CASE STUDY INVENTORY

PUBLIC DRAFT

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EXECUTIVE SUMMARY

This report aims to provide an overview about the 32 cases studies of seven ZeroPollution4Water Cluster projects. These seven projects have received funding under Horizon Europe in 2022 and aim at preventing groundwater pollution and securing drinking water quality.

In line with the zero-pollution ambition of the European Green Deal the seven projects will use the case studies to develop and test innovative early warning systems and treatment solutions to protect water quality, from water sources to supply. All solutions will address current and future adverse climate change impacts.

The ZeroPollution4Water Cluster currently comprises three groundwater related projects and four drinking water projects. MAR2PROTECT will provide a holistic approach on managed aquifer recharge in seven coastal case studies, NINFA aims at understanding cumulative stressors and supporting groundwater management in four demo and four replication sites and UPWATER will develop hydrogeological models for decision-making scenarios for two polluted urban and one polluted rural area. H2OforAll, intoDBP and SafeCREW set their focus on tools and technologies to protect drinking water from disinfection by-products. ToDrinQ aims at treatment plant designs to also minimise PFAS in drinking water.

This Case Study Inventory serves as an overview to facilitate insights. It presents a general description of each case study including the current state and the ambition at the end of the project. This is the starting point to explore the synergy potential, strengthen the cooperation and maximise the outreach as the 32 case studies in 18 countries cover the diversity of environmental contexts and their influence on the situation in the catchment areas and water management needs.

All projects expect or already observe adversarial impacts by higher temperatures and more extreme weather events for their case studies. Many of the case studies are impacted by droughts and floods.

All case studies serve to develop and test innovative tools and guidance documents to support better prevention of groundwater pollution and management of drinking water supply systems. Improved and more effective monitoring technologies will be developed.

The Case Study Inventory can be used as a basis for the enhanced understanding of new contamination sources, the deployment of advanced prevention strategies. The case studies will demonstrate robust risk management techniques and innovative water treatment solutions.

The Case Study Inventory facilitates insights in common features of the case studies as well as in their different contexts and objectives. Exploiting the synergies and differences of the 32 ZeroPollution4Water case studies will increase and consolidate the EU scientific and technological base on measures to manage groundwater and drinking water quality and provide evidence and guidance for policy-making and implementation, particularly with respect to the groundwater directive, the drinking water directive and to water resilience related strategies.

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1 INTRODUCTION

This report aims to provide an overview about the 32 cases studies of seven ZeroPollution4Water Cluster projects. These seven projects have received funding under Horizon Europe in 2022 and aim at preventing groundwater pollution and securing drinking water quality.

In line with the zero-pollution ambition of the European Green Deal the seven projects will use the case studies to increase the preparedness of the EU water sector for challenges arising from climate change and support EU environmental legislation and policies related to groundwater and drinking water consumer protection. They focus on preventing freshwater pollution, enhancing water quality, and ensuring safe use for both humans and ecosystems, among others. The approach involves the entire drinking water production cycle, with an emphasis on developing innovative and robust monitoring and early warning systems on drinking water quality, from sources to supply.

The three projects MAR2PROTECT, NINFA, and UPWATER provide 18 groundwater related case studies while the four projects H20forALL, intoDBP, SafeCrew and ToDrinQ work on 14 case studies related to drinking water.

Box 1: The ZeroPollution4Water Cluster

The ZeroPollution4Water cluster is an initiative originated from the coalition of seven different projects from two Horizon Europe calls aiming at:

- Prevent groundwater contamination and protect its quality against harmful impacts of global and climate change.
- Secure drinking water quality by protecting water sources against pollution, providing innovative monitoring and treatment solutions, and ensuring safe drinking water distribution.

Focusing on the European Union's zero-pollution ambition and the European Green Deal, the cluster aims to leverage the cooperation and synergies among these seven projects to develop advanced prevention and mitigation strategies, effective risk assessment and management systems, and innovative monitoring and treatment solutions for drinking water and groundwater management. It also aims to develop new technologies ready for the market to prevent or tackle water pollution.

The objectives of the ZeroPollution4Water (ZP4W) Cluster are to:

- **Enhance our understanding** of new contamination sources, pathways, and impacts on water systems. This includes preparing for new challenges through forward-looking research.
- **Develop and deploy advanced strategies** for preventing contamination and mitigating its effects, ensuring the safety of our water sources from global and climate change impacts.

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Box 1: The ZeroPollution4Water Cluster

- **Implement robust risk management** techniques, incorporating early warning systems and decision-support tools for water safety.
- **Innovate in water quality monitoring and treatment**, introducing cost-effective sensors, analytical methods, and treatment technologies (e.g.: nature-based, advanced disinfection) to ensure source protection and water quality.
- **Support policymaking** with a solid scientific and technological foundation, offering guidance and recommendations for water quality management and further implementation of the European Green Deal.

Six ZP4W Working Groups

- **The Management and Coordination Working Group (WG1)** orchestrates the strategic and operational framework.
- **The Policy Advisory Working Group (WG2)** identifies and develops policy recommendations based on the outcomes of the ZP4W projects.
- **The Communication Working Group (WG3)** engages in amplifying the reach of the outcomes.
- **The Technology and Innovation Working Group (WG4)** seeks to identify, develop, and facilitate the implementation of technology-based solutions.
- **The Data Management and Sharing Working Group (WG5)** aims at devising strategies to elevate data management and sharing.
- **The Research and Innovation to Impact Working Group (WG6)** will facilitate the transition of R&I to the market uptake in the water sector.

2 Background and scope

The ZeroPollution4Water Cluster currently comprises three groundwater related projects and four drinking water projects. Each project targets the expected outcomes of the two Horizon Europe 2022 calls in a different way and sets different objectives for its case studies. The case studies are characterised by many common features as well as a diversity of approaches and complement each other well.

Figure 1 Map of the case studies (taken from the ZP4W cluster website)

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A brief introduction for each project is given below.

Three groundwater related projects

MAR2PROTECT - Preventing groundwater contamination related to global and climate change through a holistic approach on managed aquifer recharge.

MAR2PROTECT (M2P) will provide a holistic approach to preventing groundwater contamination from the impacts of global change and climate change, based on a new-generation Managed Aquifer Recharge (MAR). This will be tested in seven cases studies in Europe and beyond. MAR2PROTECT case studies centre around coasts in Mediterranean, Atlantic, and North Atlantic climate. The groundwater protection technological approach (MAR) covers aquifers in diverse contexts, including dunes and surface water and the use waste water. Societal concerns cover pollution and droughts. The core of this innovative Managed Aquifer Recharge is the M-AI-R Decision Support System that will incorporate technological and societal engagement information. The prediction of the impacts of global and climate change on groundwater quality in a specific context, prevention of diffuse pollution from agriculture, development of groundwater management strategies and innovative real-time integrated sensing systems and innovative analytical methods for the monitoring of pollutants form the focus.

NINFA - TakiNg actIoN to prevent and mitigate pollution oF groundwAter bodies)

The NINFA project deals with groundwater (GW) management solutions in the context of global and climate change. Contaminants of emerging concern (CEC) like pharmaceuticals, antibiotic resistance genes (ARG), hydrocarbons, heavy metals, and microplastics (MP) infiltrate groundwater from sources, such as wastewater treatment plants (WWTPs) and urban runoff during storms, are impacting interconnected water bodies like rivers, wetlands, and oceans. Although efforts exist to monitor and protect GW, gaps remain in understanding cumulative stressors and developing cost-effective monitoring and decision-making tools for sustainable governance and management. NINFA's eight case studies, four test beds and four replication sites, offer the opportunity to build a groundwater knowledge observatory to better address these challenges and improve safeguarding groundwater quality and resilience in the face of ongoing environmental changes. The NINFA case sites are under the threat of salinity intrusion.

UPWATER - Understanding groundwater Pollution to protect and enhance WATER quality

The UPWATER project addresses the widespread issue of groundwater pollution by identifying effective regulatory and legislative preventive measures and developing cost-efficient methods to measure pollutants, identify their sources and to mitigate the pollution. These methods shall be validated in three case studies in different EU climates. Two UPWATER case studies are characterised as polluted urban areas, the third one as polluted rural area. Pollutants include pesticide wastes, high load nutrients, ammonium, metals, contaminants of emerging concern (CEC) and pathogens. Hydrogeological models for

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decision-making scenarios shall be developed, which consider multiple stressors and climate change projections. The scale-up of bio-based solutions shall be prepared. Policy recommendations target EU as well as local/regional levels, including the update of chemical priority lists.

Four drinking water related projects

H2OfoAll - Innovative Integrated Tools and Technologies to Protect and Treat Drinking Water from Disinfection By-products (DBPs)

The H2OforAll project focuses on disinfection by-products (DBPs) that result from the interaction of disinfectants like chlorine with natural organic materials in water. Currently, its case study site, the Águas de Coimbra drinking water network, provides high quality drinking water. However, extreme climate events (floods and droughts) may impact the quality and the complexity of water contamination by contaminants of emerging concern (CEC) is an arising problem. The case study serves to understand & monitor disinfection by-products (DBPs) and their spread through drinking water distribution systems, to develop breakthrough water treatments to remove DBPs or avoid their formation during water disinfection processes, paying attention to their life cycle analysis, costs, and risks, and to establish preventive measures for water protection engaging public and stakeholders.

intoDBP - Innovative tools to control organic matter and disinfection by-products in drinking water

The intoDBP project will develop, test, scale-up, validate, and benchmark innovative tools and strategies to protect catchments and minimize human exposure to disinfection by-products (DBP) under current and future climates, without compromising disinfection efficacy, and which could be applied at the global scale. The project will develop its comprehensive approach from source to tap on four case studies combining rural and dense urban areas, emphasizing cost-effective sensors and analytical methods. The case study sites complement each other in terms of the DBP precursors in the source water, the setting, their climate, their current treatment and disinfection strategy. THM abundance is high.

SafeCREW - Climate-resilient management for safe disinfected and non-disinfected water supply systems

The SafeCREW project will develop management solutions for drinking water supply systems with and without disinfection in the context of climate change. SafeCREW will use four case studies in northern Germany, Italy, Spain and the Ukraine to improve comprehensive water quality characterisation, to develop novel treatment solutions to actively respond to identified threats and to guide better management of water distribution networks to maintain high drinking water quality. Novel data sets on the occurrence and concentration of so far unknown DBPs will be created, and commercial actors stimulated to further develop tools for DBP quantification and mitigation. This will include all processes from source via treatment and up to distribution. Impacts from potential declining water

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availability and quality with increasing water demand, high seasonal variations of river surface water as well as increasing concentration of dissolved organics and microorganisms due to climate change and increased migration from relining resins shall be minimized by optimal risk-based management of drinking water treatment plants.

ToDrinQ - TOolkit for aDaptable, Resilient INstallations securing high Quality drinking water

The ToDrinQ project addresses the impact of climate change and increased pollution on drinking water quality. The project will support evidence-based treatment plant design and enhance operational awareness and response in the overall water system. ToDrinQ aims at supporting the implementation of the revised drinking water directive, enhancing scientific and technical knowledge on drinking water quality protection, monitoring, and treatment, increasing the resilience of drinking water systems in terms of both increased robustness and adaptability, and ensuring high-quality drinking water by minimising the concentration of (in)organic micropollutants, pathogenic micro-organisms and disinfection by-products (DBPs). Five case studies with different environmental and societal context shall serve to test and demonstrate the solutions.

The Case Study Inventory – an overview to facilitate insights

This Case Study Inventory serves as an overview to facilitate insights. It presents a general description of each case study including the current state and the ambition at the end of the project. This will be the starting point to explore the synergy potential, strengthen the cooperation and maximise the outreach.

The 32 case studies cover the diversity of environmental contexts with their influence on the situation in the catchment areas and water management needs. They are situated in 18 countries. Beyond the twelve EU countries represented, case studies are located in the western Ukraine, Colombia, Mexico, Tunisia, Egypt and South Africa. Seventeen case studies centre around the Mediterranean Sea with eight case studies in Spain and three in Portugal. With eleven case studies focusing on groundwater pollution, this illustrates the already existing climate related water stress and promises deep insights into challenges and zero pollution solutions for the Mediterranean region. The concentration around the Mediterranean region may also enhance the direct transferability of results. Comparing case studies in northern Europe, eastern Europe, the Mediterranean region, South Africa and South America will stimulate the understanding of context dependent impacts and mutual learning and shall enhance the wide uptake of the results. Learning from the wide country representation also may lead to better adapted water related policies, regulation and legislation regionally, nationally and on the European level.

Case studies in coastal regions show the influence of salinity and floods (NINFA). Case studies in polluted urban areas can be evaluated against study sites in rural environments (e.g. UPWATER, intoDBP). Many case studies already face significant challenges by high pollution and climate change related events (e.g. MAR2PROTECT, all) whereas other case studies still have a good water quality (Safe CS#1, Safe CS#2, H2OforAll).

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All projects expect or already observe adversarial impacts by higher temperatures and more extreme weather events for their case studies. Many of the case studies are impacted by droughts and floods. Depending on the specific contexts of each case study, this leads to effects as water scarcity and groundwater depletion, higher concentration on natural organic matter, salinity and a wide range of pollutants, including contaminants of emerging concern. A need for increased disinfection of drinking water is expected with higher formation potential of previously unknown disinfection by-products. The aggregation of context specific analysis of the expected climate change and pollution related challenges in the case studies on the cluster level will increase data and knowledge as the basis for adaptable and transferable mitigation approaches.

Some of the case studies currently operate under very basic conditions. These case studies call for monitoring and treatment methods which work with limited resources.

All case studies serve to develop and test innovative tools and guidance documents to support better prevention of groundwater pollution and management of drinking water supply systems. Improved and more effective monitoring technologies will be developed. Including online sensors and predictive modelling approaches. This will enable guidance on risk management and early warning systems. Novel treatment technologies shall ensure water quality from source to tap and protect human health. Nature based solutions and managed aquifer recharge approaches will be developed to prevent or remove groundwater pollution, Methods and approaches to prevent the formation of disinfection by-products, to detect previously unknown disinfection by-products, and remove DBPs effectively will be developed from the data collected at the four drinking water projects. The best practices collected and their application and market potential will be evaluated in depth in the ZP4W working groups in the upcoming months. This will also allow validated input to water related regulation, e.g. GWD and DWD beyond the first policy brief already published.

These examples show how the Case Study Inventory can be used as a basis for the enhanced understanding of new contamination sources, the deployment of advanced prevention strategies and providing a solid scientific and technological foundation for policy making. The case studies will demonstrate robust risk management techniques and innovative water treatment solutions, and thus fully support the objectives of the ZeroPollution4Water Cluster.

The following chapters present the specific characteristics of the 32 case studies.

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3 MAR2PROTECT case studies

MAR2PROTECT includes seven case studies which are included in the presentation below:

- Case study 1 – Mar1 - Katwijk, Netherlands
- Case study 2 – Mar2 - Nabeul, Tunisia
- Case study 3 – Mar3 - Frielas, Portugal
- Case Study 4 - Mar4 - Emilia-Romagna, Italy
- Case Study 5 - Mar5 - Cape Flats, South Africa
- Case Study 6 - Mar6 - Marbella, Spain
- Case Study 7 - Mar7 - Lima river estuary, Portugal

3.1 MAR2PROTECT Case Study 1 - Katwijk, Netherlands

MAR2PROTECT Mar CS#1	Tertiary treatment of lake water and subsequent managed aquifer recharge of a dunal aquifer affected by salinity intrusion
Location	Katwijk, Netherlands
Pictures illustrating the case studies	

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Keywords	Surface water treatment, salinity intrusion, micropollutants, managed aquifer recharge.
Description	Due to the rapidly increasing water demand resulting from population and economic growth, the water utility Dunea needs to start treating surface water from a Lake before infiltration in the Berkheide dunal aquifer. Managed Aquifer Recharge using water from the nearby Lake Valkenburg has been identified as the best strategy for long-term aquifer protection and preservation. Fed by the river Old Rhine, it is increasingly contaminated by salinity (salt intrusion from the sea) and micropollutants. Therefore, treatment of the lake water is needed in order to prevent groundwater contamination resulting from Managed Aquifer Recharge. To this goal, Dunea and the IHE Delft Institute set up a membrane-based lake water treatment process in a 15 m^3/h pilot plant, where different combinations of inline coagulation, rapid sand filtration, ultrafiltration and reverse osmosis are being tested.
Scale & treatment	Dunea and IHE designed and installed a pilot plant treating 15 m^3/h of surface water. The pilot plant is articulated in 2 lines, aimed at comparing two alternative treatment approaches: 1) Coagulation/flocculation + dissolved air flotation + ultrafiltration + reverse osmosis 2) Coagulation/flocculation + dissolved air flotation + rapid sand filtration + adsorption on activated carbon

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	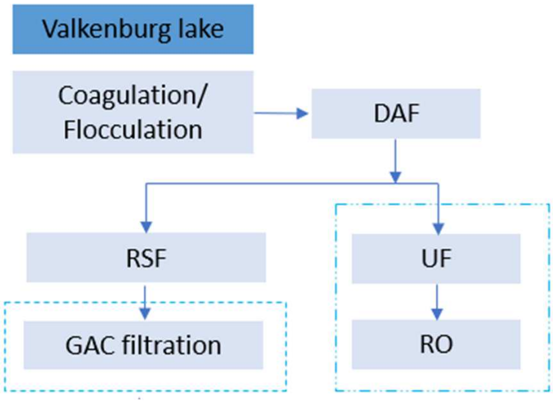
Relevant climate change or pollution related challenges	As a result of climate change, the Lake Valkenburg water is increasingly affected by high salinity. Due to the rapidly increasing water demand from population and economic growth, the water utility Dunea needs to start drawing surface water from Lake Valkenburg before infiltration in the Berkheide dunal aquifer.
Key intervention and objectives	• Develop a cost-efficient surface water treatment before it is used for managed aquifer recharge and eventually for drinking water production. • Assessment of two alternative treatment lines at a demonstration scale (15 m^3/h). • Development and validation of innovative monitoring methods for the assessment and early detection of fouling phenomena in ultrafiltration, reverse osmosis and sand filtration systems.
Current status of the case study:	• The pilot plant has been set up at the onset of MAR2PROTECT, and it has been in operation for over 1 year with very positive results in terms of removal of the main (micro)pollutants, with no indications of membrane fouling. • The final adsorption step with activated carbon in line 2 was not installed yet
Expected outcomes	• A cost-efficient treatment of surface water before it is used for managed aquifer recharge and eventually for drinking water production, validated at demonstration scale

Relevant sectors	Water utility Dunea (water production and dune management), Rijkswaterstaat (national authority, river management), Rijnland water authority (sewer network), Vewin (national association of water utilities), Katwijk municipality (local authority), Meijendeel nature reserve association (tourism in the dune aquifer nature reserve), Dunea information centre in the dunes, Meijendeel restaurant, Civil Society Organisations (Waarneming.nl; nature rangers; birdwatchers).
Ambition at the end of the project	• Validation at demonstration scale of a cost-efficient treatment of surface water before it is used for managed aquifer recharge and eventually for drinking water production. • Validation of innovative monitoring methods for the assessment and early detection of fouling phenomena in ultrafiltration, reverse osmosis and sand filtration systems. • Assessment of the proposed technologies, enhancement of their replication potential and implementation of civil society engagement activities, through the involvement of a large stakeholder community by means of a living lab based on this case study
Ambition beyond the project:	• Facilitate the replication of the selected surface water treatment sequence in other regions facing similar surface water and climate challenges. • Increase the awareness of civil society groups on the issues of water scarcity and groundwater protection
Key EU legislation applicable	• **Water Framework Directive (WFD) 2000/60/EC:** Establishes a framework for the protection of inland surface waters, transitional waters, coastal waters, and groundwater. • **Groundwater Directive 2006/118/EC:** Establishes specific measures as provided for in Article 17(1) and (2) of Directive 2000/60/EC in order to prevent and control groundwater pollution
Key national or/and regional legislation / policies	
Replication implications	• The proposed technologies for surface water treatment have a very high potential for replication across Europe, given the high number of sites in which surface water contaminated by salinity and micropollutants are used for managed aquifer recharge and/or drinking water production.

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Policy implications	• The results of the proposed technologies for surface water treatment could be used to develop policy recommendations and national legislation on the use of surface water for managed aquifer recharge.
Market implications	Market placement of the best-performing treatment sequence for the treatment of surface water before its use for managed aquifer recharge and drinking water production.

3.2 MAR2PROTECT Case Study 2 - Nabeul, Tunisia

MAR2PROTECT Mar CS#2	**Tertiary treatment of municipal wastewater and subsequently managed aquifer recharge of an over-exploited coastal aquifer affected by micropollutants and saline intrusion**
Location	Oued Souhil, Tunisia
Pictures illustrating the case studies	   **Oued Souhil experimental station**
Keywords	Wastewater treatment, salinity intrusion, micropollutants, managed aquifer recharge, and real-time sensors.

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Description	The 330 km^2 Oued Souhil aquifer, located in the Cap Bon Peninsula in Tunisia, is strongly overexploited due to increasing water demand for domestic use and irrigation. GW level is rapidly declining and water quality is deteriorating due to seawater intrusion (total salinity reaching 7 g/L) and diffuse pollution from agriculture (pesticides, fertilizers). In response, the local basin authority started aquifer recharge operations with treated MWW from two WWTPs SE3 (oxidation ditches) and SE4 (activated sludge). using 4 infiltration basins (737 m^2). This method was used irregularly until 2010 then was abandoned and replaced by irrigation as an indirect method of aquifer recharge. Treated MWW from the SE3 and SE4 WWTPs is polluted by high salinity, some pathogens and micropollutants at low concentrations. There is thus a strong need to implement an effective tertiary treatment at the SE3 and SE4 WWTPs, to minimize the introduction of these pollutants in the aquifer.
Scale & treatment	The University of Tunis El-Manar, the leader of this case study, is developing several technologies for the advanced treatment of municipal wastewater before its use for aquifer recharge: • Constructed wetlands, as tertiary treatment of treated wastewater • Low-cost selective adsorption of selected micropollutants (Diclofenac, Bisphenol A and Ofloxacin) using locally available agricultural residues, and treatment of the saturated sorbents with ligninolytic fungi • Photovoltaic-powered hybrid nanofiltration / reverse osmosis process for salt and micropollutant removal from treated wastewater and brine phytoremediation with halophytes
Relevant climate change or pollution related challenges	As a result of climate change and population growth, groundwater level is rapidly declining and water quality is deteriorating due to seawater intrusion (total salinity reaching 7 g/L) and diffuse pollution from agriculture (pesticides, fertilizers).
Key intervention and objectives	• Develop a cost-efficient advanced treatment of secondary-treated wastewater before it is used for managed aquifer recharge and irrigation. • Development and validation of an innovative aptasensor for the real-time detection of pathogen bacteria in groundwater and wastewater. • Development and implementation of an innovative methodology to establish LivingLabs across MAR2PROTECT case studies.

