

# Ecological flows and the Water Framework Directive implementation: An effective coevolution?

V. Ramos<sup>1\*</sup>, N. Formigo<sup>2</sup> and R. Maia<sup>1</sup>

<sup>1</sup> Department of Civil Engineering, University of Porto, Portugal

<sup>2</sup> Department of Biology, University of Porto, Portugal

\* e-mail: vmr@fe.up.pt

**Abstract:** The Water Framework Directive (WFD) is the first piece of European environmental legislation addressing hydromorphological modifications and impacts on water bodies. Accordingly, in those water bodies where the hydromorphological pressures are having an impact on the ecological status, action is needed to achieve WFD objectives. Ecological flows appeared as one of the answers to this challenge. Due to their importance, Member States (MS) have been looking to integrate ecological flows in the River Basin Management Plans (RBMPs) and Programmes of Measures (PoMs). More than 16 years after WFD adoption, this study aims to provide a systematic review of the use of ecological flows within the WFD implementation and their contribution to the achievement of those environmental objectives. It is based on analysis of official documentation reporting the progress of WFD and ecological flows implementation, as well as the answers of MS contact points and country experts to understand how this topic has been assessed. Even though an evolution on this theme can be perceived, some challenges still arise, namely the need for clear and common definition and a methodology for ecological flows calculation. These difficulties are related with the lack of a common approach to these issues, since there is no standard solution for this problem. More efforts are required, namely in the: i) the development of a verifiable link between ecological flow regimes and biological indicators and ii) the implementation of an ecological flow regime and the assessment of its effects in the water bodies status.

**Key words:** Water Framework Directive, ecological flows, water bodies status

## 1. INTRODUCTION

Water managers around the world, pressed by stakeholders and water policies, are increasingly aware of the importance of preventing freshwater ecosystems degradation, which indirectly support people through the provision of ecosystem services (Acreman and Ferguson 2010; Acreman et al. 2014b). Amongst others, environmental flows appear as a possible answer to this challenge. A globally and widely used definition for describing environmental flows is “the quantity, timing and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems” (Brisbane Declaration 2007). This definition recognizes and highlights the importance of flow temporal variability to sustain structure and functions of riverine ecosystems. Hence, within this concept, the link between hydrology and ecological condition has a key role.

This definition has been evolving accordingly to scientific knowledge and debate. Initially, environmental flows (or ecological flows) were usually defined as minimum flows, because they were considered the limiting factor to achieve a healthy ecosystem (Acreman et al. 2014b). In the 1980s, scientific community recognised that not only minimum flows dictate the structure and functions of riverine ecosystems (Bunn and Arthington 2002), but also that the temporal patterns of flows were fundamental (Arthington 2012). The idea is that too much flow in the wrong period of the year can have negative consequences similar to having too little flow (Acreman et al. 2014a).

Even though some scientific advances have been perceived, namely related with the definition of flow-ecology relationships (i.e. between water flows and ecosystem state), attempts to implement environmental flows have raised several questions, for example, related with who should decide the

target condition of the ecosystem (Poff et al. 2010; Acreman et al. 2014b).

In the European Union, all water bodies must achieve at least good water status/potential (European Commission 2000). This goal was introduced with the adoption of the Water Framework Directive (WFD), one of the most influential pieces of European legislation. WFD is implemented through several 6 year cycles, through River Basin Management Plans (RBMPs) and the associated Programme of Measures (PoMs), for each European Member State. The WFD does not explicitly refer to the term environmental flow (or ecological flow), although it expresses that action is needed in those situations where the hydromorphological pressures are having an impact on the ecological status, interfering with the capacity to achieve WFD objectives (European Commission 2012a). In 2012, the European Commission, EC (European Commission 2012b), stated that there is a need to *“put quantitative water management on a much more solid foundation, namely the identification of the ecological flow, i.e., the amount of water required for the aquatic ecosystem to continue to thrive and provide the services we rely upon. Fundamental to this is the recognition that water quality and quantity are intimately related within the concept of ‘good status’. However, there is no EU definition of ecological flow, nor a common understanding of how it should be calculated”*. To address this gap, the EC proposed, within a CIS (Common Implementation Strategy) working group, the development of a Guidance Document (European Commission 2012b, 2015a, b).

