UN/ECE Task Force on Monitoring & Assessment
under the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Helsinki, 1992)

Work Programme 1997-2000

Guidelines on Monitoring and Assessment of Transboundary Rivers

First review of the 1996 Guidelines on Water-quality Monitoring and Assessment of Transboundary Rivers

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Preface

These Guidelines on monitoring and assessment of transboundary rivers were finalised by the ECE Task Force on Monitoring and Assessment and discussed and adopted at its seventh meeting in Bled (Slovenia) in November 1999 as part of the 1997-2000 workplan under the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Helsinki, 1992).
These Guidelines were endorsed by the Parties to the Convention at their second meeting (The Hague, Netherlands, 23-25 March 2000).

These Guidelines are a first review of the ECE Guidelines on water-quality monitoring and assessment of transboundary rivers, which were adopted in 1996 by the ECE Committee on Environmental Policy and published in the ECE Water Series. A review after a three-year period was already announced in the introduction to the 1996 Guidelines.

The review was carried out by an expert group established by the Task Force in November 1998. The group was made up of M. Adriaanse (project leader, Institute for Inland Water Management and Waste Water Treatment (RIZA), Netherlands), Zs. Buzas (Ministry of Transport, Communication and Water Management, Hungary), R. Enderlein (ECE secretariat), M. Landsberg-Uczciwek (State Inspectorate for Environmental Protection, Poland), P. Rončak (Slovak Hydrometeorological Institute, Slovakia) and J. Timmerman (Institute for Inland Water Management and Waste Water Treatment (RIZA), Netherlands). Various other national and international experts made useful comments and proposals.

The experience with implementing the 1996 Guidelines in a series of pilot projects in European river basins played an important role in this review.

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1. Introduction and general recommendations

1. Objectives and character of the Guidelines

These Guidelines are based on the 1996 Guidelines on water-quality monitoring and assessment of transboundary rivers [1, 2]. They are intended to assist ECE Governments and joint bodies (e.g. bilateral or multilateral river commissions) in developing and implementing procedures for monitoring and assessing transboundary waters in their region[1]. The target group comprises decision makers in ministries or agencies with responsibilities for the environment, water management or human health and all those who are responsible for managing the monitoring and assessment of transboundary rivers.

The character of these Guidelines is strategic rather than technical[2]. The Guidelines are not legally binding. They are based on the ecosystem

Major amendments and additions to the 1996 Guidelines

1. Particular attention was given to the further development of recommendations for monitoring and assessing of water-quantity aspects. This concerns especially floods (protection, flood risks, forecasting), water sharing and water scarcity (waterbalances), river regulation, operation of reservoirs and ice problems.
2. The Guidelines have also been revised in the light of the recently adopted Protocol on Water and Health.
3. The findings of the pilot projects on the implementation of the 1996 Guidelines, which covered eight river basins in the UN/ECE region, have also given rise to modifications and additions.
4. More attention has been given to the analysis of water management issues in river basins, as the outcome of this analysis defines the scope of environmental information which is relevant to the respective transboundary river and its catchment area. In transboundary river basins, there is generally an urgent need for good practices to identify problems and to find the cause- and-effect relations between pressures and transboundary impact.
5. The role of inventories and preliminary surveys has been further elaborated, as these activities precede the regular monitoring activities. Inventories and preliminary surveys are also excellent tools for problem analysis.
6. Special attention has been given to the evaluation of legislation. Comparison with internationally accepted risk assessment criteria is required. There is also a need to compare the existing national legislative systems with recent developments in EU legislation, for example, the draft Directive establishing a framework for Community action in the field of water policy.
7. The role of indicators in environmental information has been emphasised. Environmental information should not only focus on the state of the transboundary river, but also on the pressures and the driving forces that can affect the river and/or its catchment area now and in the future. Information on the impact of that state and the response of society is indispensable and is politically relevant to decision-making. These considerations are in line with recent developments by leading international institutions, such as the European Environment Agency (EEA) and the Organisation for Economic Cooperation and Development (OECD).
8. Recommendations on approximate calculations (estimates) of pollution loads from point sources and diffuse sources have also been incorporated, as such estimates are of the utmost importance for the receiving waters (lakes, estuaries, seas) as well as for pollution abatement strategies in river basins.
9. The institutional aspects have been further elaborated, as have the links to the relevant provisions of the Convention.

Note:
[1] In the Guidelines, "region" means a geographical area which covers at least one transboundary catchment, unless otherwise specified (e.g. ECE region).
[2] For technical details, the background reports prepared by the task force in 1995 ([5] to [9]), and international literature and handbooks on operational practices of monitoring and assessment should be consulted (see references).

approach in water management [16]. Consequently, the Guidelines take into account the entire water system in the catchment area of a transboundary river, including the various components of the aquatic and riparian ecosystems it supports.
Whenever reference is made to transboundary rivers, it is understood that the Guidelines cover both their first-order and other tributaries, whether or not they are transboundary.
Guidelines on the monitoring and assessment of other types of transboundary waters have recently been drafted, e.g. the Guidelines on monitoring and assessment of transboundary groundwaters [17] or will be drawn up soon, e.g. Guidelines on monitoring and assessing international lakes and estuaries.

After a period of four years, amendments and additions to the river Guidelines were necessary, especially in view of the international strategic and scientific developments of the past few years. Considerable experience was also gained with best practices to carry out monitoring and assessment activities under the Convention.

2. The need for monitoring and assessment

Both the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Helsinki, 1992) and its Protocol on Water and Health (London, 1999) include provisions on monitoring and assessment [3,4].

The Convention covers such items as monitoring and assessment of transboundary waters; the assessment of the effectiveness of measures taken to prevent, control and reduce transboundary impact; the exchange

The need for monitoring and assessment arises from the Convention

The Convention is intended to strengthen local, national and regional measures to protect and use transboundary surface waters and groundwaters in an ecologically sound way. It obliges its Parties particularly to prevent, control and reduce the pollution of transboundary waters with hazardous substances, nutrients, bacteria and viruses. The precautionary principle and the polluter-pays principle have been recognised as guiding principles in the implementation of such measures, together with the requirement that water management should meet the needs of the present generation without compromising the ability of future generations to meet their own needs. This will protect and conserve not only water resources but also soil, flora, fauna, air, climate, landscape and cultural heritage.

To prevent, control and reduce transboundary impact, emission limits for discharges from point sources are to be based on the best available technology. The Parties are also required to issue authorisations for waste-water discharges, adopt water-quality objectives and apply at least biological or equivalent processes to treat municipal waste-water. Moreover they have to develop and implement best environmental practices to reduce the input of nutrients and hazardous substances from agriculture and other diffuse sources.

Parties bordering the same transboundary waters have to conclude specific bilateral or multilateral agreements that provide for the establishment of joint bodies (e.g. river or lake commissions). They are also required to consult each other on any measures to be carried out under the Convention, jointly set water-quality objectives, develop concerted action programmes and provide assistance to each other in critical situations.

of information between riparian countries and public information on the results of water and effluent sampling. Riparian parties should also harmonise their rules for setting up and operating monitoring programmes, including measurement systems and devices, analytical techniques, data processing and evaluation procedures.

Under the Protocol on Water and Health, effective systems for monitoring and assessing situations likely to result in outbreaks or incidents of water-related disease and for responding to them or preventing them are to be established. This will include inventories of pollution sources, surveys on high-risk areas for microbiological contamination and toxic substances, and reporting on infectious and other water-related diseases. The Parties will also develop integrated information systems to handle information about long-term trends in water and health, current concerns and past problems and successful solutions and the provision of such information to the authorities. Moreover, comprehensive national and/or local early-warning systems are to be established, improved or maintained.

Major provisions of the Protocol on Water and Health linked to monitoring

Adequate supplies of wholesome drinking water which is free from any micro-organisms, parasites and substances which, owing to their numbers or concentration, constitute a potential danger to human health: this shall include the protection of water resources which are used as sources of drinking water, treatment of water and the establishment, improvement and maintenance of collective systems.

Adequate sanitation of a standard which sufficiently protects human health and the environment: this shall in particular be done through the establishment, improvement and maintenance of collective systems.

Effective protection of water resources used as sources of drinking water, and their related water ecosystems, from pollution from other causes, including agriculture, industry and other discharges and emissions of hazardous substances: this shall aim at the effective reduction and elimination of discharges and emissions of substances judged to be hazardous to human health and water ecosystems.

Sufficient safeguards for human health against water-related disease arising from the use of water for recreational purposes, from the use of water for aquaculture, from the water in which shellfish are produced or from which they are harvested, from the use of waste-water for irrigation or from the use of sewage sludge in agriculture or aquaculture.

3. River-basin management

The Convention fundamentally focuses on the river-basin approach, as the issues of pollution, ecological quality and quantitative aspects of transboundary waters are common to all riparian countries. Targets, programmes and measures should be drawn up jointly. All riparian countries should be involved in monitoring and assessment activities to support river-basin management with adequate and reliable information.

4. Downstream estuarine and marine environment

River systems are considered to include their tidal estuaries with often dominating sedimentation problems (polluted sediments, dredging). Given the intense interaction between rivers and the seas into which they discharge, it is essential to harmonise the approaches to monitoring and assessment with those adopted under the existing sea treaties. Further reference to cooperation with joint bodies established to protect the marine environment is provided in chapter 9.

5. Integrated approach

Adequate understanding of the human uses and the ecological functioning of a river, the main issues (for a description see paragraph 2.2 and table 1), and the cause-effect relations between issues and uses indicate principally that a river is more than just water. The state of the river and related ecosystem should therefore be assessed in an integrated manner, based on criteria that include water quality and quantity for different human uses as well as flora and fauna.
A systematic analysis and assessment of water quality, flow regimes and water levels, habitats, biological communities, sources and fate of pollutants, as well as mass balance derivations, should be conducted in order to provide reliable information.

Rivers are part of the whole water cycle. To monitor rivers, their interaction with other waters should be understood. This refers to groundwaters, as explained in more detail in the Guidelines on monitoring and assessment of transboundary groundwaters [17]. It also refers to other surface waters (lakes and reservoirs) and the relation between fresh water and marine waters.

DEFINITIONS used in these guidelines

Monitoring:
Monitoring is the process of repetitive observing, for defined purposes, of one or more elements of the environment according to pre-arranged schedules in space and time and using comparable methodologies for environmental sensing and data collection. It provides information concerning the present state and past trends in environmental behaviour.

Assessment:
Evaluation of the hydrological, morphological, physico-chemical, chemical, biological and/or micro-biological state in relation to reference and/or background conditions, human effects, and/or the actual or intended uses, which may adversely affect human health or the environment.

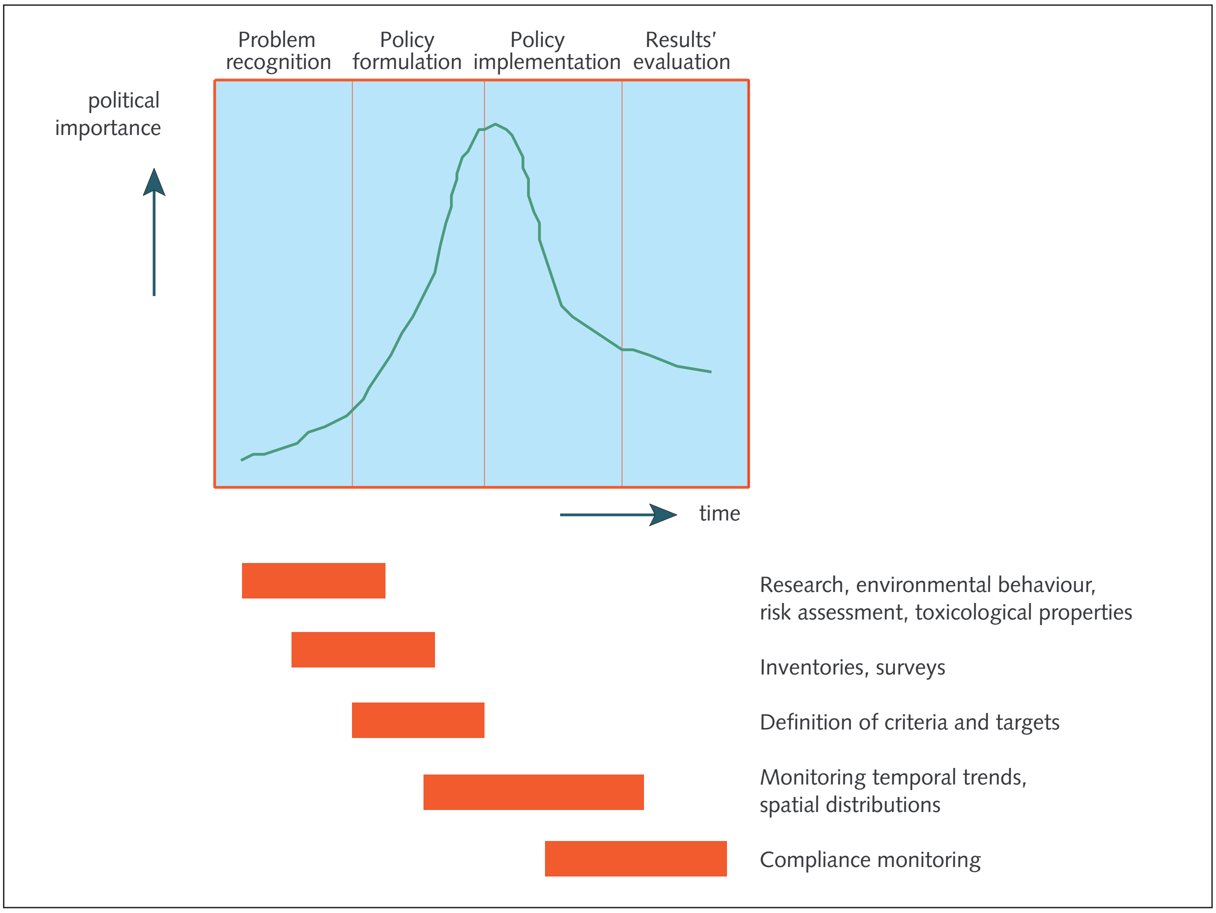
Survey:
A finite duration, intensive programme to measure, evaluate and report the state of one or more components of the environment for a specific purpose.

6. Monitoring and the policy life cycle

The information needed to assess transboundary rivers or to address a problem linked to these waters can be derived from monitoring and other investigations. This can be demonstrated with the help of the policy life cycle [18, 19]. Figure 1 shows that a problem and the policy needed to resolve it pass through successive phases. Handling the "problem recognition" phase requires different kind of activities than the "policy formulation", "policy implementation" and "results' evaluation" phases. The first phase needs research. Thereafter, inventories and surveys are important. It will be necessary to set criteria and targets, start monitoring temporal trends and spatial distribution, and finally focus on compliance monitoring.

With regard to the link between this policy life cycle and the monitoring and assessment of transboundary waters, three major activities can be distinguished: analysis of water management activities, drawing-up of an assessment strategy, and monitoring. These are elaborated in the following chapters and sections.

Figure 1
Policy life cycle



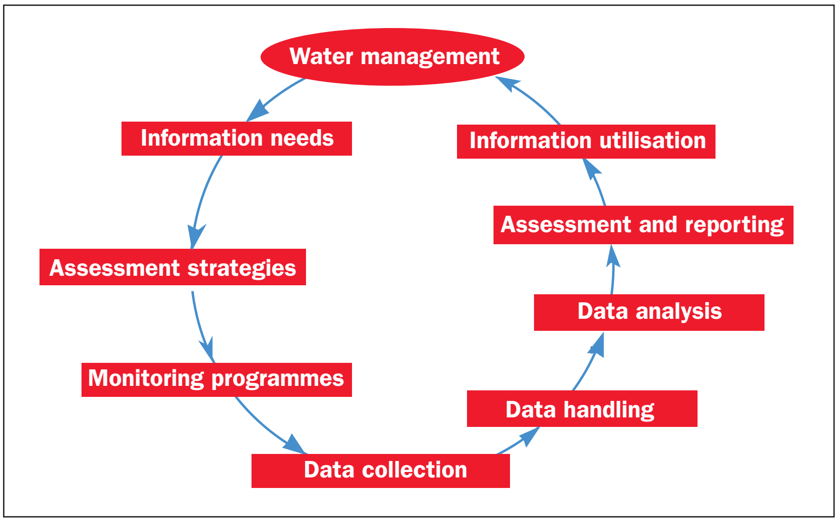
7. Monitoring cycle

The process of monitoring and assessment should principally be seen as a sequence of related activities that starts with the definition of information needs, and ends with the use of the information product. This cycle of activities is shown in figure 2.

Successive activities in this monitoring cycle should be specified and designed based on the required information product as well as the preceding part of the chain. In drawing up programmes for the monitoring and assessment of river basins, riparian countries should jointly consider all stages of the monitoring process.

The evaluation of the obtained information may lead to new or redefined information needs, thus starting a new sequence of activities. In this way, the monitoring process will be improved.

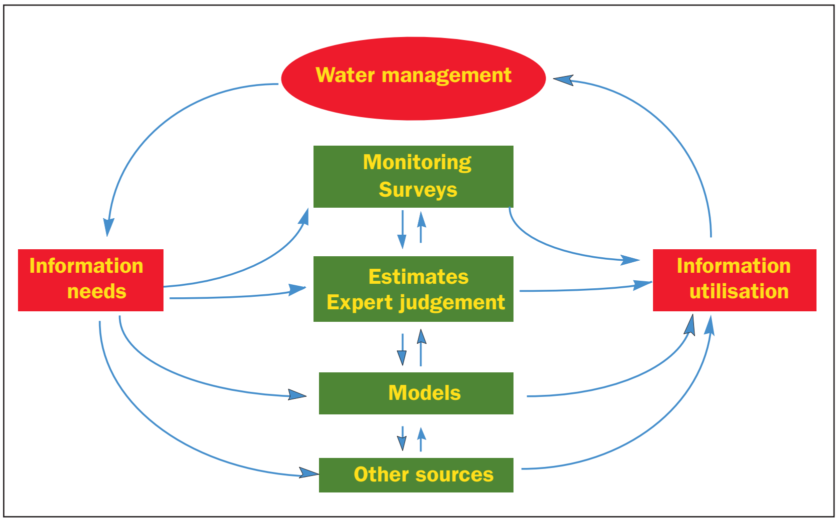
Figure 2
Monitoring cycle



8. Information sources

Information for river-basin management can be obtained from primary sources such as monitoring programmes, computations and predictions with models, expert judgement, and other sources (e.g. databases) containing statistical or administrative information (see figure 3). Using these information sources in combination is the most effective and often reduces costs.

Figure 3
Sources of information



9. National programmes

The results of national monitoring programmes carried out under the responsibility of national or local[3] governments will form the basic information sources under the Convention.

Note:
[3] Following the terminology used in the Protocol on Water and Health [4], "local" refers to all levels of territorial unit below the level of the State.

10. Revision of the Guidelines

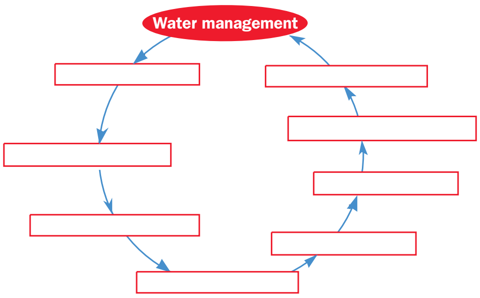
The Meeting of the Parties to the Convention will evaluate progress made in the implementation of these Guidelines and, if need be, make arrangements to revise them.

To this end, the Guidelines will be reviewed by the Working Group on Monitoring and Assessment on the basis of experience gained with the implementation in pilot projects carried out in various transboundary catchment areas in the ECE region.

