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River Basin Management - Challange to Research

Walter Geller (Ed.)

UFZ Centre for
Environmental Research Leipzig-Halle

Department Inland Water Research

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River Basin Management – Challenge to Research

Proceedings of the international conference 8-9 June 1999
at the UFZ Centre for Environmental Research Leipzig-Halle
Magdeburg Dependency

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Department Inland Water Research
UFZ Centre for Environmental Research Leipzig-Halle

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Preface

Even in the past, the protection of individual waters and river systems, as well as the protection of groundwater resources was already the subject of intense effort. The international commissions for the protection of the Rhine and the Bodensee lake were active in the thirties and laid the foundations for the analysis of sources of pollution and for the derivation of suitable measures to improve water quality and the ecological condition of the waters. The successful approaches towards whole river catchment area management are also decades old, as the example of the Tennessee Valley Authority shows. It became clear that the problem complexes associated with "river catchment area management" could not be tackled with water-economic approaches alone.

Management measures with a tightly focused target direction (e.g. fisheries, water quality, water-economic or environmental protection aspects) are often inconsistent, as the inherent contradictions cannot be seen and taken into account: agricultural practise versus environmental protection and issues of drinking water quality, fishery management practises versus water quality issues, local versus regional and global protection targets.

The development and assessment of management concepts for an economically and ecologically sustainable development of complete river systems and their coastal regions requires a co-ordinated bundelling of very varied activities which are aimed at the following areas:

- material outflow from landscapes (biotic and abiotic material transformation processes, nutrient balances, transportation, the ground as a filtering and buffering system),
- material transportation and transformation in coastal ecosystems (material spread, dynamic flat-water processes, biogeochemical processes,
- socio-economic factors of the material flows (acceptance surveys, cost-benefit analyses, community values systems, stakeholder analyses, scenario development),
- combining models and development of scaling rules (multi-block approaches, scenario calculations, forecasting instruments, data management).

For most of the areas mentioned above there is a host of reliable knowledge available, but the need for research continues to be great. The landscape blocks of ground, river and coast, as well as socio-economics need to be analysed in much more detail, and these main areas of work need to be linked together into multi-block approaches with mathematical modelling methods. In the medium term, the modelling of balances and of the behaviour of conservative materials, biologically reactive nutrients and pollutants should be possible. Different scale levels (e.g. lysimeter, catenas, catchment areas) must be linked to one another through scale boundaries and accompanying models brought together. Changing system behaviour under changing framework conditions (e.g. climate shifts) should be included and integrated into the relevant simulation calculations.

The EU Water Framework Directive is the reason why expert knowledge is being put into a binding legal framework right across Europe, which makes the putting into practise of available knowledge compulsory. The solution to the problems comes less from the direction of defined technical measures, and more from the level of correctly placing and tuning framework demands on water, agriculture and forestry economics. Knowledge and research based on an integrated concept can provide solution approaches for both local and national problems at various scales, which can be used to develop scientifically sound and firm proposals as options for action for politics and the economy. Only on these complicated paths can we come increasingly closer to the target of a sustainable use of ground and surface waters, measured in centuries.

Magdeburg, 1st August 1999

Walter Geller

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Thank you Prof. Geller, Prof. Fritz,
ladies and gentlemen,

Firstly I would like to convey the greetings of our Research Minister, Ms Bulmahn. I know that as she is so committed to environmental research and water protection, she would have liked to open this European conference so near to her home city of Hannover herself. She is unable to do so, however, because of urgent appointments in the south of Germany.

It is no coincidence that today's conference is taking place here in Magdeburg, as this town is the headquarters of the water and shipping agency, and the secretariat of the International Commission for the protection of the Elbe is also situated here. Magdeburg also made a good name for itself in GDR-times as a place for water research and water management. For experts, we are in a highly-renowned, historical location.

After the re-unification, we added several things to Magdeburg's itinerary; e.g. this new and fine building which I had pleasure in handing over to the UFZ almost one year ago. I am especially pleased to see how the scientists working here have filled the rooms with life. Finally, the Magdeburg water-protection seminars, which are organised by the water-research section of the UFZ and held at a different location every two years have a good and long-known reputation.

The subject of our conference is a tongue-twister in both German as in English - River Catchment-Area Management. Let us not be confused by this, nor through the technocratic expression "management":

It is to do quite simply with clean rivers and healthy landscapes - here on the Elbe, in Germany, in the EU, and with a view further afield, on the oceans and the planet as a whole. This is why we can speak at this international conference of global environmental responsibility. We must answer the questions:

- what is global environmental responsibility?
- And what are the questions that it asks of science?

I believe that we will firstly have to demand global responsibility everywhere where there are distribution problems. Distribution problems mean when there are arguments between those places which stand to gain from economic decisions and those areas which stand to lose out as a result.

The shift can be inter-regional: the advantages are in one region, the disadvantages carried over to another. The shifts (disadvantages) can also be inter-temporal, that is they are shifted into the future and thus onto coming generations, and are not therefore carried by those who gain from them. Where do these distribution effects exist? Which building blocks belong to the solution profile? What are the questions for Science?

- To the question: where are the distribution effects?

Distribution effects can always be seen when environmentally damaging consequences of economic activities are transported over boundaries.

This affects principally the media of air and water; the pollutants, once emitted, can be transported over long distances. This means that we are talking about our atmosphere, the oceans and river systems. But the export of toxic waste also falls into this category.

Distribution effects can also occur "indirectly", though, when standards of living are fundamentally threatened by human intervention in natural systems. The emission of greenhouse gases is a prominent example of this. Although mostly harmless in their own right, they can cause massive distribution effects through the regional differences in climate change, via their role in the climate system.

In times when globalisation and unification of continents are dominating the headlines, one could believe the commonly accepted worry over large rivers and the oceans they feed into as being something very modern. Indeed, it is indisputably that too, when one remembers the North Sea protection treaty of 1994, the treaty on the protection of the Baltic or on the international treaty on the protection of the Rhine, Danube, Elbe and Oder.

But, ladies and gentlemen, partnerships between river-sharing countries are not so new; the first legally-binding treaty between federal Switzerland, imperial Germany and the kingdom of the Netherlands to protect salmon in the Rhine and its tributaries was agreed in 1885. Allow me to quote from the imperial law gazette nr. 18 from 30.06.1885:

"To raise the stock of salmon in the Rhine area, please note that the natural spawning sites in the tributaries (of the Rhine) are to be reconnected and made accessible to ascending salmon where possible. The reproductive elements, roe and milk, of caught salmon are, where possible, to be used for purposes of artificial breeding" (Imperial office Berlin).

Back then, it had to do, among other things, with the Swiss salmon farm in Huening near Basel and the Dutch, who released salmon into the Moselle.

It is true that it has since then taken us almost 100 years to reach the point our great-great-grandfathers (and -mothers) had already reached. This sounds harsher than is meant. For it is also true on the other hand, that we have, by now, made a good deal of progress in becoming aware of our environmentally-political responsibilities in Europe and in Germany.

Here some evidence:

- Our rivers have become much cleaner. The single-point inputs have gone down greatly. We are dealing (where possible with integrated measures) with the problems of diffuse pollutant and nutrient inputs.
- We have not only learnt essential things about the ecological importance of river landscapes through the study of "Model Implementation of Ecologically-Based Cleaning Concepts for Small Water-flow Systems", but have, for the first time, developed the relevant integrated cleaning technologies.
- The new Rhine-Protection Treaty, which was agreed on 12th April of this year in Berne, sets up a comprehensive ecological concept for one of Europe's largest catchment areas, including flood-protection measures and the inclusion of ground-water questions in management.
- What can demonstrate the supra-national advance in water protection more than the EU Water Framework Directive, which will probably come into effect in the year 2000 and make a new dimension of river catchment-area management binding?

Our government minister Edelgard Bulmahn has made sustainable management a leading subject of her politics. What sustainable management means, however, is not so easy to describe.

In this I see the obligation to handle natural and human resources in such a way that following generations have the same amount of chances for development as those alive today. For the Environment Minister, this also means accounting for the effects and side-effects of measures in social and economic areas. We need instruments with which we can still be able to act when there is a conflict of targets. We need procedures to allow more weight to be given to long-term thinking.

I would like to specially point out that the organisers BMBF and UFZ have very consciously brought together catchment-area experts from Western Europe with German colleagues and our eastern neighbours from the other side of the Oder, Elbe and Danube, so that the learning effect is as broad and fruitful as possible.

If we reflect on the subject of our conference "River Basin Management - Challenge to Research" with respect to the background of previous research promotion of the BMBF and the demands of the EU, then it becomes clear that the foundation of natural sciences needs to be specifically broadened to account for water uses, and that knowledge will need to be brought into the development of application-orientated decision support systems more than in the past.

Ladies and gentlemen, I would certainly disappoint your expectations if I limited myself on our subject today, to talk of responsibilities of politics and government in the field of water protection. As a civil servant in the Ministry for Research, I have to speak of the responsibilities of scientists and technology developers in this field, even when many of them understand more about it than I do.

Nobody will disagree when I say that science and research have a responsibility for water protection that can't be overestimated: in analysis, diagnosis, ecological conceptioning, preventative and renovation technologies etc. etc.. A look at the variety of the presentation and discussion topics is enough to see that research and development must continue here, as everywhere, with decisions on measures, or rather, decisions on the implementation of investments.

What are the criteria that we should attach to the decisions on our future research profiles? I believe we should:

- concentrate on the solution of questions and problems which the Federal Republic has played a role in creating and which have effects on our European neighbours (water pollution and flood prevention are two important keywords here),
- do our bit where innovative solutions can be applied to national as well as cross-border problems (sewage technologies, integrative management strategies and technology transfer, also with a view to the future extension of the EU community of states), and
- we should investigate how and where German scientists, the economy and government bodies, are in a position to play a part in solving national, European and international questions in the environmental sector.

Ladies and gentlemen, I would like to finish my comments on the subject of the responsibilities of water research and water technology in catchment-area management by sharpening my comments once more: science and research are in debt. Naturally this doesn't mean repaying a debt without money, as the Federal Republic, the Länder and the communities should, and will, support and finance good research projects. But I also believe that many of the questions worthy of research, of still unworked-out fundamental methods, or the regional adaptation of new water technologies, must be brought to the attention of political decision-makers by scientists and development teams. Civil servants and financial experts may, perhaps, be able to correctly manage research financing, and sometimes also to describe deficits and problems accurately, but they still need the ideas and creativity of research and inventors.

With this in mind, I wish our conference, the exchange of ideas and efforts to find solutions for a sustainable management for complete catchment areas, the best of success.

MinDir Dr. Eckhard Lübbert

Ladies and Gentlemen,

I would like to welcome you to the Centre for Environmental Research and this meeting on "River Basin Management - Challenge to Research". This meeting was initiated by the Ministry for Education and Research, and I would like to welcome Dr. Lübbert from this ministry. The UFZ is not totally unknown to you, and I would like to take the occasion to thank you and your colleagues at the ministry for your essential assistance in the support of this meeting.

The links within the European Union are of fundamental importance for the activities of the UFZ, and we are always very pleased if it is possible to show this support.

Ladies and Gentlemen,

In recent years, there has been a significant evolution in the management of water resources. In less than 20 years hydrology and hydrogeology have gone from the analysis of individual small aquifer systems to the analysis of entire aquifers and in recent years more and more to the analysis of entire drainage basins. This is a very logical, yet also very important evolution since surfacewater runoff cannot be treated as an isolated phenomenon. It is influenced by groundwater discharge where we have to note that groundwater movements in many drainage basins are closely linked to the physical structure of the drainage basin and the resulting hydraulic gradients as well as the biological situation.

The relevance of such analyses at a basin scale was demonstrated a few years ago within the continental deep drilling programme of the Federal Republic of Germany. There, the geophysicists assumed that it would suffice to make geothermal gradient measurements on individual boreholes of a length not exceeding about 100 m, whereas the hydrogeologists predicted on the basis of the basin's structure that the depth of active groundwater flow would probably exceed 1000 m. The geothermal gradient established during drilling confirmed the view of the hydrogeologists and very significant corrections to the achievable depths of drilling had to be made.

More important, however, are quite clearly such investigations within the framework of waterresources management. Under this topic, the research interests of the UFZ are encountered at several levels. Our researchers are engaged not only in the water flow through basins but also the material transport from basins of various shapes and sizes to the surfacewater systems. Especially noteworthy is here a project carried out in collaboration with colleagues in Russia that compares the water and material budget of sections of the River Elbe and the River Oka. It is anticipated that these investigations will be extended to the River Volga, and we may even begin a project in Brazil - in collaboration with colleagues in Brazil and of other German research institutions - where the basin management in subtropical regions is addressed.

The challenge of the future lies not only in understanding and quantifying water and material transport, but also the effect of biology on these systems, in other words, a link between problems of biodiversity, landuse and water management has to be made. In this context, geographic information systems play a very major role, and the Department of Applied Landscape Ecology at the UFZ is already engaged in relevant activities. It should be mentioned that models and tools developed at the UFZ are at the point of commercialisation, and we hope that within the coming months a small private company will exit from the UFZ to market the computer models which allow a landuse planning at a very detailed scale.

Returning to Magdeburg I should like to mention that our research potential for work on surface water systems has been dramatically increased through the acquisition of a research vessel which allows us to work on the Elbe and other river systems with on-site investigations. We hope that the vessel will be used in international programmes such as the ones discussed during this meeting and we also hope that this meeting helps to firm up established contacts to other German and foreign colleagues. I wish you interesting and fruitful discussions, enjoy your visit to Magdeburg, and maybe you will even find the time to go to the Garden Fair which is very close to your place of meeting.

Last not least, Ladies and Gentlemen, I would like to thank our local organisers for the preparation of this meeting. I hope you will find that their efforts have been well directed and the results will lead to a pleasant and enjoyable meeting.

Prof. Dr. Peter Fritz

TOPIC I :
EU: FRAMEWORK FOR RESEARCH AND ENVIRONMENTAL POLICY

The Amended Proposal for a Council Directive Establishing a Framework for Community Action in the Field of Water Policy

Udo Bosenius, Ministry for the Environment, Nature Protection and Reactor Safety, Bonn

Since the beginning of the seventies, many decisions have been made at an EU level that are relevant to water. 20 years later the sum of decisions was so large, and the areas concerned so heterogeneous, that a harmonisation was necessary. In February 1996 the Commission presented a communication to the Council and to the European Parliament (EP) on European Community Water Policy, which also contained elements of the future water-policy. On the basis of this they passed a proposal for a Directive establishing a framework for Community action in the field of water policy on the 26.02.1997 (H OJ No C 184 of 17.44.1997, p. 20 ff.), which should be the basis for an agreed, unified, common EU water policy.

On the basis of consultations in the Environment working group, informal talks by the Commission with the Member States about rules for small and medium-sized companies, and the first statements by members of the European Parliament, the Commission changed the suggestion for a Water Framework Directive through additions on 26.11.1997 (H OJ No C 16 from 20.01.98, p. 14) and 17.02.1998 (H OJ No C 108 from 07.04.1998, p.94 ff.).

The Environment working group worked out a new draft of the Water Framework Directive under British presidency, which the Council of Environment Ministers unanimously passed as political consensus on 16.06.1998.

Mainly on the basis of 122 proposals for amendments by the Environment Committee on 26.06.1998, the European Parliament first made its statement on 11.02.99 in the first reading. The Council of Environment Ministers voted for a common position for the draft directive on 11.03.1999.

The aim of the Water Framework Directive is partly a prevention of a deterioration in the ecological condition of waters (= maintaining the so-called acquis communautaire), and partly to achieve a good condition of surface waters and groundwater. The good quality of surface waters is determined according to biological, physicochemical and hydromorphological parameters as well as through the observing of EU-widely valid threshold and quality values for approx. 30 so-called priority substances. Thus the Water Framework Directive fulfils the requirements of an integrated waters assessment. The good quality of the groundwater is derived from qualitative elements (= chemical nature) and quantitative elements (volume definitions). Thus, appendix V lays down, for example, that the volume of groundwater available must not be exceeded by the long-term yearly average of withdrawal.

The Directive also serves to reduce the effects of floods and drought.

Whereas the proposal of the Commission planned to reach this target in 13 years after the Directive came into effect, the member states of the EU reached a consensus of 16 years on 16.06.1998.

In the framework of consultations in the relevant Environment working group, exceptions to the obligation to create a good condition of waters were added. These include the extension of time given to measures for reaching these aims to up to 34 years as well as the laying down of less tough environmental targets when an improvement is impossible, or the costs are out of proportion within the framework of a cost-benefit analysis.

The Directive envisages the management of waters for the whole catchment area of a river, from its source to its meeting the sea. The member states must form catchment area units for this. Furthermore, the authorities responsible for the management of these river catchment areas must be founded or named. When allocating groundwater reserves to the relevant river catchment areas, the natural relationship between surface waters and groundwaters must also be considered.

With the changes of 17.02.1998, and on the basis of consultations with a working group of member states, the Commission laid down the technical criteria for measuring, classifying and monitoring the ecological and chemical condition of surface waters, as well as the volume and chemical condition of groundwater, in Annex V of the proposal for the Directive.

In determining the ecological condition of surface waters, biological, physicochemical and hydromorphological parameters are to be considered. The assessment of the ecological condition of the waters is based on each worst value obtained during the biological and physicochemical monitoring. Thus the ecological condition can be classified in categories ranging from very good to bad. The definition stems from the difference to conditions set down for an identical waters which has remained largely unaffected.

Annex V continues with obligations for monitoring the condition of surface waters, the presentation of results of monitoring, the laying down of national quality targets as well as the classification of the ecological condition.

The Water Framework Directive also contains rules for artificial (e.g. canals), or heavily altered (e.g. straightened) waters, which have been made navigable or safe from flooding.

The Member States do not have to orientate themselves towards a very good waters quality for the biological assessment of heavily modified and artificial waters; they only have to set down a maximum ecological potential which such waters can achieve. As an environmental target, the Directive lays down the reaching of the so-called good ecological potential, which is defined as a small change from the maximum ecological potential. For the physicochemical quality components, the same conditions apply as for unmodified waters, that is, the target is to reach a good condition of the waters.

The condition of the groundwater is split into a volume and a chemical component. To classify the chemical condition, the groundwater's conductivity, the priority substances of the Directive and the inexhaustible list of undesirable pollutants in Annex VIII are to be used.

The member states must draw up management plans for the river catchment areas, which however, differ from the management plan described in § 36 b of the Federal Water Act. The content of the plans is set down in Annex VII of the Directive. In main basic characteristics, it is orientated towards the action plans which the Rhine Protection Commission decided on for the management of the Rhine. The management plans consist of programs with basic and supplementary measures. The following belong to the basic measures, which must be made binding by all member states:

- observation of current EU (water protection) law,
- controls over the abstraction of water with a right to refuse authorisation,
- controls over extension work with a right to refuse authorisation,
- a right to refuse authorisation, or the registration of point-source pollutant output,
- prevention of pollution of the waters through priority substances,
- forbidding of direct output of pollutants into the groundwater,
- measures to prevent leakage at technical sites.

In the management plan the condition of the waters and the harmful influences must be measured and assessed. From this, a decision on measures must be derived, which are necessary to achieve a good condition. They are to be set up 10 years after the Directive comes into effect and implemented within 13 years. After a further 3 years, success must have been appeared, i.e. but for reasoned exceptions, a good condition of waters must have been reached everywhere in the member states.

The Member States must take into account the principle of cost-coverage for all water services. The river management plans must contain information on relevant measures. As a basis, comprehensive economic analyses are to be carried out. The Directive does not, however, set deadlines, nor concrete material requirements for the introduction of this principle. Especially, it does not define how the environmental and resource costs are to be measured.

The Water Framework Directive contains the obligation by Member States to identify and protect the waters used to provide drinking water, and that the requirements of the Drinking-Water Directive are observed. The Commission only assumes in its reasoning, however, that quality norms which allow the observation of the Drinking-Water Directive thresholds will be set for these waters, independent of meeting relevant treatment procedures.

Especially as a result of a German initiative comes the specific inclusion of the use of the so-called combined approach to emission values and quality targets. The current Directive on the discharge of dangerous substances into waters from 1976 still sees an equally weighted use of emission values and quality targets. This has, until now, not led to good results. The Water Framework Directive makes it clear that there is now one classification system: firstly the emissions values are absolutely to be met. If the quality aims should still not be reached through this, then tougher emissions limits are planned. The Commission will provide the Council with a list of especially relevant substances (won through monitoring-know-how and substance assessments) (= so-called priority substances) by December 1999. According to the Framework Directive, it must present a draft on EU-wide emissions limits and quality standards on these within two years. It cannot be ruled out, however, that use-restrictions or bans could be put on certain pesticides in place of emissions limits.

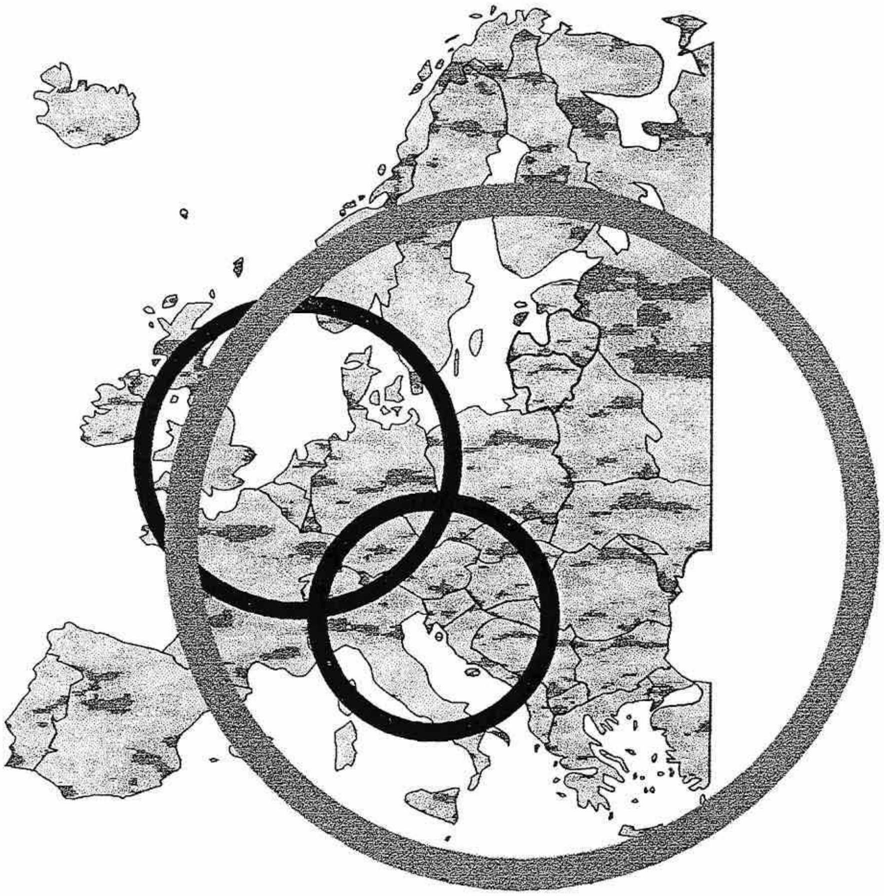
On 11.03.1999 the environment ministers of the EU reached consensus on the Water Framework Directive. It contains numerous elements which also conform to the aims of German water management practise, e.g. reaching a good waters quality, the integrated management of waters from the source to the sea, and the combined approach of emissions restrictions and ambitious quality aims based on hazardous substances with harmonised standards that are laid down Europe-wide. The introduction of binding rules for the administrative organisations, which would have been against the German constitution, especially the setting up of a central body for laying down and implementing the management plan, could be prevented. The criteria for determining quality standards conform to German practise.

The main alterations to the Water Framework Directive in the common agreement from 11.03.99 are:

- Europe-widely uniform, comprehensive and binding rules for assessing the quality of all waters,
- the requirement of an integrated water management plan according to river catchments,
- stronger consultation with the public in the creation of the management plan,
- the introduction of full-cost water prices on the basis of economic analysis and under observation of the polluter pays principle,
- the introduction of the combined approach of emissions controls and quality standards.

As the approval of the European Parliament has been necessary since the putting into effect of the Amsterdam Agreement on 1.05.1999, it is to be expected that in the process of decision proceedings, further elements of an advanced waters politics will be included in the Water Framework Directive.

The Commission was very reserved in estimating the costs of implementing the obligations in the Water Framework Directive. A correct implementation of the currently valid water directives, e.g. the Directive on Urban Waste Water Treatment for direct output, and the Nitrate Directive for diffuse sources, and the implementation of obligations on the protection of marine waters will form the main part of action towards the goal of achieving good-quality waters.



Topic 2:
European case studies

The "Agences de l'Eau"

Patrick Weingertner, Agence de l'eau Rhin-Meuse, Division Milieu Naturel et Données Techniques, Moulins-Lès-Metz, France

Statement of the Water Laws
Article 1
Water is the property of the state. Its protection is in the general interest.
Article 2
The concept for keeping waters clean requires a balance between the necessary water protection and economic interests.
Article 3
Discussion should bring about a plan for a clean-keeping concept.
Article 4
Water use requires the people to observe certain laws; this is guaranteed by the state.
Article 5
Water has an economic value. One must be aware that it can become scarce and expensive.
Agences de l'Eau

1 Introduction

The Agences de l'Eau, founded through the water law of 1964, have been at the centre of waters policy in France for over 20 years, thanks to its unique structure, which is supported by the continuous dialogue between authorities, users, associations and the state.

The revitalisation of water polices, equally desired by the state and the local groups active in every catchment area, led to a national conference (19-20th March 1991). These polices took shape through the sixth program (1992-1996) of the Agence de l'Eau. With the support of the Government, the Agences de l'Eau received the chance to secure 35 billion Fr. Francs (thousand million) in financial aid for the period 1992 to 1996, a doubling compared to the previous period. This amount originates from the charges levied by the Agences de l'Eau according to the "polluter pays principle". This sum will help towards financing the 81 billion Fr. Francs needed for environmental protection.

The priorities of the Agences de l'Eau:

- to make sure that the new requirements of the European Union, especially in the areas of collecting and treating household and industrial waste water, are observed by the users. In this way the quality of the rivers, groundwater and coastal waters should be re-achieved,
- to make sure that the supply of water is sufficient to meet the needs of all,
- to support farmers in the fight against environmental pollution caused by farming, while taking the EU regulations on nitrate pollution into account.

1.1 Regional Environment Departments as Institutional Partners of the Agences de l'Eau

The regional environment departments were founded and put into use in 1992. Their responsibilities as far as water is concerned are as follows:

- implementation of the water law and the directives of the EU. They are responsible for policing the quality of the water,

- working out the overall plan for water management together with the Agences de l'Eau, the area bodies and the users of waters and groundwater,
- making proposals on the subjects of waters protection and restoration,
- creating databases on water reserves and participation in considerations to develop methods of economic analysis in this area.

In France, water policies are followed in three directions:

- observing the new water law of 3rd January 1992, whose main aim is the principle of administrating all water reserves which can be seen as commonly owned,
- modernising the institutional bodies through the foundation of a water office (Direction de l'eau), with its headquarters in the Ministry for the Environment, and through the foundation of regional environment departments (Directions régionals de l'environment).
- doubling the investments, supported by the Agences de l'Eau, to be able to observe national and international obligations.

2 The Agences de l'Eau are in Favour of a New Relationship Between People and Water, Namely in the Whole Management of Waters

The administration of waters is being worked out on the basis of a unit, the river. The basic principle is to take into account the surrounding area and its physical and ecological nature. This is the philosophy according to which the Agences de l'Eau act. They look at the whole course of the river, watch how the water is used, and incorporate the users of the water into the program to keep waters clean. France's waters distinguish themselves through their great variety and extraordinary wealth of waters. Despite this, this treasure is not always carefully treated and sometimes even neglected.

The waters are a protective and nutrient-providing whole body for the entire animal and plant world. The waters and their banks make up an exceptional ecosystem. However, the unconsidered actions of man can destroy this subtle balance and lead to impoverisation of the natural environment.

The Agences de l'Eau are in the best position to help lay down the requirements for a new relationship between people and water. The harmonised implementation of the program for keeping the precious waters clean requires:

- above all, the acceptance that a catchment area or a groundwater landscape is one whole unit,
- an understanding that the protection of this unit is one of the most important conditions to best meet the water needs of the various users,
- a target to be set, which is valid for every environment, and to take all the necessary measures to reach it,
- acceptance of others and their legitimate right to water, and thus the cutting back of one's own requirements for water.

One should always bear in mind that water is the natural habitat for fish, which provide an excellent indication of its environmental quality. One must also be aware of the priceless value of the invisible, and thus not well-known, groundwater.

2.1 Lake Agreements

For waters, just as for any natural area, it is necessary to co-ordinate all the protection measures undertaken. A "lake contract" has been signed by Parentis. Others are being prepared in Aiguebelette and Paladru in the Alps.

Within the framework of a pre-project study, an overview of the situation was carried out. All useful aspects - the various uses of the lake and its proximity, potential for fish farming, the area-use plan, restoration, neighbouring building activities etc. - are listed in it. When this balance has been published a contract will be drawn up. It will contain the requirements for preliminary work, work and financing, and will be signed by the state, the area bodies, and the Agences de l'Eau.

3 The Agences de l'Eau Determine Waters Policy Together with their Comités (of the Catchment Areas)

To protect the water reserves, and to guarantee the restoration of waters and a keeping of the balance of the water world, the Agences de l'Eau apply certain policies in agreement with Government policy laid down by the Ministry for the Environment, through the relevant Comités of the catchment areas. The strength of these Comités lies in their uniqueness: the bringing together of all those "interested in water", while taking the various interests into account and while respecting nature. They act as a local government for water, where the policies of the catchment area are worked out, while conforming to overall Government policies.

3.1 The Comités' Planning and Mediating

The main responsibility of the Comités lie in mediating. They must continue to make sure that the planning of the waters-management of a catchment area takes place at a global level.

Every Agence de l'Eau and its Comité works in the framework of adjusted water programmes. It has to do to a certain extent with joint projects for water, the waters environment and groundwater, namely:

- a five year plan on the activities of the Agence de l'Eau, which lays down the targets for the restoration of waters in the relevant catchment area (rivers, groundwater, public health), and the financial means (subsidies and charges). The plan of the Agence de l'Eau and its organisational committee underlies the agreement of the Comité.
- the planned ideal and the water management framework plan ("Sdage" = Schémas directeurs d'aménagement et de gestion des eaux and "Sage" = Schémas d'aménagement et de gestion des eaux). They stem from the water law of 1992 and serve as planning tools.

3.2 The Agences de l'Eau Inform and Encourage

To change the behaviour of those who disturb the water ecosystem, each of the Agences de l'Eau has access to:

- economic means (charges and financial aid),
- certain powers to implement the proposals which result from the technical competence and scientific know-how of the Agence de l'Eau employees,
- a social control, which is achieved through a clear presentation of priorities, responsibilities and results, bound together in a suitable information policy.

4 Injections of Finance, Encouragement Tools of the Agences de l'Eau

Through the granting of subsidies and the levying of charges, the Agences de l'Eau have an economic as well as a financial role.

Through the granted subsidies, the Agences de l'Eau take part in the financing of projects for the common good, such as the management of water resources, the fight against environmental pollution and the restoration of the waters environment. They make available their technical and financial means, and their public and private circle of people who are active for the common good, in accordance with their programmes.

Through the revenue from charges, the Agences de l'Eau can fully finance their budgets. They are empowered to levy three types of charge on users of water:

- for harming water quality,
- for using water,
- when water conditions change.

Through the polluter pays principle operated by the Agences de l'Eau, the consumer is made aware how water pollution and abstraction affects the waters environment, and what costs can occur therein. These environmental "sinners" also restrict their neighbours in their possibilities for using water.

This principle of levying charges, which makes all people take responsibility for the negative effects on the quality of nature, through the emission of pollution or abstraction of water carried out by them, could be the trigger for taxation according to environmental aspects, and the levying of an ecotax.

4.1 The Charges

Public or private groups of people, whose activities cause a pollution of the environment, are subject to charges by the Agences de l'Eau.

The basis for the charge is the pollution which is caused on a "normal" day of the month, with maximum pollutant output. A list stating which physical, chemical, biological and microbiological elements must be taken into consideration when assessing the level of pollution, has been laid down in a decree.

The list is updated according to knowledge of the influence of certain substances on the water ecosystem. The elements used as a base for the charges include insoluble substances, substances that can be oxidised, toxins and inhibitors with immediate effects, as well as nitrates and toxins with delayed effects.

5 The Allied Agences de l'Eau

Drinking-water and sewage treatment often concerns several communities, as rivers and groundwater ignore administrative boundaries. It is therefore necessary that a higher institution, which is above local interests, equally considers the interests of the waters and its users. The Agences de l'Eau were founded with the law of 16th December 1964, and their binding role laid down as follows: "The aim of the Agence de l'Eau is to make easier the various activities of groups with a common interest in a catchment area or combined catchment areas...".

This founding principle was first put into effect with the foundation of the Comités in the catchment areas, which were set up as the executive to the Agences de l'Eau . They bring together industry, authorities, farmers, and associations around one table. This form of dialogue makes sure that the solidarity between all users of water in a catchment area can be expressed.

The together-bringing role of the Agences de l'Eau can also be seen in all areas where it is financially or technically involved - e.g. in the framework of a river contract. Here they work at the side of area bodies, the general and regional assemblies, industry and associations, in order to lay down the work required to restore and protect a river, and to co-finance these at an average of 40%.

5.1 Reclamation of the Sea Coast Artois-Picardie

The restoration program of the coast belongs to a widely spread campaign, led by the Agence de l'Eau Artois-Picardie. It brings together the European Union, the General Assembly of the Departement Pas-de-Calais and the Regional Assembly of the region Nord-Pas-de-Calais. This program can only be fulfilled with the help of inter-communal partnership, the solidarity that has been forged and the unifying polices of the financial partners.

The strategy of the Agence is not limited to an acceptable quality of bathing water. It also contains a further development of French and European norms. The future treatment works will aim to eliminate the nitrates which are responsible for the algal blooms in the coastal area. Along the whole coastal area one finds a strong sense of environmental consciousness; there is no community which is not involved in one phase or other of planning or implementing the project.

6 The Agences de l'Eau as Technical Advisor and Tutor

The Agences de l'Eau, partner to area bodies, industry and farmers, give tips on suitable management, cleaning and restoring natural waters. They thus take on an important role as expert consultant.

The many contracts signed with various companies to finance restoration programs put the Agences de l'Eau in an important position as surveyor and expert consultant.

Concerning the choice of methods (e.g. feasibility studies, pre-diagnosis etc.), the estimation of costs and the adjustment of work to the norms, the Agences de l'Eau always take the individual needs of their discussion partners into account.

In addition to technical and financial support, the Agences de l'Eau hold training seminars, especially for managers of treatment works or for the river police. They also provide symposiums and information days wherever required, which are intended for authorities, industry, farmers, environmental protection groups, fishermen, technical and administration departments.

6.1 Scientific Consultant in the Catchment Area Adour-Garo

Because of the ever-recurring periods of drought in the catchment area Adour-Garonne, the responsible Comuté has made announcements on the implementation of a far-reaching program (1998-1999) on water reserves.

A commission "River and Water Resources Ecology" (Ecologie des rivières et des réserves en eau) will lay down the rules for implementing this ten-year plan. Its aim is to make sure that the natural environment of the valley is taken into account while carrying out the planned work.