In this context, the main goal of this study is to understand how the inclusion of ecological flows has been evolving in the context of WFD implementation.

## 2. RESEARCH DESIGN

To achieve the main goal of this paper, the authors designed a questionnaire (see link: [www.goo.gl/geqLCp](http://www.goo.gl/geqLCp)) to evaluate: a) if ecological flows were included in the 1<sup>st</sup> RBMPs and 2<sup>nd</sup> RBMPs, and b) some key aspects related with the definition, implementation and monitoring of ecological flows in the 2<sup>nd</sup> RBMPs. The two first questions of the questionnaire were related to the inclusion of ecological flows within the 1<sup>st</sup> RBMPs (Question 1 – Q1) and the 2<sup>nd</sup> RBMPs (Q2). The other questions, related with the 2<sup>nd</sup> RBMP, wanted to assess: a) the sites selected to assess ecological flows (Q2.1), b) if MS have legislation or guidelines to assist in the definition of ecological flow regimes (Q2.2), c) the methodologies applied to assess ecological flows (Q2.3), d) the time frame for the application of ecological flow regimes (Q2.4), e) if the defined ecological flow regimes are ecologically relevant, in other words, if the defined regime show a clear relation/connection between flow and biology (Q2.5), f) the inclusion of ecological flow regimes into the Programme of Measures (Q2.6), g) if the defined ecological flow regimes are being implemented and their effects are being evaluated (Q2.7), h) which metrics have been used to assess ecological flow effects (Q2.7.1). After contacting the Environment Water Team (Env-Water Team) of the EC, the questionnaire was sent to Member States contact points of the WFD CIS Working Group Ecological Status (WG ECOSTAT). In total, thirty questionnaires were sent (three for Belgium representatives from Flanders, Wallonia and Brussels-Capital Region, and one for each of the remaining twenty-seven EU Member States). Figure 1 identifies those countries that answered the questionnaire.

To enhance knowledge about the inclusion of ecological flows within the 1<sup>st</sup> RBMPs, an analysis of official European documentation was performed. Until now, four implementation reports (IR) were published (Maia 2017). Within this work, a special attention was given to the 3<sup>rd</sup> IR and 4<sup>th</sup> IR. The 3<sup>rd</sup> IR presents a review of the progresses in the implementation of WFD, based on information reported by MS. The 4<sup>th</sup> IR focused on the Programmes of Measures.

The next section (3) presents the obtained results. Firstly (section 3.1), considerations about the results assessed in the official European documentation are presented. Then (section 3.2), a special focus is given to the guidance document developed by a CIS working group (EC, 2015). Finally, (section 3.3) questionnaire results are presented.

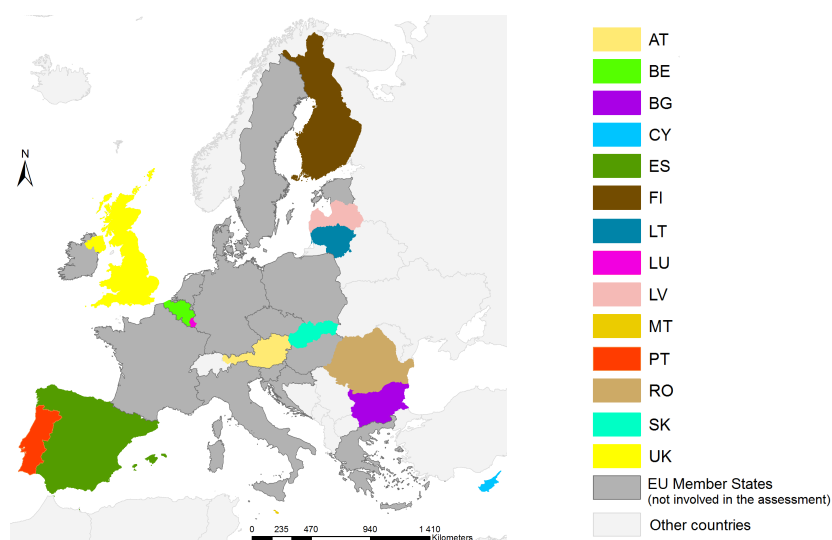


Figure 1. Countries involved in the assessment of ecological flows progress.

