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Basic principles for selecting the most cost-effective combinations of measures for inclusion in the programme of measures as described in Article 11 of the Water Framework Directive

HANDBOOK

by

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16. **Summary**

In this project, a methodology for selecting the most cost-effective sets of measures as part of the river basin management plans to be set up for each river basin by 2009 according to article 11 of the Water Framework Directive (WFD) has been developed. Based on a description of the relevant national and European guidelines for the implementation of the WFD and a case study analysis of the prevailing pressures on German water bodies, an exemplary catalogue of applicable measures and instruments was compiled. The included measures and instruments are described in greater detail in data sheets contained in the annex. The study differentiates between concrete technical measures and administrative, economic and informational instruments, which facilitate and support the implementation of the measures.
Starting point for the methodology developed in this project is the analysis of pressures and impacts according to the WFD until December 2004. Based on an inventory of the prevailing pressures and sources, potentially relevant sets of measures and supporting instruments are selected. In the ensuing multi-step evaluation process taking into consideration the ecological effectiveness of these sets, the probability of reaching the WFD-objectives until 2015, the time frame necessary for their implementation and a prioritization with respect to the direct and indirect costs involved, the most cost-effective combination is identified. While the derived method constitutes a preliminary recommendation to decision-makers in water management, a further development and specification as well as an adjustment of the proposed method to local conditions and experiences is mandated. In addition to the practice-oriented handbook, a more extensive study, featuring additional background material, has been prepared.

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LIST OF ABBREVIATIONS

AbwV	Waste Water Ordinance
AFS	Substances removable via filtration
ALLB	Department for Agriculture, Countryside and Soil Conservation
AWB	Artificial Water Body
BLAC	Federal/Land Task Force on Chemical Safety
BOD_5	Biological Oxygen Demand
BMU	Federal Environment Ministry
BWK	Association of Water Industry, Waste Industry and Land Improvement Engineers
CAP	Common Agricultural Policy of the EU
CIS	Common Implementation Strategy
COD	Chemical oxygen demand
EPER	European Pollutant Emission Register
IE	Inhabitant Equivalent
GEP	Good Ecological Potential
GES	Good Ecological Status
HMWB	Heavily Modified Water Bodies
HQ_2	Two-year flood discharge
HQ_5	Five-year flood discharge
ISAR	Information System for the Selection of Efficient Renaturation Measures
IPPC	Integrated Pollution Prevention and Control
LAWA	Working Group of the Federal States on Water Problems
LEL	State Office for Development of Agriculture and Rural Regions
LfU	State Office for Environmental Protection
MEP	Maximum Ecological Potential
MNQ	Mean minimum water discharge
N	Nitrogen
NH_4	Ammonium
N_{total}	Total nitrogen
NID	Nitrate Information Service
PAH	Polycyclic aromatic hydrocarbon
P	Phosphorous
P_{total}	Total phosphorous
HM	Heavy Metals
UBA	Federal Environmental Agency
WFD	Water Framework Directive

1. INTRODUCTION

The European Directive establishing a framework for Community action in the field of water policy (Water Framework Directive, WFD), adopted in the year 2000, will prompt far-reaching changes and a fundamental reorientation of Germany's management of aquatic resources (v. Keitz and Schmalzholz, 2002). This includes the attainment of specified environmental targets for all water bodies by 2015[1], whereby ecological aspects in particular, as well as economic considerations, must be taken into account in all decision-making processes affecting water management.

The Water Framework Directive stipulates that a good status must be attained in surface waters and in groundwater by the year 2015. En route to this target, a number of stages must be implemented by the Member States. For example, as well as a description of river basins including, *inter alia*, identification of the significant anthropogenic stresses, an economic analysis of water uses must also be completed by December 2004 (Article 5 (1)). Annex III furthermore stipulates that this analysis must contain adequate information to allow the principle of cost recovery by the water services to be taken into account, and contribute to an assessment of the most cost-effective combinations of measures for the programme of measures required under Article 11 of the Water Framework Directive. Based on this preparatory work, by the end of 2009, concrete management plans must be prepared for the individual river basins, including programmes of measures. Thereafter, the programmes of measures are to be translated into practice within a three-year period. When implementing the Water Framework Directive, the tasks which must be completed by that date in order to meet the objectives outlined will take place parallel to one another, and should be handled in an integrated manner.

1.1 Objectives of this Handbook

This Handbook proposes an approach for the systematic derivation of cost-effective combinations of measures with due regard for the requirements of the Water Framework Directive, and hence serves as a basis for decision-making when preparing the programmes of measures. Users of the Handbook are provided with all the necessary information to enable them to select the most cost-effective combinations of measures. The Handbook therefore facilitates the practical, methodologically stringent selection of cost-effective combinations of measures.

This Handbook is aimed at decision-makers in the water management authorities and independent planning offices entrusted with the tasks of the Water Framework Directive. The

[1] In this respect, it is important to ensure that the largels of other valid EC Directives (such as the Directive concerning urban waste water treatment (91/271/EEC) are met.

results will provide these target groups with a work aid and argumentation guide for use in the sub-basins, which they should combine with their own experiences. As well as the Handbook, there is also an extensive study entitled, "Basic principles for selecting the most cost-effective combinations of measures for inclusion in the programme of measures as required in Article 11 of the Water Framework Directive"[2]. This study outlines relevant European and national implementation guidance documents for the Water Framework Directive and case examples in greater detail.

Generally speaking, it is important to remember that the proposals regarding measures and combinations of measures are tailored to the EU reporting level in terms of their level of detail. The Handbook does not purport to provide instructions which must be followed to the letter, but instead represents a proposed methodology based on experiences in the preparation of programmes of measures and the requirements pertaining to the practical application thereof. Another important point concerns concrete references and starting-points for inter-sectoral collaboration, particularly between agriculture, the water industry and nature conservation, aimed at minimising water body pressures. The Handbook focuses primarily on the implementation of the Water Framework Directive after 2004, i.e. the subsequent procedure once inventories have been completed in the river basins. Based on an analysis of a river

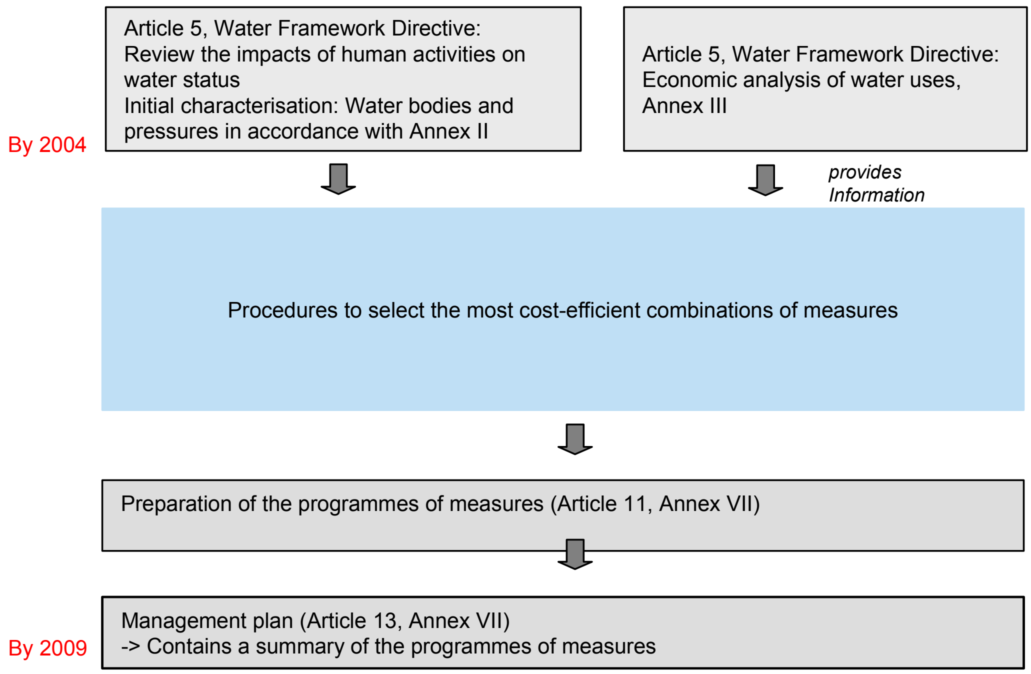

Figure 1-1 Incorporation of the project into the implementation process of the Water Framework Directive (WFD)

[2] The final report of the project will be available for loan from the Federal Environmental Agency (in German language only)

basin's features, and after recording any significant pressures and performing an economic analysis, the project therefore provides a nationwide basis for the selection of measures up to 2009. Its incorporation into the implementation process of the Water Framework Directive is depicted in Figure 1-1. Nevertheless, it is important to remember that at the present time, a number of decisive factors governing the choice of measures, such as the definition of "good ecological status", have not yet been uniformly regulated from a technical or legal viewpoint. The recommendations in this Handbook should therefore be adapted in line with future regulations.

1.2 Scope of this Handbook

Selection of measures and instruments

Within the context of this Handbook, a distinction is made between measures and instruments. Here, the term '**measure**' refers to a concrete technical precaution which tends to have a local effect, such as a structural precaution, whilst **instruments** are of an administrative, economic or advisory nature. As such, instruments serve to support the implementation of measures (which tend to be more technical in nature) by creating incentives for the relevant players to modify their behaviour. One consequence of this is that instruments have a more long-term, more widespread effect than measures, and require coordination at a higher administrative level. However, both measures and instruments should be seen as 'measures' within the meaning of Article 11 of the Water Framework Directive. [3]

Based on the typical pressure situations for water bodies in Germany identified in pilot studies (cf. chapter 3), for the purposes of this project, the most relevant measures and instruments in this connection were selected in collaboration with the client. As such, the scope of the project is confined to 17 measures and ten instruments, which together cover many of the significant problems as defined by the Water Framework Directive. Given the large number of potential pressure scenarios, an exhaustive account cataloguing every conceivable measure and instrument would exceed the brief of this project.[4]

During the course of practical implementation, these measures and instruments should be adapted to the respective problem situation, supplemented, and compared with experimental values. As such, the catalogue of instruments and measures is explicitly seen as an "open" catalogue, which may need to be extended in specific cases. Another conceivable option would be to interactively supplement the open catalogue in the form of a nationwide database. This

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[3] According to Article 11 and Annex VI, the Water Framework Directive distinguishes between "basic measures" which must be included in the programmes of measures, and "supplementary measures", which may be included. Instruments represent a sub-group of "supplementary measures", whereby no clear terminological demarcation is made between measures and instruments in the Water Framework Direcitve.

[4] A pressure scenario contains (many) different kinds of pressures in a river basin.

elucidates the fact that the measures and instruments under consideration may differ from case to case.

Groundwater

The Handbook is primarily concerned with identifying the most cost-effective combinations of measures in order to attain a good status in surface waters. The area of groundwater is partially covered by a number of measures and instruments which may be applied to both surface water and groundwater, for example in the area of diffuse pollutants. [5]

Admittedly, further significant changes will occur in this area once the Daughter Directive on Groundwater, currently available in draft form has been adopted, for example, with respect to the specification of limit values and the provisions governing trend reversal. Furthermore, these changes will also necessitate alignment of the IMPRESS guidance document vis-à-vis groundwater.

Generally speaking, the methodology for selecting cost-effective combinations of measures and instruments developed in this Handbook may also be applied to groundwater protection. However, adjustment will often be required in order to adapt the procedure developed in the Handbook in line with the relevant statutory framework conditions.

1.3 Relevance of other policy-making areas

Selecting cost-effective combinations of measures, above and beyond the concrete context of the Water Framework Directive and the procedure proposed in this report, is also dependent upon further general developments in environmental policy. As a more detailed consideration of all the relevant correlations would exceed the brief of this project, the relevance of the EU common agricultural policy can be mentioned here as an example only. When determining the programmes of measures and their subsequent implementation, greater consideration must be given to these processes.

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[5] The following measures and instruments are particularly relevant for qualitative groundwater protection: Measures 1.4 on desealing and seepage of rainwater, 2.2 on the minimisation of nitrogen discharges, 2.3 on the minimisation of phosphate discharges and 2.4 on the environmentally compatible handling of pesticides, together with instruments I – IV to minimise diffuse pressures from agriculture, and instruments VII and VIII on cooperation with and consultation of farmers. In the field of quantitative groundwater protection, only instrument V on water abstraction charges is currently in place. However, farther-reaching measures and instruments are required in order to guarantee the required balance between the recharge and abstraction of groundwater.

2. PROJECT-RELEVANT GUIDANCE DOCUMENTS

Given the complexity of the requirements of the Water Framework Directive, there is a significant demand for clarification on the part of the Member States, particularly amongst the competent authorities, regarding the work needed in order to implement the Directive. For this reason, at EU level, within the context of the common implementation strategy (CIS) for the Water Framework Directive, various guidance documents have been developed, aimed at supporting interpretation of the Water Framework Directive and facilitating a harmonious, uniform implementation process, although these are not legally binding. Parallel to the efforts at European level, the Working Group of the Federal States on Water (LAWA) has produced reference documents for the implementation of the Water Framework Directive, which are based on the European guidance documents but tailored specifically to the situation in Germany.

Some of the guidance documents focus specifically on the issues relevant to the current project. They must be taken into account when drawing up a catalogue of measures, because their implementation produces important information regarding the pressures and impacts existing in the river basins, and hence the measures and corresponding instruments required as a result.

Project-relevant guidance documents include two documents dedicated to the identification of significant pressures (EU-IMPRESS Working Group: Guidance document to the analysis of pressures and impacts in accordance with the Water Framework Directive" and LAWA: "Criteria for the detection of anthropogenic pollutants and evaluation of their effects for timely, meaningful reporting to the EU Commission", also known as the LAWA criteria document). They also include the relevant content of the implementation guidance document by the EU-WATECO Working Group[6], which addresses the issue of economic analysis, and its equivalent at German level, the LAWA guidance document to economic analysis[7]. Moreover, the document of the EU Working Group on heavily modified water bodies (HMWB) also supplies a number of additional key aspects.

An in-depth account of these guidance documents may be found in the comprehensive study (long version) belonging to this project, which can be ordered in German language from the Federal Environmental Agency, Berlin.

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[6] Guidance Document for the Implementation of the Economic Elements of the EU WFD

[7] Work aid by LAWA on implementation of the EC Water Framework Directive: Supplement to Part 2: „Preparatory work and remarks on preparing an EC management plan", chater 1: „Essential work that must be completed 4 years after entry into force", 1.4 economic analysis of water use in accordance with Article 5 and Annex III

3. TYPICAL PRESSURE SITUATIONS

The aforementioned guidance documents may be consulted in order to determine the pressure status of a water body. The predominant pressure scenarios for water bodies in Germany, their causes and the situation in selected pilot areas are outlined in the following chapter. A detailed account of the individual case examples may be found in the detailed study belonging to this project. Some of these areas mentioned above are used in chapter 5 when assessing the methodology developed for determining the most cost-effective measures.

3.1 Typical Pressure Situations in Germany

The current situation of surface waters in Germany may be characterised in terms of chemical (nitrogen and phosphorous), morphological and biological quality (e.g. saprobic organisms). Pressures are derived from these three components.

In many cases, the existing ecological deficits in surface waters are no longer purely the result of continuous sewage discharges, but in many cases are comprised of several different components.

During recent years and decades, the origins of pollutants in the surface waters have shifted away from point sources in favour of diffuse sources due to sewage plant upgrading measures. Consequently, in populated areas, the quality of point discharges can only be optimised, but can no longer be significantly improved, apart from a few exceptional cases. However, pollution problems in the category of point sources also include combined sewage discharges (rain spillway basins) in urban regions and discharges into surface waters caused by a lack of sewage treatment plant connections, generally in rural regions. Nevertheless, with accumulative water pollution, such as the transportation of nutrients of nitrogen and phosphorous from the Federal territory into the North Sea, the proportion of diffuse sources, particularly from agriculture, predominates over substance discharges from point sources. Diffuse discharges account for around 70 % of the total load of 819 kT nitrogen and 66 % of the total load of 37.2 kT of phosphorous in the Federal Republic of Germany (cf. Behrendt et al., 2000). There are considerable differences between the individual river basins, depending on the predominant uses.

Regarding the structure of water bodies, water quality atlas of the Federal Republic of Germany shows that only 10 % of German water bodies are unmodified or only slightly modified. 30 % of water bodies are moderately to significantly modified, whilst the remaining 60 % are classified as structural quality class 5 or worse (heavily, very heavily and completely modified) (cf. Figure 3-1).

The fact that “unmodified” to “moderately modified” sections account for only a small proportion of water bodies may be attributed to the hydraulic engineering measures of recent decades and centuries affecting the more heavily hydromorphologically modified rivers. In the majority of cases, the length has been shortened, banks have been obstructed, dams constructed, water diverted into canals, and flood protection constructions created. In many cases, extensive drainage measures have been carried out in favour of agriculture and the development of human settlements.

The consequences of expansion and maintenance work have led to significant structural changes in the majority of rivers and streams. This is particularly apparent on large rivers, many of which have been equipped with weirs and locks for the benefit of shipping and hydropower use. Smaller and medium-sized rivers have also been modified for the purposes of hydropower, to protect human settlements against floods, as transport routes or for agricultural use (e.g. land reclamation).

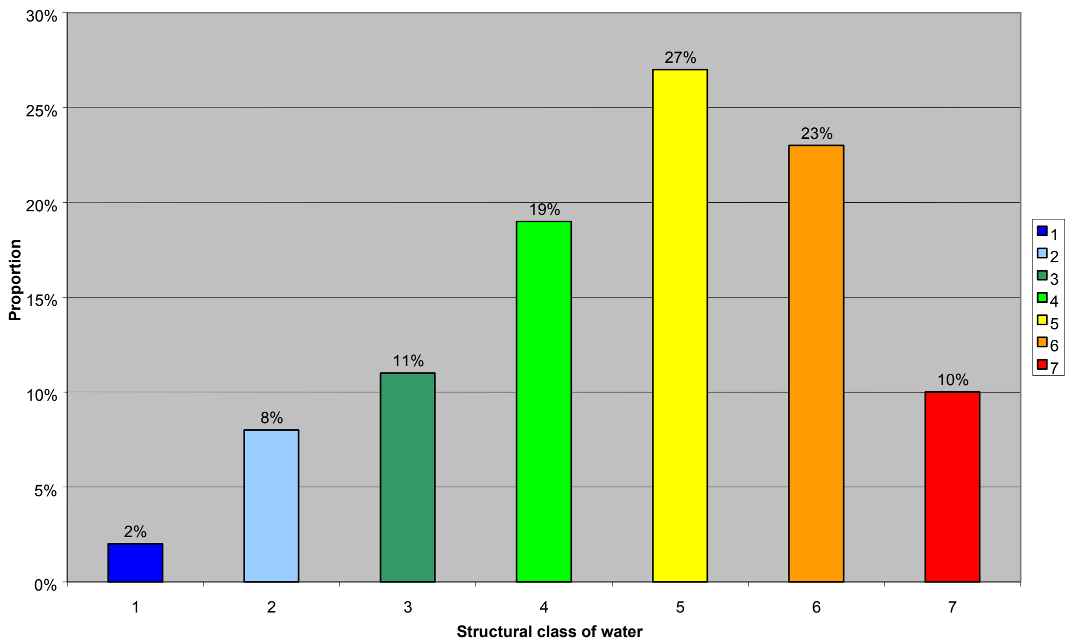


Figure 3-1: Water body structure in the Federal Republic of Germany 2001

The biological water quality map, representing the results of the saprobic quality classification of water bodies, published every five years since 1975 by the Working Group of the Federal States on Water (LAWA), indicates a trend towards improvement in the biological situation of surface waters in the Federal Republic of Germany. The proportion of mapped rivers with quality class II or above has increased from 47 % in 1995 to 65 % in 2000 (cf. Figure 3-2).

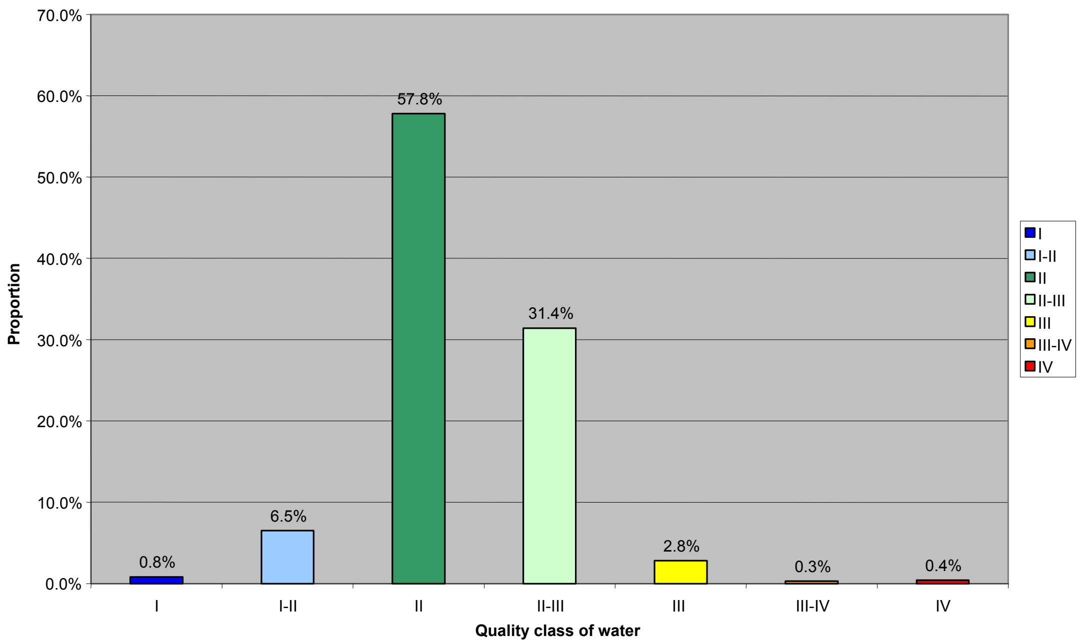


Figure 3-2: Biological water quality in the Federal Republic of Germany 2000

The improvement and intensified application of sewage treatment measures since the Seventies has effected a significant improvement in biological water quality.

In summary, it can be asserted that German surface waters are impaired by a number of pressure categories. As outlined above, the areas of diffuse sources and (hydro)morphology play a particularly important role. Significant pressures from point sources also contribute to this very common situation in selected cases. As a result of nutrient discharges and horizontal structures constructed for flow control purposes, many rivers indicate high trophic levels.

3.2 Brief characteristics of the case studies

In order to illustrate the situation of German surface waters, the CIS guidance document and/or the LAWA guidelines were applied to a number of specific river basins in order to detect significant pressures. The case examples depicted in the following table represent typical main pressure scenarios in Germany, i.e. pressures caused by deficits in morphology and as a result of discharges from diffuse sources.

Lahn	- Sample implementation of the identification procedure for heavily modified water bodies - Bibliography: *Fallstudie Lahn – Erheblich veränderte Gewässer in Europa* (2003). Editors: Federal Environmental Agency Berlin (currently under preparation)
Große Aue	- Sample preparation of a river basin management plan - Identification of pressures and effects - Application of current LAWA criteria - Main pressures: Diffuse sources, flow control, morphological changes, land use - Bibliography: Bezirksregierung Hannover, Dezernat 502, Bezirksregierung Detmold, Dezernat 54 (2001): *Pilotprojekt zur Umsetzung der EU-Wasserrahmenrichtlinie, "Modellhafte Erstellung eines Bewirtschaftungsplanes am Beispiel des Teileinzugsgebietes Große Aue im Flussgebiet Weser",* Hannover/Detmold
Seefelder Aach	- Sample preparation of a river basin management plan - Identification of pressures and effects - Preparation of a programme of measures - Main pressures: Diffuse sources, morphological changes, other pollutants (hygiene-relevant pollutants) - Bibliography: Institut für Gewässerforschung und Gewässerschutz, Universität Gesamthochschule Kassel, Borchardt, D.; Geffers, K.; Funke, M. (2001): *Modellprojekt Gewässerbewirtschaftung im Einzugsgebiet der Seefelder Aach*
Main	- Sample preparation of a river basin management plan - Procedures for the provisional identification of heavily modified water bodies - Main pressures: Morphological changes

The case studies reflect the range of typical pressures. By virtue of their development history, the individual river basins have varying types and degrees of use. Furthermore, the inherent heterogeneity of the river basins means that every area under observation at local level has its own individual character. These differences in characteristics are also reflected in the intensity of pressures on the surface waters. For the case studies, the main pressures were derived at a generalised level. The list (Table 3-1) clearly shows that our selection of case studies is representative of the current situation in Germany in terms of the main pressures.

Table 3-1: Measure-relevant pressures in the selected examples

Case study	Diffuse sources	Point sources	Flow control	Water abstraction	Water body morphology
Lahn	x	x			x
Große Aue	x		x		x
Seefelder Aach	x	x			x
Main	x	x	x		x

Table 3-1 also shows that although there are varying pressure situations within Germany, the simultaneous occurrence of certain pressures is quite common, although pressures may vary in their intensity. In the river basins of the examples given, pressures caused by a modified water body morphology and as a result of chemical discharges are very common. Specifically, pressures caused by flow control and, to a varying degree, point and diffuse sources, often coincide. In the case examples given, diffuse discharges and water body morphology are always involved in the respective pressure combinations.

As in the case studies, the same problems also apply to other sub-basins in the Federal Republic of Germany. Pressure situations that are attributable solely to morphological deficits or solely to chemical deficits, where these exist at all in Germany, are very rare. In terms of pressures, this necessitates an effective combination of measures, so that all pressure categories may be adequately covered. The following chapters refer to typical pressure situations in the Federal Republic of Germany as outlined above.

4. OVERVIEW CLASSIFICATION OF MEASURES AND INSTRUMENTS

If an impairment to the water body is ascertained, the risk assessment explained in chapter 2 leads to the preparation of a plan of measures. In accordance with the implementation schedule of the Water Framework Directive, the plan is to be prepared by 2009. The measures are designed to minimise the respective impairment and/or pressure so that the quality targets of the Water Framework Directive may be achieved by 2015. According to the Water Framework Directive, when selecting these measures, it is important to ensure that the chosen combination of measures is cost-effective, i.e. the maximum possible degree of ecological effectiveness is achieved at low cost.

A clear breakdown and classification is needed as a basis for the selection of cost-effective combinations of measures and instruments, which will provide rapid access to the relevant information. The classification chosen for the purposes of this Report is based on the inventory outlined in Annex II of the Water Framework Directive, on which a report is to be submitted to the EU by December 2004. This stipulates that the significant pressures, sub-divided according to pressure and polluter categories, must be recorded in order to facilitate an initial assessment of the water body status.

Consideration of chemical pressures

The Water Framework Directive distinguishes between chemical (contamination) and hydromorphological pressures (water abstraction, flow control, morphological changes) which may lead to failure to achieve a good ecological status. Measures for both types of pressure have been formulated and defined in this study. With regard to material pressures, consideration was given to the two nutrients phosphorous and nitrogen, BOD_5, COD, pesticides and other hazardous substances such as heavy metals (cf. Figure 4-1).

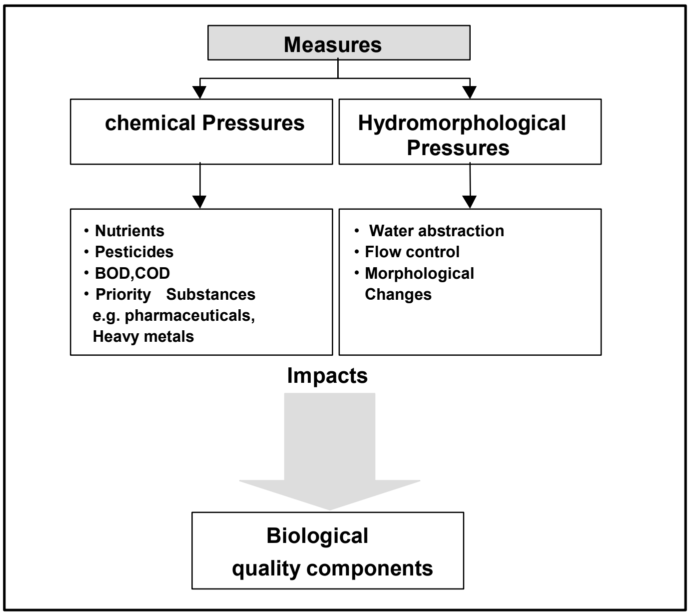


Fig. 4-1: Overview of pressures to be taken into account under the Water Framwork Directive (WFD)

In future, increasing numbers of organic and inorganic substances and substance groups will also need to be considered, where these occur in significant or toxicologically relevant concentrations in surface water or groundwater. In this respect, pharmaceutical and veterinary products play a key role. The principal sources of discharge are households and indirect discharges via sewage plant outfalls and combined sewage, but these substances also enter surface waters via diffuse discharges such as atmospheric deposition or fertiliser discharges from agricultural land via seepage, surface run-off, erosion or drainage. This problem is currently being investigated within the context of special analysis programmes (e.g. study by BLAC (Federal Government/*Land* Task Force on Chemical Safety) on pharmaceuticals in the environment). For these substances, discharge into water bodies cannot be prevented by sewage treatment alone, since particularly in the industrial/commercial sector, the limits of technical and financial feasibility have already been reached for the most part. Success may be achieved in particular by avoiding or reducing the discharge of hazardous substance into sewage “at the source” (v. Keitz, 2002). In addition to targeted monitoring of occurrence and dispersion in the aquatic environment, in future, attention must focus in particular on prevention and avoidance strategies. These include phasing out certain hazardous substances and substituting them with less hazardous alternatives, for example in the pharmaceuticals industry, and promoting production methods with closed substance cycles and regulations governing the use of veterinary pharmaceuticals.

4.1 System of pressures

In this Handbook, measures are classified, and measures and instruments are combined on the basis of three different systems, which are explained below. In line with the objective of this project, we have only provided a selection of measures and instruments. In total, we cite examples of 17 measures and ten instruments covering a large proportion of significant problems relevant to the general water situation in Germany.

The first stage in this process is the system of pressures (Figure 4-1). This overview diagram, which is based on the ***pressure categories*** of point sources, diffuse sources, water abstractions, flow control and morphological changes (column 1), identifies the ***polluter categories*** most relevant to these pressure situations (column 2). For the area of diffuse sources, for example, we have included agriculture, local authorities and industry. In a subsequent stage, we list the typical ***pressure types*** for the respective pressure category and polluter category (column 3). Within the context of the aforementioned combination ‘diffuse sources’ / ‘agriculture’, for example, the pressure type is ‘substance discharge from agricultural land’.

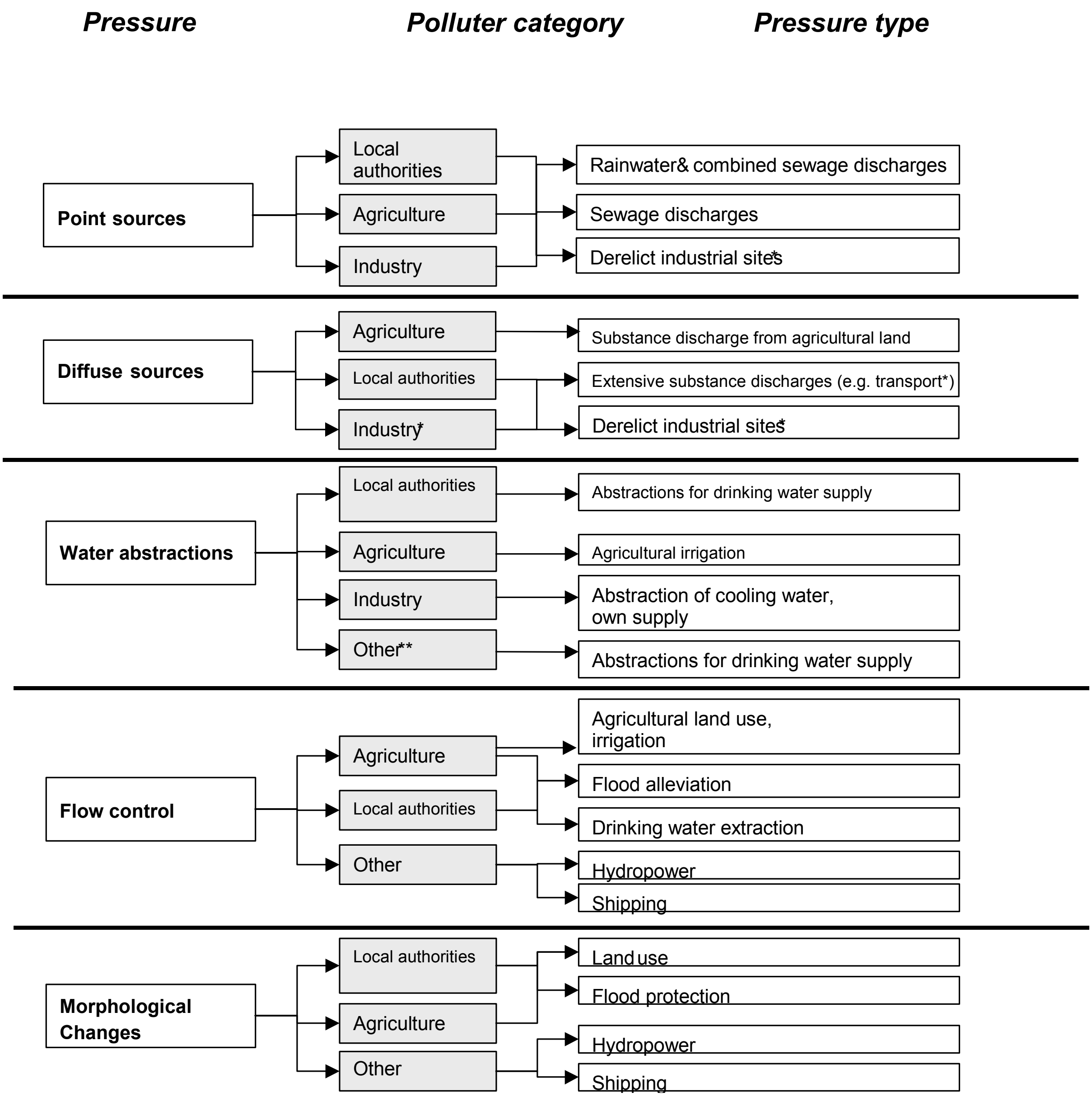


Figure 4-1: **System of pressures: Pressure categories (column 1), polluter categories (column 2) and pressure types (column 3)**

(*) Not considered in greater detail here, because it was not considered a priority for the purposes of this project and as such, no measures were formulated

(**) Particularly supra-regional, non municipal water supply companies

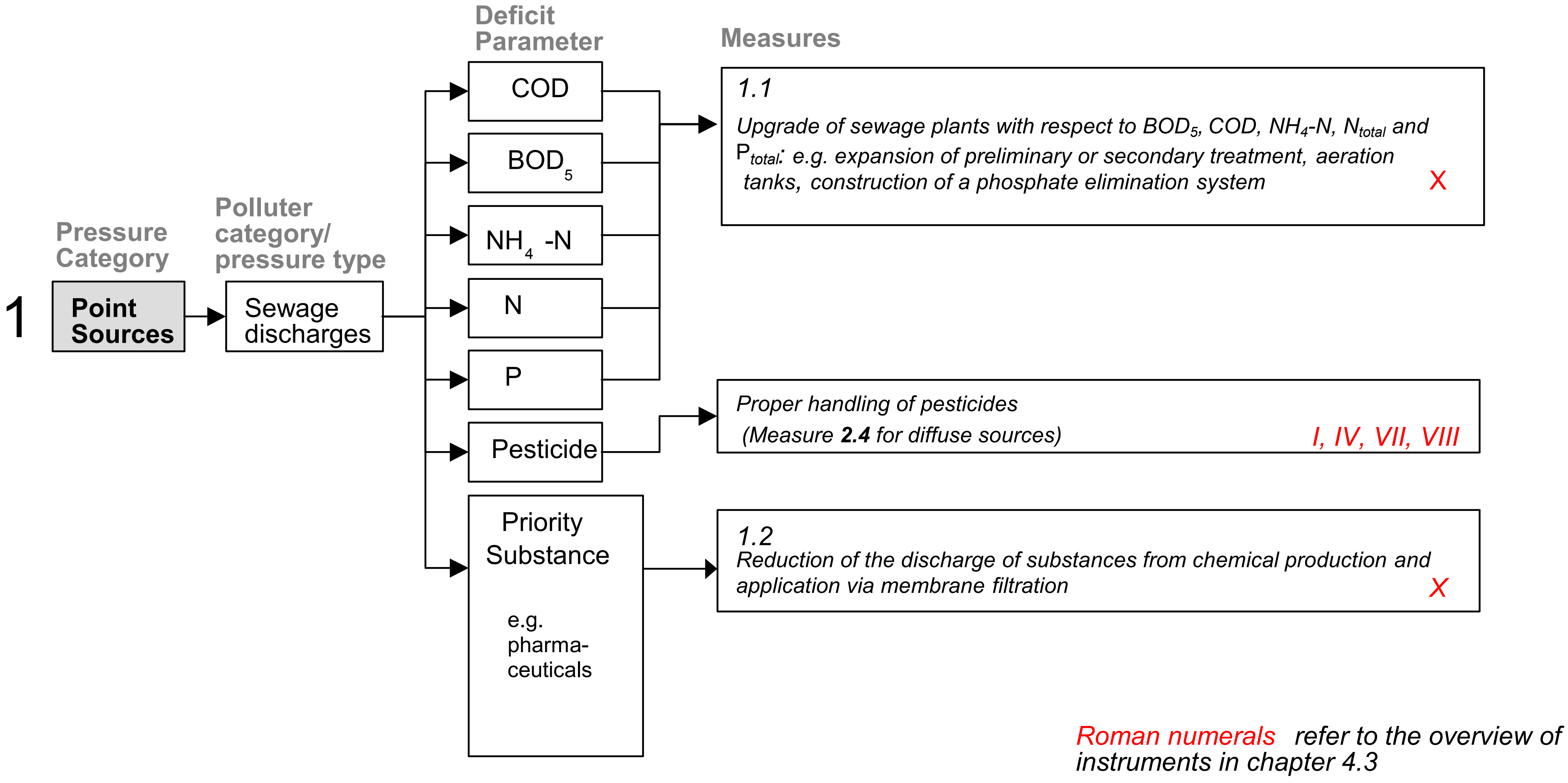
4.2 System of measures

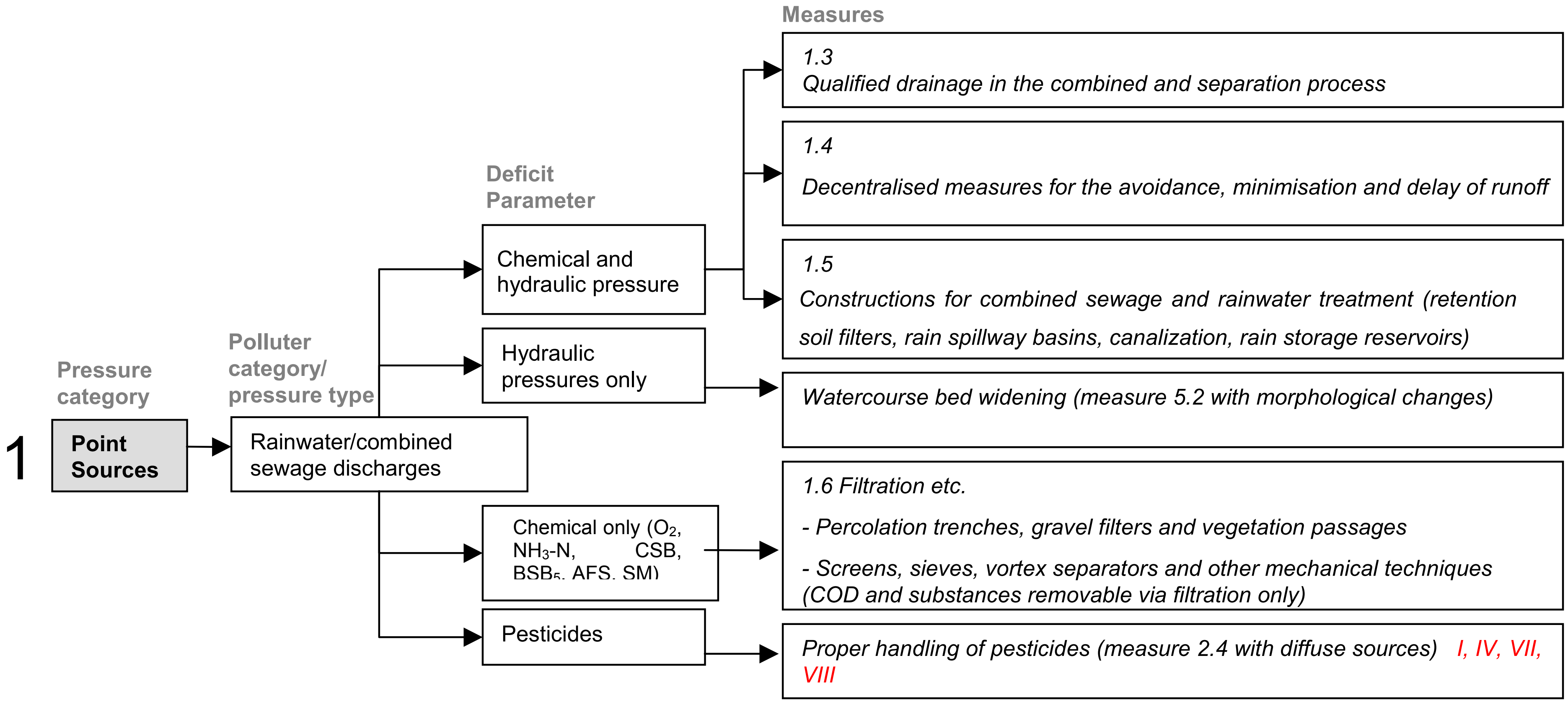
At the next level of detail, we have listed the respective environmentally relevant impacts for each pressure category and the corresponding pressure types, and assigned suitable measures to them. In this way, based on the pressure category / pressure source, via the polluter category / pressure type, it is possible to identify the deficit parameters and then the corresponding measures. In total, six systems of measures have been developed.

In this system, the measures are outlined briefly in a few key words. In addition, for each measure that is explained in greater detail, we have included a reference to the detailed measure sheet in the Annex to this Report (**numbers in bold**). In addition, we also include references to the potential instruments (*Roman numerals (red italics)*), for which separate instrument sheets have been prepared. The various instruments are shown in summarised form in the overview of instruments (cf. section 4.3). For those measure sheets to which no separate instruments have been allocated, the respective measure sheet includes a brief account of possible supporting instruments.

As a general principle, it should be noted that the emphasis was on surface waters when selecting measures. Measures for groundwater are included in selected cases, since measures to minimise substance discharges from diffuse sources are also relevant for groundwater. The systems of measures should be adapted and supplemented for practical use. Care should be taken to ensure a coordinated procedure between the various sub-basins.

