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"Water is the best of all things"

PINDAR (C. 522-C. 438 B.C.), Olympian Odes

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LIST OF ABREVIATIONS

CEDEX	Center for Studies and Experimentation in Public Works of Spain
CIS	Common implementation strategy
DARES	Diatom assessment of river ecological status
ECOSTAT	Overall Approach to the Classification of Ecological Status and Ecological Potential
EEA	European Environmental Agency
EQR	Ecological quality ratio
EU	European Union
IBD	Biologic index for diatoms
IBMWP	Iberian Biomonitoring Working Party
IHF	Fluvial habit index
IPS	Specific pollution-sensibility index for diatoms
IVAM	Macroscopic aquatic vegetation Index
MDIAT	Multimetric index for diatoms
MEDPACS	Mediterranean prediction and classification system
MS/MSs	Member State/Member States
PoMs	Programme of measures
QBR	Riparian vegetation quality index
RBMP	River basin management plan
RBD	River basin district
RIVPACS	River invertebrate prediction and classification system
SIA	Spanish integrated system for water information
SNIFFER	Scotland and Northern Ireland Forum for Environmental Research
UKTAG	United Kingdom technical advisory group
WFD	Water Framework Directive
WISE	Water Information System for Europe

ABSTRACT

At the outset, the EU Water Framework Directive states that ‘‘water is not a commercial product like any other but, rather, a heritage which must be protected, defended and treated as such’’. This piece of legislation aims to “achieve the Good status for waters and aquatic systems for 2015”; an objective which is innovative in its content and ambitious with regard to the timeframe. This master thesis describes the steps of implementation leading to the preparation of a river basin management plan (RBMP) and addresses the degree of accomplishment of the implementation steps taken thus far. Only 9 of 27 Member States completed their RBMPs in time to meet the Directive deadline (which was December, 2009). The cases of Spain and the United Kingdom, characterized by a significant difference of implementation pace, have been chosen to describe and analyze the characterization of the surface water bodies; the monitoring of the ecological status; the definition of quality objectives; and the establishing of programmes of measures (PoMs) to realize the defined objectives. The implementation requires adjustment of the administrative structure in each of the member countries. However, the administrative procedure to implement the RBMP is left to the discretion of Member States and it is different in the two assessed states. Using the literature available in this field and the database of the national water agencies in both countries, a thorough examination of the main difficulties of implementation, methodology for the river basin modeling, and initiatives at the national and regional level is carried out. This Master’s thesis highlights the weaknesses experienced by these two Member States on the complex process of implementation and points out the existing risk of not meeting Good status in 2015. However, important steps have been made ‘towards Sustainable Water Management in the European Union'. The implementation is bringing new impetus to water management and significant progress (e.g. restructuring of administrations, compilation of information and assessments, public awareness) is observed in both Member States. Nevertheless there is still a long and challenging road ahead.

I. INTRODUCTION

1. Background and motivation

Water has been perceived for centuries as a mere ‘exploitable good’. The water policy objectives were exclusively targeted to increasing water supply in order to foster economic growth. Spain and the United Kingdom have in common a long history of large scale public intervention for the regulation of their watercourses for its storage and distribution. As bibliographic sources from both countries state (Del Valle, J., 2005; Francese La-Roca, 2008; POSTnote 259, 2006) the 20th century was characterized by enormous and uncontrolled private water abstractions and scarce attention to the prevention of diffuse and point sources of pollution. “The industrial revolution not only resulted in two hundred years of gross pollution pouring into water courses in Great Britain, but also resulted in massive modifications to rivers and estuaries, through canalization, port building, river straightening for flood defense and so on” (Keith Hendry, K., 2008). In addition the concept of public participation (still currently difficult to develop) didn’t exist and the water policy was closed and opaque to society.

In 1995 the European institutions agreed that a fundamental review and restructuring process was needed for Community water policies and in 2000 the Water Framework Directive (WFD) entered into force. Integrated management of water resources focusing on an equilibrium between human needs and the protection of ecological values of water systems is a new idea that has imposed itself on the international scientific and political communities (Santiago M. Álvarez, 2003). This sums up the radical change in mentality that the WFD brings to Europe, which also represents a real challenge for water management. The features bought up by the analysis of the directive are the following: it refers to the state of ecosystems, not just to the chemical quality as it was common in the past; it represents a common and obligatory objective for all the Member States; it intends to ‘fight’ the outdated water policies oriented exclusively towards the increase of water supply for economic growth; and finally it intends to fight the worrying deterioration state of the European waters (Abel la Calle, 2009). The Directive establishes a framework for water protection. It is based upon ecological and chemical elements and its aim is, for the first time in the history of water policy, to achieve good water status for 2015 of groundwater, inland surface waters, estuarine waters, and coastal waters for all the member states. Its purpose is to establish a framework in order to achieve the following four main objectives of a sustainable water policy: (1) sufficient provision of drinking water; (2) sufficient provision of water for other economic requirements; (3) protection of the aquatic environment (4) alleviation of the adverse impact of floods and droughts. For this purpose, surface waters within the River Basin District (RBD) are required to be divided into water bodies, representing the classification and management unit of the Directive. This master thesis will focus on surface waters.

2. State of the art

The Environmental European Agency states in its different reports[1] that communitarian waters are subjected to an increasing pressure as a result of the continuous growth of the demand for high quality water in sufficient amount to satisfy all human uses. Within four years of the WFD's entry into force (2005), member states were to complete an analysis of the characteristics of each RBD, a review of the impacts of human activities on their water resources, an economic analysis of water use and a registry of areas requiring special protection. Within nine years (the past December 2009) they had to produce a river basin management plan (RBMP) and programme of measures (PoMs) for each RBD. The Directive envisages a cyclical process where RBMPs are prepared, implemented and reviewed every six years.

Successful implementation of the Directive in Europe has advanced at a very uneven pace (FNCA[2], 2009). The UK stands out for its ability to meet the deadlines for implementation thus far. Spain, however, experiences a notable delay according to the established calendar. In a 2007 report the European Commission noted that several EU member states might fail to meet the 2015 target, particularly because of

[1] The Environmental European agency reports about the state of the europen waters can be consulted in the website: http://themes.eea.eu.int/Specific_media/water/reports.

[2] Fundación Nueva Cultura de Agua, III symposium on the implementation of the WFD in Spain, October 2009

the physical deterioration of aquatic ecosystems as a result of overexploitation of water resources, and the high levels of pollution from point and diffuse sources. The report also cited problems in meeting the deadlines for incorporating the directive into national law.

Classification systems are needed to assess the state of the environment at any point in time comparing its status with reference conditions (systems with the same characteristics but with no human alteration). Such schemes demonstrate where the environment is of good quality and where it may require improvement. However, no exact methodology is presented by the WFD, and MS have to develop their own approaches on how to classify water bodies along the quality elements provided by the Directive.

In addition to the determination of the water quality status, pressures and impacts analyses have a central role in the river basin management planning process. Their principal aims are to consider how pressures would likely develop prior to 2015 and to identify where and to what extent human activities may be placing the achievement of the Directive's environmental objectives at risk.

Within the EU, both community law and national law shape the implementation of the WFD in individual member states. Within this common framework, national law and practices allow a certain degree of variability between member states. The measures or concrete instruments that any state should apply, according to the principle of constitutional autonomy, are not predetermined and states can therefore undertake different actions, depending on their legislative and administrative framework in force (prior to Directive entering into force) (Fanlo, A. 2008).

3. Thesis structure and central research questions

It is the objective of this thesis to evaluate national differences in what the author has considered to be the key implementation requirements of the directive. This constitutes the main body of the work, presented in the following sections: water status characterization (section 3), including the determination of the river basin districts (3.1.) and the different river typologies (3.2); the establishment of the reference conditions (section 4); the evaluation of the ecological status of the rivers (section 5); the identification of pressures and risk of not meeting the WFD objectives (section 6) and the setting up of a programme of measures (section 7). Information about these five main steps are presented and analyzed for two European member states, Spain and the United Kingdom. These descriptions and analyses are preceded by a summary and conclusions (section 8) and finally, the bibliographic sources consulted (section 9).

In this thesis, the different technical methodologies used to assess the water quality status are contrasted, as well as the results of such assessments and the actions taken to overcome the weaknesses found by each country. Furthermore, the different pressures likely to place water bodies at risk of failing to achieve ecological and chemical good status (point and diffuse sources of pollution, physical or morphological alteration of water bodies, etc) are identified. This evaluation leads to the identification of significant differences in these nations’s WFD implementation and exposes certain practices that some member states would be wise to learn from others.

The focus of the directive is to achieve a central harmonization through community law. In order to address the challenges in a co-operative and coordinated way, Member States, Norway and the Commission agreed on a Common Implementation Strategy (CIS) for the WFD. Nevertheless, by uncovering the main weaknesses of the process certain issues are identified for which, due to a broad disparity of hydrological characteristics among the countries, synchronization on the protocol of implementation might be especially difficult to attain.

II. RESEARCH METHODOLOGY

The aim of this thesis, identified in the previous section, was achieved by identifying and comparing a set of criteria that are included in the "technical" aspects of WFD gathered in the Common Implementation Strategy (CIS), together with the technical aspect specified by the two targeted nations. No primary data was generated or analyzed in the sense of empirical work. However, this master thesis is based on an extensive review of the characterization of the water quality and risk assessment reports, the river basin management plans, legislative texts, policy reports, scientific papers published by national universities addressed to improve certain methodologies and other associated literature.

The main literature for this thesis was provided by the different national institutions in charge of WFD implementation and water policy making in general. For Spain it is the Spanish Ministry of Environment, Rural and Marine Affairs, and for the United Kingdom they are: Scotland and Northern Ireland Forum for Environmental Research (SNIFFER); the Environment and Heritage Service (EHS), Northern Ireland; the Scottish Environment Protection Agency (SEPA); and the Environment Agency of England and Wales. To gather this information the author contacted directly, by email or telephone, the people responsible for water management issues in each region. Furthermore, an analysis of the websites of the competent authorities was essential to this piece.

III. CHARACTERIZATION OF THE RBDs, WATER BODIES AND TYPOLOGIES

The WFD requires that surface waters within each river basin district (RBD) be differentiated into water categories: rivers, lakes, transitional waters and coastal waters. They represent the classification and management unit of the Directive, which suggests the following hierarchical approach to identify surface water bodies:

(i) The definition of the RBD.
(ii) The division of surface waters into one of six surface water categories (i.e. rivers, lakes, transitional waters, coastal waters, artificial and heavily modified water bodies).
(iii) The sub-division of surface water categories into types, then assigning the surface waters to one type.
(iv) The sub-division of a water body of one type into smaller water bodies according to pressures and resulting impacts.

Due to different national conditions concerning the natural status of and the anthropogenic pressures on water bodies, the MS are allowed to perform the characterizations differently (The CIS Guidance, 2003).
It makes sense that the number of water bodies not maintaining Good ecological status will be dependent upon how the characterization is performed. The methodology includes many subjective and political considerations. Hence it can be foreseen that the EU MS will handle the characterization step differently, which will have tangible implications for the national management and action plans and thereby on most sectors affecting water quality, for examples: agriculture, forestry and aquaculture.
Because the sorts of animals and plants found in upland, rocky, fast-flowing streams are very different to those found in lowland, slow flowing-meandering rivers, surface water bodies are grouped into different types according to their physical and chemical characteristics. The types dictate, in very general terms, the sorts of plants and animals likely to be present in water bodies of that type (Western Wales RBMP,

2009). The method by which waters of similar ecological sensitivity are grouped into types for the Directive, is referred to as a typology. The term ‘type’ has particular meaning and use in the Directive, which sees the ecology as determined by type and seeks to characterize water bodies according to type (UK Technical advisory group, 2006). The types in which the water bodies are subdivided are based on natural factors (such as altitude, longitude, geology and size) that might influence ecological communities. This division forms the basis of water bodies, which are the basic management units for reporting and assessing compliance with the Directive’s environmental objectives and are essential to precisely determine the ecological status by using geomorphological parameters (DOCE, 2000). With this typology the different ecotypes will be obtained within the ecoregions determined by the WFD. Those ecotypes should be homogeneous in that which concerns environmental and biological characteristics. The Directive, in Annex II, proposes two methods to classify typologies, based in physical and geomorphological parameters. The System A is based on 3 attributes: altitude, basin size and geology. The system B allows for more attributes, some of them related to more peculiar characteristics of the river and the basin. Once this classification is performed the reference conditions will be established and also the biological communities corresponding to each type.

1. Characterization in the UK

1.1. River basin districts in the UK

The UK has identified 15 river basin districts. There are eleven in England and Wales, one in Scotland and three in Northern Ireland (including three international RBDs). There has been a recent devolution of administration within the UK, during which the Scottish Parliament, The Welsh assembly and the Northern Ireland Assembly have taken over some of the governmental power from the national government in their regions. In the EU, UK is acting as a single entity, but domestically the four regions are to some extent independent and Scotland, Northern Ireland and Wales have their own administrative bodies responsible for the implementation of the EU WFD.

A brief outline of the administrative structure is given in Figure 1. It shows the different regional agencies responsible for the characterization of water bodies in the four parts of the country.

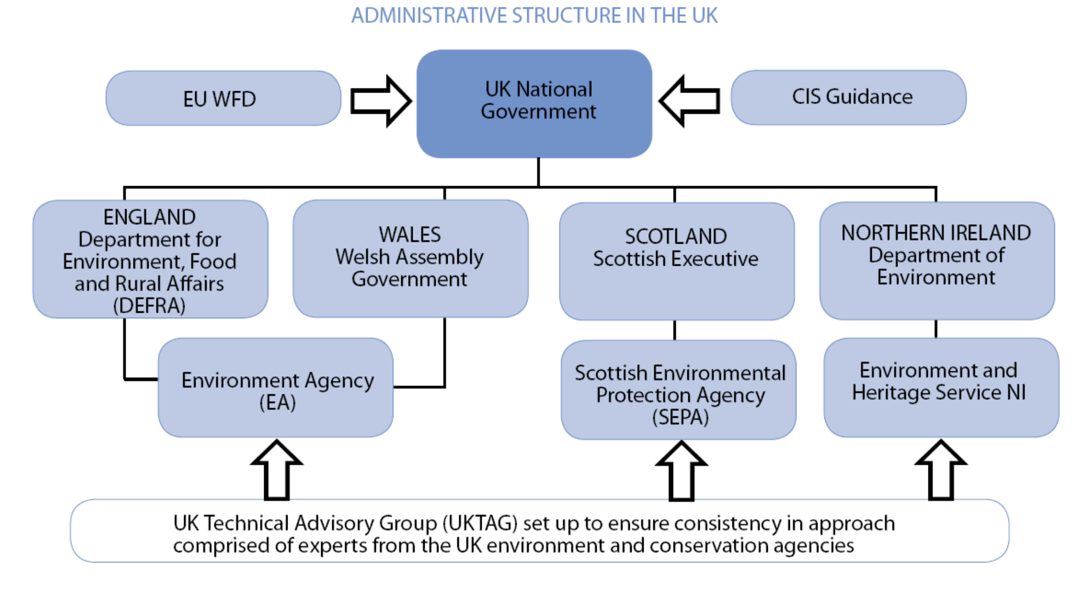


Figure 1. Outline of the administrative structure in the UK. The different regional agencies responsible for the characterization of water bodies in the four parts of the country. Source: UKTAG, 2005

The river basin districts in the UK are drawn in Figure 2., and are the following: Thames, South East, South West, Anglian, Severn, Dee, Western Wales, North West, Humber, Northumbria, Solway Tweed, Scotland, North Eastern Neagh Bann and North Western. The Solway Tweed is shared with Scotland and the Dee and Severn are shared with Wales. This structure has been the basis for water management for the last 20 years, so the WFD has not entailed any changes in this respect.

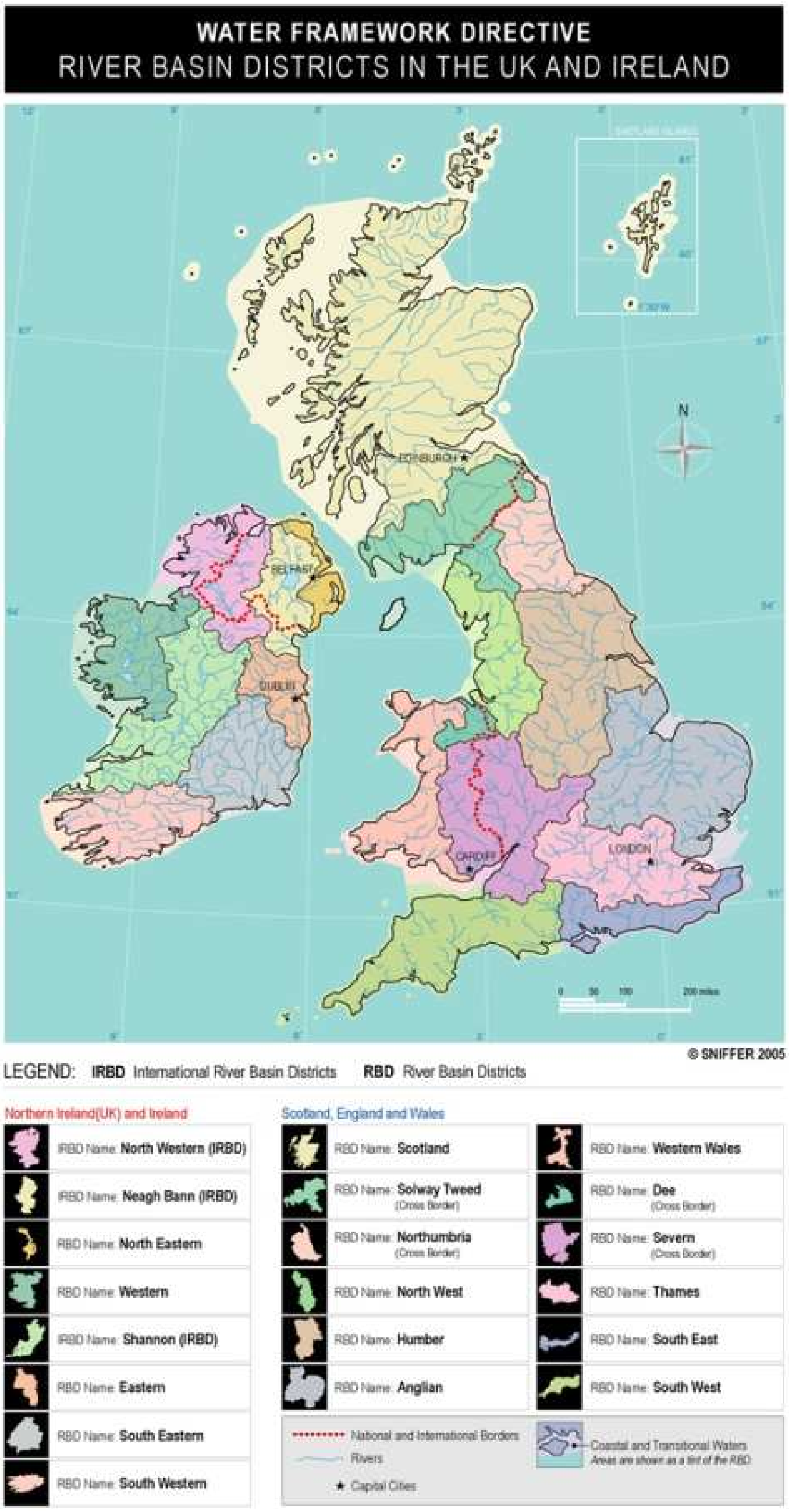


Figure 2. River basins districts in UK. Source: SNIFFER 2005

1.2. Determination of river typologies in the UK:

According to the River Basin Characterization Project performed by the Environment Agency, the UK adopted system A of the WFD in deriving the basic typology for natural rivers. The resultant typing categories are listed below:

Table 1. Basic typologies for natural rivers in the UK. Source: Environment Agency, 2005.

Altitude (mean catchment)	Catchment size (km^2)	Dominant geology
<200m	<10	Siliceous
200 - 800m	10 - 100	Calcareous
>800m	100 - 1000	Organic
	1000- 10,000	Salt

In England and Wales this typology theoretically generates 48 river types, although in practice many of these do not exist or are not significantly populated. The application of this typing system to the river network has provided a typology map that has identified 21 types. The dominant type of river is type 2 - low altitude (<200m), small size (10-100 km^2), calcareous rivers (34% or river water bodies). The additional two types with catchment size <10 km^2 and the dominant geology of salt are not listed in the Water Framework Directive. This typology does not deal with artificial linear watercourses (canals). It also does not include small coastal catchments which are smaller than 10 km^2 and have a river stretch less than 1km in them.

The criteria followed for Northern Ireland river network has been the same, producing a typology map with 12 river types, and the dominant river type is the same as in England and Wales. For the whole UK, typologies will be further developed, when the data become available, into a system B typology using hardness as a surrogate for geology (if available), mean slope and river discharge. This system B will be compared with the system A typology to ensure both its ecological relevance and its usefulness as a water quality management tool (Art 5 Characterization Summary Report, 2005).

2. Characterization in Spain

2.1. River basin districts in Spain

Spain has 24 river basin districts (Figure 3), out of which six are international sharing water courses with France to the northeast and Portugal to the east. There is an old tradition of water management through river basins by the interregional River Basin Authorities (Confederaciones Hidrográficas). Such policy organisms control the following river basins: (Cantábrico, Miño-Sil, Duero, Ebro, Tajo, Júcar, Guadiana, Guadalquivir y Segura). The intraregional river basins are competence of the regional authorities: Cuencas Atlántica y Mediterránea Andaluzas, Internas Catalanas, Baleares, Canarias, Galicia-Costa and Internas del País Vasco. Nevertheless the final version of the Spanish "water map" is still not completed (the exact definitions of borders and geographic scope for the river basins and the RBD) (FNCA, 2009[3]). Since the transposition of the WFD into the Spanish law on December 2003, there is in each interregional basin a cooperation organism called Committee of Competent Authorities (CCA), whose function is to guarantee the proper cooperation on the application of norms entailing water protection. In those policy organisms the three policy levels are represented: national, regional and local administrations.

