administrative Act No. 772/2003), issued under the main 2002 law to further clarify and enforce its provisions.
- The **Water Pollution Control (Sensitive Areas for Urban Wastewater Discharges) Order of 2004** (RAA 111/2004)
- The **Sewerage (Amendment) Law of 2004** to the original Sewerage Systems Law of 1971 to 2001 (Law No. 108(I)/2004)

Through this legislative framework, the **Republic of Cyprus** has **fully adopted the requirements of Directive 91/271/EEC** on urban wastewater treatment, ensuring **protection of the environment and public health** from the impacts of water pollution, improving wastewater treatment infrastructure, and promoting **sustainable water resources management**.

The **Standard Management Regulation 379/2015** (2015_1_379, 2015) of Cyprus, referred to as the **Regulation for the Control of Water Pollution (General Terms for Wastewater Discharge from Urban Wastewater Treatment Plants)**, amends the previous **Standard Management Regulation 374/2003**. It introduces changes and additions to the **standards, specifications, and requirements** related to the **management of sewerage systems and urban wastewater treatment** in Cyprus.

This regulation specifically defines the **quality characteristics** of the **treated effluent** at the outlet of the final treatment stage that is intended for **irrigation reuse** (Table 4 and Table 5).

Table 4: Requirements for discharges from urban wastewater treatment plants into sensitive areas where eutrophication occurs, as defined in Annex II, point A

Parameter	**Concentration**	**Minimun reduction percentage**	**Standardized reference measurement methods**
Biochemical Oxygen Demand (BOD_5 at 20°C) without Nitrification	25 (mg/L) 0_2	70-90 % 40% according to Regulation 3, paragraph 2	A **homogenized, unfiltered, non-settled sample** is used to determine the **dissolved oxygen concentration (DO)** before and after a **5-day incubation period at 20 ± 1°C**, in **complete darkness**. A **nitrification inhibitor** is added to prevent interference from the oxidation of nitrogenous compounds, ensuring that the measurement reflects only the oxygen demand due to carbonaceous matter (CBOD).
Chemical Ocygen Demand (COD)	125 (mg/L) 0_2	75%	Homogenized, unfiltered, unsettled sample. Potassium dichromate
TSS	35 mg/L (3) 35 according to Regulation 3, paragraph 2 (for over 10,000 population equivalent)	70% according to Regulation 3, paragraph 2 (for 2,000–10,000 population equivalent)	**Filtration** of a representative sample through a membrane filter of 0.45 μm. Drying at 105°C and weighing. **Centrifugation** of a representative sample (for at least 5 minutes, at an average acceleration of 2800–3200 g). Drying at 105°C and weighing.
Total Phosphorus	60 mg/L according to Regulation 3, paragraph 2 (for 2,000–10,000	80%	**spectrophotometry**

	population equivalent)		
Total Nitrogen	• 2 mg/L P (for 10,000 – 100,000 PE) • 1 mg/L P (for more than 100,000 PE)	70-80%	**spectrophotometry**

(1) Reduction depending on the load of incoming wastewater.
(2) Total nitrogen means the sum of Kjeldahl nitrogen (organic nitrogen and NH_3), nitrate nitrogen (NO_3), and nitrite nitrogen (NO_2).
(3) Alternatively, the daily average must not exceed 20 mg/L N. This requirement refers to a water temperature of at least 12°C during the operation of the wastewater treatment plant's bioreactor. Instead of the temperature condition, a limited operational period may be applied, depending on local climatic conditions. This alternative is valid provided that the conditions set out in paragraph 1 of Part B of the Annex are demonstrably met. Depending on local conditions, one or both parameters may be applied. Either the concentration value or the reduction percentage is applied.

Table 5 : Quality Characteristics of Treated Wastewater Intended for Irrigation Use (Cyprus National Standards)

Parameter	**Permissible limits – All crops & public green areas with unrestricted access (a)**	**Vegetables cooked before consumption (b)**	**Products for human consumption (non-raw), green areas with restricted access**	**Fodder crops**	**Industrial crops**
Biochemical Oxygen Demand (BOD_5)	10 mg/L	10 mg/L	25 mg/L	25 mg/L	25 mg/L
Chemical Oxygen Demand (COD)	70 mg/L	70 mg/L	–	–	–
Suspended Solids (SS)	10 mg/L	10 mg/L	–	–	–
Fats and Oils	5 mg/L	5 mg/L	5 mg/L	5 mg/L	5 mg/L
Intestinal Coliforms (E. coli)	5 E. coli / 100 ml	50 E. coli / 100 ml	200 E. coli / 100 ml	200 E. coli / 100 ml	200 E. coli / 100 ml
pH	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5
Electrical Conductivity	2500 μS/cm	2500 μS/cm	2500 μS/cm	2500 μS/cm	2500 μS/cm
Chlorides (Cl^-)	300 mg/L	300 mg/L	300 mg/L	300 mg/L	300 mg/L
Boron (B)	1 mg/L	1 mg/L	1 mg/L	1 mg/L	1 mg/L

Residual Chlorine	2 mg/L	2 mg/L	2 mg/L	2 mg/L	2 mg/L

Notes:
(a) Irrigation of leafy vegetables, bulbs and tubers consumed raw, and strawberries is prohibited.
(b) Includes potatoes and sweet potatoes.
(1) BOD_5 analysis method must be performed with nitrification inhibition.

Regulation (EU) 2020/741 on Water Reuse

The **Regulation (EU) 2020/741** on minimum requirements for water reuse is directly applicable and binding on all Member States.It sets out the **quality classes of reclaimed water**, the corresponding agricultural uses, and the acceptable irrigation methods. It also specifies **minimum water quality parameters and monitoring requirements** to ensure the safe use of reclaimed water under an integrated water resources management approach (Table 6 and Table 8).

Table 6 Quality classes of reclaimed water, permitted agricultural use and irrigation methods.

Minimum reclaimed water quality class	Crop category*	Irrigation method
A	All food crops consumed raw where the edible part is in direct contact with reclaimed water; root crops consumed raw	All irrigation methods
B	Food crops consumed raw where the edible part is produced above ground and not in direct contact with reclaimed water; processed food crops; non-food crops including feed for dairy and meat-producing animals	All irrigation methods
C	Food crops consumed raw where the edible part is produced above ground and not in direct contact with reclaimed water; processed food crops; non-food crops including feed for dairy and meat-producing animals	Drip irrigation** or other methods avoiding direct contact with the edible parts of the crop
D	Industrial, energy and seed crops	All irrigation methods***

Table 7 Quality requirements of reclaimed water for agricultural irrigation

Reclaimed water quality class	Indicative treatment objective	E. coli (cfu/100 ml)	BOD5 (mg/L)	TSS (mg/L)	Turbidity (NTU)	Other requirements
A	Secondary treatment, filtration and disinfection	≤ 10	≤ 10	≤ 10	≤ 5	*Legionella spp.*: < 1,000 cfu/L when aerosolisation risk exists; Helminth eggs ≤ 1 egg/L for irrigation of pastures or forage crops

Reclaimed water quality class	Indicative treatment objective	E. coli (cfu/100 ml)	BOD5 (mg/L)	TSS (mg/L)	Turbidity (NTU)	Other requirements
B	Secondary treatment and disinfection	≤ 100	According to Directive 91/271/EEC (Annex I, Table 1)	According to Directive 91/271/EEC (Annex I, Table 1)	–	–
C	Secondary treatment and disinfection	≤ 1,000	–	–	–	–
D	Secondary treatment and disinfection	≤ 10,000	–	–	–	–

A comparison between the **Cypriot national standards** for treated wastewater reuse and the **European framework under Regulation (EU) 2020/741** shows both alignment and divergence. Cyprus, having a long tradition in reuse, has developed detailed standards that are generally stricter in certain physicochemical parameters (COD, SS, pH, conductivity, residual chlorine), and also explicitly prohibited the use of reclaimed water for the irrigation of leafy vegetables, bulbs, tubers and strawberries consumed raw, reflecting a precautionary approach to protect public health. The EU Regulation, on the other hand, focuses primarily on microbiological quality (E. coli) and introduces a tiered classification system (A–D) linking water quality directly to crop type and irrigation method, leaving flexibility to Member States for additional requirements.