Figure 4-2: System of measures for the pressure category "point sources"





Roman numerals refer to the overview of instruments in chapter 4.3

Figure 4-3: System of measures for the pressure category "diffuse sources"

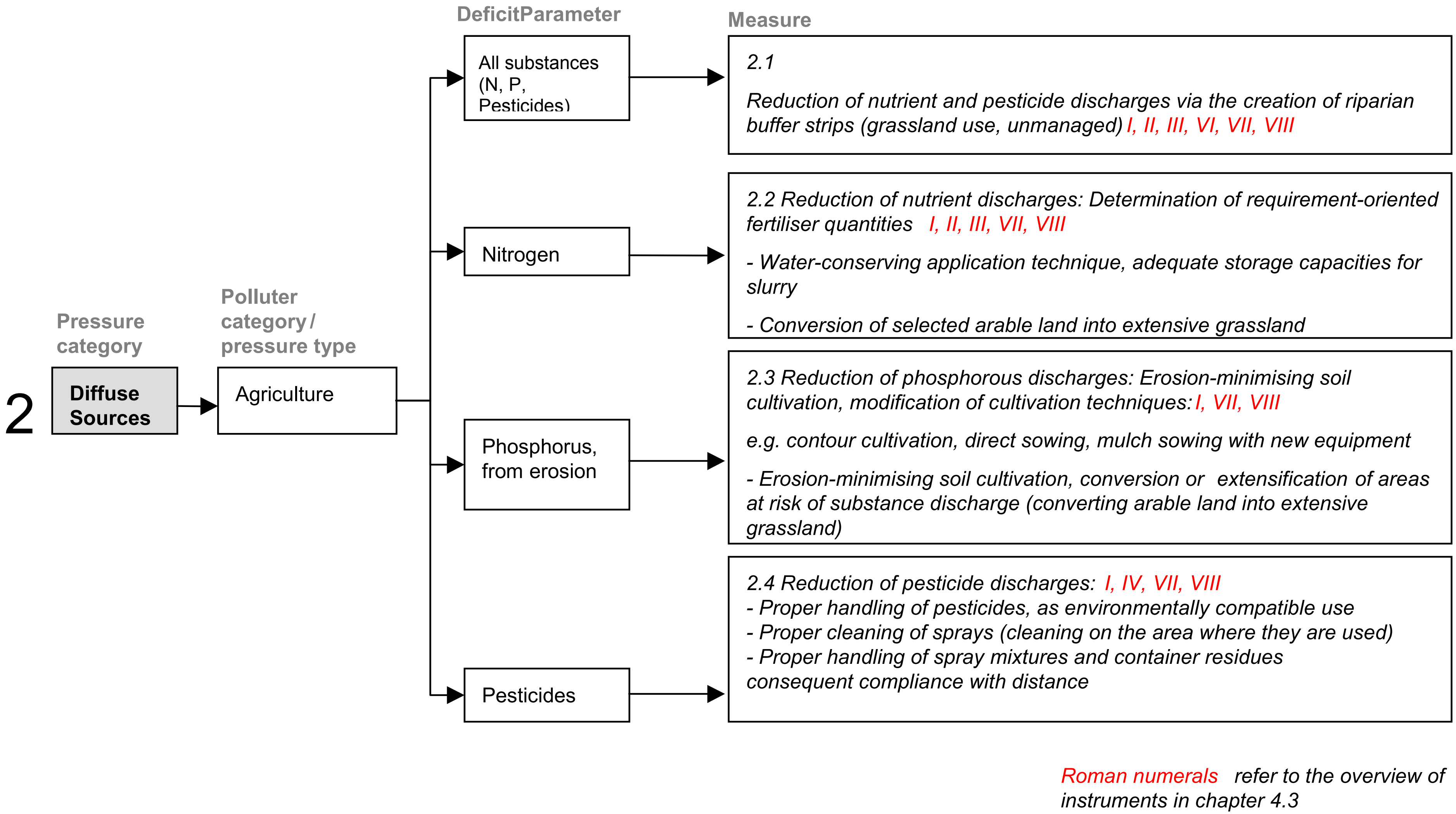


Figure 4-4: System of measures for the pressure category "water abstractions"

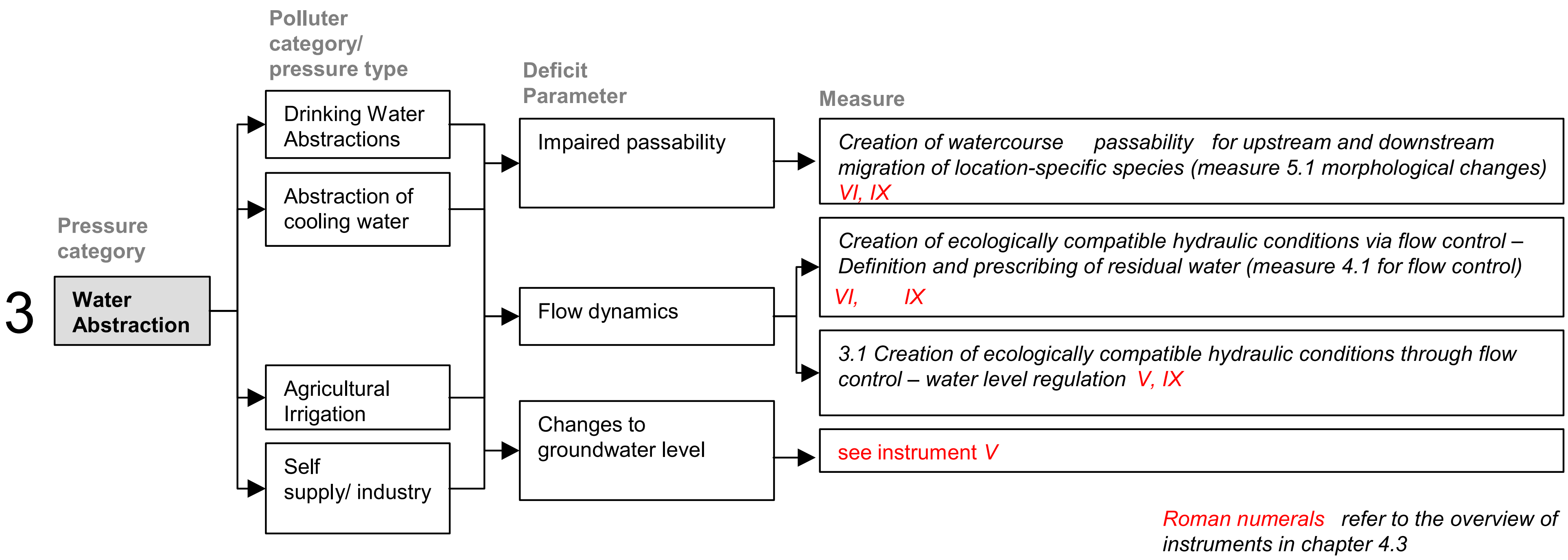
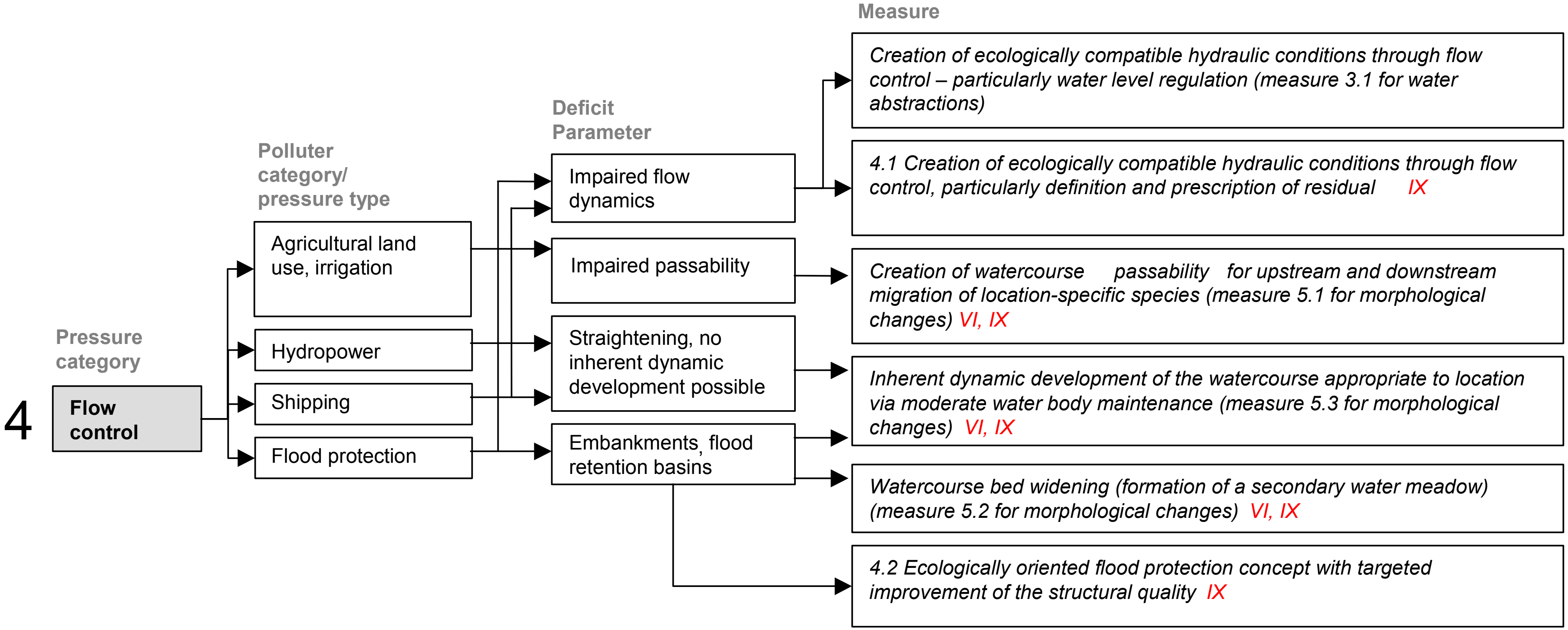
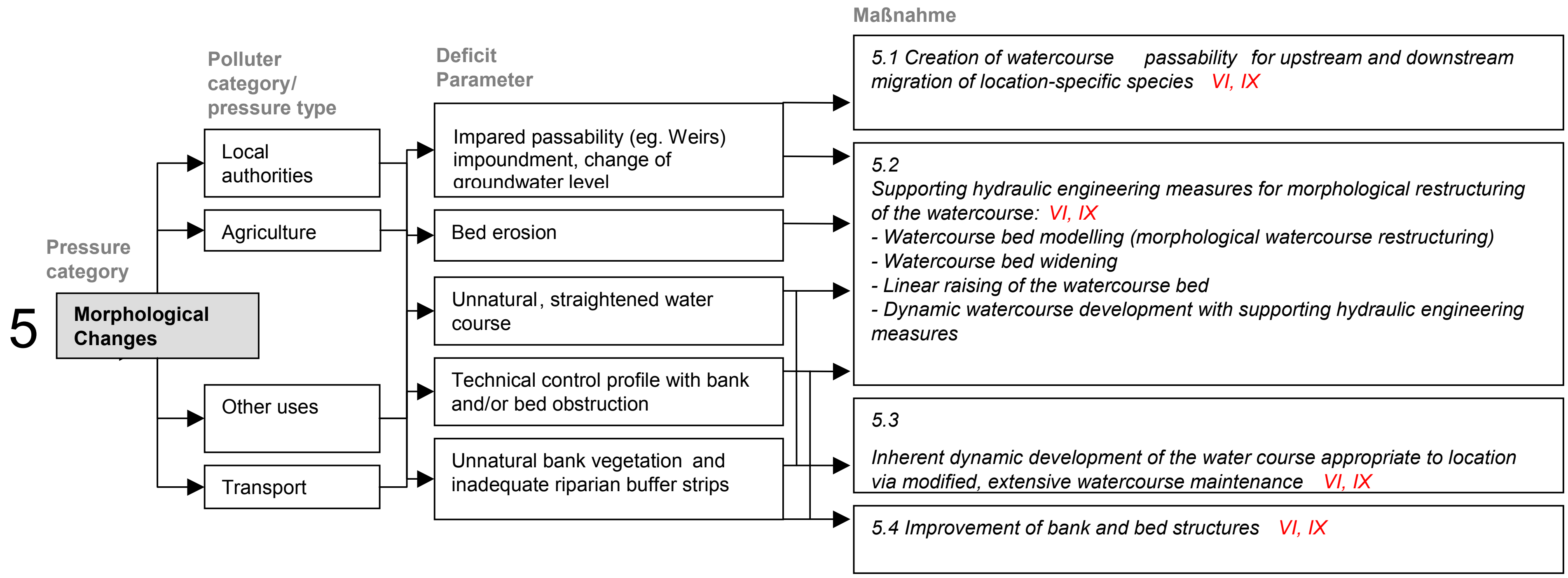


Figure 4-5: System of measures for the pressure category "flow control"



Roman numerals refer to the overview of instruments in chapter 4.3

Figure 4-6: System of measures for the pressure category “morphological changes”



4.3 Overview of instruments

The following overview classifies instruments into the following categories: charges/financial incentives, cooperation arrangements, advisory approaches, and statutory instruments. In this respect, it is worth remembering that initially we have largely excluded the amendment and creation of statutory regulations and institutional framework conditions that effect the implementation of measures, since they do not generate their "own" effect, but merely create a framework for the effectiveness of the measures. One exception to this is the reinforcement of synergy effects between the IPPC Directive and the Water Framework Directive (instrument no. X).

A. Charges/financial incentives

No. I: Financial subsidising of organic farming

No. II: Charge on organic fertilisers from non-free range farming

No. III: Charge on mineral nitrogen fertilisers

No. IV: Charge on pesticides

No. V: Greater use of environmental charges, e.g. water abstraction charges

No. VI: Restructuring of the nature conservation and fishing charge

B: Cooperation arrangements

No. VII: Creation of effective cooperation structures between farmers and the water industry
(This instrument represents a large number of possible cooperation arrangements between different players at the various levels).

C. Advisory approaches

No. VIII: Advice to farmers on optimum operation from the viewpoint of water pollution control

No. IX: Advice to the competent authorities to optimise water body maintenance

D. Statutory instruments

No. X: Reinforcement of the synergy effects between the IPPC Directive and the Water Framework Directive

Furthermore, with regard to the instruments listed here, it should be noted that some can and will be implemented straight away without the need to create an additional statutory basis (such as the advisory instruments). For others, implementation on the basis of existing legislation is fundamentally possible (e.g. fishing and nature conservation charge, no. VI). For a third group, however, statutory foundations will need to be created first, which means that the time required until application will be correspondingly longer (e.g. charges on diffuse discharges – instruments no. II - IV).

Another key aspect with the consideration of instruments is the identification of the players responsible for application of the instrument. A corresponding overview may be found in Figure 4-7. This shows that competence for the implementation of numerous instruments lies at European or Federal Government level, or there is at least a need for coordination with superordinate levels. By contrast, other instruments are to be implemented by the local authorities and at *Länder* level. As a general rule, the autonomous application of instruments by associations or by private initiatives is not possible, although implementation often occurs in collaboration with associations and private players. Furthermore, it is important to note that there is often one main actor for implementation of the measure (indicated by the letter X), but in most cases it is still necessary to coordinate with the other actors cited.

Instruments	EU	Federal Gov.	Länder	Local authorities	Associations	Private individuals
Financial subsidies for organic farming	X	X	X			
Charge on organic fertilisers from non-free range farming		X				
Charge on mineral nitrogen fertilisers		X				
chrage onpesticides		X				
Greater use of water abstraction charges			X			
Restructuring of the natur conservation and fishing				X		
Formation of effective cooperation structures between the water industry and farmers				X		
Advising farmers on optimum operation from a water protection viewpoint				X		
Advising the competent authorities on the optimisation of watercourse maintenance			X			
Reinforcing the synergy effect between the IPPC Directive and the WFD		X		X		

Figure 4-7: Responsibilities for application/implementation of the instruments

5. SELECTING COMBINATIONS OF MEASURES

This chapter outlines a methodological proposal for the selection of measures and combinations of measures within the framework of the programmes of measures required under the Water Framework Directive to improve the ecological and chemical status of at-risk water bodies (cf. chapter 2). It is intended primarily as a work aid and argumentation guide for decision-makers in the sub-basins, and as a manual for the use of the measure and instrument sheets (Annexes I and II). In this chapter, we develop a general procedure for the selection of measures which, based on the initial characterisation of the sub-basins (Annex II of the Water Framework Directive), facilitates the generation of polluter-specific programmes of measures in accordance with the significant pressures previously identified. Based on the experiences from the pilot projects for the initial characterisation and identification of significant pressures, it can be assumed that preparation of the programmes of measures will need to be gradually adapted, supplemented and precisely defined.

Analysis and assessment of the most efficient combinations of measures is envisaged immediately following preparation of the initial characterisation under the Water Framework Directive (by 12/2004), and will form the basis for preparation of the programmes of measures for river basin districts as part of the River Basin Management Plans by 2009.

In this connection, effective and/or cost-effective combinations of measures will be drawn up for water bodies at risk. Generally speaking, the competent water authorities[1] in the sub-basins are responsible for this work, since in most cases they already coordinate water pollution control measures. Admittedly, as a result of the Water Framework Directive, the German water industry is currently facing a major turning-point (von Keitz, Schmalholz, 2002, page 40), since there is a need to formulate and implement cross-media, trans-sectoral management approaches which exceed current practices. Coordination of the programmes of measures for one river basin district will necessitate new cooperation instruments for the water management administrations, who in turn will need to structure their plans across *Länder* and administrative borders and in collaboration with other sectors (von Keitz, Schmalholz, 2002). To date, only initial attempts have been made to tackle these institutional challenges. Moreover, chapter 4 highlights the fact that in order to improve the status of the water body, not only are water management measures and instruments needed, but also financial and advisory ones.

These instruments are intended to reinforce the effect of the measures, by aiming to persuade the relevant players and water users to modify their behaviour. As such, these instruments play a key role in initiating a trend reversal of the main pressures.[2]

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1 As the structures of authorities may vary between individual *Länder*, this section addresses the competent water authorities in each case.

2 However, the consideration of instruments in the proposed approach makes the process more complicated: Firstly, many instruments only become effective in the long term, and therefore are only able to make a long-

Based on the current status of knowledge and the heterogeneous reporting character for the identification of significant pressures, there can be no patented recipe for the selection of measures. The selection of efficient measures and instruments depends to a large extent on local peripheral conditions and the technical, social and financial framework conditions. Consequently, the following methodology represents a practical approach which systematically combines the required work stages and the locally available information.

Catalogues of measures and cost calculation bases may already exist in a number of sub-basins. The proposed approach is designed in such a way that it can be developed, expanded and adapted in line with the latest findings, based on application experience in the sub-basins.

In order to facilitate assessment of the somewhat complex ecological and economic interactions in the work stages, as well as specialist knowledge on the part of the responsible individual, it is also necessary to combine various interests of the relevant sectors. This may be achieved in a variety of ways, e.g. in the form of working parties or "round tables". Many of the considerations and assessments arising within this process should additionally be discussed within the context of participation by the general public in accordance with Article 14 of the Water Framework Directive in order, firstly, to improve the quality of the decisions, and secondly, to ensure acceptance of the chosen combination when it is implemented (cf. excursus on participation by the general public on page 27).

When determining the most cost-effective combination of measures, in practice, there are two main cases (in simplified terms):

(1) A pressure situation exists in which a given combination of measures and instruments is clearly the most efficient choice. In such cases, the most cost-effective combination of measures may be implemented using the approach outlined without further ado.

(2) A pressure situation exists which is comprised of significant multiple pressures. Handling such pressure situations is a complex process, since there is a lack of detailed information for quantifying and comparing the cost efficiency of the various different combinations of measures. In such cases, our outlined approach provides indications on where and to what extent farther-reaching investigations are needed.

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term contribution towards attaining the target of good ecological status. Secondly, the water authorities are responsible for the implementation of concrete measures, whereas application of the instruments described must be decided at *Länder*, Federal Government or even EU level. Allowance has nevertheless been made for the instruments, since they indirectly influence the economic and political environment in which the selection of measures takes place. In particular, these variables must be taken into account when selecting combinations of measures: Negative trends can be averted in advance by means of instruments. In this way, it is possible to avoid expensive technical measures.

5.1 Approach

The most cost-effective combinations of measures are selected in 7 stages (cf. Figure 5-1). Stages 1 to 5 are aimed at selecting and combining measures and instruments. The most cost-effective combination is then determined in stage 6.

Following the selection of measures and instruments, in addition, stage 7 entails planning coordination with the programmes of measures of other sub-basins. Although a consideration of this stage exceeds the brief of this project, we thought it appropriate to at least mention it. In principle, it is possible that the efficiency of a chosen local combination of measures would be evaluated differently if considered from the viewpoint of the entire river basin district and compared with other sub-basins.

The results of the initial characterisation with demarcation of the water bodies, identification of significant pressures, designation of polluter categories and the assessment of chemical and ecological status based on the inventory data are needed for the concrete stages outlined above, with due regard for the quality components listed in the Water Framework Directive (WFD, Annexes II and V). The results are consulted for the assessment of ecological cause/effect relationships and ultimately for the selection of measures and instruments. Above and beyond the selection of sample measures outlined here, it is up to the individual, based on the measures in chapter 4, to relate his or her existing catalogues of measures at operational level to the requirements of the Water Framework Directive.

Figure 5-1 illustrates the approach, starting with the identified pressures, through to the development of cost-effective combinations of measures. The individual work stages are explained in greater detail in the following sub-chapters.

Excursus: Participation of the general public when selecting combinations of measures

The participation of the general public in a consultative capacity is prescribed at various points in the implementation process, according to Article 14 of the WFD. For example, the drafts of the management plans to be prepared, including the programme of measures, must be made accessible to the general public to allow them to form an opinion.

However, from the outset, one should aim to ensure comprehensive, active participation, particularly by organised experts in the public domain, with the selection technique we have developed for identifying the most cost-effective measures. In this way, recourse may be made to the valuable expertise and expert knowledge of relevant interest groups during the decision-making process. This is of particular significance, for example

- when determining the economic costs (stage 5)
- when weighing the various decision-making parameters during the course of selecting an efficient combination of measures (stage 6), and
- when coordinating with other planning instruments (stage 7).

Early participation will contribute to a higher level of transparency of the selection process. Ultimately, this will lead to greater efficiency when selecting combinations of measures, as well as greater acceptance for the chosen measures and instruments.

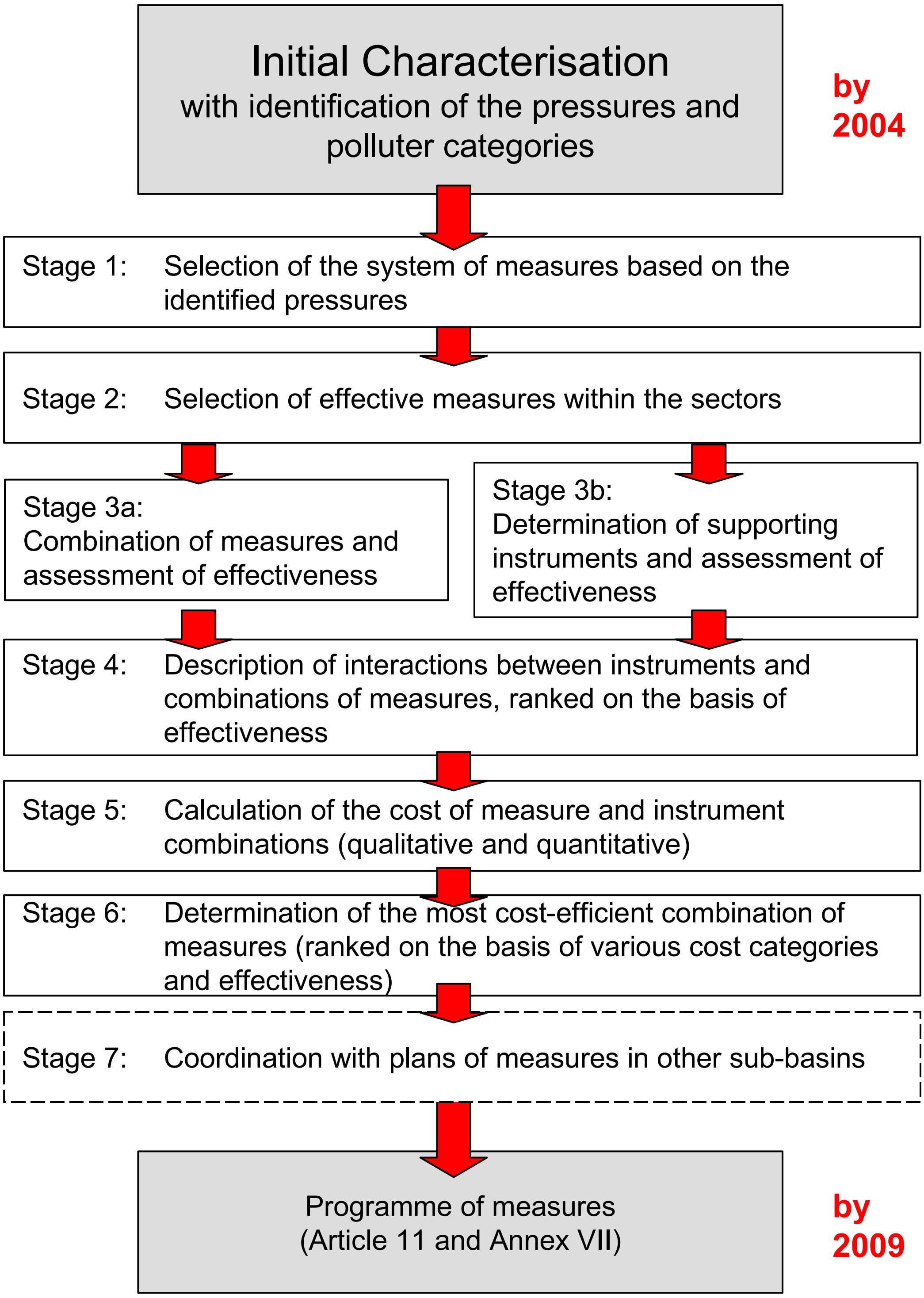
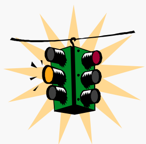


Figure 5-1: Approach for determining the most cost-effective combination of measures

Stage 1: Selecting the system of measures based on the identified pressures

The starting-point for this stage is the initial characterisation of river basin districts, which the Water Framework Directive stipulates must be completed for all river basins by December 2004. The results of this inventory provide the foundations for subsequent work stages, since the content of the river basin district descriptions are of central importance when selecting and combining the measures and instruments. For example, a good ecological and chemical status can only be achieved efficiently if the measures are coordinated with the significant pressures, polluter categories and other characteristics of the water body.



Note:

The following materials are essential or helpful:

- Documentation of the initial characterisation of the river basin
- Supplementary information on the current status derived from monitoring (particularly biological indicators)
- Regional and/or local catalogues of measures
- Location-specific cost information
- Information from the economic analysis
- Optional: Various supporting planning documents

Initially, the pressures of the respective water bodies identified in the initial characterisation are summarised in order to depict the individual pressure situations. In this respect, care should be taken to ensure that the polluter category and the degree of pressure are at least outlined, based on the classification stipulated in the Water Framework Directive (five stages). Based on the pressure situation, the relevant systems for identifying measures (cf. chapter 4) are then selected:

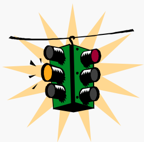
- Pressure category “point sources / sewage treatment plants” ⇒ System on page 16
- Pressure category “point sources / precipitation” ⇒ System on page 17
- Pressure category “diffuse sources” ⇒ System on page 18
- Pressure category “water abstractions” ⇒ System on page 19
- Pressure category “flow control” ⇒ System on page 20
- Pressure category “morphological changes” ⇒ System on page 21

Stage 2: Selection of effective measures

Based on the systems chosen in stage 1, the measures that are effective in principle[3] are selected and where possible supplemented with locally available information on additional measures or separate catalogues of measures already existing. In order to make allowance for local knowledge and location-specific cost foundations when making decisions on the basis of "polluter category/pressure type" and "deficit parameters", one or more measures may be identified. The potential measures are first listed in tabular form and arranged on the basis of ecological effectiveness.

A cause/effect matrix (cf. Figure 5-1), which is to be prepared individually for each water body, serves as an aid for assessing the effect of individual measures on the respective body of water. Based on the matrix, for each concrete case, it is necessary to assess the extent to which measures impact the indicators of ecological deficits. In order to make it easier, and hence faster, to assess a measure's ecological effect, only the primary effect, as described in general in the sheets of measures, should be taken into account here.

3 In principle, effective measures are those which are deemed fundamentally suitable for achieving an improvement effect within the respective pressure category. The actual effectiveness of the measures is assessed in a subsequent stage.



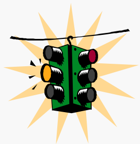
Note:

- A separate “cause/effect matrix” is prepared for each water body.
- The measures and combinations of measures refer to the water body as defined in the Horizontal Guidance (EUROPEAN COMMISSION 2003) or to aggregation levels comprised of water bodies.
- Based on the current actual status, primary effects of the measures under consideration are assessed for the relevant indicators
- As a general rule, local experts should be consulted during this stage of assessing cause/effect.
- Based on the effect on biological indicators, the relevace of the measure for subsequent stages can then be derived. Only relevant measures are considered in subsequent stages.

It should be noted that the measures are initially weighted individually, and not on a trans-sectoral basis, with regard to their ecological effect. The cause/effect matrix is derived individually for each body of water. As this stage entails assessing the improvement effects of individual measures in relation to the actual status, the results of the initial characterisation and the monitoring programmes, as well as the ecological “on-site knowledge”, must be combined in order to assess the effect intensity. The lay person will find it difficult to follow effect chains, starting from the cause through to the biological indicator, and for this reason, it is essential to consult local experts at this stage for listing in the cause/effect matrix. A certain level of expert biological and ecological knowledge is a pre-requisite when evaluating effects. If it emerges that individual measures are not relevant due to their improvement effect on the water body status (see below), these may be ignored in subsequent work stages. In this way, ineffective measures relating to the specific case in question are eliminated from the study early on, so as to rationalise the work stages.

Preparation of the cause/effect matrix

The matrix template (cf. Figure 5-1) represents the selection of measures that are effective in principle and the assessment of effectiveness in a clear, logical format. When evaluating the effectiveness of measures, the essential indicator groups (algae, macrophytes, macro-zoo-benthos, fish fauna) defined in Annex V of the Water Framework Directive must be taken into account. The effectiveness of measures on the water body indicators or pressure situation should be evaluated in four stages. A low improvement effect of a measure on the biological indicator is marked with an “x” in the cause/effect matrix, those with a medium effect are marked with “xx”, and those with a high effect with “xxx”. If the measure is not expected to produce any effect in a biological indicator, this can be marked with "-".



Note:

- All the affected specialist departments in the environmental administration must be incorporated into the work process early on.
- Committees comprised of representatives of selected interests should accompany the work stages in a constructive manner, consult during preparation, and verify work results.

For example, for a description of the effect of hydropower use on freshwater systems (canalised rivers), benthic invertebrate fauna and fish are the most important groups for evaluation (cf. EUROPEAN COMMISSION 2003, page 44). Consequently, for water bodies whose significant pressure arises solely from the use of hydropower, the columns “Benthic invertebrate fauna and fish fauna” may need to be edited.

Once an assessment of the measures’ effectiveness has been incorporated into the cause/effect matrix against the background of the current water body situation using the evaluation (x, xx, xxx), the next step is to roughly prioritise the measures. Prioritisation depends on the effectiveness of the individual measure and additionally on how widespread its effects are on the indicators of the Water Framework Directive. To this end, an overall evaluation is implemented for each individual measure in the form of the sum total of “x” (x = 1, xx = 2, xxx = 3). In order to derive prioritisation on this basis, a classification of the overall value is needed. This classification is depicted as the function of significant indicators. Hence, for each water body, a points system should be employed, and the individual measure should be classified. For this purpose, a four-stage classification (0, 1, 2, 3) has proven practical.[4] Measures which are expected to have no or only a marginal positive effect (e.g. values < 1) on the ecological status of the water body can then be eliminated from further consideration in subsequent stages. However, the cut-off criterion should be determined separately for each individual case (water body). In this way, ineffective measures are filtered out during the initial stages. At the same time, this valuation approach facilitates a prioritisation of individual measures according to their effect on the current water body status.

The prioritisation of individual measures in this stage is a pre-requisite for the subsequent stage 3a for deriving combinations of measures.

Table 5-1: Derivation and prioritisation of the ecological effectiveness of measures using the "cause/effect matrix"

(This table is designed as a template only and when handling this work stage, it should be adapted to the case in question and supplemented with regard to the ecological effect on indicators; examples of use may be found in chapter 5.2)

Measure	Indicators of ecological deficits (WFD, Annex V)				Sum total of individual evaluations (∑)	**Classifi-cation of priority**
	Macrophytes	Algae	Benthic invertebrate fauna	Fish fauna		
1.1						
1.2						
1.3						
1.4						
1.5						
1.6						
2.1						
2.2						
2.3						
2.4						
3.1						
4.1						
4.2						
5.1						
5.2						
5.3						
5.4						
Other measures						

4 In principle, however, finer graduations are possible in the classification.

The cause/effect matrix explained using a fictitious example

The fictitious example shows a possible cause/effect matrix in a pressure situation comprised of deficits in the areas of point sources, diffuse sources and morphology (cf. Table 5-1). For the six measures previously selected via the system of measures, the ecological effectiveness on Water Framework Directive indicators has been entered in the matrix by way of an example. In the column "Sum total of individual evaluations", the number of "x" entries for this measure have been added together. For measure 1.1 "upgrading of the sewage treatment plant" with a low level of effectiveness (x) on the indicator "macro-zoo-benthos" and the indicator "fish fauna", therefore, the sum total is calculated with a value of 2. Classification of the priority was subsequently derived with the aid of the linear classification key shown here by way of an example (Table 5-3), which may differ for other water bodies. As measure 1.1 falls within the value range with a low level of ecological effectiveness, the classification "1" for "low ecological effectiveness" was entered in the final column.

Table 5-2: Example of a cause/effect matrix with classification of priority

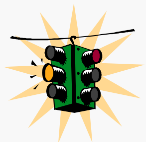
Measure	Indicators of ecological deficits (Water Framework Directive, Annex V)				Sum total of individual evaluations	**Classification of priority**
	Macrophytes	Algae	Benthic invertebrate fauna	Fish fauna		
1.1			x	x	2	**1**
1.3				x	1	**1**
2.1	xx	x	xxx	xxx	9	**3**
4.2	x		xx	xx	5	**2**
5.1			x	xxx	4	**1**
5.3	xx		xx	xx	6	**2**

Table 5-3: Assumed classification key

Sum total of individual evaluations	**Description of effectiveness**	**Classification**
12 - 9	High level of ecological effectiveness	3
8 - 5	Medium ecological effectiveness	2
4 - 1	Low level of ecological effectiveness	1
0	No ecological effectiveness	0

Stage 3a: Combination of measures

This work stage focuses primarily on sectoral and trans-sectoral combinations of measures. To this end, a matrix of the combinations of measures is prepared, which is used to explain the various conceivable combinations of measures in a way which third parties will understand. Initially, the principal evaluation criterion for identifying the combinations of measures is ecological effectiveness.



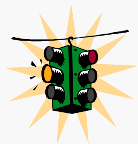
Note:

- Only relevant measures from stage 2 are transferred into the matrix of measure combinations.
- Decisions are dependent upon the local problem situation and cannot be readily standardised.

As there are many different theoretical combinations for the 17 relevant measures cited as examples (as well as other relevant measures at local level), the decision must be restricted by the practical aspects of river basin management. Consequently, stage 2 includes a prioritisation of those measures within the sectors which meet the individual situation of the water body based on the cause/effect matrix. Based on this result, the effective and implementable measures identified in stage 2 for the respective water body are then combined with one another. Table 5-6 lists all the measures which were outlined in detail in the catalogue of measures for the purposes of this Handbook, by way of an example. In practice, however, only those measures which are actually classified as relevant for the water body in question should be included in such a matrix (stage 2). In this way, the matrix of measure combinations is clearer and more manageable. Particular emphasis should be given to the traceability of decisions and general comprehensibility, because the matrix showing combinations of measures serves as an argumentation basis for subsequent discussion processes when implementing the programmes of measures.

Preparing the matrix showing combinations of measures

The matrix showing combinations of measures must be generated separately for each body of water (cf. Table 5-6) in order to make allowance for local framework conditions. Generally speaking, it should be structured in such a way that the positive correlations between two measures are shown in the top section (top right), whilst any negative correlations are noted in the lower section (bottom left). For negative correlations, we propose a single-stage classification ("-" poor effect). Positive correlations should be differentiated according to a three-stage classification (+++ very good effect, ++ good effect, + minimal effect), since in such cases, a weighting of individual combinations of measures is relevant to subsequent processing. In this way, the matrix allows us to portray the interactions between the relevant measures and to evaluate each combination of two with regard to efficient interaction. A brief explanation of the decision should be given separately, e.g. as a footnote, particularly for those cases with a good (++) and a very good (+++) effect.



Note:

Positive and negative correlations are noted in the matrix, whilst reasons are given in the form of footnotes.

Assessing the ecological effectiveness of combinations of measures

The assessment method on which the matrix showing combinations of measures is based is derived from the matrix of preferences according to BACHFISCHER (*1978, page 102).* Using the simple matrix of preferences, it is possible to interconnect two features. Table 5-4 shows the general procedure for linking and evaluating two measures whose effectiveness has been classified on a scale of 1 to 3 in stage 2.[5]

Table 5-4: Matrix of preferences according to BACHFISCHER (1978)

		Measure 1		
	Class	**1**	**2**	**3**
Measure 2	**1**	+	++	++
	2	++	++	+++
	3	++	+++	+++

It should be noted that the effectiveness of combinations of two measures (shown in grey in Table 5-4) must be evaluated on the basis of causal relationships and local knowledge, where available. Depending on this, the combination of a measure of class 2 and a measure of class 3 may produce an overall value of 2 (++) or 3 (+++). The same applies analogously to combinations of measures in classes 1 and 2.

In the interests of easier understanding, only the two-dimensional matrix of preferences has been given here (i.e. combinations of two measures only). A three-dimensional or multi-dimensional matrix of preferences would also be conceivable, although this makes the plausible linking of the combination and visual representation of the process more difficult. For this reason, it is recommended that combinations of two measures should be formed initially, and if

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5 Measures with no effect (effectiveness = “0”) for the respective water body are not pursued any further.

necessary, further measures should be added by means of an interpretation stage. This procedure is outlined below.

For the purposes of assessment, the details of ecological effectiveness from stage 2 (cause/effect matrix) are evaluated using the matrix of preferences and the evaluation of local causal relationships contained therein. The resultant combinations are also described with respect to ecological effectiveness, the time scale until effectiveness, and the likelihood of successfully attaining the target.

Main combination and other measures to achieve the targets of the Water Framework Directive

The combinations of measures with the best ecological effectiveness[6] compared with other possible combinations of measures represent main combinations. These are considered in greater detail during the subsequent procedure to identify cost-effective combinations of measures. They are initially examined according to the criterion of target achievement.

Since in the majority of cases a combination of two measures will probably be insufficient to attain the target, in addition to the combinations of measures (main combination) which ideally indicate a very good effect (+++) even in the simple combination, those individual measures which indicate a similarly good effect (++) or which are necessary in order to attain the target (e.g. creation of linear passability) should also be added. The measures under consideration may be taken from the matrix and interpreted according to their suitability. During this interpretation stage, it is important to scrutinise the interactions[7] between the measures on the basis of prior technical knowledge and local knowledge. Depending on the pressure situation, it may be necessary to add one or more measures which cover the deficit areas not addressed by the main combination.

A knowledge of local conditions is particularly important when adding individual measures in order to complete the main combination, and should additionally be based on information from the sheets of measures, research results for the success monitoring of measures, and local experience. The central test criterion when compiling combinations of measures is attainment of the objectives of the Water Framework Directive by 2015. The possible combinations of measures, which may vary significantly in their composition, should also be backed up with arguments. The derived combinations of measures should be validated gradually by the competent trans-sectoral bodies.

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6 The combinations of measures with the best ecological effectiveness should indicate the evaluation “very good effect” (+++) or in special cases “good effect” (++) if there is no combination with a very good effect available.

7 General comments on interactions may be found in the sheets of measures.

Example of formulating main combinations using a fictitious example

In order to illustrate this method, we will reconsider the fictitious example from stage 2. It contains the measure “Reduction of nutrient and pesticide discharges via the creation of riparian buffer strips (2.1)” with class 3 and the measure “Inherent dynamic development of the water course appropriate to location via extensive maintenance (5.3)”, which was rated as class 2. Based on the matrix of preferences (Table 5-4) this produces a value of 3 (+++), which for this combination is indicated by “+++” in the matrix of measure combinations (Table 5-6). The matrix of preferences also expresses the causal relationships resulting from the fundamental knowledge or local knowledge of the competent individual. For example, an assessment of the effectiveness of a measure combination would need to be downgraded if, for example, existing restrictions along the water course were to clash with the objectives of the Water Framework Directive, as is the case, for example, in urban areas. If there are no significant restrictions, the combination of measures 2.1 and 5.3 provides an alternative with the best effect (+++) compared with other combinations (++ or +), i.e. a main combination. All combinations with a very good effect likewise offer alternative main combinations, such as the combination 2.1 and 4.2, which is examined with a view to target attainment and treated as an alternative to the combination 2.1 and 5.3 in subsequent work stages.

Table 5-5: Creating a matrix of measure combinations for a fictitious example

Measure sheet number:		Ecological effect of measure combinations					
		1.1	1.3	2.1	4.2	5.1	5.3
Point sources: Sewage treatment plants	1.1		+	++	++	+	++
	1.3			++	++	+	++
Diffuse sources	2.1				+++	++	+++
Outflow	4.2					++	++
Morphological changes	5.1						++
	5.3						

Key

Main combination 2.1 and 4.2

Main combination 2.1 and 5.3

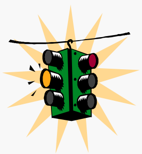
Example of formulating additional measures to achieve the targets of the Water Framework Directive based on the fictitious example

The sample combination of measure 2.1 and 5.3 (see above) represents a main combination due to the anticipated effectiveness “very good” (+++). Should this main combination alone fail to facilitate the attainment of a good status, further measures must be added. This stage presupposes interpretation of the prepared matrix of measure combinations as outlined above.

For the assumed pressure situation, which is comprised of point, diffuse and morphological pressures, it is now necessary to investigate whether measures in the area of point sources indicate a good or very good interaction with the measures already chosen in the main combination in order to cover all deficit areas or the entire spectrum of applicable pressures. Hence, one conceivable option would to be to apply measure 1.1 "Upgrading of sewage treatment plant" at suitable points if this combination facilitates attainment of the targets of the Water Framework Directive. For certain pressure situations, presumably, several additional measures would need to be selected. When supplementing measures, target attainment as stipulated by the Water Framework Directive is a central criterion. Parallel to this, however, it is always necessary to consider the local causal relationships so that the “additional measures for target attainment“ do not lead to negative effects within the combination: For example, implementation of the measure 5.3 "Inherent dynamic development of the water body appropriate to location” could lead to substantial adverse impacts on the ecological status of the water body with existing residual pollution in the water meadows, and hence the effectiveness of the combination of measures could deteriorate significantly.

In order to make this rather complex process of combining measures more readily accessible to users of the Handbook, chapter 5.2 contains concrete case examples illustrating the methodology of this work stage.

With future experimental values from the inspection cycles of the EU Water Framework Directive, or improved forecasting methods based on detailed information about the weighting of individual measures within the combination and the way in which they correlate with one another, the evaluation method will also need to be adapted and refined still further. In this regard, it is both practicable and expedient to assess the combinations of measures vis-à-vis their ecological effectiveness and the time needed by the competent coordinating bodies (working parties, “round tables”). In this way, local expert knowledge can also be incorporated.



Note:

- Coordination of the work stage in collaboration with the various sectors in the coordinating bodies.
- It is advisable to consult local expert knowledge.

The results of the above selection process, i.e. the combinations of measures with the greatest ecological effectiveness, are grouped according to main combinations, additional measures for target achievement, and time scale, and explained in detail. In this respect, the main emphasis is on the criteria of "ecological effectiveness" and "time scale" until the effect comes into play.

The ecological effectiveness is derived directly from the procedure for creating the matrix of measure combinations, which is based on the assessment in stage 2 as well as on the statements in the measure sheets and local knowledge.

The statements pertaining to the time scale of whether a combination of measures will become effective in the short, medium or long term is derived from the catalogue of measures, whereby expert knowledge and local experience may prove very helpful for this assessment in detail. The time scales are defined as follows:

Short-term:	The combination of measures will take effect **quickly** and **well before 2015**.
Medium-term:	The effect will occur **slowly** or **with a time delay**, but still **by the year 2015**.
Long-term:	The effect will essentially come into play **after the year 2015**.

Table 5-6: Matrix of measure combinations

(This table is designed as a template only and must be adapted to the specific case in question when handling this work stage)

Key: Positive correlations (+++ very good effect, ++ good effect, + minimal effect) are entered in the top right, and negative correlations (- negative effect) in the bottom left .