Within the river basin units there are subunits of managements called 'water resource systems'. They are defined in the river basin management plans, but they already existed before the enter into force of the Directive, and have not been replaced or eliminated. Such water resource systems are groups of rivers or fragments of them and hydrogeological units especially interrelated. There are currently 138 water resources systems, each of them formed by an assemblage of surface and ground water masses, hydraulic civil infrastructure, norms of water utilization according to the characteristics of the demand, and rules of extractions that allows respecting the environmental objectives. Nevertheless, these management units are often criticized by some water legislation experts such as Abel la Calle, (2010) who is of theopinion

3 Fundación Nueva Cultura de Agua, report on the Monitoring of the Implementation of Public Participation in Spain in the framework of the WFD.

that the water administration should be focused on the management units stated by the Directive.

Fig 3. River Basin Districts in Spain. Source: SIA, 2010.

The first step for characterization of the river basins in Spain was to define a 'network of hydrographic relevance'. This was performed by CEDEX[4] in collaboration with the competent authorities for each River Basin District. As a result, the minimum size chosen to define the starting point for this network of hydrographic relevance was 10 km^2, the smallest size defined by the Directive. Rivers have been derived from a 100 m x 100 m Digital Elevation Model (DEM) provided by the Spanish Army Geographic Service, using algorithms developed specifically for this action by CEDEX. The results showed that a high number of courses that are usually found dried, appeared forming part of the river network. Figure 4 shows an example in the driest southern areas of the Júcar RBD territory. Jucar River has a drainage area above 250 km^2 where no flow usually circulates.

4 Center for Studies and Experimentation in Public Works of Spain

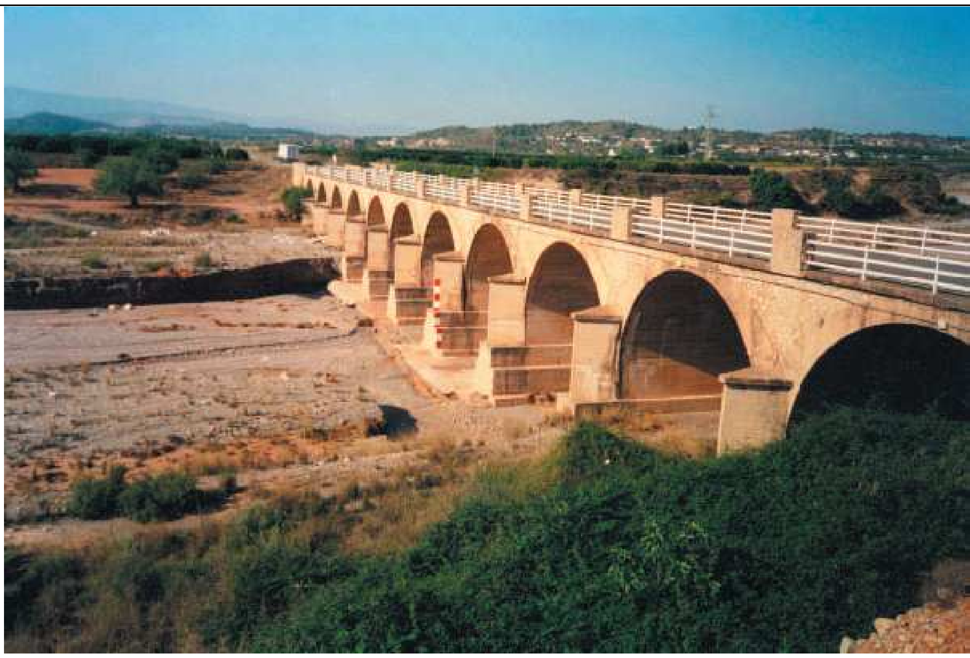


Figure 4. Ephemeral water course Rambla de la Castellana. Source: Jucar RBD, 2010

Due to the peculiar hydrological regime in Spanish rivers, it was considered necessary to introduce in addition a hydrological criteria, given the fact that many of its regions with river flow over 10 km^2 carry water just sporadically along the year and it does not seem reasonable to consider them water bodies. The final criteria combine surface, mean annual flow, variation, coefficient and percentage of months with no flow. The results are then tested with the different monitoring networks in the District (quantitative, qualitative and biological), which, in some extent, reflects the management interest of the RBD. As a result a river body has been considered existing just when the basin surface is over 10 km^2 and the mean annual flow is over 100 L/s (3.15 hm^3/year). Remote sensing techniques have been used for the purpose of selecting river fragments meeting these criteria. In addition a high time-consuming fieldwork was developed in order to elaborate a map that classifies, according to the irregularity of flows, the water courses into two main categories: continuous flow and ephemeral flow. Wide criteria have been followed for doing this classification, since many rivers defined as continuous do not flow most time of the year, for natural reasons or due to human activities. Figure 5 illustrates the result of this characterization in the Jucar RBD.

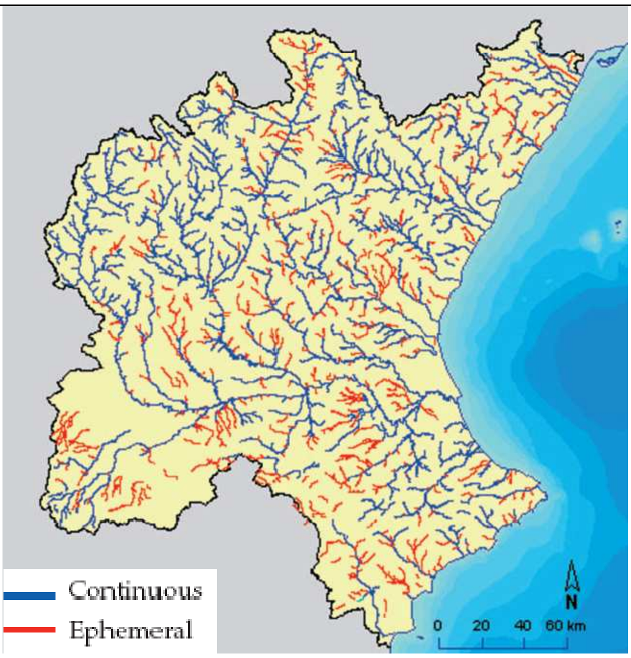


Figure 5. Categories of rivers according to the irregularity of flows. Jucar RBD, the Spanish Pilot RBD for the WFD. Source: Jucar RBD, 2010.

2.2. Determination of river typologies in Spain

Once the 'network of hydrological relevance' was determined, 4,630 surface water bodies were defined, from which 3,344 were identified as river water bodies. The step following was to point at the river typologies. Spain did not consider the Directive system A for determining river typology. The reason, according to Núria Bonada at al., (2002) is that the system A was based exclusively in the geographic position, the basin surface and the geological nature of the basin, and lacked supportive ecological basis. Other reasons were that not having included climatic variables or flows variations made rivers of different bio-geographical environments to be included in the same class. In addition, the three levels proposed by the Directive for geology (calcareous, siliceous and organic) provided an excessive simplification of the geologic characterization. For example, for the whole territory of the Júcar RBD only one class was found (calcareous), while materials are highly diverse in the RBD. The system B (Table 2) was chosen instead. It embraces the obligatory factors and some optional ones: physiographic factors, chemical factors, climatic factors. The criteria used combines values of basin surface and surface runoff. More precisely, the variables selected for defining typology have been: altitude, annual thermal amplitude, river basin surface, average annual flow, specific average annual flow, conductivity, latitude, longitude, Strahler stream order, average river basin slope, slope orientation, degree of mineralization of the basin, percentage of months with zero flow and average annual temperature.

Table 2. System B for river typology characterization. Source: WFD, 2000.

SURFACE WATER BODY TYPES FOR RIVERS	
Alternative characterisation	Physical and chemical factors that determine the characteristics of the river or part of the river and hence the biological population structure and composition
Obligatory factors	altitude latitude longitude geology size
Optional factors	distance from river source energy of flow (function of flow and slope) mean water width mean water depth mean water slope form and shape of main river bed river discharge (flow) category valley shape transport of solids acid neutralising capacity mean substratum composition chloride air temperature range mean air temperature precipitation

The ecotypological analysis was performed using several variables measured in studies, and other variables obtained from maps or data bases (e.g., geology). The methodology for classification consisted on the progressive segregation of river basin subgroups by establishing boundaries for the selected variables (Síntesis de Estudios Generales, 2005). The method included the analysis of the calibration between variables, the clustering of stations and a discriminative analysis. The latter revealed which factors were distinctive of each group. According to the setting of thresholds of those variables, 41 river types have been distinguished in the peninsula and Balearic Islands. As an example, figure 6 shows the nine river typologies established for the Ebro RBD.

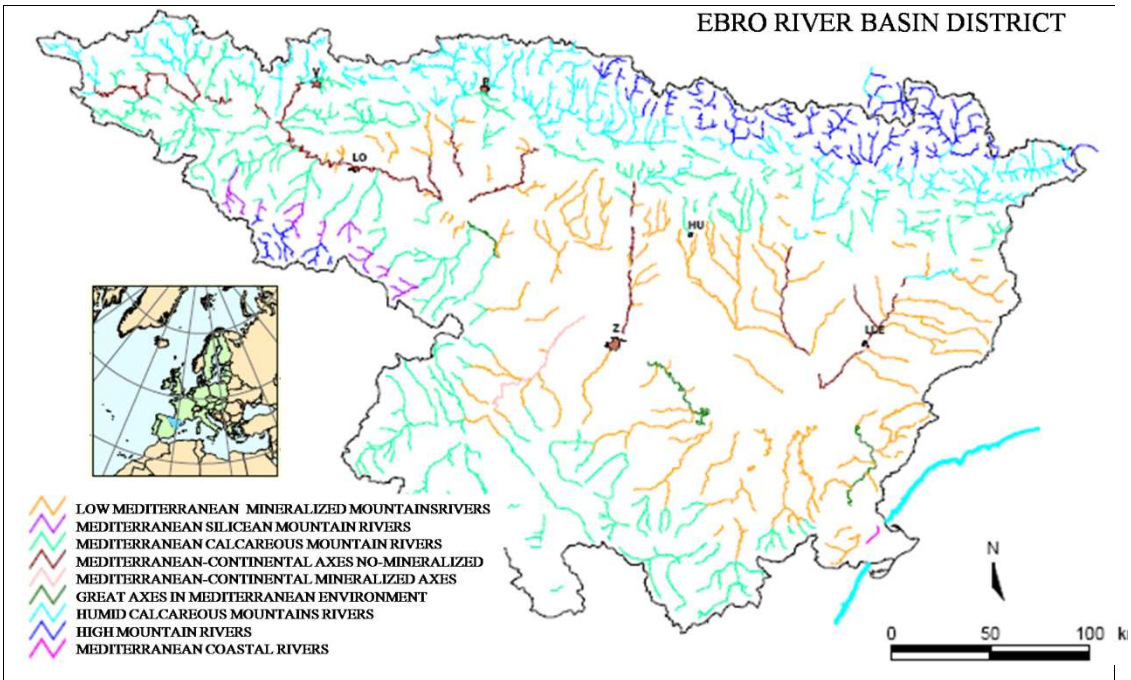


Figure 6. Source: River typologies in the Ebro RBD. Source: Modified from *MIMAM*, 2004.

The classification process performed by the Ebro RBD was based on the determination of subgroups according to the boundaries established for the different variables. The first segregation was conducted by assigning each river one of the big biogeographical regions existing in the peninsula: Eurosiberian or Mediterranean region. As segregation criteria the river flow was used to divide the rivers into two subcategories: Cantabro-pirinee rivers and Mediterranean rivers. Within the Mediterranean region new divisions were established: the first one separates the principal axes with an average flow superior to 9,5 m^3/s from the rest of the rivers.

For the rest of the rivers another subdivision is conducted between mountain rivers if the average slope of the basin is superior to 2%, and plains rivers if the slope is inferior. The other main variables used were altitude, orientation, water calculated mineralization, annual mean temperature and river order. The same characterization was preformed for the Cantabric-pirinee region.

IV. ESTABLISHMENT OF THE REFERENCE CONDITIONS

The WFD requires member states to assess the ecological quality status of water bodies, which is based upon the status of the biological, hydromorphological and physicochemical quality elements. It is extremely difficult to establish the environmental quality of an ecosystem in absence of a reference value or knowledge of the state of the system (Maksimov, 1991). The reference conditions, for a water body type is a description of the biological quality elements that exist, or would exist, at a High biological status, with no, or only very minor disturbance from human activities. The identification of appropriate High status sites is vital in setting the benchmark on which classifications can be based and against which appropriate standards and conditions can be set (UKTAG[5], 2006). For example, if a classification tool shows that the diatom community in a water body is at High status, then the species composition and abundance of diatoms in that type of water body are what would be expected under reference or undisturbed conditions. Reference conditions are type-specific so as to take into account the broad diversity of ecological regions in Europe (Angel Borja at al. 2004). This means that a reference conditions network must be established for each water body type with a sufficient number of sampling stations.

The WFD identifies four options for deriving reference conditions: (1) An existing undisturbed site or a site with only very minor disturbance; (2) historical data and information; (3) models; (4) expert judgment.

Because reference conditions must incorporate natural variability, in most instances they will be expressed as ranges. Reference conditions should be derived with a view to distinguishing between very minor[6], slight[7,] and moderate[8] disturbance. The description of the biological reference conditions must permit the comparison of monitoring results with the reference conditions, in order to derive an Ecological

5 UK Technical Advisory Group on the Water Framework Directive, a national advisory group of scientists.
6 'Very minor' disturbance could be defined as just detectable in the sense that the disturbance is more likely to be anthropogenic, than not.
7 'Slight' disturbance could be defined as anthropogenic, at a prescribed level of confidence.
8 'Type specific' reference conditions are to be established for the biological quality elements for that type of surface water at a high status.

Quality Ratio (EQR), which will be explained in the next chapter of this thesis. The reference conditions become the basis for the classification schemes, with consequences for all subsequent operational aspects of the implementation of the WFD (including monitoring, assessment and reporting).

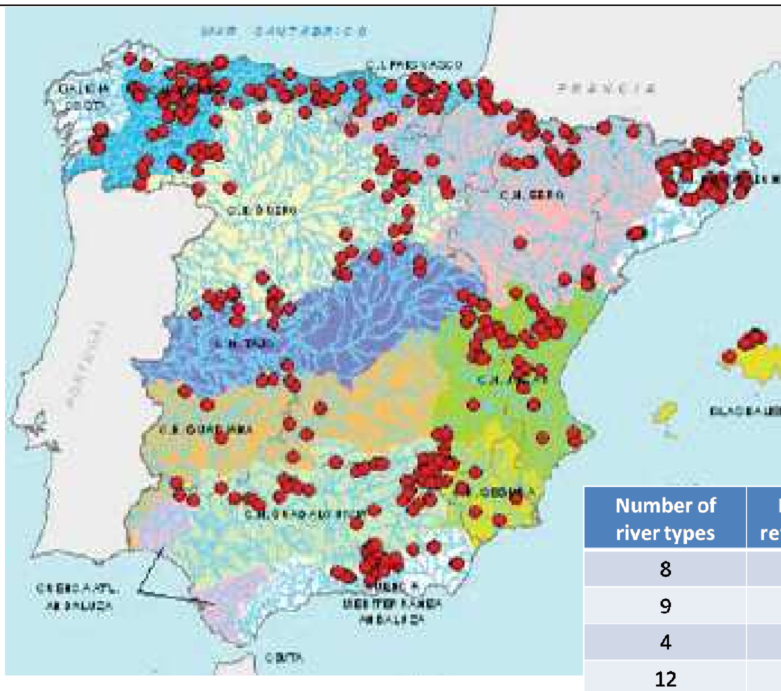
1. Reference conditions in Spain

In the first place, a river portion free of human alteration must be selected. This has been and still represents a problem in Spain, due to the little information available about the river ecosystems and the difficulties to find unaltered river bodies. Due to this knowledge fragmentation, very often the reference conditions have been established according to expert's opinions from the different river basins. Nevertheless there is an established protocol very well implemented for the northern river basins and in process of implementation in the rest of the country. The intervals for the indicators of reference conditions are stated in the Spanish Order ARM/2656/2008, from 10th September, from which the Instruction of Hydrological Planning is approved.

This network of unaltered fragments must have enough spots in good status in order to build a sufficient level of trust. The Ministry of Environment recommends together with the CEDEX the use of indirect indicators of the pressures which originate the most relevant impacts. In those selected river fragments they must observe the value of the biological, physicochemical and hydromorphological indicators in order to define the "High status" of each water body type. To give some examples, indicators of the natural conditions of the river basin based on the soil uses was taken into account to establish reference conditions. In addition indicators of the incidence of water flow regulation, based on the capacity of dams were selected, as well as indicator of the morphological alterations. The criteria selected for the country was elaborated by the GUALDALMED Project (2002) and the following conditions must be met: water use for agricultural, urban or industrial uses must be <10%; the riparian vegetation must be natural and with no significant alterations; the river bed must be natural and lack any kind of regulation; adequate river bed habitat (big stones in high parts, grave in the medium and sand and lime in the lower parts);

ammonia concentrations below 0,5 mg/L; $N\text{-}NO_2$ concentration below 0,01 ml/L; $P\text{-}PO_4$ concentration below 0,05 mg/L.

A total of 500 reference sites have been established in Spain (Figure 1) but just 24 river types out of the existent 33 have reference sites. Within those 25 types, just 16 have enough number of referent sites to perform an adequate quality assessment.



Number of river types	Number of reference sites
8	0
9	<5
4	5-10
12	>10

Figure 1. Gauging stations set to define the reference conditions. Source: Modified from Javier Ruza, 2005

In the Table 1 an example of the intervals of reference conditions for different indicators is shown for the river type ‘Mediterranean Mountain rivers’. The figures corresponding to different ecological indicators are used to be compared to the current values and determine the ecological status of the rivers.

According to Ortiz, J.L. (2006), some important considerations have been taken into account when selecting said indicators, such as pristine conditions of the basin[9] and abstractions and discharges from urban, industrial and agricultural activities. In this term, the water demand has been considered to reflect the approximate effect of pollution and water abstraction.

[9] Surfaces are divided into two categories: natural and modified soil. The pristine soil has 85% of natural surface. The slightly altered has 70-85% of natural surface.

Table 1. Reference conditions for Mediterranean Mountain Rivers. Source: ANNEX III Spanish Hydrological Planning Instrument.

MEDITERRANEAN MOUNTAIN RIVERS		
ELEMENTS	**INDICATOR**	**REFERENCE CONDITION**
Phytobenthonic Organisms	IPS[10]	17
Benthic Invertebrates	IBMWP[11]	150
Morphological conditions	IHF[12]	74
	QBR[13]	85
Oxygen conditions	Oxygen (mg/L)	9.7
Salinity	Conductivity (µS/cm)	510
Acidification State	pH	8.2

The selection process for the reference zones is completed with an analysis of the areas suffering hydromorphological alterations. For such analysis, data about channeled segments and the delimitation of existing dams have been considered. Also river fragments flowing through urban or irrigation areas are been identified.

For every indicator, thresholds are established from which we can consider that the pressures are not significant and then the reference conditions are established. When for certain water body typology unaltered portion is very hard to find, other methods are used such as models and consultation with experts.

Once the first selection of waters not affected by significant pressures and slightly altered has been performed, the next step is to verify those water bodies and confirm that they are with no doubt in high status. Those segments will then form part of the reference net established by the Annex II of the Directive.

According to the WFD the water bodies slightly altered must be determined using the results from the analysis of pressures and impacts, which will be useful to preliminary set the reference conditions when no pristine system are yet found.

This is one of the problems in deriving reference conditions, since the evaluation of pressures is incomplete for many of the RBDs. Another trouble, as already mentioned, arises from the absence of unimpacted areas. One example is the case of

[10] IPS (Specific Pollution-sensitivity Index)
[11] IBMWP (Iberian Biomonitoring Working Party).
[12] IHF (Fluvial Habit Index)
[13] QBR (Riparian Vegetation Quality Index)

the Basque Country, where many river systems have been historically impacted upon by human activities (Cearreta et al., 2004). Moreover, some regions have no pre-industrial historical data, in which, according to Borja et al (2003c) the use of ‘virtual’ reference locations[14] should be considered. The reference values from these locations are often based upon the Spanish LQM (Littoral Water Quality Monitoring and Control Network database) and legal quality values (Borja et al., 2003c). The process of the establishment of reference conditions for every water body in Spain is still taking place. There are several river basin districts that haven’t completed such task yet. It is the case in many Spanish rivers, that the establishment of trustful reference conditions might not be achievable because it is not possible to find an indicator useful and consistent for the whole river length and time of the year. In that case, where the indicator presents a high natural variability (not just seasonal variability) the Directive (annex II.1.3) allows withdrawing it from the assessment.

2. Reference conditions in the UK

The analysis aiming at defining reference conditions is done by water body type. The way reference values have been determined for each of the biological elements is given in the UKTAG Assessment Methodologies. The reference conditions for the river types in UK describe the morphology of the river, its hydrology, macrophyte assemblages, macroinvertebrates, fish, and physicochemical conditions that would be expected to occur in natural or nearly natural conditions. Reference condition descriptions have been established using available monitoring data and expert opinion, but not concrete values of the indicators are available to the public.

