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Comparative analysis of the implementation of the Water Framework Directive in Austria and Scotland

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supervised by

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Affidavit

I, **ALEXANDRA BOYER**, hereby declare

1. that I am the sole author of the present Master's Thesis, "COMPARATIVE ANALYSIS OF THE IMPLEMENTATION OF THE WATER FRAMEWORK DIRECTIVE IN AUSTRIA AND SCOTLAND", 120 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

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Abstract

Water is one of nature's most important resources and it is essential to life. Although about 70% of the earth's surface is covered by water, only 1% can be used as drinking water. Due to rising populations and economic interests our water resources are more and more under pressure and water quality and quantity protection is one of the major issues that our society has to deal with. The European Union recognized the high importance of water protection and introduced a new, European-wide and overarching piece of water legislation – the Water Framework Directive (WFD). The main aim of the WFD is to achieve "good ecological" and "good chemical" status for all European water systems by 2015. In this respect, the WFD prescribes a comprehensive system for river basin management and water quality assessment, which is based on a continuous six-year reporting cycle and which had to be transposed by the Member States into national law by the year 2003. The regulations within the Directive serve as a "framework" and therefore the detailed translation into national law was left up to the Member States. For this reason, the applied technical methods, administrative procedures and timely implementation can vary greatly between different European countries. This Master thesis describes the implementation of the provisions of the WFD in two selected Member States – Austria and Scotland. The focus of the analysis was given especially to the determination of the water quality status, the Programme of Measures (PoMs), as well as cost-effectiveness of the PoMs. For this purpose a literature study was conducted, taking into consideration national and international technical reports, legislation and scientific papers. In general it can be said that Austria and Scotland have a lot of similarities, in particular concerning water body characteristics as well as pressures and impacts on the water bodies. Both countries have developed comprehensive national instruments for the implementation of the provisions of the WFD and can serve as best practice for other Member States. Methodical differences can be found mainly in regard to the structure and focus of the PoMs, as well as to the cost-effective analysis. Austria and Scotland represent countries, which might have fewer environmental problems than other European countries, however, both countries will not be able to reach "good ecological status" for all water bodies by 2015. This implies that the envisioned objective in the WFD is too ambitious and that a "step-wise" approach to reach the goal in 2027 might be the best solution.

We forget that the water cycle and the life cycle are one.

- ***Jacques Cousteau***

A river seems a magic thing. A magic, moving, living part of the very earth itself.

- ***Laura Gilpin - From The Rio Grande, 1949***

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List of acronyms

AWB	Artificial water bodies
CAR	Water Environment (Controlled Activities) Regulations 2011
CEA	Cost-effective analysis
CEC 1975	Directive concerning the quality of surface waters intended for the abstraction of drinking water (75/440/EEC)
CEC 1976a	Directive concerning the quality of bathing water (76/160/EEC)
CEC 1976b	Directive concerning pollution caused by dangerous substances discharged into the aquatic environment (75/440/EEC)
CEC 1978	Directive concerning the quality of fish and shellfish waters (78/659/EEC) and (79/923/EEC)
CEC 1980a	Directive concerning quality of water for human consumption (80/778/EEC)
CEC 1980b	Directive concerning the protection of groundwater against pollution caused by certain dangerous substances (80/778/EEC)
CEC 1991a	Directive concerning urban waste water treatment (91/271/EEC)
CEC 1991b	Directive concerning protection of water against pollution by nitrates from agriculture (91/276/EEC)
CIS	Common Implementation Strategy
CRP	Collaborative Research Programme
DEFRA	Department for Environment, Food and Rural Affairs
DPMAG	Diffuse Pollution Management Advisory Group
EQR	European Quality Ratio
GIG	Geographical Intercalibration Groups
EC	European Commission
HWMB	Heavily modified water bodies
NGP	Nationaler Gewässerbewirtschaftungsplan
PoMs	Programme of Measures

RBD	River Basin District
RBDs	River Basin Districts
RBMP	River Basin Management Plan
RBMPs	River Basin Management Plans
SEARS	Scotland’s Environmental and Rural Services
SEPA	Scottish Environment Protection Agency
SUDS	Sustainable Urban Drainage Systems
UKTAG	UK Technical Advisory Group
WFD	Water Framework Directive

1 Introduction

1.1 Background and motivation

The issues of water shortage and water quality degradation are among the major current and future challenges for humans. Also in Europe, water bodies are more and more subject to increasing pressures resulting from continuous economic growth, increased land use and urbanization. Taking into account these problems and the scientific evidence of water shortage and water quality problems in the future, the European Union decided in 1995 to elaborate a substantial European-wide water policy. Five years later, in the year 2000, the European institutions adopted this new policy – the Water Framework Directive (WFD). The WFD introduces an innovative integrated water management system focusing on the protection of the ecological quality of all European water systems. This idea of a common sustainable water management system will bring a radical change in mentality not only to the responsible water authorities but also to all other relevant stakeholders and to the public (Holda 2005, p. 1).

Before the adoption of the WFD, water management was mainly a national issue, regulated through national regulations. The WFD is the first European-wide legislation, which addresses the water bodies according to their natural flow and belonging to catchment areas across national boundaries. Furthermore, the focus is not only on the prevention of the deterioration of water bodies, but also on the improvement of the chemical and ecological quality. The main goal of the Directive is to achieve "good ecological status" and "good chemical status" for all European surface water bodies, "good quantitative" and "good chemical status" for ground water bodies, and "good ecological potential" and "good chemical status" for heavily modified and artificial water bodies by 2015 (Holda 2005, p.1).

To achieve the above-mentioned goal, the Member States had to identify national and international "River Basin Districts" (RBDs) and establish respective authorities for each RBD. All surface water bodies within these RBDs had to be divided into different water body types according to their natural characteristics, representing the "*classification and management unit of the Directive*" (Ortega 2010, p. 2).

As a next step, the task was to set up monitoring networks in order to determine "reference conditions" (which are defined as "natural" conditions) for all water body types and to facilitate a continuous surveillance of the defined biological, physico-chemical and hydro-morphological quality elements. Through the comparison of the data of the monitored quality elements with reference conditions, the member states had to define the actual ecological status (high, good, moderate, poor or bad) for each water body and at the same time identify water bodies, which are at risk of failing the envisioned goal within the WFD.

Additionally, an analysis of the anthropogenic pressures and impacts for all water bodies had to be conducted. Building on the results of the analysis, measures to mitigate the identified pressures and impacts had to be developed. The so-called programme of measures (PoMs) forms the main part of "River Basin Management Plans" (RBMPs), which have to be produced every six years and are the main reporting tool about the current status of the national/international water bodies to the European Union.

The WFD sets clear objectives to be achieved and regulations to be transposed into national laws. However, it recognizes the diverse conditions and needs in the Community and therefore solutions adjusted to regional conditions with responsibility lying with the local authorities are suggested. Therefore, a significant level of flexibility is given to the Member States concerning the determination of methodologies and measures applied to reach the objectives envisioned in the WFD. In that sense, the implementation of the WFD is not only shaped by community law, but also by national laws (Castillo 2010, p.1; Holda 2005, p. 1).

For this reason, the implementation of the WFD in different Member States can be very different. For the harmonization of methodologies and assessment methods, specifically in relation to the determination of the "good status", a European wide "Common Implementation Strategy" (CIS), which provides advice and guidelines to the Member States, has been established. Many Member States apply the recommendations given by the CIS, however the national regulations, methodologies and assessment methods can still be very diverse and the implementation of the WFD has evolved in uneven pace. In this sense, not sufficient research has been done to assess the differences in the implementation of the WFD between countries. In order to get an insight in how the regulations are transposed into national laws and how successful the applied methods and measures are in complying on the one hand with the regulations of the WFD, and on the other hand in achieving the objective to reach “good ecological status” of all water bodies by 2015, it is necessary to assess and compare the various methodologies applied by the Member States.

1.2 Focus of the research and thesis structure

The objective of this Master thesis is to assess the implementation of various aspects of the WFD in two European countries – namely Austria and Scotland. The focus will especially be on rivers and on the determination of the “good ecological status”, the establishment of Programme of Measures (PoMs) within River Basin Management Plans (RBMPs) and the aspect of cost-effectiveness. These aspects have been chosen as they are considered to be “key implementation requirements” and at the same time represent the main innovations by the Directive.

The main research question can therefore be derived as: “What are the differences in the determination of the “good ecological status”, the establishment of “Programme of Measures” and the consideration of “cost-effectiveness” of the Programme of Measures in Austria and Scotland?”

To answer this question, the different methodologies applied to determine “good ecological status” are compared. For this purpose the various steps and aspects of the status determination (typification of water bodies, definition of reference conditions, classification, and pressure and impact analyses) will be discussed and compared between the two countries. Furthermore, the results of these status assessments and the possibility to reach the objectives of the WFD, as well as the methods applied to establish and select the Programme of Measures, with a focus on cost-effectiveness, will be presented and analysed.

The evaluation should lead to the identification of similarities and differences concerning the implementation of the WFD and may detect “best practices” which other Member States could apply in the future.

1.3 Research methodology

In order to analyze the defined aspects of the implementation of the WFD in Austria and Scotland, a comprehensive literature survey was conducted. The selected literature included the national River Basin Management Plans, national legislation, other relevant national documents (e.g. technical reports on methodologies, pressure and impact assessments, etc.), scientific papers published by national universities or other institutions involved in the implementation process and other associated literature.

The literature used was partly found on the Internet, in national libraries or was provided by the main responsible national institutions as the Ministry for Agriculture, Forestry, Environment and Water Management and the Umweltbundesamt in Austria, and the Scottish Environment Protection Agency in Scotland and the Environment Agency of England and Wales. To gather the information, the institutions were contacted directly by telephone and email.

2 Water legislation in the European Union

2.1 Social and economic developments influencing water legislation

The motivation for new water guidelines was a response to a changing socio-economic and political environment, which can be classified into three different parameters of change.

The first parameter is the increasing public concern for the environment. Due to technological progress the socio-economic and political environment changed rapidly during the last century. In the 1970s, more and more people became concerned about the effects of these developments on the environment and "green parties" and environmental groups flourished. Nowadays, environmental protection is almost on every political agenda and has institutionalized in Non-governmental organizations (NGOs), quasi- Non-governmental organizations, regulatory bodies as well as civil environmental groups (Dietz et al 1988; Kaika 2003;).

These facts lead to the second parameter, which is the changing number of participants in the water sector. The growth of urban areas created the need of new quantitative and qualitative water management programs in order to cope with the growing water demand and to manage and reduce the ecological footprint. The growing demand often could not be met with local resources and made it necessary to import water from abroad. This development called for the establishment of international institutions to independently manage international water sharing agreements. Furthermore, the ongoing market liberalization enabled private business to become new actors in the water market creating the need for new institutional regulations. The water market is therefore not anymore subject to state-led decisions; it became a complex "*set of actors and institutions, such as governmental organizations and industrial organizations, which are necessary to regulate and control the market*". (Kaika 2003, p. 6).

The third parameter, as analyzed by Kaika (2003), is the multiplication of actors in the water industry. This fact led to a diversification of the decision-making process as the institutions involved in the water sector now do not only have to deal with water management on national level, but also on European and international level. This development reflects the shift from state (government) controlled management to fragmented decision making clusters (Jessop 1997).

2.2 The history of EU water legislation

According to Kallis et. al. (2001), the history of European water and environmental legislation can be subdivided into three periods.

During the first period (from 1973 – 1986), the European Union could only regulate "*areas affecting the core objectives of the Community*" (Kallis et. al. 2001, p. 126). The EU mandate was therefore very limited and affected mainly public health protection. The water related legislation acts enacted during this time can be classified into water use directives and water pollutant directives (Somsen, 1990). The directives for water use set quality standards for drinking water (CEC 1975), water for bathing (CEC 1976a) and for fish and shellfish harvesting (CEC 1978). In contrary, the water pollutant directives were intended to regulate levels of discharges of pollutants. This happened through the directive for the emission of dangerous substances to surface (CEC 1976 b) and the directive for ground water bodies (CEC 1980 b). Additionally, the EU elaborated two lists of harmful substances. In the first list, emission limits and quality standards were set by the European Commission while in the second list the member states had to prepare programs for the reduction of certain substances (Kallis et. al. 2001, p. 127).

During the second period (1987 – 1992) the EU was assigned to establish a common environmental policy as it is stated in the Treaty of Maastricht 1992. During a meeting of Europe's environment ministers in 1988 a number of gaps of the community water legislation were identified. Major concerns were the worsening of the quality of ground, surface and coastal waters especially through eutrophication. According to Kallis et. al. (1999) the strategy of the European Union was "*Prevention at source" and "guided the development of the two subsequent directives for the control of pollution from urban wastewater disposal (CEC 1991 a) and the control of* *diffuse nitrate pollution from agricultural uses (CEC 1991 b)*" (Kallis et. al. 1999, p. 8). The success of national implementation of the two directives varied greatly. Member states were at first place very concerned about the high implementation costs of the urban wastewater directive but as the directive gained a lot media and public attention, it was of high importance in national policy agendas and the costs were dispersed among the urban communities. For these reasons the implementation of the directive was satisfactory with very few local exceptions. In contrary, the Nitrate directive was the first environmental framework legislation of the European Union. The extremely poor implementation success of the nitrate directive (only five countries have established correspondent programs, 13 countries were non-compliant and five countries failed) is on the one hand a warning signal for the effectiveness of framework directives, but can be explained on the other hand by the difficult situation in the agriculture sector (European Parliament 1998). Due to fewer subsidies for farmers, it was a politically hard task to convince them to carry the implementation cost of the directive (Kallis et. al. 1999, p. 6-7).

During the Ministerial Summit in Frankfurt in the year 1988, the first discussions came up to safeguard the general ecological quality of all waters on European level. The heated debates were about legislation on European level versus subsidiary and deregulation. These catchwords characterized the third period of European water policy and ended in the Water Framework Directive (Kallis et. al. 2001, p. 128). According to Kaika (2003) it is a combination of "*preceding approaches and provides a common framework for EU water policy*" (p. 4).

In 1995, the Environment Commission of the European Union, the Environmental Commission of the European Parliament and the Council of environment ministers agreed to initiate and elaborate a more global European-wide water policy. In the following year, the European Commission made a first draft (COM (96) 315) to record these ideas. Negotiations for the Water Framework Directive turned out to become a difficult task for the European Union as the member states had different views. Some countries, like France and the UK, wanted a more decentralized and deregulated approach and called for less stringent standards as they feared high costs of implementation. On the other side were member states like Germany and Denmark which already had more stringent water and environmental standards and the European Parliament which according to Kallis et. al. (2001) "*has always maintained a strong "pro-environment" position*" (p. 129). They pushed for a centralized

European water approach (with an European inspectorate body, binding ecological standards and strict public health standards for drinking and bathing water) and highlighted the positive past effects of European centralized environmental legislations (Kallis et. al. 2001, p. 128-129).

Another argument for European-wide equal environmental standards was that economic competition could foster a battle for the lowest environmental standards in order to attract company investments. Environmental NGOs and partly the water industry supported these points of view and also pointed on the latest findings of the "state of the environment" report (EEA 1995), which showed a clear deterioration of European water quality, in especially groundwater (Kallis et. al. 2001, p. 129).

It was a difficult task to combine the different approaches into a single water directive. According to Kallis et. al. (2001) this problem turned "*into a political battle for virtually every article of the proposal between the political proponents of the different perspectives and resulted in the first institutional conciliation procedure between the Parliament and the Council since the Amsterdam Treaty*" (Kallis et. al. 2001, p. 129). After a long consultation and communication process between all interested parties (representatives of member states, regional and local authorities, water providers, agriculture, industry, NGOs, environmentalists and water users) the European Commission published a first proposal for the Water Framework Directive in 1997. Three years later, in late 2000, the Water Framework Directive was published and finally entered into force and is since then recognized as one of the "*most ambitious and comprehensive pieces of European environmental legislation to date*" (Usländer 2004, p. 1532).

2.3 The European Water Framework Directive (WFD)

2.3.1 The WFD – and integrated policy approach

The European Water Framework Directive combines former provisions and applies the precautionary principle, preventive action principles, the polluter pays principle and the principle of dealing with environmental damage at source.

The commission explicitly states in the preamble that "*diverse conditions and needs in the Community require different specific solutions*" (WFD 2000, p. 3). Thus the European Commission (EC) suggests solutions adjusted to regional needs and conditions with responsibility lying with the local authorities. Furthermore, the EC highlights that the successful implementation of the WFD depends on "*close cooperation and coherent action at Community, Member State and local level as well as on information, consultation and involvement of the public, including users*" (WFD 2000, p. 3). The future implementation of protection and sustainable management of water into other European policy areas (such as tourism, energy, transport, agriculture, fisheries and regional policy) is declared necessary. The preamble further points out the vulnerability of estuary and coastal waters as their quality strongly depends on the quality of inland waters.

In general, the WFD can be used a common basis for all member states to hold a continued dialogue in order to integrate other policy areas as well. The EC also highlights that the new water management directive will also have a positive economic impact for the member states as for example higher benefits from coastal fisheries. Another positive effect stressed in the Preamble is that through the implementation of the WFD, obligations in other international agreements protecting marine waters, such as the Helsinki Convention 1994 and the Paris convention 1998 can be automatically met (WFD 2000, p. 4-5).

2.3.2 Legislative issues concerning the WFD

On December 22nd 2000, the WFD was published and immediately entered into force. All member states had to transpose the regulations into national law until December 22nd 2003. The deadline for new member states joining the European Union in 2004 was May 1st 2004.

In case that any member state fails to implement the provisions of the WFD, the European Commission can start an infringement procedure according to article 226 of the Treaty Establishing the European Union. If so, the EC would first send a written warning to the member state and sets a time period of 2 months to answer to the incriminations. If the member state does not answer or cannot justify the legal unconformity, the EC will issue a final warning, the so-called "reasoned opinion". Then, the indicted member state has 2 more months to comply with EU law. If not, the EC can bring the case to the European Court of Justice. In case the ECJ decides that European law was infringed, the member state has to take the necessary steps to comply. In the event of incompliance with the judgment, the EC can act according to article 228 and ask the ECJ to issue a financial penalty against the concerned member state (Holda 2005, p. 7-8).

2.3.3 Relationship of the WFD to other directives

The WFD will rationalize the European water legislation, as the provisions of the WFD will replace legislative aspects, which were covered by former legislation. Article 22 of the WFD lists the three directives, which were repealed in 2007, and four directives to be repealed in 2013 (Holda 2005, p. 8; Frederiksen et al 2006, p. 8).

Table 1: Directives to be replaced by the WFD

Directives to be replaced by the WFD	
2007	2013
• Drinking Water Abstraction Directive • Sampling Drinking Water Directive • Exchange of Information on Quality of Surface Freshwater Decision	• Shellfish Directive • Freshwater Fish Directive • Groundwater Directive dangerous substances • Dangerous Substances Directive

The above-mentioned directives still had and have to be transposed by the member states until 2007 or 2013 respectively, when the WFD replaced/ will replace them.

2.3.3.1 Daughter Directives and Decisions included in the WFD

Due to certain obligations in the WFD, special legislations and proposals had to be developed by the European Commission. For example, a new directive for groundwater pollution, which constitutes a respond to the WFD requirement of the assessment of the chemical status of groundwater, was elaborated.

As the WFD also requests the development of river basin management plans and flood risk management plans which are part of integrated river basin management a new flood risk management Directive entered into force in 2006 (Frederiksen et. al. 2006, p. 8).

2.3.3.2 Directives included in the Program of Measures

Eleven Directives contain regulations and measures, which, have to be included into the River Basin Management Plans the member states have to elaborate. These Directives relate to different areas of legislation. Frederiksen et al (2006) classifies these directives as follows:

Table 2: Directives included in the WFD; (Source: Frederiksen et. al. 2006, p.8)

WFD			
Water related directives	**Protection of biodiversity**	**Pressured related directives**	**Procedural Directives**
Bathing Water Directive	Birds Directive	Sewage Sludge Directive	IPPC Directive
Drinking Water Directive	Habitats Directive	Nitrates Directive	EIA Directive
		Plant Protection Products Directive	SEVESO II Directive
		Urban Wastewater Treatment Directive	

Water related directives deal with the quality of water, while the birds and habitats directive relate to protection of biodiversity of the water bodies. The Sewage Sludge, Nitrates and Plant Protection Products Directives relate to the regulation of pressures on water, the procedural directives deal with the requirements for issuing permits and improving safety management for the handling of dangerous substances (Frederiksen et. al. 2006, p. 8).

2.3.4 Objectives of the WFD

The primary aim of the WFD is the protection of European surface waters and ground waters through the creation of a common integrated sustainable water management. Through this common and integrated water management, all water bodies in the EU member states shall achieve a “good status” by 2015 (Mihaiescu 2009, p. 56).

Apart from these key targets the objectives of the WFD, as specified in article 4 of the WFD are as follows (Holda 2005, p. 5):

- Prevent deterioration of the quality status of the water bodies
- Achieve good ecological potential and good surface water chemical status in case of artificial and hydro-morphologically heavy modified waters
- Enhance, protect and restore surface and ground waters
- Support sustainable use of all water bodies (e.g. through effective pricing of water services)
- Reduce discharges of priority substances and abandon discharges of priority hazardous substances
- Secure reduction of groundwater pollution
- Defuse risks and damages of floods and droughts
- Protect the marine environment
- Achieve compliance with any standards and objectives of protected areas by 2015
- Enhance level of public participation in water management issues

The achievement of the above goals should ensure a sustainable and equitable use of water resources, which will be the base for future economic success and social well-being.

2.3.5 Innovations of the WFD

The WFD can be seen as an overarching piece of legislation trying to harmonize European water legislation and to improve the quality of all European water bodies. Page (2003) identified seven key changes of the WFD in comparison to former legislation:

1. **A more integrated approach**: Article 4 of the WFD merges environmental objectives and strategies to reach the objectives for all different types of water bodies - drinking water, bathing water, surface water and groundwater, which before were treated separately. This innovation was a first attempt "*to understand water quality within the broader scientific notion of an integrated system*" (Page 2003, p.4).

2. **River basin management**: Through the WFD water management is now organized according to the hydrological unit of river basins and covers all waters (used and unused). For each river basin a so-called "river basin management plan" (RBMP) will be drawn up and updated every six years (Page 2003, p. 4).

3. **Combination of pollution control strategies**: The WFD combines two existing pollution strategies for surface water bodies - environmental quality standards (EQS) and emission limit values (ELV) to a combined approach (Article 16 of the WFD 2000). Page (2003) defines the two strategies as follows: *"EQSs are the legal upper limits for the concentration of pollutants that can be measured in specific water bodies. ELVs are upper limits for the amount of the pollutant that can legally be released into the environment."* (Page 2003, p. 4). ELVs have to be applied first and have to be implemented using either best available technology or best environmental practice. In case they fail to reach certain EQSs, stricter ELVs have to be elaborated and applied by the Member States. EQSs are set for 33 priority substances in Annex II of the Directive on Environmental Quality Standards, also known as the Priority Substances Directive. (Page 2003, p. 4-5). To reach "good chemical status", the respective surface water body has to comply with all 33 EQS established. For groundwater the regulations are different as "*it should not be polluted at all*" (European Commission 2013c). For this reason, there is a general prohibition on direct discharges to groundwater and therefore no

chemical quality standards are set within the WFD, as this may "*give the impression of an allowed level of pollution to which Member States can fill up*" (European Commission 2013c).

4. **Good water status**: The fourth innovation is the definition of what constitutes "good water status" which before used to be a very broad definition. During the negotiations for the WFD environmental lobby groups surged for making the criteria legally binding. Therefore, it was necessary that the criterion is clear, measurable and specific (Page 2003, p.4). The good status will be defined more extensively in the following chapter.

5. **Water quantity management**: For the first time, regulations for water quantity management were established, which were neglected in former directives. The WFD requests that the abstraction and recharge of water should be in balance. This balance has to be ensured in the river basin management plans. The European Commission predicts that this measure will protect water from an environmental and economic point of view (Agence de L'Eau, 2000).

6. **Water pricing**: The sixth innovation was article 9 of the WFD, which deals with water pricing at full cost recovery. This regulation should help to control the consumption of water in the face of an ever-rising demand. According to Page (2003), this principle was a very controversial issue during the negotiations of the WFD as some countries in the EU charge fees for water whilst others supply it for free and recovers the costs through taxation (e.g. Ireland). At the beginning, the WFD foresaw full-cost pricing for drinking, irrigation and industrial water supply. The Council of Ministers made pressure against this measure and so member states now only have to ensure that the price of water charged to the consumers will "*take into account the full environmental costs*" (Page 2003, p.4). But the WFD still offers the possibility to grant subsidized drinking water supply and wastewater services especially for low-income households (Page 2003, p.4).

7. **More participation in water policy making**: In article 14, the WFD foresees more involvement of the public (citizens, non-governmental organizations, interested parties) especially "*in the production, review and updating of the river basin management plans*" (WFD 2000, p.21).

3 Analysis of the key components within the WFD

This chapter will focus on the assessment of the "ecological status" for surface water bodies and on the analysis of "River Basin Management Plans" (RBMPs) in respect to the Programme of Measures (PoMs) and cost – effectiveness (CEA). These aspects will also be the main components in the case studies of Austria and Scotland in the following chapters.

3.1 Assessment of the water quality status according to the WFD

Article 4 can be seen as the "core article" of the WFD as it defines the environmental objectives. As Holda (2005) states, "*the overall objective of the WFD is to achieve a good status of European Community waters, and that means good ecological status and good chemical status of surface waters and ground waters, by December 2015*." (Holda 2005, p. 13).

The chemical status for surface water bodies is assessed using a two-stage scheme, namely "good chemical status" or "failing to achieve good chemical status". As mentioned in the previous chapter, in order to reach "good chemical status", the respective surface water body has to be in compliance with all environmental quality standards set for the 33 defined priority substances in the Directive on Environmental Quality Standards (European Commission 2013c).

In relation to the "ecological quality status", the European Commission uses a five-stage classification scheme in which the envisioned "good status" represents the second highest standard. The ecological quality is assessed by biological, physio-chemical and hydro-morphological quality elements. For each quality element so-called "reference conditions" have to be established which represent the "high" or "natural" ecological condition. Due to the ecological variability of the water bodies, reference conditions are "type-specific" representing the natural conditions with only minimal anthropogenic influence of the various water body types defined by the

Member States. The ecological quality can then be determined in comparing the type-specific reference conditions, which the measured data for each quality element. This ratio is named "European Quality Ratio" (EQR) and sets the class boundaries between the five status classes (European Commission 2013c).

In order to have a common understanding of what a "good status" means among the member states, the so-called "intercalibration exercise" is carried out by each Member State. The intercalibration exercise plays a key role in harmonizing the environmental objectives and enabling a comparison between Member States (Holda 2005, p. 13; European Commission 2012).

