Convention on the Protection and Use of Transboundary Watercourses and International Lakes

GOOD PRACTICE FOR MONITORING AND ASSESSMENT OF TRANSBOUNDARY RIVERS, LAKES AND GROUNDWATERS

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PREFACE

A major activity in the field of capacity building in the countries in Eastern Europe, the Caucasus and Central Asia (EECCA) is the project “Capacity for Water Cooperation” (CWC project). It is part of the work programme 2004-2006 under the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention). The CWC project strengthens the capacity of decision makers, planners and practitioners in EECCA countries. Cross-fertilization among policy, science and practice, and exchange of experience between ongoing projects and countries is a particular feature of it. The CWC project also establishes a network of EECCA experts involved in transboundary water management.

This publication is the outcome of the third workshop under the CWC project, the **workshop on joint monitoring and assessment of shared water basins, including early warning and alarm systems** (Tbilisi, 31 October – 2 November 2005), which was prepared by the Finnish Environment Institute and the United Nations Economic Commission for Europe (UNECE) in cooperation with the Ministry of Environment of Georgia and the Regional Environmental Centre for the Caucasus.

The publication explains the key principles and approaches of monitoring and assessment of transboundary watercourses and provides for strategies to monitor and assess these watercourses. It particularly focuses on areas of interest to policy and decision makers in EECCA countries as brought forward during the workshop. The publication is also important for those, who are involved in, or responsible for, establishing and carrying out cooperation between riparian countries as well as representatives of joint bodies (e.g. bilateral and multilateral commissions).

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INTRODUCTION

Information based on well-organized monitoring programmes is the key prerequisite for accurate assessments of the status of water resources and the magnitude of water problems. These assessments are essential for preparing proper policy actions at the local, national and transboundary levels. Moreover, integrated water resources management in transboundary basins shared by two or more countries calls for comparable information. There is a need for a common basis for decision-making, which requires harmonized and comparable assessment methods and data management systems as well as uniform reporting procedures.

Decision makers and planners need to know the underlying legal, administrative and institutional aspects of monitoring and assessment. To secure funding for monitoring and assessment, senior managers need to be able to make a funding case that sets out both the benefits of monitoring for management of water resources and water quality, and the possible costs in environmental degradation and other impacts of not monitoring. To make the best use of available resources and knowledge, often a step-by-step or phased approach is recommended to respect the countries' economic situations. Securing reliability of laboratory work is another theme, which requires the attention of policy makers and planners. This also applies to early-warning systems, which are still to be improved in EECCA. Establishing and implementing monitoring programmes, managing data and making assessments as well as reporting and using information are other important activities of transboundary water monitoring, which can only be properly undertaken if policy makers, planners and senior managers provide their inputs.

Thus, the publication deals with the constraints and opportunities for cooperation. The publication also contains the findings of invited lectures, both from Western European and EECCA countries, as well as conclusions and recommendations of the workshop.[1]

The workshop showed that there was a need for specific technical guidance on such distinct issues as hydrobiological monitoring including biotests to warn for hazardous substances, advantages and disadvantages of automatic water-quality measuring stations, self-monitoring of operators of industrial installations, and monitoring and assessing the impact of diffuse pollution sources on the status of watercourses. Not all of these technical issues are being dealt with in this publication. It is therefore strongly recommended to use the guidance developed by specific working groups under the Water Convention, particularly the UNECE Guidelines on monitoring and assessment of transboundary rivers[2], groundwaters[3] and lakes[4] and other guidance documents, such as the 1996 Guidelines on licensing wastewater discharges from point sources into transboundary waters.[5]

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[1] http://www.unece.org/env/water/cwc/monit_assess.htm

[2] Guidelines on monitoring and assessment of transboundary rivers, 2000, UNECE Task Force on Monitoring and Assessment, available at http://www.unece.org/env/water/publications/documents/guidelinestransrivers2000.pdf

[3] Guidelines on monitoring and assessment of transboundary groundwaters, 2000, UNECE Task Force on Monitoring and Assessment, available at http://www.unece.org/env/water/publications/documents/guidelinesgroundwater.pdf

[4] Guidelines on monitoring and assessment of transboundary and international lakes, 2003, UNECE Working Group on Monitoring and Assessment, available at http://www.unece.org/env/water/publications/documents/lakesstrategydoc.pdf and at http://www.unece.org/env/water/publications/documents/lakestechnicaldoc.pdf

[5] Guidelines on licensing wastewater discharges from point sources into transboundary waters. In: Water Series No. 3: Protection of transboundary waters – guidance for policy- and decision-makers. Economic Commission for Europe, ECE/CEP/11, United Nations, New York and Geneva. 1996.

1. BASIC PRINCIPLES AND APPROACHES

1.1 Monitoring and assessment

Monitoring is usually understood as a process of repetitive measurements, for defined purposes, of one or more elements of the environment according to pre-arranged schedules in space and time, using comparable methodologies for environmental sensing and data collection. Measurements and observations are to be made and samples are to be collected as far as possible at the same locations and regular time intervals.

Measurements are at the root of assessments of the current state of water quantity and quality and their variability in space and time. Often, such assessments are appraisals of the hydrological, morphological, physico-chemical, biological and/or microbiological conditions in relation to reference conditions, human effects and/or the existing or planned uses of water. Obviously, the ways and means of making assessments will determine or at least influence the design of the monitoring programme. Therefore, a methodology for assessing watercourses should be drawn up in parallel with the design of the monitoring programme.

The ultimate goal of monitoring is to provide the information needed to answer specific questions in decision-making or operational management at the local, national and transboundary levels. Thus, monitoring systems are expected to provide accurate and reliable hydrometeorological data and information (e.g. air temperature, humidity, evapotranspiration, quantity and quality of precipitation, depth of snow cover, ice drifts, water level and run-off, hydrological regime of glaciers) as well as other data and information to characterize the state of, and impact of natural and anthropogenic factors on, the aquatic environment, forests, wetlands, soils, fauna and flora as well as human health and safety. This may require that monitoring systems provide information on background pollution levels.

A special feature of monitoring systems is the provision of information in critical situations, such as floods, ice drifts and droughts. Telemetric systems are often used to transmit data whenever the water level changes by a predetermined amount.

Early-warning stations, which use sensors for certain physico-chemical parameters as well as fish, daphnia, algae and/or bacteria to warn for acute toxic effects, are a means to warn for accidental pollution of watercourses. In the long term, monitoring and early-warning systems should be integrated. To this end, information is needed to identify hot spots, considering state and technology of production facilities. The exchange of such information should be organized among the various involved sectors and institutions.

For transboundary waters, data and information is gathered from the national monitoring networks, established and operated according to national laws and regulations and international agreements. Thus, the national legislation, obligations from international agreements and other commitments should be carefully examined to establish, upgrade and run these systems.

1.2 Applying the river basin approach

The river basin forms a natural unit for integrated water resources management. It is a natural unit in which rivers, lakes and groundwaters interact and which is linked – through coastal environments – with the oceans or enclosed seas.

Consequently, monitoring programmes should be designed for entire river basins. This may be difficult to achieve in some countries in Eastern Europe, the Caucasus and Central Asia (EECCA), where water management is not always based on river basins due to inappropriate legislation and inappropriate institutional capacity.

The level of detail of monitoring and assessment depends on the density of the network, the frequency of measurements and observations, the size of the basin and/or the issue under investigation. For example, when a measuring station at the outlet of the river basin reports water-quality changes, often a more detailed monitoring network is needed to reveal the source, the causal agent and the pathways of pollutants. The interaction between surface waters and groundwaters may also be different in the upper and lower parts of the river basin. In these cases, assessments are needed for the smaller catchment areas of tributaries to the main river, catchment areas of lakes or recharge areas of groundwater aquifers, whether transboundary or not. Monitoring networks, frequencies of measurements and determinands are to be adapted to these conditions of the basin.

As river basins usually stretch over different administrative units (e.g. States of a Federal Government, provinces), geographical units (e.g. mountainous and lowland areas) and State borders, cooperation between competent actors is needed. Competent actors include environmental and water agencies, hydrometeorological services, geological surveys organizations, public health institutions and water laboratories. They also include research institutes and universities engaged in methodical work on monitoring, forecasting and assessment. Such cooperative arrangements and institutional frameworks will largely influence the efficiency of monitoring and assessment.

1.3 Analyzing water management issues and functions and uses in a river basin

Water management issues in a river basin (e.g. flooding) and its various uses and functions (e.g. drinking water use, maintenance of aquatic life) should be well known, documented and prioritized to build up a useful monitoring and assessment programme.

In a river basin, various functions and uses may compete or even conflict, in particular if water is scarce or its quality deteriorating. Examples include the competition for water within a country (e.g. water use for drinking, recreation, industry and agriculture) and different upstream-downstream interests of riparian countries (e.g. hydropower production in an upstream country and irrigational water use in a downstream country). The matrix in Table 1 provides guidance to this end.

In analyzing water management problems, both water management and political priorities should be made clear. Political priorities include targets and target dates for achieving good status of watercourses, safe drinking water supply and adequate sanitation. The analysis of sources of conflicts, such as competing upstream-downstream interests, is an additional precondition to set priorities.