There is a large monitoring network consisting of primary, secondary and minor sampling sites. Sites showing only minor disturbance were used to help define reference conditions for the types they populated. There are relatively few sites across the UK at which all quality elements are in reference conditions and from which data suitable for establishing reference values are available. Consequently, reference values have been derived from sites at which the quality element concerned

14 Virtual locations do not exist in reality, but are based upon experience gained of the area and conceived as the ‘potential’ components (biological parameters, chemical concentrations, etc.) that should be present.

is estimated to be in its reference condition but other elements at the sites may not be so (UKTAG, 2007). For the river types that had very few monitoring sites showing minor disturbance the reference conditions were derived using a combination of expert judgment and use of available data. Techniques employed for that purpose include:

- Analogy with sites presently at reference condition (very few, none for most freshwater type classes).
- Interrogation of natural history records, mostly from nineteenth century.
- Interrogation of angling club and fishery records.
- Palaeoenvironmental reconstruction, such as palaeolimnology[15], diatom-inferred phosphorus- and pH-status, palynology[16] and other emerging techniques for macrophyte fossil.
- Reconstruction of past ecology by examination of response curves between physicochemical pressures and biological water quality elements.
- Modeling approaches to reconstruct past nutrient status, based on examination of the annual agricultural census, decadal population census, export rates by crop or livestock type and fertilizer application rates and management among others.

UKTAG has been set up to advise the regional authorities in order to ensure consistency between the regions. The group is now publishing type specific reference conditions for water bodies of the different classes. In some cases the definitions are very vague, because there is very little data on the reference state of some water types (Penny Johnes, 2005). The main problem is the previous deterioration and impoverishment of UK rivers, situation which might bring the danger that significantly degraded environments would be taken for high status waters, leading to inappropriate establishment of low standards. An example is the concentration standard for ammonia, BOD and phosphorous in UK rivers. According to the UKTAG (2006) it is very likely that those had contributed to the adoption of lower standards for some river types. That is the reason why many of them have been just regarded as ‘provisional’ reference conditions.

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15 Concerned with reconstructing the old environment of inland waters and changes associated to some events such a climate change

16 Science studying the fossil palynomorphs (pollen, spores, etc.) and other particulate organic matter found in sediments.

V. WATER QUALITY STATUS

The status of river bodies is obtained by the combination of both the ecological and the chemical status. In the figure 1, a summary of the components of the overall river water status according to the WFD is presented.

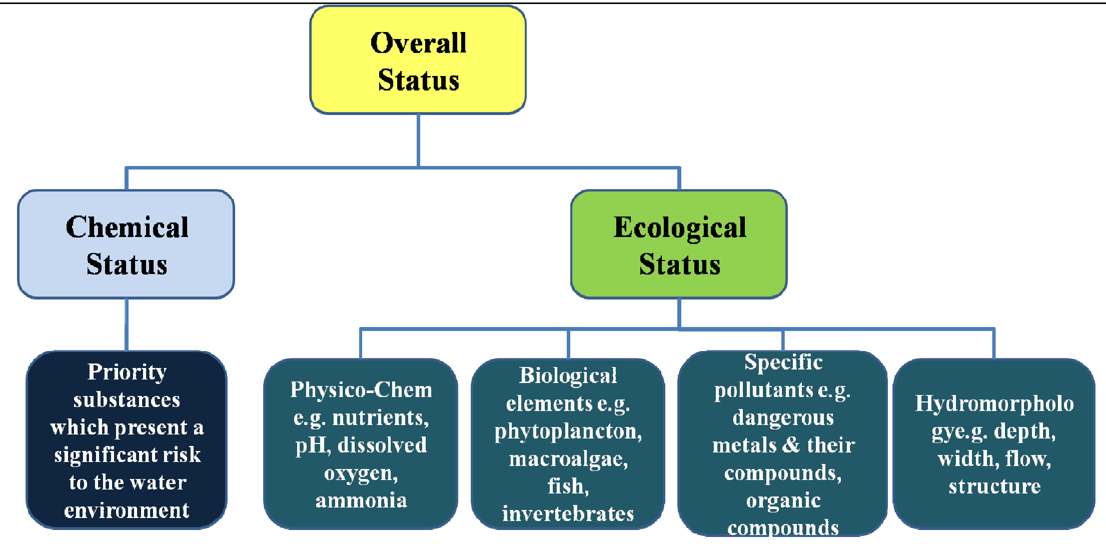

Figure 1. The components of overall status. Source: adapted from:UK Environment Agency, 2010.

Classification systems are needed to assess the state of the environment at any point in time. Such schemes demonstrate where the environment is of good quality and where it may require improvement. However, no exact methodology is stated by the Directive, and Member States have to develop their own approaches on how to classify water bodies along the quality elements provided by the Directive (UK-TAG-WFD21, 2009).

The WFD introduces a classification system that is based on a far wider range of assessments than before, which uses a principle of 'one out, all out'. Indicators are combined in order to get a unique value and the poorest individual result sets the overall classification. This new monitoring and classification system provides a more sophisticated assessment of the whole water environment to help us all understand it better, and take action where it is most needed (Environment Agency England and Wales, 2008). Nevertheless, according to the Environment Agency the "one out all out" principle of the classification system can sometimes mask the picture of the underlying biological health of the water environment. The ecological status as a means to assess the water quality is the most innovative approach of the WFD. As mentioned in the introductory section, the chemical composition of water, also essential to determine water quality, is the conventional methodology used since the origin of the water management history. Chemical status[17], recorded as Good or Fail, is assessed by compliance with environmental standards for chemicals. In this thesis just the ecological status will be addressed.

1. Determination of the Ecological Status

There are three main components comprising the ecological status for river systems: biological, physicochemical and hydromorphological assessments. In this section emphasis will be given to the biological dimension. Each of such component is identified by one or several elements (ie. macroinvertebrates communities for the biological assessment). The combination of different specific indicators for each element will result in the assessment of the ecological status. When the water bodies are artificially created or considered to be irreversible modified by the human influence, the Directive categorizes them as “heavily modified” (Article 5) and they are asked to meet not the Good ecological status but the Good ecological potential, which takes into account the river system’s limitations. In none of the cases further deterioration is permitted. The UK is one of the four Member States with more than 50% of their water bodies provisionally identified as heavily modified or artificial (European Commission, 2007) in Europe. This implies that the effort needed to achieve the Good status is less challenging. Using the WFD classification system, results for assessed rivers in England and Wales presented in Figure 1 show that for overall ecological classification 26% of rivers are good or better, 60% are moderate, 12% are poor and 2% are bad, including ecological potential of artificial and heavily modified water bodies.

17 The quality elements relevant in assessing surface water chemical status are:

- Priority substances (Annex X to the WFD) for which EQSs are to be agreed at European Community-level; and
- List I Dangerous Substances for which EQSs are specified in the relevant European directives listed in Annex IX to the WFD.

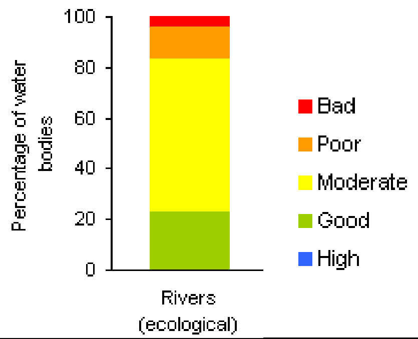

Figure 1. Results from the ecological status classification of river in England and Wales. Source: Enviromental Agency, 2010

In accordance with the requirements of the WFD the assessment of the ecological status must be done as a deviation from the reference conditions, and it should be measured by means of the 'Ecological Quality Ratio' (EQR) (WFD, 2000). The EQR is defined as the ratio between the observed and expected values (EQR = O/E) for different quality elements (in the WFD Annex V Section 1.1 is the complete list). Whereas observed values are obtained from the water body assessed, expected values should be obtained from a reference dataset that represents the best condition available (Stoddard et al 2006).

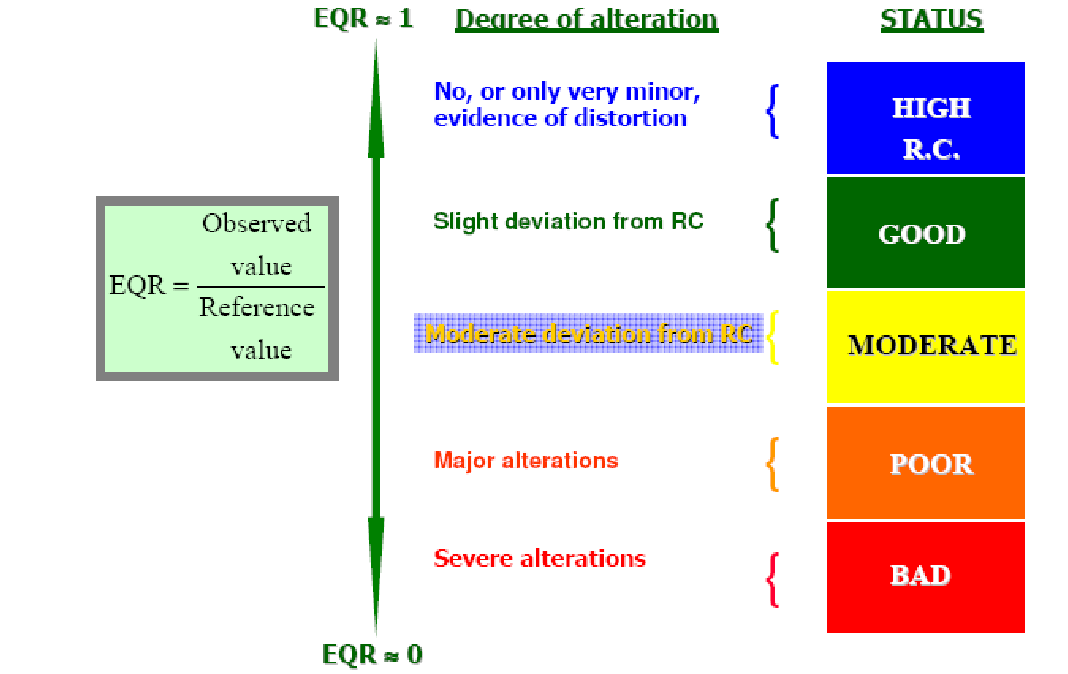

Figure 3. Ecological Status resulting from comparing to the reference conditions.
Source: Ruza, J., 2009.

In this way, as observed in Figure 3, EQR values close to one would denote a high similarity between the observed and expected values for the metric used, and therefore a high ecological status. On the other hand, EQR values close to zero will reflect some perturbation, which would result in a bad ecological status for the water body assessed. The WFD establishes that the ecological status gradient must be categorized in five levels: High, Good, Moderate, Poor and Bad.

Next, Figure 4 illustrates the relative roles of biological, hydromorphological and physicochemical quality elements in the ecological status classification for surface waters according to the normative definitions in Annex V (section 1.2) of the Directive.

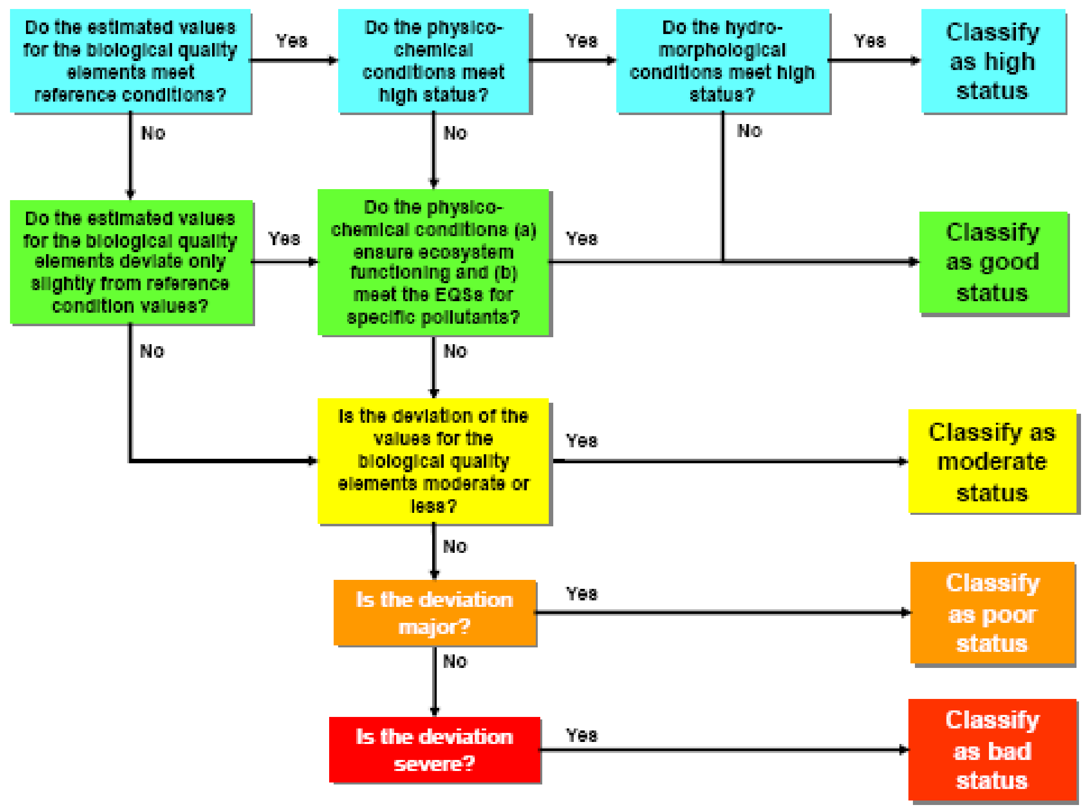

Figure 4. Decision tree illustrating the criteria determining the different ecological status classes. Source: UKTAG Classification Guidance.

Intercalibration process

There are major gaps in the monitoring and assessment systems between all MSs to support the classification of the water status. In order to fight such gaps, the good status class boundary values (i.e. ecological quality ratios) for the biological quality elements identified by each country are being compared through the Intercalibration Exercise. The essence of intercalibration is to ensure that the High-Good and the Good-Moderate boundaries in all MSs's assessment methods for biological quality elements correspond to comparable levels of ecosystem alteration (CIS Guidance on the Intercalibration Process 2004-2006). Intercalibration is not necessarily about agreeing a common EQR values for the good status class boundaries as measured by different assessment methods. Common EQR values only make sense, and are only possible, where very similar assessment methods are being used or where the results for different assessment methods are normalized using appropriate transformation factors. This is because different assessment methods (e.g. using different parameters indicative of a biological element) may show different response curves to pressures and therefore produce different EQRs when measuring the same degree of impact. The 27 MSs are obliged to harmonize the interpretation of the High status among them.

Spain and the UK both belong to the same intercalibration European area: the Central-Baltic Region, from which other 16 members participate providing their data. The UK is leading the intercalibration process, since it was the first to put into practice biological, morphological and physicochemical indicators (which are being homogeneously used through its whole territory). Such indicators have been later used by other members but have been adapted to suit each one's particularities (Wouter van de Bund, 2008). For the case of Spain, just two biological indicators (benthic macroinvertebrates and diatoms) have been produced for the Directive and introduced in this process. Nevertheless such indicators are at present used just by the northern RBDs. The rest of the country still uses indexes predating the Directive, which do not really take into account the diversity of the river basins and different typologies. According to Pardo, I., (1010), representative of Spain in the intercalibration process in the EC, this MS is much delayed and plenty of work in this regard is still needed. National legislation stating homogeneous sampling methodologies has just entered into force and studies on other indicators such as fish and macrophytes under the Directive requirements are under development.

1.1 Biological quality elements

In this section summarized the way in which the biological assessment is performed in both countries. In addition, some examples are giving about the setting up of different biological indicators.

1.1.1 Biological quality elements in Spain

In Spain, the status of the water is reported by each river basin authority, since the hydrographic and hydrological features and the status of the water bodies are related to the characteristics of the region where they are. There is currently no data about the present ecological status of the Spanish waters, since the RBMPs have not been published yet. According to the results of the Committee of WFD Implementation Monitoring, more than half of the water bodies do not currently meet the Good status. In order to calculate the water ecological status the Order ARM/2656/2008 is used, through which the Hydrological Planning Instruction is approved (HPI), where the quality indicators are established. The approach complies with the European Common Implementation Strategy (CIS) Guidance issued by Working Group A (ECOSTAT[18]): 'Overall Approach to the Classification of Ecological Status and Ecological Potential (2003)'. Each River Basin Authority has first selected the quality elements (macrophytes, fish, etc.), parameters (composition, abundance, etc.) and metrics (number of taxa, chlorophyll concentration, etc.) that allowed establishing the ecological status. Secondly they identified the guidelines regarding to the biological quality elements and parameters to facilitate the design of controlling networks (surveillance and operational networks[19]). Finally they elaborated the sampling protocols, identification protocols and calculated the metrics.

[18] European intercalibration process that will support defining the thresholds between statuses of water bodies under the WFD (high, good, moderate, poor).
[19] Monitoring and operational controls are required by the Directive (art 1.3.1 and 1.3.2) in order to assess the initial water status and complete the evaluation of impacts. They are also required as measures of temporal surveillance which will allow to establish the long term changes due to natural conditions or anthropogenic activities (surveillance control), as well as determining the status of

The Biological quality elements used are the ones covered in the WFD. Nevertheless, Spain has developed its own indicators for each element and different water typology, taking into account studies from the national and international scientific community and the norms suggested by the European Commission of Intercalibration. A very broad set of indicators are specially found for the invertebrate benthic community element and macrophytes. At the end of the section, a table is available with the biological quality elements covered by the Directive (Annex V.1.1) and the most common indicators used in Spain and the UK.

1.1.2. Biological quality elements in UK

In the UK, in 2004, the UKTAG (UK Technical Advisory Group) initiated a review tasked to 'coordinate the adaptation and development of suitable surface water classification tools for the biological quality elements' (Outline UKTAG Work Programme 2003). The approach also complies with the CIS. Classification tools for rivers are also being developed in the UK and Republic of Ireland, but they will require a harmonization across respective systems, to ensure a coherent approach by both Member States in the shared international river basin districts. The tools are being developed by UK's leading independent experts in ecology, hydrology, geomorphology and chemistry and by consultants, and thousands of sites across the UK have been monitored. The approach includes the review and adaptation of existing methods (e.g. macroinvertebrates assessment within RIVPACs), development of new tools for elements not previously monitored in the UK and review of methods from Europe that could be adopted as part of the UK suite of tools (e.g. fish assessment methodology for rivers). There are some elements that are not being fully addressed neither in UK nor Spain, such as phytoplankton in rivers. The reason for this in the UK is that the turnover in the majority of its rivers is too high to support a phytoplankton community and has not been monitored along history.

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waters that cannot achieve the environmental objectives and evaluate the changes in those water bodies as a result of the programmes of measures (operational control).

1.1.3. Examples of biological indicators: Benthic invertebrates

This section describes the methods and indicators that both countries use for monitoring, assessing and classifying rivers in accordance with the requirements of Article 8; Section 1.3 of Annex II; and Annex V of the WFD. In Table 1, the elements and parameters dictated by the WFD are presented, as well as the most used indicators in Spain and UK. Aquatic macroinvertebrates are inhabitants (at least during part of their life cycle) of the benthos aquatic systems (sediments, trunks, rocks, litter, macrophytes, etc.).

Benthic invertebrates are ubiquitous and abundant organisms, and therefore could be affected by environmental perturbation in different types of aquatic ecosystems. An elevate number of species provides a big number of responses to different perturbations, both physical and chemical (organic pollution, eutrophication, acidification, habitat alteration, hydrological regulation, canalizations, etc.).

Table 1. Indicators to evaluate the biological quality elements in river bodies. Sources: (Annex V.1.1 WFD, 2000; UKTAG; Spanish Order ARM/2656/2008; Narcis Prat, 2007)

BIOLOGICAL QUALITY ELEMENT	PARAMETERS DMA	INDICATOR SPAIN	INDICATOR UK
Macrophytes and phytobencton	• Composition • Abundance • Bacterial tufs and coats	**Main:** • IPS (Specific Pollution sensitivity Index) • MDIAT (Multimetric Index for Diatoms) **Other:** • IBD (Biologic index for diatoms). • IVAM (Macroscopic aquatic vegetation Index)	• Macrophytes (LEAFPACS) • Diatom Assessment of River Ecological Status (DARES)
Benthic invertebrates	• Composition • Abundance • Ratio sensitive/no sensitive taxons • Presence of the principal taxonomic groups • Diversity	**Main:** • IBMWP (Iberian Biomonitoring Working Party). • IBMWPC (for Catalonia) • Specific multimetric according to river typology	**Main:** • River Invertebrate Classification Tool (RICT) • Scottish Acid Water Indicator Community (SAWIC)

		Other: • ICM-11a (multimetric index). • RIVPACS (River invertebrate Prediction and Clasification System. • AQUEM (Assessment System for the Ecological Quality of Streams and Rivers) • IASTP	**Other:** • Lotic Index for Flow Evaluation (LIFE) • Intercalibration Common Metric index (ICMi).
Fish fauna	• Composition • Abundance • Age structure (failures in reproduction) • Presence of sensitive species	• Proportion of individuals of local species **Other :** • IBICAT (metric index)	• Fish Classification System (FCS) • Species comp only (HIFI) • European method (FAME)

Similarly, their sedentary nature allows spatial analyses of the perturbations, and their long life cycle compared with other groups, allows identifying temporal changes on such perturbations (Helawell 1986; Newman et al. 1992; Rosenberg y Resh 1993; Hering et al. 2004; Alba-Tercedor, 1996, 2006; De Pauw et al. 2006). Aquatic invertebrate indicators enable an assessment of the condition of the quality element, "benthic invertebrates", listed in Table 1.2.1 of Annex V to the Water Framework Directive. Figure 5 presents the evolution of methodologies based on macroinvertebrates most used in Europe.