In case of groundwater, the chemical status and the quantitative status has to be determined. Both consist of the two status classes "good" or "poor". The groundwater classification is based on the regulations defined in Annex V of the WFD and in Annexes I – III of the Groundwater Daughter Directive. For groundwater the ecological status is therefore not assessed, but "*the classification process takes account of the ecological need of the relevant rivers and groundwater dependant terrestrial ecosystems that depend on contributions from groundwater*" (Water Framework Directive Ireland 2008).

As mentioned before, the following chapter will focus on the ecological water quality assessment for surface water bodies. In order to determine the ecological status of surface water bodies, the Member States have to ensue the below steps:

1. *Classification of the water bodies*
2. *Definition of reference conditions*
3. *Determination of the water quality status*
4. *Identification of pressures and risks*

Each step will be elaborated in detail in the following chapters.

3.1.1 Classification of the water bodies

The Member States have to identify and classify their water bodies as part of the analysis of the characteristics of their river basin districts (European Commission 2003b, p. 3). The deadline for the completion of the first analysis was December 22nd 2004. This first analysis has to be reviewed and updated by December 22nd 2013.

The CIS Guidance document on typology produced by the working group 2.4 explains the primary purpose of classification and typology as follows:

"The purpose of typology is to enable type specific reference conditions to be established. These then become the anchor for classification systems. Typology has consequences for all subsequent operational aspects of the implementation of the Directive including monitoring, assessment and reporting. Classification and typology should be completed as soon as possible because all successive steps of Annexes II and V build on typology" (European Commission 2003d, p. 35).

This means, once the classification of the water body is performed, the reference conditions can be defined and hence the biological communities corresponding to each water body type (Castillo 2010, p. 7).

The WFD distinguishes in general between the following water systems and gives different water quality targets according for each type (Zessner, 2013a):

Table 3: Water body types defined in the WFD and their quality target; (Source: Zessner 2013a)

Water type	Quality target
Surface waters (rivers, lakes, coastal waters)	Good ecological and chemical status
Heavily modified water bodies (rivers)	Good ecological potential
Groundwater	Good chemical and quantitative status Reversal of trends of deterioration

As it can be seen from table 3, the overall target for surface waters is to achieve "good ecological status" and "good chemical status" in all surface waters by the year 2015. As it will be impossible to achieve this objective for some European water bodies, the WFD allows the member states in accordance with article 4.3, to designate surface waters as “artificial water bodies (AWB) or “heavily modified water bodies” (HMWB). The overall objective for AWB and HMWB is to reach a “good ecological potential” and “good chemical status”, also to be achieved by 2015 (European Commission 2005a, p. 2). For groundwater a good chemical and good quantitative status has to be reached and trends of deterioration have to be reversed. (As the focus of this Master thesis lies on surface water bodies, the assessment of the “good status” for ground water will not be further elaborated).

Concerning surface waters, the WFD (Annex II) requires all Member States to “*identify the location and boundaries of bodies of surface water”* and to *“carry out an initial characterization of all such bodies*” (WFD 2000, p. 29). As the natural status and anthropogenic pressures on the water bodies are very different across Europe, the member states have the right to carry out their classification differently. Following this provision, the WFD suggests a hierarchical approach for the identification and classification of surface water bodies (WFD 2000, p. 29; Castillo 2010, p. 6):

1) Definition of the River basin district (RBD)
2) Division of surface waters into one of six surface water categories
3) Sub-division of surface water categories into types, then assigning the surface waters to types
4) Sub-division of a surface water type into smaller water bodies according to pressures and resulting impacts.

Annex II further lists the following surface water types within river basin districts:

- Rivers
- Lakes
- Transitional waters
- Coastal waters
- Heavily modified surface water bodies
- Artificial surface water bodies

According to the suggested hierarchical approach for water body classification, the Member States have to assign each water body to one of the above listed category. The next step in the process is the type-specific classification. As the diversity of flora and fauna is very different between e.g. fast flowing alpine rivers and slow-flowing low-land streams, according to their physical and chemical conditions, each surface water type has different reference conditions.

Annex II of the WFD proposes two types for the differentiation of water body types, namely System A and System B and allows the Member States to choose between the two systems. System A gives a set of fixed factors to be used for typification, whereas System B provides the possibility to additionally use other optional factors:

Table 4: Comparison between System A and System B for rivers; (Source: WFD 2000, p. 30)

System A (for rivers)	System B (for rivers)	
Obligatory factors	**Obligatory factors**	**Optional factors**
Altitude typology • High: > 800m • Medium: 200 to 800m • Low: < 200m Size typology based on catchment area • Small: 10 – 100 km2 • Medium: 100 – 1000 km2 • Large: 1,000 – 10,000 km2 • Very large: > 10,000 km2 Geology • Calcareous • Siliceous • Organic	• Altitude • Latitude • Longitude • Geology size	• Distance from river source • Energy of flow • Mean water width • Mean water depth • Mean water slope • Form and shape of main river bed • River discharge category • Valley shape • Transport of solids • Acid neutralising capacity • Mean substratum composition • Chloride • Air temperature range • Mean air temperature • Precipitation

Most of the Member States have chosen System B and share the opinion that it describes the biological composition and community structures in a more realistic way as it recognizes more attributes than System A (European Commission 2003d, p. 37).

Annex XI of the WFD lists 25 European eco-regions, which have been established according to European regional characteristics, and some natural aquatic fauna. The eco-regions should serve as a “first typification” for Member States applying System A; Member States first have to determine the eco-regions within which their water bodies lie and then can further differentiate the water bodies according to System A. (Chave 2001, p. 67). The eco-regions listed in the WFD are:

Table 5: European Eco - regions defined within the WFD; (Source: WFD 2000, p. 76)

European Eco-regions according to WFD			
1. Iberic- Macarone-sian region	8. Western highlands	15. Baltic province	22. Fenno-Scandian shield
2. Pyrenees	9. Central highlands	16. Eastern plains	23. Taiga
3. Italy, Corsica and Malta	10. The Carpathians	17. Ireland and Northern Ireland	24. The Caucasus
4. Alps	11. Hungarian low-lands	18. Great Britain	25. Caspic depres-sion
5. Dinaric western Balkan	12. Pontic province	19. Iceland	
6. Hellenic western Balkan	13. Western plains	20. Borealic up-lands	
7. Eastern Balkan	14. Central plains	21. Tundra	

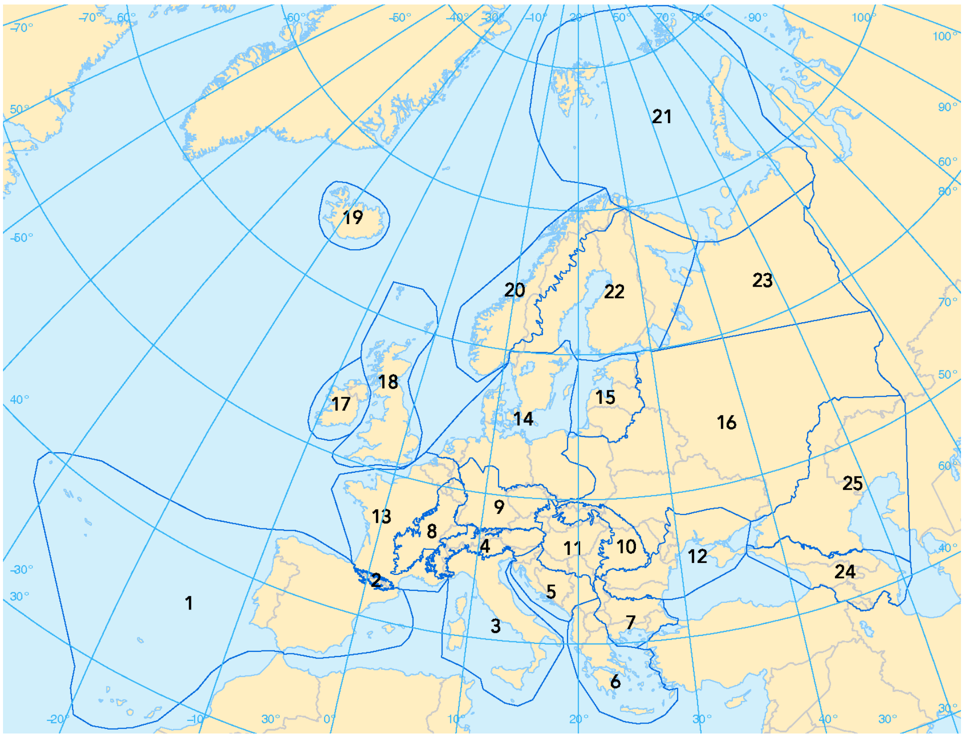

Figure 1: European Eco-regions; (Source: European Environment Agency 2013a)

3.1.2 Establishment of reference conditions

The definition of "reference conditions" in ecological literature is not homogenous. Some define reference conditions as a "former" or "natural" environment of the past without any anthropogenic influence. Other authors support the view that reference conditions are regionally representative conditions with minimum or no anthropogenic influence (Economou 2002, p. 11).

Reference conditions within the WFD are equated to the "high ecological status" of the monitored water body and therefore vital for the determination of the actual ecological status. Within the WFD the high ecological status (and therefore the reference conditions) are described as follows:

"There are no, or only very minor, anthropogenic alterations to the values of the physico-chemical and hydro morphological quality elements for the surface water body type from those normally associated with that type under undisturbed conditions. The values of the biological quality elements for the surface water body reflect those normally associated with that type under undisturbed conditions and show no or only very minor, evidence of distortion" (WFD 2000, p. 43).

This definition clearly reflects the above-mentioned second understanding of "reference conditions" in which minor anthropogenic influence is allowed, but also leaves space for interpretation. The WFD further demands:

"For each surface water body type characterized in accordance with section 1.1, type specific hydro morphological and physicochemical conditions shall be established representing the values of the hydro morphological and physicochemical quality elements specified in point 1.1 in Annex V for that surface water body type at high ecological status as defined in the relevant table in point 1.2 in Annex V. Type-specific biological reference conditions shall be established, representing the values of the biological quality elements specified in point 1.1 in Annex V for that surface water body type at high ecological status as defined in the relevant table in section 1.2 in Annex V (WFD 2000, p.33).

Therefore reference conditions have to be established for each water body type, taking into account the ecological diversity. For this reason, a monitoring network with sufficient sampling stations for each water body type has to be set up. (Castillo 2010, p. 17).

Besides monitoring at an undisturbed site or a site with only very minor disturbance, the WFD gives three other options for deducing reference conditions:

- Historical data and information
- Models
- Expert judgment

As it is important to respect natural variability, in most cases, reference conditions will be defined as ranges. As stated above the reference conditions will be then used to compare them to monitoring results from the related water body type and the actual ecological status will be derived (as it will be explained in detail in the following chapter) (Castillo 2010, p. 17).

Reference conditions are established for different quality elements, comprising biological, hydro morphological and chemical/physico-chemical elements. Table 6 presents those quality elements according to Annex V of the WFD (WFD 2000, Annex V, p. 43 - 46):

Table 6: Water body types defined in the WFD and their quality target; (Source: WFD 2000 Annex V, p. 43 - 46)

Quality elements for the determination of the ecological status		
Rivers	**Biological elements**	Aquatic flora Benthic invertebrates fauna Fish fauna
	Hydro morphological elements	**Hydrological regime** (quantity & dynamics of water flow, connection to GW) **River continuity** **Morphological conditions** (river depth and width, structure or river bed and riparian zones)
	Chemical- and physico-chemical elements	**General:** Thermal conditions, oxygenation, salinity, acidification status, nutrient conditions; **Specific pollutants:** Pollution by priority substances, Pollution by other substances discharged in the water body.
Lakes	**Biological elements**	Phytoplankton Aquatic flora Benthic invertebrates fauna Fish fauna

	Hydro morphological elements	**Hydrological regime** (water flow, residence time, connection to GW) **Morphological conditions** (lake depth, quantity, structure and substrate of lake bed, structure of lake shore)
	Chemical- and physico-chemical elements	**General:** Transparency, thermal conditions, oxygenation, salinity, acidification status, nutrient conditions; **Specific pollutants:** Pollution by priority substances, Pollution by other substances discharged in the water body.
Transitional waters	**Biological elements**	Phytoplankton Aquatic flora Benthic invertebrates fauna Fish fauna
	Hydro morphological elements	**Morphological conditions** (depth variation quantity, structure and substrate of the bed, structure of intertidal zone) **Tidal regime** (freshwater flow, wave exposure)
	Chemical- and physico-chemical elements	**General:** Transparency, thermal conditions, oxygenation, salinity, nutrient conditions; **Specific pollutants:** Pollution by priority substances, Pollution by other substances discharged in the water body.
Coastal waters	**Biological elements**	Phytoplankton Aquatic flora Benthic invertebrates fauna
	Hydro morphological elements	**Morphological conditions** (depth variation structure and substrate of the coastal bed structure of the intertidal zone) **Tidal regime** (direction of dominant currents, wave exposure)
	Chemical- and physico-chemical elements	**General:** Transparency, thermal conditions, oxygenation, salinity, nutrient conditions **Specific pollutants:** Pollution by priority substances, Pollution by other substances discharged in the water body.
AWB & HMWB	The quality elements applicable to artificial and heavily modified surface water bodies shall be those applicable to whichever of the four natural surface water categories above most closely resembles the heavily modified or artificial water body concerned.	

3.1.3 Determination of the water quality status

In order to assess the ecological status of a water body, the monitored quality elements need to be compared to the determined reference conditions. The deviation between these two values is expressed using a numerical scale between zero and one, the so-called "Ecological Quality Ratio" (EQR) (Bund et. al. 2007, p. 4).

The EQR is defined in the CIS guidance document on monitoring as follows:
"Ecological Quality Ratio (EQR) - The ration between the value of the observed biological parameter for a given surface water body and the expected value under reference conditions. The ration shall be expressed as a numerical value between 0 and 1, with high ecological status represented by values close to one and bad ecological status by values close to zero" (Bund et. al. 2007, p. 5).

The WFD states explicitly that one of the main purposes of calculating an EQR is to enable comparability between different assessment methods. As each Member State can develop its tailor-made monitoring and assessment methods, the EQR should enable harmonization of the outcomes through the intercalibration exercise (Bund et. al. 2007, p. 5). Figure 2 shows graphically the basic concept of the EQR:

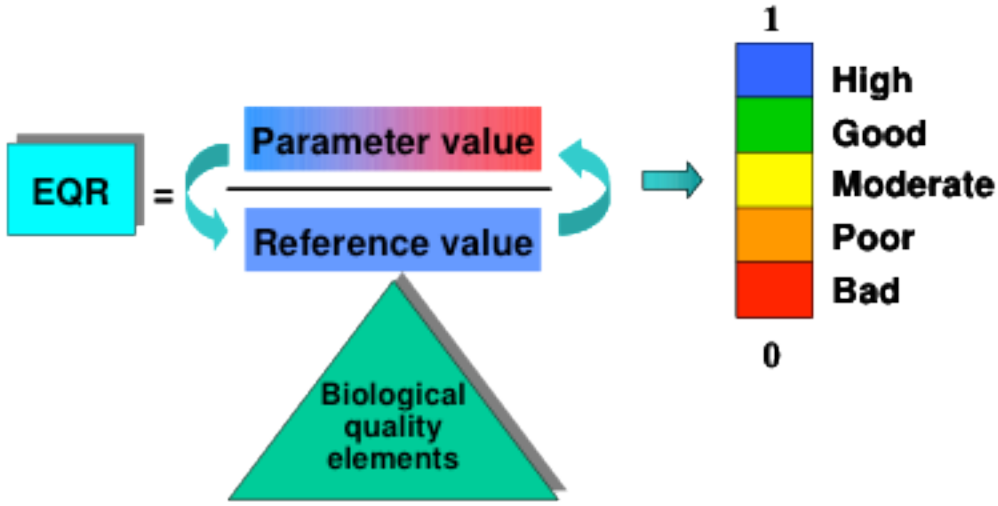

Figure 2: Concept of the EQR; (Source: Bund et. al. 2007, p. 5)

The EQR values determine the class boundaries for each quality element. The WFD distinguishes between five ecological status classes for surface waters:

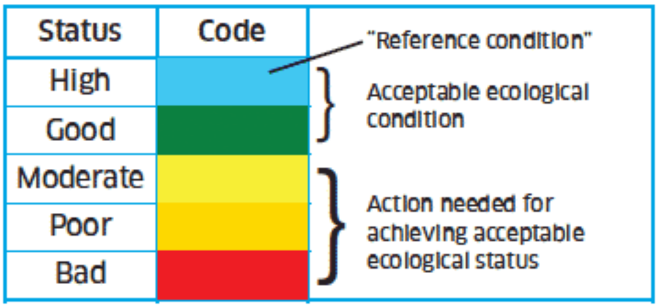

Figure 3: Ecological and Chemical status; (Source: Scottish Government 2013)

Annex V (table 1.2) of the WFD gives a general, qualitative description of the five ecological status classes for surface waters:

- A "**high ecological status"** shows *"no, or only very minor, anthropogenic alterations to the values of the physico-chemical and hydro morphological quality elements for the surface water body type from those normally associated with that type under undisturbed conditions. The values of the biological quality elements for the surface water body reflect those normally associated with that type under undisturbed conditions, and show no, or only very minor, evidence of distortion. These are the type-specific conditions and communities"* (WFD 2000, p. 42).

- The "**good ecological status"** is described as follows: *"The values of the biological quality elements for the surface water body type show low levels of distortion resulting from human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions"* (WFD 2000, p42).

- At a "**moderate ecological status"**, the "*surface water body type deviates moderately from those normally associated with the surface water body type under undisturbed conditions. The values show moderate signs of distortion resulting from human activity and are significantly more disturbed than under conditions of good status*" (WFD 2000, p. 42).

- A water body is classified as “**poor ecological status” shows** “*evidence of major alterations to the values of the biological quality elements for the surface water body type and the relevant biological communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions*” (WFD 2000, p. 42).

- Water bodies shall be classified as “**bad ecological status”** if the water shows “*evidence of severe alterations to the values of the biological quality elements (…) and in if large portions of the relevant biological communities normally associated with the surface water body type are absent*” (WFD 2000, p. 42).

The boundaries between the ecological status classes are defined as “a certain level of deviation from the reference conditions” (Bund et. al. 2007, p. 6). The definition and criteria for setting reference conditions directly affect these class boundaries and are crucial for the comparability of the values across Member States.

As described in the previous chapter, reference conditions are determined for quality elements, which are combined in quality element groups. Furthermore each quality element has certain parameters, which measure and determine the actual situation or status of the quality element under certain pressures (European Commission 2005a, p. 9).

The WFD prescribes to classify surface water bodies at quality element level. Thereby, the quality element with the worst result defines the final classification according to the „one out, all out“ principle. At parameter level, it is not mandated how the parameters within a quality element are combined. A solution would be to combine the parameters in a multimetric index, but any other approaches are possible as well (Bund et. al. 2007, p. 7; European Commission 2005a, p. 11). Figure 4 shows combination possibilities of parameters and the application of the one-out, all out principle:

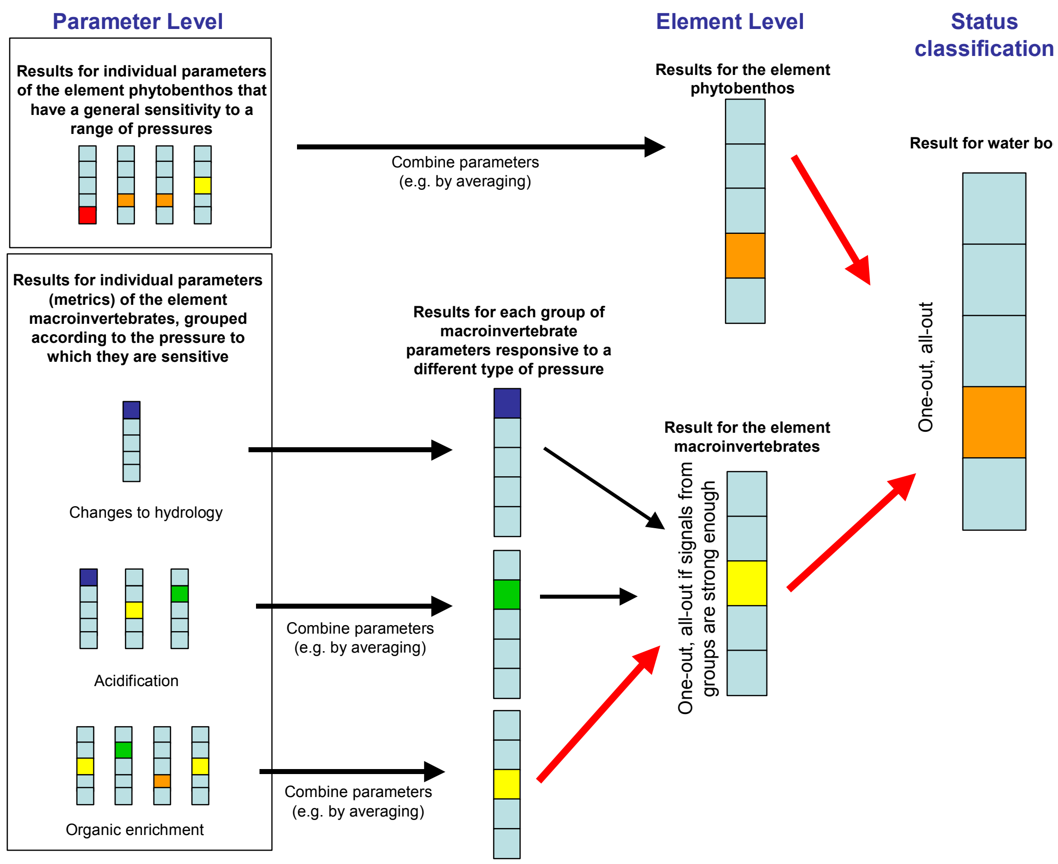

Figure 4: Possible combinations of parameters; (Source: European Commission 2005a, p.11)

For the determination of the ecological status, it is not necessary that for all three groups of quality elements (biological, hydro-morphological and physico-chemical quality elements) EQR values for each status class are determined. The hydro–morphological and physico–chemical quality elements are supporting elements of the biological quality elements for the determination of the "high" and "good status". This means that only for the "high" status biological, physico-chemical and hydro–morphological quality elements need to meet the requirements for the "high status". For the "good status", only biological and physico-chemical quality elements have to meet the defined EQR values, whereas hydro– morphological quality elements have to be in such condition to allow the biological quality elements to reach "good status". For the moderate, "poor" and "bad" status classes, only the biological quality elements have to be in the defined EQR ranges and hydro–morphological and physico–chemical parameters have to enable the biological quality elements to be in these ranges (European Commission 2009, p. 28). Figure 5 illustrates the criteria determining the ecological status classes:

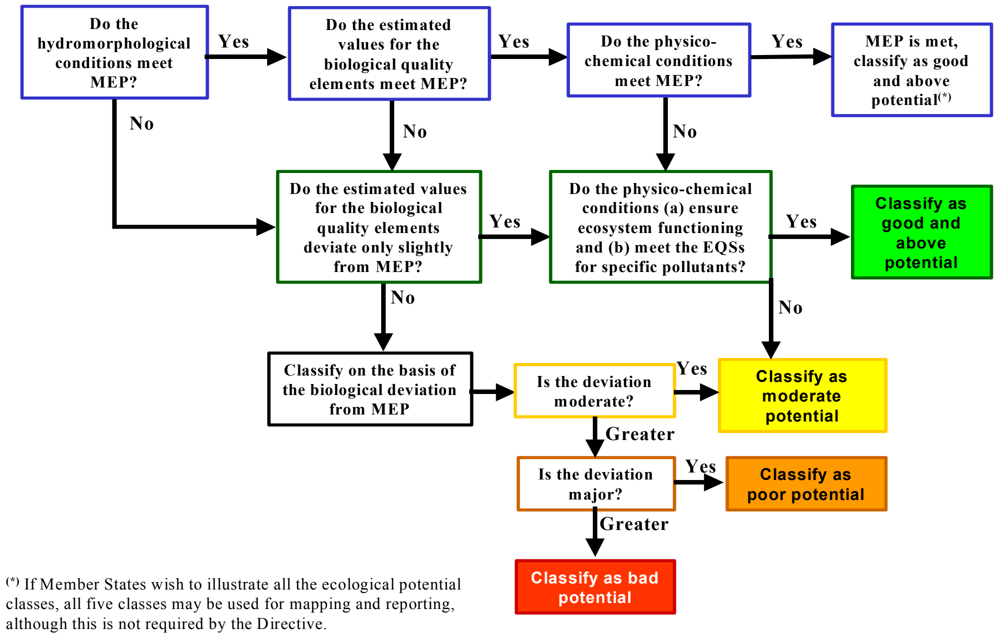

Figure 5: Decision tree illustrating the criteria determining the ecological status: (Source: European Commission 2005a, p. 5)

As the main purpose of the EQR is to achieve comparability between the different countries, the easiest solution would be to agree on Union-wide values for the class boundaries (e.g. 0.8 for the high-good boundary, and 0.6 for the good-moderate boundary). This solution would be applicable when very similar assessment methods would be used. If the assessment methods vary (e.g. different parameters are used to assess a biological quality element) the comparability cannot be assured, as different methods produce different response curves to pressures and lead to different EQR values. In some cases, the pressure–response curves may even be inverse. An example would be phytoplankton biomass, as the amount of biomass increases with increasing anthropogenic pressure. In these cases other calculation schemes for the EQR have to be applied (Bund et. al. 2007, p. 19).

As mentioned above, the WFD determines the biological quality elements, which have to be considered in order to derive the ecological status, but how these quality elements are assessed is left flexible to the Member States. In order to compare and harmonize "*the understanding of "good ecological status" in all Member States, and to ensure that this common understanding is consistent with the definitions of the Directive*" (European Commission, 2013a), the so-called *intercalibration exercise* is carried out according to the provisions of Annex V section 1.4.1 of the WFD. In other words, the intercalibration exercise compares the values assigned by each Member State for the high - good and good – moderate ecological class boundaries and reconciles these values (Bund 2009, p. 6). The intercalibration exercise therefore does not harmonize assessment systems; it harmonizes their results (European Commission, 2013a).

The intercalibration exercise is carried out by Working Group A on "Ecological Status" under the framework of the Common Implementation Strategy (CIS) of the WFD. The technical coordination is led by the Joint Research Centre of the European Commission. All 27 Member States are involved, including Norway (which participates on voluntary basis), and are subdivided into 14 geographical intercalibration groups (GIGs). The groups consist of Member States, which have similar ecological water body types (river, lakes, coastal/transitional waters) and can therefore more easily compare their results among themselves. About 500 experts from all Member States and Norway are involved in the intercalibration processes (Bund 2009, p. 6; European Commission 2013a).

The first phase of the intercalibration exercise was rather difficult. Due to the lack of national assessment categories complying with WFD requirements and therefore lack of data, not all biological quality elements could be intercalibrated. In October 2008, the European Commission published the first results of the intercalibration exercise. The work was then continued in a second phase from 2008 onwards (European Commission 2013a).

