IMPLEMENTATION OF MONITORING REQUIREMENTS FOR THE NEW EUROPEAN WATER POLICY

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Biographical sketch
Authors are employed as senior project manager at the Institute for Inland Water Management and Waste Water Treatment RIZA in the Department of Information and Measurement Technologies and are involved in the Dutch national inland water quality and quantity monitoring and assessment. Jos Timmerman is occupied with linking information to water management in several national and international projects, René Breukel is a member of the Monitoring Working Group for the implementation of the EU Water Framework Directive, Paul Latour is member of the Intercalibration Working Group.

Abstract
After some five years of preparation and discussion, the European Water Framework Directive (WFD) came into force in December of 2000. This directive will be the main international water law for European countries for the next 20 years. The environmental objective of this directive is to achieve a good surface water and groundwater status within 15 years in all the waters of the European Union countries. The WFD prescribes extensive reporting on the status of the water and consequently, vast monitoring efforts are required. This necessitates thorough considerations on how the information needed can be fulfilled at reasonable cost.

The WFD has chosen for an integrated, river basin approach. Consequently one of the basic assumptions of the WFD is that water management can only be performed for a whole river basin. Countries are obliged to produce river basin management plans. As many of the European rivers are transboundary, such river basin management plans have to be produced in close cooperation between the riparian countries. This also requires collaborative efforts in monitoring to describe the progress of the policy.

The WFD does not give strict requirements for each monitoring aspect but mainly provides a framework, the elements of which have to be defined by the countries, thus providing the opportunity to tune in to specific local situations. Currently, this process of making up guidelines to implement the WFD is underway. In this paper, a short description of the WFD will be presented, with emphasis on the monitoring requirements. First results of the way the requirements are fulfilled will be introduced.

Introduction
European water legislation started in 1975 with water quality standards for drinking water abstraction. These were followed by legislation on, among others, polluting substances, fish waters, shellfish waters, bathing waters and ground waters. Its main emission control element was the Dangerous Substances Directive. Review of the existing legislation led to adoption of, among others, the Urban Waste Water Treatment Directive, Nitrates Directive, a new Drinking Water Directive, and a Directive for Integrated Pollution and Prevention Control in the 1990's. An increased awareness of the public and other parties for water and the need to address water policy and water management in a coherent way led to a fundamental rethinking of the water policy starting mid 1995 (Blöch 1999).

This rethinking of water policy resulted in a proposal for a Water Framework Directive that, after some 5 years of discussion in the member states, was finally adopted and came into force in the winter of 2000. From the viewpoint of water quality monitoring, there are two major objectives in the WFD:

- Water management is based on (whole) river basins

- Goal is a good status of the waters where good status is determined as an integrated assessment of chemical, hydrological, ecological and morphological quality elements.

These two major objectives will be discussed in the next sections. Following will be a description of the organization of the work, specifics for monitoring, and the way monitoring and assessment is harmonized over the member states.

River basin management

One important objective of the WFD is that rivers and lakes will need to be managed by natural geographical and hydrological units instead of administrative or political boundaries. Already several member states used this approach towards water management, but it is not the case in all member states. Member states are required to designate river basins and competent authorities within their territory or in co-ordination with other states for international waters. A sub-division can be made into river basin districts, based on hydrological characteristics. Some of these river basin districts will transcend national frontiers. Ground waters and coastal waters are assigned to the nearest or most appropriate river basin district (Blöch 1999; Kallis and Butler 2001).

For each river basin district, a river basin management plan (RBMP) must be prepared and implemented in 6 years periods. The RBMP will include a series of maps (amongst which a map of monitoring networks), identification and assessment of the significant pressures on the aquatic environment, an economic analysis of water use, and summary information on all measures taken to achieve goals and comply with the legislation (Kallis and Butler 2001).

Existing water management in river basin districts may be divided over different countries and within countries over different administrations. Designation of a competent authority in this situation will be a serious task. Furthermore, cooperation between countries, and even within some countries, is hampered by the problem of different languages. Combined with the fact that several international river basins also involve non-EU states this makes clear that institutional consequences of the WFD are considerable.