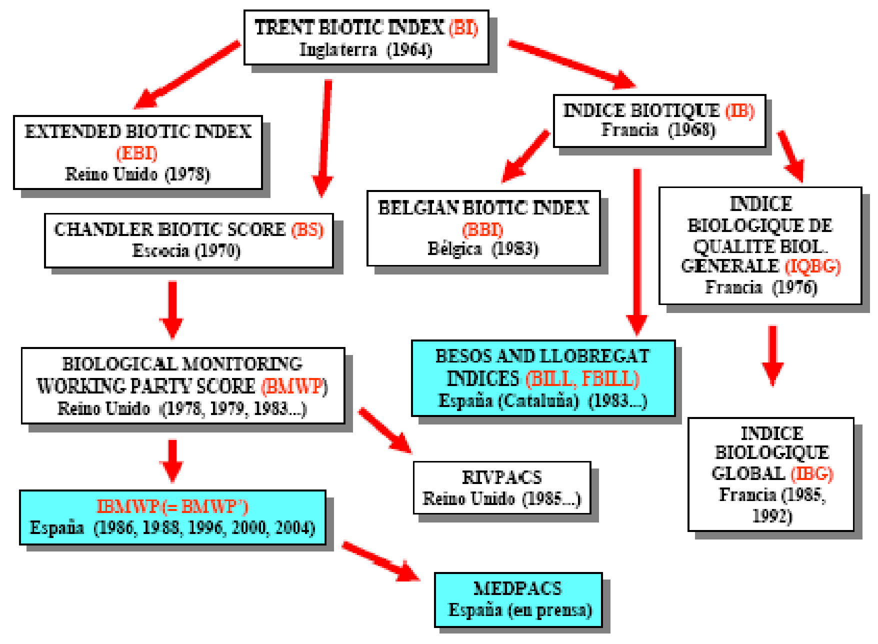


Figure 5. Evolution of methodologies based on macroinvertebrates most used in Europe. Source: Alba, J., 2007.

a) Benthic invertebrates indicators in Spain

The Iberian Peninsula adapted the British BMWP/ASPT index into the IBMWP[20] index (Alba-Tercedor et al. 2004). It is currently the most widespread tool among the scientists and managers for the ecological status assessment of the Spanish streams. However, since the entering into force of the WFD several others multimetric indices have been developed adapting to new requirements, such as the North Spain Multimetric Indices. Both of them are at present representing the Spanish biological indicators in the Intercalibration process and are officially accepted WFD methods.

The Mediterranean Prediction and Classification System (MEDPACS) is a system to evaluate the ecological status of the Spanish Mediterranean streams, and this methodology is adapted for many other water bodies in the country (Poquet, Alba-Tercedor, Puntí et al., 2009). Such system is based on the development of predictive models for the aquatic macroinvertebrates communities, following the previous experience of other countries like the United Kingdom (RIVPACS) or Australia (AUSRIVAS). MEDPACS has a web application designed to allow the evaluation of

[20] Iberian Bio-Monitoring Working Party

the ecological status by a predictive approach, as well as by using biotic/multimetric indices. It allows calculating both the biotic index IBMWP/IASPT and the multimetric index ICM-11a for the whole of Spain. In total there are more than 10 benthic macroinvertebrates methods spread over the different RBDs in the country. It is of a great importance to perform a national intercalibration that proves the the obtained results have the same scientific quality and comparability.

The IBMWP (Iberian Biomonitoring Working Party) is based on the tolerance of aquatic macroinvertebrates for environmental pollution. This index gives different values to the diverse families regarding to their tolerance for pollution (1 for very tolerant families and 10 to those with no tolerance). The obtained values are added in order to calculate the extent of pollution in the assessed river section.

Table 2. Ecological Status resultant from assessing the IBMWP index for benthic invertebrates. Source: Alba-Tercedor, 2009.

ECOLOGICAL STATUS	QUALITY	IBMWP
High	Good. No contaminated waters or no altered in a sensitive way	≥101
Good	Acceptable. Evidences of some contamination elements	61-100
Moderate	Doubtful. Polluted waters.	36-60
Poor	Critical. Very polluted waters	16-35
Bad	Very critical. Strongly polluted waters.	≤15

b) Benthic invertebrates indicators in UK: RICT and RIVPAC

RICT

According to the UKTAG report for assessment methods for benthic invertebrate fauna (2008), one of the methods most commonly used in the UK is known as the River Invertebrate Classification Tools (RICT). It can be applied to rivers in England, Northern Ireland, Scotland and Wales. The RICT method assesses the condition of the quality element using parameters indicative of the impact of organic enrichment on the quality element. They are calculated using information on benthic macro-invertebrate species and groups of species and are the following:

a) Number of taxa (NTAXA): the sum of the number of different taxa of 45 benthic invertebrates present in one or more of the samples obtained from the sampling site in the same calendar year.
b) Average Score Per Taxon (ASPT). Each taxa identified as present in a sample should be assigned the corresponding pressure sensitivity score (PS) ranging from 1 to 10.

From both of the previous parameters the ecological quality value is determined taking into account the reference conditions. The EQR is in turn translated into an ecological classification under the WFD (Table 2). The values set for the good/moderate were adjudged to be compatible with the WFD normative definitions. In particular, the good/moderate boundary was demonstrated to be that point where typically it could be expected that “major taxonomic groups” could be lost.

Table 3. Boundaries for assessing river status according to the River Invertebrate Classification Tool (RICT) for invertebrates. Source: (UKTAG, 2005)

Boundary	ASPT EQR	NTAXA EQR
High-good	0.97	0.85
Good-Moderate	0.86	0.71
Moderate-Poor	0.75	0.57
Poor-Bad	0.63	0.47

NTAXA EQR causes approximately 10 – 15% of sites in the UK to be downgraded from the class they would be in if only ASPT EQR were used for the classification. The primary intention of using NTAXA EQR is to detect severe toxic pressures. Table 4 shows the percentage of river corresponding to each quality boundary (UKTAG Summary Proforma for RICT).

Table 4. The approximate percentage of sites across the UK. Source: UKTAG, 2004	
WFD Class	**% in class**
High	32
Good	32
Moderate	19
Poor	10
Bad	7

RIVPACS

The River Invertebrate Prediction and Classification System (RIVPACS) is designed to determine the ecological status of flowing freshwaters in the UK, through comparing the presence and log abundance of sampled benthic invertebrate families, with the community assemblage predicted under high ecological status (Philine zu Ermgassen, 2009). RIVPACS is the agreed national method for the intercalibration process. This method is sensitive to pollution as well as other disturbances such as habitat alteration. Through entering a number of site specific environmental variables, the probability of finding certain species can be predicted. The observed invertebrate fauna (collected through standardized sampling methods) at the site is then compared with what would be "expected" from the RIVPACS model to give an Ecological Quality Ratio (EQR). The EQR is then translated, as done in the previous method, into an ecological classification under the WFD.

RIVPACS is now built into the River Invertebrate Classification Tool (RICT) for use by the Environment Agency. RICT incorporates RIVPACS alongside other invertebrate bioindicator tools: Acid Water Indicator Community (AWIC), Lotic Index for Flow Evaluation (LIFE), and the Intercalibration Common Metric index (ICMi).

1.2. Indicators of physicochemical quality elements

Physicochemical quality elements are based on 'Environmental standards', which are standards for the non-biological quality elements that need to be achieved to protect the biological quality elements, establishing the programme of measures and setting objectives under the river basin planning process. Member States are required to derive environmental quality standards for synthetic and non-synthetic pollutants or specific pollutants (i.e. other substances identified as being discharged in significant quantities into the body of water) in accordance with Annex V (1.2.6) of the Directive. In table 5, the indicators chosen by the UK and Spain are presented.

Table 5. Indicators to evaluate the physicochemical quality elements in river bodies. Source: WFD, 2000; UKTAG, 2004; Alba-Tercedor, 2009

QUALITY ELEMENTS (WFD)	PARAMETERS (WFD)	INDICATOR SPAIN (table 10 IPH)	INDICATOR UK
General Conditions	Temperature	Average water temperature	Average water temperature
	Oxygenation conditions	Dissolved Oxygen Oxygen Saturation ratio DBO_5	Dissolved Oxygen
	Salinity	Electrical conductivity (20ºC) Optional: total hardness, chlorides and sulphates	-------
	Acidification State	pH Optional: Alkalinity	pH
	Nutrients	Total Ammonia Nitrates Phosphates Optional: total Nitrogen (TN) and PO_4^{3-}	Soluble reactive phosphorus concentration
Specific synthetic and no synthetic pollutants	Other substances discharged in significant quantities	Those listed in the regulation (RPH, Rules of Hydrological planning, annex IV), not present in European regulation	---------

The values of change of status will be established for the limits between moderated, good and high. When in a water body a point of pollution discharge is found, several areas within that body can be delimited where one or more contaminants exceed the environmental quality values due to source proximity, and whenever the norms in the rest of water mass would be accomplished.

Despite both countries seem to choose the same kind of indicators, some significant differences have been found in the assessement of physicochemical characteristics. It was noticed for both countries that some parameters are general for all the rivers bodies and some are considered within different intervals depending on the river type. The acidification state, for example, is assessed by pH values in both countries, but in UK the intervals do not vary with river typology, while in Spain the pH intervals are different from one typology to another. pH values for the Spanish typology ‘atlantic-cantabric rivers’ have been shown in the table 6, in order to compare it with the ones established for the UK.

<table>
<tr><th colspan="6">Table 6. Acidification State in river systems assessed by the water pH</th></tr>
<tr><th></th><th>Reference conditions</th><th>High</th><th>Good</th><th>Moderate</th><th>Poor</th></tr>
<tr><td>Spain</td><td>7</td><td>6.3-7.7</td><td>6-8.4</td><td></td><td></td></tr>
<tr><td>England, Wales and N. Ireland</td><td></td><td colspan="2">≥6-≤9</td><td>4.7</td><td>4.2</td></tr>
<tr><td>Scotland</td><td></td><td>≥6-≤9</td><td>5.2</td><td>4.7</td><td>4.2</td></tr>
</table>

In the UK, all the physicochemical elements are determined refering to the WFD status intervals. For example they have based their standards for dissolved oxygen in rivers in terms of the oxygen regime and invertebrate communities found at sites with Good Status. Similarly, the UK has set their phosphorus standards for rivers by looking at sites which have Good Status for plant communities (UKTAG, 2006). High concentrations are classed as greater than 0.1mg/l for phosphate-P (SRP) and 30mg/l for nitrate (7mg NO_3-N). According to the Environment Agency an improvement is seen in terms of nutrient pollutions. In 2008, 51% of English rivers had high concentrations of phosphate compared with 69% in 1990. High concentrations of nitrate were found in 32% of English rivers in 2008 compared with 36% in 1995.

8.5% of Welsh rivers had high concentrations of phosphate in 2008, compared 26% in 1990. High concentrations of nitrate rarely occur in Welsh rivers.

In contrast, In Spain the standards of values according to the Directive criteria for every river type is just determined for oxygen concentration, salinity and acidification state. The boundary for the ‘high-good status’ is considered when the concentration values correspond to a less than 15% of deviation from the value established for the reference condition. For the boundary ‘good-moderate status’ the limit value is the corresponding to less than 25% deviation from the reference conditions, always when those concentrations meet the values contained in the following table (Table 7).

Table 7. Maximum limits to establish the limit for 'good status' for some physicochemical indicators in Spanish rivers. Source: Spanish Order ARM/2656/2008.

Limit for the good status
Dissolved Oxygen > 5mg/L
60% < **Oxygen saturation ratio** < 120%
6<**pH**< 9
DBO5< 6mg/L O_2
Nitrate < 6 mg/L NO_3- N
Ammonia < 1mg/L NH_4
Total Phosphorous < 0,4 mg/L PO_4

The next table (Table 8) represents the guidelines that the Environment Agency (UK) has developed in with the Countryside Council for Wales and English Nature as part of the process of reviewing permit conditions in order to meet the Directive's requirements. Spain's limit value for Nitrate is strangely low. The reason might be that it is not specified if the oxygen in the NO_3 molecule is counted or not. The case of phosphorous is very similar, the legislation does not specify what exactly "total phosphorous" means, which makes the value not comparable to those given for the UK.

Table 8. Solid reactive Phosphorous limits for most rivers in UK. Source: UKTAG. 2006

Total reactive Phosphorous (µg/l)	
High Status	20-30
Good status	40-100

1.3. Indicators of hydromorphological elements

Altering hydrology and morphology can have significant impacts on the flora and fauna of rivers. The hydromorphological pressures are the changes caused by human influences to either the flow regime (hydrology) or the morphology of the stream that affects the biota. The morphological and hydrological condition of water bodies must be assessed in order to determine whether they can be classified as high status[21] for hydromorphological quality elements. Such element is just established for the change of limit between good and high. Hydromorphological quality elements embrace the hydrological regime, tidal regime, river continuity and morphological conditions as listed in Annex V of the Directive. The most important hydromorphological pressures are:

- Building dams or weirs for hydropower, water supply or other purposes
- Canalization and/or dredging of rivers or streams to improve drainage or for navigation
- Weed cutting to improve drainage
- Abstraction of water directly from the stream or from ground water for water supply or irrigation, or diversion (hydropower or irrigation)

According to Bente Clausen (2006) some other influences worth to mention are: urbanization, afforestation/deforestation, draining of wetlands, transport and supply of water from outside the river basin to increase river discharge at dry period, and high discharges of water treatment plants in small river basin.

1.3.1. Indicators of hydromorphological elements in Spain

In Spain, in order to determine the morphological elements, a common practice is to qualitatively calculate the extent of anthropogenic alterations affecting rivers for both the direct and indirect pressures. For such task they take account of the following: (1) the extent of direct physical modification of the river beds or banks; (2) the presence of structures that prevent or limit migration of aquatic organisms and sediment transport; (3) the presence of flood and defense structures and embankments; (4) the

[21] As it was observed when the reference conditions were studied, a water body may only be classified as high status if there are no, or only very minor anthropogenic alterations to the relevant hydromorphological quality elements.

structure, condition and extent of riparian zone vegetation; (5) land use and land management including agriculture and built development on land adjacent to the river network and within the water body catchment area.

In second place the hydrological conditions must be evaluated by considering the nature and extent of anthropogenic alterations to hydrological regime of the water body. The high hydrological is assigned to any water body that meets the criteria for high status in each of the following tests:

- Abstraction test → the total quantity of upstream abstraction must be less than 5% of the Qn95[22] flow at the water body outflow point, including non consumptive abstraction;
- Discharge test → the total upstream discharges must be less than 5% of the Qn95 flow at the water body outflow point, including local return of water associated with abstractions and dry weather flows from sewage treatment works;
- Flow regulation test → the total surface area of reservoirs in the upstream catchment must be less than 1% of the total catchment area;
- Urbanization influence test → the total area of urban and sub-urban land within the total upstream catchment must be less than 20% of the total upstream catchment area, and the total area of urban land within the total upstream catchment must be less than 10% of the total upstream catchment area

A water body cannot be considered for high status unless the hydrological regime for both total abstraction and total discharge is less than 5% of Qn95.

Table 9 includes the main indicators used in Spain and UK for hydromorphological element.

[22] QN95 is the level of flow exceeded for 95% of the time at the point of measurement over a ten year period.

Table 9. Indicators to evaluate the hydromorphological quality elements in rivers to assess the ecological status.

QUALITY ELEMENT	PARAMETERS	INDICATOR SPAIN (IPH)	INDICATOR UK
Hydrological regime	**Flow and hydrodynamics**	• Hydrologic flow • HAS (Hydrological alteration index) • Connection with ground waters. **Others:** • IFIM (Instream Flow Incremental Methodology)	• Quantity and dynamics of water flow
	Connection		Connection with ground waters
River continuity	**Continuity**	• Average length free of artificial barriers. • Barrier typology. • Riparian Quality Index (RQI) • Fluvial Habit Index (RHI) **Others:** • Provision of passage of aquatic organisms.	• River continuity
Morphological conditions	• **Variation in depth and river width** • **Structure and substrate of the river bed** • **Structure of riparian zone**		• River bed and width variation • Structure of riparian zone

Example hydromorphological indicator: Fluvial Habit Index (FHI)

FHI assesses the heterogeneity of natural components in the water course. It is a simple method to evaluate the quality of a fluvial body. It is a modification of one American Environmental Protection Agency's rapid habitat assessment method (Babour et al 1999). It takes into account the variation of depth and river wide, the structure and substrate of the river bed and the structure of the riparian zone. In concrete the resultant value is a addition of the scores as a result of several factors such as rapids and talwedges[23], periodicity of rapids, river substrate composition, speed and depth, shade percentage in the river course, heterogeneity elements (dead

[23] The deepest part of the river

leaves, logs and branches presence, exposed roots and natural dikes) and aquatic vegetal cover.

Table 10. Values to assess river water ecological status using the IHF. Source: Pardo, I., 2002)

ECOLOGICAL STATUS	QUALITY	IHF
High	Good. No contaminated waters or no altered in a sensitive way	61.5
Good	Acceptable. Evidences of some contamination elements	0,91

To evaluate those elements, values of the annual average conditions will be used, reference values and values of the change category limits. Such values won't be applicable in case of perduring drought.

According to the RD 907/2007[24], a mass of water do not reach very good status due to its hydrological regime in the following cases:

a) The requirements of sufficient ecological flow regime are not met.
b) It is a high hydrologically altered water mass.
c) Connection with groundwater masses is a significant aspect along the river course.

1.3.2. Indicators of hydromorphological elements in UK

The overall policy aims for determining hydromorphological elements in the whole UK are very similar. Nevertheless, the UKTAG Classification Report has identified that different parts of the UK may have to take somewhat different methodological approaches to classification.

The UK national methods all include assessment criteria for in-channel, riparian zone, catchment and infrastructure pressures that can adversely affect the morphological condition of river water-bodies. It is their common view to establish well-developed morphological condition survey methods (eg. River Habitat Survey, Morphological Impact Assessment System & Rapid Assessment Technique) in order to provide reasonable certainty in the assessment of pressures and impacts (UKTAG, 2008). The methods use a number of parameters (channel, bank, foodplain, etc.) and a scoring system to evaluate the status of the stream from a reference condition.

[24] Real Decree 907/2007, 6 of July, by which the Hydrologic Planning Regulation is approved

VI. IDENTIFICATION OF ASSOCIATED PRESSURES AND RISKS ON THE WATER BODIES

The purpose of this chapter is the description of relationships between a combination of pressures coming from human activities (agriculture, urbanization, etc.) and ecological status of the rivers. The ecological impacts are not only determined by clearly identified point sources discharges, but also by series of complex human influences including diffuse pollution, alteration of sediment and water regimes, hydromorphological changes, connectivity breaks, etc (Borchardt and Richter, 2003).
As part of a review of the impact of human activity on the status of surface waters (the pressures and impacts analysis), Article 5 and Annex II of the WFD require Member States to: (i) collect and maintain information on the type and magnitude of the significant pressures to which surface water bodies in each River Basin District are liable to be subject; and (ii) carry out an assessment of the risk that surface water bodies will fail to meet the Directive's environmental objectives.
There are three essential terms required to understand the functioning of the Directive: Pressures, impacts and risk.

a) Pressures: Three kinds of water bodies are defined according to the pressures they experience: (1) those submitted to significant pressure, (2) those which are not under any pressure and (3) if no data is available about the pressures they suffer.

b) Impacts: The water bodies are divided into four categories: (1) water bodies with proven impact if their quality is such that they do not meet the environmental objectives stated in the WFD; (2) water bodies with possible impact, when their status is deteriorated despite they most provably meet the environmental objectives (yet they risk failing future more restrictive legislation); (3) water bodies with no evident impacts, which are expected to meet the environmental objectives; (4) water bodies lacking data about their pressures.

c) Risk: The risk is the combination of the pressure that one water body is subject to together with the resultant impact.

Pressures and impacts analyses have a central role in the river basin management planning process. Their principal aim is to identify where and to what extent human activities may be placing the achievement of the Directive's environmental objectives at risk (CIS, 2002). In order to describe the significant risk and pressures, the same three groups of relevant data appearing along this thesis need to be identified: biological, hydromorphological and physicochemical. The WFD allows from one month to six years of data antiquity[25,] period after which the characteristics could have changed and new data need to be gathered.

Human influence (controlling forces) can cause pressures which lead to impacts on surface waters. Nevertheless, neither every kind of human influence has effect on the waters nor every pressure causes a significant impact. In order to define the impacts we must first select the different kind of human influence, the pressures they cause, and finally, which of those pressures leads to a significant impact. In the assessed countries the natural and human geographical context are very diverse, and thus the relationship among pressures and ecological status might vary according to the sensitivity of river ecosystems and combination of pressures.

The pressure categories considered in the initial characterization are: (1) point source pollution, for example effluent from waste water treatment and industrial discharges; (2) diffuse source pollution, such as runoff from farmland, urban areas and acid rain; (3) abstraction and flow regulation, regulation of water in order to produce hydropower or for navigational purposes; (4) morphological alteration such as structures for flood protection or river straightening for agricultural purposes; and (5) alien26 species.

The Member States in 2005 submitted The European Commission the reports which include an inventory of the water bodies that have initially been assessed as ‘at risk’ or ‘not at risk’ of failing to meet the environmental objectives of the Directive by 2015. The results of the initial risk analysis are used a posteriori to prioritize the future environmental monitoring, to identify those water bodies and protected areas where more immediate action to improve the status of the water environment was required. Said results are hence followed by three main tasks represented in the next table (Table 1) and listed below:

25 WFD annex V, sec 1.3.4

26 Invasive species

Table 1. Risk Management . Adapted from: Source: Modified from: The Environmental Ministry of Spain, 2005.