3.1.4 Pressure and impact analysis

The requirement to analyse pressure and impacts is given in article 5 of the WFD, which demands "a review of the impact of human activity on the status of surface waters and ground waters" (WFD 2000, p. 15).

Annex II of the WFD further specifies the provision given in article 5, and requires Member States to "*collect and maintain information on the type and magnitude of the significant anthropogenic pressures*" (WFD 2000, p. 34) on the water bodies.

The WFD further broadly categorizes pressures for which information has to be obtained. These are:

- Point source pollution
- Diffuse source pollution
- Effects of modifying the flow regime through abstraction or regulation
- Morphological alterations

As a first step of the analysis, the Member States have to identify the “significant” pressures to their water bodies. A pressure is significant if it has a negative impact on the ecological quality of a water body and therefore endangers the compliance with the quality targets. The second step is the impact assessment for which information from the pressure analysis and any other information (e.g. monitoring data) is used. The objective of the impact assessment is “to determine the likelihood that the surface water body will fail to meet its environmental quality objectives” (Pietiläinen 2007, p.5).

For the identified water bodies at risk of failing the objectives set under article 4 of the WFD, the Member States have to consider implementing additional monitoring and optimizing the programme of measures required under article 11 (WFD 2000, p. 34; Pietiläinen 2007, p. 5).

The analysis of pressure and impacts additionally has to take into account how pressures would be likely to develop prior to 2015, and could therefore put water bodies at risk of failing to achieve “good status” in the case that appropriate measures were not implemented. For this analysis, future effects of existing legislation and forecasts about e.g. economic developments have to be considered (Pietiläinen 2007, p. 6).

In general, the assessment of the pressure and impacts plays an important role during the elaboration of a River Basin Management System and the River Basin Management plans as the design of the monitoring programmes and the Programmes of Measures depend on the results of the pressure and impact analysis (Pietiläinen 2007, p. 6).

For general guidance on this process, the working group 2.3. of the CIS has published a guidance document for the analysis of pressures and impacts which describes a general approach for the analysis and key steps that need to be carried out.

3.2 River basin management plans

As mentioned in the previous chapter, the WFD uses a new approach of water resource management. Prior to December 2000, the directive required all members to identify their river basins (including all ground waters, estuaries and coastal waters) and appoint them to so-called “River Basin Districts” (RBD) (according to art. 2 and 3 of WFD 2000). The RBD are not based on national or administrative borders, but on natural hydrological units. In case of international rivers, the riparian states have to assign the river basin corporately to an international RBD (Carter et. al. 2006, p. 289).

Each RBD has to have a designated competent authority, be it only on national level, or if the RBD is transboundary, in co-ordination with the other bordering states. The authorities of the RBDs have the responsibility to elaborate and implement a River Basin Management Plan (RBMP), according to article. 13 of the WFD, within six years. If a joint RBMP for international rivers cannot be reached, each riparian state should elaborate a plan for its part of the RBD. According to Kallis et. al. (2001) and Annex VII of the WFD, the RBMP has to include the following aspects:

- A description of the general characteristics of the river basin
- Protected areas within the RBD
- Monitoring network of the RBD
- Identification and assessment of the significant pressures on the aquatic environment (e.g. estimation of point and diffuse pollution, land uses, estimation of abstractions, etc.)
- Economic analysis of the cost of water
- Summary on measures to be taken in order to achieve all objectives and obligations of the WFD

The deadline for the first RBMPs was set for December 2009. Three years before, the member states already had to publish a timetable and work plan, in 2007 they had to present an overview of significant water management issues, and in 2008 a draft RBMP according to article 14 of the WFD. Table 7 summarizes the main deadlines of the WFD in general, and for the establishment of RBMPs in particular:

Table 7: Deadlines in the WFD; (Source: Mostert 2003, p. 525)

WFD Deadlines	
2003	Identification of river basins, assignment to districts, identification of competent authorities
2004	Characterization of RBD, pressures and review of impacts, economic analysis (2013, 2019, etc.)
2006	Monitoring operational
2006	Work plan for RBM planning and public participation (2012, 2018, etc.)
2007	Overview of main issues (2013, 2019, etc.)
2008	Draft RBMP (2014, 2020, etc.)
2009	RBMP and programs of measures (2015, 2021, etc.)
2010	Implementation of water pricing policies
2012	Programs of measures operational (2018, 2024, etc.)
2015	Environmental objectives reached (with some exceptions)

The aim of the RBMPs is to improve the ecological status and potential of the water bodies, and reach a "good status" by 2015 as it is envisaged in the WFD. If it is not possible to reach "good status" for some water bodies, the WFD gives the possibility to apply exemptions (under article 4.4, 4.5, 4.6 and 4.7 of the WFD), which have to be justified in the RBMPs. Possible exemptions include (WWF 2011, p. 2-5; Water-sketch 2013):

- *A phased achievement of the objectives* – the deadline of reaching "good status" can be extended by two RBMP cycles so that the objective to achieve "good status" has to be reached the latest in 2027 (according to article 4.4 of the WFD 2000).
- *Less stringent environmental objectives* – can be applied if the water body is strongly affected by anthropogenic pressures that the achievement of "good status" by 2014 is not feasible or the costs are disproportionate (according to article 4.5 of the WFD 2000).
- *Temporary deterioration* – in the case of natural causes or "force majeure" (e.g. severe floods, droughts, etc.) a temporary deterioration of the affected water body is possible (according to art. 4.6 of the WFD 2000).

- *New modification to the physical characteristics* – are possible if it is a result of new sustainable development activities (according to art. 4.7 of the WFD).

The development of RBMPs is part of the “River Basin Management Planning Process” which is pictured in figure 6:

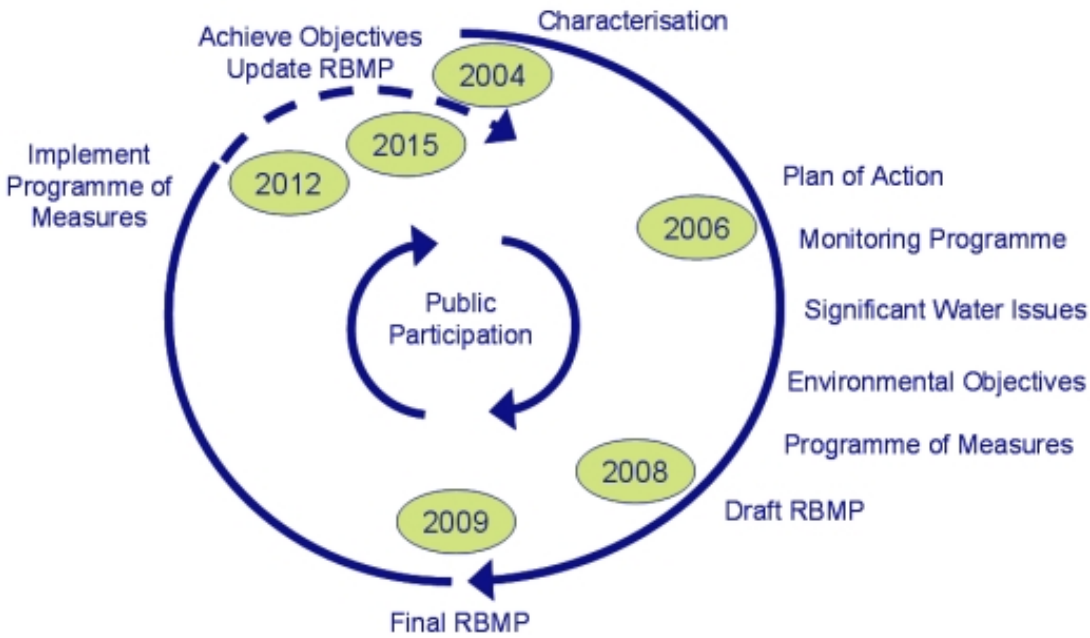

Figure 6: River Basin Management Planning Process; (Source: Socope 2013)

The first steps in the RBM Planning Process were the preliminary assessment of the quality status of rivers and the establishment of monitoring programs according to the WFD requirements. With the gathered data and the comparison to reference conditions, as described in the previous chapter, the water bodies were classified corresponding to the five status classes. Through this analysis, the so-called “GAP-analysis”, discrepancies between the existing quality statuses and the envisaged “good status” could be detected and water bodies at risk failing to achieve good status by 2015 were identified (Foundation of Water Research 2013).

After the determination of the status of the water bodies within a river basin district, the river basin authorities have to, according to article 11 of the WFD, develop a “Program of Measures” (PoMs) in order to meet the environmental objectives prescribed in the WFD (in particular to reach a “good status” by 2015) (Griffiths 2002, p. 12). According to the Foundation of Water Research (2013), the PoMs “*is at the heart of river basin management planning, as it sets out the actions to be taken dur-*

ing the plan period to secure Directive objectives". In order to determine the PoMs, the River Basin authorities have to conduct studies addressing the key pressures on the water bodies. Article 11 of the WFD (2000) specifies so-called "basic measures" which have to be included in the PoMs, and lists "supplementary measures" which should be applied when basic measures are not sufficient to achieve the environmental objectives. As pictured in Figure 7, basic measures are primarily based on existing legislation and policies like e.g. the Drinking Water Directive, the Bathing Water Directive or the Nitrates Directive. A complete list can be found in Part A of Annex VI of the WFD (2000). Supplemented Measures are formulated in Part B of Annex VI of the WFD (2000) as a comprehensive list of measures ranging from emission control, economic and fiscal instruments to rehabilitation projects (Griffiths 2002, p. 12).

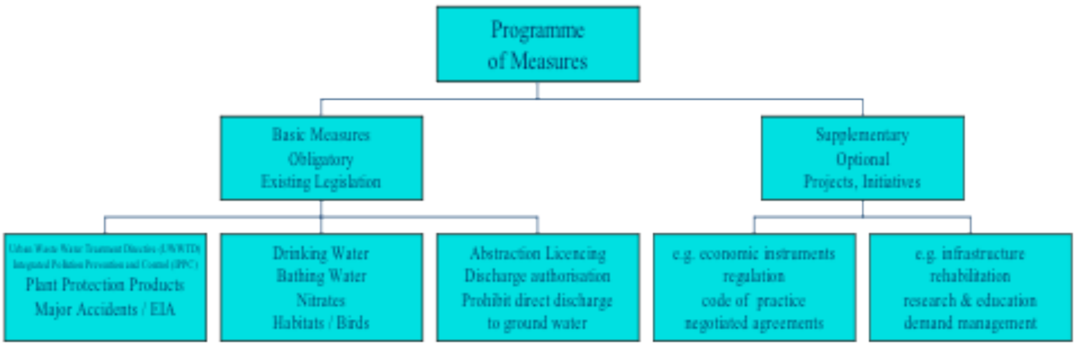

Figure 7: Structure of Program of Measures; (Source: Griffiths 2002, p. 12)

Basic measures are legally binding and have to be implemented into national law. Supplementary measures are in most of the cases only implemented at local level, which means at river basin or water body level. In order to select supplementary measures, it has to be evaluated which ones are technical feasible. Then these selected measures are assessed using different analysing tools like cost-effectiveness analysis, impact assessment or strategic environmental assessment. The most relevant and cost-effective measures for meeting the objectives for the water body and the river basin district as a whole will be selected and implemented (Castillo 2010, p. 62).

The PoMs will also address heavily modified (HWMB) and artificial water bodies (AWB) within the RBDs and any provisions necessary to reach or maintain their objective of good ecological potential. As the WFD includes the possibility of exemptions, these deviations are furthermore included in the PoMs (Foundation of Water Research 2013).

Economic analysis is a major part during the elaboration of the Program of Measures. The Foundation of Water Research sums up the uses and outcomes of economic analysis as follows (Foundation of Water Research 2013):

- Evaluation of the costs and effectiveness of potential measures (which will be explained in detail in the next chapter)
- Support of the determination of heavily modified water bodies
- Construction of a cost-effective Program of Measures
- Evaluation of the disproportion of costs
- Assessment of the financial implementation of the Program of Measures

If the costs of measures are disproportionate to the benefits for a specific water body and if no alternative action can be found, the application of the provision for a permanent derogation might be possible (according to article 4.3 of the WFD). On the other hand, if there is for example a lack of information in order to decide for the right measures, or the application of the measures is very costly, a temporary derogation would be appropriate (according to article 4.4 of the WFD). As the Program of Measures is reviewed every six years, the need for these permanent and temporary derogations is verified and re-evaluated (Foundation of Water Research 2013, Castillo 2010, p. 62).

After the determination of the PoMs according to pressures on the water bodies, the RBMPs had to be prepared until 2009. RBMPs are a “snapshot in time” and therefore need to be reviewed regularly, which happens in a six-year cycle as mentioned above. The review and update of the RBMPS can be seen as a refining process in which e.g. improved data is implemented and measures are adapted. As the Foundation of Water Research (2013) summarizes, RBMPs fulfil the following tasks:

- Inventory and documentation mechanism: e.g. environmental objectives, quality and quantity of waters, anthropogenic impacts and pressures on the water bodies
- Coordination of Program of Measures and other relevant programs

- Progress reporting mechanism as required by art. 15 WFD (2000) to the European Commission

Before, during and after the preparation of the RBMPs, stakeholders and the public need to be informed and consulted as article 14 of the WFD (2000) requires Member States to "*encourage the active involvement of all interested parties in the implementation of this Directive, in particular in the production, review and updating of the river basin management plans*" (WFD 2000, p. 21).

For this reasons the WFD prescribes to publish and make available for comments the following information (WFD 2000, p.21, Foundation of Water Research 2013):

- A timetable and work program for the production of the plan
- An interim overview of the significant water management issues identified in the river basin
- Draft copies of the river basin management plan
- On request, access to background documents and information

In order to facilitate active involvement and consultation with stakeholders and the public, the Member States have to allow six months to comment in writing on the published documents (WFD 2000, p.21).

The WFD required the Member States to finalize all RBMPs by December 2009 and all measures to be operational by 2012. In April 2013, the European Commission states that: "*there are however serious delays in some port of the EU, and in several countries consultations are still on-going, or the river basin management plans have not yet been established*" (European Commission 2013b). Initially, each program of measure should be updated by December 2015 according to the envisaged six-year review cycle. Due to the delay in delivery in many countries this review–cycle will be behind schedule. As the RBM process is an on-going process new deadlines are continuously set.

3.2.1 Cost – effectiveness of the PoMs

Among the various economic analyses during the establishment of RBMPs, the cost –effective analysis of proposed mitigation measures is one of the most important ones. Annex III (b) of the WFD requires that "*judgements about the most cost – effective combination of measures in respect of water uses to be included in the PoMs under article 11 based on estimates of the potential costs of such measures need to be made as part of the River Basin Management Plans*" (WFD 2000, p. 37). This means that the selection of measures to achieve good ecological status has to be based on their cost – effectiveness.

Cost–effective analysis (CEA) is therefore a decision-support tool, which enables the assessment of the costs and effectiveness of the measures proposed for the achievement of the objectives set in the WFD. According to Ortega (2012) CEA is based on the following steps:

- The environmental target to be met has to be determined (in case of the WFD this has be done in article 4 of the WFD)
- Measures to achieve the stated objective have to be identified by the Member States
- The effectiveness of measures has to be assessed
- The costs of implementing the measures are estimated
- The measures are assessed according to the ratio between costs and effectiveness (costs per unit environmental outcome) (Ortega et. al. 2012, p. 16)

The effectiveness of a measure can be measured in relation to the reduction of pressures and in relation to the reduction of the ecological impact. If the effectiveness is measured according to the reduction of the related pressure it has to be considered that there is not always a direct relationship between the reduction of a pressure and the reduction of an environmental impact, which could lead to incorrect results in some cases. The information for assessing effectiveness comes mainly from environmental monitoring or expert judgments (Ortega et. al. 2012, p. 18).

The next step is the estimation of the costs for a specific measure. For the analysis full economic costs (including investment costs, opportunity costs, operational costs, maintenance costs, etc.) have to be taken into account. As the estimation usually includes an uncertainty factor, the costs can be given in ranges. The estimated numbers are also used to decide whether the costs for a needed measure for a specific water body are disproportionate. If this is the case, the national authorities can decide to use the possibility of exemptions for this water body by applying e.g. article 4.4 (time extension) or article 4.5 (less stringent objectives) (European Commission 2003b, p. 24).

The last step of the CEA is the analysis of the actual cost-effectiveness, which is the relation between the effectiveness and the costs for implementation of a specific measure. Through the relation of the effectiveness with the costs, it results that the costs per percentage point of effectiveness are determined (Lebensministerium 2007a, p. 7).

More information about CEA can be obtained from the CIS Guidance Document Nr. 1 (2003), established by working group 2.6 (WATECO), on „Economics and the Environment".

4 Case studies

4.1 Austria

4.1.1 River basin districts and legal implementation in Austria

Austria, with its 8.1 million inhabitants, had a gross domestic income per capita in 2011 of 35.710 EUR. The economy is mainly service-dominated followed by industry and trade. Austria is an alpine country, dominated by mountains and forests and about 44% of the land is used for agricultural purposes. The country is situated within three transboundary river basin districts (RBDs), namely the Danube, the Rhine and the Elbe (see Figure 8). As a land-locked country there are hence no transitional or coastal water bodies (Lebensministerium 2005).

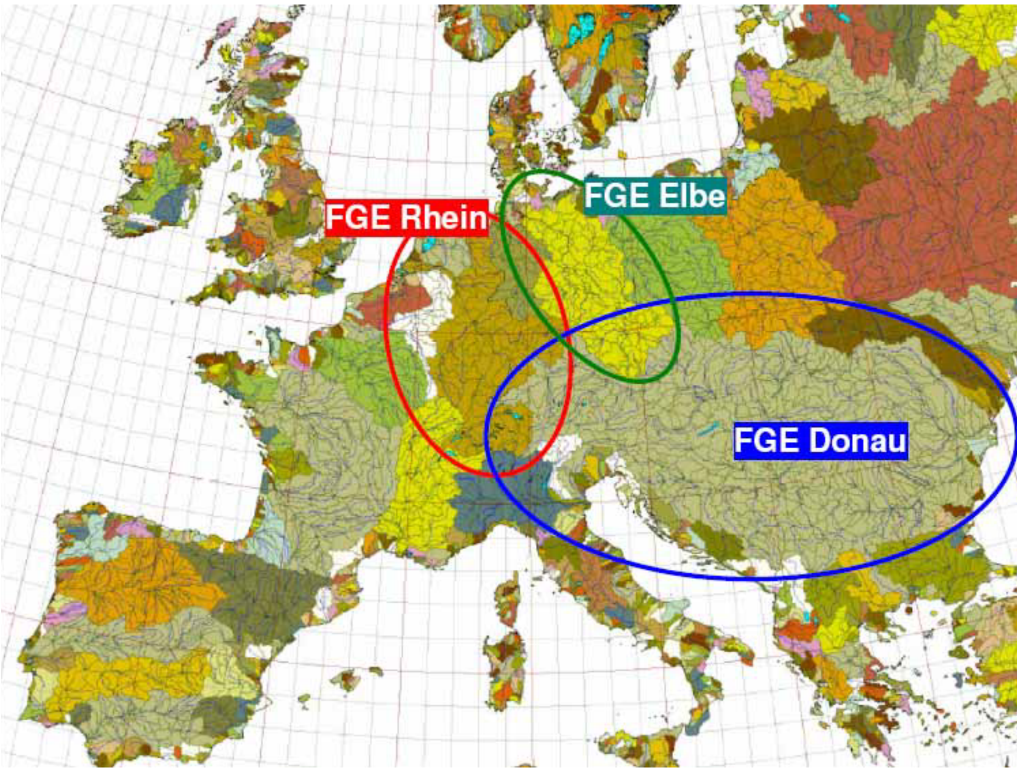

Figure 8: the three international river basin districts of Austria; (Source: Lebensministerium 2005, p. 3)

As all three RBDs are transboundary, they are governed by International River Basin authorities. Austria acts as river basin party in the Danube RBD, and as it only has very minor shares within the Rhine and Elbe basins (1% and 0.6% respectively), has observer status in the other two RBDs. The country is a federal republic, which is formed by nine provinces. The WFD was transposed to Austrian law in 2003 through the amendments to the "Wasserrechtsgesetz 1959 (BGBl. Nr. 215/1959). The competences within the water act are shared between the national and regional authorities. The Ministry for Agriculture and Forestry, Environment and Water Management is the competent authority at federal level, whereas the operational implementation of the water provisions falls under the competency of the provinces, the so-called "Länder" (European Commission 2012a, p. 3; Lebensministerium 2005). The criteria for the determination of the ecological and chemical status are regulated in special directives (Qualitätszielverordnung Ökologie, Qualitätszielverordnung Chemie). In 2006, the provisions of the WFD concerning monitoring were implemented and regulated in the so-called "Gewässerzustandsüberwachungsverordnung (GZUV, BGB. II Nr. 479/2006) (Umweltbundesamt 2013).

Austria has contributed to the elaboration of the international RBMPs of the above-mentioned river basins. Additionally, a national RBMP has been established, the "Nationaler Gewässerbewirtschaftungsplan 2009" (NGP) in which all three river basins are covered, and provisions and methodologies of the WFD are implemented (European Commission 2012, p. 5). As it can be seen from table 8, the main RBD within Austrian territory is the Danube river basin. The following case study will focus on the national RBD of Austria.

Table 8: Information on Austria´s three river basin districts; (Source: European Commission 2012, p. 2)

River Basin	Size of River Basin (Km^2)	% National territory within RBD	Countries sharing the RBDs	Coordination category in %
Danube	80,565	96%	AL, BA, BG, CH, CZ, DE, HR, HU, IT, MD, ME, MK, PL, RO, RS, SI, SK, UA	10%
Rhine	2,365	3%	BE, CH, DE, FR, IT, LI, LU, NL	1%
Elbe	921	1%	CZ, DE, PL	0.6%

4.1.2 Classification typology of surface water bodies

The typification of Austrian surface water bodies follows the recommendations of the CIS guidance document “CIS Horizontal Guidance on establishing reference conditions and ecological status class boundaries for inland surface waters” established by the CIS working group 2.3 (REFCOND). Water typologies have been established for all Austrian watercourses, including those with a catchment area smaller than $10km^2$, cartographic visualization has been done for water bodies with a catchment area bigger than $10km^2$. According to the Austrian Ministry of Agriculture, Forestry, Environment and Water Management the Austrian system for typification follows the above step-wise approach:

- Abiotic typification according to System B of the WFD
- Validation of the abiotic water body types with biological data (Benthic invertebrates, fish, algae/macrophytes;) from reference condition sites
- Final determination of water body types – differentiation of longitudinal zones into subtypes within the bioregions and special types based on benthic invertebrate analysis (European Commission 2012a, p.6)

As specified in System B in Annex II of the WFD, the relevant authorities first had to assign the water bodies to the 25 European Eco-regions established by ILLIES (1978). Austrian territory lies within six European Eco-regions, namely (Fink et al. 2000, p. 10):

- The Alps (61%)
- Central Highlands (19%)
- Hungarian Lowlands (15%)
- Dinaric Western Balkan (5%)
- The Carpathians (< 1%)
- Italy (< 1%)

Additionally the following parameters were used for abiotic typification of watercourses with a catchment area bigger than $10km^2$ (Lebensministerium 2007a, p. 7):

- Geology
- Size of catchment area (absolute and in classes)
- Altitude of 75% of catchment area
- Altitude of estuary
- Water body reference number according to Strahler (Strahler number)
- “Fließgewässer – Naturraum” classification according to the system of “Fink, Moog and Wimmer (2000)” (pre-classification system of water bodies taking into account geologic bedrock, climate, vegetation, soils, physio-geographic parameters and hydrologic characteristics)
- Runoff-regime at water bodies with gauge stations

Through the first analysis of the above-mentioned abiotic factors, 17 regional types and 9 special types (“big rivers” with a catchment size of over 2,500 km2 and/or a Strahler number of > 7) were identified. These, all together 26 types, are labelled as basic abiotic watercourses. The biological review of the basic abiotic types, taking into account benthic invertebrates, fish, algae and macrophytes) lead to the determination of 15 riverine bioregions which could be clearly distinguished through their aquatic biocenosis (Lebensministerium 2007a, p. 8). Austria’s 15 bioregions are presented in figure 9:

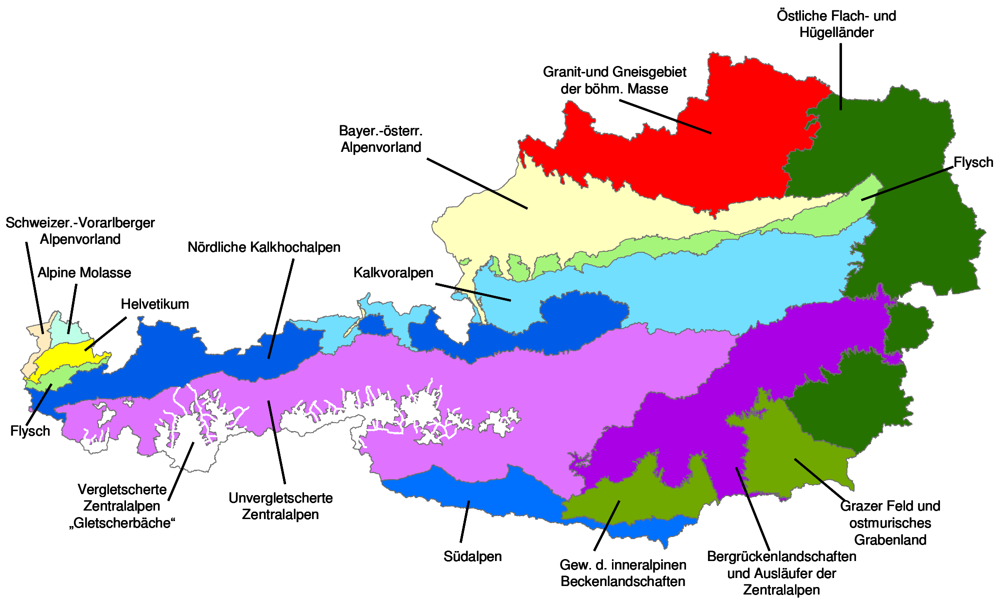

Figure 9: Bioregions in Austria; (Source: Lebensministerium 2007a, p. 8)

During the last step of typification, the borders of the bioregions were revised and, as mentioned before, the longitudinal differentiation and division of the bioregions into subtypes was carried out. The subdivision is mainly based on the results of the Benthic invertebrate analyses (they require the highest differentiation grade) and is expressed through the correlation to saprobic initial states. The saprobic initial states were in turn derived from altitude classes, size of catchment area and biological data. In total, 39 subtypes within the bioregions were identified. The type of a water body is therefore determined by bioregion, saprobic initial state, catchment size area and altitude (Lebensministerium 2007a, p. 9; Lebensministerium 2012a, p.9). Figure 10 displays the classification of Austrian Bioregions according to altitude, catchment size and saprobic initial state:

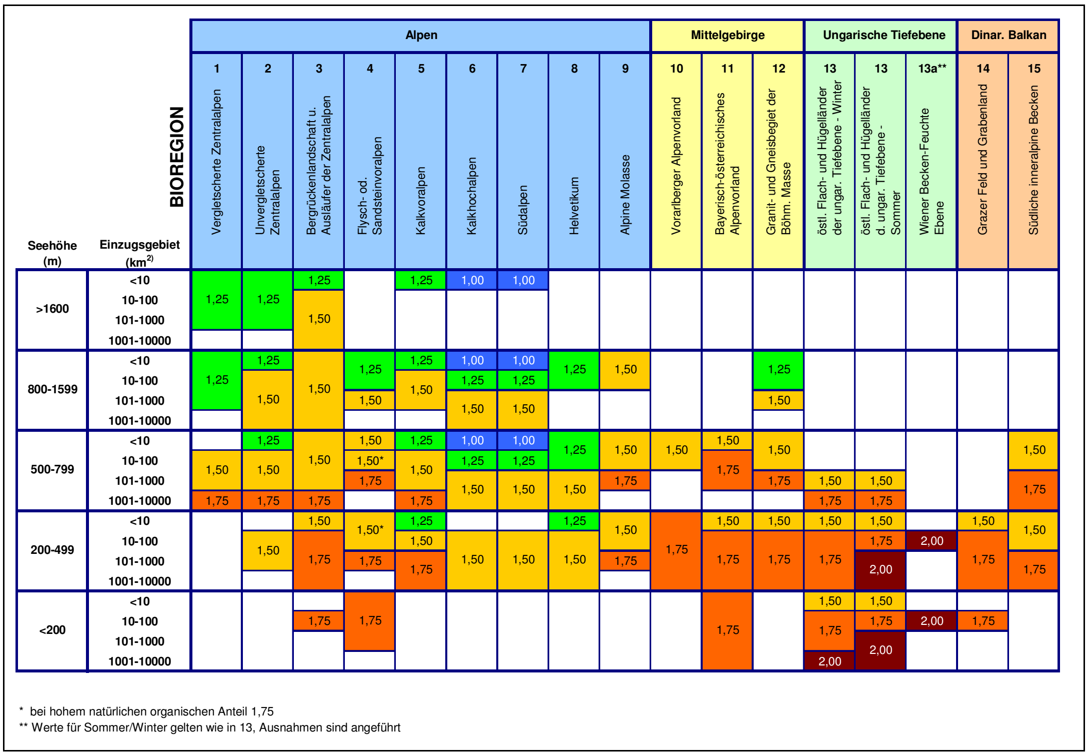

Figure 10: Austrian Bioregions according to altitude, catchment size and saprobic initial state; (Source: Lebensministerium 2007a, p. 10)

Additionally, some specific water body types and type specifications were described for which it was not presently possible to develop assessment methods for the quality elements, due to high natural variability of reference conditions or insufficient data. Special water body types and special type specifications are for example:

Table 9: Special water body types and special type specifications; (Source: Lebensministerium 2007a, p. 9 - 11)

Special water body types	Special type specifications
Glacial streams Water bodise < 10km2 catchment size Big rivers Marsh streams Thermal streams Etc.	Waterfalls Canyons Naturally dammed areas Etc.

