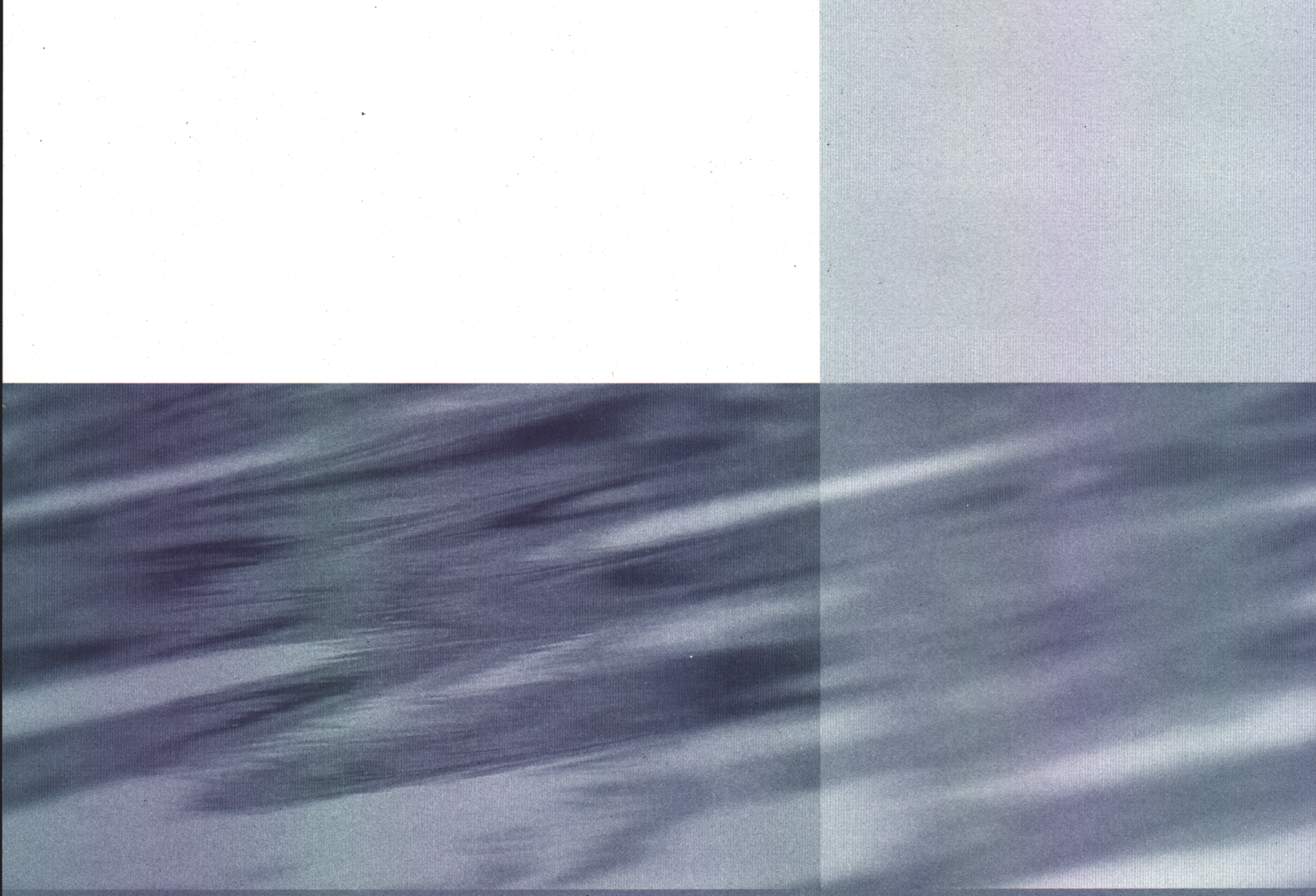


www.environment-agency.gov.uk

R&D Strategy to Support Implementation of the Water Framework Directive – Preliminary Scoping Report

R&D Technical Report P2-143/TR

ENVIRONMENT AGENCY

R&D Strategy to Support Implementation of the Water Framework Directive

Preliminary scoping report

R&D Technical Report P2-143/TR

S Nixon, R Montgomerie

Research Contractor:
WRc plc

Commissioning Organisation:
Environment Agency
Rio House
Waterside Drive
Aztec West
Almondsbury
Bristol BS32 4UD

Tel: 01454 624400 Fax: 01454 624409

ISBN: 1 85705 672 8

June 2002

Dissemination status
Internal: Released to Regions
External: Released to Public Domain

Statement of use
This report represents an initial scoping of the broad areas of the Water Framework Directive which may require R&D to be progressed in England & Wales to meet the implementation requirements of the Directive. The report will be used by the functions, WFD project team and R&D staff to further identify and develop a programme of R&D to meet the immediate and longer term needs of the Directive.

Research contractor
This document was produced under R&D Project P2-143 by:

WRc plc
Henley Road
Medmenham
Marlow
Buckinghamshire
SL7 2HD

Tel: 01491 636500 Fax: 01491 636501

WRc Report No.: 11753-2

Environment Agency's Project Manager
The Environment Agency's Project Managers for R&D Project P2-143 were:
Alison Bramwell (Head Office) & Dave Forrow (WFD R&D Manager, WFD Project)

Further copies of this report are available from:
Environment Agency R&D Dissemination Centre,
c/o WRc, Frankland Road, Swindon, Wilts SN5 8YF

Tel: 01793 865138/012 Fax: 01793 514562 E-Mail:
publications@wrcplc.co.uk
URL: www.wrcplc.co.uk/rdbookshop

CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

1. EXECUTIVE SUMMARY

The overall objective of this project is to develop an initial R&D strategy that will enable the Agency to undertake the tasks necessary to implement the Water Framework Directive (WFD) and begin to establish a programme of research for delivery under the WFD R&D "umbrella project", Agency functional programmes, collaborative programmes and by influencing external research agendas.

To that end the Agency first requires information on how its current operations and tools meet the requirements of the Directive. This would lead to the identification of potential 'gaps' or shortfalls. Options for bridging any gaps would then have to be considered. These would include the instigation of its own national research (such as the WFD R&D "umbrella project" and functional programmes), collaboration and contribution to international research projects (such as the 5th Framework Programme), and collaboration and contribution to other European initiatives such as those instigated by the European Commission and the European Environment Agency. There will clearly need to be a balance between these options as some international research may be too academic and too long term, and may not be applicable to the UK situation. Similarly there may need to be tools specific to operations in England and Wales. There will also have to be a balance between the need for fundamental scientific research that will underpin the aims of the WFD (such as into ecosystem functioning and processes), and tools that will be affective at an operational level in the timescales available. In this way the Agency is developing a strategy that will seek to bridge the gaps in the most cost effective way.

Information on current and planned R&D has been collected from UK and European sources including the Environment Agency's own programmes, SEPA, SNIFFER, DETR (now DEFRA), NERC, the European Commission and the European Environment Agency, it's National Focal Points and the European Topic Centre on Inland Waters (ETC-IW). Over 80 projects relevant to the implementation of the WFD have been identified and briefly summarised in this report.

In addition, Agency staff were consulted at a workshop aimed at identifying potential gaps in the Agency's current knowledge and operational tools.

The European Commission has a central role in the implementation of the WFD and has identified a number of priority projects for inclusion in its Common Strategy on the Implementation of the Water Framework Directive. These include providing guidance on:

- analysis of pressures and impacts;
- designation of heavily modified bodies of water;
- classification of surface water status, including a protocol for identification of reference conditions;
- development of typology and classifications systems for transitional and coastal waters;
- economic analysis;

- monitoring;
- intercalibration;
- tools on the assessment and classification of groundwater; and,
- improved data and information management and reporting.

The Agency is already involved in many of the Working Groups for these projects and the UK is leading those on heavily modified water bodies, on analysis of pressures and impacts, and on typology and classification systems for transitional and coastal waters.

The continued active participation in, and contributions to, these Working Groups should be a key element in the Agency's Strategy for implementing the WFD.

It is clear that gaps exist and will need to be filled for the Agency to adequately address the requirements of the Directive. A number of these gaps reflect the change in emphasis of the Directive from the traditional approach of chemical surface water quality monitoring to one that focuses on ecological status and groundwater status. In doing so it creates a greater pressure on the Agency to develop techniques and tools for not only measuring ecological quality accurately across a range of ecotypes but also tools, which describe the relationship between habitat quality, water quality, physicochemical parameters and ecology. One option for achieving this is through a shift away from the traditional community structure based indices of ecological health to measures of ecosystem function such as catchments scale river metabolism and energy flow studies which maybe useful for achieving harmonisation of monitoring across Europe.

There is a need for fundamental scientific research particularly into ecosystem functioning and processes, and into the inter-relationships between groundwater and surface waters. This research is likely to be long term and its outputs will not be available to meet the time requirements of the WFD. The Agency should be involved as 'end users' and as facilitators of this research. The major national and international research agencies should fund such research.

At a more operational level the Agency (in common with many other European Regulatory Agencies) requires urgent research to meet the timetable of the Directive.

This includes the development of assessment systems and operational indicators for:

- fish in rivers, lakes and transitional waters;
- benthic plants in all water body types;
- riparian zones for lakes/reservoirs and transitional/coastal waters;
- establishment of methods using macrobenthos in lakes/reservoirs, transitional waters and coastal waters. (For rivers the current RIVPACS model needs to be validated against the requirements of the Directive);

- phytoplankton in lakes/reservoirs and estuaries/coastal waters and large rivers if relevant.