The numbers in superscript represent the numbering of the main correlations, and are not indicative of prioritisation. WA: Water abstractions

Measure sheet number:		**Ecological effects of the combinations of measures**																
		1.1	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**	**2.1**	**2.2**	**2.3**	**2.4**	**3.1**	**4.1**	**4.2**	**5.1**	**5.2**	**5.3**	**5.4**
Point sources	**1.1**																	
	1.2																	
	1.3																	
	1.4																	
	1.5														**-**			
	1.6														**+**			
Diffuse sources	**2.1**														**++**			
	2.2														**+++**[4]			
	2.3																	
	2.4																	
W A	**3.1**																	
Out-flow	**4.1**																	
	4.2																	
Morphological changes	**5.1**																	
	5.2																	
	5.3																	
	5.4																	

Stage 3b: Determination of supporting instruments and assessment of effectiveness

Once the potential measures for use in a given pressure situation have been ascertained in stage 2, this stage entails identifying those instruments which will produce an appropriate potential combination for the pressure types identified. The potential instruments to supplement the respective measures are specified in the system of measures in chapter 4. In addition, the measure sheets contain further details of potential combinations with instruments, as well as the type of interactions. An overview for determining the instruments can be found inTable 5-7.

As a general rule, instruments take effect in the background in the medium to long term, and hence support the effect of the measures. Often, the instruments address the causes of the pressures and may therefore have a prophylactic effect. In the long term, instruments are an efficient supplement or alternative to direct measures aimed at the treatment of acute pressures, in that they support a long-term trend reversal.

An assessment of instruments' effectiveness generally entails a number of major uncertainties, since instruments are primarily aimed at effecting behavioural changes and therefore tend to contribute indirectly to an improvement in environmental status. However, behavioural changes are by their very nature difficult to predict. Furthermore, the instruments presented are effective in the medium to long term, and as a result, the correlation between cause and effect is subject to numerous different influences and as such cannot be measured as accurately. The potential economic costs or savings incurred can often only be predicted very imprecisely. However, an initial assessment of effectiveness can be made based on the instruments' intervention intensity:

1) Legal instruments

Legal instruments, such as orders and prohibitions, are characterised by the highest level of intervention intensity, in that they prescribe or prohibit certain modes of behaviour. However, this study did not consider statutory instruments in greater detail, since as a general rule, they merely create a framework for concrete measures and instruments but do not influence the way in which these measures and instruments work. One exception to this rule is instrument X for reinforcing the synergy effects between the Integrated Pollution Prevention and Control (IPPC) Directive and the Water Framework Directive (WFD).

2) Charges and financial incentives

Fiscal instruments such as charges and levies represent an instrument of medium intervention intensity. By altering the relative prices, they create incentives for a certain type of conduct, but do not prescribe it. Instruments I – VI fall under this category. Subsidies and financial concessions represent a "softer" form of fiscal instruments, in that they only create positive incentives.

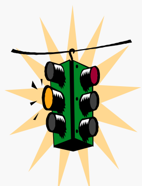
3) Cooperative instruments and voluntary agreements

Cooperative solutions indicate a lower level of intervention intensity than fiscal instruments, since although they reward modified behaviour, as a general principle, the consent of the parties involved is assumed. Furthermore, in many cases, incorrect conduct is not sanctioned. Instrument VII falls under this category, and should be seen as representative of numerous possible cooperation arrangements and agreements between a variety of players.

4) Advisory instruments

Advisory instruments have the lowest level of intervention intensity. They put the onus on the affected parties to modify their behaviour by simply referring to the benefits of modified behavioural patterns. No provision is made for sanctions. Instruments VIII and IX are advisory instruments.

As a general rule, it is true to say that instruments with a higher level of intervention intensity have a higher degree of effectiveness. At the same time, the effectiveness of an instrument is dependent upon its dimensioning and concrete design (such as the level of a tax or the scope of regular and advanced training courses). As the relevant literature often only allows provisional statements to be made on the effectiveness and dimensioning of the instruments, an iterative approach is advisable here. The dimensioning may be adapted in stages if the instrument fails to produce success or is thought to be responsible for a stagnation or deterioration in the pressure situation. Alternatively, after assessing the economic consequences, instruments with a higher level of intervention intensity may also be used. If advisory instruments or cooperation solutions fail to produce the desired success, for example, the introduction of a system of charges may be considered for the individual case in question. Legal and fiscal instruments may also be used to reinforce the effectiveness of softer instruments. In this respect, it should be noted that instruments with a higher level of intervention intensity are often associated with higher administrative costs, and generally incur higher economic costs. The latter is particularly true of statutory instruments which leave the affected party with comparatively few options.



Note:

The decision-making process – which can at times be protracted – regarding the selection and use of instruments must not lead to a situation where ecologically effective measures and the implementation thereof are prevented. If necessary, these should be carried out without the support of the respective instruments

Stage 4: Description of the interactions between instruments and combinations of measures

This stage combines stages 3a and 3b, in that it assesses the effectiveness of the ascertained combinations of measures with respect to their interactions with instruments. This stage focuses on the following key questions:

- Generally speaking, does the combination of measures and instruments produce different approaches offering a higher degree of efficiency than conventional approaches?
- How can the effectiveness of the measures be enhanced through instruments, and should the efficiency of individual measures be reassessed as a result?
- How can measures and instruments be specified and dimensioned in relation to one another in such a way that positive interactions are exploited?

Details of interactions may be found in the appropriate section of the measure and instrument sheets (cf. Appendices I and II) and in Table 5-7. Generally speaking, the following types of interactions between different measures and instruments are possible:

A a ***contrary*** (antagonistic) effect,

B a ***neutral*** effect (no interaction),

C a **complementary** (additive or synergetic) effect.

In the case of contrary effects (A), a preferred solution must be chosen from the potential instruments and measures or combinations thereof. This case is unlikely to apply to the measures and instruments addressed in this study. If different instruments and measures are neutral in relation to one another (B), they may be considered and implemented independently of one another.

In the interests of selecting cost-effective combinations of measures, however, attention should focus primarily on those combinations offering parallel effects in the same direction (C). A distinction may be made between four different cases:

Case C1: Measures and instruments may reinforce and stabilise one another in their effects. In such cases, both should be pursued simultaneously. One example is a combination of improved advice to farmers (instrument VIII) and a reduction in N and P discharges from agriculture (measures 2.2 / 2.3). In the following overview, these interactions are labelled with a “**u**”.

Case C2: If instruments and measures have similar effects, it is possible that they could replace one another. In individual cases, this may lead to a situation where individual measures become obsolete – for example, if a high tax on pesticides (instrument IV) renders measures to reduce pesticide discharges superfluous (instrument 2.4). In practice, however, this case is unlikely. In the following overview, these types of interactions are labelled with an "**o**".

Case C3: With instruments and measures that replace one another, if it is possible to reliably assess the interactions in advance, measures may be planned on a correspondingly reduced scale or in a less expensive form. For example, greater cooperation between farmers and the water industry (instrument VII) may mean that measures to reduce diffuse discharges (2.2, 2.3, 2.4) may be downsized accordingly. In the following table, these types of interactions are labelled with a "**g**".

Case C4: Additionally, a fourth case is conceivable, whereby a given instrument necessitates the implementation of a measure. This is the case, for example, if an instrument creates the legal basis for a measure or secures its financing. This type of interaction is common, but was only considered in exceptional cases for the purposes of this study, since the synergy effects in such cases are limited. In the following overview, these interactions are labelled with a "**b**".

Table 5-7 provides an overview of the interactions between measures and instruments. When examining the interactions, allowance should be made for the fact that within the context of this study, many measures had no instruments assigned to them, or only selected instruments.. In practical application, it may be necessary to supplement these with additional instruments, which are not included in this sample selection. As such, the process of considering interactions will be shortened. Additionally, an in-depth examination of interactions is only expedient in those cases which are expected to have a significant impact on the selection or dimensioning of measures. The majority of instrument sheets also contain qualitative assessments of effectiveness, whereas other cases propose quantitative assessments. Compared with our own experimental values, these may be used as an initial guidance document to the cases where substantial impacts apply.

Wherever possible, the examination of interactions should be simplified using more generalised basic principles. As a general rule, precautionary measures and instruments are more cost-effective than retrospective, corrective interventions. In this way, fiscal instruments, in particular, help to support the effect of measures by means of modified incentives.

Because most instruments only have a long-term effect, and as the decision-making process regarding the use of instruments may be time-consuming, it may be the case that the associated efficiency gains will not come into play until some time later. Initially, an assessment of the extent to which measures may be supported, supplemented or replaced by mechanisms should be based on qualitative considerations. In many cases, a precise quantitative assessment will not be possible, because only limited experimental values are available regarding the effectiveness of the instruments. For this reason, in such cases it will be necessary to perform a rough assessment of the interactions between measures and instruments, and to adapt these assumptions as more precise findings come to light during subsequent processing.

Table 5-7: Overview of interactions between measures and instruments

MEASURE		POINT SOURCES Sewage treatment plants & industry					POINT SOURCES Combined sewage/precipitation				DIFFUSE SOURCES				WA	FLOW CONTROL		MORPHOLOGICAL CHANGES			
		1.1				1.2	1.3	1.4	1.7	1.9	2.1	2.2	2.3	2.4	3.1	4.1	4.2	5.1	5.2	5.3	5.4
INSTRUMENT		BOD, COD	NH_4-N	N_{total}	P_{total}	Membrane filter	Combined & separation process, qualified	Decentralised measures	Rain spillway basin, rain ret. pond, soil filt.	Percolation trenches, filters etc.	Riparian buffer strips	N discharges	P discharges	Application of pesticides	Water level	Residual water	Flood protection	Passability	Restructuring	Inherent dynamism	Bank and bed
Charges/financial incentives																					
I	Subsidised organic farming		(O)	(O)	(O)						(U)	U	U	U (O,G)							
II	Charge on organic fertilisers		(O)	(O)							(U)	U, G									
III	Tax on mineral N fertilisers		(O)	(O)							(U)	U, G									
IV	Tax on pesticides										(U)			O,G							
V	Use of water abstraction charges														(U)				(G)		(G)

MEASURE		POINT SOURCES Sewage treatment plants & industry					POINT SOURCES Combined sewage/precipitation				DIFFUSE SOURCES				WA	FLOW CONTROL		MORPHOLOGICAL CHANGES			
		1.1				1.2	1.3	1.4	1.7	1.9	2.1	2.2	2.3	2.4	3.1	4.1	4.2	5.1	5.2	5.3	5.4
INSTRUMENT		BOD, COD	NH_4-N	N_{total}	P_{total}	Membrane filter	Combined & separat-ion process, qualified	Decentralised measures	Rain spillway basin, rain ret. pond, soil filt.	Percolation trenches, filters etc.	Riparian buffer strips	N discharges	P discharges	Application of pesticides	Water level	Residual water	Flood protection	Passability	Restructuring	Inherent dynamism	Bank and bed
VI	Restructuring of the nature conservation & fishing charge										B (U)							B (U)	B (U)	B (U)	B (U)
Cooperation arrangements / voluntary agreements																					
VII	Cooperation between water industry & agriculture		(G)	(G)							(U)	U, G	U, G	U, (O,G)							
VIII	Advice to farmers		(O)	(O)	(O)						U	U	U	U							
IX	Advice to local authorities on water body maintenance														U	U	U	U	U	U	U

MEASURE		POINT SOURCES Sewage treatment plants & industry					POINT SOURCES Combined sewage/precipitation				DIFFUSE SOURCES				WA	FLOW CONTROL		MORPHOLOGICAL CHANGES			
		1.1				1.2	1.3	1.4	1.7	1.9	2.1	2.2	2.3	2.4	3.1	4.1	4.2	5.1	5.2	5.3	5.4
INSTRUMENT		BOD, COD	NH_4-N	N_{total}	P_{total}	Membrane filter	Combined & separat-ion process, qualified	Decentralised measures	Rain spillway basin, rain ret. pond, soil filt.	Percolation trenches, filters etc.	Riparian buffer strips	N discharges	P discharges	Application of pesticides	Water level	Residual water	Flood protection	Passability	Restructuring	Inherent dynamism	Bank and bed
Statutory instruments																					
X	Synergy effects between IPPC and WFD	U, B[8]	U, B[12]	U, B[12]	U, B[12]	U,B[12]															

Case 1:	Instrument supports measure	= U
Case 2:	Instrument necessitates implementation of the measure	= B
Case 3:	Instrument causes measure to become obsolete	= O
Case 4:	Instrument leads to reduced/less expensive implementation of the measure	= G

8 Only in the polluter category “industry” (in-house sewage treatment plants)

Stage 5: Determination of costs

For the combinations of measures prioritised on the basis of effectiveness, this stage ascertains the costs incurred for the individual water bodies until attainment of the quality targets. As a general principle, a distinction should be made between direct (or operational) and indirect (or economic) costs.

Direct costs are payable for the implementation of specific measures, such as the cost of structural measures in water protection, or administrative costs for collection of taxes. As a general rule, direct costs can be reliably estimated on the basis of experimental values. The measure and instrument sheets contain estimates and bandwidths for the direct costs. For the selection of measures on site, direct costs ascertained within the context of a comparative operational analysis are decisive in the majority of cases. Although, in principle, the calculation of direct costs entails fewer problems than indirect costs with respect to demarcation and balancing, a coordinated, uniform approach is likewise essential. For this reason, the calculation of direct costs is addressed in a separate excursus (cf. page 49).

Indirect or ***economic costs*** are incurred by measures and instruments in the sense that the measures restrict or change the uses of a water body, or necessitate adaptation measures. In contrast to direct costs, a significant proportion of economic costs are comprised of lost revenue.[9] This makes the calculation of economic costs fairly complex. A practical approach for calculating economic costs is therefore discussed in a separate excursus on the following page.

Dialogue between the individuals concerned is particularly important as a way of ensuring a uniform approach to the methodology of evaluating the various cost types, avoiding extra work and advancing the development of practical suggestions. When calculating the operational costs, for example, the LAWA guidelines on the cost comparison method provides a methodological basis adapted to the water industry segment (see below). However, this method is less developed for the purpose of economic costs. In both cases, the planning of measure and instrument combinations can be facilitated via the collation and exchange of experimental values, for example within the context of a LAWA working group. Another aim is to develop scientifically proven "rules of thumb“ (see below) to shorten and simplify the decision-making process.

Estimating the cost of measures

When considering the cost of a measure combination, initially, the direct costs arising for the implementation of specific combinations of measures are ascertained. These costs may be estimated using the results of the initial characterisation, information from the measure sheets,

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9 These costs are also known as *opportunity costs*. *External costs* are another component of economic costs.

and own experimental values. The data from the measure sheets will only facilitate a rough estimate of the cost of the measure combinations on the basis of bandwidths. In order to limit these bandwidths when estimating costs, where possible, location-specific cost information and experience from the implementation of measures should also be incorporated. By contrast, the indirect or economic costs of a combination of measures are only estimated in a separate calculation in cases where they could potentially influence the result of a selection of measures (see excursus below on the calculation of economic costs).

Additionally, it is important to bear in mind that measures are not applied to the entire stretch of water, but only to those areas that are subject to significant pressures. For example, if the water body structure is valued at worse than class 6 or 7 on 70 % of its length, this does not mean that 70 % of the stretch is actually in need of renaturation in order to attain good ecological status in the water body. The reasons for this are explained in the approach for structural mapping of the water body (on-site mapping records 100 m sections, which are evaluated as class 6 or 7 in their entirety if a certain percentage of the section is affected). Moreover, the significance limits in the CIS documents should not be interpreted as environmental quality targets. Ultimately, the decisive factor for the intensity or extent of the measure is the water body's classification based on its biological indicators to Appendix V and the chemical parameters outlined in Annexes VIII, XI and X.

Estimating the costs of the instruments

In many cases, the costs incurred as a result of application of the instruments may only be roughly estimated to begin with. This is true of administrative costs as well as the burdens incurred to third parties as a result of application of the instruments. Where quantitative estimates are available, these have been listed in the instrument sheets. Where possible, a distinction should be made based on the costs for various user groups (e.g. agriculture, water industry, shipping and consumers). From a societal viewpoint, it is conceivable that the additional costs for one user group are cancelled out by the savings of another.

Furthermore, the additional costs for instruments are often offset by savings with measures. For example, the use of instruments may tend to reduce the cost of corrective intervention, and instead, a greater burden will be placed on the polluters. At the same time, the efficiency of the procedure is increased, because instruments address the root of the problem.

When calculating the costs arising from the application of instruments, a variety of demarcation problems should be taken into account. The direct costs of instruments are primarily comprised of the administrative costs. Unlike the cost of measures, these costs incurred to the executing authority tend to be low. Additionally, the direct costs arising from administrative expenditure are calculated differently from structural measures: as a general principle, the costs over time should be taken into account in both cases. However, administrative work cannot be depreciated.

In addition, the direct cost of instruments are often exceeded by the indirect (economic) costs incurred to the affected economic players.[10] This is illustrated, for example, by the introduction of a tax on fertilisers or pesticides: only administrative costs are incurred to the implementing authority, whilst the bulk of the costs are apportionable to the farmers required to pay the tax. For the farmers, in turn, *opportunity costs* make up a significant part of the burden. Such costs are incurred, for example, when farmers switch to alternative crops or cultivation methods in order to avoid the tax, and generate lower profits as a result. For this reason, calculating of the cost of instruments is by nature more complex than calculating the cost of measures, and entails greater uncertainties.

Representation of costs

The calculated costs may be represented in a variety of ways. As a general principle, mean averages and bandwidths should be given for the cost, provided the available cost information permits this. As seen in the examples (chapter 5.2), various reference variables are conceivable and expedient, depending on the intended objective:

- Overall costs, e.g. in the form of the cash value of project costs (cf. excursus below on the calculation of operational costs)
- Specific costs:
  - per inhabitant,
  - per household,
  - per river kilometre
  - in relation to real net output in the river basin,
  - in the form of annual costs (annuity) (see below).

The most appropriate form depends on the intended purpose and should be decided in each individual case. For example, when considering which pressures are deemed reasonable for the citizen, the costs per inhabitant are decisive. For this reason, general recommendations cannot be made at this point. However, it should be noted that the costs given must remain comparable and compatible between the various sub-basins. Hence, it is also necessary to document the assessment basis (number of river kilometres, number of households or inhabitants) and, where applicable, the scope, together with any demarcation issues.

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10 One exception to this are cooperative instruments and advisory instruments, since in these cases, no costs are incurred to the affected parties, or else the costs are reimbursed.

Excursus: Calculation of operational costs

When calculating operational costs, consideration should be given to the following cost types:

- Investment costs (including planning costs, cost of land acquisition, and cost of substitute investments and upgrading);
- Depreciations;
- On-going operating costs (including cost of materials, personnel, maintenance and repairs);
- Financing costs, where applicable.

When comparing different measures, it is essential that the respective costs are calculated according to uniform procedures. For example, when calculating depreciation rates, uniform depreciation periods must be adhered to. Furthermore, the type of depreciation (increasing balance method / decreasing balance method / linear or variable) should also be uniformly specified. If the period of use differs significantly for different measures, corresponding substitute investments and upgrade costs should be outlined in order to obtain cost figures for a uniform period. If financing of the measure is to be included in the cost comparison, separate costs should likewise be shown for this purpose (usually at an interest rate of 3 % per annum, in this respect cf. also the LAWA guidelines on cost comparisons[11]).

Furthermore, it is important to remember that the costs of measures are incurred at different times and may be spread over a long period in some cases. The cost comparison method is designed to represent the cost of measures uniformly and clearly over time, so as to facilitate selection of the most cost-effective variant. In the water industry, two main approaches to the cost comparison method are used: the ***present value of project costs*** and the ***annual costs***.

The ***present value of project costs*** is designed to relate the costs arising throughout the entire term of the project to the present. As such, it indicates the costs needed in order to carry out a measure ***today*** and to maintain it for a given period (generally 50 or 100 years). Future costs are *discounted* at a uniform interest rate. Depreciations are not considered separately, provided the investment volume is depreciated over the term of the project (in such cases, the costs of the initial investment are taken into account). Only if the depreciation period of an investment exceeds the period of time under consideration will the (discounted) residual value of the installation at the end of the period under consideration be deducted from the initial investment.

When considering ***annual costs*** (annuities), on the other hand, the total costs incurred during the term of the project are converted into equal nominal annual costs. In such cases, the annual depreciation rates should be considered, rather than the initial investments. The annual costs are intended primarily to facilitate clear, comprehensible representation, rather than to reflect the costs as they are actually incurred over time.

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11 "Leitlinien zur Durchführung dynamischer Kostenvergleichsrechnungen" <KVR-Richtlinien>, cf. LAWA 1998

For both calculation methods, assumptions will need to be made at various points. Although indicative values are already available in some cases (cf. also the LAWA guidelines on the cost comparison method), we are unable to prescribe a compulsory, uniform approach at this point. One minimum requirement in this respect is that the assumptions made should be uniform for all compared options within the cost comparison. To this end, in particular, uniform regulations must be specified for the following parameters:

- the interest rate used,
- the depreciation periods and the depreciation pattern,
- how possible price increases and other influencing factors will be treated

Furthermore, the supra-regional and international coordination of calculation methods should also be ensured in order to facilitate cost comparisons between different sub-basins (cf. stage 7).

The assumptions made should be portrayed clearly and concisely so as to facilitate future reviews of the results. Finally, a sensitivity analysis should also be included as part of the cost comparison; it is important to investigate the extent to which the result of the investigation may be altered by a slight change to one of the parameters (for example, if a different interest rate is chosen). If this causes the result to change, this means that the meaningfulness of the study is limited, or the results are very close together.

Excursus: Calculation of economic costs

Economic costs arise when economically relevant water uses are restricted by water protection measures. They are incurred, for example, if the use of a river for inland shipping is restricted (seasonally or geographically) as a result of renaturation measures; this entails costs for shipping itself, as well as for riparian companies forced to switch to more expensive modes of transport. On the other hand, such measures may also bring economic benefits, e.g. by reviving tourism and water sports. Assessing the economic costs is a comparatively time-consuming and labour-intensive process. For this reason, costs should only be considered in greater detail in those cases where:

1. The direct costs of different measure combinations are so close that prioritisation on the basis of direct costs is not possible.
2. Significant economic costs can be assumed for at least one of the favoured combinations of measures and instruments.

Only in such cases can it be assumed that the economic costs will have a significant influence on the choice of measures and instruments (see stage 6).

In order to assess whether a combination of measures and instruments leads to significant economic costs, a preliminary assessment should be carried out initially, based on the compilation of uses in the initial characterisation. For the preliminary assessment, the following questions should be answered:

- What uses are available in the sub-basin?
- Are these uses influenced by the measures?
- Are significant adverse economic impacts on use associated with this impairment?

In this connection, the (large-scale) results of the economic analysis required by the Water Framework Directive should also be taken into account. These will be available from 2004. A significant influence on economic costs is anticipated, for example, in the areas of inland shipping, agriculture and hydropower. Previous studies in these areas[12] have provoked much controversy. Particularly in the field of inland shipping and hydropower, economic efficiency is often doubtful in view of the ecological damage caused. For this reason, from an economic viewpoint, it is often advisable to restrict corresponding uses, rather than minimising the associated pressures at great technical and financial cost.

When making a preliminary assessment of economic costs, it may also prove helpful to be guided by existing knowledge in the form of general statements, wherever this is expediently possible. For example, a number of studies have proven that a reduction in diffuse pressures can generally be achieved far more cheaply by reducing discharges than by implementing technical after-treatment measures.[13]

If, based on the preliminary assessment, the competent individual is satisfied that significant economic costs do not apply, the reasons for this assumption must be clearly outlined. As the economic costs concern various sectors and user groups, the reasons for dispensing with such an account should be made accessible during the course of public participation.

If the results of the preliminary assessment indicate that significant economic costs are anticipated, a detailed investigation is needed. During the course of this, it is necessary to determine the extent to which the chosen measures impair the economic uses of a water body; these effects are subsequently subjected to an economic evaluation. This may take the form of a monetary value, but may also take the form of a qualitative assessment. In many cases, the measure and instrument sheets contain details of potentially affected sectors and economic activities. The subsequent evaluation of economic costs, however, can only be provided by an economic study, unless relevant estimates are already available. However, an outline of the methodology required would exceed the brief of the project at this stage.

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12 Cf. Meyerhoff et al. (1998), Bunge et al. (2001), Federal Environmental Agency (2002).

13 Cf. Gramel and Urban (2001)

Stage 6: Identifying the most cost-effective combination of measures

Comparing the results from stages 3 and 4, the cost efficiency of various different measure combinations may be weighed up against one another and compared. As the result of this process, it is possible to determine the measure or combination of measures which produces the greatest ecological effect in relation to costs. In this way, the intention is to provide a logical account showing with which investments and over which period the ecological objectives can be achieved.

When choosing the most cost-effective combination of measures, the various options should be weighed up against one another. The aim of this process is not so much to determine a theoretically conceivable “ideal solution” with the lowest costs, but rather to depict the various criteria in a uniform way which must be weighed up against one another within the context of the process. Identifying a single, optimum solution is likely to prove difficult, because some of the costs and the likelihood of target achievement can only be qualitatively assessed.

The weighting of the individual criteria in the trade-off process should be coordinated with affected interest groups within the context of subsequent public participation (cf. excursus on page 17). The trans-sectoral results agreed in previous work stages provide a basis for the discussion process. For more complex cases, the use of more time-consuming, more structured assessment methods may prove expedient, e.g. on the basis of a multi-criteria analysis or via the development and analysis of scenarios.

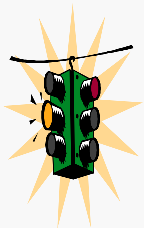
When selecting the most cost-effective combinations of measures, a trade-off processes should be implemented between the following criteria:

(A) Probability of target achievement by 2015
(B) Ecological effectiveness of the measure/instrument
(C) Time scale until effectiveness of the combination
(D) Direct costs
(E) Indirect economic costs

Within the context of the trade-off process, the effect of the measure combinations is initially assessed in relation to the objectives of the Water Framework Directive. Next, the costs of the measures are compared.

Evaluating the effect of measure combinations against the background of the Water Framework Directive

Three criteria play a central role in evaluating the effectiveness of combinations of measures and instruments: the likelihood of target attainment by 2015 (A), the ecological effectiveness of the combination of measures (B), and the time scale until effectiveness of the combination (C). The likelihood of attaining the target by 2015 (A) and the ecological effectiveness of a combination of measures and instruments (B) must be assessed for each combination and individually for the water body in question.



Note:

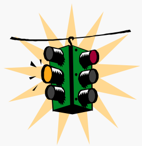
Following the selection of measures and instruments, it is first necessary to assess the probability of achieving the target of good ecological status by the year 2015 for each derived combination of measures and instruments. It is advisable to perform a rough classification as follows:

- Highly probable: The targets will be met within the deadline. The risk of the targets not being met is minimal.
- Probable: The risk of the targets not being met within the deadline does exist with a certain degree of probability.
- Improbable: In all likelihood, the targets will not be met by 2015.

If none of the potential combinations of measures and instruments is expected to meet the target with a certain degree of probability, it is necessary to assess, for example, whether to aim for a deadline extension in order to attain the environmental targets (as an exceptional circumstance pursuant to Article 4, paragraph (5) of the Water Framework Directive) or to aim for the attainment of less stringent environmental targets (pursuant to Article 4, paragraph (4) of the Water Framework Directive).

The required information on ecological effectiveness is obtained from stages 2 to 4, which in turn builds on the data contained in the measure and instrument sheets and the local information. The time required until the combination of measures becomes effective (C) can be assessed on the basis of the results from stages 3 and 4. The time scale of a measure is important, not only for the initial selection of measures. In addition, this criterion also highlights when work should begin on the implementation of a combination of measures, and at which point additional measures may be needed if target attainment is at risk.

To begin with, primarily those combinations which are highly likely to attain the target of good ecological status by 2015 should be examined in greater detail.



Note:

The time scale until effectiveness of the combination is represented in the categories short-term, medium-term and long-term, analogous to stage 3a. Short-term means that the combination will have an effect on ecological status well before 2015. Medium-term combinations of measures will take effect by 2015, whilst long-term measures will essentially only become effective after 2015. Details of the individual combinations of measures are taken from stage 4.

Note:

This study also addresses instruments and measures which, although they are cost-efficient and ecologically expedient, will only become effective in the long term. For example, this concerns inherent dynamic development (measure 5.3) or instruments aimed at a trend reversal in diffuse discharges (instruments I-IV). From the viewpoint of target attainment by 2015, these measures are rarely considered. In order to achieve a procedure which remains cost-efficient in the long term even after 2015, therefore, target attainment should be considered a priority criterion, but not an exclusive one. For example, it is possible that one combination will be considerably cheaper, yet unlikely to attain the target by 2015. If such an alternative exists, it is necessary to investigate whether a deadline extension pursuant to Article 4 represents a more expedient option for attaining the targets of the Water Framework Directive.

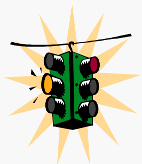
Evaluating measure combinations on the basis of cost

After having assessed the combinations of measures and instrument with regard to their effect on the targets of the Water Framework Directive, one must then consider the cost of these combinations. To begin with, the direct costs (D) of the chosen combinations are assessed. The estimate of costs is derived from stage 5.

In most cases, when comparing direct costs, one combination of measures and instruments will clearly emerge as the most cost-effective. In cases where there is no clear result, indirect costs must additionally be taken into account.

Consideration of indirect costs

Generally speaking, the indirect costs (e) of a combination of measures and instruments are also relevant when selecting a cost-effective combination within the meaning of the Water Framework Directive. However, as a general rule, the indirect costs of the various combinations should only be included as a decision-making criterion in cases where the direct costs of the combinations are roughly the same and / or in which at least some of the favoured combinations is expected to produce substantial indirect costs. If the indirect costs are not taken into account, the competent individual (analogous to stage 5) should outline why the indirect costs are being ignored.



Note:

- If there are no estimates of indirect costs available because these were not considered relevant for a given combination, then minimal costs are assumed.
- Because the indirect costs affect other sectors and interest groups in particular, at this stage, a transparent and well-documented procedure is important for mediating the decision within the context of public participation.

Presentation of results

The following table depicts the result of the trade-off process for four (fictitious) combinations of measures. In this case, based on the criterion of target attainment, the combinations of J, C and G would initially be short-listed, since there is clearly no justification for a deadline extension or less stringent environmental targets in accordance with Article 4 of the Water Framework Directive. By contrast, combination S would need to be excluded, since this is not expected to meet the targets of the Water Framework Directive by 2015 (A). When considering the direct costs, combination C clearly emerges as the most favourable: As the direct costs of this combination are considerably lower than those of the other combinations and the indirect costs are only classified as moderate, this combination would need to be considered in greater detail.
During the course of subsequent trade-offs, priority should be given to the combinations J and C. Combination G can be ruled out as comparatively less efficient, since in spite of considerably higher costs, it does not indicate any obvious advantages compared with combination C. The trade-off process between variants J and C must be decided within the context of participation by the general public. For this reason, when preparing for public participation, only the favoured options J and C should be portrayed on the basis of the five criteria, without valuing the combinations at this stage. The criterion of target attainment (A) will play a central role when

drawing up programmes of measures, whereas the criteria B, C, D and E may receive different weightings in the trade-off process, depending on the framework conditions.

Table 5-8: Sample representation of the trade-off criteria

(for fictitious combinations of measures)

Combination of measures	Target attainment by 2015	Ecological effectiveness	Time scale	Direct costs	Indirect costs
	A	B	C	D	E
Combination J	**highly probable**	**very good**	**short-term**	**500,000 -600,000 €**	**high**
Combination C	**probable**	**good**	**short-term**	**50,000 -100,000€**	**moderate**
Combination G	**probable**	**good**	**medium-term**	**300,000 -400,000€**	**low**
Combination S	**improbable**	**low**	**medium-term**	**450,000 -550,000 €**	**very high**

Stage 7: Coordinating with programmes of measures in other sub-basins

After determining the most cost-effective combinations of measures for the sub-basin based on stages 1 to 6, the final stage serves to coordinate with other programmes of measures in the same river basin district. Such a stage should be integrated into the process from the outset, since measures and instruments also impact other sub-basins. In cases where the benefit of measures is reflected to a large extent in other sub-basins (problem of upstream/downstream countries), it is likely that the cost efficiency of selected programmes of measures will be evaluated differently from a superordinate perspective. In particular, this applies to aspects of passability as well as chemical pressures (particularly nutrients and hazardous substances).

Consequently, supra-regional coordination serves three purposes:

1. As a general principle, it is necessary to check whether a more efficient procedure is possible if the envisaged measures and instruments are considered integratively in the entire river basin district. To this end, the local programmes of measures for the sub-basins are combined for the entire river basin district, and the efficiency of the measures compared. This comparison must be coordinated between the sub-basins and at river basin district level. During the course of forthcoming international cooperation in transboundary river basin districts, this coordination acquires additional significance.

2. Another purpose of supra-regional coordination lies in ensuring compatibility and comparability between different programmes of measures. Decisions regarding measures and instruments affecting the entire river basin district (e.g. in the field of flood protection or fiscal instruments) are considerably simplified if the information from different sub-basins is based on a uniform methodology. The same applies to a decision regarding local measures which impact other sub-basins. In order to ensure that the results from the sub-basins remain compatible, uniform methods must be applied, uniform assumptions used as a basis, and resolutions outlined in a logical sequence, particularly when calculating costs. In this way, greater supra-regional coordination should help to establish uniform cost categories, depreciation periods and methods, uniform interest rates, and comparable methods for determining indirect costs. Part of this coordination should also include data collation, in which experimental values on the direct and indirect costs of measures are made available. This data basis may also provide a valuable foundation for other components of the economic analysis within the Water Framework Directive.

3. As already remarked in stage 5, coordination of the approaches and methods may also contribute to more efficient handling, so that, rather than every sub-basin re-inventing the wheel, uniform methods and approaches are agreed for certain stages. For example, synergy effects are possible when developing practicable and meaningful methods for

assessing economic costs, and when formulating "rules of thumb", on the basis of which the process of selecting measure combinations may be shortened and simplified.

The development of such a coordination instrument would exceed the brief of this project and needs to be carried out by LAWA or within the context of the international river basin district. In the following excursus, we discuss other aspects and application cases of supra-regional coordination.

Excursus: Other application cases for supra-regional coordination

Coordination regarding the use of instruments

Unlike measures where the competent local water authorities decide on their use, generally speaking, the application of instruments does not fall within the competency of local authority or regional water authorities, but is decided at EU, Federal Government or *Länder* level.[14] Consequently, as a general rule, there is a different approach for the application of instruments: firstly, these include the political framework conditions that must be considered when selecting combinations of measures. Secondly, in the long term, a cost-effective approach is most likely to be achieved by creating incentives to modify harmful behavioural patterns by means of financial, legal or advisory instruments. Consequently, in order to achieve a cost-effective approach, it is necessary to ensure coordination at instrument level. However, as decisions regarding the use of instruments are not made locally in the majority of cases, the water authorities' role is to encourage the introduction of instruments at a higher level.

For cooperation solutions and advisory instruments whose use is decided at local level, the procedure is considerably simpler. As it is easier, in such cases, to evaluate whether the instruments can be implemented and how long this will take, the instruments may be included in the selection of measures with a higher degree of certainty. However, the direct ecological effectiveness of such instruments can only be assessed to a certain degree.

Coordination with other planning instruments

Another point that must be taken into account when preparing cost-effective programmes of measures but which exceeds the brief of this study concerns coordination with other planning instruments. These include, for example, land use plans, landscape plans, agrarian structural

14 Advisory instruments and cooperation solutions tend to be the exception here; these instruments may also be used at local level or, in the case of cooperation solutions, suggested. In this context, it is also worth noting that during the course of implementing the Water Framework Directive, the competencies for certain instruments will shift. Even if there are no plans as yet for a future restructuring of competencies, it can be assumed, for example, that measures in the area of agriculture are more likely to be enforceable under the future structure.

development plans, flood protection plans and specialist plans in the areas of transport planning and farmland consolidation. Consideration of these planning instruments is expedient, since on the one hand they can provide important (ecological and economical) inventory data, whilst on the other, they also represent important interfaces for implementation of the measures (particularly in agriculture). The resultant synergies should be utilised consistently.

5.2 Concretising the approach for determining cost-effective combinations of measures using case examples

The following section uses examples to illustrate how cost-effective combinations of measures may be derived based on the initial characterisation (ascertainment of pressures). We focus on three pressure categories:

- Diffuse substance discharges,
- Point substance discharges and
- Hydromorphological changes.

In order to outline and elucidate this approach, we have used the case studies Lahn, Seefelder Aach and Große Aue from chapter 3, since these examples require varying types of action in order attain a good status, because of differing pressure scenarios.

The stages outlined in chapter 5.1 are used as a basis for the selection, combination and prioritisation of measures. In this respect, it is important to consider that the seven stages up to the identification of cost-effective measure combinations in the case examples are only outlined in detail in those cases where existing studies and information from documentation of the case studies so permit. For this reason, adaptation to the outlined approach was prepared on the basis of theoretical considerations, rather than with the local knowledge of a specialist or by way of consensus with the relevant bodies. Nevertheless, the results obtained in the projects, some of which are trans-sectoral, have been incorporated into the illustrative account of the following case examples. Accordingly, these proposals are intended solely to illustrate the approach, and do not purport to offer a patented solution for the catalogues of measures to be prepared in the selected regions.

Case example: “Lahn”

In order to illustrate the approach, plausible cost-effective combinations of measures within the meaning of the Water Framework Directive are derived using a section of the Lahn as an example (cf. case studies in chapter 3). In addition to the document on the Lahn case study (2003), the study “Die Lahn, ein Fliessgewässerökosystem” <*The Lahn, a Watercourse Ecosystem*> (Regierungspräsidium Gießen 1994) was also used as a basis when preparing the following work stages.

Case example “Lahn” - Stage 1: Selecting the system of measures based on the identified pressures

Morphological pressures in particular were ascertained along the Lahn, based on the individual parameters of structural river mapping. For the “central potamal" section of the Lahn (a water body selected by way of an example), in addition, significant chemical discharges from diffuse and point sources were also identified:

Morphological pressures:	Bank obstruction > 30 % of the total length, unnatural and straightened bank course[15]
Aim:	To achieve predominantly natural river dynamics, and to liberate the water body within the available flood plains
Discharges from diffuse sources:	Nitrogen pollution of the Lahn at 7.5 kg N/ha a, corresponding to 60 % of the total load Phosphate discharge at 0.2 kg P/ha a
Aim:	To avoid substance discharge from agricultural land To minimise soil erosion with anti-erosion measures
Discharges from point sources:	Most of the total phosphate load of 450 t/a originates from local authority sewage treatment plants and combined sewage discharges
Aim:	To achieve a significant reduction in phosphate discharges by upgrading sewage treatment plants and expanding rainwater or mixed sewage discharges

15 It is anticipated that linear passability for the water body “central potamal of the Lahn” will be achieved as early as 2004 (cf. IGuG 2003) and therefore need not be considered in greater detail at this point.

Based on the identified pressures (see above), with the aid of chapter 4, systems of measures may be selected for the main pressures outlined in the Water Framework Directive, Annex II. The following systems of measures are relevant for the case example of the Lahn:

- System of measures for the pressure category “diffuse sources”
- System of measures for the pressure category “point sources”
- System of measures for the pressure category “morphology”

For this example, the system of measures “5. Morphological changes” (Figure 4-6) is particularly relevant.

Case example “Lahn” – Stage 2: Selection of effective measures

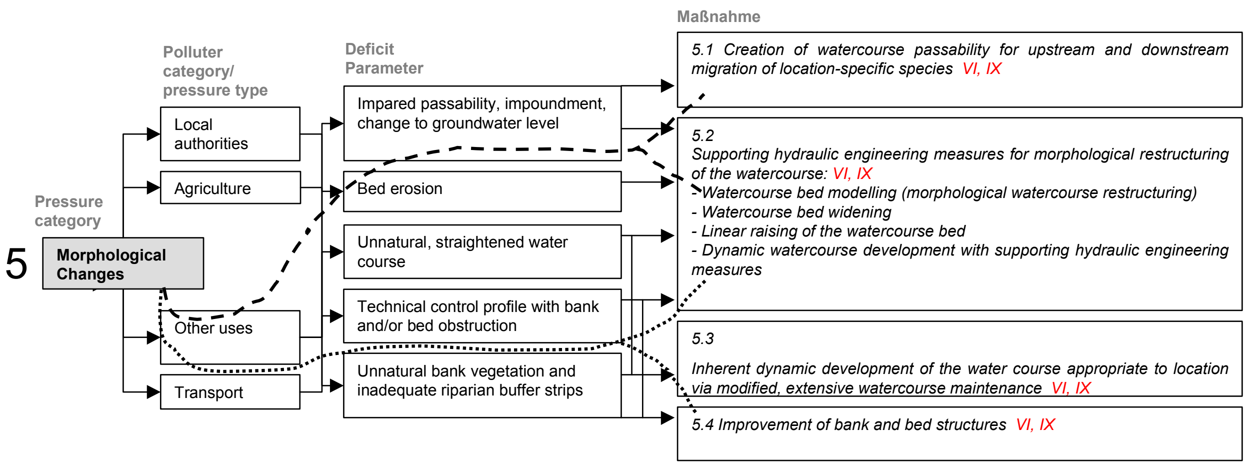


Figure 5-2: Representation of the selection of measures for the case study “Lahn”

Figure 5-2 represents the selection process from “pressure category” via “polluter category” and “deficit parameter” through to the measure, using system of measures for morphological changes by way of an example. Hence, via the fields “other uses” (here: shipping and hydropower), one arrives at the deficits “impaired passability” and “technical control profile with bank and bed obstruction”. Consequently, suitable measures for the area of morphology are:

“Creation of linear passability” (5.1),

“Supporting hydraulic engineering measures” (5.2) and

“Improvement of bank and bed structures” (5.4).

The selected measures are summarised in Table 5-9. In order to ensure the comprehensibility of the selection, the various pressure categories, polluter categories, deficit parameters and measures are entered in the table using the same structure as the system of measures.

Table 5-9: Result of the selection of measures based on the system of measures

Pressure category	Polluter category	Deficit parameter	Measure	
Point sources	Sewage discharges	P_{total}	1.1	Upgrading of sewage treatment plants
	Mixed sewage discharge	Chemical and hydraulic pressures	1.3	Qualified drainage
			1.4	Decentralised measures
			1.5	Structures for the treatment of combined sewage and rainwater
Diffuse sources	Agriculture	N_{total} and P_{total}	2.1	Reduction of nutrient and pesticide discharges
		N_{total}	2.2	Reduction of N discharges
		P_{total}	2.3	Reduction of P discharges
Morphology	Other use Shipping and hydropower	Horizontal structures (height >30 cm)	5.1	Creation of linear passability
		Technical control profile with bank and/or bed obstruction	5.2	Supporting hydraulic engineering measures
		Unnatural, straightened water course	5.4	Improvement of bank and bed structures
			5.3	Inherent dynamic development

The effect of the respective measures on the ecological status of the water body is derived by drawing up a cause/effect matrix for the water body “central potamal of the Lahn” (cf. Table 5-10).

Table 5-10: Assessment of the ecological effect of measures for the central potamal of the Lahn

Measure	Indicators of ecological deficits (WFD, Annex V)				Sum total of individual values (∑)	**Classification of priority**
	Macrophytes	Algae	Benthic invertebrate fauna	Fish fauna		
1.1	xx	xx	x	xx	7	2
1.3	x	x	x	x	4	1
1.5	x	x	x	x	4	1
2.1	xx	xx			4	1
2.2	xx	xx	xx	xx	8	2
2.3	xx	xx	x	x	6	2
5.1			x	xxx	4	1
5.2	xxx		xxx	xxx	9	1
5.3	xxx		xxx	xxx	9	3
5.4	x		x	x	3	1

Key: x = low ecological effect, xx = medium ecological effect, xxx = high ecological effect

Classification is achieved with the aid of a classification key that has been tailored to the framework conditions of the water body (Table 5-11).

Table 5-11: Classification key

Value range for ∑	**Description of effectiveness**	**Classification of priority**
12 - 9	High level of ecological effectiveness	3
8 - 5	Medium level of ecological effectiveness	2
4 - 1	Low level of ecological effectiveness	1
0	No ecological effectiveness	0

From the evaluation of cause and effect of individual measures shown in Table 5-10, we are able to deduce which measures are relevant for the water body “central potamal of the Lahn”. The individual measures classified in classes 2 and 3 should be favoured with regard to the widespread effect on biological indicators in accordance with Annex V.
A process to create linear passability of the Lahn is currently underway and is expected to be achieved by the year 2004; as a result, measure 5.1 “Creation of linear passability” has been disregarded in the following account.

