COMMON IMPLEMENTATION STRATEGY
FOR THE WATER FRAMEWORK DIRECTIVE
(2000/60/EC)

Guidance Document No. 37
Steps for defining and assessing ecological potential for improving comparability of Heavily Modified Water Bodies

Document endorsed by EU Water Directors at their meeting in Helsinki on 26 November 2019

Foreword

This document is a deliverable of the CIS working group ECOSTAT. It was developed and drafted by a core-group of experts listed below, with the support of Eleftheria Kampa (Ecologic Institute) as consultant (Contract 07.0201/2018/779441/SER/ENV.C.l). It contains synthesis of the output of discussions that have taken place in the context of the working group ECOSTAT and of the Ad-hoc Task Group on Hydromorphology. It builds on the input and feedback from a wide range of experts and stakeholders that have been involved throughout the procedure of Guidance development through meetings, workshops, and written consultation, without binding them in any way to this content. It has been endorsed by the EU Water Directors at their meeting in Helsinki on 26 November 2019.

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EXECUTIVE SUMMARY

1. Review of designation and objectives needed in appropriate intervals (see section 1 and section 4)

- This CIS Guidance Document No. 37 proposes a common practical framework for defining Good Ecological Potential (GEP), as a main mechanism for assisting comparability of approaches between Member States. The focus is on updating and further refining approaches already being used (reference approach and mitigation measures approach), based on practical experience of their application by the Member States.
- The recommendations are based on a common understanding of the requirements of the WFD and good practice for implementation developed within the Common Implementation Strategy (CIS).
- The principles agreed under CIS Guidance No. 4 on the Identification and Designation of Heavily Modified and Artificial Water Bodies (HMWB and AWB) are still valid. Key aspects that should be considered in the designation of HMWBs are summarised in the present document to provide a clear context for defining Maximum and Good Ecological Potential (MEP and GEP).
- A proper review of all the designated HMWBs and their objectives is expected when preparing the River Basin Management Plan (RBMP) and Programme of Measures (PoM) for a new planning cycle. This review should be efficiently designed and performed to provide a proper HMWB designation according to the requirements of the WFD; it should also take into account monitoring outcomes, new modifications (e.g. new flood protection structures, hydropower plants, etc.), effects of implemented measures, emerging good practice on hydromorphological assessment methods and relevant mitigation measures as well as reconsidering the criteria for assessing significant adverse effects, where appropriate.
- GEP should be rechecked occasionally, as knowledge/expertise can increase and also economic aspects may change over time.

2. A more detailed step-wise framework for GEP (see section 5)

- A logical series of steps should be followed to determine GEP. In this document, a new flow-chart presents a step-wise framework for defining GEP and shows the two routes or approaches (reference approach and mitigation measures approach) to follow the framework. By following the steps included in the new flow chart (step-wise approach), a comparable outcome in ecological terms is expected.
- The steps included in the step-wise approach follow the requirements of the WFD. If, in following the routes through the framework, it is not possible to take all steps, relevant justification is therefore needed in the RBMP. Member States should make sure they can complete the remaining steps by improving data availability and knowledge on the links between hydromorphology and biology. In particular, improved monitoring data is crucial.
- To ensure comparability, a national, regional or basin-specific method for GEP definition has to be developed, although its application will be at water body level taking into account site-specific conditions.

3. Consideration of all relevant mitigation measures (see section 5)

- To identify **relevant mitigation measures** in a HMWB or series of heavily modified water bodies, the following issues are important:
  - the nature and extent of the physical modification(s) and their implications for the hydromorphological supporting elements,
  - if appropriate, physico-chemical supporting elements in the impacted water bodies need to be understood,
  - the consequent effects on the biological quality elements, and hence the measures that are needed to meet GEP.
- To define MEP, a wide range of potential mitigation measures should always be considered, and several measures are normally expected to mitigate modifications. To select best combinations of measures, the following needs to be evaluated:
  - i) the relevance of measures in terms of the hydromorphological alteration(s) and physicochemical characteristics of the water body as well as in terms of other water body characteristics relevant to the biota (e.g. whether modification is within the fish zone/outside the fish zone, fish community types etc.),
  - ii) the measures' ecological effectiveness and benefits in the specific context of the water body or water bodies (i.e. is measure appropriate for addressing the existing ecological impacts and can it deliver a proven ecological benefit),
  - iii) whether or not the measures will have a significant adverse effect on use or the wider environment,
  - iv) ensuring best approximation to ecological continuum, and
  - v) the requirements of Article 4(8) for the achievement of objectives in other water bodies within the same river basin district.
- The criteria for **judgements on the significance** of any effects of measures on use or the wider environment should be clear, transparent, justified and set in a consistent way at the national, regional or local level. Decisions on when such adverse effects are significant are important, because they may affect the level of ambition of ecological improvements and intensity of measures.
- When assessing mitigation measures regarding their potential for a significant effect on use, differing intensities of a measure or combinations also have to be considered, as a lower intensity of a measure (e.g. a reduced amount of additional flow, or a smaller area of habitat enhanced) might still deliver a substantive benefit without having a significant adverse effect on the use in question.
- For defining GEP, measures are then excluded that, even in combination, are predicted to deliver only a slight ecological improvement. GEP is ultimately defined as the biological values that are expected to be achieved after successfully implementing the selected mitigation measures.
- In general, when defining GEP, the first option should be to optimise the conditions for the original natural water body type (if appropriate). If this is not possible, the alternative should be to optimise the conditions for the existing closest comparable natural water body type, or combinations of water body types.
- Combinations and site-specific adaptations of measures are necessary in many cases within a set of measures to ensure the best possible ecological improvement and approximation of ecological continuum.

4. Best approximation of ecological continuum (see section 5)

- Best approximation to ecological continuum (WFD Annex V 1.2.5) is a key aspect of ecological potential. Ecological continuum refers to movements of energy, material, and organisms within the aquatic ecosystem. Achieving ecological continuum ensures that the habitats for type-specific aquatic species are interconnected in space and time so that the species can fulfil their life cycles in self-sustaining populations.
- Measures implemented in this regard should be relevant for the closest comparable water body type and related quality elements. For example, if the modifications to a river make it more closely resemble a lake, the set of measures shall take this into account.
- The best approximation to ecological continuum requires consideration of all hydromorphological measures that could mitigate any obstacles to migration (of biota, sediment and water) and improve the quality, quantity and range of habitats affected by the physical modifications. This can include connectivity to groundwater and/or to riparian, shore and intertidal zones, as well as a sustainable supply of an appropriate sediment type. WFD emphasises both migration of biota and sediment transport. Priority should therefore be given to appropriate and effective measures reducing any obstacles that significantly inhibit longitudinal (both upstream and downstream) and lateral migration of aquatic biota and ensure appropriate sediment conditions. For achieving ecological continuum, it should also be considered whether there is an ecological benefit or a need to restore continuity in order to support upstream and downstream water bodies in achieving their environmental objectives (especially for migratory fish).
- "Best approximation" is interpreted as being as close as possible to undisturbed ecological continuum. MEP requires that best approximation to ecological continuum is ensured. A water body can only be at GEP if a condition close to best approximation is achieved. This is a prerequisite for the functioning of the ecosystem.

5. European mitigation measures library (see section 5)

- A consistent understanding of when the available measures are relevant is crucial, by linking drivers, pressures, impacts and ecological effects. To support this, a European 'library' of emerging good practice mitigation measures for HMWB has been set up for this CIS Guidance No. 37 (https://ec.europa.eu/environment/water/water-framework/facts_figures/guidance_docs_en.htm).
- This European library represents the emerging good practice especially for rivers and transitional and coastal (TraC) waters, while the library content on measures for lakes will need to be improved and updated based on further discussions in the future.
- The library describes the typical implications of different types of physical modification and suggests potentially relevant mitigation measures to address typical effects in each water category (rivers, lakes/reservoirs, transitional/coastal waters). The library includes key groups of mitigation measures, which are expected to be considered for ecological improvements in order to address certain modifications. Due to the Europe-wide nature of this library, it was not possible to produce fully comprehensive lists and some of the physical modifications or measures which are considered in the Member States may not be included. The library of mitigation measures is a living document and updates will be provided in regular intervals.
- When there is a lack of suitable biological assessment methods and/or data sensitive to modifications, the approach to the selection of mitigation measures should be more

precautionary and more measures may need to be considered until there is sufficient evidence to exclude measures from MEP and GEP.
- The assessment of hydromorphological conditions after having implemented all mitigation measures defined for GEP can be used as an intermediate tool until monitoring results of hydromorphology-sensitive biological assessment methods are available. Increased efforts are needed in many countries to establish appropriate biological monitoring and develop and apply hydromorphology-sensitive biological assessment methods.

6. Definition of GEP in quality elements terms and slight change (see section 5)

- Good ecological potential is defined in the WFD as an ecological state in which "there are slight changes in the values of the relevant biological quality elements as compared to the values found at maximum ecological potential" (WFD Annex V 1.2.5). With respect to "slight changes from MEP", HMWB should follow the same principles as natural water bodies, with a functioning ecosystem being a prerequisite for a water body to be at GEP.
- According to WFD Annex V 1.2.5, the values for the biological quality elements at MEP should reflect, "as far as possible, those associated with the closest comparable surface water body type, given the physical conditions which result from the artificial or heavily modified characteristics of the water body". Slight change cannot be equivalent to a complete/temporary absence or severe change of the biological quality elements relevant for the closest comparable water category and type (e.g. of fish for rivers within the fish zone).
- Slight changes to the biological quality elements have to be supported by corresponding conditions in the supporting quality elements (e.g. flow, habitats, continuity). With regard to ecological continuum, "slight change" means that a condition close to best approximation to ecological continuum should be ensured (instead of best approximation).
- Physico-chemical quality elements should also be defined in the GEP definition process. For physico-chemical parameters, the closest comparable water body type is in general the original natural water body type (before physical modification). For those physico-chemical parameters that are significantly modified by the hydromorphological alterations causing the heavily modified character, and that cannot be mitigated, other types should be considered (the closest comparable natural water body type, or combinations of water body types).

7. Implementation of measures to achieve GEP (see section 6)

- A clear distinction between the selection of measures needed to define and achieve GEP and the implementation of measures (objective setting in the RBMP) is crucial for more transparency and common understanding.
- To assess the effects of any mitigation measures already in place and the need for further mitigation measures, the ecological condition of the HMWB should be monitored. The main decisive elements are (apart from specific pollutants) the biological quality elements that determine the class of ecological potential. These are supported by hydromorphological and physico-chemical quality elements. If a proper assessment based on biological quality elements is not yet possible (e.g. due to a lack of hydromorphology-sensitive methods), monitoring of hydromorphological (and physico-chemical) quality elements can be used as proxy to estimate the effectiveness of the mitigation measures already in place and thereby the ecological potential class. If the classification of the ecological potential is not based on hydromorphology-

sensitive biological assessment methods, the classification result should include the information that the confidence level is low.

- If one or more of the selected GEP measures cannot be implemented due to disproportionate costs or infeasibility, it has to be checked whether the remaining measures are still sufficient to achieve the biological conditions at GEP. If this is not the case, a review and possibly re-design of the measures will be needed to avoid the need to use exemptions: for example, selecting another combination/intensity of measures may deliver the desired ecological improvement.
- If it is not possible to implement all the measures needed to achieve GEP, it will not be possible to reach GEP conditions and the water body will have to be classified as being at moderate potential or lower and would therefore need an exemption. Nevertheless, all the remaining measures would still have to be applied to improve/avoid deterioration of the conditions of the water body as far as possible.
- If monitoring shows that expected GEP conditions are not achieved after the implementation of all measures, it should be checked whether the reasons for not achieving GEP are linked to delayed biological responses to restoration, overestimation of the biological response or to other significant impacts (e.g. multiple pressures) and the measures may need to be refined accordingly, if appropriate. This requires that well-defined goals are set up as well as suitable methods for monitoring.
- Implementation of measures to achieve GEP should be seen as an iterative process.

8. Intercomparison of ecological potential (see section 7)

- As for natural water bodies, the requirement for intercalibration of HMWB (WFD Annex V 1.4.1) implies that there is a need to ensure GEP classification methods are set in compliance with the WFD, and that classification results are comparable between EU Member States.
- The step-wise approach and the mitigation measures library set out in this document should ensure a better common understanding and support the intercomparison of ecological potential.
- Comparability of classification results can be evaluated by analysing how Member States have addressed key steps of the procedure, especially:
    - Identification and assessment of hydromorphological impacts and alterations causing the failure to meet good status (from the designation phase) , distinguishing those related to the use
    - Identification and consideration of the full range of potentially relevant mitigation measures, then excluding measures with a significant adverse effect on use or the wider environment, in a transparent and consistent way
    - Definition of ‘slight’ changes for biological conditions and removal of measures only leading to “slight” changes as well as consideration of approximation to ecological continuum.

Abbreviations:

ATG	Ad-hoc Task Group
AWB	Artificial water body
BQE	Biological quality element
CIRCABC	Communication and Information Resource Centre for Administrations, Businesses and Citizens
CIS	Common Implementation Strategy
DPSIR	Driving forces, Pressures, State, Impacts, Responses
ECOSTAT	WFD CIS working group dedicated to the ecological status of surface water bodies
EQR	Ecological Quality Ratio
GEP	Good ecological potential
GES	Good ecological status
HMWB	Heavily modified water body
HPP	Hydropower plant
Hymo	Hydromorphology/Hydromorphological
MEP	Maximum ecological potential
MS	Member States
NWB	Natural water body
RBD	River Basin District
RBMP	River basin management plan
TraC	Transitional and coastal waters
PoM	Programme of Measures
QE	Quality element
SQE	Supporting quality element
WFD	Water Framework Directive
WISE	Water Information System for Europe
WG	Working Group

1 INTRODUCTION

Key messages for this section:

- The water directors have recognised the need for complementary guidance to CIS Guidance Document No. 4 and for further clarification of the procedure for defining GEP of HMWB. This is needed to ensure more comparability and consistent implementation of WFD principles relevant to hydromorphology, HMWB and class boundaries for good ecological potential.
- This CIS Guidance Document No.37 proposes a common practical framework for defining GEP, as a main mechanism for assisting comparability of approaches between Member States. The focus is on updating and further refining approaches already being used (reference approach and mitigation measures approach) based on practical experience of their application by the Member States.

1.1 A new Guidance Document No.37 on the ecological potential of heavily modified water bodies: What for?

This document aims at guiding experts and stakeholders in the implementation of Directive 2000/60/EC establishing a framework for Community action in the field of water policy, commonly referred to as the Water Framework Directive (WFD). The document focuses on the definition of good ecological potential (GEP) which is the environmental objective of heavily modified water bodies (HMWB). Member States can designate HMWB when the physical structure of water bodies has been heavily modified to serve various uses, e.g. navigation, flood protection, hydropower, and agriculture. In many cases, as acknowledged by the Directive, it is not viable nor desirable from a socio-economic perspective to abandon such uses and to remove the physical modifications which affect the water bodies, but still possibly further mitigate ecological effect thereof by measures.

The document further elaborates on the issues already outlined in CIS Guidance Document No.4 on the designation of HMWB and artificial water bodies (AWB) and on GEP setting, which was published in 2003. This new Guidance Document No.37, developed under the auspices of the WFD Common Implementation Strategy (CIS) process since 2016, is based on a more mature common understanding and emerging good practice on the designation of HMWB and GEP setting. This has further evolved since the publication of CIS Guidance No. 4 in 2003, as outlined in several CIS workshops and technical reports (see list of relevant CIS activities in section 1.2).

The definition of ecological potential has been a subject of long discussions between Member States and the Commission in the context of the CIS. Defining ecological potential is a challenging and complex subject in WFD implementation, and this new Guidance Document No.37 aims to provide complementary guidance and further clarification by taking into account the experience of Member States in designating HMWB and defining GEP during the 1st and 2nd river basin management planning cycles.

This additional guidance is intended to address:

- The need to provide clarifications to previously issued CIS guidance, namely CIS Guidance Document No.4.

- The need to review the designation of HMWB in every WFD planning cycle (for further information on this issue, please refer to section 4.2).
- The need to improve methods for GEP definition and to have a transparent and clear process for this aspect of the WFD.
- The need to take into account Member State experience gained so far on HMWB designation, definition of GEP and the use of hydromorphological assessment methods, which has been documented in numerous CIS technical documents and workshop agreements since 2003.
- The need to achieve intercomparison of HMWB, which is being supported by the principles put forward in this CIS Guidance Document No. 37. For further information on the intercomparison of HMWB, please refer to section 7 of this document.

This Guidance Document No.37 proposes a common practical framework for defining GEP, as a main mechanism for assisting comparability of approaches between Member States. The guidance focusses on updating and refining the existing CIS methods based on practical experience of their application by the Member States.

A comparable assessment of natural water bodies and HMWB is fundamental as a technical and legal basis for consistent, efficient and transparent river basin management. Both natural water bodies and HMWB have ambitious environmental objectives. Good ecological status in natural water bodies is based on deviation from reference conditions. HMWB are a specific water body category[1] with their own classification scheme and objective, GEP. GEP is based on deviation from maximum ecological potential (MEP) and requires the identification and consideration of measures to mitigate the effects of the physical modifications associated with the use so as to improve the overall environmental condition of the water bodies to ensure the best approximation of ecological continuum. GEP also takes account of judgements on the adverse effects of mitigation measures on use and site-specific characteristics of the local conditions, as described in this document. Therefore, the application of a common framework for defining GEP does not mean that all water bodies classified as at GEP will have an equivalent quality of aquatic ecosystem structure and function.

This CIS Guidance Document No. 37 sets out a transparent process for defining GEP in which the roles of technical and policy considerations are made clear, and which results in comparable levels of ambition for these water bodies. It is also important to keep in mind that HMWB are not a type of exemption. Exemptions from GEP under WFD Articles 4.4, 4.5, 4.6 and 4.7 may apply to HMWB in the same way as they apply to natural water bodies.

The recommendations in this CIS Guidance Document No.37 are based on the common understanding of the requirements of the WFD and good practice for implementation developed within the CIS. Member States are not legally required to follow the recommendations contained in this guidance. Member States are, however, required to use methods and approaches compliant with the requirements of the WFD.

The guidance is specifically addressed towards:

[1] Please refer to CIS Guidance Document No.36 which states that "Artificial and HMWBs are considered as a specific water body category with its own classification scheme and objectives" as well as CIS Guidance Document No.2 on the identification of water bodies with mention of four categories river, lake, transitional and coastal water. A HMWB can be one of these four water categories. It should be taken into account that when delineating water bodies, a water body is not allowed to consist of different categories and a HMWB cannot be mixed with natural categories.

- Water managers and river basin authorities developing river basin management plans.
- Authorities responsible for taking decisions on the review or the issuing of permits for activities or projects that might impact the hydromorphology of a water body/water bodies.
- Interested stakeholders and representatives from civil society organisations.

The main contents of this Guidance Document No. 37 are as follows:

- Section 2 discusses fundamental principles on the role of hydromorphology in WFD implementation.
- Section 3 explains the scope of the wider environment and human development activities which is one of the terms for designating water bodies as heavily modified.
- Section 4 reflects on key aspects of CIS Guidance Document No.4 for the process of designating HMWB and discusses key principles and issues to consider when reviewing the designation of HMWB in upcoming cycles.
- Section 5 proposes a step-by-step approach for defining MEP and GEP, building on previous approaches and methods discussed within the CIS process. It also introduces and describes how to use the European library of mitigation measures, which is included in a separate document supporting this guidance[2].
- Section 6 addresses the process for the implementation of measures to achieve good ecological potential for HMWB.
- Section 7 provides information on the intercomparison of HMWB.

The Annexes to this document include the following:

- Annex I: Illustrative case studies on the steps for defining ecological potential.
- Annex II: Example of Ditches as Artificial Water Bodies (on the use of mitigation measures to improve the ecological situation).
- Annex III: Glossary of key terms used in this CIS Guidance No.37.

Disclaimer on Good Ecological Potential for Artificial Water Bodies:

Good ecological potential is also the Directive's default objective for artificial water bodies (AWB). However, with the notable exception of the Netherlands, AWB tend to be far less numerous than heavily modified water bodies. The present document concentrates on the definition of GEP for HMWB. Generally, the procedure for setting GEP is comparable between AWB and HMWB, including the consideration of mitigation measures and adverse effects on use. Because AWB are developed with a specific function in mind, the criteria for adverse effects on use as a consequence of proposed mitigation measures are in many cases easily met.

However, there are also some clear differences between HMWB and AWB. AWB are created at a place where no water existed before, while HMWB are related to a formerly natural water body. Restoration measures required to achieve GES cannot be considered for AWB, because the concept of reference conditions does not apply. An AWB is created by human activity and this creation has (or has had) a clear purpose to serve a specified use, and this use usually is related to the ones referred in Article 4(3). An example is provided in Annex II on the use of mitigation measures to improve the ecological situation of ditches, which are designated as AWB in the Netherlands.

[2] Available at: https://ec.europa.eu/environment/water/water-framework/facts_figures/guidance_docs_en.htm

1.2 Overview of CIS activities relevant to HMWB and GEP

The implementation of the WFD raises a number of shared technical challenges for the Member States, the Commission, the Candidate and European Economic Area (EEA) Countries as well as stakeholders and Non Governmental Organisations (NGOs). In addition, many of the European river basins are international, crossing administrative and territorial borders and therefore a common understanding and approach is crucial to the successful and effective implementation of the Directive.

In order to address the challenges in a co-operative and coordinated way, the Member States, Norway and the Commission agreed on a Common Implementation Strategy (CIS). Since 2001, the activities delivered under the CIS have aimed towards a coherent and harmonious implementation of the WFD. The focus is on methodological questions related to a common understanding of the technical and scientific implications.

In this context a series of working groups and joint activities have been undertaken since 2001. One of the first working groups established within the CIS focussed on issues related to the provisional identification and designation of HMWB and AWB, including the definition of good ecological potential.

Since the development of the resulting CIS Guidance Document No. 4 "Identification and Designation of Heavily Modified and Artificial Water Bodies", a number of CIS workshops have led to key conclusions and recommendations for good practice related to hydromorphology issues, HMWB and ecological potential (workshop results available at CIRCABC).

In 2015, the Water Directors identified work on best practice and guidance on dealing with hydromorphology as one of three priority issues to be addressed through an ad- hoc task group (ATG) on hydromorphology. This ATG aims to ensure coordination of strategic hydromorphology issues aimed at a common understanding and harmonising environmental requirements in hydromorphologically-impacted water bodies.

Table 1 provides an overview on the main CIS activities and key CIS supportive documents relevant for HMWB and GEP since the adoption of the Directive. More detailed information can be obtained from the related documents.

Table 1: Overview CIS activities and key documents relevant to ensure common implementation of HMWB, hydromorphology and GEP according to WFD

When	Who	Output
2003	Water Directors	Guidance Document No. 4 "Identification and Designation of Heavily Modified and Artificial Water Bodies"
2005	CIS process	Summary report of workshop on WFD and hydromorphology. As a result, an alternative approach to defining good ecological potential based on mitigation measures was put forward (known also as the "Prague" approach)
2006	CIS process	Technical report on WFD and hydromorphological pressures
2007	Water Directors	Policy paper on WFD and hydromorphological pressures
2007	CIS process	Summary report of workshop on WFD and hydropower
2009	CIS process	Summary report of workshop on Heavily Modified Water Bodies
2011	Water Directors	Recommendations on assessing and improving comparability of Good Ecological Potential (GEP)
2011	CIS process	Issues Paper and Summary report of workshop on water management, WFD and hydropower

When	Who	Output
2014	CIS process	Proposal to establish a CIS Ad-hoc Task Group (ATG) on hydromorphology
2015	Water Directors	Guidance Document No. 31 "Ecological flows in the implementation of the Water Framework Directive"
2015	CIS process	Summary report of workshop hydromorphology and WFD classification
2016	Water Directors	WFD reporting guidance 2016
2016	CIS process	JRC report on common understanding of using mitigation measures for reaching Good Ecological Potential for HMWB – Part 1: Impacted by water storage
2017	CIS process	Summary report of workshop on GEP inter-comparison case studies on water storage
2017	CIS process	Summary report of workshop on mitigation measures and GEP for inland navigation water use
2018	CIS process	CIS reports on methods for river hydromorphological assessment and monitoring
2018	Water Directors	Guidance Document No. 36 "Exemptions to the environmental objectives according to Article 4(7)"
2018	CIS process	JRC report on common understanding of using mitigation measures for reaching Good Ecological Potential for HMWB – Part 2: Impacted by flood protection structures – Part 3: Impacted by drainage
2018	CIS process	Summary report of workshop on significant adverse effect on water use & wider environment
2018	CIS process	Summary report on hydromorphology of ECOSTAT classification workshop

Source: All documents are available on CIRCABC.

2 ROLE OF HYDROMORPHOLOGY IN WFD

Key messages for this section

- Supporting elements (hydromorphological and physico-chemical) provide the boundary conditions for the biological quality elements and any alteration in those can translate into a corresponding change of biological conditions at various time scales.
- The WFD defines ecological status as "an expression of quality of the structure and functioning of aquatic ecosystems associated with surface waters" (Art. 2. 21, WFD). Change in land use and other human activities have profound effects on hydromorphological processes, causing fragmentation and loss of habitats, with direct and indirect consequences for the structure and functioning of the aquatic ecosystem.
- Ecological status is defined in terms of all quality elements. Hydromorphological conditions are only explicitly described for the high status in WFD Annex V, corresponding totally or nearly totally to undisturbed conditions. For good and moderate status, hydromorphological conditions are defined as to be "consistent with the achievement of values specified for the biological elements". This implies there is a need for 5-class biological assessment methods sensitive to hydromorphological alterations. The development of such methods requires hydromorphological assessment methods that are able to reliably assess hydromorphological conditions along the full degradation gradient, from good to bad hydromorphological status.

Given the relevance of hydromorphological assessment in all the steps regarding HMWB designation and GEP definition, this introductory section deals with the role of hydromorphology in the WFD. This section also aims to improve the understanding of the differences between dealing with GES and GEP.

2.1 Overview

Hydromorphology is a term that is used to describe the hydrological and geomorphological characteristics (including continuity) of rivers, lakes, coastal, and transitional waters including the underlying processes from which they result. Water and sediments interact at different scales and shape the physical environment, determining physico-chemical processes and providing physical habitat for the biota.

Therefore, hydromorphological conditions are a key aspect of aquatic ecosystems and the WFD considers hydromorphological quality elements as "supporting" biology, together with the physico-chemical quality elements. The supporting elements provide the boundary conditions for the biological quality elements, and any alteration in those can translate into a corresponding change of biological conditions at various time scales.

The WFD defines ecological status as "an expression of quality of the structure and functioning of aquatic ecosystems associated with surface waters" (Art. 2. 21, WFD), classified in accordance with Annex V. Hydromorphological alterations are one of the most dominant reasons for failure to reach good ecological status in water bodies. Change in land use and other human activities have profound effects on hydromorphological processes, causing fragmentation and loss of habitats, with direct and indirect consequences for the structure and functioning of the aquatic ecosystem.

The hydromorphological quality elements for each water category are listed in Annex V, together with the relevant aspects to be considered (e.g. for rivers: conditions of flow regime, sediment transport, river morphology, lateral channel mobility and more in general continuity - i.e. longitudinal, vertical, lateral, which are expressed in terms of some aspects listed in Annex V).

WFD recognizes the fundamental role of hydromorphology in different steps and aspects of WFD implementation, as highlighted in Table 2 and summarised in the following paragraphs.

Table 2: Role of hydromorphology in different steps and aspects of WFD implementation

WFD stage	Consideration of hydromorphology	Articles	CIS Guidance
Water body delineation	Ensure uniform hydromorphological conditions within water bodies to allow sound delineation of water bodies.	Art. 5 Annex II	2
Risk analysis	Consider hydromorphological conditions in the analysis of pressures and their impacts	Art. 5 Annex II.1.4; 1.5	3
Monitoring strategies	Requirements to monitor the hydromorphological quality elements, focus on hydromorphological alterations and their effects on the BQEs in operational monitoring in water bodies at risk of failing the objectives because of	Art. 8; Annex V 1.3	7

WFD stage	Consideration of hydromorphology	Articles	CIS Guidance
	hydromorphology; design investigative monitoring of some specific hydromorphological aspect in more complex situations.		
Typology and Reference Conditions	Consider hydromorphological conditions in the definition of water body types. Consideration of unaltered hydromorphology in reference conditions	Annex II 1.1-3	5,10
Status assessment	Hydromorphological conditions and related biological response	Art. 4 Annex V	13
Design and implementation of measures	Measures to improve hydromorphological conditions	Art. 11.3 Annex VI	31
HMWB designation	Hydromorphological pressures and alteration	Art. 4.3.c	4
Ecological Potential assessment	Hydromorphological conditions, status and mitigation measures	Art. 4 Annex V	4,13
Exemptions	Deterioration of hydromorphological condition also to less than good should be predictable to fulfil Article 4.7 principles	Art. 4.4, 4.5, 4.6, 4.7	20,36

2.1.1 Characterization

Look out!

In the characterization phase, major catchment controls are considered (topography, geology, hydrology) to delineate water bodies and to define water body types – groups of water bodies sharing the same behaviour and character. Hydromorphological functions and features (e.g. energy, channel morphology, sediments) are key factors that need to be taken into account. **WFD typologies should reflect the natural variability in hydromorphological characteristics and processes**, which in turn will result in different reference values in those BQE methods that are sensitive to hydromorphological alterations (WFD CIS Guidance Documents No.2&10; Oslo, 2015).

It is important to ensure that hydromorphological conditions are sufficiently homogeneous within each water body when they are delineated. This can only be confirmed by applying a hydromorphological assessment method which can assess hydromorphological conditions along the full degradation gradient. The initial delineation of spatial units and their characterization are crucial, because they are the basis for all further steps and in particular for decisions on appropriate and effective measures. These measures are likely to turn out far more costly in the long term or even infeasible if delineation and characterisation are not taken into account thoroughly at the outset.

If the delineation of water bodies is based on a proper initial segmentation and categorization into hydromorphological types, the assessment of hydromorphological conditions will be much easier and significant. Defining water body types on a rigorous basis and also taking hydromorphological conditions into account allows like-with-like comparison and identification of the type-specific indicators that are meaningful for monitoring, assessment and for the design of measures.

2.1.2 Pressure and impacts and risk analysis

Hydromorphological pressures (e.g. abstractions, damming, etc.) and their impacts on the type-specific hydromorphological conditions and biological quality elements in water bodies need to be evaluated in the context of water body type. A preliminary classification is undertaken on the basis of the pressures on the different water bodies and the expectation with regard to the risk for BQEs to fail the environmental objectives. This risk assessment requires hydromorphological assessment methods that are able to predict the risk of not achieving good ecological status due to hydromorphological pressures (CIS Guidance Document No. 36).

2.1.3 Monitoring

WFD Annex V 1.3.1 requires the monitoring of parameters indicative of all hydromorphological quality elements for the surveillance monitoring.[3]

For water bodies at risk from significant hydromorphological pressures, Member States need to monitor parameters indicative of the hydromorphological quality elements most sensitive to the pressure identified.[4] Sufficient monitoring points are needed within a selection of the water bodies in order to assess the magnitude and impact of the hydromorphological pressures. The selection of water bodies must be indicative of the overall impact of the hydromorphological pressure to which all the water bodies are subject (Annex V 1.3.2).

Monitoring frequencies must be selected which take account of the variability in parameters resulting from both natural and anthropogenic condition. For hydrology, the WFD recommends a continuous monitoring. For morphology and continuity, recommended minimum frequencies are provided (Table 3). No recommendations are given for tidal regime in coastal and transitional waters.

Table 3: Assessment and minimum requirements for monitoring frequencies of hydromorphology for surface water bodies

Hydromorphological QE	River	Lake	Transitional	Coastal
Continuity	6 years	n.a.	n.a.	n.a.
Hydrology (rivers, lakes)	Continuous (daily)	1 month	n.a.	
Tidal regime (transitional, coastal)	n.a.	n.a.	No minimum requirement	No minimum requirement
Morphology	6 years	6 years	6 years	6 years

Notes: Derived from Annex V, 1.3.4. Guidelines for frequencies for monitoring surface waters for hydromorphological quality elements (for operational monitoring). As indicated in the table, the WFD requires

[3] Surveillance monitoring provides a general description and a representative picture of the water status in each water district or basin. The surveillance monitoring should also be used to assess long-term changes in natural conditions and of large-scale human impact.

[4] Operational monitoring is carried out in order to determine the status of the surface water bodies that are deemed to be at risk of failing to meet the environmental quality objectives set for the bodies under Article 4 and to follow up if the programs of measures put in place in order to achieve the desired effect and goals.

minimum monitoring frequencies for certain aspects but not for others ("n.a." stands for "not applicable"). In cases where no minimum monitoring frequency is required, there is still a need for determining the monitoring frequency based on natural variability. Considering these frequencies, it is possible to update monitoring data (e.g. morphology) for water bodies where changes are expected. If it can be assumed that no changes occurred since the last monitoring cycle, a new assessment is not obligatory.

2.1.4 Ecological status

The WFD considers hydromorphological quality elements as supporting elements for biota and aquatic ecosystems. Ecological status is defined in terms of all quality elements. Hydromorphological conditions are only explicitly described for high status in WFD Annex V, corresponding totally or nearly totally to undisturbed conditions (Table 4). For good and moderate status, hydromorphological conditions are defined as being "consistent with the achievement of values specified for the biological elements". This implies there is a need for 5-class biological assessment methods sensitive to hydromorphological alterations. The development of such methods **requires hydromorphological assessment methods that are able to reliably assess hydromorphological conditions along the full degradation gradient, from good to bad hydromorphological status**.

Table 4: Definition of high, good and moderate status for hydromorphological quality elements (WFD Annex V)

Element	High Status	Good Status	Moderate Status
General	There are no, or only very minor, anthropogenic alterations to the values of the physico-chemical and hydromorphological quality elements for the surface water body type from those normally associated with that type under undisturbed conditions. The values of the biological quality elements for the surface water body reflect those normally associated with that type under undisturbed conditions, and show no, or only very minor, evidence of distortion. These are the type-specific conditions and communities.	The values of the biological quality elements for the surface water body type show low levels of distortion resulting from human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions.	The values of the biological quality elements for the surface water body type deviate moderately from those normally associated with the surface water body type under undisturbed conditions. The values show moderate signs of distortion resulting from human activity and are significantly more disturbed than under conditions of good status.
Hydrological regime (Rivers)	The quantity and dynamics of flow, and the resultant connection to groundwaters, reflect totally, or nearly totally, undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	
Hydrological regime (Lakes)	The quantity and dynamics of flow, level, residence time, and the resultant to groundwaters, reflect totally of nearly totally undisturbed conditions	Conditions consistent with the achievement of the values specified above for the biological quality elements.	
River continuity	The continuity of the river is not disturbed by anthropogenic	Conditions consistent with the achievement of the values specified above for the biological quality elements.	

Element	High Status	Good Status	Moderate Status
	activities and allows undisturbed migration of aquatic organisms and sediment transport.		
Morphological conditions (Rivers)	Channel patterns, width and depth variations, flow velocities, substrate conditions and both the structure and condition of the riparian zones correspond totally or nearly totally to undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	
Morphological conditions (Lakes)	Lake depth variation, quantity, and structure of the substrate, and both the structure and condition of the lake shore zone correspond totally or nearly totally to undisturbed conditions	Conditions consistent with the achievement of the values specified above for the biological quality elements	
Morphological conditions (Transitional)	Depth variations, substrate conditions, and both the structure and condition of the intertidal zones correspond totally or nearly totally to undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	
Morphological conditions (Coastal)	The depth variation, structure and substrate of the coastal bed, and both the structure and condition of the inter-tidal zones correspond totally or nearly totally to the undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	
Tidal regime (Transitional)	The freshwater flow regime corresponds totally or nearly totally to undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	
Tidal regime (Coastal)	The freshwater flow regime and the direction and speed of dominant currents correspond totally or nearly totally to undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	

Even if it may only be required for the classification of ecological status of water bodies in high status, the assessment of hydromorphological conditions is crucial for the management of all water bodies. Knowledge of hydromorphological conditions is required to develop and to predict effects of measures that aim to restore these conditions or to mitigate hydromorphological alterations. It is also required to forecast the risk and extent of deterioration in case of a new project leading to hydromorphological alterations (see also CIS Guidance Document No.36 on exemptions to the environmental objectives according to Article 4(7), which outlines practical considerations for the role of supporting elements). This also allows not only a better understanding of responses and the possibility to monitor the progress and efficiency of measures, but also the designation of HMWB, which requires the evaluation of the significance and permanence of modifications and the definition of ecological potential. This is not possible with a single qualitative 2-class method.

2.1.5 Reference conditions and typology

The ecological status of a water body is classified based on five classes (from high to bad) and is defined on the basis of the degree of deviation from the conditions that would occur if the water body had no or negligible pressures acting on it. Reference conditions describe this undisturbed or very slightly altered situation that is based on type-specific characteristics for all quality elements. This requires that hydromorphological conditions are properly considered in the definition of water body types, minimizing within-type variability at reference conditions.

2.1.6 Measures

According to WFD, in order to reach the environmental objectives, measures have to be designed and implemented. Article 11 lists the basic measures (minimum requirements) to be complied with and among them obligatory measures on water abstraction and impoundment (11.3.e) and measures to ensure that the hydromorphological conditions of the water bodies are consistent with the achievement of the required environmental objectives (11.3.i). In addition to the basic measures, other supplementary measures aimed to enhance hydromorphological conditions may be necessary (e.g. restoration, abstraction controls, rehabilitation projects – Annex VI part B). Such measures have to be listed in the RBMPs.

2.1.7 Exemptions

Hydromorphological conditions may be one of the reasons to delay reaching the environmental objective or to set a less stringent objective. Exemptions may then be agreed if the relevant conditions listed in Art. 4 are met. The justification for exemptions is based on the knowledge of nature and dynamic of the specific hydromorphological processes and, similarly to the stage of designing measures, it implies the prediction of hydromorphological conditions under certain management scenarios (e.g. Art. 4.7).

2.2 Hydromorphology in HMWB designation and assessment of ecological potential

By definition, a HMWB has undergone a substantial change in character as a result of physical modification due to sustainable human activity. Because of that, it cannot reach good ecological status and it is not possible to restore this without significant adverse effects on the use of the water body or the wider environment.

The change in character must be extensive enough to prevent the achievement of good ecological status. This requires assessment methods which are sensitive to hydromorphological alterations. Detection of such changes in character requires assessment through a full gradient hydromorphological method (CIS Guidance Document No.4, step 6), and proper consideration of the temporal dimension of processes.

