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Implementation of e-flows in the EU
Final report

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Ecologic Institute, Fresh Thoughts Consulting GmbH , Milieu Consulting
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Final report

Directorate-General for Environment

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1. EXECUTIVE SUMMARY

Ecological flow (e-flow) is the amount of water required for the aquatic ecosystem to continue to thrive and provide the services we rely upon. It is a key element for sustainable water use in river basins along with water balances and water allocation mechanisms. In 2015, a guidance document was developed under the Common Implementation Strategy (CIS) for the Water Framework Directive (WFD), to provide an EU definition of ecological flows and a common understanding of how they should be calculated, so that e-flows can be applied more consistently in river basin management plans.

Eight years after the publication of the 2015 CIS guidance document, the integration of e-flows assessments in the RBMPs has steadily increased from the first to the third WFD planning cycle. This report reviews progress in implementing e-flows and in addressing implementation challenges. This report elaborates the main challenges faced by water management institutions in implementing e-flows in EU MS, presents country progress in developing relevant good practices and presents relevant implementation examples from MS practices.

Regarding the major challenges:

- There is mixed progress of Member States in terms of **institutional, legal and governance measures and mechanisms to establish and support e-flows**.
    - Most countries have already established (or are in the process of establishing) abstraction permit systems that respect e-flows, as well as processes for reviewing water rights to introduce e-flows requirements.
    - At the same time, important challenges remain in terms of taking account of cumulative impacts and of impacts of climate change on water availability.
    - Implementing e-flows for heavily modified water bodies needs to be further developed.
    - Several countries are still facing challenges in terms of the legal and policy basis, which needs to be further elaborated for implementing e-flows, and in terms of stakeholder involvement, ecological benefits evaluation and finding ways to deal with opposition to implementation because of reduced economic benefits of major water users.
- **Enforcement of and compliance with** e-flows remains a challenge for many Member States, in particular related to monitoring gaps and to systems of administrative fines when limits of permits are not respected.

In addition, large **uncertainties in both hydrological and biological regimes** make it difficult to establish direct connections between the need to implement e-flows and changes in ecological status, and pose a challenge to an adaptive approach for e-flows implementation.

On the other hand, **jurisprudence** regarding implementation of e-flows does not seem to be a major challenge in most countries. In some countries, specific training of lawyers and judges is organised by environmental authorities, though in other countries, this potential issue has not been detected yet because of the lack of legal cases on e-flows to this date.

Overall, many EU river basin managers have to cope with water availability that has been falling over the past century. At the same time, water is needed in our rivers and estuaries because it is essential for species survival and ecosystem preservation. The **establishment and implementation of e-flows is thus key for achieving good ecological status as required by the WFD** both in water quantity and water quality terms.

In view of the still pressing challenges that need to be tackled to advance the implementation of e-flows, the following **recommendations** are made to strengthen scientific support, political commitment and communication with stakeholders and citizens on this topic:

- Improve the **legal regime and policy basis** for implementing e-flows, including the consideration of climate change projections.
- Establish **processes/mechanisms to make e-flows and their role in water use policy more widely known and accepted** by different stakeholders, including water users and relevant competent administrations (e.g. flood management authorities).

- Elaborate and address differences in the **implementation of e-flows for natural and HMWB** and relevant implementation strategies.
- Use available **financial support tools** to reduce trade-offs between the implementation of e-flows and economic water uses (e.g. energy and food production); share experiences in dealing with opposition from water users and on the use of relevant funding mechanisms at country level.
- EU financing instruments should be more explicit on their requirements to respect the WFD, including reference to e-flows.
- Improve the **evaluation of ecological benefits** of e-flows and ecosystem services; Exchange information and ongoing progress on relevant pilot work and studies on the description of ecological benefits and on thresholds between increasing ecological benefits and decreasing economic benefits of water users (trade-offs in e-flow implementation).
- Improve **mechanisms for more effective enforcement** of e-flows (including compliance monitoring systems for different water uses and penalties/fines).
- Further exchange information on MS approaches concerning the **implementation of e-flows during drought** events (e.g. prioritisation methods and restrictions applied).
- **Integrate e-flows into water allocation schemes**, for example concerning the priority of e-flows and water uses under water stress and how to allocate water for environmental needs under climate change.
- **Intensify communication with stakeholders and citizens** to update them on changing water conditions and the importance of e-flows.

2. CONTEXT

In 2022 and 2023, the Ad-hoc Task Group on water scarcity and drought under the Common Implementation Strategy for the Water Framework Directive has addressed several related topics. Three background documents have been drafted to review and foster the implementation of, respectively, water balances, water allocation mechanisms and ecological flows.

Water balances take stock of the available water resources and existing water uses and conclude with a review statement of water supply feasibility and/or overexploitation. They constitute a knowledge basis for the establishment and implementation of water allocation mechanisms, which allow certain water uses in a certain area or time. Water allocation mechanisms are also key for ensuring that ecological flows are implemented, ensuring the achievement of good ecological status/potential under the Water Framework Directive and of broader biodiversity and sustainability goals.

3. INTRODUCTION: ECOLOGICAL, ENVIRONMENTAL AND GEP FLOWS

The WFD explicitly acknowledges the importance of the flow regime for the status of aquatic ecosystems and includes it as one of the key elements supporting biological elements in the classification of the ecological status. Although the WFD does not prescribe the establishment of ecological flows, it acknowledges the critical role of water quantity and dynamics in supporting the quality of aquatic ecosystems and the achievement of environmental objectives, and thus requires taking adequate response measures, such as Article 11(3)e "controls over the abstraction".

The establishment and enforcement of adequate ecological flows for all water bodies in Europe is essential for dealing efficiently with water scarcity and drought issues and for achieving good ecological status as required by the WFD, as well as securing significant co-benefits for energy savings, climate change mitigation and adaptation, nature and biodiversity. It requires the adaptation of current water allocation to consider the ecological needs of water-dependent ecosystems (EC, 2012).

In the global environmental policy context, water flows are notably relevant to achieve Sustainable Development Goal 6 (Ensure access to water and sanitation for all), which includes targets to protect and restore water-related ecosystems including rivers, wetlands, aquifers, and lakes (SDG 6.6, SDG 15.1). Environmental water requirements are explicitly referenced and defined in

SDG indicators 6.4.2 (Level of water stress) and 6.6.1 (Change in the extent of water-related ecosystems over time). Ecological flows contribute to improvements in the production of freshwater and estuarine foods such as fisheries (SDG 14.2), thereby contributing indirectly to other SDGs[1].

Ecological flow, which is the amount of water required for the aquatic ecosystem to continue to thrive and provide the services we rely upon, is a key element of sustainable water use in river basins along with water balances and water allocation mechanisms. Defining an ecological flow and taking measures to maintain it is important for restoring and managing river ecosystems, to preserve the communities of biota as well as support the delivery of other ecosystem services. At the same time, the need to maintain an ecological flow in river ecosystems may lead to conflicts with other water users of the same river ecosystems because of the need to limit existing and future abstractions.

The 2015 CIS guidance no. 31 (CIS 2015) was drafted after previous WFD CIS interactions on water scarcity and drought, including the definition of appropriate EU-wide indicators, and introduced the definition of the term "ecological flow" as "*a hydrological regime consistent with the achievement of the environmental objectives of the WFD in natural surface water bodies as mentioned in Article 4(1)*". This document provides guidance and case studies to connect such a hydrological regime with the different steps in preparing and implementing River Basin Management Plans (RBMPs), including a description and an overview of strengths and weaknesses of existing methods to derive ecological flows (grouping the several hundred specific methods in three major types) and providing insights into implementation challenges. The Guidance document explicitly avoided offering "a full protocol for the implementation of ecological flows in water bodies", and states that it is not "intended to lead to uniform implementation of ecological flows".

In 2019, CIS Guidance no. 37 (CIS 2019) introduced the additional term "GEP flow" with the following definition: GEP flow (GEP stands for Good Ecological Potential) is flow considered within the context of the WFD as a "hydrological regime consistent with the achievement of the environmental objectives of the WFD in heavily modified water bodies (HMWB) as mentioned in Article 4(1), considering a condition close to best approximation to ecological continuum as mentioned in Annex V 1.2.5." GEP flow is also relevant for artificial water bodies (AWB).

A further term used in discussions and in this document is "environmental flow" which describes 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 (from Brisbane Declaration, International River Foundation 2007). Thus, environmental flows is a broader term that can be used for mitigation measures on flows aimed to reach any environmental objective. In this context, environmental flows could include less stringent objectives under the WFD, whereas the concept of ecological flow is linked explicitly to good status of natural water bodies and GEP flow is linked to good potential of HMWB and AWB.

In this document, we use the abbreviation "e-flow" for environmental flows and ecological flows (as described above) and "GEP flow" for good ecological potential flow at HMWB and AWB.

Despite its significant potential to contribute to solving water scarcity problems, the implementation of ecological flows was assessed as insufficient in the second River Basin Management Plans of Member States. By 2015, in many Member States ecological flows were still not derived or not applied in many water bodies, whilst there was action starting or underway in most of them (EC, 2019a). The key gaps or weaknesses identified in the assessment of the second River Basin Management Plans with respect to ecological flows were:

- Overall lack of derivation and effective implementation once derived of ecological flows across a large number of RBDs and Member States, though several Member States were in the process of design and implementation of methodologies.
- General exemptions to the implementation of ecological flows applied in few Member States, due to their disproportionate costs (not necessarily including proper justifications).
- Difficulties in implementing ecological flows as an add-on to existing water use permits, and/or the use of unclear measures.

The 2019 EU Water Policy Fitness Check concluded with regard to ecological flows that the WFD provides a comprehensive framework for protecting and managing the quantitative aspects of water bodies. Sound water management requires joint management of qualitative and quantitative aspects,

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[1] Adapted from Angela H. Arthington et al. (2018): The Brisbane Declaration and Global Action Agenda on Environmental Flows. Front. Environ. Sci., 02 July 2018 | https://doi.org/10.3389/fenvs.2018.00045 (2018).

the latter being implicit in the definition of good ecological status and explicit in hydromorphological elements (i.e. flow regime). Furthermore, good quantitative status is required for groundwater, where Member States must ensure a balance between water abstraction and recharge rates. As quantitative issues in particular are bound to become yet more salient in the coming period due to the impacts of climate change, Member States will need to make the best possible use of the framework offered by the WFD to address them. It is worth exploring how this process can be facilitated at EU level. The Fitness Check also concluded that CIS Guidance Document no. 31 on ecological flows is a concrete example of where the CIS has been useful in helping Member States to implement the WFD. It provides guidance on establishing coherent rules on setting the flow regimes that have to be maintained in order to safeguard ecosystems downstream of large infrastructures such as dams (EC 2019b).

Overall, progress is being made by Member States in establishing methods to define e-flows and integrate them in RBMPs. A survey of the CIS WG ECOSTAT in 2022 concluded that the integration of e-flow assessments in the RBMPs should be increased in the third WFD cycle, with more Member States having e-flows methods in place compared to the first and second WFD cycle (see Figure 1 on status of e-flows methods and their use in RMBPs).

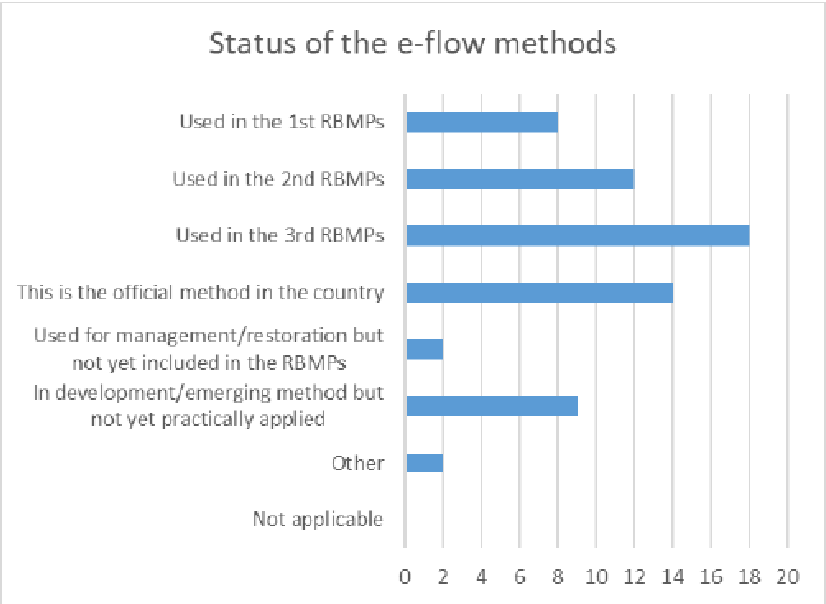

Figure 1 Status of e-flow methods and their use in RBMPs (number of MS)

Source: ECOSTAT questionnaire on e-flows methods - summary of the main results and questions for discussion for the ECOSTAT workshop (30 June - 1 July 2022)

In order to support and further speed up the achievement of the WFD environmental objectives, the EU Biodiversity Strategy 2030 (EC 2020) set further concrete targets for the implementation of key measures. With respect to the quantitative management of water, the Strategy calls on Member State authorities to review water abstraction and impoundment permits and to implement ecological flows in order to achieve good status or potential of all surface waters and good status of all groundwater by 2027 at the latest.

4. AIM OF THIS REPORT

4.1. SCOPE AND PURPOSE OF REPORT

The purpose of this report is to elaborate on measures implemented to achieve ecological flows in EU Member States and to define actions in support of enhanced implementation of ecological flows. The overall objective is to support Member States' exchange of information on enhancing the implementation of ecological flows as valuable measures to support the WFD objectives and to ensure that the needs of nature for adequate flows in river basins are respected.

The focus is on the implementation and not on the definition of ecological flows. In parallel to the work that took place to develop this report under the Ad-hoc Task Group on water scarcity & droughts, parallel work of the CIS WG ECOSTAT has been ongoing to support Member States in improving the definition of the ecological flow.

4.2. METHODOLOGY

This report has been developed in a stepwise process, driven by the consultants, steered by the European Commission and engaging the members of the Ad-hoc Task Group on water scarcity & droughts of the WFD Common Implementation Strategy (CIS). The main steps of the process have been:

- Analysis of literature, including scientific publications, evaluation reports and other sources by the consultants to identify challenges in the implementation of e-flows which are likely to be/are being faced by the water management institutions, primarily by the corresponding river basin authorities.
- Development of good practice options (brief descriptions) for each of the challenges identified
- Consultation of the Ad-hoc Task Group on water scarcity & droughts at its autumn 2022 meeting on the two previous steps
- Development and responses from 19 Member States (AT, BE Wallonia, BE Flanders, CY, CZ, DE, DK, EL, ES, FI, HU, IT, LT, LU, NL, PL, PT, SE, SK, IE) on a self-assessment questionnaire aiming at identifying the situation of challenges and good practice across the EU
- Synthesis of responses and discussion with the Ad-hoc Task Group on water scarcity & droughts at its spring 2023 meeting on preliminary findings and invitation to Member States to contribute good practice examples from their national/sub-national implementation of e-flows for the challenges identified of highest priority for further exchange
- Development and responses by ATG WSD members of good practice examples using a good practice example template
- Validation of good practice examples, preparation of draft technical report including good practice examples and draft recommendations, discussion at the autumn 2023 ATG meeting
- Finalisation of the technical report

Coordination with the work on e-flows definition developed under the WG ECOSTAT and with the development of the consultant reports in cooperation with ATG WSD on water balances and water allocation mechanisms has taken place along the steps outlined above.

5. KEY CHALLENGES FOR IMPLEMENTING E-FLOWS

The key constraints and challenges identified on the implementation of e-flows based on information from the assessment of the RBMPs and other literature (scientific publications, grey literature) have been grouped into three themes for the purpose of this report, taking into account issues that can contribute to (or hinder) the achievement of WFD objectives and of sustainable and climate resilient water management. The three themes are:

- Implementation strategies, i.e. institutional, legal and governance measures and mechanisms to establish and support e-flows
- Jurisprudence regarding the implementation of ecological flows
- Enforcement approaches and methods.

These three themes are elaborated in more detail into a number of specific implementation challenges in the following sections. The list of specific challenges was discussed with the Ad-hoc Task Group on water scarcity & droughts at its autumn 2022 meeting and adapted based on feedback received from the ATG members.

The challenges are considered to be broadly applicable to the whole of the EU, and therefore more or less relevant to the individual Member States.

5.1. IMPLEMENTATION STRATEGIES

The theme of « implementation strategies » refers to institutional, legal and governance measures and mechanisms to establish and support e-flows.

A number of specific constraints and challenges that may be faced in EU Member States are elaborated below.