11. Structure of the Guidelines

The monitoring cycle (see figure 2) was taken as the basis for structuring the Guidelines. However, the strategic character of the Guidelines implies that much attention was paid to the first steps, including the analysis of water management, information needs and the strategies of monitoring and assessment (chapters 2,3 and 4). Monitoring programmes and measurements are dealt with in more detail in chapter 5. Data collection, data handling and data analysis are combined in chapter 6. Chapter 7 describes the steps from data to information use and includes data analysis and reporting. Quality management is dealt with in chapter 8, and chapter 9 covers institutional aspects.

2. Identification of river-basin management issues



2.1 Introduction

1. Multi-functional approach

Various functions and uses - both human and ecological - of water bodies can be identified from existing policy frameworks, international conventions, bilateral and multilateral agreements and strategic action plans for river basins and seas.
Uses may compete or even conflict, in particular if water is scarce or its quality deteriorating. A multi-functional approach tries to strike a balance between all desired uses, including ecosystem functioning. It allows the introduction of a hierarchy in uses and provides flexibility for the different levels of development of water resources management policies and for prioritisation in time. This could be important for those countries where basic needs like the supply of wholesome drinking water are so urgent that other uses will have lower priority, or for countries where water resources have deteriorated to such an extent that "higher" uses can be gradually restored only over a long period of time and in priority order.

2. Sources of conflicts

Water management is always facing conflicts of interests. Most issues in a river basin are more or less closely linked with these conflicts. The sources of conflicts are threefold:

a) The competition for water (consumptive uses vs. non-consumptive uses, e.g. navigation, the river as a recipient of waste water);
b) The conflicts between all human interventions and nature (and vice versa, e.g. when watercourses should be revitalised);
c) Different interests of riparian countries (e.g. upstream/downstream countries, political priorities).

In the analysis of water management issues, political priorities should be made clear; the analysis of sources of conflicts is a precondition for the setting of priorities.

3. River-basin management plan

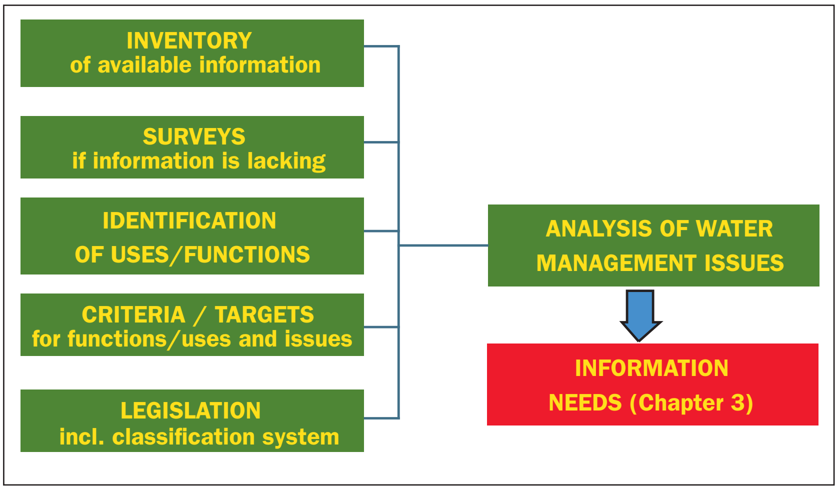
The preparation of concerted (harmonised or joint) water management plans for the transboundary river basin falls within the scope of the Convention. These plans are based on the results of existing monitoring programmes. The basic requirements for a more developed monitoring and assessment programme should be derived from these water management plans. These refer to water transfers, the intake and release of used water (uses and discharges, irrigation and drainage of excess water) and flood protection.

They also include aspects of land use, deforestation, erosion and diffuse pollution of water, etc. Preferably they should also include an analysis of other information needs, a strategy for tailor-made monitoring and assessment, the sharing of information among the riparian countries, and the assessment of the effectiveness of measures taken under these plans.

4. Analysis of water management issues

The information needs for the management of a transboundary river should be based on agreed management issues and the decision-making process in river-basin management. To identify issues and priorities for the protection and use of a transboundary river, several activities are needed, such as: the identification of functions and uses of the river basin, inventories on the basis of available (and accessible) information, surveys if information is lacking, the identification of criteria and targets, and the evaluation of the water legislation in the riparian countries (figure 4). A well developed international river-basin management plan provides this.

Figure 4
Water management analysis

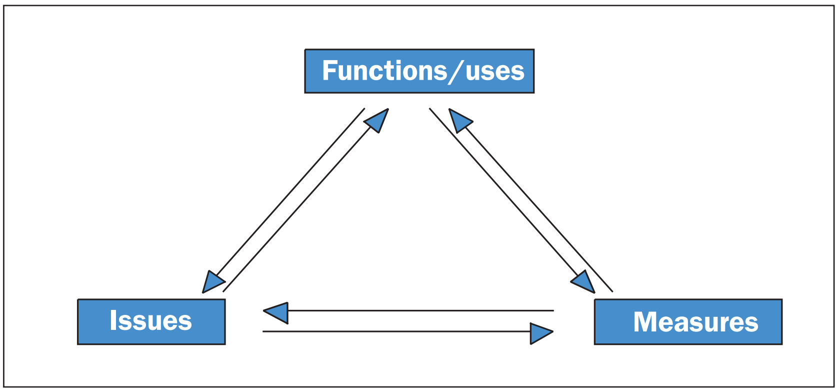


2.2 Identification of issues

1. Core elements in water management

The need for information should be based on the core elements in the management of a river basin and on the active use of information in the decision-making process. These elements can be defined as the functions and uses of the river, the issues (where criteria for use and functioning cannot be met) and measures with their specific targets and impacts on the overall functioning of the river basin.

Figure 5
Core elements in water management



An issue can be seen as an existing or future problem or threat (e.g. flooding). An issue can also indicate a positive impact on parts of the environment as is partly the case with eutrophication and the production of fish. The core elements and their interactions are shown in figure 5.

2. Elements of the analysis

Riparian countries need to individually identify and collectively agree upon:

a) Specific human uses and the ecological function of a river basin;
b) The issues with an impact on human uses and the ecological functioning of the river;
c) The existing and future pressures which constitute the issues;
d) The relation between the state of the river basin and the functioning of receiving waters (reservoirs, lakes, estuaries, seas);
e) Criteria for uses and functions (e.g. water-quality objectives, design levels for flood protection, definition of good ecological quality);
f) Quantified management targets (e.g. pollution reduction targets, flood risk reduction), to be implemented within a specified time period.

In doing so, they should take into account actual or envisaged measures, policies and action plans in water management.

3. Functions and issues

This specification of human uses and the ecological functioning of a river and the identification of pressures, issues and targets should include the full range of qualitative and quantitative aspects in river-basin management (see table 1).

Table1
Examples of relations between functions/uses and issues of a river basin

FUNCTIONS/USES / ISSUES	Human health	Ecosystem functioning	Fisheries	Recreation	Drinking water	Irrigation	Industrial use	Hydro power	Transport medium[1]	Navi-gation
Flooding	x	x		x					x	x
Scarcity	x	x	x	x	x	x	x	x	x	x
Erosion / sedimentation	x	x			x			x	x	x
Biodiversity		x	x	x						
River continuity		x	x	x				x	x	x
Salinisation		x			x	x	x			
Acidification[2]		x	x		x					
Organic pollution[3]	x	x	x	x	x					
Eutrophication	x	x	x	x	x	x	x			
Pollution with hazardous substances[4]	x	x	x	x	x	x				

x Main impact on functions/uses (problem).
1 Transport of water, ice, sediments and waste water.
2 Dry/wet acid deposition, eventually followed by leaching to groundwaters or run-off to surface water.
3 Organic matter and bacteriological pollution by waste water discharge.
4 Specific substances, e.g. radio-nuclides, heavy metals, pesticides.

4. River-basin-specific issues and priorities

As the Convention focuses on the river-basin approach, riparian countries should identify the issues that are specific to their transboundary river and indicate priorities. These priority issues and targets determine to a large extent the information needs in the context of transboundary cooperation. Issues, targets and information needs identified at different levels (global scale, ECE region-wide, river basin and local levels) should be clearly distinguished.

DEFINITIONS used in these Guidelines

Criterion:
A principle, an objective, a standard or any other kind of statement that a thing is judged by. More specifically, the Guidelines refer in some chapters to water-quality criteria, water-quality objectives or water-quality standards.

Water-quality criterion:
A numerical concentration or descriptive statement recommended to support and maintain a designated water use. Water-quality criteria are developed by scientists and provide basic scientific information about the effects of water pollutants on a specific use (e.g. drinking water) or function (e.g. support of aquatic life).

Water-quality objective:
A numerical concentration or descriptive statement which has been established to support and to protect the designated uses of water at a specific site, river basin or part(s) thereof. The drawing-up of water-quality objectives is not a scientific task but rather a political process that requires a critical assessment of set priorities, present and future water uses, forecasts of industrial and agricultural development, and other socio-economic factors.

Standard:
A principle, a criterion, an objective or any other kind of statement that is recognised in regulations or enforceable environmental law applicable at the international, transboundary, national and/or local levels.

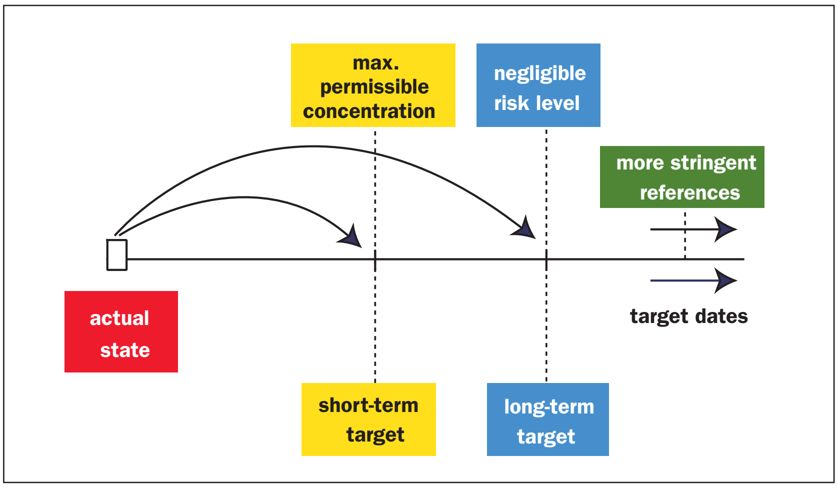
Water-quality standard:
A numerical concentration, descriptive statement or objective that is recognised in regulations or enforceable environmental law applicable at the international, transboundary, national and/or local levels.

Target:
A water-quality criterion, objective, standard or any other kind of statement to be attained after a period of time.

5. Criteria and targets

Criteria for uses or functions should be specific requirements that follow from risk assessment considerations. Quantified management targets for the transboundary river should be based on water management policies agreed upon by riparian countries (figure 6). Targets can be criteria, standards or any other kind of statement.

Figure 6
Targets and target dates for hazardous pollutants



2.3 Inventories and surveys

1. Problem recognition

To identify issues and recognise problems and risk factors, preliminary investigations such as inventories and surveys are needed. These should clarify what the problems are, whether there are specific problems and how big the problems are. Furthermore, these problems have to be specified. Inventories and surveys can even resemble detective work (tracking traces).

2. Inventories of available information

Inventories should bring together the information which is available, but often incoherent and distributed among different agencies/institutions or their various departments. This includes not only the listing of information available from historical data, licenses, etc. in administrative databases, but also a general screening and interpretation of all information relevant to the aspects under consideration. For inventories of pollution sources, this implies looking for the source of information, e.g. production processes, use of raw materials, verification of suspicion by additional questioning.

3. Subjects of inventories

Inventories should cover the major aspects that are relevant to the identification of the issues. These include for example: water uses and water needs in the river basin; run-off characteristics and the probability of flood waves and ice drifts in the river basin; water quality (not only physico-chemical, but also sanitary, biological, ecotoxicological); the most important point sources of pollution from industry and municipal waste, characterising these in terms of production process, pollution composition and discharge load; land uses and diffuse pollution sources from land use, with an inventory of the use of fertilisers and pesticides in agriculture; other sources of diffuse pollution may include traffic, pipelines, airborne pollution; potential sources of accidental pollution. A review of the findings of previous and ongoing studies can be a useful source of information.

Inventory of pollution sources - an example

Assume that facilities for the production of iron and steel are located in the river basin. Inquiries can give insight into applied production processes. Maybe phenolic compounds and polyaromatic hydrocarbons (PAH's) are likely to be discharged into the river from the coke battery or coke oven plant. Given the negative impact of these substances on water quality, one can conclude that the available data are not enough and additional questions have to be asked when interviewing people at such a factory. Also, an additional survey could provide information about the occurrence of these pollutants by screening the effluent discharge.

4. Surveys

Additional surveys are needed if insufficient data are available from the inventory to identify a problem and to specify what monitoring is needed. It is an essential characteristic of surveys that they create new data. Surveys could be related to a broad range of subjects, such as the evaluation of site conditions (e.g. post-flood surveys), the variability of monitoring parameters in space and time, or the screening of the occurrence of pollutants or toxic effects in water and sediments (water-quality surveys).

Water-quality surveys

Water-quality surveys are intended to give a first insight into the functioning of the aquatic ecosystem and the occurrence of pollution and toxic effects in the water. The biological quality of the aquatic zone of a river can be assessed by investigating the structure of the macro-invertebrate community, the upstream and downstream differences in the river reach and the changes during a period of one year. Chemical screening of surface water, sediment and effluents at hot spots and key locations can be performed with mass spectrometric methods. Additionally, specific target compounds that might be expected according to the inventory can be analysed. Toxic effects in surface water, sediments and effluents can be investigated at these locations. With a set of ecotoxicological tests, a broad range of chemicals and variation in sensitivity among species can be covered.

5. Identification of hot spots

Hot spots in surface water, effluents and sediments should be identified through preliminary investigations. Inventories of available information from effluent discharges and monitoring data will give a first indication of where a combination of toxic effects is to be expected. The 'hot spots' can be characterised with the detailed chemical, ecotoxicological and biological data from additional in-depth surveys.

2.4 Evaluation of legislation

1. Agreement on criteria and targets

In a transboundary river basin, each riparian country has, as a rule, its own assessment criteria, water management targets and water-quality classification system. These are often part of the national water legislation, including legal measurement obligations. In a transboundary context, riparian countries have to agree upon common assessment criteria and management targets.

2. Commitments and legal obligations

Riparian countries should compare and evaluate their national water legislation and legal and other obligations for monitoring and assessment arising from conventions, EU environmental legislation, agreements and other arrangements. They should agree on criteria and targets in the context of transboundary cooperation (e.g. water classification system, flood risk criteria, water abstraction policy).

3. International developments

It is recommended that optimal use should be made of international standards and internationally recognised risk assessment criteria, as far as these are based on experimental data and actual knowledge (e.g. water-quality criteria based on ecotoxicity data). The recent achievements and experiences of international organisations and river commissions can also be helpful.

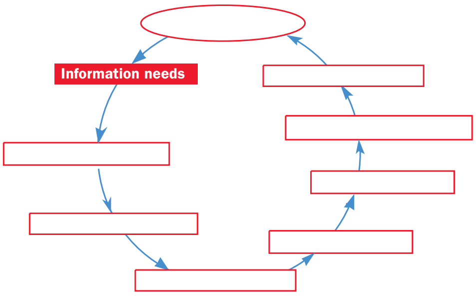
4. Harmonised classification system

A harmonised system of water classification (e.g. for water quality, sediments, ecological quality) should be developed. It should not conflict with the national legislation in riparian countries and be in line with internationally recognised assessment practices.

Terms of Reference EVALUATION OF LEGISLATION (as used in the 1999 pilot project programme [20] under the Convention.)

- Make an inventory of water-related environmental legislation and water classification methods in countries. Inventory existing regulations for data exchange between countries.
- Identify function-related international standards for the quality of surface waters.
- Identify recent developments in EU environmental legislation on surface waters.
- Identify significant experiences with the development of water-quality objectives in European river commissions (e.g. International Rhine Commission).
- Compare water legislation and classification methods of riparian countries and compare with international standards and EU legislation.
- Compare applied standards (related to their objectives) with internationally recognised risk assessment criteria.
- Propose a harmonised system of water classification that does not conflict with the existing national legislation systems.

3. Information needs



1. Introduction

Adequate information and public access to the information are necessary pre-conditions for the protection and use of transboundary waters and for the implementation and enforcement of the Convention. As many monitoring programmes are still "data rich, but information poor", attention should be directed towards the end-product of monitoring, which is information. The ultimate goal of monitoring is to provide the information needed to answer specific questions in decision-making. Thus, the most critical step in developing a successful, tailor-made and cost-effective monitoring programme is the clear definition and specification of information needs. The term "information needs" means a precise question on which information has to be provided within a certain context. Information needs have to be specified to such an extent that design criteria for the monitoring and assessment system can be derived.

2. Involvement of the right institutions and people

The institutions responsible for the protection and use of the transboundary river should be involved in the process of specifying information needs. The information needs of the institutions responsible for receiving waters (lakes, estuaries, seas) should also be taken into account. Both information users and information producers should be identified first. The analysis of the water management of the river basin and the identification of the issues, as discussed in par. 2.2, are the basis for specifying the information needs. A distinction should be made between information used for policy preparation and/or evaluation, and information used in operational water management. To specify information needs, both the information users and the information producers should closely interact.

3. Information needs per issue

The information required for the assessment of sustainable water uses and ecological functioning should be structured on the basis of issues, pressures and water management measures. The proper identification of information needs principally requires that the concerns and decision-making processes of information users are defined in advance.

Different criteria for water uses

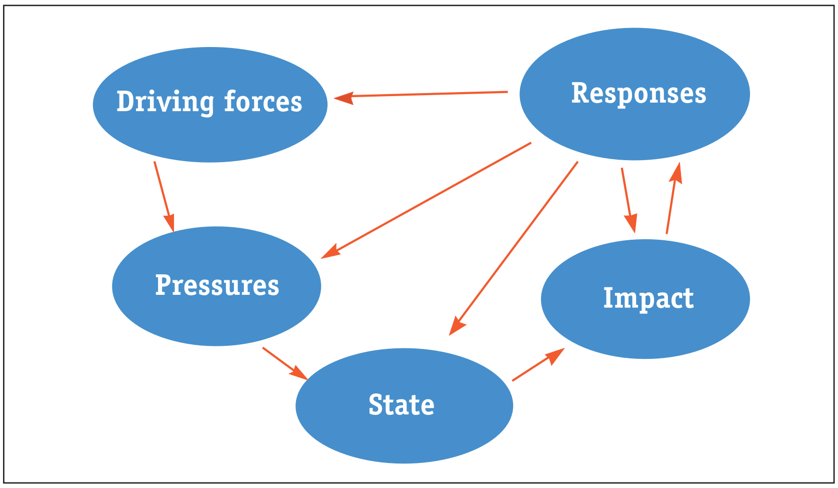
A particular concentration of some chemical dissolved in water may reflect either good or bad quality water, depending on the intended water use. For example, a concentration of 2 parts per million boron in a river may not affect any present uses of the river, and the river water might be considered to be of good quality. However, if the water is subsequently required for regular irrigation of certain horticultural crops, the boron concentration will be too high and the water may then be considered to be of poor quality (that will certainly be the irrigator's view). (source: [21]).

As discussed in Chapter 2, inventories and preliminary surveys can help significantly in problem recognition and identification of issues and, subsequently, in the specification of information needs.

4. Cause-effect relations

When focusing on a specific water management issue, information is needed on the origin and the effects of the problem and the measures taken. Causality chains, like the DPSIR framework (figure 7), distinguish between the different aspects of an issue. Information needs can be specified for one or more of these aspects.
Driving forces describe the human activities, like urbanisation and agriculture, that are the main sources of problems or threats. The pressures describe the stress that the problem puts on the functions/uses of the river basin. The state of the river basin is described in terms of concentrations, hydrological or ecosystem characteristics. The impact describes the loss of function/use, like toxicity or bad taste of drinking water. Responses describe the policies that have been or are being developed to deal with the problem.