The ecological conditions of a HMWB have to be monitored and assessed with respect to its environmental objective, namely good ecological potential (GEP). The whole procedure for defining GEP is outlined in section 5, including details on the selection of mitigation measures for GEP. Once a water body is designated as HMWB, there is a need to predict the effects of potential mitigation measures on BQEs sensitive to hydromorphological alterations; this requires hydromorphological assessment methods able to predict such effects.[5] These hydromorphological assessment methods need to cover the full degradation gradient with respect to hydromorphological, physico-chemical and biological conditions related to the pressures behind HMWB designation.

If monitoring results (of BQEs or of supporting quality elements as proxy) show that the ecological potential is moderate or lower, mitigation measures have to be put in place to reach GEP. In the design of measures, hydromorphological processes need to be identified and actions to mitigate the hydromorphological impacts and restore ecological processes have to be planned.

Mitigation measures should aim to improve the quality and connectivity of habitats and enhance transfer of energy, material (water, sediments, etc.), and organisms (for rivers, this includes flow releases, sediment management, in-channel habitat enhancement, connection to floodplain and side branches, etc.).

3 WATER USES, WIDER ENVIRONMENT AND OTHER SUSTAINABLE HUMAN DEVELOPMENT ACTIVITIES

Key messages for this section

- Member States may designate water bodies as heavily modified only if measures for restoring the water body to good ecological status would have a significant adverse effect on (a) the benefits provided by the water body's use or (b) the wider environment.
- In principle, any water use or human development activity serving significant benefits to society may lead to designation if it causes a permanent physical modification, a substantial change in character of the water body and impacts on ecology which lead to failure to achieve good ecological status.
- Human development activities in the context of HMWB designation should be important and still ongoing sustainable activities according to WFD Article 4(3)(a), thus serving significant societal benefits and including provisions to minimise negative effects on the environment.

According to WFD Article 4(3)(a), Member States may designate a body of surface water as artificial or heavily modified when the changes to the hydromorphological characteristics of that body which would be necessary for achieving good ecological status would have significant adverse effects on:

i. The wider environment.
ii. Navigation, including port facilities, or recreation.
iii. Activities for the purpose of which the water is stored, such as drinking water supply, power generation or irrigation.
iv. Water regulation, flood protection, land drainage.
v. Other equally important sustainable human development activities.

[5] Such methods can be either simulations with morphodynamic or hydraulic models and then application of a hydromorphological assessment method or directly applying hydromorphological assessment methods to the different scenarios of measures (e.g. Morphological Impact Assessment System (miMaS), Morphological Quality Index (MQI)).

In the 1st cycle RBMPs, several human development activities (water uses) related to the designation of HMWB, such as water storage, flood defence and navigation, were clearly specified by the Member States and in line with Article 4.3(a) of the WFD. However, several other human development activities related to the designation of HMWB were not as clearly specified or not explicitly mentioned in Article 4(3), e.g. it was not clear whether agriculture refers to land drainage or other activities.[6] In addition, detailed reporting into WISE on the specific human activities (water uses) and physical modifications linked to the designation of each HMWB was not required in the 1st cycle RBMPs.

Important!

WFD Article 4(3)(a) provides a list of human development activities (specified water uses) which can be related to the designation of HMWB. In principle, any **water use or human development activity** serving significant benefits to society may lead to designation if it causes a permanent physical modification, a substantial change in character of the water body and impacts on ecology which lead to failure of achieving good ecological status.

It should be noted that in the context of HMWB designation under the WFD, the term "**physical**" refers to the "shape" of a water body, defined by morphology, e.g. channel pattern, continuity, and hydrology (e.g. amount of water in river/lake water bodies) or tidal regime (e.g. wave exposure in coastal/transitional water bodies). As stated in CIS Guidance Document No.4, for the provisional identification of HMWB, the failure to achieve good status results from physical modifications to the hydromorphological characteristics of a water body. It must not be due to other impacts, such as physico-chemical impacts, except if the physico-chemical impacts are directly linked to the physical modifications.

Despite this, it is noted that not every human development activity can automatically be used as a reason for designating HMWB. Human development activities in the context of HMWB designation should be important and still ongoing sustainable activities according to WFD Article 4(3)(a), thus serving significant societal benefits and including provisions to minimise negative effects on the environment. Key benefits related to the main human development activities (water uses) and the wider environment in the context of designation of water bodies as heavily modified have been outlined in the Summary Report of the Workshop on Significant Adverse Effects on Use or the Wider Environment from Measures.[7]

It is acknowledged, however, that many water bodies are designated as heavily modified due to uses that would not be considered as sustainable according to current sustainability principles. In these cases (and assuming that the use is still present and/or the modification is still required), sustainability should be interpreted according to principles applicable, knowledge available and societal benefits considered at that time when the use leading to physical modifications in the water body was initiated. For any physical modifications that have taken place after 2003, and for future new modifications, sustainability of use should be interpreted as described in CIS Guidance Document No.36 on exemptions under WFD Article 4(7) (section 3.3).

The application of WFD Article 4(3)(b) also ensures sustainability by assessing whether the beneficial objectives served by the modifications of the HMWB can be achieved by other means, which are a significantly better environmental option. The issues which should be considered when assessing

[6] See Key Conclusions. Heavily Modified Water Bodies: "Information Exchange on Designation, Assessment of Ecological Potential, Objective Setting and Measures". Common Implementation Strategy Workshop, Brussels, 12-13 March 2009.

[7] Kampa et al. (2018). Summary Report. Workshop on Significant Adverse Effects on Use or the Wider Environment from Measures, 23-24 April 2018, Brussels.

other means as better environmental options are illustrated in CIS Guidance Document No.4 (section 6.5.3), while examples on the assessment of other means as better environmental options are provided in the Toolbox (2003) on the identification and designation of AWB and HMWB. Section 5.3 of CIS Guidance Document No.36 also discusses how "significantly better" can be demonstrated.

The following explains the scope of wider environment and of the physical modifications linked to sustainable human development activities (uses) under WFD Article 4(3)(a), which is one of the criteria for designating water bodies as heavily modified, as these have been addressed in the context of CIS activities on hydromorphology in recent years:

- **The wider environment** refers to the natural and human environment including archaeology, heritage, landscape and geomorphology[8] (CIS Guidance Document No.4). Specific aspects which should be considered may include cultural heritage sites or assets (e.g. a sluice which no longer serves a water management purpose but is protected under heritage legislation), Natura 2000 sites and protected species, other nationally and locally important sites and wider biodiversity. For the purpose of designating HMWB, relevant aspects of the wider environment should be related to substantial changes in the hydromorphological character of a water body. Other aspects that are not linked to substantial changes in the hydromorphological character, such as informal recreation not requiring infrastructure (e.g. canoes, angling), may however be relevant later in the process, when determining whether mitigation measures for defining GEP will significantly affect the wider environment (see section 5.4.4.2 on significant adverse effects on use or wider environment).
- Physical modifications linked to **navigation** refer to man-made structures, such as port infrastructure, locks and physical modifications to water bodies, such as dredging, for commercial, recreational (e.g. sailing) and military navigation purposes. Navigation infrastructure enables in particular the transport of goods or passengers.[9]
- Physical modifications linked to **water storage** refer to larger structures (reservoirs due to dams) for impounding water for useful purposes, such as water supply (industry, drinking), flood protection, power generation or irrigation. However, water storage can occur also to serve a range of other benefits and/or uses, including industrial water supply, aquaculture, recreational uses and navigation.[10] Such structures may include abstraction intakes and dams in rivers or lakes/reservoirs for permanent longer term (days – interannual) storage of surface water.[11]
- Physical modifications linked to **flood defences** refer to all the structures aimed at preventing or reducing the detrimental effects of floods, including actions on vegetation and sediments. Floods are defined as "the temporary covering by water of land not normally covered by water". This includes floods from rivers, mountain torrents, Mediterranean ephemeral watercourses, and floods from the sea in coastal areas, and may exclude floods from sewerage systems.[12]

[8] Geomorphology in relation to wider environment can, for example, refer to special geomorphological protected areas.
[9] See Summary Report & Conclusions. Workshop on 'Significant adverse effects on use or the wider environment' of measures in the context of HMWB designation and GEP definition, 23-24 April 2018, Brussels.
[10] See Summary Report & Conclusions. Workshop on 'Significant adverse effects on use or the wider environment' of measures in the context of HMWB designation and GEP definition, 23-24 April 2018, Brussels.
[11] JRC Technical Report, Working Group ECOSTAT report on Common understanding of using mitigation measures for reaching Good Ecological Potential for heavily modified water bodies, Part 1: Impacted by water storage, 2016.
[12] Directive 2007/60/CE (Floods Directive), Article 2.

Flood defences represent hydromorphological pressures resulting from the use of flood protection. The focus of the CIS work was on pluvial and fluvial flood defences.[13] Flood defences may protect urban and agricultural areas, or important infrastructure leading to channelization, straightening of river plan form, bank and bed fixation, etc. As highlighted above, not every flood defence activity can automatically be used as reason for designating HMWB. It has to be proven that the flood defence activity is sustainable and the beneficial objectives cannot be achieved by other means, which are a significantly better environmental option. For example, flood defences for the protection of grazing land might not be automatically a valid reason for designation as HMWB.

- Physical modifications linked to **land drainage** refer to man-made structures or physical modifications (straightening, channelisation, using culverts) to water bodies to improve a specific land area for a certain purpose such as agriculture, forestry, urbanization, or tourism.[14] Drainage refers to a change in the drainage function, usually by removing excess water from the soil to lower groundwater level.
- Physical modifications linked to **water regulation** as used in Article 4(3)(a) of the WFD relate to all other uses described above, i.e. navigation, flood protection, water storage and land drainage.

WFD Article 4(3)(a) also refers to **other equally important sustainable human development activities**, which may include any other water use/sustainable human development activity which leads to a permanent physical modification, substantial change in character and such impact on ecology which leads to failure of achieving good ecological status. Examples of uses/activities which can be considered under “other equally important sustainable human development activities” are urbanization, commercial fishing, specific industries, mining or infrastructure such as highways and railways.[15]

Example: Due to the limited area for settlements in narrow valleys of the alpine area, railways or highways are often built directly along rivers. Flood protection measures (e.g. bank fixation, straightening) were implemented to safeguard from flooding. Those measures usually have led to a failure of good status. There is no option (no space) to improve habitat diversity and restore the type-specific hydromorphological conditions to achieve good ecological status by shifting the highway /railway away from the river.

Figure 1 presents the number of water bodies which have been designated as heavily modified in the 2nd RBMPs due to specific human development activities or the wider environment.

The most common uses for designating HMWBs in the second cycle RBMPs are hydropower (ca. 5800 water bodies) followed by flood protection (ca. 4500 water bodies), land drainage for agriculture (ca. 3500), urban/other (use other than drinking water supply) (ca. 2200), drinking water supply (ca. 1500) and irrigation for agriculture (ca. 1400). A large number of water bodies are designated as heavily

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[13] JRC Technical Report, Working Group ECOSTAT report on Common understanding of using mitigation measures for reaching Good Ecological Potential for heavily modified water bodies, Part 2: Impacted by flood protection structures, 2018.

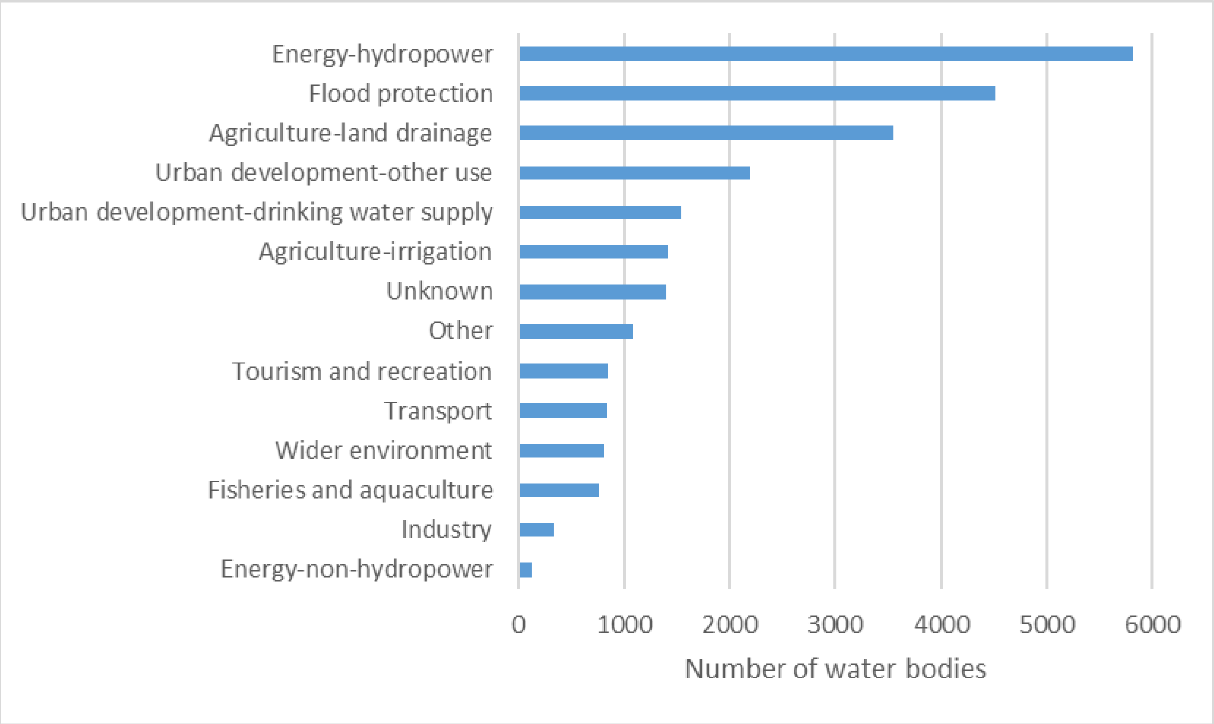
[14] JRC Technical Report, Working Group ECOSTAT report on Common understanding of using mitigation measures for reaching Good Ecological Potential for heavily modified water bodies, Part 3: Impacted by drainage, 2018.

[15] Kampa & Laaser (2009). Updated Discussion Paper. Heavily Modified Water Bodies: “Information Exchange on Designation, Assessment of Ecological Potential, Objective Setting and Measures". CIS Workshop, Brussels, 12-13 March 2009. Note: Information is based on the filled-in questionnaires of 24 European countries on HMWB designation in the first cycle RBMPs.

modified due to unknown activities (1400 water bodies) or other activities (1100) (i.e. activities which do not match any of the water use categories in the WISE reporting).

The percentage of HMWB in the second cycle RBMPs in Member States varies from 3% to approximately 50% of the total surface water bodies, with a European average of 13%.

Figure 1: Number of HMWB designated in the 2nd RBMPs due to specific human development activities or the wider environment



Source: WISE reporting 2016.

Notes: Data from https://www.eea.europa.eu/themes/water/european-waters/water-quality-and-water-assessment/water-assessments, 15 July 2019. Based on data reported for 26 Member States and Norway; no data are included for EL and LT .

It should be noted that a variety of different human activities (multiple uses) can depend on the same physical modification (e.g. a dam that serves energy production, flood protection and irrigation supply in a combined way). For this reason, many water bodies in the EU are designated as heavily modified due to more than one human activity. Section 5.4.4 in this document provides more information on the linkages between different types of physical modification, various human activities and relevant mitigation measures.

4 RE-CAPPING THE DESIGNATION OF HMWB

Key messages for this section

- HMWB designation should only be considered for water bodies that are substantially changed in character due to hydromorphological alterations linked to one or several specific sustainable uses (often due to specific European legislation - e.g. Floods Directive, Renewable Energy Directive etc.).
- Substantial changes in character must be extensive/widespread or profound. Typically this should involve substantial change to both the hydrology and morphology of the water body.
- If the morphology of a water body is substantially changed in character, then the changes are likely to be long-term. Such changes in morphology are very likely to result in changes in hydrology (not necessarily substantial).
- In cases of temporary, short-term and easily reversible substantial hydrological changes, the water body is not to be considered substantially changed in character. Substantial hydrological alterations may also result in long-term or permanent substantial changes in character when they have impacts on sediment dynamics and habitat conditions (morphology, turbidity etc.).
- Possible restoration measures to achieve good ecological status need to be identified and the reasons and criteria for judgements on significance of adverse effects of such measures on use or wider environment have to be made clear.
- HMWB are a specific water body category with their own classification scheme and objective, namely good ecological potential (GEP). Exemptions from GEP under WFD Articles 4.4, 4.5, 4.6 and 4.7 may apply to HMWB, as they apply to natural water bodies. Further, when setting the objectives for HMWB designated under Article 4(3), the requirements of Articles 4(8) and 4(9) must also be met.
- A proper review of all the designated HMWB and their objectives is expected in due time when preparing the RBMP and PoM for a new planning cycle. This review should be efficiently designed and performed to provide a proper HMWB designation according to the requirements of WFD Article 4.3 and Annex V, 1.2.5; it should also take account of monitoring outcomes, new modifications (e.g. new flood protection structures, hydropower plants, etc.) the effects of implemented measures, emerging good practice on hydromorphological assessment methods and relevant mitigation measures as well as reconsidering the criteria for assessing significant adverse effects, where appropriate.
- GEP should be rechecked occasionally, as knowledge/expertise can increase and also economic aspects may change over time.

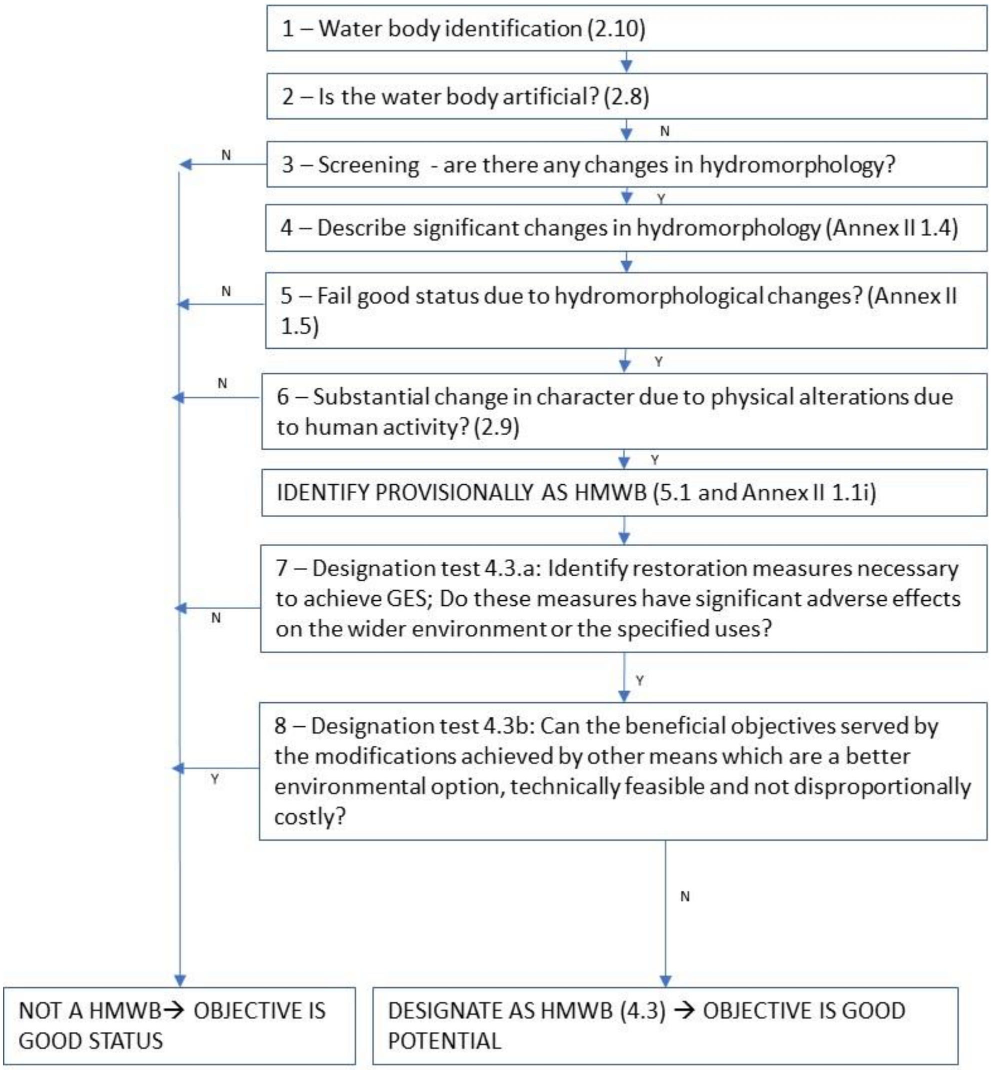
This section re-caps the key aspects which should be considered in the designation of HMWB (see CIS Guidance Document No.4 for details) to provide a clear context for defining MEP and GEP. It also provides a reminder of the importance of reviewing the designation of HMWB and the set GEP in each new planning cycle, outlining a check-list of issues and questions recommended as a basis for such a review.

4.1 Recap of key issues relevant to the designation of HMWB

CIS Guidance Document No.4 on the Identification and Designation of Heavily Modified and Artificial Water Bodies presents the EU-wide common understanding for the designation of HMWB and AWB. The principles agreed under CIS Guidance Document No.4 are still valid, and the Guidance is being used by Member States when preparing their river basin management plans. In both the first and the second RBMPs, heavily modified water bodies have been designated to a significant extent in Member States (on EU level, approximately 12-13% of total number of surface water bodies are HMWB and 4% are AWB)[16], reflecting the amount of modifications that have taken place historically in Europe.

CIS Guidance Document No.4 presented the key steps that should be followed to establish whether a water body may be designated as heavily modified or artificial (Figure 2). Steps 1 to 6 present the initial tests to provisionally identify a water body as heavily modified. Once potential HMWB have been identified, the key final designation tests under steps 7 and 8 should be carried out.

Figure 2: Key steps in HMWB designation (after characterisation and pressure analysis).



Note: Based on CIS Guidance Document No.4.

[16] European Commission (2019) Commission Staff Working Document, European Overview - River Basin Management Plans, Accompanying the document Report from the Commission to the European Parliament and the Council implementation of the Water Framework Directive (2000/60/EC) and the Floods Directive (2007/60/EC) Second River Basin Management Plans First Flood Risk Management Plans, SWD(2019) 30 final

Key aspects which should be considered in the designation of HMWB are recapped below to provide a clear setting for the next step of defining MEP and GEP for HMWB, which is now addressed in more detail in the present CIS Guidance Document No.37:

- **Water body identification:** It is crucial to ensure that hydromorphological conditions are sufficiently homogeneous within each water body.
- **Assessment of hydromorphological alterations:** The significant hydromorphological alterations causing the water body to fail good status need to be described. The "screening" of hydromorphological alterations as part of the provisional identification of HMWB is an important step (step 3 in Figure 2) for an efficient implementation of the WFD. It is possible to carry out broad-scale assessments of hydromorphological alterations, so that detailed assessment efforts are only concentrated on those water bodies where there is uncertainty or specific issues requiring further attention for possible designation as HMWB.
- **Substantial changes in character:** HMWB should be water bodies that have undergone significant hydromorphological alterations such that the water body is substantially changed in character (WFD Article 2(9)). The change in character must be extensive/widespread and profound. Typically, this should involve substantial change to both the hydrology and morphology of the water body (CIS Guidance Document No.4). Further guidance and examples on substantial changes to the morphology and hydrology are given in this section below. Suitable thresholds (e.g. percentage of river reach irreversibly affected) can be used to justify judgements on whether there are substantial changes in character and to ensure that significant modifications are not overlooked.
- **Proper assessment of ecological status:** The designation process needs to be based on a clear understanding of the expected failure of good status of biological quality elements due to hydromorphological alterations. Therefore, the proper assessment of ecological status is a prerequisite for HMWB designation. If GES is achievable, or if monitoring shows that GES has been reached since the previous review, designation as HMWB is not justified.
- **Assessment of significant adverse effects of restoration measures:** HMWB designation can only take place if the changes to the hydromorphological characteristics of that body which would be necessary for achieving GES would have significant adverse effects on use or the wider environment. Possible restoration measures to achieve GES need to be identified and Member States need to establish criteria and thresholds for deciding if these measures would have a significant (or not significant) effect on use. This is a key issue for achieving a clear and transparent process of designating HMWB.[17] Criteria need to reflect the effects on different benefits provided by the water use. Thus, not only one criterion may be considered but several criteria may need to be used.

  CIS Guidance Document No.4 gave different options for assessing significant adverse effects on different scales. Effects can be determined at the level of a water body, a group of water bodies, a region, a RBD or at national scale (CIS Guidance Document No.4). In the initial HMWB designation stage during the 1st RBMP cycle, the assessment of significant adverse effects normally took place at a regional or national scale. Detailed information on pressure-biological response relationships or administrative capacities for detailed feasibility studies were often missing at this stage. The assessment of significant adverse effects at a regional or national scale was a pragmatic approach, since there was generally no detailed project data available

[17] JRC technical report on common understanding of using mitigation measures for reaching Good Ecological Potential for heavily modified water bodies (2016).

in terms of restoration measures at the water body level in the 1st RBMP cycle. However, Member States should have collected such data in the subsequent RBMP cycle.

In this context, it has to be assessed whether the effect is important and to what extent it matters at a national or regional scale. For example, in case dam removal is needed to restore a water body to GES, or if a previously dredged channel is allowed to infill and behave naturally from a geomorphological perspective, the contribution of the modified water body to the regional or national economy could be lost or significantly reduced.

A significant adverse effect at local level may be insignificant in a regional or national context or vice versa. Overall, it is important to define at what level the main importance of the use lies (local, regional, national level or a combination). If the main importance of the use lies at national level, then local effects should be accumulated at national level to assess significance. In such a case, a single local effect will not necessarily be assessed as significant. In addition, the assessment at local scale should not be related to the private interest of one person/or company but to broader public interest.

The assessment of significant adverse effects of restoration measures is closely linked to the possible exclusion of mitigation measures with significant adverse effects when defining MEP/GEP. See section 5.4.4.2 of this document for further guidance on issues which should be addressed to achieve a transparent and clear process for assessing significant adverse effects of mitigation measures, including types of effects, consideration of socio-economic issues, scale of assessment and possible criteria.

- **Assessment of other means:** For HMWB designation, it must also be demonstrated and described that the beneficial objectives of the physical modifications cannot be achieved by other means, which are a significantly better environmental option, technically feasible and not disproportionately costly. For example, wind power can be taken as another means that can produce electricity instead of a hydropower plant. It has to be assessed whether this option would be technically feasible and not disproportionately costly. The better environmental option is assessed as being another renewable resource but might avoid damage leading to a failure of good ecological status.
- **Designation of HMWB is not a type of exemption**. HMWB are a specific water body category[18] with their own classification scheme and objective, namely good ecological potential (GEP). Exemptions from GEP under WFD Articles 4.4, 4.5, 4.6 and 4.7 may apply to HMWB, as they apply to natural water bodies. Further, when setting the objectives for HMWB designated under Article 4(3), the requirements of Articles 4(8) and 4(9) also should be met (see section 5 and section 6 for further information).
- The **methodology and specific criteria for HMWB designation** (application of all relevant steps according to CIS HMWB Guidance no. 4) **should be clearly explained in the RBMPs** or supplementary documents. It is recommended to include a reporting sheet for each water body in the RBMPs, which contains the information relevant for designation or non-designation as heavily modified, in order to increase transparency and to allow intercomparability.

Overall, the assessment of the first cycle RBMPs of Member States by the European Commission showed that the designation of HMWB has been based largely on expert judgement. The extent of designating water bodies as heavily modified and the transparency and/or availability of solid explanations for the implementation of the key steps of designation has been variable across Member

[18] See relevant explanatory footnote on ”specific water body category“ in section 1.1.

States.[19] Differences between Member States in the extent and manner of designation may be due to (among others):

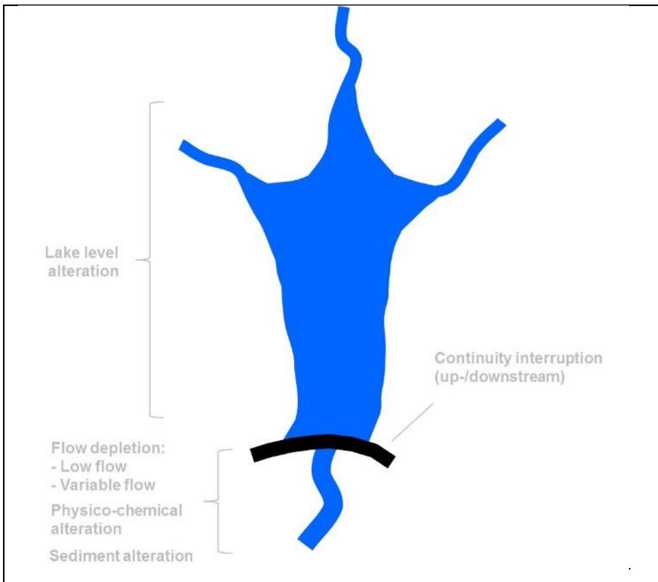
- Differences in population density, infrastructure density, intensity of use of water bodies,
- Differences in the thresholds used for identifying significant hydromorphological pressures (and thus interpreting substantial changes in character),
- Differences in the size of delineated water bodies,
- Differences in the spatial extent and type of impacts considered to be of sufficient magnitude to prevent achievement of good ecological status (and consideration of cumulative impacts or not),
- Differences in the designation methodologies applied (e.g. related to criteria on significant adverse effects of measures on use or wider environment),
- Availability of and experience with relevant mitigation and restoration measures (affecting ambition level for ecological improvements).

4.1.1 Substantial changes in character

According to CIS Guidance Document No.4, it is clear that a water body could be described as substantially changed in character if both its morphology and hydrology were subject to substantial changes (e.g. in the case of a water body downstream of a dammed river, whose morphology changes from braided to sinuous).

Example: Reservoirs with longer-term storage are usually clear cases of water bodies which are substantially changed in character both in their morphology and hydrology, even leading to a change in the closest comparable water category (from river to lake water bodies). Such water bodies are usually designated as HMWB (see **Box 1** below).

Box 1: Water body impacted by instream dam



The instream reservoir was built by damming a river. Below the dam, there is flow depletion (alterations to low flow, fish flow, variable flow). Such an instream reservoir is typical for storage purposes such as for drinking water. In case of hydropower use, the outlet of the turbines could cause additional impacts in the downstream reach, such as hydropeaking effects.

Such cases of instream reservoirs usually lead to a designation of the reservoir as heavily modified.

Graphical illustration based on ECOSTAT work on most common water storage situations for the GEP inter-comparison.

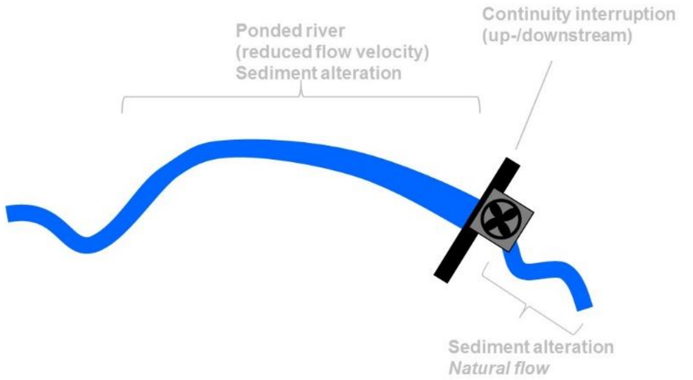
[19] Commission Staff Working Document 2012 WFD implementation (volume 2 of supporting material).

It is less clear-cut whether a water body should be considered as substantially changed in character if only morphology or only hydrology is substantially changed.

If the morphology of a water body is substantially changed in character, then the changes are likely to be long-term. Such changes in morphology are very likely to result in changes in hydrology (not necessarily substantial). A common sense approach would suggest that such water bodies should be considered as substantially changed in character (CIS Guidance Document No.4).

Example: Large impoundments definitely change morphological conditions of a river and therefore are also usually designated as HMWBs even without significantly changing the hydrological conditions (see Box 2 below).

Box 2: Water body impacted by significant ponding (impoundment)

	In this case, the river is ponded by a dam, where hydropower turbines are situated in the dam (this type of run-of-river hydropower plant is usually called "in-stream plant type"). The dam leads to a significant ponding effect upstream (impoundment). Downstream of the dam however there is the natural flow. Such cases of impoundment usually lead to a designation of the water body upstream of the dam (ponded stretch) as heavily modified.

Graphical illustration based on ECOSTAT work on most common water storage situations for the GEP inter-comparison.

The situation is more diverse for water bodies subject to substantial changes in hydrology.

In cases of temporary, short-term and easily reversible substantial hydrological changes, the water body is not to be considered substantially changed in character. The water body should therefore be considered as natural, with good status as the environmental objective.

Substantial hydrological alterations may result in long-term or permanent substantial changes in character when they have impacts on sediment dynamics and habitat conditions (morphology, turbidity etc.). This happens when hydrological alterations affect the channel-forming discharges[20] and/or those discharges with higher return intervals. These are both relevant for sediment transport and the channel will undergo severe morphological alteration as a result. In other words, the interventions would cut the high flow peaks which promote sediment transport and the shaping of the channel. Such effects are typically associated with some dams for flood attenuation, water abstractions, spillways, retention basins, etc. Alteration of low flows does not generally promote morphological changes; nevertheless,

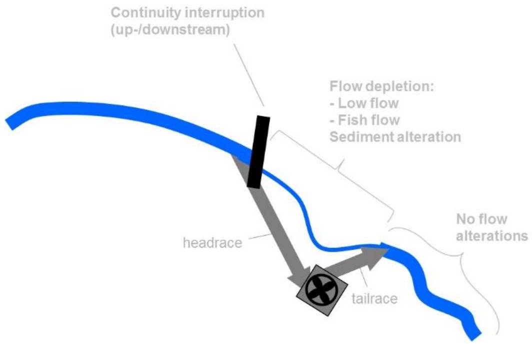
[20] Channel forming discharges are intended as those discharges having the most relevant effects on channel morphology. They correspond to those peak discharges, under natural conditions, with return period of few years (1,5 to 10 according to the specific hydrological regime and river type).

there are some exceptions, e.g. flow releases downstream of dams in rivers characterized by a typical Mediterranean hydrological regime (i.e. high flow variability and low or null water level during the summer). The release of constant flow (usually a minimum flow) during the summer, in such rivers which naturally would have little or no flow, raises the water table, promoting severe vegetation encroachment and consequent channel narrowing. In such specific cases, the application of the HMWB designation tests may be justified.

Water bodies affected by non-storage abstractions (e.g. small-capacity hydropower plants, small-scale irrigation abstractions) are in general not HMWB, because the change in hydromorphology is in most cases not large enough to cause a substantial change in character, e.g. the peak channel-forming discharge[21] is not totally eliminated by the abstraction. In small-capacity hydropower plants, there is often water abstraction to produce electricity but usually no or relatively small water storage with an impounding effect on the water body. The water abstraction will reduce the flow of the downstream stretch, but does not usually cause such a morphological change that causes a substantial change in the character of the water body; thus, the alteration is technically easily reversible by introducing more water into the depleted river reach.

Example: A small-capacity hydropower plant without water storage not causing a change in character and therefore not leading to HMWB designation is shown in Box 3 below.

Box 3: Water body impacted by abstraction without significant ponding/storage



Water is abstracted from the river by a transversal structure (usually a weir). The abstracted water is transferred "via headrace" to a powerhouse. After passing through the turbine, the water is re-discharged "via a tailrace" into the river from which the water was abstracted. Downstream of the discharge point there is the normal quantity of flow, but between the abstraction and discharge points the river is characterised by flow depletion (alterations of low flow, fish flow, variable flow). The weir at the abstraction point does not lead to a significant ponding effect. There is thus no significant storage or water retention. The abstraction still allows channel-forming discharges in high-flow situations. This situation is typical for most of the small hydropower plants (e.g. Alps). This case does not lead to a designation of the water body as heavily modified, as the water abstraction alone does not lead to such a morphological change that causes a substantial change in character; the alteration from the water abstraction is technically easily reversible to restore GES by providing an eflow.

[21] See previous footnote on channel forming discharges.

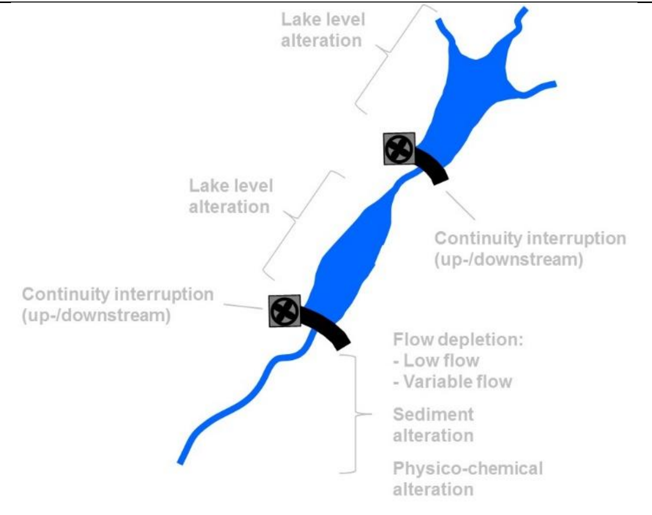
Graphical illustration based on ECOSTAT work on most common water storage situations for the GEP inter-comparison.

In general, the flow depleted reaches downstream of dams/reservoirs are sediment starved and undergo hydrological alteration. The severity of these alterations depends the way the reservoir is managed (according to its use). If the downstream reach is soon fed with water and sediments by close tributaries, it can regain its pseudo-natural character and therefore still reach the good status. Otherwise, the reach is likely to be changed in character, and the application of HMWB test is suggested.

In complex schemes (e.g. chains of reservoirs), the situation is such that the HMWB in the scheme affect the potential natural character and objectives of smaller water bodies, which may undergo the HMWB test as well.

Example: Box 4 shows an example where substantial hydrological alterations in a river stretch downstream of a chain of reservoirs can lead to changes in morphology and thus to designation as HMWB.

Box 4: Water bodies impacted by a chain of reservoirs



Several instream reservoirs were built by damming a river in different stretches. The reservoirs are clearly heavily modified and a change in category (from river to lake). Below the dams, there is a free-flowing river stretch with flow depletion (alterations of low flow, fish flow, variable flow) and sediment alteration. If such a chain of instream reservoirs severely alters conditions downstream leading to a severe change in character, the downstream water body should also be designated as heavily modified.

4.2 Review of HMWB designation in the river basin management planning cycles

The need to review the HMWB designation as well as the GEP setting for the designated water bodies every six years is stated in the WFD and CIS Guidance Document No.4. The identification and designation of HMWB is not a "one-off" process and the WFD provides for the flexibility to modify designations to take account of changes over time in environmental, social and economic circumstances. HMWB and GEP can also be modified as their environmental objective require adaptations as a result of new knowledge gained as well as a result of measures applied during a planning cycle. New or more detailed information (e.g. on economic aspects) or new projects which are exempted from the non-deterioration principle according to WFD Article 4.7 can also lead to new designations of HMWB in the forthcoming RBMP cycle.