- **The legal and policy basis (national legislation, policy documents) for implementing e-flows is not sufficiently elaborated**. This could entail the lack of provisions for ecological flow regimes under the national water acts, to be determined in further detail in the RBMPs and the programmes of measures. Further, the relevant regulations may not be sufficiently coherent and detailed, leading to the lack of consistent application within the same country.
- **E-flows are not (sufficiently) considered in the management of water resources by various policies** Policy makers and authorities at different levels may not be adequately informed and trained on issues related to e-flows and their ecosystem services due to the lack of relevant guidance documents, and lack of dissemination of relevant studies and methods developed.
- **There is lack of stakeholder involvement (regional and local authorities, water users, civil society organisations, science) in e-flows implementation discussion**. Consultation may be lacking not only in discussions at national level on the implementation of WFD measures, but also with local actors for implementation of measures at water body level.
- **There is no or insufficient information provided to the public and stakeholders on the implementation of e-flows**. The lack of information may be noted in the lack of reporting on progress in implementing e-flows in the RBMPs and in regular water monitoring reports (e.g. annual) that do not explicitly address e-flows.
- **E-flows are only implemented in a few or in insufficient number of water bodies**. This may be linked to operational challenges in introducing e-flows conditions in existing permits. Although ecological flows are implemented for new permits, existing permits may still include only requirements for minimum flows.
- **GEP flows are not considered as a mitigation measure to achieve good ecological potential of HMWB**. According to CIS Guidance no. 37 and its accompanying mitigation measures library for achieving GEP in HMWB, GEP flow should be among the mitigation measures options considered for HMWB in cases of heavily impacted flow regime.
- **Some abstractions are not subject to authorisation process when water abstracted is below a certain level**. The permitting system for abstractions show some differences between Member States. Whereas in some Member States, all abstractions are subject to licensing, in other Member States, there are exceptions and no authorisation is needed for small water abstractions or abstractions of temporary nature or even abstractions for agricultural irrigation in water-rich countries.
- **The sum of the amounts of water in existing abstraction permits is too large to enable e-flows to be implemented**. This increasingly becomes a problem when there is a significant decrease in water availability (in some regions, to be augmented due to climate change in the future) and there is no proper procedure in place to review existing permits.
- **Permitting processes are delivered on a case-by-case basis and do not take into account the cumulative impact of projects on water status and on other water users**.
- **There is no binding timeline for the review of water rights and e-flows implementation**. In some Member States, older permits for water abstraction are not time-limited, but usually new permits for water abstraction are time-limited. The timelines for reviewing water rights also differ between Member States and in some countries, there is no regular review of water rights, e.g. linked to the WFD planning cycles, and permits are reviewed only occasionally.
- **There is no legal option to introduce e-flow requirements for old water rights**. In some countries, the procedure of revising old water rights is still in development or very recently initiated.
- **There is a lack of budgets for paying compensation**. This could be a constraint in case compensation is envisaged in legislation for cases of water permit reviews. In the legal regime of most Member States though, no financial compensation is foreseen to implement e-flows in the review process of water permits.
- **There is opposition to the implementation of e-flows because of reduced economic benefits from water use (e.g. hydropower generation or agricultural**

output). Some Member States (e.g. Spain) have faced (and sometimes also overcome) significant implementation challenges using targeted subsidies for water user affected by economic losses from the implementation of e-flows. For example, hydropower-targeting strategies (e.g. in Catalonia, see Bardina et al. 2015) have included subsidised modernisation of turbines to allow for increased power generation with lower/different flows and thereby implemented e-flows with a faster timeline than awaiting for the license renewal.

- **There is lack of evaluations of ecological benefits of e-flows.** Although some relevant studies have been initiated already in pilot areas or at national level on the ecological benefits of e-flows, most of these studies are still ongoing and results are not broadly available. Especially the value of electricity versus the ecological/recreational benefits from e-flows implementation are difficult to evaluate.
- **Public investments/subsidies are not used in a targeted way for fostering e-flows.** For example, rural development programmes under the CAP may not consider e-flows directly, or the RBMPs do not include targeted measures to increase water use efficiency using CAP funding for irrigation and other EU funding instruments.
- **In case of drought, e-flows are not secured in the water allocation mechanism**.
- Particular challenges are faced in case of prolonged droughts that prevent the achievement or the maintenance of ecological flows. As drought is part of the natural hydrological variability which is a key element in the functioning and the natural dynamics of aquatic ecosystems, some countries have included the particular ecological conditions of natural droughts in the definition of ecological flows. For instance, in Portugal, e-flows for particularly dry years are defined considering the value of accumulated precipitation since the beginning of the hydrological year (October) in reference weather stations. In Spain the design of "drought flows" considers refuge habitats and connectivity, and likely temporary deterioration in water body. These flows are activated in River Basins according to their drought monitoring system.
- **The implementation of e-flows does not take into account future impacts of climate change on water availabilities, and consequently non-climate proof investments are supported**. This can be the case if water planning cycles, which include the calculation of e-flows, are not informed by updated climate change assessments and when new climate scenarios are available at national or regional level. Overall, in many Member States, a more detailed understanding of climate changes impacts and associated uncertainties still needs to be developed to to inform e-flow considerations.

Overall, implementation strategies for e-flows are also interlinked with water allocation mechanisms and readers of this report are also advised to consult the **report on water allocation**. In several cases, implementation strategies for e-flows rely on establishing allocation mechanisms at catchment level based on water balances, as in France, involving users in setting up the monitoring and reporting process, defining collectively-agreed allocation rules and procedures to reduce abstraction levels to sustainable levels.

5.2. JURISPRUDENCE

A significant number of judicial decisions have taken place over the past decade regarding the implementation of ecological flows, although relevant legal cases are limited to few Member States. For instance in Spain, there is relevant case law covering the application of "ecological flow discount rates"[2] and "economic compensations for water users"[3].

A few relevant constraints and challenges that may be faced in EU Member States are elaborated below.

- **There is lack of consideration of e-flows and their contribution to sustainable water management by lawyers and judges**. This can be due to the fact that no targeted training is organised by environmental authorities and due to the lack of relevant legal cases.
- **There is lack of understanding of issues related to the implementation of e-flows by lawyers and judges**. Although e-flows may appear in the national law, it may not be an easy concept to understand by lawyers and judges. The challenge may be augmented

[2] E.g. Spain, 2018. STS 3353/2018- ECLI: ES:TS:2018:3353
[3] E.g. Spain 2019: STS 853/2019 - ECLI: ES:TS:2019:853

by the lack of relevant legal training and legal conferences, the lack of relevant legal cases and the lack of consultation of scientific institutes with relevant expertise in case of legal conflicts.

5.3. ENFORCEMENT APPROACHES AND METHODS

In practice, competent authorities face rather often non-compliance with the established ecological flow values. For example, in the Basque Country in 2018 (Intecsa-Inarsa S.A. 2018), approximately half of the monitoring stations indicated compliance failures. These failures can be due to infrastructure constraints (lack of adaptation), illegal water abstraction, or due to natural conditions e.g. during a drought event, if the monitoring station is far downstream of the abstraction point. Overall assessments of e-flows compliance based on monitoring stations are particularly useful to get overviews at national level, e.g. Spanish example shown below, included in Mezger et al., 2019). The Spanish case is a positive and excellent example how the information can be compiled in a useful and transparent way, assessed by experts and transformed into recommendations to improve the programme of measures.

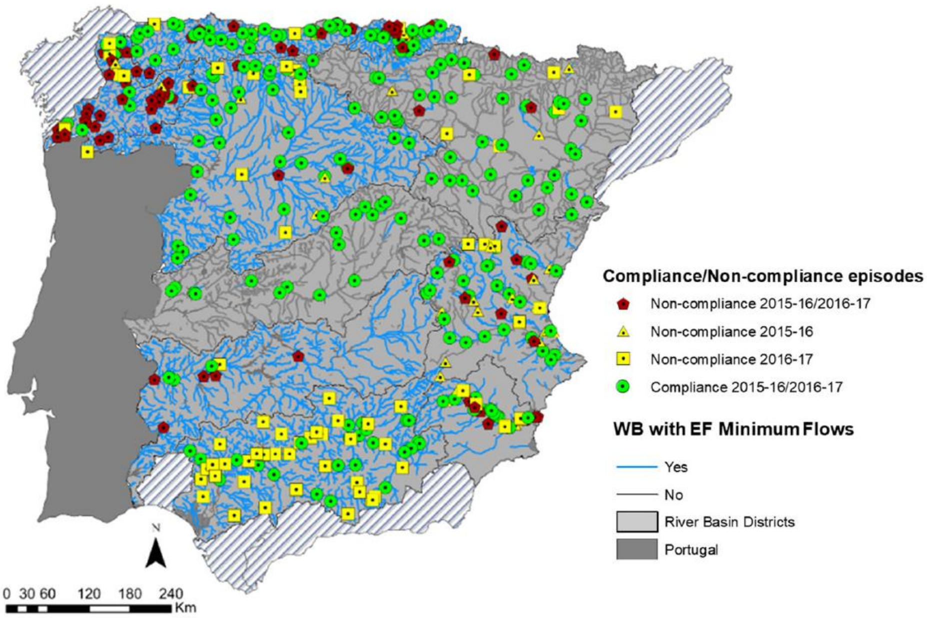

Figure 2 E-flows compliance check monitoring stations in Spain

Source: Mezger et al., 2019.

Specific implementation challenges with regard to enforcement approaches that may be faced in EU Member States are summarised below.

- **Non-compliance of e-flows is not detected due to monitoring gaps**. This is often due to the lack of an area-wide continuous flow monitoring network and the lack of sufficient resources to efficiently monitor all abstraction points. Often e-flows associated with large infrastructure such as dams are adequately monitored by permit holders, but e-flows related to irrigation abstractions are more challenging to thoroughly monitor.
- **Non-compliance of the limits of abstraction permits is not properly penalised**. Different situations may be distinguished in terms of this challenge: Administrative fines in case of infringements of abstraction permits are not high enough to be dissuasive. Also, significant infringements against limits of abstraction permits may not be treated in legal terms as environmental crime or the loss of water right is not a legal option in case of repeated infringements against limits of abstraction permits.

6. MEASURES TO IMPLEMENT E-FLOWS IN MS

In the e-flows implementation questionnaire circulated to ATG WSD members in 2022, Member States were asked to indicate the specific measures which they use to implement e-flows, and to indicate at what scale they do so (whole MS, specific regions, other). A number of pre-defined measures were provided as options and the overview of Member States responses is given in Figure 3.

The most common measures used to implement e-flows, which are used by almost all MS which responded to this questionnaire, are controls on surface and groundwater abstractions, controls on hydrological variations (e.g. in river discharges, lake levels), hydrological and morphological restoration measures.

Other types of measures which are used to implement e-flows include controls on impoundments, user restrictions, installation of e-flow release facilities (e.g. in reservoirs) and measures to mitigate hydropeaking effects. Examples of other measures used by Member States to implement e-flows include supervision, inspection and sanction regimes, ad hoc controls and measures to improve water retention.

The scale at which e-flows measures are implemented varies for different types of measures. The measures concerning controls on surface water abstractions, groundwater abstractions, impoundments and controls on hydrological variations are implemented in most Member State at the whole country level based on national law, and usually implemented by sub-national administrations.

The scale of application is different for hydrological and morphological restoration measures which are implemented rather in specific RBDs, water bodies or sites (e.g. based on priority restoration areas defined in the RBMPs or in national restoration strategies; specific projects planned and implemented at RBD to regional and water body level; application of small scale restoration measures in specific water bodies).

The implementation of user restrictions to safeguard e-flows is more differentiated. During dry seasons, user restrictions can be applied at MS or RBD level or municipalities may impose on common water suppliers the introduction of water restrictions e.g. on the use of water for gardens. The application of water user restrictions also takes place under different priority of use regimes across countries. Although in some countries, e-flows are considered a restriction prior to water uses, in others, e-flows and water demands of nature are in lower position in the priority order of water demand satisfaction.

Examples of implementing e-flow release facilities are mentioned in Member State responses for large water reservoirs (e.g. releases of water by means of reservoir gates) but rather not the case for old reservoirs and as minimum flow facilities.

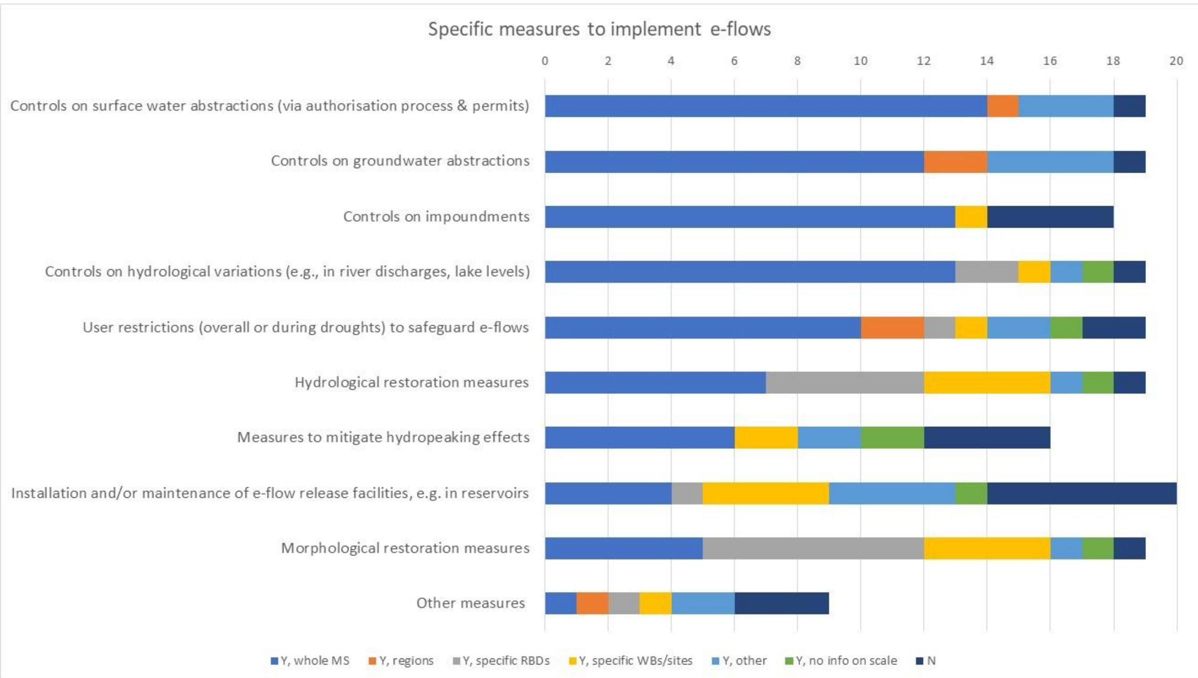

Figure 3 Specific measures which Member States use to implement e-flows

Source: MS responses to e-flows implementation questionnaire in 2022-2023.

The abstraction authorisation systems are a key component of the set of measures Member States have in place to implement e-flows. The following table 1 summarises information provided by Member States in their questionnaires on whether or not all abstraction are subject to authorisation (and if any exceptions apply) and whether cumulative impacts are considered in the authorisation process. Table 2 provides information on the different approaches of Member States on water rights reviews and e-flows implementation.

Table 1 Overview of abstraction authorisation systems

Abstraction authorisation and exceptions when water is abstracted below a certain level	Consideration of cumulative impacts in permitting process
AT: Water abstractions are in general subject to permits. The Austrian water Act foresees exemptions for (minor) abstractions of groundwater with a manual pump or in adequate relation to property. Due to effects of climate change on the water cycle in some regions existing authorized permits might have to be reviewed. BE Fl: A notification is required for temporary abstraction. For permanent abstraction, an authorisation is required. Governors can impose abstraction bans on all withdrawals during periods of drought. CY: Any abstraction of ground and surface water is subject to permitting, with the exemption of dams for drinking and agriculture purposes. These are controlled by the government and were constructed in order to abstract all available water volumes for the above uses. DK: Almost all water abstractions in Denmark require a permit. When the municipality assesses a new application for abstraction, it must consider its water supply plan and other existing permits. ES: Spanish Water Act states a private use by legal provision under certain conditions. Its article 54 is referred to two cases. Firstly, the use of rainwater flowing through a property and the stagnant water, within its boundaries. Secondly, water from springs located within a property may be used there and groundwater may be exploited therein, where the total volume does not exceed 7,000 m^3/year. In aquifers that have been declared as overexploited, or at risk of being overexploited, no new works may be carried out without the corresponding authorisation. Maintaining the ecological flow regime is considered a priority over abstractions in Spanish Water Act (art. 59). Conflicts arise when considering the diminution of water availability when e-flows are fulfilled. FI: All large scale abstractions are under permits. Agricultural irrigation intakes do not need permission and can harm e-flow possibilities under specific dry years HU: Small water abstractions are subject of authorisation by local authorities. But these registers are not included in the water	BE Fl: An assessment of the global water system is made before the imposition of abstraction bans. DK: When assessing an application for abstraction the municipality may consider how a new abstraction may affect e-flow and set the abstraction level accordingly. ES: Compatibility between a concession and the water plans are analysed as stated in the Spanish Water Act. IT: National legislation for water abstraction authorisations envisages that single effect of an abstraction in a water body and cumulative effects of other abstractions in the catchment above have to be evaluated and e-flows are ensured in the network. IE: Water Environment (Abstractions and Associated Impoundments) Act 2022 provides for the authorisation of abstractions and on a water body basis cumulative impacts will impact authorisation assessments. PT: Part of the licensing process

Abstraction authorisation and exceptions when water is abstracted below a certain level	Consideration of cumulative impacts in permitting process
balance calculation, as it would be an administrative burden due to the fact that local and regional authorities are not connected. IE: Water Environment (Abstractions and Associated Impoundments) Act 2022 when implemented will address abstraction limits to provide for e-flows IT: All abstractions are subject to authorisation nationwide. For some regions, water abstraction for "home usage" are subject only a communication to the competent authorities, due to national legislation. LU: All abstractions are subject to authorisation to avoid multiplication of small projects that may lead to deterioration and failure to achieve e-flows NL: Authorisation is determined by the water level in surface water or groundwater. If it drops below a certain level, then there is an extraction ban. There are differences between water boards also because of local effects. There are also groundwater withdrawals that are not subject to permits or reporting. Many agricultural withdrawals are not regulated. PT: All the abstractions are subject to licencing. Ecological flow regime is considered a priority over abstractions, except for drinking water. When there is a significant decrease in water availability there are conflicts SE: If it is obvious that neither public nor private interests are damaged by the impact of water extraction on water conditions, neither a permit nor a notification of the activity is required (11 Chapter of the Environmental Code). It is the operator of the activity who must be able to show that the exception is met. A permit is also not required for water extraction for the household consumption or heating needs of single or two-family homes or agricultural properties (11 Chapter 11 of the Environmental Code). Household consumption encompasses the use of water for activities such as bathing, washing, cleaning, and garden watering for non-commercial purposes. Irrigation of agricultural land is not covered by the exception.	

Source: MS responses to e-flows implementation questionnaire in 2022-2023.

