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Natural Water Retention Measures

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Case Study

MEDIWAT Project

This report was prepared by the NWRM project, led by Office International de l'Eau (OIEau), in consortium with Actéon Environment (France), AMEC Foster Wheeler (United Kingdom), BEF (Baltic States), ENVECO (Sweden), IACO (Cyprus/Greece), IMDEA Water (Spain), REC (Hungary/Central & Eastern Europe), REKK inc. (Hungary), SLU (Sweden) and SRUC (UK) under contract 07.0330/2013/659147/SER/ENV.C1 for the Directorate-General for Environment of the European Commission. The information and views set out in this report represent NWRM project's views on the subject matter and do not necessarily reflect the official opinion of the Commission. The Commission does not guarantee the accuracy of the data included in this report. Neither the Commission nor any person acting on the Commission's behalf may be held Key words: Biophysical impact, runoff, water retention, effectiveness - Please consult the NWRM glossary for more information.

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I. Basic Information

Application ID	*Malta_01*			
Application Name	**MEDIWAT project**			
Application Location	Country:	Malta	Country 2:	
	NUTS2 Code		MT00	
	River Basin District Code		MTMALTA	
	WFD Water Body Code			
	Description		Location on Bulebel Industrial Estate in Zejtun (southern region of Malta), overlying a degraded part of the sea level aquifer system, next to the old Sant'Antnin Waste Water Treatment Plant and surrounded by unutilized wells.	
Application Site Coordinates *(in ETRS89 or WGS84 the coordinate system)*	Latitude: 35°52'03.5"N		Longitude: 14°31'31.4"E	
Target Sector(s)	Primary:	Hydromorphology		
Implemented NWRM(s)	Measure #1:	*N13*		
Application short description	Aquifer recharge with highly polished treated effluents. **Please note that it has been very difficult to identify an application of NWRM in Malta. The present case study has been identified in collaboration with the local authorities as the measure which comes closest to the principle of NWRM.**			

II. Policy context and design targets

Brief description of the problem to be tackled	With a high population density and almost inexistent surface waters, Malta is in a situation of over abstraction of its groundwater resources and where its total water demand exceeds the sustainable yield of the naturally renewable freshwater resources. Demand comes from the domestic and agricultural sectors alike (the domestic use can even exceed the agricultural use with the arrival of tourists during touristic seasons). From a qualitative point of view, freshwater resources are also under threat resulting from nitrates and salt water intrusions.		
What were the primary & secondary targets when designing this application?	Primary target #1:	Natural assimilation (purification) of effluents through dilution, dispersion, and physic-chemical processes	
	Secondary target #1:	Regulation of the chemical status of freshwater	
	Secondary target #2:	Self-regulation of water by filtration / storage / accumulation by ecosystems	
	Remarks	While the primary target of this application is the assimilation (purification) of effluents to recharge the aquifer, it is only partly done in a natural way (passage through porous rock), as they are artificially treated first.	
Which specific types of pressures did you aim at mitigating?	Pressure #1:	WFD identified pressure	1.1 Point – Urban waste water
	Pressure #2:	WFD identified pressure	3.2 Abstraction – Public Water Supply
	Pressure #3:	WFD identified pressure	3.1 Abstraction – Agriculture
	Pressure #4:	Other EU-Directive's identified pressure (specify)	Groundwater Directive Direct and indirect inputs of hazardous substances in groundwater
	Remarks		
Which specific types of adverse impacts did you aim at mitigating?	Impact #1:	WFD identified impact	Organic pollution
	Impact #2:	WFD identified impact	Abstraction exceeds available GW resource (lowering water table)
	Impact #3:	WFD identified impact	Saline pollution
	Impact #4:	WFD identified impact	Nutrient pollution
	Remarks		
Which EU requirements and EU Directives were aimed at being addressed?	Requirement #1:	WFD-restoring a HMWB	
	Requirement #2:	WFD-achievement of good GWB quantitative status	
	Requirement	Other EU-Directive	Groundwater

	#3:	requirements (Specify)	Directive-protection of the qualitative status of the receiving GWB
	Requirement #4:	Other EU-Directive requirements (Specify)	Urban Waste Water Treatment Directive
	Remarks		
Which national and/or regional policy challenges and/or requirements aimed to be addressed?	The adoption by Malta and other Mediterranean countries of the Urban Waste Water Treatment Directive has seen the commissioning of an increasing number of wastewater treatment plants treating water prior to its discharge into the sea or other inland freshwater bodies. Re-use of treated effluents is progressively seen as a new source of water in local contexts of high stress-levels on freshwater resources and semi-arid climate. The Directive was transposed in Malta under the *Environment Protection Act* (2001) and its *Urban Waste Water Treatment Regulations* (2005). However, an issue concerns the controls on the qualitative status of water that need to be carried out, including a prior authorization by competent authorities of artificial recharge or augmentation of GWB.		