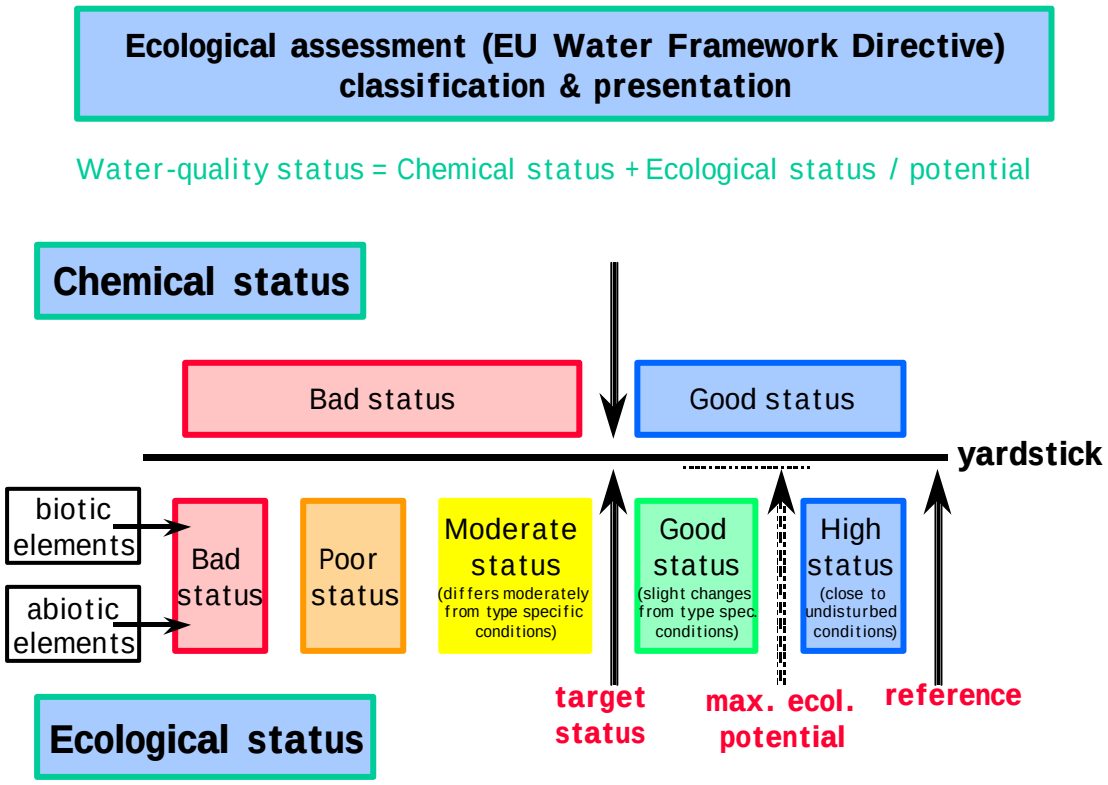

Figure 1 Classification and presentation of the water quality status

Good status
The overall water management goal of the WFD is a good and non-deteriorating status for all of Europe's waters. For surface waters, good status is a combination of ecological and chemical status (figure 1). A surface water is defined as of good ecological quality if there the biological community shows low levels of distortion resulting from human activity (European Commission 2000; Kallis and Butler 2001).

The chemical status of the surface water is classified in two categories: 'good' and 'failing to achieve good', determined by the standards set in the EU legislation for the concentration of chemicals in water. A list of priority substances has been established (European Commission 2001). The Commission shall submit proposals for the progressive reduction of discharges, emissions and losses of priority substances, and in particular for the cessation or phasing out of priority hazardous substances within 20 years.

The ecological status of the surface water is classified in five categories. The quality elements are divided into biotic elements (among others composition and abundance of aquatic flora and fauna), hydro morphological elements supporting the biological elements (among others quantity and dynamics of flow, water depth and width, structure and substrate of the water bed, and structure of the shore), and chemical and physico-chemical elements supporting the biological elements (among others thermal conditions, oxygenation conditions, salinity, acidification, and nutrient conditions) (European Commission 2000). For each element a descriptive definition of high, good moderate, poor, and bad status is given. The classification should be construed as references to ecologic al potential. Table 1 shows a division of quality-elements over different types of surface waters. Table 2 summarizes the classification system of the WFD.

Table 1 Quality-elements for different categories of waters.