Table 2 Water rights review and revision of old water rights

Member States approaches (water rights reviews, revising old water rights)
CY: Reviews of abstraction permits are foreseen in permits, but this is independent from WFD planning cycles DK: All abstractions with permits are time limited and must be reviewed when the permit expires. There are no "old water rights". According to the Water supply act all "old water rights" have expired and abstraction permits have had to be re-applied for. ES: Spanish Water Act states the review of water allocation rights to accomplish actual requirements. Every 6 years e-flows (restrictions to water uses) and allocations are reviewed. Remark that e-flows defined in Spain are restrictions to water uses, which are not guaranteed by law. FI: There are ongoing process to revise old water rights and depending on the case, e-flow possibilities are evaluated. HU: Review happens occasionally due to the fact that water rights permits are valid for a period of time (5-20 years). Where there is a risk to fail e-flow implementation the permits have shorter timeline. IE: Water Environment (Abstractions and Associated Impoundments) Act 2022 facilitates the review of abstraction licensed not more frequently than once every 3 years IT: The process is ongoing to consistently review old permits. Reviews are carried out starting from those water bodies where abstractions are the most significant pressures and subject to review if needed. LU: National law in place has overridden all old water rights PL: Reviews of abstraction permits are carried out for planning cycle. Supplement reviews of abstraction permits are carried out for water bodies at risk. If there is a threat to the achievement of environmental objectives and this is justified by data from water monitoring and the results of the additional review of water-legal permits, an old permit may be changed. SE: Sweden's older permits for water abstraction are rarely time-limited, but new permits for water abstraction are mainly time-limited. Drinking water abstractions are not time-limited. The national plan for hydropower involves a review of the permits of water flows on a national scale. PT: The revision of permits is foreseen in the Water Law, namely when the quality objectives are not achieved. Permits may be modified at the initiative of the competent authority, even if on a temporary basis, whenever: • if there is a change in the circumstances existing on the date of issuance of the title and determinants thereof, namely the degradation of the water; • substantial and permanent alterations occur in the qualitative and quantitative composition of the raw effluents or after treatment, as a result, namely, of the substitution of raw materials, changes in manufacturing processes or increase in production capacity that justify it, or in case changing the best available technique. • monitoring or other data indicate that it is not possible to achieve the environmental objectives, as provided for in article 55 of Law no. 58/2005, of 29 December; • it is necessary to adjust it to the territorial management instruments and the applicable hydrographic basin management plans; • there is a drought, natural disaster or other case of force majeure.

Source: MS responses to e-flows implementation questionnaire in 2022-2023.

7. TOWARDS GOOD PRACTICE TO ADDRESS CHALLENGES IN IMPLEMENTING E-FLOWS

7.1. HOW COULD GOOD PRACTICE LOOK LIKE FOR EACH IMPLEMENTATION CHALLENGE

In order to be able to actively promote Member State exchange on challenges and good practice in the implementation of e-flows and to go beyond the information incorporated in the 2015 CIS

Guidance Document no. 31 on the topic, the detailed set of challenges presented in section 4 has been extended by corresponding good practices options.

For each of the 23 detailed challenges, good practice options have been proposed based on the outline of the corresponding challenges (drawing from the RBMPs assessment and other literature). The options for good practice outlined in the table below were consulted with the ATG WSD in their 2022 autumn meeting and subsequently used for their further assessment in MS implementation practices.

The proposed good practice options should be seen as a starting point to be further elaborated and improved as the collection of good practice on the implementation of e-flows in Member States builds up in the CIS process.

Table 3 Challenges and good practice options for the implementation of e-flows

	Implementation constraints	Challenge	Good practice options for further assessment in MS	Justification
E1	Implementation strategies	The legal and policy basis (national legislation, policy documents) for implementing e-flows is not sufficiently elaborated	Ambitious targets for the implementation of e-flows to contribute to achieving good status (ecological flows) or potential (GEP flows) are set and enshrined in national legislation, policy documents and RBMPs	To ensure political guidance and support to action at the technical level, e.g. fixing criteria for handling trade-offs (like hydropower vs ecological flows or GEP flows)
E2	Implementation strategies	Non-consideration of e-flows in the management of water resources by various policies	Develop training courses for relevant policy makers to provide in-depth knowledge on e-flows and ecosystem services	To make e-flows and their role in water use policy and water management widely known and accepted
E3	Implementation strategies	Lack of stakeholder involvement (regional and local authorities, water users, civil society organisations, science) in e-flows implementation discussion	Targets for e-flows for specific water bodies are transparently communicated with stakeholders. There is a concertation body at the scale of the relevant territory to discuss solutions to achieve the implementation of e-flows.	To ensure a proper understanding of and support to e-flows by stakeholders
E4	Implementation strategies	There is no or insufficient information provided to the public and stakeholders on the implementation of e-flows	Information about the implementation, monitoring and infringements of e-flows and their consequences are annually provided to the public and stakeholders at the river basin district and water body level	To ensure transparency and accountability of the implementation
E5	Implementation strategies	E-flows are only implemented in a few/insufficient water bodies	E-flows (and their various components) are implemented for all water bodies where these are relevant	To ensure a broad and relevant application of e-flows, including transitional water bodies
E6	Implementation strategies	GEP flows are not considered as a mitigation measure to achieve good ecological potential of HMWB	GEP flows are considered and implemented as mitigation measure to achieve GEP in HMWB where relevant (using a differentiated approach	To ensure a broad and relevant application of GEP flows for heavily modified water bodies

	Implementation constraints	Challenge	Good practice options for further assessment in MS	Justification
			to ecological flows for natural water bodies)	
E7	Implementation strategies	Some abstractions are not subject to authorisation process when water abstracted is below a certain level	All abstractions are subject to authorisation to avoid multiplication of small projects that may lead to deterioration and failure to achieve e-flows	To consider cumulative effects of water abstractions
E8	Implementation strategies	The sum of the amounts of water in existing abstraction permits is too large to enable e-flows to be implemented	The amounts of water in authorised permits is limited to a level that allows e-flows to be achieved in a given river ecosystem	To ensure implementation of e-flows in water bodies impacted by significant water abstractions
E9	Implementation strategies	Permitting processes are delivered on a case-by-case basis and do not take into account the cumulative impact of projects on water status and on other water users	Cumulative impacts of water right permitting processes are considered, in particular for small projects	To avoid that an accumulation of small projects individually having no impacts on the resource but having an impact cumulatively remain out of the radar
E10	Implementation strategies	No binding timeline for water rights review and e-flows implementation	Reviews of abstraction permits are carried out for each planning cycle under the WFD, or in case there are changes in the e-flow objectives, and prioritized in water bodies with significant water abstraction and hydrological alteration pressures	To provide regular opportunities to adapt permits to new knowledge and conditions of the river basin (e.g. climate change) and the implementation of e-flows
E11	Implementation strategies	No legal option to introduce e-flow requirements for old water rights	The regulatory system includes provisions to change old water rights, e.g. possibility to change licenses of old hydropower plants, to guarantee e-flow	To ensure implementation of e-flows in water bodies impacted by abstractions or hydrological alterations linked to old water rights
E12	Implementation strategies	Lacking budgets for paying compensation	The water permit review process for achieving good status or potential and implementing ecological flows or GEP flows does not require financial compensation of water right holders	To ensure implementation within the WFD planning cycles
E13	Implementation strategies	Opposition because of reduced economic benefits from water use (e.g. hydropower generation or agricultural output)	E-flows implementation is combined with investments in energy/food production technology to reduce trade-offs and speed up the implementation process by early adopters	To reduce trade-offs with energy/food production and speed up implementation process
E14	Implementation strategies	Lack of evaluations of ecological benefits of e-flows	Evaluations of ecological benefits of e-flows support strategic-level decisions for the implementation of e-	To balance out evidence on economic benefits from water use

	Implementation constraints	Challenge	Good practice options for further assessment in MS	Justification
			flows by sectoral water users	
E15	Implementation strategies	Public investments/subsidies are not used in a targeted way for fostering e-flows	Investments in water use efficiency (e.g. CAP for irrigation) target in a prioritized way those areas causing significant water abstractions and hydrological alteration pressures and result in the elimination of such pressures (e.g. water savings are not increasing consumption or stored to increase the supply guarantee)	To ensure impact of investment measures
E16	Implementation strategies	In case of drought, e-flows are not secured in the water allocation mechanism	Environment and maintenance of e-flows are given high priority (after drinking water supply) in water allocation decision-systems activated in case of droughts	To ensure e-flows are accounted for next to meeting irrigation demands, in case of droughts
E17	Implementation strategies	The implementation of e-flows does not take into account future impacts of climate change on water availabilities, and consequently non climate proof investments are supported	Climate change effects on e-flows as well as associated uncertainty is taken into account in its implementation including water rights allocation. All new investments and permits are checked for their "climate proofing" when it comes to water availability.	To ensure that new abstraction permits are not going to compromise the achievement of e-flows in the future and to ensure that all new activities are authorised only if adapted to climate change.
E18	Jurisprudence	Lack of consideration of e-flows and their contribution by lawyers and judges	Judicial decisions on e-flows consider technical criteria and the value of water bodies in good status or potential and the role of ecological flows and GEP flows	To ensure the validity of e-flows in a democratic system and identify possible gaps
E19	Jurisprudence	Lack of understanding of e-flow issues by lawyers and judges	The competent authorities provide training and knowledge on e-flows to lawyers and judges	To improve institutional capacity
E20	Enforcement	Non-compliance of e-flows is not detected due to monitoring gaps	E-flows are monitored in a continuous mode to detect non-compliance	To ensure enforcement action can be taken properly
E21	Enforcement	Non-compliance of limits of abstraction permits is not properly penalised	Infringements of abstraction permits are penalized by administrative fines which are sufficiently dissuasive	To ensure the effectiveness of e-flows and avoid implementation constraints
E22	Enforcement	Non-compliance of limits of abstraction permits is not properly penalised Non-compliance of limits of abstraction	Significant infringements against limits of abstraction permits are penalized as environmental crime	

	Implementation constraints	Challenge	Good practice options for further assessment in MS	Justification
E23	Enforcement	permits is not properly penalised	Repeated infringements against limits of abstraction permits are penalized by the loss of water rights	

7.2. PROGRESS OF MEMBER STATES IN TACKLING CHALLENGES & DEVELOPING GOOD PRACTICE

For each specific challenge in the implementation of e-flows and good practice option, Member States were asked to indicate whether they face such implementation challenges or have such good practice in place. This aimed to allow identifying the key challenges that need addressing in this good practice report on implementing e-flows and potential exemplary cases for the good practices.

19 EU Member States responded to the self-assessment questionnaire to identify the relevance of the challenges and the existence of good practices which could be shared. The main findings of the exercise are displayed in the following overview tables which provide a summary of the status of implementation, and in particular challenges faced, good practice developed and ambitions for improvement according to the self-assessment of Member States participating actively in the exercise. The responses have not been validated or double-checked with other stakeholders. In addition, the overviews only display the acronyms of those Member States which can provide good practice examples.

In Table 2, implementation challenges relevant for a larger number of MS (>5) have been marked in red and additionally in bold when they are relevant in >7 MS. Good practices in place in a larger number of MS (>5) have been marked green and additionally in bold when they address a challenge which is relevant for a large number of MS (>5).

Table 3 adds information on the MS which have developed good practices and could share such specific examples which are either in progress or in place in some areas or the whole country with interested parties. It also information about how many Member States are planning to address specific challenges with concrete actions within the next 1-3 years.

Overall, **for a number of challenges, a large number of MS indicates to have made already good progress** to address the challenge and have good practices in place either in the whole MS or in some MS areas or are in the process of implementing good practice. Such a positive picture is given in particular for the following implementation challenges:

- Having some abstractions not subject to authorisation process when water abstracted is below a certain level
- Lack of binding timeline for water rights review and e-flows implementation
- Lack of legal option to introduce e-flow requirements for old water rights
- Lack of budgets for paying compensation
- In case of drought, e-flows are not secured in the water allocation mechanism
- lack of consideration of e-flows and their contribution to sustainable water management by lawyers and judges
- Lack of understanding of issues related to the implementation of e-flows by lawyers and judges
- Significant infringements against limits of abstraction permits not treated in legal terms as environmental crime
- Loss of water right is not a legal option in case of repeated infringements against limits of abstraction permits.

However, the **majority of challenges have been identified as still being relevant constraints in the implementation of e-flows implementation** for a large number of Member States (>5):

- The legal and policy basis (national legislation, policy documents) for implementing e-flows is not sufficiently elaborated
- Non-consideration of e-flows in the management of water resources by various policies
- Lack of stakeholder involvement (regional and local authorities, water users, civil society organisations, science) in e-flows implementation discussion
- There is no or insufficient information provided to the public and stakeholders on the implementation of e-flows
- E-flows are only implemented in a few/insufficient water bodies
- GEP flows are not considered as a mitigation measure to achieve good ecological potential of HMWB
- The sum of the amounts of water in existing abstraction permits is too large to enable e-flows to be implemented
- Permitting processes are delivered on a case-by-case basis and do not take into account the cumulative impact of projects on water status and on other water users
- Opposition because of reduced economic benefits from water use (e.g. hydropower generation or agricultural output)
- Lack of evaluations of ecological benefits of e-flows
- Public investments/subsidies are not used in a targeted way for fostering e-flows
- The implementation of e-flows does not take into account future impacts of climate change on water availabilities, and consequently non climate proof investments are supported
- Non-compliance of e-flows is not detected due to monitoring gaps
- Infringements of abstraction permits are penalized by administrative fines which are not sufficiently dissuasive

Out of this second list, there are some topics for which more than 7 Member States state that they are facing either:

- Major implementation challenges (e.g. institutional, governance, regulation, data) to develop this good practice, or
- Operational implementation challenges (of methodologies, tools, resources, capacity, rules or regulation) to develop this good practice.

It was discussed and agreed that this report shall focus on these challenges which affect a larger number of Member States (>7) (**priority challenges**). These include (marked in Table 2 and Table 3 in red and bold text):

- E2: Non-consideration of e-flows in the management of water resources by various policies
- E6: GEP flows are not considered as a mitigation measure to achieve good ecological potential of HMWB
- E13: Opposition because of reduced economic benefits from water use (e.g. hydropower generation or agricultural output)
- E17: The implementation of e-flows does not take into account future impacts of climate change on water availabilities, and consequently non climate proof investments are supported
- E20: Non-compliance of e-flows is not detected due to monitoring gaps
- E21: Infringements of abstraction permits are penalized by administrative fines which are not sufficiently dissuasive

The **implementation challenges in which several Member States plan to progress during the coming 1-3 years** are in particular the following:

- E1: The legal and policy basis (national legislation, policy documents) for implementing e-flows is not sufficiently elaborated
- E2: Non-consideration of e-flows in the management of water resources by various policies
- E14: Lack of evaluations of ecological benefits of e-flows

Further, Member States reported several **additional challenges** which they face in the implementation of e-flows that were not captured in the pre-defined list of challenges in the questionnaire. Examples of additional challenges are:

- Technical challenges, e.g. due to the very large number of old hydraulic infrastructure, which means only a stepwise approach to ensure area wide e-flows is possible. Technical challenges are also related to monitoring data and modelling.
- Limited availability of water resources in order to implement e-flows from dams used for drinking water and agriculture use.
- Need for continued and detailed analysis of the response of water bodies to the discharge of environmental flows to fully adequate and calibrate the e-flows regimes in coming years.
- Uncertainties related to the definition of e-flows and lack of transparent methodologies for establishing e-flows.
- Capacity challenges related to lack of financial or human resources.
- Scientific challenges e.g. related to lack of understanding of how groundwater overabstractions impact surface water flow depletion.

Table 4 Overview of number of Member States addressing e-flows implementation challenges and developing good practices

			From challenges....		... to good practice			
	Challenges	**1**	**2**	**3**	**4**	**5**	**6**	**Good practices**
		Not applica-ble	**Major challen-ges**	**Operati-onal challen-ges**	**In process**	**In place in some MS areas**	**In place in whole MS**	
E1	Legal and policy basis not elaborated	1	1	6	7	1	4	Ambitious targets set in law, policy, RBMPs
E2	**E-flows not considered in water manageme nt by various policies**	1	3	5	6	2	3	Training courses for policy makers to provide knowledge on e-flows
E3	Lack of stakeholder involvement	2	4	3	2	5	4	**Targets transparently communicated**
E4	Insufficient information to public & stakeholders	3	4	3	5	3	2	Information on implementation, monitoring and infringements provided
E5	E-flows implemented in few WBs	3	3	3	4	3	4	**E-flows implemented in all relevant WBs**
E6	**GEP flows not considered as measure to achieve GEP of HMWB**	1	4	5	3	2	3	GEP flows considered and implemented where relevant
E7	Some abstractions not subject to authorisation	1		5	4	2	7	All abstractions subject to authorisation

			From challenges....		... to good practice		
	Challenges	1	2	3	4	5	6	Good practices
	when below a certain level							
E8	Amount of water in existing abstraction permits too large to enable e-flows	1	1	6	5	2	4	**Amount of water in permits limited to allow e-flows to be achieved**
E9	Permitting processes case-by-case and no account of cumulative impacts	1	2	5	5	2	4	**Cumulative impacts of water permits considered, in particular small projects**
E10	No binding timeline for water rights review and e-flows implementation	1	2	2	5	2	7	Reviews of permits in each WFD cycle, priority for significant abstractions
E11	No legal option to introduce e-flow requirements for old water rights	1	3	2	3	1	7	Legal provisions to change old water rights to guarantee e-flow
E12	No budgets for paying compensation	5	4	1		2	6	No requirement for financial compensation
E13	**Opposition due to reduced**	4	4	4	4	2		E-flows combined with investments in technology to reduce trade-offs

			From challenges....		… to good practice			
	Challenges	**1**	**2**	**3**	**4**	**5**	**6**	**Good practices**
	economic benefits from water use							
E14	No evaluations of ecological benefits	3	4	3	8	1	1	Evaluations of ecological benefits support strategic decisions linked to sectoral users
E15	Public investments/ subsidies not used in targeted way for fostering e-flows	5	3	3	3	3	2	Investments in water efficiency prioritized for areas with significant abstractions
E16	At drought, e-flows not secured in water allocation mechanism	4		4	5	1	5	Environment & e-flows have high priority in allocation in case of drought
E17	**No account of impacts of climate change on water availability**	2	3	6	6	1	1	Climate change taken into account in implementation, permits "climate proofing"
E18	No consideratio n of e-flows and their contribution by lawyers and judges	6	1	1	4	2	3	Judicial decisions consider technical criteria and role of e-flows
E19	No understandin g by lawyers & judges	7	1	4	2	3		Authorities give training to lawyers, judges