In order to keep information and decision processes clearly understandable, the Comité decided at the end of 1991 to set up a scientific advisory council. This new structure consists of independant surveyors/assessors who are charged with the task of objectively analysing the whole technical and scientific aspects of this important program for water reserves.

The scientific council makes sure the program is implemented, gives suggestions on the work to be carried out, and runs the research program it has laid down. The council consists of 17 members, with the main expertise being in water management and water-ecosystem orientated subjects.

These members come from development and research centres, public bodies, environment protection groups, universities and administration.

7 The Agence de l'Eau, Source of Knowledge and Encourager of Research Projects

In order to simplify the choice of main subjects in the area of water, made by the authorities and those politically responsible, the Agence de l'Eau keeps them up to date on the latest knowledge on nature and restoration technology.

The experts at the Agence de l'Eau are responsible for intensifying their knowledge of nature and especially on processing methods through:

- strengthening the linked and constantly monitoring groundwater sensors (piezometric network) and those of the flowing waters (national measuring network of the catchment areas "Réseau National de Bassin"),
- carrying out studies, in order to better understand groundwater and rivers,
- taking part in setting up planning concepts, e.g. water management plans,
- choosing criteria for restoration technology,
- looking at the effects of waste water on nature, etc.

The studies with the strongest message are published and distributed to area bodies, industry etc.

The future work of the national water database and the water data management system (Sandre = Système d'administration des données relatives à l'eau) still needs to be mentioned, which has a great potential as a linked database.

7.1 A Database on the Quality of Running Waters

In order to develop a fitting and linked water restoration policy it is necessary to have a good knowledge of environmental conditions. The Agences de l'Eau have pushed to have access to a reliable and linked database of French waters since they were founded.

This measuring network, "Réseau de Bassin National", measures a large number of physical, chemical and biological parameters at the 1200 measuring points. The number of measurements per point is also continually being increased.

The Agences de l'Eau thus have access to a "database", which allows them, among other things, to regularly publish water quality maps according to catchment area.

This data is available to those in positions of responsibility and to the broad public. This makes it possible to estimate the effectiveness of restoration plants, and this data is thus a general planning and information instrument for the environment.

The UK View of Integrated River Basin Management

Martin Griffiths, Water Quality Environment Agency, Bristol, Great Britain

I am Head of Water Quality for England and Wales and am responsible for the development of policy in all aspects of Water Quality management. My role provides the principal contact between the independent Environment Agency and UK Government to ensure maximum improvement to the water environment. My team also provides the Government with technical advice on environmental matters and the development of new EU Directives, especially the Proposed Framework Directive, and the implementation of existing Directives takes up much of our time.

I would like to structure my paper into two parts to provide an overview of catchment management activities in England and Wales:

1. General overview of the benefits of River Basin Management and the need for a clear water quality planning base.
2. The proposed Water Framework Directive, identifying areas for future research.

1 River Basin Management

Integrated river basin management (IRBM) has been widely recognised as an effective way of managing the environment and human activities as they interact with it. IRBM, sometimes known as Catchment Management Planning, is seen as a key planning and management tool in parts of the United States of America, South Africa, Australia and New Zealand. In these countries the process has been developed to include an involvement of local people in the care of their environment. Only in this way is it considered possible for solutions to environmental and socio-economic problems to be found.

In England and Wales, IRBM plans have been prepared for several years and are seen as the principal way of planning and managing our water resources. Catchment Management Plans (CMPs) were prepared for many rivers by the former Water Authorities. Later, this approach was adapted and applied by the National Rivers Authority to all catchments in England and Wales. More recently, the Environment Agency has embarked on a programme of Local Environment Agency Plans (LEAPs), a successor to CMPs, covering more than just the water environment, which will provide coverage of all catchments in England and Wales by the end of 1999. 164 catchment planning areas have been identified in England and Wales.

A river basin or catchment is land, which is bounded by natural features from which all runoff water flows to a low point. This low point may be a dam, the confluence with another river system or the mouth of the river where it enters the sea. Catchment areas vary in size and make-up. Large catchment areas such as those drained by the rivers Thames, Severn, Wye or Dee are bordered by hills or mountains and include large drainage networks of smaller rivers and streams. Thus, large catchment areas are made up of smaller sub-catchment areas. Small systems may be bordered by low hills or ridges and drained by only small streams or ditches.

Human activities can have a profound impact on this water cycle. Changes in land use can affect evaporation, transpiration and recharging of the water table. Abstractions or diversion of water in one part of a catchment will have consequences elsewhere, as will the discharge of effluents, which affect the quality of water downstream. In England and Wales, we have some exceptionally good salmon and sea trout rivers in Britain. These fish have evolved to need variable and large quantities of very clean water to complete their life cycle between the headwaters of the river and the sea. Recreation and tourism is dependent on these natural systems being maintained.

Integrated river basin management involves taking account of the interdependency of natural and human factors within a catchment. Decisions on what to do in one part of a catchment are informed by knowledge of the consequences for the rest of the system. Modern IRBM has evolved to include not only scientific and technical assessments but also consideration of socio- economic issues. Successful IRBM programmes involve local communities and their representative organisations. To be successful, IRBM must integrate land use planning and development control into planning the use of water. Because it is consistent with basic ecological principles, IRBM is more likely to result in plans that are sustainable in the long term.

Public involvement and consultation is a key element in the development of catchment action plans. Fig. 1 provides an overview of the LEAP consultation process. The Environment Agency produces consultation drafts on each catchment and arranges public meetings of all interested groups, including local Authorities, NGOs, pressure groups, industry and local residents. Their views are taken into account before an action plan is finalised. The Agency is developing structured methods to improve the public input to the process and to prioritise issues identified. This work takes the form of consensus building methodologies involving the use of focus groups drawn from the local communities.

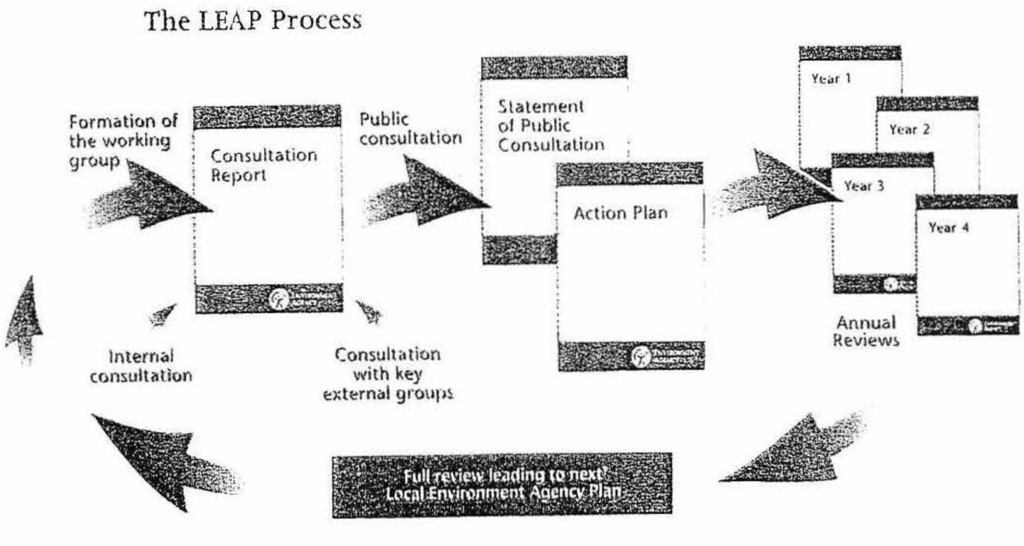


Fig.1. The Local Environment Agency Planning Process

Within the Catchment management process technical disciplines are essential if the process is not to be degraded into a well-intentioned `wish list Catchments must be well understood monitored and modelled if improvement programmes are to be credible. Improvements may require considerable investment by industry, agriculture and the public and will be subject to considerable scrutiny. The role of Environmental Quality Standards (EQS) derived either from national or international legislation are key drivers for improvement. In the UK the Rivers Ecosystem (RE) classification system is the basic building block, bringing together the requirements of the Freshwater Fish Directive with nationally agreed standards. The RE classification has been applied to all rivers in England and Wales and has been endorsed by Government.

Fig. 2 shows in diagrammatic form the factors to be taken into account when assembling a river quality improvement plan. On the left of the figure a number of well established water quality criteria provide standards for water quality, which must be met as a minimum requirement. The Rivers Ecosystem (RE) classification scheme sets standards for dissolved oxygen, BOD, ammonia and other substances including key parameters set by the EC Fisheries Directive. A suite of other Directives set mandatory (I) and guideline (G) values which apply if the river reach is designated. Nutrient standards may be set and the Agency Eutrophication Strategy will provide further guidance and prioritisation. Ecological issues need to be considered if the river is designated under the EC Habitats Directive, or if it is a designated site of Special Scientific Interest, or impacts upon one. In dotted lines, other systems are under development which will provide further guidance to water quality planners in the future. Another established principle of river quality planning is 'no deterioration'. Simply this assumes that the quality of a waterbody must not get worse and a there are well established definitions for no deterioration in the Agency Discharge Consents Manual.

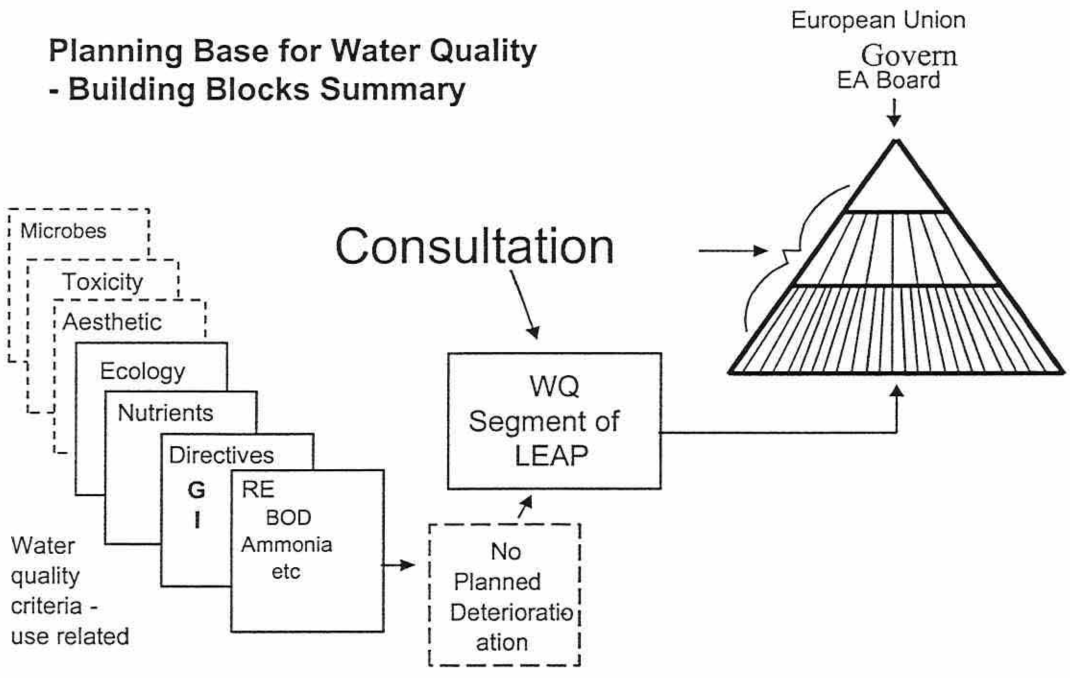


Fig. 2. Planning base for water quality - building blocks summary

In this way a suite of minimum standards is assembled which must be attained in the receiving water. If a new or changed discharge is required by industry, or a sewage treatment works, these standards must be met and the quality of the discharge can be calculated using a mass balance calculation or where multiple discharges are involved mathematical models may be used. At this point the concept of Best Available Techniques or Emission Controls can be brought into play fulfilling the 'combined approach' outlined in the proposed Water Framework Directive. Thus the proposed discharge may be required to fulfil the requirements of Environmental Quality Standards, Emission Controls and achieve no deterioration. Fig. 3 provides a diagrammatic overview of the requirements that are taken into account in determining standards for a discharge.

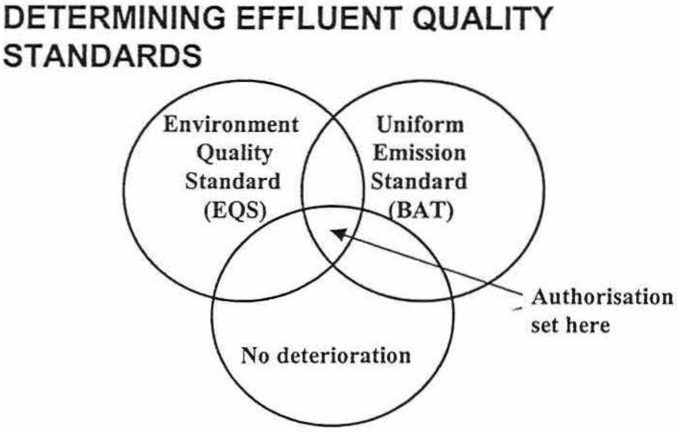


Fig. 3. The combined approach

These Environmental Quality requirements form the technical basis for the development of a catchment management plan; one component of the broader LEAP. These local or sub-basin plans may be aggregated up into larger River Basin Plans, as currently proposed to satisfy the Water Framework Directive. Further aggregation provides a national planing base for water quality and allows improvements to be identified.

This improvement programme can be costed and developed at a pace set by Government. The privatised water industry in UK is in the process of planning its investment for the period 2000 to 2005 and the Government, following advice from the Environment Agency, has committed £8 billion sterling for environmental improvements, much justified on the basis of this secure water quality planning base.

The catchment management process also allows for the prioritisation of environmental improvements and economic appraisals to be made. This methodology is in an advanced stage of development in the UK and has been used successfully in justifying expenditure required by the water industry. The Agency has developed a Benefit Assessment Methodology and a shorthand multi-attribute technique for this purpose which is most useful in ranking priorities for investment.

2 The proposed Water Framework Directive, identifying areas for future research

The Environment Agency welcomes the proposals from the Commission and supports the overall objective of establishing a coherent legislative framework for the protection and improvement of the water environment within the context of achieving sustainable development. Moreover the Agency believes that the proposed Directive could represent a crucial step in ensuring an effective structure for the application of other Community measures such as the Integrated Pollution Prevention and Control Directive.

There can be little doubt that when it is adopted the Water Framework Directive will represent a radical change in water quality management. In particular it should be recognised that the Directive will:

- apply to all waters;
- utilise ecological and chemical standards and objectives;
- integrate the consideration of groundwater and surface water; and
- require the use of River Basin Management Planning throughout Europe.

Although the Directive has yet to reach final adoption, many practitioners are beginning to assess the developments which will need to be made in our technical knowledge so as to ensure full implementation. There can be no doubt that there is much to be done. However it is crucial that even if out techniques are less than perfect, we must take this Directive forward as early as possible in order to reap the many benefits that it promises

2.1 R&D Requirements

Through a consideration of the proposed Water Framework Directive requirements and by comparing against current Agency activity the research or development needed to implement the Directive can be identified.

There are two types of R&D requirement for the Agency:

- Further development/ refinement of existing tools and techniques to bring into line with Directive requirements
- Development of new tools and techniques to plug the gaps in existing Agency activity.

In order to put a comprehensive R&D programme in place it is necessary to consider both the priorities within each of the categories and the necessary timescales required for delivery.

2.2 Further Development

Classification and monitoring of chemical status: Need to have EQSs and ELV in place for Priority List Substances by 2007 if Commission has not reached agreement.

Classification and monitoring of Ecological Status: A number of differing monitoring and assessment techniques have been developed for rivers which provide a solid foundation in meeting the requirements of the Directive.

- Benthic Invertebrates monitoring and assessment– RIVPACS is only example of a referenced based tool currently available to the Agency although it is primarily targeted at the impact of organic pollution. Need to consider the potential for assessment of the impact of acidification and toxic chemicals.
- Fish monitoring and assessment – the current monitoring approach is devised only to assess fish stock and health. An assessment system that acts as an indicator of the quality of the river is required.

The number of monitoring and assessment tools available for lakes is more limited and will also require further work.

Hydromorphological elements – the current River Habitat Survey is a system of assessing the character and quality of rivers based upon their physical structure. This tool covers many of the monitoring requirements of this element. However the means of identifying whether any distortion in habitat is having an impact upon ecological quality is needed.

Information on point sources of pollution, abstraction and water regulation is well developed however the Agency will need to be able to aggregate the information to provide the necessary summaries for inclusion in the RBMP.

Member States are requested to submit information in GIS format to the Commission. GIS based systems will need to be developed to support the manipulation and reporting of the large data sets associated with the Directive. GIS systems are in use in the Agency and links need to be established to identify specific R&D needs where appropriate.

2.3 New Tools/Techniques

Classification and Monitoring: A set of monitoring and assessment techniques is required which are indicative of the general state of the ecosystem. Individual assessment techniques for each parameter, including those described above, will not necessarily reflect the overall health of the water body. There is a need to be able to combine the differing assessment techniques to give an indication of general health of ecosystem and hence its status.

The use of a pilot catchment approach in advance of the Directive coming into UK regulations would be an invaluable opportunity to put our existing techniques into practice within the context of meeting the Directive requirements.

There is also a need to develop tools to interpret why good status has not been achieved to support the development of appropriately targeted programme of measures.

Ecotoxicological techniques could be developed to assess the impact or effects of chemical pollution on the health of a water body.

No appropriate assessment and classification tools exist for estuaries and coastal waters. Current monitoring effort also varies nationally.

Hydromorphological elements – no information, equivalent to the RHS, exists for lakes estuaries and coastal waters which supports the identification of significant morphological alterations and their impacts upon lakes, estuaries and coastal waters.

When a water body has been classified as heavily modified or artificial it must achieve good ecological potential, which is the state that would be achieved if all possible mitigation measures were taken. There is therefore a need to identify 'all possible mitigations' measures' which are practicable. This could possibly be achieved through the development and collation of methods which mitigate the ecological damage caused by physical modification of water bodies (best practice examples). It would also be useful to gain examples from across Europe. There is also a need to demonstrate when good ecological potential is achieved.

There are a number of R&D requirements with respect to Groundwaters:

- Develop and understanding of river-aquifer interactions,
- Develop an understanding of ecologically acceptable flows, not only low flow but also flow regime,
- Development of a methodology for modelling recharge,
- Development of techniques for piezometric mapping.

There is also a need to understand further the links between groundwater quality and its impact upon surface water quality.

Appendix

Definition of Local Environment Agency Plans (LEAPs)

A LEAP is the Environment Agency's integrated local management plan, for identifying and assessing, prioritising and solving local environmental issues related to the Agenc's functions, taking into account the views of the Agency's local customers. The outcome of the process is a local programme of integrated action for environmental improvement in order to optimise benefit for the local environment.

Delivery

LEAPs are delivered by Area Managers through teams in close conjunction with key partner organisations and Area Environment Groups. LEAPs are important statements of the Agency's stance on local environmental issues and approval for publishing should be in strict accord with the non financial SoD. Regions have an influencing role in ensuring consistency, technical quality, adherence to national requirements and resource allocation.

Repeat the LEAP Process

The stresses on local environments will change, and our response needs to be flexible. The annual review process will eventually not be sufficient to keep up with all of the changes likely to take place, so an entirely new LEAP should be produced at regular intervals of not more than five years following production of the initial LEAP.

The River Elbe: History, Current Situation and Prospects

Manfred Simon, Secretariat of the IKSE, Magdeburg

1 Historic Development of the River-Catchment-Related Work in the Catchment Area of the Elbe

1.1 Water and Soil Associations

River-catchment-related work was carried out in many river catchments of Germany as early as the beginning of the 20th century. The multitude of water-management problems to be solved led to the formation of water associations.

The Schwarze Elster Association (1928 - 3650 km^2), the Muldenwassergenossenschaft (Mulden Waters Co-operation) (1933 - 5500 km^2), the Weiße Elster Association (1934 - 5100 km^2) and the Spree-Havel-Verband (Spree-Havel Association) (1941 - 34360 km^2) were important water associations in the catchment area of the Elbe.

In the course of time, the sewage-water associations became water-management associations, which apart from keeping the waters clean through sewage treatment, took over the supply of drinking water and used water, waters maintenance and the building and operation of dams.

1.2 Centrally-Managed, State-Owned Water Companies in the Area of the GDR

After World War II the powerful water associations in the area of the GDR stood opposed to a multitude of similar, smaller organisations, which could only unsatisfactorily perform their tasks. During 1952, 15 centrally-controlled state-owned water companies were set up corresponding to river catchment areas in the area of the GDR, and ignoring the boundaries of districts. In the catchment area of the Elbe there used to be 11 such companies. The main tasks of these state-owned water companies was analogous to the above-mentioned water associations.

1.3 Foundation of Water-Management Offices in the Area of the GDR

As the question of managing the limitedly available water resources came more and more to the fore, seven water-management offices were founded in 1958 as budgetary organisations, corresponding to the large catchment areas. The main tasks of the water-management offices in their associated river catchments were:

- determination of the water reserves of the surface and groundwaters according to volume and nature (hydrology, water-quality studies),
- determination of the water requirements of the users,
- calculating water balances according to volume and nature in the catchment area to safeguard water provision for all users,
- water-management planning to safeguard water provision on the basis of water-management measures arising from water balances (yearly and perspective planning),
- governing the water use through legal decisions, and checking adherence to the laws on the use and protection of waters of the state waters supervisory body,
- enforcing the rational use of water in all areas of the national economy which used water,
- flood-prevention measures (extension and maintenance) on stretches of water above towns/cities,
- building and maintaining dams and other water-management sites (weirs, water-lifting devices, pumping stations),
- carrying out the technical leadership of flood prevention and accidental water pollution,

- undertaking research and development work.

The foundation for the management of water resources according to volume and nature in the river catchments were:

- the "Analyses of Water-Management Conditions", written for all river catchments in the years 1959 - 1964, and then,
- the "Water-Management Development Concepts".

The 15 centrally-run state-owned companies were disbanded when the 7 water-management offices were founded corresponding to large catchment areas on 01.07.1958.

1.4 Foundation of Water-Management Offices in the Area of the ČSSR

Following the model of the water-management offices in the GDR, water-management authorities (Povodí Labe, Povodí Ohře, Povodí Vltava) were also founded in the area of the ex-Czechoslowakian Socialistc Republic (ČSSR), which still exist in today's Czech Republic. In the catchment area of the Elbe these are the water-management offices for the stretches of river Elbe/Labe, Moldau/Vltava and the Eger/Ohře.

1.5 Co-ordination of Tasks in the Elbe Catchment in the Area of the GDR

In 1975 the position, tasks and way of working at the water-management offices were restructured. The responsibilities from the foundation of the water-management offices in 1958 were largely kept or extended, whereby the rational use of water came to the fore. Out of the 7 water-management offices founded in 1958, became 5 new ones.

The water-management offices received co-ordination and checking responsibilities at a GDR-wide level from the Ministry for the Environment and Water-Management in addition to the above-mentioned responsibilities.

Thus by 1984 the water-management office "Lower Elbe" had step by step obtained the following responsibilities in the whole Elbe catchment, which made up 73.1% of GDR territory:

- water balancing according to volume and nature in the Elbe catchment from the ČR/GDR border (Schöna) to the ex-border between the GDR and West Germany (Boizenburg) including the preparation of channelling decisions,
- the working out of restoration concepts for the whole Elbe catchment including the implementation and checking of measures, and studying their effect,
- co-ordination of the water-quality research bodies in the Elbe catchment,
- Continuous forecasting of water level and flow rates as well as flood prediction for the whole of the Elbe in GDR territory and the lower reaches of the main tributaries Schwarze Elster, Mulde, Saale and Havel,
- summary and economic evaluation of the measures of public flood protection in GDR territory.

The enforcement of this co-ordination function in the Elbe catchment lay in the hands of the director of the water-management office "Lower Elbe", who had the relevant powers over the other water-management offices, and had interdisciplinary expert groups at his disposal.

1.6 Work-Group Elbe in the Area of West Germany (old Länder)

The "Work-Group for Keeping the Elbe Clean" (ARGE ELBE) as founded in May 1997 with an administrative agreement between the Free Hansa City of Hamburg, the state of Lower Saxony and the state of Schleswig-Holstein. It served to make sure that the three states worked together in the implementation of water-management tasks along the Elbe on West German territory. This especially included:

- agreeing on water-management measures and legal decisions, especially to keep the Elbe clean, and
- information exchange between the three states in good time when planning important uses which would affect the condition of the Elbe.

The senate of the Free Hansa City of Hamburg set up the "Water Quality Office" as a work-group of the ARGE ELBE.

The ARGE ELBE thus had its main responsibilities in the area of the three states on the Elbe, limited to the level of quality, and this mainly on the Elbe. A river-catchment-related responsibility for the Elbe catchment on West German territory and a water-management according to volume and nature, were thus not given.

2 Current State of the River-Catchment-Related Work in the Elbe Catchment

2.1 Foundation of the International Commission for the Protection of the Elbe

On 08.10.1990 the Magdeburg "Agreement on the International Commission for the Protection of the Elbe" (IKSE) was signed. Thus, a river-catchment-commission was founded with responsibilities for the whole Elbe catchment totalling 148,268 km^2.

The following main aims were agreed for the Elbe and its catchment:

- to make it possible to use the waters and the sediment, especially for producing drinking water by river filtration and for agricultural uses,
- to reach as nearly a natural state of the ecosystem as possible, with a healthy species diversity, and
- to sustainably reduce the burden on the North Sea from the Elbe catchment.

The work of the IKSE was related to the whole Elbe catchment right from the start, and not just to the channel of the Elbe itself, according to the foundations of the agreement. National and International levels of river-catchment-related work were kept with this way of working. The main part of the work of the IKSE is carried out in numerous expert work-groups. A secretariat was set up as a working committee for the IKSE and its work-groups.

2.2 Expansion of the ARGE ELBE

With the step-by-step dismantling of all water-management bodies of the GDR in 1990 (from 03.10.1990) and 1991, and the foundation of the new authorities for the environment, water-management and nature protection in the five newly-created states and Berlin, the river-catchment-related work carried out since 1952 was given up. The work was strictly orientated on the relevant area of the new states.

With the reunification of Germany and partly through the work of IKSE came the task of expanding the ARGE ELBE, founded in 1977 and having three member states, by at least the new states which lie directly on the Elbe, and to adjust the spectrum and complex of responsibilities to those of the IKSE. The responsibilities of ecology and of flood protection played a large role in this. This is why a new agreement on the make-up of the Work-group for Keeping the Elbe Clean (ARGE ELBE) was signed, which took effect from 01.07.1993. The agreement partners are all seven states directly on the Elbe. The water quality office Elbe continues to be the working committee of the enlarged ARGE ELBE. The responsibilities of the new ARGE ELBE and the water quality office Elbe are in principle those from the agreement in 1977. There was an expansion in connection with the work of the IKSE. There is a close connection between the work-groups of the IKSE and the committees of the ARGE ELBE.

3 Possibilities for Future River-Catchment Related Work in the Elbe Catchment

In the opinion of the author, the following organisational decisions would be possible for implementing the EU Water Framework Directive:

1. The IKSE could be the co-ordinating body for the implementation of the EU Water Framework Directive in the international river basin district of the Elbe. Until now, however, there has been no formal declaration of intent by the member states.
2. For the relevant German and Czech Republic national territory within the international river catchment unit, the suitable implementing bodies still need to be explicitly named.
3. The national responsibility levels for the management of partial catchment areas could be as follows:

   In the Czech Republic:

• upper Elbe up to the Czech/German border	11916 km^2
• Moldau	28090 km^2
• Ohře/Eger (with the catchments Bílina and Ploučnice)	10170 km^2

   Suitable responsible bodies could be the existing water-management offices Povodí Labe (Elbe), Povodí Vltavy (Moldau) and Povodí Ohře (Eger).

   In Germany:

• Schwarze Elster	5 541 km^2
• Mulde	7 400 km^2
• Saale	24 079 km^2
• Havel	24 096 km^2
• Lower-Middle Elbe - tributary of the Saale to Geesthacht weir	16 671 km^2
• Lower Elbe (Tideelbe)	13 255 km^2

   The catchment of the Upper Elbe from the Czech/German border and the Upper-Middle Elbe up to the tributary with the Saale (5 832 km^2) could be allotted to the catchment of the Black Elster or the Mulde. Suitable responsible bodies for these river catchments in Germany would still need to be decided.

4. In the interests of clearness in river catchment planning, the chosen individual partial catchment areas shouldn't be too small. Depending on the local conditions the catchment areas should have a size of between 2000 and 6000 km^2.

The chance that the Water Framework Directive offers for river-catchment-related work should be progressively used by the existing water-management authorities.

Summary of Topic 2: "European Case Studies"

Fritz Kohmann, Federal Institute of Hydrology, Koblenz

1 Introduction

The subject in the section "European Case Studies", was less one of the question of research requirements, and more one of a presentation of how river catchment area management is already being carried out on a national level in France and England, or of what support international commissions provide for the protection of waters that cross borders, e.g. IKSR (MKOL). The following summaries will more closely look at the needs for research in individual expert areas, or for tools to better solve parts of future problems. I will summarise the thoughts which are important from the catchment area manager's point of view.

2 Socio-Economics

Very much in the foreground was the statement that in the future, additionally to water management questions (water building, water quality, waters biology), a socio-economic component must be taken more strongly into consideration. This consists of the questions:

- what is it worth for residents, to keep or achieve a certain landscape condition (view)?
- how can a greater transparency be achieved = inclusion of the public, in decision-making processes on environment-altering measures; how can the essential ecological functions complexes be presented in an understandable way, to describe the range of possible decisions in the interests of a sustainable management more exactly, and to find the best economic path while protecting the river catchment area's natural resources?
- what effects do water management, or environmental protection decisions have on regional and national economics: trade routes, production losses, loss of manpower, tourism, cultural traditions etc.?

I would also like to add the more economic-ecological aspect:

- what economic value do ecological changes in nature have, measured as the monetary service of a cubic metre of the landscape, as meant by Constanza et al (1997)?

The urgent need for socio-economic tools in combination with problem areas of water management and land use was stressed.

3 Data Management

In the management of river catchment areas, data from a great variety of fields needs to be brought together, weighted and assessed. This, rather holistic approach, also required by the coming EU Water Framework Directive, sets the highest demands on the preparation of data in the decision-making process, in connection with interference with nature.

The range is from individual chemicals, water volumes, animals and plants on the plain and in the river, to questions of socio-economics, and their influences on another, and this with a high time resolution if possible. In order to be able to prepare this information in such a way that the decision framework is understandable and transparent not only to an expert, but also to the public, an understandable assessment system must be available on the one hand, while the complex material must simultaneously be prepared and presented with the help of relevant software and hardware, on the other.

The catch-phrase for this is "GIS" (Geographical Information System). This is not a digital collection of maps, but a geo-referenced information system, which can cartographically present a wide range of questions with interrelated dependencies.

4 Decision-Making Aids

The logically-correct next step is to answer the question: what if? What will happen if single parameters in the system are changed - see Prof. Wind's presentation (WadBos). In order to answer this question, we need point 2, already mentioned, and a further structuring of the available expert knowledge, in combination with water management questions for the next decade.

When asking experts on, for example, the development of flood-plain forests in connection with changing river water levels, they have relatively clear ideas on the connections between river water levels, groundwater levels, ground moisture and flood-plain vegetation. Similarly, a picture of the destiny of individual chemical compounds, e.g. heavy metals in river water or in sediment, can be seen - see Prof. Mathies' presentation - but both play an equal role in the understanding of flood-plain ecology. There is a whole bundle of complex intertwined effects, which can be seen, and are currently dealt with separately in the various disciplines, but which can first be of use in decision-making in a combined (complete) analysis. To combine the existing knowledge interdisciplinarily, and to simultaneously show up deficits in today's knowledge, it can be seen that we need structured representation of expert knowledge in electronic expert systems. Today's hardware and software possibilities open up new perspectives for this.

5 Information Management

A main point, especially for large catchment areas such as the Rhine or Danube, is maintaining an exchange of information. Information must quickly be close at hand. But for this, it must also be made available quickly and at any time. This requires a WWW-based information management. Only this achieves open access, as well as restricted access for administrative or technical groups, cheaply and quickly. In Germany, there are appropriate approaches for this, which could also suit international requirements. As Germany, thanks to its central position and the rivers Moselle, Rhine, Oder, Elbe and Danube, already has a need for international information and adjustment like no other European country, a high level of information management is necessary. We should therefore not miss out on acquiring the relevant technologies, especially in Germany.

6 Ideals

The main foundation for transparent decision-making processes are understandable assessment systems. For this reason it is especially important to agree on clear target values or their derivatives, for highly controversial decisions in connection with changing aquatic systems - see Elbe, Havel, Saale, Eider or Danube. A sound ecosystematic knowledge is necessary for this which no one single person today has. The naming of important ecological and sociological processes in the interests of a sustainable management of river catchment areas, is thus a requirement still to be performed. This is plausible, in the form of indicator values - animals/plants or significant values of essential processes. Natural sciences and the arts must create the scientific foundation on which to define the ideals.

7 Problems of Scales

In order to achieve a higher integration of the various processes in catchment areas, which take place on different area and time scales, more attention needs to be paid to transformation problems when scale boundaries are crossed. Among the solutions to this is the observation of scale invariant multifractal dimensions e.g. flow rates over a long time period.
As with the last points, the next will also be looked at in more detail in the three following subject blocks. Thus the subject of materials transport and materials displacement on the way from surface waters via passage through the soil into groundwaters and rivers and vice versa, is only briefly mentioned here as a subject suffering from a knowledge deficit.
On possibilities further afield than research funding, knowledge of work in the international river catchment commissions Moselle/Saar, Rhine, Oder, Elbe, Danube, shows up a great need for harmonising legal frameworks, and measuring/assessment procedures for environmental conditions.