Table 1. Examples of relations between functions/uses and issues in a river basin

FUNCTIONS/USES → ISSUES ↓	Human health and safety	Ecosystem functioning	Fisheries	Recreation	Drinking water	Irrigation	Industrial use	Hydro power	Transport medium[1]	Navigation
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 loss		X	X	X						
River continuity decrease		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			

X Main impact on functions/uses (problem).
1 Transport of water, ice, sediments and wastewater.
2 Dry/wet acid deposition
3 Organic matter and bacteriological pollution by wastewater discharge
4 Specific substances, e.g. radionuclides, heavy metals, pesticides.

To make the connections between different issues in water management clearer, the Driving Forces-Pressures-State-Impact-Responses (DPSIR) framework can be used (Figure 1), which has been adopted by the European Environment Agency (EEA).[6]

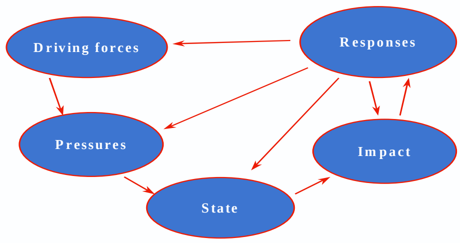

Figure 1: The Driving Forces-Pressures-State-Impact-Responses (DPSIR) framework

The DPSIR framework assumes that social, economic and environmental systems are interrelated. These links are illustrated conceptually by driving forces of environmental change, which create pressures on the environment. These in turn affect the state of the environment. The subsequent changes in status, or "impacts", include impacts on ecosystems, economies and communities. The negative impacts will eventually lead to responses by society, such as the development of policies for river basin protection. If a policy has the intended effect, its implementation will influence the driving forces, pressures, status (state) and impacts.

[6] The DPSIR framework was drawn up and adopted by the European Environment Agency (EEA) as the causal framework for describing the interactions between society and the environment. For further details see: http://org.eea.eu.int/documents/ar1997/ar97_highlights.html

Indicators under the Driving Forces-Pressures-State-Impact-Responses (DPSIR) framework

Information should preferably be presented in a condensed/aggregated way. Indicators may provide for this. The selection of an indicator is a means of reducing the volume of data without loosing significant information. Indicators are preferably made up of measurable parameters. They should be suitable for communicating to policy makers or to the public. As an example for eutrophication, total phosphorus can be a good indicator.
It is important to clarify whether the chosen indicators describe a "driving force", a "pressure", a "state", an "impact" or a "response". Such a grouping in easily understandable categories takes into account cause-effect relations. The grouping of the chosen indicators under the above five categories of the DPSIR framework, assumes that there are links between social, economic and environmental systems. These links are illustrated conceptually by driving forces of environmental change, causing pressures on the environment, which in turn affects the status of the environment. The subsequent changes of the status are termed impacts and comprise impacts on ecosystems, economy, as well as population. The negative impacts will eventually lead to responses by society, such as the development of policies for river basin protection. If the policy has the intended effect, it will after its implementation influence the driving forces, pressures, status and impacts.

The use of the DPSIR framework in EECCA

The value of the DPSIR framework for establishing monitoring and assessment systems should be brought to the attention of decision makers and planners in EECCA countries. Experience shows that the grouping of indicators under the five categories of the DPSIR framework is often neglected, which gives rise to an unbalanced use of characteristics that describe only one or another component of the DPSIR framework, thus disregarding cause-effect relations.

To characterize whether a watercourse in EECCA meets, for example, the conditions for "drinking-water use", indicators of the DPSIR framework could include:

- Driving forces: the number of people serviced;
- Pressures: wastewater quantity and composition of the wastewater (e.g. BOD) that is discharged into the surface water, treated or untreated, and the amount of water abstraction for sanitary and drinking-water purposes relative to the available water resources;
- State of the surface water: concentrations of nutrients or organic matter; State of the sanitary situation: availability of safe drinking water and basic sanitation, e.g. as percentage of the population that has access to it;
- Impact: changes in the water use patterns, such as an increasing or decreasing number of drinking-water companies that have to apply extra treatment. The impact in societal terms can be described in terms of number of people with diseases related to bad sanitary situation (e.g. reduced number of outbreaks of a given water-related disease).
- A "response" measures that aims at "driving forces" is the promotion of better hygienic behavior (e.g. location of waste and/or wastewater disposal separated from location of drinking-water abstraction). A response measures that aims at "pressures" is the application of improved wastewater treatment (e.g. number of facilities with primary, secondary etc. treatment). An example of a response measure to change the "status" is subsidizing improvements and maintenance of sewage water systems. A response measure directed at "impacts" is, for instance, an improvement of medical support for sick people or vaccination against water-related diseases.

2. LEGISLATION AND COMMITMENTS

Multilateral environmental agreements, UNECE Conventions and Protocols, EU Directives and bilateral and multilateral transboundary water agreements contain obligations for countries to monitor and assess watercourses and to report, as appropriate, to a specific body, such as an international commission, secretariat or organization. Ideally, these obligations should become part of the national legislation to steer the activities in national competent bodies. It is, however, not realistic to expect all countries to amend their national legislation in the short term.

In addition, national legislation should set out obligations and responsibilities for relevant agencies, such as hydro-meteorological services, environmental and health agencies, geological surveys and operators of water regulation structures and industrial installations to monitor and assess various components of the environment and report on the results.

Although the above conventions, directives and agreements are drivers for water monitoring and assessment, both nationally and in a transboundary context, there is still a weak knowledge in EECCA countries about these instruments and their specific provisions regarding monitoring the state of the environment, access to information, the requirement to exchange available information free-of-charge and restricted data confidentiality. National practice should observe these requirements. Moreover, existing bilateral and multilateral agreements among EECCA countries, which lack the above specific provisions, should be supplemented by Protocols or other appropriate jointly agreed rules.

A specific problem of EECCA legislation arises from the use of “maximum permitted concentrations of pollutants for a specific water use” or water-quality standards that seem to be more stringent than in other parts of Europe and impossible to comply with, partly due to the non-existence of measuring devices or lacking financial and human resources. Given the experience from other countries and organizations, new legislation should be based on water-quality objectives or even ecologically based objectives.

As already stated, it is not realistic to expect that EECCA countries would amend their national law in the short term. Given a step-by-step approach, it is recommended that transboundary commissions should agree on the above requirements and include for their day-to-day practice the use of water-quality and environmental objective. They should also agree on assessment methods to be used jointly within their transboundary basin.

2.1 Relevant UNECE Conventions and Protocols

UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention)

The 1992 Water Convention’s main goal is to prevent, control and reduce any transboundary impacts, which include significant adverse impacts on human health and safety, flora, fauna, soil, air, water, climate, landscape and historical monuments or other physical structures. The Convention is one of the most essential legal instruments for the monitoring and assessment of transboundary waters in the UNECE region. Several bilateral and multilateral agreements on transboundary waters[7] among UNECE countries support action required by the Water Convention.

In defining and specifying information needs, establishing monitoring systems and assessing the status of waters, it should be noted that the Convention requires the setting of emission limits for

[7] http://www.unece.org/env/water/partnership/part.htm

discharges from point sources on the basis of the best available technology (BAT). It also requires authorizations for wastewater discharges and the application of at least biological or equivalent processes to treat municipal wastewater.

The Convention calls for best environmental practices (BEP) to reduce the input of nutrients and hazardous substances from agriculture and other diffuse sources. In addition, Parties must define water-quality objectives for the purpose of preventing, controlling and reducing transboundary impacts.

Obligations relating to the monitoring and assessment of specific river basins that stem from bilateral or multilateral agreements should be in line with the requirements of the Water Convention. In particular, joint bodies – any bilateral or multilateral commission or other appropriate institutional arrangements for cooperation between riparian parties – have a specific role in monitoring and assessment.

Protocol on Water and Health to the 1992 Water Convention[8]

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 should 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 must also develop integrated information systems to handle information about long-term trends in water and health; current concerns, 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.

Protocol on Civil Liability and Compensation for Damage Caused by the Transboundary Effects of Industrial Accidents on Transboundary Waters (Civil Liability Protocol)[9]

The Civil Liability Protocol is a joint Protocol to the Water Convention and the Convention on the Transboundary Effects of Industrial Accidents (described in the next paragraph). It contains provisions on measures to reinstate or restore damaged or destroyed components of transboundary waters. For this purpose, it is important to know the conditions that would have existed had the industrial accident not occurred. This requires appropriate data and information on the status of transboundary waters and their components.

Convention on the Transboundary Effects of Industrial Accidents (Industrial Accidents Convention)[10]

The 1992 Industrial Accidents Convention is designed to protect human beings and the environment against industrial accidents by preventing them as far as possible, by reducing their frequency and severity and by mitigating their effects. The UNECE Industrial Accidents Notification System comprises a network of points of contact, which should be consulted if information on the occurrence and impact of accidental pollution on water bodies is required.

