European Commission

NWRM

Natural Water Retention Measures

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Service contract n°07.0330/2013/659147/SER/ENV.C1

Synthesis document n°1

Introducing Natural Water Retention Measures: What are NWRM?

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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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The present synthesis document has been developed in the framework of the DGENV Pilot Project - Atmospheric Precipitation - Protection and efficient use of Fresh Water: Integration of Natural Water Retention Measures (NWRM) in River basin management. The project aimed at developing a knowledge based platform and a community of practice for implementation of NWRM. The knowledge based platform provides three main types of elements:

- the NWRM framework with access to definition and catalogue of NWRM,
- a set of NWRM implementation examples with access to case studies all over Europe,
- and decision support information for NWRM implementation.

For this last, a set of 12 key questions linked to the implementation of Natural Water Retention Measures (NWRMs) has been identified, and 12 Synthesis Documents (SD) have been developed. The key questions cover three disciplines deemed important for NWRM implementation: biophysical impacts, socio economic aspects and governance, implementation of financing.

They rely on the detailed delineation of what NWRMs cover as described in *SD n°0: Introducing NWRMs. Natural Water Retention Measures (NWRM) are multi-functional measures that aim to protect water resources and address water-related challenges by restoring or maintaining ecosystems as well as natural features and characteristics of water bodies using natural means and processes.* Evidences included into these synthesis documents come from the case studies collected within this project (see the catalogue of case studies) and from the individual NWRMs factsheets which are available on the page dedicated to each measure (see catalogue of measures). This information has been complemented with a comprehensive literature review.

Key words: Blueprint, Directorate-General for the Environment (DG ENV), EcoSystem Services (ESS), Environment Agency (EA), Green Infrastructure (GI), Structural Safety, Water Framework Directive (WFD) - Please consult the NWRM glossary for more information.

Table of content

I. Introduction

Natural Water Retention Measures (NWRM) are a key contributor to reducing the vulnerability of EU waters and in particular negative effects of floods and droughts. (Blueprint 2012) During the past ten years, a set of devastating flood and drought events have occurred. In response to these, many projects and studies on flood protection and mitigation have been carried out (Stella Consulting for DG ENV *inter alia*). These projects have clearly shown that grey infrastructure solutions alone cannot provide 100% protection and, as stated by the English Environment Agency, "working with natural processes is becoming increasingly accepted", above all in "flood and coastal erosion risk management policy."

Several flood mitigation strategies and many River Basin Management Plans (RBMPs) have thus introduced a mix of NWRM with other approaches including hard-engineering works, and it has been increasingly recognised that NWRM provide a wide range of benefits not only for flood control but also for the provision of a set of Ecosystem Services (ES).

NWRM are a set of measures which can be applied in the RBMP framework under the Water Framework Directive (WFD) or the Flood Risk Management Plans (FRMP) under the Floods Directive (FD). Both instruments target the restoration of aquatic ecosystems and NWRM can play a key role in this. Restoration refers to a large variety of ecological, physical, spatial and management measures and practices which are aimed at restoring the natural state and functioning of an ecosystem to support biodiversity, recreation, flood management and landscape development.

The NWRM concept embraces a complex reality extending beyond floods and droughts. It also embraces a wide set of measures, many of which are already in use, but that were not addressed in an integrated way in the past. Agriculture measures were, for instance, developed to improve productivity of soil or management of water as a key production factor. Urban measures were developed to better manage run off to avoid flooding of lower-lying parts of cities and other disturbances of the urban space.

This synthesis document will provide key elements to understand where the concept comes from, what are the alternative names that cover at least in part NWRM and the key characteristics of such measures as compared to structural measures.

II. Where do NWRM come from?

NWRM is a new term which covers a complex reality:

- First of all, NWRM are "supplementary measures" in the sense used in the WFD and FD and are therefore specific means to tackle problems identified and improve the situation in the river basins.

- Secondly, the central part of the expression is the term "water retention". By extension and for the purpose of implementing WFD and FD, water retention covers a wide set of mechanisms aiming at increasing the capture of water in the basin (see policy question n°1 on biophysical impacts).

- Finally "natural" refers to a particular set of means used to pursue the aim of water retention, which use or mimic nature to regulate the flow and transport of water so as to smooth peaks and moderate extreme events (floods, droughts, desertification, and salt water intrusion).