III. Site characteristics

Dominant Land Use type(s)	Dominant land use	2.4.3. Land principally occupied by agriculture with significant areas of natural vegetation (45%)
	Secondary land use	1.1.1. Continuous urban fabric (31%)
	Other important land use	
	Remarks	
Climate zone	warm temperate dry	
Soil type	Calcisol, Leptosols, Luvisols, Regosols, Cambisols, Vertisols	
Average Slope	gentle (2-5%)	
Mean Annual Rainfall	300 - 600 mm	
Mean Annual Runoff	0 - 150 mm	
	Remarks: Infiltration from rainfalls is estimated to be only 19% of the annual rainfall. Note that information linked specifically to the site of the application is not available – the scale of data is thus the island of Malta.	
Characterization of water quality status (prior to the implementation of the NWRMs)	Established Threshold Values for the concerned GBW are as follows: Chloride: 1000mg/l Sodium: 450mg/l Boron: 0.6mg/l Sulphate: 475mg/l Conductivity: 4500µS/cm Moreover, threshold values have also been set for: Lead: 10µg/l Copper: 2mg/l	

	Zinc: 3mg/l Particularly for MT001 Malta Mean Sea Level: Fluoride: 1.5mg/l Arsenic: 5µg/l And for all GWB in the Maltese Water Catchment District: Ammonium: 0.25mg/l The Malta Mean Sea Level groundwater body presents wide-spread evidence of pollution caused by Nitrates, with six out of the nine monitoring stations having levels in excess of the relative quality standard. The Threshold Values for Chloride and Electrical Conductivity are exceeded in seven and six monitoring stations respectively, a clear indication of saline intrusion. Threshold values for Lead and Ammonium were exceeded in one station, in what is considered to be a localized exceedance. The Groundwater body should thus be considered to be in **'poor' qualitative status**.
Comment on any specific site characteristic that influences the effectiveness of the applied NWRM(s) in a positive or negative way	*Positive way:* The site in Bulebel has been chosen for the following environmental and practical characteristics: - it overlies a degraded part of the sea level aquifer system (therefore it allows to evaluate the effectiveness of the application in restoring its quality); - it has a constant supply of treated effluent from an existing plant (the old Sant'Antnin Waste Water Treatment Plant); - it is surrounded by unutilized wells which can be utilized for monitoring.
	Negative way: Parameters which influenced the scheme in a negative way are not related to the site characteristics, but rather to charactistics linked to the technique itself.

IV. Design & implementation parameters

Project scale	Small (e.g. farm, plot, building complex, block)	An artificial recharge plant and two monitoring wells
Time frame	Date of installation/construction (06.2010)	The application concerns a pilot project in the context of a research project which lasted from 06.2010 to 05.2013
	Expected average lifespan (life expectancy) of the application in years	*Unknown*
Responsible authority and other stakeholders involved	*Name of responsible authority/ stakeholder*	*Role, responsibilities*
	1. Malta Resources Authority (MRA): John Mangion, Manuel Sapiano, Brian Borg	The MRA was responsible for leading the Maltese pilot project from the MEDIWAT research project's point of view.