### 3. EVALUATION OF ECOLOGICAL FLOWS IMPLEMENTATION WITHIN WFD

#### 3.1 First WFD implementation cycle – WFD official documentation

Concerning the 1st RBMPs, official documentation about the progress in the implementation of WFD was evaluated. Through the analysis of the 3<sup>rd</sup> implementation report, some relevant aspects about ecological flows integration within the 1<sup>st</sup> RBMPs were noticed.

In 43% of the countries, the RBMPs refer the existence of (national/regional) guidelines or regulations to define an ecological flow regime. Nevertheless, since this question was not a specific requirement for reporting, other countries may also have some guidelines or regulations. In a questionnaire filled by MS (within the CIS Workshop on Water Management, Hydropower & WFD in 2011), countries were asked to report if there is relevant legislation to ensure ecologically based flow at hydropower plants (Table 1).

Table 1. Legislation used to ensure ecologically based flow at hydropower plants (adapted from 3<sup>rd</sup> IR).

There is relevant legislation	There is no legal requirement but there is relevant recommendation		No legal requirement or recommendation but defined in individual cases	Generally, no legislative means	No information about these countries
National level	National level	Regional level			
Austria, Bulgaria, Spain, Lithuania, Latvia, Romania	Slovakia, United Kingdom, Portugal	United Kingdom	Belgium, Luxembourg	Finland	Cyprus, Malta

Regarding methods for the definition of an ecological flow regime, several methods were used (Figure 2), being the static definition of minimum ecological flows the most frequently applied method.

The European Commission, made several recommendations for the 2<sup>nd</sup> and 3<sup>rd</sup> RBMPs of the overall European countries, such as: 1) the methodologies used to assess ecological flow regimes should be clearly referred, 2) it would be important to define more standardised methods and the development of a common understanding for setting ecological flow, 3) monitoring programmes should target river stretches where ecological flows are applied to enhance our knowledge about the effects of ecological flows on the biological elements used to assess WFD impacts should be crucial of their relation, 4) the establishment of ecological flows for all European water bodies is necessary, also to deal with water scarcity and drought situations.

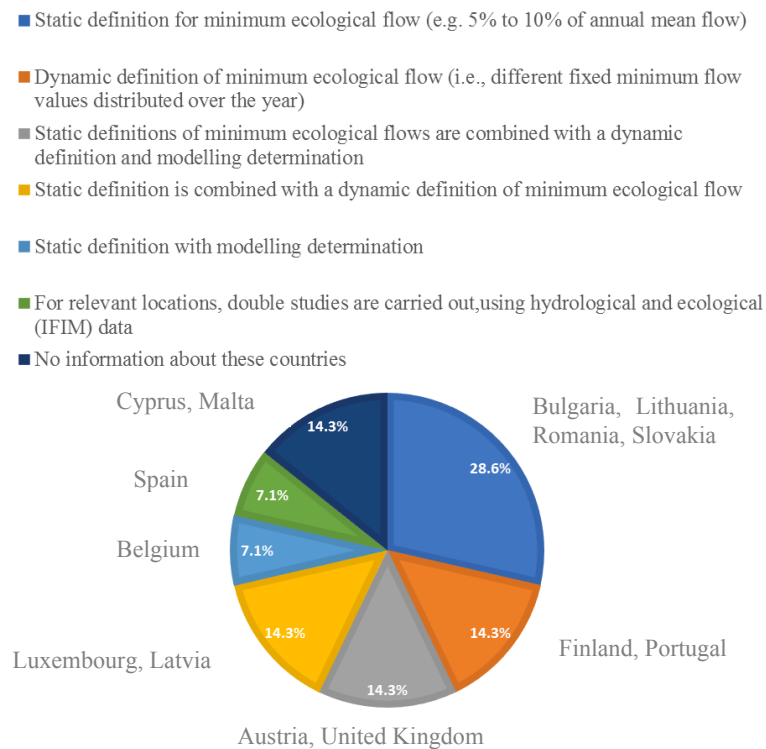


Figure 2. Methods used for the definition of an ecological flow regime (based on the 3rd IR).