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	• Organization of LivingLab activities addressed to engage stakeholders, establish LivingLab teams and co-design broader societal engagement interventions across the M2P case studies.
Current status of the case study:	• The above-listed wastewater treatment technologies are being assessed in lab-scale tests, with promising results • The scale-up of technologies at TRL 5 in the demo site is planned for May 2025 • The case study living lab has been launched, and civil society engagement activities have been designed
Expected outcomes	• A cost-efficient advanced treatment of secondary-treated wastewater before it is used for managed aquifer recharge and irrigation, validated at TRL 5 in a real environment • A robust aptasensor for the real-time detection of pathogen bacteria in groundwater and wastewater
Relevant sectors	ONAS - National Water Sanitation Utility (wastewater treatment), CRDA - Regional Commissary for Agricultural Development of Nabeul (reforestation and promotion of agricultural production), DGGREE - General Directorate for Rural Engineering and Water Development (management of water resources in the rural areas), BPEH - Planning and Hydraulic Balance Office (water management), INM - National Institute of Meteorology (development of future climate change trends).
Ambition at the end of the project	• Validation at TRL 5 of a cost-efficient treatment of secondary-treated wastewater before it is used for managed aquifer recharge and irrigation. • Validation of a robust aptasensor for the real-time detection of pathogen bacteria in groundwater and wastewater. • Assessment of the proposed technologies, enhancement of their replication potential and implementation of civil society engagement activities, through the involvement of a large stakeholder community by means of a living lab based on this case study
Ambition beyond the project:	• Facilitate the replication of the selected wastewater treatment sequence in other regions facing similar surface water and climate challenges. • Implementation of the aptasensor for the real-time detection of pathogen bacteria in different types of wastewater

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	• Increase the awareness of civil society groups on the issues of water scarcity and groundwater protection
Key EU legislation applicable	Not applicable. This case study is located in Africa.
Key national or/and regional legislation / policies	
Replication implications	• The proposed technologies for advanced wastewater treatment before its use for MAR have a high replication potential, given the high potential of managed aquifer recharge with treated wastewater.
Policy implications	• The results of the proposed technologies for wastewater treatment and monitoring could be used to formulate policy recommendations relative to guidelines and national legislation on the use of treated wastewater for MAR.
Market implications	Market placement of the best-performing technologies for the treatment of wastewater before its use for managed aquifer recharge and irrigation. Market placement of the aptasensor for the real-time detection of pathogen bacteria in wastewater and groundwater.

3.3 MAR2PROTECT Case Study 3 - Frielas, Portugal

MAR2PROTECT - Mar CS#3	**Managed recharge of a coastal aquifer, using treated municipal wastewater**
Location	Frielas, Portugal

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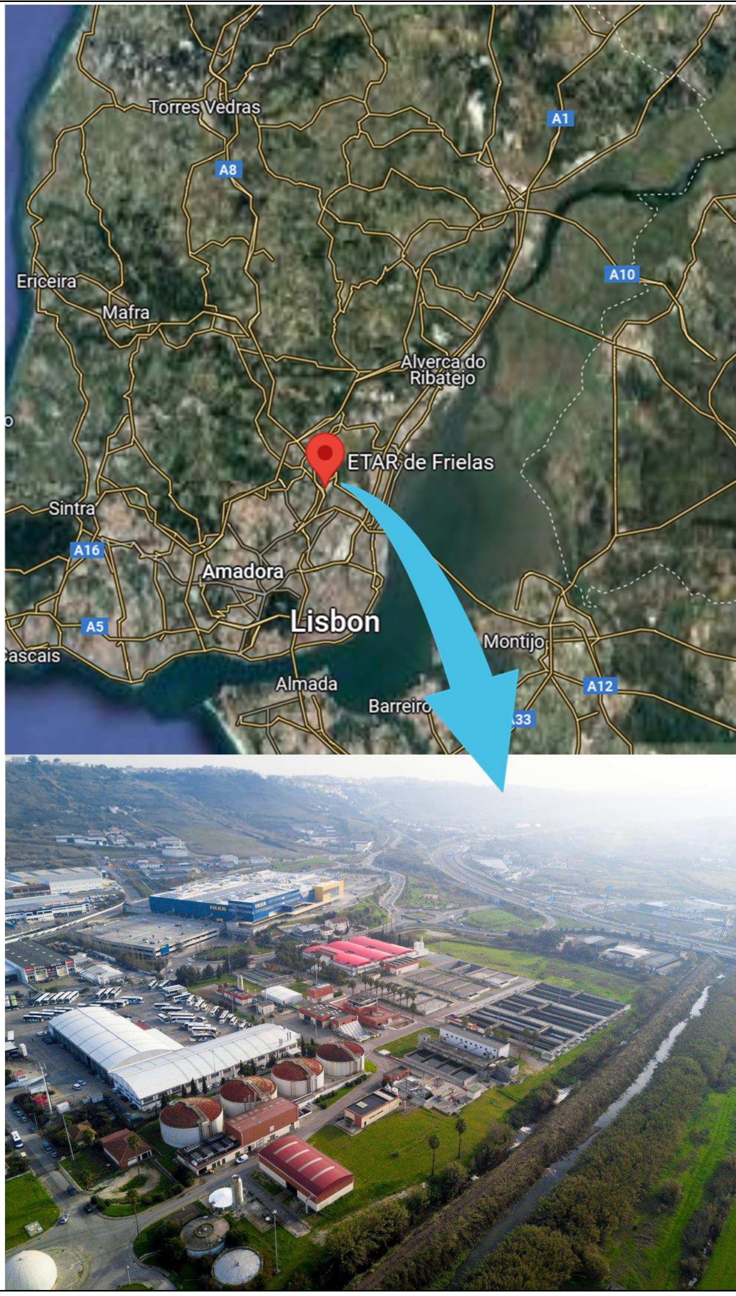
Pictures illustrating the case studies	
Keywords	Wastewater treatment, salinity intrusion, micropollutants, managed aquifer recharge, and real-time sensors.
Description	Frielas WWTP belongs to AdTA and is linked to the West edge, Tagus alluvium, and Tagus-Sado basin (left bank) aquifers, affected by relevant salt intrusion. This WWTP discharges treated effluent into the Tagus basin and treats 70,000 m^3/day. Due to a lack of technologies to remove emerging contaminants, these pollutants were detected in the effluent. The discharge of these emerging pollutants, expected to

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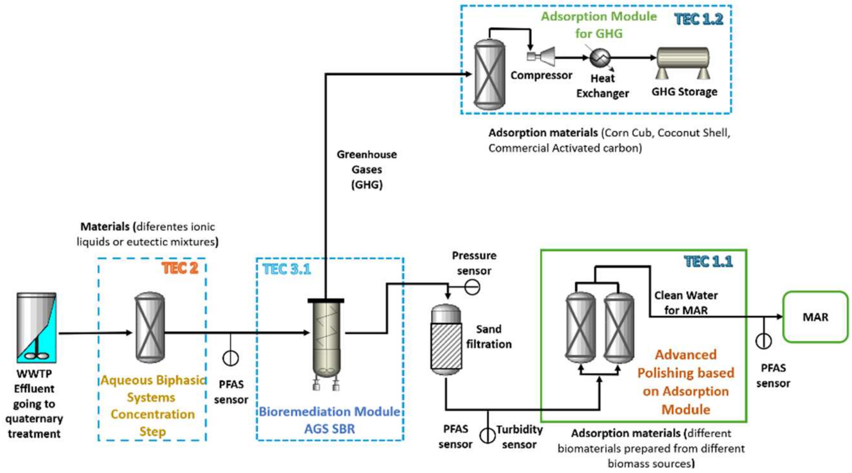
	increase with population and industrialization rise, can have a serious impact on managed aquifer recharge implementation and acceptance.
Scale & treatment	NOVA University, the leader of this case study, is developing several technologies for the advanced treatment of municipal wastewater before its use for aquifer recharge: • Removal of micropollutants (PFAS, pharmaceuticals) by adsorption on innovative biobased materials • Biodegradation of pharmaceuticals in a granular sludge bioreactor, combined with the concentration of pharmaceuticals by means of aqueous biphasic systems • Removal of gas-phase GHGs produced by the biodegradation process, using adsorption on innovative biobased materials 
Relevant climate change or pollution related challenges	As a result of climate change and population growth, groundwater levels are rapidly declining and water quality is deteriorating due to seawater intrusion.
Key intervention and objectives	• Develop a cost-efficient advanced treatment of secondary-treated wastewater before it is used for managed aquifer recharge. • Development and validation of an innovative fluorescence sensor for the real-time detection of PFAS in groundwater and wastewater. • Development and implementation of an innovative methodology to establish LivingLabs across MAR2PROTECT case studies.

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	• Organization of LivingLab activities addressed to engage stakeholders, establish LivingLab teams and co-design broader societal engagement interventions across the M2P case studies.
Current status of the case study:	• The above-listed wastewater treatment technologies are being assessed in lab-scale tests, with promising results • The scale-up of technologies at TRL 5 in the demo site is planned for May 2025 • The case study Living lab has been launched, and civil society engagement activities have been designed.
Expected outcomes	• A cost-efficient advanced treatment of secondary-treated wastewater before it is used for managed aquifer recharge and irrigation, validated at TRL 5 in a real environment • A robust fluorescence sensor for the real-time detection of PFAS in groundwater and wastewater
Relevant sectors	Water utility Águas de Portugal (water production, distribution and management), APA - Agência Portuguesa do Ambiente (national authority, environment management including water management), ZERO - Associação Sistema Terrestre Sustentável (very active NGO in Portugal), Associação Portuguesa de Recursos Hidrícos (national association related to water management), AMEAL - Agência Municipal de Energia e Ambiente de Loures (local association of energy and environment), APDA - Associação portuguesa de distribuição de drenagem de Aguas (national association of water utilities).
Ambition at the end of the project	• Validation at TRL 5 of a cost-efficient treatment of secondary-treated wastewater before it is used for managed aquifer recharge. • Validation of a robust fluorescence sensor for the real-time detection of PFAS in groundwater and wastewater. • Assessment of the proposed technologies, enhancement of their replication potential and implementation of civil society engagement activities, through the involvement of a large stakeholder community by means of a living lab based on this case study
Ambition beyond the project:	• Facilitate the replication of the selected wastewater treatment process in other regions facing similar surface water and climate challenges.

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	• Implementation of the fluorescence sensor for the real-time detection of PFAS in different types of waters • Increase the awareness of civil society groups on the issues of water scarcity and groundwater protection.
Key EU legislation applicable	• **Water Framework Directive (WFD) 2000/60/EC:** Establishes a framework for the protection of inland surface waters, transitional waters, coastal waters, and groundwater. • **Groundwater Directive 2006/118/EC:** Establishes specific measures as provided for in Article 17(1) and (2) of Directive 2000/60/EC in order to prevent and control groundwater pollution.
Key national or/and regional legislation / policies	• Lei da Água n.º 58/2005 (Water Law) https://files.dre.pt/1s/2005/12/249a00/72807310.pdf
Replication implications	• The water treatment technology object of this case study has a very high replication potential, given the widespread presence of the target micropollutants in wastewater across Europe. • The PFAS real-time sensor has a very high replication potential, given the increasing concern and the rapid legislative framework relative to the removal and monitoring of PFAS in groundwater, surface water and wastewater.
Policy implications	• The results of the proposed technologies for wastewater treatment and monitoring could be used to formulate policy recommendations relative to guidelines and national legislation on the use of treated wastewater for MAR.
Market implications	Market placement of the best-performing technologies for the treatment of wastewater before its use for managed aquifer recharge. Market placement of the fluorescence sensor for the real-time detection of PFAS in groundwater and wastewater.

3.4 MAR2PROTECT Case Study 4 - Emilia-Romagna, Italy

MAR2PROTECT Mar CS#4	**Managed recharge of a coastal aquifer, using treated municipal wastewater**

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Location	Emilia Romagna, Italy
Pictures illustrating the case studies	
Keywords	Wastewater treatment, salinity intrusion, micropollutants, managed aquifer recharge, micropollutant biodegradation.
Description	The Ravenna coastal aquifer (Emilia-Romagna) is affected by overexploitation, relevant saline intrusion (3-20 g/L), and diffuse pollution from agriculture. Climate change and increasing water abstraction due to increasing population and agricultural production are expected to increase these problems. Managed aquifer recharge with treated WW from coastal WWTPs has been identified as a promising solution to ensure long-term sustainable management of the aquifer. Preliminary investigations revealed the presence of pharmaceuticals (diclofenac, carbamazepine, ibuprofen) in the effluents of investigated coastal WWTPs. A tertiary treatment of the selected WWTP effluents is thus necessary, to remove the identified pollutants and protect the Ravenna coastal aquifer.
Scale & treatment	Bologna University, the leader of this case study, is developing several technologies for the advanced treatment of municipal wastewater before its use for aquifer recharge:

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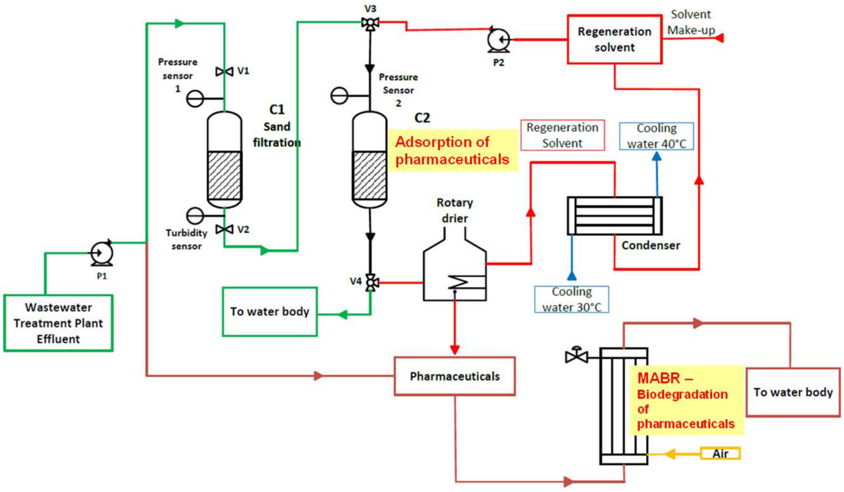
	• Removal of micropollutants (pharmaceuticals) by adsorption on commercial and innovative sorbents (Molecularly Imprinted Polymers) • Biodegradation of the desorbed pharmaceuticals in a membrane aerated biofilm reactor (MABR) The flow sheet of the proposed treatment sequence is reported below.  In addition, Bologna University is developing an innovative AI-based modelling tool (DRONE) for the design of managed aquifer recharge systems, taking into account climate change scenarios and the use of multiple water sources.
Relevant climate change or pollution related challenges	As a result of climate change and population growth, groundwater levels are declining and water quality is deteriorating due to seawater intrusion.
Key intervention and objectives	• Development of a cost-efficient advanced treatment of secondary-treated wastewater before it is used for managed aquifer recharge. • Development of an innovative AI-based modelling tool (DRONE) for the design of managed aquifer recharge systems, taking into account climate change scenarios and the use of multiple water sources. • Development and implementation of an innovative methodology to establish LivingLabs across MAR2PROTECT case studies. Organization of LivingLab activities addressed to engage stakeholders, establish LivingLab teams and co-design

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	broader societal engagement interventions across the M2P case studies.
Current status of the case study:	• The above-listed wastewater treatment technologies are being assessed in lab-scale tests, with promising results • The scale-up of technologies at TRL 5 in the demo site is planned for May 2025 • The case study living lab has been launched, and civil society engagement activities have been designed
Expected outcomes	• A cost-efficient advanced treatment of secondary-treated wastewater before it is used for managed aquifer recharge and irrigation, validated at TRL 5 in a real environment • An innovative AI-based modelling tool (DRONE) for the design of managed aquifer recharge systems, taking into account climate change scenarios and the use of multiple water sources.
Relevant sectors	Water utility HERA (manages WWTPs and GW in the region), Emilia-Romagna hydrological service (aquifer management), ARPA regional agency for environmental protection, Hydrochem (WW/GW treatment TEC provider), HERATECH (company with major laboratory for water quality monitoring), Centro Antartide (Public institution active in education and civil society engagement activities in the environmental protection field).
Ambition at the end of the project	• Validation at TRL 5 in a real environment of a cost-efficient treatment of secondary-treated wastewater before it is used for managed aquifer recharge. • Validation in a real environment of an innovative AI-based modelling tool (DRONE) for the design of managed aquifer recharge systems, taking into account climate change scenarios and the use of multiple water sources. • Assessment of the proposed technologies, enhancement of their replication potential and implementation of civil society engagement activities, through the involvement of a large stakeholder community by means of a living lab based on this case study
Ambition beyond the project:	• Facilitate the replication of the selected wastewater treatment process in other regions facing similar water and climate challenges. • Implementation of the DRONE modelling tool for the design of managed aquifer recharge systems in aquifers characterized by similar contexts.

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	• Increase the awareness of civil society groups on the issues of water scarcity and groundwater protection.
Key EU legislation applicable	• **Water Framework Directive (WFD) 2000/60/EC:** Establishes a framework for the protection of inland surface waters, transitional waters, coastal waters, and groundwater. • **Groundwater Directive 2006/118/EC:** Establishes specific measures as provided for in Article 17(1) and (2) of Directive 2000/60/EC in order to prevent and control groundwater pollution
Key national or/and regional legislation / policies	• Government Decree 100/2016 on Managed Aquifer Recharge • Draft of Government Decree under discussion, on the reuse of wastewater including managed aquifer recharge
Replication implications	• The water treatment technologies object of this case study has a very high replication potential, given the widespread presence of the target micropollutants in wastewater across Europe. • The DRONE modelling tool for the design of managed aquifer recharge systems has a very high replication potential, given the need to boost managed aquifer recharge and to design it taking into account future climate change scenarios.
Policy implications	• The MAR2PROTECT activities developed in this case study can contribute to the ongoing discussion on the draft of the Government Decree, relative to the reuse of wastewater including managed aquifer recharge
Market implications	Market placement of the best-performing technologies for the treatment of wastewater before its use for managed aquifer recharge. Market placement of the DRONE modelling tool for the design of managed aquifer recharge systems, taking into account climate change scenarios and the use of multiple water sources.

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3.5 MAR2PROTECT Case Study 5 - Cape Flats, South Africa

MAR2PROTECT Mar CS#5	**Use of tertiary treated MWW for the managed aquifer recharge of a coastal aquifer affected by saline intrusion and diffuse pollution from agriculture**
Location	Cape Flats, South Africa
Pictures illustrating the case studies	
Keywords	Wastewater treatment, salinity intrusion, micropollutants, managed aquifer recharge, and real-time sensors.
Description	The 400 km^2 Cape Flats Aquifer (CFA) is the major source of municipal water for Cape Town City (9 Mm^3/y) and irrigation (200 ktons vegetables/y). CFA is increasingly contaminated by salinity intrusion and diffuse pollution from agriculture and micropollutants. The current GW extraction rate is at 100% of natural recharge and seawater intrusion is increasing. Due to CC and the rapid increase in population (+56% in 6 years) and food production, CFA is expected to reach oversaturation during the next 5 years. A preliminary MAR project with treated MWW is starting to be developed at basin level, to increase the CFA recharge rate and curb salinity intrusion.

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	Preliminary monitoring of the effluent of the Cape Town Athlon WWTP indicated emerging pollutants, with a risk of transfer into the aquifer. A wider monitoring of pollutants by means of real-time sensors is needed, also to design suitable tertiary treatments to be implemented before the WW is used for MAR. To ensure a gradual improvement of CFA water quality, MAR needs to be associated with preventive measures aimed at decreasing diffuse pollution from agriculture.
Scale & treatment	Stellenbosch University, the leader of this case study, is developing several technologies and modelling tools for the sustainable management of groundwater and the design of managed aquifer recharge in the Cape Flats aquifer: • A real-time sensor based on receptor-binding assays for the detection of estrogenicity in wastewater and groundwater. • The FERT-ROOT technology to reduce fertilizer leaching into aquifers. • The innovative RAINREC modelling tool for the design of managed aquifer recharge systems and the assessment of runoff-recharge interactions, taking into account climate change scenarios.
Relevant climate change or pollution related challenges	As a result of climate change and population growth, groundwater level is declining and water quality is deteriorating due to seawater intrusion.
Key intervention and objectives	• Development of a cost-efficient real-time sensor based on receptor-binding assays for the detection of estrogenicity in wastewater and groundwater • Development of the FERT-ROOT technology to reduce fertilizer leaching into aquifers. • Development of the innovative RAINREC modelling tool for the design of managed aquifer recharge systems and the assessment of runoff-recharge interactions, taking into account climate change scenarios. • Development and implementation of an innovative methodology to establish LivingLabs across MAR2PROTECT case studies. Organization of LivingLab activities addressed to engage stakeholders, establish LivingLab teams and co-design broader societal engagement interventions across the M2P case studies.