			From challenges....		... to good practice			
	Challenges	**1**	**2**	**3**	**4**	**5**	**6**	**Good practices**
E20	**Non-compliance, monitoring gaps**	3	1	8	1	5	2	**Monitored in a continuous mode**
E21	**Non-compliance of limits of permits not properly penalised – low administrative fines**	2	2	6		4	6	**Infringements of permits penalized by fines which are sufficiently dissuasive**
E22	Non-compliance of limits of permits not properly penalised - infringements not as environmental crime	6	2			2	6	Significant infringements penalized as environmental crime
E23	Non-compliance of limits of permits not properly penalised – no option for loss of water rights	6		2		1	6	Repeated infringements penalized by loss of water rights

Note: Challenges relevant for a larger number of MS (>5) have been marked in red and additionally in bold when >7 (left side of table)

Good practices in place in a larger number of MS (>5) have been marked green and additionally in bold when they address a challenge relevant for large number of MS (>5) (right side of table)

Columns indicate: 1. Not applicable, 2. Major implementation challenges (e.g. institutional, governance, regulation, data) to develop this good practice, 3. In the MS, there are operational implementation challenges (of methodologies, tools, resources, capacity, rules or regulation) to develop this good practice, 4. In the whole MS or some areas, such specific good practice is in the process of being implemented, 5. In some MS areas (e.g. RBDs, regions or pilots), such specific good practice is in place, 6. In the whole MS, such specific good practice is in place

Table 3: Overview of Member States with good practices planned, in process and in place for e-flows implementation

	From Challenges….		4	5	6	… to good practice
		Action planned	**In process**	**In place in some MS areas**	**In place in whole MS**	
E1	Legal and policy basis not elaborated	5	BE WL, CY, CZ FI, NL, PL, SE	PT	AT, ES, IT, DE	Ambitious targets set in law, policy, RBMPs
E2	**E-flows not considered in water management by various policies**	4	BE WL, BE Fl, FI, HU, PL, EL	IT, PT	AT, ES, DE	Training courses for policy makers to provide knowledge on e-flows
E3	Lack of stakeholder involvement	2	BE WL, EL	FI, IT, NL, PL, PT	AT, CZ, ES, DE	**Targets transparently communicated**
E4	Insufficient information to public & stakeholders	2	BE WL, CZ, ES, FI, EL	IT, LU, NL	AT, DE	Information on implementation, monitoring and infringements provided
E5	E-flows implemented in few WBs	0	AT, BE WL, HU, PT	IT, NL, PL	CZ, ES, LU, DE	**E-flows implemented in all relevant WBs**
E6	**GEP flows not considered as measure to achieve GEP of HMWB**	2	CY, FI, HU	IT, PT	CZ, ES, DE	GEP flows considered and implemented where relevant
E7	Some abstractions not subject to authorisation when below a certain level	1	BE WL, BE Fl, HU, PL	ES, IT	AT, CY, CZ, DK, FI, LU, PT	All abstractions subject to authorisation
E8	Amount of water in existing abstraction permits too large to enable e-flows	0	BE WL, BE Fl, CY, CZ, LU	IT, PT	AT, DK, ES, FI	**Amount of water in permits limited to allow e-flows to be achieved**
E9	Permitting processes case-by-case and no account of cumulative impacts	2	BE WL, BE Fl, CZ, HU, LU	PT, DE	CY, DK, ES, FI	**Cumulative impacts of water permits considered, in particular small projects**
E10	No binding timeline for water rights review and e-flows implementation	1	CZ, LU, SE, LT, DE	BE WL,IT	AT, CY, DK, ES, FI, PL, PT	Reviews of permits in each WFD cycle, priority for significant abstractions
E11	No legal option to introduce e-flow requirements for old water rights	0	BE WL, NL, SE	IT	AT, CY, DK, ES, PL, PT, DE	Legal provisions to change old water rights to guarantee e-flow
E12	No budgets for paying compensation	0		ES, NL	AT, CY, IT, LU, PL, PT	No requirement for financial compensation
E13	**Opposition due to reduced economic benefits from water use**	1	BE WL, BE Fl, ES, PT	LU, PL		E-flows combined with investments in technology to reduce trade-offs
E14	No evaluations of ecological benefits	4	ES, BE Fl, FI, IT, PL, SE, LT, PT	DE	AT	Evaluations of ecological benefits support strategic decisions linked to sectoral users

	From Challenges….		4	5	6	… to good practice
E15	Public investments/subsidies not used in targeted way for fostering e-flows	0	CZ, IT, BE FI	ES, PL, PT	AT, NL	Investments in water efficiency prioritized for areas with significant abstractions
E16	At drought, e-flows not secured in water allocation mechanism	1	CZ, HU, IE, BE FI, DE	PL	ES, IT, LU, NL, PT	Environment & e-flows have high priority in allocation in case of drought
E17	**No account of impacts of climate change on water availability**	1	BE WL, CY, CZ, FI, LT, PT	ES	NL	Climate change taken into account in implementation, permits "climate proofing"
E18	No consideration of e-flows and their contribution by lawyers and judges	1	CZ, FI, PL, PT	NL, DE	AT, ES, IT	Judicial decisions consider technical criteria and role of e-flows
E19	No understanding by lawyers & judges	1	FI, PL	AT, IT, NL		Authorities give training to lawyers, judges
E20	**Non-compliance, monitoring gaps**	1	FI	BE WL, IT, LU, NL, PT	AT,IE	**Monitored in a continuous mode**
E21	**Non-compliance of limits of permits not properly penalised – low administrative fines**	0		BE WL, IT, NL, DE	AT, DK, ES, FI, PL, PT	**Infringements of permits penalized by fines which are sufficiently dissuasive**
E22	Non-compliance of limits of permits not properly penalised – infringements not as environmental crime	1		BE WL, NL	AT, ES, FI, IT, LU, PT	Significant infringements penalized as environmental crime
E23	Non-compliance of limits of permits not properly penalised – no option for loss of water rights	0		NL	AT, DK, ES, FI, IT, PL, PT	Repeated infringements penalized by loss of water rights

Note: Column "Action planned" indicates number of MS aiming to improve this area in the next 1-3 years.

Columns indicate: 4. In the whole MS or some areas, such specific good practice is in the process of being implemented, 5. In some MS areas (e.g. RBDs, regions or pilots), such specific good practice is in place, 6. In the whole MS, such specific good practice is in place

7.3. E-FLOW IMPLEMENTATION EXAMPLES THAT ADDRESS PRIORITY KEY CHALLENGES

The **priority challenges** identified in section 6.2 above indicate the most urgent needs for accessing good practice of implementation to overcome existing challenges across the EU. Member States with available good practice examples on these priority challenges have been requested to share information on their good practice in this report. Examples on the implementation of e-flows have been collected in summer 2023 using a template, including information about the case study location, the implementation time and duration, the objectives and main actions taken, the current situation, lessons learned in the process and contact information for gathering further details.

For the implementation of e-flows, five examples have been shared and an overview is given in the table below.

Challenge	Implementation example from MS	Short summary implementation example
E2. Non-consideration of e-flows in the management of water resources by various policies E3. Lack of stakeholder involvement (regional and local authorities, water users, civil society organisations, science) in e-flows implementation discussion	**Spain**: E-flows management and dissemination activities	Process of definition and technical dissemination of ecological flow regimes across RBDs, which made environmental flows and their role in water use policy widely known and accepted. The implementation process includes pursuing consensus with stakeholders, and adaptive monitoring. As e-flows was a new element in Spanish quantitative water management (back in first WFD cycle), many discussion and dissemination outreach actions were carried out since then (guideline documents, working groups, workshops, seminars for technical experts and stakeholders) and consultation results feed into the RBMPs.
E6. GEP flows are not considered as a mitigation measure to achieve good ecological potential of HMWB	**Finland**: Drafting criteria and guidance for applying e-flows in rivers affected by hydropower	Recent study (2023) that provides a screening of hydropower sites and water bodies to identify locations where environmental flows could yield the greatest ecological benefits. This is a new priorisation tool and scoring system that can be used by local river basin district managers, who are now provided with a list of different powerplants with scoring values to prioritize restoration actions in the programmes of measures.
E11. No legal option to introduce e-flow requirements for old water rights E13. Opposition because of reduced economic benefits from water use (e.g. hydropower generation or agricultural output)	**Sweden:** National plan for reassessment of permits for hydropower	A national plan for gradually adapting permits for hydropower through reassessment to be environmentally aligned.
E11. No legal option to introduce e-flow requirements for old water rights	**Portugal:** Implementation of E-flows in old dams	Development of a methodological guide for the determination of ecological flow regimes in Portugal and implementation of ecological flow regimes in old dams including the construction of specific devices for discharge the e-flow regime.
E17. The implementation of e-flows does not take into account future impacts of climate change on water	**None**	

Challenge	Implementation example from MS	Short summary implementation example
availabilities, and consequently non climate proof investments are supported		
E20. Non-compliance of e-flows is not detected due to monitoring gaps	**Luxembourg**: Continuous monitoring of stream gauges at two large dams in Luxembourg	System of gauges operated below and above the two largest dams which are also used for drinking water. Example of collaboration and system of communication between dam operators and water management agency.
E21. Infringements of abstraction permits are penalized by administrative fines which are not sufficiently dissuasive	**None**	

The compilation of examples of e-flows implementation has shown that:

- Overall, only a small number of good practice implementation examples can be shared so far on the e-flows challenges which still affect a large number of Member States (priority challenges). Further, some of the implementation examples shared are in early stages of implementation and lessons are still to be learned on their effectiveness.
- There is a lack of examples to be shared regarding: (E17) on taking account of future impacts of climate change in the implementation of e-flows; and (E21) on a sufficiently dissuasive penalty system for infringements of abstraction permits affecting e-flows. No MS has volunteered to illustrate these aspects in detail from their implementation practice.
- Further implementation examples from countries, with details of implementation practices, would be valuable for: (E13) managing the opposition faced in e-flows implementation due to economic disadvantages on water users; and (E20) a monitoring system to detect non-compliance of e-flows.
- It should also be kept in mind that good practice in implementing e-flows is available in several Member States on different aspects which have not been prioritised for the detailed exchange of practices in this report. For instance, several countries are planning to progress in the coming 1-3 years on elaborating their legal and policy basis for e-flows implementation (E1) and could benefit from good practice already in place in other countries or currently being implemented.

8. REFERENCES

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9. ANNEX

Full versions of the case studies

9.1. SPAIN: E-FLOWS MANAGEMENT AND DISSEMINATION ACTIVITIES

9.1.1. General information

Member State(s)	Spain
RBD(s)	Inter-community river basin districts (ES010 - Minho-Sil, ES017 - Eastern Cantabrian, ES018 - Western Cantabrian, ES020 - Douro, ES030 - Tagus, ES040 - Guadiana, ES050 - Guadalquivir, ES070 - Segura, ES080 - Jucar, ES091 - Ebro)
Location	Inter-community river basin districts (listed above)
Time period (start - end)	1985 to date (on-going)
Good practice example promoter	Spanish Ministry for the Ecological Transition and Demographic Challenge. Directorate General for Water (DGA) - River Basin Authorities (RBAs).

9.1.2. Challenge(s) faced

- E2: Non-consideration of e-flows in the management of water resources by various policies.

Even in a context of considerable spatial hydrological variability, there is a widely acknowledged problem of water scarcity in Spain. The WEI+ index varies between 0.01 and 0.78 with a value of 0.20 in Spanish territory of the Iberian Peninsula[4]. Responses were water planning and the construction of reservoirs to manage the seasonal flows but with a notable alteration of the hydrological regime. Moreover, the growing awareness on the need to preserve the water environment has led to a wide adoption of e-flows regimes. These regimes affect all socioeconomic activity, and it is therefore essential that they are understood and accepted by the stakeholders and policy makers.

- E3: Lack of stakeholder involvement (regional and local authorities, water users, civil society organisations, science) in e-flows implementation discussion.

Stakeholders, including regional and local authorities, water users, civil society organizations, and the scientific community, play crucial roles in understanding the local context, sharing diverse perspectives, and contributing valuable knowledge and expertise. An incomplete understanding of the regional challenges and opportunities related to e-flows can result in ineffective or inappropriate implementation strategies that do not align with local conditions and needs, together with the lack of ownership and acceptance by the different user groups and stakeholders.

9.1.3. Good practice(s) developed

Code of the good practice(s):

- E2. Develop training courses for relevant policy makers to provide in-depth knowledge on e-flows and ecosystem services.
- E3. Targets for e-flows for specific water bodies are transparently communicated with stakeholders. There is a concertation body at the scale of the relevant territory to discuss solutions to achieve the implementation of e-flows.

Table 5 Synthetic overview of the actions taken.

	Type of actions	Characteristics
✓	Regulatory	Water Acts (1985, 2001). Hydrological Planning Regulation (RPH). Public Hydraulic Domain Regulation (RDPH). Hydrological Planning Instruction (IPH) (1992, 2008). Regulatory documents of the River Basin Management Plans (RBMP).
✓	Technical	A multitude of technical works have been developed for the establishment and implementation of e-flows in a course of several stages: definition of methodology and criteria; practical determination; dissemination and agreement; monitoring and adaptive improvement.
✓	Economic	Since the first work to determine the e-flows (DGA, 2010) and initial dissemination, their completion (application to the remaining bodies of water or new components of the regime), technical discussion with

4 Data from DGA - CEDEX 2019.

	Type of actions	Characteristics
		stakeholders, monitoring and improvement have become customary practices in the framework of the RBMP process, specifically for their consideration in the allocation of water. This is done with the RBAs' own resources and support consultants.
✓	Research	E-flows are recognised as a crucial element of Spanish RBM planning and are the subject of numerous scientific and technical studies. The field of research concerns the estimation of natural flow regimes and their degree of alteration, the modelling of the impact on biological communities, on the status of water bodies and on socio-economic uses.
✓	Governance	The establishment of e-flows regimes, their monitoring and implementation is the responsibility of the RBAs, following the governance framework that is primarily set out in the RPH and the RDPH. It should also be noted that public initiatives and scientific and technical projects in the field of water protection have traditionally been the subject of specific outreach and participation programmes.
	Others	--

Description of the good practice:

The Spanish model relies on a broad strategy of stakeholder involvement:

- A first phase in the framework of the RBMP process involving definition, dissemination, and discussion of the rationale of e-flows regime, criteria, and methods.
- Once the technical work of evaluating e-flows is complete, a second phase of information, discussion, and active participation in the search for consensus with users, social agents, and participating administrations, which ends with the formalisation of e-flows as restrictions on use - subject to certain exceptions in drought situations (less stringent regime and, in critical situations, priority of supply to the population) - and their publication in the RBMP regulatory documents.
- Actual implementation in common management practice, requiring infrastructure interventions (adaptation of dam spillways and adjustments and water intakes), and effective monitoring of flows, reservoir volumes and drought status.

Reasons for initiating action(s):

The 1985 Water Act started from the recognition of water as a scarce and indispensable resource for socio-economic activity but whose availability must be achieved without damaging the environment. E-flows were indirectly introduced together which the obligation to develop public and binding RBMPs, that should include the allocation of water resources for current and future use, compatible with the conservation or recovery of the natural environment. More explicitly, the first IPH (1992) stated that '*for the determination of minimum flows for environmental reasons, those sections of rivers or points that are considered of interest (reservoir dams, significant diversions, significant discharges, and similar) shall be established, specifying the minimum flow that must be maintained under normal circumstances*.'

Selection of the action(s):

When the first hydrological plans were drafted in 1998, solid technical foundations for the establishment of e-flows had not yet been established, resulting in notable heterogeneity in the criteria and methodologies applied (Sánchez Navarro et al, 2007). Following the approval of the Water Framework Directive (WFD), detailed technical instructions were prepared during the drafting of the RBMPs for the 2009-2015 cycle, based on the conclusions of an ad-hoc working group composed of prominent national experts, which materialized in the IPH (2008). The IPH proposes:

- Technical determination of eflows regime based on a combination of hydrological and habitat simulation methods.
- Implementation and governance based on pursuing consensus with stakeholders, and adaptive monitoring.

Description of the action(s):

- With respect to the determination of minimum e-flows, the Spanish IPH methodology consists of the following sequential steps[5]:

  1. Water resources assessment by means of hydrological modelling as SIMPA (Álvarez et al, 2016; CEDEX, 2021).
  2. Building of daily series under a natural regime by using statistical distribution patterns from non-altered gauging stations.
  3. Application of hydrological methods for e-flows assessment, including QBM (Basic Maintenance Flow) and significant percentiles of the classified flow series.
  4. Selection of surface water bodies (SWB) for habitat modelling (10% of river-type SWB).
  5. Application of hydro-biological methodologies, including fieldwork for the characterization of selected river reaches, determination of fish indicative species, and habitat modelling with simulation software (PHABSIM, RHYHABSIM River2D).
  6. Testing of river continuity under the proposed flow regime.
  7. Assessment of hydrological alteration (tool IAHRIS[6]) and hydro-regionalization for extrapolation purposes, considering inter-annual variability, intra-annual variability, maximums, and minimums (period and recurrence).
  8. Analysis of the effect of e-flows in water allocation (supported by AQUATOOL DSS).

  The application of this methodology took shape in a series of specific works (DGA, 2010), the results of which were transferred to the 2009-2016 RBMPs and their regulatory documents.

  In addition, other components of eflows regime different from minimum flows were addressed, namely: the establishment of maximum flows, assuring that water velocity is compatible with the maintenance of suitable habitat for all fish live stages; programmed floods to restore river configuration and connection to floodplains; maximum rate of change (hydro-peaking conditioning); e-flows regime for prolonged drought situations. This set of components is designed to reproduce conditions that ensure an adequate level of provision of the various river-related ecosystem services.