In order to have a better understanding of the above given information, the most important aspects of the Austrian system of watercourse typification will be recapitulated. Austria chose System B for the abiotic determination and identified 17 region types and 9 special types. This abiotic classification was revised using biological parameters leading to the assignation of 15 riverine bioregions. In a last step, the bioregions were divided into subtypes and special types based on benthic invertebrate analyses and expressed through saprobic initial states, leading to 39 subtypes.

Each river and/or a specific stretch of a river is classified according to this system and given a type – number consisting of the number of bioregion (type 1 – 15), class of altitude (1 – 5) and class of catchment size (1 – 4).

Each watercourse type has then been described according to Lebensministerium (2012b) „Hydromorphologische Leitbilder, Band 2" with the following set of parameters:

- Share of length of the watercourse belonging to the type
- Saprobic initial state benthic invertebrates and phytozoobenthos
- Trophic initial state
- Fish region
- Runoff regime
- Flow conditions
- Valley configuration
- Base slope
- Flow characteristics
- Morphological structures (cascades, flat banks, etc.)
- Channel bed characteristics (Sand, stone, gravel, etc.)

Austria has reported in total 7,339 river water bodies. From which 7,054 are within the Danube RBD, 194 within the Rhine RBD and 91 within the Elbe RBD. The average length of type-specific watercourses in the Danube and Rhine RBD is 4 km and in the Elbe RBD 5 km (European Commission 2012, p. 7). According to the evaluation of the European Commission in December 2012, „*Austria seems to have applied a very systematic and thorough methodology to define their typology including biological testing to ensure the biological relevance of the different types – this has led to a substantial amount of types*“ (European Commission 2012a, p. 7).

4.1.3 Reference conditions

As explained before in chapter 3.1.2, the evaluation of the ecological status is based on the deviation of the monitored data for each quality element from type-specific reference conditions. For this reason, it is necessary to determine type-specific reference conditions, which are described in the „CIS Guidance on establishing reference conditions and ecological status class boundaries for inland surface waters (REFCOND)“.

An Austrian expert group (Arbeitskreis Ökologie) elaborated a strategy paper for the selection of reference sites (“Kriterien zur Ausweisung von potentiellen Referenzstrecken für den sehr guten ökologischen Zustand und Eichstrecken für den guten ökologischen Zustand”), which was published in September 2002 by the Austrian Ministry for Agriculture, Forestry, Environment and Water Management. This strategy paper provided a solid base for the selection of reference sites. The methodical approach of all monitoring issues is legally defined in the “Gewässerzustandsüberwachungs-Verordnung” published by the Ministry of Agriculture, Forestry, Environment and Water Management and came into effect in 2006. Austria was also strongly involved in European-wide research and intercalibration activities for the establishment of criteria for reference site selection. It participated in the CIS working group 2.3 and contributed to the elaboration of the above-mentioned CIS-Guidance document (REFCOND), in which elements of the Austrian strategy paper for reference criteria were included. From 2000 – 2005, Austria also participated in the European research projects AQEM (the main aim was to develop a system for assessing ecological quality in European streams with benthic invertebrates) and STAR (Standardization of river classification) (Ofenböck 2013).

The term reference site is defined in ÖNORM M 6232 as: a site within a monitored water body type in “high status”, where samples for physico-chemical and biological analyses are extracted. Monitoring sites in “good status“ are defined as „Eichstelle“. The ÖNORM M 6232 determines that reference sites have to be representative for a specific water body type (Lebensministerium 2002, p. 5).

During the development of methods for the typification of the water body types and the determination of type-specific reference conditions, about several hundreds reference sites were selected and sampled. The goal was to find sufficient reference sites for each water body type in order to enable the use of statistical methods (in most of the cases reference values are statistical calculated values like percentile or arithmetic mean of the measured data) to determine reference conditions for each water body type. The selected reference sites in Austria were monitored between 2003 and 2006 during the national monitoring and had to fulfil the requirement that all biological quality elements have to be in “high” ecological status (Ofenböck, 2013).

As the main aim of the selected reference sites was to establish reference conditions from which the ecological status can be derived, once established, it is not necessary and also too cost-intensive to continuously monitor all reference sites and parameters. Only five reference sites are still monitored in order to capture long-time environmental changes e.g. due to climate change. These five long-term monitored references sites are predominantly situated at bigger watercourses and represent an “early-warning system” for long-term developments. At the moment there are discussions to enlarge this “early-warning system” in order to better assess environmental changes as a result of climate change (Ofenböck 2013).

For reference sites established to monitor specific quality elements it was not always necessary that all quality elements be in “high status”. For example in case of the evaluation of the quality element phytobenthos it is irrelevant if the river continuity is disturbed due to hydraulic river regulations. In contrast for the evaluation of the quality element “fish” hydraulic river regulations are an important factor of influence (Ofenböck 2013).

According to the Ministry of Agriculture, Forestry, Environment and Water Management, reference sites were established for almost all water body types. However, for some water bodies no reference sites could be found due to high anthropogenic influence (as it is the case in the region “Alpenvorland” or the eastern lowlands). In these cases other evaluation methods were used as for example for the quality element “phytobenthos” where existing expert knowledge (e.g. for the evaluation of trophic levels) was applied (Ofenböck 2013).

The evaluation of the state of the water bodies was not only done through monitoring but as well through grouping of watercourses and analogies. In particular for the evaluation of the “high status“ (reference condition) the absence of pressures is important. In practice, this means for example that if a water body was in good hydro-morphological conditions and if there were no additional pressures and impacts, the watercourse was classified to be in “high status“. Additionally, in some cases historical data was used, e.g. for evaluation of the quality element “fish“ (Ofenböck 2013, Lebensministerium 2002, p. 5-6).

The quality element “fish” was also important to determine the length of reference sites. The length was defined according to fish regions. In particular this means that within the length of a reference site a minimum population of fish should be present (Lebensministerium 2002, p. 5-6). This implies more precisely that the length of a reference site has to be:

- 1km for smaller watercourses (Strahler number: 1-3)
- >5km for medium-size watercourses (Strahler number: 4-5)
- >10km for big watercourses (Strahler number: >6)
- In general, lateral fish migration should be possible

Moreover, the Austrian strategy paper defines the following indicators and criteria for the selection of reference sites:

Table 10: Criteria and impacts for the selection of reference sites; (Source: Lebensministerium 2002, p. 11)

Indicators	Criteria
Biological conditions	No input of pollutants (atmospheric, diffuse, punctual) Minimal land use in the area
Hydrology and Morphology (e.g. habitats, stream course)	No hydrological changes (in the catchment area and directly in the water body)
Floodplains	No morphological alterations and changes in the continuity of the river flow (in the catchment area and directly in the water body)
Physico-chemical conditions	No loss of connection to the hinterland
	No withdrawal of material
	No/minimal fishery within the water body
	No/minimal bio manipulation

The level of the above-mentioned impacts should be null or very low. During the intercalibration exercise, the Central Baltic GIG compared the threshold values for the evaluation criteria and impacts to select reference sites across the member states within the Central Baltic GIG. The full list of threshold values applied for Austria and other countries can be found in the "Final Intercalibration report" of the Central Baltic GIG Steering Group and in the Austrian strategy paper. Some of the threshold values applied in Austria are displayed in table 11:

Table 11: Threshold values for the selection of reference sites in Austria; (Source: Central Baltic GIG Steering Group 2006)

Pressures	Threshold values
Point source pollution	<0.4% of artificial land use in the area
	No toxic pollution discharge, ratio PEC/PNEC < 1
Diffuse source pollution	Intensive agriculture in the catchment area < 20%
	No significant risk of soil erosion
	Acidification: pH > 6
	Eutrophication: no sign of plant proliferation
Morphological alterations	"Continuity" of the river stream should facilitate movement of type specific species (fish)
	Flow impedance < 10% of the river affected by it
Biological pressures	No impairment by invasive plants or animals
	No intensive commercial fishery

In comparison to other countries, like e.g. the Netherlands where no single reference site could be found and reference values are based on modelling, the task to establish reference sites in Austria was comparably easier. This is mainly true because of the high percentage of alpine rivers, as in mountainous regions land-use and hydro-morphological alterations are rare. In the eastern lowlands it was a much harder task, as intensive land-use and hydro-morphological changes are more common. According to an expert of the Austrian Ministry of Agriculture and Environment, the biggest challenge was the high number of different water body types as Austria lies within four European eco-regions with very divers geology, altitudes ranging from < 200m to > 3000m, different base slopes, substrates, river velocities and different sizes of run-off regimes. For this reason a lot of reference sites had to be identified because of the high number of different water body types.

The derived reference values for all quality elements and water body types are published and regulated in the so-called "Qualitätszielverordnung Ökologie Oberflächengewässer" (Ofenböck 2013). For which quality elements and parameters reference values have been derived, will be discussed in the following chapter.

4.1.4 Determination of quality elements and status class boundaries

The Austrian assessment of the ecological status follows a national approach, which is regulated in the above mentioned "Qualitätszielverordnung Ökologie Oberflächengewässer" which entered into force in 2003 (European Commission 2012, p. 29). This provision determines and regulates all quality elements, defines the "high" and "good status" and lists reference values and EQR class boundaries for each quality element. The specific methodical approaches are specified in methodical guidelines for all quality elements (biological, hydro - morphological and physico-chemical quality elements) and are, according to the "Qualitätszielverordnung Ökologie Oberflächengewässer" and the "Gewässerzustands-Verordnung", legally binding.

The national regulations are in accordance with the CIS recommendations and the Austrian system therefore complies with the CIS Guidance documents "Overall Approach to the Classification of Ecological Status and Ecological Potential - ECOSTAT" and Rivers and Lakes – Typology, Reference Conditions and Classification Systems – REFCOND".

The national provision "Qualitätszielverordnung Ökologie Oberflächengewässer" determines the following quality elements for the assessment of the ecological status in Austria:

Table 12: Quality elements for the determination of the ecologic status; (Source: Lebensministerium 2010e)

Quality elements	
Biological quality elements	Macrophytes Phytobenthos Benthic invertebrates Fish
Hydro - morphological quality elements	Morphology River continuity Water balance
Chemical and physico - chemical elements	Temperature Oxygenation conditions Acidification Nutrient conditions Salinity

The Austrian specifications follow in general the definitions of the WFD and the CIS REFCOND guideline, in which hydro-morphological quality elements are not specifically defined for the "good status", but need to allow biological quality elements to be in the ranges, which were defined for the "good status". However, in case of the physico-chemical quality elements, Austria applies a deviating approach to the recommendations of the CIS guidance. As described in chapter 3.1.3, according to the CIS guideline, the physico-chemical quality elements have to be taken into consideration for the evaluation of the "high" and "good status" and therefore have to be, together with the biological quality elements, in "high" or "good status". In Austria, the physico-chemical quality elements are only taken into consideration for the evaluation of the "high status", in case of the "good status", physico-chemical quality elements are used as "supporting elements" which means they have to allow biological quality elements to reach "good status". In other words, if the biological quality elements reach a "good status" and the physico-chemical quality elements are in an inferior status class, the water body is still classified to be in "good status" (Zessner 2013b).

In the following chapters the Austrian regulations for the biological, physico-chemical and hydrological quality elements for rivers will be explained with a focus on the biological quality element.

4.1.4.1 Biological quality elements

As mentioned above, in order to assess the biological status of rivers, the analysed quality elements are macrophytes, phytobenthos, benthic invertebrates and fish. The methods applied for each quality element are explained in methodical guidelines, which are legally binding methodical approaches according to the "Qualitätszielverordnung Ökologie Oberflächengewässer". Table 13 lists modules and indices used to assess each biological quality elements:

Table 13: Biological quality elements, modules and indices; (Source: Lebensministerium 2010a)

Quality elements	Modules	Indices
Macrophytes	Composition of species Abundance	No information
Phytobenthos	Trophic state Saprobic state Reference species	Trophic state index (ROTT et al. 1999) Saprobic index (ROTT et al. 1997) Reference index
Benthic invertebrates	Saprobic status General degradation (calculated with Multi-metric indices) Acidification	Screening method Detailed MZB method
Fish	Abundance of species Age structure Biomass	Fish index Fish region index

The quality element phytoplankton is not mentioned in this list as the autochthonous occurrence of phytoplankton in Austrian watercourses plays a too minor role for a spatially inclusive and comprehensive application. For this reason no method for this quality element was developed. However, an expert assessment of phytoplankton can, when indicated, be conducted for the big rivers like Danube, March and Thaya (Lebensministerium 2010a, p. 18).

In case of the other quality elements, Austria follows the type-specific approach for the assessment of the ecological status, and therefore also for the biological quality status, according to the provisions in the WFD. As described in the previous chapter, Austrian experts identified 15 riverine bioregions, which were again divided into subtypes and special types according to longitudinal differentiation. For some of the special riverine types it was not possible until to date to develop assessment methods for all biological quality elements due to insufficient data or high natural variability within reference conditions. In these cases, advice from experts was used to assess the quality status. Table 14 gives examples for some special water body types and indicates which modules of the quality elements are measurable for these cases:

Table 14: Special riverine water body types and modules applicable for each type; (Source: Lebensministerium 2010a, p. 16)

Special riverine type	Phytobenthos			Macrophytes	Benthic invertebrates			Fish
	Throphic State	Saprobic State	Reference Species		Saprobic State	Degradation	Acidification	Fishregion
Glacial streams	yes	yes	yes	yes	yes	no	(yes) only ref. criteria	(yes)
Rivers <10km2 catchment	(yes*)	(yes*)	(yes*)	(yes*)	yes	no	(yes*)	yes
Marsh stream	yes	yes	(yes*)	(yes*)	no	no	(yes*)	(yes*)
Thermal stream	(yes*)	(yes*)	(yes*)	no	no	no	(yes*)	no
Intermittent streams	yes	yes	yes	yes	no	no	(yes*)	no
Waterfalls/ cascades/ canyons	yes	yes	yes	yes	no	no	(yes*)	(yes*)
Big rivers: Danube, March, Thaya	yes	yes	yes	yes	yes	no	no	yes

The biological quality elements differ in their sensitivity in response to the different substantial and hydro-morphological pressures and hence produce different results. As mentioned before, the Austrian biological classification system has been related to the main pressures, which are for example eutrophication, organic enrichment or hydro - morphological alterations (the main pressures in Austria will be specified in the next chapter). Together all quality elements cover all possible pressures on the water bodies. The pressures have already been taken into account during the development of the assessment methods. For example, the assessment of the quality element fish is mainly based on hydro-morphological alterations. For benthic invertebrates and phytobenthos specific evaluation modules were developed slanted towards the different pressures such as saprobic and trophic contamination. Accordingly, these developed evaluation methods are used for operational monitoring[1]. That way, only the quality element with the highest indicative informative value in relation to a specific pressure is investigated, as it is supposed that the other quality elements are inferior indicators and would indicate a better quality status

[*] The evaluation method can be applied, but the results need to be critically revised as abnormal hydro-morphological and/or physical-chemical conditions can cause discrepancies in the evaluation results.

[1] Operational monitoring is used to determine the status of water bodies identified as being at risk and how this changes according to the PoMs (Foundation for Water Research 2013). Other types of monitoring are surveillance and investigative monitoring.

(Lebensministerium 2010a, p. 19; European Commission 2012a, p. 29). Which quality element corresponds to which pressure is shown in table 15. Crosses without braces mark parameters with the highest significance, whereas crosses with braces mark parameters with information value but less significance. These parameters with less significance are used additionally to the other parameters for ambiguous results.

Table 15: Biological quality elements in relation to pressures; (Source: Lebensministerium 2010a, p. 20)

Pressures	Quality elements				
	Phytobenthos	Makrophytes	Benthic invertebrates	Fish	Phytoplankton[2]
Substantial pressures:					
Nutrients	x	(x)	(x)		(x)
Oxygen content	(x)		x	(x)	
Temperature			(x)	x	
Salinization	(x)		(x)	(x)	
Acidification	(x)	(x)	x	(x)	
Hydro-morphological pressures					
Morphological alterations		(x)	(x)	x	
River bed alterations			x	(x)	
Residual flow		(x)	(x)	x	
Water level fluctuations		(x)	(x)	x	
Backwater		(x)	x	(x)	
Disruption of river continuity			(x)	x	

As provisioned in the WFD, Austria calculates the ecological quality status through the ecological quality ratio (EQR) and thus measures the deviation from the measured quality elements from reference conditions (measured value / reference value). The EQR values are in the range between 0 and 1, whereas one represents the reference value. With these values the class boundaries for the five ecological quality status classes are determined, whereat the developers of the specific evaluation methods make proposals for the boundary values. The final determination of the values is carried out according to the European-wide intercalibration process. The Austrian EQR values are as well defined in the „Qualitätszielverordnung Ökologie Oberflächengewässer“ (Lebensministerium 2010a, p. 21).

[2] Only applies for Danube, March and Thaya

Recapitulary, figure 11 summarizes the Austrian process of the determination of the ecological quality status:

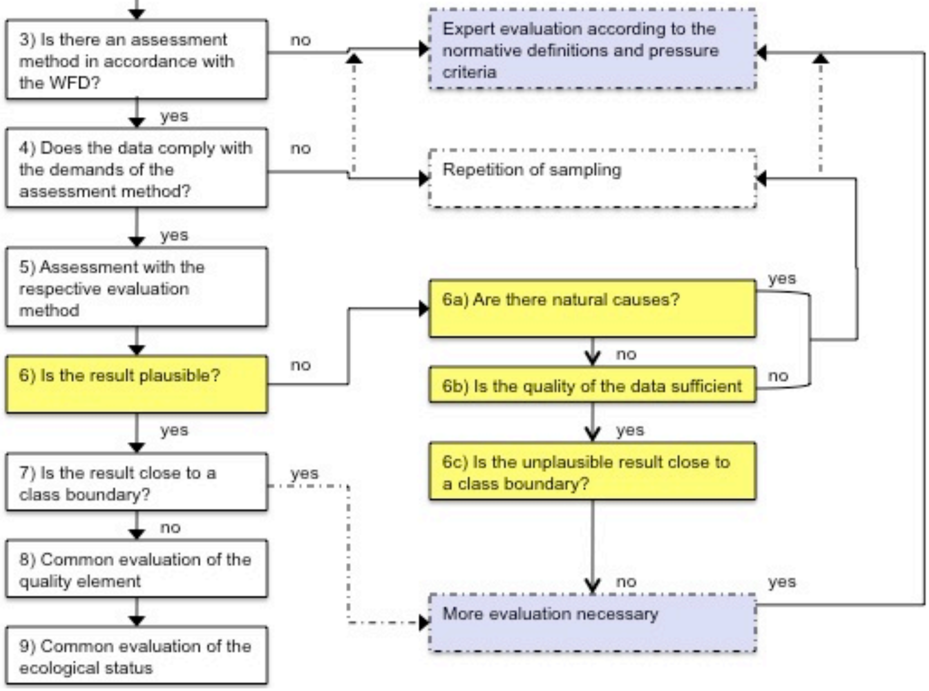

Figure 11: General approach for the determination of the ecological quality status in Austria; (Source: Lebensministerium 2010a, p. 23)

The benthic invertebrate quality element in Austria

This section will explain the assessment of the benthic invertebrate quality element as an example for the Austrian assessment methods of biological quality elements.

Benthic invertebrates are small and abundant organisms living on the riverbed. Due to their sedentary nature, spatial analyses of the effects of perturbations are possible. Furthermore, their long life cycle allows identifying temporal changes on pressures (Castillo 2010, p. 31). That means, that through the assessment of the benthic invertebrate quality element, substantial pressures and impacts of other pressures like oxygen content, organic pollution, degradation of river morphology, hydrological regulations in the catchment area, etc. can be evaluated. For the assessment of the benthic invertebrates quality element, Austria uses the "*saprobic module*" and the module "*general degradation*". The worst result between the two modules determines the qualitative status of the benthic invertebrate quality element (Lebensministerium 2010e, p. 5).

The *saprobic module* describes the reaction of benthic invertebrates to organic contamination and is based on the saprobic index developed by ZELINKA & MARVAN in 1961 and was adjusted to the provisions of the WFD by STUBAUER & MOOG in 2002. The result of the saprobic index is transferred under consideration of the saprobic natural states of water bodies (as explained in chapter 4.1.2 and pictured in figure 10) into the respective quality class. The definition of the class boundaries according to the saprobic index are in general defined as (Lebensministerium 2010b, p. 59):

- High status: </= reference value
- Good status: Deviation from reference value max. 25%
- Moderate status: Deviation from reference value max. 50%
- Poor status: Deviation from reference value max. 75%
- Bad status: Deviation from reference value more than 75%

The class boundaries are according to the above specifications converted into the following EQR values:

Table 16: EQR values for benthic invertebrates - saprobic module; (Source: Lebensministerium 2010e, p.24)

Ecological status Benthic invertebrates – saprobic module		Class boundaries				
	Saprobic Reference Value	1.00	1.25	1.50	1.75	2.00
1	High	</=1.00	</=1.25	</=1.50	</=1.75	</=2.00
2	Good	1.65	1.84	2.03	2.21	2.40
3	Moderate	2.30	2.43	2.55	2.68	2.80
4	Poor	2.95	3.01	3.08	3.14	3.20
5	Bad	>2.95	>3.01	>3.08	>3.14	>3.20

The module *"general degradation"* is based on a multi-metrics-approach and shows the effects of different pressures like the degradation of morphology, pesticides, hormone-active substances, toxic substances, residual water, etc. It consists of either one or two multi-metric indices according to water-body type which consider three different issues (Lebensministerium 2010a, p. 32-33):

- Potamalization effects: adverse effects due to warming (eg. Effluents from heating plants, or high sun exposure), backwater effects in rivers (eg. due to hydroelectric power stations), nutrient contamination, etc.
- Rhithralization effects: adverse effects through cooling, effects due to construction (e.g. straightening of river beds).
- Toxic contamination

Due to the natural variability of the water body types, different multi-metric indices in different combinations are used to assure high relevance and validity for each probed water body type. The defined class boundaries for the module "general degradation" are the following:

Table 17: EQR values for benthic invertebrates – general degradation module; (Source: Lebensministerium 2010e, p. 24)

	Ecological status Benthic invertebrates – general degradation module	Class boundaries
1	High	>/= 0.80
2	Good	0.60
3	Moderate	0.40
4	Poor	0.20
5	Bad	<0.20

The assessment method applied in Austria was developed by the University of Natural Resources and Life Sciences and by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management. Details about the calculation of the indices can be obtained from the "Leitfaden zur Erhebung der Biologischen Qualitätselemente Teil A2 – Makrozoobenthos" (Lebensministerium 2010b).

4.1.4.2 Physico - chemical quality elements

The assessment method for physico-chemical quality elements in Austria was developed by the Technical University Vienna. The focus of the development work lied on the selection of the parameters for the assessment of the elements oxygenation and nutrient conditions, and on the definition on quality targets. For the definition of quality targets for each physico-chemical quality element/parameter, the respectively most significant biological parameter was considered. Hence the quality targets of the physico-chemical quality elements relate to the typology of the most indicative biological parameter (Lebensministerium 2010c, p. 7).