		MRA is also responsible for issuing authorizations (after a quality control) for injecting water into the aquifer through boreholes.
	2. Water Services Corporation (WSC)	The WSC was responsible for assisting MRA from a technical and operational standing point. It owns the purification plant where the experiment took place, and provided the technical expertise and equipment.
	3. Malta Environment and Planning Authority (MEPA)	MEPA is the national Agency responsible for land use planning and environmental regulation in Malta and, among others, for the implementation of EU Directives. It did not directly take part in the project.
The application was initiated and financed by	The MEDIWAT project (*Sustainable management of environmental issues related to water stress in Mediterranean Islands*) was submitted with the second call of the MED programme (2007-2013). It involved 10 partners covering 6 NUTS II regions (islands in France, Italy, Greece, Spain, Malta and Cyprus). It was co-financed by the European Union and the European Regional Development Fund (ERDF)	
What were specific principles that were followed in the design of this application?	Evaluation of the feasibility (technical and economic) of using highly polished treated effluent for the artificial recharge of the island's sea level aquifer systems. Determination of the scale of the impact of artificial recharge on the status of the aquifer; enhance the sustainability of (aquifer) freshwater systems; usability for irrigation.	
Area (ha)	Number of hectares treated by the NWRM(s).	216.6 km^2 (± 21660 ha)
	Text to specify	Malta Mean sea level Groundwater body corresponds to the target area.
Design capacity	<u>Facilities</u> included: Ultrafiltration and Reverse Osmosis Unit Test-site, injection well and three monitoring wells <u>Tools</u> included: Water level and water quality monitoring probes Data loggers for continuous in-situ monitoring On the scale of the island: three treatment plants produce app. 17 million m^3 of treated effluent annually. Out of these 17 million m^3, current use is estimated at 1.2 million m^3 overall (constrained by a lack of a dedicated distribution network).	

<table>
<tr><td rowspan="1"></td><td colspan="3">On the scale of the application:
Quality: ±105 mg/l of Nitrate content was mitigated. All tested organic pollutants except Dibromochloromethane yielded a negative result. Also, Alkylbenzene content in unpolished effluent ranged between 1.5 and 2.8 ug/l.
Quantity: water level in the first well showed an increase of ±1.3m over the drawdown levels and 0.6m over the long-term background level; water level in the second well showed a variation of 0.8m compared to 0.5m pre-recharge.</td></tr>
<tr><td rowspan="6">Reference to existing engineering standards, guidelines and manuals that have been used during the design phase</td><td colspan="2">Reference</td><td>URL</td></tr>
<tr><td>1.</td><td>-</td><td>-</td></tr>
<tr><td>2.</td><td></td><td></td></tr>
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<tr><td>5.</td><td></td><td></td></tr>
<tr><td>Main factors and/or constraints that influenced the selection and design of the NWRM(s) in this application?</td><td colspan="3">The main constraints limiting the application of this technique are not so much island-size specific, but more related to the availability, the quality of the polished effluent and the cost of implementing the technique.

The factors that influenced the selection and design of the application are linked to the context of over-abstraction of the aquifers due to the high water-demands on the island and to legal requirements (especially under the Urban Wastewater Treatment Directive (91/271/EEC), as well as the Water Framework and Groundwater Directives) – including the achievement of the good status objectives of the Water Framework Directive (Dir 2000/60/EC).</td></tr>
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V. Biophysical impacts

Impact category Impact on groundwater Select from the **drop-down menu** below:	**Impact description** (Text, approx. 200 words) Combined polishing/treatment by Ultra Filtration and Reverse Osmosis is consistently effective in reducing the levels of the conventional pollutants present in the influent to extremely low and manageable levels. Third-party abstraction activities in the area possibly made changes in water level due to the artificial recharge event more difficult to identify. Also, due to the fact that artificial recharge could not be maintained consistently throughout the whole period, the initial trend observed during the three month monitoring period was not sustained. However, water levels in the two monitoring wells show a marked increase in level as compared to the conditions before recharge in the immediate post-recharge period.	**Impact quantification** (specifying units)	
		Parameter value; units	% change in parameter value as compared to the state prior to the implementation of the NWRM(s)
Runoff attenuation / control			
Peak flow rate reduction			
Impact on groundwater			
Impact on soil moisture and soil storage capacity			
Restoring hydraulic connection			
Water quality Improvements			
WFD Ecological Status and objectives			
Reducing flood risks (Floods Directive)			
Mitigation of other biophysical impacts in relation to other EU Directives (e.g. Habitats, UWWT, etc.)			
Soil Quality Improvements			
Other			

VI. Socio-Economic Information

What are the benefits and co-benefits of NWRMs in this application?	Out of the project's scope		
Financial costs	***Total:***	*0.339/m³*	The production costs for delivering and polishing the effluent in this pilot were estimated at 0.339/m³
	Capital:	*Value in €*	*Text / Specify*
	Land acquisition and value:	*Value in €*	*Text / Specify*
	Operational:	*Value in €*	*Text / Specify*
	Maintenance:	*Value in €*	*Text / Specify*
	Other:	*Value in €*	*Text / Specify*
Were financial compensations required? What amount?	*Was financial compensation required: Yes /No*		
	Total amount of money paid (in €):		
	Compensation schema:		
	Comments / Remarks:		
Economic costs	*Actual income loss:*		
	Additional costs:		
	Other opportunity costs:		
	Comments / Remarks:		
Which link can be made to the ecosystem services approach?	Water storage and natural barrier against salt intrusion functions for water security and water provision services.		