The term can in fact be defined in a restrictive and precise way: the implementation of appropriate Natural Water Retention Measures (NWRM) have as main purpose the reduction in surface runoff following rainfall events in order to reduce flood risk (JRC, 2012: p.11). This would however drastically restrict the use of this set of measures whereas the concept has the potential to embed a wide set of measures supporting the shift to a greener economy.

In this context, the Stella consulting carried a study for DG ENV in 2010 with "the aim of to provide a solid methodological and quantitative basis for identifying the financial needs and policy implications at the EU level for NWRM, and to support the Commission in identifying the best instruments to create synergies between the EU policy framework and measures at a river basin level. It also aims to help disseminate and make more visible the implementation of these measures at the EU level and their potential side benefits."

More precisely, both NWRM studies – the former and the latter – are placed within the framework three main EU policy areas, as specified in the following box.

The NWRM study is placed within the framework of three main EU policy areas and aims to contribute to the implementation of related strategies:

1. The ***Blueprint to Safeguard Europe's Water Resources***, an initiative of the European Commission (EC) for a communication, launched in November 2012, that aims to tackle the obstacles which hamper action to safeguard Europe's water resources and is based on an extensive evaluation of the existing policy.
2. The ***White Paper on Adapting to Climate Change*** that outlines a framework for adaptation measures and policies to improve the EU's resilience to dealing with the impacts of climate change.
3. The NWRM study also takes into account nature and biodiversity policy and the green infrastructure (GI) approach, in particular, the implementation of the *Biodiversity Strategy, the Climate Change Adaptation Strategy,* and the *Green Infrastructure Strategy*.

Stella consulting, 2010

From this point, an information package reassembling all the needed policy background was sent to Water Directors:

- "Towards Better Environmental Options in Flood Risk Management"
- "The White Paper on Adaptation to Climate Change" (2011)
- The "Blueprint to safeguard Europe's water resources" (2012) i.e. the new CIS work-programme
- Green Infrastructure Communication (2013)
- Climate Change Adaptation Strategy (2013)

On this basis and following intense debates, experts gathered in the Working Group on Programme of Measures (WG PoM) developed the following broader definition (Source: EU policy document on Natural Water Retention Measures):

*"Natural Water Retention Measures are **multi-functional measures** that aim to protect water resources and address water-related challenges by **restoring or maintaining ecosystems** as well as **natural features and characteristics** of water bodies using **natural means and processes**.*

*The main focus of applying NWRM is to **enhance the retention capacity of aquifers, soil, and aquatic and water dependent ecosystems** with a view to improve their status. The application of NWRM supports **green infrastructure**, improves the **quantitative status of water bodies** as such, and reduces the **vulnerability to floods and droughts**. It positively affects the **chemical and ecological status of water bodies** by restoring natural functioning of ecosystems and the services they provide. The restored ecosystems contribute both to **climate change adaptation and mitigation**."*

This definition allows delineation of what NWRM are, what they must do and which aspects of the hydrological cycle and the broader environment upon which they should have an impact on.

Generally speaking, the aim of such measures is to enhance natural characteristics and capabilities of catchments (including wetlands, rivers and floodplains but also other land areas) to hold or retain as much water as possible during periods of abundant or even excessive precipitation, so that water is available for use during dry periods and that runoff peaks are minimized. NWRM also contribute to limiting the negative effects of droughts by helping the soil and landscape to retain water and recharge groundwater more effectively. (ICPDR, 2014). Through holding water more effectively in the landscape, NWRM can also have additional positive effects on quality of water and on biodiversity (for more details see in particular policy question n°1 on biophysical impacts and n°2 on effectiveness).

Some distinctive characteristics of NWRM stemming from the definition are:

- Not every measure that increases the water stored in the landscape is a NWRM,
- NWRM are multi-functional green interventions over water related ecosystems,
- NWRM use natural processes,
- Natural water retention is not the end but the means that make NWRM relevant for water resource efficiency and sustainability,
- NWRM are not simply means to restore to their original natural condition (good status or good potential) of ecosystems modified by human actions, but means to adapt current existing developments in order to enhance or recover the reduced or lost water regulatory function.

To support this it is necessary to identify the measures that can be qualified NWRM.