As mentioned in chapter 4.1.4, the physico-chemical quality elements assessed in Austria are:

- Oxygenation conditions
- Nutrient conditions
- Temperature
- Acidification
- Salinity

For the assessment of the *oxygenation conditions,* also parameters describing the organic pollution, which have impact on the oxygenation conditions of a water body have been included. The evaluated parameters in relation to the most indicative biological parameters are therefore:

Table 18: Assessment of the oxygenation conditions in Austria; (Source: Lebensministerium 2010c, p.13)

Quality element	Parameter	Most indicative biological parameter
Oxygenation conditions	Oxygen saturation	Benthic invertebrate – Saprobic index
	BSB5	Benthic invertebrate – Saprobic index
	Dissolved organic carbon (DOC)	Benthic invertebrate – Saprobic index

Austrian water bodies are mainly phosphor – limited. Additionally to phosphor the Austrian system evaluates nitrogen and nitrate, in order to assess the *nutrient conditions:*

Table 19: Assessment of nutrient conditions in Austria; (Source: Lebensministerium 2010c, p. 14)

Quality element	Parameter	Most indicative biological parameter
Nutrient conditions	Orthophosphate – Phosphor (PO4-P)	Phytobenthos- Trophic index
	Nitrate – Nitrogen (NO3-N)	Benthic invertebrates – Saprobic index

Fish are the organisms that are most sensitive to temperature changes. During their life cycle they even have different temperature demands. For this reason fish was considered to be the most relevant biological parameter to assess the quality element "*temperature*" in Austrian water bodies:

Table 20: Assessment of temperature conditions in Austria; (Source: Lebensministerium 2010c, p. 16)		
Quality element	**Parameter**	**Most indicative biological parameter**
Temperature conditions	Temperature	Fish

The natural *salinity* of a water body depends on the geological circumstances. As areas with significantly elevated loads are locally narrowed and are not reflected in the different biotypes, the Austrian experts decided to regulate the salinity content independently from the water body types with a uniform quality target for chloride. The legal implementation is done in the "Qualitätszielverordnung Chemie Oberflächengewässer" (Lebensministerium 2010c, p. 16).

Table 21: Assessment of salinity in Austria; (Source: Lebensministerium 2010c, p. 16)		
Quality element	**Parameter**	**Most indicative biological parameter**
Salinity	Chloride	Fish

The chemical evaluation of acidity is done through the pH – value. In calciferous water bodies the pH–value stays stable at 7–8 due to the buffering capacity of the calcium carbonate. In water bodies with low calcium carbonate levels, it is possible to detect anthropogenic caused acidification by means of the pH – value (Lebensministerium 2010c, p.17)

Table 22: Assessment of acidification in Austria; (Source: Lebensministerium 2010c, p. 17)		
Quality element	**Parameter**	**Most indicative biological parameter**
Acidification	pH value	Benthic invertebrates

As mentioned before, the physico-chemical parameters are used in Austria only for the assignment of the "high status", and are considered as "supporting" elements (they have to be in such conditions to allow biological elements to be in the respective status class) for the definition of the other status classes.

4.1.4.3 Hydro - morphological quality elements

As previously explained, the hydro-morphological quality elements play especially a role for the accomplishment of the “high ecological status”, as “high“ hydro–morphological conditions are necessary in order to reach a “high ecological status”. This “high status“ is primarily defined through the absence, or rather the insignificancy of anthropogenic hydro-morphological alterations. The hydro-morphological conditions for the “good status“ and “moderate status“ have to allow the biological quality elements to reach a “good status“ or „moderate status“ respectively. Therefore, a hydro-morphological assessment with all five-status classes is according to the WFD not necessary. The Austrian authorities decided to assess the morphological parameters according to five quality status classes. Hydrological pressures and pressures caused by dams are not classified in five status classes but at defined significance boundaries, they are considered in the general hydro-morphological classification (Lebensministerium 2010d, p. 69).

The evaluation of the hydro-morphological status is always related to a water body segment of 500 m length. The parameters for the assessment of the hydro-morphological quality element in Austria are:

Table 23: Hydro-morphological parameters in Austria; (Source: Lebensministerium 2010d, p. 17)

Parameter group	Parameters
Hydrology	Water abstraction Residual flows Upsurge flows Dams
Morphology	*Main parameters:* Shore dynamics Blind level dynamics *Additional parameters:* Layout/route of running water Composition of substrate Structures in the streambed Riparian vegetation
Dams/Discontinuity of water streams	No information given

The evaluation of the morphological quality element happens through the assessment of sum parameter within the 500m sections. The parameter “dams” is subdivided into passable and non-passable dams. The division into passable and non-passable dams is related to the patency for fish. Additionally for the evaluation of the “high status” it is necessary to assess if the natural transport of sediments in a water body is still possible (Lebensministerium 2010d, p. 58).

4.1.5 Pressures and risks

“Significant pressures“ comprise mainly substantial pollution and hydro-morphological alterations. Annex II of the WFD distinguishes for substantial pollution between point sources and diffuse sources, and for hydro-morphological pressures between hydrological pressures (e.g. water abstraction) and morphological pressures (e.g. alterations in the structure of the riparian zone). As explained in chapter 3.1.4 a pressure is significant if it has a negative impact on the ecological quality of a water body and therefore endangers the compliance with the quality targets. In order to investigate these significant pressures, the Austrian authorities defined threshold values for each pressure.

The following pressure types were taken into consideration for Austrian surface waters:

Table 24: Pressure categories in Austria; (Source: NGP 2009, p. 29)

Pressure group	Pressure parameter
A) Substantial and physical pressures from point sources and diffuse source	Point sources Diffuse sources
B) Hydro-morphological pressures	Hydrology Morphology Patency of water
C) Other pressures	Fishery Alien species Climate change

Point sources are e.g. emissions from waste water treatment plants and diffuse source are mainly identified emissions from agriculture and forestry land use (N/P emissions and pesticides), emissions from traffic or airports (with organic carbon compounds and nitrogen compounds used for de-icing of airplanes), mining sites (heavy metals, chromium, copper and zinc) and contaminated sites (heavy metals and chlorinated hydrocarbons). The identification of these pressures is done through expert judgment and in case of agriculture with numerical methods. More precisely, the risk assessment for the evaluation of the effects of substantial pressures on surface waters happens on the one hand through the analyses of immission monitoring data and on the other hand on measured or projected emission loads of significant point sources, and also on information concerning land use in relation to diffuse sources (European Commission 2012a, p. 7).

Hydro-morphological pressures comprise the hydrology, morphology and passability of a water body. Hydrological pressures are caused by anthropogenic alterations, which lead to a change in the water balance, e.g. changes in the runoff or runoff dynamics of surface waters. That includes in Austria especially pressures causing strong variations in the water gauge or water discharge due to hydro-electric power stations and pressures due to water abstractions without sufficient residual water donation. Morphological pressures on the other hand are caused by anthropogenic interventions into the structure of water bodies, e.g. changes of the waterbed width or depth, changes of the substrate, the riparian zone or the flow velocity. These alterations are created due to water body regulations, riparian linings, river straightening or backwaters. Furthermore dams stress water bodies as they adjourn their natural patency and many aquatic organisms, especially fish, are disturbed in their ranging behaviour. As the main electricity production in Austria happens with hydroelectric power stations, dams represent one of the major pressures on Austrian water bodies (NGP 2009, p. 30).

Other pressures on the water biocenosis are for example commercial fishery, alien species/neobiota or climate change. These potential pressures have not been identified as the main initiators for failing the water quality targets in the WFD and have been classified as not significant in Austria. In the framework of the national monitoring programme, also long-term effects caused e.g. by climate change are monitored. In the case of alien species, environmental studies on the effects are conducted (NGP 2009, p 30).

Building on the analysis of the significant pressures, the effects with regard to the possible fail of the quality targets were estimated. This risk analysis was done according to defined risk-categories. Afterwards, the surface water bodies were classified as "no risk to fail quality targets", "risk to fail quality target" and "risk not assessable". The last category includes all water bodies with insufficient available data for classification. For every pressure–type a separate risk–assessment was carried out. The "general risk" for each water body was evaluated using the "worst-case" scenario, meaning that the highest risk of the water body reflects the general risk (NGP 2009, p. 30).

The Austrian risk analysis showed that 52% of Austrian water bodies are at risk to fail the quality target of a „good ecological status", 28% have no risk to fail and for

20% of the surface water bodies it was not possible to estimate the risk. The main reason for the classification of 52% of all surface water bodies to be in risk of failing the target is on the one hand the intensive use of hydropower as renewable energy source in Austria, and on the other hand the necessity of numerous flood control measures in Austrian alpine valleys. Table 25 shows the total risks of the three international water bodies – Danube, Rhine and Elbe and the total risks for Austrian water bodies:

Table 25: Total risks of international water bodies and of total Austrian water bodies; (Source: NGP 2009, p. 40)

Catchment areas	Total length (km)	Water body length (km)			(%) of water body length		
	Length of the water body	No risk	Risk not assessable	Risk	No Risk	Risk not assessable	Risk
Rhine	859	304	152	403	35	18	47
Elbe	409	51	202	156	13	50	37
Danube	29.986	8,395	5,662	15.929	28	19	52
Austria total	**31.254**	**8,750**	**6,016**	**16,488**	**28**	**20**	**52**

To enable a correlation to the respective risk categories, the results of the risk assessment of the water bodies are separately presented in the national management plan according to the following categories:

- General physico–chemical parameters: Carbon and nutrient parameters
- Chemical parameters: priority substances for the evaluation of the chemical status as well as other relevant substances according to the WFD for the evaluation of the ecological status
- Hydro-morphological parameters: Residual water, dams, backwaters, morphology

Table 26: Result of the Austrian risk assessment in relation to water body length; (Source: NGP 2009, p. 41)

Catchment areas	% of Water body length								
	General physico – chemical parameter			Chemical parameters			Hydro-morphological parameters		
	No risk	Risk not assessable	Risk	No risk	Risk not assessable	Risk	No risk	Risk not assessable	Risk
Rhine	94	1	5	92	4	4	35	18	46
Elbe	77	9	14	100	0	0	21	41	36
Danube	79	10	11	93	4	3	33	16	51
Austria total	**79**	**9**	**11**	**93**	**4**	**3**	**33**	**17**	**50**

As it can be seen in the table, the main pressure on Austrian water bodies comes from hydro-morphological alterations, whereas chemical pressures represent only a minor risk for the evaluated water bodies. This is due to the technical innovations of the 1980s and 1990s in the wastewater treatment industry and also because of stricter operational pollution avoidance and cleaning measures in Austrian enterprises. Concerning the physico-chemical parameters, the main problems arise due to nutrient contamination. These phenomena can be seen mostly in the north and east of the country where most of the agricultural activities take place whereas in alpine regions nutrient contamination and water quality deficits are very rare (NGP 2009, p. 41).

In the next part, diffuse source pollution in Austrian surface water bodies will be analysed in more detail.

Diffuse source pollution of surface waters in Austria

Agriculture and forestry are the most important sectors in concern to land utilization in Austria. The Austrian soil is used with 44% by agriculture followed by forestry with 43%. Grassland for cattle breeding takes 56% of the agricultural used area. Concerning substantial pressures, nitrogen and phosphor are the most relevant nutrients in Austria. For example on 23.000 km^2 agricultural area, more than 100.000 t nitrogen for mineral fertilization and 160.000t nitrogen as farm fertilizer are deployed. These substance inputs are not only relevant for Austria, but also for the black sea or the North Sea as these nutrients can accumulate and cause heavy eutrophication also in the sea (NGP 2009, p. 30).

Diffuse source pollution from agriculture and forestry happens on the one hand due to superficial rain-wash, and on the other hand through ground water. The extent of the pollution input depends on various factors such as the type and intensity of the soil utilization, the soil conditions, the amount of precipitation and soil erosion. Table 27 shows the diffuse source pathways of nitrogen and phosphor in comparison to point source inputs for the Danube catchment area:

Table 27: Diffuse source pathways of nitrogen and phosphor in the Danube catchment area; (Source: NGP 2009, p. 33)

Nutrient parameter		Direct deposition	Surface runoff	Erosion	Drainage	Groundwater runoff	Runoff from sealed surfaces	Point sources	Total
N	(kt/a)	2,310	16,790	2,970	3,370	36,370	2,530	15,200	79,540
N	(%)	2.9%	21.1%	3.7%	4.2%	45.7%	3.2%	19.1%	100%
P	(kt/a)	48	559	3,069	17	652	399	1,204	5,948
P	(%)	0.8%	9.4%	51.6%	0.3%	11%	6.7%	20.2%	100%

As it can be seen, the main pathway to surface waters for nitrogen is groundwater runoff and erosion for phosphor. For both, diffuse sources are the dominant input sources. Austria is in a special situation due to its high rainfall rate and the high share of mountainous terrain. These conditions lead to a high natural concentration of phosphor (without anthropogenic influence). In addition to nitrogen and phosphor inputs from agriculture, also emissions from combustion processes are responsible for diffuse inputs into Austrian water bodies. The relatively low share of point source pollution and pollution through sealed surfaces show the efforts and developments of the last decades in the wastewater treatment industry (NGP 2009, p.33).

Other pollutants in Austrian water bodies include pesticides, heavy metals and hydrocarbons (caused by abandoned polluted areas – in Austria there are six). However, these pollutants are significantly less than nutrients like nitrogen or phosphor.

4.1.6 Quality status assessment results in Austria

Austria designated about 12% of its water bodies as heavily modified water body (HMWB) or artificial water body (AWB). The designation follows the provisions of article 4.3 of the WFD and the guidance developed under the CIS process. As mentioned before, HMWB and AWB are treated differently and have therefore not the quality objective to reach "good ecological status". For HMWB and AWB only a two-level classification scheme is used namely "good potential" and "failing to achieve good potential". The classification results for HMWB and AWB surface water bodies are for this reason treated separately (NGP 2010, p. 80).

Natural surface waters (without HMWB and AWB) comprise 88% of the Austrian surface water body network bigger than 10 km^2. As it can be seen from figure 12, 39% of all Austrian surface water bodies reach "high" or "good status", 51% reach a moderate status and 10% a poor or bad status.

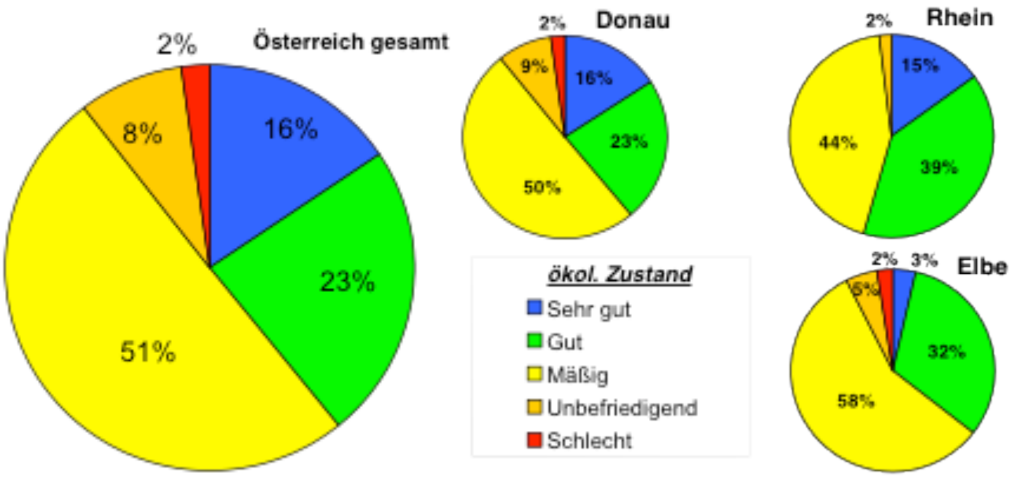

Figure 12: Quality status of Austrian surface water bodies (without HMWB and AWB) in 2009; (Source: NGP 2010, p. 71)

Austria applies a stage-wise approach to increase the status of its surface waters. As the focus of the measures lies within the first RBMP on HWMB and AWB, it results in only a small increase (3%) in quality for surface water bodies by 2015. In 2021, it is planned that half of Austrian water bodies reach "high" or "good status", and in 2027 all surface water bodies should be in "high" or "good ecological status":

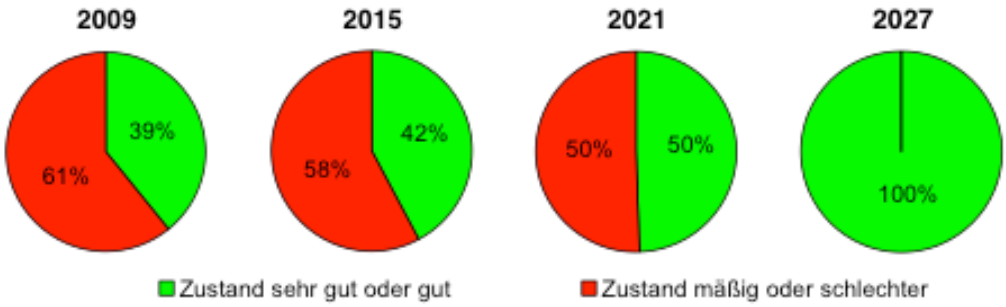

Figure 13: Step-wise approach to reach “high” or “good” ecological status in Austria; (Source: NGP 2010, p. 73)

In 2009, the majority (87%) of HWMB and AWB did not reach the targeted „good ecological potential“. This is mainly due because still many measures to improve the status without having significant negative impacts on the environment or for other uses are possible.

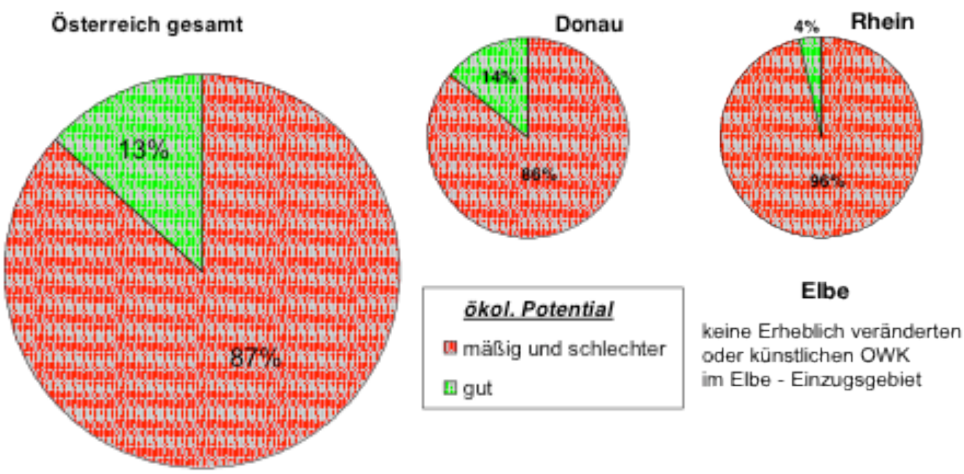

Figure 14: Quality status of HWMB and AWB in Austria in 2009; (Source: NGP 2010, p. 81)

As the focus of measures within the first national RBMP will be on HWMB and AWB, a significant improvement of the quality status is planned:

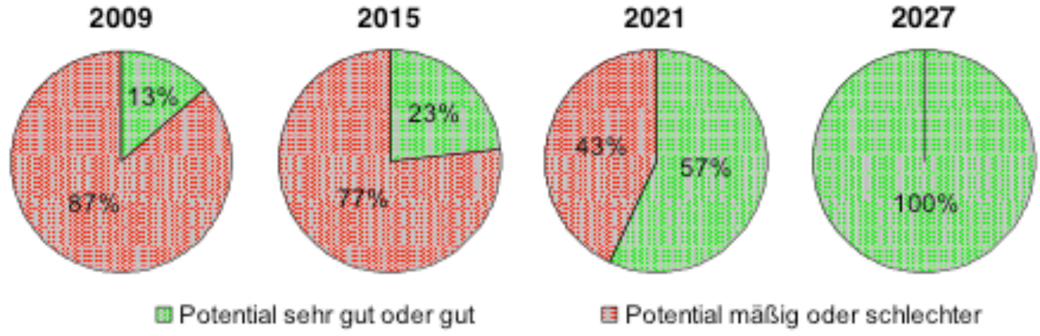

Figure 15: Step-wise approach for the improvement of the quality status of HWMB and AWB in Austria; (Source: NGP 2010, p. 82)

As it can be seen, the biggest improvement for surface water bodies and HWMB/AWB is planned to be between 2021 and 2027 as according to art. 4.4 of the WFD, 2027 is the latest possible year to achieve "good status" or "good potential". It is questionable if these envisioned improvements of 50% for surface water bodies and 43% for HWMB/AWB in a period of six years will be feasible.

Within the national RBMP, there is a general assessment of the main drivers causing the exemption of a step-wise approach. The main reasons for time exemptions under article 4.4 are a lack of technical feasibility (e.g. it is not possible to remove 20,000 barriers until 2015), insufficient knowledge concerning measures and their impact (e.g. for the creation of a cost-effective PoMs), natural conditions (e.g. the achievement of natural conditions due to hydro-morphological renaturation measures is dependent on how fast the momentum of the river, or biological processes, re-adapt to the new circumstances), and disproportionate costs (e.g. re-naturation costs are estimated to be too high to be covered by local authorities or communities by 2015). Table 28 shows the amount of natural, HWMB and AWB surface water bodies exempted according to article 4.4 in Austria:

Table 28: Number of exemptions per total water bodies in Austria (for chemical and ecological status) according to article 4.4; (Source: European Commission 2012a, p. 36)

	Technical feasibility	Disproportionate costs	Natural conditions
Total number of water bodies exempted	4,015	3,773	4,012

4.1.7 River Basin Management Plans – Programs of Measures

As mentioned before, Austria acts as river basin party in the Danube RBD and has observer status in the Rhine and Elbe river basins. According to a report of the European Commission (2012a) "*Austria has followed a national and consistent approach for the preparation of the 3 RBMPs*." The national RBMP covers all three river basin districts in Austria in one document and implements all aspects provisioned in the WFD. The structure of the Austrian RBMP follows the methodologies and approaches agreed during the Common Implementation Strategy (CIS) process. The international and national RBMPs were transmitted in 2010 in time to the European Commission after an extensive public consultation process took place between April and October 2009. During the elaboration of the RBMPs for the Danube, Rhine and Elbe, Austria showed a lot of effort to ensure international coordination, especially in the Danube catchment area (European Commission 2012a, p. 3).

4.1.7.1 Program of measures

A catalogue of Programs of Measures (PoMs) has been drafted for each of the three international RBMPs and the national RBMP. As provisioned in the WFD, all measures are responses to the water body status assessment and the related pressures. In the Danube RBD, Austria coordinated together with Member states and non-Member States a PoMs of "basin-wide importance". These measures originate from the national PoMs, which became operational in 2012. The program of measures of the Danube RBD are structured according to "significant management issues" (hydro - morphological alterations, nutrient contamination, etc.) which are highlighted priorities to be addressed in order to be able to successfully achieve the provisioned quality targets. These "significant management issues" are managed and coordinated by the International Commission for the Protection of the Danube (ICPDR). Through a high degree of international cooperation also with riverine non-Member states (e.g. in the Danube RBD), the national measures have been linked and incorporated into the PoMs of the international RBMPs (European Commission 2012a, p. 39). Table 29 shows the main focus of national PoMs linked to international PoMs, the focus of the international PoMs and the degree of international cooperation for the three RBDs:

Table 29: Program of Measures of international RBDs; (Source: European Commission 2012a, p. 38-39)

RBD	**Focus of national PoM linked to international PoM** (according to the report of the European Commission 2012)	**Focus of international PoMs (according to the** report of the European Commission 2012)	**International co-operation**
Danube	River continuity, nutrient reduction, increase of habitat diversity	River continuity, nutrient reduction, transboundary chemical pollution	Strong international cooperation also with non-Member states
Rhine	Re-establishing biological continuity/increase of habitat diversity, reduction of diffuse pollution and other pressures from point sources	River continuity, nutrient reduction, transboundary chemical pollution	Coordination also with non-Member states
Elbe	Emphasis on hydro-morphological pressures	River continuity, nutrient reduction, transboundary chemical pollution	No information given

The national RBMP distinguished between three different types of measures:

- Preservation measures
- Rehabilitation measures
- Measures for the development of river basin management

Preservation measures are measures to prevent the deterioration of certain water bodies. Most of them are already in place and comprise for example regulatory requirements for the approval of water use/abstraction. *Rehabilitation measures* are intended to facilitate the step-by-step attainment of the “good” status in water bodies with a status worse than “good”. They consist of compulsory and voluntary measures. *Measures for the development of river basin management* have been implemented to meet the often-diverse demands of water body use. These measures serve as base for overall development planning and in consequence for regional programs (e.g. devotement) (NGP 2009, p. 90).

The PoMs in the national RBMP is linked to the main pressures and describes consisting measures and the expected improvements, and new measures for specific sectors, which should enable the achievement of the quality targets. The PoMs is outlined according to the significant pressures, which could hinder the achievement of the quality targets. For every quality target, the significant pressure and the main drivers/key sectors, which have been identified as the main polluters, are indicated.

During the public consultation process the main pressures on Austrian water bodies were discussed with stakeholders and NGOs. In a nutshell, the main identified pressures/challenges for which measures have to be taken are:

- Improvements of the water body structure, flow regime and river continuity in water bodies
- Reduction of nutrient pollution (and partly organic pollution) of surface waters and ground waters with nitrate through diffuse sources.

In the following section already existing and planned measures against diffuse source pollution in Austria will be analysed in more detail.

Measures against diffuse source pollution in Austria (for the achievement of a good status)

The PoMs of the national RBMP lists the following already existing and legally binding measures against diffuse source pollution:

- *"Aktionsprogramm Nitrat":* the Aktionsprogramme Nitrat is the national implementation of the Nitrate Directive of the European Union. It contains provisions to decrease the input of nitrate from agriculture into Austrian water bodies. The provisions are legally binding and are controlled by the "Gewässeraufsicht" and in cross-compliance by the "Agrarmarkt Austria". Measures are e.g. timeframes in which the use of nitrogenous fertilizers is not allowed, provisions for the application of nitrogenous fertilizers close to water bodies, limits for the amount of nitrogenous fertilizers, etc.
- "*Immissionsschutzgesetz Luft":* contains provisions to e.g. limit NOx emissions from traffic.
- *"Emissionshöchstmengengesetz Luft":* contains national emission limits for air pollutants e.g. NOx, NH3.
- *"INVEKOS – Umsetzungsverordnung 2008":* According to the European Directive Nr. 1782/2003 of the Council, the Member States have to implement minimal standards for a good agricultural and ecological status. These provisions are implemented in the national "INVEKOS" directive. It includes

provisions for minimum distances between water bodies and agricultural used areas (e.g. for rivers the minimum distance is five meters). Furthermore, agricultural fieldwork is prohibited on frozen and flooded soils, as well as soils with snow cover (NGP 2009, p. 123 – 124).

Additionally, the following voluntary measures concerning financial incentives and consulting have been established:

- *"ÖPUL 2007":* ÖPUL is the national translation of the Directive Nr. 1698/2005 of the Council, which regulates the promotion, and development of rural areas through the European agricultural fund (ELER) from 2007 - 2013. The program includes various measures for the protection of water bodies, e.g. limits for fertilizer usage lower than the Nitrate Directive, limitations for cattle breeding density, abandonment of mineral fertilization on agricultural areas and grasslands, crop rotation conditions, etc. (NGP 2009, p. 124).

- The Austrian federal governances also organize *consulting activities* for the relevant stakeholders (e.g. farmers, general public, etc.). For example, some federal states of Austria publish the monitoring results of nitrogen for specific locations and give recommendations for the use of fertilizers for specific crops.

