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Reference conditions within the Water Framework Directive

Should water quality be measured against a static condition?

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Summary

By 2027 at the latest, Europe's waters must have achieved a good ecological and chemical status, as a result of implementing the EU's Water Framework Directive (WFD). Under the current application of WFD, a static reference condition is used for assessing the quality of ground and surface waters. The reference condition, according to the Directive, corresponds to the quality of water in an "undisturbed state".

In view of the future review of the WFD and after many comments in the debate from both researchers and government agencies, we now question the suitability of basing the fulfilment of the obligations under the Directive on a static reference condition.

This work aims to answer two questions. Firstly, what, in practical terms is an "undisturbed state"? Secondly, is such a state really desirable? The work here includes a summary of publicly available and academic material with associated analyses.

It can be affirmed that scientific articles that concern the WFD and the relevant reference conditions are few. Of the available material, five articles have been analysed in detail; these have been selected as exemplifying the particular challenges and problems which the academic community has registered in respect of the WFD's system of reference conditions.

We draw the conclusion – as things stand at present – that there is a lack of consensus about what can actually be considered to be an "undisturbed state"; the researchers, moreover, consider it impossible to define such a state in scientific terms. The material summarised here clearly illuminates the benefits of a more function-oriented viewpoint of the ecosystem, where a holistic perspective enables an ecologically, economically and socially sustainable management of water resources. A sustainable ecosystem is not necessarily synonymous with a "natural" ecosystem.

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1 Introduction

The EU's framework directive for water (Water Framework Directive) specifies that Europe's waters must achieve a good ecological and chemical status by 2027 at the latest. In order to define what is meant by good status, the EU uses a reference condition to assess the ecosystem. This reference condition is thus a standard, by which to measure deviations, which is to be used during the implementation phase of the Directive.

This reference condition, according to the Directive, shall correspond to waters in an "undisturbed state", that is to say a state where human activity has had a non-existent or very limited effect on the ecosystem. Exactly how this reference condition is to be defined is left by the EU to the respective member states to decide for themselves (EC, 2000).

The definition of what a reference condition means, during the implementation process, has been shown to vary between member states. This has raised the question whether reference conditions really constitute the best method for measuring water quality and ultimately achieving the WFD objective. First and foremost, the suitability of basing the fulfilment of the Directive's obligations on an unvarying set of conditions has been questioned.

The purpose of this work is to summarise what has been published, until now, in publicly available and academic publications concerning reference conditions (definitions, measurement methods *etc*). The work here encompasses the following: documents published by the EU, homepages of Swedish agencies and authorities as well as our consultation of documentary material at a large number of Sweden's academic libraries.

The work is mainly focused on two problems: What does an "undisturbed state" really mean? And is such a state really desirable or is there a better alternative? In order to respond to these questions at issue we have used the following questions as our starting point:

- Which are the definitions of reference conditions, currently in use or proposed?
- What is the research community's view of the prevailing application of reference conditions in the implementation of the WFD?
- Are there other approaches to be adopted than that of inflexible reference conditions for measuring water quality?

In addition to the summarisation of publicly available and academic material, the work undertaken here also constitutes a basis for carrying out further analyses.

2 Government agencies and public institutions

To facilitate the implementation of the Water Framework Directive, as well as to provide continuous monitoring of the obligations assumed by member states, a public administration of water resources has been established at a number of different levels – from the level of the EU institutions via the member states right down to the local administration level. In this section there is a summary of publicly available material concerning the WFD and the associated reference conditions.

The EU has published a large number of documents that relate to the WFD. The formal Directive document itself, instructions for interpreting the Directive and easy-to-grasp information brochures are all available via the different homepages and databases of the EU institutions. There are relatively few documents that concern the reference conditions beyond the published material that more or less directly relates to the Directive's original formulations. It is emphasised that it is up to the member states to provide further clarifications of what the reference conditions mean in practice. An inter-calibration system shall subsequently balance out possible national differences (EC, 2016a) (EC, 2016b).

The Agency for Marine and Water Management (HaV) is Sweden's national expert authority for aquatic environments with responsibility for implementing and applying the WFD in Sweden. The Agency publishes widely and informatively in respect of the Directive and also possesses the most up-to-date technical and public knowledge concerning the Directive (Havs- och Vattenmyndigheten, 2014a). The Agency, moreover, supplies different forms of regulatory documents and supervisory material for the more concrete implementation of the WFD; it also guides the regional water management authorities in their implementation work (Havs- och Vattenmyndigheten, 2014b). It is the Agency which details and defines the reference conditions for Swedish water bodies with specific directives concerning the classification and control system (Havs- och Vattenmyndigheten, 2015).