The review of HMWB should include several steps as stated in CIS Guidance Document No.4 (Chapter 8). These are illustrated in Table 5, which presents an updated check-list and questions for clarification, which are recommended as a basis for the review of HMWB and GEP setting by Member States for the next planning cycles. More updated guidance for many of these steps is given in other sections of this new CIS Guidance Document No.37.

Table 5. Updated steps for the review of HMWB designation and GEP setting for the next planning cycles

Step			Explanation/questions to clarify	More guidance/examples
Step A.1	A. Review characterisation	Updated monitoring, hydromorphological assessment and BQE assessment	Does a more compliant hydromorphological assessment or monitoring program or implementation of new BQE assessment methods now have a better link to hydromorphological alterations and BQEs? Do updated assessments show that the water body is actually reaching good status?	CIS Workshop on river hydromorphological assessment methods, Nov 2017
Step A.2		Re-delineate water bodies	Do you need to re-delineate either by splitting or merging water bodies?	
Step B.1	B. Re-designation test	i. WBs mistakenly not designated previously	Are modifications more severely impacting aquatic ecology than previously expected?	
Step B.2		ii. New modifications	Have new activities that heavily impact the water body taken place (following the requirements of WFD Article 4.7)?	Art 4.7 CIS Guidance
Step B.3		iii. Reconsiderations of designation – updated screening for changes	*See the following substeps below*	CIS Workshop on significant adverse effect upon use/wider environment
Step B.3a		a) Technical circumstances or use itself	Have the operation, maintenance or need for the modification related to the sustainable water use or the wider environment been significantly changed during the previous planning cycle?	
Step B.3b		b) Available restoration measures	Have national criteria for adverse effects on relevant use, benefits or wider environment been established/changed, so that modification may be restored?	
Step B.3c		c) Methodological approach	Do methodological modifications (due to development of monitoring and better understanding) modify designation results?	
Step B.3d		d) Other means	Can the beneficial objectives of the use be delivered by other means?	
Step C.1	C. Review of MEP and GEP	Adopt BQEs sensitive to hydromorphological alterations	Taking on board emerging good practice on BQEs sensitive to the relevant hydromorphological alterations	
Step C.2		Reference value for MEP and GEP	Review if still only a slight deviation from MEP is valid?	
Step C.3		Identification of available mitigation measures	Could ambition level for GEP be increased, if more of the ecological impacts are possible to mitigate by "new" measures not previously considered/available?	See lists of common mitigation measures in the library provided as supporting tool to this document
Step C.4		Achievement of GEP or exemption	Is GEP being achieved, taking into account the need to ensure an approximation to ecological continuum, after implementation of available measures?	See section 5

5 STEPS FOR DEFINITION OF ECOLOGICAL POTENTIAL

Key messages for this section

Best approximation of ecological continuum

- Best approximation of ecological continuum is a key aspect of ecological potential. Ecological continuum refers to movements of energy, material, and organisms within the aquatic ecosystem. Achieving ecological continuum ensures that the habitats for type-specific aquatic species are interconnected in space and time so that the species can fulfil their life cycles in self-sustaining populations.
- Measures implemented in this regard should be relevant for the closest comparable water body type and related quality elements. For example, if the modifications to a river make it more closely resemble a lake, the set of measures shall take this into account.
- The best approximation of ecological continuum requires consideration of all hydromorphological measures that could mitigate any obstacles to movement of biota, sediment and water and improve the quality, quantity and range of habitats affected by the physical modifications. This can include connectivity to groundwater and/or to riparian, shore and intertidal zones, as well as a sustainable supply of an appropriate sediment type. WFD emphasises both migration of biota and sediment transport. Priority should therefore be given to appropriate and effective measures reducing any obstacles that significantly inhibit longitudinal (both upstream and downstream) and lateral migration of aquatic biota and ensure appropriate sediment conditions. For achieving ecological continuum, it should also be considered whether there is an ecological benefit or a need to restore continuity in order to support upstream and downstream water bodies in achieving their environmental objectives (especially for migratory fish).
- "Best approximation" is interpreted as being as close as possible to undisturbed ecological continuum. MEP requires that best approximation to ecological continuum is ensured. A water body can only be at GEP if a condition close to best approximation is achieved. This is a prerequisite for the functioning of the ecosystem.

A more detailed step-wise framework for GEP

- Determining GEP should follow a logical series of steps. In this document, a new flow-chart presents a step-wise framework for defining GEP and shows the two routes or approaches (reference and mitigation measures approach) to follow this framework.
- By following the steps included in the new flow chart (step-wise approach), a comparable outcome in ecological terms is expected. The steps included in the step-wise approach follow the requirements of the WFD. If, in following the routes through the framework, it is not possible to take all steps, relevant justification is therefore needed in the RBMP. Member States should make sure they can complete the remaining steps by improving data availability and knowledge on the links between hydromorphology and biology. In particular, improved monitoring data is crucial.
- To ensure comparability, a national, regional or basin-specific method for GEP definition has to be developed, although its application will be at water body level taking into account site-specific conditions.

Consideration of all relevant mitigation measures

- The following issues are important for identifying relevant mitigation measures in a HMWB or series of heavily modified water bodies:
    - the nature and extent of the physical modification(s) and their implications for the hydromorphological and, if appropriate, physico-chemical supporting elements in the impacted water bodies need to be understood.
    - the consequent effects on the biological quality elements, and hence the measures that are needed to meet GEP.
- A wide range of potential mitigation measures should always be considered when defining MEP, and several measures are normally expected to mitigate modifications. To select the best combination of measures, the following needs to be evaluated:
    i) the relevance of measures in terms of the hydromorphological alteration(s) and physicochemical characteristics of the water body as well as other water body characteristics relevant to the biota (e.g. whether modification is within the fish zone/outside the fish zone, fish community types, etc.).
    ii) the measures' ecological effectiveness and benefits in the specific context of the water body or water bodies (i.e. is measure appropriate for addressing the existing ecological impacts and can it deliver a proven ecological benefit).
    iii) whether or not the measures will have a significant adverse effect on use or the wider environment.
    iv) ensuring best approximation to ecological continuum.
    v) the requirements of Article 4(8) for the achievement of objectives in other water bodies within the same river basin district.
- When assessing mitigation measures regarding their potential for a significant effect on use, differing intensities of a measure or combinations also have to be considered, as a lower intensity of a measure (e.g. a reduced amount of additional flow, or a smaller area of habitat enhanced) might still deliver a substantive benefit without having a significant adverse effect on the use in question.
- The mitigation measures selected for MEP exclude measures that have significant adverse effects on use or the wider environment. The criteria for judgements on the significance of any effects of measures on use or the wider environment should be clear, transparent, justified and set in a consistent way at the national, regional or local level. Decisions on when such adverse effects are significant are important, because they may affect the level of ambition of ecological improvements and intensity of measures.
- For defining GEP, measures are then excluded that, even in combination, are predicted to deliver only a slight ecological improvement. GEP is ultimately defined as the biological values that are expected from successfully implementing the selected mitigation measures.
- Combinations and site-specific adaptations of measures are necessary in many cases within a set of measures to ensure the best possible ecological improvement and approximation of ecological continuum.

European mitigation measures library

- A consistent understanding of when the available measures are relevant is crucial, by linking drivers, pressures, impacts and ecological effects. To support this, a European 'library' of emerging good practice mitigation measures for HMWBs has been set up for this CIS Guidance Document No.37.

- This European library represents the emerging good practice especially for rivers and TraC waters, while the library content on measures for lakes will need to be improved and updated based on further discussions in the future).[22]
- The library describes the typical implications of different types of physical modification and suggests potentially relevant mitigation measures to address typical effects in each water body category. The library includes key groups of mitigation measures, which are expected to be considered for ecological improvements in order to address certain modifications. The groups of measures are further elaborated with examples of specific practical measures included in these groups. Member States should consider a wide range of potentially available measures to deliver the needed ecological improvements.
- When there is a lack of suitable biological data assessment methods and/or data sensitive to modifications, the approach to the selection of mitigation measures should be more precautionary and more measures may need to be considered until there is sufficient evidence to exclude measures from MEP and GEP. The assessment of hydromorphological conditions after having implemented all mitigation measures defined for GEP can be used as an intermediate tool until monitoring results of hydromorphology-sensitive biological assessment methods are available. Increased efforts are needed in many countries to establish appropriate biological monitoring and develop and apply hydromorphology-sensitive biological assessment methods to increase the confidence level of monitoring results and classification.

Definition of GEP in biological terms

- Good ecological potential is defined as an ecological state in which "there are slight changes in the values of the relevant biological quality elements as compared to the values found at maximum ecological potential" (WFD Annex V 1.2.5). With respect to "slight changes", HMWB should follow the same principles as natural water bodies, with a functioning ecosystem being a prerequisite for a water body to be at GEP.
- Slight change cannot be equivalent to a complete/temporary absence or severe change of the biological quality elements relevant for the closest comparable water category and type (e.g. of fish for rivers within the fish zone).
- Slight changes to the biological quality elements have to be supported by corresponding conditions in the supporting quality elements (e.g. flow, habitats, continuity). With regard to ecological continuum, "slight change" means that a condition close to the best approximation of ecological continuum should be ensured (instead of best approximation) .
- Physico-chemical quality elements should also be defined in the GEP definition process. For physico-chemical parameters, the closest comparable water body type is in general the original natural water body type (before physical modification). For those physico-chemical parameters that are significantly modified by the hydromorphological alterations causing the heavily modified character, and that cannot be mitigated, other types should be considered (the closest comparable natural water body type, or combinations of water body types).

[22] The document "GEP_mitigation_measures_library.xlsx" presents a European library of mitigation measures for defining MEP and GEP, it can be accessed online (https://ec.europa.eu/environment/water/water-framework/facts_figures/guidance_docs_en.htm) and is a supporting tool to this CIS Guidance No. 37.

Section 5.3 gives an overview, and section 5.4 describes the step-by-step process for defining MEP, GEP, and thereby also less than good potential in detail. Prior to this, it is crucial to have completed a proper review of the designation-tests (see section 4.2).

The environmental objective of HMWB, i.e. GEP, has to be defined by linking biological, hydromorphological and physico-chemical conditions. As described further below, ensuring approximation to ecological continuum is one of the key aspects; more details on this are provided in section 5.2 below.

The definition of MEP and GEP is also the starting point for classifying the ecological potential of a specific HMWB into a class, corresponding to its current condition.

5.1 Approaches for defining ecological potential in 1st & 2nd RBMPs

The "CIS reference approach" and the "mitigation measures approach" (so called "Prague method") are relevant options for defining ecological potential (Kampa and Kranz, 2005)[23] as GEP is established with reference to ecological targets and functionalities in both cases:

- **Reference approach (based on the CIS Guidance Document No.4):** This approach is based on biological quality elements as illustrated in CIS Guidance Document No.4. The MEP for HMWB relates to the values of biological quality elements which are expected to be achieved after implementation of all mitigation measures, which are relevant to the particular hydromorphological alterations, are ecologically effective in the physical context of the water body and do not have a significant adverse effect on use or wider environment. GEP is defined as only slight change from those biological values at MEP.

- **Mitigation measures approach (alternative or Prague approach):** The mitigation measures approach was agreed at the CIS workshop on Hydromorphology in 2005 as an alternative method for defining GEP (Kampa and Kranz, 2005). The mitigation measures approach[24] takes a different route compared to the reference approach and bases the definition of GEP on mitigation measures. Starting from assumed measures, which are relevant to the particular hydromorphological alterations and ecologically effective in the physical context of the water body and do not have a significant adverse effect on use or wider environment, it defines MEP in the same way as the reference approach. Based on this set of mitigation measures, those measures are excluded that, even in combination, are predicted to deliver only slight ecological improvement. GEP is then defined as the biological values that are expected from implementing the remaining identified mitigation measures.

Both approaches (reference approach and mitigation measures approach) require the definition of BQE conditions for GEP. Both approaches for GEP definition (reference approach, mitigation measures approach or combinations of the two approaches) should be drivers for best respectively as close as possible approximation of ecological continuum (see section 5.2) and thus ecological improvement and

[23] Kampa, E. and N. Kranz 2005. Workshop "WFD & Hydromorphology", 17-19 October 2005, Prague. CIS Summary Report.

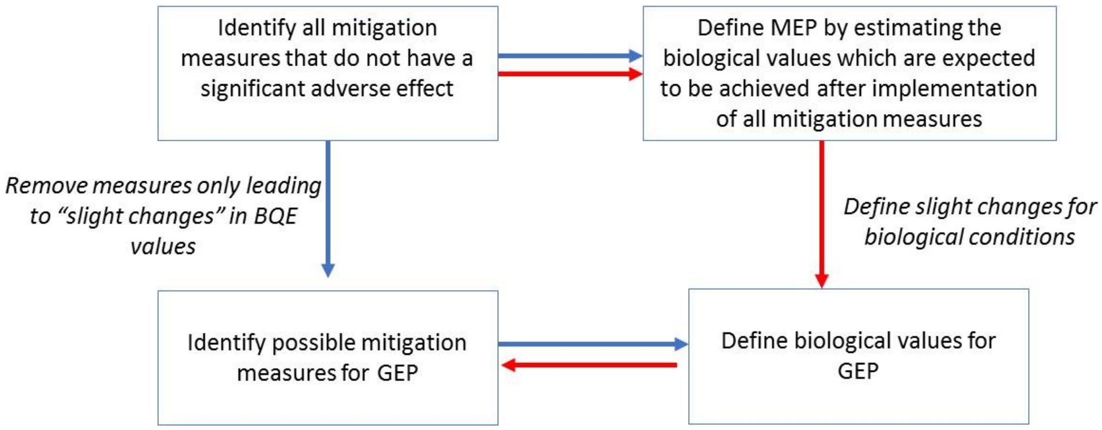
[24] See Annex II of Common Implementation Strategy for the Water Framework Directive 2006: Good Practice in managing the ecological impacts of hydropower schemes; Flood protection works; and works designed to facilitate navigation under the Water Framework Directive. 30 November 2006. Final version.

should be able to deliver comparable results in terms of ecological improvements in the water bodies on the ground.

In the first cycle RBMPs, 3 Member States had clearly used the reference approach, while a larger number of Member States (7 Member States) had defined GEP using the mitigation measures approach, according to the information provided in the RBMPs. Some Member States also used combinations or methods derived from these approaches.[25] In the second cycle RBMPs, about one-third of the Member States report to have defined GEP using the reference approach and about one-fifth of the Member States using the mitigation measures approach. Several Member States report to have used a hybrid approach combining the two approaches, e.g. using one or the other approach for different sub-sets of their water bodies.

As shown inFigure 3, all main steps under the two approaches are in principle the same. Both approaches have exactly the same concept for MEP, i.e. measures are used under both approaches in the same way for MEP. The main difference lies in the derivation of GEP from MEP. In the mitigation measures approach, GEP is derived from the mitigation measures and in the reference approach, GEP is derived from the BQE values at MEP.

Figure 3: Key steps of the reference approach (red arrows, clockwise) and the mitigation measures approach (blue arrows, anticlockwise) for defining GEP



The two approaches should lead to comparable outcomes in ecological terms. There are various ways to describe ecological targets whichever approach is applied. For example, semi-quantitative descriptions of ecosystem functioning or modified ecological quality ratio (EQR) values.

The reference approach follows the WFD requirements more directly but also the mitigation measures approach can be undertaken according to WFD requirements, if the definition of hydromorphological and BQE conditions and comparison of MEP/GEP are carried out. This means, in both approaches, derivation or verification of "slight changes" in comparison of MEP and GEP biological conditions is needed ensuring best approximation to ecological continuum. It is noted that in the mitigation measures approach, mitigation measures by themselves are not the GEP objective, but a means to define GEP. This is also valid for the reference approach.

[25] Commission Staff Working Document (2012), European Overview (2/2). on the Implementation of the Water Framework Directive (2000/60/EC) River Basin Management Plans.

5.2 Approximation of ecological continuum

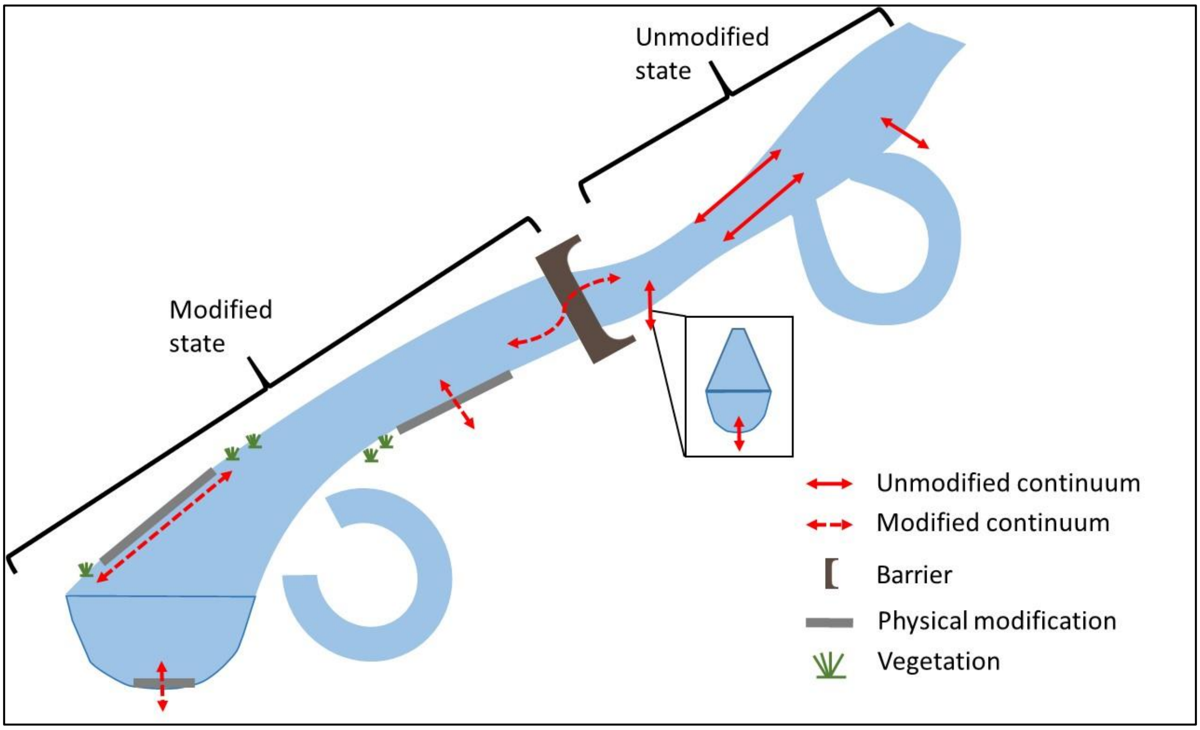
According to the WFD normative definitions in Annex V 1.2.5, the hydromorphological conditions at MEP for heavily modified or artificial water bodies are defined as being "*consistent with the only impacts on the surface water body being those resulting from the artificial or heavily modified characteristics of the water body once all mitigation measures have been taken to ensure the best approximation to ecological continuum in particular with respect to migration of fauna and appropriate spawning and breeding grounds".* This sub-section provides more detailed guidance and interpretation of the aspects related to the best approximation to ecological continuum.

Ecological continuum refers to movements of energy, material, and organisms within the aquatic ecosystem (Figure 4). Achieving ecological continuum ensures that the habitats for type-specific aquatic species are interconnected in space and time **so that the species can fulfil their life cycles**. Aquatic species (fish in particular) need specific habitats during different stages of their life cycle, for example for reproduction (spawning and breeding grounds), but also for feeding, wintering habitats or for shelter from predators. The accessibility of all these habitats at the right times is vital for survival and a prerequisite **to ensure self-sustaining populations**.

Ecological continuum is also necessary for the preservation of aquatic species in the long term, in particular regarding genetic diversity. Allowing migration of species increases genetic exchange between populations, prevents inbreeding, increases their resistance to pollution or disease, and therefore ensures that populations are self-sustained in the long term. Ecological continuum can be interrupted by barriers like transversal or lateral (e.g. river bed revetments) structures but also by changes in flow patterns, including highly reduced flows (in worst case lack of flow) as well as highly increased flow velocities which no longer allow aquatic species (or some of their very sensitive life stages) to migrate to reach their relevant habitats. This is also important, for example, for species being able to return to the original environment after having been swept away by floods.

The benefits of ecological continuum should be considered at a large scale and in the long term. In particular, in some areas, natural populations have been progressively declining due to multiple pressures, or might even have disappeared. Restoration of those populations requires action to tackle all those pressures, and the implementation of all necessary measures may take time. Furthermore, it is important to consider that the recovery and re-colonization of habitats by aquatic species is probably a long process in many cases, in particular for species with a long life cycle.

Figure 4: Different components of ecological continuum (longitudinal, lateral, vertical) in a modified and unmodified state



The best approximation to ecological continuum requires consideration of all hydromorphological measures that can mitigate any obstacles to migration (of biota, sediment and water) and improve the quality, quantity and range of habitats affected by the physical modifications. This can include connectivity to groundwater, to sediment supply and/or to riparian, shore and intertidal zones, as well as a sustainable supply of an appropriate sediment type. WFD emphasises both migration of biota and sediment transport. Priority should therefore be given to appropriate and effective measures reducing any obstacles that significantly inhibit longitudinal (both upstream and downstream) and lateral migration of aquatic biota and ensure appropriate sediment conditions. Overall, ecological continuum should be considered at river basin scale, but action should be taken at local scale.

"Best approximation to ecological continuum", which is mentioned in the WFD normative definitions of MEP, should be understood as a requirement for flow patterns that ensure migration of fish and other aquatic fauna, appropriate sediments for the habitats present (including spawning and breeding grounds) and appropriate sediment transport to ensure the long term sustainability of these habitats. "Best approximation" is interpreted as being as close as possible to undisturbed ecological continuum.

As explained in Figure 5 (section 5.3), MEP requires that best approximation of ecological continuum is ensured. A water body can only be at GEP if a condition close to best approximation is achieved. An approximation of ecological continuum is prerequisite for the functioning of the ecosystem.

It is also noted that ecological continuum should not only be guaranteed for the heavily modified water body, but is also a prerequisite for achieving good ecological status in the natural water bodies.

Example of reservoir created by damming a river: If a river was dammed to a large reservoir, there was a change in category and the biological quality elements (e.g. fish) have been adapted to a lake type, which has to be taken into account when deriving MEP and GEP. With regard to best approximation of ecological continuum and required measures, the following should be considered :

- Is there an ecological benefit or need to restore continuity to the river(s) because a fish species lives in the lake which has its spawning ground in the river(s) up- or downstream?
- Is there an ecological benefit or need to restore continuity from the lake to the river(s) up- and downstream as otherwise the river water bodies up- or downstream cannot achieve their environmental objective (e.g. fish will migrate through the reservoir to get to the river upstream for spawning)?

In this context, it is relevant to take the requirements of WFD Article 4(8) into account.

5.3 Overview of key steps for defining ecological potential in a comparable way

The following flow-chart Figure 5 describes the key steps involved in setting maximum ecological potential (MEP) as a basis for defining good ecological potential (GEP). It provides more detailed descriptions of steps 10 and 11 of the original flow-chart on HMWB designation in CIS Guidance Document No.4 (see steps 10 and 11 in Figure 1 of CIS Guidance Document No.4).

The flow-chart presents a step-wise framework and shows two routes or approaches to follow this framework (the reference approach and the mitigation measure approach). Both approaches (two different routes in the step-wise framework) are acceptable and should lead to the same outcomes (ecological condition), provided there is good knowledge available on the links and interactions between biology, hydromorphology and mitigation effects from relevant measures. The common step-wise framework aims at further clarification and better understanding of the two approaches in the context of WFD definitions and should be used as a basis for the comparability of GEP definition outcomes across water uses, river basins and Member States. Ultimately, the aim is to harmonise GEP definition across Member States, in order to achieve a more transparent and comparable level of ambition in relation to ecological improvements.

The process described in the flow-chart is relevant to all water categories (rivers, lakes, transitional and coastal waters) and closest comparable water body types.

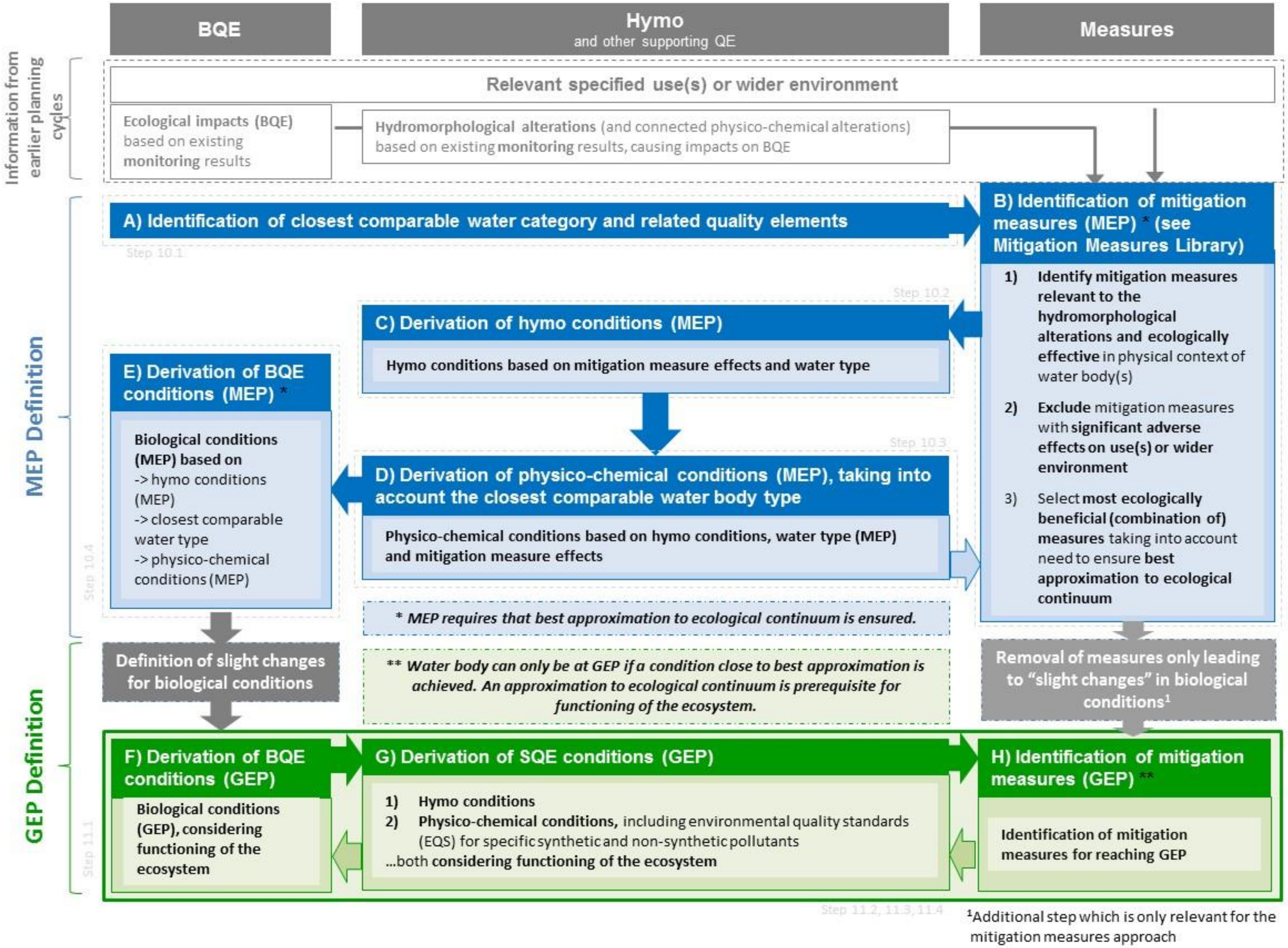
The GEP definition process is structured around eight key steps A to I, and should therefore serve as a check list to ensure that all necessary steps and actions will be taken to mitigate all relevant and significant impacts. The flow-chart is also organised vertically into 3 main columns:

- Biological quality elements (BQEs)
- Hydromorphology (and other supporting quality elements)
- Mitigation measures

This clear distinction should be helpful for communication, discussion and common understanding on the process of objective setting for HMWB.

The good ecological potential (GEP) includes all three steps F-G-H described below, i.e. it is eventually defined in terms of biological conditions, supporting quality element conditions and mitigation measures. In both the reference and the mitigation measures approach, GEP is defined as the biological quality element conditions which are expected to be achieved after implementation of the mitigation measures (prognosis of ecological effect). The definition of GEP in biological terms is supported by the conditions derived for the hydromorphological and the physico-chemical quality elements.

Figure 5: Process with key steps for defining MEP and GEP showing comparability between the two approaches (reference approach and mitigation measures approach)

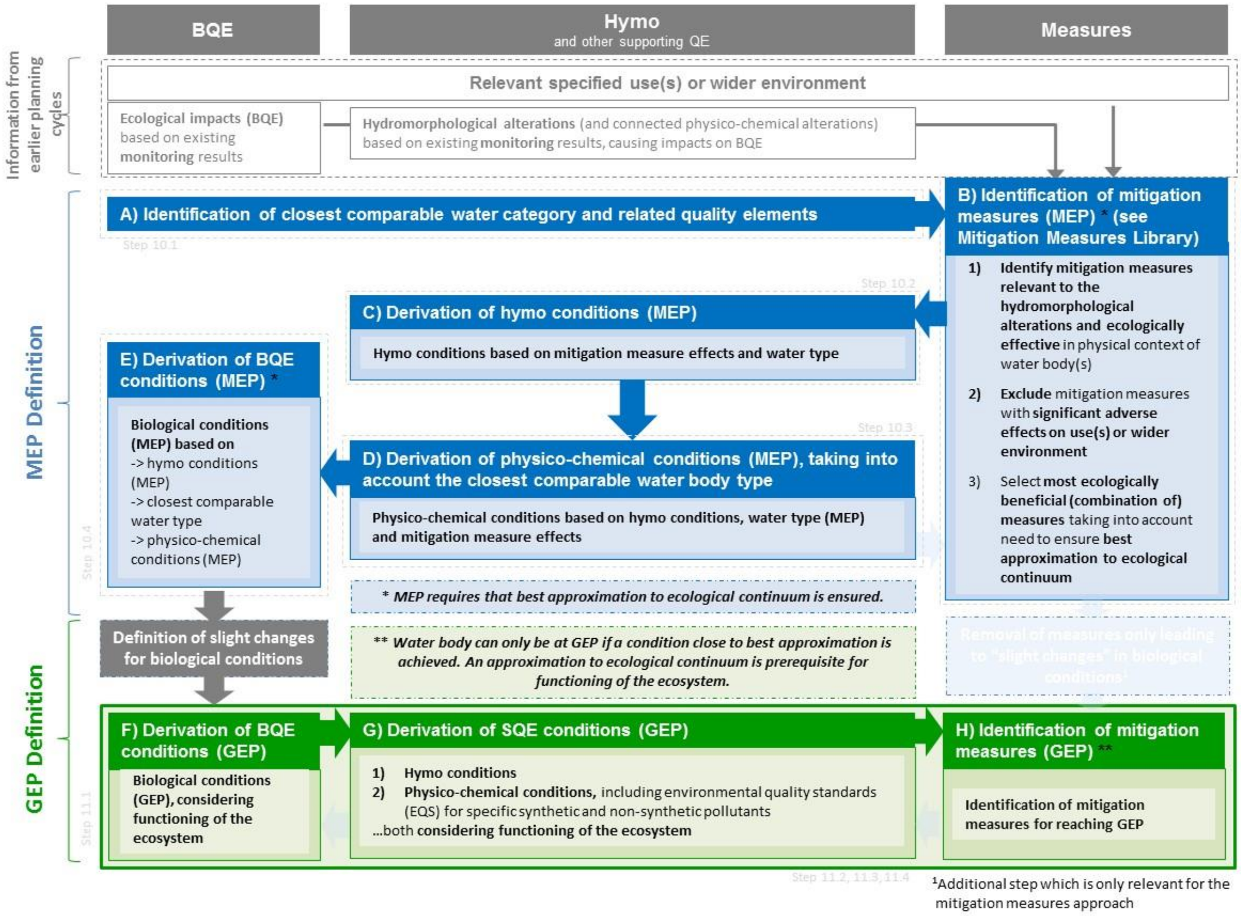


It is important to recognise that an ecological potential of a particular class can imply different ecological conditions in different water bodies. This is due to the local conditions in the water body type, ecological benefits of relevant mitigation measures and the design and operation of the modification(s)/use(s) which is/are the reason why the water body is designated as HMWB

5.3.1 "Route" of the reference approach

The complete step-wise approach in Figure 5 anticipates that Member States have enough information and knowledge (BQE, hydromorphological and physico-chemical data, mitigation measures library, ability to predict the effects of measures) to be able to follow the reference approach as set out in the WFD. In this case, all steps have to be followed to be in line with WFD requirements (route A→B→C→D→E→F→G→H). Figure 6 below indicates the sequence of steps for defining MEP and GEP when applying the reference approach.

Figure 6: Process with key steps for defining MEP and GEP showing the "route" of the reference approach



5.3.2 "Route" of the mitigation measures approach

As an alternative to the reference approach, Member States can use the mitigation measures approach. Such an approach is suggested in case it is not yet possible to predict the MEP conditions for the BQEs due to a lack of knowledge or data.

For the steps referring to MEP definition, Member States should follow steps A and B and should also go through steps C and D, insofar as the availability of information on hydromorphology and physico-chemical elements allows. Step D then feeds back into step B and the process continues from step B to step H and step G. The mitigation measures approach assumes then that the conditions for physico-chemical and biological elements are those deriving from the implementation of measures defined in step H. In summary, the route to be usually followed through the flow-chart in Figure 5, when applying the mitigation measures approach is A→B[→C→D→B]→H→G(→F).

Figure 7 below indicates the sequence of steps for defining MEP and GEP when applying the mitigation measures approach.

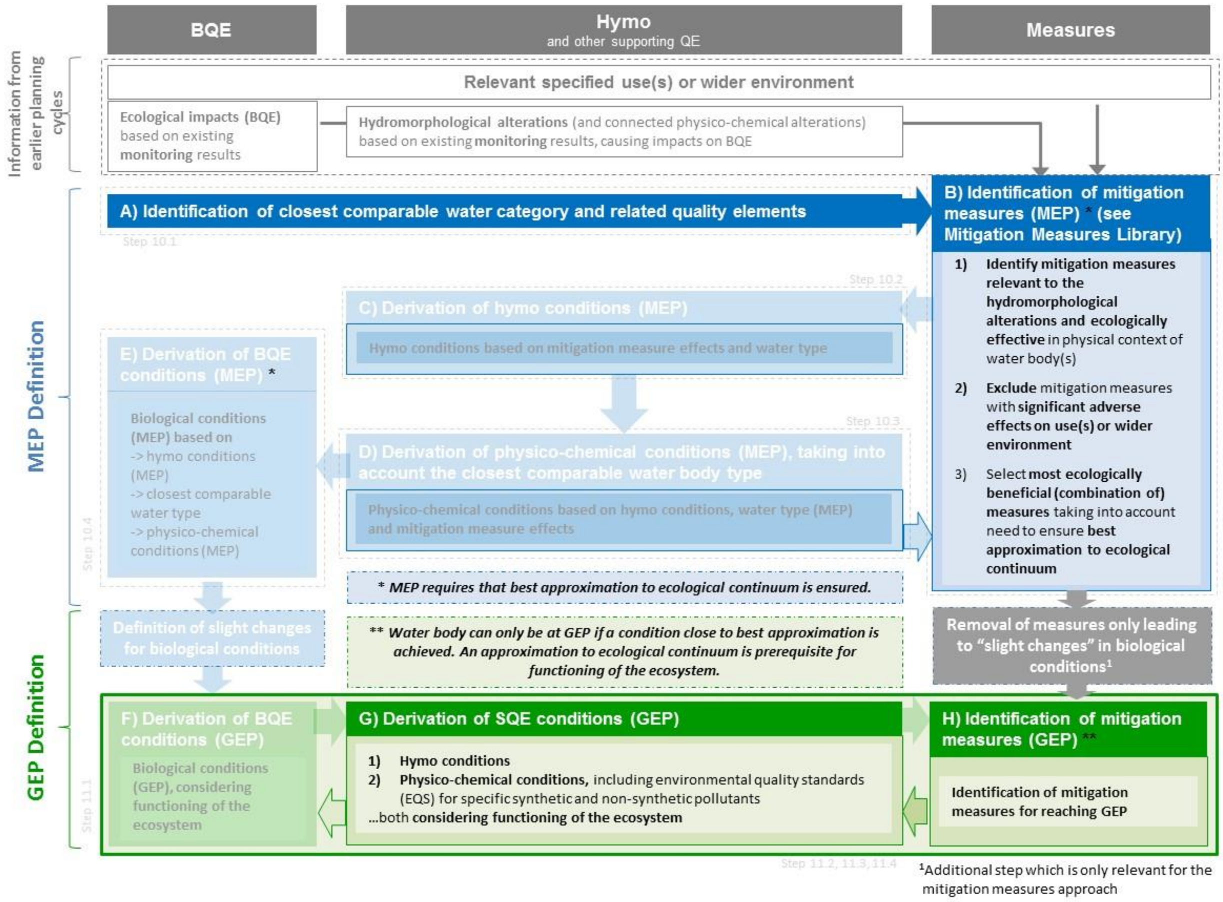
Member States following the mitigation measures approach for this cycle should complete steps E and F (derivation of biological conditions at MEP and GEP) as soon as sufficient data and better knowledge on the biological condition and/or the links between hydromorphology and biology become available. For a final decision on GEP definition, the mitigation measures approach depends on BQE assessment methods which are sensitive to hydromorphological alterations (for the verification of GEP and monitoring the ecological potential), but GEP definition can be undertaken on a preliminary or interim basis without such methods.[26] Thus, although the mitigation measures approach is an alternative route, it is not less ambitious as eventually all steps must be completed to be in line with the WFD.

It is noted that when there is lack of suitable biological assessment methods and/or data sensitive to modifications, the approach to the selection of mitigation measures should be more precautionary and more measures may need to be considered until there is sufficient evidence to exclude measures from MEP. Increased efforts are needed by Member States towards establishing appropriate biological monitoring and hydromorphology-sensitive methods for a more informed basis for the selection of mitigation measures.

The steps included in the step-wise approach follow the requirements of the WFD. If, in following the routes through the framework Figure 5, it is not possible to take all steps, suitable justification is therefore required in the relevant RBMP. Member States should make sure they can complete the remaining steps by improving data availability and knowledge on the links between hydromorphology and biology. In particular, improved monitoring data is crucial.

[26] As explained in section 6, if the classification of the ecological potential is not based on hydromorphology-sensitive biological assessment methods, the classification result in the RBMP should include the information that the confidence level is low.

