Technical paper N° 1/2021

Revision of the EUNIS inland water habitat group

Outcome of the expert workshop 16th March 2021

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28/06/2021

The European Topic Centre on Biological Diversity (ETC/BD) is a consortium of eleven organisations
under a Framework Partnership Agreement with the European Environment Agency for the period 2019-2021
MNHN Ecologic ILE-SAS JNCC NATURALIS NCA-CR S4E SLU UBA URJC WENR

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Context:

The Topic Centre has prepared this Technical paper in collaboration with the European Environment Agency (EEA) under its 2021 work programmes as a contribution to the EEA's work on EUNIS habitat classification.

Citation:

Please cite this report as

Watson, M., Arts, G. and Lyche Solheim, A., 2021. Revision of the EUNIS inland water habitat group - Outcome of the expert workshop 16th March 2021. ETC/BD report to the EEA.

The withdrawal of the United Kingdom from the European Union did not affect the production of the report.

Data reported by the United Kingdom are included in all analyses and assessments contained herein, unless otherwise indicated.

ETC/BD Technical paper N° 1/2021
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Contents

Acknowledgements

The participation of and contribution to the workshop is gratefully acknowledged:

Kamila Belka (ERCE/UNESCO), Antonio Camacho (University of Valencia), Laura Casella (ISPRA), Milan Chytrý (Masaryk University), Douglas Evans (independent expert), Hugo Fontes (Institute de recherche pour la conservation des zones humides méditerranéennes), Gary Free (CNR), Tristan Hatton-Ellis (NRW), Seppo Hellsten (SYKE), Peter Kristensen (EEA), Chris Mainstone (Natural England), Marit Mjelde (NIVA), Jose Antonio Molina (University of Madrid), Piotr Parasiewicz (IRS), Leonard Sandin (NIVA), Joop Schaminée (WENR), Rafaela Schinegger (BOKU) & Wouter van de Bund (JRC).

Additionally, the authors received further comments and material after the workshop from Chris Mainstone, Tristan Hatton-Ellis, Laura Casella, Antonio Camacho, Gary Free and Milan Chytrý, for which we are grateful.

Summary

The workshop on the revision of the EUNIS inland water habitat group of the EUNIS habitat classification was organised by the European Environment Agency and its European Topic Centre on Biological Diversity with support from the European Topic Centre on Inland, Coastal and Marine Waters to further discuss the proposed revision of level 3 of the classification, to help clarify the discriminating factors used at level 3 in order to proceed with the revision throughout 2021, and to discuss further biotic and abiotic discriminating factors to be used at level 4.

The main driver of inviting further discussions was the response to the Eionet and expert consultation on the initial proposal held in May & June of 2019. The respondents indicated that further clarification and revision of level 3 was needed as well as on how biological communities would be addressed in the revision. An NRC EIONET webinar was held on December 8th 2020 with the aim to further explain the revision, provide examples of where biological communities fit in the system and also to get more information from the Eionet countries. The outcomes of these discussions, along with the comments received during the 2019 consultation, were used as the basis of the expert workshop held on March 16th 2021.

A list of experts covering areas of inland water expertise needed to answer questions or fill in gaps in the revision, was compiled. These areas concern expertise in particular habitats and biological communities and the Habitats Directive and/or the Water Framework Directive or both. Eventually, 18 external experts, apart from the organising team were available to participate in the workshop. These experts come from 12 countries and 16 different universities and national environmental agencies across Europe, spanning most geographical regions.

The workshop was divided into 3 parts:

Session 1 consisted of a series of presentations to set the context of both the revision and the day ahead. The structure of the EUNIS habitat classification and the inland waters group in particular was presented. The Broad Types derived from the national types established for the Water Framework Directive were described. The background to the EUNIS inland water habitats revision was presented along with more detailed level examples and data sources to extract biological information.

Session 2 focussed on standing waters and presented both the main questions to be answered and proposals for solutions. The topics for discussion centred on the Level 3 abiotic factors,

additional abiotic factors for Level 4, missing types, the distinction of the Mediterranean region, the approach for descriptions of biological communities at level 4 and crosslinking to other habitat typologies.

Session 3 focussed on running waters and described dynamics of running waters and the crosslinking of running waters to other habitat typologies. The topics for discussion were the main abiotic factors at Level 3, the position of 'flow' and other factors in the proposed structure, how to define level 4 and lower levels, the distinction of the Mediterranean region, the placement of floodplains and braided rivers in the wider EUNIS system, how to represent the dynamics of river systems in the proposed structure and the description of biological communities in running waters.

In general, new ideas and concepts were discussed in terms of alternative or additional discriminating factors at both levels 3 and 4 which may be more appropriate or provide added value. In some cases, it was found that suggested factors (e.g. Environmental Zones) were a combination of discriminating factors already incorporated at level 3, or others (e.g. stream power) were based on localised data and modelling which could not be extrapolated to a European scale within the scope of this revision. However, these factors may be captured at level 4 in the proposed system i.e. region or Environmental Zones can be captured if needed and a current proposed system of describing riffles, runs and pools at level 4 captures elements of flow and stream power. It was acknowledged that these factors could be considered for a future revision of the system.

For standing waters, it was mainly concluded that ponds/pools would be included as a separate group at level 3 due to their size and importance to regional biodiversity, timberline would be used instead of treeline to distinguish between mid- to high altitude lakes and altitude and latitude would act as a proxy for temperature. Geology as a discriminating factor at level 3 reflects the natural trophic status of the water bodies due to the relationship between geology (alkalinity) and trophic status. There is no need to incorporate region/biogeographic region as a discriminating factor at Level 3, since the distinctive factors (e.g. salinity, temporary hydroperiod for Mediterranean standing waters) are already set at level 3. Helophyte habitats will be included in the wetland habitat group, but will be associated with the descriptions of aquatic habitats at level 4, when and where they occur. Isoetid communities (*Littorelletea*) are considered aquatic. Marl lakes/karstic lakes will be identified as a separate habitat type at L3.

For running waters, more thought and discussion is needed as to where and how 'flow' is incorporated into the structure. The current reference to flow is at level 4 with the description of pools, riffles and runs. Region/biogeographic region does not need to be distinguished at level 3, floodplains and braided rivers will be considered as complexes and will be included as such in the inland water habitat group.

1 Introduction

The EUNIS habitat classification is a comprehensive and extensive pan-European reference system to harmonize and facilitate the description and collection of data across Europe through the use of criteria for habitat identification (Davies and Moss 1999; Davies et al. 2004; Moss 2008, Rodwell et al. 2018). It is hierarchical, as shown below (Fig. 1), and covers all types of habitats from natural to artificial, from terrestrial to freshwater and marine. It aims to accommodate habitat types, ranging from highly aggregated types at the European level (Levels 1 to 3) to more detailed types identified at the regional and national levels (Levels 4 and lower).

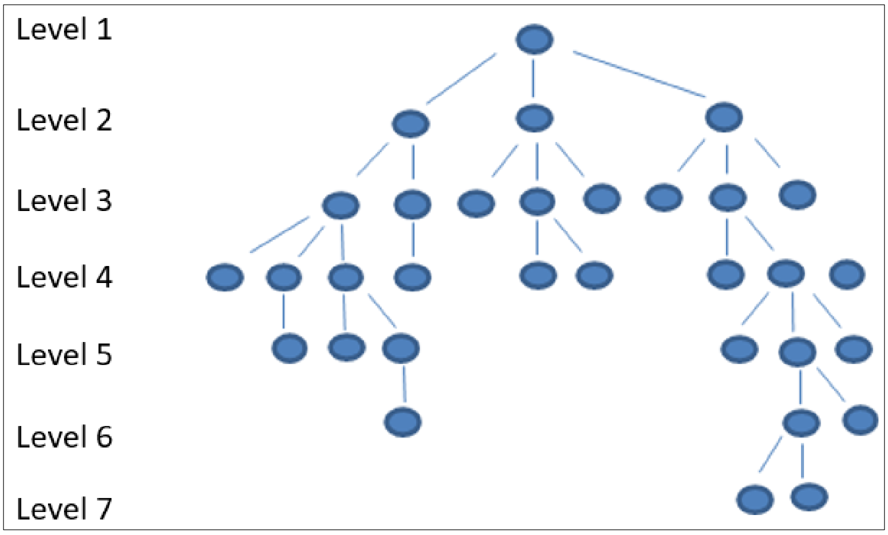

Figure 1. Indicative example of hierarchical structure of EUNIS habitat classification

Since its creation, EUNIS has undergone only modest change, but the increasing need to support European policy on nature conservation with harmonised habitat descriptions ideally underpinned by field data led to an initiation in 2012 of an extensive review of the EUNIS habitat classification. For the approaches used to revise EUNIS habitats see Box 1. Habitat groups have been addressed one by one since then including consultations with EIONET and external experts. Some revised groups have been published in Chytrý et al. 2020. Whereas a floristic approach was considered appropriate for terrestrial EUNIS habitats, which are largely defined by their vegetation, it was agreed that a different approach was required for the marine and freshwater habitats.

For terrestrial habitats, the revised EUNIS habitat classification makes extensive use of phytosociological data, which are available from initiatives such as the European Vegetation Archive (EVA, Chytrý et al. 2016, http://euroveg.org/eva-database). Such data can be also useful for inland water types as can be seen below (Fig. 2). Relevés for standing (18 170) and running (8 847) waters, as well as helophyte vegetation (46 328) from the littoral zone are included and available in the EVA database.