Any new biological assessment systems must be capable of detecting and quantifying both physical and chemical degradation of aquatic habitats, and also must not be just focused towards specific quality problems (such as organic enrichment or acidification) unless they have been designed for application to investigative and operational monitoring to identify and quantify the impact of significant pressures.

The other highest priority R&D gaps identified during the Agency WFD R&D workshop were:

- Semi real pilot studies aimed at identifying the needs of RBMP's.
- Better assessment of pollutant sources and in particular quantifying diffuse pollution.

Other medium priority gaps identified were:

- Estimation and identification of significant water abstraction as a pressure on surface waters under Article 5.
- Land use in groundwater recharge areas or river catchments.
- Classification of the ecological status for each body of surface water.
- Relating physicochemical elements (e.g. nutrients) to Environmental Quality (EQ).
- Relating hydromorphological elements to EQ.

There are some administrative aspects associated with the establishment of River Basin Districts for Article 3 that require immediate attention. Current research was thought to meet the gaps here though participants at the workshop highlighted the need for guidance from the DETR on definitions that would influence the process of establishing RBMD's.

In summary, the Agency has now to prioritise what R&D is required to fill those gaps identified taking into consideration how big (and hence costly) the gap is in terms of the current scientific knowledge base, operational practice and scale (local, regional or national) of the gap. Also the timescale required for the research should be considered as well as the date by which an operational tool is required to fulfil deadlines imposed by the Directive. It will be of undoubted benefit to the Agency for it to fully collaborate with relevant research and other initiatives at a European level. This will ensure that best-practise is transferred to the UK. Specific Agency experience will also benefit other European countries.

2. INTRODUCTION

2.1 Background and context

The overall aim of the Water Framework Directive (WFD) is to establish a framework for the protection and management of surface waters, including estuaries, coastal waters and groundwaters in the EU. The main objectives of the proposed Directive are to:

- prevent further deterioration and to protect and enhance the aquatic environment;
- achieve 'good' water quality for all surface waters and groundwaters unless it is impossible or prohibitively expensive;
- promote sustainable water management based on long-term protection of water resources.

These objectives are to be achieved by managing the water environment on the basis of river basins, by applying the combined approach of limit values (LV) and environmental quality standards (EQSs) to the control of discharges and by controlling water abstractions from both surface waters and groundwaters. The Directive will effectively provide the legal basis for the management of Community waters. Whereas previously adopted water-related directives addressed individual issues (e.g. the control of sewage effluents), the WFD aims to provide an overall framework for the management of water, both in terms of quality and quantity, thus enabling an integrated approach to be taken to achieve the objective of sustainable water management. It aims to reconcile all human activities within a catchment, using command and control measures, planning and economic instruments.

The WFD is the most significant piece of water legislation to be developed for at least 20 years. It specifies the use of River Basin Planning as the principle tool for implementing the Directive, setting out the required content of a River Basin Plan and establishing a timetable for delivery. Unlike previous Directives in the water sector that have predominantly used chemical standards as objectives this Directive sets objectives using both ecological and chemical standards. The WFD also establishes common monitoring and assessment strategies. A summary of the major tasks of Member States and their required implementation data is presented in Table 2.1.

Table 2.1: Member State tasks and their implementation date (Directive came into force on 22 December) 2000).

Article	Task	Time till Completion
3.1	Identification of River Basin Districts	December 2003
5.1 (Annex II)	Establishment of ecological quality reference sites for the inter-calibration network by Member States	December 2003
3.2	Administrative provisions including identification of competent authorities for RBD	December 2003
3.6 – 3.8	List of competent authorities and competent authorities of all international bodies	June 2003
5.1	Analysis of River Basin District characteristics	December 2004
5.1	Review of human impacts	December 2004
5.1	Economic analysis of use of water	December 2004
5.1 (Annex II)	Establishment of register of ecological quality reference sites by the Commission	December 2004
15	Survey report on analysis of RBD characteristics to Commission?	March 2006
15	Survey report on review of human impacts to Commission?	March 2006
15	Survey report on economic analysis of use of water to Commission?	March 2005
11	Adoption of measures to prevent and control groundwater pollution if not adopted at a Community level	December 2005
6.1-6.3	Register of protected areas	December 2004
4 (Annex V)	Criteria for the assessment of good groundwater chemical status and for the identification of upwards trends level	December 2006
NA	Completion of the inter-calibration exercise by the Commission	June 2006
NA	Derivation of environmental quality standards for priority substances unless adopted at Community level	December 2006
5.1 (Annex II)	Identification & designation of heavily modified waters	December 2004 & December 2009 respectively
13 (Annex	Time table & work plan for the production of the RBMP including statement of consultation measures	December 2006
8 (Annex V)	Monitoring programmes for surface and groundwaters and protected areas	December 2006
15	Overview of main issues report	December 2007
13 & 15	Draft copy of RBMP for consultation	December 2008
14	Consultation on RBMP	June 2009
13 &15	Publication of RBMP	December 2009
11.1	Establishment of programme of measures	December 2009
31	Failure to achieve good status as a result of new sustainable human development activities to be included in RBMP	December 2009
13	RBMP to be sent to the Commission	March 2010

Many existing water Directives will be repealed and replaced with new provisions, for example those on Surface Water Abstraction, Groundwater, Freshwater Fisheries and Shellfish Waters. The implementation of others, for example the IPPC, UWWT, and Habitats and Nitrates Directives, will form part of the "basic measures" for the WFD.

The WFD will affect the work of most of the Agency's functions including water quality, water resources, conservation, fisheries, flood defence, planning and environmental monitoring functions. It also has considerable overlap with existing legislation and policy, such as discharge consenting and the licensing of water abstractions. The WFD therefore represents a significant business driver but also a significant business risk to the Agency.

It is clear from an initial appraisal of the Directive requirements that the Agency does not possess all the necessary tools or expertise to ensure effective implementation. In order to ensure the effective implementation of the WFD, the Agency is developing a strategy outlining the actions that it will need to take to meet the Directive's requirements. This strategy will also identify research needs for the next 10-15 years and prioritise these to enable the Agency to meet the implementation deadlines set in the Directive.

2.2 Objectives

The overall objective of this project is to begin to develop an R&D strategy that will enable the Agency to undertake the tasks necessary to implement the WFD and establish a programme of research for delivery under the WFD R&D umbrella project, Agency functional programmes, collaborative programmes and by influencing external research agendas. This objective will be achieved through 3 main tasks:

- a survey of ongoing and planned R&D both in the UK, including Agency programmes, and Europe. The aim of the review is to identify relevant R&D that will support the Agency in meeting the WFD requirements and identify opportunities for a collaborative approach;

- planning and organising of a workshop, bringing together representatives of the key parts of the Agency involved in implementing the WFD. The aim of the workshop is to identify a more specific list of research needs through the use of an implementation case study;

- the development of an initial R&D strategy and programme seeking out what needs to be done, by when and where opportunities exist for a partnership approach. It is also important that the strategy establishes what aspects of research should be carried out at Member State or European level.

2.3 Approach

Information for the survey has been collected from UK and European sources including:

- The Environment Agency's own programmes;
- SEPA;
- SNIFFER;

- DETR;
- NERC;
- The European Commission;
- The European Environment Agency, it's National Focal Points and the European Topic Centre on Inland Waters (ETC-IW).

A list of responding organisations is given in Appendix 1.

3. ONGOING AND PLANNED R&D IN THE UK AND EUROPE

Implementation of the WFD can be broken down into stages as shown in Figure 3.1. Although the Agency, and others in the UK, have a wide range of tools and information to support implementation, further R&D may be needed to develop current approaches in order to fully meet the Directives needs. Organisations in the UK and other countries are aware of this need and are undertaking, or have undertaken R&D to support the implementation process.

Figure 3.1 Main implementation phases of the WFD

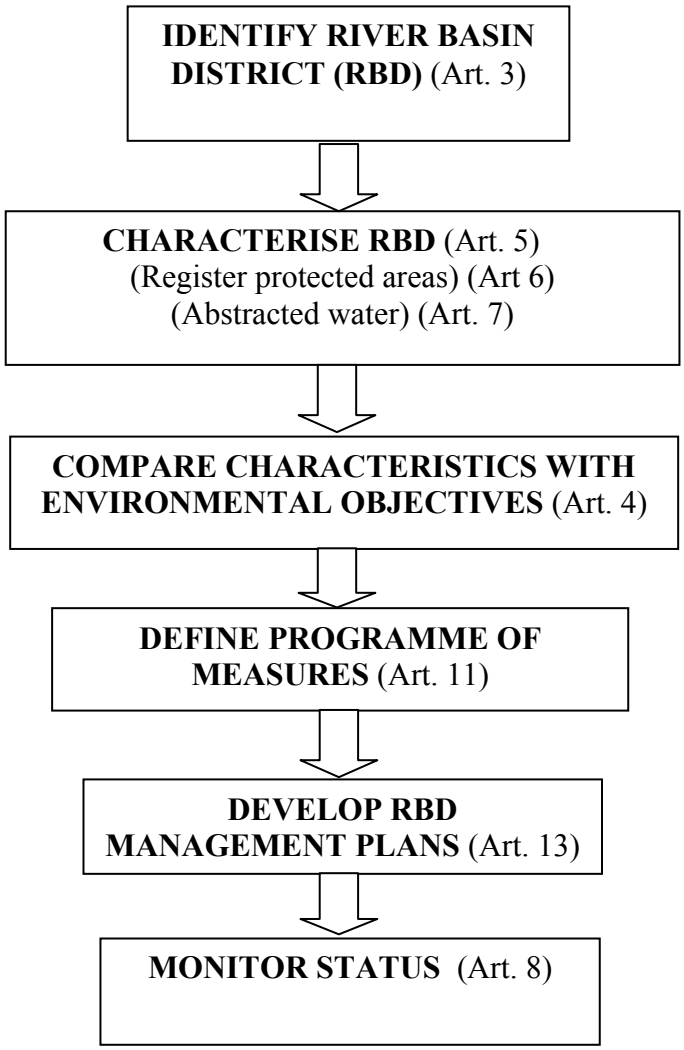


Table 3.1 summarises the requirements for each of these stages along with any research that has been completed or is currently being undertaken. The table summarises the relevant requirement of the Directive that the research project relates to and illustrates the status of any research that is connected to these requirements as either completed or current. The table also includes recommendations for projects, in areas where no research has been discovered. These recommendations are based on experience gathered during WRc's collaboration with DG

Environment on the technical specifications for the Directive, and also from work conducted on the potential costs of compliance with the Directive. The projects that have been identified reflect the responses that were received from organisations that were contacted. The relatively large number of projects from Finland reflects the strong responses received from this country.