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Current status of the case study:	• The FERT ROOT technology is being assessed in both lab-scale and field tests, with promising results • The real-time sensor based on receptor-binding assays for the detection of estrogenicity is under development at laboratory scale • The RAINREC modelling tool for the design of managed aquifer recharge systems and the assessment of runoff-recharge interactions is under development and calibration • The case study living lab will be launched during the second half of 2024 and civil society engagement activities have been designed
Expected outcomes	• A cost-efficient technology to reduce fertilizer leaching into aquifers, validated at TRL 5 in a real environment (FERTT-ROOT). The innovative RAINREC modelling tool for the design of managed aquifer recharge systems and the assessment of runoff-recharge interactions, taking into account climate change scenarios.
Relevant sectors	National Department of Water and Sanitation (Regulation of MAR in all the country), Western Cape Government Environmental Affairs, Cape Flats Agricultural Association, WWF (collaborates with SU for restoration of surface waters in CFA), Umvoto Company (in charge of installing monitoring wells in CFA), Humefert Manufacturing (fertilizers; in-kind field trails for FERT-ROOT technology)
Ambition at the end of the project	• Validation at TRL 5 in a real environment of a cost-efficient technology to reduce fertilizer leaching into aquifers. • Validation in a real environment of the innovative RAINREC modelling tool for the design of managed aquifer recharge systems and the assessment of runoff-recharge interactions, taking into account climate change scenarios. • Assessment of the proposed technologies, enhancement of their replication potential and implementation of civil society engagement activities, through the involvement of a large stakeholder community by means of a living lab based on this case study
Ambition beyond the project:	• Facilitate the replication of the FERT ROOT technology to reduce fertilizer leaching into aquifers, in other regions facing aquifer eutrophication. • Promote a wide implementation of the real-time estrogenicity sensor for the monitoring of groundwater and wastewater in different contexts.

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	• Implementation of the RAINREC modelling tool for the design of managed aquifer recharge systems in aquifers characterized by different contexts. • Increase the awareness of civil society groups on the issues of water scarcity and groundwater protection.
Key EU legislation applicable	• Not applicable as this case study is located in Africa
Key national or/and regional legislation / policies	• National Water Act 36 of 1998, sections s21(b) and s21(e) • National Environmental Management Act 107 of 1998 • National Water Services Act 107 of 1997
Replication implications	• The FERT ROOT technology to reduce fertilizer leaching into aquifers has a high replication potential, given the widespread eutrophication issues in aquifers. • The real-time estrogenicity sensor has a high replication potential, given the widespread presence of endocrine disruptors in groundwater and wastewater. • The RAINREC modelling tool for the design of managed aquifer recharge systems has a high replication potential, given the high need for MAR systems in African countries.
Policy implications	The development of an estrogenicity biosensor can represent a driver for the development of policies highlighting the need for effect-based testing of water intended for Managed Aquifer Recharge, as such testing can serve as a proxy for bio-active chemicals such as pharmaceuticals and personal care products potentially present in the waters used for MAR.
Market implications	About 98% of cities, 91% of urban-type settlements and 23% of villages are covered by centralized water supply system services in Ukraine. The total length of water supply networks is 92000 km, including 35% of dilapidated and emergency networks. Operating systems of centralised water supply in settlements of western Ukraine mainly use ground waters.

3.6 MAR2PROTECT Case Study 6 - Marbella, Spain

MAR2PROTECT Mar CS#6	**Managed aquifer recharge of a coastal aquifer affected by salt intrusion, using GW from an upstream carbonate aquifer.**

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Location	Marbella, Spain
Pictures illustrating the case studies	
Keywords	Salinity intrusion, managed aquifer recharge, decision support systems
Description	Señorío is a pliocene 5 km^2 coastal aquifer strongly affected by subsidence and salinity intrusion, during drought events with EC peaks of 3000 µS/cm. To curb salt intrusion and increase the 0.9 hm^3/yr natural recharge rate, water utility HYDRALIA implemented a 0.2 hm^3/yr MAR scheme, drawing water from an upstream 24 km^2 carbonate aquifer of high quality (EC 300 µS/cm). The following challenges need to be tackled: i) as GW abstraction from the Señorío aquifer is at 100% of natural recharge rate + existing MAR, considering the predicted increase in GW abstraction due to population growth and in sea level due to CC, the MAR rate needs to be increased by including further water sources characterized by low salinity; ii) as the water level in the upstream aquifers shows high fluctuations with no water availability during drought periods, a control

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	system of the MAR based on real-time monitoring of upstream GW level and downstream salinity is needed; iii) the MAR project needs to be integrated to Earth Obs. techniques to monitor its effectiveness in curbing subsidence.
Scale & treatment	Cetaqua, the leader of this case study, is developing: • an innovative AI-based DSS, named M-AI-R-DSS, for the design of MAR systems, the cost analysis and the optimization of MAR operation (activation of periodic maintenance, optimization of flow rate to increase recharge efficiency, control of clogging); • the REACH tool for the assessment of the impact of economic growth and climate change on groundwater quality and quantity, taking into account different climate change scenarios.
Relevant climate change or pollution related challenges	As a result of climate change and population growth, groundwater levels are declining and water quality is deteriorating due to seawater intrusion.
Key intervention and objectives	• Development and calibration to the Senorio aquifer of i) the M-AI-R-DSS tool, for the design of MAR systems, the cost analysis and the optimization of MAR operation, and ii) the REACH tool for the assessment of the impact of economic growth and climate change on groundwater quality and quantity. • Development and implementation of an innovative methodology to establish LivingLabs across MAR2PROTECT case studies. Organization of LivingLab activities addressed to engage stakeholders, establish LivingLab teams and co-design broader societal engagement interventions across the M2P case studies.
Current status of the case study:	• The M-AI-R-DSS and REACH tools are at an advanced stage of development. • The case study living lab was launched and civil society engagement activities have been designed
Expected outcomes	• M-AI-R-DSS tool, for the design of MAR systems, the cost analysis and the optimization of MAR operation, calibrated and implemented in at least 4 MAR2PROTECT case studies. • REACH tool for the assessment of the impact of economic growth and climate change on groundwater quality and

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	quantity, calibrated and implemented in at least 4 MAR2PROTECT case studies.
Relevant sectors	Water utility HIDRALIA (private water utility – groundwater exploitation), Andalusian River Basin Organization - DGPyRH (regional authority, river management/planning), ACOSOL water authority (public water utility), IGME-CSIC (Spanish Geological Survey with huge expertise in groundwater bodies' assessment), Marbella municipality (local authority of DS6), Andalucía LAB (Innovative Tourism Centre – digital solutions for sustainable tourism including water indicators)
Ambition at the end of the project	• Development, calibration and implementation in at least 4 MAR2PROTECT case studies of the M-AI-R-DSS tool, for the design of MAR systems, the cost analysis and the optimization of MAR operation, and the REACH tool for the assessment of the impact of economic growth and climate change on groundwater quality and quantity. • Assessment of the proposed tools, enhancement of their replication potential and implementation of civil society engagement activities, through the involvement of a large stakeholder community by means of a living lab based on this case study.
Ambition beyond the project:	• Promote the replication of the M-AI-R-DSS and REACH tools • Increase the awareness of civil society groups on the issues of water scarcity and groundwater protection.
Key EU legislation applicable	• **Water Framework Directive (WFD) 2000/60/EC:** Establishes a framework for the protection of inland surface waters, transitional waters, coastal waters, and groundwater. • **Groundwater Directive 2006/118/EC:** Establishes specific measures as provided for in Article 17(1) and (2) of Directive 2000/60/EC in order to prevent and control groundwater pollution
Key national or/and regional legislation / policies	• River Basin Water Plan (Andalusian Mediterranean Basins) Third cycle (2022 - 2027) • Andalusian Water Law (2010) • Royal Decree-law for the approval of the Regional Action Climate Plan (2021) • Regional Climate Change Adaptation Plan (2018)

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	• National Royal Decree-law for water reclamation (RD 1620/2007)
Replication implications	The type of MAR implemented in this case study has a high replication potential, given the high number of cases in which MAR using water from upstream aquifers represents a suitable solution for aquifer protection. Moreover, a backup MAR has been identified (Aloha MAR system) to enhance the replication potential.
Policy implications	M-AI-R-DSS can guide policy briefs to propose monitoring approaches for several types of risks involved in the design, and O&M phases of a MAR system (e.g., clogging, human health risk). The proposed monitoring approaches will be aimed at enhancing the social acceptance of MAR schemes, especially those fed with treated wastewater.
Market implications	• Market placement of the M-AI-R-DSS tool, for the design of MAR systems, the cost analysis and the optimization of MAR operation • Market placement of the REACH tool for the assessment of the impact of economic growth and climate change on groundwater quality and quantity.

3.7 MAR2PROTECT Case Study 7 - Lima river estuary, Portugal

MAR2PROTECT Mar CS#7	**Protection of coastal aquifer and decrease of salinity intrusion by microbial-assisted re-vegetation-based phytoremediation of estuary sediments and surface water**
Location	Lima River Estuary, Portugal

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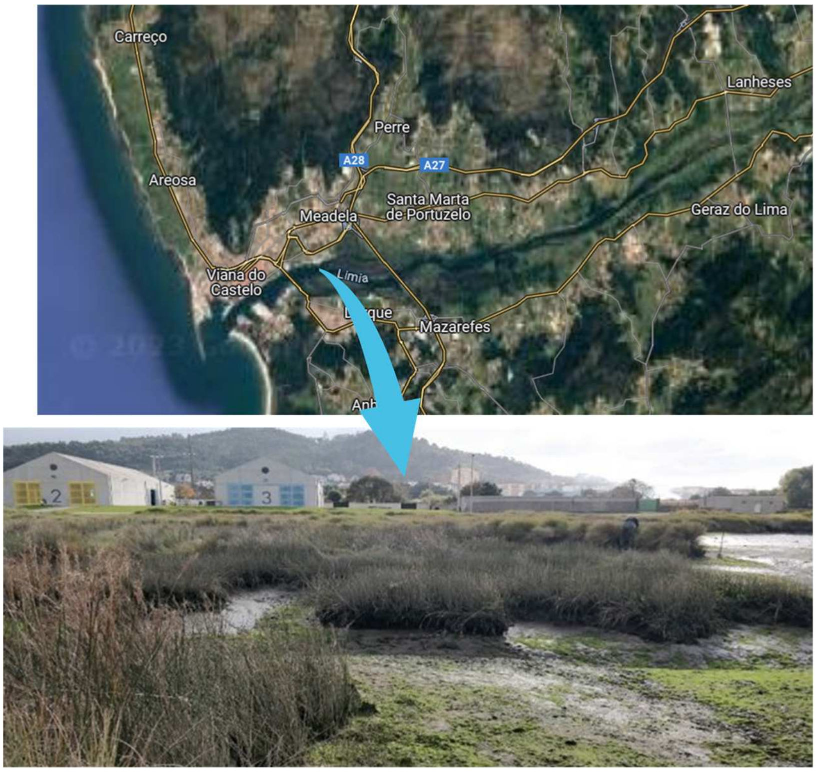
Pictures illustrating the case studies	
Keywords	Salinity intrusion, estuary, wetlands, ecosystem, phytoremediation, micropollutants.
Description	The Lima River Estuary, the end member of an international watershed in NW Portugal, receives diffuse pollution from agriculture, untreated MWW and industrial WW. Estuary sediments and SW are contaminated by nutrients, metals, EDCs and pharmaceuticals, and PAHs (all 16 considered a priority by EPA), which can generate a risk if transported to the aquifer. During tides, salt intrusion extends up to 20 km upstream in the river, strongly limiting the possibility of using river water for irrigation or drinking water production. Extreme weather events periodically cause relevant erosion.
Scale & treatment	CIIMAR, the leader of this case study, is developing: • A phytoremediation approach, based on re-vegetation of specific portions of the estuary, combined with root bioaugmentation with bacterial consortia, to promote uptake and biodegradation of sediment and surface water contaminants. • An ecosystem services model to quantify the effectiveness of estuary revegetation in reducing salt intrusion upstream in

	the river associated with sea tides and coastal erosion due to extreme sea storms, considering different climate change scenarios.
Relevant climate change or pollution related challenges	As a result of climate change and population growth, the contamination of sediments and surface water in the estuary is increasing, as well as salinity intrusion from the sea.
Key intervention and objectives	• Development of a phytoremediation approach, based on re-vegetation of specific portions of the estuary, to promote uptake and biodegradation of sediment and surface water contaminants. • Development and validation of an ecosystem services model to quantify the effectiveness of estuary revegetation in reducing salt intrusion upstream in the river associated with sea tides and coastal erosion due to extreme sea storms, considering different climate change scenarios. • Development and implementation of an innovative methodology to establish LivingLabs across MAR2PROTECT case studies. • Organization of LivingLab activities addressed to engage stakeholders, establish LivingLab teams and co-design broader societal engagement interventions across the M2P case studies.
Current status of the case study:	• The revegetation/phytoremediation approach is being tested at a lab scale. • The ecosystem model is under development.
Expected outcomes	• Validation at TRL 5 in a real estuary environment of a phytoremediation approach, based on re-vegetation of specific portions of the estuary, to promote uptake and biodegradation of sediment and surface water contaminants. • Development, calibration and validation in a real estuary of an ecosystem services model to quantify the effectiveness of estuary revegetation in reducing salt intrusion upstream in the river associated with sea tides and coastal erosion due to extreme sea storms.
Relevant sectors	Câmara Municipal de Viana do Castelo (local municipality), Capitania do Porto de Viana do Castelo (local authority), APA (National environmental agency); ARHN (Regional environmental agency); CMIA de Viana do Castelo (local org. for science dissemination to schools/general public).

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Ambition at the end of the project	• Validation at TRL 5 in a real estuary environment of a phytoremediation approach, based on re-vegetation of specific portions of the estuary, to promote uptake and biodegradation of sediment and surface water contaminants. • Development, calibration and validation in a real estuary of an ecosystem services model to quantify the effectiveness of estuary revegetation in reducing salt intrusion upstream in the river associated with sea tides and coastal erosion due to extreme sea storms.
Ambition beyond the project:	• Promote the replication of the phytoremediation/revegetation approach for the sustainable management of estuarine environments • Increase the awareness of civil society groups on the issues of water scarcity and groundwater protection.
Key EU legislation applicable	• **Water Framework Directive (WFD) 2000/60/EC:** Establishes a framework for the protection of inland surface waters, transitional waters, coastal waters, and groundwater. • **Groundwater Directive 2006/118/EC:** Establishes specific measures as provided for in Article 17(1) and (2) of Directive 2000/60/EC in order to prevent and control groundwater pollution
Key national or/and regional legislation / policies	• Lei da Água n.º 58/2005 (Water Law) https://files.dre.pt/1s/2005/12/249a00/72807310.pdf
Replication implications	• The approach promoted in this case study for the sustainable management of estuarine wetlands has a high replication potential, given the high number of estuaries characterized by water and sediment contamination and seawater intrusion.
Policy implications	• The ecosystem service model and the wetland phytoremediation approach developed in this case study can help to formulate policy recommendations aimed at promoting guidelines and legislation aimed at a stringer protection of estuarine environments and at increasing their tourist value.
Market implications	• Market placement of the ecosystem service model.

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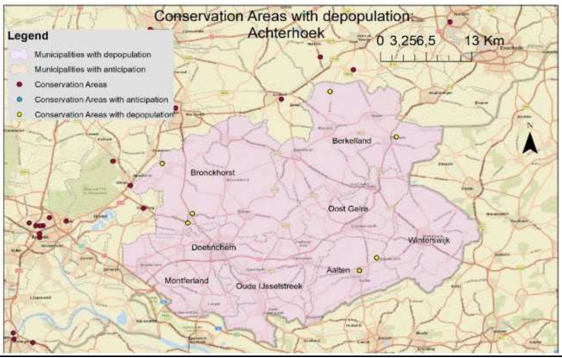
4 NINFA case studies

NINFA includes 8 case studies which are included in the presentation below:

- Case study 1 - Nin CS#1 - Achterhoek, Gelderland, the Netherlands
- Case study 2 - Nin CS#2 – Los Alcazares, Murcia, Spain
- Case study 3 - Nin CS#3 – Terrassa, Catalonia, Spain
- Case study 4 - Nin CS#4 – Butry-sur-Oise, Île-de-France, France
- Case study 5 - Nin CS#5 – Ibiza, Balear Islands, Spain
- Case study 6 - Nin CS#6 – Colombia
- Case study 7 - Nin CS#7 – Mexico
- Case study 8 - Nin CS#8 – Egypt

4.1 NINFA Case Study 1 – Achterhoek, The Netherlands

NINFA– NIN–CS#1	**Achterhoek**
Location	Gelderland, the Netherlands
Pictures illustrating the case studies	 
Key words	Groundwater depletion, drought, transport model, organic micro-pollutants
Description	The Rhine IJssel Water Board has been working on the development of this area to create a robust and future-proof water system in the Baakse Beek estate zone. Although this area is part of the GNN and its nature is protected, it has been drying up, which means that the current groundwater situation is not optimal due to human influence. Measures are being sought to create a climate-proof, robust water system in which the various functions, including agriculture, are

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	strengthened and a better situation is created for the landscape and heritage.
Scale & treatment	• The NINFA project will research how drought and drought-relief measures affect groundwater quality, with a focus on nitrate and organic micropollutants.
Relevant climate change or pollution related challenges	Regarding GW quality, droughts have been increasingly common in this area in recent years, and it is projected that they will become more severe and frequent in the future as a result of climate change. The summer of 2018 was an extreme example of drought in the Netherlands, with high temperatures and below-average precipitation causing a significant precipitation deficit.
Key intervention and objectives	• Develop a cost-efficient monitoring strategy based on the integration of existing sensors and analytical approaches with innovative tools. • Assess the existing sources and pathways of GW pollution, their synergistic effects with stressors such as droughts and floods or prevention/mitigation measures, by testing and validating hydrogeological and reactive transport models for nutrients, pesticides, and emerging contaminants from wastewater. Furthermore, it is proposed to create management scenarios and propose measures to mitigate the effects of drought on the groundwater system.
Current status of the case study:	• The study area has recently experienced drought conditions, resulting in a notable decline in the groundwater table. • This reduction in groundwater levels has had consequential impacts on agricultural and economic activities within the region. • In response, the Dutch government has undertaken initiatives to render the area more resilient to climate-related challenges. • However, there exists a knowledge gap regarding the potential effects of these governmental measures on groundwater quality. • Addressing this concern, the NINFA project endeavors to develop sophisticated transport models and scenarios aimed at effectively managing the groundwater system. • Presently, the flow model has reached its finalization stage, with plans for subsequent expansion to incorporate transport models pertaining to nitrate and select organic micropollutants.

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Expected outcomes	• Develop Hydrological and transport models using convectional AI model techniques. • Develop (at least 6) scenarios to manage the groundwater system during the drought periods considering the groundwater quality
Relevant sectors	Public authorities, software development
Ambition at the end of the project and beyond	• Development and validation of AI-enhanced hydrological and reactive transport models. • Accurate prediction and management of groundwater resources, addressing the impacts of drought and pollution effectively. • Creation of actionable management scenarios tailored to mitigate the effects of drought on groundwater systems.
Ambition beyond the project:	• Facilitate the replication of the project's successful methodologies and technologies in other regions facing similar groundwater and climate challenges. • Develop adaptive management strategies that evolve with changing climate conditions and technological advancements. • Contribute to the creation of standardized guidelines for sustainable groundwater management. • Contribute to the creation of standardized guidelines for sustainable groundwater management.
Key EU legislation applicable	• **Water Framework Directive (WFD) 2000/60/EC:** Establishes a framework for the protection of inland surface waters, transitional waters, coastal waters, and groundwater. • **Groundwater Directive 2006/118/EC:** Establishes specific measures as provided for in Article 17(1) and (2) of Directive 2000/60/EC in order to prevent and control groundwater pollution
Key national or/and regional legislation / policies	• **Environmental Management Act (Wet Milieubeheer):** Provides a comprehensive framework for environmental protection, including water and soil quality.
Replication implications	• Implementing AI-based hydrological and transport models can help utilities predict and mitigate the impacts of drought on water supply and quality, enhancing their resilience against climate change. • The assessment of sources and pathways of groundwater pollution can guide utilities in implementing targeted measures to reduce contaminants, particularly nitrate and organic micropollutants.

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	• The development of regional management scenarios based on the project's findings can help regions tailor their groundwater management approaches to local conditions, enhancing climate resilience. • The project's focus on nitrate and organic micropollutants can inform further research into emerging contaminants. • By adopting climate-proof water management strategies, regions and utilities can better withstand the effects of climate change, ensuring the sustainability of water resources. • The replication of successful measures can lead to significant improvements in groundwater quality, reducing health risks and ensuring safe drinking water supplies.
Policy implications	• **Potential)** Effective mitigation strategies can reduce the adverse impacts of drought and pollution on groundwater resources. • **(Potential)** Create frameworks for implementing drought and pollution mitigation measures, such as artificial recharge and optimized irrigation.
Market implications	Advanced software tools that use AI to predict groundwater behavior and pollutant transport under various scenarios.

4.2 NINFA Case Study 2 - Los Alcazares, Spain

NINFA – NIN – CS#2	**Los Alcazares**
Location	Murcia, Spain
Pictures illustrating the case studies	 

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Key words	Seawater intrusion, nitrate, organic micropollutants, sensors, modeling
Description	Los Alcázares is a Spanish municipality in the autonomous community of Murcia, in the southeast of Spain (see Figure below). Los Alcazares is located on the coast of Mar Menor, which is Europe's largest saltwater lagoon with almost 170 km2, and an area of great ecological, geological and scenic importance. Its surrounding areas are particularly rich in landscape values, and it is an area where up to ten approved environmental protection figures converge.
Scale & treatment	The Campo de Cartagena groundwater mass faces the threat of not meeting required quantitative and chemical standards, as highlighted by the Segura Hydrographic Confederation. This area, a crucial supplier of winter vegetables to European markets, heavily depends on irrigation, primarily sourced from the Tagus-Segura Water Transfer and groundwater. Overuse of the deeper aquifer layers is prominent, while the upper aquifer suffers from an excess of water, leading to issues such as seawater intrusion and water table elevation. Intensive agricultural practices, including fertigation and extensive manure application, contribute to contamination of the aquifer with nitrates, pesticides, and nutrients.
Relevant climate change or pollution related challenges	• Seawater intrusion, the filtration of irrigation water, which has increased since the construction of the transfer, as well as periodic intense rains, have made the water table so high that water surfaces on to the ground at some points. These upper layers of the aquifer are highly polluted with nitrates, pesticides and nutrients and drains directly to the Mar Menor which often suffers severe eutrophication episodes resulting in reduction in water transparency and several episodes of anoxia (see Figure above).
Key intervention and objectives	• Robust, real time and affordable sensors will be developed in the lab will be tested at certain sites for GW monitoring and early-detection of pollutants.