Consequently, the following factors must be taken into account for subsequent work stages:

Page number	***Measure – Brief description***
1.1	Upgrading of sewage treatment plants
1.3	Qualified drainage
1.5	Retention soil filter
2.1	Reduction of nutrient and pesticide discharges
2.2	Reduction of N discharges
2.3	Reduction of P discharges
5.2	Supporting hydraulic engineering measures
5.3	Inherent dynamic development
5.4	Improvement of bank and bed structures

Case example “Lahn” - Stage 3a: Combination of measures

In stage 3a, the relevant measures for the water body “central potamal of the Lahn” are evaluated with respect to their interactions with the aid of a matrix.

With the results from stage 2 (classification of the individual measures), derivation according to the criterion of ecological effectiveness is achieved with the aid of the preference matrix (Table 5-4). Hence, this produces the following matrix showing the combinations of measures for the water body “central potamal of the Lahn”.

Table 5-12: Matrix showing the combinations of measures for the case example "Lahn"[16]

Measure sheet no.:		Ecological effect of measure combinations								
		1.1	1.3	1.5	2.1	2.2	2.3	5.2	5.3	5.4
		Upgrading of sewage treatment plant	**Qualified drainage**	**Retention soil filter**	**All substances (P, N, pesticides)**	**Limiting of N**	**Limiting of P**	**Renaturation**	**Inherent dynamics**	**Improvement of bank and bed structure**
Point sources	**1.1**	++	++	++	++	++	++	+++1	+++4	++
	1.3			+	+	++	++	++	++	+
	1.5				+	++	++	++	++	+
Diffuse sources	**2.1**					++	++	++	++	+
	2.2						++	+++5	+++2	++
	2.3							+++6	+++3	+
Morph. changes	**5.2**								+++7	++
	5.3									++
	5.4								Bank reinforce-ment "Nassau paving" as cultural heritage	

Key: Positive correlations (+++ very good effect, ++ good effect, + minimal effect) are shown in the top right, whilst negative correlations (- negative effect) are shown in the bottom left.The numerals in superscript represent the numbering of the main combinations and are **not** indicative of prioritisation

16 Results are based on theoretical derivations within the framework of this study

Interpreting the result based on the matrix of measure combinations:

Based on an evaluation of the measure combinations in the matrix (Table 5-12), a total of seven main combinations (see footnotes), i.e. combinations of measures with the greatest effectiveness, may be derived. For the purposes of this example, we will only consider the first three measure combinations in detail. Since all three main combinations do not in themselves meet the criterion of target attainment, further measures will be added. Based on the criteria of effect, likelihood of success and time until effectiveness, these three main combinations are outlined in brief below with the additional measures required for target attainment:

Combination 1:

Main combination:	
Upgrading of the sewage treatment plants with regard to phosphorous	(1.1)
Renaturation	(5.2)
Other measures for target achievement:	
Improvement of bank and bed structure	(5.4)
Limiting substance discharges by means of riparian buffer strips	(2.1)
Ecological effectiveness:	high
Time required:	short-term - medium-term

Combination 2:

Main combination:	
Limiting nutrient discharges from agricultural land	(2.2)
Inherent dynamics of the water body	(5.3)
Other measures for target achievement:	
Soil filter	(1.5)
Ecological effectiveness:	high
Time required:	medium-term - long-term

Combination 3:

Main combination:	
Limiting phosphorous discharges from agricultural land	(2.3)
Inherent dynamics of the water body	(5.3)
Other measures for target achievement:	
Upgrading of the sewage treatment plants with regard to phosphorous	(1.1)
Soil filter	(1.5)
Ecological effectiveness:	very high
Time required:	medium-term - long-term

Case example "Lahn" - Stage 3b: Determination of supporting instruments and assessment of effectiveness

The studies examining the Lahn as a case example did not consider any instruments, and for this reason no detailed comments can be made on the choice of relevant instruments for the water body "central potamal of the Lahn"[17].

Based on the approach for selecting suitable instruments, however, it would be possible to undertake a theoretical assessment and hence provide an indication of relevant instruments.

A number of instruments are available to support the technical and operational measures, based on the descriptions of the measures in the respective data sheets:

I Financial subsidising of organic farming

II Tax on organic fertilisers from non-free range farming

III Tax on mineral nitrogen fertilisers

VII Formation of effective cooperation structures between the water industry and agriculture

VIII Advice to farmers

IX Advice to the competent local and regional authorities

Case example "Lahn" - Stage 4: Description of the interactions between instruments and combinations of measures

In the river basin district of the Lahn, cooperation models have already been initiated to protect the drinking water, including protection of the surface waters. However, as these cooperation models are disregarded in the studies under consideration (Regierungspräsidium Gießen 1994, IGUG 2003)), we have omitted this stage for the case example of the Lahn.

Case example "Lahn" - Stage 5: Calculation of costs

The following table (Table 5-13) shows the calculation of costs for the three selected combinations of measures, and refers to 81 river kilometres of the water body "central potamal of the Lahn". It is worth bearing in mind that the costs were calculated excluding the trans-sectoral work of the committees, based on theoretical knowledge of the river basin district. Hence, in reality, the result obtained is not a transferable one, but should instead be viewed as a suggested approach for identifying cost-effective combinations of measures. For this reason, the cost calculation remains imprecise and disregards additional factors such as depreciation periods.

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17 Regarding the cost efficiency of cooperation solutions between the water industry and farmers in Hesse we would refer you Gramel and Urban (2001). However, the study by Gramel and Urban has the character of an overview and is not sufficiently detailed to allow conclusions to be drawn vis-à-vis individual sub-basins.

Table 5-13: Calculation of costs for the case example "Lahn"

Measure		Combination 1 (1.1, 5.2)	Combination 2 (2.2, 5.3)	Combination 3 (2.3, 5.3)
1.1	Upgrading of the sewage treatment plant (300,000 inhabitants $^{-0.9248}$ *36,649.4)	approx. 100,000 €		approx. 100,000 €
1.5	Construction of retention soil filters (311 €/m³ for 7 retention soil filters of 1,500 m³)		approx. 3.3 million €	approx. 3.3 million €
2.1	Purchase of arable land and construction of a 10 m wide riparian buffer strip, planted (53 € / linear metre (left and right bank over 40 km)	approx. 2.2 million €		
2.2	Conversion of arable land into extensive grassland; (500 €/ ha; approx. 3000 ha) Application of slurry using hose-towed technique to minimise N (no additional cost for application using a towed hose (cf. Regierungspräsidium Gießen 1994, page 138))		approx. 1.5 million €	
2.3	Conversion of arable land into extensive grassland (500 €/ ha; approx. 3000 ha) Mulch sowing technique (No additional cost for mulch sowing techniques using existing equipment (cf. Die Lahn 1994 page 138))			approx. 1.5 million €
5.2	Renaturation (225 – 350 €/ linear metre for 20 km)	approx. 4.5 – 7 million €		
5.3	Inherent dynamics (40-90 €/linear metre for 40 km)		approx. 2.4 – 5.4 million €	approx. 2.4 – 5.4 million €
5.4	Bank and bed structural improvement (50 – 125 €/ linear metre for 60 km)	approx. 3 – 7.5 million €		
	Estimated total cost[18]	**approx. 9.8 – 16.8 million €**	**approx. 7.2 – 10.2 million €**	**approx. 7.3 – 10.3 million €**

18 Reference variables for costs were taken from the case study.

Case example "Lahn" - Stage 6: Determining the most cost-effective combinations of measures

Table 5-14 illustrates the result of the fictitious trade-off process. Combination 1 is ranked third due to the high direct costs. Measure combination 3 remains the favourite, with the highest ranking. It best meets the criteria for the most cost-effective combination of measures, because it is expected to offer a very high level of ecological effectiveness at the lowest costs. Although in this case measure combination 2 could potentially be considered for the top ranking, the choice of measure combination 3 was decided by the criterion "target attainment by 2015". By implementing combination 3, target attainment within the deadline is probable. By contrast, the additional costs of around 0.1 million € needed to upgrade the sewage treatment plants with respect to phosphorous are acceptable.

Table 5-14: Results of the trade-off process in the case example "central potamal of the Lahn"

Combination of measures	**Target achievement by 2015**	**Ecological effectiveness**	**Direct costs**	**Indirect costs**	**Time scale**
Combination 3 (2.3, 5.3)	probable	very high	**approx. 7.3 – 10.3 million €**	moderate	medium-term - long-term
Combination 2 (2.2, 5.3)	improbable	high	**approx. 7.2 – 10.2 million €**	moderate	medium-term - long-term
Combination 1 (1.1, 5.2)	probable	high	**approx. 9.8 – 16.8 million €**	low	short-term - medium-term

Case example "Lahn" - Stage 7: Coordination with plans of measures in other sub-basins

This stage was disregarded in the case example, since the objective of the study was clearly a local one. For this reason, within the context of this project, we are unable to provide an outlook for the neighbouring sub-basins and coordination within the river basin district. This point is only mentioned here for the sake of completeness.

Case example “Große Aue”

The outlined approach (cf. chapter 2.1) was likewise applied to the case example “Große Aue”. Based on the information and results from the study “Modellhafte Erstellung eines Bewirtschaftungsplans am Beispiel des Teileinzugsgebietes Große Aue” <*Model of a management plan based on the example of the Große Aue sub-basin*> (Bezirksregierung Hannover 2001), the individual stages for determining the most cost-effective combination of measures are explained in detail. The results of the stages were coordinated with the study wherever possible and expedient. Additions made on the basis of theoretical considerations and general derivations based on the sheets of measures are highlighted in the text.

<u>Case example “Große Aue” – Stage 1: Selecting systems of measures based on identified pressures</u>

Pressures exist throughout the entire river basin district of the Große Aue, due to the increased discharge of the nutrients phosphorous and nitrogen. Furthermore, flow control via horizontal structures and significant morphological changes also represent significant pressures:

Discharges from diffuse sources:	Nitrogen pollution of the Große Aue at 3711 t N/a and phosphate pollution at 117 t P/a
Aim:	Required reduction in the nitrogen load of 61%, reduction in the phosphate load from diffuse sources of 7 %
Morphological pressures:	Impassable artificial horizontal structures with a drop of > 30 cm, unnatural and straightened bank course
Aim:	To remove horizontal structures and/or install fish ladders, renaturation of selected sections of the water body with regard to obstruction and straightening

Hence, the following systems of measures are relevant for the case example “Große Aue”:

- System of measures for the pressure category “diffuse sources”
- System of measures for the pressure category “morphology”

Case example "Große Aue" – Stage 2: Selection of effective measures within the sectors

The following table illustrates the selection of relevant measures based on the relevant systems of measures.

Table 5-15: Selecting the systems of measures based on the significant pressures for the case example "Große Aue"

Pressure category	Polluter category	Deficit parameter	Measures
Diffuse sources	Agriculture	All substances (N, P, pesticides)	2.1
		Nitrogen	2.2
Morphological changes	Agriculture	Impaired passability (weirs, drop structures, pipelines)	5.1
		Unnatural straightened water course	5.3
		Unnatural bank vegetation and inadequate riparian buffer strips	5.4

Based on the above table, the effects of individual measures on the biological quality components (Annex V, Water Framework Directive) of the water course are subsequently assessed using a cause/effect matrix. Table 5-16 represents the cause/effect matrix for the case example of the Große Aue.

Table 5-16: Assessing the ecological effectiveness of measures using the "Große Aue" as an example

Measure	Indicators of ecological deficits (Water Framework Directive, Annex V)				Sum total of individual evaluations (∑)	**Classifi-cation of priority**
	Macrophytes	Algae	Benthic invertebrate fauna	Fish fauna		
2.1	xxx	x	xx	xx	8	2
2.2	xxx	xxx	xx	xx	10	3
5.1			x	xxx	4	1
5.3	xx	x	xxx	xxx	9	3
5.4	xx		xx	xx	6	2

Classification is achieved with the aid of a classification code that has been tailored to the framework conditions of the water body (Table 5-17).

Table 5-17: Classification code

Value range for ∑	Description of effectiveness	Classification of priority
12 - 9	High level of ecological effectiveness	3
8 - 5	Medium ecological effectiveness	2
4 - 1	Low ecological effectiveness	1
0	No ecological effectiveness	0

Case example “Große Aue” - Stage 3a: Combination of measures

After having ascertained in stage 2 that all the selected measures are relevant for the water body, combinations of measures are then derived for the five individual measures using a matrix. These are derived according to the criterion of ecological effectiveness and based on the preference matrix according to Bachfischer, which has been adapted for the water body of “Große Aue” (cf.Table 5-4).

This produces the following matrix of measure combinations for the water body “Große Aue”.

Table 5-18: Matrix of measure combinations for the case example “Große Aue”[19]

Measure sheet number:		Ecological effect of the combinations of measures				
		2.1	**2.2**	**5.1**	**5.3**	**5.4**
		All substances (P, N, pesticides)	**Limiting of N**	**Passability**	**Inherent dynamics**	**Improvement of bank and bed structure**
Diffuse sources	**2.1**		**+++[4]**	**++**	**+++[3]**	**++**
	2.2			**++**	**+++[2]**	**+++[1]**
Morph. changes	**5.1**				**++**	**++**
	5.3					**+++[5]**
	5.4					

Key: Positive correlations (+++ very good effect, ++ good effect, + minimal effect) are shown in the top right, and negative correlations (- negative effect) are shown in the bottom left
The numerals in superscript represent the numbering of the main combinations, and do **not** reflect prioritisation.

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19 Results are based on theoretical derivations within the context of this study.

As indicated by the matrix of measure combinations, a total of five measure combinations may be derived as the main combination (+++). This approach is illustrated by way of an example only, rather than discussing all the main combinations here. Only the first three combinations will be considered in subsequent stages.

Combination 1:

Main combination:

Improvement of bank and bed structure (5.4)

Limiting of nitrogen discharges from agricultural land (2.2)

Other measures for achieving the target:

Linear passability (5.1)

Ecological effectiveness: very high

Time required: medium-term

Combination 2:

Main combination:

Inherent dynamics of the water body (5.3)

Limiting of nitrogen discharges from agricultural land (2.2)

Other measures for achieving the target:

Linear passability (5.1)

Ecological effectiveness: high

Time required: medium-term

Combination 3:

Main combination:

Limiting of substance discharges by means of riparian buffer strips (2.1)

Inherent dynamics of the water body (5.3)

Other measures for achieving the target:

Improvement of bank and bed structure (5.4)

Ecological effectiveness: minimal

Time required: short-term - medium-term

Case example "Große Aue" – Stage 3b: Determination of supporting instruments and assessment of effectiveness

In order to support the technical and operational measures, based on the descriptions in the measure sheets, a number of potential instruments are available for the specific pressure situation of the Große Aue:

I Financial subsidising of organic farming

II Charge on organic fertilisers from non-free range farming

III Tax on mineral nitrogen fertilisers

VII Formation of effective cooperation structures between the water industry and agriculture

VII Advice to farmers on optimum operation from a water protection viewpoint

IX Advice to the competent regional and local authorities

However, no instruments were considered in the pilot study for the Große Aue, and for this reason, no further details on the choice of instruments or on the interactions between measures and instruments may be given here.

Case example "Große Aue" – Stage 4: Description of the interactions between instruments and combinations of measures

Using the case example of the Große Aue, in the early Nineties, a number of cooperation models were introduced between the water industry and agriculture. Although these were aimed primarily at the protection of drinking water, they also include the protection of surface water. However, as these cooperation models were disregarded in the study, this stage will not be considered for the current case example. The results from stage 3a will be considered in the following stage.

Case example "Große Aue" – Stage 5: Calculation of costs

Detailed information on the cost calculations for the individual measures may be found in the measure sheets in Appendix I. Table 5-19 illustrates the costs for the three different measure combinations that were identified as possible combinations in stage 3. In this respect, it should be noted that the cost assessment cannot be applied to a real case, and is merely intended to illustrate the proposed approach.

Table 5-19: Cost estimate for the case example " Große Aue"20

Measure		Combination 1 (5.4, 2.2)	Combination 2 (5.3, 2.2)	Combination 3 (2.1, 5.3)
2.1	Purchase of arable land and construction of a 10 m wide riparian buffer strip, planted			approx. 53 €/ linear metre (left and right bank)
2.2	Conversion of arable land into extensive grassland;	approx. 500 €/ ha;	approx. 500 €/ ha;	
	Application of slurry using the drag net technique	approx. 1.8 €/ m³ slurry per annum	approx. 1.8 €/ m³ slurry per annum	
5.1	Creation of linear passability	5,000 – 30,000 €/ measure	5,000 – 30,000 €/ measure	
5.3	Inherent dynamics		approx. 40 – 90 €/ linear metre	approx. 40 – 90 €/ linear metre
5.4	Improvement of the bank and bed structure	approx. 50 – 125 €/ linear metre		approx. 50 – 125 €/ linear metre
	Estimated total cost[21]	**approx. 70,000 – 230,000 € per river kilometre**	**approx. 60,000 – 135,000 € per river kilometre**	**approx. 143,000 – 268,000 € per river kilometre**

20 Results are based on theoretical derivations within the framework of this study.

21 The reference variables for costs were derived from the case study.

Case example "Große Aue" – Stage 6: Identification of the most cost-effective measure combinations

Table 5-20: Trade-off process based on three measure combinations using the case example "Große Aue"

Combination of measures	Target achievement by 2015	Ecological effectiveness	Direct costs	Indirect costs	Time scale
Combination 2 (5.3, 2.2)	probable	high	60,000 – 135,000 € per river kilometre	moderate	medium-term
Combination 1 (5.4, 2.2)	probable	very high	70,000 – 230,000 € per river kilometre	moderate	medium-term
Combination 3 (2.1, 5.3)	improbable	low	143,000 – 268,000 € per river kilometre	low	short- to medium-term

A comparison between the three different measure combinations in Table 5-20indicates that Combination 2 is to be favoured from both an economic and an ecological viewpoint. Achievement of the target of a good ecological status by 2015 is probable, and implementation of the measures can be achieved in the medium term.

Case example "Große Aue" – Stage 7: Coordination with the plans of measures in other sub-basins

This stage was not carried out in the pilot project and therefore, is disregarded here.

Case example “Seefelder Aach”

Seefelder Aach was chosen as a third case example to illustrate the outlined approach for determining cost-effective combinations of measures. Like the other case examples, Seefelder Aach is considered a suitable example because its pressure distribution is typical for Germany. The stages for determining cost-effective combinations of measures were implemented using the information and results from the study “Modellhafte Gewässerbewirtschaftung im Einzugsgebiet der Seefelder Aach” <*Model watercourse management in the Seefelder Aach river basin district*> (IGuG 2001) . The results of the individual stages were coordinated directly with the content of the study. Any additions which exceeded the brief of the study due to theoretical considerations and general derivations based on the measure sheets are highlighted in the text.

Case example “Seefelder Aach” - Stage 1: Selecting the systems of measures based on the identified pressures

In the case of Seefelder Aach, several pressures were identified in the characterisation of the river basin district. Seefelder Aach is subject to pressures as a result of:

- Discharges from diffuse sources
- Deficits in water quality
- Deficits in river morphology.

Water body hygiene was considered with regard to its significance for the use of Lake Constance as bathing water. This aspect is only connected with the measures and objectives of the Water Framework Directive to a certain extent.

Discharges from point sources:	Contamination with the pathogen *E. Coli* as a result of combined sewage discharges (critical to severe)
Aim:	To reduce pathogenic micro-organisms
Discharges from diffuse sources:	N pollution 283.3 t N/a
Aim:	To reduce nitrogen loads from agriculture
Morphological pressures:	Artificial horizontal structures with a drop of > 30 cm, 50 % of the water body structure is poorer than grade 4.2 (corresponding to a classification of class 5 – poor ecological status)

Aim: To improve the water body structure via natural river dynamics, and to remove and/or convert horizontal structures to restore linear passability

Based on the initial characterisation and the pressures identified therein (see above), with the aid of chapter 4, systems of measures may be selected for the main pressures stipulated in Annex II of the Water Framework Directive. For the example “Seefelder Aach”, the following systems of measures are considered relevant:

- System of measures for the pressure category “diffuse sources”
- System of measures for the pressure category “point sources”
- System of measures for the pressure category “morphological changes”

Case example “Seefelder Aach” - Stage 2: Selection of effective measures within the sectors

With due regard for the relevant systems of measures, for the case example “Seefelder Aach”, this produces the potential measures outlined in the following table.

Table 5-21: Selection of systems of measures based on identified pressures

Pressure category	Polluter category	Deficit parameter	Measures
Point sources	Local authorities / households	All substances, hydraulic pressure	1.3
		All substances, hydraulic pressure	1.4
		All substances, hydraulic pressure	1.5
Diffuse sources	Agriculture	Nitrogen, phosphorous	2.1
		Nitrogen	2.2
Morphological changes	Agriculture / hydropower	Horizontal structures (height > 30 cm)	5.1
	Agriculture	Unnatural, straightened water course	5.2
		Unnatural bank vegetation & inadequate riparian buffer strips	5.4

The effect of the respective measures on the ecological status of the water body is derived with the aid of a cause/effect matrix for the water body “Seefelder Aach” (Table 5-22).

Table 5-22: Assessing the ecological effect of measures for “Seefelder Aach”

Measure	Indicators of ecological deficits (Water Framework Directive, Annex V)				Sum total of individual valuations (∑)	Classification of priority
	Macrophytes	Algae	Benthic invertebrate fauna	Fish fauna		
1.3	x	x	xx	xx	6	2
1.4	x		xx	x	4	1
1.5	xx	xx	xx	xx	8	2
2.1	xxx	xx	xx	xx	9	3
2.2	xxx	xx	xx	xx	9	3
5.1			x	xxx	4	1
5.2	x		xx	x	4	1
5.4	-	-	-	-	0	0

(x = low ecological effect, xx = medium ecological effect, xxx = high ecological effect)

Classification is implemented with the aid of a classification key which has been tailored to the framework conditions of this water body (Table 5-23).

Table 5-23: Classification key

Value range of ∑	Description of effectiveness	Classification of priority
12 - 9	High ecological effectiveness	3
8 - 5	Medium ecological effectiveness	2
4 - 1	Low ecological effectiveness	1
0	No ecological effectiveness	0

Although Seefelder Aach indicates deficits in terms of morphology, and particularly linear passability, in this particular case, this pressure plays only a subordinate role in the attainment of a good ecological status. Due to the natural and geographical conditions (Rheinfall waterfall, Lake Constance) of the water course, linear passability for long-distance migratory species can only be achieved on Seefelder Aach to a limited extent. Admittedly, according to the Water Framework Directive, passability must also be ensured for short- and medium-distance migratory fish and for trout, which climb from Lake Constance into Seefelder Ach, as a local peculiarity. Measure 5.4 is disregarded in subsequent stages, since the ecological improvement it would bring for Seefelder Aach would be minimal. Hence, the following measures are relevant for Seefelder Aach:

Page number	*Measure – Brief description*
1.3	Qualified drainage
1.4	Decentralised measures for the avoidance, reduction and delay of outflow
1.5	Retention soil filter
2.1	Reduction of nutrient and pesticide discharges
2.2	Reduction of N discharges
5.1	Creation of linear passability
5.2	Supporting hydraulic engineering measures

Case example "Seefelder Aach" - Stage 3a: Combination of measures

This stage entails the derivation of suitable combinations from the selected and classified measures. In this respect, it is important to verify the extent to which individual measures may influence one another in both a positive and a negative sense. Based on the criterion of ecological effectiveness, this is derived with the aid of the preferences matrix (cf. Table 5-4). The following diagram illustrates the effects of measure combinations on the Seefelder Aach water body.

Table 5-24: Matrix of measure combinations for the case example “Seefelder Aach”

Measure sheet number		Ecological effect of the combinations of measures: 1.3 Reduction of overall loads	1.4 Hydraul. relief	1.5 Reduction of overall loads, hydraulic relief	2.1 Limiting of nitrogen/ phosphate	2.2 Limiting of nitrogen	5.1 Pass-ability	5.2 Renatur-ation of the water course
Point sources	1.3		++	++	+++3	+++1	++	++
	1.4			++	++	++	+	+
	1.5				+++2	+++4	++	++
Diffuse sources	2.1					+++5	++	++
	2.2						++	++
Morphology	5.1							+
	5.2							

Key: Positive correlations (+++ very good effect, ++ good effect, + low effect) are shown in the top right, and negative correlations (- negative effect) are shown in the bottom left.
The numerals in superscript represent numbering of the main combinations and do not indicate prioritisation.

Overall, this produces five combinations of measures as main combinations with a very good ecological effect. For the example in question, however, only the first three combinations are elucidated with examples. The following measure combinations are considered in greater detail for the next stage of cost calculation.

Combination 1:

Main combination:

Reduction of overall loads (1.3)

Limiting of nitrogen discharges from agricultural land (2.2)

Other measures for achieving the target:

Hydraulic relief; reduction of overall load (1.5)

Renaturation (5.2)

Passability (5.1)

Ecological effectiveness: very high

Time required: short- to medium-term

Combination 2:

Main combination:

Hydraulic relief, reduction of overall load	(1.5)
Limiting of substance discharges via riparian buffer strips	(2.1)
Other measures for achieving the target:	
Limiting of nitrogen discharges from agricultural land	(2.2)
Renaturation	(5.2)
Passability	(5.1)
Ecological effectiveness:	high
Time required:	medium-term

Combination 3:

Main combination:

Reduction of overall loads	(1.3)
Limiting of substance discharges via riparian buffer strips	(2.1)
Other measures for achieving the target:	
Hydraulic relief	(1.4)
Renaturation	(5.2)
Passability	(5.1)
Ecological effectiveness:	low
Time required:	medium-term

Case example "Seefelder Aach" – Stage 3b: Determination of supporting instruments and assessment of effectiveness

One could choose from a number of potential instruments to support the technical and/or operational measures:

I Financial subsidising of organic farming

II Charge on organic fertilisers from non-free range farming

III Tax on mineral nitrogen fertilisers

VII Formation of effective cooperation structures between the water industry and agriculture

VIII Advice to farmers

IX Advice to the competent regional and local authorities

No instruments were allocated to the Seefelder Aach river basin and are therefore not described in greater detail in this context.

Case example "Seefelder Aach" – Stage 4: Description of the interactions between instruments and combinations of measures

In the case of Seefelder Aach, the determination of suitable combinations of measures is supported by means of in-depth advice to farmers on the spread of water-conserving practices in agriculture (instrument VIII). For example, within the framework of the conception process for Seefelder Aach, trans-sectoral working parties decided to set up an advisory office for farmers. Supplementary to this, work groups were set up and information evenings were held on selected topics.

In this way, the farmers were able to find out about the latest technologies and obtain suggestions and concepts from an advisor on managing their own farms more efficiently and minimising material discharges from the land. The measures drawn up within the context of the model project Seefelder Aach (IGUG 2001) for minimising chemical pollution in rivers provided the basis for this advice.

A further result of the work groups was the formation of a machinery cooperative which would provide the required apparatus e.g. for hose-towed application for all farmers.

Advisory activities in the Seefeler Aach basin were designed to ensure compliance with good agricultural practice. Hence, the favoured combination of measures is expediently supplemented by instrument VIII and therefore increases the likelihood of target attainment.

The estimated costs for one employee to advise farmers, including overheads, totals around € 70,000 per annum. This produces a financial expenditure of 2 € per inhabitant, per annum.

Case example "Seefelder Aach" – Stage 5: Calculation of costs

The detailed cost information was taken from the report on the Seefelder Aach pilot project and refers to a depreciation period of 30 years. Table 5-25 shows the costs for the three combinations of measures ascertained.

Table 5-25: Estimated costs of the selected measure combinations for the case example Seefelder Aach

Measure/instrument		**Combination 1 (1.3, 2.2)**	**Combination 2 (1.5, 2.1)**	**Combination 3 (1.3, ,2.1)**
1.3	Expansion of rainwater treatment and mixed sewers	approx. 14 €/(inhabitant p.a.)		approx. 14 €/(inhabitant p.a.)
1.4	Land desealing			approx. 7 €/(inhabitant p.a.)
1.5	Construction of retention soil filters	approx. 5 €/(inhabitant p.a.)	approx. 5 €/(inhabitant p.a.)	
2.1	Purchase of arable land, and construction of a 10 m wide riparian buffer strip, planted		approx. 6 €/(inhabitant p.a.)	approx. 6 €/(inhabitant p.a.)
2.2	Conversion of arable land into extensive grassland;	approx. 15 €/(inhabitant p.a.)	approx. 15 €/(inhabitant p.a.)	
	Application of slurry using the hose-towed technique	approx. 13 €/(inhabitant p.a.)	approx. 13 €/(inhabitant p.a.)	
5.2	Natural river development	approx. 23 €/(inhabitant p.a.)	approx. 23 €/(inhabitant p.a.)	approx. 23 €/(inhabitant p.a.)
XI	Advice to farmers		approx. 2 €/(inhabitant p.a.)	approx. 2 €/(inhabitant p.a.)
	Estimated total cost[22]	**approx. 70 €/(inhabitant p.a.)**	**approx. 64 €/(inhabitant p.a.)**	**approx. 52 €/(inhabitant p.a.)**

22 The reference variables for the costs were taken from the case study.

Case example "Seefelder Aach" – Stage 6: Determination of the most cost-effective measure combinations

Table 5-26: Trade-off process based on three measure combinations for the case example "Seefelder Aach"

Combination of measures	Target achievement by 2015	Ecological effectiveness	Direct costs	Indirect costs	Time scale
Combination 2 (1.5, 2.1)	probable	high	64 €/inhabitant p.a.	moderate	medium-term
Combination 1 (1.3, 2.2)	probable	very high	70 €/inhabitant p.a.	low	short- to medium-term
Combination 3 (1.3, 5.2)	Improbable	low	52 €/inhabitant p.a.	moderate	medium-term

This table shows that in terms of both ecological effectiveness and financial expenditure, combination 1 is the most efficient combination of measures. Since with the above case examples, the foundations for cooperation models in agriculture were laid during preparation of the programme of measures, these instruments may have a supporting effect early on. As a result of this, the likelihood of attaining a good ecological status on schedule is increased.

Case example "Seefelder Aach" – Stage 7: Coordination with plans of measures in other sub-basins

This stage was excluded from the pilot project and is therefore disregarded here.

6. SUMMARY AND OUTLOOK

This Handbook and the associated research report outlines a methodological concept for the procedure for selecting cost-effective combinations of measures in accordance with the Water Framework Directive, including the sample application thereof.

The starting point for the methodology developed in this project is the inventory required by the end of 2004 under the Water Framework Directive. By recording the pressure situation and the respective polluters, this leads to the identification of potential combinations of measures and supporting instruments. In the subsequent multi-stage trade-off process, the most cost-effective combination is ascertained, with due regard for the ecological effectiveness of these measure combinations, the likelihood of target achievement by 2015, the time scale for implementation, and a prioritisation on the basis of operational and economic costs. This approach represents an initial recommendation for decision-making levels in the water industry.

In this way, the fundamental stages of measure selection may be carried out in a comprehensible manner. As this concept breaks new ground in a number of key areas, although all detailed work stages were carefully considered from a theoretical viewpoint, a practical procedure for measure selection has yet to be finalised. For this reason, the approach outlined here needs to be further adapted, supplemented and concretised in a variety of ways during the course of practical implementation, particularly against the background of results from the inventory report to be submitted by the end of 2004.

Cost-effective measure combinations, as an important step in the preparation of a management plan, must be identified early on, due to the numerous questions associated with this on which a consensus must be reached at international level. The keen public interest in Germany[23] and in other European countries[24] has demonstrated this repeatedly, and the material available provides a suitable basis for this purpose.

Very soon after the first inventory has been prepared as per December 2004 in accordance with the Water Framework Directive, the process for the selection of measures must be specified, both in terms of content and in organisational terms, so that on this basis an initial draft of the programme of measures for river basin districts can be drawn up promptly.

The Handbook may also be used as a module of the report due for submission in Brussels by the end of 2004 on implementation of the economic analysis in Germany. To this end, it will be recommended to the Working Group of the Federal States on Water Problems (LAWA) (who were involved in the preparation of this Handbook via an accompanying research group).

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23 For example, a workshop to present and debate a draft version of the Handbook in September 2003 was well-attended, with active and constructive participation from those present, leading to a number of helpful suggestions for improvements within the context of a questionnaire. The authors would like to take this opportunity to reiterate their explicit thanks for the constructive criticism and numerous suggested improvements provided at the workshop and afterwards.

24 Apart from this English version of the Handbook, a Dutch version is likewise currently under preparation.

Regarding the activities needed for a concretisation of the proposed procedure, the first worth mentioning is a practical trial of the Handbook. The greatest possible number and range of cases under consideration (varying sizes, main pressure types etc.) would be helpful in this respect. A pilot project within the framework of an international river basin district is also recommended, since it can be assumed that only this kind of international project will facilitate the required solution to the pending questions at international level.

Other tasks that must be addressed until the approach outlined in the Handbook can be used on an area-wide basis are as follows:

- As soon as the targets of the Water Framework Directive have been operationalised ("good ecological status" etc.), they should be integrated into this Handbook;
- As the objectives of the Water Framework Directive must be achieved in the year 2015, it would seem expedient to conduct a risk analysis for the water bodies on the basis of projections for the year 2015 (as proposed in the European WATECO document on economic analysis). These projections should include the central, assessable modifications that are relevant for the attainment of environmental targets (e.g. if a significant reduction (or increase) in agricultural activity is expected in a given region, the corresponding effects on the environment should be included in the risk analysis). If such an approach is to play a key role in the subsequent implementation of the Water Framework Directive, this should be integrated into the current methodology;
- The new Groundwater Directive will entail essential concretisations in the field of groundwater protection; accordingly, following adoption of the Directive, the procedure should be extended to include this aspect;
- Furthermore, based on the first economic analysis, it is necessary to consider which information from this analysis is of interest for the selection of measures and/or for the associated trade-off processes. It is already clear that smaller-scale information, e.g. concerning the significance of certain types of water use, is needed for a concrete selection of measures at sub-basin level.
- Cooperation with the development and implementation of changes in other relevant policy-making areas (such as agricultural policy) should be concretised and linked more directly to the approach outlined here. For example, it is necessary to outline the extent to which changes in the political environment will affect the selection, dimensioning and application method of measures and instruments;
- Once the requirements governing the invocation of exceptional circumstances according to Article 4 of the Water Framework Directive have been concretised, the work should be more closely linked to work on the selection of measures, so as to avoid the duplication of work and inconsistencies. The invocation of exceptional circumstances presupposes that the

most cost-effective combinations of measures by which a good status could be achieved have first been investigated;

- In order to simplify practical formulation of the choice of measures, it is important to determine early on which stages can be formulated within the context of a joint approach (e.g. within LAWA), and within which institutional framework this should take place (e.g. concretisation of the operational costs of measures via the specification of uniform cost categories, interest rates and depreciation periods). It would also be expedient to set up a central database in which local findings on direct and indirect costs, together with any additional measure sheets available, can be exchanged.
- When evaluating and selecting measures, it would be helpful to evaluate selected instruments at a “higher” administrative level (LAWA/Federal Government or – in the case of transboundary river basin districts – at international level). As the implementation of such instruments requires a long lead time, the corresponding evaluation process should begin as soon as possible, without postponing the implementation of essential measures;
- As soon as further relevant results are available from the CIS working parties at European level, these should be integrated into the current procedure[25];
- More weighting should be given to the spatial dimension of the choice of measures, i.e. stage 7 of the procedure needs to be concretised within the framework of international river basin districts as well;
- Last but not least, it is important to determine at which stages of the process, at which times, in which form and with which content the participation of the general public is to be facilitated.

In summary, it can be asserted that the comprehensible process of selecting cost-effective combinations of measures in accordance with the Water Framework Directive offers a major opportunity for the European water industry to further increase efficiency and transparency in water protection. The approach still needs to be concretised in a number of areas. Over the next few years, these must be formulated gradually and based on the concretisations of the Water Framework Directive’s requirements arising in other areas and by other parties. Where expedient, recourse should be made to existing experience, and there is still a need for research with certain sub-aspects (e.g. in the area of ecological river development in collaboration with agriculture). In future, the proposed approach, which is based on the principles of the WFD, will help to ensure that considerations regarding the choice of measures for attaining environmental targets in water protection can be conducted in a transparent and comprehensible way, with the involvement of the relevant players.

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25 For example, the CIS sub-working party DG ECO1 will be addressing the selection of measures in 2004.

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GLOSSARY

Capital costs: Comprised of new investments, depreciation on existing investments, and → *opportunity costs* (cf WATECO-Guidance).

Cash value of project costs: The cash value of project costs is the money needed to finance the project (investment, operation and reinvestment) for the assumed project term on the basis of current costs. In other words, in today's prices, the cash value of project costs indicates the sum needed in order to perform/construct a measure, to maintain it for its useful life, and to remove it at the end of its useful life.

Deficit parameter: The pressure in the → pressure categories can be determined on the basis of so-called deficit parameters. These are determined as part of the *LAWA Arbeitspapier*, part 3 (criteria document). Within the context of this project, the most relevant deficit parameter for the purposes of practical application is selected for each of the pressure categories. Examples include chemical or hydraulic pressures

Discount rate: According to economic theory, consumption which occurs today is valued more highly by the consumer than future consumption (time preference), and accordingly, credit available today has a higher value than future revenue. In the financial industry, therefore, investments must at least generate the same yield as an investment with a comparable risk would produce (cf. → opportunity costs). For this reason, costs and benefits are "discounted", i.e. reduced by a fixed percentage. The standard discount rate for costs and benefits from environmental protection projects is 3 % (source: US environment agency US EPA)

Economic costs (also known as indirect costs): Costs arising *indirectly* from the performance of a measure / instrument. The indirect costs are not borne by the executing authority but by other players: Indirect costs are incurred to the users of a water body if their usage is restricted from an environmental aspect. One example is a loss of revenue for a farmer who is forced to switch to different produce or a more extensive method of farming. Furthermore, these costs also entail indirect costs of a secondary and tertiary nature: they are incurred if the sum total of individual revenue losses leads to a weakening of regional economic strength overall. However, these follow-on effects may only be assessed by means of extensive economic modelling.

Environmental costs: The monetary value of the damage incurred to the environment and ecosystems as a result of water use, such as a reduction in the ecological quality of an aquatic ecosystem or the salification of agricultural land. Environmental costs generally fall under → *external costs* (cf. WATECO-Guidance).

Financing effect: The use of fiscal instruments exerts both a steering effect and a financing effect. The financing effect is derived from the use of funds generated e.g. from taxes. The financing effect pre-supposes that revenue from a tax is *earmarked* (cf. instrument VI, reorganisation of the equalisation tax under nature conservation law and the fishing charge).

Initial characterisation (also known as inventory): According to Article 5 of the Water Framework Directive, this entails an analysis of the characteristics of a river basin district, including a review of the environmental impacts of human activities and an economic analysis of water use. More precise specifications on inventories may be found in Appendices II and III, which also address the most cost-effective combinations of measures. The initial characterisation must be prepared by December 2004.

Instruments: These are designed to modify framework conditions, so as to indirectly influence the conduct of the relevant players. Instruments may alter the legal or financial framework conditions, but may also help to bring about behavioural changes by means of improved information and education. In this way, the instruments support the implementation / enforcement of measures. According to the nomenclature of the Water Framework Directive, instruments are classed as “supplementary measures” within the meaning of Annex VI, part B of the Water Framework Directive, although it has to be said that the Water Framework Directive likewise fails to make a clear distinction between measures and instruments.

Measures: Within the context of this Handbook, measures refer to intervention leading directly to an improvement in the water body status, by eliminating or ameliorating a pressure. This primarily, although not exclusively, concerns measures of a structural nature and measures performed directly on the water body. With the reduction / prevention of discharges, this comprises both end-of-the-pipe and integrated measures. Measures become effective in the short term within a limited area with a high degree of probability; as such, their effectiveness is comparatively easy to predict. A decision regarding the use of measures is generally taken locally by the competent water authorities.

Operational costs (also known as direct costs): Costs incurred *directly* for the performance of a measure or application of a instrument. As a general rule, these costs must be borne by the executing authority. These include, for example, the construction costs for structural measures, HR expenditure and administrative costs incurred to the authority as a result of the performance of a measure or instrument.

Opportunity costs: The opportunity costs of a measure refer to the lost value of the next-best alternative. For example, the opportunity costs of an investment project could be comprised of the interest that would have been earned, had the sum been invested in a high-interest account instead. Opportunity costs represent a component of capital costs.

Polluter category: For each of the selected → pressure categories, in addition to the respective → deficit parameters, it is also necessary to determine the relevant polluter categories. Polluters refer to any anthropogenic activities that impair the quality of a water body. Examples of polluter categories include sewage discharges, the abstraction of cooling water, and agricultural irrigation.

Pressure category: According to Annex II, No. 1.4 of the Water Framework Directive <WFD>, Member States are required to collate and maintain information on the type and magnitude of significant anthropogenic pressures (cf. also *LAWA Arbeitshilfe*, part 3, II./1.1.4). Within the context of this project, consideration was primarily given to the following pressure categories: Point sources, diffuse sources, flow control, water abstractions and morphological changes.

Programme of measures: Article 11 of the Water Framework Directive requires the preparation of cost-effective programmes of measures at river basin district level in order to achieve the targets of the Water Framework Directive as outlined in Article 4. The programmes of measures must have been prepared by 2009, and the measures outlined must have been implemented by 2012. From 2015 onwards, regular reviews of the programmes of measures at six-yearly intervals are envisaged.

Public participation: According to Article 14 of the Water Framework Directive, the involvement of the general public is prescribed at various different points, including preparation of the management plan and the programme of measures. This is designed, firstly, to ensure that the local knowledge of the (expert) public is incorporated into the management plan, and secondly, to act as a control in order to verify the plausibility of the evaluation and the choice of measures. This is of particular significance when determining the economic costs, when weighing up various different decision-making parameters, and when coordinating with other planning instruments.

Resource costs: These measure the value of lost opportunities which are withheld from other users because a resource is being exploited to excess (i.e. above the rate of regeneration). Within the context of the Water Framework Directive, the term refers primarily to groundwater: in such cases, for example, resource costs are incurred if the level of water abstraction increases due to the development of tourism in a coastal region, and for this reason, less water is available to agriculture for irrigation purposes. From an economic viewpoint, therefore, resource costs are a form of → *opportunity costs*. For the user, furthermore, they represent a form of → *external costs* (cf. WATECO-Guidance).

River basin district: According to Article 3, paragraph (1) of the Water Framework Directive, an area of land or sea designated as a main unit for river basin management consisting of one or more adjacent river basins and the related groundwater and coastal water.

Steering effect: The use of fiscal instruments exerts both a steering effect and a financing effect. The steering effect lies in the fact that certain modes of behaviour or action alternatives are deliberately made more or less expensive by means of a tax or subsidy. This creates greater incentives to modify behaviour without making this behaviour compulsory.

Sub-basin: Within Germany, 10 river basin districts (Rhine, Weser, Danube etc.) have been designated principal units for the management of river basins. These are listed in Annex 1 to the Federal Water Act. In order to facilitate the preparation and coordination of the management plan, the programmes of measures and other work, the river basin districts are subdivided into smaller sections. These are known as sub-basins.

Water body: Within the meaning of the Water Framework Directive, a body of surface water means a discrete and significant element of surface water such as a lake, a reservoir, a stream, river or canal, part of a stream, water or canal, a transitional water or a stretch of coastal water. A body of groundwater is defined as a distinct volume of groundwater within an aquifer or aquifers (Article 2 (10 and 12) of the Water Framework Directive). Article 4 of the Water Framework Directive stipulates that all bodies of surface water shall be protected, enhanced and restored with the aim of achieving good surface water status by 2015 at the latest. Accordingly, the body of water is the unit to which evaluation and potential measures for the attainment of a good status must refer.

Water services: According to Article 2, point 38 of the Water Framework Directive, this refers to "all services which provide, for households, public institutions or any economic activity: abstraction, impoundment, storage, treatment and distribution of surface water or groundwater; and waste-water collection and treatment facilities which subsequently discharge into surface water".