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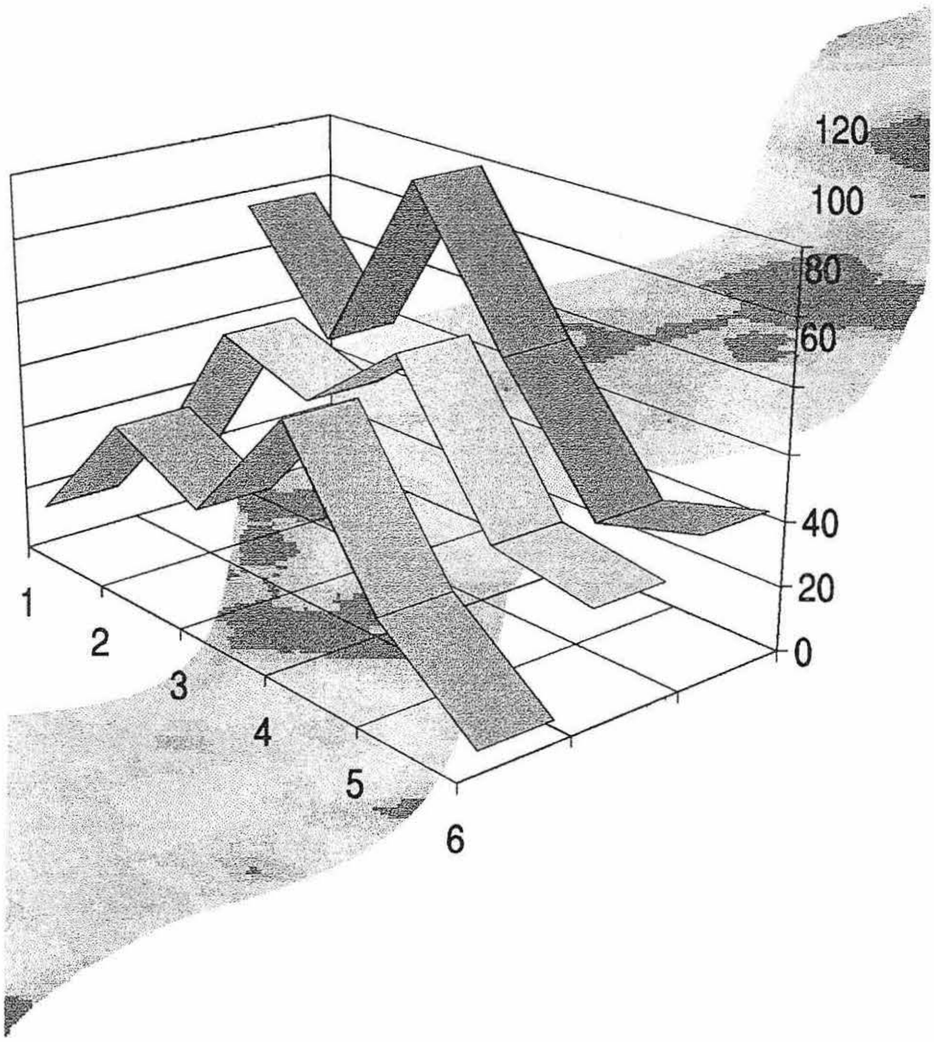

TOPIC 3:

ASSESSING THE STATUS OF RIVER BASINS

Problems of Scale in Hydrology

Peter Braun, Bavarian Ministry for Water-Management Munich

1 Scales - at First more Questions than Answers

Everyone knows of the problem of scales in everyday life: when using a topographical map to get an idea of the pattern of roads, paths, rivers etc., experience tells us that the resolution (scale) of the map is very important: a high resolution guarantees the inclusion of many details and vice versa. The scale obviously has something to do with the amount of information that can be held on the map. Generally one can ask: what happens to process information when they are obtained at various scales (grids, resolutions)? Do "coarse-grained" measurements of objects contain adequate amounts of information about details which lie below the grid width (i.e. can one usefully interpret the details from measurements made with coarse grids?). Do practically relevant objects exist at all in which the "parts" already include a lot of information about the "whole"? It is intuitively clear that the scale is going to be an important parameter in such thoughts. If one could fully describe the dependence of the "whole" on the "parts" through "scale functions", then most of the questions above could be answered positively. The problem is: How can one determine such scale functions?

2 Specific Answers to General Questions

As far as we know, the questions posed above on the existence of universal scale functions, have not yet been answered mathematically. However, there are specific scale functions, which, among other things, describe structurally complex geometrical objects in such a way that one can use knowledge of the object on one scale, to obtain object properties on another, using simple scale transformations. Such objects are called self-similar: certain basic properties, such as geometrical position relationships, distribution functions of patterns, or rather, statistical identifiers such as moments of distributions and many more, are determined using simple transformation rules, which allow the conversion of these identifiers from one scale into another. It is characteristic of these transformation rules that they are not dependent on any particular scale (resolution): they are thus scale invariant. Mathematically, such scale-variant transformations lead to so-called power laws. The decisive parameter of such a power law is the scale exponent of the power law. When objects are self-similar, one says that the objects are "scaling".

The exponent has a simple relationship to the "fractal" dimension - a term which should underline the difference between fractal geometry and normal Euclidean geometry. While the latter uses whole number exponents to determine relationships such as length to area (think, for example, of a square, whose area is simply the square of the length of one side), fractal geometry uses rational number exponents. A very well-known example of self-similar objects is the famous MANDELBROT-Set: if you enlarge the picture, the characteristic initial pattern keeps on returning in the scaled picture. Other famous examples of self-similar objects are, for example, mountain relief and rock-chunk relief on the same mountain: on photos it is necessary to state the scale in order to correctly categorise both objects.

Using fractal scale laws it is possible to characterise objects that are obviously not Euclidean, such as clouds, dusts, whirls, blood vessels, nerve fibres, mountain reliefs, river channeling, erosion grooves, layers of sediment, cracks in solid objects, stock market rates, drainage time sequences and many more. The father of fractal geometry, B.B. MANDELBROT (1982), even says in his classic work "The Fractal Geometry of Nature" that objects with fractal geometry are rather more the rule than the exception. For practical use, a few specific remarks are called for:

- The scale invariance of real objects refers to more or less restricted scales (e.g. a self-similarity from a molecular scale up to that of macroscopic objects such as mountains is not known).
- Real fractals are statistical fractals: the self-similarity is not mathematically exactly determined for any one point, but exists only as a statistical average (this means, for example, that a magnified picture of the same picture section is more or less blurred).
- Many real fractals can be parameterised by a simple power law (monofractals). On the other hand, though, even more objects are being discovered in which the scale exponent becomes something sophisticated, which produces a/an (infinite) set of scale laws. One speaks illustratively of multifractals.
- Fractals exist not only in the form of real geometrical objects, but also in the area of dynamic systems: thus time sequences of dynamic systems are often self-similar objects.
- In connection with this it is important that statistical identifying functions of time sequences, such as autocorrelation functions, spectra, distribution functions and others, can often be described in terms of (sometimes multifractal) scale laws.

3 Are Hydrologically-Relevant Objects Fractals?

Even Mandelbrot (1982) dealt with many hydrologically-relevant fractals in his above-mentioned foundation work. He recognised already existing laws of empiric hydrology, such as the important HACK's law which links the length of the main river to its catchment area, and is now empirically very well verified, as being (mono-)fractal.

The natural scale in hydrology is the size of the catchment area - which is why the fractal objects in hydrology still to be discussed are often scaling with the size. There is now also a comprehensive literature on fractals in hydrology, which cannot nearly be discussed fully in this short overview. The interested reader will find in what has now become a "classic" book by Rodriguez-Iturbe and Rinaldo (1997): "Fractal River Basins", an extraordinary amount of material on the fractal structures on natural drainage systems. It should be stressed that many empiric hydrological laws, sometimes known for a very long time, have been discovered by the authors to be fractal structures. To at least give an initial idea of hydrologically-relevant objects which have fractal characteristics, I will mention the following objects:

- Time sequences of discharge show multifractal characteristics. This has several, sometimes very serious consequences for the structure of these sequences. Especially, it can be seen that classical probability distributions (e.g. Gauss distribution) don't accurately describe the extreme discharge which can be observed in real sequences. Fractals, in particular multifractal processes, characterise themselves through the occurrence of extreme events which have a markedly higher probability of occurring than are expected when exponentially weighting distribution probabilities. Fractal processes are strongly asymmetrical, "long-tailed" distributions, which are only explicitly known in a few cases. Furthermore, the existence of long-term correlations is characteristic.
- Channel structures (river trees) are fractal objects in many ways. It is now evident that not only does the length of a main river scale with the catchment area, but that such morphologically-important relationships such as HORTON's laws, which are basic to the structure of natural drainage networks, are also tightly connected to certain fractal dimensions of the river tree. The famous HORTON numbers RB and RL (number of

branching points in the river tree and the length of stretches of river between branches), for example, are directly connected to the fractal dimension of the entire river network. The meandering of a river can also be parameterised by a fractal dimension (Rodriguez-Iturbe and Rinaldo 1997).

- Slopes, "natural" channel cross-sections of rivers, "contribution areas" for drainage, the drainage itself, the stationary flow rates in river networks and many more seem to be ruled by fractal scale laws.
- The well-known relationships of Leopold and Maddock (1953) also fit into this group of phenological findings in hydrology, whereby the flow depth, flow width and flow speed along a river can also be formulated as power laws of flow under stationary conditions (Rodriguez-Iturbe and Rinaldo 1997).
- Special dynamic magnitude, such as the UNIT-HYDROGRAPH, which transforms the time-variable rainfall in runoff, are also closely linked to the fractal characteristics of the catchment area (Braun et al. 1997 a).
- Probability distributions of yearly peak water levels (or rather their quantiles), scale with the size of the catchment area - and are thus to be seen as fractals.

4 Consequences for the Management of Large River Catchments

Although the subject of fractals in hydrology is being intensively worked on internationally, there is still a great need for research, especially in our country. To make clear which concrete uses could arise out of this new way of thinking, here is a list of some possible primary applications for the management of large catchment areas:

- The fractal structure of time sequences can be used to obtain much more realistic statements about trend behaviour, or rather, about the nonstationary time sequences of the water budget.
- The creation of long time series of runoff on the basis of empirically-determined fractal scale laws ("fractal signatures"). These so-created sequences take account of long-term correlations as well as the principally non-linear structure of multifractal processes, which, in some circumstances, can lead to a dramatic shift in the appraisal of "rare" events.
- The backing-up of initial statements of regionality by explicitly taking account of scaling properties (e.g. with the derivative of HQ-quantiles in unstudied areas).
- Fractal scale laws cannot only be used to interpolate and simulate extremely complex dynamics (as Mandelbrot 1998 has recently shown in the multi-fractal simulation of time sequences on the stock market), but can perform systematic comparisons to other geophysical time sequences which are interesting to hydrology, via fractal signatures (those which can be intepreted as "fingerprints"). Thus it is possible, for example, to consider a systematic extension of our hydrological observation window of typically 100 - 120 years in connection with the debate on climate. This could happen through the comparison of fractal signatures of dendrochronistic sequences (up to 3000 years), sediment stratigraphies and others. If it should be that these signatures are very similar, then one could fairly safely conclude an identical origin of these processes. This would have the important consequence that we could be much more certain of the definition of "natural noise" and its statistics - with direct consequences for the long-term analysis of risks.
- Applications are also conceivable for ecological structures: perhaps flow channels could be checked for "nearness to nature" (or rather quantitatively assessed) in terms of the

fractal signature of their banks or flow cross-sections. The amount of meandering could also give an idea of the "naturality" of the channel.

- Grid-based models are often used to simulate the water budget of an area. When parameterising these area-differentiated models it is possible to a certain degree to cancel out the loss of information which occurs through gridding the catchment area too coarsely, with the help of scale transformations (Braun et al. 1997 b).

5 Conclusion

The train of thought described here in short is still very much in motion on the research side. The study of space-time aspects of self-similar processes still requires a great deal of work. Some of this is highly controversial among experts, which is not surprising for a paradigm change of this sort. Considering our own experiences which we have already made in Bavaria with this new way of thinking, and the realistic appreciation of international recognition, one can, however, say that a neglect of knowledge of fractal theory in hydrology, or rather, water management, would be a neglect of qualifying our knowledge of water-management processes, that would be hard to justify.

Therefore, it is our opinion that it is necessary to explicitly demand research which would try to cancel out the existing deficit in Germany in comparison to the level of international research, in the area of self-similar hydrological processes. The special charm of these methods lies in their basic simplicity - as well as from the highly systemising effect on apparently totally disparageous phenomena, which comes very much to the good of practical applications. The study of properties of self-similar processes and objects should not, however, replace process-orientated research into causal links, but should effectively supplement it.

The diagnosis of self-similarity is, at present, mainly an opportunity for broad empirical research. The necessary tools for diagnosis - which I wasn't able to go into here, are being continuously improved and are already suitable for being applied in practical water management.

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Assessment of Waters in Austria

Andreas Chovanec[1], Johannes Grath[1], Veronika Koller-Kreimel[2], Otto Moog[3], Rudolf Philippitsch[2], [1] Austrian Federal Environment Agency, Vienna, Austria, [2] Federal Ministry for Agriculture and Forestry, Vienna, Austria,[3] University of Agricultural Sciences, Vienna, Austria

1 Introduction

The following article deals with chosen aspects of the assessment of surface waters and groundwater in Austria (see also BMLF 1996). The central topic is developments since 1990: this time period is relevant for understanding the current situation for the following reasons:

- Through the amendment in 1990, the phrase "ecological integrity" (EI) was widely anchored in Austria's Water Act (WA), which professes the Government's belief in an eco-system-based view of waters (e.g. Oberleitner 1994).
- Since the beginning of the nineties, typological criteria have played an essential role in the description and assessment of surface waters (e.g. Moog and Wimmer 1990). Water assessments are based on the comparison of current conditions with a type-specific reference situation. This approach also found its way into the draft of the Water Framework Directive (WFD; Rat der EU 1999).
- Since the beginning of the nineties there has been a national monitoring network to investigate the quality of groundwater and running waters (e.g. WWK/UBA 1997).
- OENORM M 6232 (Austrian Standard; Österreichisches Normungsinstitut 1995) summarises the main aspects of running water assessment, e.g. the assessment of EI (Chovanec et al. 1994, Moog and Chovanec 1998).
- The EU WFD, which exists as a draft (version March 1999), has both qualitatively and quantitatively important influence on the assessment procedures for groundwater and surface waters.

2 Surface Waters

2.1 National Typology Programs

The demands for creating waters typologies stems from many factors in Austria, e.g.:

- from legal requirements (especially WA);
- from the water-type-based assessment of the EI;
- from the expected requirements of the WFD (especially appendices II, V).

Water-typology-based approaches allow:

- the understandable structuring of waters in a hierarchical system according to clear, characterising criteria,
- the characterisation of waters not comprehensively studied until now, and their description according to their properties,
- the description of differences and similarities of various waters,

- information on waters to be made available in a short and clear form,
- the description of natural / nearly natural reference situations,
- the creation of a base for an ecologically oriented water management (Mader et al. 1996).

In connection with the typology of waters, the following completed or currently running studies and projects should be mentioned:

- catalogue of stream orders of Austrian running waters (Wimmer and Moog 1994),
- flow regime typology of Austrian running waters (Mader et al. 1996),
- typological characterisation of all running waters with a catchment area >10km^2 on the basis of: natural area units (Fink et al. in preparation), flow regimes, geology, size of catchment area, stream orders, altitude. An analogous project is being prepared for standing waters,
- working out running-water-type specific macrozoobenthos-coenoses with the main points: saprobic condition, biocoenotic region, "key species".

The typological characterisation of running waters and the working-out of reference coenoces are main steps in creating the basis for implementing the WFD. The typology of running waters also forms the basis for adapting the country-wide monitoring network (see following section) to conform to the WFD: placing of monitoring sites on waters of all representative types, and defining of type-specific reference sites.

2.2 National Assessment Programs

Country-wide standardised monitoring of water quality at 245 running water sites

The creation of the relevant legal framework in 1990 and 1991 (e.g. Ordinance on water quality monitoring, OWQM) enabled the establishment of an Austria-wide water quality monitoring system, which consists of 245 running-water monitoring sites. Both, federal and provincial authorities as well as a large number of private contractors are involved in this program, which started in 1991. At the monitoring sites up to 100 physicochemical parameters are measured 12 or 24 times a year in water samples, and sediment investigations and assessment of the saprobiological water quality are carried out once a year. The publication of results is regular (e.g. WWK/UBA 1997, Chovanec 1997). The results can also be called up via the Internet (http://www.ubavie.gv.at). The discharge of running waters is monitored at 790 sites.

Definition of type specific river sections

In this study, running waters with mainly undisturbed morphological and hydrological characteristics are described. The study was carried out at all rivers with a catchment area >500 km^2. The results form the basis, among others, for the description of type-specific reference conditions and for environmental protection decisions (Muhar et al. 1998).

Classification catalogue of benthic invertebrates

With a comprehensive classification catalogue of benthic invertebrates (Moog 1995), a sapropic catalogue with Austria-wide validity was created, which allows a national comparison of saprobiological studies. In addition to this, the membership of the individual species to functional feeding groups and their longitudinal zonation are shown in numeric form. This compendium has the advantage that analyses concerning benthic aspects of the EI, according to OENORM M 6232 can be carried out at a species level with little extra effort; the data basis for this is the same as that to be created in saprobiological water quality assessments (species and frequency). Additionally, an evaluation program enables the electronic use of the catalogue ("Eco-Prof").

Indicator Lists for benthic algae

For the benthic algae present in Austria, a saprobic catalogue (Rott 1997) as well as indicator lists as a basis for the trophic assessment of running waters has been set up (Rott, in press).

3 Groundwater

The quality of the groundwater has a high ranking in the public discussion on environmental matters in Austria. This is due, not least, to the fact that groundwater is the basis for the drinking water supply in Austria. More than 99% of the drinking water comes from groundwater, of which about 50% comes from porous ground water media in valleys and basin regions, and about 50% from karst groundwater resources (mostly springs). In order to guarantee a comprehensive assessment of groundwater quality and to derive measures of quality-improvement from this, a wide-ranging monitoring program for Austrian groundwater resources based on the OWQM was set up in 1991. The aim of this country-wide program is to determine pollution from diffuse sources (e.g. agriculture). A total of approx. 1800 monitoring sites in porous groundwater regions, and approx. 250 in karst groundwater are generally monitored quarterly. The criteria for the assessment of groundwater quality in Austria is laid down in the "Ordinance on groundwater threshold values". The threshold values contained in this order are generally set at 60% of the height set for the relevant drinking water threshold. The results are continuously published (e.g. WWK/UBA 1997) - also on the Internet (see point 2.2). Quantitative aspects are monitored at 2900 measuring sites.

The measuring of groundwater quality, according to the OWQM, and the groundwater quantity, will be the basis for implementing the WFD as far as monitoring the condition of groundwater will be concerned.

4 Need for Action

From the implementation of the WFD come the following needs for action in the near future:

- characterisation of groundwater areas, including the description of anthropogenic influences,
- working out precise descriptions of the five levels of ecological status,
- the identification of anthropogenic influences on surface waters and their assessment,
- the identification of artificial and structurally heavily-modified waters, and working out of the "maximum ecological potential", based on water types.

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Assessment of the Chemical and Ecological Condition of Surface Waters According to the EC Water Framework Directive

Ulrich Irmer, Federal Environmental Agency, Berlin

With regard to the requirements of the future EC Water Framework Directive (WFD, EG 1999), an overview is provided in the following of the methods used in Germany in current monitoring practice for the chemical and ecological assessment of rivers. Additionally, the subject of whether, and how far, the requirements of the WFD will be met by these procedures and in what areas there is priority need for research, will be discussed. For this, there is an assessment of methods, according to whether they "don't fulfil", "partially fulfil" or "fulfil" the requirements.

1 Overview of Important Obligations of the WFD

The aim of the available draft of the EU Water Framework Directive is to achieve a good quality of surface waters at an EU level. The Directive envisages an assessment of the chemical waters quality (EU-wide quality standards for approx. 30 priority substances) and a five-step classification of the ecological quality of waters, with the steps high, good (target value), moderate, poor and bad. The reference point in the assessment of the ecological part are the reference conditions which equate to high waters quality and should characterise the condition of waters largely unaffected by human influences. Sites which represent the reference conditions for the individual waters types are to be selected according to hydromorphological and physicochemical features and then to be characterised according to biological features. For flowing waters, the following three features complexes are planned:

1. the biology with the four elements phytoplankton, macrophytes/phytobenthos, macrozoobenthos and fish fauna,
2. the hydromorphology with the three elements hydrology, continuity and morphology, and
3. the physicochemical conditions with the three elements general conditions, synthetic pollutants and non-synthetic pollutants (other than the above-mentioned 30 priority substances).

The "high status" class I equates to fully or nearly fully natural conditions, while "good status" class II differs slightly, and "moderate" class III differs moderately from the reference level.

To reach a good chemical condition the EU will formulate legally-binding quality standards, which cover all uses and aspects of protection.

Additionally, quality standards are necessary for further relevant substances (see 3), which the member states must derive according to a fixed scheme, in order to achieve a good ecological quality.

2 Flowing Waters Assessment in Germany

Deviating from the requirements of the WFD, the waters quality classification in Germany is always according to a 7-step system, the biological and chemical assessment scheme with 4 main and 3 subclasses. As the principal of both classification systems are identical (especially class II as main quality target), an adaptation of the German system is, however, easily possible. A unification and adaptation could take place in which classes I and I-II merge to class I and the two worst classes III-IV and IV merge to become class V.

2.1 Hydromorphological Quality Classification

The hydromorphology of small and medium-sized flowing waters is characterised via 25 individual parameters, which are grouped into 6 main characteristic groups (LAWA 1999). With this system, which has been successfully tried in a number of German states, a comprehensive assessment of the 6 main characteristic groups and the total hydromorphological condition is obtained. The individual characteristics concern the ecomorphological quality of the water bed, the banks and the surrounding area. The reference condition is the ideal of the potentially natural condition, which would come about in the future without human intervention. On the basis of this very wide-ranging system, a simplified procedure is being worked out which should allow an overview mapping of larger waters to take place by 2001.

The hydromorphological requirements of the WFD are already being fulfilled. An adaptation to the 5-step system of the EU is not necessary, as only class I (reference conditions) is hydromorphologically defined in the WFD (all the other classes are biologically classified). It only needs to be checked whether class I, or as described above, a merging of classes I and I-II should be used as a reference condition in terms of the WFD.

2.2 Physicochemical Quality Classification

The Physicochemical Quality Classification includes synthetic and non-synthetic pollutants as well as the most important general elements such as nutrients, temperature, oxygen, pH (LAWA 1998). The substance concentrations, or other values which equate to quality class I, characterise, in this, a condition without human intervention. The respective most stringent of the "quality targets" for all protected asset considered is assigned to class II; it enables the use of waters as well as the protection of the aquatic habitats. The foundations for deriving the quality targets to protect the aquatic communities are substance-based ecotoxicological studies (Irmer et al. 1995) on representatives of four central trophic levels of waters biocoenoses (bacteria, green algae, small crustaceans, fish). The procedure mainly conforms to the way of proceeding described in the WFD. A main difference of the physicochemical assessment approach, however, can be seen in two ways: firstly the German classification procedure takes all relevant protected assets into account, i.e. also the provision of drinking water from surface waters, fishing or the spreading of sediment on agriculturally-used areas. Secondly, for non-synthetic pollutants (heavy metals), a different assessment procedure to the above is used for the protection of the aquatic habitat, as it became clear that the given "quality targets" when using the above-used procedure would lie in the area of background concentrations (Irmer et al. 1997). The targets for these substances was therefore pragmatically chosen at twice the maximum height of the background concentration (about factor 2); it is thus four times the average background concentration. Because of analytical conditions (detection limit) the matrix is the suspended particulate matter (SPM) and not the water phase. The quality targets for heavy metals in SPM are checked as a yearly value with the 50-percentile, for oxygen with the minimum and for all other given targets with the 90-percentile.

The physicochemical requirements of the WFD are already being fulfilled. An adaptation to the 5-step system of the EU is not necessary because in the WFD only class I and II are physical-chemically defined (the other classes are characterised biologically). The EU-class II is defined by environmental quality standards that correspond to the water quality targets to a large extent, whereby a lowering of requirements takes place if protected assets other than the aquatic communities have had tougher requirements referring to the water quality targets. A lowering of standards certainly takes place through the use of the average value rather than the 90-percentile. For non-synthetic pollutants, however, there are demands through the EU Commission to firm-up the quality norms. The procedure laid down is practicable for synthetic pollutants, but not for heavy metals.

2.3 Biological Quality Classification

The biological waters quality in Germany is currently routinely carried out via the measuring of saprobic quality make-up. Further indicator systems are used in individual German states or are under development or currently being tested.

Phytoplankton

For plankton-dominated impounded watercourses a trophic indicator was worked out, which is currently being tested. The classification is by chlorophyll/phosphate content. Additionally, a method that would cover the upper quality range is being work out using diatom flora measurements.

The requirements of the WFD are currently only partly being fulfilled. It seems questionable whether investigations into the composition and abundance of algae can lead to a usable assessment instrument. In flowing waters the phytoplankton communities change continuously without human-related impacts being apparent. It should therefore be checked whether the costly and time-consuming recording of phytoplankton biocoenoses can be done without, at least in a first step, in favour of a simple trophic indicator via the classification of the chlorophyll content.

Macrophytes / Phytobenthos

In some German states, macrophyte-stocks are inventoried to determine the trophic status of the flowing waters. As far as macrophytes occur in flowing waters (this is only rarely the case), a classification of the indicator organisms can show the trophic level of the waters. Youthful diatoms are probably better suited as a trophic indicator, which, as opposed to macrophytes, colonise all aquatic habitats. A trophic indicator procedure using sessile Diatoms was developed at the beginning of the nineties as part of a research project. Diatoms are also good indicators of water acidification.

The requirements of the WFD are currently only partly being fulfilled. This is mainly because macrophytes only rarely occur in flowing waters and are thus basically only suitable as an indicator of waters quality to a certain degree. A research project has been initiated to work out an assessment system that is consistent across Germany, which should also further develop the procedure of trophic indicators using diatoms.

Macrozoobenthos

The macrozoobenthos are used as the basis for the determination of the saprobic quality of flowing waters in Germany (LAWA 1996). The resulting Biological Water Quality Map serves as the indication of biodegradable organic substances. Other human influences, such as acidification, eutrophication, ecotoxicity or waters withdrawal are not, or unsatisfactorily, reflected. Upland waters act as a reference, which have higher flow rates, and thus higher oxygen content than those in lowlands. This means that quality class I can only be achieved in mountainous area, and not in flat area, i.e. the assessment system is not geared to the type-specific reference conditions.

The requirements of the WFD are currently only partly being fulfilled. An adaptation to the 5-step EU system is necessary. Above all this includes the expansion of the system to all important function complexes such as the selection of reference biocoenoses for the individual waters types. The latter will probably cause lowland waters to be assigned a better quality value compared to the current Biological Water Quality Map, and highland waters a lower quality value. Relevant work has been initiated through a research project.

Fish Fauna

There are regular comprehensive studies of the fish fauna in the larger German flowing waters. A complete record of the species composition and abundance is not seen as possible, however. Harmonised methods for making stock inventories don't exist. Whether the choosing of indicator species can enable an assessment of waters quality is being checked.

The obligations of the WFD are currently not being fulfilled. It will be for future research projects to work out a relevant assessment system.

3 Conclusion

The requirements of the Water Framework Directive are already now mostly being fulfilled in Germany in terms of the features complexes of hydromorphology and chemistry. There are, however, considerable deficits in the meeting of biological characteristics: the best possibilities for meeting these are seen to be with the macrozoobenthos. Promising approaches also exist with trophic indicators using diatoms and macrophytes. However, it is also necessary to measure the waters quality according to the fish fauna. It is not only in Germany that there is a considerable need for research and development. Within the framework of work by the Federal State and the Länder, biological research procedures are currently being developed for all river catchment areas in Germany, which should reflect all human influencing factors. Implementation of the Directive should be made as easy as possible in Germany through the development and use of uniform assessment procedures in the large river catchment areas.

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The Development of Water-Ecological Ideals as a Base for Integrated Assessment of Running Waters

Volker Thiele, biota, Society for Ecological Research, Planning, and Consultancy Ltd, Güstrow

The discussion on ideals has been very intensive and sometimes controversial in the last few years (Herbst 1998, Bock 1998). The main aim was their use in determining restoration targets in water protection. Kohmann (1997) defined the ideals as:

- today's, potentially natural condition of waters,
- which mirrors today's knowledge of the natural function of the running-waters ecosystem,
- is orientated towards today's natural-environment potential (irreversible changes are accepted), and
- will become more differentiated with growing knowledge (without changing its basic content).

This definition is generally accepted, lifts the ideals out of a directly operational level and puts them at a visionary level (Herbst 1998). It makes a regionalisation of ideals possible, so that topologies measured with different yardsticks can also be taken into account.

Relevance to ideals, though, is also a basic prerequisite for the integrated evaluation of flowing waters. Biocoenotic ideals often play a central role in this. Integrated evaluation procedures are being demanded more and more, nationally and internationally, for the monitoring of water quality, and for monitoring after ecological restoration work on flowing waters.

Agenda 21 thus orientates the world-wide protection of quality and volume of freshwater resources to the setting-up and operation of systems for monitoring water quality and the determining of physicochemical and biological quality standards.

In competition with this, the currently discussed proposal for the European Water Framework Directive has the following main aims:

- prevention of a deterioration of the ecological condition of surface waters
- prevention of their pollution
- restoration of degraded waters (good quality)
- achieving a good ecological potential and a good chemical condition on heavily altered or artificial waters.

In the Directive, the setting-up of a monitoring network is called for (ecological and chemical condition of the surface waters), which will make it possible to determine the quality, according to type, of the waters, by using biological, hydromorphological and physicochemical parameters. Human-caused degradation should be categorised in five groups and classified in the form of hemerobiotic classes (representing an increasing degree of man-made stress). Bio-indicative evaluation strategies have a special importance in connection with this. ISO-, CEN- and DIN-norms have already been derived from the European Water Framework Directive, which especially lay down the methodological framework for an ecological evaluation of flowing waters (e.g. ISO/CD 8689 1998a, b).

In the last few years a far-reaching change in the types of tasks has also taken place in German water management practises. Whereas into the eighties one still mainly orientated matters on guaranteeing a regulated water flow, on the provision of high-quality drinking water and on the non-damaging treatment of sewage, in the nineties a main target of maintaining habitat functions for a flora and fauna typical of the locality was added (Herbst 1998). This is expressed in both §

1a of the WHG (1996), and in the criteria for National Waters-Protection Concepts (LAWA 1996), which, apart from demanding the preservation and restoration of waters habitat functions, also demand the ideals-orientated appraisal of all human load factors on waters, banks and plains, and the targeted uncovering of deficits through use of an integrated viewpoint. The development and use of bio-indicative evaluation procedures is one of the most important prerequisites for achieving these aims.

Thus it is only a natural consequence, that parallel to these political developments, the evaluation procedures have also changed course. In addition to the "classical" methods, such as physicochemical and saprobic water quality analysis, the structural quality and sediment nature analyses, the analysis of acidity in small streams and the trophic nature of plankton-dominated rivers (Friedrich 1996), procedures are coming in more strongly, which look integratively at the whole altered condition of waters. The potential ideal plays a central role in determining the 100% point on the classification scale. Friedrich (1998) split these procedures into two large groups:

With the bottom-up approach to integrating evaluated characteristic values, existing evaluations of single characteristic values, either weighted or unweighted, are brought together into one conformable statement. On this basis, Braukmann and Pinter (1997), for example, have presented evaluation procedures for small and large streams. Apart from generally accepted quality targets, which are the basis of the individual targets to be integrated, the use of an ideal (e.g. of today's potential natural condition of vegetation) to determine the condition of biological values, can also be found in this evaluation method.

The top-down approach starts with the classification of highly-integrated elements of waters. The Reference biocoenosis, for example, is such an element. The procedures based on this approach orientate themselves mainly on the biocoenotic ideal from reference areas and use the difference from this for the evaluation of hemerobiotic sections. These procedures are primarily diagnostic, so that one often cannot exactly interpret the causes.

As an example, the RIVPACS-procedure (Armitage et al. 1990, Wright 1995, Johnson and Law 1995) is based on this ideals-based approach. The principle stems from a comparison of the type-specific reference condition with the current condition to be evaluated. This is carried out using physicochemical parameters and biocoenoses. Statistical procedures enable the coupling of central abiotic parameters with typical biocoenoses of the relevant flowing waters. If these physicochemical parameters can be specified for a stream or river to be evaluated, then it is possible to assign it to a suitable reference- biocoenosis. This is numerically compared to the actually observed nature of the species community, and an Ecological Quality Index (EQI) derived.

A similar procedure was developed for north-east German flowing waters with the place-type index (Thiele et al. 1994a, b, 1996, Thiele 1995, Thiele et al. 1999). It is aimed at man-made stress indication and assesses waters, banks and valleys equally according to an integral approach (compare Friedrich 1998). To lay down the individual quality classes, the difference to biocoenotic ideals of the relevant flowing water type are used. In addition, the types of reference biocoenoses and the various anthropogenically affected biocoenoses are allocated to ecological categories according to type (eurytope to stenotope species), and these then calculated to index values. The index value area of nearly natural stretches (biocoenotic ideal) is used to define the best quality class. Using the degree of nearness to nature of differing waters and river valley stretches, the class widths for higher hemerobiotic degrees are set. The procedure defines 5 quality classes and is thus conform to the ISO (ISO/CD 8689 1998a, b).

When considering the great importance of biocoenotic ideals for integrated evaluation procedures, the questions of which species groups are best suited to being evaluated bioindicitavely, and how one can define biocoenotic ideals using these taxa arise.

The EU Water Framework Directive already sets such species groups for waters in appendix V. The macrozoobenthos and the macrophytes form the backbone for the bioindicative evaluation. Biocoenotic ideals are being drawn up for both of these taxa in almost all German states (compare Braukmann 1998), and a project of the Federal Environment Agency (UBA) is also working nationally on their creation. Internationally, most bioindicative evaluation procedures are based on these two taxa.

For the river valleys, the picture is less uniform. Gerken (1980), Foeckler and Bohle (1991), Thiele (1995), Oostermeijer and van Swaay (1998) analysed the literature interdisciplinarily and came to the conclusion that relatively immobile species with small space requirements (e.g. Coleopters, Lepidopters, molluscs), were generally accepted as bioindicators. They should be present widely-enough in the individual valley floor types and their autecological requirements well known. Thiele and Mehl (1995), and Wolf (1998) found especially the lepidopters, carabids and syrphids to be suitable in studies to determine good indicators. The vegetation of the valley also proved to be a superb bioindicator. The criteria for testing suitability was indication (by the tested indicator) of man-made valley degradation.

Braukmann (1998) describes ways towards zoocoenotical typification which are an important prerequisite for the definition of biocoenotic ideals. Apart from analysing the structure of the biocoenoses, he discovers the importance of previously typifying the flowing waters according to water-based, geographical and geomorphological criteria. The derivation of biocoenotic ideals then follows through statistical methods (similiarity analysis, cluster analysis etc.), whereby the definition of ideal and differential taxa play a central role.

For the state of Mecklenburg-Vorpommern Mehl and Thiele (1998) have prepared a typology which is aimed at biocoenotic relevance. Apart from hydrological, physicochemical, glaciomorphological, pedological and microclimatic typification parameters, especially biocoenotic criteria (habitat structures, ecological group spectra, the length of existence of trees and shrubs in the Quaternary etc.), were taken for typification. Thus, among others, the derivation of ideal and differential species was also possible, during which the macrozoobenthos for the aquatic area, and the lepidopters and carabids for the terrestrial area, were looked at more closely. This work is an important prerequisite for the definition of type-based ideals. For held-back and plankton-dominated waters such ideals have already been defined (Thiele et al. 1996). Through the coupling of these ideals with the procedures of the place-type index, the development of an integrated evaluation method will be attempted, in the form of a top-down approach.

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Natural Runoff and Runoff Dynamics

Christian Leibundgut, Alexander Hildebrand, University of Freiburg, Institute of Hydrology, Freiburg, Germany

1 The Importance of Runoff Dynamics in Integral Waters Protection

The far-reaching importance of runoff dynamics with a view to maintaining healthy aquatic ecosystems has, until now, been underestimated in River Basin Management. The concentration, the strong fixation, on minimum flow rates skewed the view towards runoff dynamics (Power et al. 1988, Leibundgut 1996). "Ecologically correct" runoffs require a mechanism for maintaining the runoff dynamics (variable with time) and the structural diversity (variable with area) of the stretch of river under study. Runoff dynamics and runoff volumes are important factors when looking at the ecology of flowing waters. Among other things, they have an effect on the water temperature and the gas content, the river and channel morphology, habitat diversity, the transport of solids, the substrate distribution, the interaction with the groundwater, turbulence etc.