<table>
<tr><th colspan="2" rowspan="2">RISK</th><th colspan="6">IMPACT</th></tr>
<tr><th>PROVED</th><th>POSSIBLE</th><th colspan="2">NO IMPACT</th><th colspan="2">NO DATA</th></tr>
<tr><td rowspan="3">SIGNIFICANT PRESURE</td><td>SUBJECT</td><td>Programme of measures (immediate)</td><td rowspan="3">Programme of measures (long term) Establishment of Operational Monitoring</td><td colspan="2">Additional characterization</td><td colspan="2">Establishment of Operational Monitoring</td></tr>
<tr><td>NOT SUBJECT</td><td>Additional characterization (if the origin of the impact is unknown)</td><td colspan="2">Maintain the current conditions to avoid further deterioration</td><td colspan="2">Predicting the impact (long term)</td></tr>
<tr><td>NO DATA</td><td>Establishment of the Operational Monitoring</td><td colspan="2">Additional characterization (medium term)</td><td colspan="2">Additional characterization (immediate)</td></tr>
<tr><td colspan="2">RISK</td><td>HIGH</td><td>MEDIUM</td><td>LOW</td><td>NULL</td><td>MEDIUM</td><td>LOW</td></tr>
</table>

A) Development of a programme of measures

It consists on establishing basic measures to achieve the Directive's environmental objectives in 2015. Such measures must be included in the RBMPs27 and must be taken under two different circumstances:

(1) Immediately, when there is a proved impact placing the water body under "high" risk of not meeting the WDF objectives (waters subject to a significant pressure).

(2) In the long term when the impact is possible and the risk of failing the objectives is "medium" (regardless the significance of the pressures).

B) Additional characterization

Through additional characterization surface waters must be further characterized in order to optimize the risk management; in other words, to improve the information

27 River Basin Management Plans

available on the existing pressures and impacts on each water body. This additional characterization must be performed in several cases:

(1) The water body seems to be not subject to any pressure but still there is a proved impact and it is considered to be under high risk.

(2) There is no impact on the water body, but it is known to be subject of significant pressure or no data about the pressure is available. In this case the risk is low.

(3) There is uncertainty about both, the impact on the water body and the pressures it is subject to. The risk to fain the Directive's objectives is low in this case, but immediate additional characterization must be performed.

C) *Establishment of an operational monitoring*

This task is meant to redesign and adapt the monitoring and controlling networks that are currently under use. The gauging stations must be reallocated in a way all the water bodies are perfectly under control, and redefine if necessary the parameters of control and frequencies, to include the control of biological indicators, to establish new analytical methods, etc.

1. Risk characterization in Spain

The results from the risk evaluation are summarized in the document IMPRESS[28] according to the article 5 of the WFD. The same as the diagnosis of water status, different pace and effectiveness of implementation within the country in the characterization of pressures and impacts on the water bodies are observed (Francesc La Roca, 2008). The extensive methodology intended to be used is available to the public and has been produced with reference to the proposed by the CIS-Guidance-IMPRESS[29]. The IMPRESS protocol to evaluate risks embraces two different procedures:

[28] Study of pressures and impacts
[29] Chapter 3.3.1 CIS-Guidance-IMPRESS. Luxembourg: Office for Official Publications of the European Communities, 2003.

- Qualitative IMPRESS: Based on the data coming from the emission sources inventory and the results from control and surveillance networks of existent waters. This procedure classifies the water masses into four groups: high, medium, low and no risk.

- Quantitative IMPRESS: applies mathematical models which allow ordering the water bodies according to their risk of not achieving the Directive environmental objectives. Each water body is assigned a relative digit that allows prioritizing them for the programme of measures.

The quantitative procedure has not yet been developed in most of the river basin districts. Hence in this section I will focus on how the qualitative IMPRESS was performed. In addition, the impact analysis taking place in Spain is mostly estimative, since a solid network using biological and morphological indicators is not yet in operation.

The main elements used to develop the methodology to study the impacts human activity on the water status are the following ones: (1) Identification of pressures; (2) Identification of the most significant pressures; (3) Impact analysis; (4) Evaluation of the probability of not meeting the WFD objectives.

The risk is evaluated as a result of combining the identification of pressures with the evaluation of impacts. The pressures are determined by the current inventories of anthropogenic activities in the country. The impact evaluation is performed according to the data provided by the Surveillance of the Water Quality Network. As a result, the water bodies are classified into four groups: Water bodies under high risk, medium risk, low risk and no risk. The following figure (Figure 1) represents the working protocol.

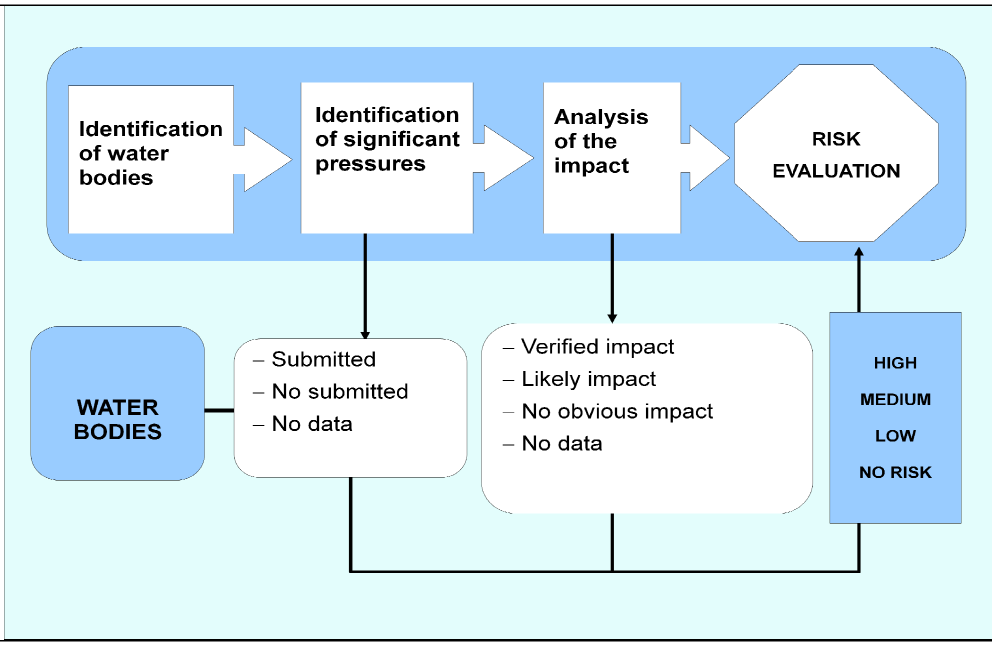


Figure 1. Qualitative IMPRESS. Source: Modified from: The Environmental Ministry of Spain, 2005.

In the qualitative IMPRESS, the risk is calculated as the combination of results coming from the identification of significant pressures and the impact analysis according to the following table (Table 2):

Table 2. Risk categories. Source: Modified from: The Environmental Ministry of Spain, 2005.

RISK		IMPACT			
		PROVED	POSSIBLE	NO IMPACT	NO DATA
SIGNIFICANT PRESURE	SUBJECT	HIGH	MEDIUM	LOW	MEDIUM
	NOT SUBJECT			NULL	LOW
	NO DATA			LOW	Can't be assessed

Finally, an adaptation of risk categories was performed resulting in just three kinds of risks in regard with the reliability of the data: (1) Water bodies under undoubted risk (UR), when they will fail the objectives; (2) Water bodies under study (US) when information is missing; (3) water bodies with no risk (0R) when they will meet the objectives. Such combination of pressures and impacts is presented in the following table (Table 3):

Table 3. Transformed risk categories. Source: Modified from: The Environmental Ministry of Spain, 2005.

RISK		IMPACT			
		PROVED	POSSIBLE	NO IMPACT	NO DATA
SIGNIFICANT PRESURE	SUBJECT	UNDOUBTEDRISK (UR)	RISK IN STUDY (RS)	NO RISK (R0)	RISK IN STUDY (RS)
	NOT SUBJECT				
	NO DATA				------

As mentioned before, the risk of not meeting the environmental objectives is determined by the water status of the water bodies: biological, physicochemical and morphological, where the two last ones are determined according to their capacity to affect the biological status. According to the Spanish IMPRESS document (the first and the only existing one up to now), just information about the physicochemical parameters is available, so the only means they have to evaluate the risk was expert judgments. In addition the reference status is not well defined in the whole country. As a result, in most of the cases it was not possible to find the cause-effect relationship between the pressure and the resultant risk. Another handicap regarding to this difficulty is the synergic effects of the pressures.

Despite the gaps suffered by the methodology that creates significant amount of incertitude, the results of the characterization of pressures were published in 2005. The global result was that 9% of the surface water bodies present an undoubted risk (UR), the 72% are under study (RS) and just the 19% present no risk (Dirección General del Agua, 2005).

From the 28% of water bodies that were characterized, as shown in Figure 2, 67% that are under absolutely no risk will be guarantee the maintenance of conditions. For the 33% under undoubted risk, a PoMs[30] is being currently implemented and Operational Control installed.

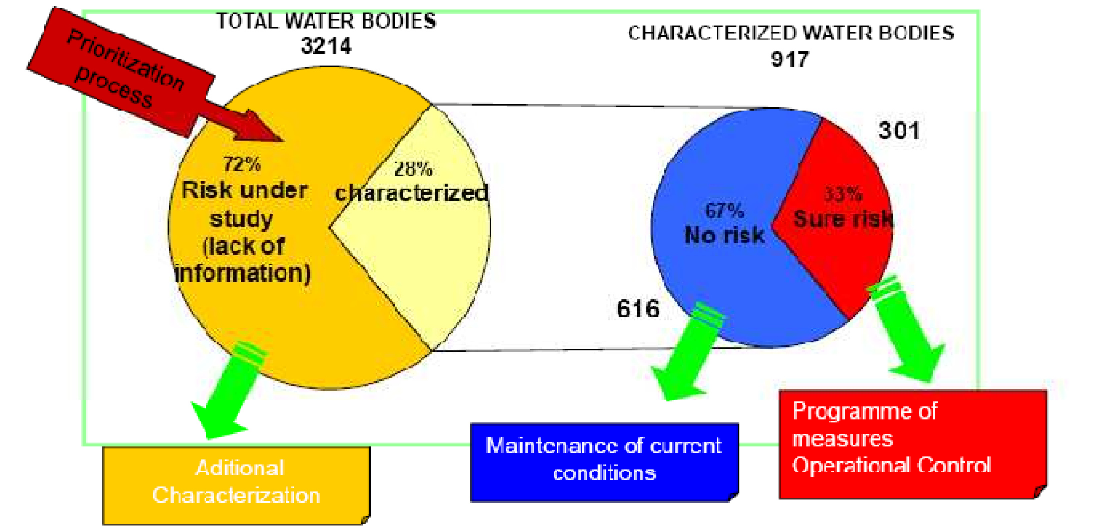


Figure 2. Results from the analysis of significant pressures. Source: Modified from: Environmental Ministry of Spain, IMPRESS Document, 2005.

- 9% of the water bodies are under assured and high risk (proven impact). Since they do not currently meet quality standards legislation, those water bodies were demanded to be urgently included in the PoMs. They are in addition included in the operational control network so the results from the program of measures can be checked.

- For the 72% of water bodies information available is not sufficient to characterize the risk. In some cases, a likely impact is known to exist but there is not information about it. Nevertheless it is known that the pressure is relevant and those water bodies are also included in the PoMs. Additional characterization must be started as soon as possible to optimize the risk evaluation through a better identification of pressures and impact analysis.

- Just for the 19% of the water bodies the risk of not meeting the WFD objectives is null. Even if in some cases there are significant pressures, there is no resultant impact. Following the precautionary principle, preventive measures to avoid farther

30 Programme of measures

deterioration must be set. For instance, when the administration gives authorizations for the use of the public hydraulic domain or discharges, the status of the water bodies must be protected. In addition cooperation with agriculture is an important factor to avoid water pollution. Finally, any action related to territorial planning must consider the status of the water bodies to which it can affect.

The main pressures affecting Spanish water bodies are represented in Figure 3, grouped into seven main categories: point sources diffuse sources, abstractions, hydromorphological alterations, flow regulation, soil uses and other incidences.

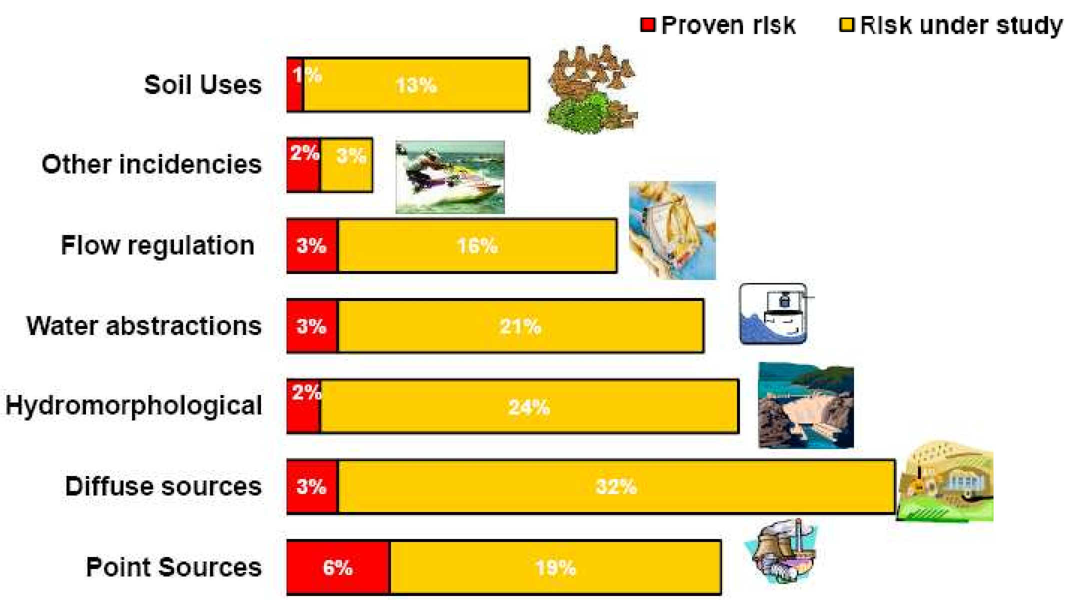


Figure 3. Results from the analysis of significant pressures. Source: Modified from: Environmental Ministry of Spain, IMPRESS Document 2005.

In figure 4., the pressures have been narrowed down to just four different pressure categories and represented for each river basin district. This figure, adapted from the same document used for the previous figure (5.4) (Spanish Ministry of Environment, 2005) shows however different results. While in figure 5.4 diffuse sources is the predominant pressure, in Figure 4 point sources stands for a higher percentage. In addition, no information is available to the public about the exact pressures embraced in those categories, so even if it seems that point sources of pollution represent the highest threat to the water systems, exactly which kind of source is unknown.

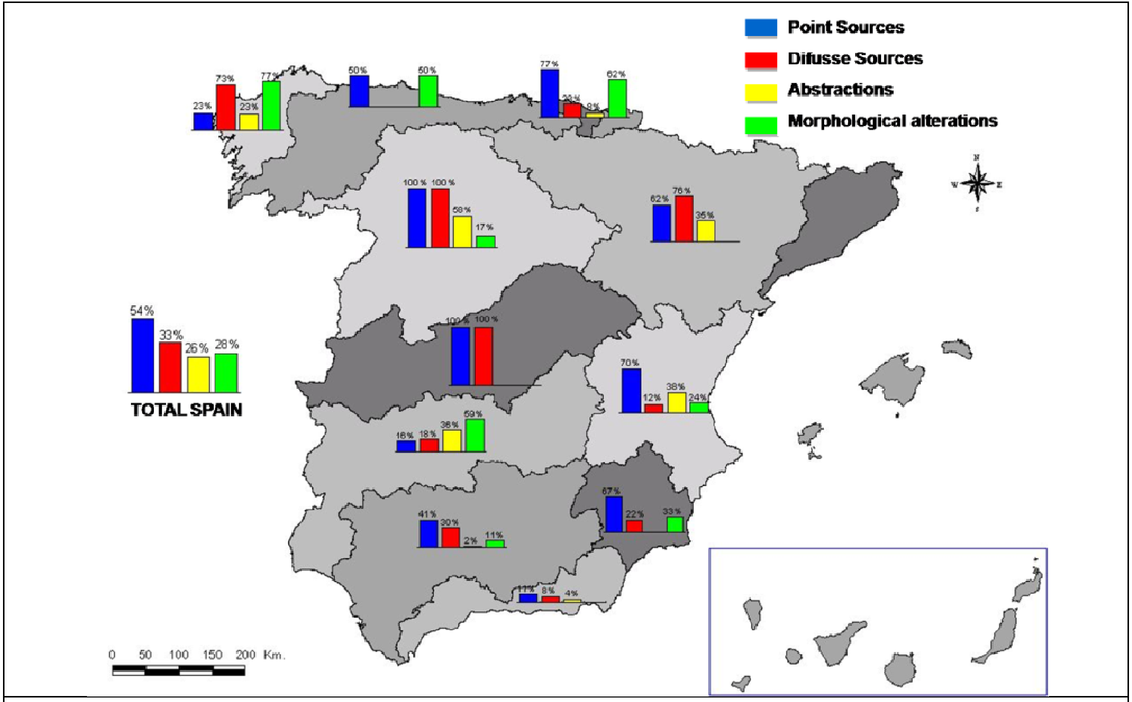


Figure 4. Main causes of risk for no meeting the WFD objectives in each river water basin. Source: Modified from: Environmental Ministry of Spain, IMPRESS Document 2005.

As an alternative interpretation of the two previous figures, it can be concluded that point sources pollution seems to be the main pressure in the Spanish surface waters. Nevertheless, for those waters whose risk is under study, diffuse source of pollution has been estimated more significant.

The lack of data, as mentioned at the beginning of this section, is due to the fact that no biological indicators are effectively applied. The area where the impact is proved is mainly due to the failure of chemical status. It means that many other water bodies having a good chemical status are still under risk of no meeting the environmental objectives for not meeting the biological status, so until an efficient mechanism of assessing biological status is not put on practice, a huge gap of results will remain, with consequences on the actions taken by policymakers.

The identification has not yet been made according to the WFD. The Ministry of Environment publishes data periodically about authorized discharges. In the last update from 2008, the main pressures were waste water discharges from cities, industries, fish farms and mining activities altering the water quality not just with the addition of toxic substances but also thermal energy coming from industrial refrigeration systems.

2. Risk characterization in the UK

For the risk assessment report, criteria set by the UKTAG were used in the assessments. For assessments undertaken only in Wales and England and not covered by UKTAG guidance, the Environment Agency used alternative methods. There are substantial differences in the scope, quality and quantity of information available within the different parts of the UK and the Republic of Ireland for use in the pressures and impacts analysis. For example, there are extensive and often quite detailed data on water abstraction pressures in England and Wales whereas in Scotland and Northern Ireland such information is very limited (UKTAG Work Plan Task 7.a, 2004). The method adopted in the analysis also differs between different parts of the UK, since they were developed according to the information available locally. Nevertheless UKTAG has produced guidance documents to achieve a consistent approach to the pressures and impact analysis across the UK, one for each specific pressure (point and diffuse source discharges, abstractions, etc).

The UK has included in the characterization of risks the places where they identified a high degree of uncertainty with their current assessment (e.g. due to lack of data) by having two further categories of 'probably at risk' and 'probably not at risk'.

Table 4 sets out the risk categories with respect to identifying water bodies at risk of failing to meet an environmental objective.

Table 4. Risk categories. Source: Modified from UKTAG, 2004.

WFD Risk Category	UKTAG Reporting Category
1. Water bodies at risk of failing to achieve an environmental objective	**(1.a)** Water bodies at significant risk Note: Identifies water bodies for which consideration of appropriate measures can start as soon as practical
	(1.b) Water bodies probably at significant risk but for which further information will be needed to make sure this view is correct
2. Water bodies not at risk of failing to achieve an environmental objective	**(2.a)** Water bodies for which confidence in the available information being comprehensive and reliable is low
	(2.b) Water bodies for which confidence in the available information being comprehensive and reliable is high

Figure 5 shows how they use those risk categories to prioritize different types of monitoring programmes in order to increase the confidence in the assessment and fill in the data gaps.

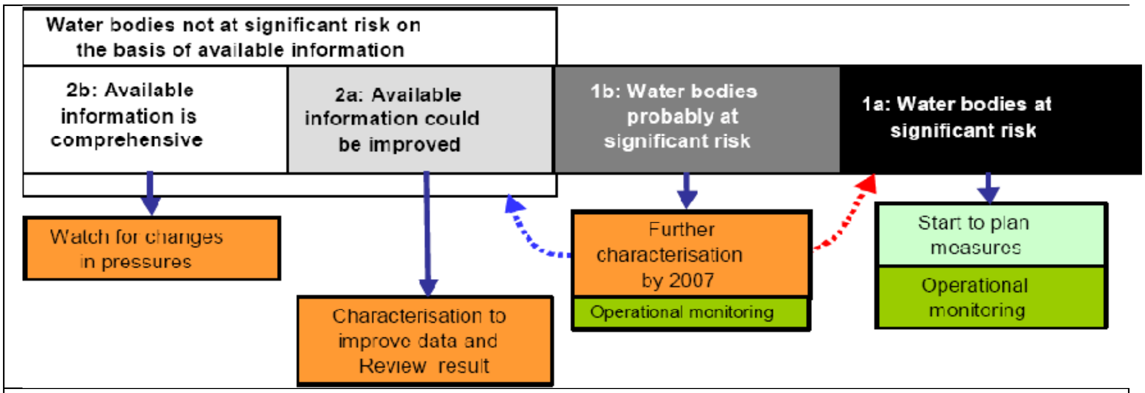


Figure 5. Diagram showing UK risk assessment categories and follow-up action. Source: Department for Environment, Food and Rural Affairs, Department of the Environment Northern Ireland, Scottish Executive, Welsh Assembly Government, 2005.