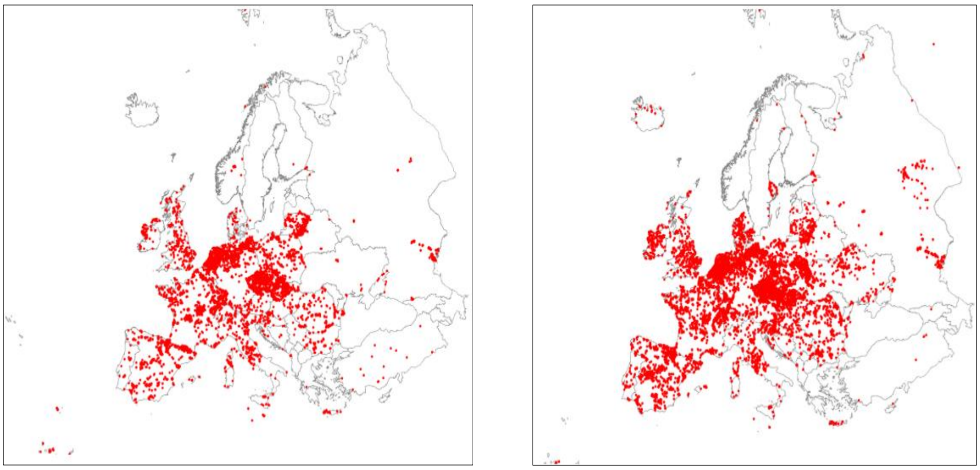

Figure 2. Relevés for standing and running waters (left) and helophytes (right), extracted from the EVA November 30th 2020. 18,170 for standing and 8,847 for running waters, as well as 46,328 relevés for helophyte vegetation in the littoral zone

However, as many typologies of rivers and lakes in Europe do not use floristics as the main discriminating factor, it was decided to look into other existing European typologies that could be used as the starting point, such as the Water Frame Directive types, which are based on a limited number of abiotic discriminating factors (Lyche Solheim et al. 2019). As a broad typology derived from the WFD common intercalibration types for lakes and rivers was also being developed (ETC-ICM 2015, Lyche Solheim et al. 2019), it was decided to investigate the potential for aligning those Broad types with the EUNIS revision. Various additional data sources can be used to describe the biological communities of each habitat e.g. the EVA database for vegetation, WISER database for species level information (phytoplankton, macrophytes, benthic invertebrates, fish), and the various Intercalibration Technical Reports under the Water Framework Directive with biological information based on a specific water body type e.g. a highland, deep, calcareous lakes in the Alpine region. The following are intercalibration reports describing other water body types: Solimini et al. 2014, Gassner et al. 2014, Pall et al. 2014, Wolfram et al. 2014, Portielje et al. 2014 Böhmer et al. 2014, Sandin et al. 2014, Hellsten et al. 2014, Olin et al. 2014, Lyche Solheim et al. 2014, Kelly et al. 2014, Birk et al. 2018, Borics et al. 2018.

Using the discriminating factors from the broad types allows links to be made with Habitat Directive Annex I habitat types (i.e. through the relationship between alkalinity and trophic state referred to in the Annex I descriptions). To further describe lower level inland water habitats, the European Red List descriptions can be used as a basis. There is already a strong relationship between the Red List and EUNIS, and the Red List types will be linked to the broad types via EUNIS. These linkages in typologies further connect EU nature and water policies.

It is important to note that while the proposed EUNIS structure at level 3 is based on the broad type system, the broad types do not cover all water body types. As all types need to be acknowledged in the EUNIS system, the proposed level 3 is a combination of the broad types, previous EUNIS types not included in the broad types and additional types as a result of discussions from the workshop.

The aim of the classification is to be a wall-to-wall classification where all inland water habitat types can be placed. The habitats can be separated and identified by biological groups (characteristic species or species groups) as well as by additional abiotic features at level 4 and lower levels.

Box 1: Approaches used to revise EUNIS habitat classification

The EUNIS classification is revised down to level 3 through three different approaches:

1) **Floristic approach** (main approach for terrestrial habitat types but also used in some marine and inland water types),
2) **Abiotic approach** – **substrate/depth zone/marine region** (the main approach for marine benthic types),
3) **Abiotic approach** – **altitude/catchment size/geology/depth/flow** (main approach for inland water types).

Most of the habitats can be separated and identified by biological features (characteristic species or species groups for habitats following approach 1) at level 3 or 4.

In an entire ecosystem, like a river system, a coastal area or a wetland, the relevant habitat types may have been revised through one, two or all approaches. It is necessary to look at many elements in order to have the full systemic perspective. For example:

- For a river ecosystem, it would be necessary to select river type and flood plains from the *inland water habitat* group, gravel bars from the *sparsely vegetated habitat* group and, depending on the extent to which the ecosystem is being looked at, estuaries from the *habitat complexes* group. A floodplain might also include the grasslands in the floodplain from the *grassland habitat* group and the alder forests from the *forest habitat* group.
- For a delta ecosystem, it may be necessary to select bog habitat (e.g. calcareous fens) types from the *wetland habitat* group, forest types (e.g. *Salix alba* and *Populus alba* galleries) from the *forest habitat* group, grasslands from the *grassland habitat group* and lakes/ponds and rivers/streams from the *inland water habitat* group.

The review of the inland waters group began in 2016 with a scoping study to compare the current system with other European typologies: European Red List of habitats, Annex I habitats under the EU Habitats Directive and the Broad Types derived from the Water Framework Directive (ETC/BD 2016). Based on this, a first workshop was held in 2018 to look more closely at how the current EUNIS system could be represented based on the typology factors used for the Broad Types (ETC/BD 2018). A proposed structure was put to public consultation in 2019, the outcome of which was an evident desire to further look at the structure and the factors used to discriminate at level 3 (ETC/BD 2019). Due to Covid 19 and travel restrictions, an expert workshop was delayed in the hope of holding an in-person meeting in 2021. An EIONET webinar was held in December 2020 to further explain the proposed structure and to establish if and how EUNIS is used in the Eionet countries (ETC/BD 2021). Eventually, a virtual workshop was held on March 16th 2021 (Fig. 3). The agenda of the workshop can be seen in Annex 1. The revision of EUNIS inland water habitat group will be developed from EEA, ETC/BD and ETC/ICM based on the outcomes of the studies and meetings mentioned above.

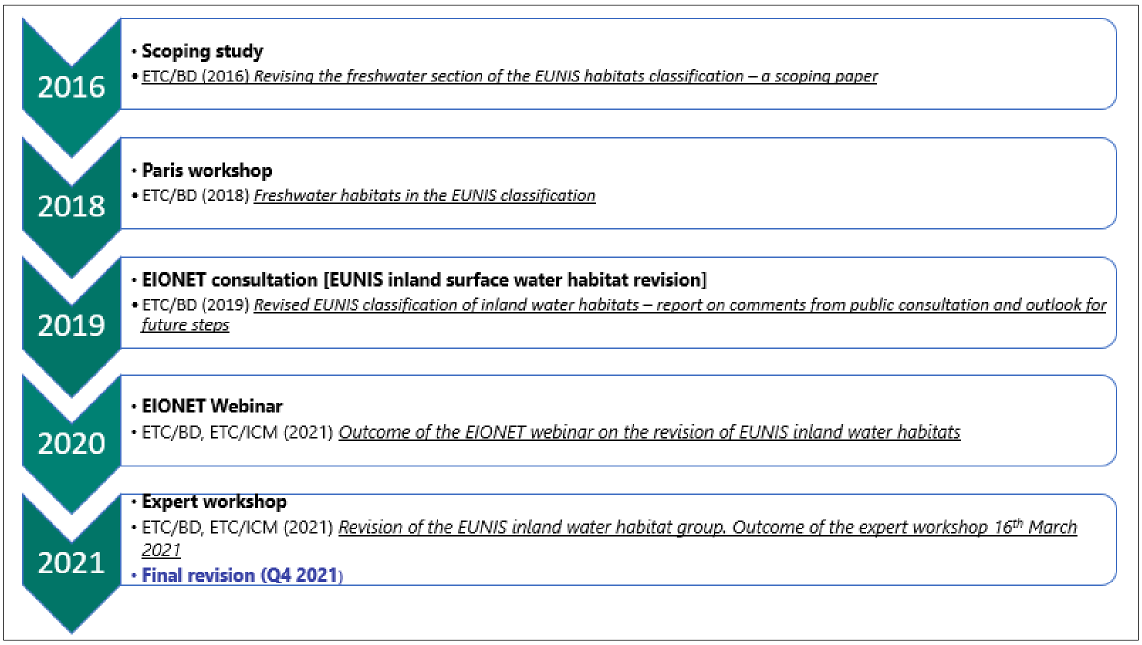

Figure 3. Timeline of revision of EUNIS inland water habitat group

The principles of the proposed EUNIS surface waters revision prior to holding the expert workshop were:

1. To broadly align the EUNIS inland waters at level 3 with the Broad Types developed from Lyche Solheim *et al.* 2019, which are derived from the intercalibration types of the Water Framework Directive;
2. To cover other inland water habitats by adding further types where the Broad types do not cover water body types identified in the countries;
3. To include underground inland water bodies that are not considered in the current EUNIS inland water habitats;
4. To add smaller water bodies that are not covered by the broad types;
5. To use geology (alkalinity) as a proxy for trophic state as a parameter to describe the water bodies' natural (pristine or unimpacted) state;
6. The revision should capture differences in all biological communities, not just vegetation, where there is a clear difference in at least one part of the taxonomic assemblages (e.g. fish, benthic algae, macrophytes, macroinvertebrates, phytoplankton, zooplankton), this may constitute a different habitat.

2 Workshop overview

Careful consideration was put into the identification of experts for coverage of the areas needed to answer questions or fill in gaps in the revision. These areas concern expertise in particular habitats and biological communities and to the Habitats Directive and/or the Water Framework Directive or both in addition to expertise with inland waters across geographical regions of Europe. Eventually, 18 external experts, apart from the organising team were available to participate in the workshop from 12 countries and 16 different universities and national environmental agencies (Annex 2) across Europe.

The aims of the workshop were to:

- Clarify rationale behind the proposed structure consulted on in 2019,
- Address concerns arising out of the consultation and the EIONET webinar,
- Engage experts with a diverse background covering as many areas of freshwater ecology as possible,
- Get further guidance and direction on proceeding with the level 3 structure,
- Present and discuss proposed level 4 discriminating factors,
- Establish the appropriate placement of other abiotic factors to both standing and running water habitats,
- Investigate further biological data sources to be exploited.

Introduction

Eleni Tryfon (EEA) presented an '*Overview of the EUNIS habitat classification and European classifications and typologies*', describing the structure of the EUNIS classification system (i.e. levels 1 to 3), the features of the classification system, progress with the revision, the structure of the current EUNIS inland water habitat group, challenges and issues with the current structure and other inland water habitat typologies.