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	• Assess the existing sources and pathways of GW pollution, their synergistic effects with stressors such as droughts and floods or prevention/mitigation measures, by testing and validating hydrogeological and reactive transport models for pollutants of interest. • Develop a train of treatment technologies including nature-based solutions, to minimize nutrients, pesticides and other pollutants (metals and antibiotics from manure) leaching to GWs.
Current status of the case study	• The hydrological model for the case study is currently in development. • The sensory device underwent testing in the lab, and fieldwork is scheduled for summer 2025 to install and test these sensors at the case study site.
Expected outcomes	• Develop robust, real-time, and affordable sensors for groundwater monitoring. • Explore prevention and mitigation measures for groundwater pollution. • Validate hydrogeological and reactive transport models for targeted pollutants. • Design a treatment train comprising membrane-based technologies, Advanced Oxidation Processes, and nature-based solutions. • Implement the treatment train to minimize leaching of nutrients, pesticides, metals, and antibiotics from manure into groundwater. •
Relevant sectors	Groundwater treatment, water utilties, technology providers, sensor development
Ambition at the end of the project and beyond	• Develop advanced sensors that are able to characterize the groundwater quality aspects. • Apply different trains of technologies to minimise the infiltration of nitrates and pesticides in GW
Ambition beyond the project:	• Support continuous innovation in monitoring systems, hydrological models, technologies and management strategies.
Key EU legislation applicable	• **Water Framework Directive (WFD) 2000/60/EC** : Establishes a framework for the protection of inland surface waters, transitional waters, coastal waters, and groundwater. • **Groundwater Directive 2006/118/EC :** Establishes specific measures as provided for in Article 17(1) and (2) of Directive 2000/60/EC in order to prevent and control groundwater pollution.

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	• **Regulation (EU) 2020/741:** Lays down minimum water quality requirements for the safe reuse of treated urban wastewaters for agricultural irrigation between EU countries
Key national or/and regional legislation / policies	• **Royal Decree 1620/2007**: Establishes a legal framework for the reuse of treated wastewater for 5 intended reuse categories and lays down minimum water quality requirements.
Replication implications	• Water utilities can replicate the cost-efficient monitoring strategies developed in this project, integrating existing sensors with innovative tools. This can improve the detection and management of groundwater quality issues. • Implementing hydrological and transport models can help utilities predict and mitigate the impacts of drought on water supply and quality, enhancing their resilience against climate change.
Policy implications	• Real-time monitoring can lead to more responsive and adaptive management strategies. • Organic and circular fertilisers can be promoted in sensitive and highly impacted areas.
Market implications	• Development and commercialization of advanced groundwater monitoring sensors and systems, and modular trains of technologies.

4.3 NINFA Case Study 3 – Terassa, Spain

NINFA – NIN – CS#3	Terrassa
Location	Terrassa, Barcelona, Spain
Pictures illustrating the case studies	
Key words	pilot site, train of technologies, reclaimed water , urban runoff

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Description	Terrassa is a city located in the comarca del Vallès Occidental with an extension of about 70.2 km² and which belongs to the province of Barcelona, one of the four provinces that are part of Catalonia, Spain. Terrassa originated as a Roman city of Egara in the 1st century, during the reign of the Roman emperor Vespasian. It was founded close to the Vallparadís torrent, which originates in Matadepera and passes through Terrassa
Scale & treatment	• Terrassa is located in an area with good permeable and porous materials that conform the aquifer and would allow the passage of rainwater. However, a big part of its central area is an urban area, all paved with concrete and asphalt, which difficult drainage and leads to severe floods in the center of the city after storm events. The surroundings of the city center suffer a strong industrial activity which may increase the vulnerability of the aquifer due to the high pollution and the high rate or permeability.
Relevant climate change or pollution related challenges	Although there are no water quality wells, GW is suspected to be contaminated with urban runoff, since 43.2% of the aquifer area is urban/industrial soil.
Key intervention and objectives	• Identify and select a pilot site in Terrassa for addressing groundwater contamination caused by urban runoff. • Develop and test an optimized train of technologies to produce reclaimed water from urban runoff, focusing on biological (Nature-based solutions, NBS), chemical (Advanced Oxidation Processes, AOPs), and physical processes (membranes). • Evaluate the effectiveness of using reclaimed water for various purposes such as irrigation, street cleaning, and indirect aquifer recharge. • Implement the train of technologies to remove hydrocarbons (HCs) and microplastics (MPs) from urban runoff. • Incorporate processes for the recovery of selected metals (Platinum (Pt) and Palladium (Pd)) originating from car catalysts and brakes into the treatment train. • Monitor the performance and efficiency of the treatment train in removing contaminants and recovering metals..
Current status of the case study:	• A pilot site has been set in a parking zone to collect all runoff water from the area and measure HC, MP and HM. • Contacts with the Municipality of Terrassa has been made to study any potential location of a new urban pilot.
Expected outcomes	• Develop and test an optimized train of technologies to produce reclaimed water from urban runoff, focusing on biological (Nature-based solutions, NBS), chemical

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	(Advanced Oxidation Processes, AOPs), and physical processes (membranes).
Relevant sectors	Water utilties, treatment technology providers
Ambition at the end of the project and beyond	• Develop and test an optimized train of technologies to produce reclaimed water from urban runoff
Ambition beyond the project:	• Promote local water reuse with quality to either recharge aquifers or for direct use (irrigation, urban uses, etc) by implementation of the proposed treatment technology train.
Key EU legislation applicable	• **Water Framework Directive (WFD) 2000/60/EC**: Establishes a framework for the protection of inland surface waters, transitional waters, coastal waters, and groundwater. • **Groundwater Directive 2006/118/EC:** Establishes specific measures as provided for in Article 17(1) and (2) of Directive 2000/60/EC in order to prevent and control groundwater pollution. • **Regulation (EU) 2020/741:** Lays down minimum water quality requirements for the safe reuse of treated urban wastewaters for agricultural irrigation between EU countries
Key national or/and regional legislation / policies	• **Royal Decree 1620/2007**: Establishes a legal framework for the reuse of treated wastewater for 5 intended reuse categories and lays down minimum water quality requirements.
Replication implications	Treatment train with specific low-cost unit operations that can be implemented in other urban areas.
Policy implications	Foster the implementation of SUD's and other treatment devices to effectively eliminate HC, MP and HM infiltration to the GW in the urban planification.
Market implications	Development and commercialization of urban advanced modular trains of technologies.

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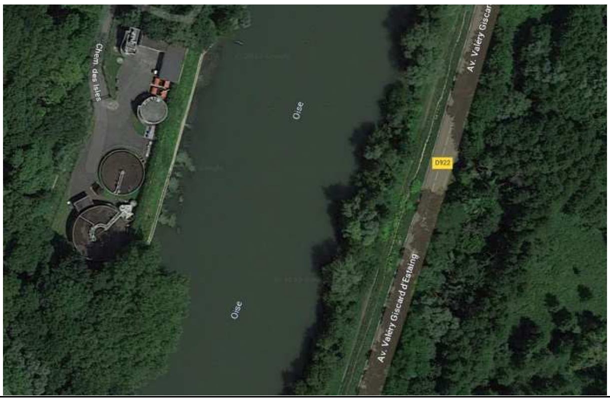
4.4 NINFA Case Study 4 - Butry-sur-Oise WWTP, France

NINFA – NIN – CS#4	Butry-sur-Oise WWTP
Location	Butry-sur-Oise, Île-de-France, France
Pictures illustrating the case studies	
Key words	Tertiary wastewater treament technologies, contaminants of emerging concern (CEC), water reuse
Description	The wastewater treatment plant (WWTP) at Butry-sur-Oise (Figure 15) treats on average 1163m^3/day of wastewater which corresponds to a nominal capacity of 6700 population equivalent (PE). The WWTP has a secondary treatment stage where primary effluent is treated using an extended aeration activated sludge system. The treated water is then released into the Oise River which is in the Seine-Normandy watershed. The WWTP does not have a specific tertiary treatment for the elimination of contaminants of emerging concern (CECs) like pharmaceuticals, microplastics (MPs) and antibiotic resistant bacteria/antibiotic resistant genes (ARBs/ARGs), which can lead to their presence in the effluent, along with certain nutrients like nitrates and phosphates. Due to the possible connection of the watershed to aquifer, the GW might present contamination with these pollutants.
Scale & treatment	• Investigate the tertiary treatment of treated wastewater for possible reuse by indirect aquifer recharge (or other uses based on the quality) • Evaluate the performance of a combination of technologies for the removal of CECs.
Relevant climate change or pollution related challenges	• Climate change effects such as extended periods of droughts limit the amount of water that is available for irrigation and/or recharge groundwater by infiltration. • CECs present in WWTP effluents can potentially pollute soil and/or groundwater.

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Key intervention and objectives	• Characterise the main composition of CECs (pharmaceuticals, MPs and ARB/ARGs) in the WWTP effluent. • Application of a combination of low-cost Advanced Oxidation Processes, activated carbon, and biofiltration for the removal of the contaminants characterised.
Current status of the case study:	• Currently wastewater undergoes only secondary treatment with activated sludge at the WWTP. The WWTP does not have a specific tertiary treatment for the elimination of CECs. •
Expected outcomes	• • Elimination of CECs (pharmaceuticals, MPs and ARB/ARGs) • Obtain reclaimed water with requested quality standards that can be used to recharge aquifers indirectly or other uses based on the quality.
Relevant sectors	Water utilties, technology providers
Ambition at the end of the project and beyond	• Setup and validate pilot units of tertiary wastewater treatment technology train at WWTP at Butry-sur-oise
Ambition beyond the project:	• Promote local water reuse with quality to either recharge aquifers or for direct use (irrigation, urban uses, etc) by implementation of the proposed treatment technology train.
Key EU legislation applicable	• **EU Regulation 2020/741** on minimum requirements for wastewater reuse
Key national or/and regional legislation / policies	• **Decree 2023/835 of August 29, 2023** codifying provisions on the use and conditions of use of rainwater and treated wastewater (French). • **Order of December 14, 2023** on conditions for production and use of treated wastewater for watering green spaces (French). • **Order of December 18, 2023** concerning the conditions of production and use of treated wastewater for crop irrigation (French).
Replication implications	Treatment train with specific low-cost unit operations that can be implemented in other WWTPs.

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Policy implications	Current water policies are being recast to consider the presence and elimination of CECs, the proposed treatment technologies will help to achieve the quality standards regarding CECs and in a wider perspective, water reuse in the context of water stress.
Market implications	Treatment train with specific low-cost unit operations that can be implemented in other WWTPs.

4.5 NINFA Case Study 5 – Ibiza, Spain

NINFA – NIN – CS#5	**Ibiza**
Location	Ibiza, Balear Islands, Spain
Pictures illustrating the case studies	
Key words	Replication site, Groundwater overexploitation, Saline intrusion
Description	Potable Water Treatment Plant (PWTP) in Ibiza, situated in a Mediterranean climate, serves a landmass of 572 km² and a resident population of 147,914 individuals. However, with 2,000 tourists per every 100 residents, the island contends with significant socio-environmental pressures. .
Scale & treatment	Notably, the overexploitation of groundwater resources stands out as a major concern. The island's proximity to the sea and limited natural replenishment contribute to severe issues of saline intrusion.
Relevant climate change or pollution related challenges	Ibiza faces a critical water supply challenge, prompting the installation of desalination plants as part of the solution
Key intervention and objectives	The monitoring data collected will contribute to the creation of the Groundwater Knowledge Observatory as part of the NINFA project. Additionally, it will aid in validating the NINFA Platform, ensuring its accuracy and effectiveness.
Current status of the case study:	During RP2 data will be gathered and NINFA DSS will be adjusted.

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4.6 NINFA Case Study 6 - Colombia

NINFA – NIN – CS#6	Colombia
Location	Colombia
Pictures illustrating the case studies	
Key words	Replication site, Wastewater Treatment Plant Potable Water Treatment Plant
Description	Two sites have been engaged: • El Salitre Wastewater Treatment Plant (WWTP) in Bogota: Serving a population of 7.7 million, this facility operates in a temperate climate due to its high altitude (2540-4650 m). Located in the Sabana de Bogota aquifer region, it caters to 3 million people and has recently been expanded to enhance water quality in the Bogota River • Potable Water Treatment Plant (PWTP) in Villa del Rosario: Serving 88,433 residents, this plant operates in a tropical-dry climate. It draws water from the Tachira-Cretaceous aquifer, which is shared with Venezuela.
Scale & treatment	• In line with SDG6, the National Government stablished a Plan for achieving potable water access to 8,573,951 people in 2022 (100% population in 2030) and increasing the percentage of treated wastewater up to 54.3% in 2022.
Relevant climate change or pollution related challenges	• The Bogotá River faces contamination from various sources, including Contaminants of Emerging Concern (CECs), Antibiotic Resistance Genes (ARGs), and Microplastics (MPs). • Both the Tachira River and the aquifer are polluted with nitrates and wastewater treatment plant effluents. The absence of a complete purification system results in insufficient drinking water quality. Efforts are underway to address these challenges and improve water safety.
Key intervention and objectives	• The monitoring data collected will contribute to the creation of the Groundwater Knowledge Observatory as part of the NINFA project. Additionally, it will aid in validating the NINFA Platform, ensuring its accuracy and effectiveness

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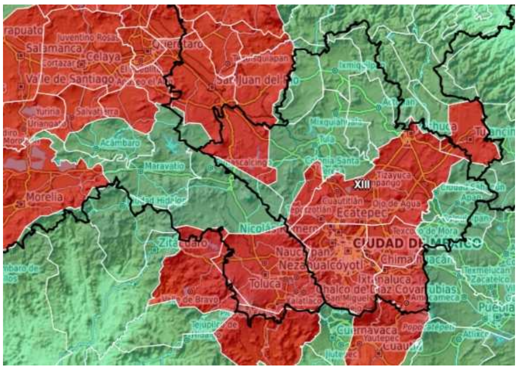
Current status of the case study:	• During RP2 data will be gathered and NINFA DSS will be adjusted.

4.7 NINFA Case Study 7 - Mexico

NINFA – NIN – CS#7	Mexico
Location	Mexico
Pictures illustrating the case studies	 Aquifer overexploitation in Mexico (red), with sites highlighted in yellow
Key words	Replication site
Description	Two key sites are targeted for intervention: • Cuernavaca WWTP (341,029 inhabitants; Dry-winter subtropical highland climate; Cuernavaca aquifer) • San Javier PWTP in Querétaro (794,789 inhabitants; Cold semiarid -steppe- climate; Queretaro aquifer): the aquifer is overexploited (average availability of -63.7 hm^3/year)
Scale & treatment	• In Mexico, significant challenges persist regarding wastewater treatment and access to potable water, with only 37.8% of wastewater treated and 10.5 million lacking sewage access, alongside 9 million without potable water access. Moreover, 157 out of 653 aquifers were overexploited in 2019, with 50 becoming overexploited in the last two years.
Relevant climate change or pollution	• Cuernavaca WWTP generates effluents contaminated with CEC, ARGs, MP;

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related challenges	• San Javier PWTP in Querétaro: the aquifer is overexploited with presence of nitrates due to agriculture activity; 4 of 6 wells also present contamination with fluorides.
Key intervention and objectives	• The monitoring data collected will contribute to the creation of the Groundwater Knowledge Observatory as part of the NINFA project. Additionally, it will aid in validating the NINFA Platform, ensuring its accuracy and effectiveness.
Current status of the case study:	• During RP2 data will be gathered and NINFA DSS will be adjusted.

4.8 NINFA Case Study 8 - Egypt

NINFA – NIN – CS#8	Egypt
Location	Egypt
Pictures illustrating the case studies	
Key words	Replication site
Description	The Nile Delta aquifer, vital for groundwater supply, including the Abu Rawash Wastewater Treatment Plant (WWTP), is under pressure. Despite Nile replenishment, the aquifer is impacted by direct exposure to the Mediterranean Sea and Suez Canal. Groundwater availability has annually declined since 1981, while pollution from agriculture, population density, and wastewater effluents, notably from the Abu Rawash WWTP, degrade water quality.
Scale & treatment	• Although the aquifer is replenished directly by the Nile water, it is also in direct contact with the Mediterranean Sea (north) and the Suez Canal (east). Since 1981 the GW potentiality is decreasing annually in a linear fashion by 0.1 billion m^3.
Relevant climate change or pollution related challenges	• Egypt faces a critical water scarcity challenge, nearing "absolute water scarcity" levels defined by the UN. • Contaminants in the WWTP effluent include nutrients, Contaminants of Emerging Concern (CECs), Antibiotic Resistance Genes (ARGs), and Microplastics (MP).

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Key intervention and objectives	• The monitoring data collected will contribute to the creation of the Groundwater Knowledge Observatory as part of the NINFA project. Additionally, it will aid in validating the NINFA Platform, ensuring its accuracy and effectiveness.
Current status of the case study:	• During RP2 data will be gathered and NINFA DSS will be adjusted.

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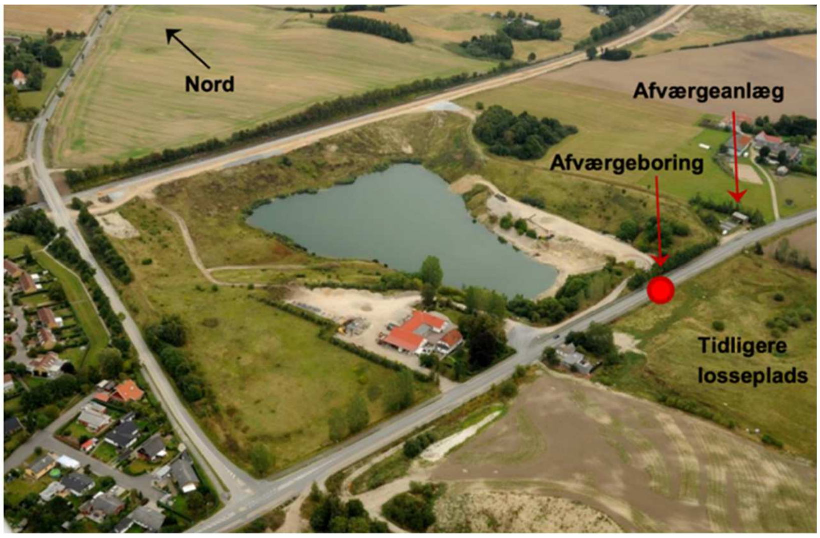
5 UPWATER case studies

UPWATER includes 3 case studies which are included in the presentation below:

- Case study 1 – UP CS#1 - Stengaarden dumpsite in Denmark
- Case study 2 – UP CS#2 - Athens metropolitan region in Greece
- Case study 3 – UP CS#3 - Besòs Barcelona metropolitan region in Spain

5.1 UPWATER Case Study 1 - Stengaarden dumpsite in Denmark

UPWATER– UP– CS#1	Stengaarden dumpsite in Denmark
Location	Aquifer beneath Stengaarden dump site, Region Sjælland, DK
Pictures illustrating the case studies	 Picture of Stengaarden dumpsite. The dumpsite is now covered with soil (Bown field front –right)

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	 The Stengaarden pilot in autumn 2023. From left to right: 1) white tank: Inlet buffer tank; 2) black cylinders (1 front and one hind): Moving Bed Biofilm Reactors (MBBR), 3) white tanks: buffer tanks as inlet for the biofilters; 4) steel tanks (outside the container): biofilters
Key words	**Dumpsite, pesticides, rural area, temperate climate, Nature-based solutions**
Description	Polluted rural area at which the groundwater is impacted by pesticide wastes; Pollutants to be studied: Phenoxy acid pesticides, iron; Monitoring systems: direct sampling plus direct HPLC-MS/MS in comparison to ceramic passive samplers for organic contaminant monitoring, diffusive gradients in thin films for trace metal monitoring, source apportionment-modelling; Mitigation solution: Moving Bed Biofilm Reactors (MBBR) and biofilters
Scale & treatment	• MBBR and biofilters will be used to remove pesticide contamination from groundwater – both technologies will at the large work as biofilm systems, with the biofilters being expected to also be able to utilise phytoremediation. The MBBR will be tested for bio-Fenton capacities. • two parallel trains with a capacity of about 30 L/h. Testing for capacity will be a major part of UPWATER. The size is about 1/1000 of full-scale • It is expected the solution will work as managed aquifer recharge (MAR)
Relevant climate change or pollution related challenges	• More intensive rainfalls and related transfer of pollutants into the groundwater • Prolonged periods of drought and related increases in contaminant concentrations

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Key intervention and objectives	• MBBR and biofilters will be used to remove pesticide contamination. The aim is to achieve drinking water quality • Elaboration of effective preventive measures to diffuse pollution in participatory processes with stakeholders to produce policy recommendations
Current status of the case study:	• MBBR pilot correctly installed and ¾ of a year of experiments conducted and continuous monitoring ongoing. • 1st monitoring campaign on groundwater completed
Expected outcomes	• It is expected to be demonstrated whether a biofilter can in principle be operated all year round under Danish weather conditions • It is expected to demonstrate whether the approach is resilient to the high iron load or can even utilise it. • Developed biobased solutions will be able to prevent and mitigate GW pollution to concentration levels below toxicity and water quality guideline thresholds, but at least an 90% reduction is expected for chemicals to reach drinking water quality to defuse the situation for a well field for producing drinking water nearby. • Policy briefs at national level - to provide evidence of harmful pollutants affecting GW with case-specific recommendations
Relevant sectors	As direct treatment of raw drinking water is not accepted by Danish laws, this serves as an indirect pretreatment of contaminated water before the pollution has spread to the drinking water wells and at source thus a) the economy is better as potentially a smaller volume needs treating b) the pollution is fought before spreading.
Ambition at the end of the project and beyond	• Validate NBS in environmental conditions to mitigate ground water pollution with pesticides, moving from TRL 3 to 5 • Develop compound specific isotope analysis for pesticides and in combination with ceramic passive samplers
Ambition beyond the project:	• Application of novel NBS solutions which will enable the operator to i) protect GW pollution and ii) save developing and applying energy intensive chemical treatment and thus save CO_2 emission equivalents for 35 Wh/m^3 • Implementation of integrated passive sampling instead of traditional grab water sampling which will imply an overall cost reduction for the GW directive of 2Meur/year in GW routine monitoring (market size = 15.930) • Implementation of integrated passive sampling instead of traditional grab water sampling which will imply an overall cost reduction for the WFD directive of 60Meur/year in WFD routine monitoring (market size = 146.510) • Influence relevant local/regional and EU policy updates

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Key EU legislation applicable	• EU drinking water directive • EU groundwater directive
Key national or/and regional legislation / policies	• Pesticide taxation scheme • Missing legislation on diffuse groundwater pollution
Replication implications	In Northern Europe temperatures below zero are expected in winter. Thus, the demonstration on operationality of the solution for minus temperatures is crucial.
Policy implications	Independently from the concrete case Stengaarden, in Denmark there are missing policies on protecting groundwater against diffuse pollution such as groundwater protections zones. UPWATER will discuss groundwater protection zones as preventive measures to groundwater contamination a) by law and b) by mutual agreements (PPPs) with the Danish authorities and utilities. Findings from this case study may be incorporated into recommendations for improvements in existing and proposed EU policies, including Water Framework Directive, Groundwater Directive, Drinking Water Directive, and the proposed Water Resilience Initiative, if it proceeds.
Market implications	MBBRs have proven quite successful for treating wastewater. It is the first time these are used for treating contaminated groundwater. There are two companies that would be interested in approaching this market. Biofiltration is getting more and more popular (both rapid and slow filtration), though it is difficult to transfer knowledge from one case to another.