Table 3.1 Completed, current and recommended research relevant to the WFD.

Ref. No.	Article	Directive Requirements	Research: Completed / Current/ Recommended	Start/End
3.1	3	Identify River Basin Districts	**NERC Groundwater Systems & Groundwater Quality Programme - National Groundwater Survey. (contact: Hazel Baxendale, BGS Keyworth).** Synthesis and interpretation of knowledge at a regional scale. Collaboration possible in definition of River Basin Districts at catchment scale. Status: current.	?
3.2	3	Identify River Basin Districts Identify competent authority	**Scottish Executive Rural Affairs Department.** This project which was completed in 2000 was a preliminary project aimed at identifying and assessing information gaps associated with River Basin Management Planning (RMBP) in Scotland. Status: current.	01/01/2000
3.3	3	Identify River Basin Districts Identify competent authority	**Scottish Executive Rural Affairs Department.** The rationale for the current project is to provide the Scottish Executive with the necessary information and guidance to enable it to develop RBMPs and implement the WFD in Scotland. Status: current.	01/10/00-01/10/02
3.4	3	Identify River Basin Districts Identify competent authority	**EA.** Integrated appraisal for river basin management plans. The aim of this project is to scope out how the economic appraisals of measures to achieve good water quality status and consultation on them could be carried out so as to aid decision making on these measures and identify and investigate any issues and problems regarding such appraisals.	?
3.5	3	Identify River Basin Districts Identify competent authority	**Finnish Environment Institute.** Development of planning processes required by the WFD (heikki.makinen@vyh.fi , antti.lehtinen@vyh.fi). Status: current.	?
4.1	4	Prevent pollution of surface waters	**EA (0610). Review Of Pollution Prevention R&D Outputs.** Status: completed.	?
4.2	4	Reverse any significant upward trend in pollutants	**DG Environment Adhoc – (Austria) statistical aspects of the identification of groundwater pollution trends, and aggregation of monitoring results**. After initial characterisation, bodies at risk require detailed characterisation of human impacts. Surveillance to verify if those identified at risk actually are is then required using indicative parameters. Plus operation monitoring of those confirmed at risk. This research clarifies statistical aspects. Status: current. Now part of the water group 2.8 under the Commissions Common Strategy	?
4.3	4	Designation of artificial and heavily modified bodies	**DG Environment Adhoc (EA, SNIFFER, DETR/Germany EPA). Designation process for heavily modified waters.** This project is using case studies to identify/ resolve practical difficulties involved with modified bodies. Involves 1) collection of survey data on hydromorphological pressures/impacts 2) selection of bodies of water which are candidates for designation 3) identification of possible remediation measures to achieve objectives 4) identify possible methods for determining biological quality for good ecological potential. Status: current.	01/11/99-1/11/01

4.4	4	Environmental objectives	**Finnish Environment Institute.** Ecological basis for the discrimination , classification and monitoring of Finnish water bodies (krister.karttunen@vyh.fi , anas.pilke@vyh.fi). Status: current.	?
4.5	4	Environmental objectives	**Finnish Environment Institute.** Ecological basis for the discrimination and classification of regulated lakes in Finland (Mika.marttunen@vyh.fi). Current.	?
4.6	4	Environmental objectives	**Finnish Environment Institute.** Analysis of existing monitoring data for ecological classification of coastal waters (saara.back@vyh.fi). Status: current.	?
4.7	4	Environmental objectives	**Finnish Regional Environment Centre.** Use of macrozoobenthos in assessing the ecological state in the coastal waters of the Quark region (hans-goran.lax@vyh.fi). Status: current	?
4.8	4	Environmental objectives	**Finnish Regional Environment Centre (Finland).** Ecological status of streams in Vuoksi River basin (kari-matti.vuori@vyh.fi). Status: current.	?
4.9	4	Environmental objectives	**Finnish Regional Environment Centre.** Applicability of periphyton methods for biomonitoring and classifying ecological status in the Vuoksi watercourse in littoral and pelagical zone (pekka.sojakka@vyh.fi, pertti.manninen@vyh.fi). Status: current.	?
4.10	4	Environmental objectives	**Finnish Regional Environment Centre.** Development of aquatic macrophyte monitoring for the national implementation of the WFD (olavi.sandman@vyh.fi). Status: current.	?
4.11	4	Environmental objectives	**Finnish Game and Fisheries Research Unit.** The analysis of fish community structure as a basis for the development of ecological classification and monitoring of surface waters (martti.rask@rktl.fi). Current.	?
4.12	4	Environmental objectives	**Helsinki University (Finland).** The control mechanisms required by the WFD and its Finnish implementation (jukka.matinvesi@vyh.fi, kai.kaatra@mmm.fi**).** Status: current.	?
4.13	4	Environmental objectives	**LIFE (Ian Codling ,WRc, UK) Efficiency of Applied Policies regarding the Prevention and Control of Diffuse Pollution in Surface Waters: Inventory and comparison of approaches in seven countries, Germany, Denmark, France, The Netherlands, Sweden and the UK.** Project highlights those practices relevant to the aims of the proposed WFD which seek to achieve good water quality status within river catchments through control of both point and diffuse sources of pollution. Status: current	Nov 1999-April 2000
4.14	4	Environmental objectives	**EA (E78). European pollution control and philosophy Phase 4.** Balancing costs and benefits, learning from a European Approach**.** Status: completed.	2000
4.15	4	Environmental objectives	**Finnish Regional Environment Centre. Typology and restoration of the lakes of lowered water level (**heikki.tanskanen@vyh.fi **).** Status: current.	?
4.16	4	Environmental objectives	**EA (P279) Review of cost-benefit issues for groundwater clean up.** Cost and benefits associated with remediation of contamination. Current	2000-2001
5.1	5	Characterise water body types	**EU Conference on the ecological status of transitional and coastal waters held by (among others) SNIFFER in Scotland in November 2000.** Established 3 regional working groups. Status: completed.	-

Ref. No.	Article	Directive Requirements	Research: Completed / Current/ Recommended	Start/End
5.2	5	Characterise water body types	**DG Environment ad-hoc. Development of a typology and classification systems for transitional and coastal waters .** This project aims to establish a thematic network and develop guidance on typology and classification systems to aid facilitation of the WFD. The guidance that is developed will be included in the Commission's Common Strategy for the Implementation of the Water Framework Directive	?
5.3	5	Characterise water body types	**Scottish Executive Rural Affairs Department** recently commissioned a research project to develop methodologies that apportion point and diffuse source contributions to observed concentrations and environmental quality standards at catchment scale. Status: current.	01/04/01-01/04/03
5.4	5	Characterise water body types	**NERC. URGENT. Urban regeneration research – water, land and air projects in urban catchments.** Status: unknown.	?
5.5	5	Characterise water body types	**EA (E1A(01)01. Development of an estuaries classification scheme.** This project is to field test the proposed scheme in England and Wales. Status: current.	?
5.6	5	Characterise water body types	**FP5. TARGET. Functional assessments of surface water body ecological status.** Status: current.	?
5.7	5	Type specific reference conditions	**DG Environment ADC –(Sweden) protocol for identification of reference conditions.** This project aims to develop a protocol for identification of water bodies corresponding to the boundary between high and good status and good and fair status for classification regime for ecological equality (Annex V). Involves the setting of reference conditions (i.e. baseline with no anthropogenic pressures and considers the 3 stages involved in establishing reference conditions). Defining ecotypes, ii) identification of conditions resulting from a minor change in anthropogenic pressure on values of physico-chemical/hydromorphological quality elements and iii) identification of biological parameters corresponding to those conditions. The project also aims to establish general criteria for determining the point at which a slight departure from reference conditions becomes a moderate departure (i.e. good and moderate status) using biological parameters. Status: current. Conference arranged for May 2. Now part of the Commissions Common Strategy (Project 2.3)	01/11/99-01/11/01
5.8	5	Type specific reference conditions	**EA (1721). Trial classification of Lake Water Quality in England and Wales.** This project aims to develop both spatial and state-changed approaches to classification of Lake Quality. Status: completed.	Published March 2000
5.9	5	Identification of pressures	**EA (W4A(01)01. National Environmental issues and capacity modelling.** This project aims to use better digitised information already available to the Agency, by developing a GIS tool and treasury type model, to identify environmental issues contingent upon any land use proposal. Status: current.	?
5.10	5	Identification of pressures	**EA (W5-054) Head Office. River management guidelines – Phase 2.** This project aims to produce guidelines on river management best practice to meet the engineering and environmental requirements of the Agency. Status: current.	01/08/99-30/08/01

