Ezousas artificial groundwater recharge of treated effluent in Cyprus

Year of issue

2025

Summary

Along the lower ~8 km of the Ezousa riverbed near Paphos, a MAR/SAT scheme uses the aquifer as a natural reservoir: tertiary-treated effluent from the Paphos WWTP is conveyed to infiltration ponds in the riverbed, naturally filtered, stored and later abstracted for irrigation. Built in 2003, the system comprises five pond groups (23 basins in total) supplied by a 500-mm main, with a design capacity of roughly 9,000–12,000 m^3/day. Annual recharge increased from ~1.63 Mm^3 (2004) to 4.44 Mm^3 (2015); WDD's assessment (2006–2015) reported no adverse effects attributable to recharge, with only occasional chlorination by-products detected downstream. Research at the site indicates slight attenuation of nutrients and notes copper in groundwater exceeding EPA standards, likely of geogenic origin. Today, all reclaimed water produced in Paphos is routed to the Ezousa aquifer and then pumped and distributed for irrigation through the government network.

Since 2021, real-time sensors (water level, EC, temperature) linked to the INOWAS platform complement routine sampling, strengthening operational control.

Photo Gallery



Location

34.762277, 32.51429

Project

NWRM

National ID

Cyprus_01

Sector

Hydromorphology

Installation Date

2004-01

Implementation status

Completed

Contact

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Overview

Location of the project

Along the Ezousa River alluvial channel east of Paphos, from the coast inland to ~8 km upstream. Infiltration pond groups lie between Acheleia (near the Paphos WWTP and airport) and the Agia Varvara area

Country

Cyprus

NUTS2 Code

Κύπρος (Kýpros)

Sponge measures implemented in the case study

Restoration of natural infiltration to groundwater

Ponds and scrapes

Objectives

Recharge and store tertiary effluent for later irrigation supply and intrusion control with targets of ~9,000–12,000 m^3/d design throughput and ≈3 Mm^3/yr recharge; an effective aquifer storage capacity of ≈4.2 Mm^3/yr.

Involved partners

Authority type	Authority name	Authority role	Authority responsibility
National water authority	Water Development Department	Implementation	Responsible

Authority type	Authority name	Authority role	Authority responsibility
Other	Sewrage Board of Paphos	Implementation	Responsible

Site Information

Climate Zone

Warm temperate dry

Precipitation

500.00 mm

Temperature (°C)

18.70 °C

Evapotranspiration

1060.00 mm

Runoff

10.00 mm

Runoff coefficient

0.18

Imperviousness

18.00 %

Elevation range

78m

Slope range

1.0

Vegetation class

Unvegetated riverbed (engineered earth-banked infiltration ponds within the alluvial channel). Surroundings: irrigated citrus orchards and vegetables.

WFD Ecological status

Moderate

WFD Chemical status

Failing to achieve good

Water quality status

Key pressures at this coastal aquifer: high irrigation demand/over-abstraction and risk of seawater intrusion; artificial recharge mitigates but “only up to a point.”

Design and Implementation

Project scale

Meso

Project scale specifications

A river-corridor intervention spanning five infiltration complexes distributed along ~8 km of the Ezousa alluvial aquifer (regional/river scale rather than a single plot).

Project area

14500

Area subject to Land use change or Management/Practice change (ha)

4.61 ha

Size

46000.00

Size unit

m2

Basis of design

Storage of tertiary treated water in periods of low agricultural water demand.

Constraints

Aquifer not used for domestic water. Permeable lithologyin unconfined aquifer with sufficient storage availability.

Favourable preconditions

Aquifer previous lithology, sufficient storativity of aquifer, proximity to a STP or availability of treated effluent.

Financing

Total cost

4000000.00 €

Total cost information

Includes ponds (shallow earth walls structures) with simple concrete inlets and outlets. Drilling of wells equipped with pumps, pipes for water transport, monitoring equipment (water levels/meters and quality probes). Staff to monitor and run the NWRM.
€3.9 M for tertiary plant, pumps and transfer main; ≈€0.1 M for ponds, boreholes and pumps

Costs investment

4000000.00 €

Costs investment information

Tertiary treatment plant, pumping installation and pipe transfer of treated effluent to the NWRM had a capital cost of 3.9 million euros. On this some 0.1 million euros are added for ponds, boreholes and pumps. These latter figures are to be verified.

Costs operational information

Monitoring staff and operation supervising.

Costs maintenance information

Maintenance of structures after occasional flooding. Renovation of infiltration capacity.Servicing of pumps.