Figure 6 illustrates a more simplified overview of how classification and risk are used to define objectives and measures to be taken.

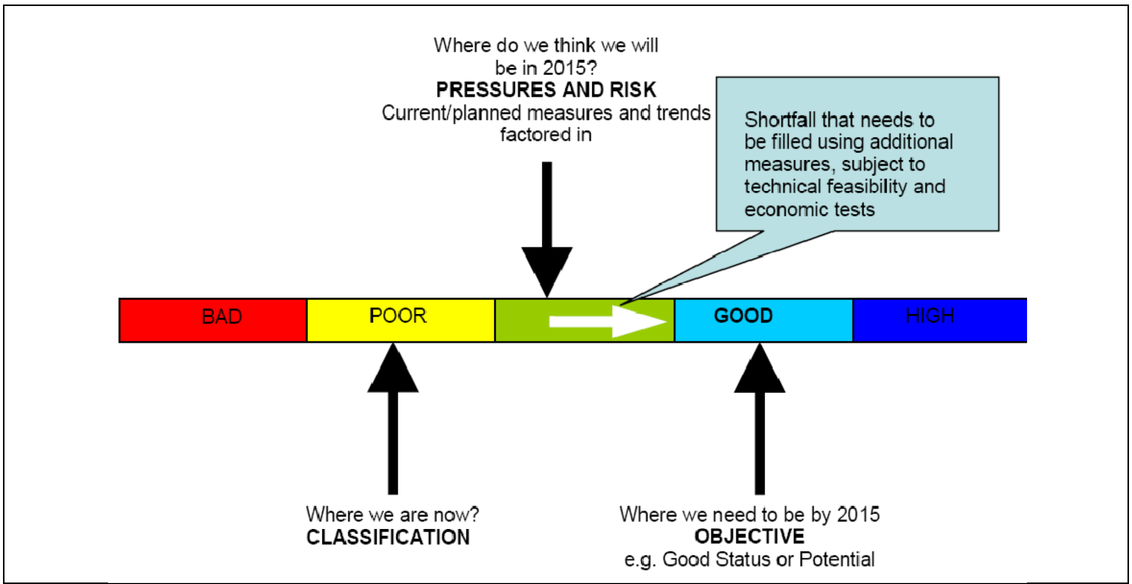


Figure 6. Definition of objectives from the the resultant assessment of ecological status, pressures and risk. Source: Environmental Agency, 2009.

Under the directive, all inland, estuarial and coastal waters must aim to achieve “good ecological status” by 2015. More than 80% of water bodies in England and Wales currently fail to reach this status (POSTnote, 2008). The Environment Agency estimates less than 30% of water bodies in England and Wales will meet “good” status in 2015, with possible deterioration in the status of some. In the UK, past improvements in aquatic ecology have been delivered through regulating gross organic pollution and the oxygen depletion this caused. However, aquatic ecology continues to be affected mainly by the following pressures: diffuse pollution from multiple sources including agriculture, urban areas and transport systems; pollution originating from a single point such as a sewage treatment work's pipe outfall; the impact of physical modification on water bodies, such as flood defenses; amounts and rates of water taken from the environment for human use (abstraction) leading to low river flows and depleted groundwater levels (POSTnote, 2008). Since there are RBMPs published for every river basin district, very comprehensive and detailed information is available about the main pressures threatening the water systems. A common methodology has been applied homogeneously in the country for each of the main pressure.

Table 5. Pressures placing UK waters under risks of not meeting the Directive's environmental objectives. Source: Self elaborated.

PRESSURES	ANG	DEE	HUM	N.HU	NW	SEV	SOL	SE	SW	TH	WW
Abstraction and other artificial flow pressures	1		1			1			5	1	
Invasive non-native species	2	2	6	5		2			4	2	8
Nitrate	3	4	3	2	2	3	4	1	3	3	
Phosphorus	4	3	9	8	1	5	1	4		4	1
Physical modification (morphology)	5		4	3		6		4	2	5	
Sediment delivery	6	6	10	9	4	7	2	6	1	6	5
Pesticides		1	8	7	5	4	3	3	7		4
Urban and transport pollution		5	5	4	3	8	5	7	9	7	
Other pollutants – Metals		7							8		
Commercial Fisheries		8							10		
Mines and minewaters			2	1	6		6		6		2
Organic pollution (ammonia and BOD)			7	6				2	11	9	3
Faecal indicator organisms										8	6
Acidification					7		6				7

The risk categories for UK waters are slightly different that those used by Spain: water bodies at risk, probably at risk, not at risk and not assessed.

A review of the chapter regarding to pressures and risks from the UK RBMPs, the pressures indicated in Table 5 have been found to be the most relevant. For each river basin, a number has been given to each pressure depending of its significance from (being number one the most important pressure). The number of pressures putting UK waters under risks of not meeting the Directive's environmental objectives ranges from six (Anglian River Basin District) to eleven (South West RBD).

Works undertaken by the UK Environment Agency states that many water bodies in England and Wales are 'probably at risk' or 'at risk' of not meeting the 'good status' criteria in 2015 due to abstraction. According to the information summarized in the previous table, nitrate pollution is one of the main pressures coming principally from agriculture (61%) and sewage treatment works discharges (32%) (England and Wales, Defra 2004). In urban areas the main inputs are from contaminated land, leaking sewers and water mains. The magnitude and balance of diffuse and point sources vary across river basin districts, as will the extent of inputs to surface and groundwater. In addition, high phosphorus concentrations are the main cause of eutrophication[31] in fresh waters, and hence seen as one of the main critical pressures. Activities that can be affected include water abstraction, water sports, angling, wildlife conservation and livestock watering. In standing fresh waters, blue-green algal blooms can occur; many such blooms are toxic and pose a hazard to humans involved in water sports and to animals that drink the water. Furthermore, the sediment delivery also represents a serious threat on the quality of the river systems. Most of it is caused by the increasing rate of soil erosion which occurs as a consequence of land based activities such as forestry, construction and, particularly, agricultural cultivation and grazing practices. Despite sediment represents an essential component of the ecosystem to maintain many animal species it is also a sink of metals and toxic organic compounds. Even if demonstrating exact evidences of ecological impact as a result of human influenced sediment load is complicated,

[31] the enrichment of waters by nutrients causing excess plant/algal growth and leading to undesirable effects on the ecology, quality and uses of the water

there are significant amount of scientific studies that argue that high concentrations of suspended solids can have devastating effects on the biota. As an example “The Salmon Stock Conservation Review” (2004) identified sedimentation as the first factor causing a failure in 12 of the 22 Welsh Salmon Action Plan (SAP) rivers.

The risk assessments, however, do not reflect the current quality or status of a water body. Being 'at risk' does not mean that a water body has already failed its objectives, only that it might do so. Such assessments, as the Directive mandates, have been used to target monitoring programmes and to provide the evidence to help develop measures needed to deliver environmental objectives. This will help us to manage threats to the water environment before problems occur or restore water bodies if they are already impacted.

If the assessments of all the possible pressures are combined, the result will be as shown in the map in Figure 7. That map and Table 3 indicate that the situation in England and Wales, as already stated, is rather bad. 92,7 % of the rivers are at risk of not achieving the WFD objectives of good ecological status by 2015.

Table 3. Percentage of surface water bodies at risk of not achieving WFD objectives. Source: Kungl. Skogs, 2006.

PRESSURES	RIVERS
Point discharges	23.1
Diffuse pollution	82.4
Abstraction	10.7
Physical changes	48.2
Alien species	21.1
Overall % of water bodies at risk	**92.7**

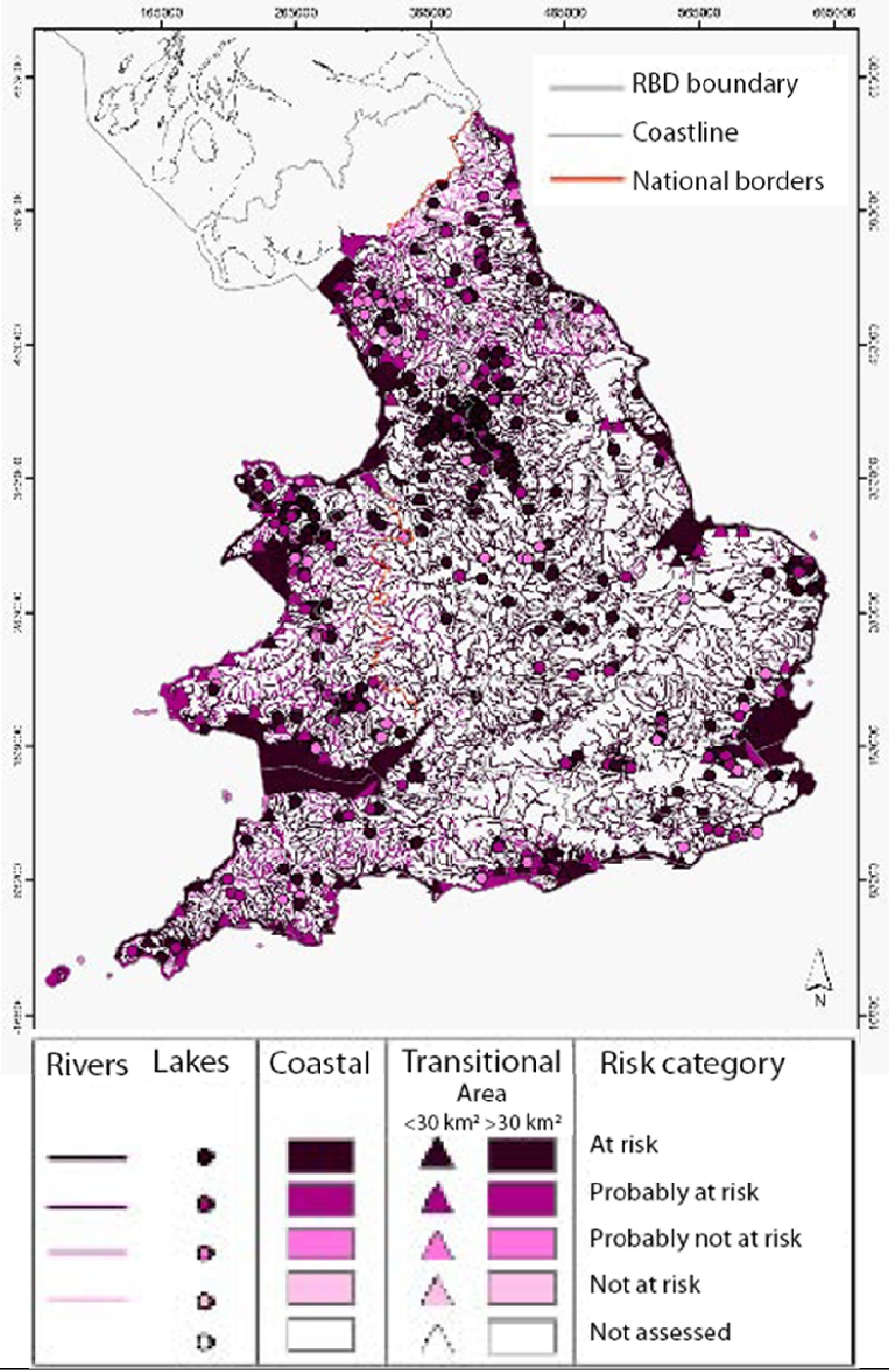


Figure 7. Surface water bodies at risk of not achieving WFD objectives. Source: Kungl. Skogs, 2006.

In addition, the next figure (Figure 8) explains a conceptual risk model using example of the pressure from phosphate (P) fertilizers for the UK rivers.

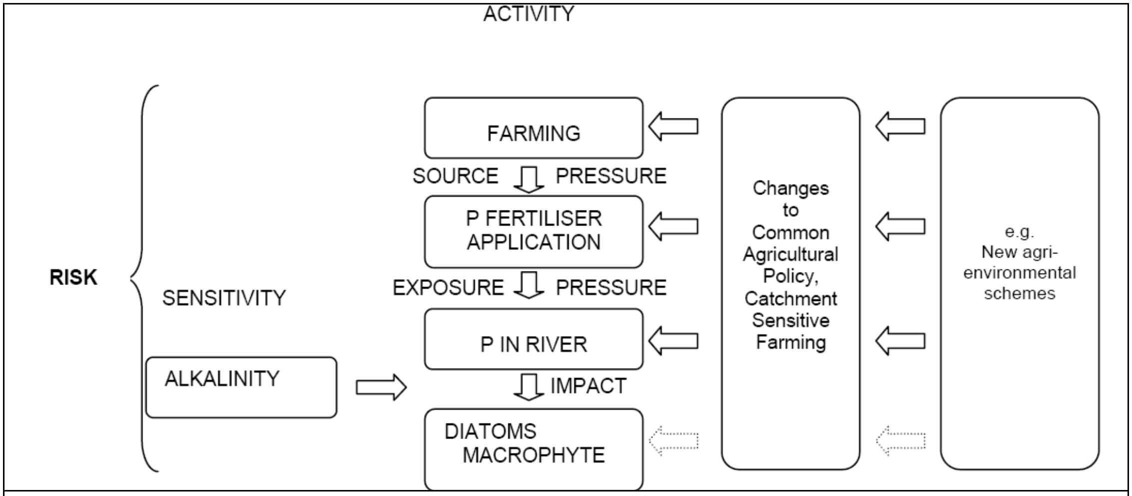


Figure 8. Example of conceptual risk model using example of the pressure from phosphate (P) fertilizers. Source: River Basin Management Plans England and Wales, 2009.

Farming activities is in this case the source of diffuse pollution. Unsustainable fertilizer application (the pressure) results in a rising concentration of phosphorous in the rivers. This leads to the detection of bad status of the rivers (impact) detected by the biological indicators (diatoms and macrophytes) and the chemical indicators (alkalinity). The process of determining pressures will indicate which objectives are appropriate and establish programmes of measures through which action will be taken to achieve the agreed objectives. In this example, measures taken by the competent authorities could be the revision of the Common Agricultural Policy and improvement of the farming activities taking into account the sensitivity of the river catchment.

Identification of pressures is to the author's opinion the most complex step of characterization of water bodies. In most cases various pressures act simultaneously and to find a hierarchy amongst them to identify priority actions is extremely difficult. The reason is that those pressures are not evenly distributed on the territory and are generated for such numerous kinds of activities. According to Ana García (2006) the policies to restore river ecosystems must be targeted to the whole socio-economical structure: agricultural sectors, industry, urban areas, etc. The role of classification in this process for the UK is summarized in Figure 9.

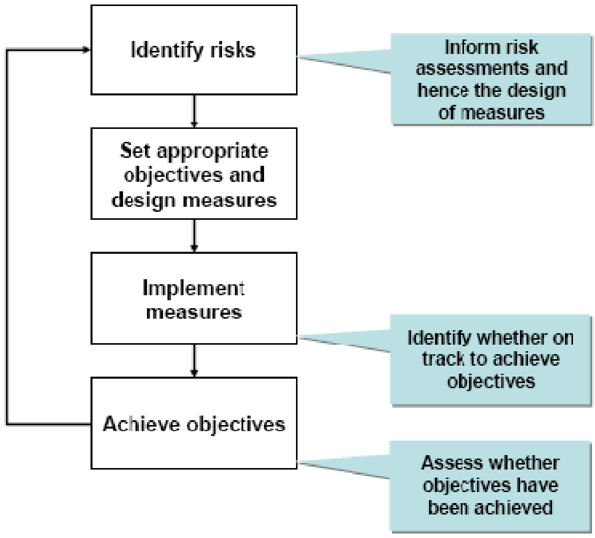


Figure 9. Key roles of classification information in river basin management planning.
Source: UKTAG, 2009

VII. RIVER BASIN MANAGEMENT PLANS: PROGRAMME OF MEASURES

The purpose of the River Basin Management Plan is to improve the ecological status and potential of water bodies. The planning process involves identifying the pressures facing the water environment in each RBD, setting objectives for each water body, and developing PoMs to meet those objectives (Figure 1). It is normally prepared in consultation with a wide range of organizations and individuals and it is established for a series of six-year planning cycles.

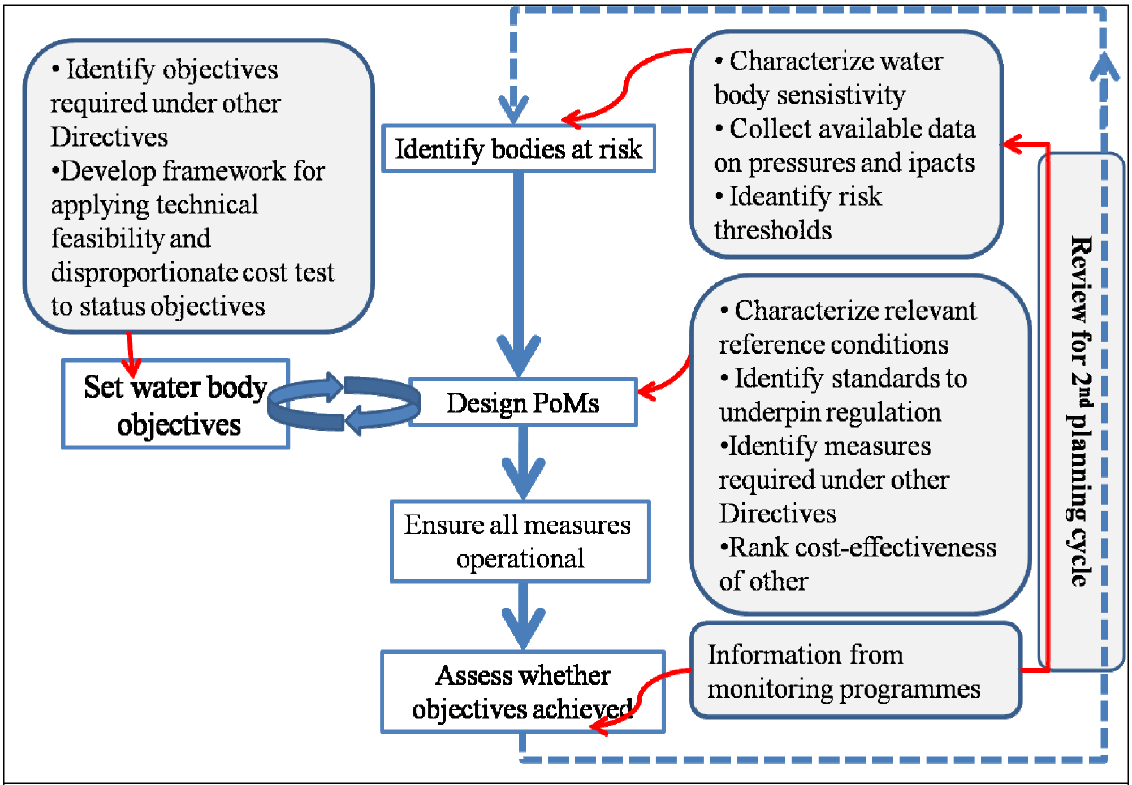


Figure 1. PoMs Diagram, according to the WFD. Source: modified from UKTAG, 2009.

According to the Directive, PoMs implemented at a national or local level within countries may include wide-ranging actions such as:

- measures to manage specific pressures arising from: forestry, agriculture, urban development, etc;
- control regimes or environmental permitting systems;

- water demand management measures;
- economic instruments such as incentives, taxes on fertilizers, etc;
- river restoration strategies, etc

How these are applied will depend on identifying the most cost effective mechanism to meet the objectives set for each RBD.

Each MS must complete a series of studies by RBD to arrive at a comprehensive list of measures that will assist in achieving the WFD objectives. Each study should address a key pressure on the water environment. Article 11 of the directive sets out the type of measures that must be included in the plan: 'basic measures', largely based on existing European legislation and policies, and 'supplementary measures', additional measures needed where basic measures are not capable of achieving objectives in the timescale required.

Examples of basic measures include the Nitrates Directive (91/676/EEC), the Habitats Directive (92/43/EEC), the Urban Waste Water Treatment Directive (91/271/EEC) and the Integrated Pollution Prevention and Control Directive (96/61/EC) (Patrick Kavanagh, 2009). These measures must be implemented by way of national regulation and are legally binding. When application of the basic measures will not be enough to achieve the objective of good status by 2015, additional supplementary measures need to be identified and considered. They are mainly implemented at local level (at the river basin or water body level). The first step in this process is the preparation of supplementary measures that are technically feasible. Then a set of tools is used to appraise the feasible measures such as cost-effectiveness analysis, disproportionate cost analysis, strategic environmental assessment and impact assessment.

The measures must be available for public consultation in the draft RBMPs, and the final set of measures for each water body for the first six-year cycle of river basin management will be determined in the final plans. The most relevant and cost-effective measures will be chosen from the list for implementation. The basic measures do not differ from the two countries assessed in this master thesis. They are easier to identify and must be applied regardless their costs. Nevertheless there is a distinction between basic measures not open to alternatives, such as those required for the transposition of the legislation related to water protection to the domestic level, and those other general measures proposed by the WDF, which can allow for certain variations according to the cost-effectiveness principle. Some examples of the latest are cost-recovery (Article 11.3.b WFD), efficient and sustainable water use (Article 11.3.c WFD), control over the water abstraction and storage (Article 11.3e WFD), etc. This section focuses on the complementary measures chosen by two RBDs (one from the UK and another form Spain). Those additional measures are open to alternatives, and the concept cost effectiveness is the key for their selection or ruling-out. They are generally mentioned in Part B of Annex VI from the WFD and are further developed by national legislation. An equivalent analysis of the PoMs was not possible to be carried out since it has not been drawn up yet in the majority of the Spanish RBDs.