Ref. No.	Article	Directive Requirements	Research: Completed / Current/ Recommended	Start/End
5.11	5	Identification of pressures	**EA (W4-013) South West. Carrying capacity of catchments.** This pilot project is aimed towards providing practitioners of planning liaison and LEAPS with guidelines on how to determine threshold, in order to provide meaningful responses in respect of development pressures. Status: current.	01/03/00-30/08/01
5.12	5	Identification of pressures	**Recommended by WRc.** This project would aim to establish pollution inventories on a river basin level. Much of this information already exists on pollution registers but this will need to be collated and considered in a comprehensive manner, in particular to take account of diffuse pollution.	-
5.13	5	Identification of pressures	**EA (W6-062) Midlands. River aquifer interaction (IGARF 2).** This project aims to develop a tool to enable hydrologists to decide where abstractions will effect surface water and incorporate this knowledge into Agency licensing process, groundwater modelling and general understanding of aquifers. Status current.	30/12/99-30/08/02
5.14	5	Identification of pressures	**EA (E1D(00)03). Stress data for GQA 2000 (contact: J. Murray-Bligh).** The aim of this project is to collect data on the stress on ecological communities at riverine sites in the 2000 GQA survey and analyse these in the light of setting biological and river quality objectives. Status current.	?
5.15	5	Integrated Catchment Management	**EA (P2-241) Midlands. Groundwater and surface water interaction.** This study is aimed at identifying work that will enable the Agency to more effectively manage catchments as a whole through an improved understanding of ground and surface water interactions. Status current.	31/10/00-30/06/01
5.16	5	Assessment of impacts	**FP5 (contact: Prof. Ferrier, Soil Science Group, Macauly Land Use Research Institute, UK). RECOVER 2010 - predicting recovery in acidified freshwaters by 2010.** This project is designed to assess impact of current/future anthropogenic pressure on sensitive freshwater ecosystems. Will identify main drivers to identify driving processes governing time and magnitude of recovery. Will use enhanced predictive models to evaluate degree of compliance with respect to restoration of acidified waters by the year 2010. Status: current.	2000-2002
5.17	5	Assessment of impacts	**EPA (contact: Larry Stapleton, Environmental Monitoring and Labatory Services Division, Ireland). Investigation of eutrophication processes in the littoral zones of western lakes.** This project developed an 'early warning' system capable of detecting subtle changes of how lakes respond to nutrients, especially phosphorous inputs into the littoral areas. A large body of data has been assembled and an assessment of the eutrophication process has been conducted. Status: completed.	1995-1998
5.18	5	Integrated catchment management	**EA (W1-041) North West region.** The aim of this project is to apply the River Habitat Survey methodology to local and EA plans to deliver an integrated approach to river basin management. Status: current.	01/04/99-31/03/02
5.19	5	Integrated catchment management	**EA (P2-211) South West. Agricultural land use and diffuse pollution.** Development of methods to bring about changes in agricultural land use towards sustainable land management practises.	01/02/00-30/10/02
5.20	5	Analysis of characteristics	**FP5 (BGS) (contact: Bob Harris, National Centre for Groundwater and Contaminated Land). BASELINE – Natural baseline quality of European groundwaters: A basis for aquifer management.** This project aims to establish criteria for defining water quality baselines and a standardised approach is considered to assess the baseline geochemistry of European aquifers. It also aims to establish the dominant controls on natural groundwater quality and timescales across a range of climatic zones. Status: current.	01/01/00-01/12/04

5.21	5	Analysis of characteristics	**NERC Groundwater Systems & Groundwater Quality Programme (contact: Hazel Baxendale, BGS Keyworth). Diffuse Pollution and Transport in UK Aquifers.** Research into processes of natural attenuation, transport and modelling. Possible collaboration on prevention of pollution by pesticides, nitrates and cryptosporidium. Status: current.	01/04/00-01/03/02
5.22	5	Analysis of characteristics	**NERC Groundwater Systems & Groundwater Quality Programme (contact: Hazel Baxendale, BGS Keyworth). Quaternary Hydrogeology.** Research into the development of permeability and storage in aquifers during the Quaternary period, aims to improve definition of water bodies, monitoring strategies, abstraction management of individual sources. Status: Current.	01/04/00-01/03/03
5.23	5	Analysis of characteristics	**NERC Groundwater Systems & Groundwater Quality Programme (contact: Hazel Baxendale, BGS Keyworth). Recharge Processes through Superficial Deposits.** Research to gain a quantitative understanding of the influence of drift deposits (in particular) on recharge. Aims to improve the accuracy of the total available groundwater resources. Status: current.	01/04/00-01/03/02
5.24	5	Analysis of characteristics	**EA (W6/i722) Baseline quality of aquifers.** Status: completed.	June 1999
5.25	5	Identification of pressures	**EA (PS/i639/1) Sources and impacts of nutrients in estuaries - phase 2.** Status: completed	June 1999
5.26	5	Analysis of characteristics	**Finnish Environment Institute. The application of the WFD in heavily modified water bodies in Europe** – The Lake Kemijarvi case study (mika.marttunen@vyh.fi). Status current.	?
5.27	5	Analysis of characteristics	**FP5 An operational system of Groundwater Recharge at European scale.** Contact persons: Professor M.A.Mimikou, Dr. E.A.Baltas. To develop a simple consistent and reliable system to estimate groundwater recharge at the catchment and regional scale. Status: recommended.	?
5.28	5	Analysis of characteristics	**FP5 River basin modelling for holistic catchment management.** Contact persons: M. A. Mimikou, Dr E. A. Baltas. The aim of this project is to establish current state of the art in river basin scale modelling and catchment management to identify issues for research to underpin the implementation of the WFD.	?
5.29	5	Analysis of characteristics	**FP5 Decision Support System for Integrated Water Resources Management.** Contact persons: Professor M.A.Mimikou, E.L.Varanou. Managing water resources on the river basin scale as the proper physical unit to account for the interaction between surface water and ground water as well as water quantity and quality. Status recommended.	?
5.30	5	Analysis of characteristics	**FP5 Hydrological and Hydrometeorological Systems for Europe – HYDROMET (FP 4)** Contact persons: Professor M.A.Mimikou, Dr. E.A.Baltas. This project aimed to develop weather radar system for hydrological applications. Status: completed.	?
5.31	5	Analysis of characteristics	**FP5 Impact of Climate Change on Hydrological and Water Resource Systems in the European Community (FP 4).** Contact persons: Professor M.A.Mimikou, Dr. E.L.Varanou. This project aims to assess the impacts of climate change on water resources in Northern Greece on a regional basis (catchment scale). Status completed.	?

Ref. No.	Article	Directive Requirements	Research: Completed / Current/ Recommended	Start/End
5.32	5	Analysis of characteristics	**FP5 European River Flood Occurrence & Total Risk Assessment System – EUROTAS (FP 4).** Contact persons: Professor M.A.Mimikou, E.L.Varanou. To develop and demonstrate an integrated catchment model for the assessment and mitigation of flood risk. Status: current.	?
5.33	5	Analysis of characteristics	**FP5 Climate Hydrochemistry and Economics of Surface – Water Systems – CHESS (FP 4).** Contact persons: Professor M.A.Mimikou, E. C. Gkouvatsou. This project aims to investigate how expected changes in climate and land cover will affect the quality of freshwater resources in Europe. Status: current.	?
5.34	5	Integrated Catchment Management	**FP5 (EVK1) Data assimilation within a unifying modelling framework for improved river basin water resources management (contact Cees Veerman).** The aim of this project is to develop, implement and test a model that incorporates stream channel, land surface and soil components.	2000 - 2001
5.35	5	Integrated Catchment Management	**FP5 (EVK1) Integrated evaluation for sustainable river basin governance (contact Leopoldo Guimaraes).** This project aims to develop a set of guidelines for river basin authorities describing an integrated evaluation process, establishing criteria for assessing the sustainability of an evaluation process and providing practical tools to make the guidelines operational.	2001 - 2004
5.36	5	Integrated Catchment Management	**FP5 (EVK1) Freshwater integrated resource management (contact Peter Brooks, University of Surrey).** The aim of this project is to improve water resource planning through the use of multi-agent models that integrate hydrological, social and economic aspects of water resource management through the representation of stakeholder decision making.	
5.37	5	Analysis of characteristics	**EA Diffuse water pollution umbrella (contact Helen Richardson).** This project aims to undertake research and development to clarify the Agency's strategy with regard to the management of diffuse sources of water pollution in urban and rural environments.	
8.1	8	Determine ecological status .	**EA (E1-S01). Use of macrophytes for environmental monitoring of rivers.** This project aimed to develop a macrophyte-based methodology for monitoring the ecological health of river environments, and assessing their rehabilitation requirements. Status: completed.	?
8.2	8	Determine ecological status	**EA (E1D(01)07. National trialing of the Phosphatase Methodology (contact: M Christmas).** This project aims to develop a tool for measuring trophic status under the WFD. Status: current.	?
8.3	8	Determine ecological status	**EA (E1D(01)13 Use of algal/macrophyte/fish data for water resource management.** Status: current.	?
8.4	8	Determine ecological status	**EA (E1D(01)14. Use of the trophic status of invertebrates for water resource management.** Status: current.	?
8.5	8	Determine ecological status	**EA (E1D(01)15. Assessment of LIFE scores to link freshwater invertebrate communities to flow conditions.** Status: current.	?
8.6	8	Determine ecological status	**EA (E1D(01)08. Use of GQA type monitoring for water resources management. (contact J. Murray-Bligh).** Status: current.	?
8.7	8	Determine ecological status	**EA (E1-083). Role, application and guidance for use of bioassays in the monitoring and management of the water environment,.** This project uses ecotoxicological bioassays in the monitoring and management of the water environment. Status: current.	01/04/00-30/12/01