Quality-element	Rivers	Lakes	Transitional waters	Coastal waters
Phytoplankton	X	X	X	X
Phytobenthos	X	X		
Macrophytes	X	X		
Macro-algae			X	X
Angiosperms			X	X
Benthic invertebrate fauna	X	X	X	X
Fish fauna	X	X	X	
Hydro morphological elements	X	X	X	X
Physico-chemical elements	X	X	X	X

Artificial and heavily modified water bodies
Different objectives can be set for heavily modified water bodies or artificial water bodies which are created by human activity such as canals constructed for navigation, water power plants and irrigation and drainage channels (artificial water bodies), and water bodies which, as a result of physical alterations by human activity, are substantially changed in character and cannot meet the good ecological status objective, as a consequence of impact resulting from the physical pressures related to existing uses. Such water bodies are designated as Heavily Modified and will be required to achieve an objective of "good ecological potential" (GEP) and good chemical status. The good ecological potential is achieved when there are slight changes in the values of the relevant biological quality elements as compared to the values found at maximum ecological potential.

Organization of the implementation process of the WFD
As the objectives of the Water Framework Directive are ambitious, and because of the risk of wrong application due to complexity of the technical requirements, a common implementation strategy of the WFD will be established. Therefore the Member States and the Commission have initiated a number of working groups, which are coordinated by the Strategic Co-ordination Group for WFD implementation (consisting of representatives from the Member States and chaired by the European Commission). The task of these working groups is to provide guidance for the different issues, tasks and requirements of the WFD in order to ensure transparent, smooth and successful implementation of the WFD in Member States. Besides the WFD stipulates the need for new Community law for specific areas. The Commission will develop proposals for new legislation in an open consultation process with the help of so called Expert Advisory Forums. Finally, stakeholder groups, NGO's, and candidate countries can give input to the entire process.

Table 2 Summary of WFD-classification system (after European Commission 2000)

Element	Status[1]		
	High status	**Good status**	**Moderate status**
General	The values of the biological quality elements for the surface water body reflect those normally associated with that type under undisturbed conditions, and show no, or only very minor, evidence of distortion.	The values of the biological quality elements for the surface water body type show low levels of distortion resulting from human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions.	The values of the biological quality elements show moderate signs of distortion resulting from human activity and are significantly more disturbed than under conditions of good status.
Biological elements	The taxonomic or species composition corresponds totally or nearly totally to undisturbed conditions. The average abundance is wholly consistent with the type-specific physico-chemical and hydromorphological conditions and shows no signs of alteration from undisturbed levels.	There are slight changes in the composition and abundance in taxa or species compared to the type-specific communities. Such changes do not indicate any undesirable disturbances to the balance of organisms present in the water body or to the physico-chemical quality of the water or sediment.	The composition of taxa or species differs moderately from the type-specific communities. Abundance is moderately disturbed.
Hydrological regime	The quantity and dynamics of flow reflect totally, or nearly totally, undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Morphological conditions	Channel patterns, width and depth variations, flow velocities, substrate conditions, etc. and both the structure and condition of the riparian zones correspond totally or nearly totally to undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
General physico-chemical conditions	The values of the physico-chemical elements correspond totally or nearly totally to undisturbed conditions. Nutrient concentrations remain within the range normally associated with undisturbed conditions. Levels of salinity, pH, oxygen balance, acid neutralising capacity and temperature do not show signs of anthropogenic disturbance and remain within the range normally associated with undisturbed conditions.	Temperature, oxygen balance, pH, acid neutralising capacity, transparency and salinity do not reach levels outside the range established so as to ensure the functioning of the type specific ecosystem and the achievement of the values specified above for the biological quality elements. Nutrient concentrations do not exceed the levels established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Specific synthetic pollutants	Concentrations close to zero and at least below the limits of detection of the most advanced analytical techniques in general use.	Concentrations not in excess of the standards set in accordance with the procedure detailed in section 1.2.6 without prejudice to Directive 91/414/EC and Directive 98/8/EC. (<Environmental quality standard)	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Specific non-synthetic pollutants	Concentrations remain within the range normally associated with undisturbed conditions (background levels).	Concentrations not in excess of the standards set in accordance with the procedure detailed in section 1.2.6 without prejudice to Directive 91/414/EC and Directive 98/8/EC. (<Environmental quality standard)	Conditions consistent with the achievement of the values specified above for the biological quality elements.

[1] Waters achieving a status below moderate shall be classified as poor or bad.