1. Programme of measures in Spain

In Spain, the major challenge for the implementation of the WFD is to overcome the existent competition between two objectives that should be interconnected: the Good ecological status of the water bodies and the guarantee of water supply. Such a challenge calls for a strategic vision of water resources management which should integrate measures addressing water demand management and measures focused on the recovery of the environmental services offered by the water bodies and associated ecosystems. In these terms, the PoMs are an instrument for coordination and integration of water and sectorial policy actions. Within those actions the following issues should be clearly defined: sources of finance, the actors responsible for executing the measures, the temporary horizons of objectives achievement, control indicators and monitoring of the measures undertaken (FNCA[32], 2009). The 'ad extra' integration is recognized by the Directive as a necessity. This refers to an effective and coherent coordination between the public policies related. Said coordination must be granted in a structural way through territorial planning and hydrological management. The PoMs meet this function since they include the measures required for the protection and sustainable use of the water bodies, even if

[32] Fundación Nueva Cultura del Agua. Report on the state of implementation of the WFD in Spain.

they are to be adapted by different authorities (La Calle, A, 2008). According to La Calle (2008) the more relevant fields in need of clearer patenting are: energy, transport, agriculture, fishing, regional policy and tourism.

For the programme of measures to be effective there are several very important requirements: establishment of the operative definition of the objectives to reach, the characterization of the water masses and the identification of pressures. As already mentioned, at most of the RBDs there is still a high level of uncertainty concerning the definition of objectives. In addition, the characterization of ecological status of the water bodies is incomplete due to the absence of a comprehensive set of biological and geomorphological metrics (indicators); there is a delay of the intercalibration process, etc. Finally, is it worthwhile to remark that in essence, the drawing up of wide-ranging and effective PoMs depends on the government's position, and its political will, to invest the necessary amount towards the realization of the measures. The conflict of interests of the diverse sectors and stakeholders within the regions is the main barrier to significant progress on this matter. The government decisions often lean toward giving priority to the economic sectors (in this case agriculture), rather than to environmental protection. This problem will certainly hinder the success of the adoption of appropriate PoMs. The RBMPs have been published (not yet reported to the Commission) only by three RBDs (Catalonia, the insular RBMP from Baleares and Mediterranean Eastern Basin) out of 27. Nevertheless, the rest of the RBDs and river basin authorities have published a broad explanation of the important issues necessary to be tackled as a previous step to the establishment of the definitive PoMs. Such documents gather the main problems of the RBD and the possible measures to solve them.

Next, the Guadalquivir RBD is presented as an example of interregional RBD located in Southern Spain. A "list of important issues to be addressed" was published and it is now awaiting the approval of the competent authority for the next step towards the publication of the PoMs, whose synthesis will be included in the RBMP. Some of the measures proposed next are already on their way to becoming established and the difficulty resides in that the analysis must be done water body by water body, as stated in the WFD. In order to avoid this handicap of another unit of work, the sub-basin, has been defined. The sub-basin integrates a group of water bodies and allows for a broader vision that would be otherwise lost in the unitary observation of the water body. Five different sub-basins have been differentiated for this RBD: Jaen, Granada, Cordoba, Seville I and Seville II.

In the Guadalquivir RBD from 334 to 380 (depending on the bibliographic source) river bodies have been identified. According to the national IMPRESS document submitted to the Commission in 2005, 12% of the water bodies are under sure risk, 65% under study and 23% are not at any risk. Looking at Figure 2 the impression is given that higher percentage of the water bodies is at certain risk rather than under study. This is another example of the ambiguity of the available data sources. The most relevant problems concerning surface waters have been classified into four different categories: quantitative problems (use and demand), qualitative problems (environmental issues), problems related to extreme meteorological phenomenon (droughts and floods) and problems related to the water governance.

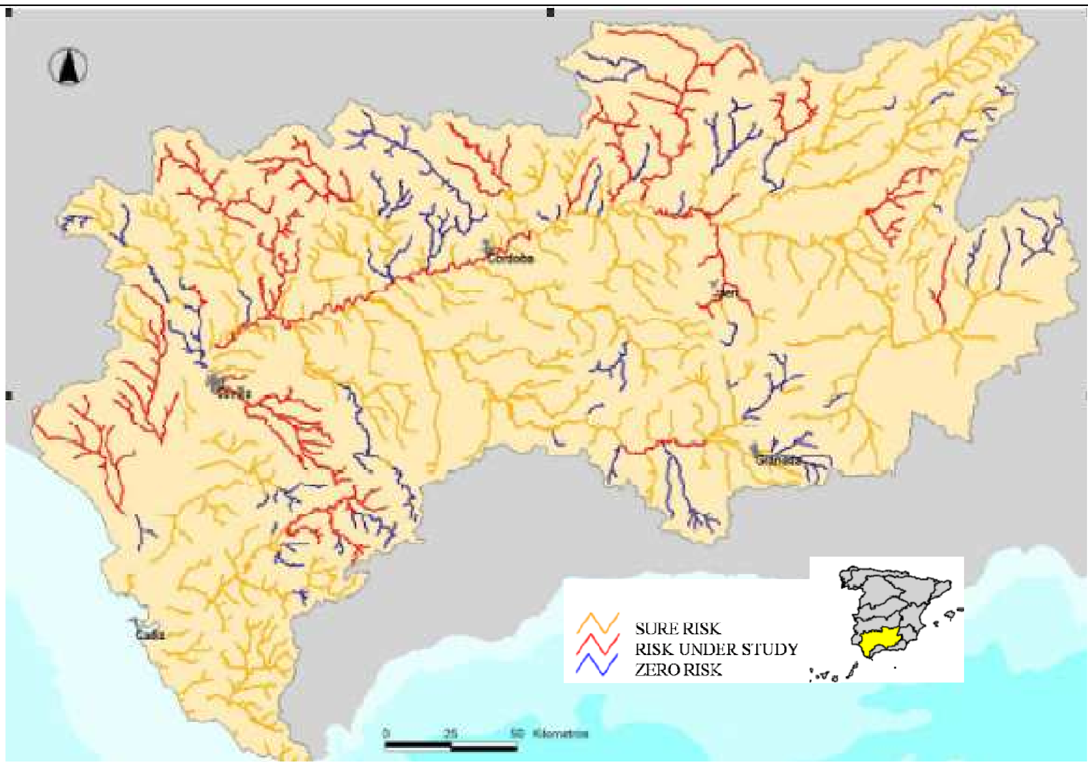


Figure 2. Guadalquivir RBD. Source: Environmental Ministry of Spain, IMPRESS Document, 2005.

1.1. The quantitative problem

The quantitative problem is characterized by the lack of equilibrium between the water supply and demand and by the water deficit in the whole district, often related not just to the low precipitation but also to the decrease of water availability due to a deficient quality status. Such deficit leads to a high vulnerability of the system towards droughts and a frequent failure of the water supply during dry years. Some of the proposed measures are the following:

a) Advising and training programmes addressed to the responsible for watering in order to achieve higher efficiency in water exploitation.
b) Application of a modernization programme for irrigation.
c) Improvements of urban water supply: reductions of leakages in the distribution network, regulation and enhancement of household devices addressed to reduce water consume.
d) Water invoices according to the volume consumed and improvement of the water readers installations.
e) Restructuration of water tariffs aiming at the 100% of the services costs, plus a moderate introduction of environmental cost and the cost of the resource itself.
f) Modernization program for the rice sector directed towards water savings.
g) Promotion of a switching of cultivation, replacing the more water consuming ones by more profitable ones such as olive trees with dripping irrigation.
h) Recovery of water administrative concessions[33] addressed to cultivations with low social and economic profitability.
i) Strict control form the RB administration addressed to avoid illegal irrigation
j) To deny new water concessions of any kind unless it is strictly necessary.
k) The update of the Water Registry[34] in order to harmonize the reality of the water supply with the supply of water administrative concessions. This will

[33] An administrative water concession is a private sector arrangement where the water ownership remains in public hands but where the private operator is responsible for its use, new investments, as well as operating and maintaining the resource.
[34] The Water Register records water entitlements with integrity, enables proper water accounting, keeps track of the water market and produces crucial information for managing water resources

avoid conflicts in the future concerning new water uses of more profitability and interest for the territorial development.

l) Establishment of a Center of Concession Rights Exchange (Public Water Bank) managed by the administration.

m) Reuse of waste treatment water, where possible, in urban and industrial use.

n) To give incentives to transform private water into public.

1.2. The qualitative problem

60% of the surface river bodies are found to have ecological status below Good, due to diverse pressures such as urban and industrial pollution, diffuse pollution coming from agriculture, regulation of water flow, abstractions, morphological alterations, etc. Among all, organic pollution and nitrates seem to be the biggest threat to water quality. They find their origin in leaching[35] from fertilizers, intensive animal farming and urban and industrial discharges. In addition, trace metals such as mercury, lead and arsenic among others have been detected beyond the limit values for dangerous substances. Some of the proposed measures are the following:

a) Assurance of environmental flow regimes[36] adding the water required from the reservoirs, including special measures normally vital during summer.

b) Tighten the control by the government officials in charge of environmental protection and improve the monitoring of the controlling network to make sure that environmental flow regimes are respected, especially during periods of drought, for which concrete norms have already been established in the provisions of the "Special Plan of Droughts"[37].

c) Application of basic measures established in the National Plan for Water Quality in the Guadalquivir RBD concerning construction, maintenance and exploitation of waste water treatment plants for urban settlements beyond 2.000 inhabitants.

[35] Leaching is the movement of water and possibly nutrients down into and potentially beyond the turfgrass rootzone.

[36] Environmental flow is the amount (and timing) of freshwater that is required to maintain the health of aquatic ecosystems

[37] Plan redacted according to article 27 of the National Water Law 10/2001, 5 July, aiming at minimizing the environmental, economic and social impacts in case of a drought period.

d) Basic measures responding to the European 1991/271/EEC for the adaptation of the waste water treatment to the legislation standards for the elimination of nutrients in zones declared “Sensitive” by national legislation.

e) The setting up of a group of measures of extensive application concerning agricultural good practices in order to avoid diffuse pollution.

f) Also to fight diffuse pollution, another basic (but not compulsory) measure is the establishment of the “Agro-environmental Aid”[38] for several matters such as ecologic agriculture and cattle farming, integrated rice production, cotton, olive trees and lucerne in the vicinity of dam targeted for human consumption, agriculture targeted for herbaceous conservation and slope vineyards.

g) Plan for dismantling obsolete industrial installations.

h) To identify, monitor and ameliorate landfills and to regulate and eliminate the illegal ones

i) Definition of the action protocols in case of accidental pollution.

j) Measures targeted at protecting the soil against erosion and subsequent suspended solid pollution in surface waters.

1.3. Problems related to extreme meteorological phenomena: floods and droughts

a) Floods

In Andalusia, severe precipitation episodes can lead to high intensity freshets[39]. These freshets are often the origins floods, even in the main rivers (Genil and Guadalquivir). Moreover, sea storms cause floods in the lowest parts of the river course. The main consequences are human and material damages, but also pollution by dragged contaminated soils. Measures targeting floods can be preventive or structural.

1) Preventive measures:

[38] Government subsidies established in the Andalusian Plan for Rural Development 2007-2013.
[39] A sudden overflow of a stream resulting from a heavy rain or a thaw.

- To complete the boundaries of the public waters (inventory maps) and eliminate the infrastructures located in it.
- To define floodable areas and transpose them to the urban planning.
- Elaboration of risk management plans for floods according to the EU floods Directive and the National Guideline of Civil Protection.

2) Structural measures:

- Actions referred in the “Andalusian Plan for the Prevention of Freshets and Floods in the Urban Water Courses”
- Restoration of forests affecting water courses
- The design of new infrastructures for increasing the water storage during flooding episodes.

b) Droughts

The Guadalquivir RBD is characterized by a regular occurrence of drought episodes. During droughts, all water consumption sector are affected, especially irrigation, but also the urban supply even if they by law enjoy priority among the other uses. Moreover, the environment gets highly affected by the scarce water flows and hence the excess of pollution diluted. Since there is a lot of experience in this field, the concerning measures are all embraced in programmes already initiated by the competent authorities such as the following:

1) Special Action Plan for Alert and Drought Situations in Guadalquivir RBD
2) Andalusian programme against droughts, addressed to urban supply and interconnection of water supply systems.

1.4.Problems related with knowledge and governance

a) Knowledge

Despite the efforts from the competent authorities to perform studies about diverse water management related subjects there is still an urgent need for knowledge in order to give precise answers to multiple questions that must be addressed in the RBMP. Some matters which need to be further explored in depth are:

- The knowledge about water demand, especially as related to agriculture. In this area, improvements of the demand inventory started in 2004 are required, with the integration of remote sensing and field work. The tools need to be sharpened and water demand must be aligned with the corresponding supply source.
- The definition of environmental flows based in both, hydromorphological and biological criteria.
- Improvements of the control networks in order to monitor the parameters constituting the ecological water status.
- Studies related to the intercalibration process, which must be adapted to each water body typology.
- Progress of the indicators system aiming at characterizing the water quality status. Moreover, there is a need to advance on the definition of values establishing the reference conditions and pointing at the change of status for each different typology.

b) Governance

The water governance refers to the sphere of activities in the political, social, economic and administrative system in which the development and the management of the water resources and the supply of services to the different levels of society take place. Facilitating communication between key politicians and other stakeholders, water managers and users, in an effort to address critical issues of water governance is the main concern. The Directive calls for the incorporation of new scientific arguments (from those inspired by economy to the phenomenon of climate change) and for the inclusion of new experts (apart from engineers, biologists, geographers, etc). Efforts must be put on enhancing active public participation as a main tool to establish the guidelines for the RBMP. In this regard, a group of experts has been set up, a forum in the institutional website and thematic workshops in order to define the RBMP objectives and the programme of measures.

2. Programme of measures in UK

The PoMs comprised in the RBMPs are being and will be implemented through a mix of regulation, incentives and voluntary measures in England and Wales. In Scotland, the Water Environment (Diffuse Pollution) Regulations 2008 allowed the Scottish Environmental Protection Agency to control specified polluting activities in all areas. In England and Wales, Water Protection Zones (WPZs) were the government's means of dealing with diffuse pollution in areas where advice and incentives have failed. More targeted measures, such as catchment management measures will be adopted on a plan by plan basis, if partner organizations, such as the National Trust or water companies, have the resources to undertake the measures. (POSTnotes, 2008). Since the RBMPs have been published for each RB all over the UK (with the exception of Gibraltar), the preliminary PoMs, as presented for Spain in the previous section, have already gone through the process of participation, and hence are no longer available to the public. However, the RBMPs contain the prioritized measures according to the cost-effectiveness analysis. The author has chosen a concrete RB in the UK, the Dee RBD in Wales (Figure 3), to describe some measures that are being taken to address the main pressure in order to achieve the good status in 2015: nutrients. The Dee's RBMP describes the river basin district and the main pressures that the water environment faces: phosphates and nitrates, abstractions, pesticides, invasive non-native species, among others less severe. It shows what this means for the current state of the water environment, and what actions and which programme of investigations will be taken to address the pressures, particularly those associated with diffuse pollution. It sets out what improvements are possible by 2015 and how the actions will make a difference to the local environment.

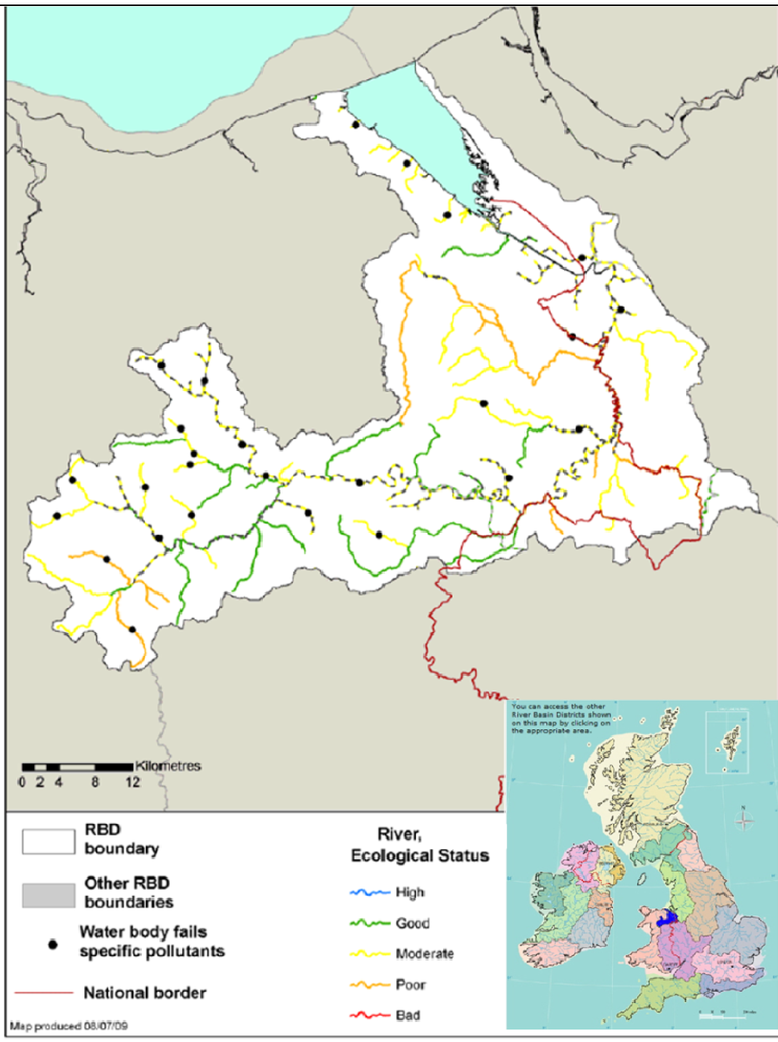


Figure 3. Ecological Status of the Dee RBD. Source: Adapted from: Environment Agency. River Basin Management Plan, Dee River Basin District. Current state of waters, 2009

At the local level, the Environment Agency works closely with a wide variety of organizations and individuals to deliver the commitments contained in the plan. The PoMs or planned actions are mentioned generally for the whole RBD, and later into detail for each river catchment within the district. Decisions on the management measures at the catchment level need to balance competing local priorities, which cannot be achieved through consideration of the scientific advice alone. They require appropriate mechanisms of engagement between public bodies, local stakeholders and the wider public.

The RBMPs offer a clear description of every pressure, where exactly in the RBD it represents a risk for the water quality, which measure will be taken, the location or geographical extent of the action, and finally, the organization responsible for delivering the action and other organizations that may be involved. The actions are assigned to the sectors originating the pressures: agriculture and rural land management, industry, mining, navigation, urban and transport, water industry, etc. Each sector is characterized for several activities originating pressures. Very often, when the same pressure comes from different sectors, the measures are the same for those sectors. The PoMs starts with a long list of actions that any individual can take at his house, garden or office in order to prevent water pollution, protect wildlife and save water. They are some simple measures such as: ensuring that household oil storage is in good condition, with an up-to-date inspection record; to check that household appliances are connected to the foul sewer, not the surface water drain; to seek expert advice to eliminate invasive non-native species from gardens, disposing of them responsibly and to not buy, plant or release invasive non-native species, etc. Those measures are followed by the ones segregated according to the sectors.

The Dee River Basin District is mainly rural in character; agriculture and forestry are the dominant land uses. The agriculture and rural land management sector impact water quality in a number of ways. Agriculture is an abstractor of water, as well as a source of pollution. Pollution of the water environment occurs as sediment, manure, fertilizers and pesticides, which enter rivers, estuaries and groundwater causing ecological impacts and affecting the quality of water supplies – sometimes driving expensive water treatment. These runoff problems are likely to be exacerbated by predicted climate change. The most significant pressures are those related to nutrients, organic pollutants and sediment. The measures synthesized in the RBMP are listed below.

- Influence Town and Country Planning Act authorization process to help minimize risk of diffuse pollution from new developments (e.g. implement sustainable drainage systems and use of Water Resource Act Planning Guidance).
- Follow The Code of Good Agricultural Practice - comply with published advice for operators on nitrate control.
- Implement the Planning Policy Guidance Statement on controlling pollution of groundwater. Where appropriate, submit to the Environment Agency making an adequate case to the Secretary of State and/or Welsh Minister and carrying out a

twelve week public consultation designating a limited number of Water Protection Zones. Regulatory tools to control diffuse pollution in high risk areas where other mechanisms are not working or are unlikely to work.

- Comply with Environment Agency notices. Make use of site-specific notices to remove nitrate pollution risk to groundwater.
- Enforcement of Sludge Regulations on controlling nitrate releases to land and water
- Implementation of site specific notices to remove nitrate pollution risk to groundwater.
- Local agricultural partnerships e.g. NGOs such as Rivers Trusts, Landcare, Farming & Wildlife Advisory Group - Advice to farmers on nitrate control.
- Implement new regulatory approach (via Environmental Permitting Regulations) arising from implementation of new Groundwater Directive (2006/116/EC)
- Use of statutory notice powers (WRA S86 and S161, Groundwater Regulations, Silage Slurry and Agricultural Fuel Oils Regulations).
- Establish and enforce Nitrate Vulnerable Zones in catchments at a high risk from nitrate pollution, requiring farmers to follow a programme of measures to reduce nitrate entering the water from farmland.
- Establish and maintain a nationally funded advice-led programme under the Environment Agency Wales Catchment Initiatives to influence land management to bring about changes in practice that are likely to impact water quality and achieve multiple outcomes – integrating diffuse pollution mitigation with habitat creation, localized flood risk and fisheries issues.
- Targeted catchment campaigns to ensure effective implementation of codes of good agricultural practice.
- Education, training and awareness on diffuse pollution issues associated with forestry and woodland management.
- Farm visits and investigations, education and awareness campaigns - targeting rural catchments identified as having significant diffuse pollution problems. Agri-environment schemes/ Environmental Stewardship - payments for best practice to limit nitrate input and control agric-chemicals.