Anne Lyche Solheim (ETC/ICM – NIVA) presented '*Broad European Types of Lakes and Rivers: Rationale, identification and application*'. This presentation looked at common issues between the EU Habitats Directive and the Water Framework Directive, ways to align the Habitats Directive and EUNIS inland water types with the Broad Types derived from the WFD, a description of how the Broad Types were derived, including the descriptors used, and a justification for the broad types as an ecologically relevant basis for the EUNIS revision.

Michelle Watson (ETC/BD – MNHN) presented the *'Revision of EUNIS inland water classification*' which detailed the background to the EUNIS inland water habitat revision, the development of the proposal including the changes between the current and the proposed structure and the final proposed list of standing and running water types, issues with the current littoral habitat group, the proposed descriptions of biological communities at level 4, the outcome of the EIONET webinar and data sources to be exploited to describe biological communities at lower levels.

Session 1 – standing waters

Anne Lyche Solheim (ETC/ICM – NIVA) led the discussion on the standing waters session. The discussion was loosely based around the following questions:

1. Do you agree with the main abiotic typology factors proposed for level 3?
   -If not, should one or more of these factors be supplemented or replaced by others?

-If yes, which factors and why?

2. Do you agree with the additional abiotic factors proposed for level 4 (size and depth)?
   - If not, should one or more of these factors be supplemented or replaced by others?
   - If yes, which factors and why?
3. Are some important habitat types still missing from the proposal in order to encompass your specific types at the lower levels?
4. Do you support the distinction of the Mediterranean region as a separate geographical region or is that not needed if brackish/saline and temperate lakes/ponds are added at level 3? Do you agree that the other regions are merged at level 3, and can be further specified at more detailed EUNIS levels?
5. Would you agree that the helophyte vegetation could be moved to a revised Wetlands section?
6. Would you agree with the proposed approach for descriptions of the biological communities at level 4 (using European datasets, e.g. WISER or EVA database, WFD intercalibration Technical Reports). Are there other databases of use here?

Session 2 – running waters

Gertie Arts (ETC/BS – WENR) led the discussion on the running waters session. The discussion was loosely based around the following questions:

1. Do you agree with the main abiotic typology factors proposed for running waters at level 3 (altitude, geology, catchment size)?
2. Should flow be included at level 3 or 4? And if at level 3, should it be an additional factor or a replacement?
3. Do you support the distinction of the Mediterranean region as a separate biogeographic region?
4. Should floodplains and braided rivers be added to Habitat complexes or to Sparsely vegetated land sections, or be included in the running waters?
5. How to accommodate the dynamics of river systems?
6. Where to include the riparian zone that is temporarily flooded?
7. Description of biological communities.

The main themes of the sessions are described in Section 3. As the discussions overlapped several of the themes identified in the proposed questions, these have been summarised by theme rather than chronologically. For the list of standing water and running water types proposed for discussion in the workshop please refer to Annex 3.

3 Session 1: Standing waters

3.1 Discussion

Below is a summary of the main discussions on standing waters during the workshop. In general, it was accepted that the proposed level 3 abiotic factors work well for standing waters. It was noted that the concept of 'reference condition' from the Water Framework Directive typology was important as EUNIS needs to describe habitat types in their natural condition. It was also argued that the use of the trophic status should not be used as a classification factor as it may commonly result from anthropogenic eutrophication pressures rather than from natural causes. It was noted that for a habitat to be distinguished from another at least part of the characteristic species must be different, otherwise it will result in overlapping habitats. It was discussed that there was a need for pragmatism when choosing the discriminating factors at level 3. For other topics discussed no clear agreements were made.

While the discussions below for standing waters are separated into different headings and sub-headings, some of these themes and topics overlapped each other during the workshop. Additionally, where themes were common between standing and running waters (e.g. alkalinity, geology) these are discussed in detail only once in the report.

3.1.1 Main abiotic factors at Level 3

Do you agree with the main abiotic typology factors proposed for level 3?
- If not, should one or more of these factors be supplemented or replaced by others?
- If yes, which factors and why?

Size:
It was decided that ponds & pools should be added as a separate type at level 3. This is to give this particular water body type more visibility in the hierarchy. It was proposed to distinguish ponds & pools with an area of <5 ha. Area is still retained as a separate abiotic factor for all other standing water body types at level 4. This is further discussed in 3.2.2 Additional abiotic factors at Level 4.

Geology/Alkalinity:
The use of alkalinity at level 3 (i.e. geology) was discussed in terms of the link with natural nutrient concentration (natural trophic state). A significant positive correlation is shown between phosphorus concentration and alkalinity in low and moderate to high alkalinity lakes, based on the data compiled in the REBECCA FP6 project[1]. The relationship described was shown for reference lakes after removing all impacted lakes from the analysis (Lyche Solheim et al. 2006, 2008). Another large empirical dataset confirming the positive relationship between alkalinity and TP emerged from the WISER FP7 project showing a clear correlation between alkalinity and phosphorus, nitrogen and chlorophyll, and inverse correlation with altitude based on multidimensional scaling of data from 1795 lakes and 20 countries, including also

[1] The REBECCA project aimed to establish links between the ecological status of surface waters and physico-chemical quality elements and pressures from different sources.

Mediterranean countries and Eastern European countries (Phillips et al. 2013). Further evidence of this positive relationship is given by paleo-ecological data in UK lakes (Bennion and Simpson 2011). These lines of evidence are the basis for the identification of alkalinity ranges in different broad types, which also reflect equivalent ranges used in the WFD common intercalibration types for describing biological reference conditions and class boundaries for WFD high and good ecological status.

There were several discussions, both in the workshop and through correspondence with experts afterwards, about the nature of this relationship and its strength across all European lake types. One of the workshop participants commented that there is no fundamental reason for a high alkalinity lake to have a high phosphorus concentration and this was demonstrated in a study from the 1980s in the Canadian shield lakes (D'Arcy & Carignan, 1997) where high phosphorus concentration was due to catchment size and the residence time of phosphorus in soils rather than a high alkalinity concentration. The positive relationship between alkalinity and phosphorus was seen as being mostly statistical without a clear reason as to why such a relationship should exist. After the workshop, the chair of the standing waters session suggested that one possible reason may be that the dominating mineral for phosphorus in natural catchments is apatite, which are calcium-phosphate compounds [$Ca_{10}(PO_4)_6(OH)_2$, $Ca_{10}(PO_4)_6F_2$ and $Ca_{10}(PO_4)_6Cl_2$]. Another reason can be the relatively high content of alkalinity and phosphorus found in marine deposits, which are dominating the catchments in lowland areas of Nordic lakes, due to the land uplift after the last glaciation.

In an ad-hoc meeting with experts after the workshop, there was further discussion about the applicability of this relationship to Mediterranean lakes in particular. The positive relationship between alkalinity and total phosphorus (natural trophic status) as demonstrated via the REBECCA and WISER projects included Mediterranean reservoirs, but did not include natural lakes from the Mediterranean region. Mediterranean lakes with moderate or high alkalinity can sometimes have quite low phosphorus concentration (= naturally oligotrophic state) due to co-precipitation of phosphorus with $CaCO_3$ (but they are not considered to be marl lakes). These Mediterranean lakes either need to be identified as a separate type at level 3 or to be captured at level 4, as a subtype of calcareous lakes to ensure that the Mediterranean natural lakes with high alkalinity and low phosphorus can also fit within the system.

The positive relationship between alkalinity and phosphorus, as described above, does not apply to karstic or marl lakes. Such lakes have very high alkalinity combined with low phosphorus concentrations due to phosphorus being co-precipitated with calcium-carbonate (e.g. Danen-Louwerse et al. 1995). Karstic lakes are to be included as a separate type at level 3.

Altitude:
The upper altitude limit is denoted by the treeline in the proposed structure however it was suggested to use the timberline instead. The timberline is a limit beyond which the change in climate is evident. This would also capture the changes seen when moving from South to North in latitude.

The altitude threshold of 200m between low and mid altitude lakes was also supported from a Central European point of view.

Latitude is important to consider in order to account for the change from a cold/wet oceanic climate in North-Western Europe to a warm and dry Continental or Mediterranean climate in South-Eastern Europe.

It was discussed whether temperature could be a better discriminating factor than altitude/latitude. However, temperature is a complicated variable to incorporate in terms of what to measure (air or water), how it needs to be measured (min, max, over what time period) and how to obtain this information. This applies to running waters as well. Altitude/latitude is seen as a proxy for temperature.

3.1.2 Additional abiotic factors at Level 4

Do you agree with the additional abiotic factors proposed for level 4 (size and depth)?
- If not, should one or more of these factors be supplemented or replaced by others?
- If yes, which factors and why?

Size:
The placement of 'ponds' in the proposed structure was discussed in detail. By strict definition, ponds are a very different habitat to lakes. Lakes are dominated by fish communities, phytoplankton, zooplankton. Ponds can sometimes be without fish and therefore invertebrates or amphibians can be top predators, along with phyto- and zooplankton. This difference should be captured in the typology, an option is to include ponds as a separate category to lakes at level 3.

It was agreed that <10 ha area is too big as an upper size limit division under which to describe ponds. Some water bodies can be only $100m^2$ in size. It's important that these size classes are captured even though some of water bodies may not be classified as ponds but actually relatively deep lakes, which has strong implications for their biological communities (e.g. the Annex I habitat 3190 lakes of gypsum karst can occur with small surface areas but be either shallow or deep). A size limit of <5ha was discussed, within which further divisions of 1ha, 0.1ha and smaller can be distinguished. It was suggested to further divide ponds at level 4 based on dystrophic, non-dystrophic, lime pools etc. Dystrophic (humic) lakes are captured already at level 3 as well as alkalinity (lime lakes). Differences in depth will be captured at level 4.

It was noted that there is a difference between pools and ponds, and the title of this group at level 3 should capture both pools and ponds. In terms of area it was questioned whether there is a size cut-off for when a pool should be considered as part of the wetland habitat section. There are small pools of 2x2m present in bog habitats but based on the vegetation present (i.e. non-aquatic) they belong in the wetland habitat section.