  Since e-flows was a new element in Spanish quantitative water management, many **discussion and dissemination outreach actions** were carried out, most notably:

  - Guideline documents published during that period, such as Magdaleno (2005), Martínez et al. (2006), Alcácer et al. (2008), Magdaleno (2009), Magdaleno (2011), OPH Tajo (2011). In addition to the IPH itself, these publications facilitated the dissemination and understanding of the rationale of e-flows, the scientific foundations and the technical methodologies for assessment.
  - Working groups were set up -within the framework of the National Strategy for River Restoration[7] that was developed in parallel to the first RBM planning cycle- for exchanging ideas among the agents involved. Discussion focused on possible actions, measures, or commitments to support the good ecological status of rivers, as required by the WFD. Specifically, the round table «Alterations to the river flow regimes» addressed the situation of the hydrological regimes of Spanish rivers and the role of e-flows as a restoration instrument (García de Jalón et al., 2007).
  - Multiple workshops to address the implementation of the WFD and its interweaving with other policies, aimed at improving understanding and reinforcing cooperation among competent authorities. The technical presentation and discussion of the new environmental flow regimes played a prominent role in these meetings[8].

- The development of technical studies is only the first stage of e-flows regime implementation and must be followed by: 2) public consultation and agreement, including a negotiation process -at least in strategic SWBs- with the aim of making water use rights

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5 A descriptive summary of the methodology can be found in European Commission 2014.
6 https://ambiental.cedex.es/hidromorfologia-iahris.php
7 https://www.miteco.gob.es/es/agua/temas/delimitacion-y-restauracion-del-dominio-publico-hidraulico/estrategia-nacional-restauracion-rios/
8 See, for example Ferrer Polo 2007, Magdaleno 2011, and Sánchez et al. 2007.

compatible with the environmental flow regime; and 3) implementation and adaptive management.

In the following years, the process progressed at an uneven pace in the various RBDs. At present, minimum e-flows have been determined for all river-type water bodies, both for normal situations and prolonged drought, but the development and coordination of the other components (peak flows, flood pulses, hydropeaking) is not entirely complete.

Furthermore, monitoring the level of compliance with e-flows regimes is compulsory and the subject of an annual report in each RBD (RPH, art. 88). The IPH also establishes the need for adaptive monitoring to check that they are fulfilling their function adequately, i.e., maintaining the functionality and structure of the associated aquatic and terrestrial ecosystems, thus contributing to achieving good ecological status or potential in rivers and transitional waters.

Discussions and consultations have been held throughout the three planning cycles so far to disseminate the results of the studies and to promote understanding, consensus and ultimately ownership of users and policy makers. The development and results of these sessions are fed into the RBMPs. Among the many possible examples, the RBMP of the Douro 2nd cycle contains the following information:

- Annex 4 describes the progress made in defining the ecological flow regime, including the technical information to be provided at the consultation meetings9.
- Annex 9 gives a detailed account of these meetings (including minutes)10, which were attended by representatives of the agricultural and hydroelectric sectors, regional administrations, conservation groups and the RBA, as well as a mediation team.

Another example is the Ebro RBMP, where the extension of the minimum eflows regime to all river-type water bodies was the subject of a specific workshop during the third cycle[11]. For the fourth cycle, another workshop «Methodological approach to studies for the determination of maximum flows, generating flows and rates of change in the Ebro RBD» has recently been organised to address the remaining eflows components[12].

Both Douro[13] and Ebro[14] have made the scenario simulation models (AQUATOOL) available to the public, so that anyone can reproduce RBMPs management scenarios or modify them to assess impacts on demand and compliance with eflows, thus encouraging a more fruitful discussion with the various stakeholders.

- Other initiatives have supported the discussion and dissemination of e-flows outside the formal process used by the Water Administration. In this regard it is worth mentioning:
  - The symposiums, seminars and courses organised by the Botín Foundation's Water Observatory. For example:
- «9º National Seminar: Water and Nature» (2012)[15]
- «The implementation of ecological flows in Spain and its ability to mitigate hydrological alterations caused by dams» (2020)[16]
  - The study of environmental issues related to the water environment has gained a high social impact and political weight, to the point that water administrations actively promote research and the dissemination of its results. Two examples of scientific and technical projects to characterise ecosystem services are provided below, including hydrological, hydromorphological, water quality, cultural, socio-economic, and recreational aspects:

9 https://www.chduero.es/documents/20126/89007/PHD15-040_04_CauEco_Concertacion1-v03_00.pdf
10 https://www.chduero.es/documents/20126/89007/PHD15-100_05_ParPublica_MemoriaConcertacion-v03_00.pdf
11 https://youtu.be/tw9ZrK886lw https://www.chebro.es/documents/20121/261374/Informe+Taller+2+%28Caudales+ecologicos%29.pdf/6a739abf-0ee2-0011-0d80-4960abc1f809?t=1644855334749
12 https://www.chebro.es/documents/20121/1036547/Seminario+Inicial+QM%C3%81X.pdf/af728484-7800-6e01-7c0e-58bdd8c5cdb3?t=1684493365423
13 Annex 6 (Model graphs) https://www.chduero.es/web/guest/plan-hidrol%C3%B3gico-del-duero-vigente-
14 Annex 6 (Ebro models SIMGES) https://www.chebro.es/web/guest/plan-hidrologico-2022-2027
15 https://fundacionbotin.org/sala-de-prensa/9o-seminario-nacional-agua-y-naturaleza/
16 https://fundacionbotin.org/sala-de-prensa/coloquios-online-del-observatorio-del-agua/

- «Project Drainage» (2018-2021)[17] that, in addition to improving flood risk management, aims at ensuring the overall good status of all water bodies and contributing to the optimization of the provision of ecosystem services.
- «Project Q-Clima» (2017-2020)[18] aimed at determining the impact of climate change projections on available water resources and, more specifically, on the establishment of ecological flow regimes.

Dissemination programs comprise publications, conferences and workshops, news releases, social media…

Effort of the action(s):

The Directorate-General for Water, with the support of CEDEX and various scientific and academic experts, played a key role in the first phase of discussion and definition of eflows methodologies.

Since then, the work has been mainly the responsibility of the RBAs, who must maintain the monitoring systems, finalise the technical definition of the eflows regimes, organise and lead the consultation meetings and finally integrate the results into the RBMPs. This work is done by their own staff with the support of technical consultancy companies, either as part of wider technical services for the RBM planning process -including the update of water resources inventories and the simulation of water management scenarios, tasks that are also relevant for assessing compliance of eflows and levels of supply to users- or through specific contracts, e.g. for the mediation in the concertation sessions.

Result(s) achieved so far:

After this long process, e-flows are now widely known and their role in conditioning any policy that requires the use of water is basically accepted. The very nature of the concertation process has helped considerably in this achievement. This is not to say that their magnitude and impact on users are not the subjects of ongoing and open debate.

An illustration of all the above can be found in the round table: "Ecological Flows in Hydrological Planning" organized by the National Federation of Irrigation Communities of Spain (FENACORE)[19]. The event included technical high-level presentations that gave way to a round of debate with interventions by the attendees, among which were representatives of the Directorate General for Water and the irrigators themselves.

Difficulties faced and remaining constraints:

It is true that after three planning cycles, the concept of e-flows and its policy implications are well understood and have been widely discussed. However, there are some outstanding issues that hinder effective implementation.

On the one hand, there are some purely technical difficulties in the definition of e-flow regimes (uncertainty of data and criteria for establishing regimes), their monitoring (financial and practical limitations of having an extensive monitoring network to collect and analyse measured data) and implementation (structures for the release of flows, monitoring, and control of compliance by users).

On the other hand, there are some intrinsic difficulties that prevent easy acceptance and implementation. The numerical values that characterise the flow regimes are the result of combining a family of hydrological and habitat methods that provide a wide range of possible values. The IPH establishes criteria and reference thresholds that together provide a margin of discretion in the specification of these values. This is positive because it makes it easier to find common ground in the discussion, but it also opens up the regime to challenge by any actor.

In addition, flows are conceptually and legally linked to the good status of the water body, a link that is not easy to establish unequivocally. Finally, climate change introduces even more uncertainty about the regimes and whether they should be adapted to the new conditions.

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[17] http://drainage.cedex.es/

[18] https://fnca.eu/investigacion/proyectos-de-investigacion/q-clima#:~:text=El%20proyecto%20Q%2DClima%20tiene,de%20reg%C3%ADmenes%20de%20caudales%20ecol%C3%B3gicos.

[19] https://fenacore.org/news/jornada-tecnica/

Planned next step(s):

In addition to continuing the usual work of reviewing, completing and agreeing ecological flow regimes and assessing their impact under different climate change scenarios, two new initiatives are currently being undertaken by the DGA:

- «Technical service for monitoring the impact of the ecological flow regimes established by the RBMPs on the water bodies of the inter-community RBDs». The aim is to provide technical support to improve and update the knowledge base for adaptive monitoring of eflows, analysing the impact of these flows on the river environment and the aquatic and riparian ecosystems they support.
- «Technical assistance for the technical support work for the preparation of the Catalogue of Shared Aquifers and the update of the IPH». This includes the analysis of the ecological flow regimes established in the third cycle RBMPs and the assessment of their impact on water supplies, and the updating of the IPH, with particular attention to the revision of the technical criteria and methodologies for the determination of eflows.

Transferability:

The definition and technical dissemination of ecological flow regimes requires a holistic approach involving a variety of experts (geomorphology and river dynamics, aquatic biology and river ecology, hydrological planning, environmental legislation). The Spanish model is transferable, but logically needs to be adapted to the hydrological and management characteristics of each RBD. Effective transfer to stakeholders, users and policy makers requires their early involvement and a transparent deployment of the whole process.

9.1.4. Further information

- Websites:

AQUATOOL (https://aquatool.webs.upv.es/aqt/). Official website of the Decision Support Systems (DSS) development environment for planning and management of river basin or water resource systems.

Proyecto Q-Clima: Caudales ecológicos: valoración de experiencias en las cuencas españolas y propuestas adaptativas frente al cambio climático. Ecological flows: evaluation of experiences in Spanish river basins and proposals for adapting to climate change. https://fnca.eu/investigacion/proyectos-de-investigacion/q-clima#:~:text=El%20proyecto%20Q%2DClima%20tiene,de%20reg%C3%ADmenes%20de%20caudales%20ecol%C3%B3gicos.

Proyecto Drainage: Gestión Integral del Riesgo de Inundación. Integrated Flood Risk Management http://drainage.cedex.es/

- Scientific articles / books:

Alcácer, C., Ballester, A., De Stefano, L., Hernández, J., Lacalle, A., Magdaleno, F. & Schmidt, G. (2008). Recomendaciones para la concertación de regímenes ecológicos de caudales en el marco de la planificación hidrológica española. https://www.researchgate.net/publication/312319016_Recomendaciones_para_la_concertacion_de_regimenes_ecologicos_de_caudales_en_el_marco_de_la_planificacion_hidrologica_espanola

Álvarez-Rodríguez, J., Barranco Sanz, L.M., García Bravo, N., Potenciano de las Heras, Á., Villaverde Valero, J.J. (2016). Evaluación de los recursos hídricos en España. Spanish version. July 2016. M-129. Centro de Estudios Hidrográficos. CEDEX. Centro de Publicaciones. Secretaría General Técnica. Ministerio de Fomento. ISBN: 978-84-7790-578-3 https://ceh.cedex.es/tienda/?product=evaluacion-de-los-recursos-hidricos-en-espana-m-129

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Martínez, C. & Fernández Yuste, J.A: (2006). Índices de alteración hidrológica en ecosistemas fluviales. Editor: CEDEX. ISBN: 9788477904267.

- Main Regulations:

Law 29/1985, of 2 August 1985, on Water. Ley 29/1985, de 2 de agosto, de Aguas. https://www.boe.es/eli/es/l/1985/08/02/29

Order of September 24, 1992, approving the instructions and complementary technical recommendations for the preparation of the Hydrological Plans of intercommunity river basins. Orden de 24 de septiembre de 1992 por la que se aprueban las instrucciones y recomendaciones técnicas complementarias para la elaboración de los Planes Hidrológicos de cuencas intercomunitarias. https://www.boe.es/eli/es/o/1992/09/24/(4)

Royal Legislative Decree 1/2001 of 20 July 2001, approving the revised text of the Water Act. Real Decreto Legislativo 1/2001, de 20 de julio, por el que se aprueba el texto refundido de la Ley de Aguas [TRLA]. https://www.boe.es/eli/es/rdlg/2001/07/20/1/con

Royal Decree 907/2007, of 6 July 2007, approving the Hydrological Planning Regulation. Real Decreto 907/2007, de 6 de julio, por el que se aprueba el Reglamento de la Planificación Hidrológica [RPH]. https://www.boe.es/eli/es/rd/2007/07/06/907/con

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- Contact:

Directorate-General of Water, Secretary of State for the Environment, Ministry for the Ecological Transition and the Demographic Challenge

Contact email: bzn-sgph@miteco.es

9.2. FINLAND: DRAFTING CRITERIA AND GUIDANCE FOR APPLYING E-FLOWS IN RIVERS AFFECTED BY HYDROPOWER (E6)

9.2.1. General information

Member State(s)	Finland
RBD(s)	All Finnish river basins
Location	All Finnish provinces
Time period (start - end)	4/2023 - ongoing
Good practice example promoter	Finnish environment institute SYKE

9.2.2. Challenge(s) faced

Code of the challenge(s): E6: GEP flows are considered and implemented as mitigation measure to achieve GEP in HMWB where relevant (using a differentiated approach to ecological flows for natural water bodies)

Description of the challenge: Hydropower is playing a key role in regulatory power of Finnish grid. In Finland, hydropower comprises approximately 20-25 % of total electricity consumption, but 80 % of the power in flexible energy market. There are more than 220 hydropower plants in Finland (> 0.1 MW). Most of the large rivers and lakes are under flow and water level regulation due to hydropower production and flood defence. Additionally, there are many small rivers affected by small hydropower plants. Based on the latest reporting period of WFD, there are 1854 natural river water bodies, of which 264 are affected by hydropower or flood defence. 106 river water bodies are designated as heavily modified or artificial of which 87 is affected by hydropower or flood defence. Furthermore, there are 4581 lake waterbodies, of which 101 are affected by hydropower and 59 artificial or heavily modified lake waterbodies of which 44 are affect by hydropower. Migratory fish populations have strongly declined, and other riverine biota is altered by hydropower development although majority of hydropower permits include some compensation measures e.g. fish stocking and hydromorphological measures like protection of shorelines, but especially in old permits measures are not sufficient to mitigate biodiversity losses. Recently, an increasing number of new fish passes have been built to increase river connectivity and enhance salmonid fish stocks, thanks to State funding provided to support dam removal and implementation of fish passes. There are also several cases where fish passes have been or will be implemented through permit revision. However, environmental flow has been very rarely applied in river basin management. Due to flow diversion channels, there is completely dry old river channels that could be subjects to flow allocation and environmental flows.

9.2.3. Good practice(s) developed

Code of the good practice(s): E6: GEP flows are considered and implemented as mitigation measure to achieve GEP in HMWBs where relevant (using a differentiated approach to ecological flows for natural water bodies) `

Table 6 Synthetic overview of the actions taken (select the tick box in the first column of those types of actions that have been taken in your example and include a short paragraph of their characteristics)

	Type of actions	Characteristics
x	Regulatory	Drafting criteria and guidance for applying e-flows in rivers affected by hydropower.
	Technical	
	Economic	
	Research	
	Governance	
	Others	

Description of the good practice:

Reasons for initiating action(s): There is a growing need for applying environmental flows in regulated rivers, but there was no systematic approach to identify locations where environmental flows could yield the greatest ecological benefits. Prioritization tool and scoring system was completely missing and local river basin districts were unable to prioritize measures.

Selection of the action(s): Selection of environmental flow criteria and scoring is based on general ecological knowledge of most effective restoration measures and ecological importance of hydrological and morphological properties of river water bodies. Criteria and scoring have been proposed by SYKE researchers (Finnish Environment Institute) with support of ministries and hydropower companies. The relevant report will be published in 2023 for general public and consultation starts by local environmental authorities.

Partly different criteria were selected to locations where permanent eflow to dry river reaches was considered the main target of environmental flow and to locations where the main river water body is the main target of eflow. Following criteria were selected:

1. Area of potential juvenile salmonid habitats in the dry river reach (dry reaches)
2. Current minimum flow of dry river reach (dry reaches)
3. Number of threatened fish species (dry reaches, river water body)
4. Connectivity to feeding migration areas (dry reaches, river water body)
5. Water quality (dry reaches, river water body)
6. Riffle areas below hydropower plant (river water body)
7. Current regulations in hydropower permits related to minimum flow (river water body)

Description of the action(s):

Detailed questionnaires were sent to hydropower plant owners and technical information of their plants and environmental conditions was collected including also description of permits and hydromorphological conditions around the plant. Open data sources of Hertta-environmental information system and GIS data were used and merged to information related to migratory fishes.

All hydropower plants got specific scores with following criteria:

1. Area of potential juvenile salmonid habitats in the dry river reach

Smallest area in the data – lower quartile (25 %-point) = 1 points.,

Lower quartile – median (50 %-point) = 2 p.,

Median – Upper quartile (75 %-point) = 3 p.,

Upper quartile – Largest area in the data = 4 p.

2. Current minimum flow of dry river reach

- Minimum flow > 5 % of mean annual river flow (MQ) diverted to the reach = 0 points
- Minimum flow 3- 5 % of MQ = 1 p.,
- Minimum flow 1-3 % of MQ = 2 p,
- Minimum flow < 1 % of MQ = 3 p.,
- No flow to the river reach = 4 p.

3. Number of threatened fish species

The table below shows the endangered fish species that were considered in the fish species criteria. The current and historical occurrence of the species in a site were assessed based on existing data, historical information and expert judgement. The occurrence of each species was weighted according to its conservation status with fish species points (scale: 1-3) in order that the occurrence of most endangered species was weighted with the highest points. The sum of the fish points was calculated for each site and re-scaled in a following manner:

- 1-2 fish points = 1 p.
- 3-4 fish points = 2 p.
- 5-6 fish points = 3 p.
- >= 7 fish points = 4 p.