NWRM are diverse by nature, and a set of 21 measures divided into four categories: forest, urban, agricultural and water storage was identified by a previous project (Stella consulting, 2010). Within the current NWRM project, the list was extended to 53 NWRM also divided into four categories, but the water storage was extended to hydromorphology to include additional relevant measures.

It is very important to emphasize that the list of measures is not a list of recommended measures but rather a list used for evaluating the potential (advantages and disadvantages) of using each individual measure as NWRM. In other words the list covers all measures that can qualify NRWM, but for each it is necessary to check the way it is implemented according to the NWRM definition to allow the measure to quality as NWRM. The current list allows structuring the knowledge at the EU level but other

measures or actions, similar to these measures with for example a different name, might also qualify as NWRM. It is therefore recommended to link as much as possible these measures to the proposed list for exchanging information at EU level.

Table 1: list of 53 NWRM

A1	Meadows and Pastures	U1	Green roofs	N1	Basins and ponds	F1	Forest riparian buffers
A2	Buffer strips and hedges	U2	Rainwater harvesting	N2	Wetland restoration and management	F2	Maintenance of forest cover in headwater areas
A3	Crop rotation	U3	Permeable surfaces	N3	Floodplain restoration and management	F3	Afforestation of reservoir catchments
A4	Strip cropping along contours	U4	Swales	N4	Re-meandering	F4	Targeted planting for "catching" precipitation
A5	Intercropping	U5	Channels and rills	N5	Stream bed re-naturalization	F5	Land use conversion
A6	No till agriculture	U6	Filter strips	N6	Restoration and reconnection of seasonal streams	F6	Continuous cover forestry
A7	Low till agriculture	U7	Soakaways	N7	Reconnection of oxbow lakes and similar features	F7	"Water sensitive" driving
A8	Green cover	U8	Infiltration trenches	N8	Riverbed material renaturalisation	F8	Appropriate design of roads and stream crossings
A9	Early sowing	U9	Rain gardens	N9	Removal of dams and other longitudinal barriers	F9	Sediment capture ponds
A10	Traditional terracing	U10	Detention basins	N10	Natural bank stabilisation	F10	Coarse woody debris
A11	Controlled traffic farming	U11	Retention ponds	N11	Elimination of riverbank protection	F11	Urban forest parks
A12	Reduced stocking density	U12	Infiltration basins	N12	Lake restoration	F12	Trees in urban areas
A13	Mulching			N13	Restoration of natural infiltration to groundwater	F13	Peak flow control structures
				N14	Re-naturalisation of polder areas	F14	Overland flow areas

III. Are NWRM known by other names?

When listing the measures that can qualify as NWRM, it becomes obvious that many projects and organisations are already implementing NWRM to a certain extent, and sometimes have been for several years or even centuries. This was also raised in several of the Workshops organised by the project. Hence the measures gathered in the list above are mostly not new, but have often been implemented for a different objective or set of objectives than the primary objectives of NWRM (see definition above). Many cases can be found where the above NWRM are organised in a list to address specific issues like protection of soil, of biodiversity, etc.

Several national organisations, established in countries already familiar with the use of natural techniques for solving environmental issues, have identified measures close to NWRM in terms of functionality. Other terminology used for NWRM, or measures similar to NWRM, include:

- In 2006, the DTI Global Watch Mission reported that urban storm water NWRM were known as Best Management Practices (BMP) and/or Low Impact Developments (LID) in the US, and as Sustainable Drainage Systems (SuDS) in the UK. Elsewhere, other terms are used, such as Water Sensitive Urban Design (WSUD) in Australia and much of the Far East.
- The UK Environment Agency and Newcastle University implemented "runoff attenuation features" on farms in 2011.
- The Scottish Environment Protection Agency (SEPA) identified in 2013 a set of measures close to NWRM under the name of "Natural Flood Management" (NFM). NFM measures are techniques that work with natural features and which characteristics can contribute to managing flood risk. They seek to store or slow down flooding waters through measures such as planting of woodland, wetland creation, river restoration, or the creation of intertidal habitats. In addition to flooding benefits, NFM measures can also provide many additional benefits to biodiversity, water quality and recreation. They may be particularly appropriate where hard defences are not, or as a complement to such defences, making them more resilient to climate change.
- The French national association of water technicians and engineers (ASTEE) in collaboration a.o. with ONEMA and the French Ministry of Environment published in December 2013 a document on "Ingénierie écologique appliquée aux milieux aquatiques, pourquoi, comment [ecological engineering applied to aquatic environment, why? How?]". The document presents key concepts and the different dimensions to manage aquatic environment and then a full set of applied examples. It is also more and more recognised within the water management community that rain water coming from private properties should be managed at the earliest stage, i.e. closest to where it is generated. SUDS techniques, allowing multi functionality, are the most suited as they allow protection of urban land, make use of local infiltration/retention capacities and improve resilience (personal communication, SUDS OIEau trainer).
- In 2014, Manning-Jones and Southgate used the term Catchment Riparian Intervention Measures (CRIM) as "measures that can increase the connection between the aquatic (river) and terrestrial (land and floodplain) zones and increase floodplain 'roughness'. As opposed to hard engineering solutions, such as concrete and river dredging, CRIM offer a way to use natural river processes and features to reduce and remove the power and the damaging elements of a flood."
- Finally, the first Western Network workshop highlighted the concept of Sustainable Flood Management (SFM) as a way to tackle flood management with the use of natural approaches.

Different organisations of the measures are possible, and necessary to adapt to the local situation. To allow for the organisation of information and manage the system of NWRM at the EU level, it is desirable to have a structured system with its own semantics. The definition of NWRM and the list of NWRM with their definition and the information gathered in the catalogue of the project allow each actor to map the terms and definitions they use to the common list. This forms the ground of an information system that will allow, for example, easier exchange of information and data between experts and actors, and better delineation of the targeted biophysical impacts of the measures and of the financing possibilities.

IV. What are their specificities and how NWRM relate to structural measures?

When implementing measures to address a problem, the analytical approach leads to identifying the main drivers or functions for this problem and for each, implement a specific measure or a set of measures that have a single or a core function and minimum side effects, and target and adapt to the local situation. This allows a detailed dimensioning and assessment, and controlled timing for implementation but does not often consider an integrated approach. This last is required by recent EU legislation (in particular WFD and FD with their required management plan). NWRM, by providing multiple functions, allow consideration of water retention but also other effects and benefits such as water quality improvement, soil protection and biodiversity enhancement.

However the timing question can be an important aspect, as identified when focusing on the NWRM targeted to river restoration. These NWRM can be said to take "either passive or active forms and be implemented singly or in combination. Passive techniques (e.g., pulse flows, changes in watershed land use, creation of buffer strips, etc.) rely on natural recovery process and "allow the river to do the work." (Stanford et al., 1996) Therefore, passive measures require a longer time to become effective, whereas active techniques are used when longer recovery times are inconsistent with meeting management or environmental policy goals (Wheaton et al., 2004). Often, active restoration measures attempt to mimic the form of analogous natural structures/features (e.g., a present day or historical 'natural' analogue) based on local knowledge, and project implementation are improvised (Kondolf, 2000; Wheaton et al., 2004a). (Ayres et al. 2014)

Spatial aspects of NWRM must be satisfactorily addressed so as to meet the targets of the relevant EU legislation without entailing excessive costs: the space needed for NWRM can be of high value for other purposes and flexibility is needed in the implementation of NWRM to allow improvement of Ecosystem Services (ES) provided in the basin.

NWRM should be used as part of a systemic approach to managing run-off, lowering flood risk and increasing water absorption. They are good examples of being able to deliver multiple benefits but need to be planned and targeted as part of future catchment management. As regional Workshops organised in the NWRM project have shown (see Regional Workshops), NWRM have key advantages and can be solutions to favour and combine with other measures in a wide set of possible measures.

Structural measure: "any physical construction to reduce or avoid possible impacts of hazards, or application of engineering techniques to achieve hazard-resistance and resilience in structures or systems". Common structural measures for disaster risk reduction include dams, flood levies, ocean wave barriers, earthquake-resistant construction, and evacuation shelters. However these all belong to grey infrastructure measures. When it comes to green infrastructure, measures that either recreate pristine conditions (example: re-meandering which is recreating meanders that primarily existed), or that mimic key functions of this pristine situation (creating a wetland, not necessarily where it primarily existed but elsewhere in the river basin to replace a wetland that previously existed) could be considered structural measures.