IV. Operation

IV.1 Monitoring plan

Monitoring is conducted at three levels:

- Regulatory: 20 samplings/year by the Ministry of Agriculture and 4/year by WDD.
- Operational: Continuous for sensor-based monitoring for key parameters (flows, DO, Turbidity)
- Lab analysis: all the parameters in Table 8, and Visual and microscopic inspection: Biomass health, and filamentous growth.

Data is reviewed by trained WWTP staff who adjust aeration, sludge retention times, and chlorine dosing accordingly.

Daily sampling from the treatment stages is conducted following **defined procedures and a sampling schedule** provided by the consortium's sewerage board, which sets the **minimum required sampling frequency** (Table 8).

The methodology includes:

- **Instant grab sampling**
- Use of **24-hour composite samplers** to ensure continuous monitoring of wastewater quality throughout treatment

Specifically, 24-hour samplers are placed:

- At the **inlet manhole** to sample the incoming raw wastewater
- At the **overflow outlet** of the secondary clarifiers
- At the outlets of both **tertiary treatment lines** (Ayia Napa and Paralimni)

Sampling is conducted by collecting **50 mL samples** every **30 minutes**, ensuring that an adequate volume is gathered to calculate an **average daily concentration** of key quality parameters.

Table 8: Minimum internally planned sampling and quality control in the different treatment stages

Parameter	Inlet	Outlet (tertiary treatment)	Secondary treatment	Bioreactors	Recirculation
PH	DAILY	DAILY	DAILY	DAILY	DAILY
Conductivity	DAILY	DAILY	DAILY	DAILY	DAILY
TSS	DAILY				
MLSS				DAILY	DAILY
SVI				DAILY	
BOD_5	3/WEEK	3/WEEK	3/WEEK		
COD	DAILY	DAILY	DAILY		
$N\text{-}NH_4$	DAILY	DAILY	DAILY		
$N\text{-}NO_3$	5/WEEK	5/WEEK	5/WEEK		
$N\text{-}NO_2$			3/WEEK		
N-total	3/WEEK	3/WEEK	3/WEEK		
P-total	3/WEEK	3/WEEK	3/WEEK		
Temperature	DAILY	DAILY	DAILY	DAILY	DAILY
Intestinal Warms		2/WEEK			
E-Coli		2/WEEK			
$f.Cl_2$		DAILY			
Cl-			DAILY		
Flow/Quantity	DAILY	DAILY	DAILY		DAILY

IV.2 WWTP Operation study

All processes and their main electromechanical equipment, as well as the corresponding energy consumption, were studied based on the operation data of the last 4 years (2021–2024) in order to **assess the overall energy efficiency of the WWTP, identify potential areas for optimization, and evaluate the impact of the recent energy upgrades on treatment performance and operational costs**. Data were collected to record all inflow and outflow streams of the plant in order to calculate and compare specific energy consumption factors across the full treatment process, within the system boundaries.All **primary data** used are the **property of the Sewerage Board** of the Paralimni–Ayia Napa and were derived from **daily records and laboratory chemical analyses**, performed by the monitoring laboratory of the facility.

Data Collection

To complete the inventory analysis, the data collected and evaluated regarding energy and the quality characteristics of the facility under study based on the operators' recording with the full support of the plant's **operational manager and water quality control officer for irrigation reuse,** Dimitri Tzelio.
The data span a period of **4 years**, and in some cases includes data for the last 10 years in order to check the efficiency of the plant with the energy efficiency upgrade deployed in 2018. The data collection and analysis were conducted through various monitoring and measurement procedures, including:

- **Daily recordings of energy consumption**
- **Daily sampling** from control points, followed by **laboratory analysis of quality parameters**

Energy Monitoring Systems
The **energy consumption data** for the operation of the WWTP come **exclusively from the energy meters** installed and monitored by the **Electricity Authority of Cyprus (EAC)**.
There are **three main energy meters** within the plant's system boundaries:

1. One meter covers the **pre-treatment**, **secondary treatment**, **sludge pumping systems**, and **dewatering unit**.
2. The second meter monitors the **tertiary treatment of Paralimni**.
3. The third covers the **tertiary treatment of Ayia Napa**.

VI.2.1. Hydraulic and Organic Loading Profile of the WWTP

The WWTP operation is fully aligned with the seasonal population variations throughout the year. During the winter period (November–March), the plant handles wastewater from residents, a small number of tourists, and workers (mostly from the construction sector). The area is undergoing rapid development, with new hotel units increasing the wastewater volume annually.
In winter, the average inflow is around **4,500 m³/day**, corresponding to an **equivalent population of 25,000**. During this period, only one of the four biological reactors is in operation. As the summer season approaches and tourist numbers rise, the WWTP prepares for a **nearly fivefold increase in wastewater volume**, reaching up to **31,500 m³/day** (with an annual growth rate of ~500 m³/day). By **April**, a second reactor is put into operation, and by the **end of May**, all four reactors are fully operational.
The tourist season lasts approximately six months, and from **October to December**, the number of operating reactors is gradually reduced back to one. The seasonality of the inflow is shown in Figure 35.The plant has the capacity to treat **over 10 million cubic meters annually**. On Table 9 the annual production of reclaimed water in Paralimni WWTP is shown for the last 10 years.