VII. Monitoring & maintenance requirements

Monitoring requirements	Background conditions at the recharge site monitored through two wells located in the immediate vicinity of the recharge well (pre-recharge): use of two multi-parametric groundwater probes – measured parameters included water level (height of water column above probe), salinity, electrical conductivity and groundwater temperature, readings logged every 15 minutes for a period of around three months. Also, a regulatory analysis on the feasibility of the artificial recharge in view of the requirements of the EU's Water Framework and Groundwater Directives was carried out. Water level monitoring (post-recharge): use of a water level contact gauge. Readings were taken every 5 minutes for a period of 2 hours, following which readings were taken every 8 hours. Recharge was undertaken by allowing a constant flow of 35m³/day from the polishing plant to discharge down the recharge borehole.
Maintenance requirements	N/A
What are the administrative costs?	N/A

VIII. Performance metrics and assessment criteria

Which assessment methods and practices are used for assessing the biophysical impacts?	Pre-recharge: background groundwater conditions assessed (see "monitoring requirements" for the assessment method). Quality of the effluent also assessed. Post-recharge: water level variations assessed.
Which methods are used to assess costs, benefits and cost-effectiveness of measures?	N/A
How cost-effective are NWRM's compared to "traditional / structural" measures?	Not relevant (not part of the project's scope).
How do (if applicable) specific basin characteristics influence the effectiveness of measures?	Fairly stable background conditions of the aquifer at the recharge site allowed for the monitoring to take place. However, short- and long-term cyclic behaviour in the water levels was observed.
What is the standard time delay for measuring the effects of the measures?	N/A

IX. Main risks, implications, enabling factors and preconditions

What were the main implementation barriers?	The application of the pilot at a full scale elsewhere requires the following preconditions, which may be seen as barriers: - The availability of sufficient treated effluent which assumes the presence of a sewage treatment plant of sufficient capacity to produce a flow of treated effluent which exceeds the demand for secondary water in the region, at least during a significant part of the year. - The quality of the polished effluent which, according to the EU's Water Framework and Groundwater Directives, has to respond to the requirement that any activity undertaken to augment groundwater resources does not result in a deterioration of the quality of the same groundwater. The fact that conventional (biological) treatment is generally not effective in the removal of hazardous substances has to be addressed. Also, only treated effluents from wastewater treatment plants treating domestic/urban sewage should be considered for the supply of feed water for artificial recharge, due to the risks posed by industrial wastewater. - The costs of delivering and polishing the effluent can also be seen as a barrier. First estimates indicate that the polished effluent used in this pilot has a production cost of 0.339/m^3 Euros, the main components of this cost being electrical power and chemicals. This makes it difficult to sustain the scheme in the long term.
What were the main enabling and success factors?	N/A (a pilot project financed by a research project…)
Financing	N/A
Flexibility & Adaptability	N/A
Transferability	N/A

X. Lessons learned

Key lessons	Any proposed artificial recharge scheme using treated effluents should seriously consider the impact on the aquifer system, through a hydro-geological assessment of the aquifer system in order to assess the prevalence of local and regional groundwater flow. If not so, groundwater users located in the immediate vicinity of the scheme could be strongly impacted should an unplanned incident occur, whereas the impact on a regional scale could only be minor.

XI. References

Source Type	*Project Report*		
Source Author(s)	Manuel Sapiano, Michael Schembri, Clive Brincat		
Source Title	Assessing the environmental impact of artificial recharge by highly polished treated effluent on an unconfined aquifer system		
Year of publication	2013		
Editor/Publisher	MEDIWAT Final conference proceedings, Palermo, 24 May 2013		
Source Weblink	http://www.mediwat.eu/sites/default/files/D.1.1.6.pdf		
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