Ref. No.	Article	Directive Requirements	Research: Completed / Current/ Recommended	Start/End
8.8	8	Integrated catchment management	**EA (E1-090) North East. Interactive monitoring.** This uses prediction and classification techniques for assessing environmental quality of river basins to allow a holistic approach for integrated river catchment management. Status: current.	01/02/00-28/02/01
8.9	8	Determine chemical status	**EA (P2-248). Development of the integrated water resources and water quality data modelling strategy.** Status: current.	01/11/00-30/04/02
8.10	8	Determine chemical status	**EA (E1C(01)01. Developing new sensor technology for WFD application (contact: T Long).** The aim of this project is to develop a whole-cell sensors as a viable field test surrogate for whole organism toxicity tests. Status: current.	?
8.11	8	Determine ecological status	**EA (E1A (01)02. Implementation of the PYSM system for the ecological assessment of ponds.** The aim is develop a co-ordinated monitoring programme for ponds and small water bodies in England and Wales. Status: current.	?
8.12	8	Integrated catchment management	**EA (P2-150) Thames Region. Nutrient modelling on the River Kennet.** This project aims to improve the Agency's nutrient modelling capability. Status: current.	01/12/98-30/11/01
8.13	8	Determine ecological status	**NERC (contact: Dr. Anne Macfarlane). LOCAR.** Predicting the response of permeable lowland systems to direct and indirect anthropogenic influences, through the development and application of integrated models. Status: current.	?
8.14	8	Determine ecological status	**Workshop on Monitoring and Assessment of Ecological Status of Aquatic Environments. Helsinki**. Organised by Finnish Environment Institute. Proposed contributors from across Europe. Status: completed.	28/9 to 1/10/2000
8.15	8	Determine ecological status	**EA (PR W1/017/1). PLANTPACS – A Study into the Feasibility of Producing a Predictive System to Assess River Quality and Ecological Status using Macrophytes.** This project was designed to develop a predictive system for macrophytes in rivers to determine overall environmental quality. Status: completed.	Published January 2000
8.16	8	Determine ecological status	**EA (E1-091). Still water ecological classification systems.** This project aims to review ecologically based classification systems that would be applicable to temperate standing freshwaters over 0.5km^2 surface area. Status: current.	04/05/99-31/03/01
8.17	8	Determine ecological status	**EA (W1-063) North West. Setting river habitat objectives for English and Welsh rivers.** This project will utilise RHS and other information. Status current.	01/10/00-01/06/03
8.18	8	Determine ecological status	**EA (TR E57). Alternative Methods for the Biological Classification of Rivers.** Reviews current international methods of classification in order to facilitate a transparent system of biological classification of rivers that will be accepted by the EC. Status: current.	Published December 1999.

Ref. No.	Article	Directive Requirements	Research: Completed / Current/ Recommended	Start/End
8.19	8	Determine ecological status	**NERC (Dr Anne McFarlane). Lowland Catchment Research (LOCAR**). This project uses 3 flagship catchments to provide basic data that can be used to calibrate and validate integrated hydrological, hydrochemical, hydrogeological, geomorphological and ecological models of the catchments that can be used predictively for catchment management schemes and to assess the impacts of environmental change. Status: current.	1999-2004
8.20	8	Determine ecological status	**FP5 (contact: Jim Wharfe, Ecotoxicocogy & Hazardous Substances, National Centre). TARGET - Integrated assessment tools to gauge local functional status within freshwater ecosystems.** Develop a suite of generic tools for assessing functional status of running water ecosystems, based on modified versions of existing limnological and ecotoxicological tests. Has created Ecological Quality Manual containing procedures for the selection of tools and interpretation of results within ecoregion studied. Status: current.	2000-2002
8.21	8	Determine ecological status	**FP5. EMERGE European Mountain Lake Ecosystem Regionalisation Diagnostic and Socio-economic Evaluation (contact: Simon Patrick Environmental Change Research Centre UCL).** Assessing the status of remote mountain lake ecosystems following the requirements of the WFD. Provides an evaluation of findings in ecological, environmental and socio-economic terms. Status: current.	2000-2002
8.22	8	Determine ecological status	**FP5 (contact: Dr Daniel Hering Institute of Ecology, Department of Hydrobiology University of Essen DE). AQEM, assessment method for defining ecological quality of surface water using benthic macroinvertebrates.** To develop an assessment procedure for rivers that meets the demands of the WFD using benthic macroinvertebrates. System based on fauna of near natural reference streams, new data sets to be comparable. Status: current.	2000-2002
8.23	8	Determine ecological status	**FP5 (contact: Prof. Brian Moss, school of Biological Sciences, University of Liverpool). ECOFRAME - Ecological quality and functioning of shallow lake ecosystems with respect to the needs of the WFD.** Shallow lakes are complex systems due to importance of higher plants, and thus pose particular problems for the implementation of WFD. Aims to test robustness of proposed sampling frequencies, to decide best criteria for determination of ecological status (high, good, moderate and worse). Status: current.	2000-2002
8.24	8	Determine ecological status	**FP5 (contact: Prof. Edwin Taylor; School of Biological Sciences, University of Birmingham, UK). CITYFISH.** This is a project that is modelling ecological quality of urban rivers: ecotoxicological factors limiting restoration of fish populations. Status: current.	2000 - 2002
8.25	8	Determine ecological status	**EPA (contact: Larry Stapleton, Environmental Monitoring and Laboratory Services Division, Ireland). Remote sensing of lakes: improved chlorophyll calibration and data processing.** Project developed aerial remote sensing facility to produce routine chlorophyll estimations for Irish lakes, as well as information on lake macrophytes and catchment land-use. Led to creation of a GIS suitable for lake management purposes. Status: completed.	1995-98

Ref. No.	Article	Directive Requirements	Research: Completed / Current/ Recommended	Start/End
8.26	8	Determine ecological status	**EPA (contact: Larry Stapleton, Environmental Monitoring and Laboratory Services Division, Ireland). Ecological assessment of Irish lakes.** Developed field based assessment technique similar to that developed for rivers, to allow lakes to be graded using a range of ecological characteristics – flora, fauna, catchment type, and trophic status. Provided a data set of biological and chemical characteristics and catchment data (land use, rainfall) to investigate associations between patterns of land use and lake nutrient concentrations. Status: completed.	1995-99
8.27	8	Determine ecological status	**FP5 Predicting aquatic ecosystem quality using artificial neural networks: impact of environmental characteristics on the structure of aquatic communities (contact Raymond Bastide Universite Paul Sabatier de Toulouse III).** This project aims to develop the methodology for linking environmental characteristics and community structure and at a functional level the sensitivity of organisms and their response to disturbance.	2003
8.28	8	Determine ecological status	**FP5 Integrated assessment tools to gauge local functional status within freshwater ecosystems (contact Amadeu Mortagua, Universidade de Coimbra).** The aims of this study which is based in Portugal, The Netherlands and the UK, are to develop an integrated set of tools for assessing ecological processes that maintain ecosystem services. The biassays include energy supply, energy consumption and transfer.	2000 - 2003
8.29	8	Determine ecological status	**FP5 (EKV1) Towards harmonised procedures for quantification of catchment scale nutrient losses from European Catchments.** The aim of this project is to evaluate 10 tools that are currently used to support policy reporting at national and international level for estimating diffuse losses of N and P across a range of catchment types.	?
8.30	8	Integrated Catchment management	**FP5 (EVKI) Management of the environment and resources using integrated techniques.** The aim of this project which is based in Spain, UK, Italy and Denmark is to develop an integrated water resource management methodology that incorporates environmental, economic, social and political impacts using the Bayesian belief network.	?
9.1	9	Recovery of costs for water services	**EA (E92) Cost recovery charging effectiveness.** Status: completed.	Oct 1999
9.2	9	Recovery of costs for water services	**Workshop in Lille France, on "Economic evaluation and its integration into decision processes. Organised by Agences de l'Eau**	Sept 2000
9.3	9	Recovery of costs for water services	**Helsinki University (Finland).** The regulating system for the cost recovery principle (jukka.matinvesi@vyh.fi, kai.kaatra@mmm.fi). Status: current.	1999-2000

Ref. No.	Article	Directive Requirements	Research: Completed / Current/ Recommended	Start/End
x		Miscellaneous	**Recommended by DG Environment/WRc: Development of new assessment systems** Develop river assessment system using fish, benthic plants, riparian zones, phytoplankton. Higher vertebrates etc. **Research into links between physical status and biological status** To enable forecasting need to relate physical quality to defined biological responses: **Development of physical typology for rivers** Used to define physical river typology and to assess physical quality of river **Development of functionally orientated systems for assessing ecological quality** Largest gaps in assessing quality is transitional and coastal waters. **Define criteria for low and ecological flows** Add hydrological evaluations of rivers to morphological criteria – need to improve biological reality of predictions of flows **Define guidelines for selecting suitable toxicity tests** Develop suitable battery of toxicity tests for evaluation of toxicological status and to account for variability. **Bioassays for all water types** Further development of ambient toxicity tests is required **Linkage of toxic and sub-lethal effects to changes in ecosystems** Link between stress measured and functional/structural changes needs to be related. **Intercalibration exercise and network** Consideration of: the definition of reference conditions, use of appropriate typologies for identification of comparable water bodies, assessment of inter-country comparability, evaluation of quality measured by different elements.	-
		Miscellaneous	**UKWIR.** This ongoing project aims to identify potential business impacts of the WFD, identify other stakeholders and possible partners, identify potential funding requirements for AMP4 and beyond, identify policy issues and propose a policy positioning statement and to identify areas of uncertainty which need further research. Status: current.	01/11/00-01/04/01