The 4<sup>th</sup> IR was developed by the European Commission with the aim to provide an overview of the progress made by MS in the development and implementation of Programmes of Measures under the WFD, enabling the Commission to understand what are the strengths and weaknesses of the implementation of WFD, in the different MS. This document also provides recommendations for each Member State to fill the gaps within the 2<sup>nd</sup> RBMPs. Regarding those measures related with the improvements in ecological flow regimes and/or establishment of minimum ecological flow, the 4<sup>th</sup> IR indicates that most of the countries had not completed the process or did not even started it. EU Commission makes some recommendations about this topic, for some of the assessed countries: 1) Austria and Finland should conduct a review of hydropower permits as restoration measures and the establishment of an ecological flow downstream of hydropower plants will be necessary to achieve good surface water status; 2) Bulgaria, Spain and Latvia should develop a proper methodology to establish a link between ecological flows and the good ecological status as well as to guarantee that ecological flows are applied through a review of the permits. Moreover, the Commission asked Spain to “avoid presenting the maintenance of ecological flow in new dams as an ecological benefit of the dam, while they should be considered as a mitigation measure”, 3) for Romania the indication was that this country should “further develop and analyse ecological flow using the information on ecological status and the information available under the Common Implementation Strategy (CIS)”.

### 3.2 Guidance n° 31 – Ecological flows in the implementation of the WFD

The assessment of the progress of WFD implementation, made it clear that actions should be taken to boost several topics within the WFD agenda. In this context, in 2012, the Commission prepared the Blueprint to Safeguard Europe’s Water resources. One of the main objective is to ensure that people, the economy and the environment have sufficient quantity of good quality water available. In fact, the “Blueprint” recognizes that water quality and quantity are intimately linked with the concept of “good status”, enhancing the importance of an EU-wide acknowledgement of the ecological flows role. In this context, the “Blueprint” proposed the development of a guidance document, within the WFD common implementation strategy (CIS), regarding ecological flows.

The objective was that the recommendations of this guidance were applied in the 2<sup>nd</sup> and 3<sup>rd</sup> RBMPs. A CIS Working Group presented the guidance, in 2015, with the main goal to support a shared understanding of ecological flows and ways to use them in the RBMPs. The document covers several aspects, such as: 1) a working definition of ecological flows in the context of WFD, 2) steps in the WFD cycle where eflows are relevant, and 3) lessons learned from case studies that have been developed in several EU-MS. Nevertheless, the document highlights that it “does not offer a full protocol for the implementation of Eflows in water bodies, nor is it intended to lead to uniform implementation of eflows”. In fact, MS are encouraged to “make best use of the shared understanding of eflows in all steps of the WFD process” while considering the site-specific eflows implementation (related with several aspects, namely the national or regional legislation, specific environmental values or ecosystem services).

In the guidance, the CIS Working Group choose to adopt the term “ecological flows”, that within the context of the WFD, is defined as: “an hydrological regime consistent with the achievement of the environmental objectives of the WFD in natural surface waters bodies as mentioned in Article 4(1).” It should be emphasized that, within this definition, according to Article 4(1), the environmental objectives refer to: 1) non-deterioration of the existing status, 2) achievement of good ecological status in natural surface water body, 3) compliance with any standards and objectives for protected areas. The definition provided is referred as a “working definition of ecological flows” that does not cover those ecological flows that should be implemented in heavily modified water bodies and/or those qualified for an exemption. For those water bodies, ecological requirements “are to be derived taking into account technical feasibility and socio-economic impacts on the uses that would be affected by the implementation of ecological flows”. Throughout the document several recommendations are provided:

- The national frameworks should include ecological flows: 1) that consider all flow components of the natural flow regime (and not only the minimum flows), 2) defined considering their link with biological requirement according to the objectives of WFD and Birds and Habitat Directives (BHD);
- MS should develop methods for the classification of ecological status based on metrics more sensitive to hydrological pressures, considering the relationship between hydrology, morphology and the biological impacts. The idea is to use metrics that are appropriately sensitive to hydrological alteration;
- A suitable definition and implementation of ecological flows requires the monitoring of hydrology to get a full picture of hydrological alterations and the associated impacts on habitat/morphology and biology, to support the achievement of ecological flows. The results from monitoring will enable the assessment of the effectiveness of flow restoration actions (as part of the programme of measures);
- The selection of the most suitable method to define ecological flows is influenced by the information available (such as monitoring data) and by the severity of the pressures;
- The programmes of measures should guarantee the implementation of ecological flows (through the incorporation in basic measures, controls on surface and groundwater abstractions, impoundments and other activities that impact hydromorphology, authorization process and regular review of permits);
- The assessment of costs associated with the implementation of ecological flows should not be used to change the ecological flows developed based on technical/scientific process.
- Public participation on ecological flows should be developed in all the phases of the WFD planning process, from its design, implementation plan and effective implementation follow-up.