The implemented measures lead to a significant reduction of the usage of mineral fertilizers, to a reduction of nutrient excess on agricultural areas and in general to a reduced nutrient input into Austrian water bodies. From 1991 to 2012 there was a significant reduction of the usage of mineral fertilizers such as nitrogen, phosphate and potash fertilizer. Also, the emission limits for NOx for traffic and the industry contribute to the reduction of diffuse source water pollution. Through the implemented measures, the quality status of water bodies with "bad" or "poor" status" could be improved to "moderate status". With the consequent implementation of the Austrian Nitrate Directive, and the additional voluntary measures like "ÖPUL" and consulting activities, a further reduction of diffuse source pollution is expected in the future (NGP 2009, p. 126).

Table 30 gives a summary of the implemented measures against diffuse source pollution of Austrian water bodies:

Table 30: Summary of measures against diffuse source pollution in Austria; (Source: NGP 2009, p. 128 - 129)			
Desired improvement	**Measures**	**Responsible sector**	**Implementation mechanism**
Achievement of good status in concern to eutrophication	• Timeframes for fertilization • Minimum distances between fertilized area and water body	Agricultural sector	• "Aktionsprogramm Nitrat" • Control through inspection (Gewässer-aufsicht)
Reduction of nutrient input	• Minimum distances between fertilized area and water body • Grassland conservation • Limits for fertilization lower than the Nitrate Directive • Greening of agricultural areas • Crop rotation regulations • No fertilization on elution-endangered soils • Recommendations for fertilization • etc.	Agricultural sector	• INVEKOS • ÖPUL 2007 • Consulting activities
Reduction of NOx emissions	• Traffic limitations • Implementation of air pollution inventory	Traffic Agricultural sector	• Immissionsschutz-gesetz Luft • Emmissionshöchst-mengengesetz Luft

4.1.7.2 Cost effective analyses regarding the program of measures

The Austrian national RBMP describes the approach applied for cost–effective analysis (CEA) for the three main significant pressures, which are diffuse source pollution through nutrients and nitrate, nutrient input from municipal sewage disposal and hydro-morphological pressures. The national RBMP hereby refers to the so-called "Maßnahmenkataloge" (catalogues of measures). These catalogues of measures were elaborated by the Austrian Ministry for Agriculture, Forestry, Environment and Water Management, regional authorities and external experts and are compilations of measures relevant to the significant pressures, which should support the elaboration of the PoMs.

These catalogues of measures are not legally binding documents and have been established for three key areas responsible for the main significant pressures (Lebensministerium 2007c, p. 1):

- Agriculture: measures against diffuse source pollution with nutrients of surface and groundwater bodies
- Urban Development: measures for the reduction of input of nutrients and oxygen consuming substances from municipal sewage disposal
- Hydro–morphology: measures for the reduction of pressures on watercourses caused by hydrological and morphological alterations.

Catalogues of measures should serve as "tool box" for the selection of measures for the PoMs and therefore comprise measures with very different impacts, costs and efficiencies. All three catalogues follow the same structure (Lebensministerium 2007c, p. 2):

- Pressures – description of negative impacts on relevant quality parameters
- Measures for mitigation of the relevant pressure
- Effectiveness of the measure – qualitative assessment of the impact on biological quality elements according to WFD
- Description of further impacts of the measure – timeframe until effect of the measure can be seen, impact on other sectors and initiators, possible combinations of measures
- Financial costs of the measure – divided into investment and operational costs, lifetime of the measure
- Cost–effectiveness of the measure

The Preamble (2007c) of the catalogue of measures states: „*The information about the costs are a significant importance as with this instrument the selection of the most cost–effective combination of measures shall be supported*" (Lebensministerium 2007c, p. 3). The cost analysis was based on already implemented measures, available data and scientific studies, as well as expert judgements. The costs for each measure were either denoted as specific cost ranges (for urban development and hydro–morphology), or were rated qualitatively according to a four-level scale (for agriculture) (Lebensministerium 2007c, p.3).

The following section will explain the cost – effective analysis established within the catalogue of measures for agriculture. The effectiveness of measures is related (for all measures concerning agriculture) to the possible reduction of the emission/pressure. The impact is assessed using four classes:

Table 31: Assessment of effectiveness in Austria; (Source: Lebensministerium 2007b, p.5)

Imagery representation	Qualitative description	Reduction of the emission/impact in %
+	Low effective	0 – 25%
++	Moderate effective	> 25 – 50%
+++	High effective	> 50 – 75%
++++	Very effective	> 75 – 100%

The costs for each measure are evaluated for agriculture per ha area. The costs per measure were also scaled according to four groups:

Table 32: Assessment of costs in Austria; (Source: Lebensministerium 2007b, p.5)

Imagery representation	Qualitative description	Cost range
€	Low costs	0 – 100 euro/ha/year
€€	Moderate costs	> 100 – 200 euro/ha/year
€€€	High costs	> 200 – 300 euro/ha/year
€€€€	Very high costs	> 300 euro/ha/year

The cost-effectiveness of a measure is the relation between the effectiveness and the costs for implementation. For the calculation of cost-effectiveness, the reduction of emissions into surface and ground waters was considered, whereas further effects were not considered. Furthermore, the actual costs were used for calculations. This means that not the mean average of the defined classes was calculated, but rather the actual effects and costs were taken into account. The costs per percentage point of the effect were divided into four groups (Lebensministerium 2007b, p. 5):

Table 33: Assessment of cost - effectiveness in Austria; (Source: Lebensministerium 2007, p.5)

Imagery representation	Qualitative description	Range of cost effectiveness
+	Low cost - effectiveness	>45 euro / % point
++	Moderate cost - effectiveness	>15 – 45 euro / % point
+++	High cost – effectiveness	>5 – 15 euro / % point
++++	Very high cost - effectiveness	0 – 5 euro / % point

Within the other catalogues of measures some different approaches were applied. In the catalogue of measures concerning hydro–morphology, the effectiveness of the measures was related to the environmental impact on the biological quality elements, whereas in the catalogue of measures concerning urban development the same approach as for agriculture was applied (assessment of the effectiveness by the reduction of the pressure). For hydro-morphology and urban development the costs were given for each measure by costs per hectometre (for hydro–morphological measures) and in euro per kg reduced pollutant per year (for measures concerning urban development) (Lebensministerium 2007b, d, e).

Table 34 summarizes the methodologies for cost–effective analyses (CEA) in Austria:

Table 34: Summary of CEA methods applied in Austria; (Source: Lebensministerium 2007b,d,e)

Attributes	Methodology applied in Austria
Type of costs considered for CEA	Financial costs In some cases opportunity costs are included
Effectiveness estimates	Focus on pressures reduced applied for two key areas (Agriculture, Urban development) Focus on environmental impact applied for one key area (Hydro–morphology)
Treatment of uncertainty	Range of estimated values of costs
Main type of measures included in CEA	Diffuse pollution measures (Agriculture, Urban development) Hydro–morphological measures Source pollution measures (Urban development)
Main information sources	Expert judgments, Scientific studies

The catalogues of measures can be accessed on the homepage of the national Water Information System in Austria (WISA).

4.2 Scotland

4.2.1 River basin districts and legal implementation in Scotland

Politically Scotland is part of the United Kingdom but during the past years Scotland, Wales and Northern Ireland have taken over more and more governmental power from the national government. Also, the responsibilities for river basin management of the RBDs in the regions were completely devolved to the regional governments. The transposition of the WFD into Scottish law happened through the Water Environment and Water Services Act 2003 (WEWS Act), which gives the Scottish Ministers the powers to „*introduce regulatory controls over certain activities in order to protect and improve Scotland's water environment*" (Foundation of water research 2013).

The competencies concerning RBM in Scotland are shared between the Scottish Environmental Protection Agency (SEPA) and the Scottish ministers. The Scottish Ministers set the policy requirements, approve objectives, the programs of measures and the RBMP for the Scotland RBD, whereas SEPA is responsible for leading and coordinating the implementation of the WFD and compilation of the RBMP (Foundation of water research 2013, SEPA 2013b). According to the website of the Foundation of water research (2013), the duties of the SEPA specifically are:

- *The establishment of River Basin Districts and cross border issues*
- *Characterization of River Basin Districts*
- *Identify water bodies for designation as Drinking Water Protected Areas*
- *Establish a register of protected areas*
- *Monitoring efforts in Scotland*
- *River Basin Management Planning including associated programs of measures*
- *The development of cost and benefit measures*

The Scottish government further designated by order public bodies, whose activities impact the Scottish water bodies, to support the work of the SEPA and hence to help to secure „*a successful implementation of the Directive in Scotland*“ (Foundation of Water Research 2013).

These authorities are e.g.:

- Local authorities
- Scottish water
- Scottish natural heritage
- Forestry Commission Scotland
- National Parks authorities
- Etc.

Scotland is located within three RBDs, whereas only the Scottish RBD lies entirely in Scotland and the Northumbria RBD and the Solway Tweed RBD are shared with England.

- Scottish RBD
- North Umbria RBD (no surface waters in Scotland, only underlying ground water bodies on Scottish territory)
- Solway – Tweed RBD (no surface waters in Scotland, only underlying ground water bodies on Scottish territory)

Within the North Umbria RBD and the Solway Tweed RBD Scotland shares no surface water bodies with England. Only some ground water bodies belonging to these two RBD are located on Scottish territory. This Master thesis will focus on the Scottish RBD as it is the only RBD with surface water bodies in Scotland.

The Scottish RBD covers about 113,920 km^2 from the Shetland Islands in the north to Glasgow and Edinburgh in the south. This area is home to about 4.8 million people. The main economic activities in the area comprise agriculture, aquaculture, whisky manufacturing, tourism and industry. In general, the Scottish RBD faces fewer environmental problems than others in the UK. The most significant pressures however are identified around the main capitals namely Glasgow and Edinburgh (Scottish Government 2009b, p. 6).

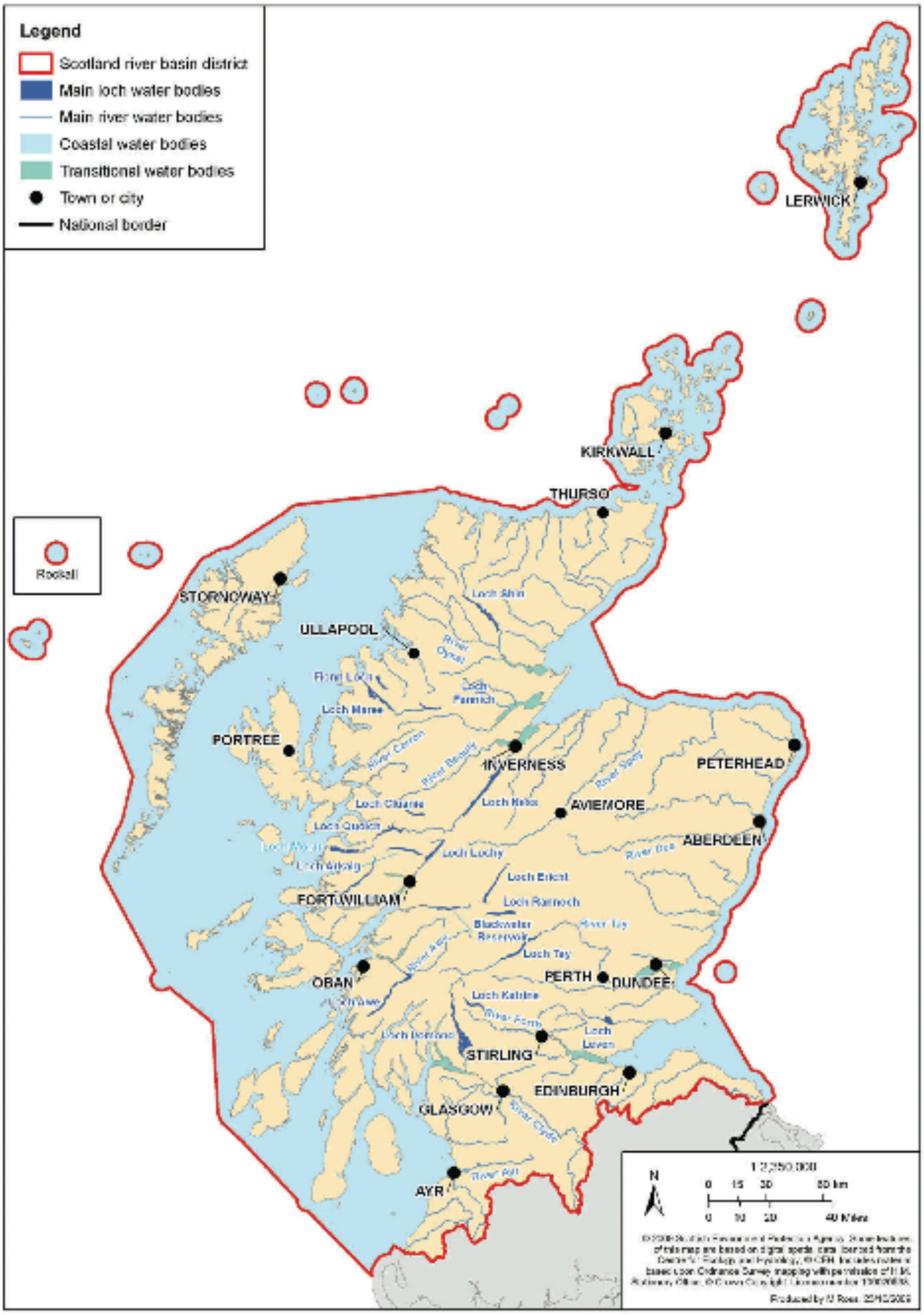

Figure 16: Scottish RBD; (Source: Scottish Government 2009b, p. 5)

Within the Scottish RBD there are 2,013 rivers, 309 lochs, 284 estuaries and 449 coastal water bodies. One particularity of the RBD is the large number of protected areas. These protected areas require special protection for their surface and groundwater or their wildlife directly depending on water.

4.2.2 Classification typology of surface water bodies in Scotland

The system for river typology was elaborated by the UK Technical Advisory Group (UKTAG), which published the guidance document “Guidance on Typology for Rivers for Scotland, England and Wales“ in 2003. River types in Scotland are according to the guidance document defined according to System A of the WFD. The typing factors and ranges used for defining water body types are according to the WFD the following:

Table 35: System A for river typification applied in Scotland; (Source: UKTAG 2003, p.2)

Altitude (mean catchment)	Catchment size (Km2)	Dominant geology
< 200m	10 – 100	Siliceous
200 – 800m	100 – 1000	Calcareous
> 800m	1000 – 10,000	Organic

The application of System A creates theoretically 27 river types of which 21 are actually found in England, Wales and Scotland. Out of these 21 types, 15 are found in the Scottish RBD. Table 36 shows the distribution of river types in lengths in Scotland:

Table 36: River types in Scotland; (Source: UKTAG 2003, p.4)

Water body type UK	Scottish km	Mean catchment altitude (m)	Total area (Km2)	Dominant geology
1	3034.4	< 200	10 – 100	S
2	3726.0	< 200	10 – 100	C
3	1201.2	< 200	10 – 100	O
4	238.3	< 200	100 - 1000	S
5	422.3	< 200	100 - 1000	C
6	156.5	< 200	100 - 1000	O
7	0	< 200	>=1000	S
8	0	< 200	>=1000	C
9	0	< 200	>=1000	O
10	10,129.3	200 – 800	10 – 100	S
11	1,922.0	200 - 800	10 - 100	C
12	1,154.2	200 - 800	10 - 100	O
13	3,255.7	200 - 800	100 – 1000	S
14	386.5	200 - 800	100 - 1000	C
15	90.2	200 - 800	100 - 1000	O
16	539.9	200 - 800	>=1000	S
17	15.3	200 - 800	>=1000	C
18	74.7	>=800	10 - 100	S

The methodology applied in Scotland does not include artificial linear water canals and small coastal catchments (< 10km^2) in the assessment. The small coastal catchments will be assessed by SEPA on a case-by-case basis. As it can be seen from table 36, the dominant river type (38% of Scottish rivers) is type 10 with a mean catchment altitude of 200 – 800 m, small size (100 – 100 km^2) and siliceous riverbeds. In Scotland all typologies for rivers, and also lakes, have been tested against biological data (RIVPACS macro invertebrate groups and macrophyte NVC communities) (UKTAG 2003, p. 3).

It is planned to develop the river typology system into a System B methodology according to the WFD, incorporating additional parameters such as slope of the river or river discharge, when more data will be available (Castillo 2010, p. 10).

4.2.3 Reference conditions

Reference conditions have been developed under a collaborative partnership across the UK and in cooperation with the Republic of Ireland. Reference conditions are set in relation to the ecology to be expected for each river type and describe benthic invertebrates, fish, macrophytes, hydrology and physico-chemical conditions expected in undisturbed or nearly undisturbed conditions. There is a large monitoring network in the UK in general and therefore also in Scotland, which consists of primary, secondary and minor sampling sites. But reference values are not only derived from monitoring data, the approach used depends on the availability of data. The following methodologies for deriving reference values in Scotland are (SEPA 2005, p. 13):

- Networks of reference sites (for river types with undisturbed stretches),
- Modelling approaches (for river types with no or very few undisturbed stretches),
- Expert judgment (for river types with no or very few undisturbed stretches).

In general, there are relatively few sites in the UK at which all quality elements are in reference condition. The UKTAG therefore mainly recommends reference values based on monitored references sites in which the quality element concerned is in reference condition. This means that not all quality elements have to be in reference conditions (UKTAG 2007, p.7). However, in Scotland it was a much easier than in the rest of the UK to find reference sites, as many water bodies are already in "high status".

In case where monitoring data was not available, a combination of expert judgment and modelling data was applied. For that purpose the following techniques were used (Castillo 2010, p.21):

- Analogy with sites presently at reference condition
- Interrogation of natural history records (mostly from the 19th century)
- Interrogation of angling club and fishery records
- Palaeo-environmental reconstruction (e.g. diatom-inferred phosphorus and pH-status)

- Reconstruction of past ecology by examination of response curves between physico-chemical pressures and biological water quality elements
- Modelling 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, etc.)

The reference conditions for Scotland are described in the RBMP and according to UKTAG (2005), reference conditions have been reviewed in 2010 and will influence the second RBMP in 2015.

4.2.4 Determination of quality elements and status class boundaries

The Scottish Environmental Protection Agency (SEPA) follows the recommendations of the UK Technical Advisory Group for the determination of quality elements for rivers. The following parameters were therefore used in Scotland:

Table 37: Quality elements used in Scotland; (Source: UKTAG 2007)

Quality elements	
Biological quality elements	Benthic invertebrates Fish Macrophytes and Phytobenthos Phytoplankton
Hydro - morphological quality elements	Quantity and dynamics of water flow Connection to ground water bodies River continuity River depth and width variation Structure and substrate of the river bed Structure of the riparian zone
Chemical and physico - chemical elements	Thermal conditions Oxygenation conditions Acidification status Nutrient conditions

According to the provisions of the WFD, the assessment of each of the quality elements was based on the most sensitive indicator, or indicator to each pressure, on the respective water body. The information on the relevant indicators was collected through spatial monitoring. Water bodies that were not monitored were grouped with other monitored water bodies (UKTAG 2007, p.4).

In the future, SEPA in cooperation with UKTAG, plans to expand the number of quality elements. The additional indicators will be e.g. phytoplankton mainly for estuaries, marshes, coastal waters and lochs. Within the intercalibration exercise, Scotland is part of the UK, which belongs to the Central Baltic intercalibration group (Central Baltic GIG). The UK was the first country, which put into practice biological, morphological and physicochemical indicators (which are, as mentioned above, homogeneously used throughout the whole UK territory) and is leading the intercalibration process within the Central Baltic GIG (Van de Bund 2008, p. 9). In Scotland all class boundaries for ecological status assessment are consistent with the intercalibration decisions (European Commission 2012, p. 37).

Standards for the assessment of the quality elements have been set for all biological quality elements, but not for all physico–chemical and hydro–morphological quality elements in support of the biological assessment. The biological, physical–chemical and hydro–morphological quality elements will be further explained in the next chapters.

4.2.4.1 Biological quality elements

Classification tools for all biological quality elements are progressively being developed under the auspices of UKTAG. The Scottish SEPA uses these proposed methods for the biological classification in Scotland. The proposed quality elements and indices by UKTAG are presented in table 38:

Table 38: Biological quality elements and indicators in Scotland; (Source: UKTAG 2007, p. 48)

Quality elements	Indices
Macrophytes	• Macrophyte prediction and classification system • (LEAFPACS) • Canonical Correlation Analysis based assessment system (CBAS)
Phytobenthos	• *Diatoms for assessing river ecological status (DARES)*
Benthic invertebrates	• River Invertebrate Classification Tool (RICT) • Lotic – invertebrate index for flow evaluation (LIFE index) • Scottish Acid Water Indicator Community (SAWIC) • Intercalibration Common Metric Index (ICMi)
Fish	• (Fisheries Classification Scheme (FCS))

These quality elements have been also related to significant pressures in the UK as illustrated in table 39:

Table 39: Biological quality elements in relation to pressures; (Source: UKTAG 2007, p. 48)

Pressures	Quality elements: Phytobenthos	Makrophytes	Benthic invertebrates	Fish	Phytoplankton
Substantial pressures:					
Nutrients	x	x			
Acidification	(x)[3]		(x)		
Organic pollution			x		
Hydro-morphological pressures					
Morphological alterations		x		x	
Abstraction of water			x	x	

For rivers, standards to assess phytoplankton have been established, but SEPA stopped to use this quality element for the assessment of the biological status, as many rivers are relatively short and fast flowing and do not support phytoplankton communities (Scottish Government 2009a, p. 8).

At present, also the "Fisheries Classification Scheme" is not fully developed and needs to be further assessed and tested especially for application in Scotland as well as Northern Ireland. Therefore, there is currently no system for the evaluation of fish communities in Scottish rivers. Additionally, the impact of acidification on the biological quality elements is not fully developed by the UKTAG. For this reason the Scottish government proposed to use interim assessment methods in concern to river invertebrates and acidification (the method applied counts the number of specific taxa), and fish assessment (the method applied is based on fish abundance, age classes, taxa) (Scottish government 2013b).

According to the evaluation report of the European Commission (2012), the applied biological assessment methods *"are able to detect all major pressures*".

[3] (x) = not fully developed

The benthic invertebrate quality element in Scotland

The assessment system used for benthic invertebrates in rivers was the so-called *"River Invertebrate Prediction and Classification System"* (RIVPACs) software for classification. RIVPACS is used to predict benthic invertebrate samples of a specific site with a reference database of British riverine water bodies. This method allows the prediction of expected benthic invertebrate taxa at a specific site. "*This prediction is of the taxa to be expected if the site were of high ecological quality. Thus it offers a target against which the fauna observed at the site can be assessed. Rivers in poor conditions can then be identified*" (Plymouth University, p. 2-3). The comparison between the actual and expected benthic invertebrate fauna from the RIVPACs database enables the calculation of the Ecological Quality Ratio (EQR), which is then translated into the corresponding ecological classification. The RIVPACs method is sensitive to pollution and other pressures (e.g. habitat alteration) on the surface water bodies (Castillo 2010, p. 35; UKTAG 2007, p. 52).

In order to be compliant with the provisions in the WFD, the RIVPACs has been further developed to the "*Rivers Invertebrate Classification Tool" (RICT)* (Northern Ireland Environment Agency 2009, p. 8). The RICT method assesses especially the impact of organic enrichment on benthic invertebrates. Additionally the assessment method is sensitive to toxic pollution and may detect the impact of other pressures as well. RICT uses the following parameters:

- 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*" (Castillo 2010, p. 34).
- Average Score per Taxon (ASPT)
  "*Each taxa identified as being present in a sample should be assigned to the corresponding pressure sensitivity score ranging from 1 to 10*" (Castillo 2010, p. 34).

For the NTAXA parameter, as well as the ASPT parameter, EQR values are derived by comparison with reference conditions. The RICT assessment is conducted one to three times over a three-year period. During each assessment, samples of the respective rivers are taken in spring and autumn and in some cases samples are also taken in summer. The EQR for each year will be then calculated from the average of the spring and autumn sample, and the annual classifications will be combined to a three-year classification (UKTAG 2007, p. 52).

The class boundaries according to the RICT comply with the normative definitions within the WFD and were set as follows:

Table 40: Class boundaries for the quality element benthic invertebrates in Scotland; (Source: Castillo 2010, p. 34)

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

The NTAXA EQR values cause about 10 – 15% of riverine sites within the UK to be downgraded from the class they would be in if only ASPT EQR values would be applied. The main reason to use NTAXA EQR values is to uncover severe toxic impacts. Across the UK about 64% are according to the RICT assessment in a high or good status, 19% have a moderate status, 10% have a poor and 7% a bad status (Castillo 2010, p. 35).

4.2.4.2 Physico – chemical quality elements

The physico–chemical quality elements in support of the biological quality elements used in Scotland follow as well the recommendations of the UKTAG. The elements assessed are:

Table 41: Physico - chemical quality elements applied in Scotland; (Source: UKTAG 2007, p. 8)

Quality element	Indicators for which standards have been proposed by the UKTAG
Thermal conditions	Temperature
Oxygenation conditions	Dissolved oxygen concentrations
Acidification status	pH
Nutrient conditions	Soluble reactive phosphorus concentration Ammonium

According to the Environment Agency (2011) the biochemical oxygen demand was not used as parameter to assess the physico–chemical status, as persistent and gross organic pollution of rivers is rare. However, biochemical oxygen demand is still used for other regulations such as setting permit limits. Temperature is assessed only for some riverine water bodies and does not form part of the final status classification. It is however included in special cases for water bodies with thermal discharges (Environment Agency 2011, p. 7).

In the Scotland RBD one missing parameter in the assessment of the physico-chemical status for rivers is “salinity“. This is because of no identified pressures influencing the salinity of rivers (European Commission 2012b, p. 37).

Table 42 shows the number of water bodies within each quality status according to the results of the assessment of the physico–chemical quality elements in the Scottish RBD in 2008:

Table 42: Results of physico - chemical quality assessment in Scotland RBD in 2008; (Source: Scottish Government 2009a, p.10)

Measured conditions of indicator	Phosphorus	Dissolved oxygen	Ammonium	Acidity as pH
High	1,338	1,560	1,554	1,438
Good	202	38	68	190
Moderate	106	27	23	7
Poor	13	5	9	6
Bad	0	3	6	0

4.2.4.3 Hydro – morphological quality elements

As mentioned in the previous chapters, hydro–morphological quality elements are taken into consideration to decide whether a specific water body is in a “high status”. In this sense the WFD requires that there are only very minor anthropogenic hydro–morphological alterations. Following these provisions, UKTAG provided recommendations on standards and condition limits for the hydro–morphological assessment and suggests to use these for the classification of “high status” when the necessary data is available. In the case that no data is available, it is recommended to base the classification on the best available alternative information and comparable assessment criteria. As at good, moderate, poor and bad status the hydro-morphological quality elements must allow the biological quality element values to reach the respective quality status, the standards and condition limits established by the UKTAG are such that they enable to assess the risk of failing to achieve the necessary values (UKTAG 2007, p. 11).