Water uses: Apart from water services, water uses also comprise all other activities which may have a significant impact on water status as set out in Article 5 and Annex II of the Water Framework Directive, such as the expansion of a water body for shipping purposes.

APPENDIX I: SHEETS OF MEASURES

Data Sheet No.1.1

Pressure category according to the Water Framework Directive, Annex II: *Point sources*

Polluter category: *Local authorities/households ⇒ Sewage treatment plants*

Description of the measure

No. 1.1: Upgrading of a sewage treatment plant with regard to the parameters BOD_5, COD, NH_4-N, N_{total} or P_{total}

Brief description / specification of the measure

By discharging the outflow from a sewage treatment plant into a low-efficiency outfall, high BOD_5, COD, NH_4-N or P_{total} loads or concentrations may adversely affect the aquatic system. Hence, in selected cases, increased demands must be placed on the sewage treatment plant.

Regarding the parameter N_{total}, it is worth considering that the nutrient loads discharged into a water course are of relevant significance for the conservation of coastal seas. Although around 70 % of the total load of 819 kt N from diffuse sources, particularly from agriculture (BEHRENDT et al., 1999), enters the North Sea, nevertheless, corresponding nitrogen elimination in sewage treatment plants (including sewage treatment plants for < 10,000 inhabitants) may achieve a further reduction in N emissions (cf. also effect analysis). Additionally, in selected cases, the discharge of N_{total} may contribute to eutrophication, particularly in slow-running rivers.

In order to reduce the pollutant loads from sewage treatment plants, therefore, the individual measures listed below may be initiated:

a) Upgrading of the sewage treatment plant with regard to the parameters BOD_5 and COD: Expansion of preliminary and secondary treatment (sedimentation basins) or aeration and/or use of farther-reaching treatment techniques (such as membrane filtration).

As a general rule, every local authority sewage treatment plant must have a mechanical-biological treatment stage, i.e. preliminary or secondary treatment and aeration (or comparable biological techniques) must be present in order to comply with the requirements stipulated by the Waste Water Ordinance. In this particular case, farther-reaching requirements would be an expansion of the existing pond volume or possibly the addition of a filtration stage to the sewage treatment plant.

b) Upgrading of the sewage treatment plant with regard to the parameter NH_4-N: Expansion of the pre-existing biological treatment stage via the addition of a nitrification stage.

c) Upgrading of the sewage treatment plant with regard to the parameter N_{total}: In sewage treatment plants, including those for < 10,000 inhabitants, construction of a biological purification stage (denitrification), or for sewage treatment plants for > 10,000 inhabitants, expansion of the pre-existing denitrification stage (expansion) and/or the use of farther-reaching treatment techniques (such as biologically intensified filtration, sand filtration, membrane filtration).

d) Upgrading of the sewage treatment plant with regard to the parameter P_{total}: Construction (sewage treatment plants up to an expansion size of < 10,000 inhabitants) or expansion (sewage treatment plants for > 10,000 inhabitations) of a P_{total} elimination system. Phosphate elimination may be achieved, for example, by means of biological P elimination or by means of filtration techniques (such as membrane filtration).

Players involved in implementing the measure

☐ Federal Government	☑ Local authorities	☑ Associations, independent organisations
☐ *Länder* Government	☐ EU	☐ Private individuals

Effect analysis

Primary effects:

In many cases, the existing ecological deficits on water bodies are no longer the result of continuous sewage discharges, but are instead attributable to a variety of human influences. Nevertheless, deficits may occur as a result of sewage treatment plant discharges, particularly in slow-running outfalls, which prevent the attainment of a good ecological status.

Re a) Increased oxygen depletion may occur in water bodies due to excessively high COD or BOD_5 loads, which under certain circumstances may lead to a situation where water biocoenosis is at risk due to a lack of oxygen supply. Particularly water bodies with a low drag force, low level of physical gas exchange and/or high water depths are at risk with respect to oxygen balance. By enlarging the preliminary or secondary treatment stage (the efficiency level is approximately 28 % for BOD_5, 36 % for COD), expanding the aeration stage (the efficiency is approximately 60 % for BOD_5 and approximately 50 % for COD) or e.g. via membrane filtration, farther-reaching purification and hence a reduction in the discharged loads can be achieved.

Re b) NH_4-N may be converted into toxic ammonia in the water body depending on the pH value and the temperature. Fish, in particular, react sensitively to ammonia. By expanding the aeration stage and hence increasing nitrification, the concentration of NH_4-N entering the outfall can be reduced.

Re c) The discharge of nutrients into water bodies leads to pressure on the coastal seas and may exacerbate the problem of eutrophication, particularly in slow-running waters. By expanding the sewage treatment plant to include a denitrification stage or by adding a filtration stage, the quantity of total nitrogen discharged may be reduced.

Based on the N emission data from local authority sewage treatment plants in Germany (classified according to various size categories and purification techniques) drawn up within the context of a project by Schmoll (1998), the future reduction for N may be roughly estimated via specific inhabitant-related emission factors. Compared with the emissions of 176 kt N calculated for 1995, this produces reductions of 67 kt N (38 %).

Re d) Phosphorous, as an essential nutrient for primary producers, is often the minimum factor, and hence the cause of eutrophication problems in rivers and lakes. Hence, a reduction in the concentration of P discharges would be desirable.

Based on the P emission data from local authority sewage treatment plants in Germany (classified according to various size categories and purification techniques) drawn up within the context of a Federal Environmental Agency (UBA) project by Schmoll (1998), the future reduction for P may be roughly assessed using specific inhabitant-related emission factors. Compared with the emissions of 9.9 kt P calculated for 1995, this produces reductions of 2.5 kt (26 %).

According to Schmoll (1998), the total loads for sewage treatment plants in the size category 1,000 to 10,000 inhabitants for P_{total} are 1.8 kt/a. Targeted P elimination in all plants of this size category would facilitate an additional reduction of approximately 70 % (1.3 kt/a).

Size category 5 (> 100,000 inhabitants): 4,587 million m³ sewage (1991); a reduction of 0.8 mg/l to 0.5 mg/l P_{total} (average) would reduce the load by 1.4 kt P (by way of comparison: local authority sewage treatment plants overall according to Schmoll, 1998: 9.9 kt/a)

Secondary effects:

<u>Material:</u>

Depending on the process technology used, heavy metal emissions may also be reduced by reducing the substances removable via filtration. Additionally, by reducing particulate substances in the sewage, sediment and sludge formation in the river is reduced, which in turn lessens the impairment to natural habitats.

Re b) If only nitrification occurs in a sewage treatment plant, but no denitrification, the quantity of NO_3-N and NO_2-N discharged is increased. Under certain circumstances, this may contribute to an increased risk of river eutrophication.

Commercial / social effects:

Effects on public budgets in accordance with the level of subsidy granted from public funds.

Time required

Until implementation: a)-d) short-term

Until effectiveness: a), b) and d) generally short-term

c) short- to medium-term (with regard to the problem of eutrophication) to long-term (with regard to the reduction of nutrient discharges into the coastal seas)

Geographical effect

☑ local (a-d) ☐ regional ☑ Nationwide/EU-wide (c)

Interactions with other measures

Measures to reduce chemical pressures are generally supplemented by measures to improve the structural quality. Particularly via the creation of riparian buffer strips to reduce additional substance discharges from diffuse sources (cf. measure no. 2.1), the planting of copses in order to achieve better shading of the water body (in this way, for example, an additional discharge of P_{total} and excessive light exposure due to a lack of shade may lead to an increase in the pH value, which in turn has a negative effect in terms of ammonia content) and by improving the bed structures (cf. measure no. 5.4), the effects of sewage treatment plant discharges may be minimised.

Cost estimates

In order to be able to estimate the costs arising for the expansion of a sewage treatment plant, sample costs are listed below.

Re a) Cost of constructing a **preliminary / secondary treatment tank**

From: *Investitionskosten der Abwasserversorgung* <Investment costs of sewage disposal> (Günthert, Reicherter, 2001), derived from project data, particularly from Bavaria:

$X = 7{,}998.65 * m^{3\ -0.4206}$ [€/m³]

From: “Verordnung über pauschale Investitionszuweisungen zum Bau von Abwasseranlagen” <*Ordinance on lump-sum investment allocations for the construction of sewage treatment* *plants*>, Hesse (as per 2002): the cost of upgrading the sewage treatment plant to include a preliminary or secondary treatment tank or of enlarging the tank are as follows:

Tank volume	Indicative cost
X< 200m³	1,050 €/m³
200m³ ≤ X ≤ 14,500m³	7,457 $X^{-0.37}$ €/m³
X > 14,500m³	215 €/m³

Re a, b and c) Cost of constructing an **aeration tank**:

From: *Investitionskosten der Abwasserentsorgung* (Günthert, Reicherter, 2001), derived from project data, particularly from Bavaria:

$X = 4{,}608.32 * m^{3\ -0.3338}$ [€/m³]

As well as construction and mechanical engineering costs, the figures also include the cost of excavation works, sheet piling, pondage, and pipelines.

The cost of upgrading the sewage treatment plant to include a biological treatment stage (aeration tank), or of enlarging the pre-existing biological stage, are as follows:

Tank volume	Indicative cost
X< 400m³	945 €/m³
400m³ ≤ X ≤ 10,000m³	5,704 $X^{-0.30}$ €/m³
X > 10,000m³	360 €/m³

The indicative costs for the aforementioned construction work also include the cost of the related mechanical and process engineering, ventilation and circulation equipment, pumps and cables required for operational purposes.

Re a, c and d) In the case of using **more extensive purification techniques**: The specific costs of a filtration stage are approximately **0.1 – 0.15 €/m³** of sewage (ATV-AG 2.1.6, 1997). For membrane filtration connected downstream of secondary treatment, Dittrich et al. (1997) specify total costs of **0.26 – 0.51 €/m³**, which were determined on the basis of small-scale experimental equipment.

In another study (Franke, W., 2003), investment costs of

$X = 730,45 - 61.973 * Ln(A_{MBR})$ €/m² (operation with 20 l/(m²*h – calculation of A)

were calculated for the construction of a membrane filtration system.

Energy costs make up the bulk of the operating costs (in this respect, cf. also measure 1.2). They vary considerably according to the technique and design of the circulating pumps (which in turn depends on the membrane geometry). At present, membrane systems have a higher energy consumption than conventional systems.

Re d) According to Günthert and Reicherter (2001) the cost of constructing **phosphate precipitation systems** are approximately 36,649.4 * inhabitant-0.9248 [€/inhabitant].

According to Grünebaum (1993), the specific costs of P elimination are **12.8 – 20.5 €/kg$_{eli}$** P. In order to reduce emissions by 1.3 kt/a P, this produces total costs of approximately **15.4 – 25.6 million €/a**.

According to the ATV Handbook “Biologische und weitergehende Abwasserreinigung” <*Biological and Advanced Sewage Purification*> (1997), the investment costs, depending on precipitation, are as follows:

- Construction of a preliminary or simultaneous precipitation system: Silos and storage containers for precipitating agents (V = 25 – 30 m³), including metering device and possible reprocessing, cost in the region of **100,000** to **150,000 €.**
- For the construction of two-point precipitation with two different precipitating agents, the costs are doubled.

Facilities for the storage and dissolution of iron (II) sulphate are significantly more expensive, and cost between **250,000 and 500,000 €.**

When using lime in the form of slaked lime $Ca(OH)_2$ the required plant costs around **100,000 to 125,000 €,** whilst for quicklime CaO, a slaking bunker is needed, costing around **125,000 to 150,000 €.**

The report “Kosten-Wirksamkeitsanalyse von nachhaltigen Maßnahmen im Gewässerschutz” <*Cost/effect analysis of sustainable measures in water protection*> (UBA, 2002) cites the following specific costs in respect of the eliminated P load (in the report, costs are given in DM. For the purposes of this account, these have been converted into Euros using a factor of 2) (cf. also Grünebaum, 1993):

- P elimination via simultaneous precipitation: approximately **20 to 35 €/kg P**
- P elimination via flocculation filtration: approximately **100 to 500 €/kg P**
- P elimination via downstream membrane filtration: approximately **335 to 1,650 €/kg P**

Uncertainty factor

If the measure is incorporated into the implementation process of water legislation, it will mean an increase in sewage charges for private households.

Summarising qualitative assessment

The benefit of the measure lies in the fact that it provides direct assistance for a specific problem (pollutant) and can generally be implemented at fairly short notice. Overall, however, it is important to bear in mind that the measure, apart from reducing the discharge of nutrients into coastal seas, is only suitable for rehabilitation of a regionally restricted area.

Furthermore, measures in the field of "sewage treatment plant upgrading" tend to be more cost-intensive than measures aimed at reducing discharges of nutrients from agriculture (cf. also "*Kosten-Wirksamkeitsanalyse von nachhaltigen Maßnahmen im Gewässerschutz*", UBA 2002). With regard to the reduction of the total nitrogen loads into coastal seas, overall, the expansion of sewage treatment plants in Germany offers little potential compared with agriculture.

As such, the upgrading of a sewage treatment plan will tend to be more expedient if needed e.g. due to an increased protection requirement for the water body, or if a plant fails to reflect the best available technology.

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Data Sheet No.1.2

Pressure category according to the Water Framework Directive, Annex II: *Point sources*

Polluter category: *Industry ⇒ Direct and indirect dischargers, local authority sewage treatment plants*

Description of the measure

No. 1.2: Reducing the discharge of substances from chemical production and application via membrane filtration

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Brief description / Specification of the measure

The chemical industry produces and uses a large number of substances that are hazardous to humans and the aquatic environment. Even if used correctly, many of these substances enter the groundwater and surface water as a result of application losses, leakages and via sewage discharges. This may have adverse impacts on the aquatic system and various uses. The most relevant hazardous substances at present are listed in Annexes VIII Nos. 1 to 9, IX and X of the Water Framework Directive.

As a general rule, industrial sewage is purified at special in-house sewage treatment plants prior to discharging into a river (direct dischargers) or fed into a public sewage treatment plant via the sewerage system (indirect dischargers). However, this must not be disadvantageous for the public sewage treatment plants, as a result of which sewage is generally pretreated. A few other problematic substances such as pharmaceuticals, hormones etc. enter sewage ubiquitously and therefore can only be eliminated in a local authority plant, if at all.

There are numerous options and techniques for reducing sewage loads, whereby the choice of technique is influenced to a large extent by the substances contained in the sewage. Once important technique for the purification of industrial sewage is **membrane filtration**.

Players involved in implementing the measure

☐ Federal Government	☑ Local authorities	☑ Associations, independent organisations
☐ Länder Government	☐ EU	☑ Private individuals

Effect analysis

Primary effects:

Reducing the pollutants discharged into rivers is significant for the attainment of good ecological and chemical status as required by the Water Framework Directive. By employing suitable techniques, the discharge of chemical substances into rivers may be minimised.

Membrane techniques are purely physical techniques for substance separation, in which the process water or sewage being treated is separated into purified water (filtrate or permeate) and a concentrated phase (concentrate). Unlike conventional filter technology, pressure-driven membrane techniques permit separation down to the molecular range. They may be used for the treatment of water or for concentration of its constituents. The optimum choice of membrane depends on the key criteria of required separation limit, membrane material, specified module type and technique (IVT, ISA, 2003). Depending on the porosity of the membrane, a distinction is made between micro-filtration, ultra-filtration, and reverse osmosis.

The requirements placed on the membrane vary considerably. Apart from the composition of the water, requirements governing the permeate (filtrate) also play an extremely important role.

Ultra-filtration is the technique with the broadest spectrum of applications, whilst reverse osmosis is the most efficient method, permitting the concentration of substances with a low molecular weight. The usability of both techniques depends on the location of the products.

Ultra-filtration is used to treat oil/water mixtures occurring in industry, as well as in the chemicals industry, metal-processing industry, textiles industry etc. Reverse osmosis permits the separation of nearly all organic and inorganic pollutants, i.e. including heavy metals. The application areas of reverse osmosis are diverse and range from the production of completely desalinated water, to the reconcentration of landfill leachate, through to the recovery e.g. of lye and rinse water.

The application of reverse osmosis and ultra-filtration is limited according to the concentration range of the solutions being treated. For example, at lower ranges, the use of an ion exchanger is more cost-effective. Ion exchangers are used to remove salts (cations and anions) from the water.

Secondary effects:

Material:

Membrane filtration also reduces substances that may be filtered off. Reducing the particulate substances in the sewage also helps to reduce sedimentation and sludge formation in the water body, and hence minimise the impairment to natural habitats.

Economic / social effects:

Costs are incurred for industry and local authorities.

Time required

Until implementation: Short-term

Until effectiveness: Short-term

Geographical effect

☑ local ☐ regional ☐ Nationwide / EU-wide

Interactions with other measures

The discharge of substances from the chemical industry cannot be adequately restricted with an "end-of-pipe" system alone. As such, it is important to achieve a reduction/avoidance of substance discharges at the source using suitable instruments. In the area of industrial discharges, this approach is addressed by the IPPC Directive and the corresponding national legislation (Waste Water Ordinance, Emissions Declaration Ordinance, Quality Target Ordinance).

The process to develop the best available technology (BAT) is particularly relevant for ensuring that membrane filter technology becomes more widely used (cf. instrument X to strengthen the synergies between the IPPC Directive and the Water Framework Directive). Within the context of continuous advancement of the state of the art, as specified in the Annexes to the Waste Water Ordinance, the use of membrane filters should be taken up wherever practicable and financially expedient.

Cost estimates

The principal factors influencing a plant's cost efficiency are the on-going operating costs and the membrane replacement costs. With regard to the membrane replacement costs, the service life of the membrane is a key factor. The service life, in turn, depends on the sewage composition, the membrane material, the type of purification agent, the number of purification operations etc. The bulk of the energy costs are attributable to ventilation. This is likewise dependent upon the contaminant load of the sewage.

All in all, it is difficult to specify generally transferable costs in the industrial sector, since these depend to a large extent on the nature of the sewage.

Energy requirement figures vary from 0.7 – 1.5 kWh/m³ of purified sewage for aeration and membrane filtration (cross-flow micro-filtration) (KA, 2000). In a membrane plant which commenced operation in May 2003, around 0.35 to 0.6 kWh/m³ was attributable to the filtration stage alone (D. Wedi, S. Kexel, H. Resch, 2003).

For further details of cost, cf. measure 1.1.

Uncertainty factor

With all membrane filtration processes, deposits in the membrane are unavoidable, even with adequate and proper pretreatment. The nature and degree of fouling depends on a number of different factors, such as the quality of the input water, the membrane type, the membrane material, the construction of the plant, and the monitoring system. In this way, under certain circumstances, high operating costs may be incurred. Theoretically, reverse osmosis and ultra-filtration are reversible processes occurring at a constant temperature with minimal energy input. In practice, however, it has been found that the expenditure on equipment is high (investment and repair costs are key factors of cost efficiency).

Summarising qualitative assessment

The upgrading of a local authority sewage treatment plant or pretreatment using membrane filtration may help to resolve a local problem. Furthermore, one aim of water protection in Germany is to prevent, avoid or permanently reduce the contamination of surface water and groundwater with pollutants (LAWA, 1990). Membrane technology is a promising method with respect to industrial pollutants, and a key technology for ensuring sustainable water protection.

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Data Sheet No. 1.3

Pressure category according to the Water Framework Directive, Annex II: *Point sources*

Polluter category: *Local authorities/households ⇒ Rainfall/combined sewage discharge*

Description of the measure

No. 1.3: Qualified dehydration in the combined and separation process

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Brief description / Specification of the measure

- Qualified dehydration in the combined and separation process: Ecologically expedient and economically justifiable separate collection and discharge of rainfall and sewage, discharge of heavily contaminated rainwater only after prior treatment, better exploitation of existing capacities, continuing construction of relief plants, greater consideration of the increased purification capacity of more modern treatment techniques such as soil filters.
- Modified separation and combined system: Separate collection of rainfall and dirty water. Breakdown of rainfall into different sub-flows. Heavily contaminated rainfall is either conveyed separately to a treatment plant (modified separation system) or enters the combined sewer together with domestic, commercial or industrial sewage (modified combined system). Any rainfall not conveyed to the sewage treatment plant or to a separate treatment plant either seeps away or is discharged locally into the outfall.
- Combined sewers: Nationwide implementation of existing *Länder* requirements; increase in the volume for intermediate storage via the optimised use of existing capacities (sewer, sewage treatment plant) and via the construction of relief structures and retention soil filters for greater minimisation of chemical and hydraulic pressures (cf. measure no. 1.5).
- Separate sewers: Discharge of heavily contaminated rainfall only after prior treatment. Farther-reaching requirements depending on the pressure situation of the water body (cf. for example ATV-AG 2.1.7, 1998).

Players involved in implementing the measure

☐	Federal Government	☑	Local authorities	☐	Associations, independent organisations
(☑)	*Länder* Government	☐	EU	☐	Private individuals

Effect analysis

Primary effects

Measures in the area of rainfall management may reduce the hydraulic pressure on the water bodies as well as the chemical pressure. From a chemical viewpoint, nutrients and heavy metals are particularly important.

Modified collection and discharge of rainwater and dirty water: Generally speaking, from an ecological viewpoint, it is preferable to discharge rainfall and sewage separately. The principle of decentralism may be followed, i.e. seepage of the rainfall (in such cases, the rainwater remains in the natural water cycle) or addition to the outfall, preferably at the site of occurrence. Unacceptably contaminated rainwater requires pretreatment before it is discharged, so as to minimise the chemical pressure.

Combined sewer (accounting for approximately 2/3 in Germany): Based on a specific storage volume requirement averaging at 0.35 m³/inhabitant, Dohmann et al. (1997) estimated the storage volume demand in 2010 at approximately 18 million m³. The derived loads of substances removable via filtration could be reduced by approximately 50 % in total in this way. Corresponding improvements can also be achieved for pollutants that are discharged primarily in particulate form (some heavy metals; polycyclic aromatic hydrocarbons (PAH)). Depending on the proportion of dissolved pollutant, however, the effect is significantly lower (e.g. in the case of COD, the improvement is only approximately 20 – 30 %). According to very rough estimates (e.g. in Borchardt et al., 1998), farther-reaching measures are needed in approximately 30 to 50 % of cases, due to the water body situation. The purification capacity with more widespread co-treatment at sewage treatment plants or when using soil filters is significantly higher than that of sedimentation tanks which act mechanically (e.g. for substances that may be filtered off, elimination is more than 75 %; e.g. Born, 1997) (cf. also measure no. 2.7 “retention soil filter”).

Separate sewer (accounting for approximately 1/3 in Germany): The pollutant pressure in rainwater discharged from separate sewers is comparable with that of combined sewage discharges in the combined system via rain spillway basins, and may even be significantly higher for certain pollutants. To date, tank volume for rainwater treatment in separate systems has only been created to a minimal extent (until 1995: 0.7 million m³ rain purification ponds; plus an additional 9.2 million m³ rain storage reservoirs). Consequently, a considerable reduction in pollutant loads is also to be expected from the construction of efficient additional ponds.

Secondary effects

Effect on other media:

Separation system: Foul sewers may be dimensioned smaller than combined sewers because they are not required to discharge large outflows of rainwater which only fall for a few hours a year. Nevertheless, increased costs may be incurred with separate discharge, and sewage discharges into the rainwater sewer (faulty connections), which occur quite frequently in practice, are another disadvantage.

Economic / social effects:

Effects on public budgets: Pressure depending on the subsidy portion from public funding.

Time required

Until implementation: Short- to medium-term

Until effectiveness: Short- to medium-term

Geographical effect

☑ local ☑ regional ☐ Nationwide / EU-wide

Interactions with other measures

The reduction in the volume of water discharged into the sewer network reduces the hydraulic pressure on the rivers (cf. measure no. 5.2 in the area of river structure).

Measures no. 5.4 “Improvement of bank and bed structures” and sub-measure 5.2 “River bed widening” should likewise be considered as measures to minimise the effects of rainfall discharges. Measures to improve the bank structures and hence create shade have a beneficial influence on the oxygen balance and possible ammonia concentrations (temperature dependency). River bed widening may ameliorate hydraulic pressures on rivers.

There are some overlaps between the areas of “rainfall treatment” and “flood protection” (cf. measure no. 4.2). Via retention in populated areas and the adapted use of rainwater, the volume of water is reduced and/or part of the outflow volume is retained and discharged with a time delay.

There are also interactions with other measures designed to minimise chemical and hydraulic pressures from rainfall / combined sewage discharges (measures no. 1.4, 1.5, 1.6).

Cost estimates

- Implementation of the minimum requirements for combined sewers: with a cost of approx. **750 €/m³** for rain spillway basins (average basin size in 1995 was 655 m³) this produces total costs of **4 billion €** for the construction of rain spillway basins at the end of 1998.

- Implementation of the minimum requirements for separate sewers: According to ATV-AG 1.4.3 (1994), the specific volume of rain purification ponds is approximately 10 m³/ha of stabilised catchment area, with average production costs of around **1,000 €/m³.** The total pond volume requirement for Germany is unknown (differing provisions in the various Federal *Länder*). According to statistics supplied by the Federal Statistical Office (StaBu, 1995; 1998), just under 70,000 m³ of pond volume per annum was constructed between the years 1991 to 1995, which is roughly equivalent to an investment total of approximately **70 million € per annum**.

- cf. also measures no. 1.4 and 1.5

Uncertainty factor

When estimating emissions from human settlement drainage, it is important to bear in mind that according to existing studies, the concentration levels of the various substances in the different outfall compartments fluctuate widely, and as a result, corresponding calculations are likewise subject to significant fluctuation ranges (UBA, 2002).

The actual local effects of measures (e.g. avoidance of acute toxic effects from NH_4-N/NH_3-N pressures) depend to a large extent on the governing peripheral conditions, and must therefore be considered on a case-by-case basis.

At present, it would seem that costly measures are difficult to enforce in the local authority sewage sector. Admittedly, in future, more cost-effective solutions may become possible with rainfall management, thanks to more recent concepts and technical developments.

There is also a considerable need for coordination between the Federal *Länder* for a joint approach.

Summarising qualitative assessment

Despite potential problems with implementation and the existing need for coordination, the measure is important for reducing chemical and hydraulic pressures from human settlement drainage (rainfall treatment). The proportion of overall emissions attributable to the area of rainwater management, and hence the potential for reducing emissions, is high.

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Data Sheet No. 1.4

Pressure category according to the Water Framework Directive, Annex II: *Point sources*

Polluter category: *Local authorities/Households ⇒ Rainfall/Combined sewage discharge*

Description of the measure

No. 1.4: Decentralised measures for the avoidance, reduction and delay of outflow: Utilisation of desealing potential and rainwater seepage; recommendations for a split fee scale

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Brief description / Specification of the measure

“Semi-natural rainwater management” via the use of desealing potential, or via “desealing programmes”, rainwater seepage, rainwater use, direct discharge into overground watercourses, roof gardening measures, where technically and ecologically expedient (groundwater protection) and economically justifiable.

Currently in Germany, some 100 to 120 ha per day is converted into human settlements and transport infrastructure. This consumption should be reduced to 30 ha per day by 2020 (Schröter, 2000). The proportion of sealed land is to be reduced to an unavoidable minimum. Seepage or a combined system should be provided in order to drain the land which remains sealed.

Seepage may occur via surface storage (land seepage, trough seepage, pond seepage) or underground storage (trenching and pipe seepage, trough trenching seepage or manhole seepage). Allowance must be made for specific precautionary measures, such as fitting these systems with qualified filters.

In this respect, it is important to note that when implementing this measure, there are significant differences between new developments and existing developments. The land requirement and modifications to drainage plans may be taken into account more readily with land that is to be newly developed. As such, this measure may implemented more expediently and with greater economic justification in new developments. Land desealing on existing developed land generally entails disproportionately high costs.

As a general rule, with "semi-natural rainwater management" measures, it is important to consider what effects these will have on the water balance, the soil and other resources as well as on groundwater quality, so as to prevent adverse impacts on other media to offset the positive impacts on the water balance. Generally speaking, rainwater seepage may only occur in drinking water protection areas via the aerated soil zone, because otherwise this could result in a deterioration in the groundwater quality.

Players involved in implementing the measure

☑ Federal Government	☑ Local authorities	☐ Associations, independent organisations
☑ *Länder* Government	☐ EU	☐ Private individuals

Effect analysis

Primary effects:

This causes a reduction in the overall load discharged into surface water bodies. The desealing potential in Germany is approximately 10 % of sealed land, whilst more seepage-friendly coverings are possible on a further 22 % of land (BMU, 1998). The maximum seepage potential, according to an ATV survey of local authorities which already practice seepage, is estimated at approximately 14 – 24 %. Overall, the proportion of land which may be disconnected from the sewer network in the medium term via the aforementioned measures, thanks to desealing and seepage, is estimated at approximately 10 – 15 %. As the purification effect of existing treatment techniques is directly dependent on the volume of water, the resultant reduction in pollutant loads may be estimated at approximately 10 – 15 %.

Measures to avoid, prevent and delay outflow may effect considerable hydraulic relief for sewer networks, sewage treatment plants and outfalls.

Secondary effects:

Material:

Higher levels of seepage increase the quantity of water returned to the groundwater. In this respect, it is important to remember that the groundwater level may rise and the groundwater may become more heavily polluted under certain circumstances.

As a general rule, measures to avoid, reduce and delay outflow are used for outflows with low levels of contamination. One consequence of this is that the outflows into rainwater networks based on the separation technique and in combined sewage networks indicate higher concentrations (less dilution of more heavily contaminated rain outflows which continue to be discharged and the dry weather outflow). This factor should be taken into account when dimensioning the plants for rainfall treatment (MURL NRW, 1999).

Generally speaking, with persistent pollutants (such as heavy metals), rainwater management measures will not effect a reduction in emissions into the environment, but will instead lead to a displacement into the soil or waste sector. For this reason, parallel measures are needed at the emission sources e.g. targeting the use of heavy metals outdoors or the sources of air emissions.

<u>Effects on other media:</u>

For sewer networks in need of modernisation, greater seepage may lead to an increase in the quantity of foreign water. Conversely, a reduction in the proportion of foreign water via sewer modernisation measures will increase the sewer and sewage purification plant capacity available for improved rainwater treatment. Generally speaking, when a sewer is due for modernisation, all the opportunities for rainwater seepage must be taken into account.

Time required

Until implementation: Medium- to long-term

Until effectiveness: Medium- to long-term

Geographical effect

☑ local ☐ regional ☐ Nationwide / EU-wide

Interactions with other measures

The reduction in the quantity of water discharged in the sewer network reduces the hydraulic pressure on water bodies. Measures no. 5.4 “Improvement in bank and bed structures” and sub-measure 5.2 “River bed widening” should likewise be considered as measures to minimise the impacts of rainwater discharges. Measures to improve the bank structures and hence create shade have a positive influence on the oxygen balance and potential concentrations of ammonia (temperature dependency). River bed widening may ameliorate hydraulic pressures on the water bodies. As such, there are interactions with the measure under consideration.

There are also interactions with other measures designed to minimise the chemical and hydraulic pressures from rainwater / combined sewage discharges (measures no. 1.3, 1.5, 1.6). Measures to avoid, reduce and delay outflow may increase the concentration of pollutants in the outflow, with both the separation technique and the combined technique. This factor must be taken into account when dimensioning the relief equipment.

Cost estimates

An overview of costs for seepage plants was published by Londong/Nothnagel (1999). These fluctuate according to a variety of factors (soil quality, own input by the parties involved, new development or existing development etc).

Cost of rainwater seepage in **€/m²** in relation to $\mathbf{A_{red}}$ (in the original version, costs are specified in DM/m², for the purposes of this account, these costs were converted into Euros at the official exchange rate):

Technique	Mean	Median	Lowest value	Highest value
Trough seepage	**5.62**	**5.11**	**1.28**	**15.34**
Pipe or trenching seepage	**11.76**	**7.67**	**3.58**	**24.54**
Manhole seepage	**13.29**	**12.27**	**3.83**	**25.56**
Trough trenching seepage	**25.77**	**24.03**	**6.14**	**42.95**
Other trough combinations	**16.05**	**14.32**	**8.44**	**31.70**
Retention and restricted discharged	**15.49**	**11.91**	**9.20**	**33.23**

Whether the area in question is a new development or an existing development plays an important role for semi-natural rainwater management. In new developments, local disposal of rainwater can often be achieved cost-effectively. According to an evaluation by Hamacher (2000) of the comparative calculations documented in the literature, semi-natural rainwater management is the more cost-effective solution compared with conventional disposal (although he questions whether negative examples are published to the same extent). It is generally more difficult and time-consuming to achieve semi-natural rainwater management by means of modifications to the existing stock. The following table lists cost data for the desealing and/or seepage of rainwater in existing developments (in the original, costs are given in DM; for the purposes of this account, we have used the official exchange rate for conversion into Euros) (from: Kostenwirksamkeitsanalyse von nachhaltigen Maßnahmen im Gewässerschutz <*Cost-efficiency analysis of sustainable measures in water protection*>, UBA, 2002):

	Favourable conditions	Average conditions	Unfavour-able conditions
Construction costs for desealing **(€/m²)**	**15.34**	**30.68**	**51.13**
Utilisation period of stabilised seepage areas	25 years		
Operating costs **€/(m²*a)**	**-0.77**	**-0.51**	**0**
Annuity for desealing **€/(m²*a)**	**0.072**	**1.22**	**2.93**
Construction costs for seepage **(€/m² $A_{red.}$)**	**5.11**	**15.34**	**25.56**
Utilisation period for seepage equipment	25 years		
Operating costs **€/(m²*a)**	**-0.72**	**-0.38**	**0.26**
Annuity for seepage **€/(m²*a)**	**-0.47**	**0.48**	**1.74**

It should be noted that desealing and seepage measures may lead to savings in the sewer network required, sewerage redevelopment and sewage treatment.

Uncertainty factor

There is a substantial need for coordination between the Federal *Länder* for a joint approach. Furthermore, costly measures are deemed difficult to implement at present in the local authority sewage sector. However, cost-effective solutions for rainwater management are possible in future, thanks to more recent concepts and technical developments. It is important to remember that land desealing of existing developments generally entails disproportionately high costs.

The actual local effects of measures (e.g. avoidance of acute toxic effects as a result of NH_4-N/NH_3-N pressures) depend to a large extent on the respective peripheral conditions and must therefore be considered on a case-by-case basis.

Summarising qualitative assessment

The consequences of the drainage of developed and stabilised land may be at least partially reduced by means of “semi-natural rainwater management”. Overall, the proportion of emissions from rainwater management as a share of total emissions, and hence the emission reduction potential, is high. Handling rainwater in a manner compatible with the requirements of ecological water body management, with due regard for technical, ecological and economic requirements, therefore represents an important step in the attainment and preservation of the targets outlined in the Water Framework Directive.

Furthermore, in future, cost-effective solutions for rainwater management are also possible as a result of more recent concepts and technical developments.

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Data Sheet No. 1.5

Pressure category according to the Water Framework Directive, Annex II: *Point sources*

Polluter category: *Local authorities/Households ⇒ Rainfall/combined sewage discharge*

Description of the measure

No. 1.5: Structures for combined sewage and rainfall treatment (retention soil filters, rain spillway basins, canalisation and rain storage reservoirs)

Brief description / Specification of the measure

Retention soil filters are structures for the retention and purification of dirty rainwater and combined sewage outfalls. They help to reduce both chemical and hydraulic pressure on the water bodies. As such, retention soil filters meet the two principal requirements for rain water treatment from the viewpoint of holistic water protection.

Rain spillway basins, canalisation and rain storage reservoirs are structures for rain discharge. They are stipulated in order to minimise the inflow to the sewage treatment plant in case of rain, and to store and mechanically clarify (filter, sedimentation effect) the outflow discharged into the water body.

Administrative measures

- Purchase of land (relatively large amounts of land required for soil filter systems)

Structural measures

- Construction of a retention soil filter, possibly behind existing rain spillway basins with inadequate capacity (in terms of retention and/or purification)
- Construction of rain spillway basins, rain storage reservoirs, connected downstream as attenuation basins, storage reservoirs and similar devices

Players involved in implementing the measure

☐ Federal Government	☑ Local authorities	☐ Associations, independent organisations
☑ *Länder* Government	☐ EU	☐ Private individuals

Effect analysis

Primary effects

Minimisation of the hydraulic pressure from combined sewage / rainwater discharges: storage and/or delayed discharge of rainfall. This has a beneficial effect on the water body structure.

Retention of chemical pressures (retention soil filters: including dissolved substances, otherwise solids), thereby helping to prevent damage to living communities in the water body and silting of the river bed.

Reduction of clouding in the water body, retention soil filters are also effective with the elimination/conversion of ammonium (common cause of species poorness in water bodies).

Retention soil filters: Retention of pathogenic pressures, which is significant for the use of a water body as bathing water, for irrigation purposes or for drinking water abstraction (detailed investigations of this problem have yet to be carried out, however).

Secondary effects

<u>Effects on other media:</u>

- Relief of the downstream sewer network and the sewage purification plant, and hence reduction of costs in these areas

Retention soil filters:

- Meet the principal requirements of rainwater treatment with a better cost/benefit ratio than with larger concrete structures
- Enrichment of the landscape: Plants instead of concrete ponds
- Soil filters planted with reeds are classified as a compensatory measure

Time required

Until implementation: Short- to medium-term

Until effectiveness: Short- to medium-term

Geographical effect

☑ local ☑ regional ☐ Nationwide / EU-wide

Interactions with other measures

The measures influence the sewer network below and must therefore be taken into account with other measures to relieve the sewer network (measures no. 1.3, 1.4, 1.6).

Furthermore, the hydraulic action of the storage device should also be taken into account with measures to improve the structural quality (e.g. river profile widening to minimise the influence of combined sewage/rainwater discharges, cf. measure no. 5.2).

Measures no. 5.4 “Improvement of bank and bed structures” and sub-measure 5.2 “River bed widening” should likewise be considered measures designed to minimise the impacts of rainwater discharges. Measures to improve the bank structures and hence to create shade have a beneficial influence on the oxygen balance and potential ammonia concentrations (temperature dependency). River bed widening may ameliorate hydraulic river pressures.

There are overlaps with the areas of “rainwater treatment” and “flood protection” (cf. measure no. 4.2). Via retention in human settlement areas and adapted rainwater use, the quantity of water is reduced, or part of the wave volume is retained and discharged with a time delay.

Cost estimates

Retention soil filter:

The construction costs of a soil filter basin depend on its volume. The larger the basin, the lower the specific costs. With soil filter basins, these are significantly lower than with concrete structures (HMULF, 2002). However, the cost of the overall plant under normal combined sewage treatment requirements, tend to be higher than with rain spillway basins, since the land required for retention soil filters is greater, and additional equipment is required for the separation of solids (e.g. rain spillway basins, canalisation, sieves). These must be additionally taken into account in accordance with the relevant indicative costs.

A few indicative costs are given below by way of examples:

The Bavarian State Ministry for Rural Development and Environmental Issues, in its guidelines on the allocations for water management projects (RZWas2000), provides the following guidelines for retention soil filters :

Indicative cost = **7,299 * $x^{-0.46}$ [€/m³]; max. 640 €/m³**

Apart from the cost of structural and mechanical engineering, the costs also include the cost of earthworks, sheet piling, pondage and pipelines.

In North-Rhine Westphalia (MUNLV, 2003) the construction prices of built installations were compiled, and the following indicative cost was ascertained:

Indicative cost = **3,415 * $x^{-0.385}$ [€/m³]** (net price);

The costs include earthworks and filter construction including drainage system, inlet and outlet structures, seals, measurement and control systems, planting, and other expenditure.

The following indicative costs apply in Hesse (HMULF, 2002):

Storage volume	Indicative cost
< 500 m³	**500 €/m³**
500 m³ ≤ X ≤ 2,000 m³	**7,235 $X^{-0.43}$ €/m³**
> 2,000 m³	**275 €/m³**

The indicative costs include total expenditure for the soil filter and the equipment needed for operation, and refer to the storage volume required in accordance with the licensing notice.

The particular advantages of constructing soil filters for the relief of rivers should be taken into account by means of a fixed 25% surcharge on the amount calculated for the soil filter based on the indicative cost.

Rain spillway basin, rain storage reservoir, canalisation:

The construction costs are dependent upon the basin volume. The larger the basin, the lower the specific costs. Various cost information is listed below.

The Bavarian State Ministry for Rural Development and Environmental Issues, in its guidelines on the allocations for water management projects (RZWas2000), provides the following guidelines for rain basins (depending on the usable tank volume):

Indicative cost = **2,925 * $x^{-0.22}$ [€/m³]; max. 1,280 €/m³**

For rain basins constructed in the earth, an indicative cost of: **62 €/m³** applies.

This includes the related regulation and control devices, as well as the sewers and relief sewers connecting the structures up to a total of 20 m.

Investitionskosten der Abwasserentsorgung <*Investment Costs of Sewage Disposal*> (Günthert; Reicherter, 2001) cites the following formula for the calculation of costs:

Indicative cost = **8,427.62 * $x^{-0.3543}$ [€/m³]**;

The cost given includes structural and mechanical engineering.

The following indicative costs apply in Hesse (HMULF). The indicative costs include expenditure on regulation devices, controls, as well as the basin overflow and the discharging structure. The sewers and relief sewers connecting the structures, up to a length of 20 m in each case, are already included in the indicative costs.

Rain spillway and rain storage reservoirs (open design):

Storage volume	Indicative cost
< 500m³	**740 €/m³**
500m³ ≤ X ≤ 2,000m³	**16,545 X-0.50 €/m³**
> 2,000m³	**370 €/m³**

Rain spillway and rain storage reservoirs (closed design):

Storage volume	Indicative cost
< 100m³	**1,650 €/m³**
100m³ ≤ X ≤ 2,000m³	**12,024 X-0.50 €/m³**
> 2,000m³	**455 €/m³**

Canalisation:

Storage volume	Indicative cost
< 90m³	**1,742 €/m³**
90m³ ≤ X ≤ 1,550m³	**13,801 X-0.46 €/m³**
> 1,550m³	**470 €/m³**

Uncertainty factor

The following factors may have a major influence on the success of purification:

- Choice of suitable filter substrate depending on the purification objective, load frequency and load level of the filter, dry period between loads (retention soil filter)
- Chemical composition of the water
- Regional and network-specific circumstances (e.g. sealing, problem of foreign water)
- Sedimentation in the sewer network following long periods of dry weather

The costs are dependent upon the local circumstances (for example, rising groundwater may increase the costs enormously)

Summarising qualitative assessment

Retention systems are suitable for both urban and rural areas. They may be considered for all types of development measures. Against the background of the required reduction in water body pressures and the determination of immission-specific requirements, the subsequent expansion of retention systems is vital. In this way, direct discharges into the water course may be reduced. The staff and material input for operation is comparatively low.

In particular, retention soil filters are a very interesting proposition in view of the aforementioned background, since in many cases, they meet the requirements of holistic water protection.

However, the retention soil filter is not a cheap substitute for a rain spillway basin. Soil filters are effective, inexpensive systems for more extensive combined sewage treatment which, in addition to reducing pollution loads, may also help to relieve the hydraulic pressure on the water body and the downstream sewage treatment plant (LfU, 2002).

In case of problems in the sewage treatment plant with an increased inflow of combined sewage and with farther-reaching requirements pertaining to combined sewage treatment, however, the minimal cost disadvantage of conventional rain spillway basins may be transformed into an advantage, because:

- the volume of the cheaper soil filter basin as a proportion of the required overall volume increases,
- improved water pollution control can be achieved, thanks to a larger storage volume,
- pressure on the sewage treatment plant is also relieved, thereby allowing savings to be made with operating costs (LfU, 2002).

From these aspects, retention soil filters are a very inexpensive component of ecological combined sewage treatment, capable of competing with all other forms of rainwater management.

Particularly with a view to implementation of the EU Water Framework Directive (greater orientation towards the requirements of combined sewage treatment depending on the water body situation), retention soil filters are gaining in significance, since their use facilitates compliance with future requirements.