Figure 7
The Driving Forces-Pressures-State-Impact-Responses (DPSIR) framework [22]



5. Specification of information needs

Information needs should be further specified, to be able to design a monitoring and assessment system. It should be kept in mind that monitoring is not the only source of information (see Chapter 1, par. 8); often a combination of sources has to be used to meet the information needs.

The specified information needs should include the following items:
- The selection of appropriate parameters and/or indicators. They should sufficiently represent a specific information need;
- The definition of criteria for assessment, e.g. considerations for the setting of standards or criteria for the choice of alarm conditions for early warning in the event of floods or accidental pollution;
- Requirements for reporting and presentation of the information should be specified (e.g. visualisation, degree of aggregation, indices);
- Relevant margins have to be specified for each monitoring parameter. What detail is relevant for decision-making? A relevant margin could be defined as the information margin that the information user is concerned about;

- The response time should be specified. The response time is the period within which the information is needed. In early-warning procedures, information is needed within hours, whereas for trend detection information is needed within weeks or even months after sampling;
- It has to be decided what reliability is required. To what extent is false information allowed? 100% Reliability is impossible or prohibitively expensive. Depending on the consequences, information should be more or less reliable. Together with the relevant margin, this is a determining factor when locations, frequencies and methodologies are chosen in the design of monitoring programmes.

6. Indicators

Information should preferably be presented in a condensed/aggregated way.
It should be comparable between places and situations, and should be linked to specific issues, which are in turn based on specific management needs. Indicators may provide for this and, in this respect, indicators also may facilitate the specification of information needs.

Table 2
Possible indicators for specific function - issue combinations

Drinking water

Recreation

Ecosystem

	Driving force	Pressure	State	Impact	Response
Acidification	Production of heat and electricity	Emissions of SO2 and Nox	Aluminium concentrations Alkalinity	Toxicity Changes in fish community	Capacity of SO2 and NOx abatement equipment
Organic pollution	Number of households	Emission of untreated domestic waste-water	Oxygen concentrations	Changes in macro-invertebrate community	Percentage of population with access to waste-water treatment
Eutrophication	Surface area of agricultural land	Amount of fertilisers used	Nitrate and phosphate concentrations	Algal bloom, changes in fish communities	Change in agricultural practices
Pollution with hazardous substances	Chemical industry production	Emissions of toxic substances	Concentrations of toxic substances	Ecotoxicity, deformations in aquatic organisms	Changes of toxic contents in products and production processes

Flow regime

	Driving force	Pressure	State	Impact	Response
Flooding	Wood harvesting density	Water-retaining capacity of soils	Water level, forest area change	Damage from floods	Changes in forest management
Erosion/ sedimentation	Land cultivation	Soil load into the river	River-bed morphology	Cost of dredging	Changes in physical planning
Hampered river continuity	Hydropower production	Percentage of river flow blocked	Level of disturbance of natural flow regime	Changes in migration fish populations	Percentage of dams with provisions for fish migration

The selection of an indicator is a means of reducing the volume of data without loosing significant information. Indicators are preferably measurable parameters. Such a parameter is influenced by the water's conditions (physical, chemical, biological, etc.) and accurately reflects these conditions for a specific issue. As it represents an environmental process, it also has a significance for the overall ecological functioning of the water. Also, they should be suitable for communicating to policy makers or the public. As an example for eutrophication, total phosphorus can be a good indicator of the status of the river.

Table 2 gives examples of indicators by combining the function-issue table (table 1) with the DPSIR framework (figure 7).

7. Identification of indicators

To identify suitable indicators, appropriate parameters have to be selected. These parameters should sufficiently represent functions and uses of water bodies, characterise water quantity or quality, characterise an effect on a function or use, characterise the pollutant discharge, and/or be of value for testing the effectiveness of measures.

Riparian countries should agree on the choice of an indicator. Important criteria for choosing an indicator are:
- Communication: the indicator should be appealing to those who will use it in all riparian countries;
- Simplification: the indicator should provide insight into the situation, without giving much detail. A low oxygen concentration in a river, for instance, indicates that the situation is not good. A high oxygen concentration situation indicates good potential;
- Availability of data: if few or no data for the indicator can be made available, its information content may be too low.

8. Information objectives

Different information objectives can be distinguished, showing the intended use of the information (purpose) and the management concern (e.g. protection of a specific use). The main information objectives for both effluents and rivers are:
- The assessment of the actual status of a river basin by regular testing for compliance with standards. Standards should be defined for various human uses and targets should be established for the ecological functioning of the river basin concerned;
- Testing for compliance with permits for water withdrawal or discharge of waste water, or for setting levies;
- Verification of the effectiveness of policy measures, by indicating the degree of implementation of measures, by detecting long-term trends in water levels, concentrations and loads, and by demonstrating to what extent the intended targets were reached;
- Provision of early warning to protect the intended water uses in the event of flooding or accidental pollution;
- Recognition and understanding of water-quantity and water-quality issues through investigations by surveys, for example, of erosion patterns or the presence of toxic substances.

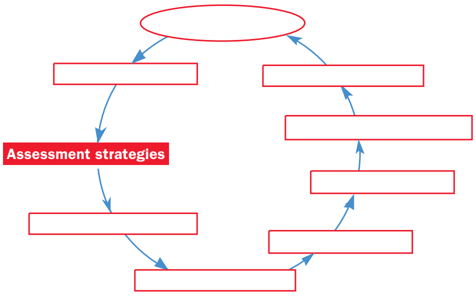
9. Prioritisation of information needs

As information needs are derived from issues, the prioritisation of issues consequently leads to a prioritisation of information needs. Information is mostly needed on high-priority issues. If the same information need arises from various issues, this information need should be given high priority, because by collecting this information once, a variety of issues is addressed.

10. Evolving information needs and continuity in monitoring

Information needs evolve as water management develops, targets are attained or policies changed. Consequently, monitoring strategies often need to be adapted over time. Information needs require a regular rethinking (revision) of the information strategy in order to update the concept. However, one should not neglect the need for continuity (in parameter, location, analytical method, etc.) in time series of measurements. This continuity is necessary to detect significant and reliable trends in river-basin characteristics.

4. Strategies for monitoring and assessment



4.1 General strategies

1. Introduction

After the specification of the information needs, assessment strategies are required to design and operate monitoring programmes in such a way that the desired information is obtained. Strategies define the approach and the criteria needed for a proper design of the monitoring programme. Thus they imply the translation of information needs into monitoring networks.

After the general recommendations in this section, four categories are considered in more detail. These are water quantity of rivers, ecological functioning, water quality for human uses, and effluents and pollution loads.

2. The need for integrated assessments

Modern water management implies that water resources are managed, as far as possible, in an integrated manner on the basis of catchment areas, with the aim of linking social and economic development to the protection of natural ecosystems and of relating water resource management to regulatory measures for other environmental media. Such an integrated approach applies across the whole of a catchment area, whether transboundary or not, including its associated coastal waters, the whole of a groundwater aquifer or the relevant parts of such a catchment area or groundwater aquifer (Protocol on Water and Health, [4]).

Such an integrated approach will influence the way in which monitoring strategies are designed and assessments made. An important consideration (Guidelines on the ecosystem approach in water management, [16]) is that aquatic ecosystems are not closed ecological systems; they exchange materials and energy with their surroundings. Therefore, there is a need to substantially broaden the scope of assessments to the exploration of the linkages and interactions within the ecosystem. A challenge lies in discovering abiotic and biotic factors, as well as the key linkages that provide for the ecosystem integrity, and in maintaining an energy, chemical, physical and biological balance in the interlocking ecosystems. The movements of chemical substances into and out of the catchment area and the internal dynamics within the catchment area should be studied. The transfer of pollutants from one environmental medium to others should also be assessed.

An integrated approach is also a departure from the earlier focus on localised pollution and management of separate components of the ecosystem in isolation. The profound influences of land use on water quality and water quantity should be taken into account. Furthermore, encroachments and changes in human activities and the corresponding habitat and other changes along water bodies, that may affect the aquatic ecosystem should be assessed.

An integrated approach includes humans as a central element in the well-being of the system. This implies recognition of social, economic, technical and political factors that affect the ways in which human beings use nature. These factors should be assessed because of their ultimate effect on the integrity of the ecosystem.

Consequently, assessments should be based, as far as possible, on integrated criteria in terms of water quality and quantity as well as flora and fauna. To provide the basis for such assessments, water quality, flow regimes and water levels, habitats, biological communities, the sources and the fate of pollutants as well as mass balances should be analysed systematically.

3. Integrated assessment by a triad of approaches

The policy used in water pollution control for the prediction, detection and control of waste loads to the receiving river basin, the assessment of the water quality of river basins, and the ecological functioning of the aquatic ecosystems requires the integration of the following elements:

a) Physico-chemical analysis of water, suspended matter, sediments and organisms;
b Ecotoxicological assessments;
c) Biological surveys.

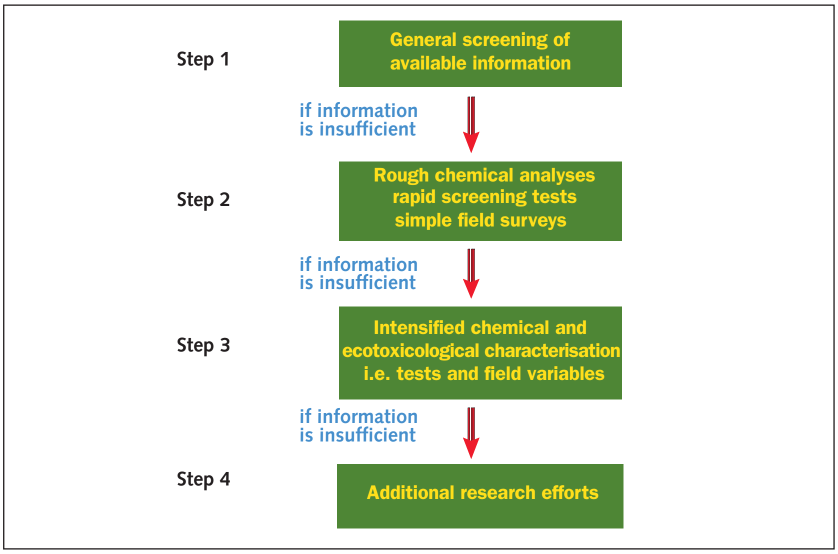
The combined use of biological surveys, bio-assays and chemical analyses improves the interpretation possibilities with respect to cause and effect (e.g. media (water/sediment), contaminants and bio-availability). This approach also leads to a more cost-effective assessment strategy, compared with an approach dominated by the monitoring of a rapidly increasing number of individual chemicals.

4. Stepwise and phased approaches

As assessment of environmental quality serves different aims (e.g. to signal, control or predict) and as the information needs vary from broad indications to fine-tuned diagnostic figures, the choice of parameters and methods (e.g. ecotoxicological indicators) also depends on them. Stepwise approaches, which, in general, will lead from coarse to fine assessments, are recommended. Each step should be concluded with an evaluation of whether or not the information obtained is sufficient. Such stepwise testing strategies can ultimately lead to a reduction in information needs for further monitoring programmes (figure 8).

In general, a phased approach to bringing into operation monitoring efforts, going from broad to fine, and from simple to advanced, is advisable for reasons of cost-effectiveness. Additionally, for developing countries or countries in transition, prioritisation in time is recommended for the introduction of new monitoring strategies, going from labour-intensive to technology-intensive methods. In many cases, the lack of appropriate, consistent and reliable data and the non-existence of an adequate baseline against which progress can be measured make a phased approach realistic.

Figure 8
Stepwise testing strategies



5. Risk assessment as a tool for prioritising monitoring efforts

Risk assessment can help considerably in prioritising the monitoring activities. This is illustrated by the following two examples:

a) The central aspects in flood prevention are the question as to what safety is available at what price and the notion of the remaining risk which has to be accepted by society. Risk assessment (or more comprehensively flood risk management that includes risk assessment, mitigation planning and the implementation of measures) will show which hydrological, meteorological and other data are to be monitored or observed;
b) One can assume that the water quality in a relatively small transboundary catchment in a sparsely populated area is hardly affected by threats, i.e. there is hardly a risk to human health. On the contrary, if there are refuse dumps or industrial plants, even a high risk to human health and/or aquatic ecosystems is possible.

Thus, by using risk assessment the authorities can decide which (part of the) monitoring activities have higher or lower priority. This could be quantified or made visible with the concept of expected damage, i.e. what goes wrong when insufficient information (because of a lack of monitoring) is available? What is the loss when less than optimal decisions are made because of this? The same questions can be asked in the design or optimisation of monitoring networks. What are the consequences for the decision-making if there are no or only limited results from monitoring?

6. Risk assessment and the selection of parameters.

Risk assessment is recommended for the selection of parameters in the transboundary monitoring programme. Predictions can be made regarding the environmental concentrations of chemicals which are (or will be) produced and emitted into the river.

Based on the ratio between predicted concentration levels and expected harmful effects, these chemicals might be included as parameters in the water-quality monitoring programme. Because of limited technical and financial means, not all chemical substances can be chosen as monitoring parameters. Risk assessment can be used to prioritise specific pollutants, based on their physico-chemical properties and toxicity (see Annex 1).

Risk assessment, both regarding biological agents and chemical substances, will also help in setting priorities for establishing health-related monitoring and/or early-warning systems, in general, and in selecting appropriate parameters for monitoring, in particular. Although good systems are still to be developed, these will include hazard identification, dose-effect relationships, exposure assessment and risk characterisation (both qualitative and quantitative). Guidance is expected to be given by the Working Group on Water and Health under the Convention.

7. Use of models

Models (numerical, analytical or statistical) may play several roles in the monitoring and assessment of transboundary rivers. They can assist in the integrated assessment of the transboundary area, in screening alternative policies, in optimising monitoring network design, in assessing the effectiveness of implemented measures and in determining the impact on surface water systems and the risks to human health and the ecosystem. Computer models of the rivers and surrounding areas, linked with geo-referenced databases, can be used to analyse the impact of proposed measures, e.g. by simulating the flow and water level variations in the river and on flood plains during floods. Models play an important role in early-warning systems (flood forecasting, travel time computations in emergency warning systems in the event of accidental pollution). Models can be used in addition to monitoring, but also as part of monitoring optimisation programmes (e.g. to help understand which media should be monitored).

Models should be carefully calibrated and validated (e.g. on the basis of historical data) to avoid unreliable results, which can lead to misunderstandings and erroneous decision-making in river-basin management.
Successful mathematical modelling is possible only if the methodology is properly harmonised and integrated with data collection, data processing and other techniques/approaches for the evaluation of surface water system characteristics. When riparian countries decide on the modelling of a transboundary water system, they should realise that the standardisation and the accessibility of data (interfaces to databases and to GIS) are of the utmost importance, rather than the standardisation of software (see par. 6.6).

8. Cost-effectiveness aspects

The effectiveness and efficiency of monitoring and assessment should be improved by:

a) Specifying information needs and properly setting up accountable monitoring programmes;
b) Using a combination of monitoring and models where beneficial (e.g. correlation models in water-quality assessment, rating curves for river flow, flood forecasting);
c) Selecting policy indicators and using aggregate parameters, mixture toxicity parameters, etc.
d) Integrating chemical and biological monitoring (including bio-assays) which can increase the effectiveness of monitoring (cause and effect relations) as well as the efficiency. Where appropriate, the application of biological methods may be cheaper than chemical analytical methods. The advantages of biological methods for problem

indication, however, do not eliminate the need for chemical analysis for diagnostic purposes and for tracing back the pollution source;
e) Using stepwise approaches for the screening of water, sediments and biota to gain more information at lower cost.

The inventoried and specified information needs will probably require different monitoring networks to fulfil the different monitoring objectives. The integration of monitoring activities for reasons of cost-effectiveness in an early stage of the monitoring cycle may cause over- or undersizing of monitoring networks. Therefore, it is recommended that an information strategy should be developed per monitoring objective or information need first. Integration of monitoring efforts may be considered in the implementation phase.

4.2 Water quantity

4.2.1 Water-quantity assessments

1. Basic characteristics

The frequent measurement of water levels and river flow is of the utmost importance for the management of a river basin. These basic characteristics play a role in all functions and uses of the river, but are especially important for such aspects as water supply, navigation, ecological functions and protection against flooding. Besides water level and river flow, other water-quantity characteristics, e.g. sediment discharges, water temperature, ice and snow characteristics, are also important.
For specific purposes, additional information is required, such as:
a) Catchment characteristics influencing the run-off process (land use, forestation);
b) Water-use data (intakes and discharges, releases from reservoirs, diversions from and to the river);
c) River flow conditions (river regulations, construction of reservoirs and dykes);
d) Precipitation, snow cover, air temperature, soil moisture content.

2. Planning and operational assessments

For the assessments of management issues, such as flood control, water use and river regulation, the information needs can be divided into two parts:
a) In the planning (regulatory) phase, time series of historical data are needed;
b) In the operational phase (daily operation, early warning), real-time data and forecasts are needed.

3. Water management balance and water sharing

Water management balances should be drawn up for (parts of) a river basin, when and where the careful sharing of available water resources for different water uses is of special importance. Water management balances compare water resources with water uses, consumption and ecological water demand. In addition to undisturbed river run-off, a water management balance includes, for instance, intakes from and discharges to the river by municipalities, industries, irrigation and drainage and fishfarming; diversions from and into the river; reservoir storage and release; discharge of groundwater resources into the river, mine dewatering, etc.

4. River training and flow regulation

The impact of river training works and other human activities on transboundary rivers should be evaluated. The changes in water levels, flow characteristics, and sedimentation or erosion, due to the above measures will affect the ecological functioning, water supply, navigation, protection against flooding, and other functions/uses. The operation of reservoirs can have a negative effect on the transport of sediments and hazardous substances. River training works and the operation of reservoirs form important links in the integrated management of a transboundary river basin and are an important subject for cooperation and information-sharing between riparian countries.

5. Flood protection and flood risk

The criterion for flood prevention and flood protection is the acceptable flood risk. For a transboundary river, riparian countries should agree on what is the acceptable risk. Flood risks should be defined as the product of frequency of flooding and associated damage. Both economic and ecological damage are to be considered. Flood-risk mapping is a useful management tool to indicate the areas that are the most vulnerable to flooding in a geographical overview of the river basin.

For the statistically reliable estimation of the flood frequency along the river reach, long-term series of water levels and discharges are a prerequisite. Also geo-morphological information on flood plains is needed to estimate the flood frequency of connected areas. Hydrodynamic models can be used to estimate the flood situation in the river during extreme flood events. Model computations should also be used to estimate the impact of human activities on flood risks (such as river regulation works, flood protection works, water retention).
Further guidance on flood protection is given in the Guidelines on sustainable flood prevention [23].

6. Drought assessment and management

Low-flow conditions on rivers and drought over the catchment cause problems in water uses and the river's ecological functioning.
For the statistically reliable estimation of drought conditions, long-term series of flow data are needed together with corresponding climatic characteristics. In most cases information concerning the synchronous appearance of extremes of available water and demand is also needed.

In case of drought, more frequent information and data exchange on reservoir operation, diversions and water uses, as well as on hydrological and meteorological parameters might be necessary.

7. Assessment of ice conditions

The assessment of ice conditions on rivers, lakes and reservoirs is of great interest in regions where ice formation affects navigation, interrupts the operation of river-regulating structures, or results in damage to structures, and where ice jams may form (even to the extent of damming a major river). The obstruction of stream flow by ice can cause serious local flooding. Long-term data on ice conditions in rivers are used in designing various structures, in studying ice formation and dissipation processes, and in developing ice-forecasting methods.

4.2.2 Hydrological forecasting

1. Regular hydrological forecasting

Water levels and flows should be forecast daily in view of a river's many functions and uses, like water supply, navigation, ecological functions, river training works and operation of reservoirs, protection against flooding, etc. As the travel time of accidental pollution in a river mainly depends on the flow characteristics, provision should be made to use hydrological forecasts when accident emergency warnings are prepared for a river basin. Seasonal outlooks for the potential water supply for irrigation, power production or inland navigation can be seen as a longterm hydrological forecast. Forecasting is also particularly important during periods of drought, when river flows are low and the supply of water is inadequate to satisfy different water uses.