Figure 7: Process with key steps for defining MEP and GEP showing the "route" of the mitigation measures approach



5.3.3 Overview of individual steps

The individual steps (steps A – H) of the step-wise process are briefly illustrated below, while the following sub-sections describe these steps in more detail:

Information from earlier planning cycles (pre-step): In this pre-step, information on the assessment of biological and hydromorphological impacts from the designation phase of HMWB and existing monitoring results are used to support the subsequent steps of defining MEP and GEP.

Step A (Identification of the closest comparable water category and related quality elements): This involves the identification of the most comparable water category (e.g. lake, river, transitional or coastal water) which should in general be derived from the original water category (i.e. prior to modification). If a change in category is necessary due to the modifications, the most comparable category should be chosen, e.g. for a reservoir created on a former river, the most comparable water category would be a lake.

Step B (Identification of relevant mitigation measures (MEP)). This involves the selection of mitigation measures for defining MEP. Measures should be ecologically effective, relevant to the water body and the modifications that have taken place, and ensure the best approximation of ecological continuum. The mitigation measures can be selected from a national or European mitigation measures library based on information about the water category and water body type, the nature of the physical modification, its effects on the hydromorphological (and physico-chemical) supporting elements and their effects on the BQEs. Mitigation measures that have significant adverse effects on use(s) or the wider environment are then excluded. Having excluded measures with significant adverse effects, it is necessary to identify the measure or combination of measures that delivers the best improvement, taking into account the need to ensure best approximation to ecological continuum.

Step C (Derivation of hydromorphological conditions for MEP): The derivation of hydromorphological conditions for MEP should be based on the hydromorphological conditions in the water body altered by the physical modifications linked to the use and a prediction of the effects of the set of mitigation measures (for MEP) on hydromorphological conditions. MEP hydromorphological conditions are impacted by physical modifications. The values for the biological and general physico-chemical quality elements at MEP depend on the MEP hydromorphological conditions. The hydromorphological conditions may resemble those of a different type compared to the natural water body type before the physical modification. Thus, the hydromorphological conditions defined for MEP can be used to identify or derive the closest comparable water body type, which is in particular relevant for defining the MEP conditions for biological quality elements and those physico-chemical parameters which are affected by the hydromorphological conditions.

Step D (Derivation of physico-chemical conditions for MEP, taking into account the closest comparable water body type): The physico-chemical conditions for MEP result, inter alia, from the hydromorphological conditions at MEP and a prediction of the effects of the mitigation measures (for MEP) on physico-chemical parameters, which is comparable to an assessment of the remaining impacts. The identification of the closest comparable water body type is a supportive tool in this context. For physico-chemical parameters, the closest comparable water body type is in general the original natural water body type prior to physical modification. For those physico-chemical parameters that are significantly modified by the hydromorphological alterations causing the heavily modified character, and that cannot be mitigated, other types should be considered (the closest comparable natural water body type, or combinations of water body types). Requirements for specific synthetic pollutants at MEP are the same as those for natural water bodies.

Step E (Derivation of BQE conditions for MEP): The derivation of biological quality element conditions for MEP is based on the identification of the closest comparable water type, the predicted hydromorphological and physico-chemical conditions (for MEP) and a prediction of the values for BQEs based on methods used for status assessment. When deriving BQE conditions for MEP, it is also critical to consider the WFD requirements concerning the best approximation of the ecological continuum.

Step F (Derivation of BQE conditions for GEP): Good ecological potential is defined in WFD Annex V 1.2.5 as an ecological state in which “there are slight changes in the values of the relevant biological quality elements as compared to the values found at maximum ecological potential”. With respect to “slight changes”, HMWB should follow the same principles as natural water bodies, with a functioning ecosystem being a prerequisite for a water body to be at GEP. Slight change cannot be equivalent to a complete/temporary absence or severe change of the biological quality elements relevant for the closest comparable water category and type (e.g. of fish for rivers within the fish zone). Slight changes to the biological quality elements have to be supported by corresponding conditions in the supporting quality elements (e.g. flow, habitats, continuity). With regard to ecological continuum, “slight change” means that a condition close to best approximation of ecological continuum should be ensured (instead of best approximation).

Step G (Derivation of supporting quality elements for GEP): The derivation of supporting quality elements (SQE) for GEP entails hydromorphological conditions and physico-chemical conditions. The hydromorphological conditions have to be consistent with the biological values set for GEP. For physico-chemical conditions, the same values should be met as for good ecological status of the original natural water body type, except if the parameter is impacted by the hydromorphological alteration having led to HMWB designation (e.g. changed water temperature due to hydropeaking).

Step H (Identification of mitigation measures (GEP)): The mitigation measures within GEP are those needed to achieve the derived biological conditions by improving conditions of relevant supporting elements for GEP. Following the mitigation measures approach, mitigation measures for GEP are obtained after removing, from the set of mitigation measures identified for MEP, any measures which only lead to slight changes in biological conditions (alone or in combination).

It is noted that Annex H to this document presents illustrative case studies which demonstrate how to apply the key steps of the flow-chart for defining MEP and GEP. The case studies follow either the reference-approach or the mitigation measures approach or both.

Please note that with step H in the flow-chart, the definition of GEP is concluded. After having defined GEP with corresponding GEP conditions for the biological and supporting quality elements, mitigation measures are to be implemented within the programme of measures and the relevant process is explained in section 6 of this document.

5.4 Detailed key steps for defining ecological potential in a comparable way

5.4.1 Information from earlier planning cycles (pre-step)

The process of defining MEP and GEP is closely related to the steps of the iterative process used to designate HMWB (either of existing HMWB designated in previous cycles or new HMWB designated in the current cycle). As a starting point, the following issues from the designation phase need to be taken into account for the water body:

- The identification of relevant specified uses/human activities or the wider environment which would be significantly adversely affected by measures to achieve GES and are thus reasons for the designation.
- The assessment of the main ecological impacts based on the BQEs, which is based on existing monitoring results (from earlier planning cycles) (see Box 5 below). The assessment of biological impacts takes into account measures already taken in the previous planning cycle(s).
- The identification of key hydromorphological alterations (and related physico-chemical alterations) that cause impacts on the BQEs, taking into account the water type. This assessment is also based on existing monitoring results from earlier planning cycles.
- Information from monitoring on which quality elements fail good status is important for a more targeted selection of mitigation measures in the later process of defining MEP and GEP. Information on the conditions of the quality elements should already exist from the earlier operational monitoring prior to designation of the water body as HMWB, as the prerequisite for HMWB designation is that the water body fails good status due to hydromorphological alterations.
- In this context, the water body type based on national typology should be considered, as this is important for the selection of mitigation measures in the first steps of defining MEP and GEP.

It is noted that the assessments of hydromorphological impacts and biological impacts may be further refined within the process of GEP definition, using the relevant assessments that were carried out in the designation phase as a starting point.

Box 5: Monitoring results from earlier planning cycles

The requirements of the WFD with regards to monitoring are mainly set out in Article 8, Annex II and Annex V. As for natural water bodies, biological, hydromorphological and physico-chemical quality elements and chemical status for HMWB must be monitored. This means that the monitoring programmes for HMWB must follow the same monitoring requirements as for the natural water bodies. CIS Guidance Document No.7 "Monitoring under the Water Framework Directive" gives in-depth guidance regarding these monitoring requirements. The establishment of an appropriate monitoring programme, including monitoring of hydromorphological quality elements, is key as an information basis for the initial designation of HMWB and for reviewing the designation of HMWB in subsequent planning cycles. Part of the designation process is to assess whether or not the water body fails good status due to hydromorphological alterations and therefore should be designated as HMWB; this is done by applying the targeted (to hydromorphological problems) methods used in **operational monitoring**. For a water body that was designated as HMWB in a previous cycle, the operational monitoring gives evidence on whether or not the water body is at GES and if it still qualifies as a HMWB. If the operational monitoring shows that conditions have improved so much that the water body reaches GES, the water body is de-designated as HMWB and has to be treated as a natural water body. If the water body is not in GES and GES cannot be reached, the environmental objective may be good ecological potential (GEP) (if the requirements of WFD Art. 4(3) are fulfilled) and the procedure for defining MEP and GEP should be followed (i.e. GEP should be re-assessed). When selecting sites for operational monitoring of water bodies designated as HMWB, it is recommended to focus on how and where it is best to monitor the impact resulting from the water body being substantially changed in character.

!	**Reference approach ←→ Mitigation measures approach** The pre-step using information from earlier planning cycles is used under both the reference approach and the mitigation measures approach.

5.4.2 Identification of the closest comparable water category and related quality elements (Step A)

According to WFD Annex V 1.1.5, "the quality elements applicable to artificial and heavily modified surface water bodies shall be those applicable to whichever of the four natural surface water categories (above) most closely resembles the heavily modified or artificial water body concerned".

In general, the closest comparable water category should only be different from the original water category if this is necessary due to the modifications, e.g. for a reservoir created on a former river, the closest comparable water category would be a lake. The following are the most common situations for the identification of the closest comparable water category:

a) A river remains a river category

b) A river resembling a lake category[27]

c) A lake remains a lake category[28]

d) A transitional water body remains a transitional water body category

e) A transitional water body resembling a lake category

f) A coastal water body remains a coastal water body category

g) A coastal water body resembling a transitional water category (e.g. if a lagoon is formed)

5.4.3 Is the closest comparable water category for HMWB always clear?

For coastal and transitional waters, the closest comparable water category it is usually clear. For rivers and lakes (reservoirs), it may be less clear, as for instance some water bodies used for water storage may be in the transition between river and lake-type aquatic ecosystems. A relatively clear case is when a river has been dammed to create a large reservoir. In such a case, there is a change in category and the water body is a heavily modified river that resembles a lake. The biological quality elements (e.g. fish) which have to be taken into account when deriving MEP and GEP therefore have to be those of a lake. However, conditions in impounded rivers may range from very close to river conditions (e.g. with high flow velocities and the same quantity of flow upstream and downstream of the impoundment, indicating a short residence time) to more still water conditions (e.g. with significantly reduced flow velocities and long residence times) resembling lake-like ecosystems.

In case of river water bodies used for water storage that are in transition between river and more lake-type aquatic ecosystems (e.g. large impoundments with permanent flow and a short residence time of a few days), it needs to be decided whether a river or a lake is used as closest comparable water category. Where conditions are in-between clearly defined water categories, both categories should be considered in the process of defining MEP and GEP. For example, if a river is chosen as the closest comparable water category, lake measures and habitats as well as quality elements, species and assessment methods also need to be considered. Conversely, if a lake is chosen as the closest comparable water category, river measures (e.g. measures for improving continuity, by-pass channels, etc.) and habitats as well as quality elements, species and assessment methods should be considered, too. In such cases, it might even be appropriate to use different categories depending on quality elements. For example, a hydromorphological assessment method for lakes could be most suitable describing the hydromorphological conditions at MEP and GEP, while biological quality elements could be assessed with river methods (e.g. for fish) with the highest confidence.

[27] Including cases of several brooks which have become one large lake reservoir.
[28] Including cases of small lakes which have become one large reservoir.

> **!** **Reference approach ←→ Mitigation measures approach**
>
> Step A is identical for both the reference approach and the mitigation measures approach.

5.4.4 Identification of relevant mitigation measures (MEP) (Step B)

The mitigation measures for defining MEP should be a selection of measures which are relevant to each of the hydromorphological alterations, ecologically effective **and** which alone or in combination ensure the best approximation of ecological continuum.

The identification of mitigation measures for MEP involves three sub-steps:

- Identify mitigation measures relevant to each of the hydromorphological alterations and ecologically effective in the physical context of the water body or water bodies (step B1)
- Exclude or redesign restoration measures that have a significant adverse effect on use or the wider environment (step B2)
- Select the most ecologically beneficial (combination of) measures addressing all hydromorphological alterations, taking into account the need to ensure the best approximation of ecological continuum (step B3)

In summary, the (potentially relevant) mitigation measures can be excluded from MEP (and GEP) due to the following reasons:

1. The mitigation measure is **not relevant** for the type of water body, hydromorphological alterations or impacts causing failure in achieving good status (see section 5.4.4.1).
2. The mitigation measure is **not ecologically effective** or does not give sufficient ecological benefits in the physical context of the water body or water bodies, e.g. lack of spawning habitat upstream (see section 5.4.4.1).
3. The mitigation measure has **significant adverse effects** on use(s) or the wider environment (see section 5.4.4.2).

The following paragraphs explains in more detail the sub-steps (B1, B2 and B3) which need to be taken into account to define the set of mitigation measures for deriving MEP conditions.

> **!** **Reference approach ←→ Mitigation measures approach**
>
> Step B is identical for both the reference approach and the mitigation measures approach.

5.4.4.1 Identify mitigation measures relevant to each of the hydromorphological alterations and ecologically effective in the physical context of the water body or water bodies (Sub-step B1)

The first step identifies the mitigation measures that are relevant to the type of hydromorphological alterations or impacts causing failure in achieving good status.

The relevant mitigation measures can be selected from a national or European **mitigation measures library** based on information about the water category and water body type, the nature of the physical modification, its effects on the hydromorphological (and physico-chemical) supporting elements and their effects on the BQEs.

The **"GEP_mitigation_measures_library.xlsx"** (https://ec.europa.eu/environment/water/water-framework/facts_figures/guidance_docs_en.htm) is a supporting tool to this document and presents a European library of mitigation measures for use in defining MEP and GEP. This mitigation measures library is structured in distinct tables for different water categories (rivers, lakes/reservoirs, transitional/coastal waters) (see overview of key elements in Table 6). Please note that due to the Europe-wide nature of this library, it was not possible to produce fully comprehensive lists and some of the physical modifications or mitigation measures that are considered in the Member States may not be included. The library of mitigation measures is a living document and updates will be provided at regular intervals.

Table 6: Overview of key elements included in European library of mitigation measures for rivers, lakes/reservoirs and transitional/coastal waters to be considered in the stepwise approach for defining the ecological potential of HMWBs

Elements in library / Water categories	Rivers	Lakes/reservoirs	Transitional/coastal
Uses	Navigation; ports Flood protection Hydropower Water supply Recreation Drainage Urbanisation		Navigation; ports Recreation; marinas; infrastructure Urbanisation including industry Flood protection Energy (renewables, oil and gas, associated infrastructure) Fishing activity; fish farms; aquaculture
Existing physical modification	List of physical modifications of rivers, e.g. Dam, weir, barrage or other transversal structure Channel straightening Embankments, dykes	List of physical modifications of lakes/reservoirs, e.g. Shore fixation or modification Physical modifications caused by maintenance activities (e.g. sediment dredging) Deepening of lake by excavation	List of physical modifications of transitional/coastal waters, e.g. Dredged for navigation, flood conveyance Aggregate extraction Breakwater, groynes, jetties, piers

Elements in library / Water categories	Rivers	Lakes/reservoirs	Transitional/coastal
Potential for direct or indirect effect on hydromorphological supporting elements at water body scale *[++] always or usually* *[+] sometimes* *[o] rarely or never*	Hydrology: quantity and dynamics of flow Hydrology: connection to groundwaters River continuity Morphology: river width and depth Morphology: river bed structure, substrate Morphology: riparian zone structure	Hydrology: quantity and dynamics of flow Hydrological regime: residence time Hydrology: connection to groundwaters Morphology: depth Morphology: quantity, structure, substrate of bed Morphology: structure of shore	Morphology: depth variation Morphology: bed structure, substrate Morphology: intertidal zone structure Tidal regime: freshwater flow (only transitional water bodies) Tidal regime: dominant currents direction (only coastal water bodies) Tidal regime: wave exposure
Potential for direct or indirect effect on physico-chemical supporting elements at water body scale *[++] always or usually* *[+] sometimes* *[o] rarely or never*	Thermal conditions Oxygenation Salinity Acidification Nutrient conditions Specific pollutants	Transparency Thermal conditions Oxygenation Salinity Nutrient conditions Specific pollutants	Transparency Thermal conditions Oxygenation Salinity Nutrient conditions Specific pollutants
Likelihood of effect on BQEs *[++] strong or moderate likelihood* *[+] low likelihood*	Phytoplankton Macrophytes and phytobenthos Benthic invertebrate fauna Fish fauna		Phytoplankton Macroalgae (seaweeds) Angiosperms (seagrass, saltmarsh) Benthic invertebrate fauna Fish (only transitional water bodies)
Overview of typical impacts on original ecology	Short descriptions provided per physical modification		
Relevance of typical mitigation measures* *[++] always or usually* *[+] sometimes* *[o] rarely or never*	List of typical mitigation measures, e.g. Fish migration aids Environmental flow Increase habitat diversity Sediment management	List of typical mitigation measures, e.g. Ecological/environmental friendly water level regulation practice Enhancement of shore/shallow habitats Creation of secondary habitats Removal/replacement of shore fixation	List of typical mitigation measures, e.g. Improve morphological and/or habitat diversity of seabed Intertidal habitat restoration, enhancement or creation Beach or foreshore replenishment

** The typical mitigation measures are groups of measures, each of which includes specific practical measures. Examples for these specific practical measures are given in additional supporting tables in mitigation measures library.*

The mitigation measures library promotes the following approach to the identification of mitigation measures for the definition of ecological potential and delivering improvements in the biological and supporting quality elements of HMWB:

i) Confirm the specific nature of the physical modification (pressure)
ii) Understand which hydromorphological supporting elements have been directly or indirectly changed (adversely affected) as a result of the modification, and how they have been affected (state)
iii) Consider whether any physico-chemical supporting elements have been adversely affected (either directly by the modification, or indirectly as a result of changes to the hydromorphological character of the water body) (state)
iv) Establish which biological quality elements have been adversely affected and how, including any wider implications for ecological functioning and/or for ecosystem goods and services (impact)
v) Identify the range of typical and modification-specific mitigation measures that may contribute, alone or in-combination, to an improvement in the conditions of the water body (response)
vi) Evaluate possible mitigation measures to define MEP and GEP

Stages i – v are supported by the relevant spreadsheet tables in the mitigation measures library. Reference to these tables ensures an overarching approach to the selection of mitigation measures, depending on the nature of physical modifications. Stage vi on the evaluation of possible mitigation measures to define MEP and GEP is discussed in the following sections on sub-steps B2 and B3, concerning the assessment of significant adverse effects and the selection of most ecologically beneficial (combinations of) measures.

The paragraphs below describe the different elements included in the library tables and how the library can be used as a tool for selecting mitigation measures for MEP and GEP definition as well as for the identification of measures for implementation.

i) Specific nature of existing physical modification (pressures)

The starting point when using the mitigation measures library is to confirm the specific nature of the physical modification (pressure) for which a HMWB was designated or of the modification that is otherwise affecting the ability of the water body or water bodies to meet WFD objectives. All physical modifications in the mitigation measures library might be relevant reasons for designation of a water body as HMWB. In most if not all cases, it is the type of physical modification rather than the use *per se* that affects the hydromorphological character of the water body.

Example: An impounding structure might be required to support use for water supply or navigation; a water body might be straightened and deepened for agricultural drainage, navigation or flood conveyance purposes; or embankments might be constructed or raised to meet flood defence or water storage needs. The effects from such pressures on the WFD hydromorphological supporting elements and hence on the biological quality elements will be determined by the particular nature of the modification. Two examples to illustrate this point in river water bodies are provided in

Box 6 below.

Box 6: Examples of generic physical modifications to water body hydromorphological and biological quality elements

An impounding structure on a river typically affects continuity for biota and sediment. One of the most important effects is the reduction of flow velocity, which is directly related to a change in sediment composition and bed structure. Benthic invertebrates are highly sensitive to impact by those alterations, but fish are also significantly affected (e.g. by a reduction of habitats or by the transversal structure which functions as a migration barrier) and macrophyte communities are severely impacted (e.g. by reduction of flow velocity that causes changes in abundance and occurrence of species with different growth forms).

Riparian zone structure and depth are also affected by an impounding structure with a reduced flow velocity, and there may be indirect implications for certain physico-chemical supporting elements (e.g. a higher temperature caused by reduced flow velocity and reduced shading). As a consequence of these changes in hydromorphology the ability of the water body to meet its ecological objective of GES will be compromised.

Deepening also changes the hydromorphological characteristics of a water body, in this case particularly affecting depth variation and bed structure., However, there may also be implications for other hydromorphological supporting elements. Such modifications to the character of the bed of the water body typically lead to changes in benthic invertebrate fauna and phytobenthos as well as in macrophyte and fish communities.

The mitigation measures required to improve the ecological conditions of a water body are not specifically related to the use for which the water body is designated. Rather, mitigation measures should ideally aim to reduce or rectify the changes in hydromorphological character such that the natural recovery of the affected BQEs is promoted. If this is not possible, mitigation measures should aim to replicate ecological function through other means. Box 7: Examples of common mitigation measures irrespective of use below provides two examples of how mitigation measures relate to the nature of the modification rather than the use of the water body. The existing physical modifications in a HMWB determine which checklists of measures are applicable for MEP definition.

Box 7: Examples of common mitigation measures irrespective of use

Irrespective of the use for which a particular water body is designated, if an impounding structure has prevented the upstream and downstream movement of fish, the installation of a fish pass/fish migration aid may be required. Measures to improve flow of both water (e.g. e-flows) and sediments (e.g. sediment bypassing) might also be needed, along with measures to enhance riparian or benthic habitats and their diversity. In certain situations it will also be relevant to establish whether the operation of the structure (e.g. a sluice or lock) can be modified or managed so as to reduce the effects of the impoundment and improve ecological conditions.

Similarly, whether a water body has been embanked to improve flood protection or to accommodate navigation or agricultural use is less important when considering possible mitigation measures than the nature of the hydromorphological alteration. In all cases, if benthic invertebrates, fish or aquatic flora have been detrimentally affected by the construction of the embankments, the use of soft (e.g. vegetation, natural stone) rather than hard (e.g. concrete) engineering will need to be considered along with opportunities for habitat creation or enhancement elsewhere in the water body (e.g. in backwaters or by setting back the defences). Depending on the particular circumstances, re-profiling the embankments or sediment management measures such as sediment supplementation might also be explored.

In many cases, a water body may have been physically modified in a number of ways by more than one use. For example, it may have been straightened and also deepened (e.g. for navigation), or a dam (impounding structure) might also be associated with hydropeaking from a hydropower plant, resulting in multiple pressures (Table 7). If this is the case, the single uses and/or pressures should be identified based on the tables separately prior to being combined.

In using the tables of the mitigation measures library, it should be noted that the descriptions in the column headed 'Specific nature of existing physical modification' are not intended to be comprehensive. Rather, they represent the most common types of physical interventions that (broadly) impact on the water body in a characteristic way. For example:

- steel sheet piling used to create a hard water's edge in an urban landscape, masonry walls in old harbour areas, and wooden piling installed to prevent erosion or for flood defence all share the same characteristics in that they create a vertical face at the water's edge, and
- dams, sluices, weirs, barriers and barrages are all transversal structures that usually interrupt flow and interfere with continuity (especially in rivers) or potentially impact on wave exposure (in transitional or coastal water bodies).

Table 7: Example from mitigation measures library on TraC: Uses and physical modifications

DRIVER						**PRESSURE**
Uses						***Specific nature of existing physical modification***
Navigation; ports	Recreation; marinas; infrastructure	Urbanisation including industry	Flood protection	Energy (renewables, oil and gas, associated infrastructure)	Fishing activity; fish farms; aquaculture	*See list below*
+	+	+	+			Dredged for navigation, flood conveyance

ii-iii) Effects on hydromorphological or physico-chemical supporting elements (state)

The next stage is to understand how the state of the water body or water bodies has been affected by the physical modification. This is achieved by identifying the WFD hydromorphological (and, where relevant, physico-chemical[29]) supporting elements that have been directly or indirectly changed or otherwise impacted as a result of the modification(s).

The tables of the mitigation measures library use typical situations (Table 8). For both hydromorphology and the physico-chemical supporting elements, they indicate how typical it is for each element to be directly or indirectly affected by the particular type of physical modification at the water body scale. They illustrate this by differentiating between effects that are 'always or usually' experienced; those that are 'sometimes' experienced; and those that are 'rarely or never' experienced.

In addition to illustrating how this stage could be undertaken in the absence of an established national practice or procedure, the typical situations presented on the tables of the mitigation measures library might also be useful in situations where there are no detailed hydromorphological or physico-chemical data about the water body or water bodies in question. In most cases, however, Member States will have relevant and detailed information, e.g. obtained during the classification exercise or more recent WFD monitoring. Where such locally relevant data exist, the actual effects on the water body (or group of similar water bodies) should be confirmed by identifying the hydromorphological and physico-chemical supporting elements that are at less than good status (potential) or that are otherwise compromised in some way by the physical modification.

Finally, whichever method is used to establish the effects of the modification on the WFD supporting elements, there are likely to be some considerations linked to particular sites or certain elements that are too specific to be considered in the general context of this document. For example:

- when establishing whether quantity or dynamics of flow has been affected by the modification, it is important to consider and if necessary differentiate between the effects on quantity and the effects on flow dynamics
- indirect effects can sometimes be more important than direct ones (e.g. downstream bed erosion can be a significant indirect effect if a structure interferes with sediment transport)
- oversaturation of nitrogen that may lead to diving disease for fish downstream of the tailrace of high-head hydropower plants
- temperature alterations such as cooler water during summer (resulting in decreased fish growth) and warmer water during winter (resulting in increased metabolism, fish mortality, and a lack of ice cover in alpine rivers).

[29] Changes in physico-chemical supporting elements are only relevant in the context of identifying MEP and GEP mitigation measures if the change is caused by or associated with the identified changes in hydromorphology. If, for example, a change in the concentration of nutrient compounds or impacts (e.g. increased eutrophication effect) results from the impoundment of water behind a dam, this is a relevant consideration, but if a change in nutrient concentrations is the result of an increased discharge into the water body, this is an issue to be dealt with in the WFD Programme of Measures, not through GEP mitigation measures.

Table 8: Example from mitigation measures library on TraC: Physical modifications and effects on hydromorphological or physico-chemical supporting elements

PRESSURE	STATE (hydromorphological, physico-chemical alteration)											
Specific nature of existing physical modification	*Potential for direct or indirect effect on hydromorphological supporting elements at water body scale [++] always or usually [+] sometimes [o] rarely or never*						*Potential for direct or indirect effect on physico-chemical supporting elements at water body scale [++] always or usually [+] sometimes [o] rarely or never*					
See list below	Morphology: depth variation	Morphology: bed structure, substrate	Morphology: intertidal zone structure	Tidal regime: freshwater flow (only transitional water bodies)	Tidal regime: dominant currents direction (only coastal water bodies)	Tidal regime: wave exposure	Transparency	Thermal conditions	Oxygenation	Salinity	Nutrient conditions	Specific pollutants
Dredged for navigation, flood conveyance	++	++	+	+	+	+	o	+	+	+	+	o

iv) Effects on BQEs (impact)

The tables of the mitigation measures library also present 'typical' effects (impacts) on the biological quality elements (Table 9). In this case, however, the likelihood of the identified changes in the hydromorphological or physico-chemical elements resulting in direct or indirect detrimental effects on each of the BQEs is identified as being 'strong or moderate' or 'low'. In addition to considering each BQE, the tables provide a brief narrative, summarising the typical impacts on the original (pre-modification) ecology. This is relevant insofar as it highlights some of the more potentially complex interrelationships and/or on the ability of the system to sustain the provision of ecosystem goods and services.

The way in which hydromorphological alterations (and, where relevant, associated alterations in physico-chemical supporting elements) have affected the BQEs in the HMWB will often be evident from classification or monitoring evidence. The typical effects listed in the tables in the mitigation measures library should therefore be checked against the collated (monitoring-based) evidence and the significance of the measured effect in each case should be quantified or recorded accordingly.

Overall, the generic nature of the tables in the mitigation measures library needs to be taken into account, noting that it will always be necessary to understand the scale of the effect and hence its significance in the context of the particular water body.

In cases where no detailed data are available or where there are data gaps, the typical impacts identified in the mitigation measures library tables will provide an insight into how the pressure may have affected the pre-modification ecology, in turn enabling the likely need for mitigation measures to define MEP and GEP and to achieve GEP to be considered. It should be recognized, however, that such generalisations may not be reliable in all site-specific circumstances.

Table 9: Example from mitigation measures library on TraC: Physical modifications, effects on hydromorphological or physico-chemical supporting elements and effects on BQEs

PRESSURE	STATE (hydromorphological, physico-chemical alteration)												IMPACT				
Specific nature of existing physical modification	*Potential for direct or indirect effect on hydromorphological supporting elements at water body scale [++] always or usually [+] sometimes [o] rarely or never*						*Potential for direct or indirect effect on physico-chemical supporting elements at water body scale [++] always or usually [+] sometimes [o] rarely or never*						*Likelihood of effect on BQEs [++] strong or moderate likelihood [+] low likelihood*				
See list below	Morphology: depth variation	Morphology: bed structure, substrate	Morphology: intertidal zone structure	Tidal regime: freshwater flow (only transitional water bodies)	Tidal regime: dominant currents direction (only coastal water bodies)	Tidal regime: wave exposure	Transparency	Thermal conditions	Oxygenation	Salinity	Nutrient conditions	Specific pollutants	Phytoplankton	Macroalgae (seaweeds)	Angiosperms (seagrass, saltmarsh)	Benthic invertebrate fauna	Fish (only transitional water bodies)
Dredged for navigation, flood conveyance	++	++	+	+	+	+	o	+	+	+	+	o	+	++	++	++	++

v) Potentially relevant measures (response)

Once the nature of the modification (pressure), the effects on supporting elements (state), and the implications for the BQEs (impacts) are essentially understood, a list of potentially appropriate mitigation measures for MEP and GEP definition and achievement of GEP should be developed.

The tables in the mitigation measures library include key groups of mitigation measures. These are expected to be considered during MEP and GEP definition in order to address certain modifications, in the absence of good reasons for excluding the measures. Whereas some mitigation measures are useful only to address a particular type of impact (e.g. meandering would usually only be considered if a water body has been straightened or canalised), others are more widely applicable. For each water category, a number of good practice measures have been confirmed in technical reports and workshops carried out in the context of the Common Implementation Strategy[30] as being potentially suitable to

[30] Halleraker et al, Working Group ECOSTAT report on common understanding of using mitigation measures for reaching Good Ecological Potential for heavily modified water bodies - Part 1: Impacted by water storage; EUR 28413; doi:10.2760/649695.
- Vartia et al, WG ECOSTAT report on common understanding of using mitigation measures for reaching Good Ecological Potential for Heavily Modified Water Bodies, EUR 29132 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-80305-5, doi:10.2760/444293, JRC110959.
- Bussettini et al, Working Group ECOSTAT report on common understanding of using mitigation measures for reaching Good Ecological Potential for heavily modified water bodies - Part 2: Impacted by flood protection structures, EUR 29131 EN; Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-80290-4, doi:10.2760/875939, JRC110957
- Workshop report, Workshop on mitigation measures and GEP for Inland Navigation water use, 29th – 30th June 2017, Brussels.

mitigate a wide range of impacts. Habitat enhancement and sediment management are two such generic measures. The mitigation measures in the European library represent emerging good practice, especially for rivers and TraC waters. However, the library content on mitigation measures for lakes will need to be improved and updated based on further discussions in the future.

For each characteristic physical modification type, the tables of the mitigation measures library highlight the typical relevance of these commonly used measure groups and indicate whether the measure group is 'always/usually', 'sometimes' or 'rarely/never' considered for use to mitigate the effects of the modification type in question (Table 10).

Table 10: Example from mitigation measures library on TraC: Physical modifications and potentially relevant mitigation measures (key measure groups)

PRESSURE	**RESPONSE**											
Specific nature of existing physical modification	***Relevance of typical mitigation measures * [++] always or usually [+] sometimes [o] rarely or never***											
See list below	Improve morphological and/or habitat diversity of seabed	Intertidal habitat restoration, enhancement or creation	Beach or foreshore replenishment	Sediment management	Beneficial use of dredged material	Modification or management of operations or structures e.g. sluices, vessel traffic	Soft engineering solutions; use of vegetation	Realign to mitigate effects on flow	Reprofile embankments, structures	Fish pass	Seasonal or tidal constraints on activity	Selection of methods or equipment
Dredged for navigation, flood conveyance	++	+	o	++	o	++	++	+	o	o	o	o

Additional supporting tables in the library elaborate on these commonly used measure groups and provide examples of specific practical measures which are included in the measure groups (

Table 11). Experts working on the definition of ecological potential should be familiar with the broad range of different measures included in the measure groups. The mitigation measures library provided as a supporting tool to this document helps increase understanding of the breadth of available measures. Member States should therefore consider a wide range of potentially available measures to deliver the needed ecological improvements.

Table 11: Example from mitigation measures library on TraC: Examples of specific measures for selected key measure groups

Key groups of measures	**Examples of specific measures**

Improve morphological and/or habitat diversity of seabed	- Placement of rocks, artificial reefs etc. to form reef and/or other types of habitats for BQEs - Use breakwaters or groynes or shore parallel islands to create local variations in depth, exposure/shelter, etc. - Local deepening by dredging or excavation where sustainable
Intertidal habitat restoration, enhancement or creation	- Habitat rehabilitation - Managed realignment to new line - Re-open polders; setback (to higher ground; to existing secondary defence line) - Step back (create intertidal shelf against vertical wall) - Planter baskets; other planting initiatives - Improve creek or backwater habitats - Use breakwaters, shore parallel islands or similar to create sheltered conditions promoting intertidal enhancement - Offsetting measures e.g. spawning habitat for fish

For both the measure groups and the specific measures in each group, it is important to understand that the lists provided in the library are not intended to be comprehensive. Rather, these measures are intended to provide ideas and inspiration. Many Member States have their own mitigation measure libraries and these should also be referred to in determining whether alternative or more locally appropriate options exist that would deliver a similar outcome in terms of ecological improvement and definition of ecological potential. The European library of mitigation measures can support and supplement national mitigation measure libraries if such exist, and can support the development of new national libraries, if none exist in certain Member States so far.

In selecting potential mitigation measures, measures should be selected which are relevant to the hydromorphological alterations and ecologically effective in the context of the specific water body or water bodies . Box 8: below describes in more detail the meaning of “relevant” and “ecologically effective” mitigation measures.

Box 8: Selection of relevant and ecologically effective mitigation measures

The selection of potential mitigation measures, which are **relevant** to the hydromorphological alterations and **ecologically effective** in the context of the specific water body or water bodies should take into account the following:

- The natural hydromorphological and physicochemical characteristics of the water body
- Other water body or water bodies characteristics relevant to the biota, e.g. is the modification within or outside the fish zone, fish community types, sediment (e.g. coarse, fine) and habitats (e.g. river types)
- Whether measure is appropriate for addressing the existing ecological impacts and can deliver a proven ecological benefit. In this sense, measures that are not likely to deliver an ecological benefit should not be considered.

Example: The reconnection of side-arms is typically a relevant mitigation measure for restoring ecological continuum in rivers. However, if no side-arms exist to be “reconnected” in a specific HMWB, the measure is not relevant in the context that water body.

Example: Connectivity is typically relevant for all migrating biota, for the concerned water body as well as for water bodies upstream or downstream. If there is no significant ecological benefit from measures which restore continuity (e.g. due to a very short river reach within the fish zone upstream, or the connection of different river basins leading to dispersal of invasive species), continuity measures can be excluded from the selection of potential mitigation measures for MEP.

The selection of mitigation measures that are both relevant to the particular hydromorphological alterations and ecologically effective in the context of the specific water body or water bodies should not be confused with the justification of “technical feasibility” under WFD Article 4(4) and of “infeasible achievement” under WFD Article 4(5) (exemptions).

In addition, it may also be appropriate to consider inter-water body parameters and processes, when selecting potentially relevant mitigation measures. Specifically, if the effect that requires mitigation directly or indirectly[31] involves or affects fish migration, sediment transport or similar ecological or hydromorphological processes that operate beyond the water body boundary, the selection of measures should take into account the need to sustain and/or improve these processes.

Example: Measures for fish continuity may be selected whilst defining MEP and GEP in a river water body, because they are needed to reconnect upstream water bodies.

Example: Insofar as sediment is concerned, if the enhancement of a coastal fish nursery area requires a supply of sediment, it may be preferable to modify an updrift breakwater to facilitate the natural, long term movement of sediment from along the coast rather than extracting and transporting material from a source downdrift.

In practice, this means that when using the mitigation measures library, in some cases, it may be necessary to select mitigation measures that are not directly linked to the physical modifications in the particular HMWB or are even related to the list of measures for another water category in the library.

Example: In the case of a reservoir as illustrated in Figure 8, a former river section (now a reservoir) is designated as a river HMWB but is shaped more like a lake. However, the river reaches (natural water bodies) upstream and downstream also need to be taken into account when designating HMWB and defining MEP and GEP for the HMWB, based on the condition before the physical modification (natural river types).[32] Additional measures to allow the upstream and downstream river sections to achieve their objectives might be needed, as ecological continuum (e.g. possibility to migrate) also has to be ensured for the type-specific fish species of the downstream and upstream natural water bodies. In this context, it is relevant to take the requirements of WFD Article 4(8) into account.[33] It is also assumed that water bodies have been properly delineated in line with CIS Guidance Document No.2 on the identification of

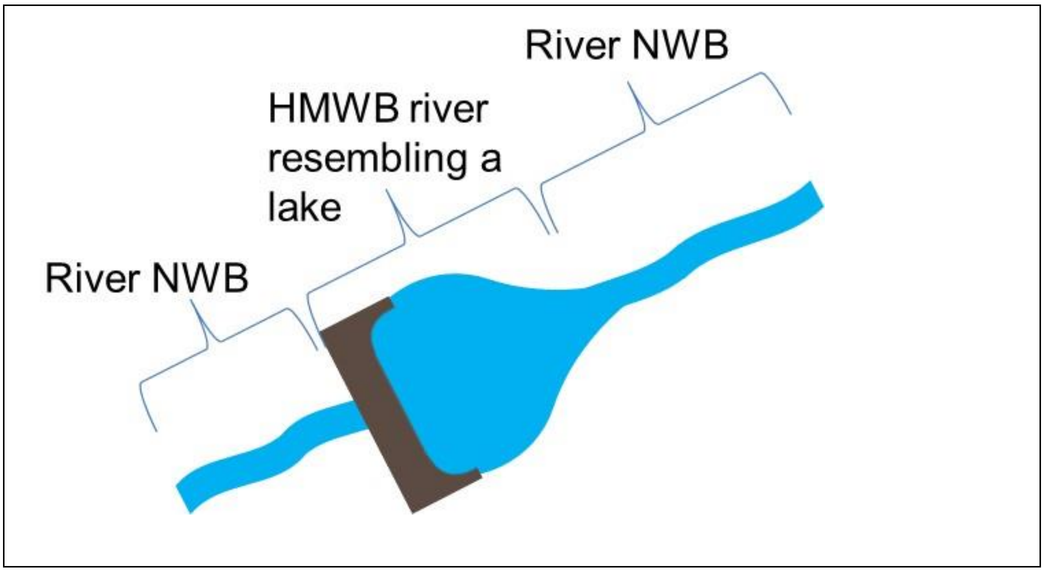
[31] Direct effects may result from the construction of a barrier or the physical removal of habitat through dredging. Indirect effects on habitats can be experienced as a result of a change in hydromorphological processes – for example deepening or widening can increase or reduce flow velocities, in turn making the environment less suitable for certain species or changing patterns of sediment accretion or erosion, indirectly changing the habitat type locally.