[8] http://www.unece.org/env/water/text/text_protocol.htm
[9] http://www.unece.org/env/civil-liability/welcome.html
[10] http://www.unece.org/env/teia/welcome.htm

Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Aarhus Convention)[11]

The Aarhus Convention stipulated, *inter alia*, that any environmental information held by a public authority must usually be provided when requested by a member of the public. The scope of information is quite broad, including information on water and human health and safety. Public authorities may impose a charge for supplying information provided the charge does not exceed a "reasonable" amount. There is an obligation to progressively make environmental information publicly available via electronic databases. The Convention specifies certain categories of information (e.g. state of the environment reports) that should be made available in this form.

2.2 EU legislation

The legislation of the European Union is a major tool for defining how surface waters and groundwaters should be used, protected and restored. The two main approaches to preventing, controlling and reducing water pollution – the "water-quality objective approach" and the "emission limits value approach" – play a decisive role in monitoring and assessing watercourses. The first approach sets minimum quality requirements for waters and the second one establishes maximum allowed quantities for pollutants discharged to watercourses.

The key directive concerning monitoring is Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for European Community action in the field of water policy (2000[12], 2001[13]), hereinafter referred to as the EU Water Framework Directive (EU WFD). Specific monitoring obligations also result from other EU Directives, commonly referred to respectively as the 1991 Urban Waste Water Treatment Directive,[14] the 1996 Integrated Pollution Prevention and Control Directive,[15] the 1991 Nitrates (from Agricultural Sources) Directive,[16] the 1998 Drinking Water Directive,[17] the 1976 Bathing Water Quality Directive[18] and the 1976 Directive on pollution caused by certain dangerous substances discharged into the aquatic environment of the European Community.[19]

The EU WFD provides the framework for the protection of surface waters, transitional waters, coastal waters and groundwaters in the EU area. The main aims of the EU WFD are to prevent further deterioration of and protect and enhance the status of aquatic ecosystems, to promote sustainable water use, and to mitigate the effects of floods and droughts. The environmental objective is to achieve good ecological and chemical status for waters by 2015 at the latest.

Within a river basin where use of water may have transboundary effects, the requirements for the achievement of the environmental objectives established under the EU WFD, and in particular all programmes of measures, should be coordinated for the whole river basin. For river basins extending beyond the boundaries of the Community, member States should endeavour to ensure appropriate coordination with the relevant non-member States. The EU WFD is to contribute to the implementation of Community obligations under international conventions on water protection and management, notably the UNECE Water Convention.

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[11] http://www.unece.org/env/pp/welcome.html
[12] http://europa.eu.int/eur-lex/pri/en/oj/dat/2000/l_327/l_32720001222en00010072.pdf
[13] http://europa.eu.int/eur-lex/pri/en/oj/dat/2001/l_331/l_33120011215en00010005.pdf
[14] http://europa.eu.int/eur-lex/en/consleg/main/1991/en_1991L0271_index.html
[15] http://europa.eu.int/eur-lex/en/consleg/main/1996/en_1996L0061_index.html
[16] http://europa.eu.int/eur-lex/en/consleg/main/1991/en_1991L0676_index.html
[17] http://www.europa.eu.int/eur-lex/lex/LexUriServ/LexUriServ.do?uri=CELEX:31998L0083:EN:HTML
[18] http://europa.eu.int/eur-lex/en/consleg/main/1976/en_1976L0160_index.html
[19] http://europa.eu.int/eur-lex/en/consleg/main/1976/en_1976L0464_index.html

The surface water monitoring network should be established to provide a coherent and comprehensive overview of the ecological and chemical status of each river basin. In order to address the challenges in a cooperative and coordinated way, member States, Norway and the European Commission agreed on a Common Implementation Strategy. In the first phase of the joint process, a number of guidance documents[20] covering, among other issues, monitoring and public participation were prepared.

2.3 Other international commitments

Legal obligations

Legal obligations regarding the monitoring and assessment of watercourses also arise from other international legal instruments, commonly known respectively as the Ramsar Convention on Wetlands,[21] the Convention on Biodiversity,[22] the Convention to Combat Desertification[23] and the Barcelona Convention,[24] as well as other regional seas conventions.[25]

The Statistical Office of the European Communities (Eurostat) collects statistics on water resources, water abstraction and use, and wastewater treatment and discharges through the Eurostat/OECD Joint Questionnaire.[26]

International programmes

One important source of information on the status of rivers, lakes and groundwater aquifers is EUROWATERNET, created by the European Environment Agency (EEA). It is being further developed to comply with the recommendations on the strengthening of national and transboundary environmental monitoring and information systems in countries of Eastern Europe, the Caucasus and Central Asia.[27]

Monitoring and assessment activities under the auspices of United Nations organizations and programmes produce valuable information, which can be used for carrying out assessments of transboundary watercourses. The GEMS/Water Programme[28] is a primary source of global water quality data and provides information on the state and trends of regional and global water quality. The Global International Waters Assessment (GIWA)[29] produces a comprehensive and integrated global assessment of international waters, their ecological status and causes of environmental problems. The World Water Assessment Programme[30] seeks to develop the tools and skills needed to achieve a better understanding of basic processes, management practices and policies that will help improve the supply and quality of global freshwater resources. Its product, the World Water Development Report, is a valuable source of information on water resources.

Data and information on groundwaters can be obtained from International Shared Aquifer Resources Management (ISARM),[31] which aims at developing methods and techniques for

[20] http://europa.eu.int/comm/environment/water/water-framework/guidance_documents.html
[21] http://www.ramsar.org
[22] http://www.biodiv.org
[23] http://www.unccd.int
[24] http://www.unep.ch/regionalseas/regions/med/t_barcel.htm
[25] http://www.unep.ch/regionalseas/legal/conlist.htm
[26] http://epp.eurostat.cec.eu.int
[27] http://www.unece.org/env/documents/2003/ece/cep/ece.cep.94.rev.1.e.pdf
[28] http://www.gemswater.org
[29] http://www.giwa.net
[30] http://www.unesco.org/water/wwap
[31] http://www.isarm.net/

improving understanding of the management of shared groundwater systems, considering both technical and institutional aspects. The International Groundwater Resources Assessment Centre (IGRAC),[32] which facilitates and promotes worldwide exchange of groundwater knowledge to improve assessment, development and management of groundwater resources, is another important source of information.

The national hydrological/meteorological services of the member States of the World Meteorological Organization (WMO) operate over 475,000 hydrological stations worldwide. National databases are good sources of water-quantity data and related information. WMO's Global Runoff Data Centre is a digital worldwide depository of discharge data and associated metadata and serves as a facilitator between data providers and data users.

Data on water-related disease can be accessed through the Health for All Database [33] of the World Health Organization (WHO). This database includes data on diarrhoeal diseases, viral hepatitis A and malaria incidence as well as on the number of people connected to water supply systems and having access to sewage systems, septic tanks or other hygienic sewage disposals. Supporting data are available from the Joint Monitoring Programme (JMP), carried out under the auspices of WHO and the United Nation's Children Fund (UNICEF). One of the goals of the JMP is to report on the status of water supply and sanitation.

3. ESTABLISHING THE INSTITUTIONAL FRAMEWORK

3.1 Institutional arrangements at the national level

Suitable institutional arrangements at the national and local levels are a precondition for monitoring and assessment of transboundary waters, to ensure cooperation among various governmental entities, the private sector and others. In making these arrangements, it is important to note that the responsibility for groundwater monitoring and assessment with regard to water quality and quantity may lie with geological survey organizations rather than environmental or water agencies. Cooperation among water, environmental and health authorities is needed to ensure the collection and use of data related to human health and safety.

Hydrometeorological services play an essential role in providing water-quantity data and early-warning information for extreme hydrological events. Organizations which operate response systems for emergencies involving water regulation structures and industrial plants are important partners in providing data to mitigate the adverse impacts of failures of such installations on transboundary waters. Industrial enterprises that monitor their own water abstractions and wastewater discharges provide data for compliance purposes. Assessment of watercourses also requires socio-economic data, including population and economic statistics, which are collected by statistical offices. In many instances, it is necessary to seek expertise from research institutions, universities or the private sector.

[32] http://www.igrac.nl
[33] http://www.euro.who.int/hfadb

Reform of the institutional basis in EECCA

In EECCA, the ongoing reform process of ministerial environmental departments and water agencies is an opportunity for harmonizing responsibilities in water management and improving cooperation among entities involved in monitoring and assessment, including new partners (e.g. the research community and academia), and designating the right institutions to supervise, guide and contribute to monitoring and assessment. On the other hand, a never ending reform of institutions and changes in their responsibilities and assignments can seriously hamper continuity and sustainability of cooperation.

It is essential to ensure at least cooperation between the various national and local government organizations and seek their assistance for the development and implementation of joint activities between riparian countries. As mentioned in Chapter 2, national legislation and international agreements should be adapted, if need be, to this end.