Financing authorities

Type of funding	Financing share
Sub-national funds	100 %

Compensations

Non

Policy and Governance

Policy description

Cyprus faces structural water deficit; irrigation and tourism demands exceed sustainable supply in the Paphos coastal plain. The measure targets groundwater quantitative stress and seawater intrusion, while enabling safe reuse of treated effluent for irrigation—consistent with WFD objectives and national recycled-water policy. Related WFD pressures at this site: abstraction (quantitative) and diffuse agriculture (nitrate); monitoring addresses chemical status (metals, organics).

Land ownership

unknown

Policy targets

Groundwater Recharge

Pollutants Removal

Oher Societal Benefits

Target remarks

Aquifer recharge and retrieval of sufficient water quantities of acceptable quality for irrigation purposes. Additionally water purification is achieved and sea intrusion is restricted.

Part of a wider plan

Oui

Wider plan

Name
Reuse of treated water effluent and improvement of aquifer status

Public consultation

Non

Has contractual arrangements

Non

Impacts and Monitoring

Monitoring System

Monitoring requirements

Routine WDD sampling at multiple wells plus continuous sensors (water level, EC, temperature) introduced under SMART-Control, with supplementary lab analyses.

Monitoring parameters

EC, boron, pH, total P (monthly); organics/biochemicals, heavy metals and persistent organics (quarterly); samples at basin inlet, six abstraction wells, and an upstream observation well.
Continuous water level, EC, temperature at selected wells; lab campaigns (every ~3 weeks Jan–Jun 2021) for physico-chemical & microbiological suites, with emphasis on nitrate, pathogens, heavy metals (incl. copper) and sulfate.

Upstream station

The sampling data for these analyses are obtained from eight locations: the entry to the infiltration basins, the six abstraction boreholes, and one observation borehole upstream of the recharge site for the native groundwater.

Downstream station

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observation borehole upstream of the recharge site for the native groundwater.

Maintenance

Maintenance requirements

Periodic reconditioning of basin surfaces to restore infiltration, repairs after occasional flooding, and routine servicing of pumps.

Impact Assessment Methodology

Performance impact assessment method

Catchment outlet

Performance impact estimation information

A three-dimensional finite element model of the area was constructed using the FEFLOW software to simulate the groundwater flow conditions and transport of Phosphorous and copper in the subsurface from the recharge process. The model was calibrated using hydraulic head and chemical data for the time period of 2002-2011. The groundwater model was coupled with a geochemical model PHREEQC attempting to evaluate nitrate and Copper processes. Inverse modeling calculation was used to determine sets of moles transfers of phases that are attributed to the water composition change in groundwater between the mixture of natural groundwater and reclaimed wastewater and the final water composition.
From the flow model it is suggested that artificial recharge can compensate the lack of upstream recharge only to a point. Thus, a water deficit could potentially be created that will induce the saltwater intrusion phenomenon in the costal area.
The general behavior of phosphorus and Copper was captured relatively well with some exceptions.

Socio-economic Impacts

Direct benefits information

Irrigation reliability & “insurance” role: MAR provides a buffer/insurance for the Paphos irrigation scheme, improving supply reliability to farmers; end-use is irrigation without post-treatment (water blended in the canal).
Conjunctive use & domestic water savings: WDD notes the scheme stores effluent for reuse, enables conjunctive use with dam water, and saves equivalent volumes of fresh water for domestic supply.
Regional demand context: the coastal area’s demand is high (≈17 Mm^3/yr agriculture; ≈3 Mm^3/yr tourism), underscoring the utility of MAR in the local economy.

Biophysical impacts: Hydrology

Retained water

12000.00

Retained water unit

m3/day

Information on retained water

The Ezousa Recharge Project (ERPr.) is designed to supplement the aquifer with 9000-12000 m3 /day of treated wastewater effluent from Paphos.
Stored/recharged water: annual recharge rose from 1.63 Mm^3 (2004) to 4.44 Mm^3 (2015); modelling (2014–2018) shows non-decreasing groundwater heads, indicating losses are compensated by recharge/pumping management.
Seawater intrusion: WDD reports the scheme controls saltwater intrusion; maximum practical recharge with existing structures estimated ~7 Mm^3/yr.

Increased water storage

12000.00

Increased water storage unit

m3/day

Information on increased water storage

The runoff reduction is nil since treated effluent is brought into the riverbed as an additional quantity of water.

Runoff reduction unit

% Percent

Information on runoff reduction

The runoff reduction is nil since treated effluent is brought into the riverbed as an additional quantity of water.

Biophysical impacts: Biodiversity

Improved biodiversity

Oui

Information on improved biodiversity

Construction of ponds has overtaken permanently part of habitats. No serious impacts expected on flora although construction works destroyed parts of flora population. Minor impacts on fauna are expected since works overtake parts of riparian habitats.