A main aim of modern waters protection is the securing and recreation of a natural area and catchment-area-specific runoff and substance dynamics. Through this the maintaining of a multi-species, stable and reproducing, healthy aquatic ecosystem should be achieved (DVWK 1996, Richter et al. 1997). Dynamics, as the "fourth dimension", is moving towards the centre of attention, but is hardly integrated into water management concepts or use models (Borchardt 1998).

The runoff regimes are characterised by amount, frequency, length, time and rate of change of runoff conditions. The runoff regime influences the physical habitat and the biotic interactions directly and indirectly through the quality of the water, and thus, the ecological balance. We assume that the runoff regime, or rather the runoff dynamics, has/have a central importance in maintaining ecological integrity.

Runoff regimes and runoff dynamics result from the nature of the catchment area. The nature is made up of the natural status and anthropogenically-caused changes. From this, comes a hierarchy of ecohydrological processes which begins in the catchment area, and thus determines the ecohydrological conditions along the length of the waters, and ultimately the habitat. From this viewpoint, we mustn't forget that the groundwater body (interstitial) in the catchment area has, until now, been more or less neglected in this approach, although it has a strong influence through its interactions with the surface waters. Today, hydroecological studies of waters protection are restricted to the stretch of waters and the habitats. We postulate an integrated view on a catchment area level, as is set down in the EU Water Framework Directive.

To answer the question of natural runoff, an integral, interdisciplinary approach is thus necessary. In this, hydrology must deal with the hydrometeorological input/output, carry out a catchment area analysis, and run the water budget models. This will make it possible to measure both the current, as well as the potential runoff regime (in the sense of an ideal). Morphology provides the link to ecology. Long-term, ecologically reasoned "development targets" of waters protection will only be reached through interdisciplinary partnerships.

2 Assessment Procedure "Hydrological Quality"

If we follow this premise, then we cannot, for example, treat the runoff dynamics in isolation either. In questions of assessment, the measurement of the condition of the water budget, which is reflected in the runoff dynamics, often remains untouched. We therefore propose a (comprehensive) assessment procedure of "hydrological quality" (in addition to the existing assessment procedures), which contains the runoff dynamics as the core of the quantitative part, but also contains the material budget and material transport.

In these assessment procedures the hydrological condition is to be seen as the framework which secures the integral viewpoint at a catchment area level. It should be a brick in the wall towards solving the demands of the EU, which, with an integral structure on the ecological level, and an open link to the economic area, have been very flexibly conceived. The measurement of the natural runoff of runoff dynamics and the material budget is firmly embedded in this assessment procedure.

The choice of parameters for assessing the runoff dynamics is currently based on the procedure of INDICATORS OF HYDROLOGIC ALTERATION (IHA) (Richter et al. 1996, Richter 1999). The procedure contains 33 ecologically relevant runoff parameters such as monthly average, size, length and timing of extremes and frequencies of change. This procedure must still be adapted to German and European requirements.

The ideal for the runoff dynamics lies in the potential runoff regime. This ideal within the assessment procedure for hydrological quality can only be reached via statistical analysis. At the moment the IHA-parameters are used, which, however, still need adding to. When using the so-called RANGE OF VARIABILITY APPROACH (RVA), with which the differences of the IHA-parameters between the ideal and the studied period can be classified and assessed, a check can be made as to how far the catchment area is still in its original, unaltered condition. The problem with this procedure often lies in the unsatisfactory data and in natural fluctuations (climate variations) which cannot easily be measured.

We therefore assume the second approach towards the use of catchment area models to simulate the runoff under the assumption of a potentially natural vegetation, to be the more promising way in the medium and long term. Catchment area models can be individually adapted and area-based statements can be made. The river catchment area management of the future will have to be based on a model anyway.

The calculation example shows an analysis for the parameter of the MQSeptember and the NM7Q for two periods (fig. 1). The area covered by the average, plus/minus the standard deviation of the reference period is, so to speak, the ideal for unaffected runoff dynamics, and for this reason is also shown in the period studied.

It can clearly be seen that the variability of the NM7Q from the reference point to the studied period has risen sharply and that the average has risen from 77 to 87 $m^3/s*d$, as a result of anthropogenically-influenced raising of low-water levels. The variability of the monthly average for September, on the other hand, has drastically decreased, and the average of this parameter has fallen (from 305 to 234 $m^3/s*d$). This is due to reservoir management in the catchment area. For a comprehensive assessment of the hydrological situation in the catchment area, all parameters of runoff dynamics are checked and analysed as to their average, their standard deviation and the variation coefficient. Through the comparison of the studied and reference periods, the main assessment is carried out. We are aware of the problems of this assessment, as a representative reference period cannot easily be determined, because the running averages underlie very strongly uncyclic, aperiodic fluctuations (fig. 2). These imply possible climatic fluctuations. Still, it is very likely that since 1950, the increased occurrence of flow levels is due to reservoir management.

With the use of catchment area models for the generation of runoff sequences, a simulation of "natural" runoff dynamics, while assuming a potentially natural vegetation (PNV), should be made possible. In this it is assumed that under PNV conditions, natural runoff dynamics rule, and that ecohydrological functionality is thus given. With suitable catchment area models, land-use scenarios with various levels of naturality and various uses of the water could be simulated.

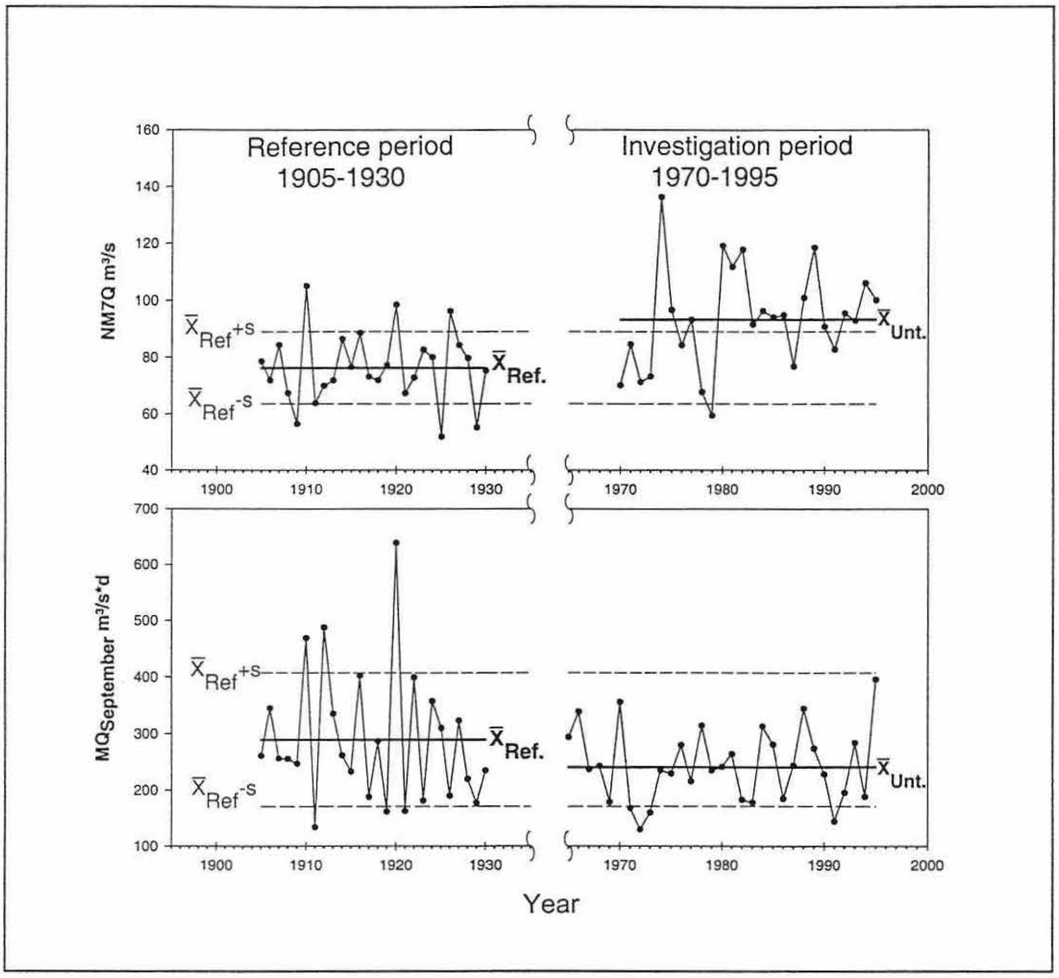

Fig. 1. Runoff dynamics parameters NM7Q and MQSeptember for the periods 1905-1930 and 1970-1995 at Level Burghausen, waters - Salzach

The catchment area models available today cannot fullfil these demands at acceptable quality. Generally the models are too strongly and too simply conceived. They do not possess a satisfactorily physical foundation (Koehler 1992, Gordon et al. 1992), with which they could fulfil the demands for prediction capabilities. Generally the uncertainty of models is too high, there are too many realisations (possible parameter combinations) to watch, so that the effects of land-use changes are swamped by the margin of error (Uhlenbrook et al. 1999).

3 Conclusion

The hydrological parameters of runoff dynamics have a central importance for the ecological functionability of flowing waters. Methods which can secure the preservation of natural runoff dynamics are called for in modern River Basin Management. A hydrological ideal of runoff dynamics, which should serve as a reference for the preservation or recreation of natural runoff dynamics, can be calculated through statistical assessments and catchment area modelling. The new assessment procedure "hydrological quality" contains the parameters which runoff dynamics measure and assess. If this catchment-area-based assessment procedure is used in modern River Basin Management, then more promising measures to improve the condition of catchment areas and their ecohydrological compartments (stretches of water, habitat) can be taken, thanks to the strong dependence of chemical, biological and ecomorphological processes on runoff dynamics.

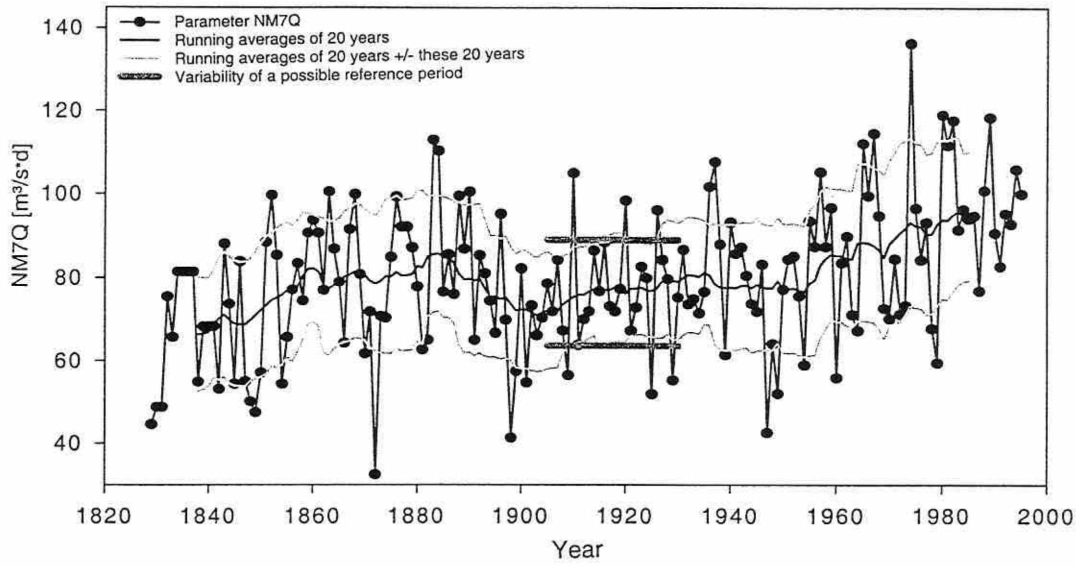

Fig. 2. NM7Q of the flow line at the level of Burghausen, waters - Salzach

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Understanding Natural Processes in River Corridors as the Basis for Ecosystem Management

J.V. Ward, Klement Tockner, Urs Uehlinger, EAWAG/ETH, Department of Limnology, Dübendorf, Switzerland

1 Introduction

Running water ecology is a young science, the conceptual foundations of which were derived mainly from research conducted in Europe and North America. However, nearly all European river corridors were already substantially modified by humans before the science of river ecology developed (Petts 1990). Although major modifications of North American river systems occurred later than in Europe, river ecology also developed later (Stanford and Ward 1979). Therefore, we have an impression of rivers as being much less heterogeneous and much more stable than they actually are in the natural state (the insightful work of Antipa (e.g. 1912) seems to have been forgotten). The thesis of this paper is that established research and management concepts may fail to fully recognize the crucial roles of habitat heterogeneity and fluvial dynamics because of a lack of fundamental knowledge on the structural and functional features of morphologically intact river corridors. In addition, a strong management focus on water quality problems, although successful in improving chemical conditions, may have diverted attention from other severe anthropogenic alterations in river corridors. Until quite recently, most concepts in river ecology were based on the implicit assumption that rivers are stable, single-thread channels hardly interactive with adjacent flood plains (Ward and Stanford 1995). Unfortunately, many European rivers are in such a state, but it should be recognized that this is not the natural condition. We believe that this incomplete understanding constrains scientific advances in river ecology and renders management and restoration initiatives less effective.

The ensuing material provides examples of the high level of spatiotemporal heterogeneity that may be attained in rivers where natural processes still operate on a large scale. The objective of this paper is to promulgate a broader and more integrative understanding of natural processes in river corridors as a necessary prelude to effective river conservation and management. Length limitations preclude detailed descriptions of the research projects or comprehensive literature citations.

2 Landscape Ecology of River Corridors

The highly complex and dynamic nature of intact river corridors are particularly amenable to a landscape ecology perspective (Ward 1998; see also Gustafson 1998). Recent research on near-natural European river corridors described briefly below demonstrates the strong links between spatiotemporal heterogeneity and hydrodynamic processes, including interactions between surface waters and ground waters .

2.1 Fluvial Dynamics in a Glacial Flood Plain

Different water sources and flow pathways, in concert with a dramatic expansion/contraction cycle, create a shifting mosaic of channel types and a remarkable diversity of habitat conditions in Val Roseg, a glacial flood plain in the Swiss Alps (Tockner et al. 1997, Ward et al. 1999a, Malard et al. 1999). The channel network within the glacial flood plain by no means consists of uniformly cold, highly turbid waters. Six major channel types were distinguished based on the correspondence between hydrological connectivity and physicochemical variables. Hydrochemical tracers showed how water sources (subglacial water, englacial water, snowpack, alluvial aquifer, hillslope aquifer) and flow paths (surface, shallow ground water, deep ground water) shifted throughout the year concomitant with the expansion/contraction cycle (Fig. 1).

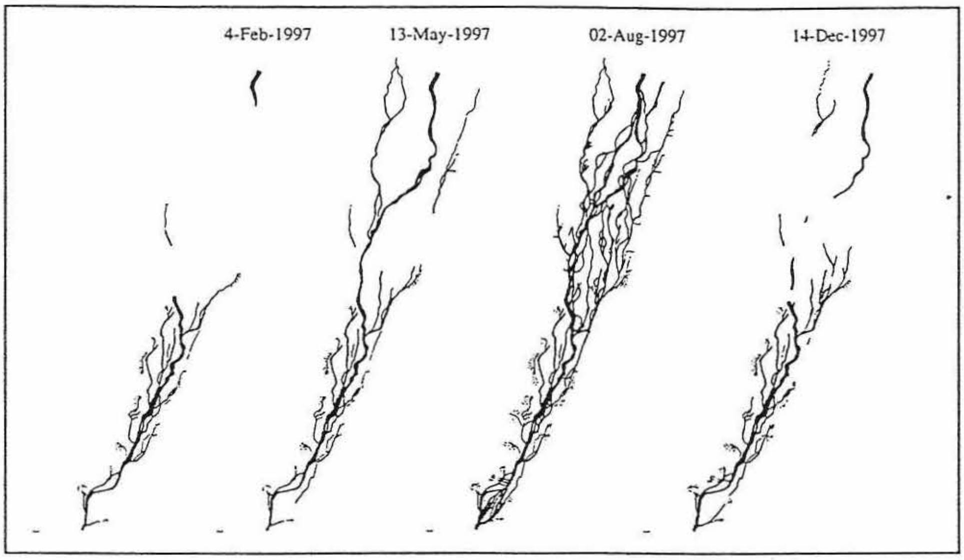

Fig. 1. Expansion /contraction of the channel network in the glacial flood plain of Val Roseg (modified from Malard et al. 1999).

A diverse array of aquatic habitats is sustained even during the maximum expansion phase in summer, when glacial melt is the major water source. Preliminary results from zoobenthic studies suggest that a highly diverse aquatic fauna inhabits the glacial flood plain. For example, 21 species of water mites (Hydracarina) have been identified from the springbrook habitat (Klein and Tockner, in press), comparable to species richness values reported from lowland springbrooks. Adaptive strategies employed by zoobenthos to locate refugia from harsh conditions in this highly dynamic system are being investigated.

2.2 Island Dynamics along an Alpine River Corridor

Riverine islands, proposed as an ecosystem-level indicator of the condition of a river corridor (Ward et al. submitted), are an endangered landform in Europe. For example, only 6 islands remain of the ca. 2000 islands historically present in the Austrian Danube. Vegetated islands are "high energy landforms" (Osterkamp 1998). Their formation requires (1) a natural flood regime, (2) an unconstrained river corridor, (3) a sediment source, and (4) a source of large woody debris (Ward et al. submitted), a combination of conditions not present in highly managed river systems.

Over 650 vegetated islands (> 0.007 ha) occur along the corridor of the Fiume Tagliamento, the only large morphologically intact Alpine river remaining in Europe (Ward et al. 1999b). Field studies, coupled with analyses of digitized maps and aerial photographs, show that islands are simultaneously forming, building, and eroding by complex processes that differ somewhat between river reaches and that operate over different time scales. Islands occur along virtually the entire length of the river, being absent only from the uppermost canyon-constrained headwaters and the lower meandering reach near the sea (Fig. 2).

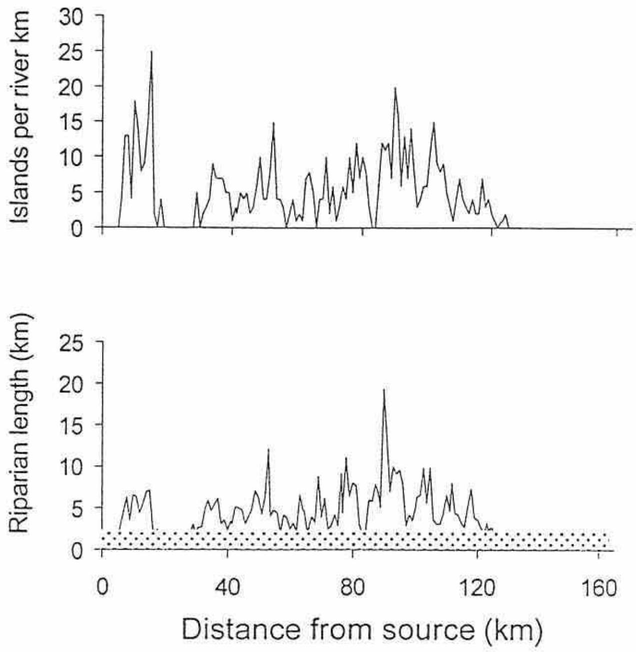

Fig. 2. Number of vegetated islands along the course of the Fiume Tagliamento and the contribution of islands to riparian ecotone length. The lateral floodplain forest along the edge of the river corridor accounts for the shaded area on the bottom graph; everything above this is attributable to islands.

Islands cover 17% of the active corridor and contribute substantially to the length of the riparian ecotone (668 km) along this 172 km long river. Preliminary results from an interdisciplinary research project on the Tagliamento, suggest that island dynamics contribute to biodiversity by increasing habitat heterogeneity (structural diversity), and the diversity of hydrarch and riparian successional stages (functional diversity) across the riverine landscape.

2.3 Reconstituting functional processes in river corridors

To be viable, river restoration strategies must be based on reconstituting functional processes to the extent that a semblance of natural dynamic interactions are possible. River rehabilitation strategies should not, for example, involve the construction of islands, but should create conditions whereby rivers have the capacity to construct their own islands. The concept is to "let the river do the work" (Stanford et al. 1996).

Tab. 1. Functional processes in the Regelsbrunn Flood Plain, Alluvial Zone National Park, Austria, during a 15-month sampling period in 1995/96 prior to restoration measures (greatly modified from Tockner et al. 1999)

Process/Property	Disconnected Phase	Seepage Phase	Connected Phase
Phase duration (%)	67.5	29.3	3.2
Retention time (d)	>13	2-13	<2
Water surface area (ha)	85	120	520
Nutrient dynamics	closed system cycling	Open system cycling	open system spiraling
Nutrient uptake	autogenic	autogenic	allogenic
Primary productivity	Medium	High	Low
P/R	Balanced	Autotrophic	Heterotrophic
Sink or source	Sink (autochthonous)	Source (DOC,Chl a)	Sink (particulate)
DOC: POC ratio	1.27	0.22	0.07
Ecological state	Biotic interactions	Primary Productivity	Transport

The Alluvial Zone National Park, located in a free-flowing segment of the Austrian Danube, contains one of the last remnants of a semi-natural alluvial landscape in Europe (Schiemer et al. 1999; Tockner et al. 1998, 1999). A high species diversity has been recorded in the river corridor and many endangered species are present. However, this river segment downstream from Vienna has embankments that stabilizes the main channel and reduces surface connectivity with the extensive floodplain system (Tab. 1). During an average year, surface connectivity between the main channel and the flood plain occurred < 8 days per year. Beginning in autumn 1996 hydrological connectivity was restored in two stages, first by lowering short sections of the embankments and then by creating artificial openings to increase the period of surface connectivity between the Danube channel and the flood plain from < 8 days to more than half of an average year. Pre-restoration sampling was initiated in 1990 and intensified in 1995. It is intended that post-restoration sampling will continue in a consistent manner for up to ten years, including abiotic parameters, biota and limnological processes within floodplain water bodies. This is important, not only to document recovery trajectories, but also to gain insight into the role played by hydrodynamic processes in the river corridor.

3 Conclusions

River ecologists are just beginning to fully comprehend the great extent by which rivers in much of the world deviate from the natural state. It is crucial to preserve as far as possible those rivers and river segments that retain some of their natural functional attributes. In conclusion, we wish to stress the following points: (1) flood plains and alluvial aquifers are integral functional components of river corridors, (2) river corridors are non-equilibrium systems the functional processes of which depend on natural disturbance regimes, (3) natural river corridors are characterized by multdimensional environmental gradients, (4) connectivity between landscape elements is crucial for sustaining functional processes, (5) hydrarch and riparian successional processes increase habitat heterogeneity, thereby contributing to the high levels of species diversity in intact river corridors, (6) effective conservation and restoration efforts require a strong conceptual foundation and a thorough understanding of natural processes, (7) ecosystem management of damaged river corridors involves reconstituting disturbance regimes and reconnecting landscape elements, and (8) once functional processes are re-established, the river itself becomes the agent of restoration (let the river do the work).

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Summary of Topic 3: "Assessing the Status of River Basins"

Volkhard Herbst, Lower Saxony State Agency for Ecology, Hildesheim

The components set down by the EU Water Framework Directive for the assessment of flowing waters requires the application of differentiated methods. These assessment methods are to be ideals orientated, and stem from the definition of "very good ecological quality". This is, compared to most assessment methods applied in the past, (e.g. water quality map according to a saprobic index), a new foundation, but is already being used in the more recent procedures such as structural quality mapping. These methods require a link to reference conditions of potentially natural conditions, i.e. unaffected by mankind. I would like to make special reference to Prof. Ward's presentation. This presentation convincingly makes clear that flowing water systems whose dynamics are not affected by mankind have very differentiated dependencies between morphological, hydrological and hydrodynamic processes, and between material concentrations, material loads and the resulting habitats, as far as their qualitative and quantitative species and its variability with time is concerned.

The high dynamics that are intrinsic to the above-mentioned conditions, are a big problem for the norming of assessment systems, especially for the determining of a null point. I see a great need for research here.

The deriving of an assessment system on the basis of this natural condition is no longer possible for most of our larger flowing waters anyway, as waters with these qualities no longer exist, and so possibilities for current measurement are also lacking.

At this point the Framework Directive gives us the chance to work with constructed models and backwards calculations. The methods presented by Mr. Brown, which can be taken for various scales of flowing waters and include the help of fractals, among others, could be used here. We can reckon with ever-occuring cases of self-similarity in hydrological and morphodynamic sectors, as well as in the chemical, and especially, biological sectors. To use these possibilities, the relevant research approaches should be specifically supported.

Further presentations were concerned with the construction of ideals.

In this, both hydrodynamics and hydrology were present (see presentation by Prof. Leibundgut). There is obviously a great need to measure and model ideal conditions, i.e. conditions uninfluenced by humans, in their dynamics and inconsistency, in order to find a foundation for the assessment systems. The need for research can also be seen here, as this less practically orientated question has apparently not been paid much attention to in the past.

A further approach is the development of integrated assessment systems, such as the procedure presented by Mr. Thiele. Initially it is concerned with a large parameter circumference, which for practical feasibility, is focused on a few "highly indicative" biotic components. Experiences up to now with this type of procedure, have often shown problems of transferability onto flowing water systems in landscape types for which this system was not specifically developed. To continue research here, to check or enable transferability, makes sense. This is under the aspects of practical application and economic viewpoints; it is a matter of less costly studies. Once transferability has been achieved, then this is certainly a suitable instrument for bioindicative assessment of hemerobes, as an initial 100% coverage, screening procedure.

Mr. Irmer gave us a further method overview which especially showed up the deficits in the measuring and assessing of the biological components. Our level of knowledge is not always as good as it is for the macrozoobenthos, and even here ideals for reference waters and assessed degradation levels are being waited for from the results of a running research project.

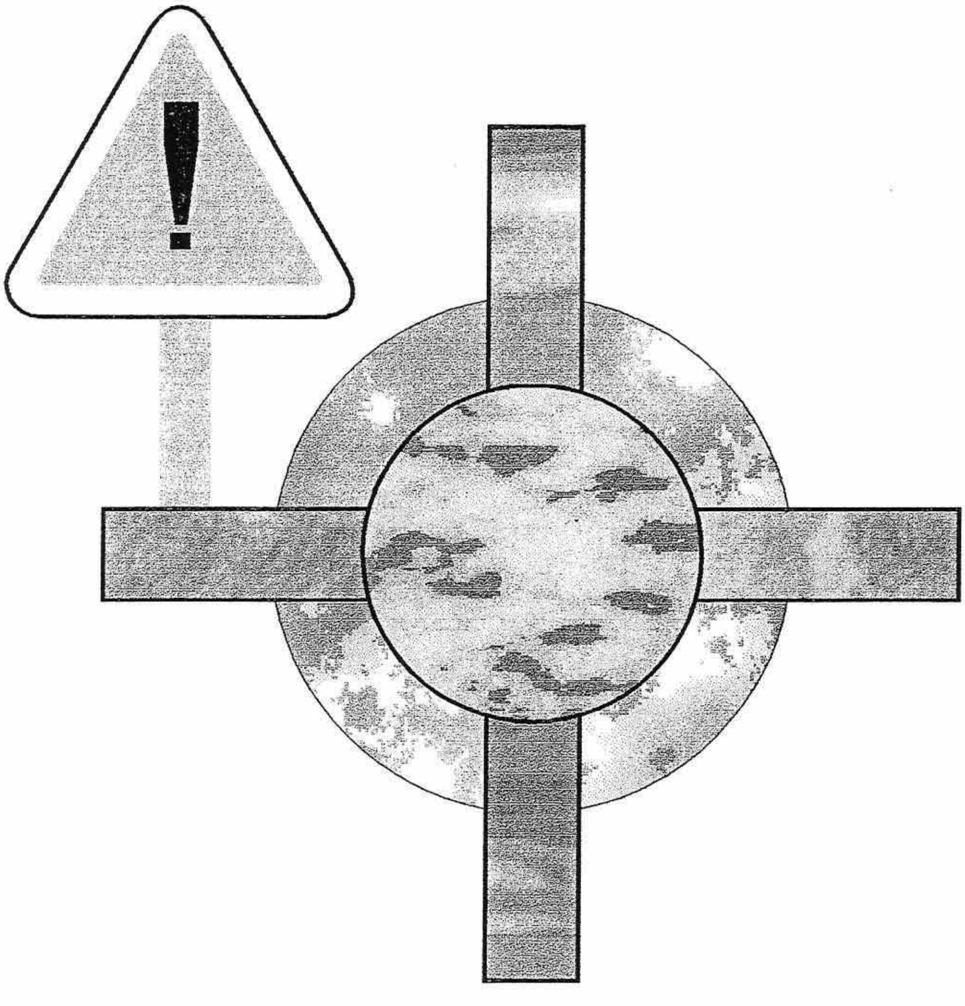
In other words, there is obviously still a large deficit with the macrophytes and fish, although the amount of data from phytoplankton and the phytobenthos is estimated as being somewhat better. If one wants to incorporate these components into the assessment, and not leave them out on the - reasoned - grounds of unsatisfactory strength of message, then one should invest in research in this area.

It is a necessary and challenging task to determine the levels of degradation. Initially these correspond to the good, or relatively satisfactory, ecological conditions of the Framework Directive. When implementing the EU-WFD, this is exactly the threshold between the desired condition - the set target - and a need to act. There will certainly be problems in this, because while the reference condition for waters was defined with ideal biocoenoses, the species composition in a degraded situation is more determined by chance. The "top-down" approach, necessary for steering measures within a management plan, is, in my opinion, only implementable on a functional level, due to reasons of natural science. This means that it is only sensible to define the stages of degradation at a functional level. There are approaches towards this in Austria, for instance.

To be implemented in Germany this additionally requires a large number of waters typical adjustments. The procedure in principle, however, could be implemented across Europe right away, and would be a suitable foundation for the "intercalibration" of the assessments that need to be carried out.

An important point, I believe, came from Mr. Ostendorp from Konstanz. The lakes, especially those which have through-flow, are without doubt part of river catchment area management. I believe that there are large deficits in the sector of lake assessment, concerning the parameter systems and method development for implementing the WFD. Especially the littoral area should be mentioned, which is not known well enough in either its role in the materials budget, or in its indicative importance. A main area of lake assessment and management should thus certainly be included. Mr. Ostendorp wants to make a proposal on this.

Overall, a large number of the necessary research tasks are connected to the area of assessing individual waters conditions. After the levels of degradation have been defined, information on materials concentrations and morphological features must be given to the planners, who are to conceive the management plans and measures. This is necessary to achieve the functional characteristics of biocoenoses onto which one can set the good ecological quality of a waters system. Measures must be optimised economically and in terms of their effect on the ecosystems.



Topic 4:
Intersection Land/ Groundwater/Surface water

Rehabilitation of the Water Budget in the East German Post-Open-Cast-Mining Landscapes and their Effects on the Water-Management Conditions in Berlin

Ludwig Luckner, Dresden Groundwater Research Centre (DGRC), Dresden

Brown coal has been mined in the Lausitz region and in Mid-Germany for over a hundred years. The areas concerned experienced an important economic upturn as a result, which, above all, affected the structurally weak Lausitz. In the period when Germany was split in two, brown coal mining and refining became a key industry in the East of Germany. More than 80% of electrical energy and 70% of heating energy in East Germany was produced from brown coal. By the end of the eighties, mining had reached more than 300 Mt per year, approx. 100 Mt in Mid-Germany and 200 Mt in the Lausitz. The mining in these areas since the beginning of the century was mainly through open-cast mining.

The ***pumping of water*** reached 500 Mm^3/a (0.5 billion cubic metres per year) in Mid-Germany and 1,300 Mm^3/a in the Lausitz. In other words an average of $6m^3$ of water was pumped from 50-100m depth per tonne of untreated brown coal mined. This caused ***large-scale groundwater cones of depression***. The water deficit in the form of pumped static groundwater reserves at the end of the eighties reached 13,000 Mm^3 in the Lausitz and 8,000 Mm^3 in the Mid-German open-cast mining area (fig. 1).

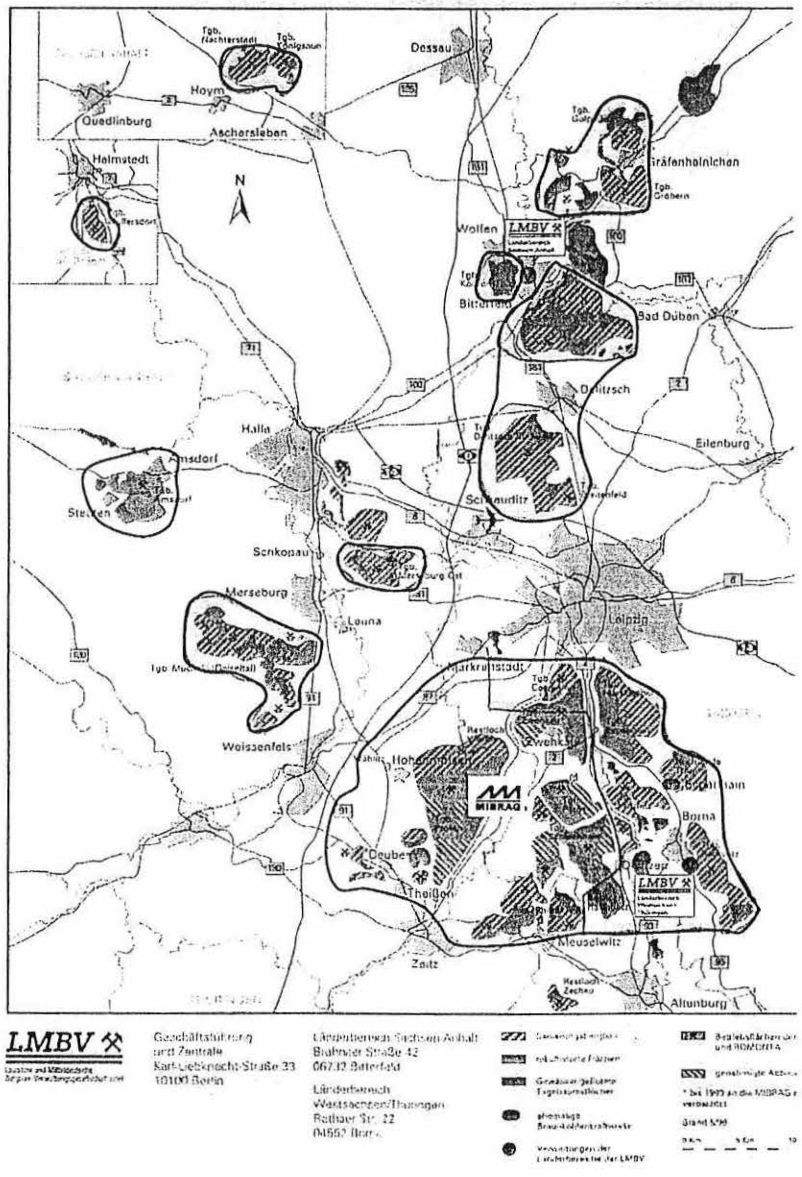
With the reunification (of Germany), demand for Mid-German and Lausitz brown coal collapsed. With a time lag, the pumping of water in the Lausitz and Mid-German coal mining areas is also now strongly declining (fig. 2), which is leading to problems of securing minimum flow levels in the affected rivers in periods of dry weather. A reorientation and restructuring has become necessary. Those open-cast mines which are still in operation in the new demand and production conditions, have been privatised. The Lausitz and Mid-German Brown Coal company was founded (LAUBAG and MIBRAG), which today run 5 and 3 operational open-cast mines respectively.