Regarding the placement of ponds/pools, it was suggested to include these as a separate group at level 3. It was questioned whether biological communities in ponds and pools react differently to altitude and alkalinity than biological communities in lakes, and if this justifies keeping them as a separate group at level 3. However, as ponds are smaller and have smaller catchments, they are easier to preserve and are important at landscape level. Including them at level 3 would ensure they stand out as a separate group and remain visible in the structure.

Links were provided to further sources of information on ponds, the Ponderful project and 'The Pond Manifesto' from the European Pond Conservation Network.

3.1.3 Missing types to incorporate

Are some important habitat types still missing from the proposal in order to encompass your specific types at the lower levels?

Marl lakes are a separate type to be included. This will be captured at level 3 under 'karstic lakes'.

Volcanic lakes will also be their own separate group at level 3. There is much difference between Macaronesian, Icelandic and Mediterranean volcanic lakes, this will be distinguished at level 4.

3.1.4 Distinction of Mediterranean region

Do you support the distinction of the Mediterranean region as a separate geographical region or is that not needed if brackish/saline and temperate lakes/ponds are added at L3? Do you agree that the other regions are merged at L3, and can be further specified at more detailed EUNIS levels?

As both saline and temporary water bodies are included at level 3, there is no need to distinguish the Mediterranean region at this level. Regional distinction can be at lower levels if it's useful.

3.1.5 Placement of littoral habitats

Although isoetids can be considered amphibious vegetation in very small water bodies (ponds and pools) in the Atlantic and Mediterranean regions, they are submerged and truly aquatic in most of the other lake habitats in all regions, and are therefore considered as aquatic vegetation to stay in the inland waters group. The amphibious nature of isoetids in ponds and pools can be described at level 3 or level 4.

Would you agree that the helophyte vegetation could be moved to a revised Wetlands section?

An argument to keep the helophytes in the inland water section is that they are already an essential part of WFD assessment of ecological status for macrophytes in lakes e.g. in Spain (Camacho et al. 2019), and also in Finland and Poland. They are very sensitive to pressures i.e. water level regulation, other hydromorphological pressures, eutrophication pressures etc. and are therefore good indicator species in terms of assessment of ecological status under the WFD. It was noted that whichever habitat group the helophytes are placed, they can be linked to the appropriate inland water habitats in terms of their descriptions i.e. at level 4. These descriptions can also refer to the functional importance of a habitat to an ecosystem and to other EUNIS habitat groups. It was discussed that helophytes are not always related to water bodies. They often occur in wet depressions distant from water bodies and their ecology is more similar to that of mires rather than the aquatic environments (actually they often represent an initial stage of mire succession).

3.1.6 Description of biological communities

Would you agree with the proposed approach for descriptions of the biological communities at level 4 (using European datasets, e.g. WISER or EVA database, WFD intercalibration Technical Reports)? Are there other databases of use here?

Additional data sources were not identified.

3.2 Main messages

Although the main discussions covered many topics, below is a summary of the main points in relation to the original topic questions asked. While some conclusions were reached on some topics, there are still some topics that needed further discussion. These are listed in the column 'General outputs from workshop'.

Table 1. Summary of the main topics discussed during the workshop for the standing water bodies

Main abiotic factors at Level 3		
Topic discussed	**Details**	**General outputs from workshop**
Ponds/pools to be included as a separate group at L3 Upper size limit <1ha or <5ha	Ponds are a very different habitat to lakes (e.g. they can be represented more by invertebrates as the top predators in the absence of fish, used more by amphibians). Ponds also have smaller catchments and are easier to conserve and incorporating them at L3 is a good way to protect biodiversity at landscape level. This also ensures they are kept visible in the proposed structure. It is proposed to further divide these based on size and depth at L4. The appropriate cut-off size for ponds/pools was discussed i.e. whether 5ha or 1ha could be an appropriate cut-off size. Many fish ponds can be over 100ha. It is important to avoid including those which are artificial fish ponds. Area is currently a defining factor at L4 so this water body type will be further divided. Small dystrophic pools in bogs are considered as inland waters based on their biological communities. These are totally separated from other water bodies, can be as small as 2x2m area.	Ponds will be kept as a separate group at L3. Also, to include ‘pools’ in the title as this will capture the smallest inland standing water bodies. The exact surface area increments are to be decided however 1ha or 5ha was discussed. It will be investigated to define further size limits at L4 (e.g. 1ha, 0.1ha, 0.01 – 0.1ha etc), however it depends on biological communities being distinguished further based on size classes.

	Water bodies with small surface areas may also have a wide range of depth e.g. Annex I habitats 3190 Lakes of gypsum karst. Depth is already considered as a discriminating factor at L4.	
Delineation of the boundary for high-altitude water bodies	As the climate clearly gets harsher above the timberline it was suggested to use this as the delineation of high-altitude waterbodies rather than the treeline. The difference being that treeline means the upper limit of single individual trees, while the timberline is the upper limit of forests.	Timberline is more appropriate and this will be used instead of treeline.
Threshold between low and mid-altitude waterbodies - 200m	There was general agreement that this an acceptable limit (also from a Central European perspective).	200m is appropriate for delineation between low-mid-altitude water bodies.
Temperature as an independent discriminating factor	Temperature by itself will not be included as a separate factor as it is often difficult to obtain this information (i.e. should be water temperature and not air temperature) and it varies a lot in space (at a scale of a few km^2 depending on local topography and size/depth of the lake) and time (at a scale of hours) and it is too difficult to get access to the data. Altitude/latitude is a good proxy for temperature so it is not needed as a discriminating factor.	Temperature by itself will not be included as a separate factor.
Alkalinity (i.e. geology) as a discriminating factor	It was discussed whether the relationship between alkalinity and nutrient concentration was statistical rather than there being a fundamental reason for this relationship. This relationship (i.e. between low/high alkalinity and low/high phosphorus) was shown in **reference** lakes (REBECCA and WISER projects, as well as from paleolimnology), but does not apply to marl-lakes, karstic lakes where the alkalinity is extremely high (because the phosphorus is naturally low due to co-precipitation with $CaCO_3$).	Geology (i.e. alkalinity) is retained as a discriminating factor at L3 as a relationship between total phosphorus (natural trophic state) and alkalinity has been shown in reference lakes (Lyche-Solheim et al. 2006, 2008, Phillips et al. 2008, Bennion and Simpson 2011). This allows a link between the revised EUNIS habitats and the HD Annex I habitat types. The positive relationship between alkalinity and total phosphorus may not apply to all Mediterranean waterbodies.

	It has been shown, in Scandinavia, where the majority of European lakes are found, the reason for this relationship is that the bedrock is often siliceous and the natural P-concentration is very low (< 5 µg/l), while in areas in the lowlands where there are marine deposits (after the last glaciation), the soils have higher P-concentration and provide naturally more fertile areas, and lakes with higher natural P-concentration (the marine deposit-line is ca. 200 m altitude in Eastern Norway and Southern Sweden and Southern Finland). Marl-lakes and karstic lakes are proposed as separate types at L3. Separately, it was discussed that this relationship may not apply to some Mediterranean water bodies e.g. calcareous lakes with low phosphorus concentrations. A system whereby alkalinity ranges are referred to in level 4 rather than at level 3 may be a way to ensure this current system is retailed while allowing these specific lake types to be included in the system.	Therefore, the system should enable these types to also be reflected either as a separate type at L3 or a sub-type of calcareous lakes at level 4.
Additional abiotic factors at Level 4		
Topic discussed	**Details**	**General outputs from workshop**
Area as a discriminating factor	Water body size (surface area) is important for biodiversity and is appropriate to be included at L4. Ponds/pools are captured as a separate group at L3. Very large lakes (> 100 km^2) are also identified as a separate type at L3 due to their huge water volume and very long retention time.	Further discussion is needed concerning finer divisions of size at L4 for ponds/pools (see the first row on '*Main abiotic factors at Level 3*' above). This subdivision depends on whether differences in biological communities can be identified at further size classes.

Depth as a discriminating factor	It was agreed that depth was an important factor for discriminating between standing water body types due to stratification and mixing patterns influencing the functioning of the lake and its biological communities. Its placement at L4 is appropriate. Depth was previously included at L3 in an earlier version of the structure. However, based on the multiple depth classes to be considered this resulted in a large number of types at L3, therefore depth was moved to L4. Water retention time is also described alongside depth at L4.	Depth and water retention time to be included at L4. Depth increments were suggested but not decided upon. Ponds will also be further divided by depth at L4.
Distinction of Mediterranean region		
Topic discussed	**Details**	**General outputs from workshop**
Inclusion of the Mediterranean region at L3.	Saline and temporary lakes are represented at L3, which is sufficient to distinguish the Mediterranean region water bodies. Regions can be included at lower levels if needed. The Metzger (2012) 'Environmental Zones' (i.e. climatic zones) is another factor which could be included at lower levels instead of region (if needed).	Region is not to be included at L3, but may be considered at L4.
Missing types to incorporate		
Topic discussed	**Details**	**General outputs from workshop**
Marl/karstic lakes to be included as a separate group at L3	To be included as a separate group at L3 (see the L3 row on alkalinity above).	To be included as a separate group at L3.
Volcanic lakes to be included as a separate group at L3	These lakes have a different water chemistry to other standing water bodies in the proposed structure. There are also regional differences i.e. between Icelandic, Macaronesian and Italian volcanic lakes. These will be distinguished further at L4.	To be included as a separate group at L3.