[32] Workshop on GEP inter-comparison case studies on water storage, 13- 14 February 2017 – Vienna, Summary Report.

[33] Article 4(8) specifies that when applying Article 4(3), “a Member State shall ensure that the application does not permanently exclude or compromise the achievement of the objectives of this Directive in other bodies of water within the same river basin district and is consistent with the implementation of other Community environmental legislation.”

water bodies. For example, if this guidance is followed, a reservoir cannot include longer free flowing river sections, except for small stretches (e.g. up to 1 km). Therefore, there should not be a mixture of different water categories in a single HMWB.

Figure 8: Change of river into lake and links to upstream/downstream river sections



Notes: NWB=natural water body. The river water bodies upstream/downstream might also be HMWB but separate water bodies.

Differentiation between measures for defining MEP/GEP and (restoration) measures for achieving GES

The measures considered as potential MEP/GEP mitigation measures in designated HMWBs will be largely the same as restoration measures potentially contributing to GES and addressing the effects of hydromorphological pressures. However, the GES objective of restoring natural hydromorphological processes has already been rejected in the designation phase, on the basis that this would adversely affect the existing use and/or the wider environment of the water body. Therefore, full restoration measures (e.g. involving the removal of a dam, flood defence, breakwater, etc. to facilitate reinstatement of natural processes) do not need to be considered as mitigation measures for GEP. Rather, the full range of measures that aim to restore the natural hydromorphological processes wherever possible and/or to restore the ecological function insofar as this can be achieved in relation to the closest comparable water category and type will need to be considered.

Example: In the example of an impoundment (change of a riverine condition to a more stagnant one), measures such as the construction of bypass channels with riverine character, creation of habitats at the head area of the impoundment etc. (or their combinations) could significantly improve the situation but would not completely reach the riverine conditions needed for achieving GES.

Furthermore, in many cases, the intensity/level of ambition of a measure and the combination of measures may be crucial for distinguishing between measures for achieving GES and measures for defining and achieving GEP.

Example: In the case of measures related to flow, while the achievement of GES is related to a set of environmental standards for ecological flow (restoring flow), the achievement of GEP is related to fewer flow components (mitigating flow) than those required to meet environmental standards. Therefore, the selection of the mitigation measure of additional flow for GEP will depend on the amount of flow available; some water can also be required for the achievement of GEP to support improvements in biological terms (GEP flow).

Initial list of potential mitigation measures for further evaluation

In the absence of an existing national library of measures and a methodology for their identification and review, it is recommended that the typical and modification-specific measures in the tables of the European mitigation measures library are assessed to determine whether each measure, alone or in combination with other measures, might contribute to an improvement in the ecological conditions of the water bodies being assessed.

This process will lead to the identification of an initial list of potential mitigation measures to be subject to further, more detailed, evaluation under the following steps, enabling the MEP/GEP objectives to be defined.

5.4.4.2 Exclude or redesign measures that have a significant adverse effect on use or wider environment (Sub-step B2)

The next step after creating an initial list of mitigation measures for MEP is to exclude measures that have significant adverse effects on use(s) or the wider environment. According to CIS Guidance Document No.4, MEP represents the maximum ecological quality that could be achieved for a HMWB once all mitigation measures that do not have significant adverse effects on use or on the wider environment have been applied.

The reasons and criteria for judging the significance of effects should be made clear in a transparent way, and decisions on when such adverse effects are significant are important as they may affect the level of ambition of ecological improvements and how intensely measures are applied.

When Member States exclude measures due to significant adverse effects on use or the wider environment, they should do so on the level of specific mitigation measures included in one of the measures groups. Whole measure groups should not be excluded, as this would not allow for case-specific differentiation (e.g. in relation to certain amounts of water in the river system).

Important!

Overall, no significant adverse effect on use cannot be equated to no effect on use, unless this is properly justified in the RBMP.

The following issues are considered as necessary to be addressed in order to achieve a transparent and clear process for assessing significant adverse effects:

- **Issue 1**: Define the key uses and the scope of wider environment interests
- **Issue 2**: Define the benefits of the key uses and of wider environment
- **Issue 3**: Define in generic terms the types of effects of measures on the key uses and the wider environment
- **Issue 4**: Define the scale of assessment of significant adverse effects for each key use and the wider environment
- **Issue 5**: For each key type of adverse effect, define criteria for assessing adverse effects and thresholds of significance

This process is developed at a strategic level in order to follow consistent approaches within the Member States.

Issue 1: Define the key uses and the scope of wider environment interests

While the definition of some uses may be clear (e.g. storage for hydropower use), for other uses it may require some further clarification (e.g. urbanisation) or a clearer definition of the scope (e.g. for wider environment). Further guidance on the scope of uses and the wider environment under WFD Article 4(3)(a) is given in section 3 of this document.

Issue 2: Define the benefits of the key uses and of wider environment

It is important to define the specific benefits of the different uses (e.g. in the case of hydropower, the importance of energy generation or for certain types of facilities providing for peaks in energy demand and regulatory power). Examples of the main benefits of the key uses and the wider environment are given in the Summary Report of the CIS Workshop on Significant Adverse Effects on use or the wider environment from measures (April 2018)[34].

Issue 3: Define in generic terms the types of effects of mitigation measures on the key uses and the wider environment

Adverse effects on the uses may include losses of/in important services (e.g. flood protection, drainage, navigability or recreation) or production losses (e.g. hydropower or agricultural goods). In assessing "significant adverse effects" on the uses, economic effects may play an important role (see Box 98 below on economic issues) and social aspects may also need to be considered (e.g. removal of flood defences may lead to displacement of population) (CIS Guidance Document No.4). Other considerations include possible health and safety, or legal implications (e.g. if an authority is legally required to provide a certain function).

[34] Kampa et al. (2018). Summary Report. Workshop on Significant Adverse Effects on use or the wider environment from measures, 23-24 April 2018, Brussels.

Examples on the types of effects of measures on the key uses and the wider environment are given in Table 12 below.

Table 12: Generic adverse effects of mitigation measures on key uses

Types of generic adverse effects of mitigation measures on use	Use-specific examples of adverse effects of mitigation measures
Loss of production	• Storage for hydropower: Loss of electricity production • Agriculture: Reduction of agricultural/forestry production
Risk to security of use	• Storage for hydropower: Significant risk to regional or national energy security • Storage for water supply: Reduction of security of water supply, also for navigation • Agriculture: Risk to food security
Risk to safety/health, societal well-being	• Flood protection: Increase of flood risk in close-by areas • Navigation: Safety implications for commercial/recreational/military navigation
Socio-economic impacts with measurable consequences for public welfare	• All uses: Loss of jobs/employment, Loss of revenue for Government (associated taxes) • Agriculture: Impact on thriving rural communities
Effects on reduced GHG emissions	• Storage for hydropower: Increased emissions from partly replacing hydropower production with conventional energy • Navigation: Additional emissions from tonnage moved to other forms of transport, especially road or air

Box 98: Significant adverse effects versus financial cost of measures

Generally speaking, the assessment of significant adverse effects should be based on the wider economic effects, while the income of a specific company should not be included in this assessment.[35] The assessment should be made in relation to the needs of society and not in relation to the economic situation of the individual. Whilst significant adverse effects from measures can be linked to a loss of revenue (benefits arising for specific water use), the ability of the user to pay is not relevant at this stage as this would potentially discriminate against efficient and profitable enterprises (CIS Guidance Document No.4). Overall business economics are part of the socio-economic assessment. The assessment must be made by Member States and should be supported by national targeting strategies. The ability of the user to pay is taken into consideration at another stage of the process when implementing measures for achieving GEP as part of the RBMPs.

CIS Guidance Document No.4 gives an overview of the related cost (and benefit) considerations for the measures that are to be considered in the different steps of the designation of HMWB and the definition of GEP (see table 4 in CIS Guidance Document No.4). Overall, the assessment of significant

[35] CIS Workshop on GEP inter-comparison case studies on water storage, 13- 14 February 2017 – Vienna.

adverse effects of measures on use or wider environment must not be confused with the assessment of disproportionate costs.

According to CIS Guidance Document No.4, the financial costs of measures are not considered in the classification process of HMWB. The costs of measures are taken into account in the objective setting process when defining the programme of measures for reaching the environmental objectives under the WFD (i.e. when determining which measures will be implemented in practice). At that stage, a decision needs to be taken on which GEP measures to include in the RBMP for implementation. This is the point at which costs are considered along with the possibility of applying an exemption based on WFD Article 4.5 per 2027 or later. Considerations at this stage include the question of disproportionate cost, which can involve political decisions.

Issue 4: Define the scale of assessment for each key use and the wider environment

At the stage of MEP definition, the local scale is generally relevant for assessing significant adverse effects. This is because, depending on the local conditions, a measure may have significant adverse effects in one location, but not in another site. After a water body is designated as HMWB, a Member State should seek to do the best it can for the ecology given the use(s) responsible for the modifications. Therefore, the assessment is about understanding how the measures that could be taken to improve or restore the ecological function will compromise or have another effect on use(s).

However, the assessment at local scale should not be related to the private interest of one person/or company but to broader public interest (e.g. safe electricity supply for people or a specific community). In addition, the assessment has to be linked to a general or national method on how to assess adverse effects and set criteria. Otherwise, cases at which mitigation has already taken place would be disadvantaged. It is thus necessary to ensure that the starting point for the assessment of significant adverse effects for different users is the same.

Example: This can be exemplified by looking at two different water abstractions from a river. The first abstraction runs on an old licence, whereby it is allowed to abstract all of the water and there is no obligation to retain some flow in the river. The other abstraction runs on a permit, which already includes a requirement for an environmental flow; however, this flow is not sufficient to achieve GES. The requirement to provide an ecological flow to achieve GES would lead to the fact that the production loss of the first abstraction would be much higher (e.g. 20%) than of the second abstraction (e.g. only 5%). It would be a large disadvantage for the second abstraction (which already follows a requirement for environmental flow) if the production loss for the first abstraction is assessed to be significant and for the second abstraction as insignificant. For this reason, production loss should in this case not be referred to a specific abstraction activity, but to the economic sector and to the effects on regional or national scale.

The scale of assessing significant adverse effects can be different for different uses and, in the Summary Report of the CIS Workshop on Significant Adverse Effects on use or the wider environment from measures (April 2018)[36], examples are given on the most appropriate scale of assessment for each of the key uses of storage, flood protection, drainage and navigation.

In addition, it is often important to consider the whole river system when taking decisions on the significance of adverse effects. In particular, a measure might have a negative effect on a use at a certain location of the river system, but at the same time have a positive effect on the same type of use at another location of the river system.

Example: In the case of energy production, energy losses at the scale of an installation upstream may in the meantime increase the energy production for another hydropower plant further downstream. Therefore, economic losses upstream may be compensated by benefits further downstream. For this reason, there is a need to assess the effects on use not only with regard to a specific installation/local situation but also with regard to possible effects at the whole river system.

Issue 5: For each key type of adverse effect, define criteria on what is significant and what is not significant adverse effect

Overall, “no significant adverse effect on use” cannot be equated to "no effect on use", unless this is properly justified in the RBMP. At the same time, according to CIS Guidance Document No.4, “significance” may vary between sectors and uses and will be influenced by the socioeconomic priorities of Member States. It is however possible to give an indication of the difference between “significant adverse effect” and “adverse effect”. A significant adverse effect on use should not be small or unnoticeable but should make a notable difference to the use. The distinction between the level of significance and levels of natural variation is important. For example, an effect should not usually be considered significant where the effect on use is smaller than the normal short-term variability in performance (e.g. output per kilowatt hour regarding base load, safe navigable depth, quantity of drinking water provided). However, the effect would clearly be significant if it compromised the long-term viability of the use by significantly reducing its performance.[37]

Example: For instance, how does a level of significance of adverse effect of less than 5% of reduction in annual electricity base load production compare to natural variation in annual production of 5-10%? Natural variation implies that, in dry years, a country would have certain energy loss, therefore any reduction to energy (base load) production should not be considered automatically as significant adverse effect.

However, in some cases, the distance between “no effect” and “significant effect” can be comparably small, for example in case of 100-year flood safety or regulatory power provision.

Overall, Member States need to establish criteria and thresholds for deciding whether measures would have a significant (or not significant) effect on use. This is a key issue for achieving a clear and

[36] Kampa et al. (2018). Summary Report. Workshop on Significant Adverse Effects on use or the wider environment from measures, 23-24 April 2018, Brussels.

[37] A factor to consider in this context is the length of time in which there should be a significant effect. This may be on a yearly basis and only in exceptional cases in the longer term. The likelihood that the effect will occur must be weighed against the damage that occurs on the use.

transparent process of defining MEP.[38] Criteria need to reflect the effect on different benefits provided by the water use. Thus, several criteria may need to be used rather than using a single criterion.

> **Look out!**
>
> The reasons and criteria for judgement on significance of effects should be made clear and transparent, and set in a consistent way at the national level. The set criteria can be applied at different scales. Setting thresholds for significance can also be relevant in some cases.

CIS Guidance Documents No.1 and No.4 have highlighted the type of methods that can be used in the assessment of significant adverse effects. **Table 13** provides examples (open list) of how some generic effects have been developed into more specific lists of possible benefits, types of adverse effects and criteria for assessing adverse effects on water storage for hydropower. The significance thresholds listed in the last column of the table are examples of thresholds that have been used by Member States in their 2nd RBMPs to assess the significance of adverse effects. These thresholds show a wide variation and thus are not necessarily best practice examples. In general, when carrying out quantifications of adverse effects of measures on use, we should not use numbers only (such as loss of production in kWh), but also relate these to percentages (such as % of total production).

Table 13: Examples of adverse effects of mitigation measures on water storage for hydropower and assessment of significance

Benefits of storage for hydropower	Effects of measures on storage for hydropower	Criteria for assessing adverse effect on use	Level/scale at which this assessment may take place	When is an adverse effect significant
Electricity production (base load)	Production loss (base load) *Effect on climate change drivers and CO2 emissions (effect on wider environment)*[39]	Exact figure (production, MWh) Compared to annual production (%)	National, regional	*Examples of national estimates of significance:* Scotland >2% of annual national production[40] AT >3% loss of annual national production at any

[38] JRC technical report on common understanding of using mitigation measures for reaching Good Ecological Potential for heavily modified water bodies (2016).

[39] It is necessary to evaluate CO2-effects of mitigation measures corresponding directly to the storage reservoir aiming at depicting clearly the consequences for EU and national CO2 reduction goals when assessing possible cuts in reservoir uses.

[40] For Scotland, the 2% maximum reduction in generation is to deliver the measures set out for all RBMP cycles up to 2027. It is a cumulative annual total across the three cycles. Sources: https://www.sepa.org.uk/media/163444/appendices-to-the-river-basin-management-plan-for-the-scotland-

Benefits of storage for hydropower	Effects of measures on storage for hydropower	Criteria for assessing adverse effect on use	Level/scale at which this assessment may take place	When is an adverse effect significant
		Compared to renewable energy targets (%)		rate (maybe already even less)[41] SE >2.3% loss of annual national production[42] NO estimates available but no specific threshold of significance[43]
Flexibility (regulatory power, peak load production)	Loss of flexible capacity; Loss in minimum safe capacity *Effect on climate change drivers and CO2 emissions (effect on wider environment)*	Range of flexibility	National, local level	Quite unlikely to set quantitative threshold for significance
Regional or national energy security[44]	Significant risk to regional or national energy safety of electricity supply Significant risk to regional or	Risk to security	National, local level	No significant risk to security can be accepted

river-bsin-district-2015-2027.pdf (Appendix 3) and https://www.sepa.org.uk/media/218891/rbmp_appendices_2015_update_solway_tweed.pdf (Appendix 8.1)

[41] Sources: https://www.bmnt.gv.at/wasser/wasser-oesterreich/plan_gewaesser_ngp/nationaler_gewaesserbewirtschaftungsplan-ngp/ngp2009.html, https://www.bmnt.gv.at/wasser/wisa/fachinformation/ngp/ngp-2015.html

[42] Sources: https://www.havochvatten.se/hav/fiske--fritid/miljopaverkan/fysisk-paverkan/nationell-strategi-for-vattenkraft-och-vattenmiljo.html and "National strategy" (In Swedish) https://www.havochvatten.se/hav/samordning--fakta/samverkansomraden/energi/nationell-strategi-for-vattenkraft-och-vattenmiljo.html.

[43] Source: http://www.vannportalen.no/brev-og-foringer1/nasjonale-foringer-for-regulerte-vassdrag/ (in Norwegian).

[44] A clear definition would be needed: security of supply and/or grid security. Whereas enhancing security of supply aims to decrease energy imports from outside EU, the stable operation of electricity grids aims at providing the commonly known low level of shortages of electricity delivery.

Benefits of storage for hydropower	Effects of measures on storage for hydropower	Criteria for assessing adverse effect on use	Level/scale at which this assessment may take place	When is an adverse effect significant
	national security of grid stability			

Note: "Run-of-river hydropower plants usually produce base load electricity while (pumped) storage hydropower plants produce electricity on demand (peak load, regulatory power). The significance of production losses thus has to be assessed differently, in particular because peak load or regulatory power are much more difficult to be replaced by another renewable energy source.

Cross-cutting issues

In addition to avoiding adverse effects on use for which the water body is designated, it is important to ensure that measures to achieve GEP also avoid adversely affecting other legitimate (i.e. sustainable human) uses. If "unintended consequences" are to be avoided, it is important to consult with all users of a water body in order to understand possible impacts of mitigation measures on other uses, including uses that have not triggered a HMWB designation.

Example: Measures to achieve GEP in water bodies affected by flood protection in rivers or estuaries may have an impact on (safety of) navigation. For instance, the measure of flood bank removal to reconnect the river with its floodplain may be selected for achieving GEP. Changing the flow of water can result in a shift in location of the main channel or in general shallowing, both of which can have potentially significant consequences for navigational safety.

Example: Another example is on a river channel which has been deepened and widened for flood defence purposes. The adverse ecological effects of the modifications could be mitigated in this case without a significant reduction in the channels' capacity to convey flood water by the establishment of a two stage channel (i.e. a deeper central channel and shallower margins within the artificially widened channel). This measure would increase habitat diversity and allow rooted plants to grow in the shallower areas adjacent to the banks. However, if the channel is also being used for navigation, such a measure might have a significant adverse effect on the navigability of the channel and therefore be inappropriate.[45]

The following are possible outcomes when assessing possible adverse effects on more than one use:

- Where several uses are present, if the effect of the mitigation measures on any one of these uses is significant, then a 'significant adverse effect on use' conclusion is triggered for that measure.
- If there are several uses present and none of these is significantly affected, but several effects are very close to the relevant threshold (i.e. are nearly 'significant'), this might trigger further investigation whether the overall cumulative effect is considered as significant.

[45] WFD and hydromorphological pressures – Technical report. Good practice in managing the ecological impacts of hydropower schemes; flood protection works; and works designed to facilitate navigation under the Water Framework Directive. November 2016.

- In other cases, if none of the uses are close to being significantly affected by a particular measure (i.e. alone), the in-combination effects would not be expected to be significant.

Assessment of significant adverse effects as an iterative process

The selection of mitigation measures that do not have significant adverse effects on use or the wider environment might also be an iterative process. The level of ambition of a measure plays a role in the selection process; a measure with a significant adverse effect could potentially be re-designed to have a reduced level of ambition, which may not have a significant adverse effect and should therefore be taken into account in the definition of MEP.

In many cases, there are several reasons than can lead to a need for case-specific differentiation, e.g. on quantity of water or length of morphological mitigation measures to be implemented.

Example: In the case of measures related to flow, the provision of a certain amount of water necessary to establish a GEP flow[46] could have a significant adverse effect on use. The establishment of additional flow with a different (reduced) volume of water may not have a significant adverse effect, and should thus be part of the set of measures to define MEP conditions.

In addition, combinations of measures can be relevant for re-designing measures in order to have a reduced adverse effect. In this context, it should be checked whether the adverse effect can be reduced by using an additional measure (including technical upgrade/refurbishment/modernisation).

Example: In the case of hydropower, production loss due to the provisioning of an environmental flow can be significantly reduced by installing a "residual flow turbine". This turbine uses the amount of water needed for environmental flow to produce additional electricity.

5.4.4.3 Select most ecologically beneficial (combinations of) measures addressing all hydromorphological alterations, taking into account need to ensure best approximation to ecological continuum (Sub-step B3)

Having excluded from the initial list of potential mitigation measures, those measures that would have a significant adverse effect on use or the wider environment, the next step is to select the measure or combination[47] of measures that deliver the best improvement in ecological function and address all relevant hydromorphological alterations, **taking into account the need to ensure best approximation of ecological continuum**. Overall, mitigation measure(s) selected for the definition of MEP and GEP are assumed to deliver sufficient improvements to aspects of ecological functioning. Improvements to ecological functioning should clearly relate to the key impacts of the physical modifications.

In order to select mitigation measures, clear knowledge is needed on type-specific ecological impacts based on BQEs and on what hydromorphological conditions should be improved to improve the

[46] GEP flow is here defined equivalent to the definition of Ecological Flow in CIS Guidance #31 as "a hydrological regime consistent with the achievement of the environmental objectives of the WFD in heavily modified surface water bodies as mentioned in Article 4(1).

[47] From a practical perspective, the meaning of "combinations" highlights that measures should take into account other measures, which might be necessary for significant improvements, e.g. a creation of floodplain habitats can be ecologically effective only if the flooding regime is sufficiently improved.

biological conditions. This means that there should be sufficient knowledge of the biological response to related mitigation measures that are relevant to the particular hydromorphological alterations. The benefits of each measure or a combination of measures to the relevant BQEs should be considered, considering timings based on ecological requirements (e.g. reproductive seasons, impacts on vegetation encroachment).

If there is sufficient information available on which quality elements are failing good status and if different measures make a contribution to the relevant ecological improvements needed, all these measures should be included in the initial list of mitigation measures for MEP definition. Furthermore, whilst identifying mitigation measures for MEP, measures should be sufficient for mitigating the ecological deficits to the maximum extent possible, i.e. measures which are only predicted to have a slight contribution to ecological improvement should be included.

In case of lack of data, a precautionary approach should be adopted. More relevant mitigation measures should be included on the initial list, which can be excluded later when sufficient supporting evidence becomes available.

It is also considered good practice to first consider mitigation measures where there is a high degree of confidence that they will improve ecological conditions and ensure the best approximation of ecological continuum.

MEP requires that the best approximation of ecological continuum is ensured. If this is ensured on the basis of the selected set of mitigation measures, the list of measures is used to define MEP and then GEP conditions, and later to select measures for the PoM to achieve GEP. In this context, the most relevant water category and water type must also be taken into account, to ensure that all relevant mitigation measures have been considered.

If the set of measures does not ensure best approximation of ecological continuum (e.g. the water body is dry at least seasonally), the initial list of mitigation measures needs to be reviewed, to check if there is another (second option) combination of measures by which best approximation of ecological continuum will be achieved.

5.4.5 Derivation of hydromorphological conditions for MEP (Step C)

The WFD defines the hydromorphological conditions for MEP as those "consistent with the only impacts on the surface water body being those resulting from the artificial or heavily modified characteristics of the water body once all mitigation measures have been taken to ensure the best approximation to ecological continuum, in particular with respect to migration of fauna and appropriate spawning and breeding grounds".

The hydromorphological conditions for MEP are therefore the hydromorphological conditions expected if all the mitigation measures that are relevant to the particular hydromorphological alterations, ecologically effective in the physical context of the water body or water bodies, and which do not have a significant adverse effect on use or the wider environment, are implemented. Though this definition is based on an assumption of which measures will be implemented, a prediction is fundamental for the following steps prior to the implementation of measures.

The derivation of hydromorphological conditions for MEP should be based on:

- the hydromorphological conditions in the water body altered by the physical modifications linked to the use.
- the expected effects of the set of mitigation measures (for MEP) on the hydromorphological conditions.

The hydromorphological conditions for MEP may resemble those of a different type (compared to the natural water body type before the physical modification). Thus, the hydromorphological conditions defined for MEP can be used to identify or derive the closest comparable water body type, which is in particular relevant for defining MEP conditions for biological quality elements and those physico-chemical parameters that are affected by the hydromorphological conditions. The closest comparable water body type is based on the most comparable water category (see Step A), national typology, hydromorphological conditions for MEP and the ecological impacts resulting from the hydromorphological alteration.

Closest comparable water body type

According to WFD Annex V 1.2.5, “the values of the relevant biological quality elements reflect, as far as possible, those associated with the **closest comparable surface water body type**, given the physical conditions which result from the artificial or heavily modified characteristics of the water body”.

If possible, the closest comparable water body type should be derived from the original natural water body type (i.e. prior to the physical modification). It is noted, however, that although the closest comparable type can be the same as the original natural water body type, it is characterised by reduced habitat quality, i.e. lower than the hydromorphological quality for good status of the original natural water body type.

The closest comparable water body type may also differ from the original natural water body type, after adopting the changed hydromorphological conditions due to the modifications of the HMWB.

Example: When a river is modified by an impoundment (not a reservoir), it changes from a more rhithral (fast flowing, high energy, associated with the upper parts of a system) to a more potamal (slower flowing, lower energy, associated with the lower parts of a system) river type; here, the most important change is the significant reduction of the flow velocity consistent with a larger river type further downstream in the river basin. The river type of a size category different to that of the original natural river type would therefore be used in this situation.

Example: With regard to a reservoir used for water storage (e.g. for hydropower generation), there is no natural lake type with comparable water level variations. Nevertheless, the reservoir can be treated like a lake type in the same region, altitude and geology, with the exception of the water level variation and all quality elements directly or indirectly influenced by this variation. This means that the nutrient level required for MEP or GEP of the reservoir will be similar to the nutrient requirements of the natural lake type. For water level variation and all other hydromorphological, physico-chemical and biological quality elements influenced by the level variation, MEP and GEP conditions/values have to be derived by taking account of the relevant mitigation measures.

Look out!

Please note that it is not considered as good practice to compare the characteristics to a type that is not already prevalent in the same region, e.g. to relate the hydromorphological conditions of a permanent river to those of a temporary river, if such features do not already occur naturally within the same landscape unit of the water body before modification.

!

Reference approach ←→ Mitigation measures approach

Step C should be taken under both the reference approach and the mitigation measures approach. Take note though that the necessary monitoring data and other information may initially be lacking, requiring further refining of step C in later planning cycles as data availability and method sensitivity improve.

5.4.6 Derivation of physico-chemical conditions for MEP, taking into account the closest comparable water body type (Step D)

According to WFD Annex V 1.2.5 normative definitions for MEP:

- The [general] physico-chemical quality elements correspond totally or nearly totally to the undisturbed conditions associated with the surface water body type most closely comparable to the artificial or heavily modified water body concerned.
- Nutrient concentrations remain within the range normally associated with such undisturbed conditions.
- The levels of temperature, oxygen balance and pH are consistent with those found in the most closely comparable surface water body types under undisturbed conditions.
- Concentrations [of specific synthetic pollutants] are close to zero and at least below the limits of detection of the most advanced analytical techniques in general use.
- Concentrations [of specific non-synthetic pollutants] remain within the range normally associated with undisturbed conditions found in the surface water body type most closely comparable to the artificial or heavily modified water body concerned (background levels = bgl).

The physico-chemical conditions for MEP should be based, inter alia, on the hydromorphological conditions at MEP and on the estimation of correspondence “totally or nearly totally to the undisturbed conditions” associated with the closest comparable water type. The physico-chemical conditions have an important influence on the values for the biological quality elements at MEP.

The identification of the closest comparable water type is a supportive tool in this context. For physico-chemical parameters, the physico-chemical reference conditions for the closest comparable water body type are often the same as for the original natural water body type (before physical modification). However, this is not always the case and, in some cases, the reference conditions are different. The example bellow illustrates such a case.

Example: In the case of an impoundment within a river, nutrient concentrations will generally not be different following modification. However, the same nutrient concentrations can have stronger “eutrophication” effects when compared to the natural river type, due to the water being more “stagnant” in the modified situation. Nevertheless, in most cases this does not lead to nutrient values for MEP and

GEP that differ from those of the original natural water body. In exceptional cases, e.g. if this occurs on a large scale where a chain of impoundments characterize a river water body, this “eutrophication” effect might be taken into account and lead to lower nutrient boundaries through the use of the reference conditions of another, closest comparable, water type which is usually a larger river type downstream of the water body.

An exceptional case are those physico-chemical parameters that are inevitably determined by the hydromorphological alterations causing the heavily modified character. In general, the closest comparable water body type for physico-chemical conditions can only be different from the original natural water body type (before the physical modification) if the altered physico-chemical conditions are caused by the modified hydromorphological conditions.

If the values of those physico-chemical conditions that are directly connected to the hydromorphological alterations of the HMWB would not correspond totally or even nearly totally with the surface water body type most closely comparable to the artificial or heavily modified water body concerned, these differences should be taken into account when setting MEP.

Example: In the case of a large impoundment in a river (not a reservoir), temperature conditions might be different after the modification that might lead to the use of reference conditions of a larger and warmer river type downstream of the water body as closest comparable water type. Temperature is usually inevitably changed if a river is modified to a lake reservoir leading to a change in category and the closest comparable lake type as basis for derivation of temperature values for MEP.

Requirements for specific synthetic pollutants at MEP are the same as those for natural water bodies.

!	**Reference approach <-> Mitigation measures approach** Step D should be taken under both the reference approach and the mitigation measures approach. Take note though that the necessary monitoring data and other information may initially be lacking, requiring further refining of step D in later planning cycles as data availability and method sensitivity improve.

5.4.7 Derivation of BQE conditions for MEP (Step E)

According to WFD Annex V 1.2.5, the values for the biological quality elements at MEP should reflect, “as far as possible, those associated with the closest comparable surface water body type, given the physical conditions which result from the artificial or heavily modified characteristics of the water body”.

The BQE conditions for MEP are the biological conditions expected if the hydromorphological conditions at MEP are assumed to be achieved after implementation of all mitigation measures that are both relevant to the particular hydromorphological alterations and ecologically effective in the physical context of the water body or water bodies.

In practice, the derivation of biological conditions for MEP is based on:

- The identification of closest comparable water type
- The predicted hydromorphological and physico-chemical conditions (for MEP)
- The available BQE methods for ecological status assessment

When deriving BQE conditions for MEP, it is also critical to **consider the WFD requirements concerning the best approximation of the ecological continuum**, as described in section 5.2. The closest comparable water type (e.g. river type) also has a fundamental importance for derivation of BQE conditions at MEP.

It is suitable to use the BQE assessment methods used for natural water bodies of the same category if those methods are sensitive to hydromorphological alterations and can cover the relevant gradient of degradation for the HMWB. In principle, BQE conditions for MEP are the reference conditions of the closest comparable type, but adjustments are needed if the hydromorphological and physico-chemical conditions for MEP differ from those conditions in the closest comparable type. In the same way, it might be suitable to combine elements of different assessment methods (e.g. different metrics) to get an appropriate system of assessment. Whichever approach is used, a transparent and reproducible way to assess ecological potential has to be found.

In some cases, it may be difficult or not possible to find a closest comparable water body type. It may however be possible to predict the BQE conditions for MEP from the hydromorphological and physico-chemical conditions for MEP, even when a comparable water body is missing.

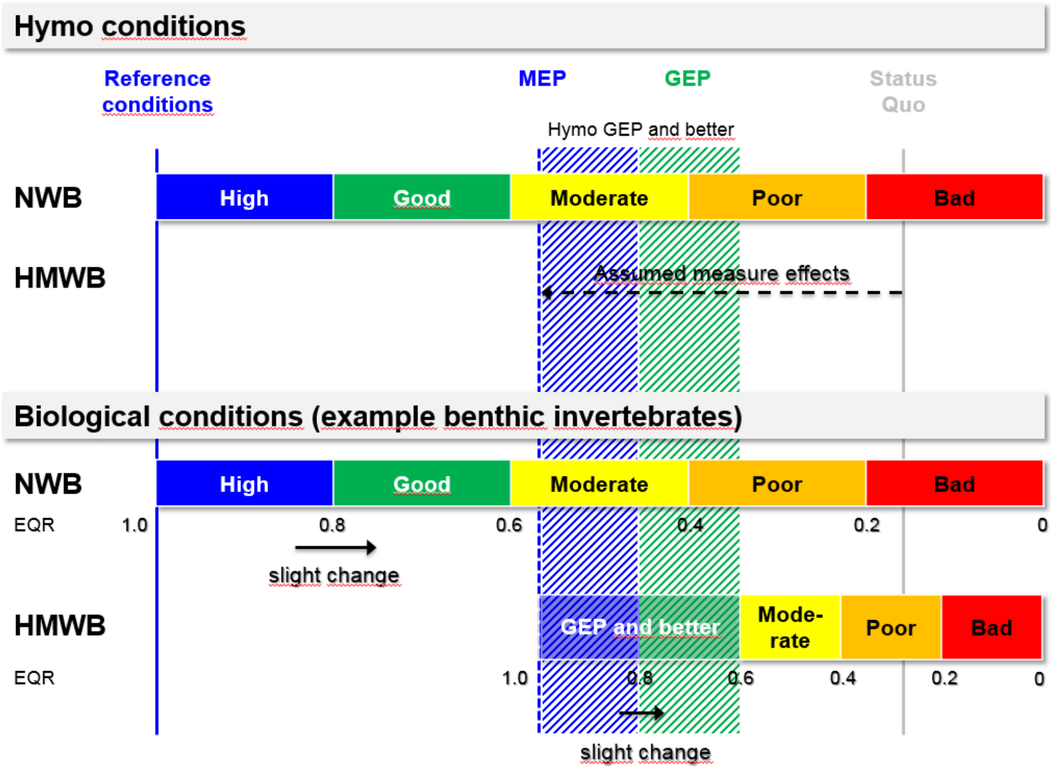
The values for BQEs at MEP might vary between countries, biological quality elements and river types depending particularly on the approach used, structure of the BQE assessment system, river characteristics and the availability of hydromorphological and biological data.

Example: Figure 9 below illustrates an example that uses equidistant classes for defining ecological potential based on benthic invertebrates. It is noted that the values used in this example can be different in other examples.

The example focuses on a river water body that is in bad ecological status considering hydromorphological conditions and the condition of benthic invertebrates (status quo). The relevant and ecologically effective mitigation measures (step B) result in hydromorphological conditions at MEP (step C) that are within the class of a moderate status taking into account the assumed effects of the set of measures. The physico-chemical conditions (step D, step G) are the same as of the original natural river water type, these are therefore not pointed out in the figure.

The conditions of benthic invertebrates at MEP (step E) result from the hydromorphological conditions at MEP that are defined by the method for hydromorphological status assessment. A maximum EQR value of 1.0 for benthic invertebrates at MEP correlates with an EQR value of approximately 0.57 in the ecological status assessment system (moderate class). Dividing the whole gradient of ecological potential into five equidistant classes results in class boundaries for all five classes for benthic invertebrates and defines the “slight change” between MEP and GEP (step F). For instance, GEP correlates with a poor to moderate ecological status for this example depending on the EQR value. The status quo shows a poor ecological potential with an EQR value of <0.3. The EQR value of >0.6 describes GEP for the water body that can be transferred into hydromorphological conditions at GEP (step G) and be used to identify the mitigation measures needed to reach these values (step H).

Figure 9: Example of five equidistant classes for ecological potential based on benthic invertebrates



!	**Reference approach ←→ Mitigation measures approach** In theory, step E should be undertaken in both the reference approach and the mitigation measures approach. In practice, however, the mitigation measures approach is often followed where there is no or insufficient data on BQEs. As a result, if step E cannot be undertaken in the current planning cycle, it should be clearly stated in the RBMP how this gap will be completed during a later cycle. In particular, this implies efforts to collect more data and improve knowledge on the links between hydromorphology and biology.

5.4.8 Derivation of BQE conditions for GEP (Step F)

Good ecological potential is defined in WFD Annex V 1.2.5 as an ecological state in which "there are slight changes in the values of the relevant biological quality elements as compared to the values found at maximum ecological potential". "Slight changes" are discussed further in Box 9.

Box 9Definition of slight changes for biological conditions

What are slight changes?

A crucial aspect in the context of defining GEP is a common understanding of "slight changes". Guidance on how to interpret "slight changes" can be found in CIS Guidance Documents No. 10, 13 and 14. CIS Guidance Document No.13 on the "Overall approach to the classification of ecological status and ecological potential" provides guidance on the interpretation of the term "slight changes" with reference to the (type-specific) conditions specified for the BQE benthic invertebrates at good status:

- There must be no more than slight changes in composition and abundance
- There must be no more than slight changes in the ratio of disturbance sensitive taxa to insensitive taxa
- There must be no more than slight signs of alteration to the level of diversity

With respect to "slight changes", HMWB should follow the same principles as natural water bodies, with a functioning ecosystem being a prerequisite for a water body to be at GEP. A "slight change" cannot be equivalent to a temporary or complete absence or severe change of the biological quality elements relevant for the closest comparable water category and type (e.g. of fish for rivers within the fish zone). "Slight changes" to the biological quality elements have to be supported by corresponding conditions in the supporting quality elements (e.g. flow, habitats, continuity). With regard to ecological continuum, "slight change" means that a condition close to best approximation of ecological continuum should be ensured (instead of best approximation itself) .

Overall, the biological conditions at GEP should be indicative of a functioning ecosystem**, taking into account the need to ensure close to the best approximation of ecological continuum**, as described in section 5.2. If the biological conditions for GEP can be validated through monitoring results of a hydromorphology-sensitive assessment method, it should be assumed that a condition close to best approximation to ecological continuum is achieved. If there is no definition of biological conditions at GEP or no biological monitoring data available, this check might be preliminarily undertaken based on hydromorphological data and mitigation measures. According to the most comparable water body type, the use of assessment systems and the level of detail for GEP description, the same principles are valid as described for biological conditions of MEP (see section 5.4.7).