The Swedish Environmental Protection Agency (NV) is also an expert authority with national responsibility for environmental toxins in Sweden; consequently it is an active stakeholder in the implementation of the Framework Directive in Sweden. This Agency published a number of regulations and other guidance documents concerning the Water Framework Directive. Now, however, the principal responsibility lies with the Agency for Marine and Water Management (HaV), as a consequence of which the number of relevant documents under the auspices of the Environmental Protection Agency and which concern the WFD are few in number. In other respects, the Agency mainly links to EU documents, parliamentary ordinances and other external sources of public information (Naturvårdsverket, 2016).

Five county administrative boards have been designated as **water management authorities** with operational responsibility for water management in Swedish waters and for the Water Framework Directive in their respective geographical area. General information concerning the Framework Directive is to be found on the joint homepages of the water management authorities (Vattenmyndigheterna, 2016a). The water management authorities also share the publications database, where a large number of action programmes, protocols and management plans are stored and are available to the general public (Vattenmyndigheterna, 2016b). The online content at any time varies between different regions: certain county authorities provide information on ongoing projects more than others and the level of access to the compiled

information and such like varies between the authorities concerned (Water Management Authority, Gulf of Bothnia, 2016) (Water Management Authority, Southern Baltic Sea, 2016). Noteworthy in the management plan for the Southern Baltic Sea 2009-2015 is the description of how water bodies shall be categorised where it is ascertained that exact reference values for the assessment of ecological status have still not been fully specified; this work will therefore continue during the future management cycle (Water Management Authority, Southern Baltic Sea, 2009).

A lesser number of **County Administrative Boards** include shorter documents concerning the Framework Directive on their respective homepages. These describe in general terms the Directive's strategic goals and refer to the respective water management authority for broader and deeper information (Örebro County Administrative Board, 2016). Regardless of the level of public communication, each county administrative board has a drafting committee with the task of assisting the regional water management authority in the implementation of the WFD (Water Management Authorities, 2016c).

As a tool in the work of the WFD, the Kalmar County Administrative Board is responsible for administering VISS, Water Information System Sweden. VISS has been developed by the water management authorities, the county administrative boards and the Agency for Marine and Water Management for the management and storing of information on all of Sweden's water bodies. VISS contains no information about reference conditions (VISS, 2013).

It is evident that the Swedish water management authorities focus their external communication on the Water Framework Directive on enlightening the public, in general terms, on the Directive and its influence on Swedish water management. Information concerning the more operational aspects of the Directive requires more in-depth searches, something that makes it difficult to clearly determine the viewpoints of the Swedish regional authorities on the formulation of the Directive.

3 The Water Framework Directive seen from an academic perspective

Even though the EU assigns to each member state to decide on the definition of what an appropriate reference condition is for their respective water resources, the WFD does offer guidelines on which methods can be used in the preparation of these reference conditions. Basically, four methods are permitted: comparisons with similar but undisturbed bodies of water, modelling, analysis of historical data and expert opinions. Exactly how the different methods are used is not regulated by the Directive.

Since scientific rigour is a precondition for enabling the implementation of the WFD, it is interesting to examine what the research community thinks about the Directive and the underlying methodology. This section therefore discusses academic publications with the focus on the WFD's reference conditions.

A search of the databases at six of Sweden's largest university libraries has been carried out. Table 1 records the number of search results at each university library for the respective search as well as the percentage share that specifically relates to reference conditions. The search only covers scientific articles. It can be observed that the number of available publications concerning the Directive is small (Column [A]), and that the number of articles concerning the WFD reference conditions is of marginal significance (Column [B]). Exceptions appear to be the University of Gothenburg and Uppsala University where over ten per cent of the articles

that mention the Water Framework Directive also concern reference conditions, something that may possibly be related to research initiatives such as WATERS (www.waters.gu.se). Comparisons between universities should be made with caution since the databases use different algorithms for undertaking searches. Even with this reservation it can be established, however, that the number of academic articles concerning the WFD and reference conditions are very few in number.

Search term	"Water Framework Directive" [A]	"Water Framework Directive" "Reference Condition" [B]	Per cent, B/A
KTH	12935	100	0.8%
GU	11719	1505	12.8%
SLU	11092	111	1.0%
SU	26972	1210	4.5%
LU	6698	144	2.1%
UU	12397	1522	12.3%

Table 1. Search results, number of articles per search term and university library

Over and above conventional searches in academic databases, manual searching of references has also been carried out through checking of the bibliographies of articles. Five scientific articles that discuss reference conditions have been analysed in their entirety. The articles are selected in order to exemplify certain of the challenges and problems which the academic world has drawn attention to in respect of the WFD reference conditions.