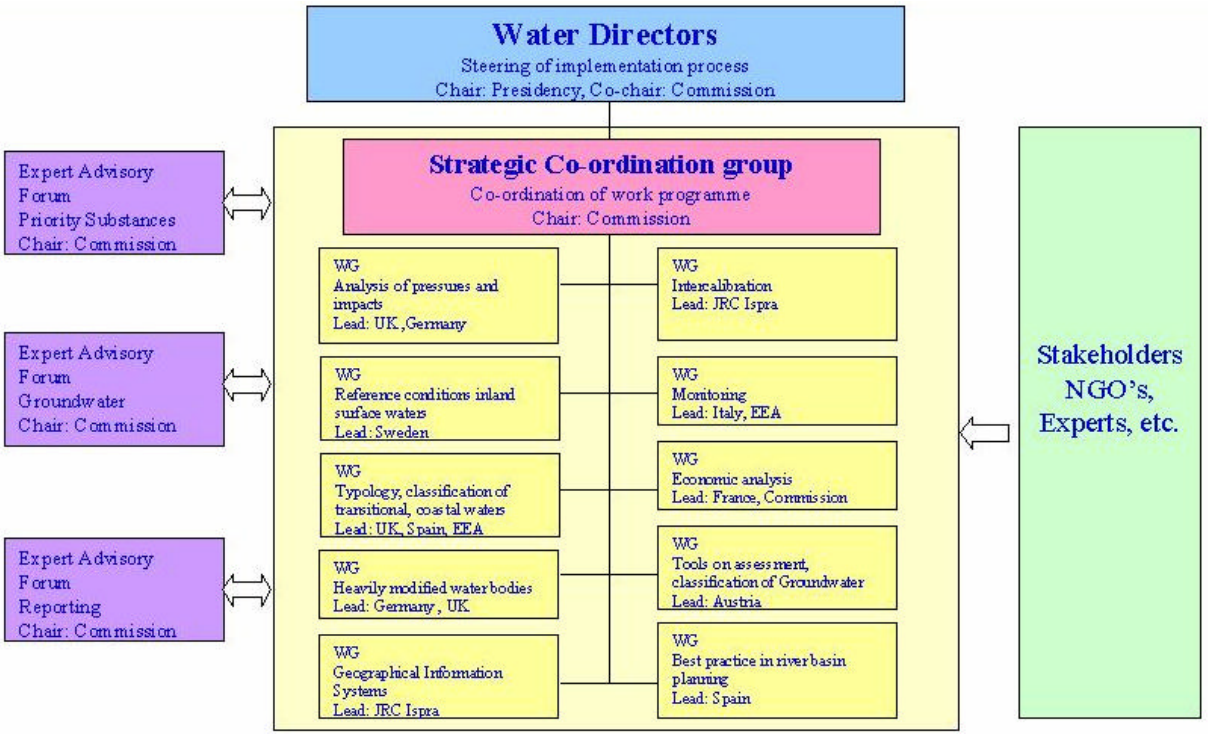

Figure 2 Organization scheme of the implementation process of the WFD

Different types of monitoring

The WFD distinguishes between surveillance monitoring, operational monitoring, and investigative monitoring. Surveillance monitoring is done to supplement and validate the impact assessment procedures as specified in Annex II of the WFD, for the design of future monitoring programmes, and for the assessment of long-term changes both in natural conditions and changes resulting from anthropogenic activities. Operational monitoring shall be carried out for all those bodies of water, which on the basis of either the impact assessment or surveillance monitoring are identified as being at risk of failing to meet their environmental objectives and for those bodies of water into which priority list substances are identified as being discharged. Investigative monitoring, finally, is carried out when the reason for any exceedance is unknown, when surveillance monitoring indicates that the environmental objectives for a body of water are not likely to be achieved in order to ascertain the causes of the failing, or to ascertain the magnitude and impacts of accidental pollution.

Surveillance monitoring puts different requirements as compared to operational monitoring regarding the selection of quality elements (sets of parameters as described by the WFD), monitoring points, and monitoring frequencies. Investigative monitoring is done for a specific purpose. Consequently no specific requirements are given in the WFD. In this paper, no further attention will be given to investigative monitoring.