!	**Reference approach ←→ Mitigation measures approach** In theory, step F should be taken under both the reference approach and the mitigation measures approach. For the mitigation measures approach, the route to step F is different than for the reference approach. While in the reference approach, step F follows from step E (derivation of biological conditions for MEP), in the mitigation measures approach, step H (identification of mitigation measures for GEP) leads to step G (derivation of supporting quality elements conditions for GEP) and step F. Under the mitigation measures approach, the BQE conditions at GEP can initially only be derived from the predicted hydromorphological and physico-chemical conditions in a situation where all GEP measures are assumed to be in place. At first, mitigation measures (or certain habitat functions that can be expected to be achieved after implementation of these measures) are identified, excluding those that, in combination, are only predicted to deliver "slight changes" (slight improvements) compared to biological conditions of MEP. In the mitigation measures approach, the measures that would only result in "slight changes" to hydromorphology are discarded, assuming that they will not modify the habitat conditions sufficiently to promote an enhancement in the biological conditions. GEP is therefore defined by the biological conditions expected from considering the remaining measures. Thus, a prediction of the improved hydromorphological conditions is needed. The mitigation measures approach assumes that by improving hydromorphological conditions, the connectivity and the habitat will improve and this will in turn elicit an enhancement in the biological conditions. If step F cannot be undertaken in the current planning cycle, it should be clearly stated in the RBMP how this gap will be addressed at a later cycle. It implies in particular efforts to collect more data and improve knowledge on the links between hydromorphology and biology.

5.4.9 Derivation of supporting quality elements (SQE) conditions for GEP (Step G)

The derivation of supporting quality elements (SQE) for GEP entails identification of hydromorphological conditions and physico-chemical conditions, including environmental quality standards (EQS) for specific synthetic and non-synthetic pollutants.

Hydromorphological conditions (GEP)

The hydromorphological conditions at GEP must support the achievement of the biological values defined for GEP. The hydromorphological conditions necessary to support the GEP values for biological quality elements must therefore be identified, in particular the values for those biological quality elements that are sensitive to hydromorphological alterations.

The hydromorphological conditions at GEP should consider ecological functioning, **taking into account the need to ensure close to best approximation of ecological continuum**. As mentioned in section 0, GEP is defined by only slight changes in the biological values set for MEP and the hydromorphological conditions have to be consistent with the biological values set for GEP. This means that, for GEP, hydromorphological conditions still have to take into account the ecological continuum with regards to migration possibilities, flow and sediment/habitat requirements that might be adequate for slightly reduced specifications for the biological criteria mentioned in CIS Guidance Document No.13 (e.g. species abundance and/or composition) of relevant BQE (particularly fish and benthic invertebrates) compared to MEP.

Physico-chemical conditions (GEP)

The physico-chemical conditions have such values to support the achievement of the GEP biological values. It is also required that the values for the general physicochemical quality elements at GEP are such as to ensure the functioning of the ecosystem.

If the mitigation measures approach for GEP definition is used, the physico-chemical conditions are based on the effects of mitigation measures (for GEP) on physico-chemical parameters.

In general, the same values for physico-chemical conditions should be met as for good ecological status for the original natural water body type, except if the parameter is impacted by the hydromorphological alteration having led to HMWB designation (e.g. changed water temperature due to hydropeaking) (see also section 5.4.6 above on the derivation of physico-chemical conditions for MEP).

Environmental Quality Standards (EQS) for the specific synthetic and non-synthetic pollutant quality elements are to be considered, with the same values to be achieved as for good ecological status.

!	**Reference approach ←→ Mitigation measures approach** Step G should be undertaken in both the reference approach and the mitigation measures approach. For the mitigation measures approach, the route to step G is different than for the reference approach. While in the reference approach, step G follows from step F, in the mitigation measures approach, step H (identification of mitigation measures for GEP) leads to step G and step F. In case the mitigation measures approach for GEP definition is used, the hydromorphological conditions at GEP are based on the effects of mitigation measures (for GEP) on hydromorphological quality elements excluding those delivering only “slight changes” (improvements) to biological conditions.

5.4.10 Identification of mitigation measures (GEP) (Step H)

In this step, the mitigation measures for reaching GEP are identified, which are in general:

- Relevant to each of the hydromorphological alterations causing failure to achieve good status and ecologically effective

- Do not have significant adverse effects on use(s) and/or the wider environment
- Take into account the need to ensure approximation to ecological continuum.

The mitigation measures within GEP are those needed to achieve the derived biological conditions by improving conditions of relevant supporting elements for GEP.

As indicated in step B (section 5.4.4), the selection of mitigation measures for GEP can be an iterative process, particularly where the mitigation measure approach is applied.

If there are still several measures remaining to choose from the list defined for MEP, it is also recommended that the principles enshrined in the mitigation hierarchy are applied. The mitigation hierarchy forms an important element in environmental impact assessment for new projects, but it is equally relevant and important for the selection of measures to define GEP objectives. The mitigation hierarchy, interpreted in the context of establishing priorities for the definition of GEP objectives, is described below:

1. First, measures that address the hydromorphological (and physico-chemical, if relevant) alteration such that the biological quality elements can recover naturally (alone or in combination with other measures) should be favoured
2. Second, measures which reinstate or improve the ecology on-site should be considered where natural recovery is not possible.
3. Third, (if neither of the above are possible) measures to create new features, communities, etc. off-site, taking into account the need for these to be self-sustaining, should be considered. Such measures often do not directly address the original hydromorphological alteration but rather seek to improve other aspects of the system such that the net effect is to reach GEP.

In addition, for the selection of detailed measures, it is important to take the whole river/catchment into account (e.g. according to interactions between river stretches). For example, measures for upstream stretches may impact downstream ones, and thus influence measures selection. In this context, it is relevant to take account of the requirements of WFD Article 4(8).

For the selection of the most effective measures combination (in terms of ecology), there is a need to consider differentiated criteria and objectives depending on the scale and size of the catchment:[48]

- In large catchments where international cooperation is important, migrators (longitudinal continuity – medium & long distance migrators), wetlands (lateral connectivity) as well as sediment and flow should be considered.
- On the regional/catchment level (national/regional level), details of the water body scale and status as well as priorities regarding the improvement potential vis-a-vis the size of stretches (e.g. improvement expected in 1 or 100 km of river length) are also important.

[48] CIS 2007 WFD hydropower workshop summary report

> ! **Reference approach ←→<-> Mitigation measures approach**
>
> Step H should be taken under both the reference approach and the mitigation measures approach.
>
> For the mitigation measures approach, the route to step H is different than for the reference approach. While in the reference approach, step H follows from step F and G, in the mitigation measures approach, step H (identification of mitigation measures for GEP) follows from step B (identification of mitigation measures for MEP). In the mitigation measures approach, mitigation measures for GEP are obtained after removing, from the set of mitigation measures identified for MEP, any measures which only lead to slight changes in biological conditions (alone or in combination).
>
> It is noted that when there is lack of suitable biological assessment methods and/or data sensitive to modifications, the approach to the selection of mitigation measures should be more precautionary and more measures may need to be considered until there is sufficient evidence to exclude measures from MEP. Increased efforts are needed by Member States towards establishing appropriate biological monitoring and hydromorphology-sensitive methods for a more informed basis for the selection of mitigation measures.

5.5 Moderate, poor and bad ecological potential

WFD Annex V 1.2.5 provides normative definitions for maximum, good and moderate ecological potential. According to these normative definitions, at moderate potential, “there are moderate changes in the values of the relevant BQEs as compared to the values found at maximum ecological potential. These values are significantly more distorted than those found under good quality.” The hydromorphological and physico-chemical conditions are consistent with the achievement of the values specified for the BQEs. The ecological potential classification presented in WFD Annex V 1.4.2 also refers to poor and bad potential.

Overall, it is very important that Member States quantify also the classes “moderate”, “poor” and “bad” for ecological potential and include them in their assessment system. National assessment systems should at least differentiate between these classes according to the values of appropriate metrics.

An example of a Member State’s description of the different ecological potential classes for benthic invertebrates, using metrics, is provided below. Furthermore, the importance of working towards the best approximation of ecological continuum is also relevant for the definition of ecological potential in classes less than good. As already noted, if it is not possible to ensure a condition close to best approximation to ecological continuum (linked to the functioning of the ecosystem), the water body cannot be classified as good ecological potential but only as a class lower than good.

In case a water body can reach good ecological potential on the basis of its hydromorphological status, it may still be classified as moderate or worse potential due to physico-chemical impacts (e.g. nutrient pollution) which are still unaddressed in the water body.

For those HMWB that are classified as moderate ecological potential or lower (i.e. where improvement is required), measures which have been identified during the definition of good ecological potential should be taken forward to the objective setting process.

The description of all ecological potential classes is important also in case of new projects which have to be assessed according to the requirements of WFD Article 4(7) (see also CIS Guidance Document No.36).[49] The non-achievement of good ecological potential or deterioration of the potential class of a HMWB due to a new modification is only allowed in case the conditions under Article 4(7) are met. A sound definition of MEP and GEP biological conditions provides the fundamental basis for the definition of the different ecological potential classes below good potential.

Example. Requirements of benthic invertebrates in river type HMWBs with land drainage in small to medium sized sand-dominated lowland rivers:

For many types of HMWB, benthic invertebrates are considered to be one of the most sensitive BQEs to hydromorphological alterations. Table 14 presents an example from a Member State of how requirements for the different classes of ecological potential relevant to benthic invertebrates in heavily modified rivers with land drainage can be defined. In the specific Member State example, these requirements are based on a multi-metric assessment system. The assessment system contains three single metrics resulting in one multi-metric index. This index value determines the overall class of ecological potential for benthic invertebrates and meets the requirements for a functioning aquatic ecosystem and best approximation to ecological continuum. The single metrics include positive (e.g. relative abundance of positive indicator species group, %) and negative indicator species (relative abundance of negative indicator species group, %). Basis for the assessment of ecological potential is the combination of natural river type and use. For comparability reasons with the ecological status classes, the boundaries are also indicated for the natural river type (small to medium sized sand-dominated lowland river).

Table 14: Member State example of definition of different ecological potential classes for benthic invertebrates in small to medium sized sand-dominated lowland river-HMWBs with land drainage

River type	**Small to medium sized sand-dominated lowland river**	
Category	**Natural water bodies**	**HMWB (Land drainage)**
Ecological potential class boundaries for benthic invertebrates		
Metric 1 (Relative abundance of positive indicator species group, %)		
high/good (HES/MEP)	51	41
good/moderate (GES/GEP)	44	32
moderate/poor	33	23
poor/bad	24	14
Metric 2 (Number of positive indicator species)		
high/good (HES/MEP)	10	6
good/moderate (GES/GEP)	8	4
moderate/poor	6	3

[49] CIS Guidance Document No 36. Exemptions to the Environmental Objectives according to Article 4(7). New modifications to the physical characteristics of surface water bodies, alterations to the level of groundwater, or new sustainable human development activities.

River type	Small to medium sized sand-dominated lowland river	
Category	Natural water bodies	HMWB (Land drainage)
poor/bad	3	1
Metric 3 (Relative abundance of negative indicator species group, %)		
high/good (HES/MEP)	9	13
good/moderate (GES/GEP)	13	18
moderate/poor	19	24
poor/bad	25	30

6 IMPLEMENTATION OF MEASURES TO ACHIEVE GEP

Key messages for this section

- For HMWB to reach GEP, sufficient mitigation (ecological improvement) is expected from measures implemented in the hydromorphologically altered water bodies, without significant adverse effects on use or the wider environment from any of these measures.
- A clear distinction between the selection of measures needed to define and achieve GEP and the implementation of measures (objective setting in the RBMP) is crucial for more transparency and a common understanding.
- To assess the effects of any mitigation measures already in place and the need for further mitigation measures, the ecological condition of the HMWB should be monitored. The main decisive elements are (apart from specific pollutants) the biological quality elements that determine the class of ecological potential. These are supported by hydromorphological and physico-chemical quality elements. If a proper assessment based on biological quality elements is not yet possible (e.g. due to a lack of hydromorphology-sensitive methods), monitoring of hydromorphological (and physico-chemical) quality elements can be used as a proxy to estimate the effectiveness of the mitigation measures already in place and thereby the ecological potential class. If the classification of the ecological potential is not based on hydromorphology-sensitive biological assessment methods, the classification result should indicate that the confidence level is low.
- If one or more of the selected GEP measures cannot be implemented due to disproportionate costs or infeasibility, it has to be confirmed whether the remaining measures will mitigate sufficiently to achieve the biological conditions required for GEP. If this is not the case, a review and possibly re-design of the measures will be needed to avoid the need to use exemptions: for example, selecting another combination/intensity of measures may deliver the desired ecological improvement.
- If it is not possible to implement all the measures needed to achieve GEP, it will not be possible to reach GEP conditions (like ecological continuum), so the water body will have to be classified as being at moderate potential or lower and would therefore need an exemption. Nevertheless, all the remaining measures would still have to be applied to improve/avoid deterioration of the conditions of the water body as far as possible.
- If monitoring shows that expected GEP conditions are not achieved after the implementation of all measures, it should be checked whether the reasons for not achieving GEP are linked to delayed biological restoration, overestimation of the biological response or to other significant impacts (e.g. multiple pressures) and the measures may need to be refined accordingly, if appropriate. This requires well-defined goals to be established as well as suitable methods for monitoring.

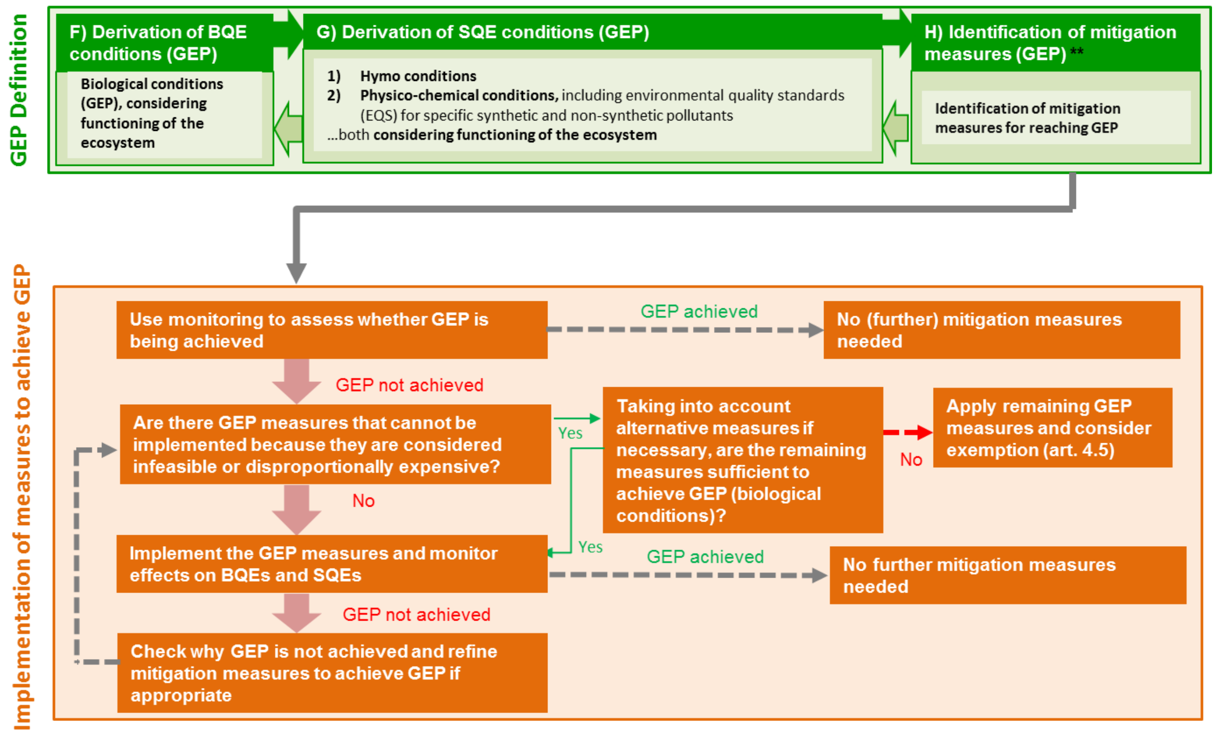
- Implementation of measures to achieve GEP should be seen as an iterative process.

The implementation of the measures to reach the objective for the HMWB (defined GEP) should be distinguished from the identification of measures for defining the GEP objective. These are two different processes related to measures for GEP, though both are closely interconnected. A distinction between these two processes is crucial for the management of HMWBs and for ensuring a more transparent and common understanding of whether GEP can be reached or not.

The identification and planning of measures to mitigate the ecological effects of hydromorphological modifications (i.e. for defining and thereby predicting GEP) takes place prior to updating RBMPs, as described in the previous sections. The final decision on whether it will be possible to implement all measures, out of those which are needed to achieve GEP, takes place for single water bodies and is an individual River Basin Management decision in the context of the programme of measures (objective setting in the RBMP). If several of the measures for GEP are de-selected for implementation at this stage because they are infeasible or disproportionally expensive, and the possibility of achieving GEP is compromised, an exemption (Article 4.5) from GEP should be considered.

The flow-chart on Figure 10 explains in more detail the process for implementing mitigation measures to achieve GEP within the programme of measures.

Figure 10: Process of implementing mitigation measures to achieve GEP



Use monitoring to assess whether GEP is being achieved

To assess the effects of any mitigation measures already in place and the need for further mitigation measures, the ecological condition of the HMWB should be monitored (see Box 10 below on monitoring of HMWB). In case of lack of existing monitoring, appropriate site-specific monitoring needs to be set up in order to assess whether the expected mitigation from the measures already in place has been delivered and whether GEP is being achieved.

Other than specific pollutants, the main decisive elements are the biological quality elements that determine the class of ecological potential. These are supported by hydromorphological and physico-chemical quality elements. If a proper assessment based on biological quality elements is not yet possible (e.g. due to a lack of hydromorphology-sensitive methods), monitoring of hydromorphological (and physico-chemical) quality elements can be used as a proxy to estimate the effectiveness of the mitigation measures already in place and thereby the ecological potential class. If the classification of the ecological potential is not based on hydromorphology-sensitive biological assessment methods, the classification result should indicate that the confidence level is low (see WFD Annex V, 1.3 on estimates of the level of confidence and precision of the results provided by the monitoring programmes). The conditions for GEP should at least be differentiated from the conditions of an ecological potential lower than GEP, so that it can be estimated if GEP is achieved or not. The classification should be reviewed in each planning cycle.

If GEP is achieved or estimated to be achieved, no (further) actions in terms of hydromorphological mitigation measures are needed. However, there might be a need for hydromorphological measures to address larger scale issues (e.g. improving continuity in the considered HMWB because this is relevant for another water body upstream to achieve and maintain the environmental objective).

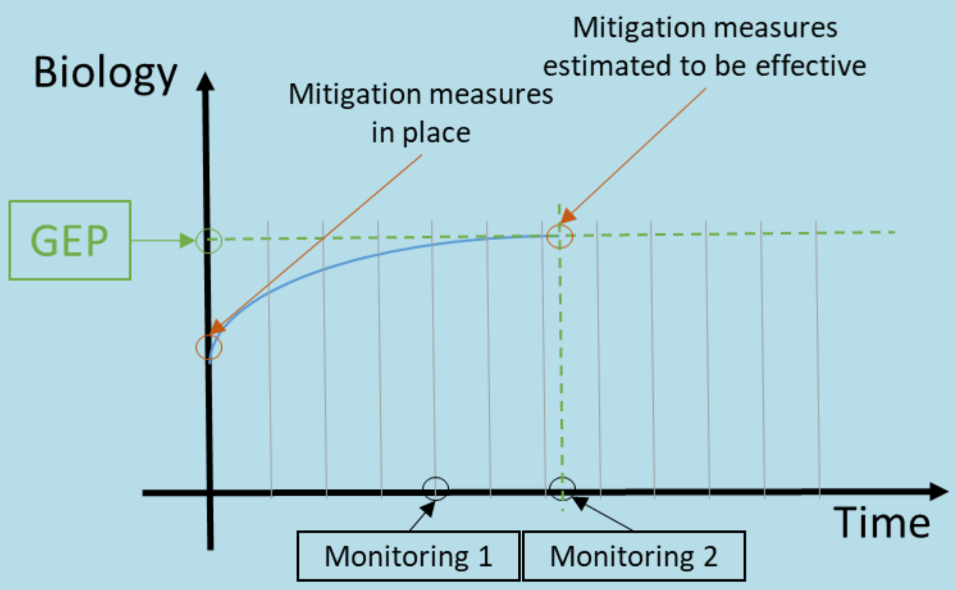
If the ecological potential is less than good (i.e. GEP is not achieved), then the reasons for this need to be clarified. As for natural water bodies, there might be several reasons, such as i) the improvement is taking longer than expected, ii) other significant pressures might have been missed or neglected, iii) the intensity of measures may not be sufficient, or iv) additional measures may be needed. Therefore, further action in terms of hydromorphological mitigation measures might be required. Otherwise an exemption (Article 4.5) from GEP should be considered. In case all mitigation measures without significant adverse effects on use are implemented but GEP values for biological quality elements are not achieved due to an overestimation of the biological response when defining the biological conditions for GEP, there is no need for further measure refinement or action; instead, GEP values have to be adapted to the proven monitored biological values.

Box 10: Monitoring to classify the ecological potential of HMWB and assess effects of mitigation measures

Operational monitoring, which is focused on hydromorphological issues, is required in HMWB to determine their ecological potential (classification), evaluate the effects of the mitigation measures after their implementation, and allow adaptive management.

The methods to be used in both cases are the targeted hydromorphology-relevant methods used for operational monitoring. Operational monitoring also makes sense in case of activities in the HMWB or within its catchment which have led to a risk of failing GEP in the risk analysis.

There is a slight but important difference between monitoring natural water bodies and HMWB regarding designing an operational monitoring program in order to monitor progress in meeting the objective. The objective for HMWB (GEP) is based on a forecast of how the biology in the water body is expected to be when all mitigation measures are in place and effective. The objective for natural water bodies (good ecological status), on the other hand, is a known value described using biological quality elements. Since GEP is a forecast, monitoring needs to measure the response of the biological communities to the measures implemented. Monitoring should be undertaken at the time when the measures are expected to be effective (see Monitoring 2 in the figure below). These values, derived from the monitoring, correspond to the exact values for GEP (see green line indicating the biological value for GEP in the figure below), once the measures are effective. However, it can be important to monitor earlier to detect progress (see Monitoring 1 in the figure below). If the reaction of the biology is different compared to the forecast, there has to be room for adaptive management resulting in change of either mitigation measures, of the objective or both.



Are there GEP measures that cannot be implemented because they are considered infeasible or disproportionally expensive?

River Basin Authorities may be of the opinion that some of the GEP measures identified in step H are disproportionately expensive (e.g. because the investment costs of measures are high) or infeasible. If this is the case, it needs to be checked if it is still possible to achieve GEP.

Example: A transboundary river is impacted by hydropeaking stemming from the upstream neighbouring country. Measures are only ecologically effective if they are implemented upstream in and by the neighbouring country. This decision is only in the national competence of the neighbouring country.

Taking into account alternative measures if necessary, are the remaining measures sufficient to achieve GEP (biological conditions)?

If one or more of the selected GEP measures have been excluded according to cost considerations or infeasibility, it has to be checked whether the remaining measures are still sufficient to achieve the biological conditions at GEP (step F in Figure 5. If this is not the case, a review and possibly re-design of the measures will be needed to avoid the need to use exemptions: for example, selecting another combination/intensity of measures may deliver the desired ecological improvement. The effects of the measures as well as the hydromorphological and physico-chemical conditions at GEP (step G) should be used as the basis for this re-design, particularly of the set of GEP measures (step H).

Besides the conditions at water body level, the conditions up- and downstream (for rivers) as well as at the catchment level have to be considered to make a valid estimation. Large scale issues can significantly override the local effects of measures in both positive (e.g. good water quality, no or extensive land use) and negative (e.g. fine sediment input, continuity interruptions) directions, so both should be considered in this context. Even if some GEP measures are disproportionately expensive or infeasible, GEP might be reached if the remaining measures have a sufficient effect (in combination). This can particularly be the case if positive effects predominate on a larger scale (e.g. on catchment scale).

If the following is the case: a) no other/additional mitigation option can be implemented, and b) approximation to ecological continuum as needed for GEP cannot be achieved, it will not be possible to reach GEP conditions and the water body will have to be classified at moderate potential or lower and would need an exemption according to WFD Article 4.5. Nevertheless, the remaining measures would have to be applied to improve the conditions of the water body as far as possible.

Implement the GEP measures and monitor effects on BQEs and SQEs

All GEP measures that can be applied and are assumed to be sufficient to achieve GEP biological conditions are then implemented. The effects of the implemented GEP measures on BQEs and supporting quality elements should subsequently be monitored and the ecological potential of the water body should be classified accordingly (see Box 10 above on Monitoring of HMWB).

If GEP is achieved based on the monitoring results, no further mitigation measures are needed.

If monitoring results indicate that the mitigation measures have such an effect on quality elements that the water body reaches good ecological status, the water body cannot be considered as heavily modified and should be redesignated as a natural water body with good status as its environmental objective. If the monitoring indicates that the mitigation measures are not sufficient to achieve good status, the designation of the water body as HMWB remains valid and the defined GEP remains as its environmental objective.

If monitoring shows that expected GEP conditions are not achieved after the implementation of all measures, then the reasons (see above) for this need to be clarified, and it is possible that the combination or intensity of measures will need to be refined. Therefore, the implementation of measures to achieve GEP should be seen as an iterative process, starting with typical measures normally expected to mitigate a certain hydromorphological pressure-impact (see the European mitigation measure library which is a supporting tool to this document) that are known to be effective in most situations. These can be subject to future refinement or even the implementation of additional measures later on, taking into account the monitoring results.

Check why GEP is not achieved and refine mitigation measures to achieve GEP if appropriate

As stated above, if the ecological potential is less than good (i.e. GEP is not achieved) after implementing all measures and monitoring the effects on biological and supporting quality elements, the mitigation measures should be further refined to improve the conditions of the water body.

In this context, the reasons for not achieving GEP should first be checked because, as indicated above, non-achievement may be due to a delay in the biological reaction, overestimation of the biological response, an insufficient intensity of measures, or the presence of other significant pressures that are not sufficiently mitigated.

The results of biological monitoring and other (e.g. hydromorphological) investigations should be used as a basis to better determine the need for refinement of the mitigation measures. It can thus be defined in further detail “how much” of a specific measure is needed to achieve GEP and/ or “where in the water body” the measure should be introduced or intensified to reach the target GEP conditions.

The refined mitigation measures then need to be checked again in terms of disproportionate costs and infeasibility (see above) before proceeding to their practical implementation or to the application of an exemption (Article 4.5).

If the defined biological conditions for GEP cannot be reached after having implemented all measures without significant adverse effects on use (considering all relevant pressures) and allowing sufficient time for type-specific organisms to react and adapt, there is no need for further measure activities but a need to amend the biological values forecasted and defined in the GEP definition process.

7 INTERCOMPARISON OF ECOLOGICAL POTENTIAL

Key messages for this section

- As for natural water bodies, the requirement for intercalibration of HMWB implies that there is a need to ensure that classification methods for GEP are set in compliance with the WFD, and that classification results are comparable between EU Member States.
- To ensure comparability, a national, regional or basin-specific method for GEP definition has to be developed, although the application will be on water body level taking into account site-specific conditions.
- The step-wise approach and the mitigation measures library set out in this document should ensure a more common understanding and support the intercomparison of ecological potential.
- Comparability of classification results can be evaluated by analysing how Member States have addressed key steps of the procedure, especially:
    - Identification and assessment of hydromorphological impacts and alterations linked to the use causing failure of good status (from the designation phase)
    - Identification and consideration of the full range of potentially relevant mitigation measures, then excluding measures with a significant adverse effect on use or the wider environment in a transparent and consistent way
    - Definition of “slight” changes for biological conditions and removal of measures only leading to “slight” changes as well as consideration of approximation of ecological continuum

Intercalibration in the WFD and applicability to heavily modified water bodies

Intercalibration is a process aimed at achieving comparable classification boundaries for the biological quality elements set in compliance with the WFD requirements. The requirement for intercalibration is specified in WFD Annex V 1.4.1, that applies both to natural and heavily modified water bodies.

The intercalibration exercise is to be carried out by the Member States and facilitated by the Commission, with a deadline set in the WFD for 2007. Intercalibration activities started soon after the WFD came into force in 2000, as a key activity under the Common Implementation Strategy (CIS). In practice the intercalibration exercise proved to be much more complicated than originally foreseen; only a part of the work could be completed by the 2007 deadline, and a second and third phase were necessary. For natural waters, it has been possible to agree on a technical intercalibration process where Member States' classification methods are checked for their compliance with the normative definitions specified in WFD Annex V. Subsequently, the high-good and good-moderate boundaries are compared and harmonised either directly or by using a common metric. A common understanding of broad intercalibration types and the type-specific reference conditions is a key prerequisite to carry out the comparability analysis for good status classification methods. An important part of intercalibration of natural waters has been to apply/agree on common criteria for reference conditions. Several CIS guidance documents describe the common understanding and agreed procedures:

- CIS Guidance Document No.6 "Towards a guidance on establishment of the intercalibration network and the process of the intercalibration exercise (2003)
- CIS Guidance Document No.14 "Guidance on the intercalibration process 2004-2006" (2005)
- Updated CIS Guidance Document No.14 "Guidance on the intercalibration process 2008-2011" (2011)
- CIS Guidance Document No.30 "Procedure to fit new or updated classification methods to the results of a completed intercalibration exercise (2015)

Results of the completed intercalibration exercises were published in COM Decisions 2008/915/EC (phase 1), 2013/480/EU (phase 2) and 2018/REF (phase 3). With the 2018 COM Decision, the exercise has been completed for the natural water bodies.

In 2011 a concept paper on Intercalibration of GEP was endorsed by the Water Directors, discussing possibilities to fulfil the WFD requirement for intercalibrating good ecological potential and providing recommendations on assessing and improving comparability of good ecological potential assessments. A pragmatic approach was proposed, including the following three elements:

a) **Review of the current state of play in defining good ecological potential taking into account the requirements** of the WFD and existing guidance documents;
b) Development of a **methodological framework** for defining and assessing good ecological potential taking into account the results of the review; and
c) **Simple comparisons** of practical approaches for good ecological potential for common uses.

The first two steps of this process are completed with this new CIS Guidance no. 37, also partly based on several background documents (JRC technical reports and CIS workshop summaries related to the main water uses), and provide the basis for a subsequent intercomparison exercise.

Proposed practical approach for assessing comparability of good ecological potential for common uses

It is not possible to apply the same intercalibration procedures that were developed for the natural water body types to heavily modified water bodies. The main reason is that ecological potential class boundaries are not 'simply' derived from agreeing what constitutes a moderate deviation from type-specific reference conditions, but also include considerations of mitigation measures and their effect on supporting and biological quality elements, as well as socio-economic considerations when taking into account significant adverse effects on use and the wider environment from measures (policy-related issues).

As for natural water bodies, the requirement for intercalibration implies that there is a need to ensure that classification methods for GEP are set in compliance with the WFD, and that classification results are comparable between EU Member States. The step-wise approach and the mitigation measures library with DPSIR-information set out in this document should ensure a more common understanding and practice for ecological standards in HMWB, following the WFD principles and requirements and allowing different approaches.

Therefore, compliance can be evaluated by analysing and comparing the method and criteria Member States have used to designate and classify their heavily modified water bodies in the latest RBMP following the steps identified in this CIS Guidance Document No.37. Comparability of classification results can then be evaluated by analysing how Member States have addressed key aspects of the procedure, especially:

- Identification and assessment of hydromorphological impacts and alterations causing failure of good status and causing a change in character (from the designation phase). This should be based on the application of suitable methods for the assessment of hydromorphological quality elements, linked to the sensitive biological quality elements (see sections 2 and 4 of this Guidance).
- Identification and consideration of the full range of potentially relevant mitigation measures for MEP based on the expected effects of potential measures on hydromorphological conditions and the biological response.
- Criteria for excluding measures with a significant adverse effect on use or the wider environment in a transparent and consistent way,
- Definition of "slight" changes for biological conditions and removal of measures only leading to "slight" changes and/or removal of mitigation measures only leading to "slight" changes in biological quality element values.
- Consideration of approximation of ecological continuum.

It is foreseen that case studies from Member States where they document how they address the key steps of HMWB designation and defining GEP for typical uses and modifications will be collected, following a common template. The illustrative case studies in the current Guidance (see Annex I) are a first step that can be the basis for the templates to be used in the intercomparison exercise.

The purpose of this exercise will be to describe and compare the national methods to establish maximum and good ecological potential on the basis of the requirements of the WFD. The comparability of Member State approaches will then be evaluated, requiring some form of independent review (similar to the review panel established for the intercalibration exercise). This will allow to identify good practices, to support good implementation of the WFD requirements regarding GEP, to progress through comparable approaches and to identify differences in interpretation/implementation leading to a lack of comparability (e.g. different interpretations of what constitutes “best approximation of ecological continuum” or different interpretations of the necessity of minimum requirements).

The intercomparison will also be an opportunity for Member States that are not able to follow key steps of the procedure (and therefore key requirements of the WFD) to provide justification.

As already pointed out above, the intercalibration of HMWB will be quite different compared to that of natural water bodies and needs to address specific challenges. For this reason, the final outcome of the intercomparison will most likely not be a Commission Decision with numerical class boundaries for the BQEs, but may be presented in a document of common understanding or, if relevant problems of intercomparability are detected, in an additional CIS guidance document to support Member States in ensuring a better comparability of GEP definition.

ANNEX I - ILLUSTRATIVE CASE STUDIES ON THE STEPS FOR DEFINING ECOLOGICAL POTENTIAL

This Annex presents practical illustrations of theoretical case studies for different water categories, which demonstrate how to apply the key steps for defining MEP and GEP (see flow-charts in sections 5 and 6). The theoretical case studies follow the reference approach, the mitigation measures approach, or both approaches. It is noted that irrespective of the water category or the approach followed, if it is not possible to take all steps included in the step-wise approach in Figure 5 of this document, clear justification is needed in the relevant RBMP, while Member States should make sure they can complete the remaining steps by improving data availability and knowledge on the links between hydromorphology and biology.

The case studies are an illustrative summary of the findings of the application of the step-wise approach for defining ecological potential. The actual evidence, e.g. from monitoring on the different steps is not provided.

The sub-sections below present the following theoretical case studies:

1. Case study of a river impoundment; this case study is described based on both the reference approach and the mitigation measures approach.
2. Case study of a river affected by straightening and bank fixation for navigation; this case study is described based on both the reference approach and the mitigation measures approach.
3. Case study of an estuary impacted by flood defence/embanking; this case study follows the steps of the mitigation measures approach only.
4. Case study on a river affected by drainage; this case study follows the steps of the reference approach only.

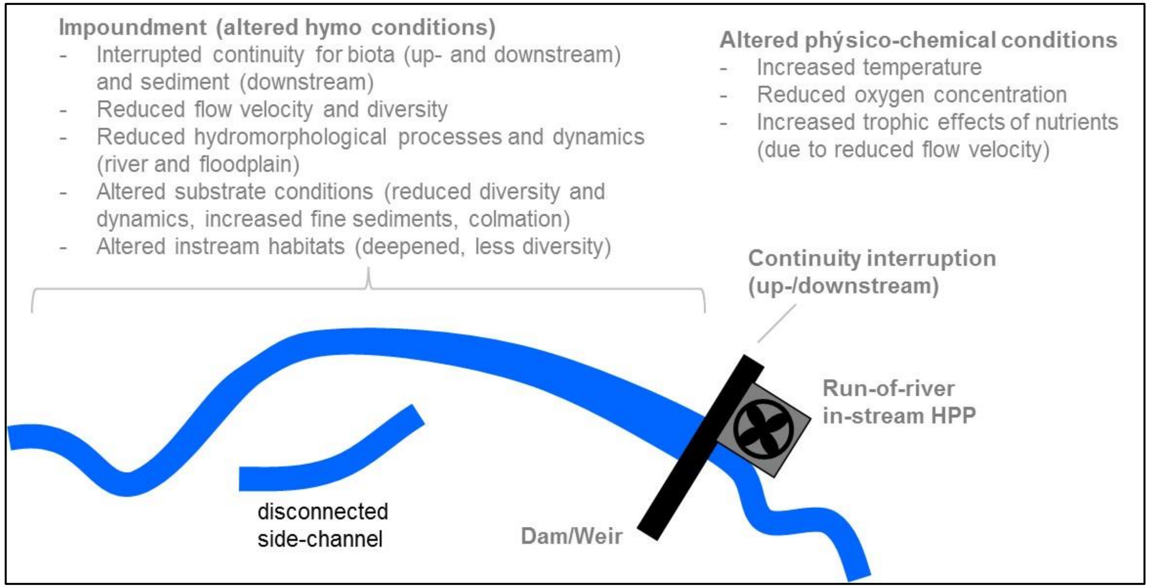
Case study 1: River impoundment (reference approach and mitigation measures approach)

<table>
<tr><th>Step</th><th>Reference approach</th><th>Mitigation measures approach</th></tr>
<tr><td>Information from earlier planning cycles (pre-step)</td><td>The river water body (high gradient small river, lower mountains (siliceous), coarse substrate, mean flow: 20 m³/s) is heavily modified because of a low head dam with a run-of-river in-stream hydropower plant, causing a significant impoundment and leading to severe hydromorphological alterations:
Interrupted continuity for biota (up- and downstream) and sediment (downstream)
Reduced flow velocity and diversity
Reduced hydromorphological processes and dynamics (river and floodplain)
Altered substrate conditions (reduced diversity and dynamics, increased fine sediments, colmation)
Altered instream habitats (deepened, less diversity)
These resulted in ecological impacts such as:
Reduced abundance / loss of rheophilic species (e.g. fish)
Increased abundance of tolerant species (e.g. benthic invertebrates)
Presence / increased abundance of stagnant species (e.g. macrophytes)
See Figure 11 (below).</td><td>The river water body (high gradient small river, lower mountains (siliceous), coarse substrate, mean flow: 20 m³/s) is heavily modified because of a low head dam with a run-of-river in-stream hydropower plant, causing a significant impoundment and leading to severe hydromorphological alterations:
Interrupted continuity for biota (up- and downstream) and sediment (downstream)
Reduced flow velocity and diversity
Reduced hydromorphological processes and dynamics (river and floodplain)
Altered substrate conditions (reduced diversity and dynamics, increased fine sediments, colmation)
Altered instream habitats (deepened, less diversity)
There are detailed monitoring data available on hydromorphological conditions (providing detailed knowledge of the hydromorphological alterations, which are used for the HMWB designation). The biological monitoring data are limited or not appropriate to be assessed considering the sensitivity to the hydromorphological alterations.