### ***3.3 Questionnaires completed by country representative experts***

In this section, questionnaire results are presented and discussed. Figure 3, shows which countries incorporated ecological flow assessment within the 1<sup>st</sup> and 2<sup>nd</sup> RBMPs (Q1 and Q2). It is important to notice that, for the overall analysis, once the three Belgium representatives provided

identical answers, no distinction was made between them, and the results are presented as “Belgium”.

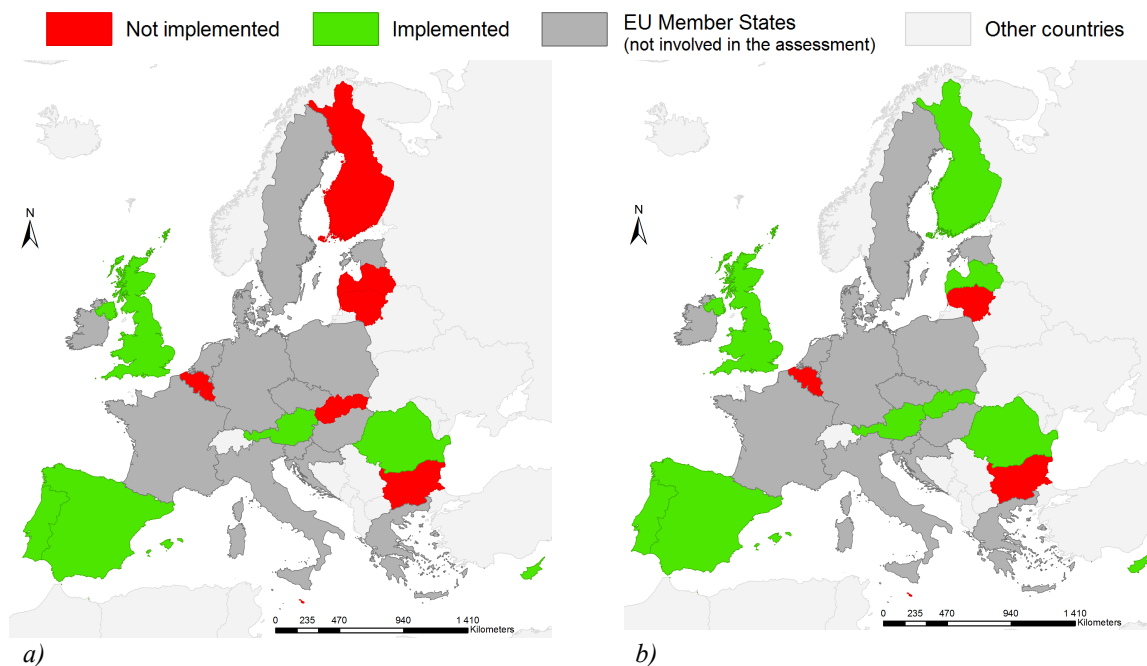


Figure 3. Status of ecological flow assessment integration within the a) 1<sup>st</sup> RBMPs and b) 2<sup>nd</sup> RBMPs.

Comparing Figure 3a and Figure 3b, it is possible to notice a progression in the integration of ecological flows assessment in RBMPs, since some countries started to include this topic within the 2<sup>nd</sup> RBMPs. Nevertheless, it is possible to notice that some countries still did not include ecological flows in their assessments: Belgium, Luxembourg, Lithuania, Bulgaria and Malta. Hence, from now on, these countries will not appear in the evaluation of the remaining questions, which are related with the way ecological flows are considered in the 2<sup>nd</sup> RBMPs. Hence, the countries evaluated from now on will be nine.