2. Flood forecasting

Flood forecasting in the case of high river flows is more intensive. Observations and data transmission are more frequent. The number of observation sites and the types of information (e.g. reservoir operation, dyke failures, other measures) are increased. Forecasts, including additional characteristics, such as time and magnitude of flood crests and flood peaks, are issued more frequently.

A flood-forecasting system is paramount in the management of floods. A first step in developing a flood-forecasting system is to agree on the critical levels at which a warning should be issued or the alarm raised. Parties involved in flood management in the river basin have to agree on the required lead time and the accuracy of the forecasts. These imply criteria against which the performance characteristics of available forecasting practices can be evaluated and/or form design criteria for the forecasting tools to be developed.

To achieve reliable warnings, optimal use should be made of combined measurements and models based on hydrological and meteorological forecasts. In principle, a flood-forecasting system is composed of three interlinked elements: (a) in the river and its tributaries, discharge rating curves and/or hydrodynamic models are used; (b) in the river basin, use is made of rainfall-run-off relations; (c) for individual sub-basins, the use of quantitative precipitation forecasts is recommended.

3. Early warning of flash floods

Special treatment is required for forecasting of flash-floods. Because of the short reaction time in the event of flash floods in mountainous areas, the warning of flash floods should be based on real-time information from an automatic precipitation gauge network combined with quantitative radar precipitation data and supported by quantitative rainfall forecasts.

4. Forecast of ice conditions

Important elements in the forecasting of the ice conditions are the temperature of water and air, the first observations of floating ice, the first observations of stationary ice, the ice cover-ratio, the thickness of the ice-cover, the formation of ice jams, water-level changes during ice cover, the weather changes which affect the start of ice breaking, features of ice destruction, and ice breaking up. After the ice regime (possibly combined with flooding), information is needed concerning: changes (damage) in river-bed configuration, transport of (polluted) sediments, negative effect on water constructions by ice problems, damage to the environment (e.g. dead fish by oxygen depletion under ice cover).

For the start of the forecasting of ice conditions, one criterion is usually chosen (e.g. the first observed 10 km of uninterrupted ice cover). The use of models for forecasting the growth of ice cover can be useful. Parameters in such models include, among other things, night temperature of water and air, wind velocity, cloud cover, flow velocity and water depth.

4.2.3 Exchange of data and information

1. Regular data and information exchange

Riparian countries should jointly agree upon the exchange of hydrological and meteorological data (including observation sites and monitored parameters, form of information products), its timescales (e.g. real-time data in emergency situations; daily, yearly and/or long-term average data) and the means and forms of transmission. There may also be a need for sharing information on reservoir operation and on parameters needed for assessing water quantity. The agreed upon information should be comprehensive enough to attain the required reliability of hydrological forecasts, hydrological evaluations and water resources and water-quality management. Riparian countries should collectively agree on the methods for the joint evaluation of hydrological parameters.

2. Data and information exchange in extreme situations.

In emergency situations, and in the event of floods and droughts, different data exchange procedures may be necessary. Agreements should be made on off-line and on-line data exchange between meteorological and hydrological (forecasting) centres, relevant water and environment authorities and between countries.

Flood protection in a transboundary river requires agreement on flood protection criteria and acceptable flood risks. Special attention should be paid to the comparability and the unambiguity of flood forecasts. This concerns especially the terminology used and the structure of messages.

It is recommended that joint post-event evaluations should take place, to lay the basis for jointly upgrading the existing monitoring network together with the data and information procedures.

4.3 Ecological functioning

1. Good ecological quality of river basins

The management of the water environment should aim at sustaining or restoring the good ecological quality of river basins where substances or structural components from human activities have no significant detrimental effects on the ecosystem. More ambitious goals such as the conservation and, where possible, restoration of aquatic ecosystems to a target state of high ecological (see the ECE Guidelines on the ecosystem approach in water management [16]) should also be considered.
The forthcoming EC Directive establishing a framework for Community action in the field of water policy [24] (which will apply to present and future Member States of the European Union) similarly characterises the good ecological status as: "The values of the biological quality elements for the surface water body type show low levels of distortion resulting from human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions."

Ecological quality assessment provides a direct measure of the functioning of ecosystems and is emphasised as a central element in the management of the water environment.

2. Ecological characteristics of river basins

The functioning of a river ecosystem should be considered in the whole catchment area. Different ecoregions can be distinguished, not only worldwide, but also on a smaller scale (the draft EC Water Framework Directive [24] mentions 25 ecoregions in Europe). It should be clearly identified which ecoregion the river basin is part of. River types and river sections should also be distinguished because of their importance for the assessment (large or small river, upper or lower reach, etc.)

3. Principles for assessment

Basic elements in the ecological assessment of a river basin include the biodiversity aspect and the identification and description of reference situations. Assessment should be closely linked to problems and detrimental aspects and be based on representative indicators. The consequences of human activities, such as pollution and problems with river continuity, are the main disturbances.

Definitions used in these guidelines

Ecoregion:
Geographical division of catchment areas based on differences in climatic conditions and (less explicit) on geological and soil aspects.

River type:
Character of the river or of a part of it, with specific physical and chemical factors, that determines the biological population structure and composition.

Biotope and habitat:
A biotope is the ecological unit in which the composition and development of communities are determined by abiotic and biotic factors. A habitat is the locality or environment in which a plant or animal species lives.

River corridor / river continuum:
An ecological zonation of communities, both functional and structural, from source to river mouth as a result of longitudinal gradients in abiotic determining factors (e.g. width and depth of the river bed, flow velocity, substrate grain size, enrichment by nutrients).

4. Detrimental effects

The aquatic ecosystem may be affected by:

a) River engineering, wiping out or reducing characteristic riverine habitats;
b) Water abstraction (in case of water scarcity) and manipulation of flow regime, decreasing biodiversity;
c) Input of hazardous substances, causing toxicity;
d) Organic pollution causing oxygen deficiency;
e) Nutrient enrichment causing eutrophication;
f) Deposition of airborne pollution causing acidification (fossil-fuel combustion) and/or radioactivity (e.g. as a consequence of nuclear accidents).

5. Indicators

To assess possible detrimental effects on the quality of the aquatic ecosystem, use can be made of the indicators mentioned below (see table 3):

a) Dissolved oxygen, biological oxygen demand (BOD), total organic carbon (TOC), nutrients, pH, thermal conditions, chlorophyll-a;
b) Hazardous substances in water, sediment and organisms;
c) Community structure of plankton, macrozoobenthos, fish, vegetation and sessile algae (taxonomic composition and abundance);
d) The presence of reference species;
e) Diseases and deformations in organisms;
f) Physical and hydromorphological factors (flow, depth-width ratio, canalisation and degree of meandering, structure of sediments, condition of banks, land use and inundation frequency of floodplains).

6. Biological assessment

Biological assessment tools should be carefully chosen with respect to the intrinsic - actual or potential - ecological value, the designated functional uses of the riverine ecosystem as well as the character and size of the watercourse. A reference state should be introduced against which the ecological condition of a system can be assessed.

The biological status of the water body can be assessed through the structure and functioning of communities. Assessments include the following indices:

a) **Biotic index:** Regional differentiation may be necessary. The establishment of a database of well-defined unaffected reference communities is a prerequisite for the implementation of a biotic index;
b) **Saprobic index:** If the organic load is the factor which dominates the water quality, a saprobic index may be used. The purpose of this index is to classify the saprobic state of the running waters, covering the full range from unpolluted to extremely polluted waters.

The benthic macro-invertebrate community is considered to be a good practical tool for routine assessment of the biological quality of the aquatic zone of rivers. Identification to species level is essential (biodiversity, improvement of indices).

7. Integrated ecological assessment

Because of the importance of biotic as well as abiotic factors for the functioning of the ecosystem, integrated ecological assessment methods should be applied in addition to the biological assessment presented in paragraph 6. Such methods should be based on selected "smart" parameters (see paragraph 5) that have proven to be representative of a community and that are sensitive to general or specific impacts on riverine ecosystem elements. Depending on the impact, an integrated ecological assessment should comprise:

a) An **ecological assessment,** i.e. an assessment of the interaction of biotic communities of aquatic organisms with abiotic factors;
b) An **ecotoxicological assessment,** i.e. an assessment based on ecotoxicological parameters, using field experiments and laboratory tests (see Annex 3);
c) A **"whole river" assessment,** i.e. the analysis of the whole river basin with an intrinsic ecological value in which all relevant information on aquatic and terrestrial communities is considered.

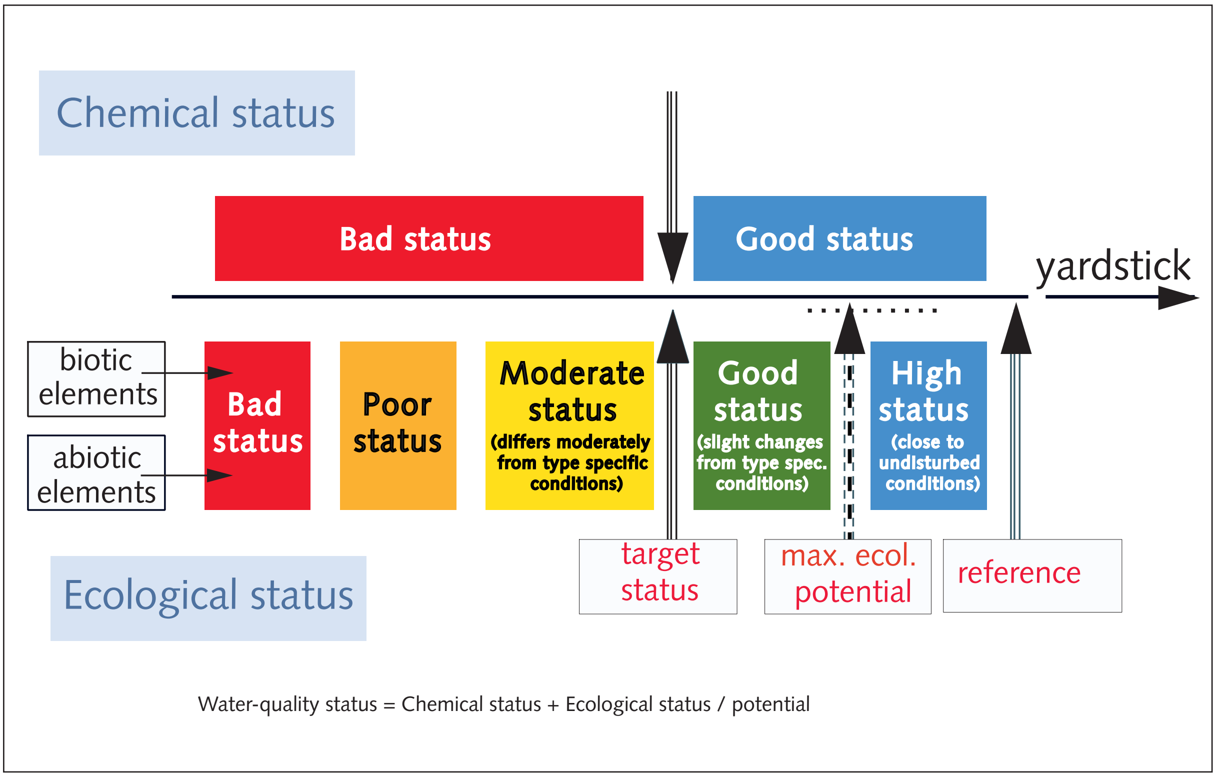
4.4 Water quality for human uses

4.4.1 Water-quality assessments

1. Sustainable water use

Sustained human use of the river basin has to be based on a multi-functional approach in water management. Demands of various uses can be characterised by the specific water-quality requirements (water-quality criteria, water-quality objectives, targets). Threatening issues and pressures should be identified in terms of their consequences for these requirements. This specifies the information that is required for the assessment of water quality for sustained water use and the protection of human health and safety (see Annex 2).

Figure 9
Ecological assessment according to the joint text of the EC Water Framework Directive [24]



2. Preliminary investigations

Preliminary investigations aim to identify the specific issues of the river basin and to set up the monitoring as effectively and efficiently as possible. Inventories and in-depth surveys should provide relevant background information with respect to water uses, (possibility of) presence of pollutants not monitored before, toxicological relevance, variability of pollutants in time and space. Water-quality criteria and targets for the specific uses have to be agreed by riparian countries.

3. Indicators and indicative parameters

Parameters which are indicative of identified issues or human uses (see table 1) should be selected. Aggregate parameters should be included, if suitable. Specific chemical parameters are included in monitoring programmes if they are the subject of special concern in the river basin (e.g. to test compliance with standards for hazardous substances) (table 3).

4. Appropriate media

Pollutants may occur in several different media, including water, suspended matter, sediment and organisms. Appropriate media for monitoring parameters should be identified considering the following criteria:

a) Distribution of pollutants over the various media;
b) Existing objectives and standards (for specific media);
c) Ability to detect substances (in the various media) within the relevant margin.

Table 3
Indicative parameters per issue

ISSUES	INDICATIVE PARAMETERS **Phase 1:** **core set of indicative parameters**	**Phase 2:** **additions for extended set**
Ecological functioning	Community structure and abundance of benthic macro-invertebrates	Community structure and abundance of fish, phytoplankton (lentic sections) and macrophytes
Organic pollution	Dissolved oxygen, BOD, faecal coliform, faecal streptococcus	COD, TOC,viruses, salmonella, macrozoobenthos
Salinisation	Conductivity	Major ions, Cl-
Acidification	Acidity (pH)	Alkalinity, sessile algae
Eutrophication	Dissolved oxygen, nutrients (total nitrogen, total phosphorus), chlorophyll-a	Ammonium, Kjeldahl-nitrogen, nitrate, ortho-phosphate, sessile algae
Pollution with hazardous substances	Floating oil, heavy metals (cadmium, mercury)	Dissolved/dispersed mineral oil,other heavy metals of relevance (e.g. As, Pb, Cu, Cr, Ni, Zn), PAHs (Bornef 6), chlorinated compounds (AOX), pesticides (acethylcholinesterase inhibition), radioactivity (total a-activity, residual b-activity) characteristics of sediments: PAHs (Bornef 6) in sediment and/or biota, PCB (indicator 6) in sediment and/or biota
	Phase 3: optional extensions for hazardous substances: Depending on the results of the inventory, screening and monitoring, optional extensions may include: - organo-P pesticides (e.g. parathion); - organo-N pesticides (e.g. atrazine); - organo-Cl pesticides (e.g. endosulphan, DDT, lindane); - chlorinated solvents (e.g. POX); - other chlorinated compounds (e.g. chlorinated phenols); - tritium (if there are nuclear power plants along the river); - g-nuclides (Cs-137, Sr-90, Po-210).	

5. Sediment quality

Monitoring and assessment of sediment quality are recommended if human and environmental health may be harmed by polluted sediments and when dredging is scheduled. Sediment-quality problems arise especially in sedimentation areas (such as reservoirs, floodplains, harbours, lower river reaches and estuaries) of river basins with substantial pollution

Indicative parameters

An information need concerning the pressure from organo-phosphorus pesticides may be satisfied with the analysis of the individual pesticides or with the (less expensive) parameter acethylcholinesterase inhibition. Both methods would provide the required information. However, costs may differ by a factor of 5 or more.

and if there is bank filtration (e.g. for drinking water production) through polluted sediments. Material which will be dredged should be monitored beforehand. An assessment is needed in order to manage the disposal, storage or reuse in an environmentally safe way.

4.4.2 Early warning of accidental pollution

1. Need for and elements of early warning

It is recommended that an early-warning system should be set up if the direct use of water (e.g. the intake of water from the transboundary river by drinking water suppliers) is threatened by accidental pollution and if that use of water can be protected by emergency measures. Measures could include the closure of drinking-water intakes or water management measures, such as directing polluted water by weirs and locks to less vulnerable areas.

Four elements can be recognised in river-basin early-warning systems: an accident emergency warning system, hazard identification by using a database, the use of an alarm model, and the local screening of river water.

2. Preliminary investigations

Prior to the establishment of an early-warning system, an inventory of potential sources of accidental pollution and available emission data in the upstream river basin (from industries, waste-water treatment, use of pesticides and herbicides in agriculture, etc.) should make clear what accidental pollutants may be expected to occur. A risk analysis should highlight the critical risk factors to functions and uses of the river (substances and critical levels for early warning). Such an inventory and risk analysis should indicate the list of priority pollutants that are subject to early warning in this river basin. This inventory will also help the choice of measured parameters and measurement systems (par. 6).

3. Accident emergency warning system

The setting-up of an accident emergency warning system is recommended as a first step in river basin early warning. This includes:

a) The establishment of a network of (international) alert centres in the river basin, where emergency messages from national or regional authorities can be received and handled without delay on a 24-hour basis;
b) Agreements on international alerting procedures;
c) The availability of a reliable international communication system through which emergency messages are forwarded to the alert centres of riparian countries along the river basin (e.g. the tributaries and the main river).

4. Hazard identification and alarm model

The following items should be taken up as the next steps when establishing a river-basin early-warning system:

a) The setting-up of a system of hazard identification, based on a data-base system for retrieving information on hazardous substances;

b) The development of a computational model to make fast predictions and forecasts of the propagation of a pollutant plume in the transboundary river or its main tributaries.

5. Local screening of river water (early-warning stations)

The initial detection of high concentrations of pollutants or toxic effects at river sites can be performed by regular (e.g. daily) analysis of river water in a nearby laboratory. The establishment of *in situ* (automatic) measurement equipment in an early-warning station may be feasible if frequent measurements and/or a fast reaction time are required.

Two objectives of an early-warning station can be distinguished. They also indicate the successive steps in an early-warning system:
a) To trigger an alarm (accidental pollutants are signalled by regular measurement of biological effects or indicative parameters at the monitoring station);
b) To make a diagnosis for tracing the cause (if pollution is measured or a toxic effect is signalled, water samples taken regularly should be analysed to precisely identify the pollutant using more advanced equipment in a supporting laboratory).

6. Selection of early-warning parameters

Appropriate indicative parameters for early warning are specific for each river basin, and should be selected on the basis of:
a) The dominating pollutants in past emergency situations (frequently occurring local risk substances);
b) Parameters indicative of issues that are specific to the river basin (e.g. dissolved oxygen, pH);
c) Further needs to detect specific micropollutants (heavy metals, pesticides) using advanced technologies.

The parameters selected for early warning also depend on the availability of equipment for measurements *in situ* and cost-benefit considerations due to the high investment costs and high operating and maintenance costs for automatic measurement devices.

Acute toxic effects can be recognised with the help of biological systems which use species from different trophic levels and functionality, e.g. fish, daphnia, algae and bacteria.

4.5 Effluents and loads

4.5.1 Effluent assessment

1. Policy of prevention, control and reduction

According to the Convention, waste-water discharges have to be licensed by the competent national authorities and authorised discharges should be monitored and controlled in order to protect transboundary waters against pollution from point sources. Limits for discharges of hazardous substances have to be based on the best available technologies. Stricter requirements are imposed when the quality of the receiving water or the ecosystem so requires. For the identification of potential hazards (including water-hazardous substances and hazardous technical installations), risk assessment methods may be used. In addition, the risk and impact of accidental pollution should be minimised by an effective hazard-control regime including adequate early-warning procedures and a contingency plan.

2. Risk management in water pollution control

There is a lack of knowledge on actual concentrations of many chemicals in surface waters, due to a lack of analytical methods and/or the prohibitive costs of sampling and analyses.

Often, information on microbiological parameters is also missing. This makes a monitoring approach solely based on ambient water quality inadequate. For this reason, the authorisation of discharges of hazardous substances is a basic tool for risk management in water pollution control. Besides, the feedback obtained from the monitoring of the affected surface water has to be used to rationalise and correct the approach.