Table 9: Annual production of reclaimed water

YEAR	Mm^3/yr produced and reused for irrigation
2014	3.2
2015	3.3
2016	3.6
2017	3.9
2018	4.1
2019	4.8
2020	2.7
2021	3.4
2022	4.0
2023	4.6
2024	4.8

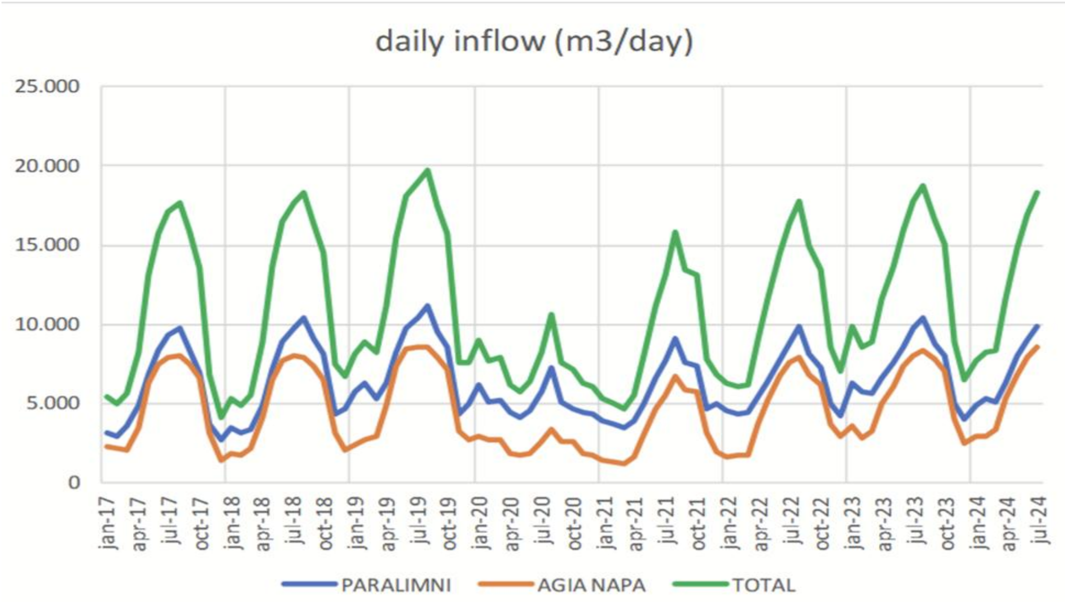

Figure 35: Daily inflow in the WWTP from Paralimni and Agia Napa

VI.2.2. Performance

A treatment system that performs its functions efficiently and effectively is essential for the evaluation of comparable measurements and events. In Figure 36,Figure 37,Figure 38,Figure 39, the percentage removal efficiency of key pollutants—**BOD_5, COD, Total Nitrogen (N_tot), and Total Phosphorus (P_tot)**—is presented, based on a time series of **monthly average concentration values**.

This data allows for performance tracking over time and supports the optimization of the biological and chemical treatment stages.

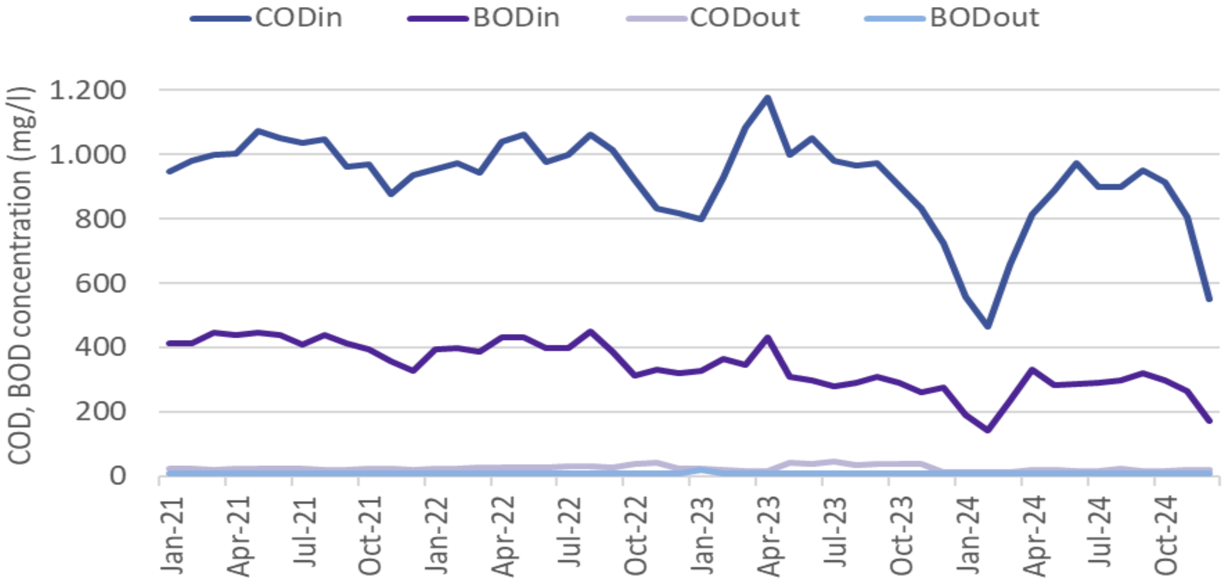

Figure 36:COD and BOD concentration in the influent and secondary effluent of the Paralimni WWTP within the last 4 years.

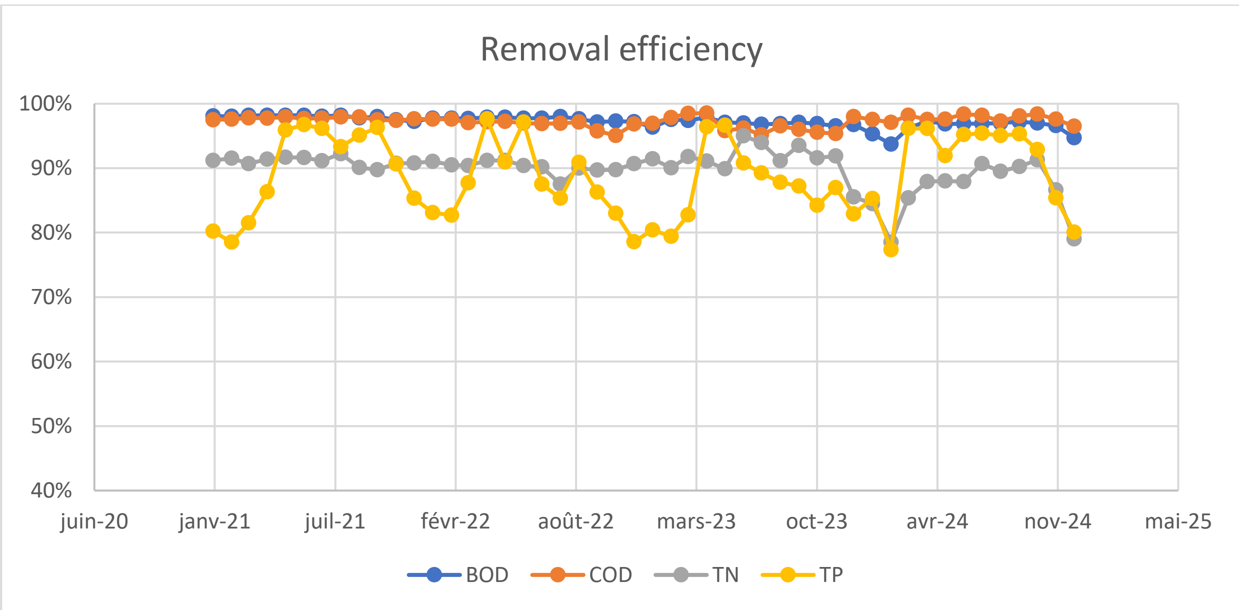

Figure 37: Removal efficiency organic compounds and nutrients in Paralimni WWTP within the last 4 years.

Figure 38: The effluent quality regarding the BOD and TSS concentration regarding the respective legislative limits.

Figure 39: TSS removal in Paralimni WWTP within the last 4 years.