Non-structural measure: "any measure not involving physical construction that uses knowledge, practice or agreement to reduce risks and impacts, in particular through policies and laws, public awareness raising, training and education". Common non-structural measures include building codes, land use planning laws and their enforcement, research and assessment, information resources, and public awareness programmes. In other words, measures that favour changes of practices in favour of enhancing key functions previously assured by the pristine conditions mentioned before.

UN/ISDR - UN Office for DRR, 2009

NWRM, when they are green infrastructure, are structural measures but as compared to classical structural measures, they tend to involve less engineered construction and a greater reliance on ES, even when they rely on simplified or constructed ecosystems as is the case with urban NWRM. While NWRM do not exclude physical constructions, they tend to limit them to the minimum possible to allow for the development of an ecosystem and associated ES. Improvement of water status is a key WFD objective and should be considered when implementing NWRM: the measures should not lead to reduced functions of the aquatic ecosystem, so artificial infrastructures to bring water to NWRM do not themselves qualify as NWRM.

The *White Paper on adapting to climate change* suggests that "working with nature's capacity to absorb or control impacts in urban and rural areas can be a more efficient way of adapting than simply focusing on physical infrastructure. […] Particular attention should be paid to the role of green infrastructure. Healthy ecosystems preserve biodiversity and provide many valuable services such as the storage of water which in turn increase drought resilience. Green Infrastructure can play a crucial role in adaptation."

Overall, implementing NWRM should target either a restoration of natural processes that were existing in the past, or enhance natural ecosystem function to help mitigate adverse effects introduced by human activities and restore more natural patterns, and thereby providing more resilience to changes like climate change, incidents, etc.

The EU Biodiversity Strategy to 2020, recently adopted by the European Commission, acknowledges that "ecosystem-based approaches to climate change mitigation and adaptation can offer cost-effective alternatives to technological solutions, while delivering multiple benefits beyond biodiversity conservation". In addition, the Green Infrastructure Strategy published in 2012 aims "to safeguard and restore valuable natural ecosystems at a broader landscape level so that they can deliver valuable services to mankind."

A programme of measures on a river basin should aim at shifting from grey to green. In other words, it should apply the **no-deterioration principle** and target the **enhancement of natural functions** of the ecosystem previously lost by the implementation of grey infrastructure (i.e. for instance before a city expanded, the soil was less impervious and water could infiltrate, be stored for plant use and not contribute as much to flooding, the programme should aim at increasing the permeability of soil and use of water for plants in the urban area or alternatively in the surrounding so that the water balance and high flows or runoff peaks of the basin are reduced). In addition, EU/national/regional authorities should help in this by providing funds.

As compared to a grey infrastructure, applying NWRM may require a combination of measures to reach the same performance for one single function, but this combination provides many additional benefits. NWRM are essentially multi-functional measures, i.e. having positive impacts on many aspects, whereas traditional/grey infrastructures target most often one single purpose (e.g. storage size or sedimentation capacity). They rely on ecosystems and therefore fulfil many functions. When implementing NWRM, a catchment-scale approach is preferable to maximise the positive interactions, and a combination of measures located in different parts of the basin may be most effective when targeting a key function. But individual measures can also be effective on their own and many projects have implemented one or a small set of measures to tackle a local problem (see case studies: Altenheim polder, traditional terracing in Veneto, etc.)

Solutions based on NWRM require longer design and implementation periods but often prove to be more cost effective, reducing adverse effects, and more efficient on the key functionalities targeted.

Questions about how much concrete or other grey infrastructure assets could be set and still allow the measure to be qualified NWRM or green infrastructure has been raised several times but it is in fact not adapted. Overall, the concept of green infrastructure does not mean that no or very limited artificial materials are used (otherwise green roofs would not qualify). The approach is more to rely on ecosystems and their multiple functions instead of a single function provided by a purely artificial system: the so-called ecosystem services (green roof instead of tile roof). However, it is not as such a question of artificial assets but more of going back to an undisturbed environment or re-establishing the key functions of such an undisturbed environment. This can be done by implementing structural or non-structural measures.

Some NWRM are simply structural measures (re-meandering or natural bank stabilisation), whereas others can be non-structural (for example meadows and pastures are based on providing funds to farmers who preserve their fields), and others combine both types. NWRM are a way to merge these two different approaches.

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