Placement of ditches	It was not decided if ditched should be kept in standing or running waters. It was suggested to include these in the title of 'ponds' at L3 if kept in the standing water group. There was opposition to including then in the EUNIS system at all as it was noted that the system needs to describe natural habitats which would not include ditches.	No decision is made on the placement of ditches.
Placement of littoral habitats		
Topic discussed	**Details**	**General outputs from workshop**
Isoetids species to describe aquatic communities	It is noted that in the Mediterranean, *Isoetes histrix* is found on wet outcrops in spring and live in dry soil for most of the year. Isoetids in both the Atlantic and Mediterranean regions can be amphibious in very small lakes, ponds and pools. However, in other lake types, the isoetids are more submerged.	Isoetids are indicator species that are sensitive to eutrophication and should be kept as aquatic vegetation and described in the inland standing water habitats.
Helophytes to be included in wetlands	This proposal is based on reed beds often occurring separately from water bodies i.e. wetland depressions in the landscape. If these are included only in the inland waters, it will result in many non-aquatic habitat types. Finland and Poland use these as part of WFD ecological status assessment for macrophytes in lakes and would prefer to keep them in inland waters. It was suggested to move the helophytes to the wetland habitat group and refer to it in the inland water habitats descriptions.	Helophytes to stay in the wetland habitat group.
Placement of amphibious habitats	This is still an ongoing discussion in relation to the revision of the EUNIS wetland habitats group.	To be further investigated in conjunction with the discussion on helophyte habitat placement.

4 Session 2: Running waters

4.1 Discussion

Below is summarised the discussions from the workshop on running waters. Clear decisions or agreements were not made for all topics discussed. In general, it was discussed that variables driving the form and function of river habitats should be more evident at level 3 e.g. a factor to measure the energy of the water course and its ability to move sediment around. This should also reflect the dynamics of the systems. It was discussed that describing at level 3 anything beyond what is already used is too detailed e.g. stream power, flow etc. The issue with describing flow in the EUNIS system is that it changes with location and with time, there many ways to define and measure flow-related variables (i.e. different variables, e.g. current velocity, slope, flow, gradient, level of braiding or meandering). Flow dynamics should be incorporated into the system in a way that can be measured and observed at a pan-European scale. Another problem with flow-related variables is that they are often modified by man due to hydromorphological alterations (e.g. hydropower, transport, urbanisation, drainage).

It was noted from one participant that EUNIS needs to inform biodiversity policy whereas the Broad Types inform water policy. The European Red List of habitats was suggested as a good starting point to describing inland water habitats at a lower level. As there is already a strong relationship between the Red List and EUNIS, incorporating the Red List allows for a link to be made with the broad types, which further allows EU nature and water policies to be linked. The Broad Types are based on purely natural abiotic factors that are important to explain natural biological variability.

While the summary of discussions below is separated into different headings, many of these themes and topics overlapped each other during the workshop. Additionally, where themes were common between standing and running waters (e.g. alkalinity, geology) these are discussed in detail only once in the report (i.e. in Section 3 above).

4.1.1 Main abiotic factors at Level 3

Do you agree with the main abiotic typology factors proposed for running waters at level 3 (altitude, geology, catchment size)?

Environmental Zones:
It was discussed which 'climate' element was most appropriate to incorporate at level 3. The Metzger et al. 2012 'Environmental Zones of Europe' was suggested as a discriminating factor to include at Level 3 (Fig. 4). The zones are based largely on the parameters described at level 3 e.g. geology as well as the climatic components, which have a direct relationship to the flow. They are represented by a composite measurement linked to each zone. This factor was also useful as a descriptor of habitat types in the AMBER project in conjunction with slope, catchment size, geological classification, Strahler order.

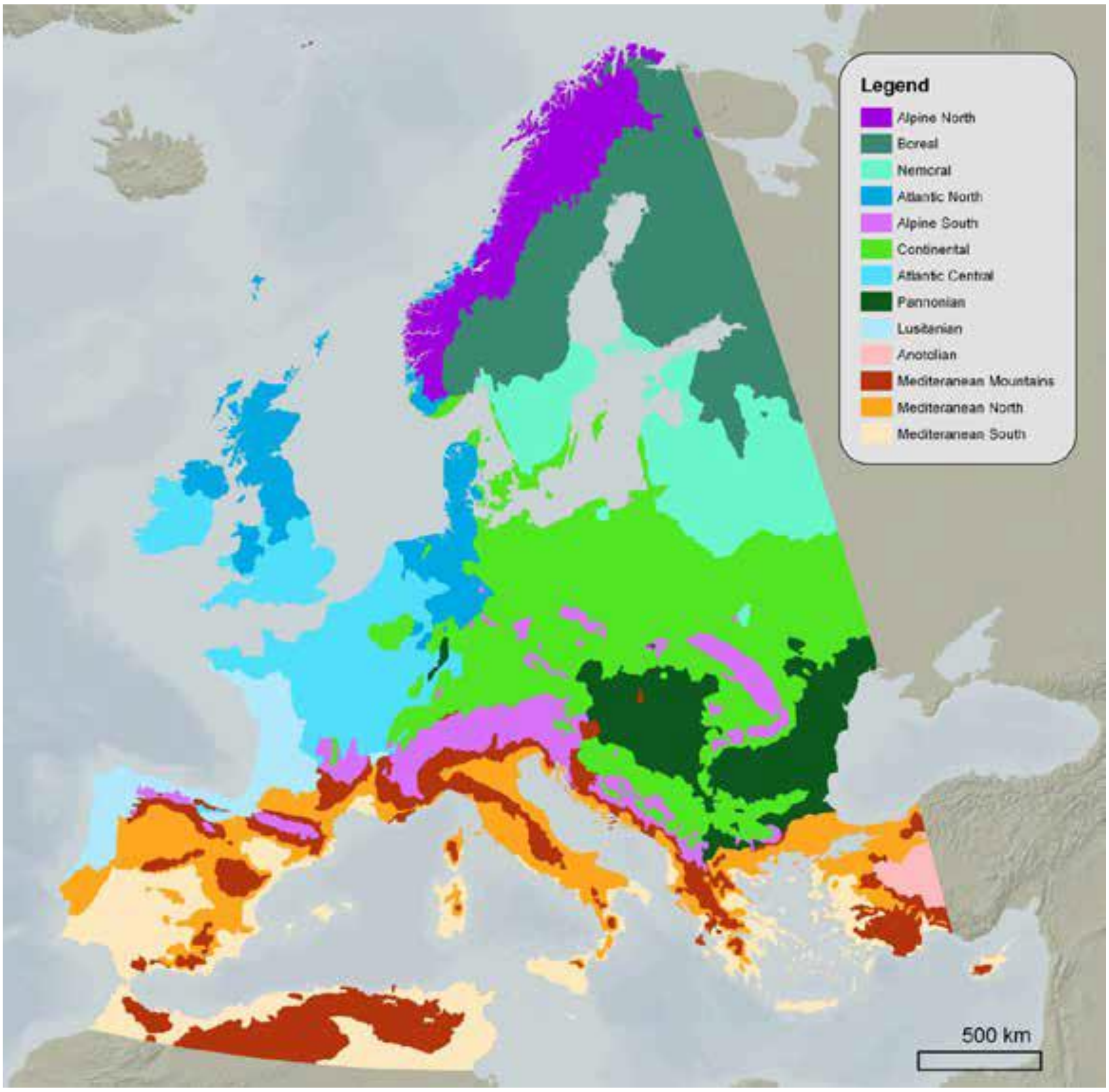

Figure 4. Metzger et al. (2012) showing the 'Environmental Zones of Europe'

Shape/form:
It was discussed that an indicator of size (form and shape) is needed at level 3. Catchment area, which is already accounted for, can capture the size of a river system. The opposite view was also presented i.e. that other factors, such as climatic factors (e.g. Environmental Zones) should be represented at level 3, with factors describing shape and form at lower levels.
Level 4 in the proposed structure describes riffles, pools and runs, which describe the form and function of a river system. However, this system is considered as too fine a scale to be described at this level i.e. a riffle and a pool can occur a few meters away from each other. The UK is investigating GIS modelling to describe form, in very general terms, across reaches of rivers (see Box 2 in section 4.1.2 below).
It was suggested that the Environmental Zones could be incorporated at level 3 or level 4, as biogeography is already incorporated. It was suggested that geology is better described at level 4 i.e. to have an abiotic, physical, functional typology at level 3, then water chemistry and other variables at level 4. However, it has been shown that factors such as geology (alkalinity), altitude and catchment size, stream order, are relatively good descriptors of biological relationships at a coarse scale (and also reflected in the Environmental Zones). Additionally, the parameters used need to be independent of human influence, an example of this is altitude and geology and catchment size. Factors like flow and stream power are not free of human influence.

4.1.2 Inclusion of flow at Level 4

Should flow be included at level 3 or 4? And if at level 3, should it be an additional factor or a replacement?

Flow:
Flow is an important factor to include when describing a river system as it is a way of capturing the hydraulic energy in the river system that is responsible for shaping it i.e. through moving and redistributing sediment and hence largely determining the geomorphological form of the river. It was discussed that to consider hydraulic energy there is a need to consider flow as well as current velocity, and that the pattern of flow velocity and its amplitude (high versus low velocity) is more important than the mean or average velocity. Whereas 'flow' is an indication of river size, 'velocity' is 'something that organisms experience'.

However, as flow is subject to human interference, this makes it difficult to incorporate in the system e.g. altering flow for dams, irrigation etc. While it was noted that direct measurements of flow are very detailed to incorporate at level 3, it was suggested that modelling flow could be an option. A system whereby GIS modelling can be used to generate unimpacted reference conditions (a necessity of describing habitats in the EUNIS system) could be considered in the future. Such a system is being developed in the UK (please see Box 2 in '*Stream power'* below). However, this would require access to Europe-wide datasets, which are not available at the moment. This analysis is also beyond the scope of this revision.

The proposed structure as it stands includes a more simplistic reference to river flow at level 4 in the form of riffles, pools and runs (described in more detail in '*Dynamics & scale'* below). 'Stream power', related to flow and velocity, is described in more detail below.

Stream power:
'Stream power', which is currently used in predictive modelling in the UK (with the aim of predicting habitats at different scales), was discussed as a possible discriminating factor at level 3. The modelling looks at the changes in reference stream power on a longitudinal basis along the entire river network and aims to relate this to changes in habitat character (using the geomorphic types of the Red List of habitats). It can be use to describe the shape of the habitat, the impact of hydraulic energy on redistributing river sediment thereby describing the functioning of a river system. It can also capture climate and catchment information.
In more detail, the GIS modelling aims to predict the likelihood of a specific reach of river of having a specific flow and substrate, such as high current velocity with big stable substrate, low velocity with finer substrates etc. This gives a picture of how sediment is generated and how it is moved around a river system.