The French researchers Gabrielle Bouleau and Didier Pont (2015) are responsible for an examination of the ecological and socioeconomic aspects of the Directive. The researchers argue that the definitions and administrative models that the Directive highlights concerning reference conditions respond to the specific needs experienced by certain stakeholders. Furthermore, the researchers affirm that the Directive in its present form risks leading to the EU member states creating unequal yardsticks for what is an “undisturbed state”.

Moreover, the Directive offers no clarity in respect of what is to be counted as a reference condition. The article written by the French researchers gives many examples of different definitions and states that the Directive appears to be based on – what the authors consider to be – outdated economic paradigms. The researchers believe that reference conditions should not be seen in terms of static historical points; rather the ecosystem is naturally unstable, changeable and unpredictable. The consequence of all this, in combination with thousands of years of human interaction with nature, is that it is impossible to define an original ecological state.

In conclusion, Bouleau and Pont consider that the Directive presupposed a direct link between different stress factors and indicators which, in their opinion, is not a correct reflection of how the earth actually functions. The key point to which the researchers wish to draw attention is the fact that the Directive’s ecological foundation is now outdated, is too simplistic and pays no regard to the ecosystem’s natural variability and the long-term interaction between human beings and the natural environment in which they live (Bouleau & Pont, 2015).

Valinia, Hansen and others (2012) have stated in an article that the WFD is an ambitious project which fundamentally changed the administration of Europe’s water resources. The authors of

the article believe, however, that the Directive is not without problems. They question, among other things, whether the achievement of a so-called undisturbed state is really a desirable goal; it is also one that lacks a clear definition.

The article's principle argument is that an "undisturbed state" as reference condition is a fundamentally subjective and impractical notion based as it is on values held by each one of us individually. This has been shown, for example, through a field study at a lake in Västergötland, with interviews conducted among the local population and decision-makers. The researchers draw the conclusion that it is only through recognising alternative conditions based on both local knowledge and scientific objectivity that the WFD's own vision concerning water quality can be realised (Valinia, *et al.*, 2012).

Simon Dufour and Hervé Piégay (2009) declare that, certain fundamental questions concerning environmental restoration remain unanswered: Why do we restore the ecosystem? When is it advantageous to do so? Which reference condition should be aimed at in the restoration of water quality?

Where the latter question and the WFD are concerned, these authors affirm that an unvarying reference state is not appropriate as an objective, in particular where river systems are concerned. The objective instead should be to achieve a certain combination of processes which, by definition, are changeable and to a degree unforeseeable.

The researchers, moreover, observe that "a pre-industrial or pre-European settlement state is no longer a realizable reference state", and also that "[...] past conditions should not be used as references because no former historical state can be justified in preference to another (*i.e.* a more natural one), since most systems were already human influenced at all prior known states". Dufour and Piégay argue for the use of a process-based and function-centred reference system instead of a static reference condition. They believe that river systems are a combination of cycles, long-term trends and short-term fluctuations that, when taken together, mean that attempting to restore some earlier "undisturbed" state is not a realistic ambition.

The article also discusses the fact that in Western cultures, mankind and nature are often depicted as being in constant antithesis. However, there is no evidence that increased human impact on the countryside must necessarily imply lower ecological diversity or functionality. The authors also analyse the problems arising from the fact that people's material living standards will need to be lowered if we return to an "undisturbed" wholly natural ecological state. What are we as a society willing to lose in such a scenario?

By way of conclusion, David Lowenthal's ideas are cited to the effect that we humans are part of nature and that there is no reason to prefer some hypothetical original world rather than today's reality. The authors also emphasise that ecological restoration is a tool, not a goal *per se* (Dufour & Piégay, 2009).

Stoddard, Larsen and others (2006) have stated in an article that the term "reference condition" is applied in a majority of national legislations and serves as a cornerstone for the Water Framework Directive, with varying meanings depending on the context and author. The researchers have produced four definitions that they believe cover different perspectives connected with the discussion surrounding reference conditions.

Minimally Disturbed Condition (MDC) is described as a state with, in principle, a total lack of influence from human activity. The authors are of the opinion that it is more or less impossible to find places that are wholly undisturbed by the global impact caused by human activities. They emphasise that it is important to acknowledge that there will always be natural variations also in an area categorised as being in a MDC and that this must be taken into consideration.