Trends in chemical monitoring

The European Inventory of Commercial Chemical Substances (EINECS) has identified about 100,000 chemicals. Several thousands of these are expected to occur in river basins. Of these, concentrations of only 30-40 chemicals are regularly monitored in important European aquatic ecosystems.

An increasing interest in monitoring additional chemicals, and at low concentration levels, may be identified, due to:

a) The increase in the number of chemicals which have to be considered in effect assessment, permits and monitoring;
b) Increasing knowledge on the adverse effects of pollutants in extremely low concentrations on human health and biota;
c) The decrease in the concentrations of individual chemicals in the effluent, due to a reduction in pollution by industry and improved waste-water treatment;
d) The rapid increase in available chemical and ecotoxicological analytical methods.

3. Objectives and strategy of effluent assessment

The objectives of effluent assessment may be identified as:

a) Effluent screening in preparing discharge permits;
b) Supervision of authorised discharge permits (measurement obligations are on the dischargers; they should, for example, carry out self-monito-ring);
c) Testing for compliance with discharge limits and the setting of actual effluent charges (inspections by authorities are to be carried out for the purpose of enforcement and control);
d) Estimation of loads, comparison with envisaged pollution reduction or evaluation of remediation activities, getting knowledge on the responses of the receiving water body to the reduced loads;
e) Early warning to indicate malfunctioning or accidental spills in the production process.

The strategy in effluent assessment depends on the identified objectives, the characteristics of the discharge (e.g. thermal discharges; oxygen-consuming, saline, toxic substances), the number of discharged substances, the complexity of the mixture discharged and the variability (irregularity) of the discharge.

4. Choice of parameters included in levies and licenses

A general screening of the discharge is required prior to discharge licensing. A stepwise approach is recommended (see par. 4.1.4). The first steps involve an inventory of all available information, followed by a broad chemical analysis and risk assessment screening to determine whether or not the use of further tests is necessary.

In a pollution charging system, levies will commonly be based on the pollution load. The pollutant load is usually specified by oxygen-consuming substances (COD, BOD) and nutrients. Priority pollutants are not commonly included, though developments are tending towards the inclusion of toxicity to organisms.
In licenses for simple discharges, the chemical analysis of specific parameters may suffice. In complex mixtures, chemical-specific analyses give only information on the "tip of the iceberg". Thus a large number of toxic compounds remain unidentified. For complex mixtures, whole effluent assessment including toxicity tests may be required in addition to chemical-specific analyses and aggregate parameters. Inclusion of these tests in discharge permits is recommended.

Whole effluent testing may include tests for the following characteristics: (a) acute and chronic toxicity; (b) persistence (of toxicity); (c) bioaccumulation properties; (d) genotoxicity.
Screening for acute aquatic toxicity and mutagenicity forms a first and relatively cheap step in a stepwise approach. Current methods for toxicity testing are listed in Annex 3. The relative investment costs and response and labour time are also given.

5. Continuous monitoring and effluent early warning

Continuous monitoring is recommended for early warning of large pollution discharges or for surveys of short duration to get insight into the variability of the effluent discharge. Parameters for continuous monitoring in effluents may be COD (and other oxygen balance associated parameters), total organic carbon (TOC), oil, suspended solids and general parameters, depending on priorities and characteristics of the discharge (e.g. specific industries). Recently developed equipment for continuous monitoring of heavy metals, various organic micropollutants and toxicity may be applicable in the future.

An end-of-pipe installation of an automated effluent early-warning system should be used for high-risk industries, if an acute danger of accidental pollution of the river exists and if such a system can prevent the direct threat to river functions by fast corrective action (e.g. to hold up discharges if effluent storage and clean-up facilities are available, or to intervene in industrial processes).
For effluent early-warning systems, the installation of extensive in-plant process control measures (e.g. the installation of safety systems) is often a more efficient strategy than end-of-pipe monitoring and alarm systems.

4.5.2 Assessment of pollution loads

1. Use of information on pollution loads

Pollution load estimates are used to assess the total input of pollutants to a river and the pollution load of that river to receiving waters (lakes, reservoirs, seas). Riparian countries can agree on pollution reduction targets within a set time interval. The assessment will concentrate on the long-term changes in the pollution loads and on the effects of the measures taken to reduce the pollution load. Pollution from all sources (diffuse and point sources) in riparian countries are to be included in these assessments, thus giving the relative contribution of the various sources in the various riparian countries to the total loads. The total load from point and diffuse sources should be inventoried and estimated.

2. Pollution load estimates

Estimates of pollution loads in a river are based on water-quality monitoring data (concentration of the pollutants) and hydrological observations (river discharge).

For transboundary rivers, the load should be estimated at the border between two countries and in the lowest part of the river, before entering the sea. Often the hydraulic processes in downstream river reaches or estuaries are so complex (due to tidal movement, density currents, broad river mouths) that accurate load estimates from measurements are hardly possible. In these cases measurements at river sites just upstream of the tidal influence should be used, and the sum of downstream effluent discharges should be added later.

Long-term loads, e.g. annual values, are needed. This requires a combination and integration of water discharge and the concentration records for the period concerned. The concentration of the pollutants and water discharge vary over time due to the nature of the pollutants and their sources (diffuse, continuous or periodical point sources), mechanisms of transport in the river, the hydrological system of the river and the frequency of extreme flow conditions.

3. Diffuse pollution loads

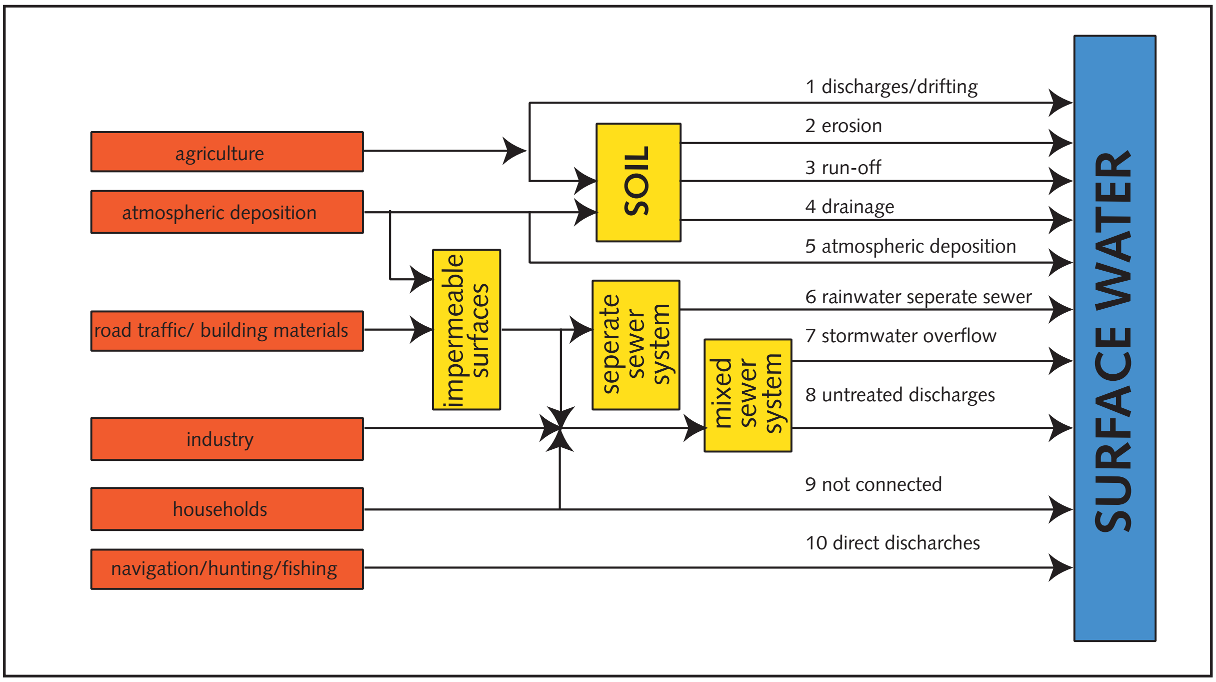
It is recommended that simple and transparent methods should be used for estimating diffuse pollution loads. Rough estimates could be fine-tuned later on, if needed. For the sake of comparability, it is of the utmost importance that riparian countries should document the results carefully and make the chosen steps transparent.

First the principal sources of diffuse pollution and the selected substances have to be defined, as well as the entry routes of the substances to the river. Then the methods for estimating the load have to be chosen. These could be of the following type:
- Emission factor times statistical variable;
- Concentration times water quantity;
- Quantity of substance used (applied, traded) times percentage that reaches the river.

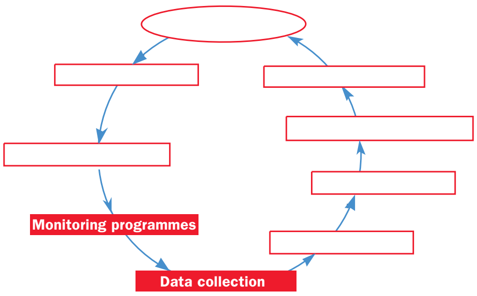
For emission factors, actual (local) values have to be used as much as possible.

Figure 10 gives the basic schedule of sources and entry routes as used by the International Commission for the Protection of the River Rhine.

Figure 10
Base schedule for sources and entry routes of diffuse pollution (International Commission for the Protection of the River Rhine)



5. Monitoring programmes



5.1 General aspects of monitoring programmes

1. Introduction

The design and operation of monitoring programmes includes many aspects, such as field measurements, sampling (sample collection, pre-treatment, method of storage and transport), chemical analysis and data collection. Therefore, in the process equal attention should be paid to all those elements. The design of a monitoring programme includes the selection of parameters, locations, sampling frequencies, field measurements and laboratory analyses.

Ten basic rules for a successful monitoring and assessment programme:

1. The information needs must be defined first and the programme adapted to them, and not vice versa (as was often the case with multi-purpose monitoring in the past). Adequate financial support must then be obtained.
2. The type and nature of the water body must be fully understood (most frequently through preliminary surveys), particularly the spatial and temporal variability within the whole water body.
3. The appropriate media (water, particulate matter, biota) must be chosen.
4. The parameters, type of samples, sampling frequency and station location must be chosen carefully with respect to the information needs.
5. The field equipment and laboratory facilities must be selected in relation to the information needs and not vice versa.
6. A complete and operational data treatment scheme must be established.
7. The monitoring of the quality of the aquatic environment must be coupled with the appropriate hydrological monitoring.
8. The quality of data must be regularly checked through internal and external control.
9. The data should be given to decision makers not merely as a list of parameters and their values, but interpreted and assessed by experts with relevant recommendations for management action.
10. The programme must be evaluated periodically, especially if the general situation or any particular influence on the environment is changed, either naturally or by measures taken in the catchment area.

2. Parameters

In general, the selection of parameters for monitoring is based on their indicative character (for uses/functioning, issues and impacts), their occurrence and their hazardous character.
For reasons of efficiency, the number of parameters should be restricted to those whose uses are explicitly identified; the surplus value of any additional parameter should be subject to cost-effectiveness consideration. Parameters, objectives and standards should be selected jointly by the riparian countries of the transboundary river in question.

3. Selection of sites

It is necessary to have a clear picture of the part of the river of which a monitoring location and its monitoring results is representative. There are two levels at which a monitoring site can be representative:

- On a macro scale the selection of monitoring sites will be determined by the information objectives (far field representative);
- On a micro scale it is the local circumstances that determine the exact monitoring location (near field representative).

For the combined use of quantity and quality data (e.g. in case of computation of loads), the location of hydrological measurements and of water-quality sampling should be the same as far as possible. Different locations are allowed only if the relationship between the hydrological characteristics of both sites is unambiguously known.

4. Sampling/measurements

Water quantity and quality, sediment characteristics and biota vary over time and in different places. The objectives of monitoring strongly influence the timescale of interest (e.g. long-term variations for trend detection, short-term changes for flood forecasting and early warning). The required frequencies and methods of sampling (e.g. grab sampling, composite sampling) should be determined on the basis of temporal and spatial variability as well as of the monitoring objectives.

5. Joint measurements

Joint measurements are recommended to improve the cost-effectiveness and comparability of results. A detailed time schedule of the common measurements and sampling campaigns should explicitly be agreed upon.

6. Quality control and inter-laboratory testing

Quality control should be performed on a national level, to ensure that institutions involved in a monitoring programme achieve an acceptable standard of accuracy and precision. To ensure the comparability of data of a transboundary river, inter-laboratory testing on the level of the whole river basin is inevitable. Information exchange on the instruments used (water quantity) and their regular calibration are also necessary. Riparian countries should agree on criteria for equal performance of measurement methods and analytical results rather than on equal methods.

5.2 Water-quantity monitoring

1. Parameters and measurements

The main hydrological and hydrometeorological parameters, like precipitation, snow cover, water level, river flow, sediment discharges (suspended sediment and bed load), evaporation and evapotranspiration, soil moisture, temperature and data on ice conditions, should be measured and estimated. The use of data has changed remarkably during the past decades, due to developments in the use of models, forecasting systems, etc. An evaluation of the use of the data could lead to a prioritisation of measurements, higher demands on the availability of data, the optimisation of the monitoring programme and/or the development of new practices for measurement, data collection or data transmission.

2. Station locations

The selection of monitoring sites for the management of a transboundary river basin should be governed by the purpose for which the data or records are collected and by the accessibility of the site. For hydrometeorological parameters, spatial representativeness is crucial.

Major locations of gauging stations are the lower reaches of rivers, immediately upstream of the river mouth or where the rivers cross borders, near the confluence with tributaries and at major cities along the river (used for flood forecasting, water supply and transport). In general, a sufficient number of gauging stations should be located along the main river to permit interpolation of water level and discharge between the stations. Water balances require enough observation stations at small streams and tributaries as well.
Gauges on lakes and reservoirs are normally located near their outlets, but sufficiently upstream to avoid the influence of drawdown.

Hydraulic conditions are an important factor in site selection on streams, particularly where water levels are used to compute discharge records via water level relationships (rating curves). Unambiguous relationships are found at stations that are located at streams with natural regimes, not affected by variable backwater at the gauge, caused by downstream tributaries or reservoir operations or by tidal effects.

3. Frequencies

The frequency of measurements, data transmission and forecasting depends on the variability of the hydrological characteristics and the response time requirements of the objective of monitoring.

Systematic water level recordings, supplemented by more frequent readings during floods, are needed for most streams. The installation of water level recorders is essential for streams whose level is subject to abrupt fluctuations. For flood forecasting or flood management, telemetric systems may be used to transmit data whenever the water level changes by a predetermined amount. Continuous river flow records are necessary in the design of water-supply systems, and in estimating the sediment or chemical loads of streams, including pollutants.

Factors to be considered in scheduling the number and distribution of discharge measurements within the year include:

- The stability of the stage-discharge relationship;
- Seasonal discharge characteristics and variability;
- Accessibility of the gauge in various seasons.

Many discharge measurements at different flow levels are necessary at a new station to define the stage-discharge relationship, while at existing stations as many measurements have to be done as necessary to keep the stage-discharge relationship up to date. Adequate determination of discharge during flood and under ice conditions is of prime importance.

4. Methods of measurement

Many international standards exist for the establishment of measurement stations and for direct and indirect methods for measuring water levels, velocities, flows and sediment transport in rivers, as well as for other parameters. [31, 32, 33]

Since discharges are usually not measured continuously, records of discharges are computed from the relationship between water level and discharge. An unambiguous relationship imposes requirements on the selection of the site of water level measurement. If these requirements cannot be met, other (more expensive) methods can be applied, such as ultrasonic measurement equipment. This method requires a well defined and stable profile of the river bed.

5. Joint measurements

To check the comparability of data, riparian countries can agree on joint measurements of discharges. The performance of measurement practices can be compared at the site by comparing the measurements of each country using its own devices and methods at the same section at the same time.
For the harmonisation of daily discharge data at stations, riparian countries can agree on the measurement of discharges on their own territory according to a set timetable.

5.3 Water-quality monitoring

5.3.1 Monitoring parameters, locations and frequencies

1. Parameters

Parameters should be indicative of the functions and issues of river basins. In table 3, a core set of indicative parameters is listed per issue. For specific human uses, standards should be formulated, making monitoring parameters explicit. For ecological functioning, parameters are specified by the selected method of assessment (indices, habitat factors) and regional reference communities. The selection of hazardous pollutants as monitoring parameters depends on:

a) Noxious, cumulative and persistence characteristics;
b) Specific problem substances (produced and/or used in the river basin);
c) The probability of occurrence; in practice this should be based on results of (site-specific) preliminary surveys.

Furthermore, nationally and internationally recognised lists of problem substances can often be used as the starting point for the selection of monitoring parameters. They draw attention to pollutants that are often a problem and that have been politically recognised. The availability of reliable and affordable analytical and measurement methods may restrict the selection of monitoring parameters. [29, 34, 35]

2. Appropriate media

Water-quality monitoring should be performed using the most appropriate media for sampling (water, suspended matter, sediments or biota). Many chemicals can be measured with sufficient accuracy only in one medium, but not in another. The selection of the medium to be examined will be determined largely by the properties of the specific substance, the characteristics of the area involved and the concrete objective of the examination. The method of pretreatment should also be sufficiently specified (e.g., filtration yes/no).

3. Sampling locations

In general, the selection of sampling sites in a river basin is based on their representativeness of the river reach concerned. The required distance between sampling locations can be critically evaluated from their degree of correlation by statistical analysis of time-series of parameters. However, this is possible only as far as these time series are available.

In transboundary rivers, sampling should preferably be performed at or near to border crossings (e.g. to be able to show the contribution towards reduction targets per country). Sampling in the river and in the main tributaries upstream of the confluence is important to show the contribution (e.g. pollution load) of different tributaries. The selection of sampling sites downstream of a confluence should avoid the uncertainties related to incomplete mixing (mixing zones can be several kilometres long, depending on the width-depth ratio of the main river).

Considerations of the local representativeness of the sampling point at the river site are to be based on preliminary surveys, taking into account the hydrology and morphology of the river. In general, locations in the main flow of the river will be chosen for water and suspended solid sampling. Bottom sediment can best be sampled in regions where the suspended material settles. As a consequence, most sediment samples are taken near river banks and in the downstream sedimentation area.

The number of sampling points for sediment monitoring strongly depends on the objectives. For trend detection, a low number of sampling points or mixing samples into composite samples can yield enough information. If spatial information is to be estimated, the number of sampling sites will increase and no composite samples will be used.

4. Sampling frequency

The selection of the sampling frequency for surface water should be based on:

a) The variability in parameter values, as related to relevant margins (in practice based on statistical analysis of time series for parameters representative of groups of parameters);
b) The statistical significance and accuracy required for specific objectives (trend detection, load calculation, compliance testing).

Sampling frequencies for suspended solids are very similar to surface water sample frequencies. For load calculation a higher sampling frequency is recommended during the start of flooding periods, when the main load of suspended solids is transported. The precision of the estimates obtained by sampling at regular intervals depends mainly upon the distribution of the total load over the year. The reliability of load estimates obtained with current monitoring programmes can be more effectively improved by increasing the sampling frequency than by optimising measurements.
For sediments, the temporal variability is rather low, so sampling

frequencies can also be low (e.g. one sample per year). A period of low discharges, when settling of suspended material can occur, is the best time for sediment sampling.

5.3.2 Sampling, transport and pre-treatment

1. Sampling methods

The necessity to obtain information which is integrated or differentiated over time and space should determine the selection of methods for measurement and sampling of water and sediment quality and biota. There are various possible methods, e.g. grab sampling, depth integrated sampling, time proportional composite sampling and space composite sampling. Protocols to ensure the comparability of the results and prevent sample contamination should be established for all sampling methods.

Monitoring of the biological status implies measurement and sampling of biotic groups. Each biotic group requires specific sampling and measurement methods, e.g. phytoplankton and zooplankton are collected by fine mesh nets, waterfowl is measured through field observations. Guidelines for measuring and sampling biotic groups may be found in the technical literature.