The modelling process accounts for artificial factors as much as possible i.e. where natural flow is manipulated. However, the dataset would need to be modelled across Europe to be useful in this context. See Box 2 below for more information on using stream power in the UK context.

Box 2: A UK perspective on abiotic characterisation of the European Red List river/stream typology and its relevance to the EUNIS review

The Red List typology includes a small set of hydraulic/geomorphic river/stream types from EUNIS Level 3 that provides a holistic basis for describing habitat character which relates to distinctive biological assemblages. Variations in habitat generated by water chemistry (particularly alkalinity/hardness) can be seen as a secondary source of variation, often involving the substitution of related species according to water chemistry preferences.

Key river/stream types are as follows:

- **Red ListC2.2a** Permanent non-tidal, fast, turbulent watercourse of montane to alpine regions with mosses
- **Red ListC2.2b** Permanent non-tidal, fast, turbulent watercourse of plains and montane regions with *Ranunculus spp.*
- **Red List C2.3** Permanent non-tidal, smooth-flowing watercourse
- **Red List C2.4** Tidal river, upstream from the estuary.

To this list can be added dynamic gravel-bed rivers or 'active shingle' rivers, which are currently only included in the Red List typology as riparian habitats.

Some of these types have strong relationships with Habitats Directive Annex I river types such as watercourses with Ranunculion /Batrachian vegetation (H3260) and alpine rivers.

On-going modelling work in the UK is looking at how the natural spatial distribution of these types can be predicted across the UK using environmental variables, with the aim of providing a simple basis for characterising key variations in habitat provision within rivers/streams. Modelled distributions can be used to help report on the condition of these different river types (for example by filtering relevant Water Framework Directive data), stratify monitoring regimes and plan conservation strategies. Further modelling work is planned to model the distribution of other Red List river/stream types.

There are various abiotic variables that can be used in this kind of prediction, all relating to hydraulic energy and the ability of river and stream channels erode and deposit sediments of varying coarseness (from boulders all the way down to silts). Any such modelling has to take account of the nested spatial scales of habitat variation inherent in river systems. The aim is to characterise general habitat character at the large-reach scale (of the order of a few kilometres), accepting that there will be smaller scale habitat variation within reaches.

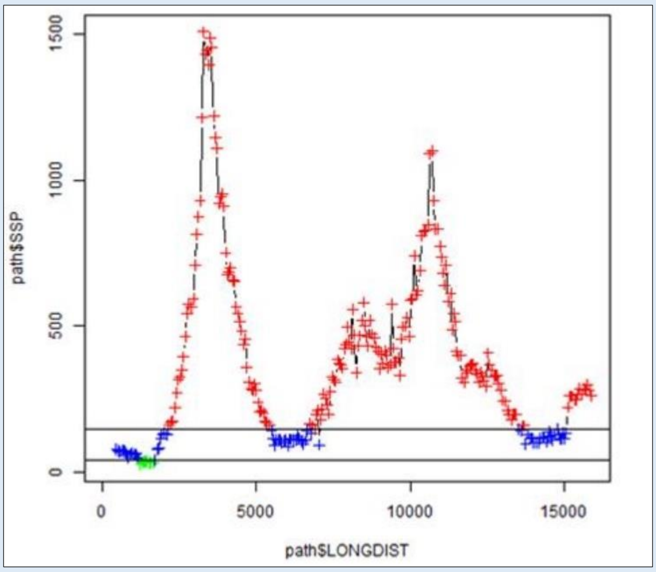

Figure 1. Modelling 'natural' longitudinal variation in stream power along the river/stream network (colours

The analysis has focused on stream power as a derived attribute that reflects the contribution of a number of environmental variables to the hydraulic energy of a river/stream section. There are issues with generating estimates of stream power that are free of anthropogenic influence, but analytical options have been chosen to be as free of human modification as possible. A simple *indicate the predicted location of different river/stream types)*

division of reach-scale stream power values can potentially provide a reasonable model of the distribution of relevant river/stream types, but to assist with the prediction of active-shingle river sections an approach has been adopted that tracks longitudinal changes in stream power down the river network (Figure 1).

Longitudinal changes in river/stream types have been estimated according to changes in stream power. Typological boundaries were estimated by reference to the habitat characteristics of a large national dataset of survey sites with low level of anthropogenic modification (using the UK River Habitat Survey method). Provisional model outputs are now being ground-truthed (Figure 2) and the model recalibrated to provide a better fit to reality. Modelling is being undertaken at high spatial resolution and then aggregated up to large reach-scale to provide an output indicating overall habitat character.

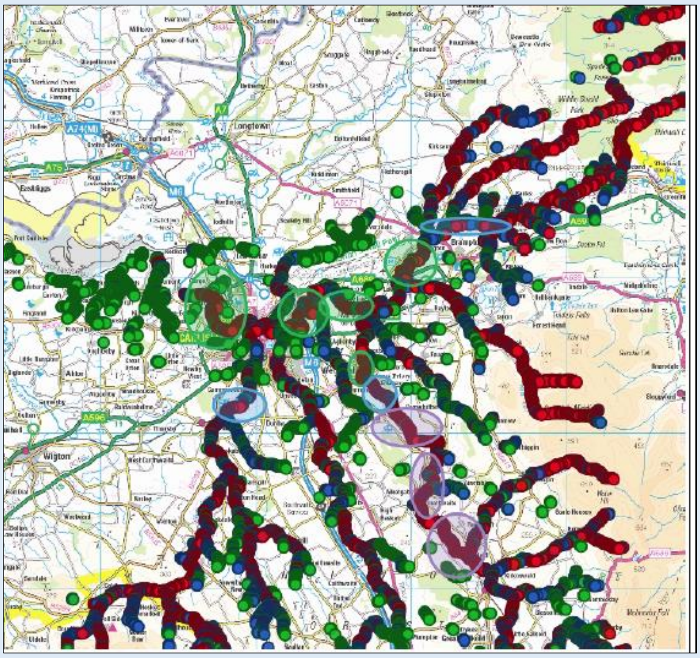

Figure 2. Ground-truthing of provisional model predictions

<u>Dynamics & scale</u>*:*
Linked to flow and stream power as described above, the incorporation of shape and form at level 4 was further discussed. The proposed structure already describes riffles, runs and pools, which, to a degree, captures the flow and form and function river system. However, this system was described as occurring within a very short distance of each other in the river i.e. pools, riffles and runs occurring within a few meters of each other in a river, which is a quite detailed scale to be described at level 4. While not appropriate for the current EUNIS inland waters revision, an example of a broader characterisation at intermediate levels i.e. where river form is characterised over a distance of a few kilometres rather than meters (as can be the case with pools, riffles and runs), is seen in (Box 2). A broader system at level 4 would allow the more detailed system of pools, riffles and runs to be described at lower levels (i.e. levels 7 or 8).

It was noted that we are working with phenomena on two different scales: coarse and fine. An example is floodplains, it can be a single habitat but also a complex of different fine scale habitats. The habitats on these two scales can exist within one system e.g. habitats on a coarse scale can include habitats on a finer scale as well. Additionally, some habitats, especially in the inland water habitat group, can include finely divided habitats from the other habitat groups. If we accept braided river floodplains or normal river floodplains as a single habitat by themselves then we risk excluding many other fine scale habitats from the system that are already there e.g. floodplain forest, floodplain scrub, and which are important to biodiversity. This 'nested spatial scale' was discussed with regard to the use of EUNIS in decision making, e.g. restoring river ecosystem through restoring their natural functions. If parts of the ecosystem are disembodied and placed in different habitat groups (e.g. habitat complex group, sparsely vegetated habitat group), it undermines the ability of the EUNIS classification to underpin decision making to promote restoration of river ecosystems. An example of this is placing the floodplains and braided rivers in the habitat complex group and not the inland water habitat group.

4.1.3 Distinction of Mediterranean region

Do you support the distinction of the Mediterranean region as a separate biogeographic region?

As discussed in the standing waters session, there is no need to distinguish the Mediterranean region at level 3 as tidal, temporary and ephemeral rivers waters are represented as separate types at level 3. However, in relation to the discussion of Environmental Zones (see 4.1.1), including this parameter at level 4 will also include an element of regional distinction (See fig. 4, Environmental Zones map).

4.1.4 Incorporation of floodplains and braided rivers

Should floodplains, braided rivers and gravel bars be added to Habitat complexes or to Sparsely vegetated land sections, or be included in the running waters?

Floodplains and Braided rivers:
Normal floodplains, not including braided rivers, are generally considered as complex of habitats and were initially proposed to be included in the EUNIS habitat complexes group. This was due to the difference stages of vegetation succession (i.e. advanced, initial development etc). It is also logical in the EUNIS system to include gravel bars in the inland sparsely vegetated habitats group (i.e. with *Epilobium fleischeri* and similar species) flooded grasslands in the grassland habitats, Salix forest in the forest habitat group.

There was disagreement about separating floodplains, braided rivers and gravel bars from the inland water habitat group. It was discussed that anything in-channel (braided channels, gravel bars) should remain with running waters as they are functional parts of the river ecosystem, and in terms of restoration, the entire ecosystem should be considered. In terms of describing a river channel, a braided river is a channel form and should be kept in this group.

In terms of including floodplains in the habitat complex group, despite being considered a 'habitat complex' in themselves, they can still be included in the inland water habitat group. It was noted that there is a need to acknowledge that some habitat types in the inland water habitat group will have the same vegetation as habitat types occurring in other habitat groups i.e. contain elements that are described in other parts of the EUNIS system.

Some of the smaller rivers may not have much of a floodplain e.g. coastal countries where many catchments are very small and/or have rivers that flow off mountains near the coast. Some of the proposed river types at level 3 refer to rivers starting small in the mountains, coming down to having large floodplains in the lowlands, which may not be the case with some rivers. There are other European river types that don't follow the same order i.e. some are a bit flashier, can have a big floodplain etc. The current typology should capture all these types.