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Data Sheet No. 1.6

Pressure category according to the Water Framework Directive, Annex II: *Point sources*

Polluter category: *Local authorities/Households ⇒ Rainfall/combined sewage discharge*

Description of the measure

No. 1.6: Supporting measures to reduce pressures from rainwater discharges

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Brief description / Specification of the measure

In order to minimise pressures arising as a result of the discharge of rainwater and combined sewage into water bodies, supporting measures may be used, such as:

a) percolation trenches, gravel filters and vegetation passages connected downstream of a reservoir structure (the filter effect when water flows over the trenches facilitates excellent retention of pollutants)

b) Rakes, sieves, vortex separators and other mechanical techniques (e.g. downflow baffle) for the retention of particulate floating debris and, to a limited extent, for the retention of suspended matter.

Players involved in implementing the measure

☐ Federal Government	☑ Local authorities	☐ Associations, independent organisations
☐ *Länder* Government	☐ EU	☐ Private individuals

Effect analysis

Primary effects:

a) Percolation trenches, gravel filters and vegetation passages have a moderate to good effect on the retention of substances. Particularly for low and medium rainfall, vegetation passages achieve good retention of substances that may be removed by filtration, thanks to sedimentation and filtration in the planted soil body. At the same time, this effects a reduction in oxygen-depleting substances. The effects with respect to the NH_3 problem are rated as slight to moderate. Percolation trenches and gravel filters which the water flows through, rather than over, as is the case with vegetation passages, have a comparable effect to vegetation passages with the retention of substances that may be removed by filtration (MURL, 1999).

b) Sieves and rakes are suitable for the retention of particulate floating debris and, to a limited extent, for the retention of suspended matter on relief structures of combined sewers. In practice, they are used when additional requirements are placed on the retention of floating debris. Their effectiveness lies primarily in the aesthetics, since coarse matter is removed. Its effect on dissolved substances has not been clearly proven. Depending on the design, however, the effect on substances removable via filtration may be quantified more clearly. By linking BOD_5 and COD to the substances that may be removed by filtration, therefore, it is also possible to improve the outfall situation in terms of these parameters.

Secondary effects:

Material:

Re b) As well as separating floating debris, a low level of effectiveness is also achieved with respect to suspended matter.

Effects on other media:

Re a) With large-scale vegetation passages, additionally, a noticeable dampening of outflow peaks may be achieved.

Time required

Until implementation: Short-term

Until effectiveness: Short- to medium-term

Geographical effect

☑ local ☐ regional ☐ Nationwide / EU-wide

Interactions with other measures

Re a) The creation of vegetation passages may have a beneficial influence on the water body structure if the area is sufficiently large to dampen outflow peaks. In this way, manifestations of erosion may be avoided or minimised.

Measures no. 5.4 “Improvement of bank and bed structures” and sub-measure 5.2 "River bed widening" should likewise be considered measures designed to minimise the effects of rainwater discharges. Measures to improve the bank structures and hence to create shade have a beneficial influence on the oxygen balance and potential concentrations of ammonia (temperature dependency). River bed widening may ameliorate the hydraulic pressures on the water body.

Interactions with the other measures to minimise chemical pressures from rainfall / combined sewage discharges continue to apply (measures no. 1.3,1.4,1.5).

Cost estimates

Re a) The costs for percolation installations vary widely depending on the circumstances such as volume of relief water, land needed, soil etc. Measure sheet no. 1.6 “Decentralised measures for the avoidance, reduction and delay of outflow: Use of desealing potential and seepage of rainwater” lists costings for various types of percolation installations. According to this, the cost of retention with a restricted discharge is between **9 and 30 €/m².**

Re b) The cost of a rake or vortex separator varies significantly depending on the quantity of water relieved, the purification volume and on whether or not the rake is self-cleaning. For a sample project (connected residents = 1,500, sealed land = 25 ha), around **50,000 €** was calculated for a self-cleaning rake with a rod spacing of 4 mm (high purification performance). Investitionskosten der Abwasserentsorgung *<Investment costs of sewage disposal>* (Günthert, Reicherter, 2001) quotes the formula: $y = \mathbf{213.3 * inhabitant^{-0.2643}}$ **[€/inhabitant]** for the construction of a new rake (as part of a sewage treatment plant). For example, with 1,500 inhabitants, this would produce costs of approximately **46,300 €**.

Uncertainty factor

Re a) The effectiveness of this measure cannot be quantified with general validity.

Re b) Effectiveness depends on the properties of the combined sewage (proportion of coarse particles, substances removable via filtration)

Summarising qualitative assessment

Re a) Percolation trenches, gravel filters and vegetation passages have a moderate effect on the retention of constituents and a low effect on hydraulic pressures. As components of relief structures that are connected downstream, they are very effective in the retention of substances removable via filtration and hence the particulate portions of substances that deplete oxygen. As a general principle, it is advisable to make them mandatory in order to improve substance retention at discharge points (MURL, 1999).

Re b) Sieves and rakes are only moderately suitable for improving the qualitative situation of a river. However, as they have a beneficial effect on the aesthetics of a river and entail minimal costs, they should likewise be attached to the relief structures as a general principle.

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Data Sheet No. 2.1

Pressure category according to the Water Framework Directive, Annex II: ***Diffuse sources***

Polluter category: ***Agriculture***

Description of the measure

No. 2.1: Reduction of nutrient and pesticide discharges via the creation of riparian buffer strips

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Brief description / Specification of the measure

By creating a riparian buffer strip with extensive use of grassland and via erosion-minimising copse planting, discharges of nutrients and pesticides into rivers may be minimised.

It is worth bearing in mind that when planning and implementing the extensive use of grassland which is geared towards nature conservation, technical expertise and a knowledge of location factors and plant communities are needed.

Generally speaking, with extensive use, it is important to realise that as a general rule, it is not the intensity of use which damages river systems, but the intensity of fertilisation – **from an ecological viewpoint, the problem lies primarily in an imbalance between use and fertilisation**. Fertilisation must be in proportion to abstraction. As such, for an ecologically justified utilisation concept, the nutrient balance of the location should always be considered decisive.

Administrative measures

- Land conversion: Riparian buffer strips (desirable width 10m) with extensive grassland use or (if ecologically and economically justifiable) discontinuation of use.
- Transition of riparian buffer strips from commercial use by the owners into the hands of public or charitable organisations by means of:
  - Voluntary, binding declaration by the owner to discontinue use of the affected riparian buffer strips.
  - Land purchase
  - Specification of a maintenance plan aimed at avoiding conflicts of interest between different parties responsible for maintenance of a riparian buffer strip.

Structural measures

Planting and greening in accordance with the principal discharge routes for surface pollutant discharges, with due regard for countryside and nature conservation requirements.

Regular pruning may enhance the effectiveness vis-à-vis nutrient retention.

Other measures

- Differentiated regulations governing use at the riparian buffer strips, i.e. strip width and adjacent use, should be coordinated with one another (e.g. agricultural use, pastures in the bank vicinity, cattle watering at grassland sites).
- Coordination between the interests of water protection and agriculture in order to ensure that the countryside is kept open. Fallow land with grass and weeds that is subject to occasional maintenance (mulching or hay harvesting) may offer a possible solution.
- Preventing the direct access of vehicles and agricultural machinery via the type of marginal vegetation so as to avert the risk of direct discharge of nutrients and pesticides due to accidents and unauthorised actions.
- Removal of plants and structures in buffer strips which pose the risk of a concentrated point discharge of pollutants (e.g. slurry stores, solid manure stores, cattle watering, machinery washing stations etc.).

Measures with an ecological orientation may be implemented within the context of compensatory measures for intervention into nature and landscapes.

Players involved in implementing the measure

☐ Federal Government ☑ Local authorities ☐ Associations, independent organisations

☑ *Länder* Government ☐ EU ☑ Private individuals

Effect analysis

Primary effects:

- Reduced discharge of nutrients and pesticides
- Copses on riparian buffer strips reduce the erosion of agricultural land due to wind, and filter surface outflows following heavy rainfall, which is associated with a reduced discharge of elutriated soil components, nutrients and pesticides into the water bodies.

- Alders and water meadows, strips of grass and bush vegetation retain nitrogen, phosphorous and heavy metal compounds.
- Water quality is improved by minimising adverse human influences on the stability and performance capability of the water bodies.

Secondary effects:

Effects on other media:

- Improvement in bank structures
- Facilitation of an inherent dynamic development of the water body
- Positive effect on the landscape

Economic / social effects:

- Disadvantage for agriculture: Reduced yields due to a reduction in usable agricultural land and due to shading.
- Advantage for agriculture: Yield studies in Bavaria revealed that the positive influences of climatic factors extending far into the field (e.g. improvements in microclimate (climate melioration), wind braking) outweigh the negative influences. In individual cases, a 20 % increase in yield was observed as a result of copse strips.

Time required

Until implementation: Short- to medium-term

Until effectiveness: Medium-term

Geographical effect

☑ local ☑ regional ☐ Nationwide / EU-wide

Interactions with other measures

The measure is complemented by measures to reduce N, P and pesticide discharges (cf. measures no. 2.2, 2.3, 2.4), and in the case of copse plantings, by measure no. 5.4 “improvement of bank structures”, by measure no. 5.3 “inherent dynamic development via the provision of land” and by measures aimed at ecologically oriented flood protection (cf. measure no. 4.2).

Implementation of the measure may be supported or enforced by a variety of instruments. Conceivable options include instrument I “Subsidising of organic faming”, VII “Improvement of cooperation between farmers and the water industry" and VIII "Advice to farmers on optimum operation from a water protection viewpoint".

Cost estimates

Land purchase:

- Agricultural land: ≈**1.30 €/m²** (**range up to 4.00 €/m²)** (cf. UBA 1999)
- Conurbation areas: Agriculturally used land **> 5.00 €/m²** (cf. UBA 1999)

When purchasing land, additional costs are incurred for a new land survey, and may be considerable in some cases.

Sample costs for planting and structural measures:

- Plant copse barrier: Plant alders at suitable locations: **13.50 €/each** (3 per linear m) (cf. UBA 1999)
- Maintenance: ≈ **1.60 €/m * a** (cf. IGuG 2001)

Cost of a sample measure:

Merely purchasing agricultural land in order to create a riparian buffer strip for a 10 km long stretch of water:

10,000m * 10m * 2 = 200,000m² * 1.30 €/m² = **260,000 €**

Construction of a riparian buffer strip and planting with alders at suitable points along a 10 km long stretch of water: 260,000 € + 13.50 € * 3 per m * 200m = **268,100 €**

Generally speaking, farmers may apply for compensation for the construction of riparian buffer strips on agricultural land. The Federal *Land* of North-Rhine Westphalia, for example, has created an area-wide system to subsidise riparian buffer strips on agricultural land. This measure is designed to reduce the discharge of pesticides and fertilisers as well as soil erosion into water bodies. The creation of riparian buffer strips is one option for meeting this target.

Uncertainty factor

There is a potential conflict of interests with other water body users and other activities on or in the water, e.g.:

- Flood protection
- Agriculture
- Interests of other private riparian owners

Furthermore, it is also necessary to investigate whether riparian buffer strips may be removed from management or used as extensive grassland. In the case of grassland use, for example, it is necessary to clarify how the grassland can continue to be used – is there a need for pasture use or the sale of hay etc.?

Summarising qualitative assessment

The creation of a riparian buffer strip should be viewed as a fundamental measure, since it helps to minimise the discharge of fertilisers and biocides and of elutriated soil from agriculturally used land into the water bodies, entails a comparatively low level of expenditure, and also makes a decisive contribution towards improving morphological conditions. Additionally, the provision of riparian buffer strips is more or less indispensable for achieving an improvement in terms of water body structure. However, the buffer strip must be of adequate width in order to actually protect the water body against discharges, as a result of which the aforementioned conflicts of use may arise.

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Data Sheet No. 2.2

Pressure category according to the Water Framework Directive, Annex II: ***Diffuse sources***

Polluter category: ***Agriculture***

Description of the measure

No. 2.2: Reduction of nitrogen discharges into surface waters and groundwater

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Brief description / Specification of the measure

Compliance with "good agricultural practice" in conjunction with a groundwater and soil-conserving management system.

a) Determination of a requirement-oriented quantity of fertiliser (e.g. according to information supplied by the nitrate information service (NID)), preparation of land and farm gate balances.

b) Applying organic fertilisers in a manner which will conserve rivers, and ensuring adequate storage capacities: Application equipment in accordance with the best available technology, application only on receptive soil and on optimum horticultural dates, sealed storage containers, adequate storage capacity (storage space for at least 6 months).

c) Conversion of selected agricultural land into extensively used grassland or land use based on the principles of organic farming in accordance with EEC Regulation 2092/91 (reduction of overall fertiliser requirements):

Land should be converted if this produces a benefit for the environment. There are examples of agricultural systems deserving of nature conservation which are based largely on arable crop production with minimial product use. In such areas, the conversion of agricultural land into grassland would have harmful impacts, and measures should be taken to ensure the continuation of varied crop rotation systems, minimal product application, and continuous agricultural use. Furthermore, if large portions of the land are subject to restrictions on use, this may lead to the complete renunciation of grassland, which is not necessarily desirable in view of its multifunctional effects. In order to select the correct measures in the individual landscape systems, an inventory of a region's requirements should be carried out (evaluation of agro-environmental measures).

Particularly in drinking water protection areas, extensive grassland should be created. This can be implemented within the context of land reparcelling.

As a general principle, with extensive use, it is important to remember that it is not usually the intensity of *use* which harms the river systems, but the intensity of *fertilisation* – the ecological problem always lies primarily in an imbalance between use and fertilisation. Fertilisation must be proportionate to abstraction. As such, the nutrient balance of the site should always be used as a yardstick for an ecologically justified utilisation concept.

Furthermore, in particular, the intensive use of drained land is to be avoided.

Players involved in implementing the measure

☐ Federal Government	☐ Local authorities	☐ Associations, independent organisations
☐ *Länder* Government	☐ EU	☑ Private individuals

Effect analysis

Primary effects:

Because over 70 % of nitrogen discharges into rivers in Germany originate from diffuse sources (Daten zur Umwelt 2002 <*Environmental Data 2002*>, UBA), there is a substantial potential for reduction in this area. Environmental impairments can be minimised via the reduced use of fertilisers (discharges of nutrients into rivers, nitrate accumulation in groundwater, ammonia losses, pollutant accumulation in soils). By observing the basic principles of good agricultural practice when fertilising (Fertilisation Ordinance), together with river-conserving application techniques, and by reducing the total quantity of fertiliser that is used and needed, these types of environmental impairments can be largely avoided.

The environmental impacts (reduction of substance discharges into rivers) depend on

- The potential for individually profitable reduction, i.e. on the extent of over-fertilisation, and
- The realisation of this reduction potential.

Bach et al., 1992 refer to a very high, uneconomical level of over-fertilisation, the reduction of which could cut nitrogen excesses by up to 50 % (quoted according to Feldwisch/Frede, 1995).

Secondary effects:

<u>Economic / social effects:</u>

Re a) Helps to cut costs on the basis of reduced application of mineral fertilisers; may lead to an increased yield risk.

Re b) The application of slurry e.g. using the hose-towed technique reduces odours (as well as adding nutrients more effectively), which in turn leads to greater acceptance amongst the general public.

Re c) The conversion of arable land is likely to significantly affect the market balance, since it means that land is taken out of production (and replaced by extensively used grassland).

Time required

Until implementation: a) short-term b) short-term c) medium-term

Until effectiveness: Measures may become effective in the short-term, as well as in the medium- or long-term, depending on regional peculiarities.

Geographical effect

☑ local ☑ regional ☑ Nationwide / EU-wide

Interactions with other measures

The effectiveness of the measure is supported by the creation of riparian buffer strips, as a result of which the discharge of pesticides into water bodies is reduced (cf. measure no. 2.1)

The willingness of farmers to practice a water conservation-oriented approach when applying fertilisers may be increased by means of financial subsidies for organic farming and by taxes on fertilisers (cf. instrument sheets nos. I, II and III). However, one factor of particular importance is operational advice to farmers on aspects of water conservation, and improved cooperation between farmers and the water industry (cf. instrument sheets nos. VIII and IX).

Cost estimates

Re a) **No charge** for utilisation of the NID, savings may arise due to the reduced requirement for fertilisers, cost of keeping a field file is approximately **5 €/ha*a** (figures taken from: Kosten-Wirksamkeitsanalyse von nachhaltigen Maßnahmen im Gewässerschutz <*Cost/effect analysis of sustainable measures in water conservation*>, UBA 2002).

Re b) Costs are incurred for the purchasing or leasing of equipment. The concluding report on ammonia emissions in agriculture by the Federal Ministry for Consumer Protection, Food and Agriculture (Bundesumweltministerium f. Verbraucherschutz, Ernährung und Landwirtschaft,

2001) cites the following costs for reducing ammonia emissions by converting slurry application (interest base rate of 6%, ~10 €/man hour, figures excluding value added tax):

Slurry application	**Minimum**	**Maximum**
	Cost in **€/m³** *	
Broadcasting	**2.10**	**4.61**
Hose-towed	**2.76**	**6.16**
Shoe-towed	**3.56**	**8.37**

** The costs were converted from DM to € (exchange rate 1€ = 1.95583 DM)*

Re a and b) In the study "Kosten-Wirksamkeitsanalyse von nachhaltigen Maßnahmen im Gewässerschutz" <*Cost/effectiveness analysis of sustainable measures in water protection*> (UBA, 2002), the following cost-effectiveness figures were calculated for a reduction in N excesses to an average of 50 kgN/ha*a and the preparation of crop rotation plans ("nationwide development of the Fertilisation Ordinance to reduce nitrogen discharges") with due regard for the savings generated from the reduced fertiliser requirement, as well as additional costs arising e.g. due to the use of suitable equipment and a reduction in yield:

Cost-effectiveness*	Bandwidths
€/kg N excess	**0.90 – 1.30**
€/kg N discharge	**2.60 – 3.85**

** The costs were converted from DM to € and rounded up*

Re c) For the conversion of arable land into extensively used arable land or grassland, farmers may apply for compensation for the reduction in market revenue. According to the Landscape Management Directive <*Land-Pflege-RL*> (1991), this amount ranges between approximately **195 and 800 €/ha,** depending on the usability of the land and the nature of subsequent use**.**

Uncertainty factor

On the one hand, farmers are under political and economic pressure to produce optimum yields and product qualities, whilst on the other, they are required to avoid damage to the environment. The future use of fertilisers should be considered against this background. A reduction in fertiliser quantities and a more water body-compatible method of application are, however, desirable in all cases. The conversion of arable land into extensively used land can only be enforced in certain areas.

Summarising qualitative assessment

Significant improvements can be achieved via the preparation of crop rotation plans, the use of loss-minimising application techniques and the conversion / extensification of land. Using the example of the Seefelder Aach (IGuG Uni Kassel, 2001), it has been calculated that nitrogen discharges may be reduced by approximately 93 % (from 217 t N/a to 14 t N/a, calculated via the route "soil elutriation below fields") by implementing the individual measures cited. Depending on distribution of the soil use types in the river basin district, the aforementioned reduction of nitrogen discharges can be considered indispensable, given the major potential it offers.

In this context, we would like to reiterate the importance of operational advice when implementing measures.

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Data Sheet No.2.3

Pressure category according to the Water Framework Directive, Annex II: ***Diffuse sources***

Polluter category: ***Agriculture***

Description of the measure

No. 2.3: Reduction of phosphate discharges into surface waters

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Brief description / Specification of the measure

a) Erosion-minimising soil cultivation: contour cultivation, direct sowing, mulch sowing with existing or new equipment, cultivation primarily at right-angles to the slope.

b) Erosion-minimising soil management: full soil coverage all year round (field planting with intermediate crops), conversion of selected arable land into extensively used grassland or land use which follows the basic principles of organic farming in accordance with EEC Regulation 2092/91:

Land should only be converted if this produces a benefit for the environment. There are examples of land management systems deserving of nature conservation which are based to a large extent on arable crop production with minimal application of products. In such areas, the conversion of arable land into grassland would have harmful impacts, and measures should be employed to ensure the continuation of varied crop rotation systems, minimal application of products, and continuous agricultural use. Furthermore, if a large proportion of land has usage restrictions, this may lead to the complete renunciation of grassland, which is not necessarily desirable in view of the multifunctional effects. When selecting appropriate measures in the individual landscape systems, an inventory of a region’s requirements should be drawn up (evaluation of agro-environmental measures).

As a general principle, with extensive use, it is important to remember that in most cases, it is not the intensity of *use* which harms the river systems, but the intensity of *fertilisation* – it is always **the imbalance between use and fertilisation that poses an ecological problem**. Fertilisation be in proportion to abstraction. As such, the nutrient balance of the site should always be used as a yardstick for an ecologically justified utilisation concept.

Players involved in implementing the measure

- ☐ Federal Government
- ☐ Local authorities
- ☐ Associations, independent organisations
- ☐ *Länder* Government
- ☐ EU
- ☑ Private individuals

Effect analysis

Primary effects:

Because around 66 % of phosphorous discharges into rivers in Germany originate from diffuse sources (around 22 % from erosion, 15 % via groundwater) (Daten zur Umwelt 2002, UBA), there is a substantial potential for reduction in this area. Environmental impairments may be caused by the improper use of fertilisers. By means of careful soil cultivation techniques and the prevention of soil erosion by converting arable land into extensively used grassland, and by limiting the fertilisers applied, these types of environmental impairments may be reduced or largely avoided.

Secondary effects:

<u>Economic / social effects:</u>

Re b) The conversion of arable land is likely to have a significant impact on the market balance, since it will cause large areas to be removed from production and replaced with extensive grassland.

Time required

Until implementation: a) short-term b) medium-term

Until effectiveness: The measures may become effective in the short-term, as well as in the medium- or long-term, depending on the regional peculiarities.

Geographical effect

- ☑ local
- ☑ regional
- ☑ Nationwide / EU-wide

Interactions with other measures

The effectiveness of the measures is supported via the creation of riparian buffer strips, as a result of which the discharge of pesticides into water bodies is reduced (cf. measure no. 2.1)

The willingness of farmers to adopt an approach to fertiliser application that is geared towards water body conservation may be increased by means of financial subsidies for organic farming and by taxes on fertilisers (cf. instrument sheets no. I, II and III). However, operational advice to farmers from the viewpoint of water protection and improved cooperation between farmers and the water industry is of particular importance here (cf. instrument sheets no. VII and VIII).

Cost estimates

Re a) For soil cultivation using mulch sowing techniques with existing equipment, by definition, **no additional costs** are incurred. Due to the reduced amount of time and petrol needed compared with conventional techniques, the costs may in fact be reduced in some cases.

Example of mulch sowing with the purchase of new equipment:

For the pilot project Seefelder Aach (cf. also chapter 3 of the main document), the costs of mulch sowing with the purchase of new equipment were calculated by way of an example:

Costs/approaches:

Species	Approaches	Source	Amounts	
				Unit
Investments	Mulch sowing equipment	ALLB	**25,565.00**	**€**
Operation	Cost reduction with machinery + labour	LEL	**-86.92**	**€/ha**
	Decline in market proceeds	Landinfo 2 1999	**56.24**	**€/ha**
	Additional expenditure on pesticides	Landinfo 2 1999	**12.27**	**€/ha**

ALLB: Office for Agriculture and Landscape and Soil Conservation
LEL: State Office for the Development of Agriculture and Rural Regions

Costs/calculation and results:

No. of mulching machines with a performance of 100ha/a:	10	
Sum total of investments:	255,646.00	€
p=Calculatory interest rate	4	%
n= Period of utilisation	30	years
Annuity factor/conversion into equiv. annual cost series	0.0578	[-]
Annual costs	**14,784.00**	**€**

In the Seefelder Aach river basin district, therefore, annual costs of around **15,000 €** would be incurred for the use of mulching machines.

In the study "Kosten-Wirksamkeitsanalyse von nachhaltigen Maßnahmen im Gewässerschutz" <*Cost/effectiveness analysis of sustainable water protection measures*> (UBA, 2002), the following cost-effectiveness figures were calculated for a reduction in the discharge of P by means of suitable soil cultivation:

Cost-effectiveness*	Bandwidths
€/kg P discharge	**120 – 245**

** The costs were converted from DM to € and rounded up*

Re b) For the conversion of arable land into extensively used arable land or grassland, farmers may apply for compensation for their reduced market proceeds. According to the Landscape Management Directive <*Land-Pflege-RL*> BW (1991) this amount is approximately **195 to 800 €/ha,** depending on the usability of the land and the nature of subsequent use**.**

Uncertainty factor

On the one hand, farmers are under political and economic pressure to produce optimum yields and product qualities, whilst on the other, they are required to avoid damaging the environment. Implementation of the measure should be considered against this background. In particular, when converting arable land into extensively used land, resistance from farmers is to be expected. However, if the loss of earnings and additional expenditure of farmers is compensated, then acceptance is likely to be significantly increased.

Summarising qualitative assessment

By modifying cultivation techniques and via the extensification of land, significant reductions in phosphorous discharges into water bodies may be achieved.

Using the example of Seefelder Aach, it has been calculated that phosphorous discharges may be reduced by approximately 30 % via the use of mulch sowing techniques (from 11.5 t P/a to 8 t P/a, calculated via the route "soil elutriation below fields"), and by 100 % (no phosphorous discharge into rivers from the most extensive land) via the conversion of arable land into the most extensive grassland.

For conversion to other cultivation techniques, additional costs may be incurred to farmers; similarly, the extensification of land will lead to loss of earnings. However, these measures are indispensable if phosphorous discharges from diffuse sources into rivers are to be further reduced.

In this context, we would reiterate the importance of operational advice when implementing the measures.

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Data Sheet No. 2.4

Pressure category according to the Water Framework Directive, Annex II: ***Diffuse sources***

Polluter category: ***Agriculture***

Description of the measure

No. 2.4: Environmentally compatible handling of pesticides – Compliance with the principles of good agricultural practice in plant protection

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Brief description / Specification of the measure

In the field of plant protection, it is vital to comply with the "principles of good agricultural practice in plant protection". Failure to comply must be linked to sanctions. At the same time, it is necessary to reduce the enforcement deficit which exists with the monitoring and control of existing statutory provisions in plant protection (Klein, 1996; in Fleischer, 1998).

Specifically, the environmentally compatible handling of pesticides means:

- Loss-minimising spray and application techniques (use of suitable and functionally reliable equipment, equipping field sprayers with additional devices for equipment and container cleaning; application only by trained personnel; application of pesticides only when there is no wind)
- Cleaning of the sprays on the area of use or at special washing stations with drainage via the slurry stores
- Proper handling of spray mixtures or container residues
- Use of authorised pesticides only, use of highly selective preparations which are effective even in small quantities, application at the time of maximum effectiveness
- In terms of timing and volume, the storage of pesticides should be reduced to an essential minimum
- Precautionary measures when mixing up the solutions
- Precautions should be taken during transportation in order to avoid contamination

- Consistent compliance with distance regulations

As an alternative to this, non-chemical pesticides may also be used (e.g. mechanical weed control methods). Chemical pesticides should only be used if economic damage would otherwise be impossible to avert.

Players involved in implementing the measure

☐ Federal Government	☐ Local authorities	☐ Associations, independent organisations
☐ *Länder* Government	☐ EU	☑ Private individuals

Effect analysis

Primary effects:

The environmental effects (reduction of the discharge of pesticides into water bodies) are dependent upon

- the individual potential for profitable reduction, i.e. the extent of over-fertilisation and incorrect application of pesticides, as well as
- realisation of this reduction potential.

Because excessive safety precautions are often assumed with the use of pesticides (as a result of which the required quantity of pesticide is over-dimensioned) (Feldwisch/Frede, 1995), there is a substantial potential for reduction here. The opportunities of realising such potential depend on the intensity and continuous evaluation and adaptation of the information measures, and cannot be precisely quantified at present.

Secondary effects:

Effects on other media:

The correct handling of pesticides – in this case, in particular, cleaning the sprays on the area where they are used – ensures that the proportion of pesticide that enters rivers via sewage treatment plants and rainfall/combined sewage discharges is minimised. This also relieves the pressure on sewage treatment plants.

Time required

Until implementation: Short- to medium-term

Until effectiveness: The measures may become effective in the short-term but also in the medium- or long-term, depending on regional peculiarities.

Geographical effect

☑ local ☑ regional ☑ Nationwide / EU-wide

Interactions with other measures

The effectiveness of the measure is supported by the creation of riparian buffer strips, as a result of which the discharge of pesticides into rivers is reduced (cf. measure no. 2.1)

Taxes on pesticides (cf. instrument sheet IV) and financial subsidising of organic farming (cf. instrument sheet I) increase the economic incentive for efficient use. However, operational advice to farmers on water protection aspects and better cooperation between agriculture and the water industry is of particular importance here (cf. instrument sheets VII and VII).

Cost estimates

For the environmentally compatible handling of pesticides, costs are only incurred for the purchase of new equipment for a loss-minimising spray and application technique. All other individual measures refer to compliance with “good agricultural practice”. In order to enforce this, costs may be incurred for the appointment of advisors, which are addressed in the aforementioned instrument sheet VII "Advice to farmers ...".

Low-loss pesticide application may be achieved using injector nozzles (in exchange for the flat spray nozzles otherwise used). Hence, the only costs incurred are for purchasing the spray.

Example: A nozzle designed for 90% drift reduction costs approximately **3.60 €** per nozzle**.** With a working width of 21 m (one nozzle every 0.5 m = 42 nozzles), this produces total costs of approximately **180 €.**

Furthermore, it is also important to consider that operating expenditure may be reduced thanks to the more targeted, and hence perhaps reduced, use of pesticides.

Uncertainty factor

Often, implementation entails additional work. For example, when considering spacing requirements, it may be necessary to use different nozzles or different pesticides than in other areas.

Summarising qualitative assessment

The loss-minimising spray and application technique and general handling of pesticides is a measure that may be realised easily, offers a comparatively high reduction potential, and also tends to be accepted by farmers.

Overall, a significant improvement may be achieved in this area with minimal costs.

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Data Sheet No. 3.1

Pressure category according to the Water Framework Directive, Annex II: *Water abstractions*

Polluter category*: Local authorities/Households ⇒ Reservoirs*

Description of the measure

No. 3.1: Creation of ecologically compatible hydraulic conditions via flow control, particularly with regard to water level regulation

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Brief description / Specification of the measure

Ecologically based reservoir management is designed to ensure that the water in the reservoir does not fall below a certain level. This water level must be designed to ensure that manifestations of eutrophication in the water body are avoided wherever possible, whilst also making allowance for the conditions for terrestrial and aquatic organisms.

Players involved in implementing the measure

☐ Federal Government	☐ Local authorities	☑ Associations, independent organisations
☑ *Länder* Government	☐ EU	☐ Private individuals

Effect analysis

Primary effects:

Due to intensive water volume management, severe water level fluctuations and, at times, very low water levels can occur in a reservoir. The water level fluctuations mean that an area forms around the banks of the reservoir which cannot be permanently inhabited by either terrestrial or aquatic organisms. Additionally, low water levels may lead to manifestations of eutrophication. Specification of an ecologically justified water level, with due regard for these factors, can help to minimise the impairments.

Secondary effects:

Material:

Low water levels may lead to manifestations of eutrophication in the reservoir. This may have an adverse impact on the downstream section of water course. As such, it is important to find an optimised system of flow control which makes allowance both for the dammed water body and for the section of river below it.

Effects on other media:

Specification of a comparatively high water level may, in turn, have adverse impacts on the section of water below it. If only small quantities of water are released from the reservoir, the flow regime of the water body below it is adversely influenced, leading to impacts on the water body structure (cf. also interactions with other measures).

Economic / social effects:

A reservoir with a high water level is more attractive to tourists and provides a more diverse range of leisure options.

Time required

Until implementation: Short- to medium-term

Until effectiveness: Short- to medium-term

Geographical effect

☑ local ☑ regional ☐ Nationwide / EU-wide

Interactions with other measures

- Measure No. 4.1 “Creation of ecologically compatible hydraulic conditions via flow control, particularly with regard to the impurity concentration of residual water” and the measure outlined above have a mutual influence on one another. On the one hand, it is important to ensure a water level in the reservoir itself which will facilitate ecologically compatible conditions (particularly with regard to the problem of eutrophication), whilst on the other, a dynamic flow must be achieved in the river below.
- Influence with measures in the area of structural quality, since a reduction in the quantity of residual water discharged may adversely impact structural quality. What is more, the better the structural quality in the river below, the lower the minimum quantity of water required in order to maintain a minimum ecological status (cf. measures no. 5.2, 5.4).

- Interactions may exist with measure 4.2 “ecologically oriented flood protection concept” if the reservoir also serves the purpose of flood protection.
- Passability ⇒ cf. measure no. 5.1 under “Morphological changes”
- Implementation of the measure may also be supported by instrument X “Advice to the competent authorities to optimise water body maintenance from a water protection viewpoint“.

Cost estimates

Compensation is payable for impaired use (reduced quantity of drinking water and service water sold, reduced energy yield for operators of hydropower plants). On the other hand, tourism in the vicinity of the reservoir may benefit.

The costs incurred directly for implementation of the measure generally consist only of the cost of preparing an expert report. An assessment of the costs arising is only possible within the context of an **individual case study**.

Uncertainty factor

One problematic aspect of implementing this measure may be its unfavourable influence on existing uses. As such, it will not always be possible to set a water level which meets the ecological requirements in full.

Summarising qualitative assessment

Practising reservoir management and thereby ensuring a water level which makes allowance for ecological requirements is a measure which should be implemented as far as possible, with due regard for existing peripheral conditions imposed by current usage, in order to satisfy the requirements of the Water Framework Directive.

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Data Sheet No. 4.1

Pressure category according to the Water Framework Directive, Annex II: *Flow control*

Polluter categories: *Local authorities/Households ⇒ Reservoirs*

Description of the measure

No. 4.1: Creation of ecologically compatible hydraulic conditions via flow control, particularly with respect to impurity concentrations in the residual water

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Brief description / Specification of the measure

In order to achieve ecologically compatible conditions in the water body, it is necessary to introduce corresponding flow control measures. The respective regulations of the Federal *Länder* prescribe varying minimum outflows (e.g. between 1/2 and 1/3 MNQ). Ecologically oriented flow controls should make allowance for the structural and physico-chemical conditions in the river below the reservoir. The impurity concentration levels in the residual water should be geared to the natural flow regime. In order to determine ecologically oriented flow controls, it is necessary to

- Evaluate existing flow levels and determine the current flow regime
- Assess the current ecosystem
- Undertake a characterisation of the water body structure (base structure, curvature, cross-section) and the river fauna and flora
- Determine the minimum volume of water that is needed from an ecological viewpoint (minimum ecological status)

A consideration of the water level remaining in the reservoir is crucial. In this respect, it is necessary to determine a balanced ratio between the remaining water level and the minimum quantity of water discharged (with due regard for uses).

Players involved in implementing the measure

☐ Federal Government	☐ Local authorities	☑ Associations, independent organisations
☑ *Länder* Government	☐ EU	☐ Private individuals

Effect analysis

Primary effects:

The reduced discharge of water from a reservoir into a river generally impacts the hydromorphological and chemico-physical conditions in the river. The flow regime is altered (dampening of flow amplitudes), and colmation of the river bed often occurs due to the deficit of detritus. The situation is further exacerbated by the fact that the emergence and development of typical natural river structures is almost non-existent, due to the absence of bed-forming flows (HQ2 to HQ5).

Furthermore, the discharge of dammed water often leads to a temperature shift and can cause material impairments in the river below. An ecologically oriented flow control may help to minimise these pressures.

The problem of impaired passability is addressed in the section on “Morphological changes”.

Secondary effects:

Material:

The increase in the volume of water discharged may lead to material impairments in the reservoir (cf. also interactions with other measures). As such, it is important to achieve optimised control which makes allowance for both the dammed water body and the section of river below it.

Economic / social effects:

An increased concentration of impurities in the residual water and hence a reduction in the dammed water may have possible impacts on existing uses (reduction in the quantity of service water available).

Time required

Until implementation: Short- to medium-term

Until effectiveness: Short- to medium-term

Geographical effect

☑ local ☐ regional ☐ Nationwide / EU-wide

Interactions with other measures

- Measure no. 3.1 “Creation of ecologically compatible hydraulic conditions via flow control, particularly with regard to water level control” and the measure outlined above influence one another. On the one hand, it is important to create a water level in the reservoir itself which will allow ecologically intact conditions (particularly with regard to the problem of eutrophication), whilst on the other, it is important to achieve a dynamic flow in the river below it.

- There is a positive mutual influence with measures in the area of structural quality, since the emulation of natural flow conditions may have a beneficial impact on structural quality. Furthermore, the better the structural quality in the river below, the lower the minimum quantity of water required in order to maintain a minimum ecological status (cf. measures no. 5.2, 5.4).

- Passability ⇒ cf. measure no. 5.1 under “Morphological changes”

Implementation of the measure may be supported by instrument IX “Advice to the competent authorities on optimising river maintenance from a water protection viewpoint”.

- Cost estimates

Compensation may be payable for impaired usage (lower quantity of drinking water and service water sold, reduced energy yield for operators of hydropower plants). Furthermore, tourism in the vicinity of the reservoir may be adversely influenced as a result of implementing the measure.

The costs incurred directly for implementation of the measure are generally confined to the cost of preparing an expert report. An assessment of the costs arising is only possible within the context of an **individual case study**.

Uncertainty factor

One problematic aspect of implementing this measure may be its unfavourable influence on existing uses. As such, it may not always be possible to set a water level which meets the ecological requirements in full.

Summarising qualitative assessment

The implementation of minimum water regulations and a greater orientation towards ecological requirements with respect to impurity concentrations in the residual water is a measure which must be implemented as far as possible, with due regard for the peripheral conditions prescribed by existing uses, in order to meet the requirements of the Water Framework Directive. In Germany, there are currently (as per 2001) 311 reservoirs in operation, each of which impacts related sections of river, some of which are fairly large. An ecological flow control system is urgently needed in order to ameliorate the impairment to the affected sections of river.

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Data Sheet No. 4.2

Pressure category according to the Water Framework Directive, Annex II: ***Flow control***

Polluter categories: ***Local authorities/Households, Agriculture***

Description of the measure

No. 4.2: Ecologically oriented flood protection concept with targeted improvement of the structural quality

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Brief description / Specification of the measure

This measure concerns optimisation of the water balance in river basin districts with a view to flood protection, with due regard for the joint flood protection programme of the Federal and Länder Governments (5-point programme of the Federal Government) with a targeted improvement in structural quality.

Administrative measures

- Development of concepts for better protection of developed areas in at-risk zones
- "Making more space for rivers" <*Den Flüssen mehr Raum geben*>
- Modification of zoning plans with a view to preventive flood protection by means of designating or changing/restricting use in areas at risk of flooding (e.g. designation of flood plains or flooding limits, formulation of plans for at-risk zones, no designation of land for new residential and commercial development in flood plains).

Water management measures

- Improve the seepage ability of the soil by reducing land use and land desealing
- Farther-reaching measures in the river basin such as afforestation and planting, terracing, forest preservation, changes in use e.g. from arable land to grassland, grassland to riparian forest and adapted agricultural use of flood plains.
- Increase in local water retention (e.g. troughs, micro- and mini-rservoirs).
- Reservoirs above village locations (e.g. retention areas, flood control basins, polders with ecological flooding).

- Increased water retention in human settlements due to sewer reservoirs, rain reservoirs and rain spillway basins, seepage at the site of rainfall
- Optimised use of reservoirs for flood retention
- Relocation of dykes
- Maintain and recreate the function of water meadows as natural flood plains
- Local renaturation in individual cases for selected rivers:
  - Promotion of inherent dynamics, removal of bank reinforcements
  - Increase in structural diversity (copse planting or copse removal, addition of shingle)
  - Aim for a potentially natural channel cross-section in smaller rivers (depth/width ratio < 1/6) (e.g. by facilitating a semi-natural river and bank development, and where applicable via the targeted use of excavations, creation of flood troughs).

Players involved in implementing the measure

☑ Federal Government	☑ Local authorities	☑ Associations, independent organisations
☑ *Länder* Government	☐ EU	☐ Private individuals

Effect analysis

Primary effects:

- As a result of land desealing, increased seepage is achieved. Furthermore, additional unevenness is caused, leading to reduced flow speeds. These effects may be reinforced via the creation of troughs, mini- and micro-reservoirs, and by means of changes to land use.
- Foreshore modelling effects an increase in storage capacity in the event of flooding. Furthermore, the reduction in flood plains caused as a result of human habitation and road building etc. is compensated without enlarging the actual cross-section of the river.
- The storage capacity of the rivers and water meadows should be re-enlarged as a result of renaturation measures (principle: reducing the flow speed)
- Rain storage reservoirs effect a dampening of intermittent pressure and help to homogenise the outflow from the water body. Reduced outflow peaks permit a more semi-natural routing and smaller flow profiles in the water body. The lower flow speed helps to reduce erosion. As a result of increased dilution, the water quality is improved.

- The relocation of dykes means that former flood plains may be reincorporated into the outflow of the river, thereby enabling a larger quantity of water to be stored.

Secondary effects:

Material:

As a result of changes to land use and desealing measures, a reduction in chemical pressures on the water body may also be achieved.

Effects on other media:

- Improvement in water body structure (renaturation of water bodies) -> beneficial influence on benthic organisms, fish fauna
- Greater formation of new groundwater (due to water retention in the land)

Economic / social effects:

Flood protection measures may have major economic and social impacts e.g. changes to zoning plans, changes to land use, loss of earnings, increased aesthetics, and leisure use value.

Time required

Until implementation/effectiveness: Given the large number of possibilities afforded by a targeted flood protection concept, some of the individual measures may be implemented and become effective in the short term, and others in the medium and long term.

Geographical effect

☑ local ☑ regional ☑ Nationwide / EU-wide

Interactions with other measures

The above measure is closely related to a large number of measures in other areas, particularly measures to improve the structural quality (river renaturation, measures no. 5.1 to 5.4). By improving the water body structure, the flood wave is corrected or delayed due to the brief retention.

However, there are also overlaps with measures in the agricultural sector (extensification of land use, measures no. 2.2 and 2.3, creation of riparian buffer strips, no. 2.1) and in the area of “rainfall treatment” (measures for desealing and retention basins, measures no. 1.3 to 1.5). Due to retention in human settlements and adapted rainwater use, the quantity of water is reduced and/or part of the wave volume is withheld and discharged with a time delay.

There may be an interaction with measure 3.1 “Water level regulation in reservoirs” if a reservoir is to be used for flood protection purposes on the one hand, but on the other, must not drop below a minimum water level in order to avoid manifestations of eutrophication in the water body and to ensure adequate conditions for terrestrial and aquatic organisms.

Cost estimates

For calculation of the costs, we would refer to measure sheets no. 5.1 to 5.4 (measures in the morphological sector), no. 2.1, 2.2 and 2.3 (land extensification, riparian buffer strips) and 1.3 to 1.5 (measures relating to drainage in human settlements).

Sample costs for a potential water course redevelopment in Hesse (renaturation) are outlined below:

In Hesse, some 50 - 60 % of water bodies of the Ist and IInd order are classified as damaged in terms of their structural quality. With an assumed length of 27,000 km and assumed specific renaturation costs of **50 - 100 €/m** in the rural region, this produces an estimated funding requirement of **0.75 – 1.5 billion €** (from: Maßnahmenplan Nachhaltige Wasserwirtschaft, UBA, 1999).

Uncertainty factor

In some cases, restrictions on and changes to use with a view to preventive flood protection can only be enforced by means of financial contributions (e.g. subsidies, land purchasing) to compensate the parties concerned for the resultant or anticipated monetary disadvantages.

In particular, this should be viewed against the background that flood protection measures can never provide absolute protection. The risk of flooding beyond the anticipated levels continues to exist, and hence so too do the risks and responsibilities of water users associated with this residual risk.

Summarising qualitative assessment

Nationwide flood protection measures can often only be achieved with a high cost input. Nevertheless, preventive flood protection measures are vital.

At the current time, the Federal Government and *Länder* are in the process of launching a joint flood protection programme. This will include cross-*Länder* action plans for the individual river basins, more widespread European cooperation on preventive flood protection, and a review of river expansion and the environmental compatibility of shipping. The flood protection programme of the Federal Government and *Länder* includes the following concepts: “Creating more space for rivers”, “Averting flooding at a decentralised level” and "Controlling human settlement development - minimising the potential damage". The sub-measures listed in this measure sheet are largely based on these concepts, or overlap with them.