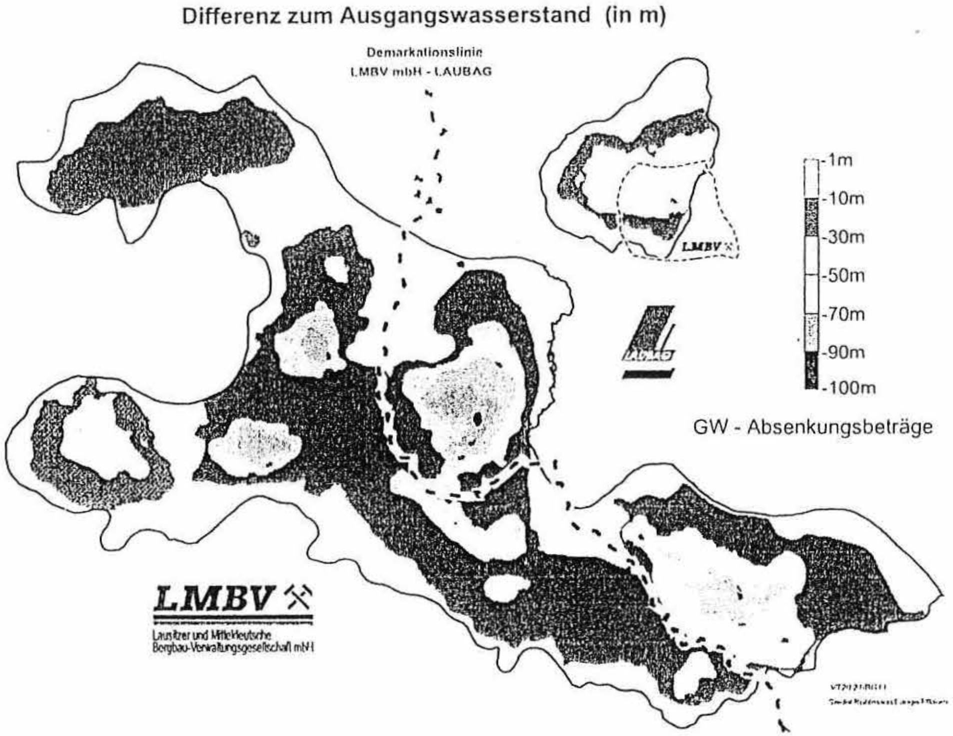
Tab. 1. Areas impacted by brown-coal open-cast mining

Seriously Affected River Catchment Areas	Weiße Elster, Pleiße, Mulde	Schwarze Elster, Spree, Neiße
Area affected by groundwater depression	1,100 km^2	2,100 km^2
Loss of static groundwater reserves	5,600 Mm^3	9,000 Mm^3
Water required to fill in the disused open-cast areas	2,500 Mm^3	4,000 Mm^3
Total water requirement	8,100 Mm^3	13,000 Mm^3

For the decommissioning of mining (i.e. the last stages of mining and site restoration), the state-owned company Lausitz and Mid-German Mining Management (LMBV) was founded. It is responsible for (among other things) the restoration of 160 remaining pits with 450 km of waste heaps which cannot be walked on because of danger of slippage, and the solving of a water deficit of 14,600 Mm^3 over an area of 3000 km^2

The restoration of the water-management conditions in the area of closed open-cast mines is generally seen as THE monumental task (century task) of mining water management, which the reunified Germany must solve. Even on its own, the cancelling out of the water deficit of the open-cast mining areas mentioned in table 1, amounting to 21,000 Mm^3, would be the same as providing 100 million inhabitants with a consumption of 130 l each per day with drinking water over almost four and a half years.





Die Flächen- und Verantwortungszuweisung für die bergbaubeanspruchten Flächen im Lausitzer und Mitteldeutschen Revier

LMBV - Fläche am Absenktrichter in der Lausitz:
$1263\ km^2 + 45\ km^2 \approx 1300\ km^2$
Defizit: 2,5 Mrd m^3 Restlochvolumen
4,5 Mrd m^3 Statischer Vorratsverlust

LMBV - Fläche in Mitteldeutschland: 720 km^2
Defizit: 2,0 Mrd m^3 Restlochvolumen
3,7 Mrd m^3 Statischer Vorratsverlust

Fig. 1. Depression funnels in the Mid-German and Lower Lausitz open-cast coal mining areas and designation for restoration or continued production

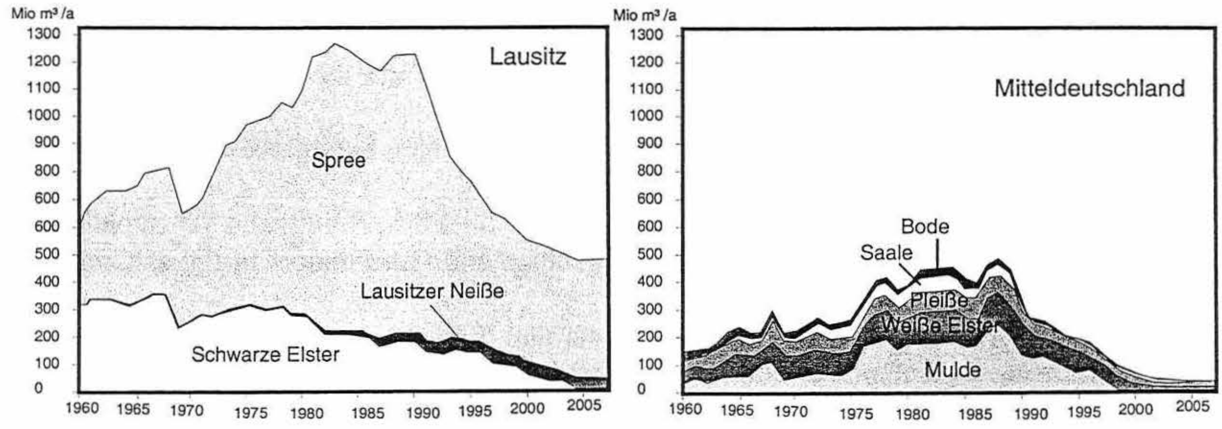


Fig. 2. Groundwater pumping in Mid-German and Lausitz brown-coal areas

The ***restoration of the water-management conditions*** in the areas impacted by brown coal open-cast mining means above all (Luckner et al. 1996a, Luckner et al. 1996b, Luckner 1997):

- ***danger minimisation*** to maintain public safety and/or the safety of private property,
- ***making areas*** used and affected by open-cast mining ***reusable***, and
- ***recreation*** of a stable, mainly self-sustaining water management in terms of amount and acquisition in the post-open-cast mining landscapes.

The use of pumped waters from active open-cast mining areas is the best way of cancelling out the water deficit in the post-open-cast mining landscapes. These conditions can be met in the southern region of Leipzig by the MIBRAG Ltd mines Profen and Vereinigtes Schleenhain, which are to be mined until well into the next century. The pumped water from these active open-cast mines is to be used to fill the remaining pits of the open-cast mines Cospuden, Espenhain, Witznitz, Haselbach, Zwenkau and Werben. The suitability of this pumped water for foreign-water flooding has been shown by many studies by the UFZ Leipzig-Halle and the Dresden Groundwater Research Centre. The ***advantages*** of the flooding option using MIBRAG pumped water are:

- a shortening of the flooding time, and thus, a quicker use of landscaped and recreational lakes
- obtaining the desired water quality through minimising the input of acidic water from the waste heaps
- reduction in the restoration work required by "quickly flooding" mechanically unstable embankments
- recreation of an almost totally self-regulating water management in the southern region of Leipzig in a relatively short time period
- reduction of costs for MIBGRAG Ltd and LMBV Ltd, as water-treatment works are not required.

The transfer of foreign flooding water is absolutely necessary in the Lausitz brown coal areas. The feasibility study on the *Restoration of the Water Budget of the Lower Lausitz on the Basis of Existing Methods*, and the *Restoration Concept of the Water-Management Conditions in the Post-Open-Cast-Mining Areas of the Lower Lausitz*, prepared by LMBV in 3/1995 and 3/1996 respectively, recommend the transfer of desperately-needed floodwater from the catchment area of the Lausitz river Neisse into the catchment of the Spree and from there into the catchment of the Schwarze Elster with down-stream return of water to maintain a balance in the individual catchment areas.

In the centre of planning studies of the LMBV and the authorities responsible for giving permission for projects are (see also Luckner et al 1996 a):

1. Water transfer in the Lausitz Neisse north of Rothenburg into the Weissen Shoeps in the catchment of the Spree
2. Water transfer from the Spree near Spreewitz into the Oberen Landgraben in the catchment of the Schwarze Elster
3. Water transfer from the mine-water treatment works (GWRA) Rainitza in the catchment of the Schwarze Elster into deficit area of Greifenhain and Graebendorf in the catchment of the Spree
4. The transfer of water from the Schwarze Elster and drainage water from the town area of Schwartzheide/Lauchhammer into lake Bergheideand lake Heidesee
5. Using both links of water from the bypass-canal south of the river Spree to flood the remaining open-cast mining pits in the mining areas of Schlabendorf/Seese and of Graebendorf.

The foundation for the decision on available mean transfer volumes and necessary hydrotechnical capacities are stochastic models by the responsible authorities of the states Brandenburg and Saxony, created with the program-system GRMDYN Spree and Schwarze Elster developed for this task. The forecast of rises in the groundwater level and in the level of remaining lakes is carried out by means of the program PCGEOFIM. The LMBV is running seven regional models for this, which are supported by location models (Luckner et al 1996 a). The forecast of remaining lake water levels is nowadays mainly carried out with the support of models.

Of course, every form of water-management in the post-open-cast-mining areas of the Lausitz must be viewed and planned in connection with the future water-economic conditions in Berlin. The new European Water Framework Directive should set the direction and framework for this. Fig. 3 shows the possibilities for supporting Berlin's regional water budget, which is at the centre of discussion.

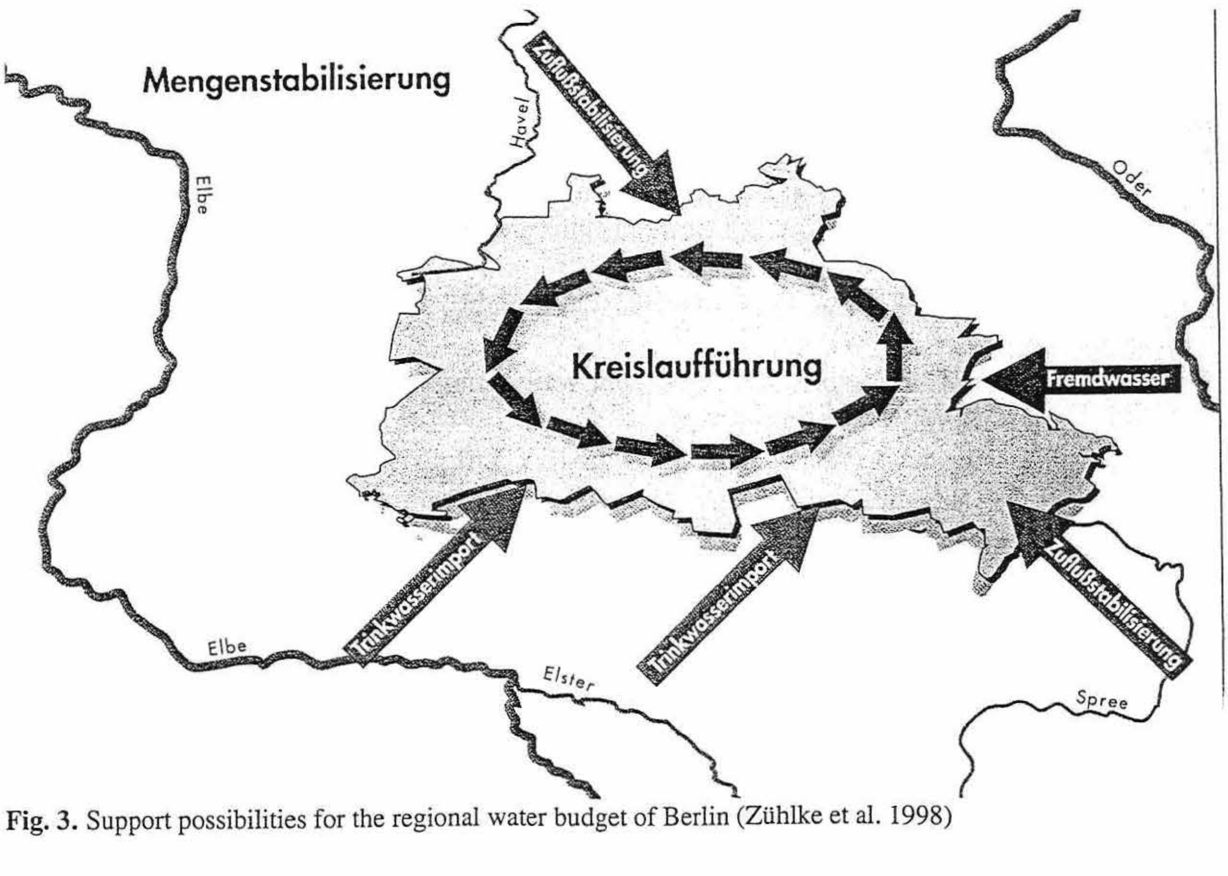


Fig. 3. Support possibilities for the regional water budget of Berlin (Zühlke et al. 1998)

A planned BMBF joint project "Study of water acquisition development of the Spree" aims to work out relevant foundations for such a model-supported control of flow characteristics and water-quality development in the catchment area of the Spree. The joint management of the new post-open-cast pit reservoirs Lohsa II 53 Mm^3, Dreiweibern 5 Mm^3, Burghammer 4 Mm^3 and Baerwalde 21 Mm^3, with a combined reservoir volume of 83 Mm^3, with the existing dams

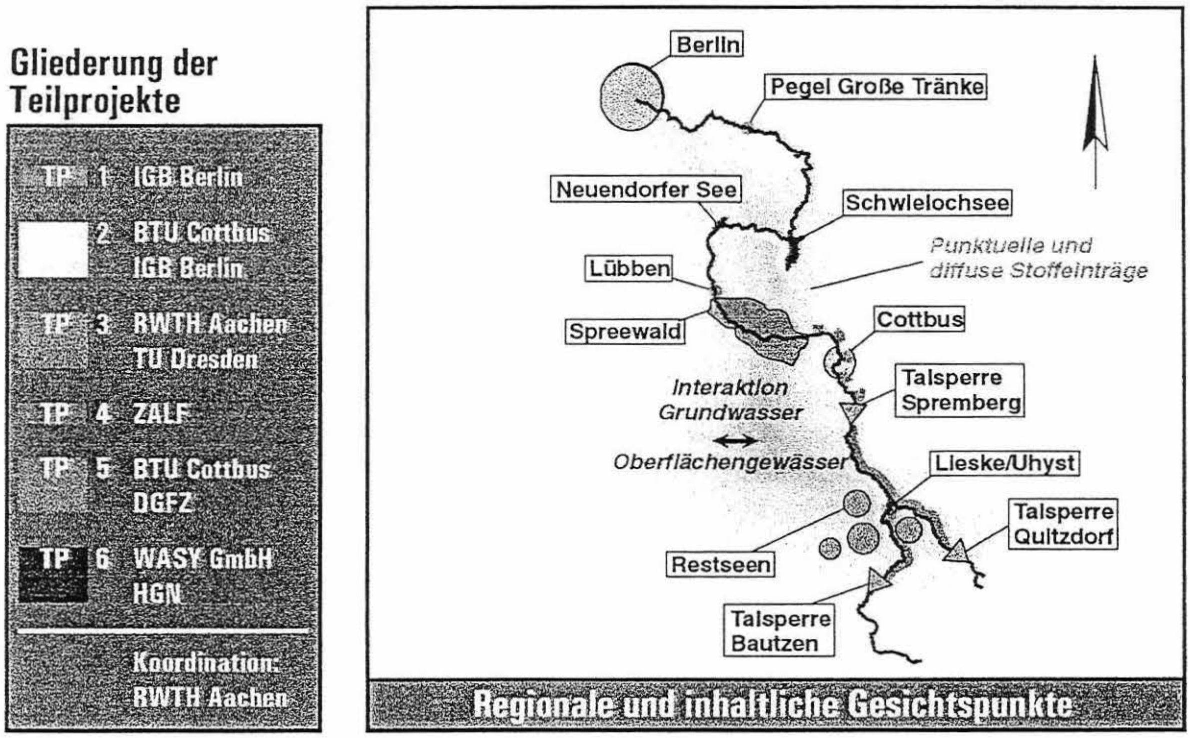


Fig. 4. Stucture of the component projects

Bautzen, Quitzdorf and Spremberg and the catchment area transfers, opens up whole a new potential for a regional water-volume and quality management of surface and ground waters in the whole catchment area of the Spree and thus also for securing a sustainable water-management development for the greater Berlin area (Luckner et al. 1996 a)

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Groundwater and Land Ecosystems

Udo Rose, Erftverband, Bergheim, Germany

In the interface between land, groundwater and surface waters lie the parts of the surface waters with a link to the groundwater and land ecosystems dependant on groundwater, which one can generally call groundwater-dependant wetlands. With a view to these *groundwater-dependant* ecosystems, the European Union Water Framework Directive places demands on the condition of groundwater. To meet these demands, or to make these directive aims more concrete, links that have not been looked at much until now need to be studied, yardsticks of quality and monitoring strategies need to be developed and the triggering levels for water-economic measures, need to be set.

1 What the EU-Water Framework Directive Demands

Article 1 of the Directive demands no deterioration in the quality of aquatic ecosystems and the land ecosystems dependant on them, to protect these systems and to improve them. These demands are carried over to the areas of surface waters and groundwater in the environmental aims of article 4. The environmental target is, above all, a "good" condition still to be standardised. For this reason article 10 plans the monitoring of the groundwater's chemical and quantitative condition. To reach the aims, measures programs and management plans are to be drawn up (article 13 and 16). For this a description of the groundwater bodies are required, as well as the inclusion and description of those groundwater bodies which are in direct contact with surface water and land ecosystems (appendix II).

Appendix V states that an unbalanced balance of volumes (average rate of abstraction is higher than the available groundwater resource), missing the ecological quality targets (as in art. 4), a deterioration in water quality and severe damage to groundwater-dependant ecosystems, are not compatible with a good quality of groundwater. The condition of the groundwater is to be monitored, interpreted and publicised.

2 Research and Concretisation Required as a Result

2.1 Foundation

The hydrological and ecological links in groundwater-dependant ecosystems are complex. The hydrological conditions affect the chemical and physical properties of these systems, such as the availability of nutrients, the constitution of the soil or the sediment. The physical and chemical factors in turn affect the biological structures such as species richness, species diversity or productivity. The other way round, the biological components, mainly vegetation, affect the chemical/physical and hydrological conditions.

Knowledge of these links is an important prerequisite for the creation of monitoring and measures programs, for the appraisal of conditions and the analysis of harmful influences. The whole structure is in part, however, still not understood. Although many either hydrological or biological/ecological monitorings of wetlands have been published up to now, analyses of reciprocal links between hydrology and biology are rare (e.g. DVWK 1996, DVWK 1998, Jeckel 1986, Kazda et al. 1992, Quast 1994, Shedlock et al. 1993). It is thus especially necessary to quantify the links between water, soil and vegetation. As a result, there is a need for thorough long-term studies of various groundwater-dependant ecosystems in differing environmental conditions.

2.2 Classification and Ecological Importance of Groundwater-Dependant Ecosystems

To identify, demarcate and describe groundwater-dependant ecosystems it is first necessary to clarify which systems are even dependant on groundwater, and in what way. This requires a general classification and a categorisation based on sensitivity of the systems to changes in hydrological factors and their ecological or protective importance. The last of these affects, above all, the demarcation of areas with a special need for protection. In a first step it would be approximately those biotopes as stated in § 20c of the Federal Environmental Protection law and the Fauna-Flora-Habitat Directive of the EU, which are to be checked with regard to their dependence on groundwater.

Important classification characteristics are in many cases still to be studied hydrological and physiochemical requirements of the living communities under scrutiny. The "Classification of Mainly Groundwater-Affected Vegetation Types" by the DVWK (1996) offers a foundation which needs to be expanded on and standardised.

2.3 Listing and Quantifying of Requirements and Harmful Influences

Groundwater-dependant ecosystems require a specific groundwater level per type, seasonal dynamics of the groundwater and a specific groundwater quality. The task is to develop standards which show from which, still to be decided, volume and number onwards of an also still to be decided key-parameter the groundwater achieves a level of good quality for the dependant ecosystem, or vice versa, the level which a harmful influence has on the system (fig. 1). While doing this, the dynamics of the influencing factors as well as the ecosystem-eminent dynamics should be taken into account.

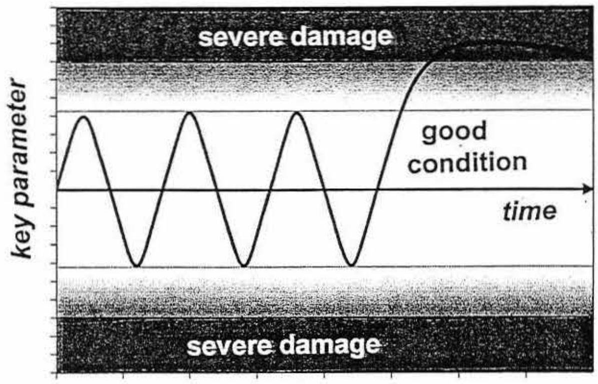

Fig. 1. Oscillating key parameter and tolerance areas to be fixed (Traxler 1997)

A starting point is possibly the groundwater balance of volumes, which must be balanced in order to achieve a "good" standard. In this balance, the water use or requirements of the ecosystems could be looked at together with the water requirements of the population, farming and industry; i.e. an amount of the groundwater available must be allocated to wetlands (Briechle 1994). Here it is necessary to determine the actual groundwater requirement of the ecosystems, or rather, define it with useful criteria.

In biotopes with stagnant water (still waters and wet areas) this can easily be done by taking the recharge of groundwater (over the area of the biotope) plus an amount for evaporation, or by deriving the sum from the complete evaporation on its own.

Groundwater-dependant parts of the landscape are often, however, flowing systems such as streams and rivers, whose basic load comes from the underground part of the catchment area. Here it might be possible to include a certain part of the outflowing groundwater as a permanent value of "outflow" in the balance. This value would then have to lie somewhere above the lowest natural yearly water outflow level.

Of course, the question of the required groundwater level is not answered by a balancing approach to groundwater requirement of the areas concerned. Because of the sensitive reaction of groundwater-dependant ecosystems to even small changes in the groundwater level, the leeway we have appears to be on the low side. Here it is necessary to examine which changes living communities can tolerate and which shifts in the species spectrum can be seen as "severe damage" to the ecosystems. It will be difficult, while doing this, to interpret and take account of natural fluctuations in the biocoenoses themselves as well as the environmental factors which have an effect.

The complications associated with the biocoenotic approach could be avoided if the natural groundwater levels, i.e. those when uninfluenced by mankind, were taken as a yardstick in the area of valuable groundwater-dependant ecosystems. These "desirable groundwater levels" can be calculated with statistical methods or mathematical models. They can then be compared with real measured values of groundwater levels for signs of possible divergence (Bucher being published).

Just as groundwater-dependant ecosystems react to changes in the water budget, they also react to changes in the chemical composition of the groundwater. Those areas most seriously affected by unwanted changes are nutrient-poor areas. Again, the yardstick that it might be possible to take here, are the natural conditions with their natural fluctuations. When human-caused values outside the natural amplitude lead to actual harm to the ecosystems, can often not be determined on the basis of currently available knowledge.

2.4 Monitoring the Condition of Groundwater

Setting standards is naturally only useful when they are regularly monitored and can even be monitored. Here it is necessary to develop monitoring strategies and measuring programs. Apart from groundwater level and quality controls, the balancing method or maybe a biocoenotic monitoring approach will need to be integrated.

2.5 Measures

The studies and monitoring will sometimes show up deficits in conditions, and thus a need for water-management action. Thus, general criteria for action as well as a catalogue of possible measures are to be drawn up. The type and effect of measures must, if necessary, be explored and examined.

3 Conclusion

During the work to be done in the future, other angles, different studying methods and evaluation yardsticks will appear. The last of these, above all, will not be justifiable alone in scientific terms. On the whole we must be careful not to amass data which doesn't, in the end, go towards saving threatened habitats. Rather more, practise-orientated standards, effective research methods and evaluation procedures must be developed, which ultimately guarantee the preservation of groundwater-dependant habitats worthy of protection, while evenly keeping an eye on both the demands of humans and nature. (Lindner and Rose 1991).

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Pollution of Surface and Groundwater from Diffuse Agricultural Sources - Odra Catchment Case Study

Waldemar Mioduszewski, Institute for Land Reclamation and Grassland Farming Falenty, Poland

1 Introduction

Agriculture, intensive crop production in particular, poses a threat to surface and groundwater quality. The surplus of nitrogen and phosphorus is considered as a contamination. Mineral and organic fertiliser used in crop production is leached from the soil and subsequently finds its way either into aquifers or directly into surface waters. Drainage and irrigation systems along with other human undertakings have caused acceleration in the cycling of mineral compounds in the soil and the catchment (increasing the amount of fertilizer leaching from soils).

It is crucial for correct planning and selection of methods aimed at reducing the adverse impact of agriculture on water quality to:

- document the actual impact of agriculture on surface and groundwater quality, by assessing the pollutant load entering the water from arable areas and identifying areas most sensitive to water pollution caused by compounds originating from agriculture,
- quantitatively assess the impact of various measures on reduction of the load of pollutants entering surface and groundwater.

Finding a solution to the first of these questions, using the Odra River catchment as a case study, is the aim of the Polish-German research project sponsored by the German Federal Environmental Agency, co-ordinated by the German Association for Water Resources and Land Improvement (DVWK) and Polish Academy of Science (PAN). Project participants include the Institute of Hydrology ZALF Müncheberg, Institute for Land Reclamation and Grassland Farming in Falenty and Wroclaw Agricultural University.

2 Diffuse Entries in Rivers of the Odra Basin

Total surface area of the Odra catchment is 136 528 km², of which 84.9% lies on Poland's territory, 10.4% in Germany, 4.7% in the Czech Republic. The study area covered 85% of the total Odra catchment (without the solid rock area and Czech part of the basin). The main task realised under the project was to assess potential hazard to water quality posed by the phosphorus and nitrogen load (by calculating the volume of this load discharged into the rivers). According to the adopted premises the pollution load volume is to be estimated using emission-orientated analysis on the basis of available statistical data i.e. size and type of crop production, amount of fertiliser applied, etc. (Mioduszewski et al. 1997).

The average phosphorus and nitrogen surplus as well as the content of biogenic compounds in soils were taken as the basis for assessing the level of intensity of agriculture as well as for identifying the main sources of non-point pollution. Assessment of the transport of chemical compounds took into consideration soil types, the relief as well as hydrogeology, hydrology and climate of the catchment (Dannowski et al. 1995).

The transport of nutrients into rivers from agricultural sources was calculated on two levels:

- transport of diffuse pollution (nitrogen, phosphorus) by surface flow as a result of water erosion processes, using the USLE method (Deumlich and Frielinghaus 1996),
- transport of nitrogen by groundwater – taking into account the vertical flow in the aeration zone (Glugla and Fürtig 1997, ABIMO model) to assess the nitrogen load released into ground water, and the horizontal flow in the saturation zone to assess the load entries rivers (Kunkel and Wendland 1997, WEKU model).

Calculations made use of the GIS geographical information system. Several thematic maps were elaborated using ArcInfo software covering the following parameters:

- climatic conditions (average annual precipitation and evapotranspiration),
- spatial variation in nitrogen and phosphorus surplus distribution,
- Odra catchment topography and the depth of the groundwater table,
- hydraulic conductivity of the first aquifer and its thickness,
- areas under different types of land use i.e., farmland, woodland, developed areas, wetlands and waters,
- the river network distinguished into subcatchments,
- soils, distinguished into classes on the basis of their hydraulic properties.

In view of the extensive area encompassed by the studied catchment the basic map scale adopted was 1:500 000 and 1:200 000, but in a number of cases data on specific parameters was recorded on 1:100 000 and even on 1:50 000 maps. An attempt was made to calculate pollution transport within boundaries of subcatchments no greater in area than 500 km^2 (for best results, between 50 and 200 km^2).

Work on the project had to overcome a number of difficulties e.g., small amount of data which was obtainable in numerical form for the Polish part of the catchment, the fact that most statistical data refers to areas corresponding to administrative units (agriculture, drainage systems etc., Pawlik-Dobrowolski and Mioduszewski 1996) and the need to introduce a number of simplifications and reduction in detail. Despite these difficulties study results obtained were sufficient for making a preliminary assessment of the load of diffuse pollution released into rivers and to identify areas with a varying degree of threat to surface and groundwater quality in the Odra catchment. This may facilitate identification of areas most sensitive to diffuse pollution and consequently targeting action in the study area. Final results is shown on maps:

- specific nitrogen loads entering groundwater (vertical transport),
- specific nitrogen loads entering surface water (horizontal transport),
- specific nitrogen and phosphorus load entering rivers because of water erosion.

3 Water Quality Protection

Methods used in water quality protection fall into two groups:

- Decreasing pollutant emission from agricultural sources,
- Reduction of pollutants in the agricultural landscape.

The former method is associated chiefly with the type of agricultural activity and its degree of intensity and includes the reduction of fertiliser application, improving the techniques of crop production, etc.

Method Two is associated with the spatial planning of agricultural land and with water management in the catchment, covering all actions intended to slow down the cycling of water and matter, including:

- the construction of small retention reservoirs, restoration of small natural ponds and wetlands, etc.,
- regulation of the outflow from drainage systems (groundwater level regulation), using drainage water for irrigation,
- creating buffer zones along streams, lakes and ponds,
- increasing forest cover, creating belts and clumps of shrubby vegetation, implementing erosion-control measures.

All are agreed that the named measures help to improve the water balance in the catchment and result in better utilisation of nutrients by plants. They also constitute one of the elements of protection and management of nature values in agricultural landscape (Mioduszewski 1998).

In effectively planning water quality protection projects it is necessary to have at hand a quantitative assessment of the result of measures undertaken. At present the body of available data is insufficient for carrying out such an assessment regarding the decrease in the nutrients content in waters subsequent to implementation of specific measures. It is known, for example, that the setting up of buffer zones leads to the purification of water but it is difficult to calculate the amount of nitrogen and phosphorus compounds intercepted by these zones when correlating the type and width of the buffer zone with the geological structure of the river valley. Similarly it is difficult to quantify the impact of the regulation of outflow from drainage systems, construction of small reservoirs or wetland restoration. Further in-depth research and analyses are needed in this respect. Despite the outlined difficulties in stage three of the DVWK/PAN Project an attempt will be made to assess the impact of diverse measures designed to reduce the inflow of pollutants from diffuse sources into the streams of the Odra catchment.

4 Conclusions

Protection of water quality from diffuse pollution originating from agriculture activity requires comprehensive research. Parallel to reducing pollutant emissions it is necessary to control their transport, primarily by increasing natural retention in the catchment and slowing down the cycling of water and matter. In order to implement appropriate and effective water management in the catchment it is necessary to elucidate a number of issues, in particular:

- quantifying the governing processes during nitrogen and phosphorus transport in the zone of aeration beneath the root zone and in the zone of saturation,
- work out more precise methods for assessing the hazard to surface and groundwater quality posed by agriculture in different geological conditions,
- elucidate processes at work in buffer zones, small retention reservoirs and wetlands as well as in drainage systems with regulated water outflow,
- design methods for quantifying the impact made by measures designed to protect quality of surface and groundwater taking into consideration the time factor as well as the economic conditioning.

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Quantification of Non-Point Source Pollution of Surface Waters

Michael Rode, UFZ Centre for Environment Research Leipzig-Halle, Interdisciplinary Department of Riverine and Lacustrine Landscapes, Magdeburg

1 Introduction

1.1 The Problem

Although in the last few years considerable successes have been achieved in quantifying non-point source pollution of surface waters (Hamm et al. 1991, Werner and Wodsak 1994, Behrendt 1993 and 1995, Meissner 1996, Mohaupt and Behrendt 1997), the effective reduction of phosphorus and nitrogen output, as demanded by society, has not yet been sufficiently achieved. Not only the seas but also the freshwater biocoenoses suffer from nutrient inputs. Long-term studies in North America show that there is a clear correlation between nutrients (especially phosphorus) and their effects on aquatic habitats. Negative effects on the fish population have been observed as a result of higher nutrient concentrations (total inorganic nitrogen > 0.61 mgN/l and total phosphorus > 0.06 mgP/l). This suggests that the reduction in point source pollutant has not been sufficient to protect aquatic habitats and that measures to reduce the non-point nutrient yields must be taken (Miltner and Rankin 1998).

The two main causes for the unsatisfactory reduction of non-point nutrient yields are:

1. high nitrogen and phosphorus balance surplus and not effective enough measures and implementation strategies to reduce them,
2. components of the water budget (groundwater recharge, base flow, interflow, surface runoff, drainage,) and their effect on the material output from the landscape has not been regionally differentiated enough.

1.2 Objective

To be able to quantify diffuse nutrient output into waters suitable methods must be available. These should meet the following requirements with a prospective towards future river basin planning:

- concrete suggestions referring to a reduction in non-point source pollution must be made for river basin management (e.g. change of land use, management, cultivation technology),
- the procedures should be applicable with generally available data or be able to derive additional parameter values,
- the verification of action must be possible by using measured data.

To understand nutrient output processes and to derive management measures for the reduction of loads on surface waters, it is necessary to link both microscale and mesoscale studies.

2 Quantifying Non-Point Nitrogen and Phosphorus Yields from River Catchments

2.1 Nitrogen

On the microscale, the effect of varying landuse intensity on nitrogen output from the unsaturated zone of the soils can be studied using lysimeters. Linking these studies with detailed work on substance budgets in small representative catchments allows conclusions to be made on the use and retention of nutrients in the landscape unit being studied.

Lysimeter studies have proven to be valuable in hydrological studies, as they allow a relatively short-term analysis of the effects of landuse changes. At the UFZ Centre for Environment Research Leipzig-Halle intensive lysimeter studies are carried out.

To obtain more conclusive statements on long-term nitrogen transport studies in large catchment areas it is possible to combine lysimeter studies with ground-modelling systems in connection with geographic information systems (GIS). For nitrogen output studies in the Parthe catchment area east of Leipzig, the Department of Soil Science at the UFZ, together with the state environmental agency Lysimeterstation Brandis, has carried out lysimeter studies to calibrate and validate the agroecological modelling system CANDY (Franko and Oelschlaegel 1995, Franko et al. 1997). Based on climate, soil type and management data, the model CANDY is able to calculate the C and N turnover, the soil temperature and soil water content down to the depth of three metres in the unsaturated zone of the soil. It has become a very robust model after many years of intensive calibration and validation at UFZ. It can satisfactorily compute the N-output out of the unsaturated zone in the Parthe catchment given the climatic and physical ground conditions (see Fig. 1 for an example). Problems occur, however, when modelling water and material flow in the unsaturated zone in soils with impermeable layers (Krönert et al. 1999).