One of the firsts steps for the definition of ecological flows is the selection of locations for which the ecological flows will be determined (Q2.1). Some years ago, the definition and implementation of ecological flows was perceived as a measure to mitigate downstream effects of dams (being frequently applied only to those locations). Currently, a global “sense of urgency has arisen” (Poff et al. 2010) to implement ecological flows for wider locations for their inclusion into basin-wide and regional water-resources planning (Dyson et al. 2003; Poff et al. 2010). Taking this into consideration, this study tried to identify the differences between European MS in terms of ecological flows definition. Table 2, presents a list of the locations for which MS had defined ecological flows.

Through the analysis of Table 2, it is possible to verify that there is a balance between those countries that already define ecological flows for the whole RBDs and those that are still focused in the development of ecological flows only for downstream dams.

Most of the countries reported (Q2.2) to have a national legislation (Austria, Bulgaria, Spain, Latvia, Portugal, Romania, United Kingdom) that provides guidance for the definition of ecological flow regimes and their inclusion in the RBMPs. Finland refers that they have a regional legislation as well as Latvia. Portugal refers the existence of a national guideline (Alves and Bernardo 2002). None of the countries reported the existence of regional guidelines.

Another important factor to assess was the ecological flow methods (Q2.3) used for the definition of ecological flow regimes within RBMPs. Table 3 presents these results.

Table 2. Ecological flows location (**A** – only for downstream dam's river stretches, **B** – for several rivers affected by different types of pressures, **C** – for the whole River Basin District (RBD, i.e. for their main rivers and tributaries).

Country	A	B	C
Austria			■
Cyprus	■		
Spain		■	
Finland			
Latvia	■		
Portugal	■		
Romania			■
Slovakia	■		
United Kingdom			■

Legend: ■ Applicable

Table 3. Ecological flows methods.

	Hydrological	Hydraulic	Habitat Simulation	Holistic
Country	Cyprus, Spain, Latvia, Romania, Slovakia, United Kingdom, Portugal	-	Spain	Austria, Finland, United Kingdom

It is possible to notice that hydrological methods are the most commonly used methods to define ecological flow regimes. To assess the evolution in the implementation of ecological flows, a parallelism is made with the methods referred in Figure 2 and Table 3. Hydrological methods and hydraulic methods include: a) static definition for minimum ecological flow (e.g. 5% to 10% of annual mean flow), b) dynamic definition of minimum ecological flow (i.e. different fixed minimum flow values distributed over the year), c) static definition is combined with a dynamic definition of minimum ecological flow. On the other hand, habitat simulation methods include: a) static definitions of minimum ecological flows are combined with a dynamic definition and modelling determination, b) static definition with modelling determination, c) for relevant locations, double studies are carried out, using hydrological and ecological (IFIM) data. Based on this parallelism it is possible to notice that Austria, Finland and United Kingdom showed an increase in the complexity of the methodologies used (changed for holistic methods). The other countries seem to use the same types of methodologies used in the 1<sup>st</sup> RBMPs.

Ecological flows are required to sustain freshwater ecosystems. Ecosystems needs would depend on the hydrological patterns, in other words, their value should change accordingly with the type of year (Q2.4).

As expected, most of the countries (67% - Finland, Latvia, Portugal, Romania, Slovakia, United Kingdom) had defined ecological flows for normal years, without considering the definition of a specific regime for drought years. This could be related to the type of methodology used, as well as, to a lack of understanding of the effects of droughts on freshwater ecosystems.

One of the recommendations of the European Commission is that ecological flows should be ecologically relevant. In other words, it would be expected that the defined ecological flows present a clear relation/connection with biological elements, which are the main elements used to assess water bodies status (Q2.5). Table 4 show the answers reported by each country.

Through the examination of Table 4, it is possible to notice that most of the countries defined ecological flows regimes that provide some insights (qualitative information) about the link between ecological flow regime and biological indicators.

As stated before, ecological flows are used as a measure to sustain freshwater ecosystems. Hence, their inclusion within the Programmes of Measures (Q2.6) of the RBMPs should be essential for the implementation of ecological flow regimes. All the countries reported inclusion of this topic, within the Programmes of Measures.

The implementation of ecological flows and the monitorization of their effects on biological communities is crucial to gain knowledge for further adjustments (Q2.7). Hence, it was considered relevant to understand if MS are not only implementing ecological flows but also monitoring its effects.