As clearly demonstrated in by the graphs above, the overall process performance regarding the removal of organic matter and nutrients is consistently high. All the parameters in the outflow are constantly lower than the respective limits of the legislation. All effluent parameters remain well below the respective legislative limits. BOD and COD removal rates consistently exceed 98%, total nitrogen (TN) removal is above 90%, and total phosphorus (TP) removal exceeds 80%. It was observed by the operators that the **energy upgrade of critical electromechanical equipment**, e.g. the replacement of the air diffusion network (diffuser system) led to better treatment outcomes under the same sludge retention times. The COVID-19 period was undeniably an unprecedented experience that brought about major lifestyle and behavioural changes. These changes were reflected not only in the volume of wastewater produced but also in the concentration of pollutants and the overall performance of the treatment system.

VI.2.3. Tertiary treated effluent

The Paralimni–Agia Napa WWTP operates two parallel tertiary treatment lines, both producing high-quality effluent consistently suitable for agricultural reuse and irrigation of public green spaces. Monitoring data collected the last 18 months (within AWARD project) confirm that both outlets deliver effluent values well below the thresholds set by **Cypriot reuse legislation** and the **EU Regulation (EU) 2020/741** on minimum requirements for water reuse.

The average concentrations from the Ayia Napa outlet and the Paralimni outlet are presented in Table 10, together with the corresponding legal limits. Results show that organic matter removal is excellent, with COD averaging ~17 mg/L and BOD_5 consistently at or below 10 mg/L, thereby meeting both Cypriot and EU requirements. Suspended solids are reduced to less than 2 mg/L, far below the 10 mg/L limit. Nutrient levels also remain low, with Total Nitrogen averaging between 5.8–6.2 mg/L and Total Phosphorus close to 1 mg/L, values that support compliance with Cyprus' stricter reuse conditions.

Microbiological quality is equally strong: **E. coli counts were consistently <5 CFU/100 mL**, thus meeting the **Class A category** under EU Regulation 2020/741 and the even stricter Cypriot limit of ≤5 CFU/100 mL. Turbidity, a key indicator of disinfection performance, was maintained at ~0.25 NTU, well below the EU limit of 5 NTU.

Operational parameters also confirm robust performance. pH remained stable, averaging 9.1 in Ayia Napa and 7.8 in Paralimni, values within or close to the acceptable ranges. Free chlorine concentrations averaged 0.7–0.72 mg/L, ensuring effective disinfection, though aligned with the residual chlorine allowable range for Cyprus (≤2 mg/L). Conductivity was ~2.0 mS/cm, comfortably below the 2.5 mS/cm limit specified nationally.

Table 10 Reclaimed Water Quality (Average Values 2024–2025) vs Cyprus and EU regulation limits

Parameter	Ayia Napa (avg)	Paralimni (avg)	Cyprus Standards (reuse)	EU Reg. 2020/741 – Class A
COD (mg/L)	16.7	16.9	≤ 70	–
BOD_5 (mg/L)	10.0	10.0	≤ 10	≤ 10
TSS (mg/L)	1.95	1.95	≤ 10	≤ 10
pH	9.1	7.8	6.5–8.5	6.0–8.5
E. coli (/100 mL)	<5*	<5*	≤ 5	≤ 10
Turbidity (NTU)	0.25	–	–	≤ 5
Conductivity (mS/cm)	2.04	2.04	≤ 2.5	–
Free Chlorine (mg/L)	0.70	0.72	≤ 2	-
Total Nitrogen (mg/L)	6.2	5.8	≤ 15	–
Total Phosphorus (mg/L)	1.0	1.1	≤ 2	–

** Based on monitoring logs where values were often below detection or reported as zero.*

In practice, the effluent quality from both outlets of the Paralimni–Agia Napa WWTP not only complies with the EU's **Class A requirements** but also satisfies Cyprus' more comprehensive standards. This positions the facility as a benchmark case for safe, reliable, and socially accepted wastewater reuse in the Mediterranean region.

The results clearly demonstrate that the Paralimni–Agia Napa WWTP consistently delivers **tertiary treated effluent of excellent quality**, fit for unrestricted irrigation of crops consumed raw, as well as for landscaping and tourism-related uses. The alignment with both Cypriot and EU standards confirms the plant's capacity to support long-term water reuse strategies in Cyprus. Moreover, the monitoring upgrades introduced under the AWARD project strengthen transparency and operational control, further ensuring compliance and building trust among end-users.

VI.2.4. Energy Consumption

The following graphs record the electrical energy consumption in kilowatt-hours (kWh) and the volume of incoming wastewater in cubic meters (m^3). Based on this data, the specific energy consumption coefficient for the first period 2021-2024 is 0.672 kWh/m^3. Based on previous reports the period 2013–2017 (before the energy upgrade of the plant), the respective value was 0.772 kWh/m^3,
During the period 2013–2017, a parallel increase in both electricity consumption and influent volumes is observed. However, the coefficient exhibited significant fluctuation: it decreases from 2013 to 2015 and increases again by 2017. This variation is mainly due to increased energy demands for addressing filamentous growth and mitigating its effects on sludge settleability and dewatering processes.
The reductions in both energy consumption and wastewater inflow between 2020 and 2022 are attributed to the decline in tourist arrivals during the COVID-19 pandemic. Nevertheless, the specific energy coefficient during the second period shows a significant reduction compared to the first.
According to Tchobanoglous et al., wastewater treatment plants using activated sludge processes and treating more than 100,000 m^3/day typically have a specific energy consumption of 0.28 kWh/m^3 on average, with this value doubling for plants treating around 10,000 m^3/day (Siatou et al., 2020).
In a 4-year monitoring study (2014–2017) of a treatment plant in southern Italy with an average flow of 157,000 m^3/day, di Cicco et al. (2019) calculated a mean specific energy consumption of 0.18 kWh/m^3.
Siatou et al. (2020) examined energy consumption in 17 municipal wastewater treatment plants in Greece, with average influent flows ranging from 300 to 27,350 m^3/day. Indicative values from plants located in coastal and tourist areas include: Agios Nikolaos (0.74 kWh/m^3), Elounda (0.44 kWh/m^3), Nea Kydonia (0.63 kWh/m^3), Lavrio (0.8 kWh/m^3), Chrysoupoli (0.76 kWh/m^3), and inland plants like Florina (0.49 kWh/m^3) and Karditsa (0.13 kWh/m^3), with the latter benefiting from higher volumetric flows.