Arrangements in Belarus to exchange and assess environmental data and information

The joint Decision No. 41/30/45 of 12 September 2005 of the Ministry of Environment, the Ministry of Health and the Ministry for Extraordinary Events, which approves the instruction on the exchange of information among the national environmental monitoring system, the socio-hygienic monitoring system and the system for monitoring and forecasting under extreme events of natural and technological origin, is an example of coordinating the information exchange between the three national entities responsible for monitoring and assessing the environment, including human health and safety. Under the auspices of the Ministry of the Environment, the "Main Information and Analysis Centre of the National System for Monitoring the Environment" acts as focal point for organization, coordination, management and scientific support. The environmental monitoring system includes monitoring stations on transboundary surface waters. Monitoring groundwater aquifer is also the responsibility of the Ministry of the Environment.

3.2 Institutional arrangements at the transboundary level

Functioning institutions and suitable institutional arrangements for monitoring and assessment at the national and local levels are a prerequisite for international cooperation, particularly in connection with the work of joint bodies, which includes the implementation of their monitoring-and-assessment-related tasks. Particular efforts should be made to build and strengthen their capacity.

Riparian countries may decide to establish a specific working group under the joint body, in which experts from different disciplines meet regularly to agree upon the implementation of monitoring and assessment activities, including the technical, financial and organizational aspects.

The setting up of permanent secretariats for joint bodies can be an asset but is not a requirement. In any case, the role and functions of ministerial and water/environmental agencies' staffs that service joint bodies, including their competences in the national context and for transboundary cooperation, should be clearly defined.

Riparian countries should, through their respective joint bodies, establish close cross-border cooperation between authorities dealing with land-use planning and development and the rational use and protection of water at an early stage of the planning process and at all levels of Government. This will help to overcome conflicting interests in sectoral planning in both the national and transboundary contexts.

Cross-border cooperation is sometimes difficult due to existing rules and formalities for border crossing of people and goods. This can hamper joint sampling near the borderline, the transport of samples across the border, and timely delivery of samples to laboratories in the riparian countries. It is advisable to seek the cooperation of Border Guards, as it was the case with the Finnish-Russian Commission whereby Border Guards are involved in the activities of the joint body and can provide support on practical issues.

Progress and bottlenecks of joint monitoring and assessment of transboundary waters shared by the Republic of Moldova and Ukraine

Transboundary monitoring in the Dniester river basin is part of the 1994 agreement between the Republic of Moldova and Ukraine on the joint use and protection of transboundary waters. In addition, monitoring activities are regulated by an agreement between the Ministries of Environment and an agreement between the Hydrometeorological Services of both countries. So far, there are only joint activities of the Hydrometeorological Services of both countries, although other entities were also made responsible for water-quality monitoring and data exchange. From the six agreed upon measuring stations, data are being gathered and exchanged from 2 stations. Almost all 30 agreed upon physico-chemical parameters are measured. No measurements are yet made for the agreed three biological parameters and the four radioactive determinands. In both countries, water laboratories have been designated as well as the entities, which are responsible for data management and information exchange.

A joint reporting scheme has been agreed and the results of the assessment are examined both nationally, by competent institutions, and jointly by the Meeting of the Plenipotentiaries, which acts as joint body. It should also be noted that the riparian countries are in the process of revising their agreement.

3.3 Institutional arrangements related to quality systems

A quality system should be set up, as it is essential for ensuring the reliability of information obtained by monitoring. The quality system should be organized around all the elements of the monitoring –and assessment cycle, starting with documenting procedures for the specification of information needs and developing an information strategy. Standards, established under the auspices of the International Organization for Standardization (ISO), the European Committee for Standardization (CEN) and other organizations for sample collection, transport and storage, and laboratory analysis, are the basis for the quality system. Protocols for data validation, storage and exchange as well as data analysis and reporting should be established and documented.[34] Riparian countries should, where appropriate, assign to their joint bodies responsibilities related to quality systems. Transboundary cooperation at the local level should be encouraged and promoted, including direct contacts between laboratories and institutions involved.

As many decision makers are not aware of laboratory quality systems, it is essential to stress that the trend throughout the broader analytical community is to strengthen laboratory quality assurance in a step-by-step approach: from simple internal quality control measures to laboratory accreditation, and finally to international standards such as ISO/IEC 17025 covering general requirements for the competence of calibration and testing laboratories.[35]

[34] http://www.iwac-riza.org/downloads/nota95_067.pdf
[35] http://www.fasor.com/iso25

3.4 Frameworks for exchanging and accessing information

According to the provisions of the Water Convention and the Aarhus Convention, riparian countries should give each other access to relevant information on surface water and groundwater quality and quantity. Arrangements for the exchange of information among riparian countries should be governed by rules jointly agreed by these countries. The arrangements should specify the format and frequency of reporting. Information should be exchanged free of charge. Also, arrangements for the provision of information to the public should be jointly agreed and should include the establishment and maintenance of a joint website.

4. SECURING FUNDING FOR MONITORING AND ASSESSMENT

Monitoring and assessment of water quality and quantity require adequate resources. Therefore, those who carry out monitoring and assessment need to be able to convincingly demonstrate both the benefits of monitoring for integrated water resources management and the possible costs (in terms of environmental degradation and other impacts) of not monitoring. This is particularly crucial for countries in which monitoring activities still seem to be insufficiently funded.

The costs of monitoring should be estimated before monitoring programmes begin, or when major revisions are planned. If the information needs are well defined, the estimate can be rather detailed. Monitoring costs can be divided into the following components (Table 2):

- Network administration, including design and revision;
- Capital costs of monitoring and sampling equipment, construction of observation boreholes or surface water sampling sites and gauging stations, transport, data processing hardware and software;
- Labour and other operating costs involved in sample collection and field analysis;
- Labour and other operating costs involved in laboratory analyses;
- Labour and associated hardware and software costs involved in data storage and processing;
- Data interpretation and reporting; production of outputs, including geographic information systems (GIS) or presentation software and report printing costs.

Table 2. Influence of monitoring components on costs

Cost component	Sampling points		Sampling frequency	Choice of determinands
	Type	Density		
Network administration	+	+	+	+
Capital for equipment	++	++	+	++[1]
Operating costs of sampling	+	++	+++	++[2]
Operating costs of analysis	+	+++	+++	+++
Data storage and processing	+	++	++	++
Assessment and reporting	+	+	+	+

Notes: +++ major influence ++ some influence + little influence
[1] May influence the type of instrumentation required in the laboratory.
[2] Introduction of field analysis of unstable determinands increases sampling costs.

The costs associated with administration as well as assessment and reporting are largely fixed and almost independent of the extent of the network. In contrast, the costs of other activities are strongly influenced by the number and types of sampling points, the frequency of sampling and the range of determinands to be analysed. The number of sampling points can be multiplied with frequency and determinands to obtain rough cost estimates.

In EECCA countries, labour and operating costs of sample collection and field analysis, laboratory analyses as well as data processing, interpretation, reporting and production of outputs were often underestimated. Ignorance or inadequate assessments of these costs were also reasons for the disruption of activities after the finalization of international assistance projects. It is, therefore, important that such international assistance projects are well embedded in the national plans and that the systems requirement are adapted to countries' resources so that operation can continue after the finalization of the project. Furthermore, there have been cases in which international projects had overlapping objectives, duplicated work and did not involve the right actors, thus wasting resources and not improving monitoring and assessment. It is a responsibility of recipient countries to streamline donors' efforts and avoid duplications and waste. At the same time, donors should respect recipient countries' priorities and indications.

Foreign assistance to resolve issues faced by the Hydrometeorological Service of the Russian Federation

Insufficient and instable financing, decrease in supply of the stations with spare parts, insufficient replacement of stations and laboratory devises with up-to-date equipment, worsening situation with sampling and sample transport from remote stations and the going away of qualified staff were among the reasons for the decline of monitoring and assessment activities. After a long period of decline, the funding situation has been considerably improved, also due to foreign assistance programmes. Currently, the Hydrometeorological Service operates 3086 measuring stations on the territory of the Russian Federation. On 1810 stations (on 1182 surface water bodies), physico-chemical water-quality measurements are carried out, and on 306 stations (on 134 surface water bodies), hydrobiological measurements are undertaken.

Because of the continuous character of monitoring, a long-term commitment to funding is crucial to ensure the sustainability of monitoring and assessment activities. This means that funding should come mainly from the State budget. Water users, such as municipalities, water and waste utilities, factories, farmers and irrigators, should contribute to funding the programmes. It may be possible to raise funds by using part of the income from water abstraction fees or by invoking the "polluter pays" principle. Donor-funded projects concerning transboundary watercourses should be coordinated with national authorities to ensure the continuity of monitoring activities, which have been established in the project.

It is essential that monitoring and assessment programmes for transboundary waters be part of the national monitoring programmes of the riparian countries. These countries should take responsibility for all costs arising on their own territory. Moreover, the riparian countries should jointly decide on funding principles and make clear agreements regarding the funding of specific joint tasks.

Armenia a case of successful fund raising

After a decline in the number of measuring stations in the 1990s, much emphasis was put in the beginning of the 2000s to re-establish the most important stations. In 2004, the network was operational on 54 surface water bodies, comprising 131 stations on rivers and 22 on other surface waters, which measure 22 physico-chemical parameters. The Environmental Monitoring Centre of Armenia was made responsible for data management, assessments and reporting. Securing funding for monitoring was one priority task for governmental agencies: the monitoring budget will grow from some AMD 5,000,000 in 2004 to AMD 70,000,000 in 2007. The growth of the budget may also help to make the first move on microbiological monitoring and groundwater monitoring.