5.2 UPWATER Case Study 2 - Athens metropolitan region, Greece

UPWATER– UP– CS#2	**Athens metropolitan region in Greece**
Location	River Kifisos, Athens, Greece

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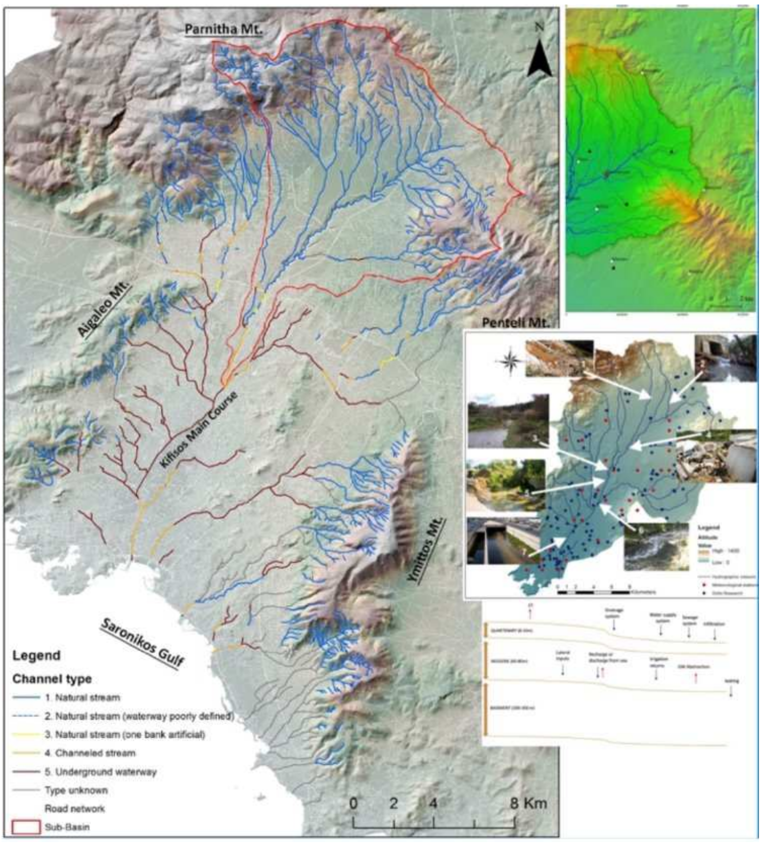
Pictures illustrating the case studies	 Map over the River Kifisos catchment, Athens, Greece  Installations of monitoring stations in: (i) Kifisos River, (ii) a selected monitoring well and (iii) construction of artificial wetland for pilot experiments at Athens Municipality Nursery.
Key words	Urban area, nutrients, contaminants of emerging concern (CECs), per-and polyfluoroalkyl substances (PFAS), polycyclic aromatic hydrocarbons (PAH), trace metals, pathogens, Mediterranean climate, nature-based solutions, shallow-infiltration wells, hydroinformatics

Description	Polluted urban area; Pollutants to be studied: nutrients, metals, CECs, PFAS and viruses; Monitoring systems: ceramic passive samplers for organic contaminant monitoring, passive samplers, virus passive samplers, diffusive gradients in thin films for monitoring of bioavailable trace metals, source apportionment-modelling; Mitigation solutions: ZVI-bioelectrochemical wetland, shallow-infiltration well
Scale & treatment	• Novel wetland technology will be used to remove contamination with nutrients, trace metals, and CECs. • 3 cells of 6 m^2 each treating a maximum water flow of 10 m^3/d • Shallow-infiltration well for in-situ remediation of river water quality (cylindrical device of 1×0.5m)
Relevant climate change or pollution related challenges	• Water scarcity and prolonged drought periods and related increases in contaminant concentrations • Flash flood phenomena in urban and peri-urban environment • Wild-fires in the mountainous zone of the catchment
Key intervention and objectives	• Floating wetlands will be used to remove contamination with nutrients, trace metals, and CECs. The aim is to achieve improvement of treated wastewater effluent, ideally up to drinking water quality, for minimisation of environmental impacts to the underlying aquifer and the marine environment • Shallow-infiltration well will be used to remove contamination with nutrients, trace metals, and CECs. The aim is to achieve improvement of infiltrating water in the hyporheic zone for MAR applications in urban environments. • Elaboration of effective site-specific preventive measures in participatory processes with stakeholders to produce policy recommendations
Current status of the case study:	• Wetland/shallow-well pilot in the process of construction • 1st monitoring campaign with passive samplers completed • 2nd monitoring campaign on-going
Expected outcomes	• Policy briefs at local/regional level - to provide evidence of harmful pollutants affecting GW with case-specific recommendations • Developed biobased solutions will be able to prevent and mitigate GW pollution to concentration levels below toxicity and water quality guideline thresholds, but at least an 90% reduction is expected for chemicals and 2-3 log units for pathogens (absolute values) • Contribute to the re-design of the monitoring network of the regional water authority based on UPWATER results

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Relevant sectors	
Ambition at the end of the project and beyond	• Optimize passive sampler technology and validate for groundwater conditions, moving from TRL 3-4, depending on sampler type, to TRL 5-6. • Validate novel NBS technology in environmental conditions to mitigate surface water pollution and protect groundwater, moving from TRL 3 to 5 • Development of an integrated monitoring scheme for real-time hydrologic data acquisition on the catchment scale • Integration of the UPWATER monitoring stations with the national research infrastructure for river gauging in Greece • Development of an urban hydro-environmental observatory for the Kifisos catchment in Athens
Ambition beyond the project:	• Application of novel NBS solutions which will enable the operator to i) protect GW pollution and ii) save developing and applying energy intensive chemical treatment and thus save CO_2 emission equivalents for 35 Wh/m^3 • Implementation of integrated passive sampling instead of traditional grab water sampling which will imply an overall cost reduction for the GW directive of 2Meur/year in GW routine monitoring (market size = 15.930) • Implementation of integrated passive sampling instead of traditional grab water sampling which will imply an overall cost reduction for the WFD directive of 60Meur/year in WFD routine monitoring (market size = 146.510) • Influence relevant local/regional and EU policy updates • Support of the UPWATER cloud platform to the Greek national research infrastructure for river gauging • Replicate the shallow-wells in rectangular-shaped units along the river-source to improve the quality of infiltrating water in the hyporheic zone.
Key EU legislation applicable	• The Water Framework Directive (2000/60/EC). • The Groundwater Directive (2006/118/EC). • The Drinking Water Directive (EU) 2020/2184. • The Urban Waste Water Treatment Directive (91/271/EEC). • Environmental Quality Standards Directive (2008/105/EC) • Industrial Emissions Directive (2010/75/EU). • REACH Regulation (1907/2006). • Water Reuse Regulation (EU) 2020/741. • Floods Directive (2007/60/EC).
Key national or/and regional legislation / policies	• Joint Ministerial Decree 145116/2011: Definition of measures, conditions, and procedure for wastewater reuse • Presidential Decree 51/2007 • Law 3199/03 on water protection and the sustainable management of the water resources

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	• Regional Water Directories and Councils • River Basin Management Plan – Attica River Basin District (GR06)
Replication implications	• The shallow-infiltration wells are envisaged to be replicated in rectangular shape constructions transversely along Kifisos river course for the improvement of infiltrating water quality within the hyporheic zone. • The shallow-infiltration wells can be replicated in similar urban environments as point Managed Aquifer Recharge (MAR) solutions for urban settings using stormwater as recharge source. • Wetland systems may be replicated in similar urban environments • Wetland systems may be upscaled and implemented in riverbed settings close to wastewater discharge zones, for large-scale treatment of wastewater treatment plant effluent
Policy implications	Findings may be relevant to updating local policies for implementing integral water cycle management, control mechanisms of contamination risks at source and before reaching natural aquatic systems and using NBS to treat wastewater and reduce marine environment pollution. As water reuse and stormwater management can increase resilience in a changing climate and water demand, policies also aim to increase the use of alternative water resources, such as NBS-treated wastewater. The elaboration of effective site-specific preventive measures can further contribute to policy improvement. Findings from this case study may be incorporated into recommendations for improvements in existing and proposed EU policies, including Water Framework Directive, Groundwater Directive, Drinking Water Directive, and the proposed Water Resilience Initiative, if it proceeds.
Market implications	• The applied LoRa technologies can be adopted by water utilities for monitoring of water-related parameters in wastewater treatment plants at several steps of wastewater treatment processes using low-energy sensors of low-cost systems with zero-cost data transfer requirements.

5.3 UPWATER Case Study 3 - Besòs Barcelona metropolitan region, Spain

UPWATER–UP– CS#3	**Besòs Barcelona metropolitan region in Spain**

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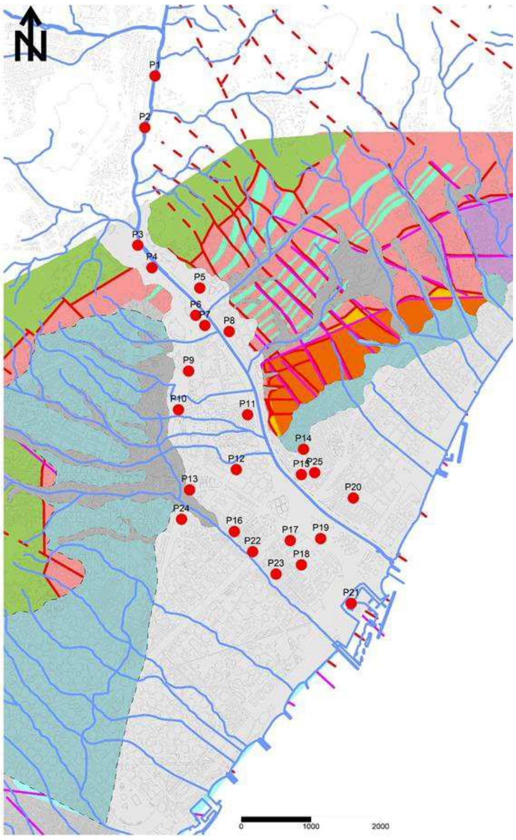
Location	Besòs, Barcelona, Spain
Pictures illustrating the case studies	 Map over the Besòs river catchment showing the 20 selected wells for groundwater monitoring

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	 Nature-Based Solutions (NBS) applied treating the outlet water of the waste water treatment plant EDAR Montcada I Reixac in Barcelona before it gets reintroduced into the river Besos.
Key words	Urban area, contaminants of emerging concern (CECs), per-and polyfluoroalkyl substances (PFAS), trace metals, pathogens, pesticides, nutrients, Mediterranean climate, NBS
Description	Polluted urban area; Pollutants to be studied: nutrients, metals, CECs, PFAS and viruses; Monitoring systems: ceramic passive samplers for organic contaminant monitoring, passive samplers, virus passive samplers, diffusive gradients in thin films for monitoring of bioavailable trace metals, source apportionment-modelling; Mitigation solutions: floating wetland + Zero valent iron-biolelectrochemical wetland
Scale & treatment	• Novel wetland technology will be used to remove contamination with nutrients, trace metals, and CECs. • 4 cells of 12m^2 each treating a maximum water flow of 20 m^3/d • The ambition of the technology is to be implemented in the Besos River and treat almost the total water volume of the Montcada i Reixac WWTP (72,000 m^3/d). This would prevent groundwater pollution in the Besòs area.)
Relevant climate change or pollution related challenges	• Water scarcity and prolonged drought periods and related increases in contaminant concentrations • Flash flood phenomena in urban and peri-urban environment • Wild fires

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Key intervention and objectives	• Floating wetlands will be used to remove contamination with nutrients, trace metals, and CECs. The aim is to achieve improvement of treated wastewater effluent, ideally up to drinking water quality, for minimisation of environmental impacts to the underlying aquifer and the marine environment • Elaboration of effective site-specific preventive measures in participatory processes with stakeholders to produce policy recommendations
Current status of the case study:	• NBS solutions correctly installed, 6-month adaptation phase of plants and microorganisms commenced • 1st and 2nd monitoring campaigns with passive samplers completed
Expected outcomes	• Policy briefs at local/regional level - to provide evidence of harmful pollutants affecting GW with case-specific recommendations • Developed biobased solutions will be able to prevent and mitigate GW pollution to concentration levels below toxicity and water quality guideline thresholds, but at least an 90% reduction is expected for chemicals and 2-3 log units for pathogens (absolute values)
Relevant sectors	
Ambition at the end of the project and beyond	• Optimize passive sampler technology and validate for groundwater conditions, moving from TRL 3-4, depending on sampler type, to TRL 5-6. • Validate NBS in environmental conditions to mitigate surface water pollution (CEC, pathogens and nutrients) and protect GW, moving from TRL 3 to 5 • Develop compound specific isotope analysis for CECs and in combination with ceramic passive samplers
Ambition beyond the project:	• Application of novel NBS solutions which will enable the operator to i) protect GW pollution and ii) save developing and applying energy intensive chemical treatment and thus save CO_2 emission equivalents for 35 Wh/m^3 • Cost reduction of water supply. Quantification of the reduction of water supply (water transport from other catchments and treatment) in 25hm^3 related the potential aquifers quality recovery • Implementation of integrated passive sampling instead of traditional grab water sampling which will imply an overall cost reduction for the GW directive of 2M€/year in GW routine monitoring (market size = 15.930) • Implementation of integrated passive sampling instead of traditional grab water sampling which will imply an overall cost reduction for the WFD directive of 60M€/year in WFD routine monitoring (market size = 146.510) • Influence relevant local/regional and EU policy updates

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Key EU legislation applicable	• The Water Framework Directive (2000/60/EC). • The Groundwater Directive (2006/118/EC). • The Drinking Water Directive (EU) 2020/2184. • The Urban Waste Water Treatment Directive (91/271/EEC). • Environmental Quality Standards Directive (2008/105/EC) • Industrial Emissions Directive (2010/75/EU). • REACH Regulation (1907/2006). • Water Reuse Regulation (EU) 2020/741.
Key national or/and regional legislation / policies	National legislation • Law 29/1985 on water • Royal Decree, RD 849/1986 on Public Water Domain • RD 817/2015 on Monitoring Criteria for surface water and environmental quality standards • Law 11/2005 on the National Hydrologic Plan • RD 125/2007 Regulation of Hydrological Planning Regional legislation: • Legislative Decree 3/2003 on water in Catalonia • Decree 86/2009on Statutes of the Water Catalonia Agency
Policy implications	Findings may be relevant to updating local policies for implementing integral water cycle management, control mechanisms of contamination risks at source and before reaching natural aquatic systems, and using NBS to treat wastewater. As water reuse and stormwater management can increase resilience in a changing climate and water demand, policies also aim to increase the use of alternative water resources, such as NBS-treated wastewater. The elaboration of effective site-specific preventive measures can further contribute to policy improvement. Findings from this case study may be incorporated into recommendations for improvements in existing and proposed EU policies, including the Water Framework Directive, Groundwater Directive, Drinking Water Directive, and the proposed Water Resilience Initiative, if it proceeds.
Market implications	• Close-to-market development of ceramic passive samplers (CPS) for organic contaminants and viral passive samplers (VPS) for pathogens monitoring in GW and SW. • 2Meur/year could be saved by applying integrated passive sampling in GW monitoring instead of traditional grab water sampling (market size = 15.930)

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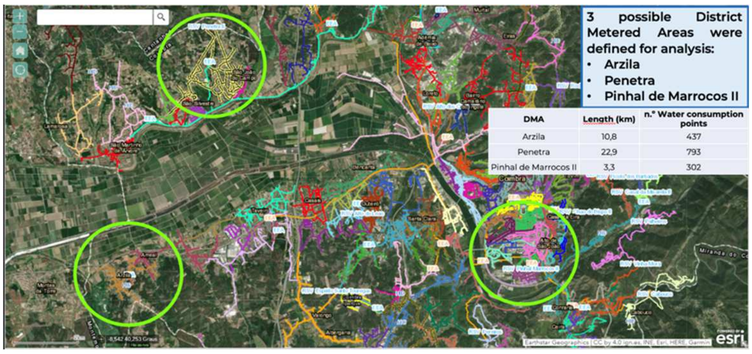
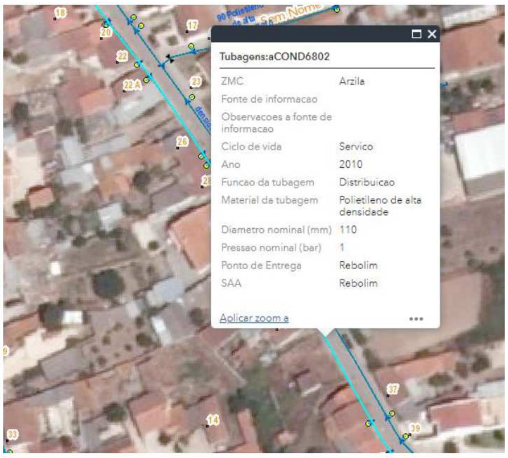
6 H2OforAll case studies

H2OforAll includes one case study which is included in the presentation below:

- Case study 1 – H2O CS#1 – Coimbra, Portugal, Águas de Coimbra Drinking water network

6.1 H2OforAll Case Study 1 - Coimbra, Portugal, Águas de Coimbra Drinking water network

<table>
<tr><td>H2OforAll – H2O-CS#1</td><td>Águas de Coimbra Drinking Water distribution network</td></tr>
<tr><td>Location</td><td>Coimbra, Portugal</td></tr>
<tr><td>Pictures illustrating the case studies</td><td>




</td></tr>
<tr><td>Key words</td><td>• Drinking Water distribution network</td></tr>
</table>

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Description	• Understanding & monitoring disinfection by-products (DBPs) and their spread through drinking water distribution systems. Removal of DBPs and their percursors from water.
Scale & treatment	• Águas de Coimbra (AC) drinking water network: this is a municipal company that provides essential public services of drinking water distribution as well as wastewater and stormwater drainage. AC encompasses 13 drinking water distribution systems (132 DMA) with 87.000 clients and 1200 km of pipelines.
Relevant climate change or pollution related challenges	• The extreme climate events (floods and droughts) have an impact in the source water quality. Moreover, the complexity of water contamination by contaminants of emerging concern is an arising problematic.
Key intervention and objectives	• Understanding & monitoring disinfection by-products (DBPs) and their spread through drinking water distribution systems. • Breakthrough water treatments to remove DBPs or avoid their formation during water disinfection processes will be developed, paying attention to their life cycle analysis, costs and risks. • Establishing preventive measures for water protection engaging public and key stakeholders.
Current status of the case study:	• Currently the drinking water is of high quality.
Expected outcomes	• Sensors combining spectroscopy with auxiliary sensors will be developed to monitor water quality. Spectroscopic based sensors will be designed to follow up the concentration of specific DBPs while auxiliary sensors will be applied to monitor water environmental parameters (pH, dissolved oxygen, …) these parameters will be correlated with the probability of DBPs production. • A Sensing infrastructure will be developed using the sensors and will incorporate real time monitoring capabilities. An algorithm will be developed to intelligently place the infrastructure in the water distribution network • Hydraulic models able to predict water quality through the water supply network. • DBPs ranking based on their toxic effect potential

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	• Innovative technologies for water treatment, disinfection and DBPs removal.
Relevant sectors	• Drinking water distribution network
Ambition at the end of the project and beyond	• Central Knowledge Base (CKB) on line tool and be available to regulators and stakeholders as a decision support tool involving information about DBPs occurrence and toxicity • Validated sensing system involving DBPs and non-target parameters able to predict the potential occurrence of DBPs • Novel technologies to treat and disinfect source water and remove DBPs • Preventive measures based on good practices analysis. • Public engagement and awareness
Ambition beyond the project:	• Central Knowledge Base (CKB) on line tool and be available to regulators and stakeholders as a decision support tool involving information about DBPs occurrence and toxicity • Validated sensing system involving DBPs and non-target parameters able to predict the potential occurrence of DBPs • Novel technologies to treat and disinfect source water and remove DBPs • Preventive measures based on good practices analysis. • Public engagement and awareness
Key EU legislation applicable	• Drinking water directive • Urban wastewater directive
Key national or/and regional legislation / policies	• Drinking water directive • Urban wastewater directive
Replication implications	The results can be replicated to other water utilities with due adaptation.
Policy implications	The information to be obtained regarding DBPs formation, fate and impact will permit to establish policy recommendations about drinking water quality

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Market implications	H2OforAll will develop new water monitoring and treatment technologies with market potential with interests to stakeholders (regulators, water supply companies, water technology industry). The involvement of several companies in the consortium as well as the involvement of relevant stakeholders through workshops and other events will potentiate the exploitation of the technologies.