Species	Status	Points
Eel (Anguilla anguilla)	Critically endangered	3
Landlocked salmon (Salmo salar m. Sebago)	Critically endangered	3
Trout* (Salmo trutta)	Endangered	2
Migrating whitefish (Coregonus lavaretus)	Endangered	2
Atlantic salmon (Salmo salar)	Vulnerable	1
Grayling (Thymallus thymallus)	Vulnerable	1
Plankton whitefish (Coregonus lavaretus)	Vulnerable	1
Lamprey (Lampetra fluviatilis)	Vulnerable	1
Asp (Aspius aspius)	Vulnerable	1

4. Connectivity to feeding migration areas

Majority of migratory fish species in Finland, with the exception of eel, are anadromous or potamodromous that spawn in rivers and migrate either to sea or inland lakes to feed and grow. Thus, connectivity between spawning habitats and feeding areas is crucial for viable population establishment. Fish passes enhance connectivity but typically even with the best fish pass structures, there is substantial population lossess in fish upstream and dowstream migration at each dam, as some species are unable to use the fish pass or large fraction of the population may not be able to find the pass. Thus, the ecological benefits of eflows to migratory fish are likely to be largest in locations that are highly connected to the feeding areas. Connectivity scores for eflow implementation sites were given as:

- Directly connected = 4 p.
- Connected via fishway(s) = 2 p.
- No connection = 1 p.

6. Water quality

Poor water quality may compromise some of the ecological benefits of eflows, especially for salmonid fishes. Although poor water quality should be improved according to Water Framework Direcitive, eflow implementation should be prioritized to sites that currently have higher water quality. The water quality criteria is scored according to the national physico-chemical water quality classification system.

High water quality = 4 p.

Good = 3 p.

Moderate = 2 p.

Poor= 1 p.

Bad = 0 p.

7. Riffle areas below hydropower plant

Fast flowing river sections such as riffles and rapids are the key mesohabitats and hydromorphological units within the river channel that inhabit distinct biodiversity and are crucial spawning and feeding habitats for fishes, such as salmonids. Moreover, shallower riffle habitats are the most sensitive habitats to the effects of flow regulation, such as hydropeaking. Due their sensitivity and ecological significance, the prevalence of these habitats below hydropower installations should be assessed or measured when evaluating the benefits of eflows.

No. of riffles or rapids = 0 p.

1 – 2 = 1 p.

3 – 4 = 2 p.

5 – 6 = 3 p.

≥ 7 = 4 p.

8. Current regulations in hydropower permits related to minimum flow

Power plant abstracts small share of water = 1 p.

Minimum flow part of environmental permit = 2 p.

Minimum flow is not part of permit, zero flows do not exist (Flow persists without full cessation, even in the absence of permit regulations related to mininmum flow) = 3 p.

Minimum flow is not part of permit, zero flows exist = 4 p.

Finally, the sum of the scores of each criteria gives the final score for the sites. The higher the score is, the greater the expected ecological benefits from the implementation of eflow in that site.

Effort of the action(s):

Work was part of the project funded by the Finnish Energy association and Ministry of Forestry and Agriculture. Project budget was around 80 000 euros. Work was divided between survey done by consultancy company and research work by SYKE. Work was monitored by steering group consisting of representatives of funders, hydropower companies and Ministry of Environment.

Result(s) achieved so far:

Currently list of different powerplants with scoring values are given to local river basin districts managers for use to prioritize restoration actions and programme of measures. Principles are going to be published as report of Finnish environment institute.

Difficulties faced:

Very small hydropower plants owners were sometimes difficult to reach, and they were not able to answer in detail the relatively complicated questionary. Actual field measurements were missing and analysis was based on GIS-work with expert judgement

Remaining constraint(s):

Scoring did not include any analysis of the costs of e-flow. The study provides first-hand screening of sites and water bodies where environmental flow could provide the largest ecological benefits. However, there is still considerable uncertainty whether environmental benefits could be reached in a given site, for example due to technical infeasibility of measures. Consequently, local-scale modelling of implementation and impact assessment is needed to get more comprehensive analysis before decision making.

Planned next step(s):

The tool and scoring will be used in river basin planning and possible problems and constraints will appear in operational use.

Transferability:

It is fully transferable depending on data availability

9.2.4. *Further information*

- Contact:

Finnish Environment Institute (Syke) Marine and freshwater solutions. Paavo Havaksen tie 3 (Ympäristötietotalo 2nd floor) FI-90570 Oulu

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9.3. SWEDEN: NATIONAL PLAN FOR REASSESSMENT OF PERMITS FOR HYDROPOWER

9.3.1. General information

Member State(s)	Sweden
RBD(s)	National
Location	National
Time period (start - end)	June 2020-2040
Good practice example promoter	Swedish Agency for Marine and Water Management

9.3.2. Challenge(s) faced

Code of the challenge(s):

- Eflows (E11. No legal option to introduce e-flow requirements for old water rights; E13. Opposition because of reduced economic benefits from water use (e.g. hydropower generation or agricultural output)
- Water allocation mechanisms (A5 Allocations reflect past societal priorities and institutional trajectories) (see report on water allocation)

Many hydropower plants in Sweden are small-scale with very old permits. Many older permits for hydropower lack or have very limited environmental considerations, especially regarding water flows and fish passages. This is a particularly important challenge since small-scale hydropower can have significant environmental impact despite low electricity production.

9.3.3. Good practice(s) developed

Code of the good practice(s):

- E11, E13, A5 (see report on water allocation)

Table 7 Synthetic overview of the actions taken

	Type of actions	Characteristics
	Regulatory	Development of new regulation
	Technical	A national plan for gradually adapting permits for hydropower through reassessment to be environmentally aligned.
	Economic	A fund has been established with funding from major electricity companies. From this fund, hydropower projects that are in line to receive new permits can apply for financial support for permit costs and implementation of necessary measures.
	Research	Knowledge about how hydropower plants can be environmentally adapted, such as regarding ecological flows, is necessary.
	Governance	Swedish Agency for Marine and Water Management: Improved coordination of dataflows between different competent authorities. County administration boards and Swedish Environmental Court are handles the examination of each individual case
	Others	Everyone involved in the assessment process.

Description of the good practice:

The purpose of the national plan is to reassess the environmental conditions of permits for hydropower production with the aim of achieving the greatest possible benefit for the aquatic environment while maintaining a nationally efficient access to hydropower-generated electricity.

Hydropower is essential for achieving the goal of a fully renewable electricity system. However, hydropower plants have an impact on ecosystems and species. To reduce this impact, it is important to utilize the best available technology and implement the most effective environmental measures while minimizing the impact on the electricity system. In this context, it is crucial to consider cultural heritage.

Requirements will be imposed on regional collaboration process, i.e for ecological flow. That will serve an important function in preparing the basis for environmental assessment and facilitating collaboration among various operators, authorities, and other stakeholders.

Permits for a hydroelectric plant regulate the water flows to be used for power production and/or bypass. The water levels upstream and downstream are also regulated in the permits if necessary. They are the key mechanisms to regulate the timing and quantity of releases from hydropower dams. The regulated water flows should be adjusted so that it should be possible to achieve good ecological status.

Since many of the hydropower plants today are operated without sufficient environmental consideration, both the ecological and hydromorphological status of the watercourses are affected. The water passages are closed and no fauna can pass and the water flows can be regulated without regard to the environment or fair allocation. With the new permits, there is an opportunity to open up the passage of fauna and for regulation that is adapted to ecological flows. The new permits should take into account all aspects of ecological flows.

According to the plan, the work on reassessments of permits will commence in 2022 and is expected to continue for a period of 20 years. Each power plant is individually assessed, and the purpose of the new permits is to reduce environmental impact and increase environmental considerations in the operations. The new permits may include climate change and (current and potentially future) demand from other (priority) uses.

Reasons for initiating action(s):

Hydropower plants constitute a significant source of impact on Swedish rivers and lakes and need to be addressed to achieve good ecological status.

Selection of the action(s):

Each catchment area has its own schedule for when hydropower within that area will be assessed. The areas are prioritized based on factors such as environmentally valuable nature.

Description of the action(s):

Nationella planen (NAP) - Nationell plan för omprövning av vattenkraft - Arbete i vatten och energiproduktion - Havs- och vattenmyndigheten (havochvatten.se)

Effort of the action(s):

It is impossible to estimate the costs and efforts required for a national program spanning over 20 years with successive reassessments of over 2000 hydropower plants.

Result(s) achieved so far:

The majority of Sweden's power plants are included in the plan, and significant supervision and supporting materials are ready for the initially scheduled hydropower plants. Unfortunately, the Swedish government has chosen to pause the work in 2023 due to the current situation of energy shortages and significantly high electricity prices.

Difficulties faced:

Knowledge about how electricity production can be environmentally adapted based on local conditions is important. However, due to energy shortages in society, the work is currently paused.

Remaining constraint(s):

The work has just begun and will progress until 2040

Planned next step(s):

Resume the work on the plan

Transferability:

It is a very large and long-term task to establish a national plan for the reassessment of a significant portion of hydropower. Most countries in the EU also do not have as many hydropower plants as Sweden, and therefore may not have the same need for a national plan in a similar way.

9.3.4. Further information

Websites:

Nationell plan för moderna miljöverktyg (havochvatten.se)

Nationella planen (NAP) - Nationell plan för omprövning av vattenkraft - Arbete i vatten och energiproduktion - Havs- och vattenmyndigheten (havochvatten.se)

Contact:

Kontakta oss - Om oss, kontakt och karriär - Havs- och vattenmyndigheten (havochvatten.se)

9.4. LUXEMBOURG: CONTINUOUS MONITORING OF STREAM GAUGES AT TWO LARGE DAMS IN LUXEMBOURG

9.4.1. General information

Member State(s)	Luxembourg
RBD(s)	
Location	Two largest dams in Luxembourg (Vianden and Esch-sur-Sûre)
Time period (start - end)	ongoing
Good practice example promoter	Water Management Administration, Ministry of Environment, Climate and Sustainable Development

Code of the challenge(s): E20: Non-compliance of e-flows is not detected due to monitoring gaps

Code of the good practice(s): E20: E-flows are monitored in a continuous mode to detect non-compliance

Table 8 Synthetic overview of the actions taken (select the tick box in the first column of those types of actions that have been taken in your example and include a short paragraph of their characteristics)

	Type of actions	Characteristics
x	Regulatory	Limits to permitted abstraction amounts; minimum discharges set in conventions
x	Technical	Stream gauges to constantly monitor minimum discharges
	Economic	
	Research	
	Governance	Regular contact between water administration and dam operators for sharing of data and adjustments to minimum discharge
	Others	

9.4.2. Description of the good practice

Stream gauges have been set up above and below the two largest dams in Luxembourg (Vianden and Esch-sur-Sûre). The minimum discharges laid down in the conventions and permits can be constantly monitored and thus, controlled.

In the case of the Vianden dam, the actual convention defines the condition that inflow = outflow. For the Esch-Sauer dam, the minimum discharge was set at 1 m3/s in the actual convention from 2003 without a more precise basis and has most of the time been guaranteed since, although due to technical problems the minimum discharge has not always been exactly 1 m3/s. Furthermore, in years with severe droughts, the minimum discharge was also reduced in order to save drinking water. This decision was taken mutually with the Water Administration.

The Water Administration has regular contact with the dam operators, and especially in the case of floodings.

The National Water Management Agency operates the stream gauges above and below the dams and the concession holder receives the data automatically partly in addition to their own data transmission infrastructure.

Overall, in Luxembourg, there is no monitoring of e-flow in place yet, but eflows are controlled by limiting permitted abstraction amounts.

9.5. PORTUGAL: IMPLEMENTATION OF E-FLOWS IN OLD DAMS

9.5.1. General information

Member State(s)	Portugal
RBD(s)	PTRH1 - MINHO AND LIMA PTRH2 - CAVADO, AVE AND LEÇA PTRH3 - DOURO PTRH4A - VOUGA, MONDEGO AND LIS PTRH5A - TAGUS AND WEST RIVERS
Location	River basin districts (listed above)
Time period (start - end)	2008 (on going)
Good practice example promoter	Portuguese Environment Agency in articulation with water users

9.5.2. Challenge(s) faced

- E11: Lack of ecological flow regimes implementation in old dams that do not have their own release device

Among the several dams already built and in operation, there are different situations regarding the level and conditions of ecological flow regimes implementation: very low fixed value are implemented; in others, e-flow regime are implemented having the same value every month; and in other cases, no e-flows are ensured, because: i) they were built before this type of measure was identified, ii) there are delays in implementing the measure or iii) the measure is not applicable.

In order to operationalise the release of e-flow regime in the old dams where this measure should be applied, it is necessary to identify the existing situation and adapt the approach according to the identified constraints.

- Lack of a Methodological guide for the determination of ecological flow regimes in Portugal

The ecohydrological characteristics of the rivers of the Iberian Peninsula restrict the direct use of many of the existing methods for determining ecological flow regimes, which is why it is necessary to identify and adopt appropriate approaches to the conditions present in Portuguese water bodies. On the other hand, many Portuguese rivers are impacted by hydraulic infrastructures, making it necessary, in those that do not yet have them, to implement effective e-flow regime, including, if necessary, the installation of specific hydraulic devices to discharge these flows.

9.5.3. Good practice(s) developed

- E11: Implementing ecological flow regimes in old dams including the construction of specific device for discharge the e-flow regime
- Developed a methodological guide for the determination of ecological flow regimes in Portugal.

Table 9 Synthetic overview of the actions taken

	Type of actions	Characteristics
✓	Regulatory	Water Law (Law n.º 58/2005, 29 December) Legal Framework on the Use of Water Resources (Decree-Law n.º 226-A/2007, 31 May) National Water Plan (Decree-Law n.º 76/2016, 9 November) Regulatory documents of the River Basin Management Plans (RBMP) Inland Fisheries Law (Law n.º 7/2008, 15 February) Legal Framework for Inland Fisheries (Decree-Law n.º 112/2017, 6 of September) Obligations introduced in the water resources permits (concession contracts)
✓	Technical	High challenges due to technical and structural safety of dams by the need of implementing specific devices for releasing ecological flows at dams already built, involving technical solutions of some complexity.

	Type of actions	Characteristics
✓	Economic	It has been included in the contractual obligations that allow stakeholders to use water resources. The remaining period of the contract should make it possible to recover the necessary investment costs, in particular for the installation of a special device for releasing the e-flows.
✓	Research	The particular and structural characteristics of Portugal's river systems restrict the direct use of many methods for determining the ecological flow regime, which is why it is necessary to identify and adopt approaches suited to the conditions in this territory, as well as to validate the results obtained, which has led to various scientific studies.
✓	Governance	The establishment of e-flows regimes in the permits, the need to build a specific device and the monitoring the impact in the water body that receives the e-flows by monitoring the state are obligations of the waters users. The publication of a methodological guide that includes the recommended methods for establishing e-flows regimes in mainland Portugal allows to harmonise the implementation by stakeholders involved for defining, approving and implementing e-flows regimes. This document also helps to integrate the recommendations contained in the European Commission's Guidance Document Nº. 31 "*Ecological Flows in the Implementation of the Water Framework Directive*" into national technical documentation.
	Others	-

Description of the good practice:

Hydrological regimes are one of the main modelling agents of river systems, presenting natural patterns of variation that are characteristic of the regions and/or river basins they are associated with, usually referred to as natural flow regimes. These can be characterised in terms of magnitude, frequency, rate of change, seasonality and duration, and define and structure river ecosystems, their communities and processes. As a result, changes in the natural regime of a water body can lead to significant changes in these ecosystems.

Human needs for flood defence, water storage for human consumption, energy production and irrigation, among others, have led to the construction of numerous hydraulic infrastructures over the centuries, such as weirs and dams aimed at regulating the natural flow regime and ensuring human use of water resources. The intensification of resource use has meant that anthropogenic alteration of natural flow regimes is currently one of the main pressures on river ecosystems globally (Guide n.º 31, EC, 2015), which is why it is necessary to adopt policies and measures to mitigate the impacts.

In this context, continuous efforts have been made to ensure the implementation and maintenance of ecological flows downstream of dams, with the aim of helping to ensure the functionality of river systems.

In order to develop guidelines for the definition and implementation of e-flow regime in mainland Portugal, it is necessary to bear in mind the particular and structuring characteristics of these river systems, namely the fact that the rivers of the Iberian Peninsula, as well as other regions with a Mediterranean climate, are subject to great natural variations in flow. Some of these rivers are even ephemeral or temporary, since there are periods when their surface runoff is zero. These hydrological specificities, together with other conditioning factors, have led to the appearance of aquatic species that are highly adapted to and dependent on these flow regimes, many of which are endemic and very important in conservation terms. The aforementioned hydrological and ecological specificities condition the direct use of many e-flow regime determination methods (see e.g. Moyle et al., 2011), which is why it is necessary to identify and adopt approaches suited to the conditions in our territory, as well as to validate the results obtained.

Among the hydraulic infrastructures already built and in operation, there are different situations regarding the level and conditions of e-flow regime implementation. In some hydraulic infrastructures, e-flows of a fixed value, very low, is implemented; in others, e-flow regime is implemented with no monthly variation; and in other cases no e-flow regime is guaranteed due to: i) having been constructed prior to the identification of this type of measure, ii) there are delays in implementing the measure or iii) this measure is not applicable.

To operationalize the release of e-flow regime in the hydraulic infrastructures where this measure must be applied, it is necessary to identify the existing situation and adapt the approach depending on possible constraints.

The Portuguese model includes a total articulation with stakeholders in order to:

- Comply with the provisions of the Portuguese Water Law (transposes the WFD) and guarantee the launch of e-flows by hydraulic infrastructures;
- Adapt e-flows regimes to the requirements of the water body, if the e-flows previously defined are not sufficient;
- Change permits in line with environmental requirements, under the terms provided for in the Portuguese Water Law ;
- Provide dams built before 1990 with specific devices for launch e-flows, however, this cannot jeopardize the safety of the hydraulic infrastructure;
- Promote monitoring to verify the effectiveness and efficiency of e-flows to achieve the environmental objectives of the water body

All these activities are coordinated by the national water authority and carried out by concessionaires. In order to harmonize the methods used to define e-flows regime a methodological guide for Portuguese rivers was developed and approved.

Reasons for initiating action(s):

Hydraulic infrastructures without an established or implemented e-flows regime correspond, generally, to uses prior to 1990, or to more recent cases for which, although there is reference to ecological flows in the permit, the e-flow regime was never implemented or even determined. There is need for a technical solution to implement a specific device in dams already existing in order to discharge the e-flow regime.