- Reduce diffuse pollution and overland flood flows by undertaking woodland planting, including wet and dry woodland, and hedgerow restoration work
- Maintain the Higher Level Stewardship Scheme offering farmers an incentive to achieve environmental benefits over and above those required under the Entry Level Stewardship Scheme.
- Target land management measures through an "agri-environment scheme" and agreements to mitigate diffuse of drainage to enhance biodiversity and achieve favorable conservation status. These measures will include: fencing watercourses where cattle are part of the farm enterprise; improving crossing points for streams and ditches; separating clean and dirty water in farmyards, raising water levels and changing drainage regimes, etc.
- Convince landowners to establish a "Favorable Conservation Management", notably by grants to aid the fencing off of sections of the river. This should reduce bank erosion by livestock, reduce sedimentation/fecal matter.

Most of the measures are mainly focused on the training of good practices and awareness, but no legally binding ones are suggested, such as controlling the intensity of farming or limiting the application of fertilizers. Nevertheless the document analyzed was a synthesis of the PoMs, so there is the possibility that these measures are narrowed down into more restrictive ones in the formal report that is not longer available to the public.

VIII. SUMMARY AND CONCLUSIONS

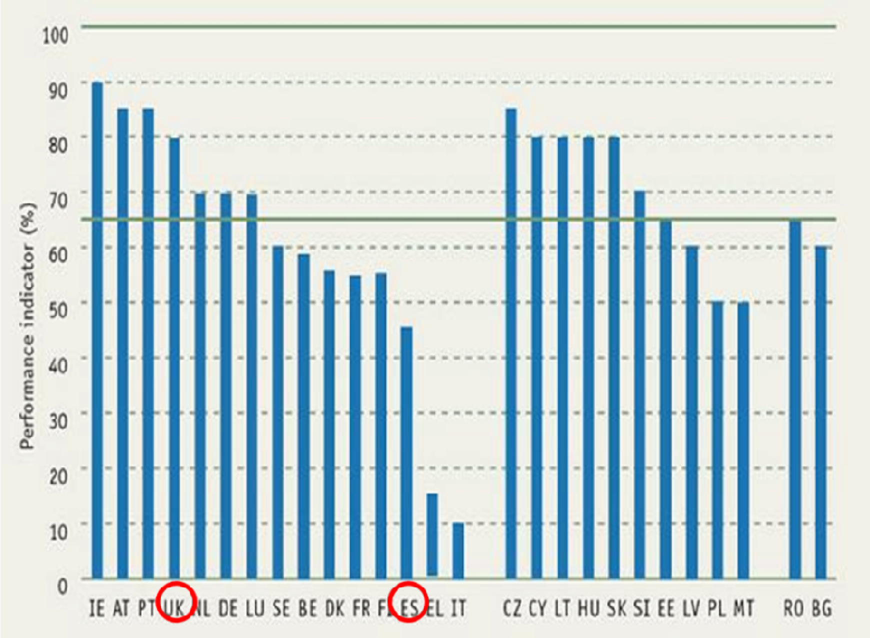
The EU WFD: the most significant water legislation Europe has ever seen

Water is vital for all living things. Rivers, lakes and wetlands support a variety of wildlife and habitats. However, the environmental need for water must be balanced against human water use. Water is obviously needed for the economic development of a country: agriculture, industry, tourism, etc. Very often the balance between users and the environment is not sustainable and water-based ecosystems are under threat. This harm risks becoming irreversible at some point, subsequently causing adverse effects on human water uses, with associated negative impacts on economy and human health. The WFD is the most significant water legislation Europe has ever seen (Neil Tytler, 2005). Its ultimate aims are for water to be sustainably managed at a river basin level and for water quality to reach good ecological status by 2015 (with extensions and less stringent objectives available). The Directive brought us a new concept: 'the environmental flow', which refers to the amount of water needed in a watercourse to maintain healthy ecosystems. Water is increasingly considered as a patrimony. The water policies objectives these days are more oriented, or are, at least, on their way towards the protection of the ecosystems and water bodies; preventing additional damages and allowing sustainable water use in the long run. The WFD sets out water policy much more restrictively than any previous one in terms of environmental issues. It emphasizes on the protection of the water systems both in the quantitative and qualitative aspect. This might force present administrations to improve many questions deficiently addressed at present such as river basin planning, control of discharges and water scarcity. The process of implementation of the WFD in Spain and the United Kingdom was and is an opportunity to change and improve the procedures of decision making in water issues and to establish solid basis for a sustainable water management which will allow reaching the Good status of the water bodies in 2015 or sometime soon after. Both countries experience, slowly but surely, a change of mentality with regard to the water resources.

Pace of implementation: it's not a race, but the sooner the better

The pace for the WFD implementation is much faster in the UK than it is in Spain. While Spain experiences noteworthy delays, the UK has reported all the documentation required until today. Figure 1 gives an idea of each EU MS's compliance with the WFD reporting. The European Commission evaluated the punctuality for the submission of the reports due for Articles 3 and 5, their clarity and exhaustiveness.

Figure 1: EU Comparison of Member State Compliance with Water Framework Directive Reporting. Source: EPA, 2007.



UK is within the Member States that have a good reporting performance and that can provide an example of "best practice" for others. It is a good start towards meeting the objectives, but nothing can be said about the quality of the implementation before their work is checked by the European Commission.

Spain is located under the average, often providing the reports late and in a quality that made the compliance assessment difficult. Assuming that the implementation is more advanced today (this report is some years old), Spain can achieve much better results in the compliance assessment if it provides better and more timely reports in the future.

Identifying water bodies and dividing the country into planning units

WFD requires Member States to set up the appropriate administrative arrangements in order to apply effectively the provisions of the Directive and achieve its objectives. In both MSs, Spain and the UK, there are implementation structures which involve a variety of authorities and public bodies.

As regards the size of the river water bodies, large differences exist between the UK and Spain. Rivers are much shorter in the UK. However, no conclusion can be drawn at this moment on the influence of the size of the water body on achieving the environmental objectives of the Directive or the administrative consequences.

The designation of river basin districts has taken place in both countries on the basis of hydrogeographic boundaries. The grouping of smaller river basins into a river basin district has been applied in a meaningful way in the UK, since there are many small catchments in its territory that often drain directly into the sea.

For Spain, the formal designation of river basin districts has not yet been totally completed since the delimitation of coastal waters is still missing for some RBDs. In accordance to the water law, a Royal Decree sets up the administrative arrangements. This Royal Decree has entered into force very recently and the European Commission is currently analyzing its contents.

The Directive proposes two methods to classify river typologies, based in physical and geomorphological parameters. The system A is the simplest, based on three attributes: altitude, basin size and geology. This is the one chosen by the UK for its characterization. System B, used in Spain, allows for more attributes, some of them related to more peculiar characteristics of the river and the basin. The UK foresees its application of System B as soon as they consider having enough data.

Due to the peculiar hydrological regime in Spanish rivers, many of them carry water sporadically along the year and it does not seem reasonable to consider them water bodies. For that reason an additional hydrological criteria was considered: river basin surface over 10 km^2 and mean annual flow over 100 L/s. Remote sensing techniques and fieldwork were developed in order to elaborate a map that classifies, according to the irregularity of flows, the water courses into two main categories: continuous flow and ephemeral flow.

Reference conditions: the base of the pyramid

The ecological status is judged by the degree to which present-day condition deviates from those in the absence of anthropogenic influence, termed reference conditions. Sites in which the biological, morphological and physicochemical elements correspond to undisturbed conditions are classed as High status. Four further categories of Good, Moderate, Poor and Bad status refer to the degree of deviation from the reference state. The establishment of reference conditions is the basis for the classification schemes, with consequences for all subsequent operational aspects of the implementation of the WFD (including monitoring, assessment and reporting).

There are relatively few sites across the UK at which all quality elements are in reference conditions and from which data suitable for establishing reference values are available due to previous deterioration of UK rivers. Consequently, reference values have been derived from sites at which the quality element concerned is estimated to be in its reference condition but other elements at the sites may not be so (UKTAG, 2007). That might contribute to the adoption of lower standards for some river types. In the UK there is a report describing the type specific reference condition for rivers, in a very descriptive way, but no intervals of values are available, which made the comparison with the Spanish values impossible to do. In Spain the legislation recently embraces in the Order ARM 2656/2008 certain intervals of values for the reference conditions and those cataloging the ecological status for water body typology. Not many parameters are included, but it is considered an important and solid step to start the homogenization of protocols within the RBDs. Selecting a river portion free of human alteration represents also a big problem in Spain, due to the little information available about the river ecosystems and the difficulties to find unaltered river bodies. According to the WFD the water bodies slightly altered must be determined using the results from the analysis of pressures and impacts, which are incomplete. This situation could lead to an undesirable result of having significantly degraded environments classified as High status waters.

Achievement of Good ecological status, how realistic is the WFD objective?

A very positive aspect of the Directive but a great challenge at the same time is the intention of unifying the sets of parameters to evaluate water status and other methodologies with regard to controlling systems and monitoring. This can help to avoid disparity and dispersion, and at the same time incertitude and distrust about the data supplied by the different competent water management authorities, which is currently one of the biggest weaknesses of the implementation, as is the case in Spain.

In Spain, as in the UK, there is a long tradition of determining water quality from the concentration of certain substances that are known to be harmful for the ecosystems and human consumption. Nevertheless, if we were to pick randomly a small stream to assess its ecological status according to the Directive benchmark, several difficulties would be found to determine the specific indicators more suitable for that water body, the methodology and the interval of values from which evaluate if such fragment of river has a High, Good, Moderate or Bad status.

As confirmed by telephone calls made to different RBD planning authorities, it seems that no coordination in the action mechanisms exist at all within the country, and very few of them knows about the methodologies followed by the other, even if some RBDs are highly advanced in some aspects of the implementation. For instance, the Catalonian RBD is highly developed in terms of evaluation of water ecological status, and has developed a set of biological indicators and methodologies to assess the ecological status of the water bodies. Nevertheless it does not seem that other RBDs have followed this example. This could be due to the lack of communication already mentioned and to the fact that the information available for the Catalonian RBD is available just in the Catalonian language.

The evaluation of the water status in Spain is incomplete because there is not yet common methodology for all the RBDs. It is surprising that five years after the publication of the IMPRESS document, no data regarding to the whole country has been published. The studies available in different formats for every RBD show that close to the half of the water bodies present an ecological status inferior to Good.

There are more than ten benthic macroinvertebrates indicators spread over the different RBDs in the country. The same is the case for fish indicators; more than ten different indicators are used but no contribution is made to the European intercalibration process, neither any attempt for the homogenization has been seen at the national level. Even if many RBDs in Spain seem to be developing serious technical bodies to define methodologies and to characterize the ecological status, it is not clear that those efforts will be transformed into a high level of exigency for meeting the environmental objectives of the WFD. In this respect it is of great importance to perform a national intercalibration that proves that the obtained results have the same scientific quality and comparability.

In contrast, in the UK, they have fewer methodologies for the assessment of the biological status but they are widely used. Agreement and cooperation among different authorities can be perceived in the way they act together and set up a common institution (UKTAG) that often work together with the Environment Agency to homogenize the characterization of the water bodies, the status monitoring and the determination of the PoMs needed to achieve Good status for 2015.

UK is one of the four Member States with more than 50% of their water bodies provisionally identified as heavily modified or artificial (European Commission, 2007). In Spain the identification of heavily modified water bodies has not been completed, but is estimated to be about 20% of the water bodies. This situation leads to a systematic reduction of the reference status conditions in the UK and confers exceptions to meet Directive’s objectives. They won’t be required to achieve Good ecological status for more than half of their water bodies, but Good ecological potential. As a result the economic effort of the WFD implementation in UK is comparatively less than what is required for Spain, who will need to struggle much more in order to meet the objectives. This is one of the reasons why Spain was not able to report in time and the preparation of the RBMPs will probably take several extra years in which additional and significant efforts must be invested. This means that it might not be possible to implement the Directive within the deadlines agreed by the Council and the European Parliament, and it is very likely that the objective of Good status for all the waters in 2015 will end up being too ambitious for Spain and other countries in a similar position.

Significant pressures: intimidating risk of not meeting the WFD's objective

One of the main objectives of the Article 5 analysis is to identify the water bodies that are at risk of failing to achieve the WFD objectives. This is considered an important knowledge base for the development of the river basin management plans, as these water bodies will be subject to the PoMs or to the application of exemptions to the objectives, if applicable.

Figure 1 shows the results of the risk assessment in Spain and the UK submitted to the European Commission.

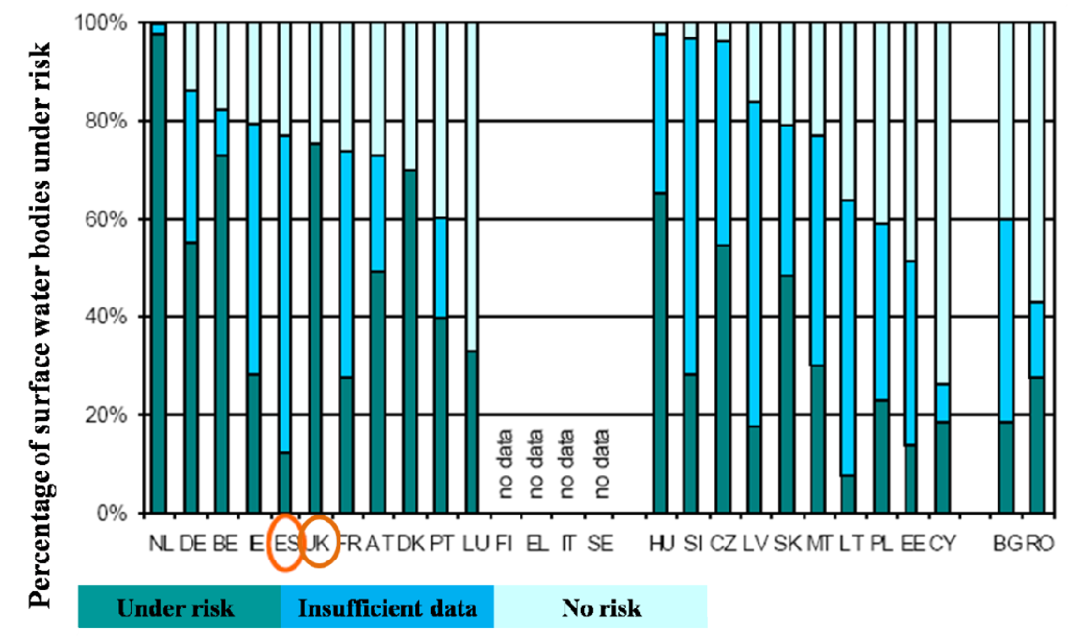


Figure 1. Current situation of the European surface water bodies. Risk analysis 2005. Source: Adapted from: European Comission, 2007.

It should be noted that the percentages in the figure do not correspond entirely with those found previously in the documents available (about the evaluation of pressures for both countries). A high percentage of water bodies were identified as at risk of failing to meet the WFD objectives by 2015 in the UK, where about 76% of the river bodies are under risk. Nevertheless just 13% are at risk in Spain, but given the big uncertainty caused by the lack of data (65% of the surface water bodies are still under study), that risk percentage could rise in the future. According to the Spanish research institution FNCA (2010) it is very likely that a considerable amount of water bodies still under study are truly in risk of not meeting the Directive's objectives. If this last forecast is confirmed true, the amount of water bodies under risk will be even for both countries (see Figure 1 above).

These high figures can be attributed to a number of reasons. First, the WFD establishes new environmental objectives addressing pressures and impacts that were not considered in previous water policies, for example hydromorphological changes. Second, the limited information on how some of these newly addressed pressures actually impact the aquatic ecosystems may have led in general to a precautionary approach, contributing to an increase in the percentage of water bodies identified as at risk or under the insufficient data category. In addition to that, at the moment the risk assessments were carried out, a precise operational definition of the WFD water status classes was not available, and this fact may have also played a role in increasing the uncertainty of the results for a significant number of water bodies. Both Member States based their risk assessment on current impact data.

From the available information, it can be concluded that diffuse source pollution is the major factor affecting UK waters. For Spain it is not so clear if it is point source or diffuse pollution. Those pressures are followed in importance by water flow regulations/morphological alterations. Water abstraction, in contrast with what was thought, especially in the case of Spain, is said to be a less important pressure.

Programme of Measures, the door to the Good status

For the drawing up of the PoMs in the UK, the origin of the pressures was attributed to the sector responsible for the impact, and specific actions were assigned to the competent authority responsible of each sector. In addition, the measures were subjected to a process of public participation, evaluated according to a cost-benefit analysis, specified in terms of the financing authority and localized in space and time. In Spain the situation is again not suitable for comparison, since 24 out of 27 RBDs have not gone further than establishing a report of “important questions to be addressed” in some RBDs much time will pass before the draft of the PoMs required for the final RBMP will be available to the public. This list of “important issues” includes many general actions not very specifically defined in terms of the sectors generating the pressures, organizations in charge of putting the measures into practice, and timeframe.

A successful and well implemented PoMs is presented by the Directive as the ultimate key to achieve the Good status of water systems. In this regard, the measures, according to the WFD will have to be running on 2012, whether the formal RBMPs are finished and submitted or not. In essence, the achievement of the Directives’s objectives will depend on the governments’ position and their political will to invest the necessary amount in the realization of the measures. The government decisions often lean toward giving priority to the economic sectors (agriculture in Spain and industry in the UK), rather than to the environmental protection. This conflict of interests within the regions is the main barrier to a significant progress of the implementation. This problem can be faced by an effective rising of general awareness and sensibility oriented towards the importance of water quality improvements and the need of decreasing demand. Such challenging task can only be achieved through efficient public participation and enhancement of cooperation within authorities in the same RBD, institutions representing the economic sectors, and the public.

Where is the information when I need it?

The main difficulty addressed during the preparation of this thesis was without a doubt the analysis of the documentation available for each river basin district and competent authorities, especially in Spain where the restricted accessibility of the information supplied was often characterized by its questionable quality and lack of consistency. According to Francisco Delgado (2003), (Spanish doctor in law specialized in water policy) it would be very naïve to intend to meet the ambitious objectives presented by the Directive taking into account the existing limitation of material and human means that characterize the country's water administration. He states that in order to overcome this challenge it is essential to perform a drastic modernization of the river basin authorities and an increase of their means, especially human, in accordance with their attributed functions and responsibilities. This is something to think about especially in the period of economic restlessness Spain is experiencing. A great effort needs to be put forth in the years to come if the WFD objectives are to be met. Said effort must be supported by obtaining and monitoring reliable data that is missing at present. Such energy will certainly be compensated in the future with a greater facility for water management and planning, and long term with a notable improvement of the water bodies.

Ten thoughts to go home with

Finally, the main conclusions drawn up from this Master's thesis are summarized in the following ten paragraphs:

1. The UK and Spain are different in terms of the existing social vulnerability to water quantity. In Spain the water shortage is much more severe, a fact which results not just in quantitative but also qualitative problems (caused by the diminishing of the dilution capacity of river bodies). The consequence is that higher economic effort is needed for the achievement of the Directive's objectives in comparison with the UK.

2. In Spain there are a number of significant shortcomings in the implementation. In particular the legal transposition of the Directive into national law is poor and inadequate. The Article 5 analysis has been carried out with a low level of detail, and the RBDPs have not been produced for most of the RBDs.

3. Significant difficulties were found in Spain for the intercalibration and determination of methodologies for the characterization of the water bodies, especially the determination of biological indicators for the ecological status.

4. The percentage of artificial and highly modified water bodies is much higher in the UK, which leads to a systematic reduction of the reference status conditions and confers exceptions to the Directive's objectives. This decreases the economic effort of the WFD implementation in UK with respect to the one in Spain.

5. The pace for the WFD implementation is much faster in the UK than it is in Spain. While Spain experiences a noteworthy delay, the UK has reported all the documentation required until today. It is for the UK a good start towards meeting the objectives, but no congratulations can be given for a "high quality implementation" before their work is checked by the European Commission.

6. An equivalent analysis of the risks experienced by the assessed countries is not totally possible since insufficient data has prevented Spain to present a conclusive risk assessment for a large percentage of water bodies. The intensity of the pressures and impacts in UK rivers are extremely high being the diffuse source of pollution the most relevant. Spain is likely to experience a similar amount of water bodies under risk.

7. A truly representative comparison of the effectiveness of the achievements of the Good ecological status for UK and Spanish waters is not possible due to the fact that in Spain the RBMPs have not been yet approved.

8. In the case of Spain, a great effort in terms of human resources and economic means needs to be put in the years to come if the WFD objectives are to be met.

Said effort must be supported by obtaining and monitoring reliable data that is missing at present.

9. In essence, the achievement of the Directive’s objectives in both countries will depend on the government’s position and their political will to invest the necessary amount in the realization of the PoMs. The conflict of interests of sectors and authorities within the regions is the main barrier to a significant progress of the implementation.

10. This Master’s thesis on the implementation of the Water Framework Directive illustrates that both countries made significant steps forward 'Towards Sustainable Water Management in the European Union'. However, there is still a long and challenging road ahead.

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