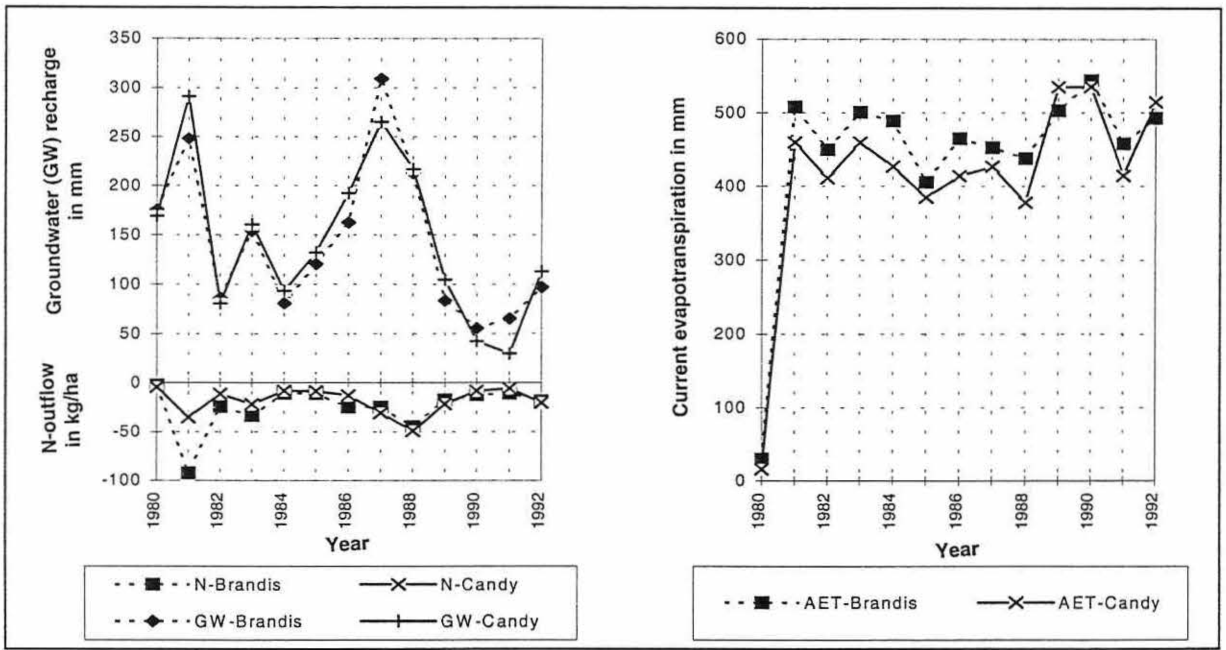

Fig. 1. Comparison of measured (Brandis) and calculated (CANDY) values; soil type is sandy loess - brown soil

The model CANDY can be combined with a GIS allowing a regionalisation of the results for larger mesoscale catchments such as the Parthe with a catchment size of 366 km^2 (Fig. 2). The average nitrogen output, calculated for the agricultural areas is 70 kg N/ha. The groundwater recharge is on average 100 mm/a. Despite low fertilisation, the results are higher than those from before German reunification (50 kg N/ha). This is due to the significantly-delayed effect of over-fertilisation in the years before 1990 (Krönert et al. 1999). These results are a superb example of how the right agro-ecological modelling system can simulate the causal relationship between climate, soil, management and nitrogen output from the unsaturated zone of soils, and the influence of changing landuse on nitrogen transport.

The present regionalisation procedure is limited to the simulation of vertical flows. There are also serious uncertainties in the description of transport and turnover processes along the path from the unsaturated zone to the surface waters. This is especially pronounced for lowlands areas. Based on process studies, areas with short flow times should be calculated separately from those with long flow durations and transport times should be placed in relationship to material transport. For this case, isotope studies in connection with conservative tracers could be used (see Fig. 3).

Tab. 1. Selected N-transport models (from Starck et al. 1997)

Criterion \ Model	CANDY	DYNAMIT	MESO-N	EXPERT-N	HERMES	MINERVA	SIMULAT	SWIM	WASMOD
Hydrology									
Soil hydrology	+	+	+	+	+	+	+	+	+
Link to groundwater	-	o	o	-	-	-	+	+	+
lateral fluxes	-	o	+	-	--	-	-	+	+
connection to channel	-	+	+	-	-	-	-	+	+
Nitrogen dynamics									
plant uptake	+	+	+	+	+	+	+	+	+
Mineralisation	+	+	+	+	+	+	+	+	+
Immobilisation	+	+	+	+	+	+	+	+	+
Denitrification	+	+	+	+	+	+	+	+	+
Nitrogen transport									
Root zone	+	+	-	+	+	+	-	-	-
To groundwater	-	-	-	-	-	-	+	-	-
To receiving water	-	-	+	-	-	-	-	+	+
Carbon cycle	+	-	+	-	-	-	+	-	+
Utilities									
Linked to GIS	+	+	+	+	+	+	+	+	+
Parameterisation tool	+	+	-	+	-	+	+	+	+

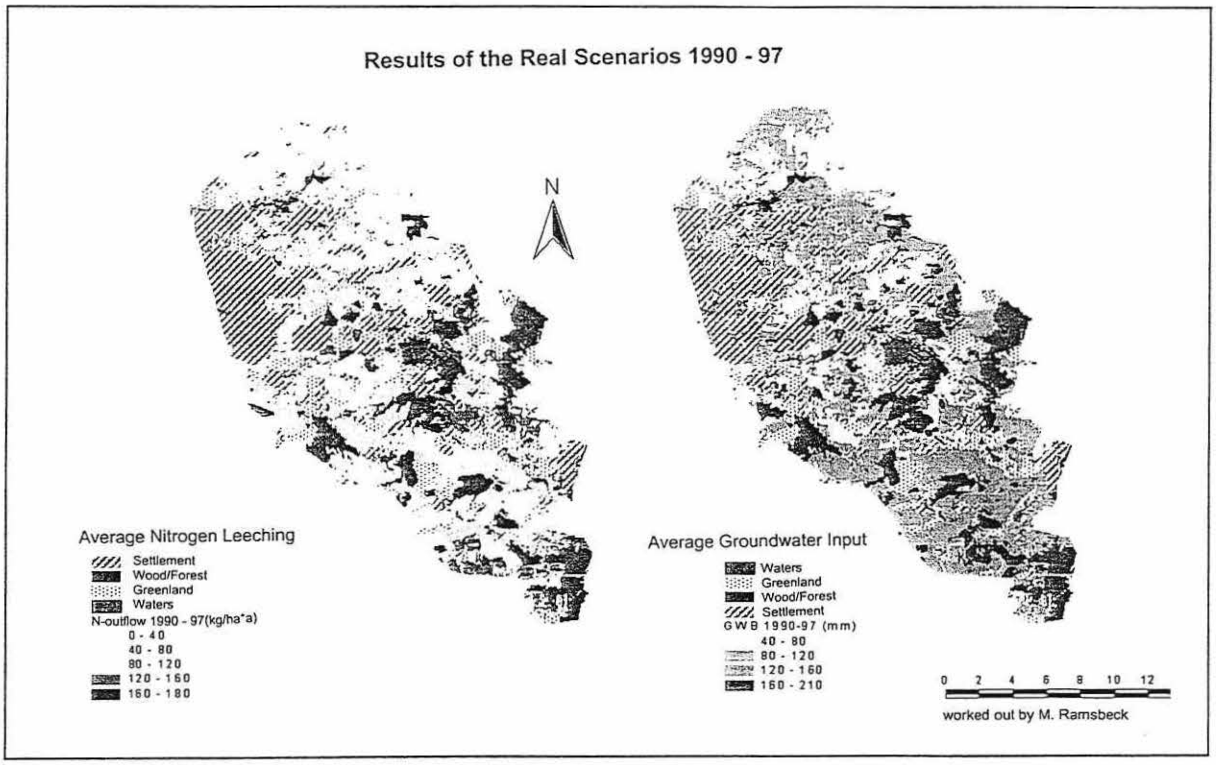

Fig. 2. Average nitrogen leaching levels & groundwater recharge in the Parthe catchment, calculated with CANDY

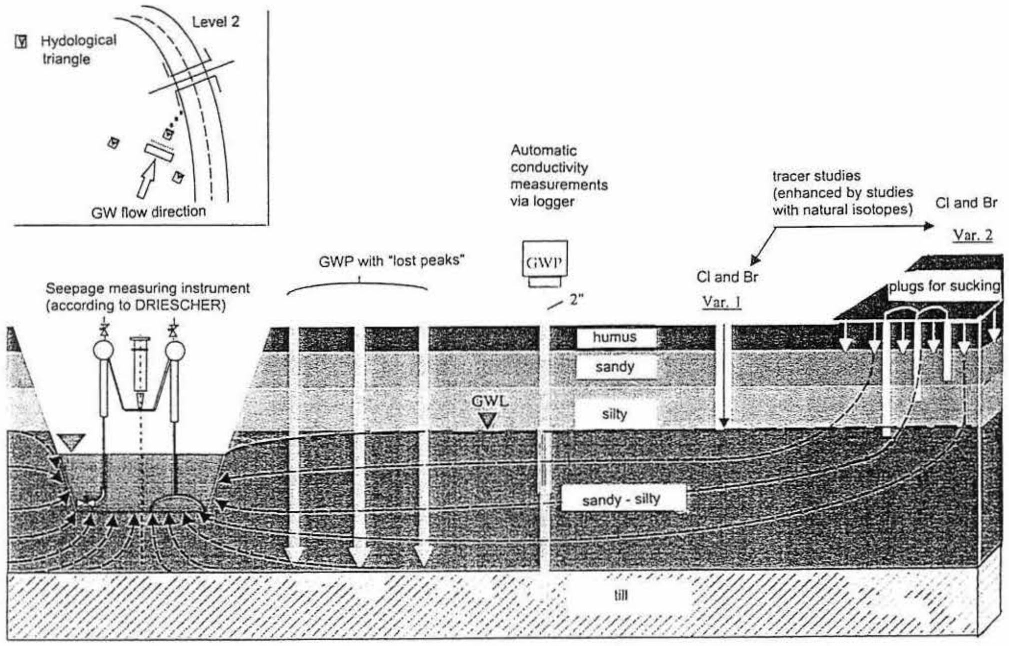

Fig. 3. Experimental study site for investigating the time behaviour of nitrogen transport in the Schaugraben catchment (from Balla and Stratschka)

At present, there is no adequate mesoscale model for dynamic N-modelling available, which completely fulfils the desired management tasks. The model systems SWIM and WASMOD/STOMOD are currently the furthest developed programmes for catchment areas, although certain components, such as the modelling of groundwater flow, are oversimplified. The UFZ is thus trying to couple models for different landscape units in its studies of the Parthe catchment. Agro-ecological modelling systems, precipitation runoff models and groundwater models are being combined in the mesoscale catchment, to calculate the substance budget that is as accurate as possible.

2.2 Phosphorus

As opposed to nitrogen, phosphorus is mainly transported into the waters viarunoff, either as particulate phosphorus (PP) bound to soil particles in connection with erosion or as dissolved phosphorus (DP). Studies by Gburek and Sharpley (1988) as well as our own studies, have shown that DP in surface runoff is generally higher than in other runoff components such as basic runoff and interflow. Exceptions are peat soils (Scheffer 1999). Thus, a requirement for the quantification of nutrient transport to surface waters is a detailed description of the different water flows. This is especially true for the surface runoff as this is the main means of transportation for both DP and PP:

In humid climates such as in central Europe, there are two main mechanisms for surface flow:

1. Horton overland flow, which occurs when the soil surface is saturated from above ground through rainfall. A requirement is that this rainfall intensity must be higher than the infiltration capacity of the top soil layer. The Horton overland flow may occur at any location in the catchment area, but preferentially on soils with low infiltration capacity such as clay soils or sealed arable soils.

2. Saturated overland flow, which occurs when the groundwater level rises and the soil becomes saturated from below. This runoff mechanism tends to occur in the proximity of streams and is the main cause of overland flow in our humid climate conditions.

As a large amount of the phosphorus is transported by runoff waters in particulate form, phosphorus erosion models must be able to adequately describe the transport of suspended substances. Unlike dissolved nutrients, the soil particles transported in the catchment are largely dependant on sediment deposition. Thus, the sediment delivery ratio, i.e. the amount of eroded soil material which is transported out of the catchment under study, diminishes with increasing catchment area size. This relationship is represented in the USDA-ARS diagram (Fig. 4). It is important to note that there is a wide range of results for a specific catchment area size, i.e. the catchment characteristics have a large influence on the sediment delivery ratio. When trying to determine particulate material runoff, emphasis is placed on the problems of soil erosion that arises on agricultural areas. Studies by Osterkamp and Toy (1997) show that channel erosion can also make up a large proportion of the soil loss from a catchment, even in humid climate regions. Furthermore, this transport process is heavily influenced by the size of the scale used. Studies in the lowlands of Denmark have shown that channel erosion can have a large share in PP transport. Kronvang (1997) shows on the basis of Cs-137 studies that this fraction was about 50% of the total soil loss in the catchment. For modelling phosphor transport the model must quantify the following three processes:

1. simulation of the overland flow, both according to Horton and saturated overland flow,
2. calculation of deposition processes of sediments in the catchment,
3. inclusion of transport processes in the channel.

The current state of mesoscale phosphorus transport modelling can excellently be shown using the model system ASGi, which was developed by the work group of Prof. Kleeberg at the military academy in Munich. It is a combination of the hydrological model WaSim, developed by Schulla (1997), and the erosion and nutrient transport model AGNPS. It is a distributed model, which can simulate both the water balance and single flood events. Based on calculated PP detachment in the catchment area, it calculates PP export in connection with the calculated overland flow. Detached P compunds can only leave the grid or subcatchment under observation when there is overland flow available. Phosphorus transport is only calculated for areas where there is overland flow. Fig. 5 shows that in the investigated catchment only a small part of the arable fields contributes to the PP yieldeven with comparatively high precipitation.

Tab 2. Selected erosion and P-transport models

Model	SEM/ SHE	ERO- SION3D	WEPP	EURO- SEM	Ann- AGNPS	OPUS	SWAT	ASGi	SWIM
Components									
Horton overland flow	*	*	*	*	*	*	*	*	*
Saturated overland flow								*	
Overland flow (total)					*	*	*	*	*
Erosion	*	*	*	*	*	*	*	*	*
Deposition	*	*	*	*	*	*	*	*	*
Crop growth			*			*	*		*
Nutrient yield					*	*	*	*	*
Time interval									
Single event	*	*	*	*		*		*	
Water balance			*		*	*	*	*	*
Area unit									
slope		*	*		*	*			
< 10 km^2	*		*	*	*	*	*	*	*
< 100 km^2					*		*	*	*
< 1000 km^2							*	*	*
Distributed model	*	*	*	*	*		*	*	*

The results presented are plausible, but still need a comprehensive comparison with measured data, so that a conclusion of this work cannot yet be made. Initial studies, however, suggest that especially the suspension-particle transport model is oversimplified.

As the overview of currently available phosphor-transport models shows (Tab. 2), there are still no models which fulfil all the main demands on mesoscale modelling.

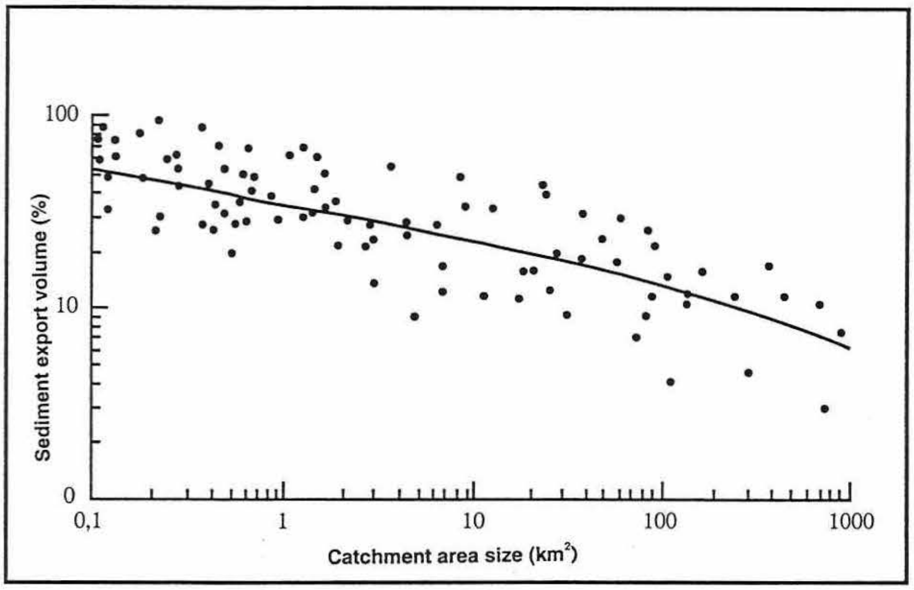

Fig. 4. Relationship between sediment delivery ratio and catchment size (from USDA-ARS)

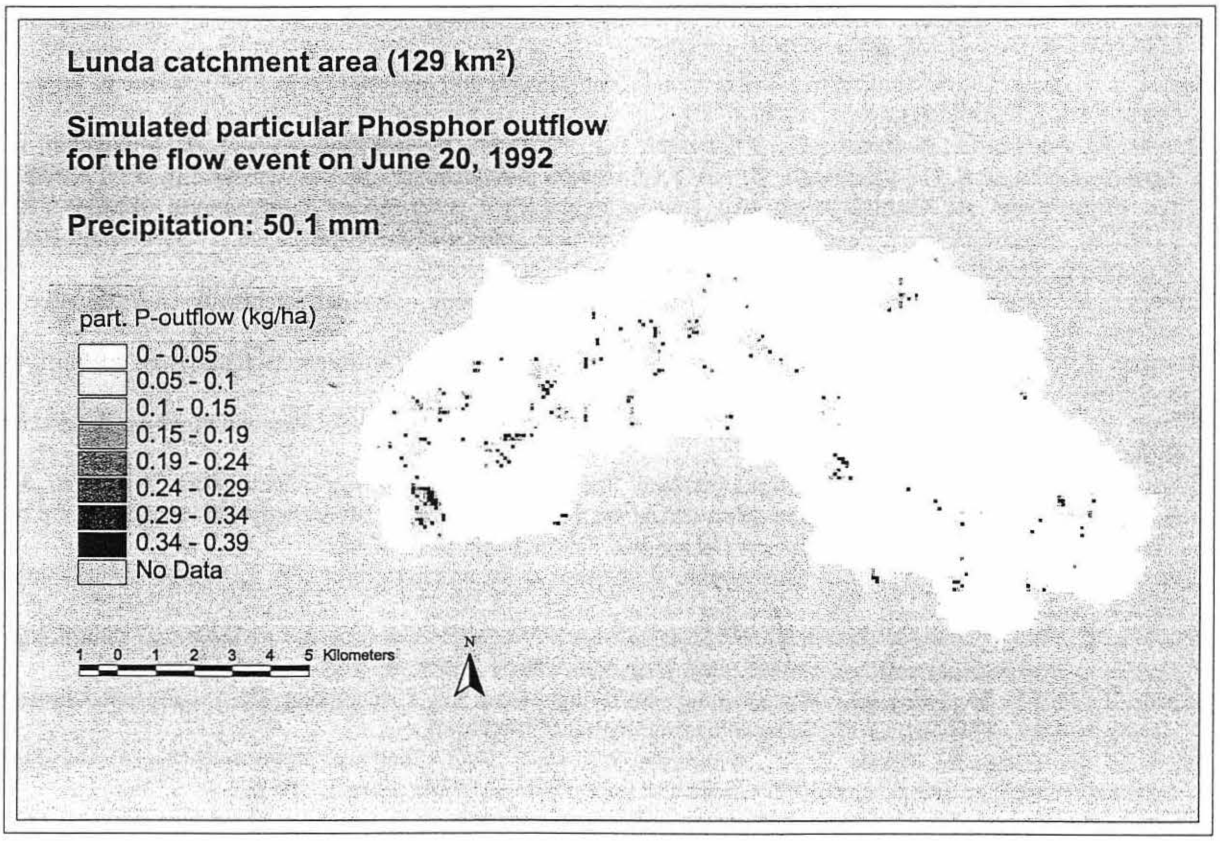

Fig. 5. Simulated particular phosphorus yields for the runoff event on June 20, 1992, in the Lumda catchment (sub-catchment of the Lahn river) in the state of Hessen, Germany

3 Conclusion

There are still large gaps in the knowledge base in understanding the processes of nutrient transport for the modelling of catchment areas in mesoscale dimensions. An additional problem is the availability of data extensive enough for use in modelling exercises. The following research requirements are needed to fill these gaps:

- For the calibration and validation of nutrient transport models, combined microscale and mesoscale studies are required.
- Deeper understanding of the temporal behaviour of nitrogen transport and turnover in representative landscape units (lateral material transport) is needed.
- Contributions from various landuses on surface runoff and phosphor transport (especially DP) still need to be determined.
- Phosphorus transport in mesoscale catchment areas with separated observations of surface runoff processes must be further studied and identified.

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The Hyporheic Interstitial of Small Running Waters - Structures, Functions and Conclusions for Water Protection

Dietrich Borchardt, University of Kassel, Kassel

1 Structures and Functions of the Hyporheic Interstitial

The hyporheic interstitial, an ecologically independent boundary zone between ground and surface waters, was recognised as a principally important compartment of running water ecosystems in a series of studies starting about 40 years ago (fig. 1).

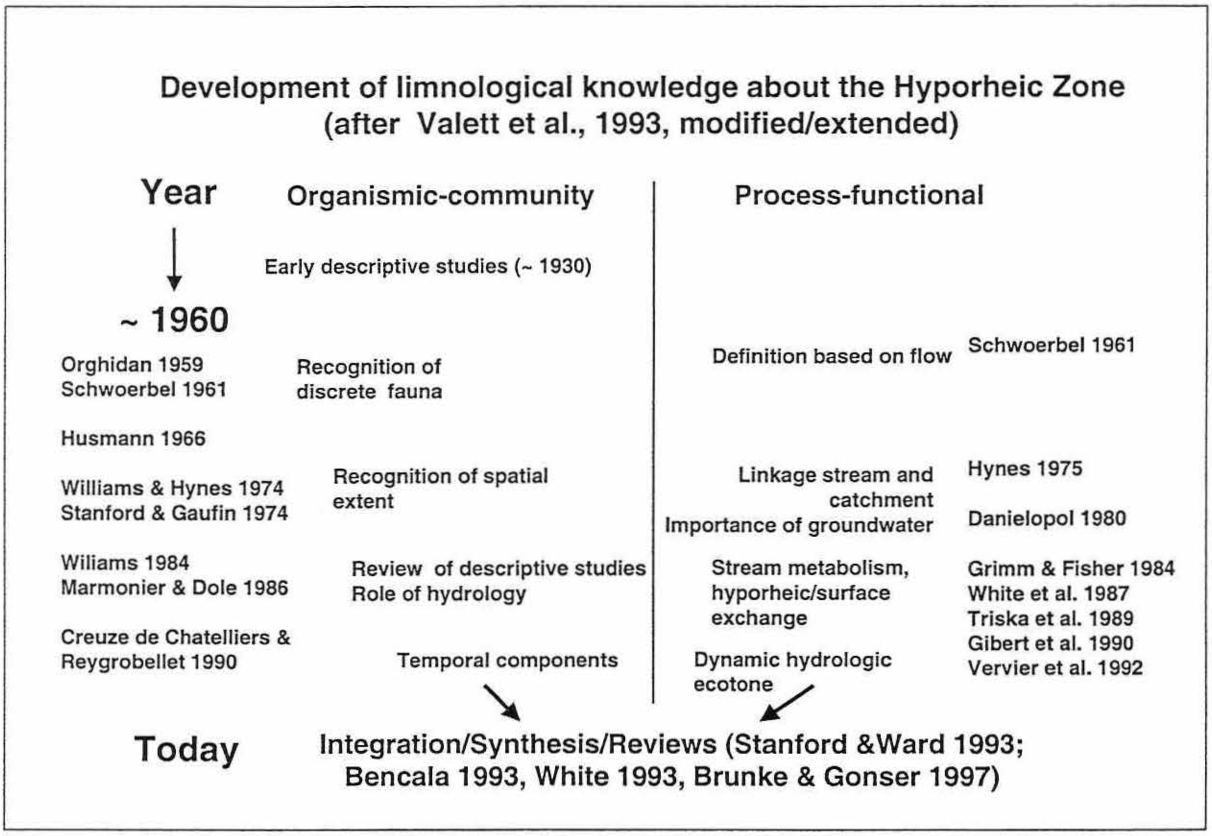

Fig. 1. Development of limnological knowledge on the hyporheic interstitial of flowing waters

The upper sediment layers with a exchange between surface waters and/or groundwaters are an important habitat for aquatic communities, since practically all running-water organisms have life-cycle stages associated with the hyporheic interstitial. At the same time, intensive material exchange processes can be identified here. Especially in "small" running waters, the material exchange and transformation processes are predominantly located at the sediment surface and in the interstitial rather than in the surface flow. As a result the abiotic conditions in the hyporheic interstitial can vary widely from those in the flowing current.

Various basic studies have shown that the hyporheic interstitial must be seen as a bottleneck for the ecological integrity in many anthropogenically affected flowing waters. Especially the population development of animal species closely connected to this habitat continues to be negative, despite improvements in the water quality of the surface flows (e.g. large mussels, certain macroinvertebrates). The population development of gravel-spawning fish (especially salmonids) in many flowing waters is thought to be limited by high mortality during the egg, embryo and larval phases taking place in the hyporheic interstitial (e.g. Neumann et al. 1998). Furthermore, the main actual uncertainty in the material budget and river catchment balances of nutrients is the large discrepancy between the potential nutrient emissions from diffuse sources and the actual loading of surface waters (e.g. Behrendt 1998). The role of the hyporheic interstitial must also be observed here, as intensive nitrogen transformations and losses through synchronous nitrification and denitrification have been observed (Borchardt and Fischer 1999).

Generally, the character of the hyporheic interstitial is to be determined according to river-typological aspects and scales. Thus the relative spread of the hyporheic interstitial usually decreases in the longitudinal direction of rivers and with the change in height from mountains to lowlands.

2 Aspects of Waters Protection

With respect to the river basin management that is expected to be introduced with the EU Water Framework Directive, the ecological functionability of the hyporheic interstitial is important for several reasons:

- the macrozoobenthos and the fish fauna, the latter also in terms of age structure and reproduction, are important indicators for the ecological quality of flowing waters according to appendix V,
- nutrient balances are to be worked out for the river area units and interpreted in terms of the causes,
- the hydromorphology is an important criterion for "ecological" quality according to appendix V,
- surface waters and groundwater are to be viewed together,
- generally, the links between anthropogenic impact and ecological quality deficits are to be found.

With this in mind, we can initially name the dangers, causes and possible approaches to measures that can be taken into account (fig. 2).

To meet the requirements of the EU-WFD it will be especially necessary to consider available data. In water protection practice, the waters quality in general and the resulting conditions for the aquatic communities in their habitats is generally analysed from water samples from the surface flow. Because of the methodological impossibility of measuring the interstitial at the same intensity as in the surface waters, an important unsolved problem is how to scientifically create a link that shows the relationship between these two environmental compartments.

A further important point is the morphological change in the flowing waters. According to the criteria of the "hydro-morphological quality", more than 2/3 of the stretches of flowing waters in Hessen are defined as morphologically damaged, based on area mapping information. In the mapping procedure, with 6 main and 26 single parameters, although the structure of the channel beds is assessed, the ecological functionability of the hyporheic interstitial cannot directly be inferred. Thus, it would be of practical importance to determine to what extent the available criteria on the water quality correlate to the functionability of the hyporheic interstitial.

Major anthropogenic disruptions of the Hyporheic Zone

Cause	Effect	Measure
Impairment of stream morphology; Channel maintenance; straightening	- Stream bed erosion - Desiccation of aquatic/ interstitial connectivity - Colmation	- „Restoration“
Soil erosion from agricultural areas	- Sediment load with particulate matter - Colmation	- Change of agricultural land use practice - buffer strips
Point source pollution (domestic wastewater; stormwater runoff)	- Sediment load with particulate matter - Colmation - Sediment load with bio-degradable substances	- Integrated management of sewerage systems
Persistent organic compounds	- Groundwater contamination - Toxicity	- Source control

Fig. 2. Anthropogenic impact on the interstitial separated according to cause, effect and measures.

The assessment of the ecological functionality of the hyporheic interstitial, dependant on hydromorphological, structural and materials parameters is thus an important question in river catchment area management. The prediction of the ecological effects for the measures shown in fig. 2 is also an important issue.

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Summary of Topic 4: "Intersection Land / Groundwater / Surface Water"

Gunnar Nützmann, Institute for Water Ecology and Inland Fishery, Berlin

The obligations on research stemming from the 5th Framework Program of the EU on the subject of river catchment area management, stress the necessity of integrated, multisectorial approaches, and the linking of ecological and socio-economic research, concentrated on the strategically important projects with regional importance, and involving potential users. The framework of future projects will be very much widened through this, and the natural connection between waters and landscapes in the proximity comprehensibly done justice to, in both a scientific and economic sense.

The presentations held in topic 4 on the intersection land, groundwater and surface water, made reference to still unsolved problems, and characterised the future research needs. Without exception, an integrated, whole approach to catchment areas was demanded, i.e. one which stresses the unity of groundwaters and surface waters. That this also has a high practical relevance was shown by the introductory presentation by Luckner on the problem of water quantity and quality management in the Lausitz open-cast coal mining region, whose effects reach as far as Berlin's water supply, and Behrendt's input on the problem of diffuse sources pollution of Germany's surface water systems and potential for its retention.

To bring forward the development of control mechanisms for the management of entire river catchment areas, the need for research was shown in the following areas, along with the large-scale water management problems, the diffuse sources pollution of surface waters through unsaturated zone and groundwater, and the importance of land-use changes (presentation by Mioduszewski). The spatial-time distribution of transport processes for dissolved nutrients and pollutants in groundwaters and surface waters are very different. This can be seen, for example, in the flow velocities, residence times and in reaction times. If both "compartments" are to be seen as a linked system, then the non-linear behaviour in the transition zone (hydro-geochemical reaction of the various compounds), is going to be a big challenge for research. This aspect will first be of great importance to our increase in knowledge, then for modelling, and later for controlling systems.

This was made clear in the presentations of Rose and Borchhardt, among others, on the role of waters sediments, their quality and the material displacement processes contained therein. The hyperrheical interstitial is a transition zone in which quality jumps take place which until now are unsatisfactorily known. Further enlightenment and modelling of this, however, is of exceptional importance to surface water management.

That this is not limited to sediments is made clear by the presentation of Rode, in which a detailed process research on solute transport (mainly for the nutrients nitrogen and phosphor), and on solute displacement in catchment areas on a micro to meso scale level is called for. A central point in this is the demand for transferability from one scale to the next-highest, for both study strategies (lysimeter - field tests - catchment area) and for modelling.

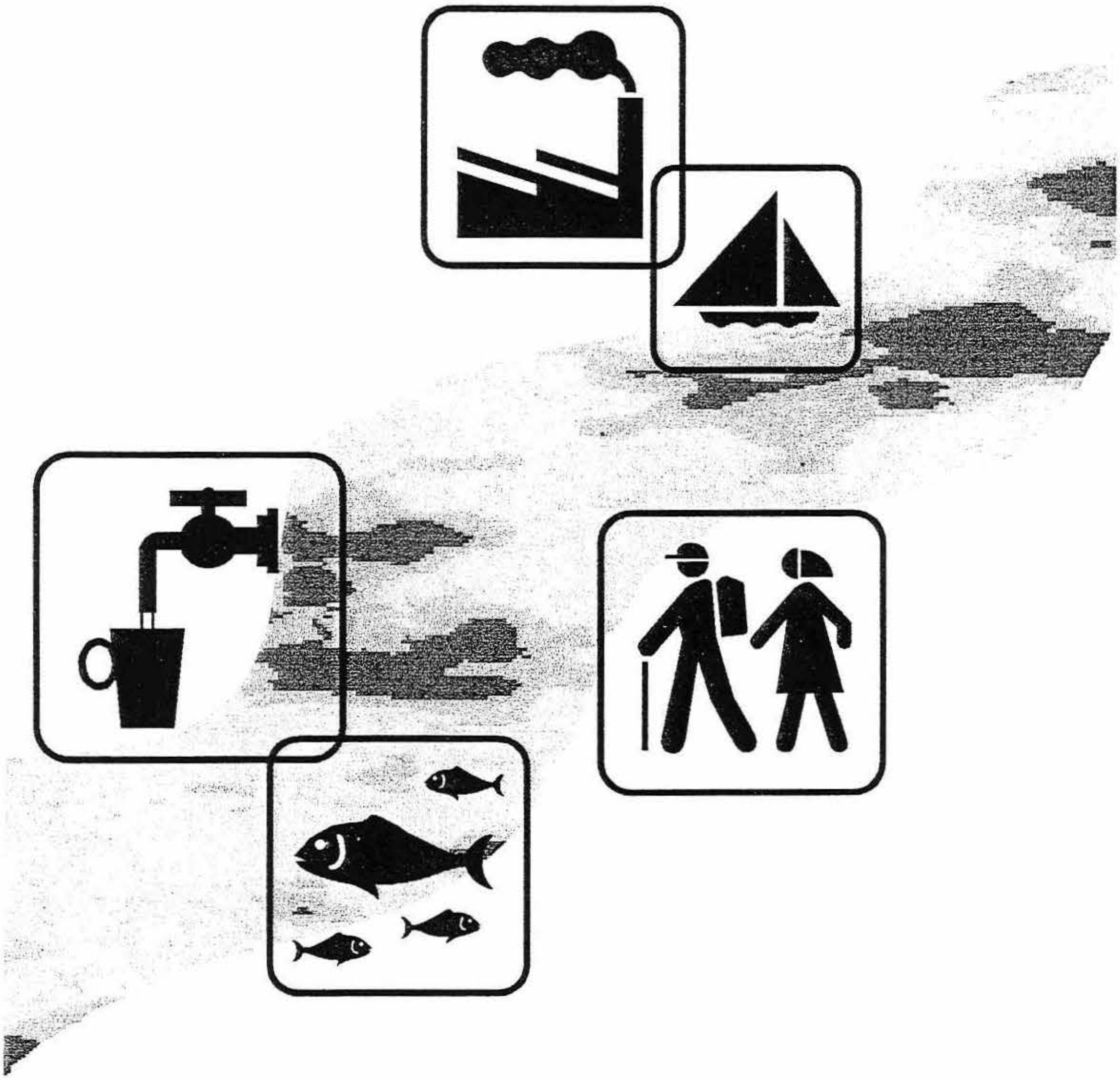
Unfortunately, nothing fundamentally new in the theory of scaling in hydrology was announced at the Magdeburg conference. The questions what kind of processes are the governing ones at which scale levels remain open, and continue to require targeted research. An integrated water resources management will only be possible in the long term and in a sustainable way, with a fundamental understanding of transformation rules from the local scale up to catchment area. One possibility for qualifying hydrological data sets, however, is to use statistical fractals (presentation by Braun in topic 3), which create a link between scales and can be used in the assessment of extreme events.