As mentioned before, the hydro–morphological quality elements applied in the Scottish RBD are:

Table 43: Hydro - morphological quality elements applied in Scotland; (Source: Environment agency 2011, p. 9)

Hydrological and tidal regime	• Quantity and dynamics of water flow • Connection to ground water
Morphological conditions	• River continuity • River depth and width variation • Structure and substrate of river bed • Structure of the riparian zone

The hydro–morphological parameter for which no standards were set is the connection to ground waters from rivers and lakes in Scotland. Therefore the hydro – morphological quality element is considered "not fully developed" by the European Commission (European Commission 2012b, p. 37).

The Scottish SEPA evaluated during the elaboration of the Scottish RBMP these hydro–morphological conditions in relation to pressures. Table 44 shows the number of water bodies in the Scottish RBD, which are not in good condition due to the related pressures:

Table 44: Number of water bodies influenced by hydro - morphological alterations and not reaching good status; (Source: Scottish Government 2009a, p. 17)

Pressures	Number of water bodies whose banks, beds and shores are not in good condition affected by the pressure
Channel realignment (e.g. straightening)	235
Removal or degradation of bank vegetation	342
Embankments and flood-walls	156
Culverting	228
Dams	151
Total	1,112

4.2.5 Pressures and risks

SEPA and other Scottish environmental bodies previously only had information about discharges for the purpose of pollution control but no comprehensive information on other pressures. In 2004, SEPA conducted the first pressure and impacts analysis for all Scottish water bodies including a public consultation process and since then, the knowledge of other pressures has improved significantly. A variety of sources have been used to gather information as for example information collected from field surveys, maps and aerial photographs, as well as environmental modelling or land use information. The combination of the gathered information on pressures with the resulting classification has helped to identify significant pressures causing water bodies to be at risk not to reach “good status“ (Scottish Government 2009c, p. 18).

In general the majority of Scottish water bodies are at good ecological status or better. However a variety of problems arise at local level and water bodies are adversely affected by anthropogenic influences. About 40% of Scotland’s waters fail the environmental standards to reach good ecological status. Especially the water bodies in the central belt, the east coast and the southwest have the poorest water quality (SEPA 2007, p.3). Table 45 shows the length/area and number of water bodies at risk failing good status within the Scottish RBD:

Table 45: Water bodies at risk failing good status in the Scottish RBD; (Source: SEPA 2007, p. 3)

Water category	Length/area at risk of failing good status in 2007 (% of total)	Total length/area of all water bodies	Number of water bodies at risk of failing good status in 2007 (% of total)	Total number of water bodies
River	9,083 km (44%)	20,819 km	828 (41%)	2,008
Loch	633 km^2 (66%)	961 km^2	162 (52%)	309
Transitional	425 km^2 (70%)	605 km^2	21 (53%)	40
Coastal	3,025 km^2 (6.6%)	45,796 km^2	53 (12%)	449
Groundwater	20,805 km^2 (31%)	66,567 km^2	142 (52%)	275
Total			**1,206 (39%)**	**3,081**

The significant pressures causing the impacts on Scottish water bodies in relation to the responsible key sectors are listed in table 46:

Table 46: Significant pressures in the Scottish RBD; (Source: SEPA 2007)

Pressure group	Pressure parameter	Key sectors
A) Substantial and physical pressures from point sources and diffuse source	Point sources	Collection and treatment of sewage Aquaculture Manufacturing Refuse disposal Mining and quarrying
	Diffuse sources	Agriculture Forestry Urban development Sea and coastal water transport
B) Hydro-morphological pressures	Abstraction and flow regulation	Electricity generation Public water supplies Agriculture
	Impacts on morphology	Historical engineering Agriculture Electricity generation Urban development Land claim
C) Other pressures	Alien species Climate change	All sectors

The affected river length and number of rivers in the Scottish RBD by each significant pressure is given in table 47:

Table 47: Affected rivers per pressure in the Scottish RBD; (Source: SEPA 2007)

Pressure type	River length (km) affected	Number of rivers affected
Point source pollution	3,488 km	287
Diffuse source pollution	5,339 km	446
Abstraction and flow regulation	3,971 km	359
Morphological alterations	5,063 km	462
Alien species	315 km	7

As it can be seen in the table, the main pressures within the Scottish RBD are diffuse source pollution and morphological alterations. Diffuse source pollution will be explained in detailed in the next chapter.

Regarding point source pollution the main precursors are sewage disposal, aquaculture, manufacturing, historical landfill sites and mining and quarrying. The control of point source pollution has improved a lot over the last decades and emitted loads have significantly decreased. The most serious problems arise e.g. with old sewers from Victorian times which overflow during heavy rain into rivers. Historical problems arise as well with old landfill sites and closed mines. Manufacturing only plays a minor role in point source pollution as heavy industry has declined and enterprises in general have taken a proactive approach by developing environmental management systems. Furthermore, industrial water discharges are regulated under a powerful control system established by the Scottish government (SEPA 2007, p. 12–18).

Abstraction and flow regulations of rivers are caused by hydroelectric power generation, abstraction for public use and water abstraction for agricultural irrigation. Hydropower is an important source for energy production in Scotland. In the Scottish RBD there are 23 major schemes and 74 small–scale hydropower plants that are privately owned. About 15% of rivers are at risk of failing to meet good status due to flow regulation and abstraction for hydropower. In comparison, about 10% of Scottish rivers are at risk of failing “good status“ due to abstraction for public water supply, and also 10% due to abstraction of water for agricultural purposes (SEPA 2007, p. 19–22).

Especially engineering and urban development are permanent changes to the river morphology and are therefore incremental. New controlling mechanisms for planned engineering activities have been established, but only few measures are in place to mitigate the impact of existing linings that cause harm. In total about 30% of all riverine water bodies are affected by morphological changes from urban development or historical engineering and are therefore at risk not to reach “good ecological status”. Agricultural activities influencing the river morphology comprise flood defence and erosion control works. There are initiatives to use public funds to provide more space for rivers, which could help both the farmers and the environment and would also reduce the impact of diffuse pollution. Currently 20% of Scottish rivers are influenced by agricultural activities concerning flood defence and erosion control and are for this reason at risk of failing the WFD objectives (SEPA 2007, p. 23–25).

In Scotland there are almost 1,000 identified alien species present in nature, from which most of them are strongly invasive or harmful to the native biodiversity. The UKTAG recommends in its guidelines for classification of water bodies to consider alien species for the classification of the “high ecological status”, meaning that in a water body in “high ecological status” evidence of established populations of alien species should not cover more than 0.5 km (or 5%) of continuous river length. To reach “good status” not more than 1.5 km (or 15%) of continuous length should be populated with alien species (Environmental Agency 2011, p. 8). Complete eradication of alien species would be expensive and difficult to realize, the best available alternative is to prevent the introduction of such species (SEPA 2007, p. 27).

Diffuse source pollution of surface waters in Scotland

Diffuse source pollution is the main pressure on Scottish surface water bodies. It is caused mainly by agriculture, forestry and urban development as presented in table 48. Agriculture is the main initiator and affects 313 water bodies within the Scottish RBD.

Table 48: Diffuse source pollution in Scotland by key sector; (Source: SEPA 2007, p. 6)

Diffuse source pollution	Key sectors	Rivers affected in length (km) and number
	Agriculture	4,025 km (313)
	Forestry	652 km (53)
	Urban development	1,044 km (88)

In Scotland, about 75% of the land area (more than 5.5 million hectares) is used for agricultural production. About 80% of this land area is used as grassland for livestock breeding of beef and sheep. The remaining 20% of the area is used by arable farming, mainly in the east of the country. The main impacts caused by agriculture diffuse pollution are (SEPA 2007, p. 7):

- Nutrient inputs from fertilizers, animal manures and slurries causes eutrophication
- Decrease of oxygen levels in rivers due to organic matter from animal waste and products (silage)
- Soil erosion can affect the light penetration into rivers
- Diffuse agricultural pollution upstream from water abstraction points (e.g. for public use) raises the need for sophisticated water treatment facilities
- 45% of all designated bathing waters and 60% of all shellfish waters in Scotland are influenced by microbiological contamination caused by agricultural production
- Contamination of public and private drinking water with nitrates, Escherichia

coli and pesticides. The public sector spends hundreds of millions pounds to protect consumers against these pollutants.

SEPA estimates that about half of the water bodies to be at risk of failing “good ecological status” are affected by diffuse pollution from agriculture.

The Scottish forest cover is about 17% of the land area and within the Scottish Forestry Strategy it is planned to expand this area to about 25% of Scotland’s land area. As concerns arose over the impact of this plan, the forestry industry decided to realize this initiative following a code of good practice with the help of financial incentives. For this reason, the forestry sector could significantly reduce its impacts on the Scottish water environment. However there are still impacts caused by forestry land use, which affects mainly the Scottish lochs as they represent one of the most sensitive water ecosystems. Even small phosphate and increased nutrient inputs caused by forestry can have an impact on the water quality (SEPA 2007, p. 8).

Diffuse pollution from urban areas is mainly caused by polluted run-off from roads, pavements, yards and roofs. The run–off is often toxic and creates an oily film on the bed of rivers and can even kill fish and insects. The main problem is that many people are not aware of this problem and illegally dispose polluting substances “down the drain”. This type of diffuse pollution is still increasing due to growing urban areas and increased traffic. It is estimated that around 10% of rivers at risk of failing “good ecological status” are affected by diffuse pollution from urban development (SEPA 2007, p. 9).

In general, diffuse pollution is regulated under the “Water Environment (Controlled Activities) Regulations 2011” (CAR). The regulation gives the Scottish SEPA the power to control key activities responsible for diffuse pollution, which are for example abstractions, engineering works and impoundments (SEPA 2013b).

4.2.6 Quality status assessment results in Scotland

In the Scottish RBD, 408 (15% of all water bodies in Scotland) HWMB and AWB were identified. SEPA has applied the approach by UKTAG, which recommends a more extensive classification approach for HWMB and AWB as they are classified according to five classes, and not in two ("good potential" and "failed to reach good potential") as envisioned in the WFD (Scottish Government 2009f, p.6-7):

- Maximum
- Good
- Moderate
- Poor
- Bad

More detailed information about the qualitative description on these five status classes for HMWB and AWB can be found in the Scottish RBMP, Chapter 4. The results for these water bodies are therefore presented according to these classified status classes.

The results of the quality status assessment in 2009 in the Scottish RBD show that 65% of all water bodies are already in good or better condition. Compared to all other Member States, this means Scotland has the highest ecological water quality in Europe. Of HVMB and AWB 50% already reach "good potential".

Table 49: Results of the assessment of the quality status of water bodies in the Scottish RBD in 2009; (Source: Scottish Government 2009b; p. 7)

2008 condition	Number of water bodies			
	All water bodies	Surface waters		Groundwater
		Natural, non-heavily modified	Heavily modified or artificial	
High/maximum	423	421	2	n/a
Good	1,576	1,158	203	215
Moderate	489	424	65	n/a
Poor	409	262	78	69
Bad	198	133	65	n/a
Totals	3,095	2,398	413	284
Proportion good or better (%)	65%	66%	50%	76%

In table 50, the results are itemized according to rivers, lochs, estuaries and coastal waters. As it can be seen, 58% of all rivers were in high or good status. Estuaries reached the best result, with 91% being in "high" or "good status".

Table 50: Results of the assessment of the quality status for different surface water body types; (Source: Scottish Government 2009c, p. 27)

Ecological status class	Rivers		Lochs		Estuaries		Coastal waters	
	Number of water bodies	Length (km)	Number of water bodies	Length (km)	Number of water bodies	Length (km)	Number of water bodies	Length (km)
High	190	1,492	60	144	14	161	158	15,695
Good	801	8,168	89	252	16	309	252	26,138
Moderate	357	4,227	36	101	3	82	27	3,863
Poor	242	2,512	20	98	0	0	0	0
Bad	126	1,508	7	10	0	0	0	0
Totals	1,716	17,907	212	605	33	552	437	45,696
Proportion good or high (%)	58%	54%	70%	65%	91%	85%	94%	91%

The Scotland RBD has fewer environmental problems than other RBD in the UK or in Europe. SEPA states in the Scottish RBMP (2009): "*The task now is to build on this achievement*" (Scottish Government 2009b). The goal is to reach 98% of water bodies to be in good status or higher by 2027.

Table 51: Step-wise approach for improvement of water quality status in Scotland; (Source: Scottish Government 2009b, p. 10)

	Proportion of water bodies in a good or better condition (%)			
	2008[4]	2015	2021	2027
All water bodies	65	71	77	98
Rivers	56	63	71	97
Lochs	66	71	77	98
Estuaries	85	85	85	98
Coastal waters	94	97	98	99
Groundwater	76	85	88	94

The measures for surface waters and HMWB/AWB are more equally distributed than in Austria, as there is not such a great difference in the percentage of the planned improvement between surface waters and HWMB/AWB.

[4] It has to be noted that the data for 2008 in table 53 differs from the data in table 52. Both data was compiled from the Scottish RBMP and no reasons for this deviation were indicated. However, the divergence is rather small (</= 6%).

Table 52: Step-wise approve for the improvement of quality status for HWMB/AWB; (Source: Scottish Government 2009d, p.7)				
	2008	2015	2021	2027
Proportion in good status or better (%)	45%	53%	61%	99%

As it can be seen, Scotland also applies a step-wise approach for about 35% of its surface water bodies and 55% of its HWMB/AWB. Similar to Austria, the biggest step has to be made between the years 2021 and 2027, which seems to be as well a too ambitious target.

Within the Scottish RBMP the use of article 4.4 for the step-wise approach is justified by difficult technical feasibility, disproportionate costs and natural conditions (e.g. the achievement of natural conditions due to hydro-morphological renaturation measures is dependent on how fast the momentum of the river, or biological processes, re-adapt to the new circumstances). As it can be seen from table 53, the most used justification to apply article 4.4 was disproportionate costs (European Commission 2012b, p. 48).

Table 53: Number of exemptions in Scotland; (Source: European Commission 2012, p. 48)		
Number of exemptions (combined for ecological and chemical status)		
Technical feasibility	Disproportionate costs	Natural conditions
20	810	51

4.2.7 River Basin Management Plans – Programs of Measures

As mentioned earlier, the first Scottish RBMP was produced by the Scottish Environment Protection Agency (SEPA) together with national and area advisory groups and has been approved by the Scottish ministers in 2009. It was then reported to the European Commission on March 22nd 2010. The SEPA is currently developing the second RBMP, which should be completed in 2015. Until February 23rd 2013, the public consultation process took place with all interested stakeholders and the public. One special feature within the establishment of the Scottish RBMP was the establishment of the above-mentioned advisory groups for river basin planning in order to secure continuous public involvement (European Commission 2012b, p. 6; Foundation of Water Research 2013).

4.2.7.1 Program of Measures

In the Scottish RBMP, the SEPA promotes a coordinated and integrated approach for the implementation of the PoMs. The integrated approach should coordinate the work of the different public sector bodies, private and voluntary organizations involved in RBM. This coordination should produce shared strategies, policies, plans in order to ensure the inclusion of all relevant stakeholders.

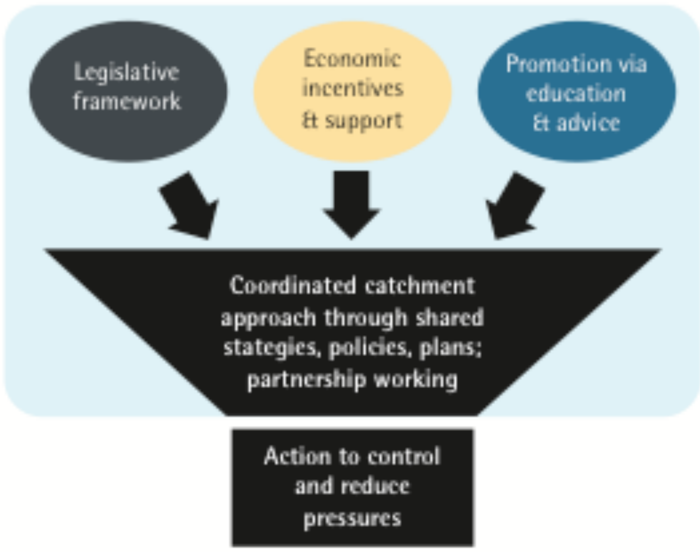

Figure 17: Integrative approach for the realization of the PoMs; (Source: Scottish Government 2009e, p. 5)

For this purpose, the Scottish government has amended legislation concerning areas affected by the WFD. These amendments should support the achievement of the objectives set in the RBMP and help to secure the implementation of the PoMs. The objectives of the PoMs have been integrated into the decision–making and action under these legislations. The implementation of the PoMs should also help to achieve other objectives of the respective legislative areas. The areas affected by amended legislation are (Scottish Government 2009e, p. 5):

- Marine and coastal activities
- Aquaculture and freshwater fisheries
- Agriculture
- Sustainable transport
- Land use planning
- Sustainable flood management and runoff regime

- Water supply
- Biodiversity conservation
- Bathing waters
- Programs for tackling pollution by agricultural nitrates

Furthermore, the Scottish government has established the Water Environment (Controlled Activities) Regulations (CAR) 2005 in order to control significant pressures. Activities, which have adverse impacts on water bodies and on the environment, have to be authorized according to the regulations in the CAR. These activities include for example (Scottish Government 2009e, p. 9):

- Activities liable to cause pollution of the water environment
- Abstraction of water
- Construction, alteration or operation of impounding works (e.g. dams)
- Building, engineering, or other works affecting water bodies
- Etc.

As illustrated in figure 18, the CAR includes three levels of control: authorization under general binding rules, registration and licenses. This approach enables to relate the environmental risk caused by an activity to the appropriate level of regulatory effort.

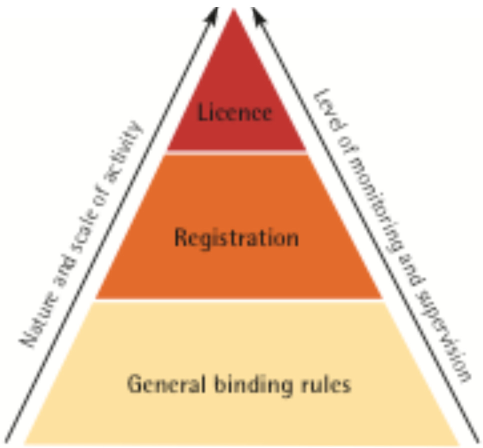

Figure 18: Regulatory levels within the CAR; (Source: Scottish Government 2009e, p. 9)

In the year 2008, SEPA further developed the CAR in regard to diffuse source pollution and introduced a set of general binding rules, which are based on widely accepted standards for good practice. (e.g. concerning the storage and application of fertilizers[5]) (SEPA 2013b, p.12).

SEPA recognizes the contribution voluntary initiatives can make to the achievement of the set objectives. Therefore, within the Scottish RBMP economic incentives and funding for encouraging the establishment of voluntary measures are considered. Examples of funding and economic incentives mentioned in the Scottish RBMP are (Scottish Government 2009e, p. 11):

- Rural development program: provides funds for voluntary initiatives in order to e.g. remove river embankments, or establish buffer strips alongside rivers;
- Restoration funding from the Scottish government for SEPA to support restoration projects to reduce impacts of historical activities;
- Public funding to reduce pressures from water abstraction and impoundment for public drinking water supply and from sewage disposal;

The PoMs is generally structured according to the identified significant pressures. According to each type of pressure, measures to prevent the deterioration of the water body quality and measures for the improvement of the water body quality are presented. The Scottish PoMs comprises all possible types of measures: regulatory, technical, agricultural–environmental, economic and advisory/information measures. In the table summary for each measure, technical measures are linked to legal actions (delivery, mechanism and support) and to the relevant authorities (Dworak et. al. 2009, p. 24–26).

Additionally, SEPA has conducted “climate checks” for each individual measure. The results of this check are presented in the summary for each measure and indicate any likely impacts of the respective measure in concern to greenhouse gas emissions, preparing Scotland for a future climate (e.g. floods, droughts, ecosystem

[5] General binding rules for the storage and application of fertilizers include e.g. minimum distances between application area and water body, condition of the soil, etc.. A complete list of rules is included in the CAR practical guide which can be accessed at http://www.sepa.org.uk/water/water_regulation/car_application_forms.aspx

services) and the action's continued effectiveness under a changed climate (Scottish Government 2009e, p. 13 – 14).

Additionally the PoMs gives information of how the implementation of each measure will be phased by 2015, 2021 and 2027 providing details per measure and water body. Furthermore, SEPA clearly states that the PoMs in the first RBMP became operational on the date of publication. SEPA will assess the success of the implemented measures as part of its six yearly review process (European Commission 2012b, p. 51).

Measures against diffuse source pollution in Scotland (for the achievement of a good status)

As described in the previous chapter, diffuse pollution is mainly caused by agriculture, forestry and urban development in Scotland. In the Scottish RBMP, specific measures concerning diffuse pollution are given by water body within the water body sheets on the GIS platform. Additionally, some priority catchments for measures tackling diffuse pollution are identified. The measures against diffuse pollution in the PoMs are presented according to the key initiators (agriculture, urban sources and forestry) (European Commission 2012b, p. 51).

With the establishment of the Scottish RBMP, SEPA has created the „Diffuse Pollution Management Advisory Group" (DPMAG). The members of the group are different relevant authorities, land managers and voluntary organisations. The main tasks of DPMAG are to develop a plan for using legislative, economic and educational mechanisms for fighting diffuse pollution and to contribute to the implementation of the plan and its continuous development. Additionally, the Scottish Government formed the "Scotland's Environmental and Rural Services" (SEARS) group, which consists of nine public bodies, which gives advice and offers education concerning measures against diffuse pollution from agriculture to rural land managers. SEARS also carries out farm inspections on behalf of SEPA in order to control if good environmental practices are applied (Scottish Government 2009e, p. 16).

Until 2015, SEPA and the Scottish Government plan to improve 74 water bodies to achieve "good status" by applying measures against diffuse pollution from agriculture. These further include:

Table 54: Measures against diffuse pollution from agriculture in Scotland; (Source: Scottish Government 2009e, p. 18 - 19)

Improvement required	Examples of measures	Who will take action
Reduced nutrient input to the water environment	**Control at source** • Manage nutrient (fertiliser) use to minimise losses to the water environment; • Implement in-field measures to minimise soil erosion and compaction; • Separate clean and dirty water at farm steadings • Intercept and store/treat • Install buffer zones, including woodland planting and wetlands; • Capture polluted run-off from steadings (e.g. in constructed farm wetlands); • Install new slurry storage systems.	Farmers
Reduce pesticide input to the water environment	**Control at source** • Test and maintain pesticide sprayers; apply integrated crop management techniques to manage reduce pesticide losses to the water environment. **Intercept and store/treat** • Install buffer strips, bio beds	Farmers
Reduced inputs of organic waste (organic matter, faecal pathogens, and ammonia) to the water environment	**Control at source** • Control access of livestock to surface waters; • Manage waste stores to minimise losses to water environment; • Prevent pollution hotspots developing at heavily used areas (gates, tracks, feeders etc); • Manage steading run- off (e.g. clean and dirty water separation); **Intercept and store/treat** • Capture polluted run- off from steadings (e.g. in constructed farm wetlands); • Install new slurry storage systems	Farmers

Concerning diffuse pollution caused by urban sources, the Scottish Government set new, sustainable standards for urban drainage systems which will be newly installed in urban areas, streets, etc.. Already existing and newly developed drainage systems will be managed and maintained by Scottish Water or the relevant road authority. New developed systems maintained by Scottish Water, must comply with the technical standards for sustainable urban drainage systems published by Scottish Water. For roads, the road authority must secure that for all new systems the standards published by the SUDS Working Party are applied. Further principal measures against diffuse pollution caused by urban sources, which should help to improve five water bodies to reach "good ecological" status by 2015, are listed in table 55 (Scottish Government 2009e, p.31 – 32):

Table 55: Measures against diffuse pollution caused by urban sources in Scotland; (Source: Scottish Government 2009e, p. 32)

Improvement required	Examples of measures	Who will take action
Reduced pollutant inputs into the water environment	**Collect and treat** • Add to, or replace, conventional surface water drainage systems with sustainable urban drainage systems[6]	Scottish Water Owners and occupiers of business premises Developers
	Collect and treat • Install treatment for highly polluting discharges (e.g. from industrial sites)	Scottish Water
	Collect and treat • Add to or replace road drains with sustainable urban drainage systems	Local authorities, Scottish Government (Transport Scotland)
	Control at source • Reduce, or avoid, pollutants entering surface water drainage system by ensuring dirty areas do not drain to surface water drains; chemicals are not disposed of in surface water drains; installing water butts, porous paving, etc	Businesses; Households

In concern to diffuse pollution caused by forestry, the UK government has set standards for the sustainable management of forests and woodlands in the UK. Furthermore the following measures were determined (Scottish Government 2009e, p. 37):

Education and advice:

- SEPA and the Forestry Commission Scotland provide training and best practice guidance in relation to the protection of water bodies.
- SEPA and the Diffuse Pollution Management Advisory Group initiated a national awareness raising campaign on diffuse pollution, which included information for forest managers on the legislative requirements.

[6] Technical standards for sustainable drainage systems are set out in „Sewers for Scotland 2" which can be accessed at: www.scottishwater.co.uk/portal/page/portal/SWE_PGP_CONNECTIONS/SWE_CORP_CONNECTIONS/SWE_CONN_SUDS

Economic measures:

- The Forestry Commission Scotland only grants financial aid under the Scottish Rural Development Programme in the case that forest managers comply with the UK Forestry Standards.

Legislative measures:

- The Forestry Commission Scotland as responsible authority will work to achieve the objectives for the water bodies envisioned in the WFD
- Forest managers must follow the regulations of the Water Environment (Controlled Activities) Regulations (CAR).
- Approvals for forest plan and felling will be granted only if the requirements of the UK Forestry Standards are met.
- Environmental Impact Assessment required for activities like afforestation, deforestation, construction of forest roads, forest quarries.

4.2.7.2 Cost effective analyses regarding the program of measures

Within the framework of the UK, Scotland has contributed to a collaborative programme for research on river basin planning economics, which was coordinated by the UK government. The programme started in 2004 and ended in 2009. During this period, methods to assess cost-effectiveness, a database of benchmark costs and preliminary cost–effectiveness analysis were established (Scottish Government 2009e, p. 8).