7 intoDBP case studies

Spain, Ireland, and Cyprus are some of the countries in Europe where THMs abundance is the highest, but also complement each other well in terms of the nature of DBP precursors in the source water (natural vs anthropogenic), setting (rural vs urban), climate (dry vs humid), treatment (basic vs advanced) and disinfection strategy (chlorination vs chloramination).

intoDBP includes four case studies which are presented below :

- Case study 1 – into CS#1 – Limassol (Cyprus) – High variability of source water and quality and high formation of THMs.
- Case study 2 – into CS#2 – Barcelona (Spain) – High THMs formation potential in distributed water and changing conditions in the source reservoirs.
- Case study 3 – into CS#3 – Madrid (Spain) – Potential formation of N-DBPs from suboptimal generation of chloramines.
- Case study 4 – into CS#3– County Mayo (Ireland) – High formation of THMs and peatland dominated catchments.

7.1 intoDBP Case study 1 – Limassol (Cyprus) - High variability of source water and quality and high formation of THMs

intoDBP – into-CS#1	High variability of source water and quality and high formation of THMs
Location	Limassol (Cyprus)

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Pictures illustrating the case study	 
Key words	DBPs minimization, fluoro-absorbance sensors, bioreporters, UV-VIS sensors, MITO3X®, hydraulic modelling, human exposure to DBPs, algorithmic models, full-scale DBP monitoring strategy in DWP and WDN.
Description	The case study involves the Limassol Drinking Water Plant (LDWP) and the Water Distribution Network of Limassol (LWDN). A MITO3X® pilot plant with fluoro-absorbance sensors will optimize pre-oxidation at LDWP. In the LDWN, four stations with UV-VIS sensors, 2 bioreporters and 2 fluorescence tools will monitor DBP transformation and model DBP formation. The study aims to understand human exposure to DBPs beyond THMs at the CS level and investigate the impact of climate change on DBP concentrations at TDWTP outflow. A survey on drinking water consumption is also carried out in the region.
Scale & treatment	• The Limassol Drinking Water Plant (LDWP) capacity is 80.000 m^3/day. It receives water from the Kouris reservoir and upon treatment, it supplies clean water to the city of Limassol, villages west of Limassol, and the British Base of Akrotiri. • The Water Distribution Network of Limassol (LWDN) serves 110,000 consumers with an annual demand of 17 million m^3.

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	• The pilot covers a residential area with approximately 4663 consumers and a daily average demand of 1600 m^3.
Relevant climate change or pollution related challenges	• Rising DBP precursor levels and formation. • Decreased surface water availability, quality. • Deteriorating catchment hydrology, soil biogeochemistry. • High DOM content from catchment soils or phytoplankton blooms.
Key intervention and objectives	• Install a MITO3X® pilot plant with fluoro-absorbance sensors at LDWP for pre-oxidation optimization and upgrade LDWP water treatment trains. • Gain new insights into human exposure to DBPs beyond THMs and patterns of tap water consumption, and investigate the impact of climate change on DBP concentrations from LDWP outflow. • Install four stations with UV-VIS sensors, 2 bioreporters and 2 fluorescence tools in the LWDN and develop models to track DBP transformations.
Current status of the case study:	• Sampling of DBPs and DBP formation potential and other parameters across the LDWP and the LWDN during 4 sampling campaigns in summer and winter. • Completed construction, telecommunication, sensor installation, and data visualization for LWDN's automated monitoring system. • Progressing on ICT architecture and data acquisition system plans for the automated monitoring system. • Ongoing hydraulic modeling and calibration, plus developing a water quality simulator for DBP fate estimation in the network. • Developed MITO3X® P&ID for CS Limassol. • Completed survey in Limassol on consumer habits regarding tap water.
Expected outcomes	• Develop fluorescence-based tools and bioreporter prototypes for utility DW quality monitoring, with algorithms for UV-VIS sensors to predict DBP formation. • Utilities adopt full-scale monitoring strategy using UV-VIS, fluorescence tools, and bioreporters. • Three DWTPs adopt MITO3X-DW technology, expecting reduced DBP formation in CS sites. • DBP precursors characterization for DW utilities. • DW distribution networks adopt full-scale monitoring strategy, covering at least 80% of the network.
Relevant sectors	Water industry, technology developers, local authorities, local and regional policy, professional networks, civil society organizations, public in general, academia other agencies, specialized agencies.

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Ambition at the end of the project	• Minimize DBP formation and human exposure through source water protection, treatment optimization, and enhanced monitoring at CS sites, aiming for a 50% reduction and achieving >30% savings in electrical energy and reagent costs. • Define optimal implementation conditions at each CS for full-scale technology deployment and integrate DBP prediction algorithm into SCAN commercial UV-VIS sensors. • Patent and license developed technologies (fluorescence/absorbance sensors and MITO3X®-DW) and apply models to predict DBP occurrence. • Describe temporal THM concentration and climate variables patterns, and enhance knowledge on human DBP exposure at the EU level.
Ambition beyond the project:	• Serve as a model for DWPs requiring chemical disinfection. • Develop monitoring strategies applicable to DWN across Europe. • Advance understanding of water pollution sources in a global, changing climate. • Promote tap water over bottled water. • Reduce bladder cancer related to THM by up to 5% in Europe. • Spin-off opportunity for DBP formation consultancy.
Key EU legislation applicable	• Water Framework Directive 2000/60/EC • Drinking Water Directive 2020/2184/EC
Key national or/and regional legislation / policies	• Quality of Water for Human Consumption Law, 2023 (Law No. 46(I)/2023) • Water Protection and Management (Amendment) Act 2015 (No. 159(I)/2015)
Replication implications	• Adopt intoDBP monitoring strategy for DW and DWN, extendable to other European utilities.
Policy implications	• Improvement of DBP Legislation.
Market implications	• Create new market for online DBP sensors and climate change forecasting models. • Develop patents for bioreporter, hardware, algorithm, MITO3X® DW technology and fluorescence/absorbance sensors for online use • Incorporate DBP prediction algorithm into SCAN's commercial UV-VIS sensors.

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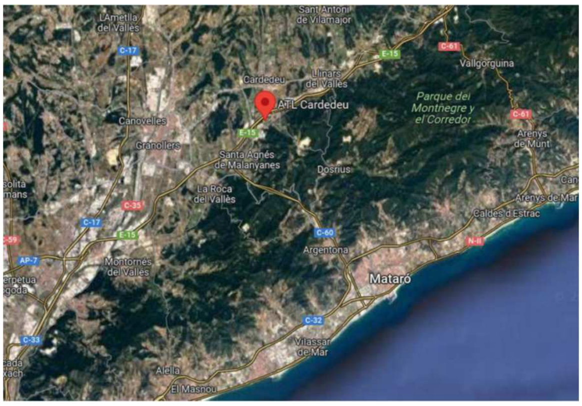
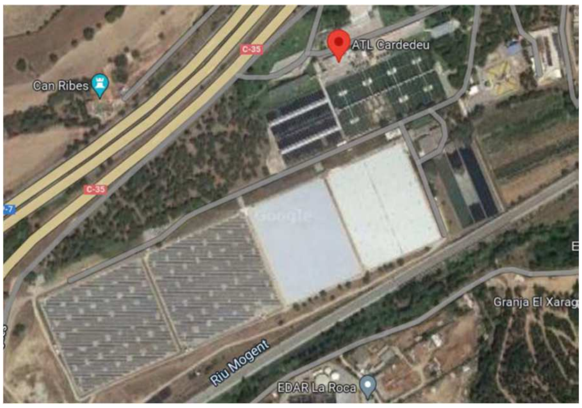
	• License developed algorithms to utilities for DBP prediction in WDN. • Potential spin-off for DBP consultancy based on dissolved organic fingerprint.

7.2 intoDBP Case Study 2 - Barcelona (Spain): High THMs formation potential in distributed water and changing conditions in the source reservoirs.

intoDBP – into-CS#2	**High THMs formation potential in distributed water and changing conditions in the source reservoirs**
Location	Barcelona and its metropolitan area (Spain)
Pictures illustrating the case study	 
Key words	DBPs minimization, fluoro-absorbance sensors, bioreporters, UV-VIS sensors, MITO3X®, full-scale DBP monitoring strategy in DWP, algorithmic models, catchment protection, DOM forecasting tool, emerging DBP predictive models, human exposure to DBPs, risk assessment to DBP formation risk.

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Description	The case study focuses on the Ter Drinking Water Treatment plant (TDWTP) in Barcelona and its surrounding area. Interventions include installing a MITO3X® pilot plant with fluoro-absorbance sensors at TDWTP for pre-oxidation optimization and placing a fluorescence sensor in the Ter water source reservoir to develop Dissolved Organic Matter (DOM) forecasting tool. The study aims to understand human exposure to DBPs beyond THMs at the CS level and the impact of climate change on DBP concentrations at TDWTP outflow.
Scale & treatment	• Ter Drinking Water Treatment Plant (TDWTP) supplies Barcelona and metropolitan area since 1966, with a capacity of 691,200 m^3/day. • TDWTP sources water from Ter River catchment and uses chlorine for disinfection. • ATL utility provides 6 online THM analyzers (since 2015) and 3 UV-VIS sensors at TDWTP and in the WDN.
Relevant climate change or pollution related challenges	• Rising DBP precursor levels and formation. • Decreased surface water availability, quality. • Deteriorating catchment hydrology, soil biogeochemistry. • High DOM content from catchment soils or phytoplankton blooms.
Key intervention and objectives	• Install MITO3X® pilot plant with fluoro-absorbance sensors at TDWTP for pre-oxidation optimization. • Implement a novel approach to upgrade TDWTP water treatment, minimizing DBP formation. • Develop a risk assessment methodology for DBP formation across Europe, investigate climate change effects on DBP concentrations at TDWP outflow, and create predictive models for emerging DBPs.
Current status of the case study:	• Sampling of DBPs and DBP formation potential and other parameters across the TDWTP and the distribution system during 4 sampling campaigns in summer and winter. • MITO3X® P&ID of CS Barcelona has been developed. • 3 UV-VIS sensors have been installed at TDWTP. • Experiments done to develop algorithms predicting DBP formation using UV-VIS and fluorescence signals. • Survey conducted in the metropolitan area of Barcelona regarding exposure to DBPs.
Expected outcomes	• Develop new fluorescence-based tools and bioreporter prototypes for utilities to monitor drinking water quality, and algorithms for UV-VIS sensors to predict DBP formation. • Full-scale adoption by DW utilities of the monitoring strategy combining UV-VIS, fluorescence tools, and bioreporters, with 3 DWTPs implementing the MITO3X-DW technology to reduce DBP formation.

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	• Characterize DBP precursors, develop a risk assessment methodology for DBP formation across Europe, and propose catchment-based source protection measures for water utilities and the EC.
Relevant sectors	Water industry, technology developers, professional networks, civil society organizations, local authorities, public in general, academia other agencies, specialized agencies.
Ambition at the end of the project	• Minimize DBP formation and human exposure through source water protection, treatment optimization, and enhanced monitoring at CS sites, aiming for a 50% reduction. • Achieve significant savings (>30%) in electrical energy and reagent costs and define optimal conditions for full-scale technology deployment at each CS. Integrate the developed DBP prediction algorithm into commercial UV-VIS sensors and adopt MITO3X®-DW technology at TDWTP. • Develop and patent a fluorescence tool to predict DBP formation and create forecasting tools for the water sector to anticipate impacts of climate change and extreme events on DOM inputs to drinking water sources.
Ambition beyond the project	• Serve as a model for DWPs requiring chemical disinfection for distribution. • Improve understanding of water pollution sources in a changing climate. • Spin-off opportunity for DBP formation consultancy. • Promote tap water over bottled water. • Reduce bladder cancer related to THM in Europe up to 5%.
Key EU legislation applicable	• Water Framework Directive 2000/60/EC • Drinking Water Directive 2020/184/EC
Key national or/and regional legislation / policies	• RD 03/2023 establishing the technical-health criteria for the quality of drinking water, its monitoring, and supply. • RD 817/2015, establishing the criteria for monitoring and assessment of the state of surface waters and environmental quality standards.
Replication implications	• Adoption of intoDBP monitoring strategy for DWP. • Adoption of forecasting models for DOM content predictions in European source waters.
Policy implications	• Improvement of DBP legislation. • Improvement of water source quality.
Market implications	• Incorporate DBP prediction algorithm into SCAN's commercial UV-VIS sensors.

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	• Create new markets for online DBP sensors and climate change forecasting models. • Potential spin-off for DBP consultancy based on dissolved organic fingerprint. • Develop patents for bioreporter, hardware, algorithm, MITO3X® DW technology and fluorescence/absorbance sensors for online use.

7.3 intoDBP Case Study 3 - Madrid (Spain): Formation of N-DBPs (e.g., NDMA) from suboptimal generation of chloramines.

intoDBP – into-CS#3	**Formation of N-DBPs (e.g., NDMA) from suboptimal generation of chloramines.**
Location	Madrid (Spain)
Pictures illustrating the case study	
Keywords	Chloramine disinfection, DBPs minimization, UV-VIS sensors, MITO3X®, hydraulic modelling, algorithmic models, full-scale DBP monitoring strategy in DWP and WDN.
Description	The Valmayor Drinking Water Treatment Plant (VDWTP) is managed by Canal de Isabel II since 1976, uses chloramines for disinfection. The project aims to install a MITO3X® pilot plant to optimize monochloramine vs dichloramine formation, reducing nitrosamine formation and improve drinking water quality. Data from 3 existing UV-VIS sensors installed in Madrid's WDN will be used to validate the hydraulic model dynamics.
Scale & treatment	• Valmayor Drinking Water Treatment Plant (VDWTP) serves DW up to 2,5 million for the city of Madrid since 1976, capacity is 1,036,800 m^3/day.

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	• Water source: Valmayor Reservoir. • Chloramine is used as disinfectant. • Canal de Isabel II provides 3 UV-VIS sensors in the WDN.
Relevant climate change or pollution related challenges	• Rising DBP precursor levels and formation. • Decreased surface water availability, quality. • Deteriorating catchment hydrology, soil biogeochemistry. • High DOM content from catchment soils or phytoplankton blooms.
Key intervention and objectives	• Install MITO3X® unit for chloramine disinfection optimization and 2 UV-VIS sensors. • Investigate and optimize monochloramine formation. • Contribute to the approval of monochloramine under EU Biocidal Products Regulation for DW. • Validate hydraulic model dynamics with UV-VIS sensor data in WDN.
Current status of the case study:	• Sampling of DBPs and DBP formation potential and other relevant across the VDWTP and the distribution system during 4 sampling campaigns in summer and winter. • MITO3X® pilot plant is undergoing testing before being shipped to Madrid. • 1 UV-VIS sensor has been installed at the plant.
Expected outcomes	• Development MITO3X® technology for chloramination in Aquasoil's commercial portfolio. • 3 DWTPs adopt MITO3X-DW technology, reducing DBP formation in CS sites. • DBP precursors characterization for DW utilities. • DWN to adopt monitoring strategy based on the combination of UV-VIS, fluorescence tools and bioreporters covering at least 80% of the network. • Contribute to the approval of monochloramine under EU Biocidal Products Regulation for DW.
Relevant sectors	Water industry, technology developers, professional networks, civil society organizations, local authorities, public in general, academia other agencies, specialized agencies.
Ambition at the end of the project	• Minimize DBP formation, treatment optimization, and enhanced monitoring at CS sites, aiming for a 50% reduction. • Achieve >30% savings in electrical energy and reagent costs with VDWTP adopting MITO3X®-DW technology. • Define optimal implementation conditions at each CS for full-scale technology deployment. • Patent and license developed technologies (MITO3X®-DW) algorithms for broader application in DWP.

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Ambition beyond the project	• Monitoring strategy for DWN applicable to other European water utilities. • Advance understanding of global water pollution sources amidst climate change. • Contribute to approval of monochloramine under EU Biocidal Products Regulation for DW. • Promote tap water over bottled water. • Reduce bladder cancer related to THM by up to 5% in Europe.
Key EU legislation applicable	• Water Framework Directive 2000/60/EC • Drinking Water Directive 2020/184/EC
Key national or/and regional legislation / policies	• RD 03/2023 establishing the technical-health criteria for the quality of drinking water, its monitoring, and supply. • RD 817/2015, establishing the criteria for monitoring and assessment of the state of surface waters and environmental quality standards.
Replication implications	• Generate an optimal technology to form monochloramines for disinfection.
Policy implications	• Improvement of DBP legislation. • Use of chloramine as disinfectant.
Market implications	• Patents: MITO3X® DW technology. • License developed algorithms to utilities for DBP prediction in WDN.

7.4 intoDBP Case Study 4 - County Mayo (Ireland): High formation of THMs from peatland dominated catchments.

intoDBP – into-CS#4	**High formation of THMs from peatland dominated catchments.**
Location	County Mayo (Ireland)

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Pictures illustrating the case study	  
Key words	DBPs minimization, fluoro-absorbance sensors, UV-VIS sensors, human exposure to DBP, catchment protection, DOM forecasting tool, emerging DBP predictive models, risk assessment to DBP formation risk.

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Description	This Case Study includes a cluster of three small Group Water Schemes located in County Mayo, supplying rural communities. The utilities are co-operative schemes which are privately managed and are represented by the National Federation of Group Water Schemes, which are located near to each other in catchments, with a high peatland prevalence. The project seeks to develop a tool to forecast the effects of short- and long-term changes in climate on DOM in drinking water sources to protect drinking water quality.
Scale & treatment	• PBKS Scheme: Carrowmore Lough source, serves 850 households, treated with UV-chlorination. • Callow Scheme: Callow Lough source, serves 1300 homes, treated with pressurized sand filtration, UV, chlorination. • Nephin Valley Scheme: mountain stream source, supplies 630 households, treated with medial filtration, ozonation, chlorination.
Relevant climate change or pollution related challenges	• Rising DBP precursor levels and formation. • Decreased surface water availability, quality. • Deteriorating catchment hydrology, soil biogeochemistry. • High DOM content from catchment soils or phytoplankton blooms.
Key intervention and objectives	• Install 1 UV-VIS and 1 fluorescence sensor in reservoirs which provide initial data for DOM forecasting. • Develop risk assessment methodology for DBP formation across Europe. • Propose catchment-based source protection measures for water utilities and the EC. • New insights on human exposure to DBPs beyond THMs. • Investigate the effect of climate change on DBP concentrations in the finished drinking water.
Current status of the case study:	• DBP formation potential of these cases study sites investigated. • Survey to investigate the habits of consumers towards tap water ongoing.
Expected outcomes	• Develop risk assessment methodology for DBP formation across Europe. • Propose catchment-based source protection measures for water utilities and the EC. • Reduce THM non-compliance risk, addressing EU DBP infringements in Ireland. • Develop new fluorescence-based tool and algorithms for UV-VIS sensors to predict DBP formation.
Relevant sectors	Water industry, local authorities, local and regional policy, professional networks, civil society organizations, local authorities, public in general, academia other agencies, specialized agencies.

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Ambition at the end of the project	• Minimize DBP formation and human exposure through source water protection, treatment optimization, and enhanced monitoring at CS sites, aiming for a 50% reduction. • Patenting a fluorescence tool to predict DBP formation. • Integrate developed DBP prediction algorithm into SCAN commercial UV-VIS sensors. • Develop forecasting tools for the water sector to anticipate short- and long-term future impacts of climate change and extreme events on DOM inputs to DW source water.
Ambition beyond the project	• Advance understanding of global water pollution sources amidst climate change. • Spin-off opportunity for DBP formation consultancy. • Promote tap water over bottled water. • Reduce bladder cancer related to THM by up to 5% in Europe.
Key EU legislation applicable	• Water Framework Directive 2000/60/EC • Drinking Water Directive 2020/184/EC
Key national or/and regional legislation / policies	• Water Services Legislation and EU (Drinking Water) Regulations 2023, S.I. No. 99 of 2023 • Water Services Acts 2007 to 2022 - This Act makes amendments to various Acts relating to water services in Ireland and in particular in relation to the Irish public water agency Uisce Éireann. • Water Environment (Abstractions and Associated Impoundments) Act 2022 (No. 48 of 2022) – This Act provides regulation of water abstraction in Ireland. • Local Government (Water Pollution) Acts 1977 to 1990 – This Act is the primary piece of legislation governing water pollution in Ireland.
Replication implications	• Adopt forecasting models for short- and long-term DOM content predictions in other European source waters. • Adopt novel DBP-related index-based risk assessment methodology in other European source waters.
Policy implications	• Improvement of DBP legislation. • Improvement of water source quality.
Market implications	• New market for climate change forecasting models. • Incorporate DBP prediction algorithm into SCAN's commercial UV-VIS sensors. • Patents: fluorescence/absorbance sensors with method measurements for online use. • Spin-off opportunity for DBP formation consultancy.