A further problem is the comparability between different catchment areas, which cannot alone be achieved through measurements and new data sets, but requires the use of models with various resolutions and complexity. The ability of current models to create forecasts or scenarios is not enough, however. To improve the uncertainty of model predictions, physically based models of run off simulation (combination of surface and sub-surface water) will need to be integrated more strongly with catchment area models (land use, socio-economic relationships), to form catchment area management models. Apart from water flow, solute transport will need to be modelled. Such systems could then allow an assessment of the connections between hydrological and ecological subjects, e.g. a quantitative analysis of the relationship between land-use forms and the diffuse material input into surface waters, which would be a qualification of the data sets that already exist. New assessment procedures for river catchment areas must also be included in the model approaches, in which management changes and their effects on the waters can be predicted. Such procedures must make these effects clear to the user/resident, and enable the testing, at least in theory, of different variations.

Last, but not least, the presentations held in topic 4 contained a series of suggestions for foundation research in hydrology and ecology, of which some should be mentioned here:

- a coupling of the ecologically, chemically and structurally orientated classification systems still to be worked out, with the model approaches to measure material input and river-system-internal material retention and losses,
- models on the input of carbon and silicon via the various point sources and diffuse paths,
- studies on N-retention/erosion (denitrification) in the unsaturated zone in groundwater and the surface waters (under what conditions, and for how long, can one expect very high erosion rates in the unconsolidated rock regions of the north-east German lowlands?),
- meso and macroscale use of model proposals on P-sorption potential of the soils and on the link between P-saturation in the soil and the P-concentration in subsurface waters.
- quantification of the flow components (especially natural interflow and basic run off) for regionally differentiated river catchments in all scales.

A further requirement is seen in working together with the European partners. With the exception of the river Oder, where a UBA project is currently running to quantify of nutrient and heavy metal input, especially the foreign parts of the river catchments of the Elbe, Danube and the Rhine could not satisfactorily be taken into consideration. A harmonisation of the relevant model approaches is absolutely necessary for working out united management plans. The approaches and sub-models used Germany-wide could be the basis for this. In any case, an inclusion of foreign partners (e.g. EAWAG; l'agence de Rhin-Meus; Institute of Water Management Prag; Technische Universität Wien) is necessary in future research projects.



Topic 5:

User conflicts and requirements to the management

Demands on Catchment Area Management from a Drinking Water Production Point of View

Jürgen Schubert, Stadtwerke Düsseldorf AG, Düsseldorf

1 Introduction

The EU Water Framework Directive will set the future framework for the protection of surface waters - including coastal and transition waters - and groundwater in the member states (Rat der Europäischen Union 1999). Special features of the directive are:

- Watermanagement activities will be based on national/international river catchment area units.
- A *good standard* is to be reached by all waters within the next 16 years. To describe the standard for surface waters, biological, hydromorphological, chemical and physicochemical quality components, as well as specific pollutants will be used. For groundwater, the quantitative condition (extraction < new generation) and chemical conditions will be looked at.
- To reach these environmental targets, measures programs are to be set up and implemented as a part of binding management plans (river catchment area management) on the basis of condition studies.
- The active participation of the public is to be encouraged through information and hearings, especially in the drafting, checking and implementation of management plans for the catchment areas.

What specific demands arise in the area of water research in order to reach the targets and plans of the Water Framework Directive?

The results of water research already carried out have already created wide-reaching foundations for the implementation of a river catchment area management (Forschungszentrum Karlsruhe GmbH 1997). It is becoming apparent, however, that certain fields, such as water appraisal, diffuse inputs and methodical procedures for the drawing up of management plans and the deciding of measures programmes, will require fundamental work to be done. Between 1991 and 1997 the DVGW-research had the following main areas:

1. treatment,
2. analysis,
3. residues.

To concentrate the limited research resources available on the changing main points of research, the DVGW-research committee for water started a survey in 1996 of water boards, relevant companies and universities (Kühn and Müller 1997). The results of this survey confirmed the change in main research areas and leads to a new list of priorities:

1. groundwater and soil,
2. toxicology,
3. waters,
4. treatment.

Main areas of water research in the past and in the future should be discussed further using the example of drinking-water production on the Rhine, whereby both the surface waters and groundwater should be kept in view.

2 Bank Filtration on the Rhine

In the Rhine region bank filtration has been used to produce drinking water since 1870. Until approx. 1950, a period of 80 years, water that was fit to drink could always be produced by bank filtration without further treatment. The natural cleaning properties of the river and in the journey through the soil was enough to get rid of the unavoidable remains of pollutants in the surface waters. This changed with a dramatic increase in water demand and thus also the amount of waste water after World War II. The increase in industrial products, especially the chemicals industry along the Rhine, the strongest of increases in population along the Rhine, in connection with not enough treatment of waste water, led to a rapidly rising pollution of the Rhine and to a drastic over-demand on the natural cleaning properties.

The continuous appeals of the water boards to introduce the desperately needed water-protection measures went almost unheeded for almost twenty years in the euphoric mood of rebuilding and economic boom. It was clear to the water utilities dependant on the Rhine that a short-term improvement wasn't in sight and that initially the only promising way to go was in the treatment of the raw water.

3 Need for Research and Development

To solve their joint problem, the waterworks of the Lower Rhine in 1953 formed the "Working Group of Lower Rhine Waterworks", the forerunner of today's ARW (Working Group of Rhine Waterworks). Under the scientific leadership of the Institute for Water Chemistry at the Technical College Karlsruhe (led by Prof. Holluta) a comprehensive work program was undertaken to initially determine the type of, and increase in the level of, pollution along the Rhine. A further main part of the work went towards asking if, and if so, with what treatment procedures, the effects of the advanced water pollution could be kept away from the drinking water.

Carrying out the work proved to be immensely difficult. The analytical instruments were unsatisfactory; new analytical methods had to be developed. The deficits in the analysis was one of the reasons why analysis was a main point of research for many years.

The problem could not be solved using the customary water-treatment procedures in drinking-water production. After a lot of development work and many failed attempts, a prototype in the high area of Düsseldorf's supply area achieved success. The so-called "Düsseldorf Procedure", with ozone and activated carbon was born. In quick succession the treatment technology was installed in the waterworks "Am Staad" (1961), "Holthausen" (1964) and "Flehe" (1967) and successfully run since then.

The process combination of oxidation with ozone, biologically-effective filtration and adsorption with activated carbon, arrived at experimentally, was the subject of several research projects in the following years, which were carried out with support from the then BMFT under the scientific leadership of Prof. Sontheimer. The main aim of the research work was the always practise-orientated working-out of scientific foundations for the dimensioning and building of treatment works and the calculating of the main parameters for their running and for quality control. This procedure, supported by superb foundations, is now used worldwide for the production of drinking water.

4 The Sandoz Accident

On 1.11.1986 a fire broke out in a warehouse of agrochemicals at a chemicals plant in Basel. Along with the water that put out the fire, insecticides, herbicides and fungicides entered the Rhine. The effects of this accident on the Rhine were serious. In this situation the experiences of the water utilities along the Rhine with previous accidents were an important help in overcoming the crisis. Of continued importance for the situation on the Rhine are the consequences taken as a result of the Sandoz accident:

- local measures to protect against accidents with materials dangerous to water (e.g. water retention basins)
- an international action plan for the Rhine
- improvement of the international warning and alert service on the Rhine
- a material-transport model of the Rhine
- research projects of bank filtration

The open questions of groundwater hydraulics, of material transport and of the cleaning powers of passage through the soil in bank filtration, were taken on under the scientific leadership of Prof. Sontheimer in a joint project by six water utilities on the lower Rhine, five scientific institutes and experts for flow and transport models at various technical colleges, and supported by the Federal Minister for Research and Technology. In these waters-orientated research projects, previous experiences with bank filtration could be taken back to their natural-science foundations. New knowledge on clogging (Kolmation) of the river bed, models for the not stationary flow and transport processes, test procedures for the decomposition processes in the soil passage and the necessary instruments for an early-warning system were developed within the framework of these projects.

5 New Main Areas in Water Research

On the basis of the point reached in water research, more strongly waters-orientated questions are coming to the fore. One example is the attempt to complement knowledge of trace-materials analysis with biological procedures, with the aim of understanding the effects of complex material mixes in aquatic systems in terms of drinking-water production.

The set standards of the Water Framework Directive set a new yardstick for the appraisal of waters and water quality classification. The implementation of these set standards will hardly succeed without the working-out of natural-science foundations in the framework of research projects.

To achieve the environmental targets of article 4, especially the remediation of groundwater bodies, it is necessary to overcome, through research, the deficit in knowledge of microbial-induced hydrochemical processes in polluted groundwater layers.

The general reduction in demand for drinking water, in connection with the demands of the new Drinking-Water Directive to permanently meet the quality objectives set at the tap, while, at the same time minimising disinfection by-products, requires a high level of biological stability of the drinking water fed into the network. The question of biofilm-growth potential and the survival chances of pathological germs come, among other questions, to a fore.

Even in the ongoing research projects we can see a smooth transition to new main research areas. The Water Framework Directive will, in addition to this, develop its own dynamics and pose demands on water research that even now cannot be forecast in detail.

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Experiences with River Basin Management in the Catchment Area of an Anthropogenic Influenced Low Montain Range River (the Wupper)

Joachim Renner, Wupper Association, Wuppertal

1 Introduction

The European Commission of the EU has submitted the draft of the so-called Water Framework Directive, the EU-WFD (last revised issue dated 26.06.98), which provides the legal and administrative basis for the implementation of the scientifically founded comprehensive approach to a sustainable waters protection in Europe. One of the main objectives is to establish the required conditions for a *River Basin Management*, which is the suitable instrument to achieve the main objective of the Directive –

a "good ecological status" of all surface waters and a "good status" of groundwater.

This good status will only be achieved, if both the chemical/physical requirements on the water body and the ecological status are adequate. River bed, bank and river plains must also be included.

The central instrument for obtaining the good ecological status of the water bodies is the *River Basin Management Plan*, which is to be established by the member states for each River Basin District.

2 Objectives of the Research Project*)

2.1 General Objectives of the River Basin Management

For many decades already have the water associations in NRW (North Rhine Westphalia) successfully been working on the basis of a comprehensive approach to a river basin.

However, if further success shall be achieved in environmental protection, especially with respect to waters protection, this will require the establishment of a River Basin Management and a better coordination of the various activities involved. In particular, it will also be necessary to seek and intensify contacts with partners in the river basin concerned (municipalities, municipal plants, private industries, agriculture, nature conservation associations etc.) and to coordinate the appropriate measures.

The Wupperverband is one of the large water associations in NRW and is in charge of the natural catchment of the river Wupper, which covers an area of 813 km^2.

The legal responsibilities of the Wupper Association, which are waste water treatment and waste disposal, operation of reservoirs to regulate the water flow of the river Wupper, the river maintenance and development as well as the supply of drinking water, must be examined for their interaction with the river system and coordinated in such a way that the best possible beneficial effect on people and nature will be achieved at acceptable costs.

2.2 Special Objectives for the River Wupper

The catchment area of the river Wupper, for which the Wupper Association signs responsible, has been anthropogenically influenced during previous centuries, especially through industrialization. It is impossible to restore the total stretch of the river Wupper to the ideal condition of a natural river as it may have been some centuries ago. It is therefore necessary to determine such development targets under consideration of the envisaged uses which can be realized in a foreseeable time and at acceptable costs.

It has now been proven by means of analyzed water quality data that the ecological status of the river Wupper is remarkably improved through investments in sewage discharge and purification technologies, through specific hydraulic and ecological measures and an enhanced self-purifying capacity. The main causes of yet still existing deficits are being analyzed.

Already today, before the data collection has been completed and the current condition finally been assessed, the following measures become apparent if the aimed status of the river shall be achieved in a foreseeable time:

- improving the quality of the river's morphological structure,
- enhancing the effectiveness of dam monitoring systems,
- further developing sewage treatment works,
- optimizing the complete system canal-sewage treatment works-river,
- setting up an information management system.

2.3 Research Requirement

The project's target is to furnish evidence by a concrete example of a densely populated area to which the new EU-WFD is applied that the required protection objectives can be achieved faster, better and less costly than on the basis of common procedures. The following points of emphasis are to be established:

- the diversity of ecological assessment standards is to be examined for their practical applicability, especially for "heavily modified water bodies",
- the establishment of concrete development objectives is to be derived from models and state-of-condition analyses,
- to demonstrate simple balancing possibilities prior to conceptional plannings,
- to optimize the entire system canal-sewage treatment works-river,
- to submit elaborated proposals for an efficiency control, especially for measures to reduce diffuse loads,
- to determine priorities for further development plans using the project area as an example,
- to prove the sustainability of the comprehensive solution,
- to demonstrate the best possible links between population, cost units, water authorities, planners and operators (here the Wupper Association and municipalities),
- to verify the technical and political feasibility of the new River Basin Management Plan.

3 Conclusion

Despite decades of experience in water management framework planning, the concrete project implementations in the area of sewerage systems, sewage treatment works, measures on the development and maintenance of rivers etc. could not be realized in practice with such effect that overall a cost-effective waters protection could be accomplished. A comprehensive approach promises a better waters protection at lower costs.

The target of the research project is to furnish evidence by a concrete example of a densely populated area to which the new EU-WFD is applied that the ambitious objective of a good water quality can be achieved less costly than on the basis of common procedures.

The results of the research project therefore are to be considered of supraregional national and international importance.

4 Supplement: Activities of Technical-Scientific Associations

In completion of the research project of the Wupperverband, the activities of the technical-scientific Associations shall be mentioned: The coordination board "River Basin Management", in which standardizing associations (ATV, BWK, DVGW and DVWK) are represented, has compiled a catalogue of topics which need research and clarification, and shall be dealt with in close cooperation with the EU-Contact Group of the LAWA and the relevant Federal Ministries.

**) The research project shall be carried out jointly by the Wupper Association and Prof. Geiger, GH University Essen.*

River Catchment Area Management, EU-Water Framework Directive and Assessment/Decision Questions

Ulrich Petschow, Institute for Ecological and Economic Research (IÖW), Berlin

1 Procedure

First, the discussion on river catchment area management and the potential advantages of the integrated procedure will be outlined (chap. 1). Then, some of the aspects of the Water Framework Directive will be listed, in so far as they are important for assessment and decision-making (chap. 2). Following this is a typified overview of the assessment process (especially monetary assessment procedures) and decision-making, in which the aspect of participation is important (chap. 3). To close, some main research questions will be presented (chap. 4).

2 River Catchment Area Management

Fragmented public investment programmes for the development and management of the resource water, which don't take into account the numerous interdependencies between user groups and their influence on other, not directly with water-use related economic and non-economic activities, often result in a mismanagement of scarce resources in developed and developing countries (World Bank 1993). Consensus is growing in international organisations that water is a limited and endangered resource, whose management should follow an approach of integrated participation (UNDP 1994).

River catchment area management sets a change of paradigm in water management, from project orientated development of water resources to an integrated water resource management. The subsectoral, or rather, project orientated development projects in water resources can be characterised as follows:

- through an optimisation at the project level,
- through the implicit assumption that water use is primarily orientated towards each specific use, i.e. project orientation/sectoral viewpoints are in the foreground.

In the framework of this approach, future effects of these projects and use conflicts are often ignored. An integrated water resource management, on the other hand, can be characterised thus:

- individual projects are developed from the background of the whole range of use demands (i.e. including environmental demands),
- conflicts such as scarcity and externalities such as "open access" are also solved by institutional innovations.

This approach can be seen as comprehensive, incentive orientated, participatory and binding towards sustainability. Le Moigne (1994) summarised the advantages that come with an integrated approach. There are chances:

- to reach the short and long term demands of river catchment area management in an economically efficient way,
- to include activities and aims that are not always economically or technically possible in individual measures,

- to reduce costs by making use of economies of scale,
- to make possibilities of taking action easier, to reach a consensus between riverside residents, and thus to reduce tension and conflict.

3 EU-Water Framework Directive

3.1 River catchment area management - an integrated approach

The EU Water Framework Directive will, in the form of a paradigm change, set a consistent framework for dealing with water. This will at least partially overcome the much criticised inconsistencies of European water laws, and thus simultaneously the externalities of varying regulatory systems. The convergence of ecological problems and regulatory processes, much demanded especially by economists, will be made possible. We must take into account, however, that problem levels must also be differentiated in the area of water: there are also regional and local problems which should also, where suitable, be solved at these levels. The prerequisite for reaching the potential of river catchment area management is the willingness to co-operate as well as a suitable co-operation structure. Some main aspects of the EU-Water Framework Directive will be outlined below:

Information base

For river catchment area management, a suitable information base must be created to enable decisions to be made about which means can be usefully employed in which place. This information base will additionally become a foundation for the carrying out of cost-benefit analyses and of decision-making procedures.

Inclusion of the quality of water structures

Apart from keeping waters clean, in which Germany has had considerable success, the quality of water structures is a main ecological problem area. The obligation to improve the quality of water structures is thus a main challenge with a view to nature and landscape.

Identification of especially heavily affected waters

Waters which appear not to be able to reach a "good ecological condition", because of the pressure of use and the associated extremely high costs involved, must be named. The criteria for such a naming must be set, e.g. through cost-benefit or cost-effect analyses.

Subsidies, full-cost rates

Full-cost rates are demanded for water prices. The environmental and resource costs should be taken into consideration (formally: "as far as possible"). This touches on the problem of externalities and at the same time on the term "subsidy" and the possibility of including external costs.

Cost-benefit analyses, cost-focused analyses etc.

The cost-benefit analyses/cost-effect analyses provide the information base for decision-making. Alternative projects can be compared to one another: in one case in terms of the relationship of cost to benefit, and in another in terms of aims to be met with a certain budget. Practical experiences with river catchment area management orientated assessment procedures as well as the decision-making procedures have not yet developed very far.

Participation
The participation concept contains the idea that "stakeholders" should be brought into the process. The framework of the EU proposal envisages that the plans should be discussed with the stakeholders affected, who can then bring in their opinions on the basis of this improved information base. This participatory approach will enable the growth of learning processes and network structures for the protection of waters. Participation is a main challenge, especially for the decision-making processes.

4 Assessment and Decision-Making Procedures

In river catchment areas there are many uses and users of water because of its multifunctionality, so that there are conflicts of use which must be solved within the framework of a river catchment area management. The following, in no way complete, overview, presents some of the functions of river catchment areas (Tab. 1).

Tab. 1. Functions (achievements) of river catchment areas

production input for marketable goods and services transport, energy supply, basis for food production, water use for commercial and industrial production, basis for land use for industrial production, basis for commercial fishing etc.
direct consumption and non-consumptive use recreation, angling, bird watching, water use and preparation for non-commercial use, aesthetic functions
assimilation capacity sink for emissions, retention areas for erosion materials
"life support" hydrological regulation and retention, influence on the global carbon budget, water quality, aerobic and anaerobic processes, retention and export of sediments, habitat support (food chain etc.).

From an ecological and socio-economic point of view thus comes the question of which functions a river catchment area should fulfil and how integrated assessment procedures (and also decision-making processes) for measures in river catchment areas can be set up. For optimisation it is of central importance to know which conflicts exist with a view to the environment, and which natural capital exists with which functions.

The assessment of measures within the framework of a river catchment area management is, however, faced with a problem of complexity, the interdependency of natural and socio-economic systems, the links between different levels (local/regional/river catchment area related), as well as the assessment questions, yardsticks and the decision-making processes. With a view to this, the question arises in cases of use conflicts of how a solution can be provided for these conflicts. This is a great challenge in the planning and layouting of a "optimal" development program for river catchment areas.

4.1 Assessment Procedures

There are many methods and approaches to carrying out assessments, whose compatibility, however, is not, or only partially, given. In the past it has often been shown that goods and services traded on the market have a priority towards economic development, especially within the framework of economic assessment procedures, with the result that other functions within the decision-making framework play a subordinate role.

Fig. 1 schematically shows the position of various assessment procedures relative to each other, whereby only the procedure of monetary assessment is shown in a more differentiated way.

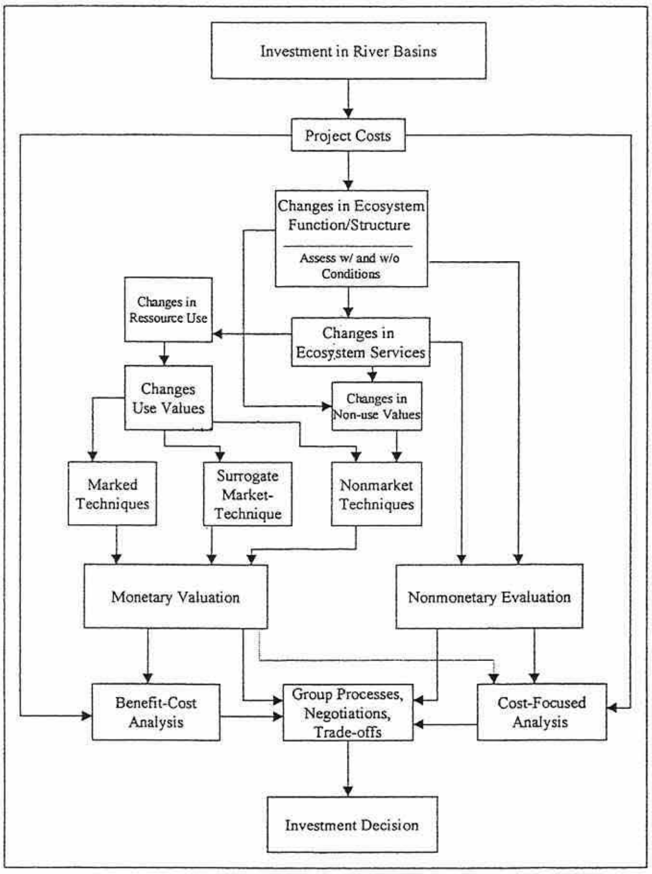

Fig. 1. Typified project assessment and decision-making procedures
source: own presentation closely following Feather et al. (1995: 4)

On the left of the diagram are the economic assessment procedures, which should enable an assessment through a monetary procedure. By taking into account the non-use values, an ecologically extended use appraisal can be undertaken.

On the right are the non-monetary procedures, which try to measure and assess the ecological changes on the basis of mostly natural-science based procedures. These non-monetary assessment procedures can be added to a cost-focused analysis, for example, whereby the costs are then only expressed in monetary terms.

The assessment procedures are, however, only preparatory to decision-making: the decision itself is not set by the assessment procedures, even though the acceptance of the assessment procedure has an influence on the decision.
There now follows a look at the cost-benefit analysis and its ecological extension.

Cost-Benefit Analysis (CBA)
Within the framework of a cost-benefit analysis all positive and negative effects of an investment project should be included. Every decision associated with the development of river catchment areas assumes prior weighing up of factors, and is thus also subject to economic calculation. Under the aspect of scarcity, which measures are to be carried out or prevented should be decided. In connection with this it is obviously decisive in which area the cost-benefit ratio is most advantageous.

The starting point for an assessment of river catchment areas should thus be the various functions (Tab. 1). Here it will be important to include approaches to quantification which not only look at the classical costs and uses, but also at the evaluation of nature (option value and existence value) in the framework of an ecologically extended CBA. In the literature the concept of the calculation of an economic value of nature and landscapes, the "Total Economic Value (TEV)" is often used (Pearce 1993: 15). In the TEV analysis, not only the goods handled via the market are taken into account, but also the public goods which are generally not included or only partially included. The overview and diagram show the main building blocks of this approach: on the one hand it has to do with identifying various use components (Tab. 1), and on the other with assessment methods to measure various use and non-use values (fig. 1). The fundamental thought behind the TEV is that the total economic value consists of various parts. The composition of the total economic value can be described as follows:

$$\begin{aligned} TEV &= [\text{use values}] + [\text{non-use values}] \\ &= [\text{direct values} + \text{indirect values} + \text{option value}] + [\text{existence value}] \end{aligned}$$

The use of an ecologically extended CBA or the calculation of the TEV, for example, is currently not very common. Currently it can be seen rather more that river catchment area strategies are focused primarily on non-monetary assessment procedures. Possibilities for monetary assessments could take on a stronger role if:

- the quantification of environmental functions of ecosystems and its components makes progress
- monetary assessment can be seen as a step forward for an increasingly technical management process.

4.2 Decision-Making Processes
The orientation of the CBA (decision preparatory) and more process-orientated approaches should be presented in a typified way. This typification should not be used as an evaluation in any way, as different assessment procedures might not be in conflict with each other in the decision-making process.

The monetary assessment, i.e. the cost-benefit analysis, is mainly aimed at the political decision makers, central decision-making bodies in other words, which can choose from the most varied of alternatives, and which ideally should choose the most economically efficient.

Other approaches to decision making are more strongly procedural. Clarke (1995) argues that traditional development models which above all are supported by expert knowledge, are becoming increasingly less able to meet the challenges of a complex world. More than anything, this is due to the increasingly accelerating structural change in which knowledge is becoming more and more dependant on context. Sustainable development is seen as being mainly process orientated under these conditions. The study by Senge (1992) on educational organisations has a special importance in this. A key for learning organisations is the inclusion of the whole "stakeholder community" in decision making. Applied to the concept of sustainable development and also to that of the management of river catchment areas, this means that relevant parties, with interests in the relevant questions, are to be included. We are thus dealing with the development of a common opinion on cause-effect relationships and the processes behind this.

Such an approach implies that a monetary assessment alone is not enough for the decision-making process (VALSE 1998: chap. 10,3) especially because of:

- system uncertainties, which make an assessment of trade-offs between environment and economic factors problematic,
- distribution conflicts, which at least partly withdraw from Pareto efficiency,
- very varied moral and political demands for the solving of conflicts in the river catchment area.

Instead of, or rather, in addition to a "top down" strategy, it is suggested that the initial approach should be a values-orientated "bottom up" one. This has to do with the way in which the inhabitants and stakeholders, for example, come to put a value on the environment. The positions held with a view to the environment in socio-political processes are certainly controversial and conflictory. Every decision can be seen as an expression of the values held. A single aggregation of preferences (e.g. as attempted in the framework of the CBA and also the ecologically extended CBA) is not enough. The values held and decisions made develop rather more within the framework of social processes. Assessment practices thus have a higher social legitimacy, and also political relevance, if they stem from the background of a social and institutional dimension of values forming (VAlSE, 1998).

5 Research Questions

As a summary, the following priority research questions can be presented:

Institutional questions

- institutional demands on river catchment area management,
- development of suitable organisational/institutional arrangements (which problem at which level with which forms of co-operation).

Information base and communication

- development of (ecosystematic) information foundations in the river catchment area,
- increased level of awareness and improved communication on pollution problems, i.e. the participatory approach.

"Water culture"

- cultural values and norms in connection with water compared interregionally. Inhibitions and opportunities for co-operation,
- awareness in dealing with water with the background of large-area water catchment management,
- increasing awareness of the aquatic system and development of ideals for the river landscape,
- understanding for socio-economic and socio-cultural factors which influence water-use behaviour.

Assessment/decisions

- costs and uses of different technical, organisational and institutional options (flood management, water cleaning measures, restoration),
- assessment of water as an economical and environmental good,
- assessment of costs including externalities (full cost recovery approach),
- assessment under conditions of complexity,
- feasibility and use of an extended CBA within the framework of river catchment area management,
- identification of suitable procedural decision-making methods that include the "stakeholder".

Instruments

- use of economic instruments for cost-efficient catchment area management (bubble models, compensation payments, negotiation agreements, financial responsibility etc.),
- increasing the responsibility of water users: identification of negotiation and compensation solutions,
- possibilities for collective use (problem of the commons - common ownership):
  - of ground water resources,
  - of the water catchment area in general.

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Decision Support Systems for River Management Based on Experience with WadBOS

Herman G. Wind[1], Tobias T. Reijngoud[2], Guy Engelen[3], Nicole Keizers[4]
[1]University of Twente, Department of Civil Engineering, Enschede, The Netherlands
[2]Ministry of Transport, Public Works and Watermanagement, Department of Watermanagement, Leeuwarden, The Netherlands
[3]Research Institute for Knowledge Systems, Maastricht, The Netherlands
[4]INFRAM BV, Zeewolde, The Netherlands

1 Introduction

Measures in estuarine and river systems often have impacts on more than one subsystem. For instance extraction of natural gas may cause a subsidence of the sea bottom affecting morphology and in its turn the change in morphology will affect the ecosystem. Recreation in an estuary affects the regional economy but implies also a burden for the birds, seals etc. In the past systems have been developed to support the decision maker in reducing the impacts of feasible measures (see Peerbolte, 1993). These systems are problem oriented. Problem oriented systems are dedicated tools, based on selected data, knowledge and measures. Also the presentation of the results is suited to the needs of the decision maker. As optimal use is made of available data and knowledge the development of these systems is very cost effective. Important functions of WadBOS are: library, analysis, communication and learning.

In the present paper a bird eye view is given for some of the aspects related to decision support systems. First the design process of the DSS for the Waddensea will be outlined, containing elements which we think are essential for a successful development of a DSS. This section is followed by a characterisation of Decision Support Systems for water management, with a focus on process models. The recreation in the Waddensea is used as a case study. It is expected that the approach, which is used for Waddensea could also be used successfully for river systems.

2 The Design Process of WadBOS

In the design process of the Decision Support System for the Waddensea, WadBOS, the institutional component and a science component are intertwined.

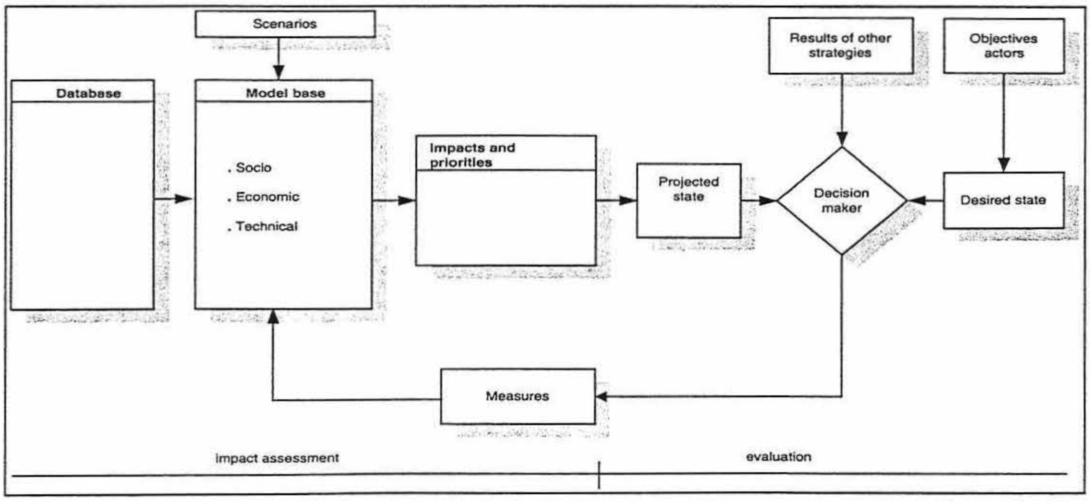

Fig. 1. Policy development and impact assessment

2.1 Inception phase

Present and future users of WadBOS are not restricted to Rijkswaterstaat, but also other Ministries such as LNV and VROM, the provinces and communities including the wadden isles in the region may use WadBOS. They all contribute to the required state, boundaries and constraints as well as to the values and criteria in which the required state will be expressed. Relevant actors are identified and the important policy documents are selected.

2.2 Qualitative System Design

In the qualitative system design of WadBOS, the processes in the Waddensea are identified and their interaction is represented schematically. An indication of the decision criteria (part of the required state) is given, together with scenario's and an outline of possible measures. This information is obtained in consultation with expert end users of the future system and from policy documents. Furthermore disciplinary specialists are asked to comment and adapt the developed system diagrams. It was decided in this phase to develop a conceptual design for the whole of the Waddensea and to specify this design initially for two areas: recreation and shell-fishing.

2.3 Quantitative System Design

Based on the information of the previous phase, disciplinary specialists are asked to indicate what type of mathematical formulation would be required in the system diagram, given the available knowledge, available models and data.

2.4 Feed back

After completing the quantitative design time is taken to pose the question: which part of the available knowledge, models and data is essential to provide the required information? This is the coupling between the right hand side and the left hand side in Fig. 1. Alternatively: the coupling between management and science. The result of this phase is a consistent and coherent set of data and models, needed for policy formulation.

2.5 Model Implementation

In the modelling phase the selected models are integrated, sometimes after some reduction and simplification, leading to the WadBOS system. During the model building phase, end users are involved to verify the performance of the partly finished models.

3 Water Management: A Characterisation of Problems and Models

3.1 Characterisation of Problems in Water Management

Only in a few cases water management is a question of solving the difference between the required state and present state by carrying out a set of measures. In that case water management is a well structured problem. Then water management reduces simply to decision making (see 1 in Tab. 1). However, a water manager only seldom is in a position of a single actor. Often there are more actors involved. Actors who contribute to part of the required state. Others posses part of the solution space and have their own perception of the required direction the decision should take, as shown by 2 and 3 in Tab. 1. This type of problem can be defined as a semi-structured problem.

Tab. 1. Typology of policy formulation. After Verbeek, 1997

	Required state clear and Accepted	Required state no clear or not accepted
Measures clear and Accepted	1. Focus on decision making	2. Focus on consistency
Measures not clear and not accepted	3. Focus on consistency	4. Focus on gathering support for problem analysis

Non-structured problems occur if neither the required state is clear nor the selected measures. In that case the focus is on processes aiming at gathering support for problem analysis. In case 2 and 3 the views of the various actors should be more consistent before a decision can be taken. To increase the consistency models can be used.

3.2 Types of Models in Water Management

In water management a wide variety of models can be applied. A subdivision based on Fig. 1, is shown in Tab. 2. It is important to notice that all types of models appear in water management, given the appropriate problem.

Tab. 2. Some models in water management and the related impact prediction

Types of models	PREDICTION OF THE IMPACT OF MEASURES
Scenario models	For the prediction of the impacts of scenario models, it is assumed that the impact of the process is small relative to the impact of the scenario.
Data models	Prediction of the impacts is based on past performance; data selection; overlay models.
Selection of measures	Prediction of impacts without process description, if these impacts are clear (past experience, simple systems) or if no alternative is available.
Decision models	Selection of a set of measures and the related impacts based on e.g. multi-criteria; cost benefit; satisfying; group dynamics etc.
Process models	Impacts prediction based on processes in the water system; ecology, economy, hydrology; water quality and many others.

3.3 Process Models

Sequential Models Feedback Models

In sequential models one process follows after the other: in case of erosion, first the flow is calculated, followed by the entrainment of material leading to a sediment yield. The change in bottom topography is assumed to be small and is generally not introduced in the next time loop. If the changes cannot be neglected anymore, then feed back is required leading to changes in non-linear systems which are not present in the sequential models.

Multidisciplinary and Interdisciplinary Process Models

In water management affects many water related functions such as shipping, ecology, economy, drinking water, safety against flooding and drought etc. The fact whether these systems should be treated as multidisciplinary or interdisciplinary depends on degree of interaction between the systems. If the interaction between the systems is weak, as is often the case in water management, it suffices to apply a multidisciplinary approach.

An important guideline for the design of process models, is the spatial and temporal process resolution. In consistent and coherent models these scales are of comparable order of magnitude. Integrating disciplines in a coherent system, may require different types of modelling, given the differences in predictive power of the various disciplines. In Tab. 3 an overview of some of these disciplines is given.