NOTE: FEI = Finnish Environmental Institute; FREC = Finnish Regional Centre; FF&G = Finnish Fish and Game, NERC = National Environment Research Council

4. THE ROLE OF THE EUROPEAN COMMISSION

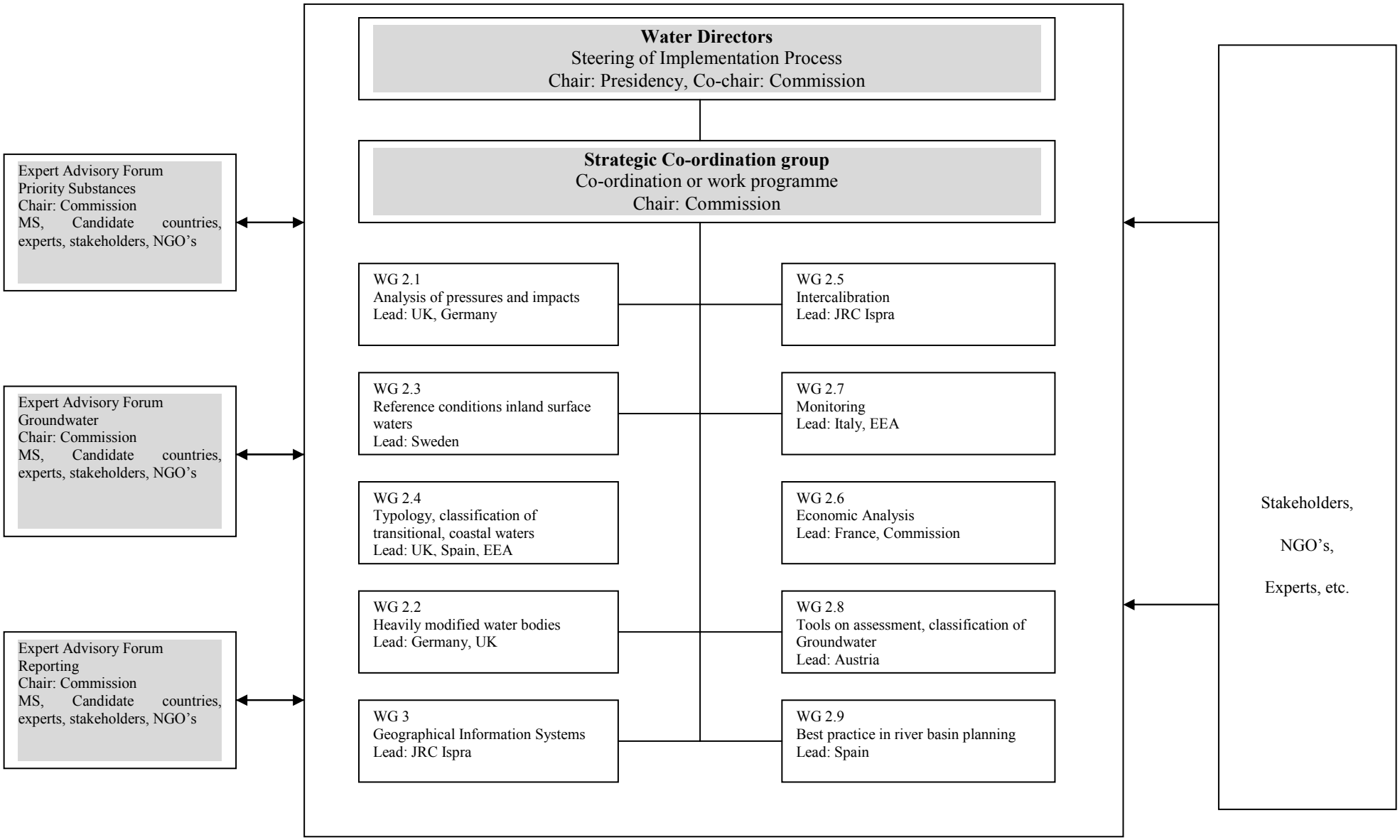
An obvious key actor in the implementation of the WFD is the European Commission and it is taking a very proactive role. For example, it has prepared a strategic document on a Common Strategy on the Implementation of the Water Framework Directive. The document is a follow up to the conclusions and general agreements reached at a meeting of EU Water Directors in October 2000. The aim is to have the draft document agreed at a Water Directors meeting during the Swedish Council Presidency in spring 2001.

The organisational structure for the common strategy is reproduced in Figure 4.1. It can be seen that there are a number of working groups to be set up working on particular priority areas. A strategic co-ordination group will be established for the co-ordination of the different working groups and activities under the common strategy. The strategic co-ordination group will evaluate the outcome of the different working groups and prepare documents and recommendations for the Water Directors' meetings. Working groups will be created for the different activities and projects. A lead country will generally chair each of the working groups with participants from interested Member States, Candidate Countries, stakeholders and NGO's. It was intended that the number of participants would be kept low (below 10) in order to ensure an effective and pragmatic working process. In practice most of the groups have 20 to 30 participants.

The key priorities and their importance are related to different phases of the implementation process determined by the deadlines laid down in the Water Framework Directive. These phases may be presented in the following sequence:

Phase 1	Transposition and identification of River Basin Districts	Deadline: December 2003
Phase 2	Establishment of reference conditions and reference sites for the intercalibration network, and preparation for specification of values for the ecological status classification systems. Analyses of the characteristics of the river basin, of pressures and impacts and the economics of water use	Deadline: December 2004
Phase 2a	Establishment of criteria for assessing groundwater	Deadline: December 2005
Phase 3	Operational monitoring programmes	Deadline: December 2006
Phase 4	Publication of River Basin Management Plans	Deadline: December 2009

Figure 4.1 Organisational structure of proposed Common Strategy for the implementation of the Water Framework Directive



A number of priority projects had been identified for inclusion in the Common Strategy. These include guidance on:

- tools for information sharing;
- information sharing – raising awareness;
- analysis of pressures and impacts;
- designation of heavily modified bodies of water;
- classification of surface water status, including a protocol for identification of reference conditions;
- development of typology and classifications systems for transitional and coastal waters;
- guidance for establishing the inter-calibration network and inter-calibration exercise;
- economic analysis;
- principles, approaches and protocols for monitoring;
- guidance on tools for the assessment and classification of groundwater;
- guidance on best practises in river basin planning;
- development of a GIS;
- integrated testing in pilot river basins;
- improved data and information management and reporting.

The Agency has delegated representation for all of these projects. The UK lead or co-lead those on heavily modified water bodies, analysis of pressures and impacts, and typology and classifications systems for transitional and coastal waters. The latter project was subject of a Conference held in Edinburgh in November (item 5.1 in Table 3.1).

5. OVERVIEW OF GAPS IN EXISTING KNOWLEDGE AND METHODS

5.1 Introduction

The aim of this section is to give an overview of the perceived main gaps (mainly at a European level) in the scientific knowledge and operational methods that will be needed by Member States to successfully implement the Water Framework Directive.

The overview should not be considered to be definitive or exhaustive. It is based on:

- Studies undertaken for the European Commission during the technical development of the draft directive, and the subsequent development of the 5th Framework Research Programme;
- Research and work undertaken for the European Environment Agency by its Topic Centres on Water; and
- Specific projects undertaken for the Environment Agency and DETR (now DEFRA).

The section loosely reflects the structure of Articles 5 and 8 of the Directive. There are undoubtedly aspects of other Articles that will require R&D. Many will relate to the measures required to achieve good surface water and good groundwater status. Thus appropriate measures might be required to cease or phase out emissions of priority hazardous substances (Article 16) and the development of water pricing and incentive policies. The R&D requirements under the other Articles are not discussed in this report.

5.2 Analysis of river basin characteristics

Article 5 of the Directive deals with the analysis of characteristics of the river basin. Annex II contains the technical details and includes the following aspects:

- Characterisation of surface water body types;
- GIS maps of geographical location of types to the Commission;
- Ecoregions and surface water body types;
- Establishment of type-specific reference conditions for surface water body types;
- Identification of pressures;
- Assessment of impact.

5.2.1 Characterisation

The characterisation of surface water body types requires the identification of the four basic surface water body types, and of artificial and heavily modified water bodies. The latter is of particular importance as it allows a less stringent Environmental Objective, that is achievement of good ecological potential (Chemical status still has to be equivalent to non-modified water bodies). As achievement of objectives requires the application of measures and hence costs, Member States and the Commission are keen to gain a common procedure for the identification of heavily modified water bodies. The importance of this is reflected in the establishment of a Commission Working Group on this subject.

When it comes to the characterisation of groundwater bodies there is the potential for much debate within and between Member States as to what groundwater is included within the Directive requirements. One interpretation would be if all water in the saturated zone (permanent and temporary) was included which would include shallow (potentially heavily contaminated) aquifers, some of which are used for private (well) supply as well as groundwater bodies. This would substantially increase the extent and cost of any measures required to achieve good groundwater chemical status. Again the importance and difficulty of issues associated with groundwater is reflected in an Expert Advisory Forum and a Working Group being established by the Commission under its Common Strategy. In addition, much of the technical details will be the subject of 'Daughter Directives' yet to be agreed under Article 17 of the Directive.