However, there is clear evidence from literature that due to the reduced flow velocity and related changes in habitats the conditions for typical riverine species (e.g. benthic invertebrates) are altered so that GES cannot be ensured with a high degree of confidence. In particular, the dam is a</td></tr>
</table>

Step	Reference approach	Mitigation measures approach
	There are detailed monitoring data available on hydromorphological conditions (providing detailed knowledge of the hydromorphological alterations) and on biological quality elements (providing detailed knowledge of the biological impacts on benthic invertebrates and fish). The valid data basis provides the knowledge that is essential for the application of the "reference approach" for defining the ecological potential. The overall ecological status is "bad" based on benthic invertebrates (bad status), fish (poor status) and hydromorphology (bad status). With regard to physico-chemical quality elements, temperature and oxygen concentration are affected by the hydromorphological alterations causing the impoundment (based on detailed data). Reduction of flow velocity will increase the trophic effect of nutrients. There are no other relevant impacts from other water uses.	barrier to fish migration that is relevant to safeguarding the riverine fish population also in the long run. With regard to physico-chemical quality elements, temperature and oxygen concentrations are affected by the hydromorphological alterations causing the impoundment (based on detailed data). Reduction of flow velocity will increase the trophic effect of nutrients. There are no other relevant impacts from other water uses.

Figure 11: River impoundment with indication of impacts

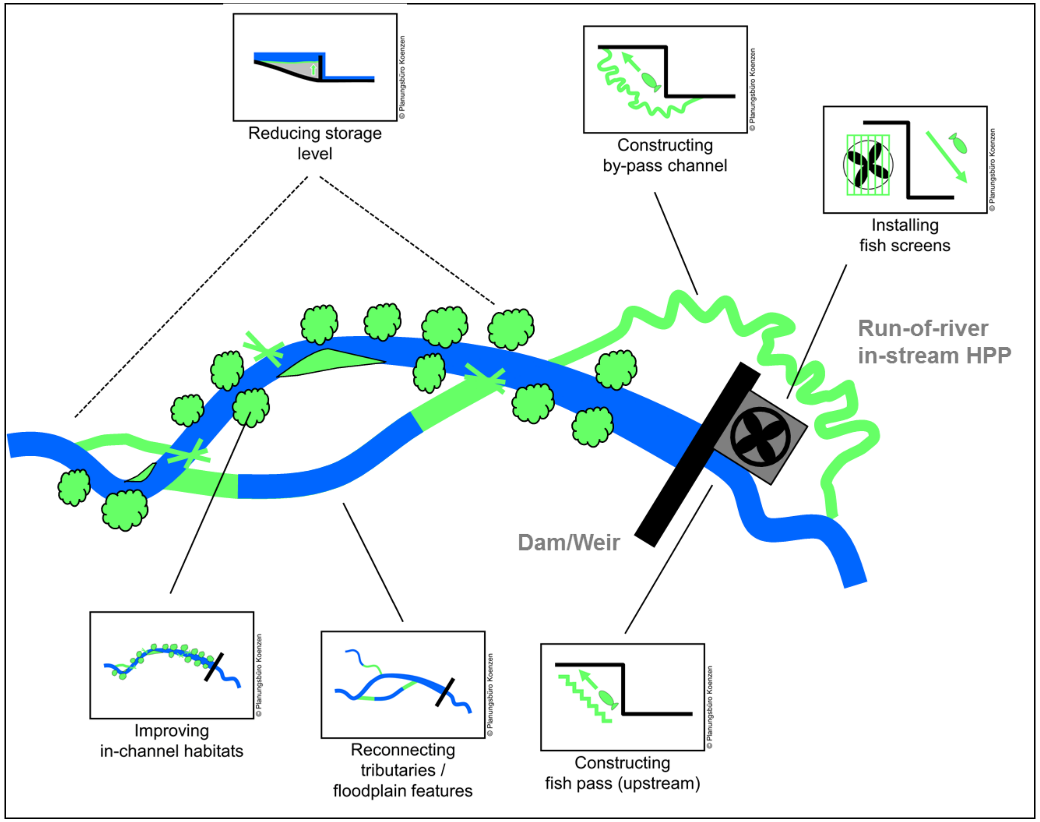


Step	Reference approach	Mitigation measures approach
A. Identification of closest comparable water category	The original river water body remains a river water body taking into account the hydromorphological and biological conditions.	The original river water body remains a river water body taking into account the hydromorphological and biological conditions.
B. Identification of mitigation measures for MEP (see	Based on the hydromorphological alterations and ecological impacts, the following groups of measures might be appropriate (selection of groups of measures from the Mitigation Measures Library):	Based on the hydromorphological alterations and ecological impacts, the following groups of measures might be appropriate (selection of groups of measures from the Mitigation Measures Library):

Step	Reference approach	Mitigation measures approach
Mitigation Measures Library)	- Fish migration aids - Sediment management - Riparian habitat enhancement - Improvement of in-channel diversity - Ecologically optimised maintenance - River depth and width variation improvement - Floodplains/ lateral connectivity improvement - Reduction negative effects of impoundment - River bed restoration	- Fish migration aids - Sediment management - Riparian habitat enhancement - Improvement of in-channel diversity - Ecologically optimised maintenance - River depth and width variation improvement - Floodplains/lateral connectivity improvement - Reduction negative effects of impoundment - River bed restoration
B1. Identify mitigation measures relevant to each hydromorphological alteration and ecologically effective in physical context of water body or water bodies	In this step, the measure groups from the Mitigation Measures Library are further specified and detailed measures identified, considering the physical context of the water body. The following detailed measures are assumed to be relevant and ecologically effective (Figure 12): a. Fish migration aids (near-natural by-pass channel, fish pass and fish screen) b. Connecting side-channel c. Riparian habitat enhancement (flatten shore zones, plant trees) d. Improvement of in-channel diversity (introduce type specific substrate in the upper part of the impoundment, introducing large woody debris) e. Raising river bed level (reduce negative effects of impoundment) Those measures will contribute to:	In this step, the measure groups from the Mitigation Measures Library are further specified and detailed measures identified, considering the physical context of the water body. The following detailed measures are assumed to be relevant and ecologically effective (Figure 12): a. Fish migration aids (near-natural by-pass channel, fish pass and fish screen) b. Connecting side-channel c. Riparian habitat enhancement (flatten shore zones, plant trees) d. Improvement of in-channel diversity (introduce type specific substrate in the upper part of the impoundment, introducing large woody debris) e. Raising river bed level (reduce negative effects of impoundment) Those measures will contribute to:

Step	Reference approach	Mitigation measures approach
	- Restore river continuity for biota (up- and downstream) and sediment (downstream) to some extent) - Increase flow velocity and diversity and shorten the length of the water body that is affected by the impoundment - Improve the hydromorphological processes and dynamics (river and floodplain) - Improve substrate conditions for riverine species - Improve riverine habitats and by this conditions for type-specific riverine species The removal of the dam/ barrier would be the most effective measure to improve biological conditions, but was not considered because: - this measure would lead to a restoration towards GES and - was assessed in the HMWB designation process to have a significant adverse effect on use (because no production of electricity would be possible)	- Restore river continuity for biota (up- and downstream) and sediment (downstream) to some extent) - Increase flow velocity and diversity and shorten the length of the water body that is affected by the impoundment - Improve the hydromorphological processes and dynamics (river and floodplain) - Improve substrate conditions for riverine species - Improve riverine habitats and by this conditions for type-specific riverine species The removal of the dam/ barrier would be the most effective measure to improve biological conditions, but was not considered because: - this measure would lead to a restoration towards GES and - was assessed in the HMWB designation process to have a significant adverse effect on use (because no production of electricity would be possible)

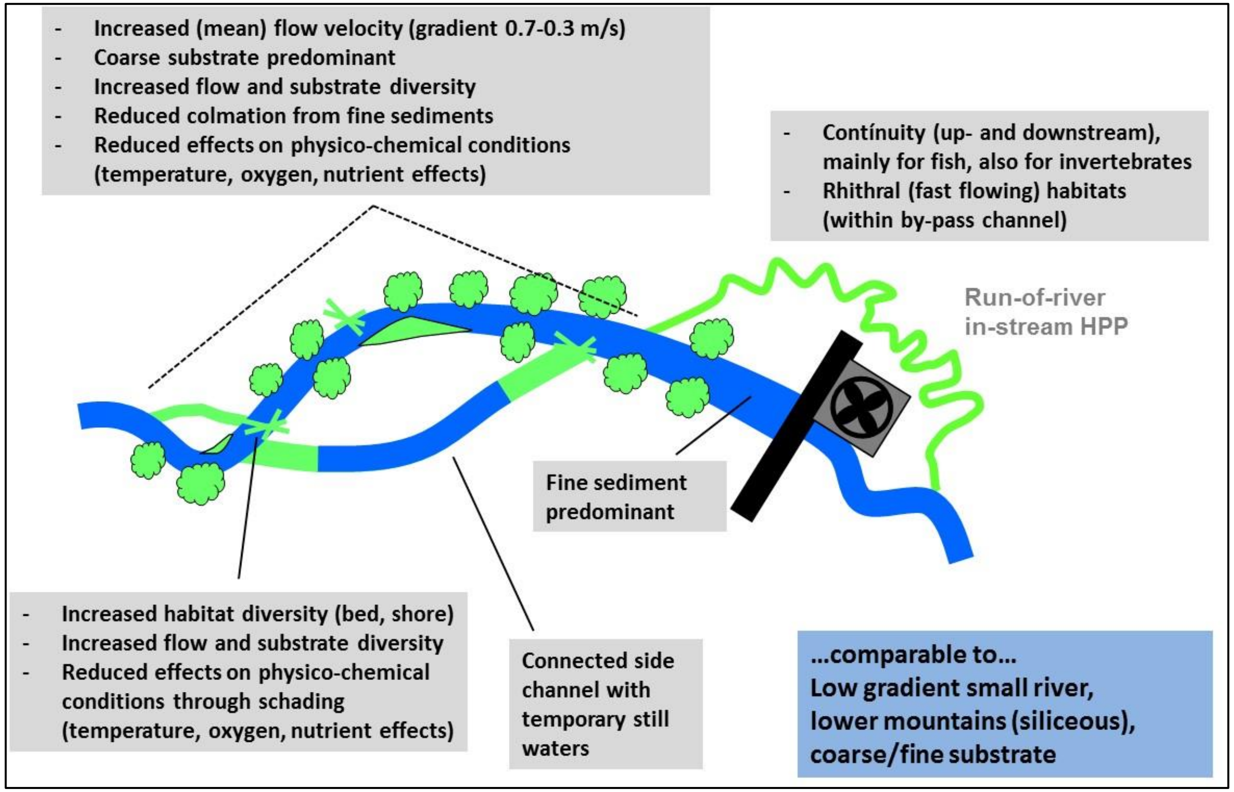
Figure 12: River impoundment with range of possible mitigation measures (MEP)



Step	Reference approach	Mitigation measures approach
B2. Exclude mitigation measures with significant adverse effect on use or wider environment	All the other measures (a-e) do not have per se significant adverse effects on the hydropower use (they do not necessarily mean a reduction of the electricity production).	All the other measures (a-e) do not have per se significant adverse effects on the hydropower use (they do not necessarily mean a reduction of the electricity production).
B3. Select most ecologically beneficial (combination of) measures taking into account need to ensure best approximation to ecological continuum	• All measures from step B1 (measures a-e) are relevant to the hydromorphological alterations in the water body, ecologically effective and do not adversely impact on use. In combination, therefore, these measures contribute to MEP. • The measures are able to significantly improve ecological continuum.	• All measures from step B1 (measures a-e) are relevant to the hydromorphological alterations in the water body, ecologically effective and do not adversely impact on use. In combination, therefore, these measures contribute to MEP. • The measures are able to significantly improve ecological continuum.
C. Derivation of hydromorphological conditions for MEP	The above measures significantly enhance habitats in the river bed, riparian zone and floodplain. The basis for deriving the hydromorphological conditions for MEP are the predicted measure effects on the existing hydromorphological conditions (see pre-step) considering reference conditions of the original water body type. The sequence of sub-steps is 1) Descriptions of hydromorphological conditions at status quo; 2) Measure effects on these conditions; 3) Description of hydromorphological conditions for MEP. The result has been compared with existing river types in the river basin to identify a closest comparable river type. The closest comparable water	It can be generally expected, that the measures identified in step B3 significantly enhance habitats in the river bed, riparian zone and floodplain. Based on predicted measure effects on the existing hydromorphological alterations (see pre-step) and considering reference conditions of the original natural water body type, hydromorphological conditions for MEP are moderately to severely changed in comparison. All relevant parameters have been defined based on these considerations using the existing national hydromorphological methods.

Step	Reference approach	Mitigation measures approach
	body type is the next more potamal river type within the same landscape from the national typology. In this case (of a high gradient small river, lower mountains (siliceous), coarse substrate), the closest comparable river type is a "low gradient small river, lower mountains (siliceous), coarse/fine substrate". See Figure 13 for a description of the derived hydromorphological conditions for MEP.	

Figure 13: Derived hydromorphological conditions for MEP

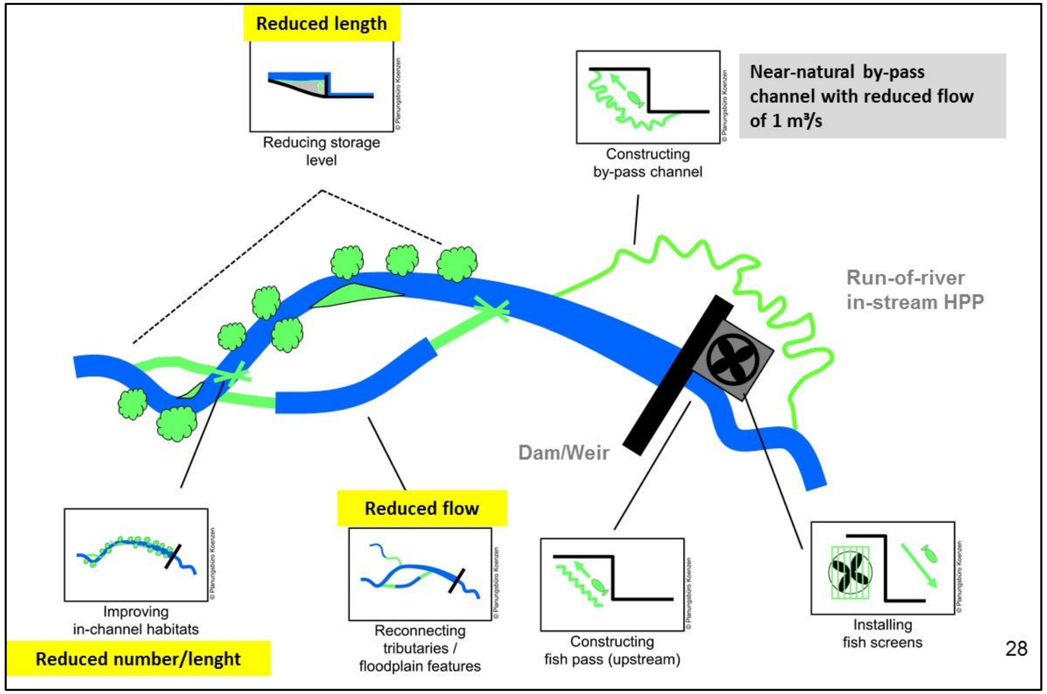


Step	Reference approach	Mitigation measures approach
D. Derivation of physico-chemical conditions for MEP, taking into account the closest comparable water body type	Physico-chemical conditions correspond to the values for high ecological status for the original river type, except for parameters that are significantly affected by the remaining hydromorphological alterations at MEP. In this case, temperature and oxygen concentration could be affected according to the closest comparable water body type ("Low gradient small river, lower mountains (siliceous), coarse/fine substrate"). In fact, temperature and oxygen values for MEP correspond to the values of the original river type, in particular based on the direct and indirect influence of groundwater, shading and optimised flow conditions on these parameters that overrule the remaining impacts on flow velocity within the impounded stretch at MEP. With regards to nutrients, trophic effects can be increased within the remaining impoundment in some ways, but this does not require values that are different from the original natural type. In any case, reference values for nutrients of the closest comparable water body type are the same as for the original natural type.	Physico-chemical conditions correspond to the values for high ecological status for the original river type, except for parameters which are significantly affected by the remaining hydromorphological alterations at MEP. In this case, temperature and oxygen concentration could be affected according to the closest comparable water body type ("Low gradient small river, lower mountains (siliceous), coarse/fine substrate"). In fact, temperature and oxygen values for MEP correspond to the values of the original river type, in particular based on the direct and indirect influence of groundwater, shading and optimised flow conditions on these parameters that overrule the remaining impacts on flow velocity within the impounded stretch at MEP. With regards to nutrients, trophic effects can be increased within the remaining impoundment in some ways, but this does not require values that are different from the original natural type. In any case, reference values for nutrients of the closest comparable water body type are the same as for the original natural type.
E. Derivation of BQE conditions for MEP	This step is based on the hydromorphological alterations and ecological impacts (see pre-step), the predicted effects of the relevant mitigation measures (see B1, B3), and the difference between hydromorphological conditions for MEP (see C) and reference conditions for the original natural river type. In conclusion, the difference in hydromorphological conditions between MEP and reference conditions for the original natural river type have been translated to BQE conditions at MEP. Based on this, BQE conditions have been defined based on the biological assessment system for natural water bodies. The EQR values have been	BQE conditions for MEP cannot be derived due to a lack of BQE data in this planning cycle and/or due to a lack of knowledge on hydromorphological alterations and biological response. However, the application of national monitoring methods to this water body in the next and future planning cycles will enable a prediction of BQE conditions at MEP to be made.

Step	Reference approach	Mitigation measures approach
	reduced with the same proportion of the gradient as the difference between reference conditions and MEP based on hydromorphological methods. The reduction is different between the BQEs, because of different sensitivity at least to some of the relevant hydromorphological (and related physico-chemical) parameters. The predicted results have been tested and amended in some aspects using a solid basis of monitoring data from comparable water bodies (same use and comparable river types) considering as much as possible the gradient of different habitat qualities from maximum to bad potential	
F. Derivation of BQE conditions for GEP	BQE conditions for GEP resulted from the biological assessment systems that use the same principle for defining “slight changes” as for the intercalibrated method for natural water bodies. Therefore, the functioning of the aquatic ecosystem can be assumed if BQE conditions result in GEP.	BQE conditions for GEP cannot be derived due to lack of BQE data in this planning cycle/ lack of knowledge on hydromorphological alterations and biological response.
G. Derivation of supporting quality element conditions for GEP	This step is based on the BQE conditions for GEP (see step F). The hydromorphological parameters have been derived based on the difference between BQE conditions of MEP (step E) and GEP (step F), considering the hydromorphological conditions for MEP (step C). Physico-chemical conditions correspond to the values for good ecological status of the original natural river type.	Hydromorphological conditions are derived by expecting conditions with assumed implementation of the GEP-measures set defined in step H. Physico-chemical conditions correspond to the values for good ecological status of the natural river type.

Step	Reference approach	Mitigation measures approach
	Functioning of the aquatic ecosystem is ensured by physico-chemical conditions as well as by the biological GEP conditions identified in step F.	Functioning of the aquatic ecosystem is ensured by physico-chemical conditions as well as by the hydromorphological conditions which contribute to improve ecological continuum by the GEP measures identified in step H.
H. Identification of mitigation measures for GEP	The following measures are within the set of qualitative GEP measures: a. Fish migration aids (near-natural by-pass channel, fish pass and fish screen) b. Connecting side-channel c. Riparian habitat enhancement (flatten shore zones, plant trees) d. Improvement of in-channel diversity (introduce type specific substrate in the upper part of the impoundment, introducing large woody debris) e. Raising river bed level (reduce negative effects of impoundment) The difference between MEP and GEP is based on BQE values ("slight change"). While the qualitative measure set is the same for GEP as for MEP in this case, the GEP measures significantly differ from MEP measures in quantity (extent) (see Figure 14 below). (There also might be certain cases where certain measures are needed for MEP but not for GEP, but those were identified to be relevant for this example.)	From the MEP-set of measures (measures a-e), no measures have been deleted because they are assumed to deliver slight improvements to ecology. Based on literature, significant effects on BQE can be expected for all measures. Therefore, the following measures are within the set of qualitative GEP measures: a. Fish migration aids (near-natural by-pass channel, fish pass and fish screen) b. Connecting side-channel c. Riparian habitat enhancement (flatten shore zones, plant trees) d. Improvement of in-channel diversity (introduce type specific substrate in the upper part of the impoundment, introducing large woody debris) e. Raising river bed level (reduce negative effects of impoundment) This is the same set of measures which was identified for MEP but the quantity/extent of the measures is reduced compared to the extent needed for MEP. See Figure 14. (There also might be certain cases, that certain measures are needed for MEP but not for GEP, but those were identified to be relevant for this example).

Figure 14: River impoundment with mitigation measures for reaching GEP



Step	Reference approach	Mitigation measures approach
Monitoring to assess whether GEP is being achieved	The modified HMWB biological assessment systems have been used to classify the ecological potential of the water body. Compared to the MEP values set for the BQEs, the overall biological monitoring results show a strong deviation from the MEP values, so that the actual ecological potential is to be classified as “poor” based on benthic invertebrates and fish. Therefore, hydromorphological mitigation	As biological conditions could not be defined for GEP in this cycle, conditions of the supporting elements have been monitored in the meantime and been compared to the conditions set in step G to identify the deviation from GEP and the need to implement the GEP-measures to achieve GEP.

Step	Reference approach	Mitigation measures approach
	measures (identified in step H) are necessary to improve conditions of the water body and achieve GEP.	Nevertheless, it is recommended to also collect data for biological quality elements (although they are not classified) and to increase the knowledge on hydromorphological conditions-biological response relationships.
Are there GEP measures that are disproportionally expensive or infeasible?	None of the GEP measures are disproportionally expensive or infeasible.	None of the GEP measures are disproportionally expensive or infeasible.
Implement GEP measures and monitor effects on BQEs and supporting quality elements	The following measures have been implemented within the next RBMP Programme of Measures: a. Fish migration aids (near-natural by-pass channel, fish pass and fish screen) b. Connecting side-channel c. Riparian habitat enhancement (flatten shore zones, plant trees) d. Improvement of in-channel diversity (introduce type specific substrate in the upper part of the impoundment, introducing large woody debris) e. Raising river bed level (reduce negative effects of impoundment) The quantitative design of the measures has been based on the adverse effects on use (e.g. for calculating maximum flow for by-pass channel)	The following measures have been implemented within the next RBMP Programme of Measures: a. Fish migration aids (near-natural by-pass channel, fish pass and fish screen) b. Connecting side-channel c. Riparian habitat enhancement (flatten shore zones, plant trees) d. Improvement of in-channel diversity (introduce type specific substrate in the upper part of the impoundment, introducing large woody debris) e. Raising river bed level (reduce negative effects of impoundment) The quantitative design of the measures has been based on the adverse effects on use (e.g. for calculating maximum flow for by-pass channel) and an estimation of the need to improve biological conditions significantly.

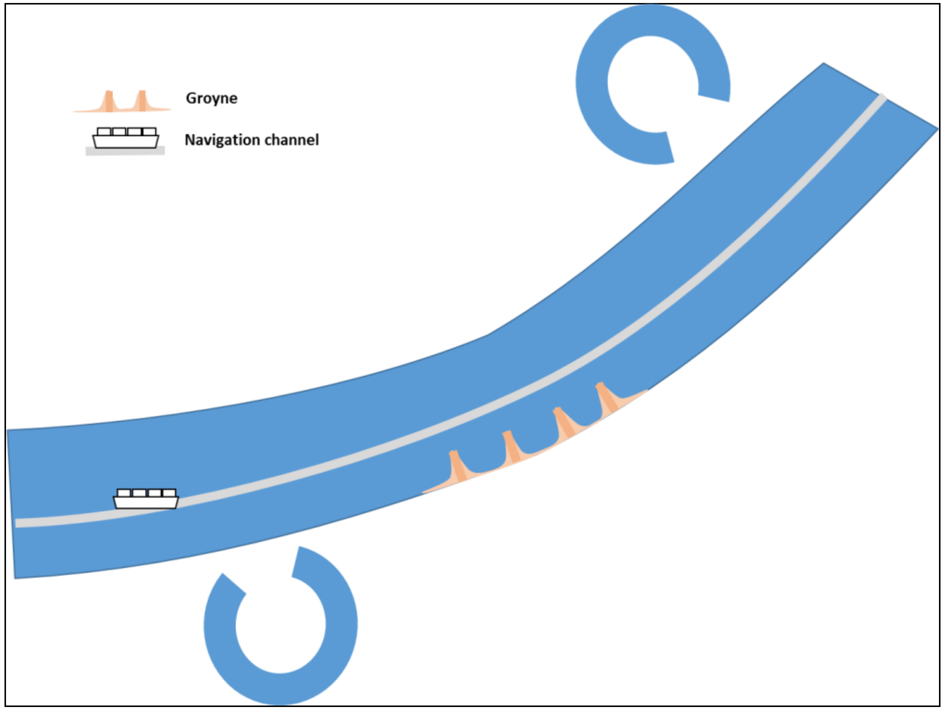
Step	Reference approach	Mitigation measures approach
	and an estimation of the need to achieve biological GEP values (see step F). Monitoring will be undertaken within the next monitoring cycle.	Monitoring will be undertaken within the next monitoring cycle.

Case study 2: River straightening and bank fixation for navigation (reference approach and mitigation measures approach)

Step	Reference approach	Mitigation measures approach
Information from earlier planning cycles (pre-step)	The river stretch is a heavily modified water body designated because of prior straightening in combination with bank fixation and associated incision (consequential deepening) to support navigation use. There are some shore-perpendicular groynes on the outer part of the bend but these structures, together with the increased velocities achieved as a result of the straightening, currently mean there is no requirement for maintenance dredging. Based on detailed hydromorphological data particularly the following alterations are known: • Straightened river with single channel planform • Deepened river profile with reduced floodplain connection • Altered flood plain habitats (e.g. cut-off meanders, infilled side-channels) • Increased flow velocity, reduced flow diversity • Reduced hydromorphological processes and dynamics (river and floodplain) • Bank fixation with hard engineering (e.g. concrete, rip raps)	The river is a heavily modified water body designated because of prior straightening in combination with bank fixation and associated incision (consequential deepening) to support navigation use. There are some shore perpendicular groynes on the outer part of the bend, but these structures, together with the increased velocities achieved as a result of the straightening, currently mean there is no requirement for maintenance dredging. There is a relative lack of WFD monitoring data for this water body but some anecdotal evidence does exist. See Figure 15 below.

Step	Reference approach	Mitigation measures approach
	• Reduced substrate diversity (e.g. lack of woody debris) • Altered river bed and riparian habitats (reduced flat riparian zones, less diversity, reduced vegetation cover) These resulted in ecological impacts such as: • Reduced abundance / loss of rheophilic species (e.g. fish), particularly altered reproduction of river type specific fish species • Increased abundance of tolerant species (e.g. benthic invertebrates) • Reduced abundance / loss of floodplain related species (e.g. fish) • Reduced species diversity (e.g. fish, benthic invertebrates) The overall ecological status is “poor” based on benthic invertebrates and fish.	

Figure 15: River impacted by straightening and bank fixation for navigation



Step	Reference approach	Mitigation measures approach
A. Identification of closest comparable water category	The original river water body remains a river water body taking into account the hydromorphological and biological conditions.	The original river water body remains a river water body taking into account the hydromorphological and biological conditions.
B. Identification of mitigation measures for MEP (see Mitigation Measures Library)	Based on the hydromorphological alterations and ecological impacts (see above in pre-step) the following groups of measures might be appropriate (selection from the Mitigation Measures Library): • Floodplains/off-channel/lateral connectivity improvement • Riparian habitat enhancement • Improvement of in-channel diversity • Increase habitat diversity with improved river depth and width variation • Ecologically optimised maintenance • Vegetation management and rehabilitation • Modification of existing structures • Sediment management • River bed rehabilitation	Reference to the Mitigation Measures Library: (i) Confirms that there are two **specific physical modifications**: channel straightening with changed planform/channel patterns including cut off meanders, and shore-perpendicular structures (i.e. groynes). (ii) Suggests that the **hydromorphological supporting elements** most likely to be affected by these types of modification are quantity and dynamics of flow, changes in (controls on) river depth and width, and changes in riparian zone structure. The presence of groynes also affects continuity in the margins on one side of the river. In this case the modifications have not affected the bed substrate. (iii) Does not identify any typically anticipated implications for **physico-chemical supporting elements**. (iv) Indicates there is a strong likelihood that these types of physical modification will impact on three **BQEs**: macrophytes and phytobenthos, benthic invertebrates, and fish fauna. A visual assessment of the water body confirms this is likely the case here.

Step	Reference approach	Mitigation measures approach
		(v) Suggests the following **groups of mitigation measures** might be appropriate to address such effects: • Improved in-channel diversity • Ecologically optimised maintenance • Enhanced habitat diversity with increased width/depth variability • Riparian habitat enhancement • Off channel/lateral connectivity improvement • Vegetation management and rehabilitation • Modification of existing structures • Sediment management • River bed rehabilitation
B1. Identify mitigation measures relevant to each hydromorphological alteration and ecologically effective in physical context of water body or water bodies	Based on the detailed data of hydromorphological alterations (e.g. with no dredging taking place) the following from the above groups of measures are not expected to be ecologically effective in addressing the identified or observed issues: ecologically optimised maintenance, sediment management and river bed rehabilitation. The focus is therefore on identifying measures for improved in-channel and riparian diversity (habitat enhancement) including width and depth variability; lateral connectivity including improved floodplain connection and floodplain habitat enhancement; vegetation rehabilitation and modification of existing structures.	Taking into account the nature of the modification (with no dredging taking place) the following from the above groups of measures are not expected to be ecologically effective in addressing the identified or observed issues: ecologically optimised maintenance, sediment management and river bed rehabilitation. The focus is therefore on identifying measures for improved in-channel and riparian diversity (habitat enhancement) including width and depth variability; lateral connectivity including improved floodplain connection and floodplain habitat enhancement; vegetation rehabilitation; and modification of existing structures.

Step	Reference approach	Mitigation measures approach
	Figure 16 illustrates the range of detailed mitigation measures corresponding to the above groups of measures. These have been identified taking into account their viability in the context of the river water body and their expected ecological effectiveness, and are described below: 1. Construct lateral islands providing a sheltered, shallow water riparian environment promoting sediment deposition and large woody debris (with fixation) as well as natural vegetation establishment (with initial planting if needed), and creation of habitat for invertebrates and fish. 2. Create a sheltered, shallow backwater in an old meander exit, to promote large woody debris (with fixation) and vegetation establishment with initial planting if needed, resulting in habitat for invertebrates and fish. 3. Sever the roots of the existing groynes to improve lateral connectivity and habitat diversity at the river margins 4. Replace hard engineered river bank with willow spiling to establish vegetation at the margins, creating habitat and improving connectivity. 5. Reconnect oxbow lake to re-establish a former meander (with water control structures if these are needed to sustain the use of the river for navigation). Create a diverse range of habitat types, supporting particularly macrophytes, benthic invertebrates and fish.	Figure 16 illustrates the range of detailed mitigation measures corresponding to the above groups of measures. These have been identified taking into account their viability in the context of the river water body and their expected ecological effectiveness, and are described below: 1. Construct lateral islands providing a sheltered, shallow water riparian environment promoting sediment deposition and natural vegetation establishment (with initial planting if needed), and creation of habitat for invertebrates and fish. 2. Create a sheltered, shallow backwater in an old meander exit, to promote vegetation establishment with initial planting if needed, resulting in habitat for invertebrates and fish. 3. Sever the roots of the existing groynes to improve lateral connectivity and habitat diversity at the river margins. 4. Replace hard engineered river bank with willow spiling to establish vegetation at the margins, creating habitat and improving connectivity. 5. Reconnect oxbow lake to re-establish a former meander (with sluices or other managed water control structures if these are needed to sustain the use of the river for navigation). Create a diverse range of habitat types, supporting macrophytes and phytoplankton, benthic invertebrates and, depending on the extent of engineering required, fish. 6. Replace hard engineered river bank with planted geotextile revetments to establish vegetation at the margins, creating habitat and improving connectivity.

<table>
<tr><th>Step</th><th>Reference approach</th><th>Mitigation measures approach</th></tr>
<tr><td></td><td>6. Replace hard engineered river bank with planted geotextile revetments to establish vegetation at the margins, creating habitat and improving connectivity.
7. Lower riparian zone and create side-channel (from formerly filled side-channel, with water control structures at the upstream part if these are needed to sustain the use of the river for navigation). Create a diverse range of habitat types, supporting particularly macrophytes, benthic invertebrates and fish.

The combination of measures is predicted to result in a best approximation to ecological continuum. If monitoring of BQE results in GEP classification, best approximation of ecological continuum can be assumed.</td><td>7. Lower riparian zone and create side-channel (from formerly filled side-channel, with water control structures at the upstream part if these are needed to sustain the use of the river for navigation). Create a diverse range of habitat types, supporting particularly macrophytes, benthic invertebrates and fish.

Depending on the scale of implementation of one or more of the above measures, it is confirmed that a best approximation to ecological continuum will be ensured.</td></tr>
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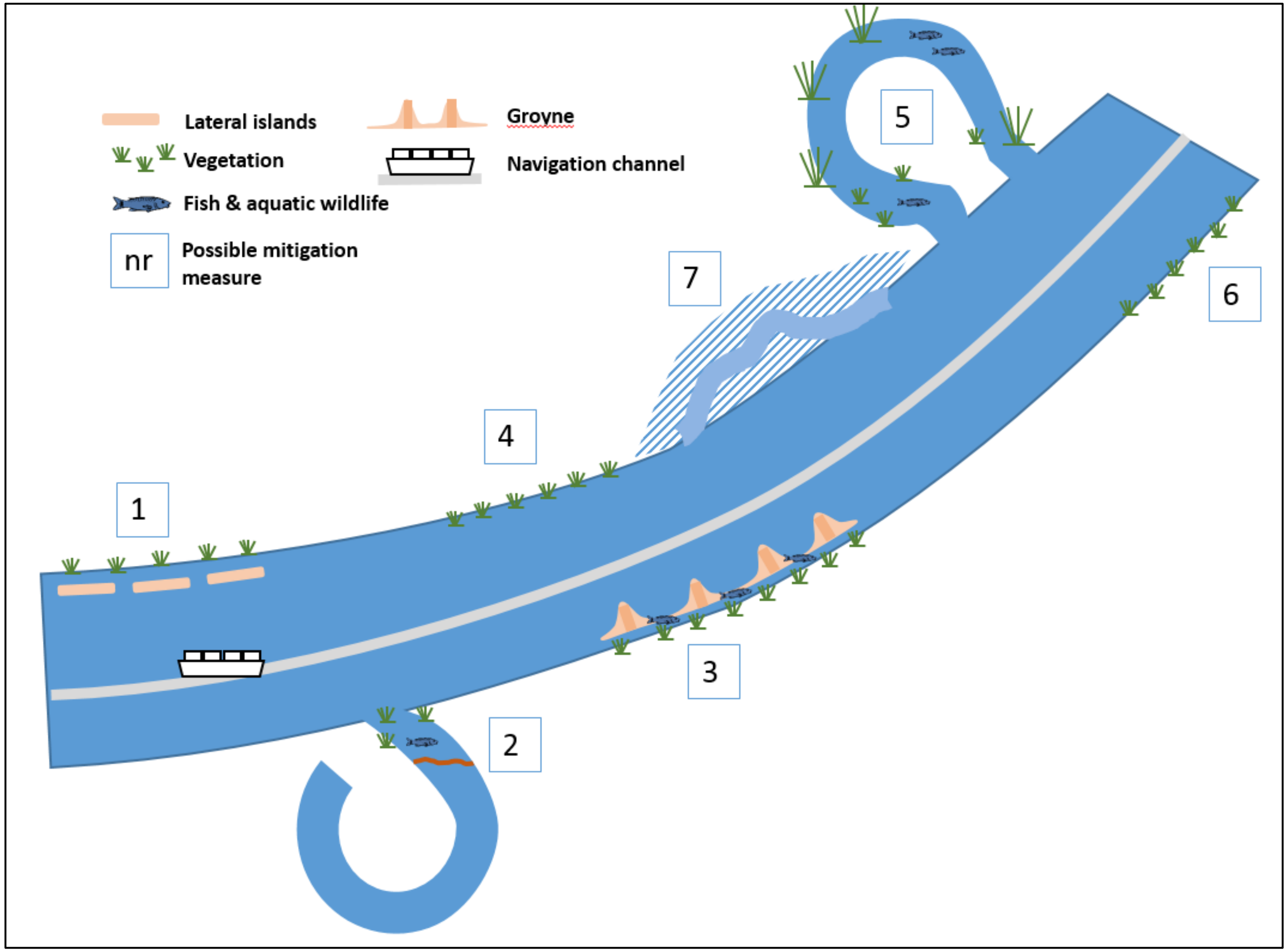
Figure 16: River impacted by straightening and bank fixation for navigation with range of possible mitigation measures



Step	Reference approach	Mitigation measures approach
B2. Exclude measures with significant adverse effect on use or wider environment	Measure 6 is ruled out because the fixed bank also serves a flood defence purpose and it is shown that the standard of protection would be compromised if the hard engineered structure were removed.	Measure 6 is ruled out because the fixed bank also serves a flood defence purpose and it is shown that the standard of protection would be compromised if the hard engineered structure were removed.
B3. Select most ecologically beneficial (combination of) measures taking into account need to ensure best approximation to ecological continuum	Measures 1 to 5 and 7 are relevant to the hydromorphological alterations in the water body, ecologically effective and do not adversely impact on use. In combination, therefore, these measures contribute to MEP.	Measures 1 to 5 and 7 are relevant to the hydromorphological alterations in the water body, ecologically effective and do not adversely impact on use. In combination, therefore, these measures contribute to MEP.
C. Derivation of hydromorphological conditions for MEP	The above measures enhance the riparian and floodplain habitat in the water body, increasing diversity in terms of variations in depth and exposure and substrate conditions. Most measures also contribute to improved lateral connectivity/ecological continuum. Based on predicted measure effects on the existing hydromorphological alterations (see pre-step) and considering reference conditions of the original natural river type (which is the closest comparable river type for this case), hydromorphological conditions for MEP are changed in comparison. While relatively near-natural floodplain habitats can be developed under MEP, the riparian habitats are more intensively changed compared to reference conditions and show several artificial elements (like groynes). The river bed habitats have also been changed as a result of the modifications made to maintain the navigation	It can be generally expected that the measures identified in steps B3, all enhance the riparian habitat in the water body, increasing diversity in terms of variations in depth, width and exposure, and providing new substrate for benthic invertebrates, macrophytes and phytobenthos and fish (including juveniles). Most measures also contribute to improved lateral connectivity/ecological continuum.

Step	Reference approach	Mitigation measures approach
	fairway. All relevant parameters have been defined based on these considerations using the implemented hydromorphological methods.	
D. Derivation of physico-chemical conditions for MEP, taking into account the closest comparable water body type	Physico-chemical conditions correspond to the values for high ecological status of the original natural river type.	Neither the modification nor the mitigation measures will affect the WFD physico-chemical supporting elements.
D. Derivation of BQE conditions for MEP	Basis for this step were the hydromorphological alterations and ecological impacts (see pre-step), the predicted effects of the relevant mitigation measures (see B1, B3) as well as the difference between hydromorphological conditions for MEP (see C) and reference conditions of the original natural river type. Considering all of these results, BQE conditions have been defined based on the biological assessment system for natural water bodies.	BQE conditions for MEP cannot be derived due to a lack of BQE data in this planning cycle. However, the application of national monitoring methods to this water body in the next and future planning cycles will enable a prediction of the BQE conditions at MEP to be made.