Table 4. Ecological flows and their link with biological indicators (A – there is a distinguishable link, B – some insights (qualitative information) are provided about this link, C – no clear connection is provided).

Country	A	B	C
Austria	■	■	■
Cyprus	■	■	■
Spain	■	■	■
Finland	■	■	■
Latvia	■	■	■
Portugal	■	■	■
Romania	■	■	■
Slovakia	■	■	■
United Kingdom	■	■	■

Legend: ■ Applicable

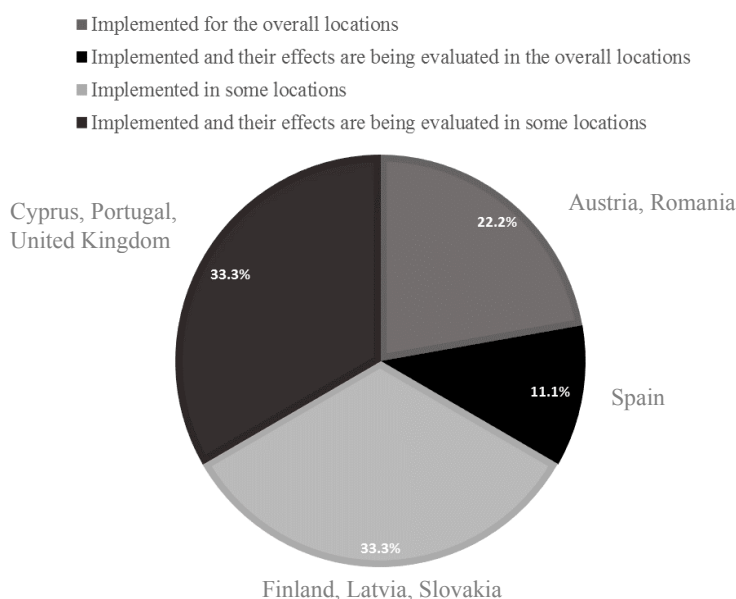


Figure 4. Status of ecological flows implementation and evaluation of their effects.

As expected, most of the countries had already implemented ecological flows only for some locations. Only four countries (Cyprus, Portugal, United Kingdom, Spain), are evaluating the ecological effects of the ecological flows regimes. The evaluation of the effects of ecological flows (Q7.1) is based on monitoring programs focused on the ecological quality assessment (considering biological, physicochemical, specific pollutants and hydromorphological elements) and chemical status, under the provisions of the WFD). This evaluation is complemented by the evaluation of other relevant aspects, namely those expected to help clarify relations between the mitigation measure and the ecological outcomes, such as detailed hydromorphological characterizations. United Kingdom is using ecological indicators of severe water resources pressures. Cyprus referred that no specific indices are used to evaluate effects of ecological flows, they rely on the national indices used to assess water bodies.

## 5. CONCLUSIONS

With this study it was possible to evaluate the overall status of ecological flow definition and implementation within the RBMPs. It was possible to conclude that, even though countries show an overall progression through the comparison between the 1<sup>st</sup> and 2<sup>nd</sup> RBMPs, MS should enhance their knowledge and efforts about this subject. Moreover, it was possible to understand that few



countries incorporated the recommendations provided in the CIS guidance document. Nevertheless, some countries highlight that actions have been taken to incorporate the suggestions in this document for the 3<sup>rd</sup> implementation cycle. The difficulties could be related with the timing of this document, that was developed very close to the deadline for adoption of the 2nd RBMPs.

Based on the analysis of the official documents and answers to the questionnaire, it was possible to conclude that countries use different methods to define ecological flow regimes. Moreover, most of the methodologies do not seem to be necessarily linked to the achievement of WFD environmental objectives. In the 1<sup>st</sup> RBMPs most of the countries used a static definition for minimum ecological flows, which does not encompass the multiple aspects of an ecological flow regime. Within the 2<sup>nd</sup> RBMPs, most of the countries are using hydrological methods, without trying to understand the relation between ecological flow regimes and biological elements, i.e. the achievement of WFD environmental objectives. To gain knowledge about this relation, monitoring programmes should be implemented to understand the effects of ecological flows on the biological quality elements. This will provide evidence about relation between flow and biological elements, as well as on how to manage ecological flows to achieve WFD environmental objectives. An overall conclusion is that it will be important to put together efforts to enable the development of a common and standardised method for setting ecological flows. In fact, these recommendations were highlighted by European Commission after the assessment of 1<sup>st</sup> RBMPs, although this necessity seems to persist within the 2<sup>nd</sup> RBMPs. This method should be of regional applicability (i.e. river basin district), taking in consideration site-specific characteristics. Indeed, the establishment of ecological flows for all water bodies could be used to enhance the achievement of WFD environmental objectives, as well as to deal with drought effects.