The identification of groundwater bodies is one of the first tasks Member States will have to undertake once they start implementing the Directive. Certainly from the experience gained through the work of the European Environment Agency and its Topic centre on Inland Waters, this will be a new concept for many countries that have not necessarily mapped or characterised their groundwaters in this way.

5.2.2 GIS Maps

Once characterised Member States have to submit maps with the geographical location of the surface water body types to the Commission. Whilst most Member States would have a national GIS capable of doing this, the Commission is keen to promote the use of a European GIS map, or at least of formats and projections that are easily convertible to a European map. At the present time there appears not to be maps of a suitable scale for the production of such a harmonised European map. However, the Joint Research Centre at Ispra is currently working on developing such a European river and catchment map. Again the importance of this subject is reflected in the establishment of a Commission Working Group on GIS.

5.2.3 Typology and reference conditions

The level of discrimination required for the typology of water bodies has already been the subject of much scientific debate at the European level. This is crucial for the establishment of type specific reference conditions against which ecological quality is compared nationally, and ultimately at the European level. Reference conditions relate

to high ecological quality and are the anchor point for the classification of ecological quality. The intention of the Commission in drawing up the proposed systems A and B was to achieve a comparable minimum level of discrimination of types between countries whilst allowing Member States to use their own, probably much more discriminatory typologies or methodologies for their own purposes and situations. System A has to date been the subject of much derision and has, by and large, been rejected by Member States that will thus use a System B type approach.

There are problems associated with using discrete ecoregion and habitat divisions in the comparison between observed ecological quality at a site and defined reference conditions. Ecosystems do not recognise rigid boundaries imposed by ecoregions and ecotypes. Boundary effects could lead to large errors in quality assessment and should be avoided where possible. Thus a site that lies on the boundary between two ecotypes can be ascribed widely different expectations of its reference state depending upon which side of the boundary it is placed. To avoid this a very detailed hierarchical classification into specific ecotypes and habitats might be required and potentially this would have to be supported by a very dense network of intercalibration sites.

Some Member States have developed assessment systems that make a more continuous adjustment of ecological expectation across the range of ecoregions, ecotypes and habitats found across their country. This may or may not be supported by a model that uses key environmental factors at any particular site to predict the most likely composition of biological communities and compares this with what might be expected at similar unimpacted (by man) sites.

In this approach the observation that in reality ecological quality varies continuously in relation to a complex relationship with ambient physical, chemical and biotic factors, and does not recognise discrete boundaries, is acknowledged. There are examples of national assessment systems which use key environmental factors to predict the most likely biological community to be present at a site over the continuum of quality under relatively non-impacted (by man) conditions.

An example of an assessment system that treats ecological quality as a continuum is the RIVPACS system which builds into a predictive model many of the main physical and structural variables that would be used to define ecotypes. However it does not require the prior separation of sites into different ecotypes. The model can differentiate 35 invertebrate assemblages but this is a statistical device and does not allocate a particular site being assessed to a particular group. Nor are the groups divided on the basis of different values for physical variables. The prediction which is made under the RIVPACs system takes a contribution from a number of relevant groups. The percentage contribution is derived from the statistical probability that the site being assessed belongs to a particular group on the basis of the physical characteristics of that site.

The reference database within RIVPACS has been periodically reviewed and revised during its development to take into account different types of river. It is likely that its reference, best quality, sites will have to reviewed again to ensure that they meet the criteria defining high ecological status under the Directive. This is perhaps supported by a study undertaken for the Agency in 1998 (Mainstone and Ellis 1998). The results indicated that a large number of sites judged to be of reference quality exhibited EQI values (for BMWP score, ASPT and the Number of Taxa) substantially higher than

unity, above that which would be expected by chance. This indicated that at that time RIVPACs might be under-predicting the potential biotic scores at a substantial proportion of sites, at least those of high quality and perhaps only in specific habitats.

Thus a balance will have to be obtained between a very detailed typology and habitat identification, each one of which will require reference conditions, and the minimum discrimination required between types that will still enable meaningful and valid comparisons to be made across Europe during the intercalibration exercise. The latter is key if a comparable level of good ecological quality, and hence a comparable target for improvement, is to be obtained across Europe.

There are three Commission Working Groups on these issues; one on reference conditions for inland surface waters, another on typology and classification of transitional and coastal waters, and a third on intercalibration.

5.3 Review of the environmental impact of human activity

This requires the identification of pressures within river basin districts including the:

- estimation and identification of significant point and diffuse source pollution;
- estimation and identification of significant water abstraction;
- estimation and identification of the impact of significant water flow regulation;
- identification of significant morphological alterations to water bodies;
- estimation and identification of other significant anthropogenic impacts;
- estimation of land use patterns.

5.3.1 Point and diffuse sources of pollution

The emission of pollutants is a major cause of the bad quality of water in Europe. However, the information currently available on emissions to water in Europe is not consistent or comparable between countries (EEA 2001, in press). Reasons for this are the lack of common nomenclature for the activities leading to emissions of pollutants, the lack of common objectives regarding the current data registers, and technical difficulties in measuring emissions to water.

There are currently many legal and moral requirements for the collection and reporting of information on emissions. There is a need for the efficient use of this information in order to avoid duplication of activities. The European Environment Agency and its Topic Centre on water are currently working on a conceptual model for an Integrated Emission Inventory for Europe, including nomenclatures for sectors and pollutants, with the aim of providing comparable information at a European level. Similarly, the OSPAR Commission is currently implementing the Harmonised Quantification and Reporting Procedure for Nutrients (HARP-Nut) and Hazardous Substances (HARP-Haz). The HARP guidelines should enable Contracting Parties to

quantify and report on nutrient/hazardous substance discharges and losses to inland and coastal waters (including the emission factors used) in a harmonised and transparent way. Both these initiatives are of potential use in developing methodologies for the collection of the required information at a national and river basin level.

Direct sampling is the most common method used to estimate point source discharges from municipal and industrial treatment plants. Sampling characteristics (frequency, type etc.) usually depend on the size of the plant or the industry type. Within the limits of the Directives' requirements, each country has established its own sampling strategy, the rule generally being to estimate pollution from the largest polluters the most precisely and reliably. Point sources are potentially identifiable and can be listed. Model calculations are sometimes used to assess pollution loads from industrial plants (e.g. in France and Portugal). These models are based on detailed information of processes within each factory.

Diffuse sources can rarely be assessed by monitoring. This is because there is no precise point where water can be sampled. Different quantification approaches (such measurements in the laboratory, lysimeters and small watershed) can be used and made comparable to obtain a reasonably reliable result. Thus many European Countries have developed models to estimate diffuse pollution.

As an example, a study has been undertaken to compare the methods and assessment procedures for estimating nutrient emissions arising from diffuse agricultural sources used in eight EU Member States (including the UK) (De Paepe 2000). It appeared that the procedures are relatively homogeneous in their basic principles with the majority being source oriented. Likewise, total nitrogen is usually assessed. As for input data, the same types are used by virtually every procedure. The main difficulties when comparing results lies in the sources that are taken into account. The ability to identify the contribution of diffuse agricultural sources is of great importance. The different characteristics of the accounted emission pathways and the retention and transformation processes are likely to strongly affect the emissions figures. Despite the fact that national procedures have been independently developed, the broad homogeneity between the principles of the procedures was very apparent. The main differences are found in the transfer steps considered but this is because they were created in response to varied objectives and their structure is therefore different.

Each national or regional model uses technical coefficients to assess certain types of emission that are not, or are only partially, monitored. It is possible to define generally accepted aggregated coefficients or locally specific ones. For example, a country or a region that may not have data collected on certain industrial emissions could use a coefficient calculated from data collected in another country for the same type of industrial activity. The choice of coefficients should take into account the reality encountered. For example, the coefficients used to calculate household emissions will be different depending on whether the national legislation does or does not allow phosphates in washing powder.

Modelling or statistical treatment of measured data are generally used to define new technical coefficients for emission calculations. The choice of the relevant coefficients, and the modelling of new ones, are part of the main activities of working groups involved in national emissions inventory programmes and OSPAR. However,

one possible research need is to carry out both a monitoring and a modelling approach in order to compare the results, and subsequently to re-adjust the coefficients used in the models if necessary. It would also be useful to develop a database of the coefficients being used by member countries.

The Directive requires the estimation and identification of 'significant' point and diffuse sources. 'Significant' has not been defined. However, it could be presumed that a source would be significant if it had an effect on the receiving water body and caused or increased the risk that the water body failed it's environmental objective. This is an important point because those water bodies at risk of failing are subject to further characterisation which is then used to optimise the design of monitoring programmes and programmes of measures. A common European understanding of what is significant and how to assess the likelihood of failing environmental quality objectives would be of benefit to Member States. The Commission has a Working Group that should provide guidance on these issues. The group is lead by the UK and Germany.

5.3.2 Water abstractions and water flow regulation

Member States will also have to estimate and identify significant water abstraction and water flow regulation.

In terms of rivers there is an urgent need to add hydrological evaluations of river reach situations to the already well-defined morphological criteria: initially this could focus on low flows. In any case for all water abstractions, it is necessary to define a minimum flow, considered useful for maintaining the river's functions and life. Low flows occur during certain key periods such as winter flow in high altitude rivers during the important hydroelectric production period or summer flow during the irrigation period.