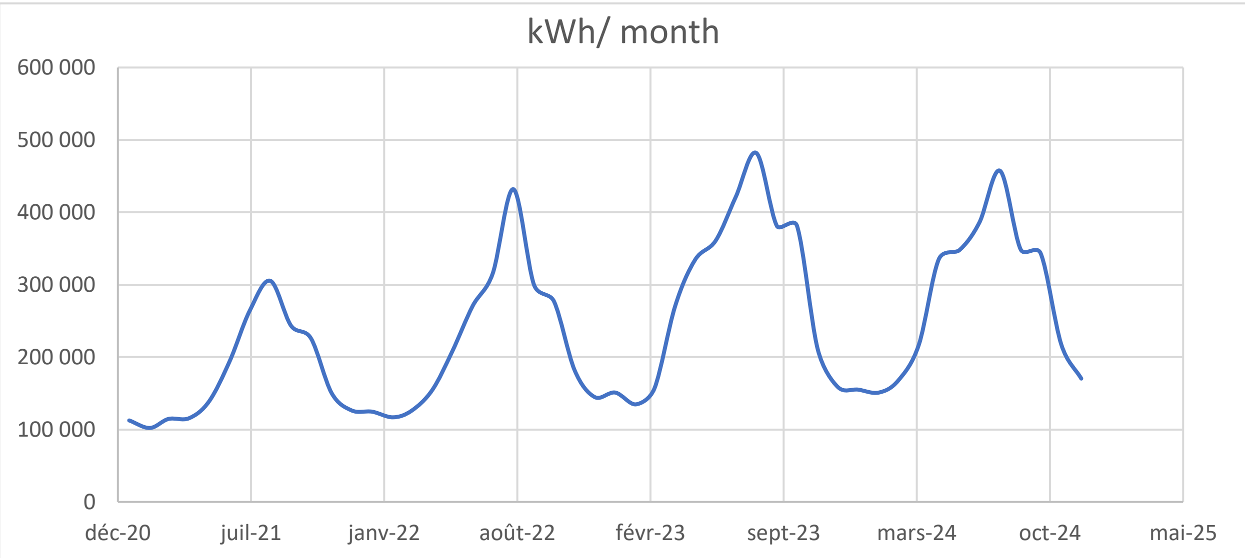

Figure 40: Monthly rates of the energy consumption in kWh within the last 4 years.

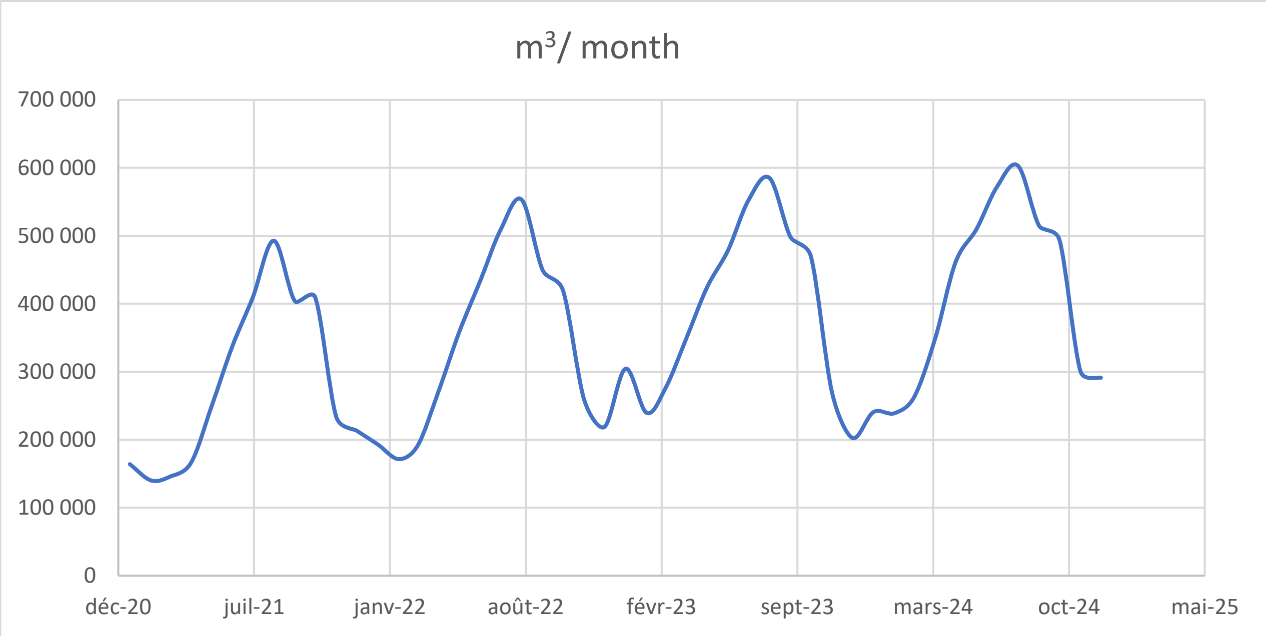

Figure 41: Monthly values of the WWTP's inflow in Paralimni.

Plotting the energy consumption for the last 4 years divided in summer and winter period we can see a low but clear differentiation, as in the higher flows and demands of the summer period the consumption is raised to 0.71 kWh/m^3, compared to 0.65 kWh/m^3 for the winter period. The respective population equivalent in winter period varies from 26000-56300 p.e. and the summer from 62527-111658 p.e.

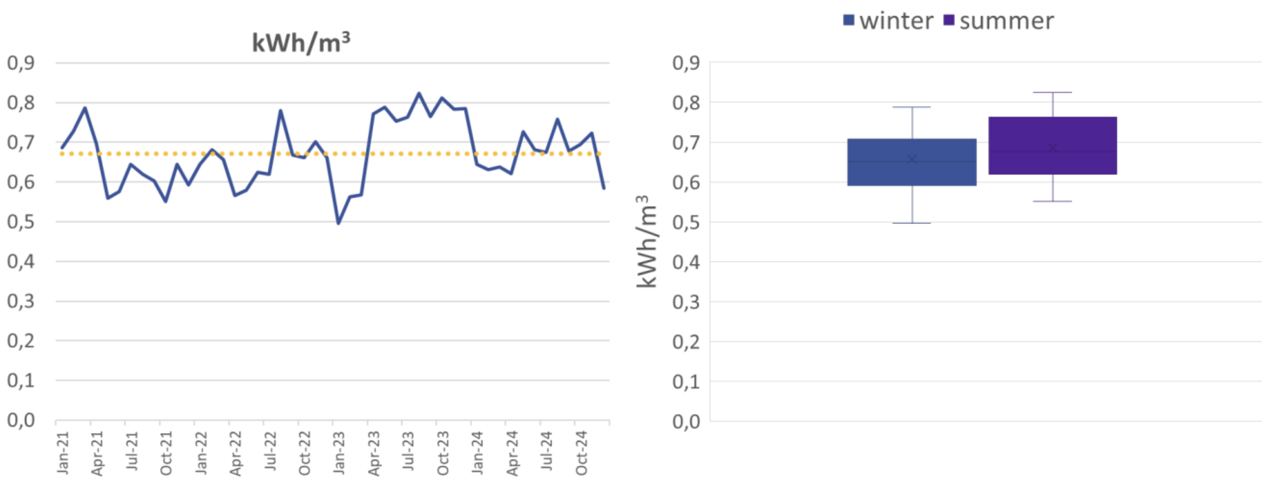

Figure 42: WWTP's energy consumption per inflow (kWh/m³) and seasonal variation (summer/winter) in energy demand.

The Siatou et al. (2020) investigation in the energy consumption of 17 municipal wastewater treatment plants (WWTPs) in Greece, with average influent flows ranging from 300 to 27,350 m^3/day, presented the respective values for the kWh/ p.e.d. for plants operating primarily in coastal and touristic areas:

- **Agios Nikolaos**: 0.1 kWh/ p.e ·d
- **Elounda**: 0.125 kWh/ p.e ·d
- **Nea Kydonia**: 0.85 kWh/ p.e ·d
- **Lavrio**: 0.9 kWh/ p.e ·d
- **Chrysoupoli**: 1.1 kWh/ p.e ·d
- **Florina**: 1.15 kWh/ p.e ·d

- **Karditsa**: 0.05 kWh/p.e·d

The lower energy intensities in some plants are attributed to their higher volumetric loads.