Continuation of step-wise process for **mitigation measures approach** (H→G→F …):

Step	Reference approach	Mitigation measures approach
H. Identification of mitigation measures for GEP	See next table	As indicated in Figure 16, Measure 3 creates a relatively small area of new habitat. Further, because Measure 6 has a significant adverse impact on use, there is limited benefit in improving connectivity along this short stretch on the outer bend. As Measure 3 therefore makes only a limited contribution to ecological potential, it is considered a MEP measure. GEP is defined by a combination of Measures 1, 2, 4, 5 and 7.
G. Derivation of supporting quality element conditions for GEP	See next table	The selected combination of measures would result in a significant improvement in connectivity (continuum) along the inner bend of the river. By tackling the impacts of bank fixation (particularly the loss of shallow margins) each of the measures also contributes substantively to improving riparian zone structure and hence to the enhancement of the riparian habitat for the three affected BQEs: macrophytes and phytobenthos, benthic invertebrates and fish fauna.
F. Derivation of BQE conditions for GEP	See next table	BQE conditions for GEP cannot be derived due to lack of BQE data in this planning cycle
Monitoring to assess whether GEP is being achieved	See next table	Monitoring of the BQEs, flow conditions and riparian zone structure confirms that the water body is not currently at GEP but provides a baseline from which the effectiveness of the mitigation measures can be determined
Are there GEP measures that are disproportionally	See next table	Further investigation is needed to ensure that Measure 5 is feasible without disproportionate expenditure on engineering structures for the water intake and outlet. This measure may therefore be ruled out on the basis of

expensive or infeasible?		disproportionate cost, and GEP may therefore not be achievable. Measure 1 similarly requires modelling to check whether sedimentation rates might compromise the feasibility of this measure.
Implement GEP measures and monitor effects on BQEs and supporting quality elements	See next table	Pending a decision on measures 1 and 5, Measures 2, 4 and 7 will be implemented via the RBMP Programme of Measures. Monitoring for the relevant biological and hydromorphological quality elements will be initiated to evaluate the effectiveness of the measures

Continuation of step-wise process for **reference approach** (F→G→H …):

Step	Reference approach	Mitigation measures approach
F. Derivation of BQE conditions for GEP	BQE conditions for GEP resulted from the biological assessment systems that use the same principle for defining "slight changes" as for the intercalibrated method for natural water bodies.	See previous table
G. Derivation of supporting quality element conditions for GEP	Basis for this step were the BQE conditions for GEP (see step F). The hydromorphological parameters have been derived based on the difference between BQE conditions of MEP (step E) and GEP (step F) considering the hydromorphological conditions for MEP (step C). Physico-chemical conditions correspond to the values for good ecological status of the original natural river type.	See previous table

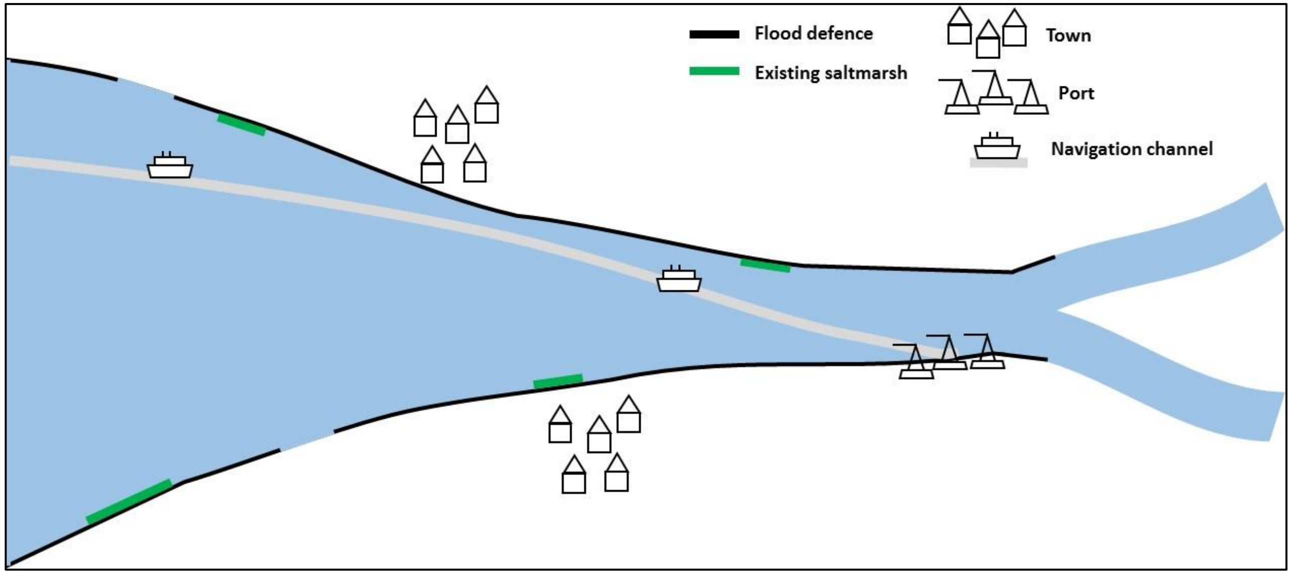
Step	Reference approach	Mitigation measures approach
H. Identification of mitigation measures for GEP	The difference between MEP and GEP is based on BQE values ("slight change"). Based on this, Measure 3 is estimated as not being necessary to reach GEP biological values, because it has only a low effect on BQE. Therefore GEP is defined by a combination of Measures 1, 2, 4, 5 and 7. While the qualitative measure set is the same for GEP as for MEP apart from measure 3 in this case (see B3), both classes significantly differ in the quantity of measures needed to achieve each class.	See previous table
Monitoring to classify ecological potential of HMWB	The modified assessment systems have been used to classify ecological potential of the water body. The overall result is "moderate" based on benthic invertebrates and fish. Therefore, hydromorphological mitigation measures are necessary to improve conditions of the water body and achieve GEP.	See previous table
Are there GEP measures that are disproportionally expensive or infeasible?	Further investigation is needed to ensure that Measure 5 is feasible without disproportionate expenditure on engineering structures for the water intake and outlet. This measure may therefore be ruled out on the basis of disproportionate cost. BQE monitoring has to show whether GEP can still be reached or not (and less stringent objectives have to be applied). Measure 1 similarly requires modelling to check whether sedimentation rates might compromise the feasibility of this measure.	See previous table
Implement GEP measures and monitor effects on BQEs and	Pending a decision on measures 1 and 5, Measures 2, 4 and 7 will be implemented via the RBMP Programme of Measures.	See previous table

Step	Reference approach	Mitigation measures approach
supporting quality elements	Monitoring will be undertaken within the next monitoring cycle.	

Case study 3: Estuary with flood defence/embanking (mitigation measures approach)

Step	Mitigation measures approach
Information from earlier planning cycles (pre-step)	The estuary is a heavily modified water body designated as such because almost 100% has been embanked for flood defence purposes. There are settlements on each side of the estuary and a small port at the upstream end. Navigation to the port uses a naturally deep channel in an otherwise fairly shallow, sediment-rich estuary. Dredging of this channel takes place occasionally. There is relative lack of WFD monitoring data but anecdotal evidence is available showing that since the estuary was embanked in the 1950s, most of the previously extensive saltmarsh has been lost due to 'coastal squeeze' caused by sea level rise. See Figure 17 below.

Figure 17: Estuary water body impacted by flood defence/embanking

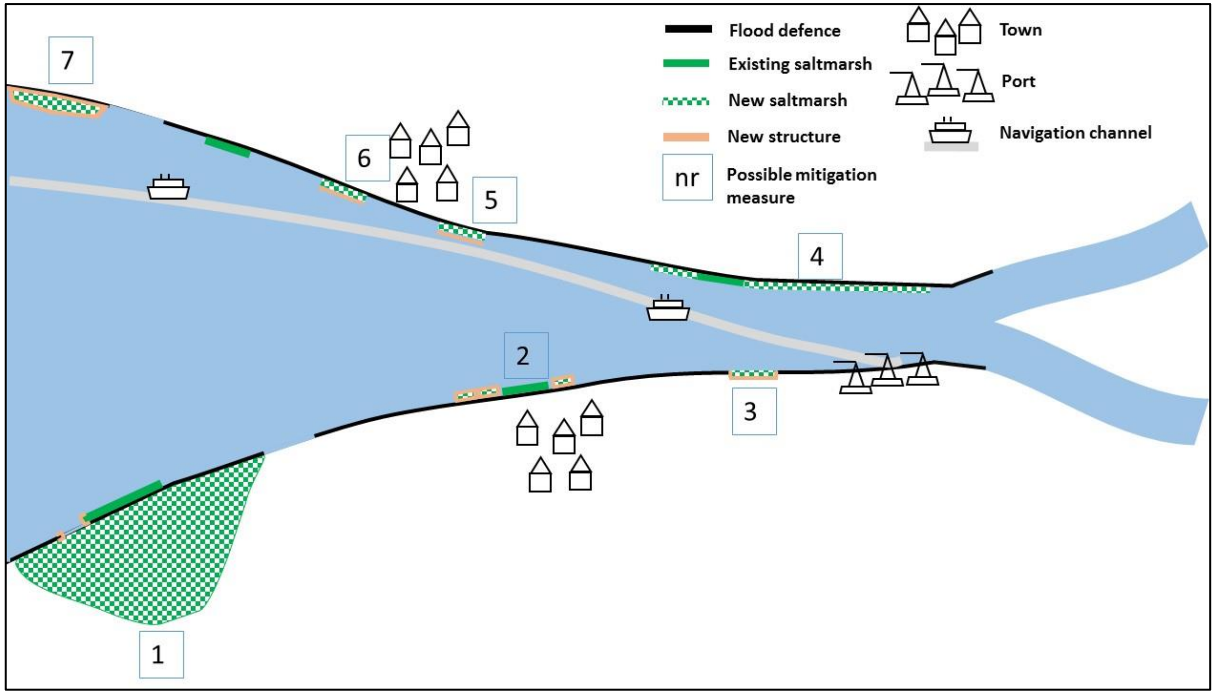


Step	Mitigation measures approach
A. Identification of closest comparable water category	The estuary was and remains a transitional water body.
B. Identification of mitigation measures for MEP (see Mitigation Measures Library)	Reference to the Mitigation Measures Library: (i) Confirms that the **specific nature of the physical modification** is 'constructed or raised dyke / levee / embankments - no water exchange (e.g. flood protection)'. (ii) suggests that the **hydromorphological supporting elements** most likely to be affected by this type of modification are morphology (intertidal zone structure) and tidal regime (wave exposure). Expert knowledge of the water body confirms this is the case. The library also indicates the possibility of effects on bed structure and substrate, and on freshwater flow. The latter effects are not evident in the water body. (iii) does not identify any typically anticipated implications for **physico-chemical supporting elements**; local experts confirm this is the case here. (iv) indicates there is a strong likelihood that this type of modification will have an effect on two **BQEs** – angiosperms (including saltmarsh; this is known to be the case) and fish. Whereas there is no site specific data on fish, saltmarshes in other estuaries locally are known to be fish nurseries, so it is possible that fish could be affected here. (v) suggests that the following **groups of mitigation measures** might be appropriate to address such effects: - intertidal habitat restoration, enhancement or creation - beach or foreshore replenishment - beneficial use of dredged material

Step	Mitigation measures approach
	- soft engineering solutions; use of vegetation - realign to mitigate effects on flow - reprofile embankments, structures
B1. Identify mitigation measures relevant to each hydromorphological alteration and ecologically effective in physical context of water body or water bodies	Taking into account the nature of the estuary (i.e. shallow, sediment rich) and what is known about the problem (loss of intertidal fine sediment substrate at an appropriate elevation relative to the tide to support saltmarsh), the latter three groups of measures are unlikely to be ecologically effective. The focus is therefore on identifying measures for intertidal habitat restoration, enhancement or creation. In this case, beach or foreshore replenishment, using dredging material if this is available, might contribute to the development of suitable habitat. Figure 18 below illustrates the range of detailed measures considered from the groups of measures indicated above, taking into account their viability in the context of the estuary and their expected ecological effectiveness (i.e. ability to support and sustain saltmarsh vegetation): 1. Managed realignment achieved via an engineered breach in the existing flood defence, allowing the tide to flood an area currently used for summer livestock grazing; sediment deposited naturally could be supplemented with dredged material if appropriate to ensure an elevation suitable for saltmarsh establishment 2. The creation of engineered 'islands' of saltmarsh on the foreshore in front of the town in an area currently used for mooring fishing boats 3. The 'step back' of a short area of redundant quay wall to create a 'shelf' at an elevation suitable for saltmarsh to establish 4. The simple replenishment and raising, using material extracted from offshore, of an area of foreshore opposite the port (i.e. in a relatively sheltered part of the estuary) 5. The construction of breakwater (1) using brushwood fencing or silt-filled geotextiles tubes in front of the town, designed to encourage the deposition and retention of silt (supplemented if necessary by the beneficial placement of dredged material) to create an area suitable for saltmarsh re-establishment

Step	Mitigation measures approach
	6. The construction of breakwater (2) using brushwood fencing or silt-filled geotextiles tubes in front of the town, designed to encourage the deposition and retention of silt (supplemented if necessary by the beneficial placement of dredged material) to create an area suitable for saltmarsh re-establishment 7. The reclamation of an area seaward of an area of high grade arable land, to be achieved by building and reveting earth embankments, in-filled with dredged material or aggregate sourced from offshore, all designed to an elevation suitable for saltmarsh establishment Depending on the scale of implementation of one or more of the above measures, a best approximation of ecological continuum will be ensured.

Figure 18: Estuary water body impacted by flood defence/embanking with range of possible mitigation measures



Step	Mitigation measures approach
B2. Exclude measures with significant adverse effect on use or wider environment	Measure 5 is ruled out because its proximity to the navigation channel is shown to pose an unacceptable risk to safety of navigation. Measure 6 is ruled out because of its adverse impact on an internationally protected rocky foreshore area with exposed fossils.
B3. Select most ecologically beneficial (combination of) measures taking into account need to ensure best approximation to ecological continuum	Measures 1, 2, 3, 4 and 7 are relevant to the hydromorphological alterations in the estuary, ecologically effective and do not adversely impact on use. In combination, therefore, these measures contribute to MEP.

Step	Mitigation measures approach
C. Derivation of hydromorphological conditions for MEP	The above measures all have the effect of improving intertidal zone structure and elevation and thus creating a substrate suitable for the re-establishment of saltmarsh. Further, by providing a buffering effect, these measures will reduce wave exposure, in turn helping to protect the remaining remnants of original saltmarsh from erosion.
D. Derivation of physico-chemical conditions for MEP, taking into account the closest comparable water body type	Neither the modification nor the mitigation measures will affect the WFD physico-chemical supporting elements.
E. Derivation of BQE conditions for MEP	BQE conditions for MEP cannot be derived due to lack of BQE data in this planning cycle. However, monitoring of angiosperms in the next and future planning cycles will enable a prediction of the BQE conditions at MEP to be made.
H. Identification of mitigation measures for GEP	As indicated on Figure 18, Measures 2 and 3 create very small areas of saltmarsh in the context of the overall water body and the extent of saltmarsh re-establishment needed to ensure ecological functioning including sustainability and continuum. These measures are therefore ruled out, meaning that GEP is defined by a combination of measures 1, 4 and 7.
G. Derivation of supporting quality element conditions for GEP	The selected combination of measures would lead to an improvement in intertidal zone structure and elevation at several locations in the water body, in turn providing a substrate suitable for the re-establishment of a significant area of saltmarsh. Measure 4 also contributes to reducing the exposure of the remaining area of existing saltmarsh along this frontage. Together the measures therefore support improvements in the affected BQEs: angiosperms (also benthic invertebrates) by enhancing the supporting habitat, and fish (by increasing the area available as a fish nursery).
F. Derivation of BQE conditions for GEP	BQE conditions for GEP cannot be derived due to lack of BQE data in this planning cycle.
Monitoring to assess whether GEP is being achieved	A national assessment monitoring for angiosperms includes a metric for the extent and quality of the salt marshes. A local monitoring programme will therefore be established to assess the effectiveness of the measures, with the current situation as a

Step	Mitigation measures approach
	baseline; the national assessment monitoring method for fish will also be applied to establish whether the measures are successfully providing habitat for fish.
Are there GEP measures that are disproportionally expensive or infeasible?	Measure 7 is ruled out on the basis of disproportionate cost (i.e. cost per unit area created)
Implement GEP measures and monitor effects on BQEs and supporting quality elements	Measures 1 and 4 will be implemented and their success monitored

Case study 4: River affected by drainage (reference approach)

<table>
<tr><th>Step</th><th>Reference approach</th></tr>
<tr><td>Information from earlier planning cycles (pre-step)</td><td>The river water body is heavily modified because of a straightened river course with a deepened cross section that is armoured with bank fixation. The directly neighbouring crop fields result in lack of shading. The floodplain is disconnected due to incision. These modifications lead to the following severe hydromorphological and physico-chemical alterations:

• Increased flow velocity with reduced flow diversity
• Reduced hydromorphological dynamics (river and floodplain)
• Altered instream habitats (deepened, less diversity)
• Altered substrate conditions (reduced diversity and dynamics, increased fine sediment input, colmation)
• Disconnected floodplain habitats
• Increased water temperature

These resulted in ecological impacts such as:

• Reduced abundance / loss of rheophilic species (fish, benthic invertebrates)
• Increased abundance of tolerant species (fish, benthic invertebrates)
• Loss of floodplain related species (fish)

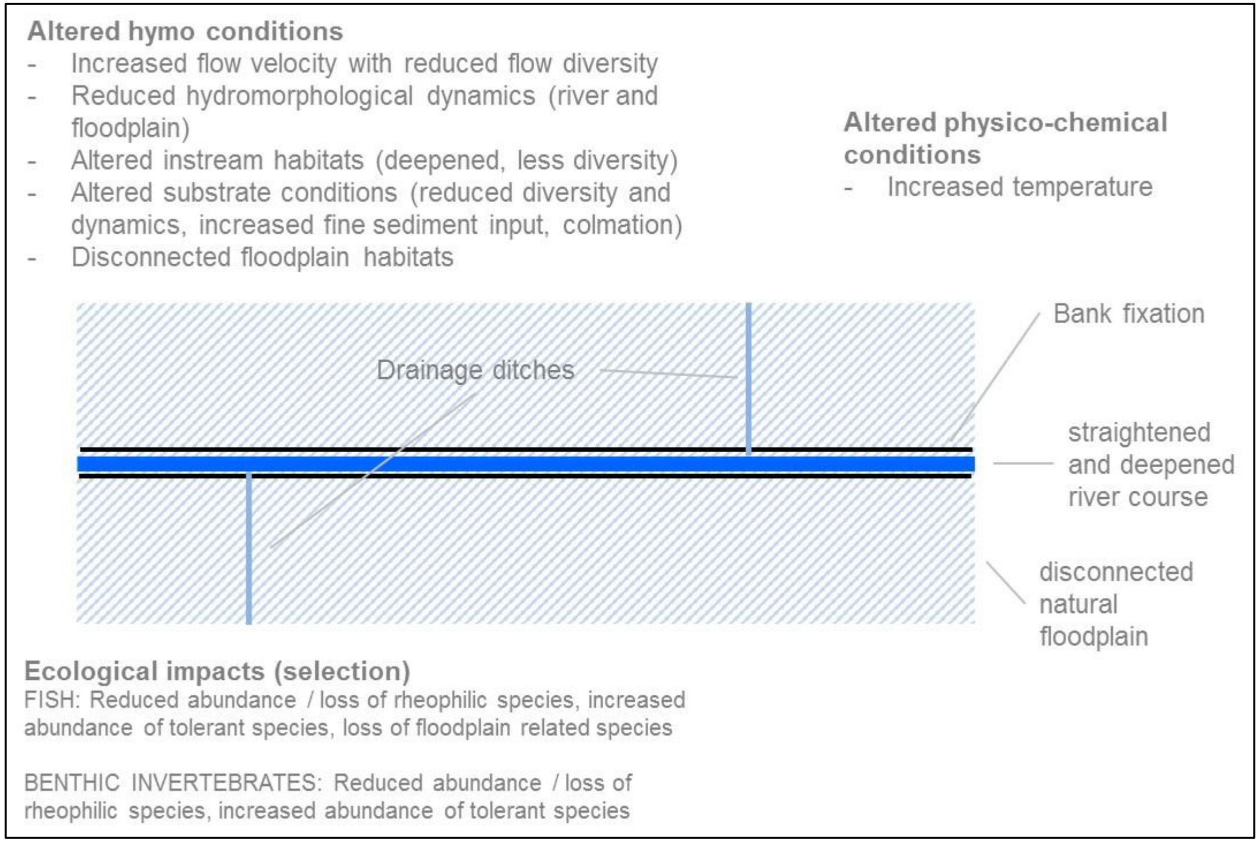
See

Figure 19.

The overall ecological status is “bad” based on benthic invertebrates and fish.

With regard to physico-chemical quality elements, “temperature” is affected by the hydromorphological alterations causing the loss of shading.</td></tr>
</table>

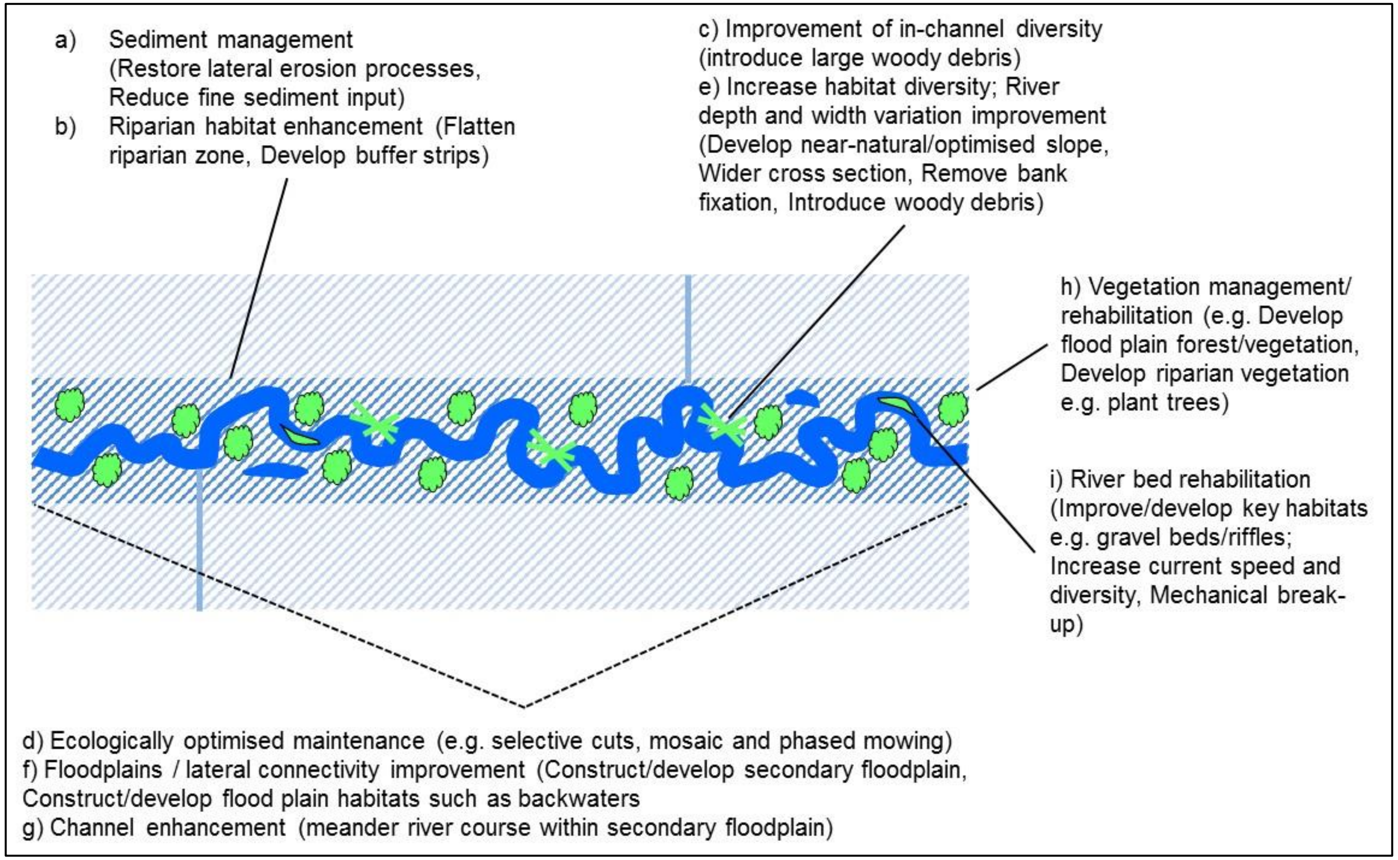
Figure 19: Drained water body with indication of impacts



Step	Reference approach
A. Identification of closest comparable water category	The original river water body remains a river water body, taking into account the hydromorphological and biological conditions.
B. Identification of mitigation measures for MEP (see Mitigation Measures Library)	Based on the hydromorphological alterations and ecological impacts, the following groups of measures might be appropriate (selection): - Sediment management - Riparian habitat enhancement - Improvement of in-channel diversity - Ecologically optimised maintenance - Increase habitat diversity; River depth and width variation improvement - Floodplains / lateral connectivity improvement - Channel enhancement - Vegetation management/rehabilitation - River bed rehabilitation
B1. Identify mitigation measures relevant to each hydromorphological alteration and ecologically effective in physical context of water body or water bodies	Based on the physical context of the water body the following measures are assumed to be relevant and ecologically effective (see Figure 20): a) Sediment management (Restore lateral erosion processes, Reduce fine sediment input) b) Riparian habitat enhancement (Flatten riparian zone, Develop buffer strips) c) Improvement of in-channel diversity (introduce large woody debris) d) Ecologically optimised maintenance (e.g. selective cuts, mosaic and phased mowing) e) Increase habitat diversity; River depth and width variation improvement (Develop near-natural/optimised slope, Wider cross section, Remove bank fixation, Introduce woody debris) f) Floodplains / lateral connectivity improvement (Construct/develop secondary floodplain, Construct/develop flood plain habitats such as backwaters) g) Channel enhancement (meander river course within secondary floodplain) h) Vegetation management/rehabilitation (e.g. Develop flood plain forest/vegetation, Develop riparian vegetation e.g. plant trees)

Step	Reference approach
	i) River bed rehabilitation (Improve/develop key habitats e.g. gravel beds/riffles; Increase current speed and diversity, Mechanical break-up) Those measures will contribute to: - Restore river hydromorphological processes and dynamic (incl. sediments) resulting in habitats for type-specific biota - Increase of flow and habitat diversity and increase of the length of the water body - Improve the hydromorphological processes and dynamics (river and floodplain) - Improve habitats for type-specific riverine species and floodplain species - Improve substrate conditions for type-specific species (e.g. gravel spawners) - Reduce fine sediment input - Reduce temperature by increased shading Raising the river bed level to connect the natural floodplain in combination with a re-meandered river course in a near-natural development corridor width would be the most effective measures to improve biological conditions, but this was not considered because: - this measures would lead to a restoration towards GES; and - it was reasoned in the HMWB designation process to mean a significant adverse effect on use (because the drainage function would be significantly impacted).

Figure 20: Drained water body with range of possible mitigation measures



Step	Reference approach
B2. Exclude mitigation measures with significant adverse effect on use or wider environment	Measure f) would have significant adverse effects on drainage, if the river bed level would get increased, but within a secondary floodplain it is possible without significant adverse effects on drainage function. The same is valid for measure g). All the other measures do not per se have significant adverse effects on the drainage use. Introducing woody debris (measure e)) is possible without significant adverse effects if the cross section is widened to ensure the flow capacity as in status quo.
B3. Select most ecologically beneficial (combination of) measures taking into account need to ensure best approximation to ecological continuum	Measures a)-i) from step B1 are relevant to the hydromorphological alterations in the water body, ecologically effective and do not adversely impact on drainage function(s). In combination, therefore, these measures contribute to MEP.
C. Derivation of hydromorphological conditions for MEP	The above measures significantly enhance habitats for river bed, riparian zone and floodplain. Based on predicted measure effects on the existing hydromorphological alterations (see pre-step) considering reference conditions of the original natural water body type, hydromorphological conditions for MEP are moderately changed compared to these. All relevant parameters have been defined based on these considerations using the existing national hydromorphological methods.
D. Derivation of physico-chemical conditions for MEP, taking into account the closest comparable water body type	Physico-chemical conditions correspond to the values for high ecological status of the original natural river type.
E. Derivation of BQE conditions for MEP	Basis for this step were the hydromorphological alterations and ecological impacts (see pre-step), the predicted effects of the relevant mitigation measures (see B1, B3) as well as the difference between hydromorphological conditions for MEP (see step C) and reference conditions of the original natural river type. In conclusion, the difference in hydromorphological conditions between MEP and reference conditions of the original natural river type have been translated to BQE conditions at MEP. Based on this, BQE conditions have been further defined based on the biological assessment system for natural water bodies. The EQR values have been reduced with the same proportion of the gradient as the difference between reference

Step	Reference approach
	conditions and MEP based on hydromorphological methods. The reduction is different between different BQEs due to different sensitivity at least to some of the relevant hydromorphological parameters (e.g. floodplain). The predicted results have been tested and amended in some aspects using a solid basis of monitoring data from comparable water bodies (same use und comparable river types) considering as much as possible the gradient of different habitat qualities from maximum to bad potential.
F. Derivation of BQE conditions for GEP - functioning aquatic ecosystem	BQE conditions for GEP resulted from the biological assessment systems that use the same principle for defining "slight changes" as for the intercalibrated method for natural water bodies. Therefore, the functioning of the aquatic ecosystem can be assumed if BQE conditions result in GEP.
G. Derivation of supporting quality element conditions for GEP - taking into account functionality of the aquatic ecosystem	Basis for this step were the BQE conditions for GEP (see step F). The hydromorphological parameters have been derived based on the difference between BQE conditions of MEP (step E) and GEP (step F) considering the hydromorphological conditions for MEP (step C). Physico-chemical conditions correspond to the values for good ecological status of the original natural river type. Functioning of the aquatic ecosystem is ensured by physico-chemical conditions as well as by the GEP conditions identified in step F.
H. Identification of mitigation measures for GEP	All measures a-i from step B3 are within the set of qualitative GEP measures. The difference between MEP and GEP is based on BQE values ("slight change"). Both classes especially differ in the quantity of measures needed (in particular the width of development corridor and meander amplitude and the conditions within the catchment (e.g. fine sediment input).
Monitoring to assess whether GEP is being achieved	The modified HMWB biological assessment systems have been used to classify ecological potential of the water body. Compared to the MEP values set for the BQEs the overall biological monitoring result show a strong deviation from the MEP values, so that the actual ecological potential is to be classified as "poor" based on benthic invertebrates and fish. Therefore,

Step	Reference approach
	hydromorphological mitigation measures (identified in step H) are necessary to improve conditions of the water body and achieve GEP.
Are there GEP measures that are disproportionally expensive or infeasible?	None of the GEP measures are disproportionally expensive or infeasible. Costs can be significantly reduced if the secondary floodplain will be developed by self-dynamic hydromorphological processes instead of construction. This is also valid according to vegetation development.
Implement GEP measures and monitor effects on BQEs and supporting quality elements	The following measures have been implemented within the next RBMP Programme of Measures: f) Construct/develop secondary floodplain, Construct/develop flood plain habitats such as backwaters g) Meander river course within secondary floodplain c) Introduce large woody debris (proved that no fixation is needed due to hydraulic conditions) d) Ecologically optimised maintenance (selective cuts) h) Develop flood plain forest/vegetation, Develop riparian vegetation (natural succession without planting to save costs) Beyond these, an improvement of the land use situation in the catchment (Improve water retention, e.g. through afforestation, restoration of rivers/floodplains, restoration of wetlands/moors,and reduce erosion of fine material from agriculture) is likely to be necessary to reach the GEP values for BQE. These measures could not be implemented yet, but can be implemented step by step within the following RBMPs. Beneath the water management, other planning sectors and instruments are relevant for implementation of these measures (e.g. agriculture, forestry, landscape planning). The quantitative design of the measures has been based on the adverse effects on use and an estimation of the need to achieve biological GEP values (see step F). Monitoring will be undertaken within the next monitoring cycle.

ANNEX II – EXAMPLE ARTIFICIAL WATER BODIES: Ditches - hydromorphological mitigation as an exception, mitigation by maintenance as a rule

Ditches in the lower parts of the Netherlands have been constructed to serve water discharge and supply. They have an estimated length of in total 300.000 km. The geometrical dimensions of these ditches have been carefully determined to suit their function: from less than half a metre wide in agricultural lands (in fact drains at the surface of the land) to several metres wide and up to a metre deep. Ditches may have a high aquatic biodiversity.

The need for hydromorphological mitigation is not so obvious, since there is no natural reference condition for ditches. However, measures may be planned to improve the ecological situation in specific cases. For example, ditches may connect biodiverse natural areas as elements of an ecological network, or be part of such natural areas. In that case, adaptation of the profile of the ditch may be considered in order to promote macrophyte growth and the biota dependent thereupon. Connectivity and/or habitat for fish may also be improved with specific measures aimed at achieving stable populations.

Ditches need regular cleaning to prevent unacceptable hydraulic resistance through the build-up of vegetation biomass. Hence, maintenance activities affect aquatic biodiversity. In many cases, the method and frequency of maintenance may be optimized for biodiversity without significant effect on the hydrological function (discharge & supply). For example, aquatic vegetation can be partially removed. Ecologically optimized maintenance (i.e. selective cuts) is an effective and feasible mitigation measure.

At the absence of a reference condition, hydromorphological mitigation will be restricted to specific cases and mitigation by ecological maintenance practices could be the rule, such as in the example above, and exceptions should be motivated.

ANNEX III – GLOSSARY

Best approximation

"Best approximation" is interpreted as being as close as possible to undisturbed ecological continuum.

Ecological continuum

For explanation, refer to section 5.2.

Ecological flow

Ecological flow is considered within the context of the WFD 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)" (from CIS Guidance Document No.31).

Environmental flow

Environmental flows describe 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, 2007).

GEP flow

GEP (Good Ecological Potential) flow is 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 as mentioned in Article 4(1), considering a condition close to best approximation to ecological continuum as mentioned in Annex V 1.2.5.

Hydromorphology

The hydrological and geomorphological characteristics (including continuity) of water bodies, including the underlying processes from which they result. The hydromorphological quality elements for classification of ecological status are listed in Annex V 1.1 and are further expressed in terms of some relevant aspects, defined in Annex V 1.2 of the Water Framework Directive.

Hydromorphological alterations

Hydromorphological alterations are alterations in the hydromorphological conditions which are caused by physical modification(s).

Hydromorphological character

The distinctive hydromorphological features and processes for a water body (e.g. river channel morphology, geometry, hydrological regime, tidal regime, sediment distribution, sediment transport).

Hydromorphological processes

The hydrologic and geomorphic processes occurring in water bodies (e.g., erosion, continuity of water, sediment and wood fluxes, sediment transport, hydrological regime,), considering temporal changes and dynamics.

Hydromorphological type

A particular group of water bodies that share similar hydromorphological characteristics (e.g. a lowland sinuous river water body). To define hydromorphological types, some kind of hydromorphological categorization is used (for example, river type: medium-large calcareous lowland river, or confined bedrock stream, or unconfined fine-grained meandering, etc.).

Mitigation measures

Measures needed to restore, supplement or replace certain natural processes, or otherwise to reduce or ameliorate the effects of physical modifications, so as to enhance the ecological conditions of a heavily modified water body (e.g. fish flow, sediment by-pass, etc.) in order to improve its ecological potential.

Physical modification

Hydromorphological change (or changes) made to the surface water body by human activity (which may result in failing to meet good ecological status). Each modification (pressure) results from the current or historical "specified use" (such as straightening for navigation, or construction of flood banks for flood defence).

Reference conditions

For any surface water body type reference conditions or high ecological status is a state in the present or in the past where there are no, or only minor, changes to the values of the hydromorphological, physico-chemical, and biological quality elements which would be found in the absence of anthropogenic disturbance. Reference conditions should be represented by values of the biological quality elements in calculation of ecological quality ratios and the subsequent classification of ecological status (from REFCOND Guidance) as well by values for the hydromorphological and general physico-chemical quality elements.

Relevant and ecologically effective mitigation measures

The selection of potential mitigation measures, which are **relevant** to the hydromorphological alterations and **ecologically effective** in the context of the specific water body or water bodies should take into account the following:

- The natural hydromorphological and physicochemical characteristics of the water body.
- Other water body or water bodies characteristics relevant to the biota, e.g. is the modification within the fish zone/ outside the fish zone, fish community types, sediment (e.g. coarse, fine) and habitats (e.g. river types).

- Whether measure is appropriate for addressing the existing ecological impacts and can deliver a proven ecological benefit. In this sense, measures which are not likely to deliver an ecological benefit should not be considered.

Restoration measure

Measure needed to restore natural processes, and hence reach good ecological status, such as e.g. ecological flows. Compare mitigation measure (from WG ECOSTAT report on common understanding of using mitigation measures for reaching Good Ecological Potential for heavily modified water bodies - Part 1: Impacted by water storage).

Slight changes

CIS Guidance Document No.13 on the "Overall approach to the classification of ecological status and ecological potential" provides guidance on the interpretation of the term "slight changes" with reference to the (type-specific) conditions specified for the BQE benthic invertebrates at good status:

- There must be no more than slight changes in composition and abundance.
- There must be no more than slight changes in the ratio of disturbance sensitive taxa to insensitive taxa.
- There must be no more than slight signs of alteration to the level of diversity.

With respect to "slight changes", HMWB should follow the same principles as natural water bodies, with a functioning ecosystem being a prerequisite for a water body to be at GEP. Slight change cannot be equivalent to a complete/temporary absence or severe change of the biological quality elements relevant for the closest comparable water category and type (e.g. of fish for rivers within the fish zone). Slight changes to the biological quality elements have to be supported by corresponding conditions in the supporting quality elements (e.g. flow, habitats, continuity). With regard to ecological continuum, "slight change" means that a condition close to best approximation to ecological continuum should be ensured (instead of best approximation) .

Sustainable human development activities

For explanation, refer to section 3.

Self-sustaining populations

Self-sustaining populations refer to the type-specific animal (e.g. fish) and plant species occurring in the water body which form autochthonous stocks.