Some indicative parameters like dissolved oxygen, pH, water temperature, redox potential, etc. are best measured *in situ*, using sensor-based instruments. These instruments require regular calibrations. *In situ* measurements are often combined with sampling for laboratory analyses. If so, it is recommended that the required *in situ* measurements should be part of the sampling protocol, including the procedure for reporting the results.

2. Transport and storage

To avoid changes in the samples during their transport and storage before analysis, sufficient attention should be paid to conservation and rapid analysis. In other words, no addition (e.g. contamination), loss (e.g. adsorption to the wall of the container) or deterioration (e.g. physico-chemical or biological degradation or transformation) can be allowed. Conditioning, pretreatment and transport of samples should follow standardised procedures.

5.3.3 Laboratory analysis

Analytical and biological methods and ecotoxicological tests should be well validated, described and standardised and be sufficiently selective and robust. The required sensitivity, accuracy and precision of analytical methods depend on the defined relevant margins for information use. Standardisation is especially important for parameters with method-dependent results (Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Adsorbable Organic Halogen (AOX), etc.). The development and use of higher-performance analytical techniques should be initiated only if defined relevant margins cannot be met, and if this is sufficiently cost-effective. [34]

5.3.4 Early-warning stations

1. Parameters and measurement equipment

Measurement systems in an early-warning station are either substance-oriented or effect-oriented. Chemical analysis screening methods can detect increases in concentrations of specific substances. However, only a fraction of the large number of chemical substances that occur can actually be measured on-line. Biological early-warning systems can detect deterioration in water-quality through the biological effects on fish, daphnia, algae, bacteria, etc.

The pollutants that are frequently occurring in the river basin in hazardous concentrations and jeopardise water uses should be target compounds for the early-warning system. Simple indicative parameters such as dissolved oxygen, pH or oil substances can be measured by automatic *in situ* sensors. If the detection of specific problematic micropollutants (e.g. pesticides) is needed, advanced analytical systems based on gas chromatography with mass spectrometry (GC-MS), high-performance liquid chromatography (HPLC) and others can be used. However, the investment, operating and maintenance costs are high. Toxicological effects in organisms on various trophic levels can be measured with automated biological early-warning systems.

Early-warning equipment puts high demands on operation characteristics such as speed of analysis, capability of identification and reliability of operation. Characteristics such as the precision and reproductivity of the analysis are less critical.

2. Sampling locations

Early warnings should provide enough time for emergency measures to be taken. Thus, the location of an early-warning station should be determined by the relation between response time (the time interval between the moment of sampling until the alarm) and the travel time of the pollution plume in the river from the warning station to the site where the water is used (e.g. water intake for drinking water). High river discharges are decisive for the latter. Furthermore, the sampling point should obviously be chosen in such a way that no pollutant is missed in the water to be used.

3. Sampling frequencies

The measurement frequency should be determined by the expected size of pollutant plumes (elapsed time for the plume to pass the station) so that no significant pollutant is missed. Dispersion of the plume occurs between the discharge location and the sampling location due to the discharge characteristics of the river. Furthermore, the frequencies should provide sufficient time to take action in the event of an emergency. Additional (intensified) sampling is recommended after the first indication of accidental pollution.

5.4 Effluent monitoring

1. Parameters

The selection of monitoring parameters should be based on the actual possibility of the occurrence of specific pollutants in an effluent discharge, based on their application and creation in production processes or their presence in used raw materials. Priority setting, based on the risk assessment in the selection process for effluent quality parameters, is highly recommended. Existing national or international priority lists of chemical substances can be helpful. In addition to specific pollutants, an increasing emphasis should be placed on aggregate parameters and total effluent toxicity testing. Selected parameters should be included in the self-monitoring obligation of the discharger's license.

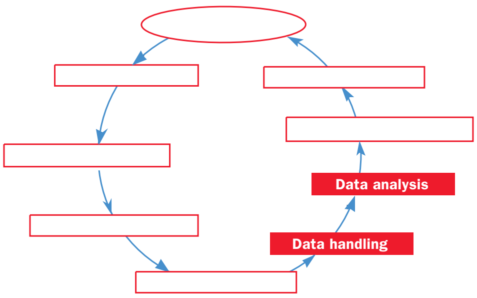
2. Aggregate parameters

The analysis of aggregate parameters provides an efficient means for rapid pre-screening and may be selected per industrial category. Examples of feasible aggregate parameters include organic halogens and acetylcholinesterase inhibition. In general, in effluents determinations of organic extractions of water samples (EOX, EOP) are preferable (in view of bio-availability) to total elemental determinations (AOX).

3. Sampling frequency and sampling method

Sampling frequencies and sampling methods of effluent discharges should be based on the amount and variability of the effluent discharged. Surveys of restricted duration (using continuous or high-frequency sampling) should be performed to gain the required insight into discharge characteristics (e.g. batch processes versus continuous processes).
The statistical significance and accuracy required for specific objectives (compliance testing, load calculation) can be a basis for the selection of sampling frequencies and sampling methods.

6. Data management



1. Introduction

Data produced by monitoring programmes should be validated, archived and made accessible. The actual goal of data management is to convert the data into information that will meet the specified information needs and the associated monitoring objectives. The combined use of data from multiple sources makes high demands on the data exchange and the data management system used.

2. Data management steps

To safeguard a valuable, future use of the collected data, four data management steps are required before the information can be properly used:

a) Data should be analysed, interpreted and converted into defined forms of information using the appropriate data analysis techniques;
b) Data should be validated or approved before they are made accessible to any user or entered into any data archive;
c) Information should be reported to those who need to use it for decision-making, management evaluation or in-depth investigation. The information should also be made accessible to the public and presented into tailor-made formats for different target groups;
d) Data necessary for future use should be stored, and data exchange should be facilitated not only at the level of the monitoring body itself, but also at all appropriate levels (international, ECE regionwide, river-basin level, etc.)

Data storage

Probably the weakest link within the data management chain is the proper storage of data. If data are not accessible and complete with respect to the conditions and qualifiers pertaining to their collection and analysis or properly validated, the data will never be able to satisfy any information need.

3. Data dictionary

The first archiving of monitoring data generally takes place at the monitoring agency itself. According to the Convention, transboundary cooperation has to involve the exchange of data. To facilitate the comparability of data, strict and clear agreements should be made on the coding of both data and meta-information. If data are to be stored, attention should be given to standardised software packages for data management, and to data storage formats to improve the possibilities for data exchange. Furthermore, framework agreements regarding the availability and distribution of data may facilitate the data exchange.
A data dictionary containing this information and agreements on the definition of terms used for the exchange of information or data should be agreed and jointly drawn up.

4. Data validation

Notwithstanding the quality control of separate procedures (for sampling, measurements, analyses), data validation should be an intrinsic part of data handling. Such a regular control of the newly produced data should include the detection of outliers, missing values and other obvious mistakes (e.g. dissolved concentrations higher than total concentrations). Computer software can help to perform the various control functions, such as correlation analysis and application of limit pairs. However, expert judgement and thorough knowledge of the water systems are indispensable for this validation. When the data have been thoroughly checked and the necessary corrections and additions made, the data can be approved and made accessible.

5. Data storage and meta-information

To be available for future use, data should be stored in such a manner that they are accessible and complete with respect to all the conditions and qualifiers pertaining to data collection and analysis. Information on the dimensions and appearance should be stored (e.g. phosphate in mg P/l or µg PO_4/l).

Furthermore, a sufficient amount of secondary data ('meta-information'), which is necessary to interpret the data, has to be stored. Characteristics regarding time and place of sampling, type of sample, preconditioning and analytical techniques are commonly stored. If monitoring is performed in media other than the water phase (e.g. suspended solids, biota), relevant meta-information such as total amount of substances in different media, particle size distribution, etc. should be recorded.

It is essential that any database system is safe-guarded against the entering of data without proper meta-information.

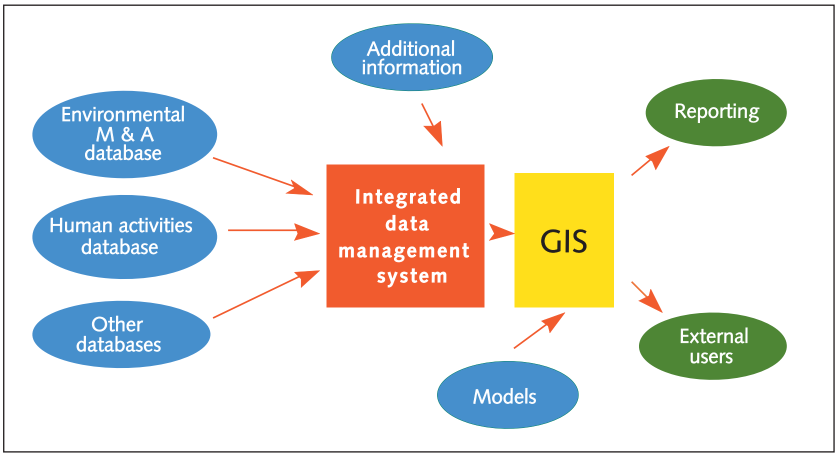
6. Data collection from multiple sources

The data needed, for instance, for the assessment of the ecological state of the river or for load calculations are often products of the monitoring programmes of various laboratories or agencies. Besides monitoring data, additional data from other sources are often indispensable for the assessments. Special attention should be paid to the validation and the quality of the process of data collection from these multiple sources. The use of software for the integration of data is unavoidable.

A geographical information system (GIS) is one of the important tools for the integrated interpretation of data with other information (e.g. maps, satellite pictures, land uses etc.) needed for water quality and quantity assessment, and in the event of accidental pollution, flooding, etc. Such a solution allows external models to be used, controlled access to the system to be given to a broad range of information users, and reports to be adapted to the recipients of the information.

Integrating data originating from different agencies/sources into one system is not easy. The databases should be harmonised to the extent necessary. Standardised interfaces should be used to interconnect databases and provide for integration with a GIS (figure 11). Preferably relational databases are to be used for the integration with a geographical information system (GIS) and models (figure 11). Data processing based on jointly accepted, compatible standards will make assessment and reporting comparable, even when the software used in the riparian countries is not the same.

Figure 11
Integrated environmental information system



7. Data analysis

Data conversion into information involves data analysis and interpretation. The data analysis should be embedded in a data analysis protocol (DAP) that clearly defines a data analysis strategy and takes into account the specific characteristics of the data concerned, such as missing data, detection limits, censored data, data outliers, non-normality and serial correlation. The adoption of DAPs gives the data-gathering organisation or country a certain flexibility in its data analysis procedures, but requires that these procedures should be documented.

In general, data will be stored on computers and the data analysis, mostly a statistical operation, can make use of generic software packages. To achieve standard automated data analysis, the use of tailor-made software is recommended.

8. Data interpretation

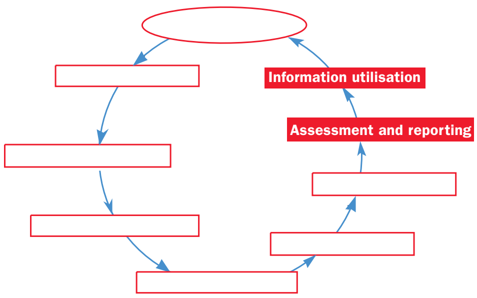
A DAP should comprise procedures for processing the monitoring data in order to meet the specific needs for data interpretation. These procedures should include accepted methods for data interpretation (e.g. calculations based on individual measurement data or yearly averages, and statistical techniques used to remove non-relevant deterministic influences). Such procedures should also include accepted methods for trend detection, testing for compliance with standards, load calculation and calculation of quality indices.

9. Data exchange format

There is a need for an agreed format for the purpose of exchanging digital data. The data dictionary should be the basis for the definition of such a format. Data storage systems of riparian countries should be able to handle the agreed data exchange format.
For international data storage purposes, a central system may be

considered. This could be a task of a joint body which includes representatives of the national authorities of the riparian countries concerned. The Guidelines and tools that are developed within the framework of EUROWATERNET may support such activities. [40]

7. Reporting



1. Introduction

Reporting is the final step in the gathering of information and links this process to the information users. The main issue here is to present the (interpreted) data in an accessible way. How this information is to be presented depends strongly on the audience that is addressed.
Reports should be prepared on a regular basis. A report is not necessarily printed on paper, any form, like oral or digital, can be appropriate. The content of the report, varying from transferring data analyses to a brief overview of the conclusions, the frequency, and the level of detail depend on the use of information. For instance, technical staff will need detailed reports more frequently than policy makers.

2. Different audiences

Reporting has to be tailored to the needs of those who request information. Public authorities, including joint bodies, usually request information in a formalised manner. In this case, the content and frequency of reporting are defined in "reporting protocols". Such reports are usually presented in writing to ensure unambiguous understanding of the results.

In addition, public authorities may have ad hoc requests for information which is not predefined in reporting protocols, but related to specific current topics in water management. This kind of reporting has to meet strict requirements concerning response time and flexibility (the right information in the right place and at the right time).

Reporting to natural persons, their associations, organisations or groups usually follows an ad hoc request for information and can hardly be predefined in reporting protocols. Guidance is provided in the Aarhus Convention [27] and the Guidelines on public participation in water management [28].

3. Quality status report

A quality status report, or environmental indicator report, should provide concise information for decision-making in water management. Quality status reports typically provide information on the functions of the water body, describe the existing problems and the pressure they put on the water body, and give insight into the impacts of corrective measures (remedies). The decision-making value of a quality status report will strongly increase if it introduces simplifying indicators and offers visualisation tools.

4. Standardisation of reports

Standardisation of reports is encouraged per river basin and/or at the international level (e.g. ECE region). It is preferable that joint river-basin quality status reports should also be produced. Reliable reports from countries, Parties to the Convention describing the state of river basins as regards safe human uses and ecological functioning will require improvements in data comparability (e.g. standardisation of laboratory analyses), and the development of a DAP.

The DAP (see par. 6.7) should be extended to reporting formats for the resulting information. A reporting protocol can help to define the different characteristics for each use or audience. The DAP should lay down the format of the report, the frequency of publication, the intended audience, distribution procedures, and the types of conclusions to be drawn and represented. The information should always refer to the information need and the monitoring objective connected to it.

5. Convention-wide reporting

It is recommended that (annual) status reports per river basin should be provided to focus on the link between policy measures (societal response) and the status of the water body of concern. A convention-wide reporting which would cover all catchment areas of the Parties to the Convention is also recommended (e.g. every three years) to encourage the evaluation of progress made under the Convention, stimulate commitment of the members involved, and make results available to the public.

6. Reporting obligations

National and international reporting obligations should be inventoried to be able to fulfil all reporting requirements laid down in water management legislation. The Reporting Obligations Database, developed by the European Environment Agency (EEA), includes an overview of many international reporting obligations. This Database may be complemented with reporting obligations of national and bilateral or multilateral legislation.

7. Internet-based reporting

The Internet provides a powerful tool for sharing and communicating information and can be used to inform and involve the public. Officials are careful about presenting environmental information and data to the public, since there is a danger of misinterpretation of the data and information by laymen. However, involving non-State actors in transboundary water management enables more sustainable cooperation to develop between countries.

8. Presentation methods

The method of presenting the date depends on the target group. Possible presentation techniques, from a detailed presentation to an aggregated overview, are:

a) Tables: by listing measurement data in a table, no data are lost. Nevertheless, the reader has to derive the information from the data;
b) Statistically-processed measurement data: statistical processing will transform the data into values that make changes in time and/or space visible. The information is available to the reader;
c) Graphs: graphs provide a view in which, for instance, trends can be recognised at a glance. By showing standards or other references in the graph, the situation is put in perspective. The amoeba-type presentation is an example of this. Graphs can be line graphs, histograms, pie charts, etc.;
d) Geographically presented information: quality data from a diversity of sources can be interrelated by means of multiple layers of geographically referenced information. This provides a better understanding of the spatial distribution of the parameters involved;
e) Aggregated information: for rapid interpretation of large amounts of data, it can be useful to aggregate the data. Indexes are useful methods for this. Quality indices are a well known instrument within biological quality assessment.

Some examples of presentation methods are given in figures 12 to 14.

Amoeba

The amoeba is a schematic representation of the present condition compared to the "natural" conditions of the past. For the water body under study, a set of parameters that is considered to be representative of the water body's condition is chosen. The reference "system" is represented by plotting the value of the parameters under "natural" conditions on a circle. The present values of the selected parameters are plotted relative to the circle and, for visualisation, these points are connected to one another. This provides an amoeba-like figure, representing deviations from the reference state.

Figure 12.
AMOEBA of the ecological status (1995) of the major Dutch rivers

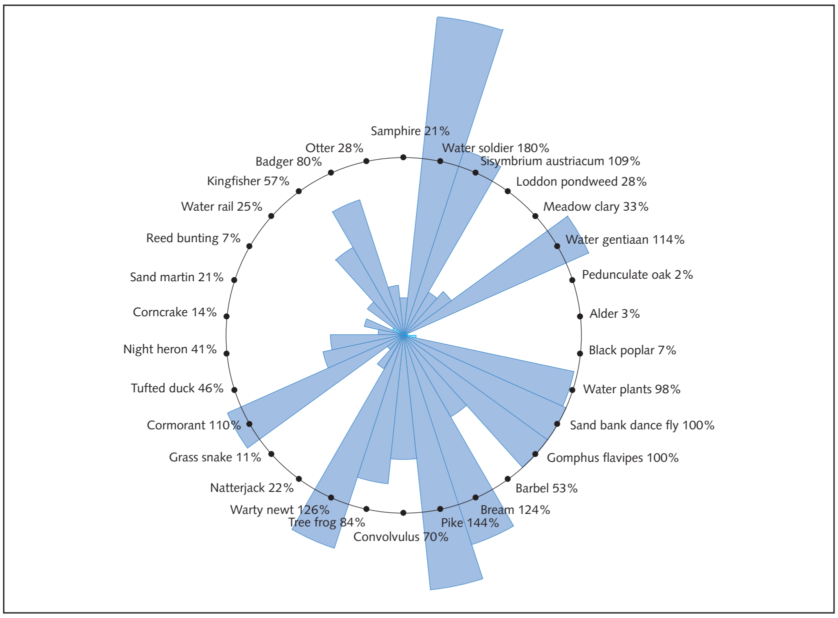
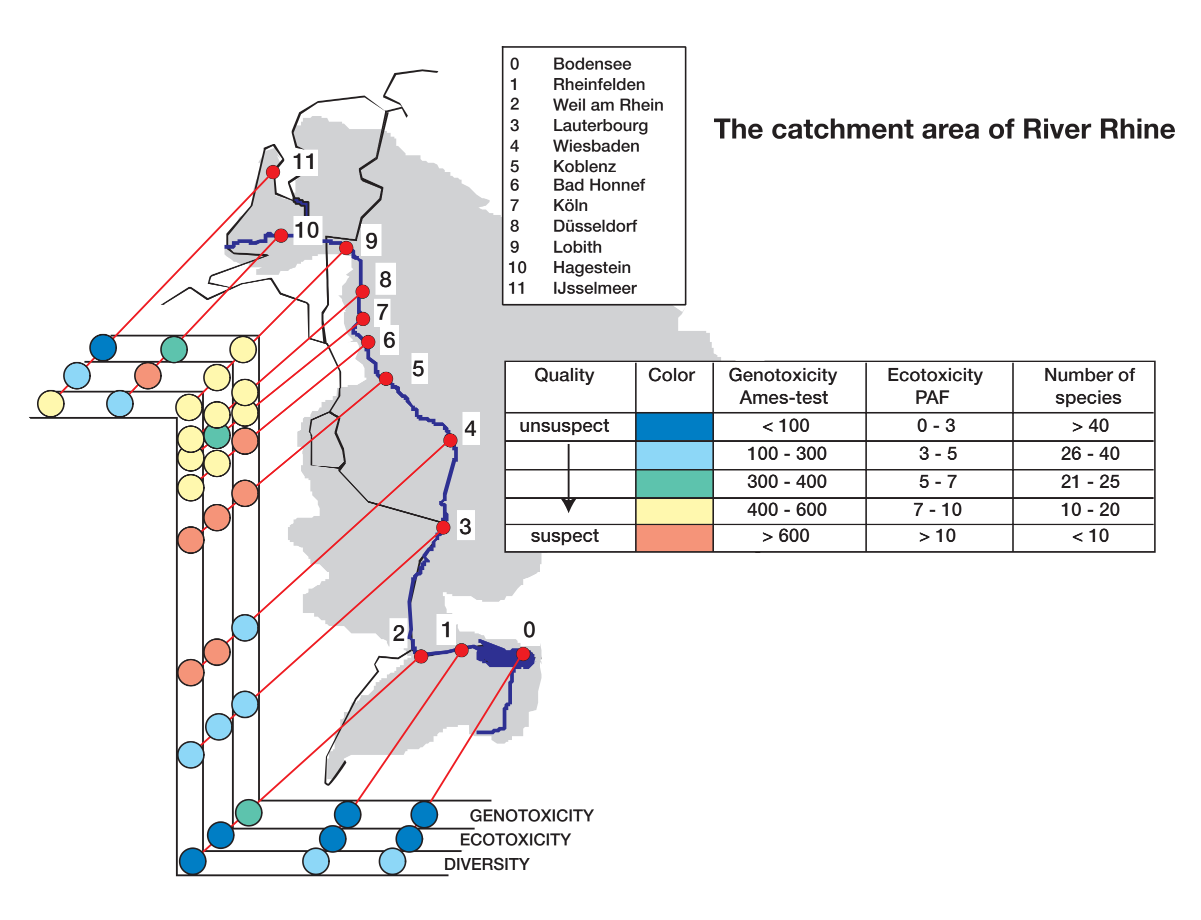