In general, the UK has been under the forerunners in concern to cost effective analysis (CEA) according to Article 11 of the WFD. In 2004, the first study on methodologies for conducting CEA in the UK according to WFD provisions has been published. Postle et al. (2004) proposed using full economic costs (and not financial costs) for the evaluation of potential measures. Furthermore, he identified a range of economic costs groups, which should be additionally considered in the CEA of PoMs:

- Direct costs of complying with the requirements
- Welfare losses to consumers
- Non-water environment

- Induced effects to the wider economy
- Transaction costs

The study further introduced a framework with which it was possible to estimate and aggregate costs at local, basin and national levels. Using the suggestions of the study by Postle et al. (2004), the UK Collaborative Research Programme (CRP) on River Basin Management Planning Economics, in which Scotland took part, elaborated six sequential projects on CEA of PoMs. The second project developed by the CRP, was about the development of a methodology and guidance to assess the cost–effectiveness of measures and combination of measures for the WFD and provides important recommendations for CEA, according to the WFD, in the UK. Following these recommendations, the Department for Environment, Food and Rural Affairs (DEFRA) conducted a serious of studies by which cost–effectiveness of measures tackling specific pollutants such as ammonium, nitrates or phosphorus were assessed. In 2007 Cuttle et al. (2007) developed a “user manual” with tools for CEA to control diffuse water pollution from agriculture, which was according to Ortega et al. (2012) more informative than the studies published by DEFRA. The agricultural sector was the key sector for which most of CEA studies have been developed. Most of them were based on the assessment of “representative farms” and not actual farms in the UK. Additionally the CEA studies have been elaborated for different scales such as field level, farm, catchments and multiple catchments (Ortega et al. 2012, p. 17 – 18).

Another important factor for CEA is the method for measuring the effectiveness. This aspect was considered by Postle et al. in 2004. He suggested a staged approach, which “*moves from the screening of measures to a generic and higher scale (national/regional) to a more detailed assessment carried out at a lower scale (river basin/water body)*” (Ortega et al. 2012, p. 18). This proposed method for the assessment of effectiveness relies on expert judgments and different modelling techniques (Ortega et al 2012, p. 18).

The CRP suggested in one of its published projects, a five-step model for the assessment of the effectiveness of measures:

1. Problem definition
2. Identifying measures

3. Predicting effectiveness (assessment of magnitude, certainty and characteristic effects based on expert judgments and environmental modelling)
4. Developing combinations
5. Comparison on combinations

The UK mainly measures effectiveness in relation to the reduction of pressures and not in relation to the reduction of the ecological impacts. In some cases this can cause problems, since there is not always a direct relationship between the reduction of the pressure and the related impact. In the worst case, this could result in a significantly different ranking and prioritization of measures in the UK (Ortega et al 2012, p. 22 – 23).

According to Ortega et al. (2012), "*the CEA approaches pursued are mainly of optimization modelling type, i.e. using variants of optimization techniques to combine model based effectiveness estimates of measures with estimates of the costs of measures*" (Ortega et. al. 2012, p. 22). Table 56 summarizes the methodologies applied in the UK:

Table 56: Summary of CEA methods applied in the UK; (Source: Ortega et. al. 2012, p. 22)

Attributes	Methodology applied in the UK
Type of costs considered for CEA	Full economic costs
Effectiveness estimates	Focus on pressures reduced (e.g. amount of P input reduced to the water body); less emphasis on environmental impacts
Treatment of uncertainty	Range of estimated values of costs
Main type of measures included in CEA	Diffuse pollution measures (e.g. buffer strips) and point source measures
Main information sources	Expert judgments and environmental modelling

In 2008, the Scottish Government commissioned an impact assessment in which the costs and benefits of the PoMs within the drafted version of the Scottish RBMP were assessed. This report was conducted by a private environmental consulting company named "ENTEC". The report utilized information from the Scottish Government, SEPA, responsible authorities, key stakeholders as well as public sources. Within the report, the measures are presented according to key sectors (agriculture, forestry, aquaculture, water industry, manufacturing, mining and quarrying, energy, navigation and water transport and recreation and other sectors) responsible for pressures on the water environment (ENTEC 2008).

For each key sector, a CEA was conducted and the methodology applied for each sector was described. In the case of agriculture the following costs were estimated:

- Costs to farms for implementing mitigation measures including investment costs, operational costs and foregone profits.
- Costs of delivery mechanisms and implementation of measures to authorities (e.g. SEPA, Forestry Commission Scotland, etc.)
- Environmental and social costs

The costs for each measure were then calculated and given as unit (e.g. GBP 8/ha/year) and total costs (e.g. GBP 770k/year) (ENTEC 2008). The whole impact assessment for the draft Scottish RBMP can be found on the website of the Scottish government at: http://www.scotland.gov.uk/Publications/2009/01/08093641/0.

5 Summary and Conclusions

5.1 The WFD – integrated river basin management for Europe

As a response to a changing socio-economic and political environment and the concerns of the Member States concerning the on-going deterioration of European water bodies, the European Union developed and adopted a new and innovative Community-wide water legislation – the Water Framework Directive (WFD). The WFD applies a "river basin–based" approach, which means that water bodies are managed across national borders according to their natural belonging to river catchments – so-called River Basin Districts (RBD). The provisions of the WFD are addressed to all waters in the EU, namely inland surface waters, ground waters, transitional (estuarine) and coastal waters. As the WFD replaces former European water legislations (e.g. the drinking water directive) and contributes to the achievement of the goals from other related policy areas (e.g. the Helsinki or Paris convention) it has a very broad scope by applying the precautionary principle, the preventive action principle, the polluter pays principle and the principle of dealing with environmental damage at source.

The main objective of the provisions within the WFD is not only the prevention of deterioration of water bodies, but also the improvement of the ecological water quality by reaching a "good status" for all European water bodies by 2015. Additionally it addresses the importance of water quantity by introducing a sustainable water consumption approach.

Although the WFD sets clear goals and provisions to be implemented into national law for all Member States, it recognizes the "*diverse conditions and needs in the Community which require different specific solutions*" (WFD 2000, p.3). Therefore, the EC suggested solutions adjusted to regional needs and conditions with responsibility lying with the local authorities. Hence, the Member States have to establish an administrative framework for the management of their designated national and international RBD. One of the main tasks for these authorities is the elaboration of "River Basin Management Plans" which comprise an analysis of the current status of the water bodies, the main pressures causing the risks of failing to achieve “good status” and a Programme of Measures including the most cost-effective measures to cope with the identified pressures in order to reach the quality objectives envisioned in the WFD.

In conclusion, the WFD is “*one of the most ambitious and encompassing pieces of environmental legislation ever undertaken by the European Union*” (Liefferink, et. al. 2010, p. 712). The main success factors for the implementation of the WFD and achieving the envisioned goals are close cooperation and coherent action at Community, Member State and local level, as well as consultation of the public. For the Member States, like Austria and Scotland (as part of the UK), the WFD brings a lot opportunities like a higher degree of public awareness, more transparency, improved water quality and quantity, etc. but also challenges like administrative burdens, costs of implementation, time deadlines, etc.. For most of the Member States it is very unlikely that the “good status” can be reached by 2015, but the WFD offers a range of flexibility and exemptions of the deadlines or relaxation of the goals are possible and an important mechanism. Although the goal envisioned in the WFD cannot be reached by 2015 for a significant number of water bodies (according to the European Commission 2012 these are around 47% of European surface water bodies), the water quality of European waters will continuously improve and due to the implementation of the provisions within the WFD the most important step towards an European-wide integrated and sustainable water management system is made.

5.2 Implementation pace and legal transposition of the WFD in Austria and Scotland

Both countries have transposed the provisions of the WFD into national law in the year 2003. In Austria, the competencies within the national water act are shared between the federal Ministry of Agriculture, Energy, Environment and Water Management and the regional governances, which are responsible for the operational implementation. In Scotland, the responsibilities for the RBD were completely devolved to the Scottish government, which shares the competencies concerning RBM with the Scottish Environment Protection Agency (SEPA). The Scottish Ministers are responsible for setting the policy requirements, approving objectives, the

PoMs and the Scottish RBMP, whereas SEPA is responsible for the coordination of the implementation of the WFD and the compilation of the RBMPs. In concern to typification of water bodies, establishment of reference conditions, determination of quality elements and cost-effectiveness analysis (CEA), Scotland follows the recommendations established by the UK Technical Advisory Group (UKTAG). These methodologies have been developed under a collaborative partnership across the UK and in cooperation with the Republic of Ireland.

Austria and Scotland, as part of the UK, are both in the timeframe provisioned by the EC for the implementation of the WFD. Both have submitted their national and international RBMPs, in time. In 2007, the European Commission compared the reporting performance of the Member States in concern to article 3 (administrative arrangement within RBDs) and article 5 (RBMPs) of the WFD and calculated a total "reporting performance score". As it can be seen, Austria (85%) and the UK (80%) are among the countries with the highest reporting performance. However, it has to be mentioned that the score does not say anything about the quality of the implementation. But it can be concluded that in terms of punctuality both countries can serve as "best practice" for other Member States (European Commission 2007, p. 42 – 43).

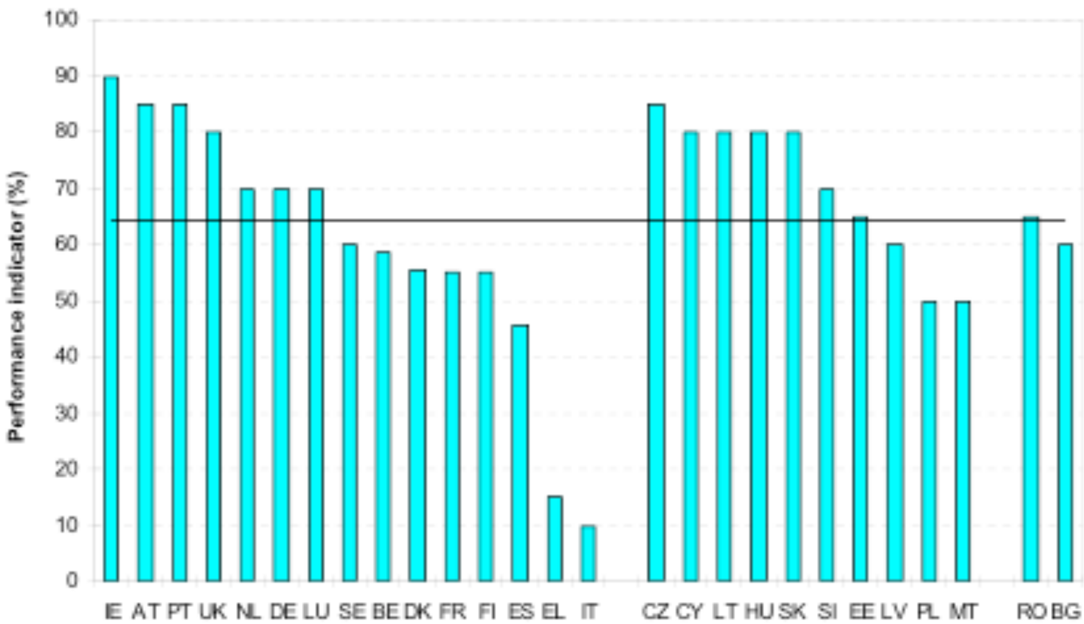

Figure 19: Reporting performance per Member State; (Source: European Commission 2007, p. 43)

5.3 Classification of water bodies

Austria is situated within three transboundary RBDs (Danube, Rhine and Elbe) and, as a landlocked country, hence has no transitional or coastal water bodies. All three RBD are governed by International River Basin authorities in which Austria acts as river basin party only in the Danube RBD, and has observer status in the Rhine and Elbe RBD. Scotland also is located within three RBDs, whereas only the Scottish RBD lies entirely in Scotland and the Northumbria RBD and the Solway Tweed RBD are shared with England. In the North Umbria RBD and the Solway Tweed RBD Scotland shares only some ground water and no surface water bodies. A particularity in the Scottish RBD is the large number of protected areas, which require special protection and are treated differently under the WFD.

For the determination of river typologies, Austria chose System B of the WFD, which consists of obligatory factors that are altitude, latitude, longitude and geology size, and some optional factors. The optional factors chosen in Austria were for example the “Strahler number”, run-off regime at water bodies with gauge stations, and a pre-established national classification called “Fließgewässer – Naturräume” according to the system by FINK, MOOG and WIMMER (2000). This first classification resulted in 17 regional and 9 special types, which were then further assessed and differentiated by using biological data from reference condition sites. The biological reviews of the basic types lead to the determination of 15 riverine bioregions in Austria. In a last step, the 15 bioregions were divided into subtypes according to a longitudinal differentiation through which 39 subtypes within the bioregions were identified. In total, Austria has reported 7,339 river water bodies from which 7,054 lie within the Danube RBD, 194 within the Rhine RBD and 91 within the Elbe RBD.

Scotland followed the recommendations of the UKTAG, which proposed to apply System A of the WFD using altitude, catchment size and geology for the determination of river types. The application of System A created theoretically 27 river types of which 21 are actually found across the UK and 15 in the Scottish RBD. Also in Scotland, all typologies for rivers have been tested against biological data. In total, within the Scottish RBD there are 2,013 riverine water bodies.

In general, both countries follow the recommendations of the CIS guidance on the establishment of reference conditions. In Scotland and in the UK in general, it is planned to adopt System B, incorporating additional parameters, when more data will be available.

5.4 Reference conditions

Reference conditions represent the “high” or “natural” ecological status at which only very minor anthropogenic influence is allowed. Through the assessment of the deviation of actual monitoring results from reference values the ecological status classes can be determined. Reference conditions are therefore the base for the determination of the ecological status of water bodies.

Austria was strongly involved in the European-wide intercalibration activities concerning reference conditions and contributed to the CIS-Guidance document on the establishment of reference conditions, in which elements of the Austrian strategy paper for reference criteria were included. The selected reference sites in Austria had to fulfil the requirement that all biological quality elements have to be in a “high” ecological status. For reference sites for specific quality elements, exemptions were made as not all quality elements had to reach “high status”. In Austria, reference sites for almost all water body types were established, with only a few exemptions if no reference sites could be found due to very high anthropogenic influence (e.g. in the “Alpenvorland” or the eastern lowlands). In such cases, expert knowledge or historical data were used to determine reference values. One challenge during the determination of reference conditions was the high number of different water body types as Austria lies within four different European eco-regions characterized by very divers geology, altitudes, substrates, base slopes and river velocities. Due to the high number of different water body types a lot of reference sites had to be identified.

In Scotland, reference conditions have been again developed under a collaborative partnership across the UK and Ireland. A large monitoring network has been established which consists of primary, secondary and minor sampling sites. As in Austria, the reference values are not only determined by monitoring, but also by using expert judgements or modelling approaches. In the UK, there are relatively few sites in where reference conditions can be found. For this reason, not all quality elements have to be in reference conditions in the UK, only the quality element of concern. However, in Scotland it was a comparable much easier task to find reference sites, as many water bodies are already in a "high" or "good status".

In general, in both countries it was a comparable easier task to find reference sites than in other European Member States. During the research of this thesis, it was much easier to find information about the determination of reference sites and reference values for Austria than for Scotland.

5.5 Determination of the "good status"

The WFD determines the biological, physico-chemical and hydro-morphological quality elements, which have to be considered for the assessment of the ecological status. How these quality elements are assessed and how EQR status class boundaries are set is left flexible to the Member States.

As a member of the Central – Baltic GIG Austria participates actively in the European-wide intercalibration exercise and in general, the national regulations are in accordance with the CIS recommendations. Only one slight deviation concerning the physico-chemical parameters is applied, as they are used as "supporting parameters" for the determination of the "good status". This means that physico-chemical parameters do not have to reach "good status", but rather have to allow the biological quality elements to reach "good status". In all other concerns, Austria follows the CIS recommendations and applies the one-out-all-out principle, meaning that the quality element with the worst result defines the classification result. Furthermore, Austria follows a "type-specific" approach for the assessment of the ecological status. The assessment methods are explicitly described in legally binding methodical guidelines for each group of quality elements. All quality elements mentioned in the WFD are assessed, with "phytoplankton" being the only exemption as the autochthonous occurrence of phytoplankton in Austrian watercourses plays a very minor role. Only for the big rivers like the Danube, March and Thaya expert assessment for phytoplankton was carried out. All other biological quality elements have been set in relation to the main pressures. For all quality elements assessment indicators have been developed which are applied homogenously by the regional authorities. Each indicator has been described in detail by the Austrian authorities. In general the Austrian authorities have established assessment methods for all relevant quality elements and a clear pressure – biological quality element relationship has been put in place.

For the determination and the assessment of quality elements, the Scottish Environmental Protection Agency (SEPA) follows again the recommendations of the UKTAG. Within the intercalibration exercise, Scotland as part of the UK, belongs like Austria to the Central Baltic intercalibration group in which the UK is leading the intercalibration process and was the first country to put into practice biological, morphological and physico-chemical indicators. In Scotland, standards for the assessment of the quality elements have been set for almost all biological, physico-chemical and hydro-morphological quality elements. Like in Austria, phytoplankton is not assessed as the Scottish rivers are relatively short and fast flowing and do not support phytoplankton communities. At present, the UK-wide "Fisheries Classification Scheme" is not fully developed, and therefore Scotland decided to apply an interim fish assessment method developed by the Scottish authorities. This is also the case for the assessment of the impact of acidification on the biological quality elements, where the UKTAG method is not yet fully developed and Scotland applies its own interim assessment method. Another missing parameter is the assessment of salinity. This parameter is not used, as there are no identified pressures in Scotland, which influence the salinity of rivers. Within the hydro-morphological parameters, the connection to ground water from rivers and lakes is not yet assessed. For all other quality elements indicators for the assessment (e.g. for benthic invertebrates the RICT) were developed and explained in detail. The information on the relevant indicators was collected through spatial monitoring. Water bodies that were not monitored were grouped with other monitored water bodies. Like Austria, Scotland applied the one-out-all-out principle and related each quality element to the significant pressures. In the future, SEPA plans to expand the number of quality elements.

In general it can be said that both countries have a well – elaborated system for the determination of the status classes according to the CIS guidelines.

5.6 Pressures and risk analysis

Article 5 of the WFD requires the Member States to analyse the anthropogenic impacts on the water bodies and to identify water bodies that are at risk of failing to achieve the WFD objectives. The analysis of pressures and impacts is an important base for the development of PoMs.

The main pressures on Austrian water bodies arise due to hydro-morphological alterations as hydroelectric power generation represents an important energy source in the country. Other problems are caused by nutrient contamination mainly through diffuse source pollution. This phenomenon happens mostly in the north and east of the country where most of the agricultural activities take place, whereas in alpine regions nutrient contamination and water quality deficits in general are very rare. The Austrian risk analysis showed that 52% of Austrian water bodies are at risk of failing the quality target of a “good ecological status”, 28% have no risk to fail and for 20% of the surface water bodies risk estimation was not possible.

The main risks for Scottish water bodies are mainly caused by morphological alterations and diffuse source pollution, whereas especially diffuse source pollution from agriculture is responsible for about half of the water bodies to be at risk of failing “good ecological status”. One other important pressure besides diffuse source pollution and hydro-morphological alterations is alien species. In Scotland there are about 1,000 identified alien species from which most of them are strongly invasive and cause harm to the native biodiversity. The UKTAG recognizes this harmful impact and for the classification of the “high ecological status” and “good status” there should be only very minor influence from these species. The Scottish risk analysis showed that about 40% of Scotland’s waters are at risk of failing the environmental standards.

5.7 Quality assessment results – can the “good status” be achieved?

Austria classified 12% of its water bodies as HMWB or AWB, which have not the quality objective to reach “good ecological status”, but “good potential”. The natural Austrian surface water bodies achieve by 39% “high” or “good status”, 51% “moderate status” and 10% a “poor” or “bad status”. Therefore, it is very unlikely that Austria can reach the quality target envisioned in the WFD by 2015. For this reason, it applies a step-wise approach, which will focus during the first cycle mainly on the improvement of HWMBs and AWBs as 87% did not reach the targeted “good ecological potential” in 2009.

In Scotland, 15% of all water bodies are classified as HWMB and AWB, from which 50% are already in “good potential”. Concerning natural surface waters, 65% are already in “good” or “high status”. With this result, Scotland reaches the highest ecological water quality in Europe. However, it will not be possible for Scotland as well, to achieve “good ecological status” for all water bodies by 2015. Therefore, it applies a step-wise approach like Austria.

Austria, and especially Scotland, represent countries which might have fewer environmental problems than other countries in Europe as for example the Netherlands or Spain. Nevertheless, they will not be able to reach the envisioned target of the WFD in time, which shows that the objective to reach “good ecological status” by 2015 is too ambitious and only a step-wise approach until 2027 represents a feasible solution. However, it can be observed that the biggest step of improvement for water bodies in Austria and Scotland is planned for the period between 2021 and 2027 (e.g. 50% improvement for water bodies in Austria, and 38% improvement for HWMB/AWB in Scotland) and it is questionable if these envisioned goals can be realistically achieved.

5.8 River Basin Management Plans and Programme of Measures

River Basin Management Plans (RBMPs) are the core planning and reporting tools for river basin management. The Programme of Measures (PoMs) established within the RBMPs includes the main means to reach the objective of a “good status” of all European water bodies.

According to a report by the European Union, Austria has followed a national and consistent approach for the preparation of its national, and the three international RBMPs. Austria showed a lot of effort to ensure international coordination, especially during the elaboration of the Danube RBMP. Once more it followed all recommendations of the CIS guidelines and all RBMPs were delivered in time to the European Commission. The PoMs in the national RBMP is structured according to the significant pressures and consisting and new measures for each pressure are described, which were discussed with stakeholders and NGOs during a public consultation process. Specifically, the PoMs focuses on improvements concerning the water body structure, river continuity and reduction of nutrient pollution through diffuse sources. In an evaluation report of the European Commission concerning RBMPs, it is criticized that Austria focuses only on already established basic measures and that very few information is given about supplementary measures.

The Scottish RBMP was elaborated by SEPA and was reported to the European Commission in time. The plan was elaborated with the help of established “advisory groups” which should enable public involvement during the whole process. Within the Scottish RBMP, SEPA follow a coordinated and integrated approach for the implementation of the PoMs. This means that the work of the different public, private and voluntary bodies involved in the process is coordinated. The Scottish government has also amended existing legislation of areas affected by the WFD, which should support the achievement of the set goals. Furthermore, the so-called Water Environment (Controlled Activities) Regulations (CAR) has been established to control significant pressures through authorization. In general, the PoMs is structured according to the identified significant pressures as in Austria. For each pressure, different types of measures to prevent deterioration and enable improvements are presented. One special feature is that SEPA has conducted “climate checks” for each measure, which indicate any likely impacts of the respective measure to greenhouse gas emissions.

Austria and Scotland have reported well-established RBMPs to the European Commission. Public participation was an important part of the process and a lot of effort was made to follow the CIS methodologies by both countries.

5.9 Cost effectiveness

The cost-effective analysis (CEA) should serve as decision-support tool, which enables the assessment of the costs and the effectiveness of the measures proposed for the achievement of the objectives set in the WFD.

In Austria, methodologies for cost-effective analysis are elaborated for measures coping with the two main significant pressures, namely hydro-morphological pressures and diffuse source pollution. The cost analysis was based on already implemented measures, available data, scientific studies and expert judgements. Costs were either denoted as specific cost ranges or were rated qualitatively according to a four-level scale. The effectiveness of the measures has been related to the possible reduction of the emission or to the improvement of the biological quality elements affected by the pressure.

Scotland has used the CEA approach developed by the UKTAG. In general, the UK has been under the forerunners in concern to CEA. Various publications starting in 2004 until to date, which suggest different methods for cost-effective analysis of the PoMs in the UK can be found. The effectiveness is mainly measured in relation to the reduction of the significant pressures, which could cause difficulties, as there is not always a direct relationship to the reduction of the related impact. In 2008, the Scottish Government commissioned an impact assessment for the Scottish RBMP in which a CEA was conducted for all planned measures. In the study full economic costs were used and presented as unit and total costs for each measure.

Both countries addressed cost-effectiveness during the elaboration of the RBMPs. The Scottish approach, as part of the UK, might be more advanced as cost-effectiveness was carried out for all measures and the selection of the measures was based on it. In Austria, the PoMs focused in general mainly on already established measures and therefore cost-effectiveness for additional measures was not considered. (European Commission 2012a, p. 4).

5.10 Information availability in Austria and Scotland

During the elaboration of this Master thesis, one difficulty was to encounter the right information for the analysis of the national documents. The documentation about applied methodologies or assessment results is done in both countries in various different documents and at the beginning it was a difficult task to understand the system behind it (e.g. which documents are legally binding, which documents relate to another, which ones include just recommendations concerning a specific topic). This was especially the case for Scotland as the Scottish Environment Protection Agency is responsible for the implementation and the establishment of RBMPs, but most of the applied methods and systems were developed for the whole UK by the UKTAG. Even the Scottish and English authorities themselves had problems to know if the relevant information has to be demanded from SEPA or from authorities responsible for the UK as a whole. In Austria, it was an easier task to find the right information as experts from the Austrian Ministry for Agriculture, Energy, Environment and Water Management helped when problems and question came up. For this reason, more information could be given for Austria in some chapters.

5.11 Ten thoughts to go home with

The main conclusions of the Master thesis are summarized in the following ten points:

1. Scotland and Austria have a lot of similarities, concerning water body characteristics as well as pressures and impacts on the water bodies.

2. In both countries it was a comparable easier task to find sites in reference conditions than in many other European Member States.

3. In Austria, assessment methods for all quality elements have been established. One difference of the Austrian system is the assessment of the physico-chemical quality elements for the “good status”. In the Austrian system physico-chemical quality elements are used only as supporting quality elements and do not have to be in “good status” but rather have to allow the biological quality elements to reach a “good status”. Scotland uses the assessment method established by UKTAG in which some quality elements currently are not assessed (e.g. fish, acidity), but for which Scotland has developed a national interim approach. In general, both countries have a well-elaborated system for the determination of the status classes according to the CIS guidelines.

4. The PoMs in Austria included mainly already established basic measures, whereas in Scotland additional economic and educational measures have been included.

5. Scotland has a more advanced system of CEA than Austria. The selection of measures in Scotland was based on cost-effectiveness. The Austrian CEA is only based on basic, and not on supplementary measures.

6. In terms of punctuality and completeness of the conducted reports, both countries are under the forerunners in Europe.

7. Austria and especially Scotland represent countries, which might have fewer environmental problems than other countries in Europe, but nevertheless, both countries will not be able to reach the objective of “good ecological status” by 2015. Therefore, a step-wise approach until 2027 is applied. The biggest improvements are planned to be in the last period between 2021 and 2027 (with e.g. 50% water quality improvement for surface water bodies in Austria or 38% improvement for HWMB/AWB in Scotland). These ambitious goals make it questionable if it is feasible to reach “good status” or “good potential” for all water bodies by 2027 in both countries.

8. The PoMs in Austria focuses during the first six-year cycle on measures concerning HWMB and AWB as currently 89% do not achieve a “good potential”. Therefore, there will be only a slight improvement in the quality of

natural surface waters in Austria until 2015. In Scotland, the measures are equally distributed between natural surface waters and HWMBs and AWBs.

9. Austria and Scotland have reported well-established RBMPs to the European Commission. Public participation was an important part of the process in both countries.

10. Both countries have developed comprehensive national instruments to implement the provisions of the WFD and can serve as best practice for other Member States.

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