5. DEVELOPING STEP-BY-STEP APPROACHES

5.1 Alternative step-by-step approaches

Monitoring and assessment of transboundary waters have multiple purposes. To make the best use of available resources and knowledge, a step-by-step approach is recommended. This entails identifying and agreeing on priorities for monitoring and assessment and proceeding from general appraisal to more precise assessments and from labour-intensive methods to higher-technology ones. Such a step-by-step approach can also help to specify the information needs and thus focus the assessment activities so that they are as effective as possible.

Developing a step-by-step approach in a transboundary context may also have other implications. It might, for example, mean starting with informal cooperation at an operational level and, as mutual trust increases, lead to more formal agreements and establishment of joint bodies. Experience suggests that one could start with modest objectives – for example, regular exchange of data and information about the sampling methods and instrumentation used. This could lead to jointly agreed measurement and sampling procedures and analytical methodologies, which would pave the way to joint measurements and sampling. The eventual target would be joint data analysis and regular joint assessments backed up by joint monitoring design.

Taking a step-by-step approach could also mean starting with data exchange for stations and sampling points close to the border and then, once this activity is well established, extending it to the whole transboundary basin or aquifer. Finally, a step-by-step approach might mean starting with the exchange of information on water status (quality and quantity) and then, as the relationship between riparian countries becomes stronger, sharing information on pressures and driving forces; evaluating the impacts on the main water uses; and considering possible responses – that is, applying the DPSIR framework.

Countries in transition often stress their difficulties in complying with the recommendations of monitoring and assessment guidelines, without paying sufficient attention to the step-by-step approaches promulgated through these guidelines. Attaining the purposes and objectives of monitoring and assessment is like creating a road map to achieving a final goal. It is a way of building “modules” for transboundary water monitoring and assessment, starting with tasks that can be easily accomplished in a given situation. These are followed by tasks that will be carried out later when there are increased human and financial resources, better knowledge and mutual understanding or otherwise improved conditions for transboundary cooperation.

In countries in transition where it is difficult to amend national legislation in the short term, a step-by-step approach could be followed by accepting the use of water-quality objectives or even ecologically based objectives as a basis for the monitoring and assessment work of joint bodies. This could become part of jointly agreed rules or even protocols to bilateral and multilateral agreements, without the need to amend national law.

5.2 Prioritizing monitoring efforts

Identification of water’s main functions and uses and the main issues relating to it is needed in order to determine the most important information needs relating to water quality and quantity, and the relevant determinands requiring monitoring. National surveys and land-use maps can provide a rapid overview of possible pressures in the basin.

Using risk assessment techniques (and recording how these were applied), those responsible for assessments can decide which monitoring activities have the highest priority. This could be done using the concept of “expected damage” – that is, determining what goes wrong when there is insufficient information because of lack of monitoring, or what losses occur when less than optimal decisions are made as a result.

No monitoring programme can measure all the variables at as many sites and as frequently as would be desirable. Therefore, in designing the monitoring approach, risk-based approaches should be used to select variables. For many variables, existing literature on their occurrence in the environment and particularly in freshwater systems can provide guidance in prioritization. Based on their properties, predictions can be made as to which chemicals are most likely to reach surface water and groundwater.

In the case of groundwater, the long-established and widely adopted approach of defining and mapping the vulnerability of aquifers to pollution can be used to prioritize monitoring. Based on the physical and chemical properties of the soil and the geological materials above the water table, the potential for pollutants to be retarded and attenuated is evaluated and mapped. Where such maps exist, they can be used to help focus monitoring in areas where groundwater has important uses and where it is most vulnerable.

Risk assessment can also be used to determine whether the chosen monitoring strategy will fully meet the information needs. Statistical modelling to help optimize monitoring design (spatial density and sampling frequency) implies an element of risk analysis. It provides, for example, information on whether the resulting decreased level of information will still meet all previously specified information needs if either density or frequency is reduced.

5.3 Use of models in monitoring and assessment

Models can play several roles in monitoring and assessment. They can be used to screen alternative assessment policies and monitoring strategies, optimize network design, assess the effectiveness of measures, and determine the impact on water bodies and the risks to human health and ecosystems. Models play an important role in flood forecasting and travel time calculations in accidents and spillages.

Models should be carefully calibrated and validated with historical data to avoid unreliable results and misunderstandings of the behaviour of the basin or aquifer. Successful mathematical modelling is only possible if the approach is properly harmonized with data collection, data processing and other techniques for evaluation of the characteristics of the whole transboundary water system. If both the conceptual model and the basic data are agreed on and reliable, then the results should be comparable even if the modelling software used is not the same.

5.4 Using pilot projects

Pilot projects have played an important role in demonstrating the usefulness of the UNECE Guidelines on monitoring and assessment of transboundary waters and in implementing monitoring obligations under the Water Convention. They helped to establish effective and efficient monitoring and assessment programmes sustainable in the specific economic context of the countries concerned. Furthermore, pilot projects helped to initiate bilateral and multilateral cooperation, leading to institutional strengthening and capacity-building.

As part of a step-by-step approach, it is desirable to implement pilot projects before setting up monitoring and assessment systems for all the riparian countries’ transboundary waters. The advantage of such an approach is that organizations with a direct or indirect stake in the use and management of transboundary waters can be involved in pilot projects. Most important, a road map is an inherent part of pilot projects, as the projects have achievable objectives and clear and realistic tasks, which take into account the specific characteristics of the basin, lake or aquifer. These characteristics include the number of riparian countries and their proportions in the basin; the political, social, institutional and economic situation of the countries; and the nature of the basin. However, the commitment, resources and time needed should not be underestimated.

A pilot project on monitoring and assessment in the Kura River basin

As it was the case with nine other river basins, a Water Convention's pilot project on monitoring and assessment of the River Kura was carried out with financial assistance from the European Commission. Water legislation, including existing standards and norms for monitoring, applicable in the three riparian countries, were compiled and assessed. The current status of monitoring vis-à-vis the UNECE Guidelines and such EU legislation as the EU WFD was examined and a hot spot analysis in the three riparian countries was conducted. Finally, the location of measuring stations and their parameters were agreed among the countries. Training of personnel, including laboratory staff and people responsible for sampling was undertaken. The pilot project led to a draft strategy on monitoring and assessment that sets out a phased approach towards attaining the monitoring and assessment requirements of the Water Convention, its Protocol on Water and Health and the EU WFD. Already during the lifetime of the project, laboratories were equipped with analytical devices.

6. SECURING RELIABILITY OF LABORATORY WORK

6.1 Quality assurance and quality control in water laboratories

A programme to assure the reliability of the laboratory data is essential. It is recognised that most analysts practice analytical quality control to varying degrees, depending partly on their training, professional ambitions, and partly on the importance of the work they are doing. However, under the pressure of daily workload, analytical quality control may be easily neglected. Therefore, an established, routine internal quality control programme, applied to each analytical test, is important in assuring the reliability of the measurement results.

When the implementation of a transboundary monitoring programme requires participation of several national, or foreign laboratories, there is a need for external quality control measures such as organisation and participation in performance-testing schemes (intercalibration programmes) organised by dedicated institutions.

The quality control programme in the laboratory has two primary functions. First, the programme should monitor the reliability of the reported results. It should provide an answer on "How good (true) are the results submitted". This phase may be termed as "measurement of quality." Second, the programme should control quality in order to meet the programme requirements. For example, the processing of spiked samples is the measurement of quality, while the use of analytical grade reagents is a control measure. As each analytical method has an analytical protocol (e.g. international/national standards), or procedures agreed by joint bodies for transboundary basins, the quality control associated with that test must also involve definite steps to monitor and assure the correctness of the results.

The steps in quality control vary with the type of analysis. For example, in the titrimetric measurements, standardisation of the titrant on a frequent basis is an element of quality control. In an instrumental method, the checkout of instrument response and the calibration of the instrument in concentration units is also a quality control function. The variables, which can affect the final results should be considered and evaluated.

Intercalibration under the auspices of the Joint Finnish-Russian Commission on Transboundary Waters

For the joint monitoring programme on Finnish-Russian transboundary waters, laboratories in both countries carry out sampling and laboratory analysis according to a programme agreed on by the Finnish-Russian Transboundary Water Commission. Water-quality data are exchanged by e-mail as soon as they are received from the laboratories. Intercalibration is one of the key issues of cooperation as there are differences in analytical methods and laboratory practice. In recent years, comparability of data was good particularly regarding phosphorus and nitrogen; recently intercalibration is made for iron, manganese and copper analysis.

6.2 Requirements for accreditation

It is strongly recommended that laboratories in EECCA that have not yet been accredited follow as close as possible the guidance documents developed by ISO and CEN (see section 3.3).

It is of utmost importance that the laboratory – which intends to be accredited – shall have managerial and technical personnel with the authority and resources needed to carry out their duties and to identify the occurrence of departures from the quality system or from the procedures for performing tests and/or calibrations, and to initiate actions to prevent or minimize such departures.