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8 SafeCREW case studies

SafeCREW includes four case studies which are included in the presentation below:

- Case study 1 – Safe CS#1 – Northern Germany (Hamburg & Berlin) - Near-natural non-disinfected Drinking Water Supply
- Case study 2 – Safe CS#2 – Milan city (Italy) – Chlorinated Drinking Water Supply System (DWSS)
- Case study 3 – Safe CS#3– Tarragona (Spain) – Chlorinated Drinking Water Supply System (DWSS)
- Case study 4 – Safe CS#4 – Ukraine – Chlorinated Drinking Water Supply System (DWSS)

Figure 2 SafeCREW case studies

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8.1 SafeCREW Case Study 1 – Northern Germany (Hamburg and Berlin; Safe CS#1)

SafeCREW – Safe CS#1	**Northern Germany (Hamburg & Berlin)** **Near-natural non-disinfected Drinking Water Supply**
Location	WW Spandau (Berlin) / WW Curslack (Hamburg)

Figure 1 Photos of the seasonal change of the sampled infiltration basin (©Christoph Sprenger)

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Figure 2 Flow cytometer installed in well chamber (left); flow cytometer maintenance and manual measurements (right) (©Christoph Sprenger)

Key words	Near-natural non-disinfected DWSS; NOM monitoring, disinfection strategies, risk management approach
Description	A future-oriented risk management approach that includes large volume sampling via ultrafiltration modules to enrich and recover relevant microorganisms, enabling their detection at very low concentrations during subsurface passage
Scale & treatment	A) Berlin: • Drinking Water Treatment (no disinfection): Source water is bank filtrate (BF, surface water impaired groundwater with moderate residual time of months) treated by aeration and filtration for Fe- & Mn-removal. Local water availability enhanced by managed aquifer recharge (MAR): River Havel water treated by coagulation, rapid sand filtration and infiltration into groundwater aquifers. • > 3.7 million inhabitants served (whole City) • 2/3 bank filtrate, 1/3 groundwater, nature based treatment (BF & MAR), aeration, rapid sand filtration B) Hamburg • Drinking Water Treatment (no disinfection): • The water works pump deep well and also swallow well water. The latter are surface water impaired source waters, river Elbe). Treatment: aeration, two filtration steps (Fe- & Mn-removal), deacidification. • 1.9 Mio. Inhabitants served (whole City) • 100% groundwater

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Relevant climate change or pollution related challenges	• Declining water availability, increasing water demand, higher temperatures, increasing concentration of dissolved organics and microorganisms in river water • Overall declining water quality as the source of DW • Elevated bacterial concentration and possible enrichment of hygienic relevant microorganisms in surface water, possible increased surface water pathogen loads and shorter hydraulic retention times if water demand increases
Key intervention and objectives	• Improve the early-warning system by integration of high volume (>40 L) sampling for microbial contamination and continuous flow cytometry (FCM) of bank filtrate • Develop a climate change adaptation roadmap for currently non-disinfected DWSS with high background DOC • Adapting technology: (i) innovative porous conductive membrane capable of selectively removing NOM fractions that are DBP precursors without use of chemicals; (ii) innovation in advanced oxidation processes via CS #03.
Current status of the case study:	• Non-disinfected DWDN with natural infiltrated or artificially recharged groundwater as source water. • High NOM background (e.g. 3-4 mg/L DOC in Berlin's DW • Current early-warning systems do not include online microbial monitoring. • Despite NOM changes and potential microbial growth in DWDN, utilities cannot quickly shift to chemical disinfection, due to the looming threat of massive DBP formation.
Expected outcomes	• Strategies available to provide safe drinking water with minimal DBPs in case of first-time disinfection. • Strategies will recommend treatment combinations for disinfection to remove DBP precursors. • Strategies will consider pipe lining material and potential reactions between residuals in the currently non-disinfected DWDN.
Relevant sectors	DW-treatment, DW-distribution, DW-sources; Water utilities, water industy, technology developers, policy and regulation;

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Ambition at the end of the project and beyond	• The novel capacitive membrane treatment shall be up-scaled to TRL3-5. • A future-oriented risk management approach including a microbial sensing methods applying continueous flow cytometry (FCM) as well as ultrafiltration to enrich and recover hygienic relevant microorganisms and enabling their detection at very low concentrations. • Quantification of the log removal capacity via FCM for a non-disinfected scheme. • Reverse QMRA helping water utilities to identify tipping points at which health targets can no longer be met. • Strategies (incl. treatment combinations) to provide safe DW with minimal DBPs, considering potential reactions between residuals in the currently non-disinfected DWDN.
Ambition beyond the project:	• Berlin and other MAR sites in Europe will implement the online field FCM measurements and reverse QMRA modelling to assess future climate change induced impacts. • The novel capacitive membrane treatment shall be up-scaled to TRL 7-8. • Roadmaps developed for implementing or avoiding disinfection in DWSS with high background DOC shall be included in the national portfolio of recommendations.
Key EU legislation applicable	EU Water Framework Directive (WFD), EU Drinking water directive (DWD)
Key national or/and regional legislation / policies	Trinkwasserverordnung (Drinking Water Ordinance), DIN-DVGW technical rules
Replication implications	All realized ambitions can be easily transferred to other waterworks with comparable source water conditions.
Policy implications	• Support science based policy making for DW consumer protection • Science based recommendations to revisions of DWD and DWD watch lists • Increase coherence with material certification in the EU and implementation into shortlist for future DWD uptake (Art. 11)

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	• Policy brief to support unavoidable transition from non-disinfected to disinfected drinking water supply systems • Policy brief regarding disinfection and disinfection by--products
Market implications	• NOM electrosorption: Innovative Membrane based process to selectively remove NOM precursor compounds to minimise DBP formation with no need of chemical dosing

8.2 SafeCREW Case Study 2 – Milan city (Italy, Safe CS#2)

SafeCREW – Safe CS#2	**Milan city** (Italy) Chlorinated Drinking Water Supply Systems (DWSS)
Location	Milan, Italy
Pictures illustrating the case studies	
Key words	Chlorinated DWSS, interaction of disinfectants with material
Description	Current research is evaluating how to exploit monitoring devices for studying bacterial dynamics and communities in treated water. In addition, the potential migration of bisphenol A (BPA) from epoxy resins is under investigation.
Scale & treatment	• 400 active wells produce 220 million m^3 of drinking water annually • Water abstracted from the aquifer is treated in 28 DWTPs • Generally undergoing activated carbon filtration and disinfection via NaOCl • DWDN is about 2.228 km long, serving 1.4 Mio. inhabitants

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Relevant climate change or pollution related challenges	Main risks for drinking water supply systems arising from increasing water temperatures: • Excessive growth of bacteria could increase disinfection request and impact water quality by DBP generation • Increased migration from relining resins due to higher residual chlorine levels and formation of new DBPs from leached compounds
Key intervention and objectives (Solution and innovation focus)	• Linking of microbiological and chemical water stability and disinfection process parameters under different operating conditions • Characterisation of bacterial presence through FCM and passive sampling • Characterisation of DBPs of relining resins along the DWDN • Application of advanced data computing to highlight correlations and develop control strategies
Current status of the case study:	• Data from online sensors currently not processed to manage disinfection • No routine monitoring of bisphenols derived from relining epoxy-resins
Expected outcomes	• Optimized set of sensors for disinfection management • Increase of microbial contamination detection probability • Monitoring plan for relining resins
Relevant sectors	DW-Monitoring, DW-Treatment, DW-distribution; Water utilities, technology providers, relining providers, regulators
Ambition at the end of the project and beyond	• Optimisation of disinfection operating parameters based on online analysis of bacterial load and soft sensors • Prediction of DBPs formation following residual chlorine and relining resins interactions • Guidelines for selection and commissioning of relining resins to minimise DBPs.
Ambition beyond the project:	• Exploitation of online sensors and advanced computing (e.g. machine learning) for process control • Improvement of consumer's safety by coupling online monitoring and lab analyses • Integrating guidelines for relining resins into the asset management strategy of Milan City.
Key EU legislation applicable	Drinking Water Directive 2020 (2020/2184)

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Key national or/and regional legislation / policies	D.L.gs 18/2023
Replication implications	Adoption of Milan strategies by other national and international water utilities
Policy implications	Building a network of water utilities for GLP and guidelines sharing
Market implications	Market orientation towards more sustainable resins and new sensors development

8.3 SafeCREW Case study 3 – Tarragona (Spain, Safe CS#3)

SafeCREW – Safe CS#3	**Tarragona** (Spain) Chlorinated DWSS
Location	Tarragona (Spain)
Pictures illustrating the case studies	

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Key words	Chlorinated DWSS, NOM, DBP formation, early warning system, combined performance indicator for chemical, toxicity and microbial risks,
Description	(I) In-depth evaluation on how changes in DWTP processes result in reduced DBP formation potential not only by lowering the NOM quantity but also by changing NOM chemical properties. (II) Development of an early alert system predicting the final generation of DBPs from the expected influent water to the DWTP, and recommend process changes to prevent formation. (III) Risk-based management of the DWTP and DWDN which combines chemical, toxicity and microbial risk in one performance indicator set.
Scale & treatment	• DWTP treating water from Ebro river and serving 800.000 inhabitants with a 400 km distribution network. • DWTP includes pre-ozonation, flocculation, sand filtration, main-stage ozonation, activated carbon filtration, ultraviolet disinfection and final disinfection with NaOCl. • Chlorination boosters along the network to keep residual free chlorine.
Relevant climate change or pollution related challenges	Main risks arising from climate change: • River surface water has high seasonal variations. • Increasing of severe droughts and storms affect water quality. • Increasing temperature increases DPB formation and bacterial growth.

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Key intervention and objectives	• Investigate the seasonal NOM quantity and composition and treatment removal capacity to minimise DBP formation. • Implement new treatment strategies to optimise NOM removal. • Develop new in-network DBP formation prediction model based on combining mechanistic and data-driven models. • Develop risk assessment tools for optimising NOM removal and chlorination boosting in the network minimising DBP formation.
Current status of the case study:	• Manual DWTP and DWDN set-point operation based on discrete sampling, which cannot guarantee compliance with the EU DWD at all points of supply. • DWTP set-points based on TOC values, without knowledge of NOM composition and final DBP formation. • Setting DWDN chlorination booster set-points without knowledge of effect on DBP formation. • No studies on the specific threats due to climate change are available to take actions in DWTPs or DWDNs.
Expected outcomes	• Optimal risk-based management of the DWTP and DWDN which combines chemical, toxicity and microbial risk in one performance indicator set.
Relevant sectors	DW-Treatment, DW-distribution, DW-sources; water utilities, technology providers;
Ambition at the end of the project and beyond	• In-depth knowledge of effect of DWTP processes in reduced DBP formation. • Develop an early alert system predicting expected DBPs and recommending process changes. • Risk-based management of the DWTP and DWDN which combines chemical, toxicity and microbial risk in one performance indicator set.
Ambition beyond the project:	• Knowledge transfer to other DWSS with surface water catchments. • The relationship between NOM, treatment and DBPs could trigger focus on new treatment processes.
Key EU legislation applicable	EU DWD
Key national or/and regional legislation / policies	Spanish Drinking water regulation (RD 3/2023)

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Replication implications	• Knowledge transfer to other DWSS with surface water catchments. • Knowledge and solutions useful for DWDN with chlorination and chlorination boosters.
Policy implications	• Improvement of DBP legislation. • Introduction of risk assessment-based legislation.
Market implications	• The relationship between NOM, treatment and DBPs could trigger focus on new treatment processes. • Risk-based management relying on network modelling could promote the digitalization of other DWDNs.

8.4 SafeCREW Case study 4 – Drinking water supply system in Western Ukraine

SafeCREW – Safe CS#1	**Drinking Water distribution network in Western Ukraine**
Location	Western Ukraine
	
Key words	Water Supply; distribution network; groundwater; disinfection
Scale & treatment	• About 98% of cities, 91% of urban-type settlements and 23% of villages are covered by centralized water supply system services in Ukraine.

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	• The total length of water supply networks is 92 thousand km, including 35% of dilapidated and emergency networks. • Operating systems of centralized water supply in settlements of western Ukraine mainly use ground waters.
Relevant climate change or pollution related challenges	• The extreme climate events (floods and droughts) have an impact in the source water quality and amount of water. Moreover, there is no experience in applying modern methods of predicting the dissemination of pollution in drinking water supply systems.
Key intervention and objectives	• Implementing risk-based management through the creation of Water Safety Plans. • Adapting hydraulic models and establishing soft sensors for conditions with limited data availability. • Identifying regulatory and real-life gaps in Ukrainian and European drinking water quality guideline values.
Current status of the case study:	• Research at the initial stage
Expected outcomes	• Information on riverbank filtration: operational practices, hydrogeological properties and water quality monitoring data will be compiled. • A risk-based assessment on a selected RBF site will be performed to identify further investigations required to reduce the uncertainty of risks and to implement remediation measures. • The ready-to-use risk-based management tool ability to predict spatial and temporal behaviour of free chlorine and DBP species formed, their risks to human health, and actions for reducing their presence will be explored with respect to the envisaged association of UA to the EU and the implementation of the EU DWD.
Relevant sectors	Water utilities, DW treatment, DW distribution
Ambition at the end of the project and beyond	• Public engagement and awareness
Ambition beyond the project:	• Public engagement and awareness

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Key EU legislation applicable	• Drinking water directive • Urban wastewater directive
Key national or/and regional legislation / policies	• Law of Ukraine "On drinking water and drinking water supply" • Water Strategy of Ukraine for the period up to 2050
Replication implications	The results can be replicated to other water utilities in Ukraine with due adaptation.
Policy implications	Increasing knowledge in the field of drinking water supply in connection with respect to the envisaged association of UA to the EU and the implementation of the EU DWD
Market implications	For transferring and applying the results of SafeCREW in UA, and enabling further collaboration at national and European levels, a concept for the non-profit CEWM, which would bridge the gap in water related applied R&D activities and foster close cooperation of R&D institutes and water utilities in UA, will be prepared. The approach of the CEWM to overcome gaps in the UA water sector by strengthening applied research and education will be summarized in a roadmap, to assist in seeking post-SafeCREW funding at national, EU and international level, and for water utilities interested in collaborating with the CEWM.

9 ToDrinQ case studies

ToDrinQ includes five case studies which are included in the presentation below:

- Case study 1 - To CS#1 - Amsterdam, Netherlands
- Case Study 2 - To CS#2 - Athens, Greece
- Case Study 3 - To CS#3 - Val de Bagnes, Switzerland
- Case Study 4 - To CS#4 - Beaune, France
- Case Study 5 - To CS#5 - Prague, Czechia

9.1 ToDrinQ Case Study 1 - Amsterdam, Netherlands

ToDrinQ - To CS#1	**Demonstrating solutions in Amsterdam**
Location	Drinking water treatment utility Leiduin near Amsterdam

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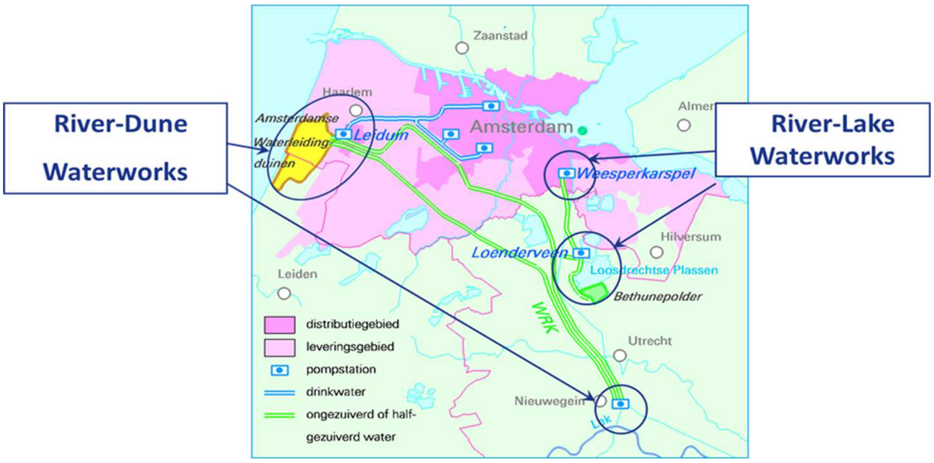
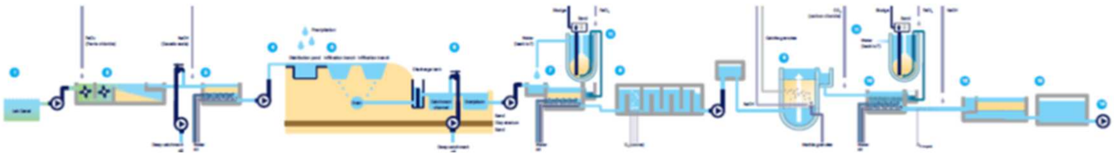


Geographical location of the drinking water treatment plant Leiduin



Treatment scheme of the drinking water treatment plant Leiduin

Key words	PFAS removal; hard sensor testing: ammonium, lead, total cell counts, bacteroides; soft sensor testing: turbidity, natural organic matter and metals, ozone optimization; design support tool; modular platform
Description	The presence of **PFAS** in the sources for drinking water is a problem for drinking water companies, especially for those using surface water. Therefore, in the ToDrinQ project the focus is on application of new innovative adsorbents which can reach the low (future) PFAS standard and do not result in a PFAS-rich waste stream. **Hard sensors** are tested for ammonium in the pretreatment, for lead in the distribution, for total cell counts in the influent and effluent of slow sand filters, for bacteroides in all steps of the drinking water treatment. There are two **soft sensors** dedicated for the Demo Case: The soft sensor for short-term forecasting of turbidity, and consequently natural organic matter and metals, in the inlet of raw water from the Lek Canal (a branch of the River Rhine) for Leiduin at the pretreatment, is a data-driven model. More specifically, the model is trained only with flow and water quality sensor data already measured for monitoring the quality of the river water and the water entering the pretreatment. The second soft sensor will be an estimation model which will predicts and optimize the ozonation process of drinking water treatment plant Leiduin.

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	The **design-support tool** for flexible drinking water treatment plant generates and evaluates alternative treatment trains for different types of water sources and raw water quality characteristics. Building on elements of past work will integrate real-time data and information on water quality from the entire system ('source to distribution') obtained from online (soft and hard) sensors and support early warning, risk assessment and risk management. The new **modular platform** is expected to improve, in real-time, operations of water intake, conveyance, treatment and distribution, and support informed decisions when unexpected situations occur.
Scale & treatment	• Sensors will be tested in full-scale treatment and in a slow sand filtration pilot plant • Drinking water treatment concerns treatment of surface water • Design support tool will cover alternative treatment trains for different types of water sources and raw water quality characteristics • The modular platform covers, in real-time, operations of water intake, conveyance, treatment and distribution, and support informed decisions when unexpected situations occur.
Relevant climate change or pollution related challenges	• Changing water quality due to climate change • Changing water demand due to population growth • Changing water demand due to economic developments
Key intervention and objectives	• Develop an efficient, cost effective and sustainable process for PFAS removal • Apply hard sensors to optimize operation and distribution • Develop soft sensors to predict raw water quality and to optimize operations • Generate and evaluate alternative treatment trains for different types of water sources and raw water quality characteristics by using the design support tool • improve, in real-time, operations of water intake, conveyance, treatment and distribution, and support informed decisions when unexpected situations occur, with the use of the modular platform
Current status of the case study:	• Case study is in the start-up phase
Expected outcomes	PFAS removal: • Using the selected adsorbent, it will be proven at pilot scale that the new PFAS standards can be met. Optimizing the process conditions (empty bed contact time, type of adsorbent, regeneration procedure), the costs and

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	environmental effects of introducing this new treatment step in drinking water production will be limited and comparable or lower than alternative treatment technologies for PFAS removal (ion exchange, reverse osmosis). Hard sensors: • IonSens ammonium analyses in the influent and effluent of the rapid sand filters gives the opportunity to anticipate on a declining nitrification in the filters at a low water temperature • Using the MetalSens from OliSense for lead analysis makes it possible to determine exposure to elevated lead concentrations in drinking water released from appendages or in house plumbing • The online flow cytometer (BactoSense) from bNovate makes it possible to follow the ripening of slow sand filters • Using the Udetect from Orvion (total cell counts) may give a better direct and real time indication of the disinfection capacity of each treatment step in the drinking water production scheme Soft sensors: • The implementation of these models is expected to significantly enhance operational efficiency and water quality management Modular platform: • improvement in access to real-time insights reducing costs and use of chemicals
Relevant sectors	DW sources, DW treatment, DW distribution
Ambition at the end of the project and beyond	• With respect to the PFAS removal technology, the exploitation of the new adsorption process is foreseeable as the present technology for PFAS removal in the drinking treatment scheme, granular activated carbon filtration, requires a very high reactivation frequency for PFAS removal which is too expensive, results in a too high CO_2-footprint, while the carbon supplier cannot guarantee the high regeneration frequency required for PFAS removal, due to capacity limitations • With respect to the hard sensors, especially the total cell counts and bacteroides (BactoSense and Udetect) offer additional information to guarantee the microbial drinking water quality and to optimize the operations. Exploitation of these sensors in the operations of Waternet is thus very likely • With respect to the design support tool, alternative treatment trains for different types of water sources and raw water quality characteristics can be generated and evaluated • With respect to the modular platform, it will give advice on optimal control and risk management interventions throughout the water supply chain, based on predictions of

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	quality at the source and assessed variations in water quality during conveyance, treatment and distribution.
Ambition beyond the project:	• The outcomes of the demo Case Amsterdam contribute to the toolkit for adaptable resilient installations securing high quality drinking water
Key EU legislation applicable	• European Drinking Water Directive • European Water Framework Directive
Key national or/and regional legislation / policies	• Dutch drinking water directive • Provisional guideline of the Dutch Institute for Public Health and the Environment (RIVM) for PFAS in drinking water
Replication implications	• A PFAS-removal technology will enable drinking water utilities to comply with PFAS standards • Hard sensors and soft sensors will enable drinking water companies to optimize operations • The design support tool and modular platform gives possibilities for drinking water utilities to deal with uncertainties, both I design and in operations
Policy implications	• Use of hard sensors and soft sensors as alternatives for pre-described analytical methods in the European Drinking Water Directive
Market implications	Hard sensors and soft sensors offer an alternative for laboratory analysis using laboratory equipment. The design support tool and the modular platform may make use of AI.