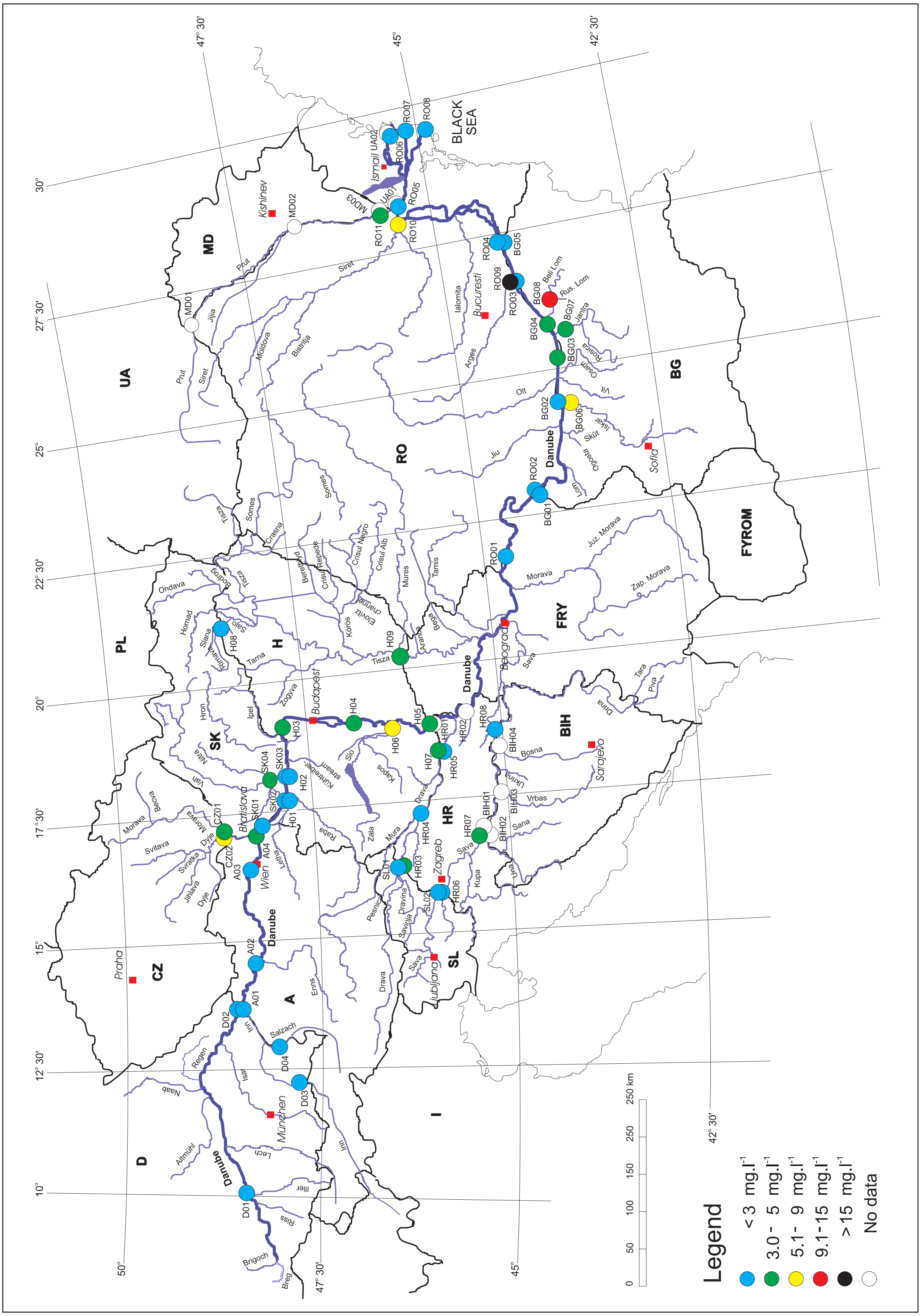
Figure 13
Presentation of effects-oriented monitoring data along the river Rhine.



Quality	Color	Genotoxicity Ames-test	Ecotoxicity PAF	Number of species
unsuspect		< 100	0 - 3	> 40
		100 - 300	3 - 5	26 - 40
		300 - 400	5 - 7	21 - 25
		400 - 600	7 - 10	10 - 20
suspect		> 600	> 10	< 10

An example of a combination of colours, a table and a map. Figure 13 is a presentation of effects-oriented monitoring data along the river Rhine: bioassays, genotoxicity and biodiversity of macrozoobenthos. For the classification and colour mapping sound criteria are crucial.

Figure 14
The annual mean of BOD_5 in the Danube in 1996.



8. Quality management

1. Goals of quality management

The main objective of performing quality management on a process is to be able to keep hold of this process. The monitoring cycle provides the structure of the monitoring and assessment process. By describing the distinctive steps and their interaction, the possibilities, limitations and requirements become clear.

The goals of quality management in monitoring and assessment can be expressed in the terms 'effectiveness' and 'efficiency'. Effectiveness is the extent to which the information obtained from the monitoring and assessment system meets the information needs. Efficiency is concerned with obtaining the information at as low a financial and personnel cost as possible.

Traceability, as a goal of quality management, is concerned with defining and documenting the processes and activities that lead to the information and how the results are achieved. If there is some peculiarity or error, it may be traced to the source and measures can be taken to improve the process.

2. Quality policy and quality management

The quality policy defines the level of quality to be reached. The joint body should declare the quality policy and thus set the prerequisites for quality management. Moreover, the commitment of all the organisations involved in performing quality management is imperative. Striving for quality involves investments in quality systems and in staff training. Quality management can therefore be put into practice only when the management of responsible monitoring organisations is committed to it and provides sufficient funds.

3. Cooperation in quality management

Especially in transboundary cooperation, arrangements for producing and sharing information are important. Quality management supports such arrangements, because it describes the procedures to be implemented and forms a basis for cooperation between riparian countries. Therefore, a quality management system should be accepted by the joint body. Such a quality system should be restricted to those activities that are not yet covered by existing quality systems within the riparian countries.

4. Quality system

The quality system should document the relevant activities, the interactions between these activities and the relevant products in the form of procedures and protocols, dealing with every element of the monitoring cycle. Also, the quality system should document the responsibilities with regard to the distinguished procedures. In drawing up procedures, special emphasis should be laid on responsibilities at points of decision, such as approval of the monitoring and assessment strategy or acceptance of samples at a laboratory. Procedures and protocols should describe what documentation should be produced about the process, for instance loss of sample trays or weather conditions during sampling.

Adherence to procedures should be checked periodically. Evaluation of the usefulness of procedures is essential, procedures should support the making of products of the required quality.

5. Protocols

Protocols for the specification of information needs, defining monitoring and assessment strategies, monitoring programmes, *in situ* measurement and sampling, sample transport, sample storage, laboratory analysis, data handling (validation, storage), data analysis, data exchange and reporting should be drawn up and agreed upon by the riparian countries. These protocols are the operational steps in a process where insufficient quality control may lead to unreliable data. By following protocols, mistakes can be traced and minimised.

For *in situ* measurements and samplings (e.g. water level, river flow, transparency, temperature and pH), special emphasis should be put on protocols describing the field activities, because such measurements cannot be reproduced. It is essential to document sampling and measurement conditions in these protocols.

6. Product requirements

Requirements for all relevant products should be made explicit and documented. The quality system describes how the requirements are integrated into the processes and how deviations from the requirements are dealt with. Standard requirements on recurrent products are set out in the quality system. If monitoring data are used as input for models and GIS presentations, these data should be suitable for this purpose.

7. Standardisation

Standards should be used for methods and techniques for, among other things, measurements and sampling, transport and storage of samples, laboratory analysis, data processing, data handling (validation, storage) and data exchange, calculation methods and statistical methods. Preferably, international standards should be used. If international standards are not available, or, for whatever reason, the use of an international standard is not adequate, national standards should be applied, or, if not available, they should be developed.

The standards used by riparian countries should be comparable. They should not necessarily be the same, but for the sake of the exchange of information, they should provide comparable data. The joint body should agree on the standards to be used by the riparian countries.

9. Joint or coordinated action and institutional aspects

9.1 Introduction

According to the Convention, riparian countries are to draw up bilateral and multilateral agreements or other arrangements on issues covered by it, including arrangements for monitoring and assessment. The Convention also foresees the establishment of joint bodies as one of the main vehicles for transboundary cooperation.

One of the critical obligations is to exchange information widely and as early as possible on issues covered by the Convention. This includes sharing data and information on the status of transboundary waters generated through monitoring activities, and informing the public about these data and information. It also includes sharing data and information generated through other activities, such as preliminary investigations, surveys, literature search (e.g. regarding water-related laws and regulations).

The recommendations made in the previous chapters and sections illustrate that improving the monitoring and assessment of transboundary waters is a complex process that requires more than improvements in technologies/techniques (e.g. better equipment to measure, more sophisticated network design or optimisation). It requires improved ways and means of specifying information needs, coming up with an assessment strategy and/or building on existing legislation. Other aspects will also have a positive or negative effect on monitoring and assessment. These include at least: the ways in which policy plans are drawn up and/or implemented, shared responsibilities among institutions, agreements on transboundary waters, access to information, and building confidence among partners. So, monitoring will contribute to achieving better results in these policy or management areas. On the other hand, progress in these policy and management areas will contribute to improving the ways in which transboundary waters are monitored and assessed (see figure 15). The following sections provide guidance on institutional, administrative and other aspects linked to monitoring and assessment.

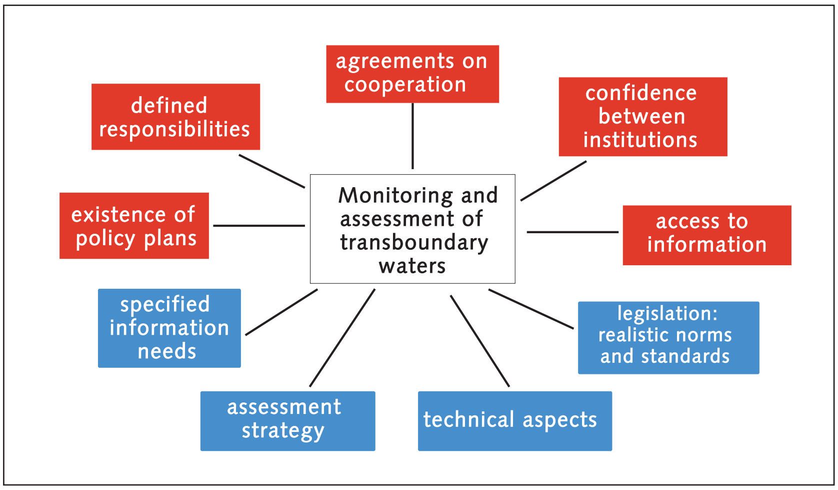


Figure 15
Monitoring and assessment related to policy and management areas.

Data and information exchange: stages of cooperation

In practice, agreements on the management of transboundary waters include various levels of cooperation on data and information exchange.

A low level of cooperation: The downstream country does not receive data from the upstream country and either has to rely on its own measurements in the frontier section or there are joint measurements by both countries.

A medium level of cooperation: Information concerning water resources and water uses, including the probability of occurrence of certain events, is given by the upstream country to its downstream neighbour(s) several times a year (and if applicable from the downstream country to the upstream country).

Close cooperation: The catchment area is managed together from the planning phase up to the operational phase; all data and information are collected and evaluated jointly.

9.2 Recommendations for joint bodies

As foreseen under article 9 of the Convention, these joint bodies are responsible for carrying out 13 major tasks as described below. An analysis of the relationship between these tasks and monitoring and assessment activities has led to the following conclusions and recommendations.

What are joint bodies?

According to the Convention, a joint body means any bilateral or multilateral commission or other appropriate institutional arrangements for cooperation between the Riparian Parties.

An example of such a joint body is the International Commission for the Protection of the Rhine, which has its own secretariat in Koblenz, Germany. Similarly, international commissions have been established for the rivers Danube, Elbe, Meuse, Moselle, Oder, Rhine, Saar and Scheldt and for Lake Geneva, which are all run by their own secretariats.

The vast majority of joint bodies do not have their own secretariats however. Most are called joint or mixed commissions, others meeting of plenipotentiaries, etc. Their secretariat functions are carried out by the staff of relevant ministries or other State entities.

Usually, joint bodies meet annually or at shorter intervals. The heads of delegations from riparian countries are in most cases senior ministerial officials. Some of the meetings may take the form of ministerial conferences, such as the Rhine Ministerial Conference.

1. **Joint bodies shall collect, compile and evaluate data in order to identify pollution sources likely to cause transboundary impact (article 9, paragraph 2 a)**
   Guidance on this task is given in chapter 2, particularly regarding inventories and surveys.

2. **Joint bodies shall elaborate joint monitoring programmes concerning water quality and quantity (article 9, paragraph 2 b)**
   The recommendations contained in these Guidelines should be used as

appropriate. Recommendations contained in the Guidelines on monitoring and assessment of transboundary groundwaters [17] should also be taken into account.

3. **Joint bodies shall draw up inventories and exchange information on the pollution sources mentioned above (article 9, paragraph 2 c)**
Guidance on this task is given in chapter 2, particularly regarding inventories and surveys.

4. **Joint bodies shall elaborate emission limits for waste water (article 9, paragraph 2 d)**
Guidance on this task is given in chapter 2, particularly regarding the evaluation of legislation.

5. **Joint bodies shall evaluate the effectiveness of control programmes (article 9, paragraph 2 d)**
The recommendations on criteria and targets in chapter 2 should be used.

6. **Joint bodies shall elaborate joint water-quality objectives and criteria and propose relevant measures for maintaining and, where necessary, improving the existing water quality (article 9, paragraph 2 e)**
The recommendations on criteria and targets in chapter 2.2 should be duly taken into account. The recommendations to ECE Governments on water-quality criteria and objectives, published in the ECE Water Series No. 1, should also be taken into account.

7. **Joint bodies shall develop concerted action programmes for the reduction of pollution loads from both point sources (e.g. municipal and industrial sources) and diffuse sources (particularly from agriculture) (article 9, paragraph 2 f)**
Riparian countries should agree on quantified management targets. These targets can be worked out in a concerted action programme or strategic plan for the river basin together with measures aiming for ecologically sound and rational water management, the conservation of water resources and environmental protection. These programmes or plans should be based on national programmes and include provisions on mutual assistance. They should be confirmed at the ministerial level. In the preparation of these programmes, plans and measures, joint bodies should use, as appropriate, the recommendations contained in the Guidelines on licensing waste-water discharges from point sources into transboundary waters [25] and in the Guidelines on the prevention and control of water pollution from fertilisers and pesticides in agriculture [26] in conjunction with the recommendations of the present Guidelines, particularly in Chapter 2 and 4.

8. **Joint bodies shall establish warning and alarm procedures (article 9, paragraph 2 g)**
Assistance on this task is given in chapter 4.4.2 which provides basic recommendations on assessment strategies for surface waters.

9. **Joint bodies shall serve as a forum for the exchange of information on existing and planned uses of water and related installations that are likely to cause transboundary impact (article 9, paragraph 2 h)**
It is important that this exchange of information should include systems for monitoring or measurements that provide water-quantity and water-quality related data. It is also important to note that such a

forum for the exchange of information is not necessarily limited to the governmental institutions of the riparian countries. It also refers to the provision of information to the public at large. In this context, the provisions of the Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters [27] should be taken into account, as appropriate. Often the question arises of whether or not data and information should be provided to another Riparian Party free of charge. The Convention does not exclude reasonable charges being made for the collection and, where appropriate, processing of such data and information. This applies, however, only to requests for data and information that is not available.

10. **Joint bodies shall promote cooperation and exchange of information on the best available technology and encourage cooperation in scientific research programmes (article 9, paragraph 2 i)**
    Best available technologies and research and development include such items as operation of monitoring programmes, measurement systems, devices, analytical techniques, data processing and evaluation procedures, and methods for the registration of pollutants discharged.

11. **Joint bodies shall participate in the implementation of environmental impact assessments relating to transboundary waters, in accordance with appropriate international regulations (article 9, paragraph 2 j)**
    A recent UN/ECE study has shown that the participation of joint bodies in environmental impact assessment (EIA) is still very limited. The current Guidelines, if properly implemented by joint bodies, provide much of the basics needed for EIA in a transboundary context. This refers first and foremost to information drawn from inventories and surveys, and information derived from the transboundary monitoring network.

Action to protect the marine environment

The action programmes established for the rivers Rhine and Elbe give definite support to a target set by the North Sea Conference: the stabilisation of the ecological state of the North Sea, the aim being to eliminate important sources of hazardous substances, as far as possible, in the catchment areas of both rivers. Consequently, monitoring programmes should provide information on compliance with this goal.
Except for the activities of the joint bodies for the rivers Danube, Elbe, Moselle, Oder, Rhine and Saar for closer cooperation with the Oslo and Paris Commission (OSPARCOM), the Black Sea Programme and the Helsinki Commission (HELCOM), cooperation with other joint bodies established for the protection of the marine environment is still in its infancy.
At least the requirements to prevent marine pollution from land-based activities should be considered, where applicable, during the "evaluation of legislation" described in these Guidelines.

12. **Joint bodies shall invite joint bodies, established by coastal States for the protection of the marine environment directly affected by transboundary impact, to cooperate in order to harmonise their work and to prevent, control and reduce the transboundary impact (article 9, paragraph 4)**
    As regards monitoring and assessment, cooperation will help in setting appropriate targets and criteria (see paragraph 2.2) as well as in selecting appropriate variables for measurements and indicators.

Cooperation with joint bodies

Within the catchment area of the river Rhine, for example, the joint bodies responsible for the prevention, control and reduction of transboundary impact include: the International Commission for the Protection of the Rhine, the International Commission for the Protection of the Moselle, the International Commission for the Protection of the Saar and the Permanent International Water Protection Commission for Lake Constance. Joint bodies dealing with other water-related activities include the commissions responsible for shipping on the Moselle and the Rhine and the International Commission for the Hydrology of the Rhine Basin.