It is necessary to specify the responsibility, authority and interrelationships of all personnel who manage, perform or verify work affecting the quality of the tests and/or calibrations. An adequate supervision is needed of testing and calibration staff, including trainees, by persons familiar with methods and procedures, purpose of each test and/or calibration, and with the assessment of the test or calibration results.

Laboratories should have a technical management, which has overall responsibility for the technical operations and the provision of the resources needed to ensure the required quality of laboratory operations. A member of staff should be appointed as quality manager who, irrespective of other duties and responsibilities, should have defined responsibility and authority for ensuring that the quality system is implemented and followed at all times, the quality manager should have direct access to the highest level of management at which decisions are made on laboratory policy or resources. The laboratory should also appoint deputies for key managerial personnel.

The laboratory shall establish, implement and maintain a quality system appropriate to the scope of its activities. The laboratory shall document its policies, systems, programmes, procedures and instructions to the extent necessary to assure the quality of the test and/or calibration results. The system's documentation shall be communicated to, understood by, available to, and implemented by the appropriate personnel.

The laboratory’s quality system policies and objectives should be defined in a quality manual. The overall objectives shall be documented in a quality policy statement. The quality policy statement shall be issued under the authority of the chief executive.

The quality manual should include or make reference to the supporting procedures including technical procedures. It shall outline the structure of the documentation used in the quality system. The quality manual should include: (a) documents of the critical procedures within the laboratory; (b) Standard Operating Procedures for the analytical methods; (c) Standard Operating Procedures for the use of instruments; and (d) Performance characteristics of each method/matrix combination.

The laboratory should establish and maintain procedures to control all documents that form part of its quality system (internally generated or from external sources), such as regulations, standards, other normative documents, test and/or calibration methods, as well as drawings, software, specifications, instructions and manuals.

The laboratory should periodically, and in accordance with a predetermined schedule and procedure, conduct internal audits of its activities to verify that its operations continue to comply with the requirements of the quality system. The internal audit programme should address all elements of the quality system, including the testing and/or calibration activities. It is the responsibility of the quality manager to plan and organize audits as required by the schedule and requested by management. Trained and qualified personnel, who are, wherever resources permit, independent of the activity to be audited, should carry out such audits.

In accordance with a predetermined schedule and procedure, the laboratory's executive management should periodically conduct a review of the laboratory's quality system and testing and/or calibration activities to ensure their continuing suitability and effectiveness, and to introduce necessary changes or improvements. The review should take account of: (a) the suitability of policies and procedures; (b) reports from managerial and supervisory personnel; (c) the outcome of recent internal audits; (d) corrective and preventive actions; (e) assessments by external bodies; (f) the results of interlaboratory comparisons or proficiency tests; (g) changes in the volume and type of the work; (h) client feedback; (i) complaints; and (j) other relevant factors, such as quality control activities, resources and staff training.

Securing reliability of laboratory work in Belarus

The workshop in Tbilisi has shown the need for guidance to understand laboratory quality management. Laboratory managers need also guidance to design or upgrade water laboratories and to obtain accreditation. Good practice for laboratory management, testing, intercalibration and accreditation is applied in Belarus, where law requires laboratory quality management. Sharing of experience among countries, particularly riparian countries, and intercalibration among laboratories in these countries is a challenge for cooperation.

In Belarus, the work of laboratories that act under the auspices of the Ministry of the Environment is based on ISO requirements for accreditation. Apart from laboratory analysis, methodological work includes the preparation of national standards, based on ISO standards (some 20 standards are currently under adaptation), which replace the governmental standards of the former Soviet Union (GOST), as well as the drawing up of guidelines to secure the sound operation of laboratories, including intercalibration. Securing reliability of work among laboratories in the riparian countries is a challenge for future transboundary cooperation.

7. EARLY WARNING OF ACCIDENTAL POLLUTION

7.1 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 recognized 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.

7.2 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 (see section 7.6).

7.3 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:

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

7.4 Hazard identification and alarm model

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

- The setting-up of a system of hazard identification, based on a database system for retrieving information on hazardous substances;
- 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.

7.5 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:

- To trigger an alarm (accidental pollutants are signaled by regular measurement of biological effects or indicative parameters at the monitoring station);
- To make a diagnosis for tracing the cause (if pollution is measured or a toxic effect is signaled, water samples taken regularly should be analyzed to precisely identify the pollutant using more advanced equipment in a supporting laboratory).

7.6 Selection of early-warning parameters

Appropriate indicative variables for early warning are specific for each river basin, and should be selected on the basis of:

- The dominating pollutants in past emergency situations (frequently occurring local risk substances);
- Variables indicative of issues that are specific to the river basin (e.g. dissolved oxygen, pH);
- Further needs to detect specific micropollutants (heavy metals, pesticides) using advanced technologies.

The variables 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 recognized with the help of biological systems, which use species from different trophic levels and functionality, e.g. fish, daphnia, algae and bacteria.

Warning and alarm systems in the Russian Federation

Under the governmental system of the Russian Federation on warning for extreme events and mitigation of their consequences, the Russian Hydrometeorological Service acts as a "sub-system" and carries out measurements and delivers assessments and forecasts in extreme situations. This includes dangerous hydrometeorological phenomena, such as floods and ice drifts, and pollution of the environment, for example, from accidents that can endanger human life and safety. Assessments and forecasts include the pollution transfer in surface waters. The response time, i.e. the time from receiving the alarm signal until the transmission of the results, should not exceed three hours. Three main problems slow down the effectiveness of the response system: (a) lack of automatic water-quality stations at decisive locations on surface waters; (b) lack of express methods for laboratory analysis of samples; and (c) lack of a Federation-wide database on current hydrological characteristics of surface waters.

8. ESTABLISHING AND IMPLEMENTING MONITORING PROGRAMMES

Monitoring and assessment of watercourses, including transboundary waters, follow a certain sequence of activities, which is reflected in Figure 2.

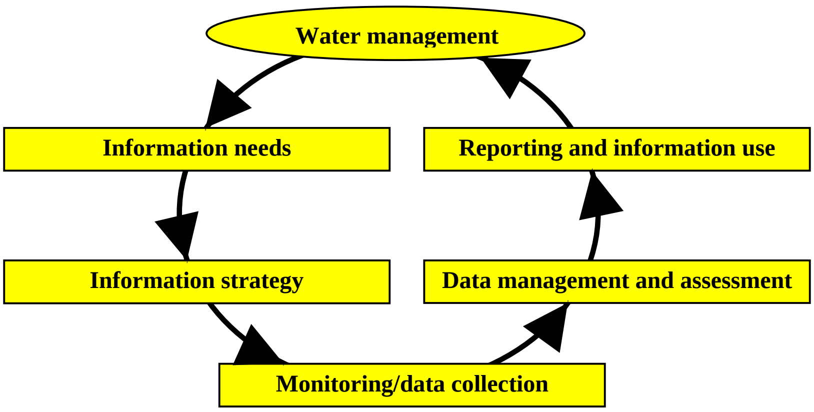

Figure 2: Monitoring and assessment for water management

The outputs produced by each of these elements are used in the consecutive element(s) of the cycle. Ideally, at the end of the cycle, the information needed for planning, decision-making and operational water management at local, national and/or transboundary levels is obtained in the form of a report or other agreed-on format. It should also become clear what kind of information is still needed for better decision-making and other water management tasks, given that policies and/or targets may have changed in the meantime. Thus, a new cycle would start, leading to redefined or fine-tuned information needs, an "upgraded" information strategy, and so on.

8.1 Information needs

The analysis of water management issues is the basis for specifying the information needs. Information needs are related to:

- Uses (e.g. drinking water, irrigation, recreation) and functions (maintenance of aquatic life) of the watercourse, which determine quality and availability requirements;
- Issues (e.g. flooding, sedimentation, salinization, pollution) that hinder proper use and functioning of the watercourse; and
- Measures taken to address the issues or improve the use or functioning of the watercourse, including environmental aspects.

The information needs should be clearly determined for different levels (e.g. river-basin-scale and local levels), and using the components of the DPSIR framework.

To identify issues and priorities related to the use and protection of a transboundary river, several activities are needed. This include identification of the functions and uses of the river basin, inventories on the basis of available (and accessible) information, surveys (if information is lacking), identification of criteria and targets, and evaluation of the water legislation in the riparian countries to identify provisions that are important for monitoring and assessment (Figure 3).