Historical Condition (HC) describes a state at some selected point of time in the system's history. This can be placed anywhere on the chronological axis, and from there describes different states. Whether preindustrial, prehistoric or a historical time point, the important thing is to be aware of which consequences the choice of time point has for the reference condition.

Least Disturbed Condition (LDC) summarises the best possible total state that a system can achieve physically, chemically and biologically with regard to the state of the system in present circumstances. A consequence of this is that LDC varies over time, in line with changes in the system itself and thereby the prerequisites.

Best Attainable Condition (BAC) is equivalent to LDC wherein the best conceivable care, conservation and management methods have been used over a longer period of time. BAC thus combines the objective set, best available technology and other parameters for determining the best possible state that a system in purely practical terms can achieve.

To summarise, the researchers seek the use of additional and well-defined terms for describing the state which is actually meant. This would diminish the confusion in academic and political discussions; it would also define more effectively what different action programmes or directives should actually achieve (Stoddard, *et al.*, 2006).

There has been a discussion, over a long period, concerning alternative methods for achieving the goals that the Water Framework Directive sets forth. Vlachopoulou, Coughlin and others in a recent publication (2014) have investigated the compatibility between the WFD and "the Ecosystem Approach" (EA), a holistic and function-based methodology that emphasises the importance of dynamical systems analysis. The authors affirm that the WFD at present has a static objective which fails to focus on the functionality of ecosystems.

The authors also argue that the EA's concept of ecosystem services and functions fits very well in to the implementation of the Water Framework Directive since the Directive's goal of achieving a good ecological and chemical status is a prerequisite for the ecological functionality that the EA strives for. The authors thus believe that the EA and the WFD have largely the same end goal but have different methods for achieving this. The article referred to here stresses that it is extremely important to understand all components in an ecological system, and how these then interact and are subject to change over long periods of time.

The article notes that the WFD has been criticised for using reference conditions that do not take account of the continuous and natural change of the ecosystem, regardless of the level of human interference. The authors are of the opinion that the EA does not have this shortcoming; on the contrary it can create a structure that takes account of the ecosystem as a whole and all interactions within and between the different water bodies.

It is emphasised that the Ecosystem Approach takes into consideration the interplay between human wellbeing and welfare and the ecosystem's functionality; an interaction that the authors believes is overlooked by the WFD in its present formulation. The article's conclusion is that the WFD's objectives would be better achieved through a working methodology similar to that

of the EA being adopted. This is a working methodology that pays due regard to all three dimensions of sustainability: environmental, social and economic (Vlachopoulou, *et al.*, 2014).

4 Background concentrations, an essential component of a reference condition

When it comes to definition of the reference conditions, it is necessary to determine what is naturally occurring and what is anthropogenic - something that is rarely straightforward. An example of this relates to metal contents in watercourses, where the contents measured today are a combination of trace elements which, in their turn, are a result of leakages from bedrock and other natural phenomena as well as discharges arising from human activities. Below follows a summary of two Swedish studies that illuminate the work and the challenges that the agencies and researchers face in tracing the origins of the metal contents in water bodies.

Over a long period, the County Administrative Board of Dalarna has investigated the metal contents of water bodies in its area of administration; it has attempted also to assess the contribution from different sources to the values measured. In a study from 2010 the Board finds that the watercourses studied have very high contents of metals and goes on to connect this with the region's thousand-year history of mining operations. The Board believes, however, that this is only a potential problem in purely local terms, and that the dilution effects make the metal contents, in principle, negligible from a macro perspective. Local action programmes moreover, in the view of the County Administrative Board, also need to balance the environmental benefit against the economic costs and other societal interests such as the preservation of cultural heritage and ongoing mining activities (Miljöenheten Länsstyrelsen Dalarna, 2010).

In a study ordered by the Swedish Environmental Protection Agency, Heléne Ejhed, Marcus Liljeberg among others (2010) have categorised different forms of discharge sources of metallic substances; they have also examined how these have affected the metal contents in water bodies nearby. These sources are then divided into two groups, namely point and non-point sources.

Examples of point sources are industrial plants, urban wastewater plants and individual drains whereas non-point sources include forests, agriculture and urban areas. The study can establish that non-point or diffuse sources account for the majority of discharges of the heavy metals Cd, Cu and Hg and that forests, clear-cut areas and, to a certain extent, agriculture are the predominant sources for most of the investigated elements. The authors also state, in general terms, that it is very difficult to assess the precise distribution between metal contents of human and natural origin. However, they are able to show that metals of anthropogenic origin dominate in proximity to point sources and certain non-point sources such as urban areas and roads. Further studies and research are required in order to determine the share of these contents resulting from human activity and the share caused by natural sources (Ejhed, *et al.*, 2010).