In a broader review of energy consumption in wastewater treatment plants across Greece, Christoforidou (2019)—using data from the national WWTP database (YPEKA, 2019), the European EEA database (2019), and energy data from 61 operational plants—calculated the average specific energy consumption at **0.136 kWh/p.e·d**.

Mamais et al. (2015) and Goliopoulos et al. (2022) also studied energy consumption per population equivalent across several WWTPs and found that for Greek plants, the specific consumption ranges between **0.04 to 0.72 kWh/ p.e ·d**, with a depending on the plant scale (Figure 43).

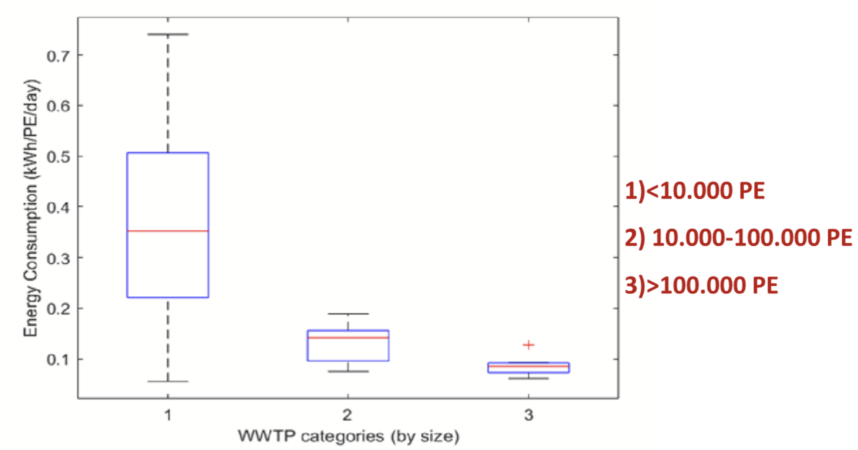

Figure 43: Average energy consumption of different scales of Greek WWTPs (Mamais et al, 2022)

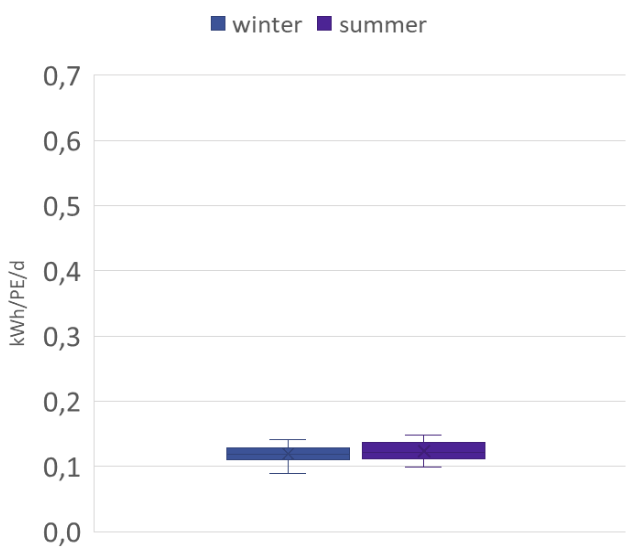

Figure 44: Kwh/PE/d for winter and summer periods as an average for the period Jan2021-December 2024

In Figure 44 the kWh/pe/d is illustrated for the winter and summer period in Paralimni WWTP for the last four years. The consumption rate is close and below the average values given in Figure 43 for this scale of WWTPs.

Table 11 presents the evolution of specific energy consumption indicators for the Paralimni–Agia Napa WWTP over a 10-year period, based on the operators' report for these periods, highlighting significant improvements between the two sub-periods (2013–2017 and 2018–2024).

A clear overall improvement in energy efficiency is observed across all indicators following the energy upgrades implemented around 2018. Specifically, the electricity consumption per cubic meter of influent decreased from 0.7720 kWh/m³ in the first period to 0.6107 kWh/m³ in the second, reflecting enhanced operational efficiency. Similarly, electricity consumption per PE dropped by over 25%.

The energy required to remove pollutants also declined substantially. For example, electricity per BOD_5 removed decreased from 1.89 to 1.41 kWh, and electricity per Total Nitrogen removed from 15.2 to 10.57 kWh, indicating more efficient biological treatment processes. The reduction in electricity per Total Phosphorus removed (from 79.7 to 66.0 kWh) suggests a notable improvement in phosphorus precipitation and sludge handling systems.

These trends demonstrate the positive impact of targeted energy upgrades (e.g., diffuser network replacement, modern pumps) not only in reducing energy consumption but also in improving treatment performance per unit of pollutant removed.

Table 11: Specific consumption coeficients.

Parameter	1st Period (2013–2017)	2nd Period (2018–2024)	Overall (Decade) (2013–2024)
Electricity per m³ (kWh/m³)	0.7720	0.6107	0.6879
Electricity per PE (kWh/PE)	0.1134	0.0839	0.0971
Electricity per BOD_5 removed	1.8934	1.4111	1.6352
Electricity per COD removed	0.6562	0.5912	0.6244
Electricity per Total N removed	15.2001	10.5661	12.6340
Electricity per Total P removed	79.7160	66.0344	72.7366
Electricity per DS removed	2.6330	2.2887	2.4615

IV.3 Upgrade monitoring plan

No structural or civil construction took place during the upgrade phase; instead, the interventions focused on **smart instrumentation, process control, and operational fine-tuning** to improve plant performance and monitoring without physical disruption. These targeted enhancements emphasized automation, transparency, and energy optimization. The main interventions included:

Instrumentation and Monitoring Upgrades

- **Installation of online sensors** in critical points of the treatment process and storage reservoirs, specifically for:
  - Chlorophyll-a – monitoring algal activity and early detection of blooms in effluent reservoirs;
  - Ammonia (NH_4^+) – real-time assessment of nitrification efficiency and overall biological treatment performance;

- Residual Chlorine – continuous verification of disinfection effectiveness and compliance with reuse criteria;
    - Oxidation–Reduction Potential (ORP) – monitoring redox conditions to optimise disinfection processes and biological stability;
    - Energy Meters – multi-point monitoring of blowers and pumps to evaluate energy demand and identify opportunities for efficiency improvements.
- **Integration of sensor data into the SCADA system**, enabling:
    - Real-time monitoring and control across treatment stages;
    - Alarm-based response mechanisms to deviations in performance;
    - Historical data logging and trend analysis to support process optimization.

These **non-intrusive upgrades** will improve the plant's **transparency, responsiveness, and resilience**, while requiring basic investment and no structural modifications, thus highlighting the sustainability of enhancing existing infrastructure without the need for new construction

Energy Monitoring and Reporting Enhancements

In parallel, a **comprehensive energy monitoring system** was established with the **installation of 9 additional energy meters** across key electromechanical units of the WWTP. These meters were placed strategically to capture high-resolution data and support process-level energy optimization. The energy-related upgrades enabled:

1. **Detailed sub-metering** of energy consumption per treatment stage (e.g., aeration, pumping, sludge management).
2. **Separation of energy loads** associated with critical units such as blowers, return pumps, and excess sludge systems.
3. **Continuous monitoring of energy use**, enabling operators to detect inefficiencies or abnormal consumption patterns.
4. **Integration of energy data into the SCADA system**, alongside process parameters, to allow combined performance and energy efficiency assessment.
5. **Calculation of specific energy consumption indicators** (e.g., kWh/m³, kWh per kg BOD/COD/N/P removed) per unit operation.
6. **Automated energy reporting**, supporting the generation of monthly and annual energy profiles.
7. **Comparative energy benchmarking**, both internally (across time) and externally (against literature and similar facilities).
8. **Support for cost optimization strategies**, through identification of high-consumption zones or units.
9. **Evidence-based planning for further energy efficiency investments**, such as motor upgrades or aeration system optimization.