In situations where the installation of a specific device proves to be technically unfeasible and/or the costs are disproportionate, it will be necessary to monitor the ecological quality of the affected water bodies through a monitoring program and, based on the results, consider the implementation of other mitigation measures, which may include, among others, the release of flows by other devices/structures (such as fish passages), exploration management and habitat recovery.

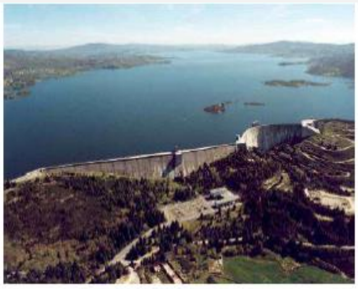
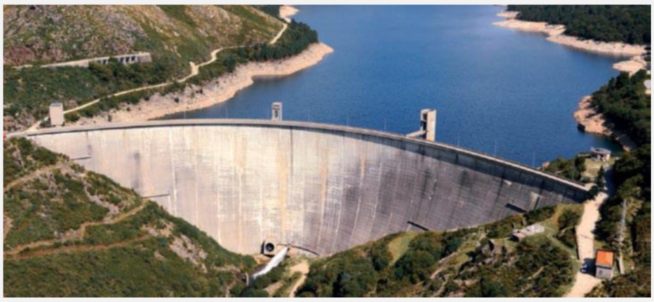
Selection of the action(s):

In order to minimize impacts on aquatic ecosystems downstream of hydraulic plants, efforts have been made to implement, for existing hydraulic plants, an e-flows regime, which requires the installation of ecological flow release devices, which is not always easy from a technical point of view, and the safety of the hydraulic infrastructure must always be safeguarded. In parallel with the release of the defined e-flow regime, monitoring programs are also developed to assess the effectiveness of the released e-flows, thus enabling the need to review the e-flow regime to be assessed if the good status is not reached in the sections downstream of the hydraulic infrastructures.

Description of the action(s):

The age and type of dams, the magnitude of the e-flows regime to be implemented and the availability or absence of auxiliary hydraulic structures, are limiting conditions for the technical and economic viability of solutions to adopt. Basic equipment, common to most solutions: metallic pipe, flow regulation valve, safety valve, flowmeter, oxygen sensor, temperature sensor, data-logger, automaton and data transmission system.

Dam / Basin	Type of actions for installing a specific device to discharge e-flow
1	**Devices with "simple" adaptation of existing pipes**
Alto Rabagão / Cávado (PTRH2)	Dam built in 1964 with 94 m height. Obligation to discharge e-flow imposed in 2008 (revision of the permit). Need for a technical solution for installing a specific device. Implemented in 2012. Two pipes derived from each of the bottom discharge shields, with regulation valve and flow disperser downstream, at the bottom discharge level (total 4x DN200)

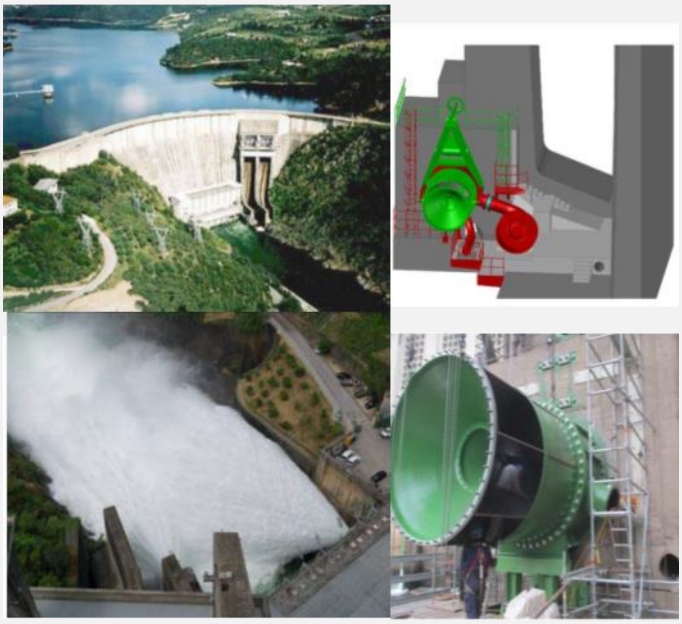
	Construction: lowering of the equipment by crane from the dam crown (94 m high). Implemented by the concessionaire: EDP, S.A. (energy producer)
  	
Vilarinho das Furnas / Cávado (PTRH2)	Dam built in 1972 with 94 m height. Obligation to discharge e-flow imposed in 2008 (revision of the permit). Need for a technical solution for installing a specific device. Implemented in 2014. The e-flow release device is located next to the bottom discharge, consisting of two pipes (DN350) with wedge-type isolation valves, ultrasonic type flowmeters and DN350 PN16 annular piston flow control valves. Lowering of the equipment by crane from the dam crown (94 m high) and the use of divers to cove circuits upstream was needed. Implemented by the concessionaire fulfilling one of the obligations of the concession contract: EDP, S.A. (hydropower producer).
 	
Paradela / Cávado (PTRH2	Dam built in 1956, with 110 m height. Obligation to discharge e-flow imposed in 2008 (revision of the permit). Need for a technical solution for installing a specific device. Implemented in 2016. Consisting of a 600 mm diameter steel conduit, welded to the bottom discharge conduit, and equipped with a wedge valve, a flow meter and a flow control valve, allowing the released water to be aerated by dispersing the jet. Lowering of equipment by crane, from the crowning (rockfill wall). Implemented by the concessionaire fulfilling one of the obligations of the concession contract: EDP, S.A. (hydropower producer).
  	
2	**Devices with complex adaptation of existing pipes**
Pracana / Tejo (PTRH5A)	Dam built in 1950, with 60 m height. Obligation to discharge e-flow imposed in 2008 (revision of the permit). Need for a technical solution for installing a specific device. Implemented in 2018. Consisting of two steel pipes with a diameter of 400 mm, each of which is equipped with an isolating valve, regulating valve and flow meter. Additional geological characterization. Localized reinforcement of old, riveted pipes. Implemented by the concessionaire fulfilling one of the obligations of the concession contract: EDP, S.A. (hydropower producer)

	
Venda Nova / Cávado (PTRH2)	Dam built in 1951, with 97 m height. Obligation to discharge e-flow imposed in 2008 (revision of the permit). Need for a technical solution for installing a specific device. Implemented in 2018. Steel pipe that derives from the bottom discharge, with a diameter of 600 mm, where the isolating valve is installed, followed by an enlargement to a diameter of 700 mm, where the regulation valve, of the ring piston type and the flowmeter, of the first-generation type. The total length of the hydraulic circuit is 5.5 m. Auxiliary structure for dismantling the bottom discharge valve and subsequent replacement. Concreting with pump at the crown (90 m height). New articulation system for the bottom discharge valve (extended). Difficulty replacing the bottom drain valve seal. Implemented by the concessionaire fulfilling one of the obligations of the concession contract: EDP, S.A. (hydropower producer)
  	
Castelo Bode / Tejo (PTRH5A)	Dam built in 1951 with 115m. Obligation to discharge e-flow imposed in 2008 (revision of the permit). Need for a technical solution for installing a specific device Implemented in 2019. It was installed in the downstream section of the bottom outlet on the left bank, supported on the existing concrete platform next to the outlet of the flood spillway, which will be widened and reinforced. This device will consist of

two steel pipes welded to the bottom discharge, one with a diameter of 700 mm and the other with a diameter of 400 mm, each equipped with an isolating valve, regulation valve and flow meter. This device work in conjunction with the bottom discharge of the left bank to complement the e-flow in the months with higher flow. Part of the time, the e-flow device works associated with small turbines (auxiliary system), that provides energy to the dam and also release ecological flow:

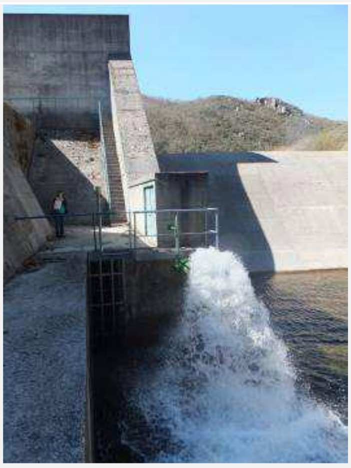
E-flow (m3/s)	Relase e-flows
<= 3	by small turbines
3 < >= 14,5	by small turbines + two pipes instaled at botom discharge at left bank, with aeration
> 14,5	by small turbines + two pipes instaled at botom discharge at left bank + bottom discharge at left bank, with aer

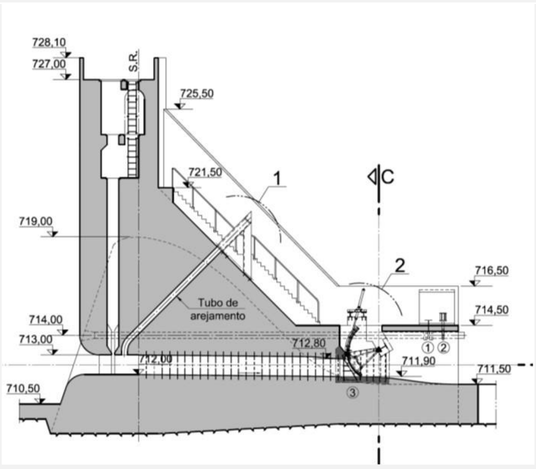
Implemented by the concessionaire fulfilling one of the obligations of the concession contract: EDP, S.A. (hydropower producer)



Aç. Trinta / Mondego (PTRH4A)

Dam built in 1994, with 11 m height, including a device for launch e-flows. Revision of the permit in 2008 define a more adequate e-flow regime that implies a construction of a complementary device, implemented in 2018. Consisting of a duct with a diameter of 300 mm and a length of approximately 28 m, equipped with two valves, one for service and one for safety, both manually operated. Installation of a new gate in the bottom discharge and extension of the ventilation duct of the existing gate. Demolition of the upper slab (coring, cutting with diamond wire and circular saw). Implemented by the concessionaire fulfilling one of the obligations of the concession contract: EDP, S.A. (hydropower producer).

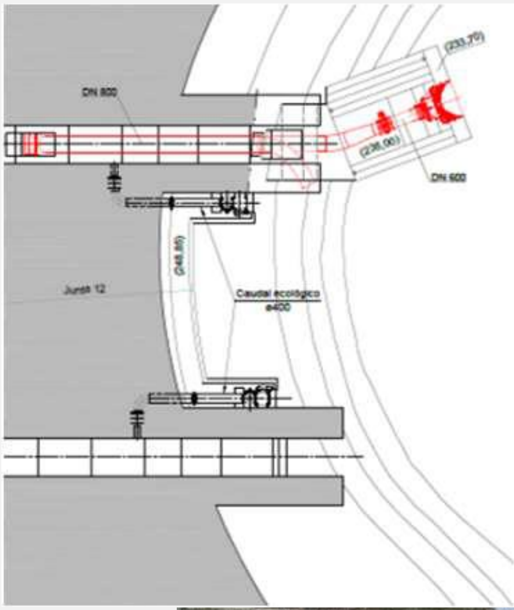


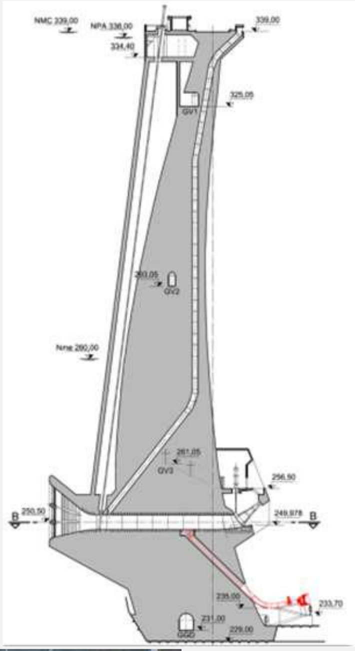


Alto Lindoso /

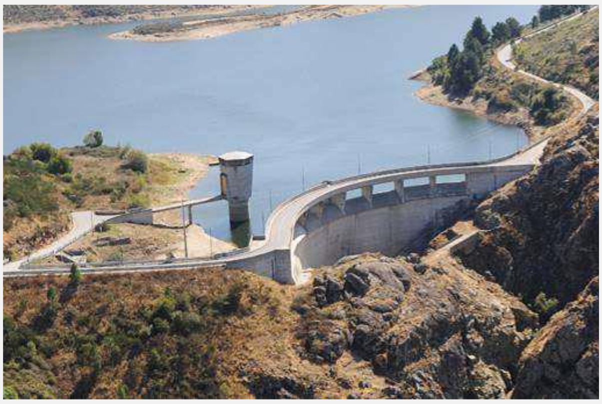
Dam built in 1992, with 110 m height including a device for launch e-flows: metallic pipe DN400 chipping in each bottom discharge (2), embedded in concrete. Revision of the permit in 2008 define a more adequate e-flow regime that implies a

Lima (PTRH1)	construction of a complementary device: reinforcement of the original device and corresponds to a new derivation of the left bank bottom discharge that would work in conjunction with the two original ecological flow circuits. The new circuit consists of a steel inlet nozzle, a section of duct measuring 800 mm in diameter, inserted into the body of the dam, approximately 15 m long and a section of duct outside the dam, with a curved profile. and development of approximately 5 m, which features a fork that will allow powering a mini-hydro plant and the final section of the device reinforcement. Implemented by the concessionaire fulfilling one of the obligations of the concession contract: EDP, S.A. (hydropower producer)





3	**Devices with new pipelines in the body of the dam**
Caldeirão / Mondego (PTRH4A)	Dam built in 1994, with 39 m height, including a device for launch e-flows. Revision of the permit in 2008 define a more adequate e-flow regime that implies a construction of a new device, implemented in 2018. Consisted of increasing the diameter of the siphon, from DN220 to DN300, and moving it to the right of the dam, no longer interfering with the flood spillway, and the dam being crossed through an opening hole in the concrete in the body of the dam. This made it possible to lower the highest point of the siphon, which had some constraints on the release of the e-flow. The DN100 auxiliary pipe was also moved to the right side of the dam, next to the new location of the siphon, which now serves the purpose of filling the siphon up to the reservoir level. Additionally, a vacuum pump was installed inside the dam gallery, connected by a stainless steel conduit to the highest point of the siphon, in the area of the dam's upstream face. Implemented by the concessionaire fulfilling one of the obligations of the concession contract: EDP, S.A. (hydropower producer).

 	
Touvedo / Lima (PTRH1)	Dam built in 1992, with 42.5 m height. Existing device. Revision of the permit in 2008 define a more adequate e-flow regime that implies a construction of a complementary device, implemented in 2019: new DN1000 pipeline in the dam body. Opening a hole in the dam body and sealing the pipeline. Cutting with diamond wire in the dam body, without lowering the reservoir level. Implemented by the concessionaire fulfilling one of the obligations of the concession contract: EDP, S.A. (hydropower producer).
  	
Salamonde/ Cávado (PTRH2)	Dam built in 1953, with 75 m height. Obligation to discharge e-flow imposed in 2008 (revision of the permit). Need for a technical solution for installing a specific device, implemented in 2012 and improved in 2016. The e-flow launching device consists of a metal pipe with a circular section DN900/800, inserted into the wall of the right wing of the complementary flood discharger inlet structure and equipped, from upstream to downstream, with a protection grid, cofferdam, valve isolation and flow regulation valve. The device ensures the natural aeration of the liquid vein, with the e-flow being returned to the complementary flood spillway in the ski jump and subsequently to the Cávado river, allowing additional aeration. Implemented by the concessionaire fulfilling one of the obligations of the concession contract: EDP, S.A. (hydropower producer)

Caniçada/ Cávado (PTRH2)	Dam built in 1955, with 76 m height. Obligation to discharge e-flow imposed in 2008 (revision of the permit). Need for a technical solution for installing a specific device. Implemented in 2018. Two pipes (DN1200 and DN800) in the block of the new flood spillway. Implemented by the concessionaire fulfilling one of the obligations of the concession contract: EDP, S.A. (hydropower producer).

Aç. Raiva / Mondego (PTRH4A)	Dam built in 1981, with 36 m height, including a device for launch e-flows. The existing device did not allow monthly modelling of the e-flow to be launched. Revision of the permit in 2008 define a more adequate e-flow regime that implies a complementary device, implemented in 2021. Complementary device: installed on the right bank consisting of two 1000 mm steel conduits in the upstream section of the dam's downstream wall and 1100 mm diameter in the downstream section, with a total length of approximately 30 m. These pipes cross the body of the dam through two holes and extend downstream, describing a guided fall supported by the constructed concrete mass. In the conduit located next to the flood spillway (furthest from the bank) a 300 mm diameter bypass was made to regulate the lower flow range. Implemented by the concessionaire fulfilling one of the obligations of the concession contract: EDP, S.A. (hydropower producer).

Effort of the action(s):

Considering the 13 old dams were the methodology was implemented the costs associated and supported by the concessionaire (EDP, S.A., hydropower producer) are:

Action	Costs (€)
Implementation specific device for 13 dams	8 190 650 €
E-flow Effectiveness Assessment Monitoring (2012-2021) (on going)	3 292 335 €

But the environmental benefits are higher than the costs as the results of the monitoring are now showing.