The recent [floodplain typology](#) devised by ETC/ICM was suggested as a way to keep floodplains in the running waters group i.e. to be described at level 4 within each river type where appropriate. It is based on altitude, slope, width and run-off.

Table 2. Floodplain typology from ETC/ICM 2020

Floodplain type	Altitude [m]	Slope [m/km]	Floodplain width [km]	Run-off [l/s/km^2]	High flow pulse [number per year]	High flow duration [days per year]
1 Very flat lowland floodplains	Lowland (< –200)	Very flat (< 1)	Very wide (> 0.6)	Low (< 20)	High number, highly varying range (1—30)	Short (< 5)
2 Flat lowland floodplains	Lowland (< 300)	Flat (1–10)	Wide (0.1–1.0)	Low (< 40)	High number, highly variable range (14–34)	Short (< 5)
3 Mid-altitude high run-off floodplains	Mid-altitude (200–800)	Steep (10–100)	Narrow (0.04–0.25)	High (> 50)	High number, highly variable range (16–32)	Short (< 5)
4 Mid-altitude low run-off floodplains	Mid-altitude (200–1000)	Steep (10–100)	Narrow (0.04–0.25)	Low (< 40)	High number, moderately variable range (14–27)	Short (< 5)
5 Mid-altitude plateau floodplains	Mid-altitude (500–800)	Flat (1–10)	Wide (0.1–1.0)	Low (< 30)	High number, moderately variable range (15–27)	Short (< 5)
6 Highland floodplains	Highland (> 800)	Very steep (> 100)	Very narrow (< 0.1)	High (> 40)	High number, moderately variable range (17–28)	Short (< 5)
7 Nordic lowland floodplains	Lowland (< 300)	Flat (1–10)	Wide (0.1–1.0)	Low (< 20)	Low number, unvarying range (1–2)	Long (> 50)

There was general agreement that including floodplains and braided rivers in the running waters group is appropriate. It was also agreed that it's difficult to deal with these specific habitats and their placement in the system and there's a big difference in how the terrestrial and aquatic habitats are dealt with (i.e. it appears to be easier to use abiotic factors to describe inland waters, unlike terrestrial habitats).

It was discussed that the EUNIS habitat complexes group could be kept to describe terrestrial (and marine) habitats only. The inland waters group will retain habitats generally considered as a complex (i.e. floodplains and braided rivers).

4.1.5 Addressing temporarily flooded riparian zone

Where to include the riparian zone that is temporarily flooded?

See discussion in 4.1.4 above.

4.1.6 Description of biological communities

Are you happy with the proposed approach for descriptions of the biological communities at Level 4 (using EU-level datasets, e.g. WISER, EVA database, Biofresh, red List, Intercalibration datasets).

No additional data sources were identified.

4.2 Main messages

Below is a summary of the main points in relation to the original topic questions asked. While some conclusions were reached, there are still some topics that need further discussion. These are listed in the column ‘General outputs from workshop’.

Table 3. Summary of the main topics discussed during the workshop for the running water bodies

Main abiotic factors at Level 3		
Topic discussed	**Details**	**General outputs from workshop**
'Environmental Zones' (Metzger et al. 2012) and the possible inclusion as an alternative discriminating factor at L3 (not to replace a factor).	Climatic factors have a direct relationship with flow (which is too difficult to characterise/measure). These are missing at L3. Environmental Zones are based on the factors used at L3 and some climatic factors (e.g. temperature). Additionally, the AMBER project used this (and other variables) and found a good relationship with fish communities. L3 needs to incorporate factors independent of human influence, Environmental Zones meets this criterion. It was proposed that this would not replace the current criterion, but complement them. Environmental Zones could be seen as a proxy for regions at L4.	The Environmental Zones were derived from the same or similar factors that are already included at L3. This would cause redundancy in the current factors. There was a discussion to include 'regions' at L4 if needed. However, this was mainly in relation to the distinct hydrology of the Mediterranean region, which is being resolved in another way (please see below).
An indicator of form or shape is needed at L3 or L4.	One view was to include form/shape at L3 and include water chemistry at L4. Catchment area was described as an appropriate factor of form, and is already incorporated. An opposite view was that L3 should be coarser, with geology, altitude, catchment size (and possibly Environmental Zones). Shape and form should then be included at more detailed, lower levels.	The factors that are incorporated in the current system (altitude, catchment size and geology) are clear and simple and represent a coarse system, anything more than this is too fine in detail.
Inclusion of flow at Level 4		
Topic discussed	**Details**	**General outputs from workshop**

Inclusion of flow in the system, including its placement in the structure (i.e. at L3 or L4).	It was discussed that a measurement describing the 'function' of a river system should be incorporated at L3 with flow being an obvious factor. However, it is difficult to measure/subject to human influences and therefore too difficult to incorporate at this level. 'Stream power' captures the 'energy' of the system i.e. the hydraulic energy. It's an indication of river size, velocity is something that organisms experience. This drives the 'shape' of the habitat and nature/dynamics of substrates. Flow is currently captured at L4 through pools, riffles and runs.	Stream power, while an appropriate measurement to capture flow, velocity and hydraulic energy, cannot be included in this revision of EUNIS. The reason being that it is based on modelling that has not yet been applied on a European scale. This can be considered in the future. However, stream power is strongly modified by man in a large number of rivers and is highly variable with time (sometimes from hour to hour due to flash floods or hydropeaking). Flow in general is an issue in terms of how to characterising it/measuring it. It changes with location and time and is subject to human influence. The proposed system includes the system of riffles, pools, runs at L4, which encapsulates flow to a degree.
Current L4 discriminating factors: Riffles, pools, runs.	It was discussed that these are very fine scale habitats and would be more appropriate to include at levels lower than 4 (e.g. L7 or 8). Further divisions are needed before describing pools, riffles, rapids and runs.	Further investigation needed for L4 factors. It was suggested to place these at levels lower than 4 (e.g. L7 or 8). It was questioned what to include at the levels in between, but there was not a clear view on this by the workshop participants. Rinaldi et al. 2016 suggests a system based on basic river typology (BRT) and extended river typology (ERT), this will be analysed in more detail in relation to describing L4.
Distinction of Mediterranean region		
Topic discussed	**Details**	**General outputs from workshop**
Inclusion of the Mediterranean region at L3.	Originally proposed as a factor due to water bodies in the Mediterranean having a more specific hydrological regime to the rest of Europe.	Not to be included as a separate discriminating factor. The inclusion of temporary, ephemeral and saline water bodies at L3 is sufficient to represent the

		distinction of Mediterranean water bodies from the rest of Europe.
Incorporation of floodplains and braided rivers		
Topic discussed	**Details**	**General outputs from workshop**
Placement of gravel bars in the EUNIS system.	It is logical to include gravel bars in the Sparsely vegetated habitat group based on its vegetation i.e. *Epilobium fleischeri*. However, there was opposition to this as it was felt that anything occurring 'in-channel' should be a part of the river, it was described as a retrograde step to take gravel bars out of the inland water habitat group.	Gravel bars to be moved to the EUNIS Sparsely vegetated habitat group. Vegetation that occurs on a gravel bar is not aquatic and therefore cannot represent an aquatic habitat. This habitat can, however, be linked to inland water habitats in the habitat descriptions.
Placement of braided rivers in the EUNIS system.	Braided rivers (and floodplains) are habitat complexes due to the different stages of vegetation succession and were originally considered to be a part of the EUNIS habitat complexes group. However, as a braided river is itself a channel form, it should be included in the inland waters group, at lower levels which will describe more the form of a river.	Braided rivers to be kept as a part of the inland water habitat group. They will be described at L4 or lower. They are part of the floodplain habitat (see Placement of floodplains below).
Placement of floodplains in the EUNIS system.	This was originally considered for placement in the habitat complex group (i.e. along with braided rivers). The rationale behind this is the different stages of succession of vegetation (i.e. initial, advanced etc). However, it was discussed that floodplains, braided rivers and the extended riparian zone should be a part of the inland water habitat group as they are a functional part of the whole river ecosystem, even if they are more characteristic of a habitat complex in terms of vegetation present. From a	Floodplains will remain with the inland water habitat group. The inland water habitat group can include complexes if the complex includes aquatic habitats. Examples are floodplains and braided rivers.

	conservation and habitat restoration perspective, the whole ecosystem is considered in terms of restoring that ecosystem to its natural structure and function and keeping floodplains as a part of the inland water habitat group ensures the conservation rationale for floodplain and riparian habitats remains linked to the conservation rationale for the whole river system. In terms of linking to other habitat groups in EUNIS system, this can be done through the habitat descriptions at lower levels.	

Overall conclusions

The workshop accommodated a much-needed discussion on inland water habitats in general, even outside of the EUNIS classification system. Issues touched were how the classification of these habitats is approached from different areas of expertise and the different needs for a classification typology (e.g. for the purpose of habitat restoration potential, additional designation of protected area, invasive alien species monitoring and for other policy needs).

While the session on standing waters showed the discriminating factors proposed at level 3 to be more straightforward and also with more agreement between participants, the running waters session revealed more differences in opinion to the approaches at levels 3 and lower. It was agreed that flow was a fundamental discriminating factor that defines the shape and form of running water bodies, as well as their biological communities, but due to the high variation of flow at small spatial and temporal scale this factor would be more suitable at a more detailed level e.g. level 4. The discussion on running waters also raised more questions about the scale at which these habitats are described. One key difference between describing standing water and running water habitats is the dynamics of the system and the role this plays in shaping the ecosystem.

This workshop enabled a frank review of the proposed approach. After discussion with the experts some fundamental changes were proposed for the finalisation of the revision. An example of this is the placement of floodplains and braided rivers in the EUNIS inland water habitats as complexes in themselves, rather than being included in the EUNIS habitat complexes group. The expert group asked the EEA and ETCs revision team to consider how to allow for complexes to stay as a part of the inland waters group mainly because of the difficulties in describing, particularly, the running waters types in a satisfactory way.