Figure 45 show the upgrade energy monitoring, integrated in the existing systems.

Figure 45: New energy meters installed.

In Figure 46 presents the updated flow diagram of the Paralimni WWTP, highlighting the strategic placement of newly installed online sensors. These sensors were integrated at key treatment stages to enable real-time monitoring of critical parameters such as ammonia, chlorophyll-a, and residual chlorine. This enhanced monitoring setup improves process control, ensures compliance with reuse standards, and supports data-driven operational decisions.

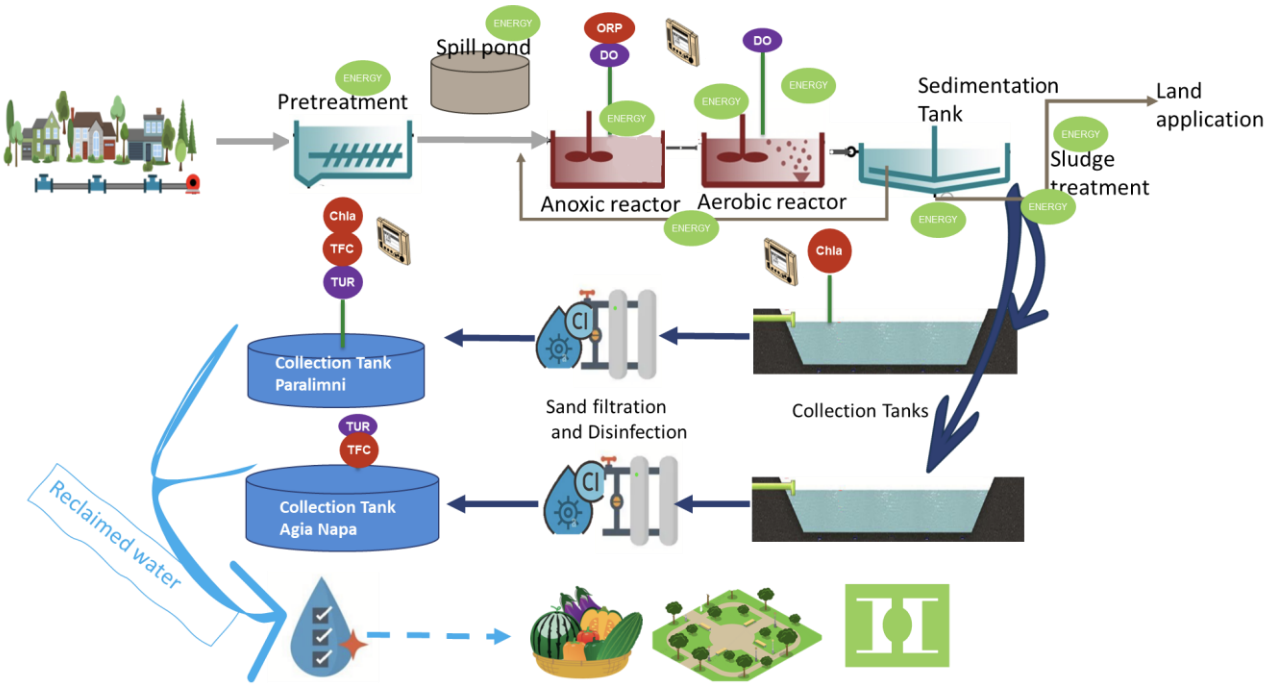

Figure 46: Flow diagram of WWTP of Paralimni with the new online sensors

Table 12: New online sensors selected for the WWTP of Paralimni

Parameter	Sensor Type	Purpose
Chlorophyll-a	Fluorometric sensor	Detect early signs of algal blooms
Ammonia	Ion-selective electrode	Track biological treatment efficiency
Energy meters	Electrical energy meter	Monitor and optimize energy consumption (e.g., blower speed)
ORP(Oxidation-Reduction Potential)	ORP sensor (electrochemical)	Monitor oxidation-reduction conditions in biological processes
Residual chlorine	Amperometric sensor	Ensure proper disinfection and safeguard effluent quality

A specific selection of cutting-edge sensors was developed with the goal of offering real-time monitoring of critical parameters that directly affect treatment efficiency, energy use, and effluent quality in order to improve the Paralimni–Agia Napa WWTP's operational control and environmental performance. The sensors that were chosen include energy meters, ORP sensors, residual chlorine analyzers, ion-selective electrodes for ammonia, and fluorometric probes for chlorophyll-a. The importance of these factors for process improvement, early operational anomaly identification, and regulatory compliance determined their ranking. For example, the installation of a fluorometric chlorophyll-a sensor enables the early detection of possible algal blooms in regions used for the storage or discharge of treated wastewater.

ORP sensors will track redox conditions that are essential for regulating the aerobic and anoxic phases, while ammonia sensors will assist in assessing the effectiveness of the biological treatment, specifically nitrification. Before being reused or released, residual chlorine sensors make sure that the right disinfection levels are maintained.

The sensors will be placed at key locations along the treatment train and discharge outlets, such as the biological reactor effluent (ammonia, ORP), the effluent channel (residual chlorine, chlorophyll-a), and the primary energy-consuming components like the aeration system (energy meters). The grab-sampling regime will be enhanced by this extra layer of high-frequency data, which will allow for quick reaction to deviations and real-time control schemes. Energy meters, for instance, will make it possible to continuously monitor electricity usage, enabling aeration blower operation to be optimized based on real demand.

As a result, the monitoring plan will be significantly upgraded from periodic with extra online sensors installation. This will allow plant operators to adjust operational parameters dynamically, based on live data, reducing the risk of non-compliance events and minimizing resource consumption. The collected data will also feed into performance dashboards and will support reporting to regulatory bodies, while creating a solid baseline for future upgrades or digital twin development. Overall, the integration of these sensors represents a shift from reactive to predictive plant management.

IV.4 Problems faced

Some challenges were encountered regarding the implementation of the upgraded monitoring system, particularly regarding the procurement of probes. Delays arose due to institutional and financial changes. The abolishment of the PSB and the establishment of the EOAA as the new operational authority led to administrative and bureaucratic delays. In parallel, the procurement process was further complicated by increased costs related to customs duties imposed by the United States on products imported into the

European Union, affecting the collaboration with the supplier HACH. Although the offer and order have been finalized, financial negotiations had to take place to manage these unforeseen budgetary increases. As of now, the probes have been successfully purchased, delivered, and installed, marking the completion of this component despite the earlier setbacks.