Biophysical impacts: Water & Soil Quality

Water quality overall improvements

Positive impact-WQ improvement

Information on water quality overall

Nutrients: slight attenuation reported; WDD also notes 15–20% denitrification/dilution of water along the conveyance from WWTP to ponds.
Metals: scientific assessment highlights copper in groundwater exceeding EPA standards; authors recommend controlling infiltration capacity and increasing travel times to improve performance.
Baseline pressures: naturally high sulphates (~450 mg/L) and boron in the area; over-abstraction and salinity pressures pre-recharge.
Overall effect: 2006–2017 monitoring found no negative impact on groundwater quality attributable to recharge; no pesticides detected in groundwater; organics only sporadically detected (mainly chlorination by-products such as chloroform) and not due to recharge.

Soil quality overall improvements

Not relevant for this application

Information on soil quality overall improvements

The application of this NWRM does not affect in any way the soil quality except within the ponds themselves.

Biophysical impacts: Others

Ecosystem impact climate regulation

Not relevant for the specific application

Information on ecosystem impact climate regulation

The application in its form does not affect in anyway climate change.

Lessons Learned

Key lessons

The coastal part of the Ezousa riverbed aquifer—about 8 km inland from the coast—is used as a natural reservoir: tertiary-treated effluent from Paphos is recharged through shallow, purpose-built ponds, naturally purified in the alluvium, then pumped back for irrigation while helping to control sea intrusion. These points remain core takeaways from the site.

Experience shows that artificial recharge with treated effluent is transferable to other drought-prone areas with comparable geology; conjunctive use of surface water and groundwater maximizes available resources; saving equivalent volumes of freshwater for domestic supply is achievable when reclaimed water is stored and later used for irrigation; and controlling sea intrusion is feasible in practice.

Design and operations matter. The scheme uses five groups of basins (23 ponds) distributed along the lower Ezousa; pilot tests reported high infiltration rates (≈70–120 mm/h), confirming the suitability of the permeable alluvium. Strategic blending with Asprokremmos canal water (e.g., 1:20 at the canal) supports irrigation quality and operational flexibility.

Monitoring under WDD’s long-running program found slight nitrate dilution and strong phosphorus sorption, with metals sometimes higher in groundwater than in the inflow; a later assessment reported copper in groundwater exceeding EPA standards—underlining the need to manage residence times and pathways. Since 2021, real-time sensors (water level, EC, temperature) linked to the INOWAS platform complement lab sampling and help track risks (including clogging).

There are limits: modelling indicates that artificial recharge can compensate for reduced upstream recharge only up to a point; likewise, sea-intrusion control is effective but not absolute, so abstractions and recharge must be balanced over time.

Barriers

Barrier type	Barrier role	Comments
Attitude of the public	Main barrier	Especially if aquifer to be recharged with treated effluent serves also domestic supply.
Other	Main barrier	Natural geochemical background (high sulphate ~450 mg/L and boron) complicates quality management.
Expected maintenance needs	Secondary barrier	Maintenance burden from occasional flooding and potential clogging of basins, implying periodic reconditioning and the value of sensor-based oversight.

Drivers

Driver type	Driver role	Comments
Organisation committed to it	Main driver	WDD is responsible for water resources management in the island.

Success factors

Success factor type	Success factor role	Comments
Existing staff and consultant knowledge	Main factor	Previous experience with succesful Artificial recharge in riverbed with fresh water.
Attitude of decision makers	Main factor	Strong public authority leadership and policy backing for reuse (WDD as driver; national policy to maximize recycled water).
Conducted assessments (incl. economic)	Secondary factor	Robust monitoring : legacy WDD program plus SMART-Control real-time telemetry—enabling adaptive operation and risk reduction.

Transferability

Highly transferable to drought-prone regions with permeable alluvial aquifers near a WWTP. Success hinges on site hydrogeology and geochemistry (e.g., copper, sulphate, boron), robust quality control and monitoring (levels, EC, temperature, nutrients, pathogens, DBPs), and regular basin maintenance to limit clogging. Conjunctive management with surface water helps; sea-intrusion control is partial. Regulatory fit and stakeholder communication are essential.

Sources

Sources

Characterization of the Ezousas aquifer of SW Cyprus for storage recovery purposes using treated sewage effluent

Case study 4: Ezousa, Cyprus

Attenuation capacity of a coastal aquifer under managed recharge by reclaimed wastewater

Αξιολόγηση αποτελεσμάτων Υδροφορέα Έζουσας… για την περίοδο 2006–2015 (Assessment of Ezousa aquifer results at recharge points, 2006–2015)

Recycled Water (WDD information page)

The Success Story of Cyprus – Fact Sheet 2: Wastewater treatment and reuse

Deliverable D5.4 – Demonstration of the SMART-Control approach at the Ezousa MAR facility, Cyprus

Assessing the efficiency of a coastal Managed Aquifer Recharge (MAR) system in Cyprus