13. **Where two or more joint bodies exist in the same catchment area, they shall endeavour to coordinate their activities in order to strengthen the prevention, control and reduction of transboundary impact within that catchment area (article 9, paragraph 5)**
In large river basins shared by more than two countries, there are usually several joint bodies established by the riparian countries to prevent, control and reduce transboundary impact. Joint bodies in the same catchment area and established by the same riparian countries may also have different functions. It is of the utmost importance to examine the terms of reference of these bodies during the "evaluation of legislation", in order to understand the possible consequences for the setting of targets or criteria and the carrying-out of other activities of the monitoring cycle.

Some more activities for joint bodies

One may conclude from the above that joint bodies that have their own secretariats may have some advantage in implementing the recommendations of these Guidelines as their staff is continuously working on, or providing guidance on, specific subjects, including monitoring and assessment. This may not be the case with the other commissions. Therefore some kind of mechanism needs to be established to enable these joint bodies to meet their obligations. Such a mechanism could be a steering committee or another form of working group.

It is important to take into account the provisions of the forthcoming EC Directive establishing a framework for Community action in the field of water policy, often referred to as the Water Framework Directive [24]. The Directive's provisions regarding river-basin districts and competent authorities and their tasks covering the entire catchment area will affect not only the EU member countries and their neighbours. They will affect all the countries within a transboundary catchment area if at least one of the EU member countries belongs to this basin. Consequently, the Directive is expected to strongly support the implementation of the Convention in general and its provisions on joint bodies in particular.

9.3 Specific recommendations for joint activities

The Convention includes a number of provisions on monitoring and assessment which call for joint action. The most prominent examples include consultations between Riparian Parties (article 10), joint monitoring and assessment (article 11), exchange of information between

Riparian Parties (article 13), warning and alarm systems (article 14), and public information (article 16) which have been dealt with in the previous chapters of the Guidelines. Recommendations on organisational and institutional aspects are set out in this section.

1. Establishment of working groups

It is useful to establish one or more technical working groups under the joint body which are responsible for ongoing work under the concerted programme or action plan related to monitoring and assessment. These groups should also draw up and implement the monitoring and assessment strategy, including its technical, financial and organisational aspects.
Although the monitoring programme should be embedded in the existing national or regional monitoring programmes and should be carried out by national or other appropriate organisations, the working groups should coordinate the different programmes.

2. Quality assurance

To set up, implement and subsequently manage the quality system and carry out the quality assurance, a quality assurance function under the joint body should be implemented. All activities performed under the joint body's programme should be subject to quality assurance and regular inspections of these activities and recommendations for improvement should be made.

3. Process of cooperation

Procedures for cooperation should be drawn up and laid down in the regulations of the joint body. It should be recognised that the experience of joint bodies clearly shows that cooperation between riparian countries should be based on confidence and needs time to grow. In this respect, a phased approach to cooperation seems most favourable.

4. Arrangements at the national level

At the national level, institutional aspects should be arranged by each country as the lack of these arrangements may considerable hamper international cooperation. Such arrangements include the cooperation between local governments, the coordination of quality and quantity monitoring by various national institutes and the appointment of a national reference laboratory.

5. Access to information

Riparian countries should provide each other access to relevant water-quality and water-quantity information. This includes, for example, information on the operation of hydraulic structures in relation to flow forecasting and ice drifts.

The public should also have access to relevant information, following as appropriate, the provisions of the Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters [27]. If progress in water management is made clear, both governments and the public will support measures.

6. Funding

Riparian countries should provide sufficient funding for the execution of the monitoring and assessment in a transboundary context. This funding should be part of the regular national budget or the regular budget of the joint body shared as appropriate among the parties involved. External funding should be sought only for specific purposes (e.g. surveys, training) as the dependence on external funds may adversely affect monitoring and assessment activities.

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In 1995 the Task Force drew up background reports on which the first edition of the Guidelines was based. These include:

5. Volume 1 Transboundary Rivers and International Lakes.

6. Volume 2 Current Practices in Monitoring and Assessment of Rivers and Lakes.

7. Volume 3 Biological Assessment Methods for Watercourses.

8. Volume 4 Quality Assurance.

9. Volume 5 State of the Art in Monitoring and Assessment of Rivers.

Extensive use was also made of the five volumes and the executive summary of the project "Monitoring Water Quality in the Future"(1995). This project was co-funded by the European Commission (EC, DG XI C5), the Netherlands Ministry of Housing, Spatial Planning and the Environment (VROM/DGM-SVS) and the Institute for Inland Water Management and Waste Water Treatment (RIZA) of the Netherlands Ministry of Transport, Public Works and Water Management:

10. Volume 1 Chemical Monitoring.

11. Volume 2 Mixture Toxicity Parameters.

12. Volume 3 Biomonitoring.

13. Volume 4 Monitoring Strategies for Complex Mixtures.

14. Volume 5 Organisational Aspects.

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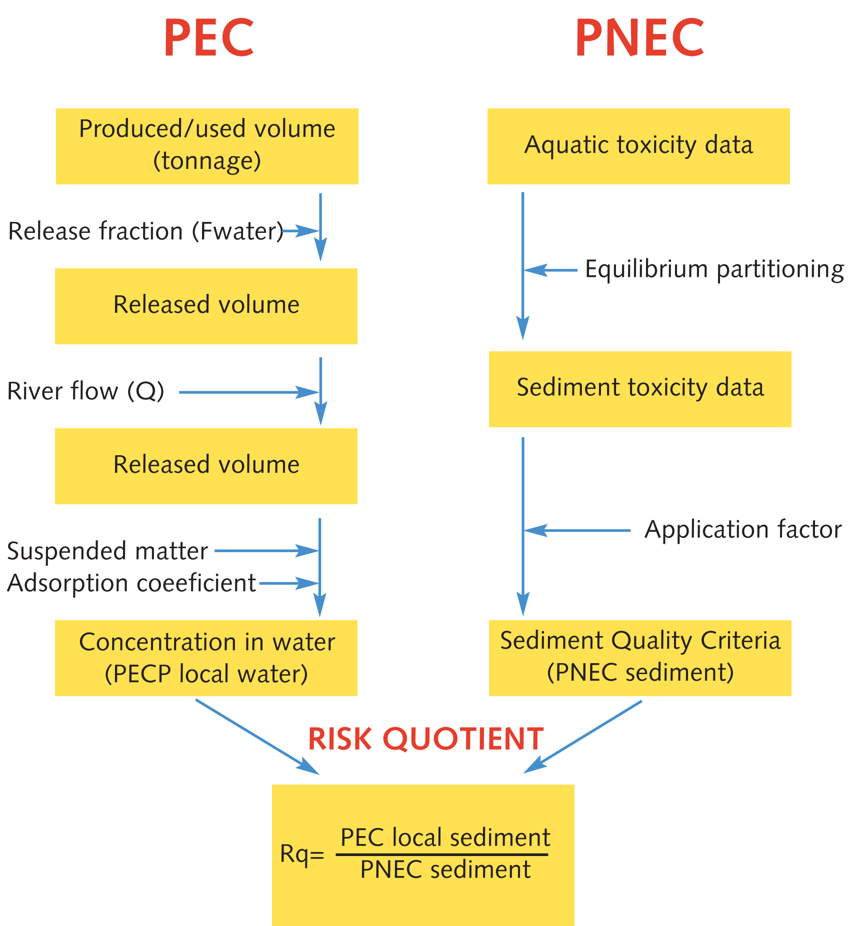
Annex 1
Monitoring and risk assessment

Data from inventories and surveys can be interpreted by risk assessment. This refers to the comparison of data on exposure (that is, measured contaminant concentrations in the environment or estimates generated by models) with environmental quality criteria. These criteria might be applied to specific functions of waters, e.g. use for drinking water, recreational use. The exposure concentrations, measured or estimated, are referred to as Predicted Environmental Concentrations (PEC), the 'safe levels' are referred to as Predicted No Effect Concentrations (PNEC). For the latter, terms like Maximum Permissible Concentration (MPC) or function-related directives are also used. The assessment of sediment quality is illustrated in the scheme below.



The outcome of the assessment is a PEC/PNEC ratio. If this ratio is < 1, little priority is given to the potential risk derived. If this ratio is ≥ 1, a certain risk is indicated. Classifying the responses might help to visualise the estimated risks in time trends or spatial gradients.

The more function-related the quality criteria used, the more specific the conclusions that can be drawn on which function might be impeded due to the pollution present.

Annex 2
Assessments of aspects related to human health and safety

1. Information needs and provisions of the Protocol on Water and Health

To satisfy the information needs for implementing the Protocol on Water and Health, the following measures are to be carried out:

- Identification of outbreaks or incidents of water-related disease;
- Identification of significant threats of such outbreaks or incidents, including those resulting from water pollution or extreme weather;
- Prompt and clear notification to the relevant public authorities about such outbreaks, incidents and threats;
- Dissemination (in the event of any imminent threat to public health from water-related disease) to the public who may be affected of all information which is held by a public authority and which could help the public to prevent or mitigate harm;
- Preparation of recommendations to the relevant public authorities and, where appropriate, to the public about preventive and remedial actions.

This will require the establishment of national and/or local surveillance and early-warning systems. Work on such systems is still in its infancy. Good systems to identify sporadic diseases linked to recreational waters (e.g. contamination by toxic substances from algae) do not yet exist.

Table 4
Examples of water-related disease and major requirements to monitor and assess surface waters

Category of disease and major route of transmission	Major requirements for surface water monitoring
Infectious water-borne disease through drinking water	Monitoring of surface waters used as a source of drinking water supply
Infectious water-borne disease through recreational exposure as well as infections and infestations, skin and other reactions through water contact	Monitoring of surface waters used for recreational purposes; monitoring of enclosed waters
Water-related via foodstuffs through irrigation, shellfish and aquaculture	Monitoring of surface waters used as a source of water supply for irrigation and the production of fish in aquaculture; monitoring of emissions into surface waters, including emissions from aquaculture and inputs from diffuse pollution sources
Sanitation-related through direct or indirect human contact with human excreta	Monitoring of surface waters used as a source of drinking water supply and water supply for irrigation and the production of fish in aquaculture
Drowning and physical injury through water-related accidents, misadventure during water-based recreation, and flood events	Measurements of flow velocity, water levels, turbidity, sediment transport; observation of waters carrying boulders and fallen trees

Moreover, outbreaks of diseases are rarely identified as such, because reporting systems, for example for family doctors, are inadequate or do not exists. Guidance will be given in the course of the further work under the Convention and its Protocol, for example, by the Task Force on water and health.

2. Major requirements for surface water monitoring to assess health aspects

The relationship between water-related disease, major routes of transmission and requirements to monitor and assess these surface waters is dealt with in table 4.

3. More than surface water assessment

One should note, however, that surface water monitoring, inventories, surveys and various reporting mechanisms provide only part of the information needed to assess whether or not a particular water use will have an adverse impact on human health. Therefore, surface water monitoring has to be supplemented with other kinds of monitoring (groundwaters, drinking water, irrigation water, etc.) as well as health-related surveillance.

Examples of targeted analysis and investigations

As concerns water-borne and sanitation-related disease, targeted analysis and investigations may include such agents of the faecal-oral group as:

- Vibrio cholerae, Salmonella typhi, Salmonella paratyphi A and B, Salmonella spp., Shigella spp., Campylobacter spp., Yersinia enterocolitica, enteropathogenic Escheria coli, Aeromonas spp.;

- Hepatitis viruses A and E, gastroenteritis viruses (caliciviruses, enteric adenoviruses, rotaviruses), enteroviruses (poliomyelitis);

- Gardia lamblia, Cryptosporidium parvum, Entamoeba histolytica, Balanthidium coli, Cyclospora spp.

4. Health-related surveillance

Activities of health-related surveillance include the public health service reporting infectious diseases, reporting system of family doctors (on the basis of questionnaires), targeted analysis of high-risk areas (natural and enclosed waters for recreation, etc.), and targeted investigations into high-risk areas for microbiological contamination and toxic agents (e.g. algal toxins).

Annex 3
Ecotoxicological indicators and laboratory testing

For pollution with toxic substances, ecotoxicological indicators and laboratory testing by bioassays can be used for monitoring ambient water, sediment and effluent, and for early warning.

Rules of thumb to consider when choosing ecotoxicological test methods to assess the quality of environmental samples are:

- Short-term random testing is less sensitive than long-term regular testing. The discriminatory power needed to distinguish differences in time or space is essential;
- Species having different physiologies and feeding strategies will have a different sensitivity to different pollutants. In general, representatives of algae, crustaceans and fish together can cover a wide variety of chemicals, when concentrations are high enough to elicit responses;
- Instead of long-term regular testing, an alternative approach to improve detection levels is the pre-concentration of environmental samples and subsequent short-term random testing. The extraction techniques available, however, will lose some of the chemicals present.

Recommended freshwater test methods[1]

(a) Effluents

Simple*	Intermediate**	Advanced***
Toxicity		
Daphnia acute	Daphnia chronic	Zebra fish ELS
Vibrio fisheri (Microtox)	Scenedesmus or	
Brachionus (Toxkit)	Chlorella (algae)	
Guppy acute		
Lemna (plant)		
Mutagenicity/carcinogenicity		
Ames	Notobranchius SCE	
Mutatox		
SOS Chromotest		
Persistence/biodegradation		
BOD/COD		
Toxicity test following biodegradation procedure		

*   : technologically simple, easy to perform, rapid screening.
** : intermediate test duration
*** : `longer test duration, adequate skills and facilities needed

Indication of costs: see table below

(b) Ambient water

See effluents.
Often the more sensitive chronic test methods (or preconcentration procedures) are needed to strengthen the discriminatory power.

(c) Sediment toxicity

Simple	Intermediate	Advanced
Chironomus 10 d *(whole sediment)*	Chironomus 28 d *(whole sediment)*	zebra fish ELS *(pore water)*
Daphnia acute *(pore water)*	Daphnia chronic *(pore water)*	Branchiura *(whole sediment)*
Microtox *(pore water)*		
Toxkits *(pore water)*		

(d) Early warning

Simple	Intermediate	Advanced
artificial substrate with regular sampling	flow through aquaria with fish	automatically operating BEWS using fish, daphnids or algae

Note:
1 These methods are well described in test protocols (see Organisation for Economic Co-operation and Development (OECD), American Society for Testing and Materials (ASTM), Society of Environmental Toxicology and Chemistry (SETAC), International Organisation for Standardisation (ISO):

Indication of relative costs of equipment, and the response and labour time for the above-mentioned bioassays. Climatised rooms are recommended (not included in the costs)

(a) Effluents

	Investments	Response time	Labour time
Daphnia acute	low	low (48hrs)	low
algae	high	intermediate (96hrs)	intermediate
guppy	low	intermediate (96hrs)	low
Microtox	high	low (30min)	low
Toxkits	low	low (24hrs)	low
Daphnia chronic	low	high (16d)	high
Zebra fish ELS	intermediate	intermediate (7d)	high
Ames	intermediate	low	low
Mutatox	high	low	intermediate
SOS Chromotest	high	low	low
Notobranchius SCE	intermediate	intermediate	high
BOD/COD	low	intermediate	low
toxicity + biodegradation	Intermediate	high	intermediate

(b) Ambient water

see effluents

Note:
Often pre-concentration techniques are recommended to enhance response levels; these are not included in the indicative costs.

(c) Sediments

	Investments	Response time	Labour time
Chironomus acute	low	intermediate (10 d)	low
Daphnia acute (pore water)	intermediate	low (48 hrs)	low
Microtox (pore water)	high	low (30 min)	low
Toxkits (pore water)	intermediate	low (24 hrs)	low
Chironomus chronic	low	high (28 d)	intermediate
Daphnia (pore water)	intermediate	high (16 d)	high
Zebra fish ELS (pore water)	intermediate	intermediate (7 d)	high
Branchiura chronic	low	high (21 d)	high
Tubifex bioaccumulation	low	high (28 d)	low

Investments in sediment assessment apply e.g. to centrifuges and mixing/shaking equipments of high capacity.

Note:
Daphnia and Chironomus are preferred above Microtox and Toxkits, whenever cause-effect relations are valuable in the assessment strategy (i.e. specificity of response to certain (groups of) chemicals). When only simple screening is of relevance, the latter simple tests are suitable.

(d) Early warning

	Investments	Response time	Labour time
artificial substrate	low		intermediate
flow through aquaria	intermediate		intermediate
autom. early warning	high		intermediate

Annex 4
Analytical costs of water-quality parameters

Indicative parameters

For the indicative water-quality parameters included in Table 3 this Annex gives an indication of analytical techniques, investment costs, labour time and operating costs.
An extended list of parameters gives additional information on some parameters often applied in inventory studies and for screening purposes.

(a) Water

Parameter	technique	investment[1]	Labour time	operating costs	
dissolved oxygen	electrode	< 5000 euros	low	low	
conductivity	electrode	< 5000 euros	low	low	
acidity	electrode	< 5000 euros	low	low	
Cl	electrode	< 5000 euros	low	low	
major ions	electrode	< 5000 euros	low	low	
	ionchrom.	40000 euros	intermediate	intermediate	
BOD)	manual	<10000 euros	intermediate	low	
COD)	automated	50000 euros	low	low	
TOC		50000 euros	intermediate	intermediate	
total-N)					
ammonium)					
Kj-N)	colorimetric	30000 euros	low	intermediate	
nitrate)	or titrimetric	30000 euros	low	intermediate	
total-P)	or ionchrom.	40000 euros	intermediate	intermediate	
ortho-P)					
chlorophyll-a		< 10000 euros	intermediate	low	
faecal co-liform		< 5000 euros	intermediate	low	
faecal streptococcus		< 5000 euros	intermediate	low	
salmonella		< 5000 euros	intermediate	low	
viruses		< 5000 euros	high	low	
floating oil	visual	---	low	low	
oil	UV	15000 euros	intermediate	low	
Cd, Hg	AAS	100000 euros	high	high	
	ICP	150000 euros	high	high	
other metals	AAS/ICP	no add.app.req.	intermediate	intermediate	
AOX	coulometric	75000 euros	intermediate	Intermediate	
EOX	coulometric	no add.app.req.	intermediate	Intermediate	
POX	coulometric	no add.app.req.	intermediate	Intermediate	
acethylcholines-terase inhibition	colorimetric	40000 euros	intermediate	high	
organo-Cl-pest.	GC2		75000 euros	high	high
organo-P-esters	(GC)		75000 euros	high	high
atrazine	(GC)		75000 euros	high	high
benzene	(GC)		75000 euros	high	high
pentachl.phenol	(GC)		75000 euros	high	high
PAH's	(GC/HPLC)		75000 euros	high	high
PCB's	(GC)		75000 euros	high	high
total-α			50000 euros	high	
intermediate					
total-ß			50000 euros	high	
intermediate					
tritium			50000 euros	high	
intermediate					
γ-nuclides	γ-counter	high	high	intermediate	

(b) Suspended solids

parameter	technique	investment[1]	Labour time	operating costs
particle size	pipet	< 10000 euros	high	low
	part.sizer	60000 euros	high	intermediate
organic carbon %	colorimetric	30000 euros	low	intermediate

EXTENSION

(c) Indicator

parameter	technique	investment[1]	Labour time	operating costs
EOP	colorimetric	100000 euros	low	intermediate
immunoas-says		25000 euros	low	high

(d) Screening

parameter	technique	investment[1]	Labour time	operating costs
GC-MS: water		150000 euros[3]	high	high
GC-MS: suspended solid		150000 euros	high	high
LC-MS		200000 euros	high	high
ICP-MS		200000 euros	high	high

Note:

[1] Investment and operational costs are based on West-European standards; The costs can differ within the UN-ECE region with a factor 1-10.

[2] A standard instrumentation should be available to do perform routine GC-analyses. This instrumentation can be used for different variables, but enough capacity should be available to account for maintenance and method development.

[3] Minimal standard equipment for laboratories includes GC-MS for identification and conformation. LC-MS and ICP-MS is not to be considered as standard equipment.