Tab. 3. Disciplines in water management

Explaining variable y_l is expressed in process variables x_l by	Examples of disciplines				
Fundamental principles	Fluid dynamics	Predictive ↑	Limited number of scientific schools ↑	Process oriented ↑	Laboratory research ↑
Repro functions (coefficients are case specific)	Economy Hydrology				
Repro functions are unknown. Process variables are known. Impacts of process variables are qualitatively known.	Geography Corals Sea grass				
Many process variables are known. Impacts are partially known.	Cultural anthropolo gy	↓ Descriptive	↓ Many scientific schools	↓ Data oriented	↓ Field research

4 An Example: Recreation

4.1 System Description and Impacts

The system diagram for the boating is represented in Fig. 2. In this system diagram both the economic system and the ecological system and their interaction can be recognised. The decision to invest in the infrastructure F is based on a cost-benefit analysis. The left hand side of [1] represents the change in infrastructure F. The third term represents the benefits of the facilities generated the number of visitors OV that stay the night and reduced with salary costs $w.{}_{RV,O}$ and government taxes.

$$f(1+bs_I)\frac{dF}{dt} = -F\{w.n_{RV,F} + bs_F + \frac{l-1}{l}f(1+bs_I)\} + OV_{RV}\{tw.BS_{RV} - w.n_{RV,O} - bs_O\} \quad [1]$$

The costs shown in Fig. 2 and in the first term on the right hand side of [1}are salary costs $w.n_{RV,F}$ related to facilities, government taxes bs_F, wear and tear of the facilities, dredging etc. It can be shown that the system in Fig. 2, on the aggregated level of the whole Waddensea, can be expressed by [1]. This expression can be used in the design stage to determine the dominant processes and the major sources of uncertainty in the analysis. If a positive cost benefit balance is obtained, investments in the infrastructure F are made. All these activities lead to recreation related employment in the region.

The interaction between the ecological system and the recreation is expressed in WadBOS in three ways. Firstly presence and sailing on the Waddensea leads to an increased load of emissions of oil, PAK, TBT and copper in the Waddensea. Secondly, the monthly spatial distribution of the ships over the Waddensea is represented in a map. Thirdly, the contribution of the boating to presence and noise is Waddensea is shown on a disturbance map.

4.2 Measures

The government agents can affect the development by means of the following measures:

- Closure of areas of the Waddensea (tools to open and close areas are available),
- Maximise the number of berths for recreation,
- Levies and taxes.

It is interesting to note that taxes on investments have a different effect than for instance the taxes on infrastructure or employment.

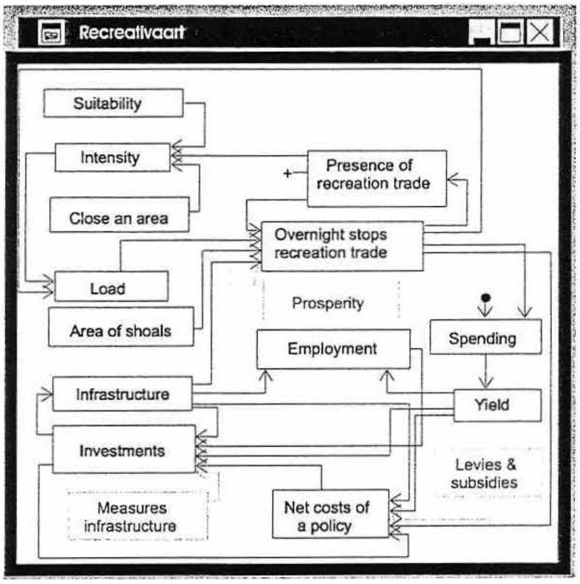

Fig. 2. Systemdiagram for boating

4.3 Scenario's

The following scenario's affect the boating in the Waddensea:

- Prosperity/welfare,
- Growth of the recreation facilities in the Ijsselmeer.

These scenarios underpin the observation that developments outside the Waddensea (and outside of the control of the responsible government agents) will also affect the change in pressure of the boating inside the Waddensea.

5 Discussion

It is expected that many of the lessons which have been learned for the WadBOS model, will also be valid for an Elbe-BOS as well as for a generic system for river management. The choice of the model depends on the problem at hand. An aspect which has not been mentioned is the decision context in which the system will be used. This context is important in the formulation of the tools. A theory on the design of multi-disciplinary systems is not available. As many institutes and universities are involved in building a DSS: team work is one of the keys to success.

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GREAT-ER a Geography-Referenced Regional Exposure Assessment Tool for European Rivers

Michael Matthies, Frank Koormann, Carsten Schulze, Jan-Oliver Wagner, University of Osnabrück, Institute of Environmental Systems Research, Osnabrück

1 Introduction

European countries possess a great variety of river basins with heterogeneous demographic and economic factors leading to variable chemical impact on aquatic ecosystems and people. The spatial and temporal pattern of waste water discharges and diffuse pollution is determined by the economy operating in that region and the population living there. Many chemicals are directly discharged from households, industries and trade or via treatment into surface water bodies (rivers, streams, estuaries). European rivers are hydrological systems having a huge variety of geometry, water flow, quality, etc. The environmental and ecological complexity can best be represented in a Geographic Information System (GIS), which provides appropriate tools for the storage, management, retrieval, analysis and visualization of hydrological, demographic, and other spatial databases. Simulation models describe the dynamics of the transport and transformation of a chemical through the chain of waste water from its use and treatment to the receiving water bodies taking into account the physical, chemical, and biological processes which affect the quantity, structure, concentration and properties of the chemical on the considered spatial-temporal scale. By coupling a GIS with such simulation models for river basins the concentration of chemicals in specific aquatic systems can be predicted. This paper briefly outlines the geography-referenced methodology for the combination of spatial data sets from various sources with dynamic simulation models for the prediction of the transport and transformation of chemicals discharged into rivers. A more detailed description can be found elsewhere (Matthies et al. 1997, Feijtel et al. 1997, Boeije et al. 1997). The GREAT-ER manual can be ordered on request (ECETOC 1999).

2 GREAT-ER modular approach

GREAT-ER was launched and carried out as an international effort to develop and validate the basic software and data methodology for the geo-referenced exposure assessment of aquatic systems. Pilot study areas in the UK, Germany, Italy and Belgium were selected and spatial and non-spatial data sets for down-the-drain chemicals (Boron, LAS) and intermediates were collated and integrated on a Windows NT platform using the desktop GIS ArcView (Fig. 1). Chemical emission and waste water pathway as well as hydrological flow data are processed to obtain a consistent spatial data set for the catchment under investigation. The whole river network is segmented into river stretches, which are related to geographical units (GU) or subcatchments. A hydrological model is used to estimate the magnitude of river flow and flow velocities at ungauged river reaches. Waste water pathway and chemical fate models are connected to approximate the impact from land use and human activities from each GU. The models can run in different complexity modes depending on the available data on the chemical and environmental properties (Trapp and Matthies 1998). GREAT-ER's direct output provides predicted environmental concentrations (PEC) linked to a river network, which are visualised as colour-coded digital maps using a GIS. With Monte-Carlo simulations the temporal probability distribution of the resulting PECs as a function of the input data variability and uncertainty is determined. Spatial probability distributions were derived over all stretches to characterise the exposure variability in a catchment: for $PEC_{initial}$ represent stochastic values near the discharges and $PEC_{catchment}$ for the whole catchment (Boeije et al. 1999).

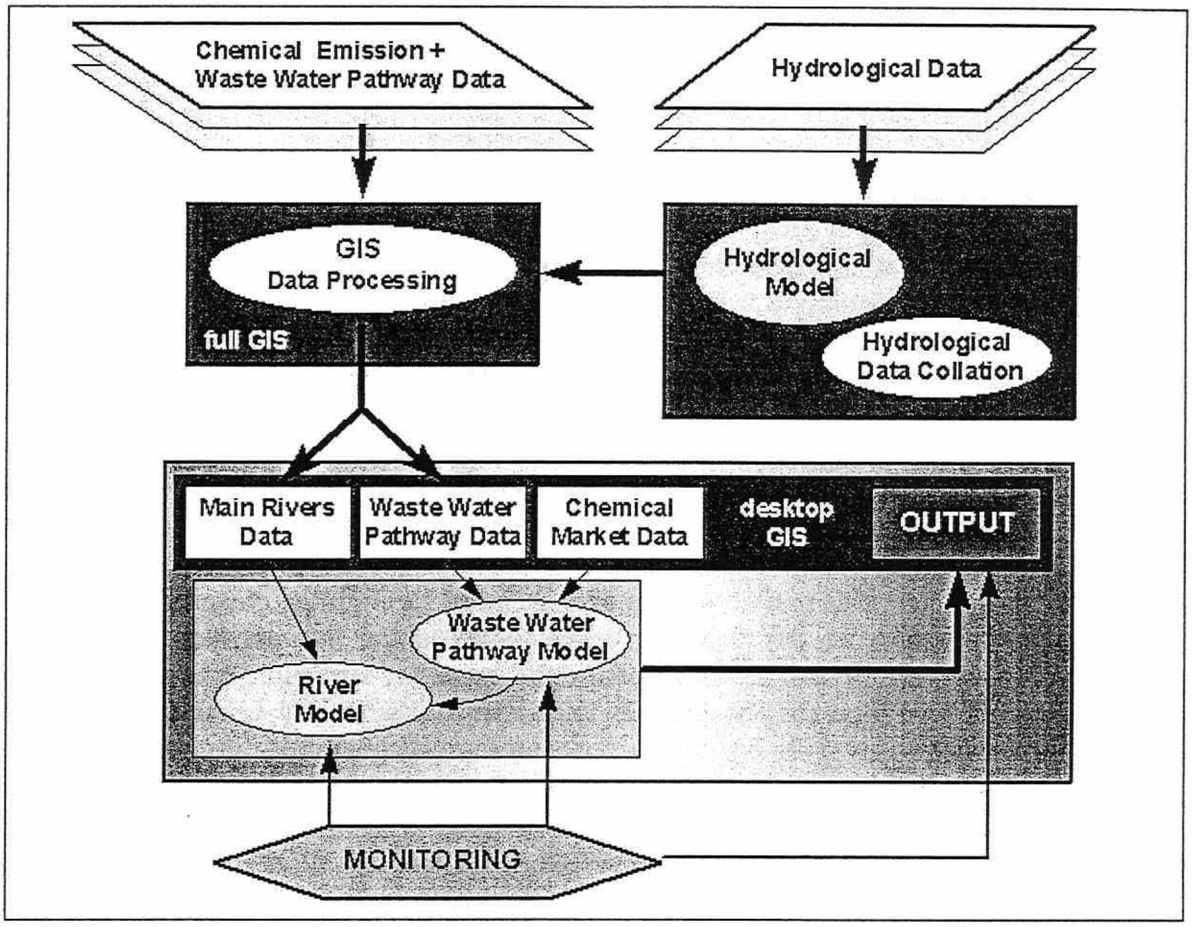

Fig. 1. Modular Approach of the GREAT-ER prototype

3 Pilot study Area Applications

The GREAT-ER software was developed and tested for various catchments in the UK (Yorkshire), Italy (Lambro), Germany (Itter, Rhine, Rur) (Koormann et al. 1998, Schulze et al., 1999) and Belgium (Rüppel). Comprehensive monitoring studies over more than two years were carried out and over 2000 river water and over 600 waste water treatment effluent samples were analysed for the surfactant LAS and Boron. Fig. 2 shows the graphical output of the simulation of the surfactant LAS in the Calder catchment located in Yorkshire (UK). Mean simulated LAS concentrations in the river are shown and classified by colours. Additional background information, e.g. general water quality maps, can also be given by overlaying onto the simulation output.

The measured concentration profiles from the monitoring programs were compared to the simulation results (Fig. 3). Only global parameters, e.g. treatment efficiency of all sewage treatment plants, were used for calibration. The accuracy of the prediction is for most of the investigated catchments below a factor of three and shows the general applicability of GREAT-ER. It is proposed to integrate more catchments located all over Europe and to extend the approach to other environmental media (e.g. soil, estuaries, air) and intermedia mass exchange processes (e.g. run-off, deposition).

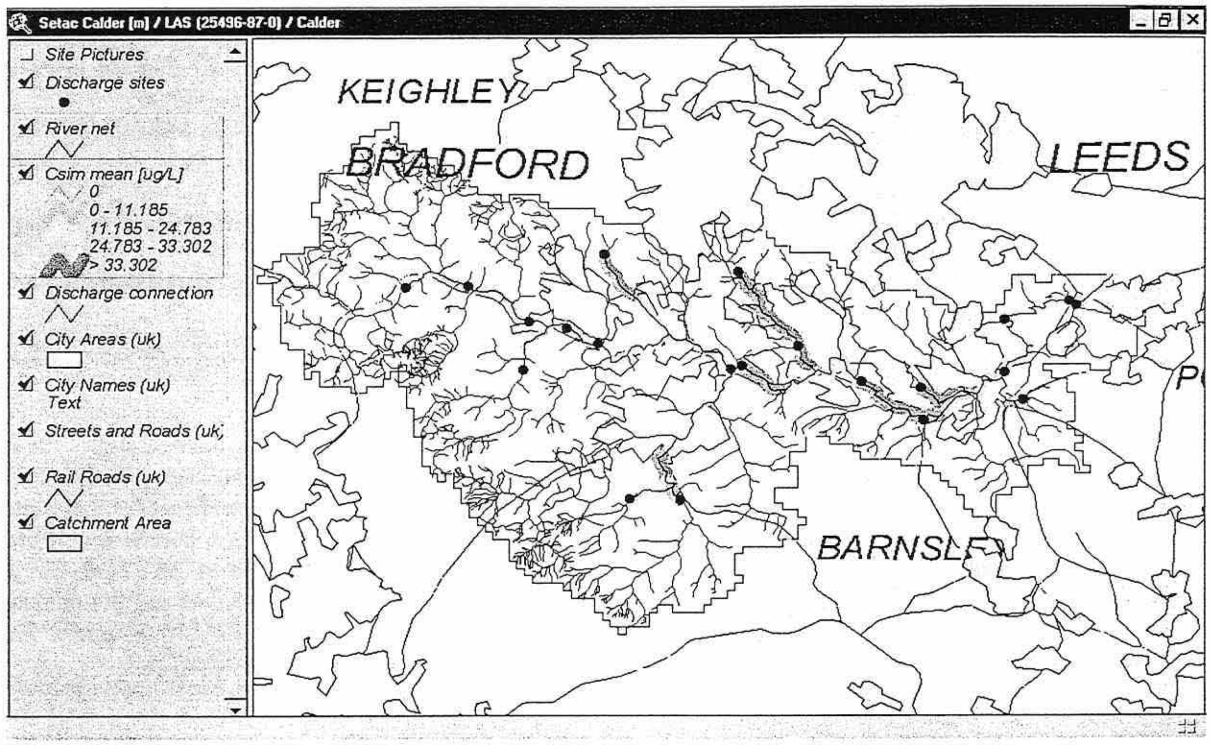

Fig. 2. Colour-coded map of mean simulated LAS concentration in the Calder (UK Yorkshire) catchment

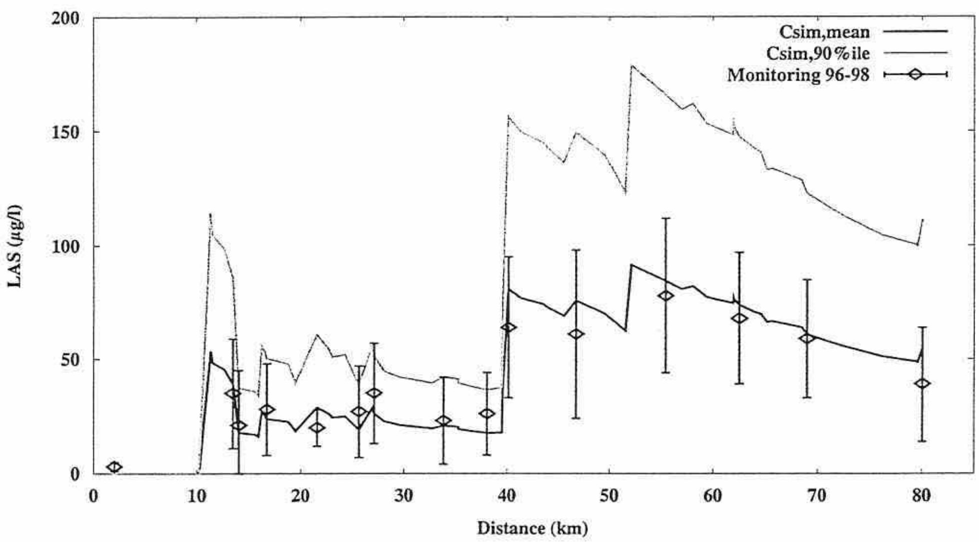

Fig. 3. Concentration profiles of simulated and measured LAS in the Calder (UK Yorkshire) catchment

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Summary of Topic 5: "User Conflicts and Requirements to the Management"

Hermann H. Hahn, President of the ATV, Karlsruhe

I am speaking to you in my capacity as ATV representative. The ATV is an association for water economics, sewage and waste, and I will therefore comment on the use of the instruments presented here from a practical point of view. Naturally, this will also include a personal component.

What has surprised me above all, is that when expounding on the subject of multipurpose use, the use as drinking water, which in the past was the motivation or target of water management, has slipped into the background in the formulation of programs as well as in the discussion. I was especially astonished how few demands the water supply or the drinking-water sector have made. I would like to ask if the drinking-water sector has become one of many users of a water system, while in the past, 25 years ago, it was definitely the priority user.

When closely looking at Mr. Renner's transparencies, one reads "Wupper Group", and underneath it "Water - Man - Environment". The sequence is also interesting, and has definitely changed. Thus, I would like to ask if we really look at muliti-dimensional uses in our management of waters, or whether we continue to see a single priority use, of words drinking water.

Secondly, I asked myself during presentations whether it would be sensible to listen to yet more case studies from water management associations. The Ruhr as the largest association, the Emscher the oldest, and the Wupper the most active. They all lie within a radius of less than 100 km, and yet they have very different philosophies. One could also extend this question (or exercise) somewhat: let's go to France and look at how river catchment area of management works, which has been practised in the Ruhr for nearly 100 years and in France for only 20 years. As the engineer that I am, I would prefer a more pragmatic way.

A third question, which was perhaps more implicitly asked than solved in the presentations, has to do with the "participatory" concept. The expression comes from Mr. Petschow. The "participatory" concepts, - participation, the working together of different participants - remains rather unsolved in the presentations. Clearly stated, especially in Mr. Wind's very interesting presentation, was participation of experts, but also here, not the participation of lay people. A lay person - that's anyone who sits by the waters, who goes fishing on Sundays, or doesn't. How do these people participate? And the Water Framework Directive, as we at the ATV see and welcome it, very clearly speaks of this participatory approach. I have heard too little on this today, also from the Wupper Group. The participatory problem par excellance, of course, is the participation of the different administrative levels in Germany. This question was posed by Mr. Heidborn and not quite satisfactorily answered. I believe that there is a type of research requirement which is possibly new, i.e. the interaction of bodies with different jurisdictions, who are hopefully sitting at around a table. But that is, at present, still an open question.

I remember very clearly that we have already once had a call to formulate management plans in Germany. There was a paragraph on it in the federal water law. It was pushed completely into the background by an amendment. Back then I was informed that this instrument was neither popular with the state waters politicians nor with government headquarters. The Ministry for Research, and later the Ministry for the Environment, financed a demonstration research projects. The latest of these research management plans was the Aller-Oker-Leine plan. Alone the formulation of the plan took five years, by the end, the data was outdated. We should have started right away again. As we can see, there are both positive and negative experiences from this management of river catchment area, and it would certainly be interesting to look at them again.

What would I, as the ATV-representative suggest? I would like to mention two subjects for research. First, the existing data or data graveyards, which should be reactivated through computer sciences. Information research means the preparation of the most varied of formats, the most varied of characteristics that this data contains, in such a way that they become useful. In my opinion this is a great need. First steps have already been made.

Second: I believe the interaction between the social and environmental sciences to be one of the most pressing tasks in the practical implementation of the Water Framework Directive. I know how difficult this is. We partly speak a very different language. I can envisage the discussion-support system, as presented by Mr. Wind, as being a method which can bring these two disciplines into contact with one another.

Discussion in the Synopsis - Final Discussion

Anon:
Mr. Hahn, you said at the end that the use of information technology is the key to success. We will only be able to get to grips with the problem of data acquisition or conversion of old databases within the time period given by the EU Framework Directive, if we start on this immediately. By this I really mean next year and not 2004. The technology is available, everything is there; we just need to structure it so that it can be used for this task.

Hamm:
To finish, I would like to ask a provocative question: what do we really expect from the EU-Framework Directive, when we look at the German situation? The quality of the waters is not exactly bad - does one actually expect an improvement, or in certain cases even a deterioration of quality standards? The relation to ideals intrinsically contains the danger of such a deterioration, and I see a need to clarify how the waters are going to look in the year 2016 after implementation of the EU-Framework Directive.

Hahn:
We at the ATV very much welcome the Water Framework Directive. I don't quite agree with you, Mr. Hamm, that our waters are alright. The liquid phase of our waters is certainly acceptable in many areas. We have spent billions on the Neckar alone. But especially as a waste water person, I can see ourselves soon asking the legitimate question: must we continue to clean waste water and rainwater, or do the main problems lie elsewhere? Until now we haven't asked this question in this way in Germany; the Ministry departments and government headquarters have been more in competition with each other than in co-operation. A common view, in my opinion, will first come through the European Framework Directive. And as you ask so provocatively - could it be that our waters - you say: could look worse - I would say: could look more reasonable. I believe that we have done a lot in the field of water treatment to look for the famous key under the even more famous lamppost, and thus missed the main problem. I can imagine that the cloudiness of some waters could perhaps increase, because we have shifted things, but that the result, viewed globally, is hopefully more reasonable for the waters as a whole. This is a hypothetical answer to a hypothetical question.

Geller:
I would like to mention one of the questions posed too little in the past, which requires further clarification. It has to do with open-cast lakes in their sulphuric acid variety. We are almost unanimously agreed that this is a lake type of its own. One shouldn't try to convert each one of these into "normal waters". One should work out the technical options so that one can do it where it is necessary, and there are research and development needs here. First we must find a way to neutralise an entire (sulphuric) acid lake in situ, and to remove the too-high concentrations of sulphates through sulphate reduction. Such approaches are on the way and must be further developed until a functioning complete process exists.
A problem that is continuing to occur, is that many acid lakes don't lie isolated in hydrological systems, but are included into others. We thus have sulphuric acid flows in the receiving water, where acidic water shouldn't really be. At this boundary we must find a further way of neutralising the outflows from acid lakes in a through-flow plant. Thirdly, in the area of open-cast lakes, and this goes for all lakes, not just the acidic variety, we have a problem with the often-practised filling of empty pits with nutrient-rich river water. Our wealth of experience doesn't reach the trophic system here. Our experiences stem from a balanced balance, in which the inflow and outflow are always approximately equal year for

reached according to the phosphor loads present. These experiences cannot be used when one fills an empty pit as a one-off, and the water input then more or less ceases. The relationship between the input phosphor and the later behaviour, the effects, is different for a lake which forms in this way, and needs to be researched.

Finally, a comment on the difficulty with scaling levels. I has been suggested here that we check the fractal approach for feasibility. In the abiotic area, the approach seems to work surprisingly well, within certain boundaries. However, with the various integration levels in the ecosystem, we have qualitative boundaries. As soon as a new integration level is reached, this larger system shows properties which the individual parts didn't have and can't be derived from these individual parts. Just one example: A mature ecosystem - plankton in a lake - show generally well-predictable reactions. If I input phosphor into the lake, then it reacts in a predictable way. If, however, I want to predict how specific plankton species increase or decrease on the level below, my predictions become very weak.

Ostendorp:
Another point has been somewhat lacking in the discussion, namely: I have always believed that lakes also belong to river catchment areas, and that these lakes, whether heavily served by flowing waters or not, have been poorly mentioned. I would like to encourage people to take this aspect into consideration, especially in the continuation of research aspects. But I could well imagine that things which affect the lakes, also affect their shores, in some points with effects much more than that which has been discussed here. I don't mean so much the substances side, i.e. the input from diffuse sources on the shores, but above all the structural loads on shores through shore building, heaping, and through use by tourists and recreation centres. All of these things have an effect on the hydrology of the lakes, and also the biocoenoses.

Geller:
Thank you for this addition, Mr. Ostendorp. I can only explicitly support this. We have lakes which are very strongly connected to the flowing waters network, and other lakes which are very isolated and have neither a surface inflow, nor a surface outflow. On this, the American colleagues Magnuson & Kratz 1998 suggested a differentiated hierarchy at the last SIL limnology congress in Dublin, which sorts the various lakes according to their level of connection to the flowing system.

Kohmann:
Mr. Geller, I would like to add to the point fractals and biology. I didn't understand this to mean that we can picture populations through fractals. But I think fractal geometries play a large role in the landscape. The development of banks and the landscape by rivers are fractal quantities. If I can describe these abiotics with such statistical, fractal, scale invariant values, then I hope to obtain more information which are relevant to areas of use in the direction of biology.

Geller:
From this point of view, I would naturally agree straight away. But the biological part of the ecosystem is out of the reach of fractalisation.

We have thus reached the end of our conference. I thank all speakers, discussion participants and chair people who have made special efforts here. I hope for us all, that the odd research partnership results from this conference, and that some of the topic suggestions are taken up by potential partners. I, myself, am glad to be at your disposal as a communication partner for research on open-cast lakes. Thank you very much and I wish you a good trip home.

APPENDIX

List of Contributors

Barth, Hartmut, European Commission, DG XII, 200, Rue de la Loi, B-1049 Brüssel, Belgien, Tel.: +32-2 / 295-6552, Fax: +32-2 / 295-2097, E-Mail: hartmut.barth@dg12.cec.be

Behrendt, Dr. H., Institut für Gewässerökologie und Binnenfischerei, Abt. Limnologie von Flußseen, Müggelseedamm 260, D-12587 Berlin, Tel.: +49-30 / 648407-17, Fax: +49-30 / 64807-10

Borchardt, Dr. Dietrich, Universitäts-GH Kassel, FG Siedlungswasserwirtschaft, Kurt-Wolters-Str. 3, D-34125 Kassel, Tel.: +49-561 / 804-3244, Fax: +49-561 / 804-3642, E-Mail: borchard@htz.uni-kassel.de

Bosenius, Ministerialrat Udo, Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, Postfach 120629, D-53048 Bonn

Braun, Dr. Peter, Bayerisches Landesamt für Wasserwirtschaft, SG 23, Lazarettstr. 67, D-80636 München, Tel.: +49-89 / 1210-1510, e-mail: Peter.Braun@lfw.bayern.de

Chovanec, Univ. Doz. Dr. Andreas, Umweltbundesamt Wien, Spittelauer Laende 5, A-1090 Wien, Österreich, Tel.: +41-1 / 31304-3680, Fax: +41-1 / 31304-3700, E-Mail: chovanec@ubavie.gr.at

Engelen, Guy, Research Institute for Knowledge Systems, PO Box 403, NL-6200 AL Maastricht, Niederlande

Fritz, Prof. Dr. Peter, Wissenschaftlicher Geschäftsführer, UFZ-Umweltforschungszentrum Leipzig-Halle GmbH, Permoserstr. 15, D-04318 Leipzig, Tel.: +49-341 / 235-0, Fax: +49-341 / 235-2791, E-Mail: gf@gf.ufz.de

Geller, Prof. Dr. Walter, UFZ-Umweltforschungszentrum Leipzig-Halle GmbH, Leiter der Sektion Gewässerforschung, Außenstelle Magdeburg, Brückstr. 3a, D-39114 Magdeburg, Tel.: +49-391 / 8109-101, Fax: +49-391 / 8109-111, E-Mail: geller@gm.ufz.de

Grath, Dipl.-Ing. Johannes, Umweltbundesamt Wien, Spittelauer Laende 5, A-1090 Wien, Österreich

Griffiths, Dr. Martin, Environment Acency, Head of the Department of Water Quality, Rio House, Waterside Drive, Aztec West Almondsburry, Bristol S32 4DU, Großbritannien, Tel.: +44-1454 / 624-420, Fax: +44-1454 / 624-032, E-Mail: wendy.johnson@ environment-agency.gov.uk

Hahn, Prof. Dr. Hermann H., Abwassertechnische Vereinigung (ATV), Theodor-Heuss-Allee 12, D-53773 Hennef, Fax: +49-721 / 661214

Herbst, Dr. Volkhard, Niedersächsisches Landesamt für Ökologie, An der Scharlake 39, D-31135 Hildesheim, Tel.: +49-5121 / 509-791, Fax: +49-5121 / 509-794, E-Mail: volkhard.herbst@hi.nloe.niedersachsen.de

Hildebrand, Alexander, Universität Freiburg, Institut für Hydrologie, Fahnenbergplatz, D-79098 Freiburg, Tel.: +49-761/203-3519, Fax: +49-761/203-3594, e-mail: hildalex@uni-freiburg.de

Irmer, Dr. Ulrich, Umweltbundesamt, Bismarckplatz 1, D-14193 Berlin, Tel.: +49-30 / 8903-2312, Fax: +49-30 / 8903-2965, E-Mail: ulrich.irmer@uba.de

Keizers, Nicole, INFRAM BV, PO Box 81, NL-3890 AB Zeewolde, Niederlande

Kohmann, Dr. Fritz, Bundesanstalt für Gewässerkunde, Kaiserin-Augusta-Anlagen 15-17, D-56068 Koblenz, Tel.: +49-261 / 1306-5320, Fax: +49-261 / 1306-5302, E-Mail: kohmann@bafg.de

Koller-Kreimel, Dr. Veronika, Bundesministerium für Land- und Forstwirtschaft, Marxergasse 2, A-1030 Wien, Österrreich

Koormann, Frank, Universität Osnabrück, Institut für Umweltsystemforschung, D-49069 Osnabrück

Leibundgut, Prof. Dr. Christian, Universität Freiburg, Institut für Hydrologie, Fahnenbergplatz, D-79098 Freiburg, Tel.: +49-761 / 203-3530, Fax: +49-761 / 203-3594, E-mail: hydrology@uni-freiburg.de

Lübbert, Eckhard, MinDir Dr., Bundesministerium für Bildung und Forschung (BMBF), Heinemannstr. 2, D-53170 Bonn, Tel.: +49-228 / 57-0

Luckner, Prof. Dr.-Ing. habil. Ludwig, DGFZ, Dresdner Grundwasserforschungszentrum e.V., Meraner Str. 10, D-01217 Dresden, Tel.: +49-351 / 4050661, Fax: +49-351 / 4050669, E-Mail: lluckner@dgfz.de

Matthies, Prof. Dr. Michael, Universität Osnabrück, Institut für Umweltsystemforschung, D-49069 Osnabrück, Tel.: +49-541 / 969-2576, Fax: +49-541 / 969-2599, E-Mail: Matthies@usf.uni-osnabrueck.de

Mioduszweski, Prof. Dr. Waldemar, Institute for Land Reclamation and Grassland Farming, Dept. of Water Resources in Agriculture, Falenty, PL-05-090 Raszyn, Polen, Tel.: +48-22 / 7200531, Fax: +48-22 / 6283763, E-Mail: w.mioduszewski@imuz.edu-pl

Moog, Univ. Prof. Dr. Otto, Universität für Bodenkultur, Max-Emanuel-Str. 17, A-1180 Wien, Österreich

Nützmann, Dr. Gunnar, Institut für Gewässerökologie und Binnenfischerei, Rudower Chaussee, D-12484 Berlin, Tel.: +49-30 / 6392-4483, Fax: +49-30 / 6392-4482, E-Mail: nuetzmann@igb-berlin.de

Petschow, Dr. U., Institut für ökologische Wirtschaftsforschung (IÖW), Giesebrechtstr. 13, D-10629 Berlin, Tel.: +49-30 / 8845940

Philippitsch, Dr. Rudolf, Bundesministerium für Land- und Forstwirtschaft, Marxergasse 2, A-1030 Wien, Österrreich

Reijngoud, Tobias, Ministry of Transport, Public Works and Watermanagement, Department of Watermanagement, PO Box 2301, NL-8901 JH Leeuwarden, Niederlande

Renner, Dr.-Ing. Joachim, Wupperverband, Postfach 202063, D-42220 Wuppertal, Tel.: +49-202 / 583-238, Fax: +49-202 / 583-302

Rode, Dr. Michael, UFZ-Umweltforschungszentrum Leipzig-Halle GmbH, Leiter des Projektbereichs Fluß- und Seenlandschaften, Außenstelle Magdeburg, Brückstr. 3a, D-39114 Magdeburg, Tel.: +49-391 / 8109-650, Fax: +49-391 / 8109-699, E-Mail: rode@gm.ufz.de

Rose, Dr. Udo, Erftverband, Pfaffendorfer Weg 42, D-50126 Bergheim, Tel.: +49-2271 / 88-295, Fax: +49-2271 / 88-210

Schubert, Dipl.-Ing. Jürgen, Stadtwerke Düsseldorf, Luisenstr. 105, D-40215 Düsseldorf, Tel.: +49-211 / 821-2396, Fax: +49-211 / 821-3002

Schulze, Carsten, Universität Osnabrück, Institut für Umweltsystemforschung, D-49069 Osnabrück

Simon, Dipl.-Ing. Manfred, Internationale Kommission zum Schutz der Elbe (IKSE), Fürstenwallstr. 20, D-39104 Magdeburg, Tel.: +49-391 / 541-4845, Fax: +49-391 / 541-0995, E-Mail: IKSE.MKOL@t-omline.de

Thiele, Dr. Volker, biota GmbH, Am Augraben 2, D-18273 Güstrow, Tel.: +49-3843 / 236160

Tockner, Klement, ETH/EAWAG, Institut für Limnologie, Überlandstr. 133, CH-8600 Dübendorf, Schweiz

Uehlinger, Urs, ETH/EAWAG, Institut für Limnologie, Überlandstr. 133, CH-8600 Dübendorf, Schweiz

Wagner, Jan-Oliver, Universität Osnabrück, Institut für Umweltsystemforschung, D-49069 Osnabrück

Ward, Prof. Dr. J.V., ETH/EAWAG, Institut für Limnologie, Überlandstr. 133, CH-8600 Dübendorf, Schweiz, Tel.: +41-1 / 823-5171, Fax: +41-1 / 823-5315, E-Mail: jvward@eawag.ch

Weingertner, Dipl.-Ing. Patrick, Agence de l'eau Rhin-Meuse, Route de Lessy, Rozierieulles, F-57161 Moulins les Metz, Frankreich, Tel.: +33-3 / 8734-4773, Fax: +33-3 / 8734-4985, E-Mail: weingertner@eau-rhin-meuse.fr

Wind, Prof. Dr. Herman, University of Twente, Drienerlolaan 5, NL-7522 NB Enschede, Niederlande, Tel.: +31-53 / 489-3546, Fax: +31-53 / 498-4040, E-Mail: h.g.wind@sms.utwente.nl

UFZ-Umweltforschungszentrum Leipzig-Halle GmbH
Sektion Gewässerforschung
Brückstraße 3A
39114 Magdeburg
Telefon ++49(391)8109-101
Telefax ++49(391)8109-111