5 Discussion

The Water Framework Directive is obviously far-reaching and ambitious; through this Directive the EU hopes to be able to ensure a holistic approach to the care of Europe's waters. As a tool in this work, the Directive introduces reference conditions, the yardstick or standard which, at the end of the day, shall determine if the Directive's objectives and requirements have actually been fulfilled. In addition to documents describing the reference condition as "an undisturbed state" which corresponds to a state where human influence is non-existent or minimal, there are no definitions of what this in concrete terms really implies. Moreover, each

member state itself defines the reference conditions that shall apply to their own water bodies, which means that the countries themselves may partly set the yardstick according to which they shall be assessed.

It is true that the WFD establishes an inter-calibration system with the object of harmonising and comparing the work of the nation states, but this system is extremely complex and both academic and institutional voices have been raised on behalf of reforming the inter-calibration process (Poikane, *et al.*, 2014). It is, therefore, relevant to question if today's system for both the establishment of reference conditions and inter-calibration is really the best one.

The EU defines an “undisturbed state” as an unvarying state for which the member states shall strive, a notion that is questioned by many researchers as being both outdated and erroneous. Bouleau and Pont hold the view that e.g. an ecosystem must be viewed as constantly changeable, regardless of the level of human impact. Within such an environment to attempt to define a fixed point as some form of “natural state” is, in their view, both impossible and misleading.

Dufour and Piégay think along the same lines; they believe that society must move towards a more function-centred approach to the ecosystem. Instead of attempting to recover some utopian and subjectively established reference condition, society would do better to decide which functions within an ecosystem are most valued over the long term. Then, on the basis of this function analysis, it could decide which restoration methods should be employed. Environmental remediation, in their opinion, is a tool but not a goal in itself.

In the hunt for suitable alternatives, Vlachopoulou, Coughlin and others have investigated the compatibility between the WFD and the Ecosystem Approach (EA), a concept that partly rests on the functionality-based viewpoint that Defour and Piégay are searching for. Moreover, the EA adopts a holistic perspective where an ecosystem's totality and complexity are assigned a high priority. One positive result of this is that the social and economic aspects of sustainability are also included in the analysis, something lacking in today's WFD according to Vlachopoulou, Coughlin and others.

The lack of clarity in the EU's Water Framework Directive concerning those objectives that actually apply is something that appears to concern researchers. How should a task be carried out if the objective is unclear? It is this confusion that Stoddard, Larsen and others have tried to rectify through creating several different alternative definitions of the reference condition, which clarifies the actual intention. Through clear-cut objectives and definitions the work itself can be given practical form and be implemented more effectively.

All the articles that this work has analysed share the view that a static and unvarying reference condition is now outdated, unrealistic in practice and indeed confusing. Instead, due regard must be paid to the ecosystem's natural changes and prerequisites, and a holistic approach – one that integrates different factors – is necessary to comprehend which particular condition at a specific time we, as a society, wish to achieve. Even where, in theoretical terms, it may be possible to restore a body of water to a “natural” state, is this really desirable? Which resources is society willing to reprioritise in order to achieve such a natural state and how much must it cost? And what exactly is it that we, as a community, actually wish to achieve with the WFD? A sustainable ecosystem is not necessarily synonymous with a “natural” one.

6 Conclusion

In an analysis of what the reference conditions mean in the application of the Water Framework Directive we have sought to find the answer to two questions: What is meant by an “undisturbed state” in specific terms? And is such a state really desirable anyway, or is there a better alternative? It can be ascertained that at present there is a lack of consensus on what is actually reckoned to be an “undisturbed state” and that many researchers consider it impossible to scientifically define such a state. Based on the material assembled here, it also seems to be counter-productive to use an unvarying original state as a measurement reference base on the present Directive is implemented. The material shows clearly the advantages of a more function-oriented view of the ecosystem, where a holistic approach enables an ecologically, economically and socially sustainable water management. The interaction between human beings and nature is complex and this fact must underlie all aspects of the common striving for a sustainable future.

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THE SWEDISH STEEL PRODUCERS' ASSOCIATION

Since its foundation back in 1747, Jernkontoret has been owned jointly by the Swedish steel companies. Jernkontoret represents Sweden's steel industry on issues that relate to trade policy, research and education, standardisation, energy and the environment as well as transport issues. Jernkontoret also manages the joint Nordic research in the steel industry. In addition, Jernkontoret draws up statistical information relating to the industry and carries on research into the history of mining and metallurgy.