Overall, the flooding problem can only be reduced to a limited extent by measures targeting natural water retention alone. Using the Hessian river basin of the Lahn as an example, it has been ascertained that the flooding risk could be reduced by between 13 % and 16 % with semi-natural water retention (Lang; Tönsmann, 2002). For this reason, we must push ahead with farther-reaching flood protection measures, supported by technical flood protection at local level.

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Data Sheet No. 5.1

Pressure category according to the Water Framework Directive, Annex II: *Morphological changes*

Polluter category: *Local authorities/Households, Agriculture, Industry, Others*

Description of the measure

No. 5.1: Creation of linear passability for upstream and downstream migration of site-specific species

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Brief description / Specification of the measure

The aim of this measure is to create a natural river continuum, which is the pre-requisite for an intact and stable ecosystem. Horizontal structures and piping must be redesigned in such a way that passability for aquatic organisms is ensured, and if possible, a natural woody debris and detritus drift is created.

Administrative measures

- Creation of river concepts and/or river development plans.
- Coordinated (optimised) designation of nature conservation and landscape conservation areas.
- Extensification: contract nature conservation programme, cultural landscape programme
- Reinforcement of species conservation programmes for stream and freshwater pearl mussels, beavers, otters, salmon etc.
- Conservation and renaturation measures on rivers using funds from water management administration.

Structural measures

- Conversion of horizontal structures (e.g. by means of rough ramps, bypass channels, installation of functioning fish ladders) in order to restore the migration of aquatic organisms.
- Removal of horizontal structures with due regard for the partial widening of the water body in order to ensure side erosion or prevent depth erosion (the removal of horizontal structures is only possible in rare cases, due to restrictive peripheral conditions, and also harbours the risk of “side-effects” on the river bed, such as bed erosion).

- Reduction of the biological barrier effect of drop structures, weirs, piping etc. in both the main flow and tributaries by means of semi-natural structuring.
- Positioning of bypass channels, e.g. with the placing of blocks above the channel mouth to reinforce gully formation and to ensure adequate water depth in the bypass channel, relocation of the river e.g. into the water meadow at constrained points, where applicable.
- Removal of piping (where applicable, restructuring as a ford)
- Incorporation of natural bed substrate into newly created areas

There is an opportunity to realise measures with an ecological orientation within the context of compensatory measures for intervention into nature and the landscape.

Players involved in implementing the measure

☑ Federal Government	☑ Local authorities	☐ Associations, independent organisations
☑ *Länder* Government	☑ EU	☐ Private individuals

Effect analysis

Primary effects:

- The species-appropriate conversion of horizontal structures and the removal of biological barriers (such as drop structures, weirs, piping) ensures vital passability for the upstream and downstream migration of various aquatic organisms.
- Removal of a horizontal structure: Creation of natural flow and depth areas in the river and hence habitats for water fauna, facilitation of a natural woody debris and detritus drift
- Possible increase in the flow momentum (depending on the measure)

Secondary effects:

<u>Material:</u>

By restoring natural river passability, the essential and diverse (chemical and biological) exchange processes in the river are able to resume.

<u>Effect on other media:</u>

The recreation of river passability may help to upgrade the landscape.

<u>Economic / social effects:</u>

If a horizontal structure is removed completely in order to recreate passability of the river, generally speaking, current uses will need to be halted or restricted.

Time required

Until implementation: Medium-term

Until effectiveness: The regeneration times for micro-habitats can be considered short-term, those for bed structures and river meadow habitats short- to medium-term, and those for sections of river and flood plains medium- to long-term.

Geographical effect

☑ local ☑ regional ☑ Nationwide / EU-wide

Interactions with other measures

The creation of river passability has beneficial effects on the entire river structure. The natural flow dynamics are restored (cf. also measure no. 4.1 "Ecologically compatible hydraulic conditions"), debris drift is facilitated, and structures are able to form once again (measures no. 5.2, 5.3, 5.4 in the area of "morphological changes").

Instrument IX "Advice to the competent authorities on optimising river maintenance from a water protection viewpoint" may help to establish the aforementioned measure.

Cost estimates

On average, the cost of river renaturation with regard to the creation of linear river passability totals some **5,000 to 30,000 €** per measure (**minimum 2,500 €, max. 75,000 €**). This cost estimate was taken from ISAR (information system for the selection of efficient renaturation measures) and is based on an evaluation of sample renaturation projects.

Uncertainty factor

The measures to create river passability can only be related inadequately to a specific length of river, and therefore a corresponding representation of cost efficiencies is not possible (ISAR).

As a result of changes to land use and zoning plans with respect to the passability of the river, potential conflicts of interest may arise in the affected population. In some cases, restrictions and changes to use can only be enforced by means of financial contributions (e.g. subsidies, land purchasing) to compensate the affected parties for the associated or anticipated monetary disadvantage.

Summarising qualitative assessment

The creation of linear river passability is a pre-requisite for a functioning river ecosystem and, particularly with regard to implementation of the Water Framework Directive, an important measure for achieving environmental targets, since the prevention of river passability has a direct influence on the biological and chemical quality components listed in Annex V of the Water Framework Directive. Under certain circumstances, the measure may entail high costs (particularly when diverting the river into a bypass channel or when removing a horizontal structure), but this will ensure the upstream and downstream migration of aquatic organisms needed in order to attain the environmental targets outlined in the Water Framework Directive.

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Data Sheet No. 5.2

Pressure category according to the Water Framework Directive, Annex II: ***Morphological changes***

Polluter category: ***Local authorities/Households, Agriculture, Industry, Other***

Description of the measure

No. 5.2: Supporting hydraulic engineering measures to restructure the river morphology

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a) River bed modelling (morphological river restructuring)

b) River bed widening

c) Linear bed raising in the form of an erosion-stable substrate packing

d) Dynamic river development with supporting hydraulic engineering measures

Brief description / Specification of the measure

With the aid of various hydraulic engineering measures, structural deficits may be restored to a semi-natural state within a short period of time.

Administrative measures

- Acquisition of land in restructuring areas / riparian buffer strips:
- Transition of riparian buffer strips from commercial use by the owners into the hands of public or charitable organisations by means of:
  - Voluntary, binding declaration on the part of the owner to discontinue use of the affected riparian buffer strips.
  - Land purchasing
- Specification of a framework maintenance plan to prevent conflicts of interest between various parties who are liable for the maintenance of a section of river.
- Requirement-oriented, extensive river maintenance

Structural measures

- Re a) Earthworks for modelling the river flow and bed, and where applicable, reactivation of bayous and flood trenches
- Re b) Earthworks for river bed widening

- Re c) Earthworks for linear raising of the river bed
- Re c) Protection measures (e.g. rows of wooden stakes) for substrate discharge
- Re a, b, c and d) Removal of solid bank and bed obstructions
- Re a, b, c and d) Supporting hydraulic engineering measures such as rock obstructions, substrate packing, woody debris, ground sills, chutes
- Re a, b, c and d) Essential bank protection using bio-engineering construction methods
- Re a, b, c and d) Indigenous planting

Players involved in implementing the measure

☐ Federal Government	☑ Local authorities	☐ Associations, independent organisations
☐ *Länder* Government	☐ EU	☐ Private individuals

Effect analysis

Primary effects:

Re a)

- Structural deficits such as course development may be restored to a semi-natural state within a short period of time
- Former bayous and flood trenches may be reactivated

Re b)

- Dynamic renaturation of uniformed, standard profile rivers
- Development of river structures and secondary river meadows
- Naturalistic river development
- Reduction of transverse stress on the river bed, option of depositing shingle
- Longitudinal banks may be developed downstream
- Linear drop may be reduced
- In the long term, a dynamic equilibrium will be created between sedimentation and subsequent transportation with a new bed position

Re c)

- Has the effect of stabilising the river bed, and hence in the long-term, facilitates the creation of a natural bed level
- Where riparian buffer strips are acquired, a link between the river and floodplain will again be possible

Re d)

- Rivers that are open to development with a high degree of dynamism and an intact river basin are again able to form naturalistic bank and bed structures
- In the long term, a natural shape of the river may be attained.

Secondary effects:

Material:

The improvement in structural quality generally has beneficial impacts on the chemical properties of a river.

Effects on other media:

The morphological restructuring of a river may help to upgrade the landscape

Economic / social effects:

- Beneficial effect on the landscape, increase in the recreational value
- Existing uses may need to be restricted in some areas (e.g. agriculture), because land will be needed for restructuring.

Time required

Until implementation: Short- to medium-term

Until effectiveness: By actively restructuring a river, structural deficits may be rectified in the short term. Certain aspects of the measure (dynamic equilibrium of the transportation of detritus, natural shape) can only be achieved in the long term. Overall, the effectiveness of the measure depends to a large extent on the openness of a river to development.

Geographical effect

☑ local ☑ regional ☐ Nationwide / EU-wide

Interactions with other measures

Selected aspects of the measure may have a beneficial mutual effect on other measures. For example, widening of the river bed effects a reduction in the hydraulic stress which often occurs beneath a combined sewage/rainfall discharge (cf. measures 1.4 and 1.5).

From a hydromorphological viewpoint, for example, positive interactions may occur with measure no. 4.2 “Ecologically oriented flood protection”. By restructuring the , the retention and delay of the outflow in the watercourse may be enhanced.

Instrument IX “Advice to the competent local authorities on optimising watercourse maintenance from a water protection viewpoint” may help to establish the aforementioned measure. There is also the option of implementing measures with an ecological orientation within the context of compensatory measures for intervention into nature and landscapes (cf. instrument VI on "Restructuring the nature conservation and fishing charge").

Cost estimates

The cost of river renaturation varies depending on the intensity of the measure, the size of the river, and whether the section of river to be renatured is in the open countryside or in a restricted area:

Re a) The cost of river bed modelling may be estimated at approximately **225 to 350 €/linear metre** (**min. 65 €/linear metre, max. 750 €/linear metre**).

Re b) If river bed widening is to be implemented, the average cost is between **200 and 325 €/linear metre** (**min. 100 €/linear metre, max. 600 €/linear metre**).

Re c) The cost of linear raising of the river bed averages at between **100 to 150 €/linear metre** (**min. 60 €/linear metre, max. 375 €/linear metre**).

Re d) The cost of supporting hydraulic engineering measures (excluding earthworks for widening or modelling the river bed) averages at between **75 and 150 €/linear metre** (**min. 50 €/linear metre, max. 175 €/linear metre**).

This cost estimate was taken from ISAR (information system for the selection of efficient renaturation measures) and is based on an evaluation of sample renaturation projects.

Uncertainty factor

In case of restrictions due to restricted peripheral conditions (e.g. in human settlement areas), only moderately naturalistic structures may be achieved.

Generally speaking, it is only possible to provide information regarding the openness of a section of river to development. This needs to be examined more closely in detailed analyses and confirmed, with due regard for the local river and river basin conditions.

Summarising qualitative assessment

The openness of a river to development will, to a large extent, determine whether naturalistic river structures are able to develop, and over what period results are to be anticipated.

The development of a naturalistic river may, for example, take several decades or even a century, whereas forms of the river bed that are in keeping with the natural environment may develop after just a few floods, and small-scale bed structures may have regenerated within the course of a year.

Even in restricted areas, short- to medium-term improvements in the river structure of 1 to 2 classes can be achieved by means of supporting hydraulic engineering measures. Under good conditions in the open countryside, there may be an improvement of 2 to 3 classes.

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Data Sheet No. 5.3

Pressure category according to the Water Framework Directive, Annex II: ***Morphological changes***

Polluter category*: Local authorities/Households, Agriculture, Industry, Other*

Description of the measure

No. 5.3: Inherent dynamic development of the water body appropriate to location via modified, extensified water body maintenance

Brief description / Specification of the measure

Renaturation of rivers open to development by means of modified, extensified water body maintenance.

Administrative measures

- Clarify river development aims
- Provide the river with adequate space for inherent dynamic development
- Acquire land in river development areas

Modified, extensive river maintenance: Minimise anthropogenic intervention and technical construction methods, extensive use of pasture land only, no renewal of obstructions, no dissection of copses, "leave the watercourse to its own devices"

- If maintenance measures are necessary (e.g. flood protection measures), these should be requirement-oriented and should make allowance for ecological requirements
- Coherent renaturation sections at least 500 m long are the pre-requisite for effective inherent dynamic development (ISAR).

Players involved in implementing the measure

☐ Federal Government	☑ Local authorities	☑ Associations, independent organisations
☑ *Länder* Government	☐ EU	☐ Private individuals

Effect analysis

Primary effects:

By means of modified, extensified land use and hence provision for inherent dynamic development of the river, rivers that are open to development (i.e. not running within a reinforced profile) may be renatured. Rivers that are “left to their own devices” may regain their structural diversity and a semi-natural course.

Secondary effects:

Material:

The measure leads to reduced discharges of substances into the river due to land extensification in the vicinity of the river (cf. also “Interactions with other measures”)

Economic / social effects:

- Possible conflicts of interest with other user groups (particularly farmers; maintenance measures for flood protection must be executed in a requirement-oriented manner)

Time required

Until implementation: Short-term

Until effectiveness: Medium- to long-term

Geographical effect

☑ local ☑ regional ☐ Nationwide / EU-wide

Interactions with other measures

Extensified land use also means that discharges of pollutants into the water body are reduced. Together with measure no. 2.1 “Reduction of nutrient and pesticide discharges via the creation of riparian buffer strips”, there is a positive mutual influence.

Hydraulic engineering measures for morphological river restructuring (5.2) may become superfluous in selected sub-sections, provided sufficient land is available for inherent dynamic development, whereas in other areas, the measures may alternate with one another depending on the river status.

From a hydromorphological viewpoint, there are positive interactions with measure no. 4.2 “Ecoogically oriented flood protection”. Extensified land use means that new retention may be created, and outflow delayed.

Instrument IX “Advice to the competent authorities on optimising river maintenance from a water protection viewpoint” may contribute towards establishing the aforementioned measure.

Cost estimates

On average, the cost of river renaturation totals between **40 and 90 €/linear metre** (**min. 10 €/linear metre, max. 120 €/linear metre**). This cost estimate was taken from the information system for the selection of efficient renaturation measures (SAR) and is based on the evaluation of sample renaturation projects.

Uncertainty factor

Given the current utilisation density, it is almost impossible to keep longer sections of a river entirely free from maintenance measures. However, efforts may be made to achieve this on the longest coherent sections possible, and to only stabilise the cross-section at certain critical points (e.g. near bridges), giving the remainder of the river a free run. Often, in restricted areas, renaturation measures may only be implemented at disproportionately high costs.

Summarising qualitative assessment

Overall, the measure, particularly in areas where a short-term improvement in the situation is not essential, should be considered a semi-natural form of water body renaturation with comparatively low costs and minimal effort, which may produce excellent results, particularly in the long term. In view of the potential success and the associated costs, a distinction must be made between sections of water bodies in restricted areas and those in the open countryside.

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Data Sheet No. 5.4

Pressure category according to the Water Framework Directive, Annex II: ***Morphological changes***

Polluter category: ***Local authorities/Households, Agriculture, Industry, Other***

Description of the measure

No. 5.4: Improvement of bank and bed structures

Brief description / Specification of the measure

The bank and bed of a river are to be restored to a largely semi-natural state by means of hydraulic engineering measures and indigenous plantings.

Administrative measures

- Acquisition of land (a narrow riparian buffer strip is sufficient, but if it is possible to acquire more buffer strips, this will reinforce the effectiveness of the measure).
- Modified, requirement-oriented river maintenance
- Differentiated usage regulations along the riparian buffer strip, i.e. width of riparian buffer strip and adjacent use should be coordinated with one another (e.g. agricultural use, grazing in the vicinity of the bank, cattle watering at grassland sites).

Structural measures

- Replacement of solid bank obstrutions with bio-engineering measures
- Indigenous plantings: Planting and grassing according to the river function and landscape type

  In forest-free agricultural landscapes:
  - Preferably bank copses (e.g. alders, copse planting in the form of unbroken hedges helps to protect against wind erosion and spray drift).
  - In areas with a higher proportion of forest and for wide rivers:
  - Preferably reeds, herbaceous bank plants and grass lichen (helps to bind the substances transported by water erosion and elutriation).
- Delimitation of the riparian buffer strips from agricultural land, particularly where there is grassland use as well (e.g. via fences).
- Modelling of small-scale bank structures (bays, offsets etc.),
- Bed chicanes, rock obstructions, substrate packing, ground sills, woody debris, sharp drops to be replaced with chutes, steep banks, broken banks and gullies should be left as

they are, replacement of slip-off slope banks and undercut-slope banks, development of reed and bank planting to protect the bank against erosion

- Keeping cattle away from the bank and water body

Players involved in implementing the measure

☐ Federal Government	☑ Local authorities	☐ Associations, independent organisations
☐ *Länder* Government	☐ EU	☐ Private individuals

Effect analysis

Primary effects:

- Increase in the morphological diversity of the river bed
- Shading with plants helps to promote the ability of the river to absorb oxygen from the atmosphere
- Protection from erosion for the bank and bed
- Equalisation of the balance of materials via nutrient removal and leaf drop in autumn.
- Promotion of the river’s biological self-cleaning capacity
- Supply and retention of woody debris as a key structural component of natural rivers
- Promotion of habitat diversity via understoreys for fish or root systems as the habitat for limnetic invertebrates.
- Reduction in the intensity of maintenance thanks to shading
- Improvement of the micro-climate
- Delay of flood discharge thanks to increased retention
- Breeding and nutrition biotope for various types of bird
- Partial habitat for amphibians and small mammals

Secondary effects:

Material:

Reduction of substance discharges into the water body.

Effects on other media:

Preservation and improvement of the landscape and the landscape structure.

Economic / social effects:

Agricultural use may be restricted because it is necessary to create a riparian buffer strip, and as a result, no use is permitted in these areas. However, this only occurs to a limited extent, since a narrow buffer strip is sufficient for this measure.

Time required

Until implementation: Short- to medium-term

Until effectiveness: Medium- to long-term

Geographical effect

☑ local ☐ regional ☐ Nationwide / EU-wide

Interactions with other measures

There are numerous interactions between the measure outlined here and other measures, both in a chemical sense and in a hydromorphological sense. To a certain degree, substance discharges from diffuse sources are retained (cf. measure no. 2.1 “Reduction of nutrient and pesticide discharges via the creation of riparian buffer strips”), and there are also positive interactions with measures for the “upgrading of sewage treatent plants” (no. 1.1), since the self-cleaning capability of the river is increased, and in particular, beneficial effects are achieved from shading.

In a hydromorphological respect, for example, beneficial interactions may exist with measure no. 4.2 “Ecologically oriented flood protection”. By improving the bank and bed structures, the retention and delay of the outflow into the water body may be increased.

Instrument IX “Advice to the competent authorities on optimising water maintenance from a water protection viewpoint” may contribute towards establishing the aforementioned measure.

Measures with an ecological orientation may also be implemented within the context of compensatory measures for intervention into nature and the countryside (cf. instrument VI on “Restructuring nature conservation and fishing charges”).

Cost estimates

On average, the cost of water body renaturation with respect to improving bank and bed structures totals between **50 and 125 €/linear metre** (**min. 37.5 €/linear metre, max. 200 €/linear metre**). This cost assessment was taken from the information system for the selection of efficient renaturation measures (ISAR), and is based on an evaluation of sample renaturation projects.

Uncertainty factor

A narrow riparian buffer strip along the water body is sufficient for the performance of this measure. As such, the likelihood of conflicts with farmers as water body users is low. Implementation difficulties may occur in restricted areas, in some cases, but structural improvements may also be achieved there as well.

Summarising qualitative assessment

Measures such as the small-scale modelling of bank structures and indigenous plantings will effect a comprehensive improvement in the river banks and bed. Additionally, the self-cleaning capability of the river will be increased and the water protected from nutrient discharges. In view of this multiple effectiveness, the measure should be considered very valuable, and should be implemented in as many places as possible.

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APPENDIX II: INSTRUMENT SHEETS

Data Sheet No. I

Pressure category according to the Water Framework Directive, Annex II: *Diffuse sources*

Polluter category: *Agriculture*

Description of the instrument

No. I: Subsidising organic farming

Brief description / Specification of the instrument

Subject: Greater subsidising of organic farming via a series of individual measures

- Provision of additional financial resources, particularly within the context of the on-going reorientation of EU agricultural subsidies
- Granting loans for converting to organic farming methods

Within the context of the on-going reform of the EU's common agricultural policy, in particular, greater use of the second pillar of Agenda 2000 (promotion of rural development and environmental protection) is necessary in order to offer adequate incentives to convert to organic farming.

Assessment basis: The subsidy is initially to be linked to compliance with the relevant existing provisions at national and EU level (e.g. refraining from the use of mineral nitrogen fertilisers and pesticides, free-range farming, crop rotation etc.). In the medium term, a gradual increase in these requirements would appear to be expedient.

Administrative measures:

- Certification of organic farms
- Monitoring of compliance with the relevant provisions

Other measures

- Improved advice and information on the subsidy opportunities for farmers (with a targeted approach in areas with high levels of water pollution).
- Measures for the qualification and advanced training of farmers
- Improved marketing of organic produce, particularly at regional and local level

Players involved in application of the instrument

☑ Federal Government	☐ Local authorities	☑ Associations, independent organisations
☑ *Länder* Government	☑ EU	☑ Private individuals

Effect analysis

Primary effects:

According to the valid EC regulation on organic farming, as a general principle, **mineral nitrogen fertilisers** are not to be used in organic farming. The use of **organic fertilisers** is subject to free-range principles, which stipulate a maximum of two livestock units per hectare of operational land, and are therefore more stringent than conventional agriculture. Kreuzburg and Müller (1997) estimate that organic farming thereby reduces nitrogen discharges by 15 kg N/ha per annum compared with conventional fertilising practices.

The use of **pesticides** is only possible in exceptional cases. Instead, the health of the crop plants is ensured by means of measures to support natural self-regulation.

Secondary effects:

Material: Not on a significant scale.

Effects on other media:

Based on the provisions regulating the use of fertilisers and pesticides, as well as general management provisions, the pressure on soils is also reduced, thanks to lower pollutant discharges and a reduced risk of erosion.

Economic / social effects:

Because organic farming leads to significantly lower consequential costs in terms of ecology and health (such as lower nitrate and pesticide contamination of soils, water and products), the promotion of organic farming should not be viewed purely as a subsidy, but also as an investment aimed at preventing damage. Furthermore, the subsidising of organic farming is ideal for supporting the ecological and social functions of agriculture (such as the preservation of jobs in rural regions, the preservation of species diversity, the conservation of cultural landscapes, the production of high-quality produce that is healthy and safe).

Furthermore, the promotion of organic farming plays a key role in the reorientation of agriculture towards high-quality, environmentally friendly food production. As well as helping to change the self-image of farmers, this also includes the promotion of regional marketing.

Time required

Until implementation: At Federal Government level, there are already a number of initiatives designed to promote organic farming more widely. However, there is also further potential at regional and local level, for example via the disclosure of information about existing subsidies. These measures may be implemented in the short term.

Until effectiveness: The instrument will only become effective in the medium to long term vis-à-vis the improvement of water quality.

Geographical effect

The geographical effect of the instrument depends upon which players are envisaged to become more involved in its implementation:

Generally speaking, the promotion of organic farming is only suitable under certain circumstances for rectifying **local** water pressures. However, conversion to organic farming can be promoted by means of targeted information to farmers in areas with high levels of water pressure.

Encouraging farmers to meet and exchange information and to market organic produce jointly has a **regional** effect. In this respect, with existing initiatives, it would be conceivable to widen the objectives in the area of water protection or to link up with existing cooperative solutions in groundwater protection.

Subsidy measures from EU programmes or programmes at Federal Government level (such as the Federal Government programme by the Federal Ministry of Consumer Protection, Food and Agriculture (BMVEL) on organic farming) have a **nationwide** effect. However, at the same time, they only contribute to a general relief of water bodies and are not suitable for counteracting local pressures from diffuse agricultural pollution.

Interactions with other measures / instruments

The levying of taxes on nitrogen fertilisers and pesticides makes organic farming methods more profitable compared with conventional farming methods. At the same time, the obvious solution is to use the revenue from taxes on nitrogen fertilisers and pesticides to promote organic farming, in order to create win/win situations and promote acceptance of the instrument.

Other supporting measures include improved advice to farmers on the opportunities for subsidies in organic farming, and regular and advanced training easures on eco-friendly farming methods (instrument VIII).

Cost estimates

Organic farming incurs costs to farmers, initially, as a result of falling (absolute) revenues due to the greatly restricted use of fertilisers and pesticides. Dabbert et al. (1996) anticipate a decline in revenues of between 10 % and 50 % in individual cases, although these must be compared with the potential higher earnings for organic produce. The additional costs resulting from a reduction in earnings in the subsidy programmes of various Federal *Länder* have been estimated at between 100 and 160 €/ha*a (Böhm et al. 2002). Kreuzburg und Müller (1997) cite somewhat lower figures of approximately 77 €/ha*a. With regard to the nitrogen discharges thereby avoided, this is equivalent to specific costs of approximately 6 € / kg N*a, whereby the specific economic costs are significantly below those of nitrogen elimination within the context of sewage purification.

In this respect, Böhm et al. (2002) assert that the costs of additionally subsidising organic farming are difficult to estimate, since they depend to a large extent on the future development of demand for organic produce. If the current comparatively high willingness to pay can be extended to a larger market segment, the additional costs of organic farming would, for the most part, be compensated by an increase in the value of earnings. By employing targeted marketing strategies, this could even lead to an overcompensation of costs. On the whole, however, it can be assumed that the higher proceeds and the elimination of costs for mineral fertilisers would reduce the additional costs to around 50 €/ha. With regard to the specific cost effectiveness (cost per kg of nitrogen excess / discharge reduced), this produces the following results (Böhm et al. 2002):

€/kg N excess	0.87 to 2.81
€/kg N discharge	2.56 to 8.44

(This does not make allowance for the effects on pesticide pollution of the soil; subject to compliance with the corresponding requirements, this will be reduced to zero.)

A special start-up subsidy to compensate for the costs of conversion during the transitional period is also included in the costs incurred. Until a farm can be recognised and certified as an organic farm, it must prove compliance with the corresponding standards for a three-year period, and for this reason, targeted support during this period in the form of a bridging loan and start-up financing is expedient.

Uncertainty factor

The Federal Ministry for Consumer Protection, Food and Agriculture, within the context of the Federal programme on organic farming, has proposed far-reaching approaches and initiatives to promote organic farming in Germany (cf. BMVEL 2003, Isermeyer et al. 2001). These are intended to contribute towards the Federal Government's objective of expanding the ratio of organic farming to agricultural land from its current figure of 3.2 % to 20 % by the year 2010. However, attainment of this target remains uncertain at present, despite the extensive opportunities for subsidies currently existing.

Furthermore, even with attainment of the target, only 20 % of agricultural land will be organically managed, which means that other instruments and measures will need to be found for the remaining 80 % of land on which conventional farming methods are used.

Summarising qualitative assessment

By subsidising organic farming, politicians have access to a solution which has proven to be reliably administered and which attains its objectives more effectively than other instruments (e.g. to reduce discharges of nitrogen or the use of pesticides). Furthermore, organic farming is distinguished by numerous beneficial side-effects, such as lower health risks for consumers, better effects on employment, the conservation of cultural landscapes, and the minimisation of erosion.

On the other hand, the promotion of organic farming is of necessity limited in its effectiveness. Even if the Federal Government's ambitious target of increasing the proportion of organic farming to 20 % by 2010 is reached, there remains the problem of ameliorating the environmental impacts in the remaining 80 % of land where conventional farming is practised. Furthermore, the subsidising of organic farming is only suitable for triggering a long-term trend reversal in the handling of water resources, or for helping to relieve pressure in certain problem areas. However, the instrument is not suitable for solving acute problems.

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Data Sheet No. II

Pressure category according to the Water Framework Directive, Annex II: ***Diffuse sources***

Polluter category: ***Agriculture***

Description of the instrument

No. II: Levying a charge on organic fertilisers from non-free range farming

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Brief description / Specification of the instrument

Subject: Levying a charge on organic fertilisers in farms which do not practice free range farming

Assessment basis: Nitrogen content of the farmyard fertiliser excess incurred (quantity of fertiliser not covered by free range farming). Generally speaking, this is possible based on the mean values for the absorption capacity of land, or else is measured according to the actual concentration of nitrogen in the soil.

The quantities of organic fertilisers incurred may likewise either be measured, or estimated on the basis of experimental figures per livestock unit.

Small farms with a nitrogen incidence of less than 1500 kg N/a should be exempt from the charge. Such an exemption limit also has the effect of reducing the administrative input in relation to tax revenue.

Amount: 0.60 € / kg N, in accordance with the tax on mineral nitrogen fertilisers.

Alternatively, the International Commission for the Protection of the Rhine (IKSR) proposes a multi-stage model in which the amount of the charge is based on the excesses incurred (IKSR 1999). For example, with an application of 120-160 kg N/ha, the charge payable would be 0.45 €/kg N, for 160-200 kg N/ha the amount would be is 0.90 €/kg N, and for quantities in excess of 200 kg N/ha, a charge of 1.35 €/kg N would be payable; this formulation should persuade livestock farmers with limited land, in particular, to use slurry properly.

Administrative measures:

- Annual declaration of the livestock and land inventory, and the quantities of slurry incurred; in addition, where applicable, information on the nitrate content of the soil

- Alternatively: Creation of a measurement system for farms which are unable to prove adequate land coverage
- Levying of charges based on the specified or measured quantities (collection of the charge, monitoring, and sanctions where applicable).

Other measures: It is worth considering the extent to which trade in organic fertilisers should be admissible in order to meet the obligations. In principle, trade in organic fertilisers is an efficient instrument for regional distribution of the pressures incurred and as a substitute for mineral fertilisers; on the other hand, however, it does increase the administrative work involved.

Players involved in implementation of the instrument

☑ Federal Government	☐ Local authorities	☐ Associations, independent organisations
☐ *Länder* Government	☑ EU	☐ Private individuals

Effect analysis

Primary effects:

The aim of the charge is to limit the application of organic fertilisers to the absorption capability of the soil, by making the quantity of slurry not covered by free range farming artificially more expensive by means of a charge. To date, however, there are few reliable findings available on the effectiveness of such a charge.

Indicative results from Austria (Pfingstner 1986): According to model analyses, a charge of 100 % of the nitrogen price would effect a 26% reduction in the quantity of nitrogen. At the same time, the quantity of wheat produced would fall by 8 % per ha, whilst the yield of suger beet would decline by 4 %.

Secondary effects:

<u>Material:</u> Not on a significant scale.

<u>Effects on other media:</u>

If trade in organic fertilisers is to be admitted, then emissions of air pollutants are likely from transportation of the fertiliser. There is also the risk of accidents during transportation, and the associated point pressures.

<u>Economic / social effects:</u>

Like other economic instruments, a charge on organic fertilisers from non-free range places the onus on individual farmers to decide whether to aeliorate the additional pressures resulting from the charge via a variety of measures (reduction in livestock, modified land use or purchase of additional land), or alternatively, to choose not to convert their production methods and to withstand the additional charge. In this way, a charge regulation theoretically leaves more scope for efficient adaptation than would be achieved by imposing strict regulations, for example.

In order to alleviate the pressure on farmers, the charge should be structured in a revenue-neutral manner; this means that the charge revenues will benefit agriculture in their entirety. The main aim of the revenues should be to support ancillary measures, such as assistance with converting to organic farming methods, improving secure storage spaces for slurry, the reduction and improved treatment of farmyard discharges, and the support of regional distribution instruments for slurry (e.g. local slurry exchanges).

Time required

Until implementation: Because of the time-consuming control and administration mechanism required by this instrument, it can only be implemented in the medium term.

Until effectiveness: The measure will only become effective in the medium term.

Geographical effect

The instrument is effective on an area-wide basis. The main relief for water bodies is to be expected in areas with large livestock populations. In this way, although the instrument is only partly suitable for the targeted treatment of local *hotspots* with high levels of water body pollution or risk, it is nevertheless recommended as a regionally effective instrument to support local measures.

Interactions with other measures / instruments

A charge on organic fertilisers from non-free range farming should be combined with a levy on *mineral* nitrogen fertilisers (instrument III) in order to prevent substitution effects in both directions. If only one type of fertiliser is subject to charges, farmers are likely to switch to the other type, which would therefore minimise the desired reduction in nitrogen discharges. Unlike the tax on mineral nitrogen fertilisers, a charge on organic fertilisers is more suitable for improving the pressure situation in local *hotspots* in a targeted manner. Furthermore, in such cases, small-scale measures with short-term effectiveness should be used to minimise nitrogen discharges (measure 2.2).

Furthermore, there are also some overlaps between a charge on organic fertilisers and the subsidising of organic farming (instrument I), since particularly stringent land-related regulations apply there. Greater promotion of organic farming therefore reduces revenues from the charge on organic fertilisers; at the same time, the charge makes switching to organic farming more financially attractive.

A charge on organic fertilisers from non-free range farming complements measures aimed at more efficient information for farmers (instrument VIII) geared towards the more economical use of fertilisers. This is even more applicable if revenue from the charge flows back to the farmers in the form of education and information measures.

Cost estimates

In a 1997 study, the Öko-Institut estimates the revenue from such a charge at approximately € 180 million (Öko-Institut 1997). Regarding the economic and social consequences, it asserts that the risk of farm closures is minimal, even if the charge were to be set at a higher level than that envisaged. By contrast, Pfingstner (1986) argues that with a 100 % tax on nitrogen fertilisers, the income of the affected farmers would be reduced by 30 % compared with the starting situation.

The administrative costs of such a charge should be estimated as comparatively high. Unlike mineral nitrogen fertilisers, organic fertilisers tend to be incurred locally in a decentralised manner, and are not generally traded. For this reason, it is not possible to record and levy the charge amongst dealers. In consequence, determining the quantities incurred poses an administrative problem and a cost factor, which will tend to reduce the efficiency of the instrument.

A comparable charge in Switzerland (totalling 1 sfr / kg N, equivalent to 0.68 €) produces estimated annual revenues of 5-10 million sfr (equivalent to 3.4 – 6.8 million €), which is used to promote environmentally compatible production methods. To date, no data is available regarding the effectiveness of the charge.

Uncertainty factor

Given the comparatively high administrative expenditure, the instrument should be considered less efficient than a tax on mineral nitrogen fertilisers, for example. Particularly with low charge rates, moreover, it is to be feared that a considerable portion of the revenues from the charge will need to be spent on administrative costs. Furthermore, considerable resistance is expected amongst affected interest groups, particularly from farms with large livestock populations.

Summarising qualitative assessment

A charge on organic fertilisers from non-free range farming is overall less efficient than other fiscal measures in the area of diffuse agricultural pressures. This is primarily attributable to the comparatively high administrative expenditure involved in recording and reviewing the quantities of slurry incurred. Nevertheless, the instrument, especially in areas with large livestock populations, may make a tangible contribution towards the avoidance of diffuse water pressures without leading to unreasonable burdens.

Furthermore, the levying of a charge on organic fertilisers from non-free range farming would appear to complement and support a levy on mineral nitrogen fertilisers, so as to avoid substitution between different nitrogen sources.

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Data Sheet No. III

Pressure category according to the Water Framework Directive, Annex II: ***Diffuse sources***

Polluter category: ***Agriculture***

Description of the instrument

No. III: Levying a tax on mineral nitrogen fertilisers

Brief description / Specification of the instrument

Subject: Levying a tax on the purchase of mineral nitrogen fertilisers

Assessment basis: Nitrogen content of fertiliser sold in kg

The tax is based on the approaches discussed in the relevant literature and practised in other countries. Here, the amount of the tax is estimated at 50 % of the current price of mineral fertiliser, corresponding to approximately 0.60 €/kg N. With regard to timing, a gradual introduction over a period of four to five years is envisaged (cf. Feldwisch and Frede 1995, IKSR 1999).

Administrative measures:

Registration of dealers and manufacturers

Recording the products that are to be subject to the tax

Measuring and labelling the nitrogen content on the products

Collection of the tax by dealers

Other measures: None

Players involved in implementing the measure

☑ Federal Government	☐ Local authorities	☐ Associations, independent organisations
☐ *Länder* Government	☑ EU	☐ Private individuals

Effect analysis

Primary effects:

Mineral nitrogen fertilisers are an operating material that must be bought in by farmers. Consequently, farmers have an interest in using them as efficiently as possible. At the same time, however, the cost of mineral nitrogen fertilisers is comparatively low, which means that at present, fertilisers are often applied more extensively than is optimum. Apart from better advice, the efficiency of fertilisation may be increased primarily by artificially making fertilisers more expensive via a tax.

Various empirical studies have identified taxes on mineral nitrogen fertilisers as an effective instrument for reducing nitrogen discharges. A price increase of 50 % is expected to achieve a 15 – 25 % reduction in use, which in turn corresponds to a reduction in discharges of 20 - 20 kg/ha.

A tax on mineral nitrogen fertilisers is easy to levy and monitor, since comparatively few manufacturers and importers are active on the German market. In addition, the amount of the tax may be varied quickly and easily according to the development of the quantities produced.

Secondary effects:

Material: There is a risk that levying a tax on mineral nitrogen fertilisers will persuade farmers to switch to other fertilisers (such as organic fertilisers or fertilisers containing phosphate), and cause them to be used more widely.

Effects on other media: Not expected.

Economic / social effects: Like other economic instruments, a tax on mineral nitrogen fertilisers puts the onus on individual farmers to decide whether to ameliorate the additional burdens from the tax by means of cost-effective measures to reduce the use of fertilisers, or instead, to opt not to modify their production methods and to bear the burden instead. In this way, theoretically, a tax provision leaves greater scope for efficient adaptation than, say, a regulatory solution. However, as fertilisers are currently used more widely than is agriculturally optimum in many cases, there is still substantial potential for the more efficient use of fertilisers, without this necessarily leading to a decline in yields.

Time required

Until implementation: Disregarding the possibility of political resistance during implementation, the instrument may be implemented in the short to medium term.

Until effectiveness: Only expected to become effective in the medium to long term. For this reason, the contribution of a tax on mineral nitrogen fertilisers to attainment of good water status by 2015 lies more in the support and accompaniment of other, more targeted measures.

Furthermore, a graduated introduction of the tax would appear to be expedient, so as to make it easier for affected farmers to convert and adapt. One conceivable option would be a gradual introduction in three stages over a period of four to five years (cf. Feldwisch and Frede 1995).

Geographical effect

Nationwide effect, since introduction would be on a nationwide or EU-wide basis As such, the instrument does not have any local effectiveness, and is not suitable for solving local water body problems (*hotspots* with high levels of pollution, or areas meriting particular protection). As such, a tax on mineral nitrogen fertilisers is more of a medium-term instrument for trend reversal and relief than for the rectification of acute water body pressures.

Interactions with other measures / instruments

A tax on mineral nitrogen fertilisers would complement a charge on organic fertilisers from non-free range farming (instrument II). If a tangible tax is to be introduced on mineral nitrogen fertilisers, this would only be expedient if combined with taxes on nitrogen fertilisers from other sources. Otherwise, a levy on nitrogen fertilisers would only lead to mineral fertilisers being replaced by organic fertilisers, which would reduce the environmental effectiveness of the measure.

In the case of local *hotspots* with a high level of N contamination, a tax on mineral nitrogen fertilisers should additionally be combined with a levy on organic fertilisers from non-free range farming (instrument II), which tends to be more local in its effectiveness. Additionally, combinations with short-term and locally effective measures would also be expedient. The tax on mineral nitrogen fertilisers is a complementary, long-term alternative to measures that are effective in the short term, such as the upgrading of sewage treatment plants (measure 1.1), the creation of riparian buffer strips (measure 2.1), and other measures to reduce nitrogen discharges from agriculture that are effective in the short to medium term (measure 2.2).

Finally, the introduction of a tax on mineral nitrogen fertilisers should be combined with a greater range of advisory services (instrument VIII) in order to help affected farmers to avoid the tax by modifying their behaviour. Improved advisory activities may also be promoted by means of the corresponding use of revenues generated from the tax.

Cost estimates

In the literature, the elasticity for the use of mineral nitrogen fertilisers is given as between -0.35 to -0.6. In other words, a doubling in the price of nitrogen fertilisers would lead to a reduction in the quantity used of between one-third and 60 %. Hence, a tax of 130 % of the mineral fertiliser price will prompt a reduction in fertiliser use from 105 to 57 kg N/ha (Weingarten and Schleef 1999). However, the higher the tax becomes, the less the elasticity is likely to be.

In this connection, a study by the British environment ministry points out that overall, the price elasticity of nitrogen fertilisers is low. At the same time, however, a tax may serve as a trigger to reduce superfluous and hence inefficient uses of nitrogen, thanks to its signalling effect (DEFRA 1998).

Becker (1992) estimates the reduction in yields caused by a 50 % tax on mineral nitrogen fertilisers at just over 3 %; this is equivalent to a burden of approximately 23 to 28 €/ha. By comparison, Møller et al. (2003) examined the effects of a 100 percent and a 200 percent tax using the RAUMIS model. They concluded that a 100 percent (200 percent) tax would lead to a reduction in income of 2 % (5 %) for agriculture, corresponding to specific costs of 2.00 (1.20) € /kg N^{red}.

Since resistance is anticipated in any case, it would seem expedient to structure the tax in such a way that it has a neutral effect on revenues. The costs may be returned to farmers, for example, in the form of advisory measures on the optimum use of fertilisers or to promote organic farming, thereby creating win/win situations.

A comparable tax debated in Switzerland envisaged a charge of 1 sfr / kg N (equivalent to 0.68 €). This would lead to estimated annual revenues of 70 million sfr (corresponding to approx. 48 million €) which could be used to promote environmentally compatible production measures (IKSR 1999). No estimates are available regarding the effects of the tax on fertiliser use.

Administrative costs:

The administrative costs for a tax on mineral nitrogen fertilisers are low, since the number of traders, manufacturers and importers is comparatively low, and the trading chains are easily traced. There are no quantitative estimates of the administrative costs available.

Uncertainty factor

Because the elasticity of the demand for mineral fertilisers is low, a significant reduction in the use of mineral nitrogen fertilisers can only be achieved with a correspondingly high tax level. For lower tax levels, the steering effect of the tax is likely to remain low, and the instrument will tend initially to lead to higher tax revenues. In this context, it is all the more important that the funds from the tax benefit the conversion of existing fertilisation practices, e.g. by promoting organic farming methods.

The enforceability of the tax should be viewed with some scepticism, since in the past it met with significant resistance amongst representatives of farmers' interests.

Summarising qualitative assessment

Theoretically, a tax on mineral nitrogen fertilisers represents an efficient instrument for reducing nitrogen pollution of the soils in a cost-effective manner. The instrument leaves sufficient scope for affected parties to decide for themselves the extent and manner in which they wish to reduce their discharges and hence to find the most cost-effective procedure. Furthermore, like other economic instruments, it also creates incentives for the continuous improvement of the methods and techniques employed.

One criticism worth mentioning is that although the tax is effective over a large area, it is not suitable for combating hotspots, i.e. locally restricted areas with extremely high concentrations of nitrate (cf. Møller 2003).

The administrative expenditure for such a tax is comparatively low. A tax on mineral nitrogen fertilisers is easily collected and monitored, since there are comparatively few manufacturers and importers active on the German market. Additionally, the amount of the tax may be varied comparatively easily according to the development of the quantities produced.

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Data Sheet No. IV

Pressure category according to the Water Framework Directive, Annex II: ***Diffuse sources***

Polluter category: ***Agriculture***

Description of the instrument

No. IV: **Levying of a tax on pesticides**

Brief description / Specification of the instrument

Subject: To make the purchase of pesticides more expensive

Assessment basis: Generally speaking, the price, the quantity (in kg), the number of standard applications per ha according to the dosage instructions, the toxicity and persistence of the active ingredient, are all suitable for use as the assessment basis for a tax. An approach based on the price or quantity is easier to implement from an administrative viewpoint, but has a significantly lower ecological steering effect than an approach based on standard applications or toxicity.

The following account considers a tax of 12 € per standard application, per ha in accordance with the manufacturer's dosage instructions. As a result, the pesticide will become more expensive by an average of 50 – 80% (cf. Dubgaard 1991, Feldwisch and Frede 1995)

Alternatively, a risk class-dependent tax on pesticides should be considered in which the amount of the tax is determined depending on risk categories. This approach is the most targeted for achieving a reduction in pesticide applications and persuading users to switch to less harmful preparations.