9.2 ToDrinQ Case Study 2 - Athens, Greece

ToDrinQ – DC#2	**Demonstrating solutions in Athens, Greece**
Location	• Polydendri Drinking Water Treatment Plant DWTP, Attica • Lake Yliki

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Pictures illustrating the case studies	 Polydendri DWTP  Lake Yliki  Unmanned Surface Vehicles for testing water (INTCATCH)

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	 Inside the Polydendri DWTP facilities. Location for the Athens Pilot unit
Key words	Water quality monitoring, drinking water treatment, hard sensors, soft sensors, innovative technologies, algal bloom, MABR.
Description	The focus is on water monitoring from the Mornos canal, Lake Yliki, and the respective boreholes, as well as on water treatment. More specifically: • Hard Sensors will be deployed to test for nitrates, ammonium levels, bacterial load and E.coli. • Soft Sensors will be tested for monitoring of chlorophyll-a and water quality in Lake Yliki. • Predictive models will be used to predict algal bloom events and nutrient runoffs. • A treatment unit with capacity of 500lt/hr will be installed in Polydendri DWPT, testing advanced MABR technology. • The FIWARE-compliant platform will integrate all these technologies, allowing for real-time data collection, analysis, and decision-making.
Scale & treatment	The Athens Case Study involves the DWTP, which has a treatment capacity of 200,000 - 300,000 cubic meters per day. The plant primarily treats water from the Mornos canal, supplemented by water from Lake Yliki and the Mavrosouvala borehole during maintenance or high-demand periods. The treatment process at Polydendri DWTP includes prechlorination, screening, coagulation, sedimentation, sand filtration, and secondary chlorination. For the ToDrinQ project, a small-scale drinking water treatment pilot unit with a capacity of 500 liters per hour will be installed within the Polydendri DWTP premises. This unit will incorporate advanced treatment technologies such as ozonation, ultrafiltration, and a Membrane Aerated Biofilm Reactor (MABR) system. The pilot unit aims to evaluate the effectiveness of these innovative treatments in

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	improving water quality, particularly when treating water from Lake Yliki, which presents challenges such as algae blooms and slight odor due to its low water circulation and surrounding agricultural activities. The results from this pilot unit will provide critical insights into the scalability and efficacy of these advanced treatment processes for potential full-scale implementation.
Relevant climate change or pollution related challenges	• High levels of sun radiation causing algal blooms in Lake Yliki • Agricultural runoff impacting water quality with nitrates and pesticides • Variable water quality due to weather conditions and seasonal changes
Key intervention and objectives	• Deploy hard sensors for nitrates, ammonium, E.Coli and total bacteria monitoring • Implement soft sensors for predictive analysis of water quality • Install a small-scale DWTP pilot unit for testing new treatment technologies • Develop a design-support tool for efficient water treatment plant operation • Integrate all technologies into a FIWARE-compliant modular platform
Current status of the case study:	• Initial deployment and testing of hard sensors in progress • Soft sensors under development with user requirements defined • Pilot unit design under development, and installation preparations will be soon underway • Design support tool under development by the respective partner • FIWARE platform has been used from EYDAP personnel in another project. Currently under expanding to include all todrinq modules.
Expected outcomes	• Improved real-time water quality monitoring, with the use of real-time monitoring technologies (hard sensors, soft sensors, satellites etc) • Enhanced operational efficiency of Polydendri DWTP • Reduction in water treatment disruptions and maintenance costs by predicting algal blooms and nutrient run-offs • Better management of water quality from source to tap • Valuable data for future water management strategies
Relevant sectors	DW-Treatment, DW-sources, DW-Monitoring

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Ambition at the end of the project and beyond	**Full Integration of Innovative Sensors:** EYDAP aims to have successfully validated and integrated the innovative hard and soft sensor technologies within its water supply and treatment network, ensuring accurate and timely water quality assessments. **Optimized Treatment Processes:** By leveraging the data collected from advanced sensors and treatment systems, EYDAP aims to optimize its water treatment processes. This includes adjusting chemical dosages and operational parameters based on real-time data to improve efficiency and reduce costs. **Proactive Maintenance and Issue Resolution:** The integration of predictive maintenance tools and early warning systems will allow EYDAP to identify potential issues before they escalate, minimizing downtime and maintenance costs. **Improved Decision Support Tools**: The design-support tool tested within the project will enable EYDAP to make informed decisions regarding the planning and operation of water treatment plants, especially in response to varying water quality conditions.
Ambition beyond the project:	**Environmental Impact Reduction**: By implementing advanced treatment technologies and optimizing operational practices, EYDAP aims to reduce its environmental footprint, particularly in terms of chemical usage and energy consumption. **Advanced Data Analytics:** EYDAP will continue to enhance its data analytics capabilities, integrating advanced algorithms and machine learning techniques to gain deeper insights into water quality trends and operational performance. **Smart Water Management**: Leveraging the data collected from various sources, EYDAP aims to implement smart water management practices, optimizing resource usage and improving overall system efficiency.
Key EU legislation applicable	• The Drinking Water Directive (EU) 2020/2184.
Key national or/and regional legislation / policies	• Presidential Decree 51/2007 • Law 3199/03 on water protection and the sustainable management of the water resources
Replication implications	• Adoption of drinking water monitoring tools for all DW sources • Adoption of forecasting models in source waters • Adoption of design support tool on Greek level and beyond
Policy implications	• Support Revised European Drinking water Directive and local directives • Improvement of DW monitoring norms

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Market implications	ToDrinQ will develop new water monitoring and treatment technologies with market potential with interests to stakeholders (regulators, water supply companies, water technology industry). The involvement of several companies in the consortium as well as the involvement of relevant stakeholders through workshops and other events will potentiate the exploitation of the technologies.

9.3 ToDrinQ Case Study 3 - Val de Bagnes, Switzerland

ToDrinQ – To CS#3	**Mayentzet, Val de Bagnes, Switzerland Testing real-time monitoring systems Bactosense and Udetect Sensor**
Location	The Mayentzet is a mountainous area located in the Swiss Alps.
Pictures illustrating the case studies	
Key words	Real-time monitoring, Bactosense, Udetect, Bacteriological analysis, Sensor, Mayentzet source, , ater reservoir, Verbier, Bacterial contamination, E. coli, Enterococci, Specialized interface, Water supply, Water distribution network, Bacteria detection, Bnovate, Orvion, Water sources, Stability of water sources, Environmental monitoring
Description	This project aims to enhance water quality management in the Valais region of Switzerland through the implementation of real-time monitoring systems. By utilizing innovative sensors such as Bactosense and Udetect, the project seeks to provide accurate water quality data, promptly detect any bacterial contamination, and improve responsiveness to pollution events. By engaging local water utilities, regulatory authorities, and the community, the project promotes the adoption of sustainable practices and raises awareness about water resource protection. The potential implications in terms of policies, markets, and innovations are geared towards strengthening environmental protection measures and fostering proactive and efficient water resource management in the Valais region.

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	The Mayentzet area contains a water reservoir fed by three water sources, which in turn supply water to the residents of Verbier. Two of these three sources are untreated, making their monitoring crucial even though they are generally very stable. However, the risk of bacterial contamination can never be entirely ruled out. This area is particularly sensitive to bacteria such as E. coli and enterococci, which originate from local animals.
Scale & treatment	Real-time Monitoring Systems: • Utilization of Bactosense and Udetect sensors. • Integration with specialized interfaces for data transmission. Water Source Details: • Mayentzet water source and its importance for Verbier residents. • Fed by three distinct water sources, with two being untreated. Bacteriological Analysis: • Real-time data on bacterial counts per sample. • Shortening analysis time for more immediate responses. Bacterial Contamination Risks: • Focus on identifying E. coli and Enterococci. • Understanding contamination sources, mainly from local animals. Environmental Monitoring: • Continuous surveillance of water quality. • Ensuring stability and safety of water sources. Challenges: • The large, extensive water distribution network. • Distant location of the reservoir complicates monitoring efforts. Key Descriptors for Other Case Studies: • Managed Aquifer Recharge (MAR) • Groundwater Quality • Surface Water Monitoring • Digital Water Management • Public Health Safety • Remote Sensing • Sustainable Water Resource Management These points and descriptors might help frame the scale and treatment aspects of various related case studies.
Relevant climate change or pollution related challenges	Distance and Accessibility: • The reservoir and critical monitoring points are located far from easily accessible areas. • The extensive water distribution network complicates frequent, on-site inspections and real-time data collection.

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	Untreated Water Sources: • Two out of the three sources feeding the reservoir are untreated, increasing the risk of contamination. • Monitoring these untreated sources is crucial due to potential stability issues. Bacterial Contamination: • The risk of contamination from bacteria such as E. coli and Enterococci, which are common in areas with local animal populations. • Any contamination can quickly impact public health, making rapid detection and response essential. Technological Integration: • Ensuring that the real-time data from Bactosense and Udetect sensors are accurately integrated and interpreted by the specialized interfaces. • Dependence on the reliability and accuracy of advanced sensor technologies for critical safety information. Environmental Factors: • Natural environmental changes or events (e.g., heavy rainfall, floods) can affect the stability and quality of water sources. • Seasonal variations might impact both the bacterial load and the overall reliability of water sources. Resource Allocation: • The need for significant investment in equipment, technology infrastructure, and trained personnel to manage and maintain the monitoring systems. • Balancing resources between routine monitoring, emergency responses, and system upgrades or expansions. Data Management: • Handling large volumes of real-time data requires robust data management systems and protocols. • Ensuring data integrity, security, and timely analysis for actionable insights is critical. These points outline the primary risks and challenges associated with the implementation and maintenance of real-time monitoring systems for the Mayentzet water source and similar case studies.
Key intervention and objectives	Key Objectives: • Enhance real-time monitoring of the Mayentzet water source. • Reduce the time required for bacteriological analysis for quicker responses. • Identify and prevent risks of bacterial contamination, particularly E. coli and enterococci.

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<table>
<tr><td></td><td>Significant Interventions:
Testing the Bactosense and Udetect sensors for continuous and precise surveillance.
Integrating sensors with specialized interfaces for real-time data transmission.
Implementing environmental monitoring systems to assess water quality and detect changes.
Key Innovations:
Utilizing advanced sensor technologies for more efficient real-time data collection.
Integrating cutting-edge sensors for early detection of bacterial contaminations.
Implementing automated systems for continuous monitoring and rapid response to potential incidents.
These points highlight the major objectives, interventions, and innovations put in place to enhance monitoring and management of the Mayentzet water source, with potential implications for other similar case studies.</td></tr>
<tr><td>Current status of the case study:</td><td>Bactosense Installation:
Bactosense has been operational for the past 6 months, providing real-time data.
Operators of the water network receive alerts in case of significant contamination events.
Udetect Usage:
The laboratory regularly utilizes Udetect to analyze various samples.
While the system functions effectively, the current protocol is deemed too time-consuming.
This information summarizes the current status regarding the deployment and usage of Bactosense and Udetect in the case study, highlighting key points for assessment and potential improvements.</td></tr>
<tr><td>Expected outcomes</td><td>improved Water Quality Monitoring:
Enhanced real-time monitoring capabilities leading to proactive contamination detection.
Timely alerts and responses to potential water quality issues.
Enhanced Public Health and Safety:
Reduced risks of bacterial contamination such as E. coli and enterococci.
Minimized health hazards for residents reliant on the water supply.
Efficient Data Transmission and Analysis:
Streamlined data transmission process for quicker decision-making.</td></tr>
</table>

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	• Improved analysis methods for more accurate and timely results. Resource Optimization: • Efficient allocation of resources through targeted monitoring efforts. • Cost savings associated with early detection and prevention measures. Technological Advancements and Scalability: • Integration of advanced sensor technologies for reliable and scalable monitoring. • Potential for broader application and adaptation of similar systems in other regions or contexts.
Relevant sectors	DW-Treatment, DW-distribution, DW-sources et al.
Ambition at the end of the project and beyond	Sustainability Goals: • Establishing a self-sustaining water treatment system to ensure long-term water quality. • Implementing eco-friendly practices to reduce the project's environmental footprint. Community Impact: • Enhancing public health and well-being through reliable access to clean drinking water. • Empowering local communities through awareness programs on water conservation and sanitation. Technological Advancements: • Incorporating innovative water treatment technologies for efficient and effective operations. • Continuously evolving and adapting systems to meet future water treatment challenges. Partnerships and Collaboration: • Strengthening partnerships with stakeholders for ongoing support and community engagement. • Collaborating with research institutions for continuous improvement and knowledge sharing in water treatment. Scalability and Replicability: • Designing the project framework with scalability and replicability in mind for future expansion. • Serving as a model for similar water treatment initiatives in other regions, promoting sustainable practices globally.

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Ambition beyond the project:	Knowledge Sharing and Capacity Building: • Establishing training programs to empower local communities in water management and conservation practices. • Sharing project insights and best practices with other regions to promote sustainable water initiatives globally. Research and Development: • Investing in ongoing research and development to enhance water treatment technologies and efficiency. • Collaborating with industry experts to drive innovation and address emerging water challenges proactively. Community Resilience: • Building community resilience through awareness campaigns, emergency response training, and disaster preparedness. • Fostering a sense of ownership and responsibility among community members for sustainable water practices. Global Impact and Partnerships: • Forming partnerships with international organizations for cross-border water management initiatives. • Contributing to global conversations on water sustainability, climate resilience, and equitable access to clean water resources.
Key EU legislation applicable	• Water Framework Directive (WFD): Framework setting out key objectives for water management and protection of EU water resources. • **Drinking Water Directive (DWD)**: Ensures the quality of drinking water across the EU and sets standards for monitoring and control.
Key national or/and regional legislation / policies	• Valais Drinking Water Quality Standards: Regulations ensuring the quality and safety of drinking water in the Valais region. • Valais Water Master Plan: Strategic document outlining objectives and measures for sustainable water management in Valais. • Valais Water Act: Local legislation governing water resource management and conservation practices in the Valais canton.
Related tasks in the project	• Water Quality Monitoring: Implementing systems for real-time monitoring of water quality. • Sensor Installation and Maintenance: Setting up and managing sensors like Bactosense and Udetect. • Data Analysis and Reporting: Analyzing collected data and generating reports for decision-making.

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	• Alert System Implementation: Configuring alert systems for immediate response to contamination events. • Collaboration with Stakeholders: Engaging with water utility operators, local authorities, and communities. • Compliance with Regulations: Ensuring adherence to relevant legislation and water quality standards.
Replication implications	• Water Utilities: Other water utility companies can replicate the real-time monitoring systems and sensor technology to improve water quality management and response to contamination events. • Regions with Similar Challenges: Areas facing similar water quality issues, especially those with untreated water sources, can replicate the monitoring protocols and alert systems to enhance public health protection. • Environmental Monitoring Initiatives: Organizations focusing on environmental monitoring and conservation can replicate the project's strategies to assess water quality and ecosystem health. • Policy and Regulatory Bodies: Replicating the project's data analysis and reporting mechanisms can assist policy and regulatory bodies in developing effective water quality standards and compliance measures. • Community Engagement Models: The community engagement and awareness programs implemented in this case study can be replicated in other regions to promote water conservation and sustainable water management practices.
Policy implications	• Enhanced Water Quality Regulations: Develop or amend policies to incorporate real-time monitoring requirements for water utilities to promptly identify and address contamination events. • Investment in Advanced Technologies: Encourage funding and support for the adoption of innovative sensor technologies in water quality management to improve monitoring precision and response times. • Community Engagement Initiatives: Implement policies that promote community involvement and awareness in water conservation and pollution prevention efforts, aligning with sustainable water management practices. • Interagency Cooperation: Facilitate collaborations between regulatory bodies, water utility companies, and environmental agencies to streamline data sharing, enhance monitoring capabilities, and ensure effective policy enforcement.

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	• Capacity Building Programs: Establish training programs for water utility staff and stakeholders on utilizing advanced monitoring systems effectively and interpreting real-time data for informed decision-making.
Market implications	• Emergence of Advanced Water Sensor Technologies: Introduction of new products and services related to real-time water quality monitoring systems for both industrial and residential applications. • Opportunities for Sensor Technology Providers: Increased market demand for sensor technology providers to supply advanced monitoring devices and data analysis tools to water utility companies and environmental agencies. • Development of Water Management Solutions: Growth in market opportunities for companies specializing in water management solutions, including data interpretation software and predictive analytics for water quality assessment. • Expansion of Environmental Monitoring Sector: Expansion in the environmental monitoring sector, with a focus on water quality monitoring solutions, leading to new market entrants and technological advancements. • Demand for Sustainable Water Solutions: Rising demand for sustainable water solutions in the market, driving innovation in water treatment technologies and promoting eco-friendly practices in water resource management

9.4 ToDrinQ Case Study 4 - Beaune, France

ToDrinQ– CS#4	**Demonstrating novel water quality monitoring solutions at Beaune, France:** **Water quality in a vineyard region**
Location	Beaune and Gevrey-Chambertin, France

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Pictures illustrating the case study	 
Key words	● groundwater, ● agricultural region, ● karstic spring, ● organic micropollutants, ● hardness, ● total bacteria
Description	**Beaune**: a French wine-growing commune of 22000 inhabitants. It is located between Dijon and Lyon. It is well known because it is considered as the capital of Burgundy wines. **Gevrey-Chambertin**: also a French wine-growing commune of 4500 inhabitants. It is located near Beaune, on the “route des Grands Crus” along the Côte de Nuits. This area is well known for its Grand Cru Burgundy wines, the most famous of which is Chambertin.
Scale & treatment	● Beaune is served by the Bouzaise plant, which treats the raw water of the Bouzaise, coming from a karstic spring (source of the Bouzaize). Potential water quality issues are nitrates and pesticides (agriculture), hardness (karstic spring) and lead in the old parts of the distribution network

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	• In Gevrey-Chambertin, the Perrigny plant treats raw water from a well (superficial aquifer) and from a borehole that collects water from the South Dijon aquifer (deep aquifer). Potential water quality issues are nitrates, pesticides and hardness, along with total count of bacteria in tap water.
Relevant climate change or pollution related challenges	• Agricultural region: nitrates, pesticides • Karstic region: hardness • Water sources: deep or superficial aquifer: variations in water quality • Internal network- older sections: lead
Key intervention and objectives	Develop a cost-efficient and rapid monitoring strategy based on rapid or on-line measurement of key parameters , with innovative tools: • **IonSens** Sensor from Olisens (OLI) to measure Nitrates and Chlorides (Chlorides is not a critical parameter for both DCs but Veolia France tested the parameter to help Olisens to get feedback on the measurement of Chlorides with its prototype). • **MetalSens** from Olisens (OLI) to measure Lead. • **Bactosense** sensor from bNovate (BNV) to measure total bacteria. • **Udetect** sensors from Orvion (ORV) for the measurement of the *E.coli* in raw and treated water. - Regarding **MetalSens** and **IonSens**, both current and forthcoming sensor deployments offer invaluable tools for efficiently managing treatment plants and distribution systems. These technologies provide rapid analyses with user-friendly portable equipment, facilitating sampling at various points from raw water sources to consumer taps. Consequently, Veolia can swiftly respond to fluctuations, particularly during sudden changes in meteorological conditions that may impact raw water quality. - The last two sensors (bacteriology) will undergo testing due to the critical importance of bacteriological parameters in the drinking water industry.
Current status of the case study:	• The progress and preliminary results in the Beaune and Gevrey Chambertin case study show significant results in water quality monitoring, particularly in the analysis of nitrates, chlorides and lead, across various locations and water types. • For nitrates, measurements were conducted in Perrigny and Bouzaise, encompassing deep and low aquifers as well as treated water from filters and tanks. The reference method employed for comparison was NF EN ISO 14911 (ionic chromatography). The prototypes utilized included IS V3 and IS V3 bi-ions, with a total of 162 measurements taken into account.

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	The results exhibited a minimal difference from the laboratory reference, with an average deviation of only 8%. The tests are complete for nitrates with Ionsens current prototype. ● New tests for lead with Metalsens will start in fall 2024.
Expected outcomes	Develop robust real-time affordable sensors for water quality monitoring of the most sensitive parameters
Relevant sectors	● Drinking water sources , ● Drinking water treatment and distribution , ● Water quality monitoring
Ambition at the end of the project and beyond	● Develop sensors for rapid monitoring of key water quality aspects ● Adjust water treatment for the elimination of pollutants even with variations in source (ground) water quality
Ambition beyond the project:	● Support continuous innovation in water quality monitoring
Key EU legislation applicable	● 2020/2184 European drinking water directive
Key national or/and regional legislation / policies	The upper limits of Nitrates and Pesticides, in the French sanitary Code are 50mg/l and 0.1µg/l per molecule for pesticides (or 0.5µg/l for the sum of all molecules analyzed) respectively. If Veolia does not respect the level for Nitrates and Pesticides, the French sanitary government can stop the distribution system and Veolia would have to find other sources of drinkable water. Hardness should be adjusted at 18° to 20°F for both sites.
Related tasks in the project	● Deploy and test sensors for nitrates and pesticides
Replication implications	Water utilities can replicate the cost efficient and rapid monitoring of water, especially in the case of groundwater sources with variations in quality

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Policy implications	Use of hard sensors and soft sensors as alternatives for pre-described analytical methods in the European Drinking Water Directive
Market implications	Reinforcing contracts by guaranteeing water quality thanks to efficient treatment and monitoring

9.5 ToDrinQ Case Study 5 - Prague, Czechia

ToDrinQ – To CS#5	**Managing upstream water quality variations and treating organic micropollutants in Eastern Europe**
Location	Prague – Czech Republic
Pictures illustrating the case studies	
Key words	
Description	As part of the Prague Water Supply and Sewerage System the Prague, Podolí DWTP abstracts the raw water from the River Vltava which crosses the city of Prague and is prone to variations in flow and quality. The process train is composed of 3 steps of treatment with the GAC filtration recently added to enhance the removal of organic micropollutants and improve taste and odour.
Scale & treatment	• Raw surface water monitoring • Raw ground water monitoring • Water treatment line monitoring • Distribution network monitoring
Relevant climate change or pollution related challenges	
Key intervention and objectives	
Current status of the case study:	• Finished test of the of-line (laboratory) analyzers for anions (Nitrates, Fluorides, Chlorides…)

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	• Finished test of the of-line (laboratory) analyzers for metals (Pb)
Expected outcomes	• Get data for on-line analyzers development • Improve quality of measurement of the of-line prototypes
Relevant sectors	• DW-Treatment • DW-distribution • DW-sources • Remote labs
Ambition at the end of the project and beyond	• Development of cheap and competitive on-line analyzers
Ambition beyond the project:	•
Key EU legislation applicable	•
Key national or/and regional legislation / policies	• Zákon 554/2020 Sb. • Zákon 167/2023 Sb. • And other legislation that deals with water and environment globally
Related tasks in the project	• Testing of analyzers prototypes in comparison with classical and accredited analytical methods
Replication implications	• Water utilities • Environmental agencies • Health state authorities
Policy implications	
Market implications	• Competition with existing producers of analytical equipment • Price • User reference

10 Conclusions and outlook

This Case Study Inventory lists and describes the current state and the ambition of the 32 case studies of the seven ZeroPollution4Water Cluster projects. It provides a first structured

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overview about the characteristics of each case study. This facilitates insights in common features of the case studies as well as in their different contexts and objectives. Based on this initial Case Study Inventory similarities and differences between regions can be mapped. The cluster envisages that further work will allow to detect common challenges and address them in a more efficient way. Societal and technological innovations developed for one case study site could hopefully be transferred to other case studies and tested and validated in different environments. With this validation, the Case Study Inventory will support the ZP4W Cluster Working Groups in coordinating initiatives for the market uptake and exploitation of solutions developed within the Cluster projects and to foster the matchmaking between demand and offer. Exploiting the synergies and differences of the 32 ZeroPollution4Water case studies will increase and consolidate the EU scientific and technological base on measures to manage groundwater and drinking water quality and provide evidence and guidance for policy-making and implementation, esp with respect to the DWD and GWD.

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