## ACKNOWLEDGEMENTS

The first author gratefully acknowledges for the PhD research grant provided by a protocol between FEUP and EDP - Produção de Energia, S.A. The authors are grateful to all those Member State contact points of the WG ECOSTAT and country representative experts that agreed to answer the questionnaire about ecological flows within the WFD implementation (Austria – Gisela Ofenböck, Belgium – François Darchambeau, Sofie Bracke, Wim Gabriels, Bulgaria – Marin Marinov, Cyprus – Gerald Dörflinger, Spain – Carmen Coletto, Finland – Marko Jarvinen, Lithuania – Audrone Pumputyte, Luxembourg – Nora Welschbillig, Latvia – Jānis Šīre, Tatjana Kolcova, Portugal – Sofia Batista, Romania – Otilia Mihail, Slovakia – Emilia Mišíková Elexová, United Kingdom – Peter Pollard, Malta – Annabelle Zammit). Thanks, are also due to the Environment Water Team of the European Commission, on behalf of Dr. Daniel Calleja Crespo (Director-General for Environment), for providing the contacts of country representative experts. Finally, the authors would like to thank Dr. Eleftheria Kampa from the Ecologic Institute (Berlin-Germany).

## REFERENCES

- Acreman M, Arthington AH, Colloff MJ, et al. (2014a) Environmental flows for natural, hybrid, and novel riverine ecosystems in a changing world. *Front Ecol Environ* 12:466–473. doi: 10.1890/130134
- Acreman MC, Ferguson AJD (2010) Environmental flows and the European Water Framework Directive. *Freshw Biol* 55:32–48. doi: 10.1111/j.1365-2427.2009.02181.x
- Acreman MC, Overton IC, King J, et al. (2014b) The changing role of ecohydrological science in guiding environmental flows. *Hydrol Sci J* 6667:1–18. doi: 10.1080/02626667.2014.886019
- Alves MH, Bernardo JM (2002) Caudais ecológicos em Portugal. Ministério das Cidades, Ordenamento do Território e Ambiente, Lisboa, Portugal
- Arthington AH (2012) Environmental Flows. Saving Rivers in the Third Millennium, Freshwater. University of California Press, Berkeley
- Brisbane Declaration (2007) Environmental Flows are Essential for Freshwater Ecosystem Health and Human Well-Being.
- Bunn SE, Arthington AH (2002) Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. *Environ Manage* 30:492–507. doi: 10.1007/s00267-002-2737-0
- Dyson M, Bergkamp M, Scanlon J (2003) Flow: The Essentials of Environmental Flows. Gland, Switzerland, Cambridge

- European Commission (2000) Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. Off J Eur Parliam L327:1–82. doi: 10.1039/ap9842100196
- European Commission (2012a) Commission Staff Working Document. European Overview (2/2). Accompanying the document Report from the Commission to the European Parliament and the Council on the Implementation of the Water Framework Directive (2000/60/EC). River Basin Management Plans.
- European Commission (2012b) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A Blueprint to Safeguard Europe's Water Resources.
- European Commission (2015a) Ecological flows in the implementation of the Water Framework Directive : guidance document n°31.
- European Commission (2015b) Policy Summary of Guidance Document No. 31. Ecological flows in the implementation of the Water Framework Directive.
- Maia R (2017) The WFD implementation in the European Member States. Water Resources Management (in revision).
- Poff NL, Richter BD, Arthington AH, et al. (2010) The ecological limits of hydrologic alteration (ELOHA): a new framework for developing regional environmental flow standards. *Freshw Biol* 55:147–170. doi: 10.1111/j.1365-2427.2009.02204.x