Selection of monitoring points

The WFD gives the following guidance for the selection of monitoring points for surveillance monitoring (European Commission 2000): Surveillance monitoring shall be carried out in sufficient surface water bodies to provide an assessment of the overall surface water status within each catchment or sub-catchment within the river basin district. In general, monitoring points for surveillance monitoring should be selected that are representative for large volumes of water and on boundary points ('ins' and 'outs'). For operational monitoring, monitoring points must be selected as follows:

- For water bodies at risk from significant point source pressures, sufficient monitoring points should be selected within each water body in order to assess the magnitude and impact of the point source. Where a water body is subject to a number of point source pressures monitoring points may be selected to assess the magnitude and impact of these pressures as a whole,
- For water bodies at risk from significant diffuse source pressures, sufficient monitoring points are to be chosen within a selection of the water bodies in order to assess the magnitude and impact of the diffuse source pressures. The selection of water bodies shall be made such that they are representative

for the relative risks of the occurrence of the diffuse source pressures, and for the relative risks of the failure to achieve good surface water status,

- For water bodies at risk from significant hydromorphological pressure, sufficient monitoring points are to be chosen within a selection of the water bodies in order to assess the magnitude and impact of the hydromorphological pressures. The selection of water bodies shall be indicative for the overall impact of the hydromorphological pressure to which all the bodies are subject.

For groundwater, the network should be sufficient to estimate the groundwater level in each groundwater body or group of bodies and to provide a coherent and comprehensive overview of the chemical status within each river basin. For groundwater bodies being at risk of failing to achieve the environmental objectives, the network density should be sufficient to assess the impact of abstractions and discharges on the level and to detect the presence of long-term anthropogenically induced trends in pollutants. For surveillance monitoring, all bodies identified as being at risk following the characterisation exercise should be included as well as bodies that cross state boundaries. For operational monitoring, all bodies identified as being at risk following the impact assessment and surveillance monitoring should be included.

Selection of quality elements

For surveillance monitoring, parameters should be selected and included that are indicative for all biological, hydromorphological, and general physico-chemical quality elements (see table 3). Furthermore, the priority list pollutants that are discharged into the river basin or sub-basin, and other pollutants discharged in significant quantities in the river basin or sub-basin should be included.

Table 3: Quality elements for the classification of ecological status

Rivers

Biological elements
• Composition and abundance of aquatic flora like macrophytes, phytoplankton, and benthic diatoms. • Composition and abundance of benthic invertebrate fauna • Composition, abundance and age structure of fish fauna
Hydromorphological elements supporting the biological elements
• Hydrological regime: Quantity and dynamics of water flow and Connection to groundwater bodies. • River continuity.   • Morphological conditions: river depth and width variations, structure and substrate of the river bed, and structure of the riparian zone
Chemical and physico-chemical elements supporting the biological elements
• General: thermal conditions, oxygenation conditions, salinity, acidification status, and nutrient conditions • Pollution by all priority substances identified as being discharged into the body of water • Pollution by other substances identified as being discharged in significant quantities into the body of water

Lakes

Biological elements
• Composition, abundance and biomass of phytoplankton • Composition and abundance of other aquatic flora • Composition and abundance of benthic invertebrate fauna • Composition, abundance and age structure of fish fauna
Hydromorphological elements supporting the biological elements
• Hydrological regime: quantity and dynamics of water flow, residence time, connection to the groundwater body • Morphological conditions: lake depth variation, quantity, structure and substrate of the lake bed, and structure of the lake shore
Chemical and physico-chemical elements supporting the biological elements
• General: transparency, thermal conditions, oxygenation conditions, salinity, acidification status, and nutrient conditions • Specific pollutants: pollution by all priority substances identified as being discharged into the body of water, and pollution by other substances identified as being discharged in significant quantities into the body of water
Groundwater
Quantitative status
• Groundwater level regime
Chemical status
• Conductivity
• Core parameters: oxygen content, pH value, nitrate, and ammonium
• Concentrations of pollutants

Operational monitoring should include those quality elements that are indicative for the pressures to which the water body is subject. To monitor the impact of these pressures, monitoring must include:

- parameters indicative of the biological quality element, or elements, most sensitive to the pressures to which the water bodies are subject,
- all priority substances discharged, and all other pollutants discharged in significant quantities,
- parameters indicative for the hydromorphological quality elements most sensitive to the pressure identified.