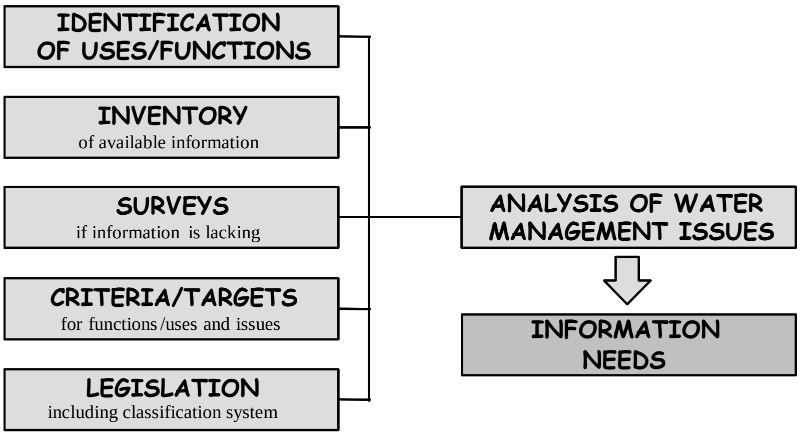

Figure 3: Analysis of water management issues

To specify information needs, information users and producers should interact closely. The institutions responsible for the protection and use of the transboundary watercourses, especially joint bodies, should be involved in the process of identifying and specifying information needs. Information needs have to be specified to such an extent that proper design criteria for the monitoring and assessment system can be derived. The information needs should be based on identified management issues and the decision-making process in river basin management.

Inventories of available information should bring together information that may, while available, be incoherent and distributed among different agencies/institutions. This includes not only the listing of information available from historical data, licenses and the like in administrative databases, but also a general screening and interpretation of all information relevant to the aspects under consideration.

Inventories should cover the major aspects that are relevant to 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; declines in groundwater levels; water quality; and, most important, sources of pollution from industries and municipal waste (especially the “hot spots"). These should be characterized in terms of, for example, production process, pollution composition and discharge load, land uses, and diffuse pollution sources with a register on the use of fertilizers and pesticides in agriculture. Other sources of pollution may include traffic and airborne pollution, potential sources of accidental pollution such as pipelines, and other existing point pollution sources (e.g. uncontrolled waste disposal sites).

Surveys will be needed if the inventory does not provide sufficient data. 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. Investigating the qualitative and quantitative structure of the biocoenose concerned makes it possible to assess the ecological status of a river, lake or estuary. Chemical screening of surface water, groundwater, sediments and effluents at hot spots and key locations can be performed. 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. Surveys of water uses may also be required.

Information needs should be further specified so as to be able to design a monitoring and assessment programme. This specification exercise should at least yield:

- Appropriate variables to be monitored;
- Criteria for assessment (e.g. indicators, early warning criteria for floods or accidental pollution);
- Specified requirements for reporting and presenting information (e.g. presentation in maps, GIS, degree of aggregation);
- Relevant accuracy for each monitoring variable;
- Degree of data reliability;
- Specified response time (i.e. the period of time within which the information is needed), for example, for flood forecasts or early warning systems (e.g. minutes/hours), for trend detection (e.g. number of weeks after sampling) and other tasks.

The relevant accuracy and the degree of data reliability are decisive factors in the selection of monitoring sites, the determination of monitoring frequencies and the choice of laboratory technology and methodologies for data management.

Information needs should be prioritized. Information is mostly needed on high-priority issues. If the same information need arises from a variety of water management problems, this information need should be given high priority, because collecting this information once makes it possible to address a variety of issues.

8.2 Information strategy

After information needs have been identified, specified and prioritized, an information strategy should be developed. This defines the best practical way of gathering data from various sources: from the monitoring network, from expert judgments, from statistical publications and the bookshelves of various institutions. The information strategy should culminate in a monitoring plan and a plan for gathering data from other sources.

The information strategy needs to be adapted over time, as water management develops, targets are attained or policies change. However, it should be recognized that there is a need for continuity in order to produce time series that make it possible to detect significant and reliable trends. Environmental monitoring programmes should always be seen as requiring long-term commitment.

Information needs analysis in EECCA and gathering data/information

The outlined steps for a thorough analysis of information needs and the setting of priorities is largely unknown by decision makers and planners in EECCA countries. Undoubtedly, in these countries there are less measuring stations (both water quantity and quality, including automated stations) in operation than at the beginning of the 1990s. The “re-establishment” of the monitoring network often results in unreasonable suggestions to re-activate the previously existing networks. Unless a thorough analysis of information needs is made, which is the most basic requirement for a decision on the number of stations, their location, parameters and frequency of measurement, an informed decision cannot be taken. There is a need for setting priorities, jointly agreed with the major actors, both nationally and in the transboundary context.

It should also be recalled that monitoring is only one of the many sources that provide data/information on the conditions of transboundary watercourses. Date have also to be gathered from other sources/disciplines such as agriculture, recreation, sociology, ecology and economics. Often local governments and municipalities are able to provide data on water purification and sewage utilities, factories, farmers or irrigators. The results of self-monitoring, i.e. monitoring of effluents and wastewater discharges by industries or municipalities, often under the conditions of their discharge license, is an valuable additional source for transboundary water assessments.

The use of models is also essential. Models provide a means to screen alternative information strategies, optimize network design and assess the effectiveness of proposed measures. In any case, models should be carefully calibrated and validated with historical data to avoid unreliable results and erroneous decisions regarding in the information strategy or the interpretation of the behavior of the river basin or aquifer.

8.3 Monitoring/Data collection

The most resource- and labour-intensive phase in monitoring is the sampling and data collection, including laboratory work. This phase also entails high risks in producing reliable and accurate data. Therefore, it is important to employ qualified and experienced personnel and comply with guidelines and standards.

The main monitoring objectives for rivers, lakes and groundwaters as well as effluents are to generate information for:

- Assessing the actual status of water resources;
- Detecting possible long-term trends in water levels or pollutant concentrations;
- Providing for hydrological forecasts;
- Assessing pollution loads from point and non-point sources;
- Testing for compliance with permits for water withdrawal or discharges of wastewater and establishing taxes, fines and sanctions;
- Verifying the effectiveness of policy measures;
- Contributing to reporting on the state of the environment;
- Providing early warning to protect the intended water uses in the event of flooding or accidental pollution;
- Recognizing and understanding processes in water and water-related ecosystems (e.g. flow regime, erosion patterns, hydrobiological processes, natural or background pollution of water bodies); and

- Enabling assessment of imminent or possible health risks and supporting predictions of long-term processes which may have health-relevant outcomes.

Each of these objectives may require specific measurement devices or sampling procedures, which are explained in detail in the large body of literature on these subjects.

9. MANAGING DATA AND MAKING ASSESSMENTS

9.1 Data management

It is of utmost importance that policy makers and planners better understand the various steps in data management. This will facilitate data exchange among the institutions undertaking the monitoring and assessment, including joint bodies. To safeguard the future uses of the data that have been collected, the following steps are required before assessments can be made.

Developing a data dictionary

To facilitate the comparability of data, clear agreements should be made between the neighbouring countries on the coding of collected data and supporting information. Collected data for a given instance include the date, location, depth and measured values. Supporting information includes information about characteristics of the location, the type of sample and the type of measurement or sampling installation, any preconditioning procedures and analytical techniques, including detection limits. A data dictionary explaining the coding and defining terms should be prepared and agreed on.

Data validation

Data validation is an intrinsic part of data management and includes regular checking and control of newly collected data (detection of outliers, missing values and other obvious mistakes). Computer programmes are available to perform various control functions, but expert judgment and local knowledge of the water systems are also indispensable for validation. When the data have been thoroughly checked and any necessary corrections or additions made, they can be approved and made accessible.

Data storage

To be available for future use, data should be stored in databases. The dimensions and units should always be included. Enough supporting information to enable interpretation and reporting should also be stored. This supporting information is often referred to as meta-information. The database should have safeguards against the entering of data without supporting meta-information.

Managing data from multiple sources

Management of data from multiple sources (monitoring datasets, maps, land-use characteristics, satellite imagery, socio-economic data) is not easy and requires computers and suitable software. In particular, simulation models and GIS support the integrated management of data. Given that different concepts for databases may be used, at least compatible interfaces should be developed.

Data exchange

Formats for the exchange of data should be defined and agreed by the users. The data dictionary should be the basis for defining such formats.

The data storage systems in the neighbouring countries need to be able to handle the agreed data exchange formats and allow the data to be imported into modelling or statistical software. For storage of data on transboundary watercourses, the relevant joint body may consider the establishment of a central system. The guidelines for data exchange developed by EUROWATERNET may be suitable for supporting such activities.[36]

Data analysis and interpretation

The conversion of data into information involves analysis and interpretation. Data analysis should be embedded in a data analysis protocol (DAP) which clearly describes how the data should be analysed and interpreted and what should be done in case of missing data, outliers, non-normality and serial correlation.

The data analysis may be largely a statistical operation or set of operations using generic software packages. Statistical techniques may be used to detect trends and trend reversals and test for compliance with standards. The use of tailor-made adaptations to the software may be desirable. The DAP should therefore include procedures for processing the monitoring data to meet the specific interpretation needs (for example, calculations based on individual measurements or yearly averages, single sites or averages for the whole water body).

The DAP should be extended to reporting formats for the resulting information. Thus, the DAP should specify the format of the report, the frequency of publication, the intended audience, distribution procedures and the types of conclusions to be drawn and represented.