The tax should be graduated over a period of four to five years in order to make it easier for manufacturers and farmers to make the switch.

Administrative measures:

- Registration of dealers and manufacturers
  - Recording the products which fall under the scope of application
  - Labelling of the content of active chemical ingredients per standard application on the products, plus classification of the active ingredient / combination of active ingredients into risk categories.
  - Tax levied via dealers

Players involved in implementation of the instrument

☑ Federal Government	☐ Local authorities	☐ Associations, independent organisations
☐ *Länder* Government	☑ EU	☐ Private individuals

Effect analysis

Primary effects:

The primary effect of a tax on pesticides lies in a tangible reduction in the use of such products, since by selectively making these items more expensive, incentives are created for more efficient use. Hence, pesticides are an operating material that must be bought in by farmers. For this reason, the farmer has an interest in using it as efficiently as possible; this can be further supported by artificially making the products more expensive.

In the past, empirical investigations have reached varying results, but all concluded that overall, there is a significant potential for reducing the use of pesticides by making them more expensive. For example, Feldwisch and Frede (1995) estimate that a price increase of 50 % would lead to a 25-50 % reduction in the use of pesticides.

Systems of taxes and charges on pesticides have been applied in varying formats in a number of EU states, including Italy, Denmark, Sweden etc. For example, in Sweden, the demand for pesticides fell by 70 % between 1981 and 1997, largely attributable to the introduction of a pesticide tax, combined with additional measures such as information and advanced training measures. Sweden's experiences with the instrument indicate that the demand for herbicides is more severely affected by the tax than the demand for fungicides and insecticides.

Secondary effects:

Material:

Substitution with other pest control methods (mechanical, biological, thermal etc.). Generally speaking, alternative methods tend to be less harmful to the environment, but may be substantially more labour-intensive.

Effects on other media:

Along with lower levels of water pollution, reduced concentrations of pesticide residues in the soil and in the food produced are also to be expected.

Economic / social effects:

Costs are incurred directly to the farmers, and indirectly to the manufacturers and distributors of pesticides. Depending on how the tax is structured, manufacturers may be able to avoid the tax by developing new products with a lower level of toxicity and tapping into new business segments. For the distributors of pesticides, admittedly, this will entail an increase in advisory work.

With respect to the consequential costs of the use of pesticides for water treatment and damage to health, a tax on pesticides would appear to be economically justified as a control instrument. Waibel and Fleischer (1998) conclude that under the system existing in 1998, the consequential costs of the use of pesticides in the old Federal *Länder* totalled up to 129 million €.

The economic burdens to farmers could be reduced by using the revenues from a tax on pesticides to finance accompanying measures, such as advice, education and training, and to promote environmentally-friendly cultivation methods and pest control techniques. At the same time, this would produce positive effects on employment.

Time required

Until implementation: A tax on pesticides is comparatively easy and quick to implement from an administrative viewpoint, since it can be linked to existing safety provisions governing the licensing and sale of pesticides.

Until effectiveness: The instrument will only become effective in the medium term. In order to make it easier for users to switch and adapt, moreover, a graduated introduction of the taxes over a four- to five-year period would be expedient.

Geographical effect

The instrument is effective on a nationwide basis, but is more suitable for large-scale trend reversal and pressure relief than for rectifying acute water pollution levels in selected areas.

As there is no opportunity for the tax to address local *hotspots* with high levels of pesticide pollution or areas particularly meriting protection, a tax on pesticides should be used as a supplementary and accompanying instrument.

Interactions with other measures / instruments

Instrument I: Subsidising of organic farming. A tax on pesticides has a signalling effect within the context of a reorientation of agricultural subsidies; as a result, switching to organic farming methods will also become more attractive from a financial viewpoint.

Instrument VIII: Advice to farmers on optimum operation from a water protection viewpoint. A tax on pesticides is complemented by advisory activities, since the economic pressures for farmers may be reduced by an improved range of advisory services. Improved advice would also appear expedient in the sale of pesticides to private individuals (such as owners of private gardens and allotments); in such cases, it might also be useful to investigate the introduction of compulsory advice.

Measure 2.4: Reduction in the discharge of pesticides. Since a tax on pesticides only becomes fully effective in the medium term, it would be expedient to combine this with a raft of measures to promote the proper handling of pesticides which would take effect in the short term.

Cost estimates

Costs to the affected players:

Costs are incurred to farms and private users resulting from the additional cost of the tax itself, the additional cost of switching to more costly techniques for weed and pest control, and the loss of earnings caused by damage from pests and diseases.

Depending on the chosen reduction target, the tax revenues generated by the measure are estimated at 230 to 330 million € for a 25- to 50-percent reduction in pesticide applications.

Archer and Shogren (2001) estimate the income losses to farmers resulting from a pesticide tax as moderate. Income losses were calculated for various tax rates, and totalled no more than 4 % of the farm income.

Empirical findings from Sweden verify that agricultural revenues there have remained more or less the same, despite massive reductions in the use of pesticides.

Administrative costs:

The administrative costs of a tax on pesticides are comparatively low, since the number of dealers and manufacturers is fairly small and easily traced. Furthermore, systems are already in place for the licensing of pesticides, and a tax on pesticides could be linked to these. However, the administrative cost will rise considerably if the tax is to be rated on the basis of toxicity. There are no quantitative estimates of administrative costs available.

Uncertainty factor

The effectiveness for private clients (owners of gardens and allotments) is dubious, since these types of clients are less inclined to consider cost-effectiveness when selecting and using pesticides than farmers. On the other hand, this category only accounts for around 5 % of the pesticide volumes sold, and are therefore generally of subordinate significance.

Precisely targeted structuring requires classification into risk categories on the basis of eco-toxicity – taxation purely on the basis of weight or volume would be incorrect. In this respect, the definition of a simple yet meaningful assessment basis (eco-toxicity index) poses a problem.

Furthermore, the enforceability of the instrument should be considered with a certain degree of scepticism: With the introduction of a tax on pesticides, considerable resistance from organised interest groups is to be expected. In the past, this has already prevented the introduction of such an instrument.

Summarising qualitative assessment

The principal advantage of this measure lies in its broad effectiveness and comparatively low level of administrative input, since various supporting measures may be combined with the system for the licensing of pesticides, which is in any case mandatory (such as toxicity analysis and classification into risk categories).

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Data Sheet No. V

Pressure category according to the Water Framework Directive, Annex II: *Water abstractions*

Polluter category: *Local Authorities and Households, Industry, Agriculture*

Description of the instrument

No. V: Greater use of environmental charges (e.g. water abstraction charges)

Brief description / Specification of the instrument

Charges for the abstraction of groundwater are already used in a number of Federal *Länder*. Different systems, assessment bases and exemption circumstances apply to these types of water abstraction charges.

In principle, water abstraction charges meet the requirement of the Water Framework Directive which states that by the year 2010, the water prices levied should cover all costs, including the financial costs of water supply as well as the environmental and resource costs. Water abstraction charges play various roles in the eco-friendly structuring of water prices: On the one hand, they serve to ensure that environmental and resource costs are charged to water consumption and external costs are internalised, in keeping with the “polluter pays” principle. Additionally, they create incentives for the more efficient handling of water as a resource. Finally, water abstraction charges play a key role via their financing effect, since revenue from this charge is often channelled back into the administration of water resources and in water conservation measures.

Regarding the financial costs of water supply, it can be asserted that the requirement of cost-covering water prices has already been largely met in Germany. However, this is only true to a limited extent for environmental and resource costs. Admittedly, the Federal Environmental Agency estimates the environmental and resource costs of water supply in Germany as rather low. It states that significant resource costs are only anticipated in those areas in which there are actual water shortages and certain uses are therefore excluded (UBA 2001).

The revenue generated from the charge should be utilised at local authority level in order to enhance the accuracy and efficiency of use. Furthermore, the charge should also be structured in a geographically flexible way, so as to reflect differing degrees of water shortage. In the past, however, water abstraction charges were measured less according to actual shortage, and were instead used primarily as a financing instrument. The revenue generated tended to be used for water conservation projects, and some of it was therefore channelled back to the payers. On the other hand, however, applications with only indirect impacts on water quality are common, such as the promotion of organic farming.

Administrative measures

- Registration of public water suppliers, industrial plants and farms which abstract water themselves.
- Registration of the volume of water abstracted and determination of the corresponding charge.
- Creation of a monitoring system in order to prevent abuse.

With regard to registration, logging and monitoring, recourse can generally be made to existing structures, which limits the administrative input.

Players involved in application of the instrument

☐ Federal Government	☑ Local authorities	☐ Private individuals
☑ *Länder* Government	☐ Associations, independent organisations	☐ EU

Effect analysis

Primary effects:

The primary effect of an abstraction charge is derived from the fact that as a resource, water becomes more expensive, which in turn leads to more efficient use and lower consumption. However – especially with the comparatively low level of water consumption in Germany compared with the European average – a comparatively low level of elasticity in the demand for water can be assumed, i.e. demand only responds slightly to price changes. This means that the charge only has a minimal steering effect - not least because the use of comparable instruments in the past has already contributed to the more efficient handling of water. Further gains could therefore be achieved more effectively via suitable use of the funds generated, e.g. to promote environmental projects and water saving measures (*earmarking*).

Secondary effects:

<u>Economic / social effects:</u> Economic consequences are derived in particular in those sectors where water consumption is associated with a comparatively low level of value added, particularly in agriculture. In affected areas, a decline in these sectors is to be anticipated.

Time required

Until implementation: Medium-term.

Until effectiveness: Medium- to long-term. With regard to effectiveness, another consideration to take into account is the fact that the instrument also becomes effective via the appropriation of revenues. However, this financing effect only occurs in the long-term, whereas the steering effect comes into play in the medium term.

Geographical effect

If the charge is intended to reflect actual shortages, it should be applied primarily at regional level; when determining the amount of the water abstraction charge, therefore, flexibility should be provided for a geographically differentiated structuring of the charge. In the past, by contrast, the instrument has been used on an area-wide basis at Federal *Länder* level. Even though such a system is imprecise from an efficiency viewpoint, it may be justified due to the lower administrative costs, provided the water shortages in different parts of the country do not vary too widely.

Interactions with other measures / instruments

Interactions with other measures / instruments are derived only from the financing effect, whereby the revenue generated from the charge is used to finance water conservation measures. Generally speaking, all measures may be considered for this purpose; however, the most expedient are those measures which serve the purpose of groundwater conservation or which contribute to the increased formation of new groundwater.

Cost estimates

In the eleven Federal *Länder* in which water abstraction charges have been levied in the past, the amount ranged between 2.5 and 30 ¢/m^3. However, numerous specific uses are exempt from the charge, such as heat abstraction, targeted lowering of the groundwater within the context of construction measures etc. Furthermore, the amount of the charge is often differentiated according to the intended purpose, whereby in some cases, public water supply has a considerable advantage over company water supplies and other purposes. At the same time, there are certain reductions designed to prevent competitive disadvantages or particular hardship for companies with a high level of water consumption.

Uncertainty factor

The degree to which an increase in the water abstraction charge affects consumption is measured according to the elasticity of water demand. The amount of this elasticity is disputed, but various studies assume that elasticity, at least for private clients, is minimal, which means that an increase in the price of water will only persuade consumers to be more economical to a limited extent. For this reason, the steering effect of the charge will be limited initially. The minimal steering effect of further price increases may, however, also be attributable to fact that drinking water prices in Germany are already fairly high by international comparison, and therefore, much of the efficiency potential is already exhausted.

Furthermore, there is also a risk that the additional costs incurred by the water supply companies are not passed on to the actual polluters or industrial plants, but instead are recharged to other customers with a greater willingness to pay, such as private customers. In this way, both the steering effect and the social efficiency of the instrument are reduced.

Summarising qualitative assessment

Overall, generally speaking, it is expedient to make the consumption of water, as a scarce resource, more expensive by means of a corresponding tax, particularly if it is possible to ensure that the revenue generated is earmarked for water conservation purposes. Such an approach, which aims to achieve full coverage of all costs including environmental and resource costs, is also required by the Water Framework Directive.

In Germany, however, water scarcity is currently only a regional problem, and for this reason, flexible structuring of the instrument would appear expedient. In areas where water abstraction is lower than the capacity to create new groundwater, further increases in abstraction charges should be dispensed with. At the same time, however, a reduction in charges does not seem justified, since this would set false signals to consumers. Additionally, this instrument may assume a greater significance in future if the water shortage extends to other regions, e.g. as a result of climate change.

Overall, therefore, it is advisable to push ahead with an increase in water abstraction charges particularly in those areas where the aim is to internalise significant external costs, i.e. for example, in areas where ecological damage in ecosystems dependent upon groundwater and subsidence damage to buildings caused by a lowering of the groundwater level are anticipated.

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Data sheet No. VI

Pressure category according to the Water Framework Directive, Annex II: ***Diffuse sources***

Polluter category: ***Morphological changes, Agriculture***

Description of the instrument

No. VI: Restructuring the nature conservation and fishing charge

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Brief description / Specification of the instrument

Subject: To widen the earmarking of the funds generated from the equalisation charge for nature conservation and fishing.

At present, funds from the equalisation charge for nature conservation may only be appropriated for selected projects. Additionally, the funds must be used for projects in close proximity to the intervention. In the past, this has meant that in some cases funds were not utilised, because no suitable opportunities were identified in the surrounding environment.

The earmarking of the nature conservation and fishing charge should be widened and extended in line with the objectives of the Water Framework Directive. An expansion specifically with regard to water body structure would therefore appear to be expedient, since there is still a significant need for investment in this area.

Hence, more of the funds from the nature conservation and fisheries charge should be used for measures to restore semi-natural water bodies and their banks and meadows, and for land acquisition in the vicinities of banks and meadows, so as to facilitate the inherent dynamic development of the river and to protect the water body from diffuse discharges.

Assessment basis: The assessment basis of the nature conservation charge and the fishing charge should be retained in principle. However, it is necessary to check whether the charges should be more closely linked with the objectives of the Water Framework Directive, for example, with respect to interventions that impact the water quality or the water body structure. In such cases, differentiation of the charge rates may be expedient so as to gear the charge more closely to the local pressure situation.

Administrative measures: Widening the earmarking of funds generated from nature conservation and fishing charges will require one-off action at administrative level. It consists of an amendment to the ordinances and administrative provisions governing implementation of the fishing legislation, aimed at expanding the concept of fishing-related measures to focus in particular on measures in the field of water body morphology. In order to widen the earmarking of the equalisation charge for nature conservation, analogous to this, amendments to the nature conservation acts and the equalisation charge ordinance need to be investigated. The aim here is to enlarge the geographical links of the compensatory measures, where funds could be utilised considerably more expediently at other locations. It can be assumed that the additional effort involved, apart from the amendment to the legal foundations themselves, is limited.

Other measures: None

Players involved in implementing the measure

☐ Federal Government	☑ Local authorities	☑ Associations, independent organisations
☑ *Länder* Government	☐ EU	☐ Private individuals

Effect analysis

Primary effects:

The principal effect of the mechanism arises from the appropriation of revenues from the charge (financing effect). The existing provision means that funds are not always appropriated for suitable projects. Due to a lack of suitable projects, moreover, the available funds have not always been utilised in full. At the same time, there is a significant need for financing, particularly with measures aimed at improving the water body structure. For this reason, the efficiency of the instrument can be enhanced without any major additional effort, by coordinating the earmarking of the equalisation charge for nature conservation and the fishing charge with the objectives of the Water Framework Directive, and in that the geographical links for appropriation of the funds are relaxed.

Furthermore, by means of suitable amendments, the incentive and steering function of the nature conservation charge can also be strengthened. Hence, the equalisation charge for projects which cause changes to water body morphology may be structured depending on the local pressure situation.

Secondary effects:

Secondary effects are not anticipated on a large scale. However, indirect social effects will occur as a result of the didactic function of a charge, which highlights the value of a water body (as a public commodity) to users.

Time required

Until implementation: Short- to medium-term

Until effectiveness: Medium-term

Geographical effect

Initially, the instrument will be effective at regional level. The instrument will develop an indirect effect on water bodies via the measures financed from the nature conservation and fishing charge (see following section). These measures are effective at local level.

Interactions with other measures / instruments

The instrument has a supporting effect in that it contributes to the financing of numerous measures to improve the water body structure. For example, this includes the creation of linear passability of the river (measure 5.1), the supporting hydraulic engineering measures (measure 5.2), the inherent dynamic development of flow (measure 5.3), and improvement of the bank and bed structures (measure 5.4). Furthermore, the instrument also promotes the creation of riparian buffer strips (measure 2.1) by making funds available for the acquisition of land in the bank and meadow sector.

Cost estimates

Administrative costs: By widening the earmarking of the nature conservation and fishing charge, only minimal additional costs will be incurred, since initially only new potential applications will be included, without altering the procedures for collection and allocation of the monies. Consequently, costs will be incurred as a result of the conversion itself (administrative costs of altering the Ordinance and communicating the changes to the affected parties). Other than this, additional expenditure will also be incurred as a result of supra-regional coordination of the appropriation of funds.

If the amount of the charges is to be additionally structured according to the local pressure situation, this will incur increased administrative expenditure on the regular evaluation and publication of the charge amount. Apart from this, the equalisation charge proposed here should have a largely neutral effect on costs.

Uncertainty factor

As the instrument is primarily effective via the financing of measures, the uncertainty factor of the instrument is minimal. On the other hand, uncertainties do exist in terms of the measures that are financed with the instrument. Assessments in this respect may be derived from the corresponding measure sheets.

Summarising qualitative assessment

In the interests of better coordination between different instruments and policy-making areas, it is advisable to gear the designated purpose of the equalisation charge for nature conservation more closely to the objectives of the Water Framework Directive, and at the same time to loosen the geographical restrictions on the appropriation of funds. Such an amendment may be achieved at low cost, but at the same time may significantly increase the efficiency of the equalisation charge and turn it into an effective financing instrument in water conservation.

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Data Sheet No. VII

Pressure category according to the Water Framework Directive, Annex II: *Diffuse sources*

Polluter category: *Agriculture*

Description of the instrument

No. VII: Improving cooperation between agriculture and the water industry

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Brief description / Specification of the instrument

The introduction of statutory regulations which facilitate cooperation agreements rather than regulatory mechanisms is proposed as a key measure to support cooperation between agriculture and the water industry.

§ 19, paragraph (4) of the Federal Water Act stipulates that farmers who are subject to management restrictions in water protection areas above and beyond the requirements pertaining to proper agricultural or forestry use are entitled to compensation. Implementation is left to the discretion of the Federal *Länder*. This provides a starting point for encouraging cooperation if the Federal *Land* in question opts for a decentralised, local regulation of compensatory payments between the parties involved. When concluding a cooperation agreement, the orders and prohibitions otherwise envisaged may be replaced by the provisions of the cooperation agreement, as stipulated, for example, in the new Water Protection Area Directive in Hesse. The cooperation agreements may regulate the use of fertilisers, the use of pesticides, soil cultivation measures, changes to use, as well as compensatory payments (cf. Feldwisch/Frede, 1995).

Cooperation solutions between farmers and water suppliers are fairly widespread in Germany; 80 % of over 500 case examples examined in a study by Dortmund-based INFU were located in Germany. The vast majority of cooperation solutions were created in order to prevent nitrate limits being exceeded and thereby avert more cost-intensive measures (Heinz 2002).

Players involved in application of the instrument

☐ Federal Government	☑ Local authorities	☑ Associations, independent organisations
☑ *Länder* Government	☐ EU	☑ Private individuals

Effect analysis

Primary effects:

Positive environmental impacts would emerge if the emission reductions attainable via cooperation solutions were to exceed those of the on-going implementation of water protection areas under administrative law.

This might be the case, since cooperation solutions generally facilitate a management method that is more tailored to location. At present, however, the opportunities and limits of cooperation cannot be finally evaluated, since proof of an improvement in drinking water qualities tends not to emerge until many years later with modified land management designed to conserve groundwater. Admittedly, a variety of different cooperation models are already reporting some success. For example, in a water conservation area in Lower Saxony, the nitrogen excess was reduced by 30 % between 1993 and 1996 (Niedersächsisches Umweltministerium <*Lower Saxony Environment Ministry*>, 1997).

A list of the environmental effects of the various existing cooperation arrangements is currently being compiled as part of a DVGW/LAWA project on “Water-conserving land management in water abstraction areas”.

Secondary effects:

Generally speaking, it has been proven that compensation regulations within the context of a cooperation agreement should be degressively structured, and should include at least some non-material components, e.g. by means of improved advanced training courses, information and training. In this way, the creation of dependencies can be avoided. Additionally, compensation provisions should exploit win/win potential in a targeted manner, so as to enhance acceptance of the instrument.

The inclusion of non-monetary compensation (such as advice and training) also helps to avert potential conflict between cooperation solutions and the “polluter pays” principle, the implementation of which is required by Article 9 of the Water Framework Directive. Compensation payments from water suppliers to farmers could conceivably be interpreted as a reversal of the polluter-pays principle.

Time required

Until implementation: Medium-term

Until effectiveness: Medium- to long-term

Geographical effect

The instrument is effective at regional level. Cooperation solutions are typically concluded at county level, or in the catchment area of a water supplier.

Interactions with other measures / instruments

Apart from water conservation areas, cooperation should be particularly promoted in ecologically sensitive areas. There is intensive interaction with instrument VIII (greater advice to farmers), since advice plays a key role within the context of cooperation.

Cost estimates

Costs are incurred to the water supply companies as a result of advice, administration and control. According to Bach/Frede (1995), these are in the magnitude of 75 €/ha agriculturally used land, per annum. Assuming an affected area of 1 – 2 million ha, this would translate into 75 - 150 million € in implementation costs per annum. This may be supplemented by compensatory payments, depending on the specific compensatory amount. According to Bach/Frede (1995) the average fluctuation range of compensatory payments is between 25 and 150 €/ha of agriculturally used land, per annum. Assuming an average figure of 75 €/ha · a, this would incur additional costs of 75 - 150 million € per annum. In total, therefore, the costs would amount to some 150 - 300 million € per annum.

Feldwisch and Frede (1995) also suggest that the compensatory payments for farmers should be geared to the yield capacity of the site, so as to render participation in cooperation solutions attractive to farmers in favourable locations as well.

Uncertainty factor

Cooperation agreements, as an alternative to statutory provisions in water protection areas, tend to attract a high level of approval, since it is left to the discretion of the farmers to conclude such cooperation agreements. However, acceptance of and interest in such cooperation agreements depends on the amount of the contract payments and the quality of advice and information.

According Feldwisch and Frede (1995), the effectiveness of cooperation agreements in areas with the most intensive land management and where there is a high risk of elutriation tends to be restricted, due to their low intervention intensity. In such cases, therefore, recourse must be made to more regulatory means.

Summarising qualitative assessment

The benefits of cooperation versus statutory or official mandates and corresponding controls lie in the fact that cooperation is more site-related and more effective (cause-oriented). They also offer a higher degree of flexibility (amendments are possible at any time) and attract a significantly higher degree of acceptance amongst the parties involved, due to the fact that they are based on private law with no government control input.

One possible disadvantage is that most cooperation arrangements are confined to those areas considered important for drinking water abstraction. Additionally, in the case of "compensatory payments", there is a contradiction with the polluter-pays principle as defined by Article 9 of the Water Framework Directive. For this reason, as a general principle, compensation should be degressively structured and should include at least some non-material elements such as advice and advanced training measures.

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Data Sheet No. VIII

Pressure category according to the Water Framework Directive, Annex II: Diffuse sources

Polluter category: Agriculture

Description of the instrument

No. VIII: Advice to farmers on optimum operation from a water protection viewpoint

Brief description / Specification of the instrument

A significant proportion of emissions from nitrogen fertilisers and pesticides from agriculture are attributable to the inefficient handling of fertilisers and pesticides. The practical and theoretical literature documents a number of cases in which the quantity of fertilisers and pesticides applied has been sharply reduced by means of improved metering and temporal and spatial management, without thereby reducing the yield. The cost of changing the cultivation method is often less than the savings generated from the reduced use of fertilisers and pesticides.

Where agricultural materials are used in excess of the optimum or at incorrect times, this is often due to a lack of knowledge. The mediation of information regarding environmentally relevant correlations between agricultural activity and environmental pressures may therefore encourage farmers to take autonomous action. Feldwisch and Frede (1995) cite the following topics for advice to farmers: site knowledge, knowledge of soil-conserving cultivation systems, environmental impacts of production materials, nutrient emissions in production, methods of integrated plant protection, fauna-friendly and environmentally compatible animal production, and the economic aspects of these measures.

Administrative measures

- Greater advisory, education and training measures on environmentally friendly cultivation methods for farmers
- Greater consideration of environmental correlations in the teaching content of vocational colleges for agricultural subjects
- Improved information regarding the opportunities for subsidies when switching to organic farming, and on other environment-related subsidy measures

Other measures

- Development and testing of new cultivation methods in local demonstration projects, aimed at presenting and teaching the methods in a practical way

In certain cases, compulsory advice is conceivable as an additional instrument, for example, linked to the purchase of pesticides. Such an approach would be particularly suitable for reaching allotment holders, home-owners or part-time farmers.

Players involved in application of the instrument

☐ Federal Government	☑ Local authorities	☑ Associations, independent organisations
☑ *Länder* Government	☐ EU	☐ Private individuals

Effect analysis

Primary effects:

The instrument only has indirect environmental impacts. Advice to farmers improves their knowledge of the environmentally-relevant consequences of agricultural activity and gives them the option of limiting these consequences via improved management methods. Because there is often still significant potential for improvements in this area, a substantial reduction in diffuse emissions from agriculture may be achieved in the medium term. Feldwisch and Frede (1995) and Böhm et al. (2002) estimate this potential at 50% of current emissions, corresponding to 0.5 kg P_{red}/ha and 15 kg N_{red}/ha.

Ideally, advice should concentrate on areas with a high level of environmental pollution, and on businesses where there is significant potential for a more environmentally compatible type of management.

Secondary effects:

<u>Economic / social effects:</u> Increases in efficiency by means of improved advice represent an example of win/win solutions: In many case, the quantities of fertilisers and pesticides applied exceed the operational optimum, which means that the quantity applied may be reduced without loss of revenue. Switching to different cultivation methods in itself implies additional effort for the farmers concerned, and may entail conversion costs. However, this one-off expenditure contrasts with lasting savings on operating materials.

Time required

Until implementation: Short-term

Until effectiveness: Medium to long-term

Geographical effect

Depending on the nature of implementation, the instrument has a local to area-wide effect. The instrument is particularly well-suited for introducing a medium-term improvement at regional level in areas with high levels of water pollution, via targeted advice to individual farms. At the same time, however, the effectiveness of the instrument is limited in areas with the most intensive land management (see “Uncertainty factor”).

Interactions with other measures / instruments

Improved advice to farmers is aimed at establishing a number of relevant measures in agriculture, including, for example, the reduction of nitrogen discharges (measure 2.2), the reduction of phosphorous discharges (measure 2.3), and the reduction of pesticide discharges (measure 2.4).

Additionally, the instrument of improved advice may be used in a targeted way to draw farmers' attention to the financial subsidies available for organic farming (instrument I) and thereby to encourage its more widespread acceptance.

Regarding interactions with taxes on pesticides, mineral nitrogen fertilisers and organic fertilisers, Feldwisch and Frede (1995) assert that improved advice and training reaches its limitations in areas where economic considerations oppose modified cultivation methods. For this reason, taxes on pesticides and fertilisers would promote the benefit of improved advice in this area, and similarly, advice may help to enhance the acceptance of these instruments.

Furthermore, improved advice to farmers may also form part of cooperation solutions (instrument VII). For example, advice may make up part of the compensation payment, particularly as a way of exploiting existing win/win potential. Furthermore, improved advice may indicate the need for modified cultivation methods and thereby enhance the acceptance of cooperation solutions.

Cost estimates

A study commissioned by LAWA points out that the considerable expansion in the range of advisory services in recent years has become a major cost factor in a number of Federal *Länder*; however, this statement is not backed up by figures.

The cost of nutrient analyses and advice is estimated at between 1 and 5 €/ha in a number of different studies. Assuming that 50% of the recommendations are implemented, in relation to nitrate, this corresponds to specific costs of between 0.15 and 0.75 €/kg N_{red}. With regard to phosphate discharges, Feldwisch and Frede (1995) assume that erosion-related P emissions can be reduced by 50 % by means of modified management methods, without loss of revenues. With equally high advice costs, this translates into a specific cost effectiveness of around 20 to 40 €/kg P_{red}. Hence, the efficiency of this instrument is considerably higher than that of many other regulatory or fiscal instruments.

The inclusion of environmental aspects in the curriculum of vocational colleges may be considered largely cost-neutral. In this area, the main challenge is to utilise the existing knowledge more effectively.

Uncertainty factor

Improved advice to farmers on optimum operation from the viewpoint of water conservation represents a "soft" instrument, since ultimately the onus is on the farmers themselves to decide the extent to which they accept the advice on offer and implement the recommendations. On the one hand, this means that the effectiveness of the instrument may only be assessed *a priori* to a certain extent. On the other, however, farmers will primarily implement those measures which do not lead to additional burdens; as such, it can be assumed that the instrument has a comparatively high level of efficiency (cf. Böhm et al. 2002)

Additionally, generally speaking, the effectiveness of improved advice is restricted in those areas with the most intensive land management and where there is a high risk of elutriation, due to the low level of intervention intensity. In such cases, therefore, recourse must be made to regulatory means (cf. Feldwisch and Frede 1995)

Summarising qualitative assessment

Improved advice and training for farmers represents a cost-effective means of tapping into existing potential for more efficient, site-compatible structuring of agricultural practices. Furthermore, by improving the advice on offer, resistance from the affected parties becomes less likely. In consequence, improved advice is to be recommended, not least as an ancillary instrument to fiscal mechanisms as a way of ameliorating the resultant burdens for farmers.

As the instrument will only become effective in the medium- to long-term, its efficiency can only be partly assessed. At the same time, it can be assumed that farmers will tend to opt for those recommendations that can be implemented with a neutral effect on costs. For this reason, a comparatively high level of efficiency with low costs can be assumed from the outset.

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Data Sheet No. IX

Pressure category according to the Water Framework Directive, Annex II: ***Morphological changes***

Polluter category: ***Local Authorities and Households***

Description of the instrument

No. IX: Advice to the competent bodies on optimising water body management from a water protection viewpoint

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Brief description / Specification of the instrument

In the past, water body management concentrated primarily on safeguarding water outflow, usable agricultural land, human settlement areas, and navigability. This resulted in numerous water body maintenance measures which are at odds with current ecological objectives. By contrast, environmental targets such as renaturation, the creation of passability, the limiting of water abstraction, the reduction of chemical discharges and the protection, maintenance and development of natural water body structures are increasingly being cited as water body maintenance objectives. The reversal away from a purely technical understanding of water body conservation towards an ecologically oriented, integrated approach is less a cost factor than an issue of approach. Particularly amongst local authorities, which are responsible for the maintenance of water bodies of the third order, there is often still a need for advice in this respect.

At the same time, pioneering initiatives are being undertaken in many local authorities, countryside organisations, maintenance associations and water associations. In this way, the federal structure leads to numerous innovative approaches which, when taken together, make up a wealth of experience. Based on this, a greater exchange of experiences is expedient, particularly with regard to implementation of the Water Framework Directive. The individual measures that are possible within the context of optimising water body maintenance are explained in greater detail in the corresponding sheets of measures (cf. below “Interactions with other measures”).

Furthermore, there are still implementation deficits regarding a number of provisions in the field of water protection. Feldwisch and Frede (1995) point out that the existing opportunities for reduction, particularly of agricultural emissions, are often not exploited in full, due to gaps in the knowledge of local farmers and the relevant administrations. The same applies to ecologically oriented maintenance of the water body. By means of improved education and training of the offices responsible for advising on and implementing agricultural and environmental legislation, in this way, the efficiency of the existing system can be enhanced, and implementation deficits may be rectified inexpensively.

Administrative measures

- Improved advice to water management offices and the relevant local authorities, countryside organisations, maintenance associations, water associations, and chambers of agriculture, etc.
- Organisation of an exchange of experience between the employees of different authorities, with mediation of the respective *best practice* and innovative case examples
- Reorientation of water body maintenance from giving priority to anthropogenic use (water outflow and shipping passability), through to an ecologically integrated approach (strengthening of natural functions, preserving the landscape etc.).
- Consistent application of existing mechanisms in water conservation

Players involved in application of the instrument

☐ Federal Government	☑ Local authorities	☑ Associations, independent organisations
☑ *Länder* Government	☐ EU	☐ Private individuals

Effect analysis

Primary effects:

- Reform of existing water body maintenance practices from the viewpoint of water protection and to recreate the ecological functions (preservation or restoration of type-specific structural and species diversity, preservation or restoration of type-specific hydrological and hydraulic conditions, self-cleaning potential)
- Integration with the requirements of flood protection and, where applicable, landscape development and recreational use

- Consistent implementation of existing regulations via instruction of the competent authorities, in turn leading to the rectification of enforcement deficits in water protection and improved forwarding of information on subsidy opportunities for environmentally friendly management methods, e.g. in agriculture.

Secondary effects:

The secondary effects consist of the more widespread application of environmentally compatible measures and approaches in water body maintenance, including for example measures to promote the inherent dynamic development of the water course, to create linear passability of the water, to create riparian buffer strips etc. (see below "Interactions with other measures / instruments").

Time required

Until implementation: Short-term

Until effectiveness: Medium- to long-term

Geographical effect

Regional or area-wide at Federal *Land* level. There are some successful examples of coordination and regional implementation via the creation of "water body communities" with varying structures (WBW Baden-Württemberg, GFGmbH of ATV-DVWK, water body communities model in Bavaria).

Interactions with other measures / instruments

The instrument of improved advice to local authorities helps to support a number of measures within the framework of water body maintenance, including for example:

- Inherent dynamic development of the river appropriate to location (5.3)
- Creation of linear water body passability (5.1)
- Creation of riparian buffer strips (3.1)
- Creation of ecologically compatible hydrological and hydraulic conditions by means of flow control (4.1)
- River bed widening (5.2)
- Moreover, the advice and advanced training of employees at the competent authorities is necessary in order to facilitate the use of other advisory instruments. This applies, for example, to improved advice to farmers (instrument VII) and the more widespread use of cooperation solutions between the water industry and agriculture (instrument VIII).

Cost estimates

Improved advice to local authorities may be achieved at comparatively low cost. For example, the models of “water body communities” that are practised in various Federal *Länder* offer a part-time neighbourhood advisor for each county. Most of the advisors are employed full-time by water management offices, environmental agencies or other regional authorities. The cost for part-time advisory services may be estimated at around € 170 to 300 per advisor, per day. Additionally, costs are incurred as a result of coordination, advanced training and information exchange between advisors.

At Federal *Land* level, this produces annual costs (for one territorial state) in the magnitude of € 60,000 for the performance and organisation of decentralised meetings. For training and exchange of experience between the neighbourhood advisors, costs are estimated at a further € 15,000, plus around € 30,000 for training materials and PR work. Around one or two permanent employees are responsible for coordination at the *Land* authorities or on their behalf. As such, the instrument is comparatively cost-effective, especially as the existing administrative structures are incorporated.

Estimated costs of € 180 to 200 per trained individual, per year may be assumed for the coordination, organisation and implementation of advanced training measures (including travel expenses and materials); these costs should be assumed over a training period of between two and four years.

Uncertainty factor

Improved advice to local authorities on optimising water body maintenance from a water conservation viewpoint has only indirect environmental impacts. For this reason, it is more suitable for ensuring the proper functioning of other measures and instruments, and increasing their efficiency.

Summarising qualitative assessment

Improved advice to the competent local authorities on optimising water body maintenance from a water protection viewpoint is a comparatively simple and cost-effective instrument to implement.

Given the low level of intervention intensity, the effects of the instrument are difficult to quantify. Against the background of implementing the Water Framework Directive, and the administrative challenges this poses, however, a greater exchange of experience between local authorities would appear to be particularly relevant.

Moreover, the instrument can also contribute to the complete implementation of existing provisions, and in this way may help to rectify existing implementation deficits and to boost the efficiency of other instruments.

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Further information and data on the implementation of and experiences with the instrument of water body communities is available from WBW Fortbildungsgesellschaft für Gewässer-entwicklung mbH, Heidelberg at Info@WBW-Fortbildung.de and from GfGmbH, Mainz at GFGmbH@t-online.de.

Data Sheet No. X

Pressure category according to the Water Framework Directive, Annex II: Point sources

Polluter category: ***Industry***

Description of the instrument

No. X: Strengthening the synergy effects between the IPPC Directive and the Water Framework Directive

Brief description / Specification of the instrument

Annex VI, part A of the Water Framework Directive cites Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control (IPPC Directive) as one of the Directives on the basis of which action is to be taken. This stipulates that the operation of certain industrial activities is subject to licensing. The aim of the Directive is to attain a high level of protection for the environment as a whole.

When issuing the licence, the licensing authority must consider the impacts of the installation on the environment as a whole, particularly direct emissions into the three environmental media of air, water and soil. In this respect, the authorities must ensure application of the best available technology. With respect to sewage treatment, this requirement is stipulated in § 7a of the Federal Water Act. The best available technology for sewage treatment is specified in Annexes to the Waste Water Ordinance for the individual sectors. In the licensing notification, the licensing authority must specify emission limits for the pollutants emitted by the plant in relevant quantities. The nature of the pollutants and the risk of potential relocation from one medium to another must also be taken into account. The determination of emission limits is the responsibility of the competent authority, which determines this individually for the respective plant. Furthermore, limits may be extended or replaced by specifying equivalent parameters or equivalent technical standards, and in certain circumstances may also be specified in abstract form. When setting emission limits, the authorities must take into account the best available techniques reference documents (BREFs) published by the Commission.

The reporting obligations of plants falling under the scope of the IPPC Directive are regulated in Emission Declaration Ordinances or comparable ordinances in the individual Federal *Länder*. These plants are also classed as significant pressures as defined by the Water Framework

Directive, and as such, the licensing conditions should be extended to include water body-related criteria. Details of direct industrial dischargers, who are liable for reporting under the IPPC Directive, are additionally included in the reporting obligations of the Water Framework Directive for 2004 under Article 5.

Specification of the instrument

§ 7a of the Federal Water Act envisages the use of certain techniques which must reflect the best available technology as a condition of licensing for plants that discharge waste water. Furthermore, the licensing notifications also contain limits, both with respect to concentrations and with regard to total emission loads. Against the background of implementing the Water Framework Directive, therefore, the requirements governing the best available technology for sewage dischargers need to be reviewed and, where applicable, further developed.

The following implementation stages serve this purpose:

a) *Linking of the IPPC Directive and the Water Framework Directive with respect to environmental quality limits.* Article 10 of the IPPC Directive envisages additional conditions in the licensing of plants where compliance with an environmental quality standard necessitates more stringent conditions than application of the best available technology. In national legislation, this link is found in § 6 of the Federal Water Act, which states that requirements pertaining to the use of water bodies and the construction and operation of plants may be stipulated by way of an ordinance in order to comply with binding resolutions by the European Community. For example, this could concern the licensing of plants which discharge into a water body which is not expected to attain good ecological status. Possible additional conditions range from the requirement to use techniques which meet higher requirements than those indicated by the Annexes to the Waste Water Ordinance, through to a ban on the licensing of new human settlements which would place additional pressure on the water body. This type of local differentiation is also supported by Article 9, paragraph (4) of the IPPC Directive; this Article envisages that when determining emission limits in the licence, local environmental conditions must also be taken into account. Hence, this provides an opening clause which allows local conditions in particular to be reflected in the licence. Specifically, more stringent requirements are possible on this basis, provided environmental quality targets are not at risk of being exceeded, but the water body into which the plant is discharging is particularly sensitive or merits particular protection in some other way.

b) *Greater consideration of the requirements derived from implementation of the Water Framework Directive in information regarding the best available technology.* In order to attain the quality targets of the Water Framework Directive, when regularly updating the best available technology in the Annexes to the Waste Water Ordinance and, at European level, the BREFs, every effort should be made to ensure an ambitious formulation. In particular, this concerns techniques on the verge of technical and economic implementability (cf. measure 1.2). In this respect, however, it is important to ensure that the integrated concept of the Directive seeks to avoid protecting one environmental medium at the expense of another. For this reason, greater consideration of water protection must not lead to increased emissions into another environmental medium.

Players involved in application of the instrument

☑ Federal Government	☑ Local authorities / district commissioners	☐ Associations, independent organisations
☑ *Länder* Government	☐ EU	☐ Private individuals

Effect analysis

Primary effects:

The aforementioned stages become effective in various forms. Effect analysis is made more difficult by the fact that, as a general rule, the stages outlined only impact the water body status indirectly. Ultimately, the effects of the instrument depend on which techniques are included in the best available technology according to the Annexes to the Waste Water Ordinance, and to which extent these are used.

a) The introduction of additional licensing conditions in cases where attainment of a good ecological status is at risk (pending violation of environmental quality limits) contributes directly to a reduction in significant water body pressures (e.g. the discharge of priority substances), in that the conditions for existing and new dischargers become more stringent. The same effect is derived for the introduction of additional licensing conditions in cases where the local environmental conditions so dictate.

b) The committed updating of the best available technology in the Annexes to the Waste Water Ordinance leads indirectly to the fact that more stringent requirements and limits are applied when licensing plants, which in turn helps to reduce significant water body pressures (such as the discharge of priority substances) on an area-wide basis.

Secondary effects:

<u>Material:</u> None

<u>Effects on other media:</u> According to the IPPC Directive, protection measures that minimise contamination of an environmental medium and thereby lead to increased pressures for other

media are to be avoided. As such, no significant effects on other environmental media are to be expected.

Economic / social effects: Particularly if the requirements under the IPPC Directive are extended to small and medium-sized companies, additional pressures are to be expected. The additional expenditure incurred to companies as a result of implementation should be kept to a minimum where possible, for example, by granting corresponding transitional periods, by subsidising the plants during the conversion phase, or by means of other supporting stages such as extended advice.

Time required

Until implementation: a) short-term b) medium-term

Until effectiveness: a) medium-term b) long-term

Geographical effect

a) By linking the licensing conditions for plants falling under the IPPC Directive more closely with the environmental targets of the Water Framework Directive (attainment of a good ecological status), the instrument is applied at regional level. The decision on more stringent licensing conditions with the risk of failure to achieve targets would lie with the competent licensing authorities, who are generally the district commissioners.

b) Greater consideration of water protection when updating and amending the best available technology, on the other hand, would be effective on a nationwide basis.

Interactions with other measures / instruments

b) Updating the best available technology in the Annexes to the Waste Water Ordinance may be used, in particular, to publicise technical water protection measures that are on the verge of technical and economic feasibility. In particular, these include measures 1.1 to upgrade (in-house) sewage treatment plants and 1.2 on the use of membrane filters.

Cost estimates

Direct costs: The administrative costs of the proposed implementation stages for the executing authority tend to be minimal, since they are linked to existing administrative procedures.

On the other hand, additional costs are incurred for the companies required to implement and finance the envisaged measures. The cost of this is generally derived from the corresponding measure sheets.

In addition, there are also indirect / economic impacts if the additional costs to the company influence the competitiveness of the firms in question. These effects cannot be evaluated collectively, but must be ascertained separately, depending on the local economic structure, for the period under consideration.

Uncertainty factor

The actual effects of the stages outlined here not only depend on which techniques are reported as the best available technology according to the Annexes to the Waste Water Ordinance, but also on the extent to which these techniques are actually used. Hence, the technology-related approach of the IPPC Directive and its implementation only leads indirectly to changes in water body pressures.

Summarising qualitative assessment

In terms of its fundamental approach, the IPPC Directive is an ideal complement to the basic concept of the selection of cost-effective combinations of measures, whereby contamination should preferably be avoided where possible at the lowest cost, provided ecological protection targets are met. By demanding integrated environmental protection in production processes, the IPPC Directive (and the national legislation based on it) tends to favour a departure from expensive retrospective environmental protection in the form of end-of-the-pipe techniques. Furthermore, national implementation of the IPPC Directive provides a suitable set of instruments for promoting the more widespread use of cost-effective technical measures in water protection. For this reason, the implementation stages outlined here are desirable, particularly in those areas where emissions from plants subject to the IPPC Directive account for the bulk of the pressures.

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