V. Social activities within DC#3

As part of the social and stakeholder engagement activities for Demo Case 3 in Cyprus, a series of coordinated actions were designed and implemented to better understand local dynamics, mobilise interest, and promote a shared vision for water reuse. These activities played a central role in bridging the technical progress of the demo with the institutional and social context, ensuring that reclaimed water was not only technically feasible but also accepted and embedded in local governance practices. They included both in-person and online meetings, involving stakeholders across different governance levels (municipal, district, national) and user groups (farmers, hotels, public authorities, consultants).

Throughout the project period, online stakeholder meetings were organised with Cypriot actors, providing a platform for continuous dialogue, exchange of views, and follow-up of demo progress. These online sessions enabled the project team to maintain a steady flow of information with partners in Cyprus and ensured the communication and connection to key stakeholders. Importantly, these online exchanges also provided the opportunity for stakeholders to raise their challenges, concerns and for the project team to exchange knowledge and operational details. Also, it help out AWARD team to understand better the organisation of Cyprus community and the governance around the water issues.

In April 2025, an extensive **on-site mission** was carried out in the Paralimni–Agia Napa area, marking a turning point in stakeholder engagement. During this mission, interviews were conducted with a wide range of relevant stakeholders, including representatives of the Agricultural Institute, the Water Development Department, the Municipality of Agia Napa (green spaces department), the Agricultural Department of Famagusta, the Ministry of Tourism, as well as farmers, hotel owners, and policy consultants (Figure 47). This exercise allowed us and WP3 partners to gain a deeper understanding of the diverse needs, expectations, and reservations across different sectors. Farmers expressed strong interest in securing stable and affordable irrigation water, particularly highlighting the comparative advantage of reclaimed water supply and its necessity for the business (agricultural activities that otherwise would be abandoned or hotel business that enables them to keep a high quality of environment and services). At the same time, they underlined the importance of guaranteed safety and transparent monitoring results, noting that they are sure about the quality but more regular information would be appreciated. Latest, the governmental stakeholders, such as the Water Development Department and the Agricultural Department of Famagusta, highlighted the persistent challenge of ensuring a **fair allocation of limited water resources** among agriculture, tourism, households, and the environment, especially as available volumes have sharply decreased in recent years. They also underlined that social acceptance of reuse in Cyprus was not immediate but the result of **many years of methodical effort**, with awareness campaigns, regulation, and gradual implementation slowly building public trust. Today, this long process has led to a cultural shift: reclaimed water is not only widely accepted for irrigation but is increasingly requested by residents themselves, even for household uses, reflecting how carefully managed governance can turn skepticism into strong demand.

Complementing the interviews, a **guided tour of the Paralimni–Agia Napa WWTP** was organised with the participation of plant operators and representatives of EOAA (Figure 48). The full day tour provided an opportunity to the technical partners for an extensive discussion on the monitoring plan and the extra opportunities for improvement that may exist.

A milestone in the social activities was the organisation of a **Local Water Forum (LWF) in June 2025**, which brought together a broad and diverse audience of local actors (Figure 49). The event was designed to serve multiple purposes: raise awareness about the upgraded WWTP and its role in safe and efficient reclaimed water reuse, provide a neutral space for open debate among stakeholders with sometimes competing interests, and initiate a community dialogue on long-term governance of water reuse. During the LWF, participants were introduced to the plant's operations and were engaged in discussions on reuse opportunities, perceived barriers, and strategies to overcome social acceptance challenges. Questionnaires were also distributed, focusing on the causes and consequences of major global water challenges, the awareness of Cyprus' own water shortage problems, concerns regarding reclaimed water reuse, and the perceived need for inclusivity and improved access to information on water issues. The interactive format of the Forum encouraged open dialogue and the expression of different concerns and needs from citizens. Overall, the responses confirmed that Cypriots are generally well informed about water challenges both globally and locally, show a clear willingness to contribute to water saving measures, and strongly emphasize the importance of more targeted awareness-raising and greater inclusivity in decision-making processes and in the involvement of social groups dealing with water management issues.

In conclusion, the social and stakeholder engagement activities in Demo Case 3 were not an ancillary component but a central driver of success. By combining continuous dialogue, field missions, transparent demonstrations, and participatory forums, the project fostered a climate of trust, awareness, and shared responsibility. These efforts provided practical feedback loops that informed the technical upgrades at the WWTP and generated governance insights that will shape the future of water reuse in Cyprus. The experience underlines that in contexts of acute water scarcity and competing demands, sustainable solutions emerge only when technical innovation and social co-ownership advance hand in hand**.**

Figure 47: Site visit in Cyprus, meeting stakeholders and conducting interviews within WP3 activities.

Figure 48: Demo site visit

AWARD

Alternative Water Resources and Deliberation processes to renew water supply strategic planning

SEL NTUA

EOAA

Alternative Water Resources in Cyprus
AWARD project

27 Ιουνίου 2025
Local Water Forum

17:00 – 17:10	Χαιρετισμοί- Καλωσόρισμα	*EOAA, NTUA*
17:10 – 17:30	Υδατικοί Πόροι και Ανανεώσιμες Πηγές Νερού στην Κύπρο: Τρέχουσα Κατάσταση Παρουσίαση του Προγράμματος AWARD	Σίμος Μαλαμής, *NTUA*
17:30 – 17:50	Παρουσίαση της Μονάδας επεξεργασίας λυμάτων Παραλιμνίου	Ανδρέας Σέπος, *EOAA*
17:50 – 18:15	Συζήτηση & Ερωτήσεις	
18:15–18:30	Κλείσιμο	

Figure 49: Local Water Forum in DC#3

VI. Final goal/Expected results

Main Objectives:

- Improve the safety and social acceptance of water reuse: By implementing advanced monitoring systems, setting high-quality treatment standards, and engaging with local communities, the project aims to address both technical and social concerns surrounding the reuse of reclaimed water.
- Enhance the resilience of urban water supply systems: In the context of increasing climate variability and seasonal water scarcity, especially in Mediterranean regions, integrating treated wastewater into the urban water cycle offers a reliable, alternative water source that reduces dependency on conventional supplies.
- Reduce pressure on groundwater resources and desalination infrastructure: Promoting the reuse of high-quality effluent alleviates over-extraction of groundwater and limits the energy-intensive use of desalination, contributing to more sustainable resource management and cost savings.
- Build local capacity for decentralized water reuse management: The project strengthens institutional and technical capacity at the municipal level, providing experience and tools for operating small-to-medium-scale reuse schemes that are safe, efficient, and locally controlled.

Replication Potential:

The successful implementation and long-standing operation of DC#3 in Cyprus demonstrate a scalable and adaptable model that can be transferred to similar contexts across Europe and beyond. Specifically, it offers a tested pathway for:

- Coastal Mediterranean towns with a strong tourism–agriculture nexus: Locations that face seasonal population peaks and agricultural water demands can adopt a similar model to balance competing water needs while maintaining environmental safeguards.
- Municipalities with existing WWTPs seeking low-cost optimization: Instead of constructing new infrastructure, this model shows how existing plants can be upgraded through targeted instrumentation, process control improvements, and stakeholder coordination to achieve water reuse goals.
- Projects integrating nature-based storage, digital monitoring, and stakeholder co-design: The integration of ecological storage systems (e.g., lagoons or wetlands), real-time data collection, and inclusive planning ensures both operational effectiveness and broad public support, making it ideal for replication in diverse socio-environmental settings.

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