Given the above data management steps, storage probably remains the weakest point of all in EECCA countries, where in many instances, water, environmental and health agencies rely on hardcopies of data. It is of utmost importance that policy makers and planners better understand the various steps in data management. This will facilitate data exchange among the institutions undertaking the monitoring and assessment, including joint bodies, as it was the case in Uzbekistan, where the State Committee for Environmental Protection was made responsible for a joint database for Central Asian countries. There are also attempts to establish, in the long run, information centres in that region.

The Hydrometeorological Services of Uzbekistan acts as a joint communication centre

The hydrological network for transboundary surface waters in Central Asia, operated by the hydrometeorological services of the five riparian countries, comprised 559 stations in the 1980s and 396 stations in 1996. In 2004, 356 stations were operational. Bilateral and multilateral agreements on the interstate data exchange have been concluded. The Hydrometeorological Service of Uzbekistan functions as joint communication centre, operates a joint database and provides clients in the riparian countries with hydrometeorological data, water-quantity related information and forecasts.

[36] http://dd.eionet.eu.int/index.jsp

Information management in the Tisza river basin and the use of GIS

Water management in the Tisza basin is based on the river basin approach. The agreement between Hungary and Ukraine of 11 November 1997 on water management in transboundary waters incorporates provisions on joint monitoring of surface water quantity and quality; deals with the prevention, protection and mitigation of floods; stipulates the improvement of early warning in critical situations and the mitigation of adverse effects. It also calls for the development of criteria for the assessment of transboundary waters as well as the assessment of the impact of wastewater discharges on the status of these transboundary waters.

To implement these provisions, an automated measuring and information management system is being set up. Currently, it consists of 16 telemetric water level gauges and one automatic water-quality station, linked via satellite. 12 more water-level gauges and 5 meteorological stations are planned. Their main purpose is to support forecasts and operative decision making on flood management. A GIS for part of the basin, the Zakarpartskij oblast in Ukraine, became operational, which helps in producing maps on flooded areas and other flood-related information.

9.2 Assessment methodology

The assessment methodology will determine or at least influence the design of the monitoring programme. Therefore, it should be drawn up in parallel with undertaking an analysis of information needs and designing the monitoring programme.

Given the purposes of assessments, a simple way of using monitoring results is based on certain key variables and indicators. Especially in cases where binding water protection targets for certain pollutants, like pesticides, have been expressed by numerical norms or standards, comparing the state of the watercourses with them is a straightforward task and can be done in a very early phase.

Also monitoring results of indicators are easy to assess. For example, for chlorophyll *a* - an indicator to estimate eutrophication - a comparison of the monitoring results with the values in the relevant literature or eutrophication classification schemes is a simple assessment method.

Another simple yet informative method of assessment is to prepare maps of the distribution of the monitored determinands for certain larger water areas. Such an assessment is particularly appealing and understandable for laypeople.

In monitoring programmes, where large amounts of data are collected continuously over several years, statistical methods are needed to effectively summarize the results of monitoring. In particular, different types of trend calculations are being used to assess monitoring data. In interpreting trends in water quality, particular attention should be paid to water-quantity data, since hydrology strongly affects water quality.

The use of water classification systems to assess watercourses is very common. Some of these systems are based on physico-chemical variables, but biological approaches (such as ecological classification under the EU WFD) are also used.

Water-quality assessment of transboundary waters flowing though Kazakhstan

The Ministry of Environment of Kazakhstan is responsible for hydrometeorological measurements and environmental monitoring, including monitoring of surface water bodies and sediments, as well as forecasting and reporting on the state of the environment. Recent reports on the status of transboundary waters on Kazakh territory have shown that the rivers Irtysh, Ishim and Ural fall under the category "good according to standards - water quality sometimes exceeds maximum permitted concentrations", whereas the rivers Tobol, Ili, Syr Darya and Chu-Talas were assessed as "moderately polluted - pollution exceeds the maximum permitted concentrations".

10. REPORTING AND USING INFORMATION

10.1 Reporting

Reporting is another essential step in the monitoring and assessment cycle. Reporting has a key role for decision-making in water management and in further development of monitoring and assessment programmes. Reports should be prepared on a regular basis. The main issue is to present the interpreted data in an easily accessible and understandable way tailored to the audience being addressed.

Reporting obligations

Environmental information is public, according to the Aarhus Convention and Directive 2003/4/EC[37] on public access to environmental information. This has an especially important role in increasing public awareness of water problems and public participation in water management.

An inventory should be made of national and international reporting obligations so as to be able to fulfil reporting requirements laid down in national water management legislation, applicable transboundary agreements and EU Directives as well as relevant decisions taken in international forums. The Reporting Obligations Database,[38] developed by the European Environment Agency includes an overview of many international reporting obligations.

Reporting formats and audiences

The level of detail included in the reports and the frequency of compilation also depend on the target audience. The content of the report should be targeted at the needs of an audience that includes international bodies, management and scientific institutions, national administrations and the public. Depending on the needs of the target group, the report contains aggregated information (e.g. indicators) and/or detailed information in tables, statistically processed data, graphs and geographically presented information.

Public authorities, including joint bodies, usually request information in a specific format and frequency, which are defined in reporting protocols or reporting schemes. 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 are not predefined in reporting protocols but are related to specific current topics in water management. This kind of reporting has to meet strict requirements concerning response time and flexibility.

[37] http://europa.eu.int/eur-lex/pri/en/oj/dat/2003/l_041/l_04120030214en00260032.pdf
[38] http://rod.eionet.eu.int/text.jsv?mode=D

Reporting to the public usually follows an ad hoc request for information and can hardly be predefined in reporting protocols. Guidance is provided in the Aarhus Convention and the EU Guidelines on public participation in water management.[39]

A state-of-the-environment report should provide concise information for decision-making in water management. These reports typically provide information on the state and 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. Their decision-making value is strongly increased by using visualization tools and indicators, in particular if the elements of the DPSIR framework are reported.

The form of a joint report for the purposes of water management in transboundary basins should be agreed upon in detail by the riparian countries. Harmonization of reporting is strongly encouraged. Joint reporting naturally requires a high level of data comparability. The reports should highlight the links between policy measures and the status of the water body of concern. Periodic assessments under the Water Convention, covering all transboundary water basins in the region, are also recommended (at regular intervals of, say, three years) to encourage the evaluation of progress made under the Convention, stimulate the commitment of the members involved, and make results available to the public.

The Internet provides a powerful tool for sharing and communicating information and can be used to inform and involve the public. Traditionally, authorities have been very cautious in presenting environmental information and data to the public because of the risk of misinterpretation of information by laypeople. However, involving non-governmental organizations and the public in transboundary water management promotes awareness and stimulates more sustainable cooperation between countries.

Good practice by the Joint Finnish-Russian Commission on Transboundary Waters

The Tbilisi workshop has shown that reporting and the use of information for various purposes is another challenge for EECCA countries. Still there is the tendency of putting data together rather than striving for reports targeted to the needs of the recipient, such as joint bodies; national water, health and environment agencies and administrations; scientific institutions and the public.

The Joint Finnish-Russian Commission on Transboundary Waters provides good practice. Under the auspices of this Commission, a permanent working group on water protection prepares annual reports on water quality of transboundary waters. Both Parties report annually on pollution loading and the measures taken to reduce it. They also exchange information on relevant projects and developments. The joint assessment of water quality is based on: the results of the joint monitoring, annual reports on pollution loading by both Parties, intensive discussions within the working group, expert judgments, and, if need be, on additional investigations and field studies.

In practice, work is carried out as follows: (a) monitoring results are exchanged every month as soon as they become available; and (b) the Parties alternate in preparing the first draft of the joint annual report. Normally, there is a first round of comments to indicate which parts of the report need to be further discussed during the working group meeting. Sometimes, there is a need to verify issues, but notwithstanding clarification, the joint report is agreed upon for submission to the joint commission, which adopts the report. The report becomes an annex to the report of the Commission’s annual meeting.

[39] http://europa.eu.int/comm/environment/water/water-framework/guidance_documents.html

10.2 Information use

The information produced must be used and should contribute to management decisions. Therefore, the information products in their various forms need to be made accessible and attractive to users. These products should convey the messages that the information users really need.

The information product should be based on the information needs as specified. In particular, the information should be clearly linked to the relevant components of the DPSIR framework. While much of the information derived from a monitoring programme has its most direct link to the status of transboundary waters, interpretation and assessment in relation to the drivers and pressures and how these are changing over time, and in relation to impacts on (for example) the health of water users, must be included. Information products specifically related to responses – for example, the effectiveness of measures to protect or restore – are required by water managers. The information product should consequently address the full range of the DPSIR framework, thereby enabling decision-making about future actions and measures.

Given the monitoring and assessment cycle, the use of the information should also feed back into the design of monitoring and assessment. This may lead to revision and improvement of the monitoring programme, as well as review of and possibly changes in the information needs and the consequent priorities for monitoring and assessment, including reviewing the most effective use of the available funding. While the monitoring and assessment programme needs stability and continuity to meet information needs, the specific activities that make up the monitoring and assessment cycle should be flexible enough to suit changing drivers and pressures, new legal requirements and obligations, and otherwise changing conditions. The monitoring and assessment cycle should, therefore, be seen as a continuously evolving, gradually improving spiral.