Additionally, several additional factors not previously considered in relation to the revision of EUNIS inland water habitats were discussed e.g. Environmental Zones of Europe, stream power. The Environmental Zones incorporate several factors already considered at level 3 and can be considered for incorporation at level 4, through the differentiation of regions identified by these zones. For stream power, while relevant to the discussion and indeed to a possible future revision of EUNIS inland water habitats, it cannot be considered until more work is undertaken to roll this concept out across European datasets.

The aim of the workshop was to move a step further in the classification of inland water habitats. It was not to provide a final list of discriminating factors for the revised structure or a final level 3 structure. However, based on some agreed topics during the workshop. The remaining unresolved discussions in tables 1 and 3 will be taken on by experts at EEA, ETC/BD and ETC/ICM and final decisions will be made with a view to developing the revised structure by the end of 2021.

List of abbreviations

Abbreviation	Name	Reference
AMBER	Adaptive Management of Barriers in European rivers	https://amber.international
BioFresh	Freshwater Biodiversity Data Portal	https://data.freshwaterbiodiversity.eu/datapolicy
EEA	European Environment Agency	www.eea.europa.eu
EIONET	European Environment Information and Observation Network	www.eionet.europa.eu/countries
ETC/BD	European Topic Centre on Biological Diversity	https://www.eionet.europa.eu/etcs/etc-bd
ETC/ICM	European Topic Centre on Inland, Coastal and Marine Waters	https://www.eionet.europa.eu/etcs/etc-icm
EUNIS	European Nature Information System	https://eunis.eea.europa.eu/index.jsp
EVA	European Vegetation Archive	http://euroveg.org/eva-database
REBECCA	Relationships between ecological and chemical status of surface waters	www.cordis.europe.eu/project/id/502158
WISER	Water bodies in Europe – Integrative Systems to assess Ecological Status and Recovery	http://www.wiser.eu

Glossary

Amphibious vegetation: Vegetation in the littoral zone of lakes/rivers adapted to both the aquatic and terrestrial environments. These macrophytes have submerged growth forms and can adapt to a period of the year when this zone is running dry by producing emergent growth forms e.g. leaves with stomata. They form part of the ecosystems of aquatic and terrestrial habitats. The littoral zone changes throughout the year for temporary surface water systems.

Aquatic vegetation: macrophyte vegetation that can complete their whole life cycle in water either submerged-rooted, submerged or floating e.g. *Charids*, some *Isoetids, Elodeids, Nymphaeids, Lemnids*.

Broad types: 'Broad Types' is a generic typology of European water body types whose basis lies in the national types of the Water Framework Directive. Through reflecting the natural variability in the most commonly used environmental type descriptors i.e. altitude, geology and size the Broad types capture 60 to 70% of all national Water Framework Directive types and almost 80% of all European river and lake bodies in almost all European countries. The environmental type descriptors reflect most of the natural variability in reference conditions for the biological quality elements. The broad types are linked to the Intercalibration types (see below).

Helophyte: emergent plants typical of marshy or lake-edge environments and shores of slow-flowing rivers, in which the perennating organ lies in soil or mud below the water table but the aerial shoots and flowers protrude above the water (e.g. *Phragmites australis*, the common reed, *Carex* and *Typha* species). They can grow on muddy land or in water.

Intercalibration types: common types for a regional group of countries based on high similarity of national types defined for the Water Framework Directive. For each common intercalibration type, the class boundaries between high and good, as well as between good and moderate ecological status for national indicators of different biological quality elements were intercalibrated between the countries sharing the intercalibration type. The aim was to ensure that the good status class boundaries were consistent with the normative definitions in the WFD Annex V for each of the biological quality elements and that they were harmonized between the countries (i.e. showing the same deviation from reference conditions).

Littoral zone: the zone along the lake shore which is subject to water level fluctuations and wave action, and where the sediments have sufficient light available for plants. The littoral zone contains typical habitats for both submerged and truly aquatic vegetation (*Charids, Isoetids, Elodeids, Nymphaeids, Lemnids*) and amphibious vegetation adapted to aquatic and terrestrial environments.

Riparian zone: the zone along the river bank which can be subject to flooding and contains vegetation adapted to both aquatic and terrestrial environments (e.g. *Salix* and *Alnus* species, *Phragmites* and *Typha*).

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Annex 1 Agenda

Agenda

Workshop on EUNIS revision of inland water habitats

16th March 2021

Introduction	
10.00-11.00	• Welcome and introduction to the workshop. *Mette Lund, EEA* • Overview of EUNIS habitats classification & Inland water habitats: classifications and typologies. *Eleni Tryfon, EEA* • Broad European types of lakes and rivers: Description of broad-types and the factors used: rationale, development and applications. *Anne Lyche Solheim, ETC/ICM* • Proposed revision of EUNIS inland water habitats, data sets for biological communities and outcomes of the EIONET webinar. *Michelle Watson, ETC/BD* *Clarification questions after each presentation*
Break 15 min	
Standing waters	
11:15-12:45	Revision of standing waters & proposed solutions *Anne Lyche Solheim, ETC/ICM*
Lunch break 1h	
Running waters	
13:45-15:15	Revision of running waters & proposed solutions *Gertie Arts, ETC/BD*
Break 15 min	
Moving forward	
15:30-16:00	Summary of topics from the standing and running waters sessions Closing the workshop. *Mette Lund, EEA*

Annex 2 Attendees

Experts and organising committee in attendance for the workshop

Invited experts	Institute/organisation
Belka, Kamila	European Regional Centre for Ecohydrology (ERCE/UNESCO) - PL
Camacho, Antonio	University of Valencia -ES
Casella, Laura	Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA) - IT
Chytrý, Milan	Masaryk University - CZ
Evans, Doug	Independent expert
Fontes, Hugo	Tour du Valat, Institut de recherche pour la conservation des zones humides méditerranéenne - FR
Free, Gary	Institute for Electromagnetic Sensing of the Environment (IREA), National Research Council of Italy– (CNR) - IT
Hatton-Ellis, Tristan	Natural Resources Wales (NRW) - UK
Hellsten, Seppo	Finish Environmental Institute (SYKE) - FI
Kristensen, Peter	EEA - DK
Mainstone, Chris	Natural England - UK
Mjelde, Marit	Norwegian Institute for Water Research (NIVA) - NO
Molina, Jose Antonio	University of Madrid - ES
Parasiewicz, Piotr	Instytut Rybactwa Śródlądowego w Olsztynie (IRS) - PL
Sandin, Leonard	Norwegian Institute for Water Research (NIVA) - NO
Schaminée, Joop	ETC/BD - WENR, NL
Schinegger, Rafaela	Universität für Boden Kultur (BOKU) Wien - AT
van de Bund, Wouter	JRC, EU Commission
Organising team	**Institute/organisation**
Arts, Gertie	ETC/BD – WENR - NL
Lund, Mette	EEA - DK
Lyche Solheim, Anne	ETC/ICM, NIVA - NO
Tryfon, Eleni	EEA - DK
Watson, Michelle	ETC/BD, MNHN - FR

Annex 3 List of standing and running water body types considered for discussion.

Below are the lists of standing water and running water body types that were considered for discussion during the workshop. These lists underwent consultation in 2019 and were further discussed in an EIONET webinar in December 2020, where minor amendments were made to the list. These lists do not incorporate changes, updates, amendments discussed in the expert workshop in 2021.

Standing water bodies
Geology: Calcareous/mixed, siliceous, humic *Altitude:* lowland 0 – 200m, mid-altitude 200 – 800m, highland >800m Separate groups for temporary and saline lakes
Lowland, calcareous or mixed lakes and ponds
Lowland, humic lakes and ponds on calcareous or mixed bedrock
Lowland, humic lakes and ponds on siliceous bedrock
Lowland siliceous lakes and ponds
Mid-altitude, calcareous or mixed lakes and ponds
Mid-altitude, humic lakes and ponds on calcareous or mixed bedrock
Mid-altitude siliceous lakes and ponds
Mid-altitude, humic lakes and ponds on siliceous bedrock
Highland, humic lakes and ponds on calcareous or mixed bedrock
Highland, calcareous or mixed lakes and ponds
Highland, humic lakes and ponds on siliceous bedrock
Highland, siliceous lakes and ponds
Permanent saline and brackish lakes and ponds
Temporary calcareous lakes, including humic lakes and ponds
Temporary saline and brackish lakes and ponds
Temporary siliceous lakes, including humic lakes and ponds
Glacier fed lakes and ponds
Underground lakes and ponds
Reservoirs
Very large lakes

Running water bodies
Geology: Calcareous/mixed, siliceous, humic *Altitude*: lowland 0 – 200m, mid-altitude 200 – 800m, highland >800m *Catchment area*: very small to small <100 km^2, medium to large 100 – 10,000 km^2, very large >10,000 km^2 Separate groups for temporary and tidal rivers
Lowland rivers and streams draining clay rich catchments
Lowland, very small to small, calcareous or mixed rivers and streams
Lowland, very small to small, siliceous rivers and streams
Lowland, very small to small, humic rivers and streams on calcareous bedrock
Lowland, very small to small, humic rivers and streams on siliceous bedrock
Lowland, medium to large, calcareous or mixed rivers and streams
Lowland, medium to large, humic rivers and streams on calcareous bedrock
Lowland, medium to large, siliceous rivers and streams
Lowland, medium to large, humic rivers and streams on siliceous bedrock
Mid-altitude, very small to small, calcareous or mixed rivers and streams
Mid-altitude, very small to small, humic rivers and streams on calcareous bedrock
Mid-altitude, very small to small, siliceous rivers and streams
Mid-altitude, very small to small, humic rivers and streams on siliceous bedrock
Mid-altitude, medium to large, calcareous or mixed rivers and streams
Mid-altitude, medium to large, humic rivers and streams on calcareous bedrock
Mid-altitude, medium to large, siliceous rivers and streams
Mid-altitude, medium to large, humic rivers and streams on siliceous bedrock
Highland humic rivers and streams on siliceous bedrock
Highland siliceous rivers and streams
Highland, calcareous or mixed rivers and streams
Highland, humic rivers and streams on calcareous or mixed bedrock
Springs
Temporary rivers and streams
Tidal rivers
Glacial rivers and streams
Very large rivers
Underground rivers and streams