For groundwater, the surveillance monitoring should, next to the groundwater level regime, include conductivity and a set of core quality parameters. Bodies that are identified as being at significant risk of failing to achieve good status shall also be monitored for those parameters, that are indicative of the impact of these pressures. Operational monitoring shall be undertaken in the periods between surveillance monitoring programmes in order to establish the chemical status of all groundwater bodies or groups of bodies determined as being at risk, and establish the presence of any long term anthropogenically induced trend in the concentration of any pollutant.

Frequency of monitoring

The WFD prescribes frequencies for different quality elements during the period covered by a river basin management plan, which is 6 years. Monitoring at a lesser frequency is allowed for physico-chemical quality elements if this would be justified on the basis of technical knowledge and expert judgement. A frequency of once in 6 years is however very low, especially when the objective is to detect trends.

For this and other reasons, a (rotating) monitoring network of once in 3 years is recommended for surveillance monitoring. Monitoring frequencies for surveillance monitoring are summarised in table 4. For operational monitoring the same frequencies hold, however, not all quality elements will have to be included, depending on the pressures on the water system. Frequencies should be chosen such as to achieve an acceptable level of confidence and precision.

Monitoring frequency in groundwater must be sufficient to allow assessment of the quantitative status of each groundwater body or group of bodies taking into account short and long-term variations in recharge. On the basis of the characterisation and impact assessment a surveillance monitoring programme shall be established for each period to which a river basin management plan applies. Operational monitoring shall be carried out for the periods between surveillance monitoring programmes at a frequency sufficient to detect the impacts of relevant pressures but at a minimum of once per year.

Table 4. Monitoring frequencies (number of measurements per year once in 3 or 6 years)

Quality element	**Rivers**	**Lakes**
Biological elements		
• Macrophytes	1	1
• Phytoplankton	2	2
• Phytobenthos	1	1
• Benthic invertebrate fauna	1	1
• Fish	1	1
Hydromorphological elements		
• Continuity	1	
• Hydrology	Continuous	12
• Morphology	1	1
Physico-chemical elements		
• General parameters	4	4
• Priority substances	12	12
• Other pollutants	4	4

Assessment
The working group on monitoring has concluded that it is not appropriate to define prescriptive methods for comparable assessment and classification of the ecological status regarding the biological and hydro-morphological quality elements. The reasons for this are:

- A number of classification systems is already in use throughout the EU, which are potentially suitable for adaptation to meet the requirements of the WFD;
- Individual member states generally understand local natural variations in biological communities; and,
- The level of habitat detail required varies for different operational indicators depending on their sensitivity to natural variation in habitat conditions.

The selection of chemical and physico-chemical quality elements can be more prescriptive than biological and hydromorphological quality elements. Already numerous international and national standards on parameters exist for monitoring purposes. The WFD mentions the individual parameters to monitor the different quality elements.

While the individual biological quality elements will require further development and/or adaptation of specific assessment systems it is critical that the system used to determine ecological quality, based on any of the biological quality elements incorporates the following key criteria:

- Enables assessment of the deviation of observed conditions to those that would normally be found under reference conditions;
- Provides for natural and artificial physical habitat variation;
- Accounts for the observed range of natural and variability arising from anthropogenic activities of all quality elements in all water types.
- Provides for detection of the full range of potential impacts to enable a robust classification of ecological status.

Regarding the assessment system for hydromorphological quality elements the key criteria are:

- Can be used to define reference conditions for which biological elements can be classified;
- Development of specific river typologies for each country to ensure the adequate characterisation of reference conditions; and,
- Development of criteria for low river flows.

These criteria should ensure that the selection of quality elements by the member states will be comparable to a certain extend.

Comparability of data
The goal of the WFD is to reach a good status for all waters in Europe. However, as no prescriptive methods are developed for the ecological status of a water and each member state can use its own assessment system, it should be made clear that the definition of good ecological status is interpreted equal, regardless any difference in ecological quality assessment system. This will be done through intercalibration between the member states. The goal of the intercalibration exercise is to establish comparable boundaries between high and good quality, and between good and moderate quality.

Conclusions
The EU WFD is a directive that tries to harmonize over different countries using different water management systems and not to unify. In this way, the directive implements a system that is not rigid but accounts for local and regional differences. As such it takes into account the background of the existing systems that have been developed over the years and that may include characteristics for which good reasons exists.

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