Result(s) achieved so far:

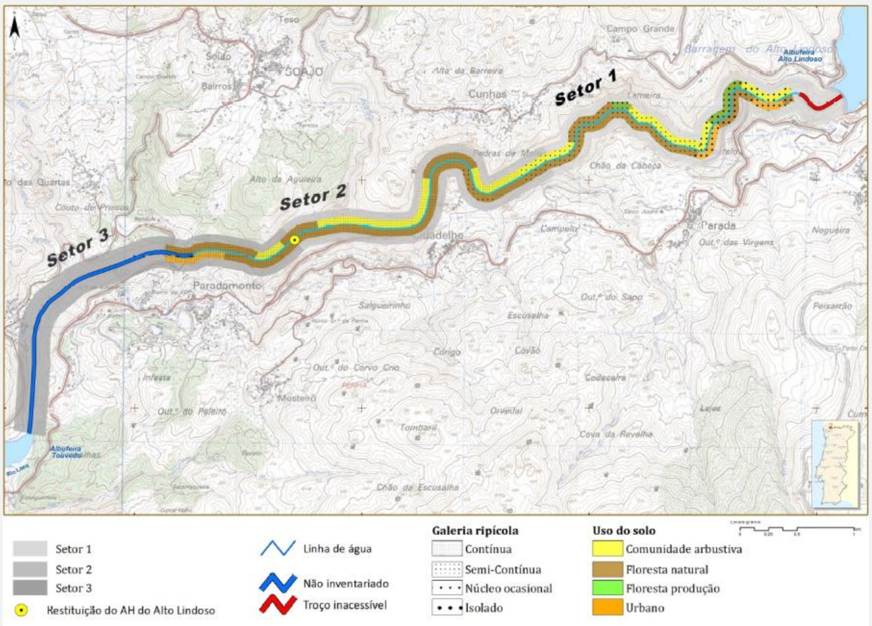
It is the results of monitoring in water bodies that receive ecological flows that make it possible to measure the results obtained. As an example, the results obtained for three situations where the flow regime was implemented are included. The e-flow effectiveness assessment monitoring is carrying out by the concessionaire (EDP, S.A., hydropower producer), to fulfil one of the obligations of the concession contract.

Alto Lindoso/ Lima (PTRH1)
E-flow Effectiveness Assessment Monitoring (2012-2019)

The water body is approximately 10.4 km long and develops between the Alto Lindoso dam and the Touvedo reservoir. In geomorphological terms, it is an area of rugged relief, with a valley surrounded by rocky slopes and steep slopes and a highly dense hydrographic network. In terms of hydrology, after the construction of the Alto Lindoso dam, the inflows of the Lima River to the section in which the dam is located began to be distributed essentially between flows boosted by the plant (which are released approximately 6.4 km after the location collection in the dam), flows discharged downstream of the dam (in a very punctual and abrupt manner) and "minimum" flows released through specific devices for discharging ecological flows.

River section of the Lima River immediately downstream of the Alto Lindoso dam

The monitoring work that has been carried out as part of the assessment of the effectiveness of the e-flows regime has allowed data to be collected in the water body along a longitudinal gradient. The sampling sites associated with the monitoring program were selected taking into account the biological, hydromorphological and physical-chemical characteristics at the local habitat scale, aiming to cover the existing hydrological diversity and, in this way, ensure the evaluation of the effectiveness of e-flows in different contexts. The water mass was divided into three sectors, which have been monitored annually since 2009.

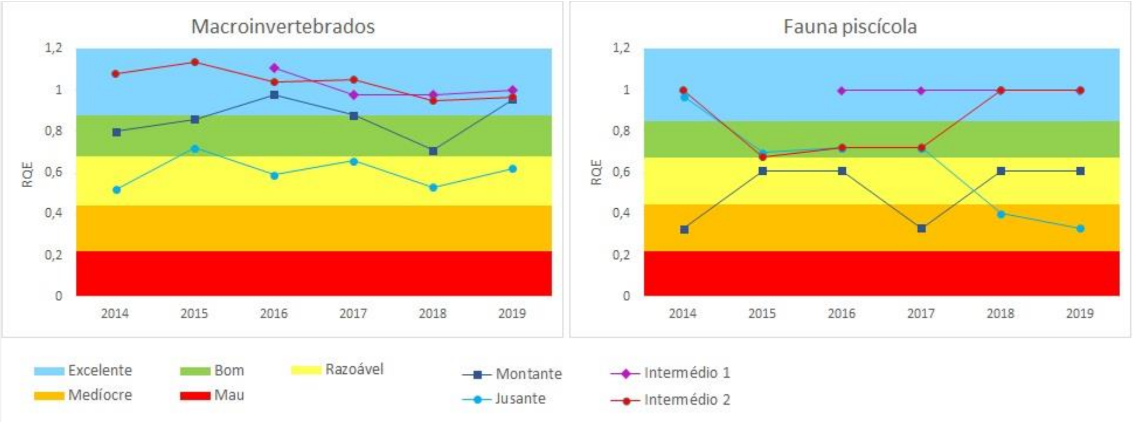


Land occupation and uses along the banks of the water body. (Source: EDP)

Regarding the distribution of aquatic habitats, the following can be seen:

- The pool-type meso-habitat is more predominant in Sector 1, which alternates mainly with small waterfalls, and there are also two continuous riffle sections. In general, the larger pools form plateaus, interspersed with small waterfalls;
- In Sector 2, riffle-type environments are dominant, with some pools also occurring;
- In the inventoried part of Sector 3, in a situation of ecological flow, that is, without the influence of turbines, riffles and pools are also observed, while in the remaining part of the sector the habitat has a lentic character due to the influence of the Touvedo reservoir.

The results (in the form of Ecological Quality Ratio, EQR) of the quality elements that were monitored annually show the patterns of change described, which tend to be lower in upstream and downstream locations, as shown in the image below.



In the period 2014-2019, the ecological quality of the water body was assessed based on the following ecological status results (to assess deviation):

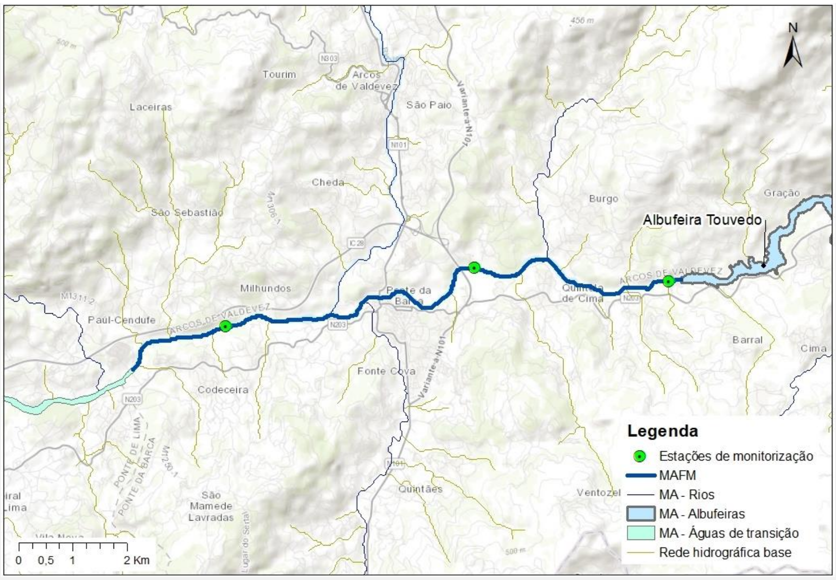
	Macrophytes	Bentic invertebrate	Fish	Physical- Chemical	Hidromorphological
2014-2019	Excellent	Good	Good	Good	Good

Touvedo / Lima (PTRH1)
E-flow Effectiveness Assessment Monitoring (2012-2019)

The water body is 12.34 km long and develops between the Touvedo dam and the water body PT01LIM0046 (Lima-WB4 - transitional water body). The river valley along its length is initially steep and with some slope, becoming progressively more open and with a smooth relief. It is located in an area with relevant ecological value, with emphasis on the overlap with a classified area that is part of the Natura 2000 Network (Special Conservation Zone (ZEC Rio Lima). The specific uses of this water body include the existence of a source of water for public supply, as well as the collection of water for irrigation, as well as recreational activities and fishing.

Section downstream of the Touvedo dam, with a fishing hole visible

The monitoring work that has been carried out within the scope of evaluating the effectiveness of the e-flow regime, and also within the scope of optimizing the functioning of the fish lift, allowed the collection of data on the water body along a longitudinal gradient. The water body was divided into three sectors, each including a monitoring point (upstream, intermediate and downstream).



The figure below shows the results (in the form of Ecological Quality Ratio, EQR) of the biological quality elements that were monitored most frequently within the scope of the monitoring program.

In the period 2014-2019, the ecological quality of the water body was assessed based on the following ecological status results (to assess deviation):

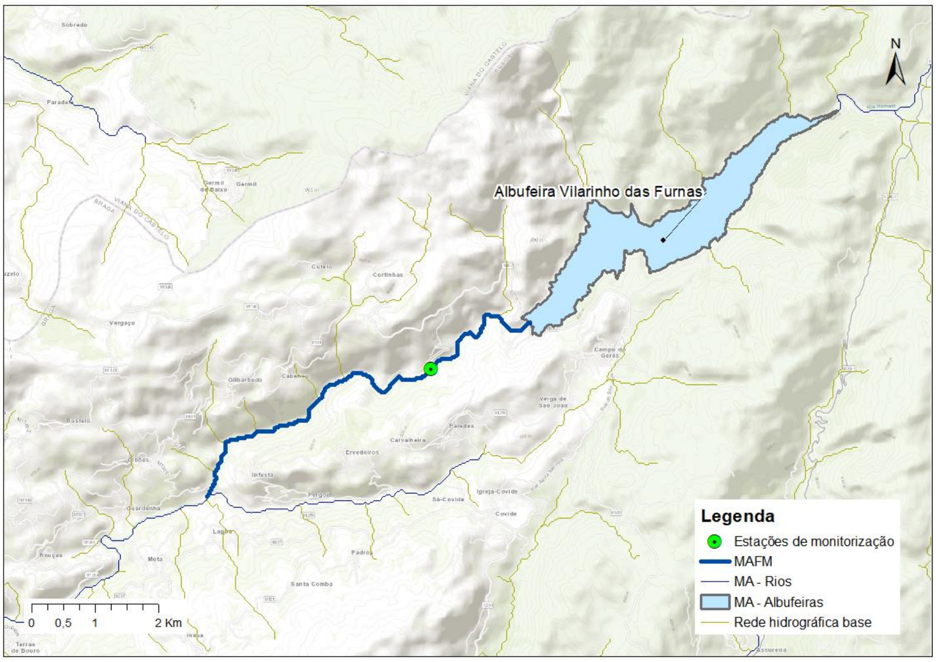
	Macrophytes	Bentic invertebrate	Fish	Physical- Chemical	Hidromorphological
2014-2019	Excellent	Good	Good	Good	Good

Vilarinho das Furnas / Cávado (PTRH2)
E-flow Effectiveness Assessment Monitoring (2012-2019)

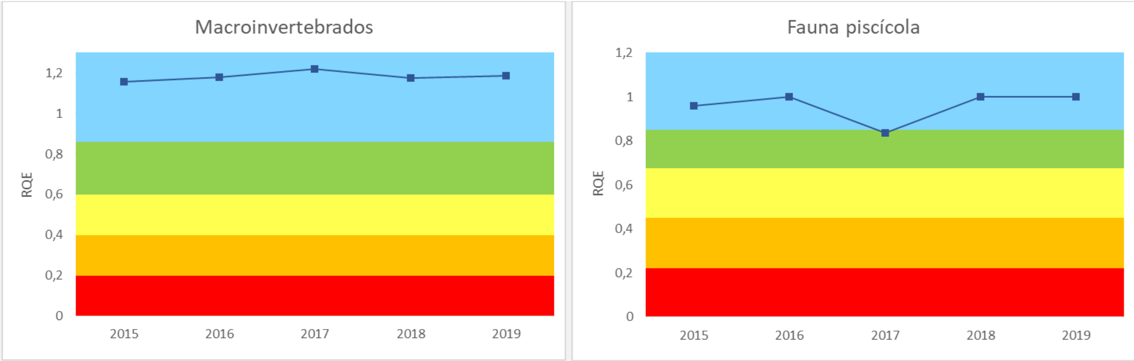
The Rio Homem water body (HMWB - Downstream B. Vilarinho Furnas) has a length of 7.62 km and corresponds to the first heavily modified section downstream of the Vilarinho das Furnas dam. The influence of the changes associated with this dam extend to the water body PT02CAV0089, which corresponds to an independent water body as a result of the different typology and confluence with a tributary of relevant size, the Roda stream (water body PT02CAV0071). This section of the Homem River is characterized by steep slopes, high sinuosity and a steep slope. The riverside gallery alternates with rocky outcrops and there is also an alternation of mesohabitats, with successions of riffles, pools and runs. The substrate is essentially made up of blocks, rock and intermediate-sized sediment. The presence of large blocks in the bed results in the existence of natural waterfalls, which can affect the movements of fish fauna.

River section of the Homem River downstream of the Vilarinho das Furnas dam.

The monitoring work that has been carried out within the scope of evaluating the effectiveness of the e-flows regime has allowed the collection of data along a longitudinal gradient that comprises the two water bodies downstream of the Vilarinho dam (PT02CAV0070 and PT02CAV0089). In this context, the water body under analysis in this form was considered homogeneous with regard to hydromorphological characteristics and a sampling station was allocated to it, as shown in the figure below.



The graphics below shows the results (in the form of Ecological Quality Ratio, EQR) of the biological quality elements that were monitored most frequently within the scope of the monitoring program.



In the period 2014-2019, the ecological quality of the water body was assessed based on the following ecological status results (to assess deviation):

	Macrophytes	Bentic invertebrate	Fish	Physical- Chemical	Hidromorphological
2014-2019	Excellent	Excellent	Excellent	Excellent	Good

Methodological Guide for e-flows definition

To determine the e-flows regime (RCE) associated with hydraulic infrastructures, a methodological guide was prepared, attached to the RBMP, which presents the recommended methods, to be used in mainland Portugal and in different scenarios, for the definition, approval and implementation of RCE.

In this guide, an analysis of existing methods was carried out, including underlying concepts and necessary information, in particular, the suitability of each method for Portuguese ecohydrological conditions was assessed. It includes:

- The most appropriate methods depending on the characteristics of national water lines, as well as the assessment to be carried out in the case of new or existing uses, without a specific device for launching the e-flow regime;
- The definition and implementation strategies are described depending on the project phase: hierarchical approach.
- The procedures to be adopted for establishing cleaning flows and e-flows for dry years are defined
- Coordination of the e-flows regime with fish passages, when existing;
- Establishes the basis for Monitoring Programs to evaluate the effectiveness of e-flows regime and guidelines for hydromorphological characterization.

The methodological guide, the basic structure and content of the monitoring programs necessary to assess the effectiveness of each e-flow regime, and the methodology for the hydromorphological characterization of the water bodies targeted by this measure also form part of the methodological guide.

This methodology has been applied to several hydraulic plants built before the 1990s and therefore without a specific device for launching them (https://apambiente.pt/agua/regimes-de-caudais-ecologicos)

Difficulties faced and remaining constraint(s):

The difficulties experienced over the years in determining e-flows regime for existing hydraulic infrastructures in mainland Portugal justified the evaluation of the results obtained so far, and the inventory and characterization of the main methods and methodologies existing worldwide, with systematization being considered necessary and dissemination of guidelines to be applied in different scenarios.

The hierarchical approach developed encompasses the following three sequential steps:

- application of the hydrological method developed within the National Water Plan 2002 (first level);

- application of the Wet Perimeter method and/or the IFIM methodology (Instream Flow Incremental Methodology) (second level); and
- application of a holistic method (third level).

The application of the first level must occur during the licensing of dam/weir projects in the Preliminary Study phase, while the higher levels can be applied in later phases of the project, following favourable environmental assessments. In cases of greater complexity, the application of the third level of the proposed approach will provide greater support for the decision on the e-flow regime to be implemented.

The application of the hierarchical approach is quite straightforward for new infrastructure projects, but in the case of existing infrastructures the situation is more complex, since the environmental conditions have already been changed and not all hydraulic infrastructures have a defined and/or released device for e-flows.

The absence of specific device or its inadequate design (e.g., abstraction level) are often the reason for non-compliance with the release of established e-flows. The existence and correct functioning of the device are fundamental conditions for ensuring the release of e-flows with values appropriate to each situation, variable throughout the year and subject to adjustment, if the results obtained in monitoring their effectiveness indicate inadequacy of the implemented e-flows regime. Under the terms established in the methodological guide, the sizing of specific release device, whether of new or old hydraulic infrastructures, must be carried out considering the e-flow values determined by the hydrological method developed within the scope of the National Water Plan 2002.

The release of ecological flows in existing hydraulic infrastructures in mainland Portugal has seen significant progress, but it is necessary to expand its operationalization, and currently the e-flows are mainly ensured in the most recent infrastructures, built after 1990, and in some older infrastructures where specific devices were installed to release these flows.

Planned next step(s):

It is important to extend these methodologies to other older dams, namely used for irrigation, to continue the implementation of e-flows.

Studies will continue to improve methodologies for defining e-flows to natural water bodies.

Provide a better communication with both stakeholders and citizens about the importance of maintaining e-flows.

Transferability:

A good practice is always useful and can be adapted to the hydrological and management characteristics of each RBD.

9.5.4. Further information

- Websites:
  - https://apambiente.pt/agua/regimes-de-caudais-ecologicos
- Scientific articles:
  - https://www.mare-centre.pt/pt/proj/642
  - https://paginas.fe.up.pt/~shrha/publicacoes/pdf/JHRHA_5as/16_ACatarina_Problem%C3%A1ticaESolu%C3%A7%C3%B5es.pdf
  - https://repositorio.ul.pt/bitstream/10451/48261/1/ulfc126349_tm_Ana_Rita_Ramos.pdf
  - https://www.repository.utl.pt/bitstream/10400.5/5373/1/Tese_Mestrado_GCRN_AECMETRFM_Jo%C3%A3o%20Martins_vFINAL_25112012.pdf
- Other publications/documents:
  - https://www.aprh.pt/Hidroenergia2019/docs/JTdH_Oliveira-EPD_Producao.pdf
  - Godinho, F.; Costa, S.; Pinheiro, P.; Reis, F. e A. Pinheiro (2014). Integrated procedure for environmental flow assessment in rivers. *Environmental Processes* 1(2):137–147.

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- INAG, I.P. (2008). *Tipologia de Rios em Portugal Continental no âmbito da implementação da Directiva Quadro da Água. I - Caracterização abiótica*. Ministério do Ambiente, do Ordenamento do Território e do Desenvolvimento Regional. Instituto da Água, I.P.
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- Alves, M.H. e Bernardo, J.M. (2003). *Caudais Ecológicos em Portugal. INAG*, Ministério das Cidades, Ordenamento do Território e Ambiente, Lisboa, Portugal.

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