Many specialists agree that much progress has been made over the past 10 years in this field. But it is now essential to improve the biological reality of predictions, as well as increasing the range of target species to upstream fish and other organisms, invertebrates and macrophytes (Moth Iversen 1999). These approaches can be complemented as necessary by before/after comparisons of flow modifications. Bringing together different national cases from across Europe would enable several years of experience to be gained and result in a sufficiently wide range of hydroecological situations.

5.3.3 Morphological alterations

Most of the important mechanisms linking physical function (hydrology, morphology, bankside woodland) and ecological function for rivers are well known and described in a qualitative way. However, when considering operational approaches, such as the identification of significant morphological alterations, it will often be important to have quantitative relationships. This is not straightforward, because of the multivariate nature of the relationships, scale effects and different temporal dynamics. It is important to make clear the main cause-effect relationships, and not to simply carry out correlations between physical and biological data. Moreover, it is necessary

to produce regional typologies of these relations. Experience indicates that factors are often the same between regions, but that their relative importance may be different.

Research is thus needed on the cause-effect relationships between physical status and biological status (Moth Iversen 1999). Most existing models are correlation or description-based and should not be used for forecasting. Forecasting is however a key step which will follow on from status assessments. For example, how can status observations lead to forecasts of the potential effects of corrective actions, and moreover at such a large scale. Thus, at the present time it is not possible to relate 'degraded' physical quality to defined biological responses and hence to equivalent biological quality. For example would 'poor' physical status equate to 'moderate', 'poor' or 'bad' biological status.

5.3.4 Linking physicochemical quality elements with biological quality elements

The Directive will require the establishment of relationships between the concentrations/levels of the physicochemical quality elements (such as nutrients) and biological quality. This will be needed for a number of aspects of the Directive such as for the:

- definition of type specific reference levels/conditions for these elements;
- assessment of the significance of point and diffuse source pollution containing or affecting these elements;
- classification of ecological status in terms of physico-chemical elements; and,
- planning and implementation of measures to improve the quality of water bodies impacted by the physicochemical elements.

One possible option for relating the concentration of nutrients to biological quality is to base it on the probabilities of biological effects occurring so that differences in nutrient concentrations relate to probable differences in biological quality. There will be type-specific differences that will have to be taken into account, the same nutrient concentrations will have different effects in different types of water depending on the type specific ambient physical and physicochemical factors.

Essentially what would be required is a methodology to establish risk based relationships between nutrient concentrations and the biological status of water bodies, and a way of interrogating type specific nutrient concentrations in way which allows the consequences of excessive nutrient concentrations (compared to the reference conditions) to be assessed in terms of:

- The number of species likely to be affected (i.e. biodiversity).
- The population size or risk of loss of individual species (i.e. abundance or risk of extinction).

As far as it is known there is not a methodology established for this yet though the Agency has initiated R&D in this area.

5.3.5 Linkage of toxic and sub-lethal effects to structural and functional changes in ecosystems

In linking physicochemical quality elements to the biological elements, the effects and stress arising from toxic substances need to be related to functional and structural changes in the ecosystem if the former are to become more relevant for the assessment of ecological status. Even though ecotoxicological assessment criteria have been developed to assess the levels of contaminants in water, sediment and biota in terms of the likelihood of structural effects being present, these links generally appear to be missing at the present time.

5.3.6 Impact of human activities: response of lakes to other water quality stressors

Eutrophication and problems related to increased nutrient loading caused by human impact are expected to be of prime importance for the future ecological quality of lakes. Nutrient (in particular phosphorus) loading from point sources has been, and is being, reduced in most western European countries, and although many years may pass, the internal phosphorus loading from the sediment will eventually decrease.

In the future problems other than those associated with eutrophication may arise with lake water quality. For several decades the use of pesticides has been intensive and the fact that these pesticides may reach ground and surface waters and thus cause extensive pollution has become increasingly evident. Little is, however, known about the impact of pesticides on lake water quality. Thus further studies into the impact of pesticides in lakes is required.

5.4 Monitoring and classification of surface water status

5.4.1 Background

The Directive has a requirement for the monitoring of ecological status and chemical status for surface waters. Technical specification for the monitoring are given in Annex V and includes the design of:

- Surveillance monitoring;
- Operational monitoring;
- Investigative monitoring;

and specifications for:

- Frequency of monitoring;

- Additional monitoring requirements for protected areas;
- Standards for monitoring of quality elements.

The requirements for the classification and presentation of ecological status and a methodology for gaining comparability of biological monitoring results are also given. This sub-section highlights some of the identified research needs associated with these aspects.

5.4.2 Existing national monitoring and classification schemes

Work undertaken by the European Environment Agency, the European Commission and others during the technical negotiations of the Directive indicated that there are potentially many gaps in current national tools, methodologies and procedures in meeting the requirements of the Directive. For example, a comparative study of national river classification schemes undertaken by the EEA (Nixon *et al*. in press) indicates that though many countries undertake assessments based on river invertebrates far fewer include macrophytes or fish.

Table 5.1 River classification or quality assessment schemes used or under development in the EU (Nixon *et al*., in press)

	Macroinvertebrates	Macrophytes/diatoms	Fish
Austria	Yes	Yes	Yes
Belgium	Yes	Yes	Yes
Denmark	Yes		
Finland	Yes		
France	Yes	Yes	Yes
Germany	Yes	Yes	
Greece			
Ireland	Yes	Yes	Yes
Italy	Yes		
Luxembourg	Yes		
Netherlands	Yes		
Portugal	Yes		
Spain	Yes		
Sweden	Yes		
UK	Yes	Yes	Yes

In addition, there are major differences between the existing national river invertebrate assessment schemes. Most EU countries use biotic indices, 2 use the saprobic index and Greece has no system. These fundamental differences (particularly between the saprobic and biotic approaches) will lead to difficulties in obtaining a harmonised comparison and level of ecological quality across Europe. These issues will have to be considered and resolved during the establishment of the intercalibration network and exercise across Europe. Intercalibration is the subject of one of DG Environments Working Groups.

Table 5.2 Use of macroinvertebrates in national river classification schemes

Saprobic index	Biotic index	Other	None
Austria	Belgium	Sweden	Greece
Germany	Denmark		
	Finland		
	France		
	Ireland		
	Italy		
	Luxembourg		
	Netherlands		
	Portugal		
	Spain		
	UK		

There are also major gaps when it comes to assessing the physical quality of rivers. Only 5 countries indicated that they had an existing or were developing such assessment schemes.

Table 5.3 River assessments/classifications based on physical characteristics

Countries	Systems / variables	Operational
Austria	Habitat and riparian zone quality, morphology	Yes
Belgium (Flanders)	Habitat quality	Under development
Germany	Geomorphology, habitat, riparian zones	Under development
France	Hydromorphology, river bed structure, habitat, riparian zones and vegetation	Under development
United Kingdom	Hydromorphology, river bed structure, habitat, riparian zones	Yes

In addition, few countries were able to provide information on whether their classification and comparison of quality was based on reference conditions as defined by the Directive. Thus most, if not all, present river classifications schemes would require modification or developments to meet the needs of the Directive.

The assessment systems adopted should be capable of reflecting the full range of impacts that may occur, including both physical and chemical disturbance. This may necessitate adaptations to the structure of, and survey procedures for, certain existing systems that are geared towards specific quality problems (such as organic enrichment or acidification) rather than the description of quality *per se*. However, such impact-orientated systems will be useful in the subsequent characterisation of quality problems relating to other aspects of the proposed Directive.

Thus Member States will have to review their biological survey procedures to ensure that the outputs produced from their candidate biological assessment systems are capable of detecting and quantifying both physical and chemical degradation of aquatic habitats.

5.4.3 Development of new assessment systems for quality elements

Similarly a study undertaken for the European Commission (Moth Iversen 1999) identified that research was required to develop operational indicators for:

- fish in all water body types;
- benthic plants in all water body types;
- riparian zones for lakes/reservoirs and transitional/coastal waters;
- establishment of national methods using macrobenthos in rivers (where not established), in lakes/reservoirs, transitional waters and coastal waters;
- zooplankton in lakes/reservoirs and estuaries/coastal waters and large rivers if relevant;
- phytoplankton in lakes/reservoirs and estuaries/coastal waters and large rivers if relevant;
- higher vertebrates if a more holistic view of the ecosystem is to be obtained.

5.4.4 Comparability of biological monitoring results

Intercalibration is of fundamental importance if a common understanding of ecological status, and more specifically the boundary between good and moderate quality, is to be obtained across Europe. The latter is of particular importance in the establishment of an equal level of ambition in achieving 'good status'. Aspects that will need consideration include the definition of reference conditions, use of appropriate typologies for the identification of comparable water bodies, assessment of inter-country comparability, and the use of ecological quality ratios for the expression of 'ecological quality'.

As part of the intercalibration there should also be an evaluation of the biological quality measured by different quality elements. Since different quality elements will be reported for different waterbody types (or major habitat types within a waterbody type), the resultant summary assessments produced from combining information on individual quality elements will inevitably focus on different aspects of ecological quality. This has an important bearing on the validity of making direct comparisons between different types of site, since different parts of the biological community (fish, macroinvertebrates, plants etc.) vary in sensitivity to different types of stress. The degree to which this will be a problem depends on the degree of discrepancy in sensitivities between different biological groups (as well as factors such as the length of recovery periods following intermittent stress). For this reason, care should be taken when comparing sites that have been assessed using different quality elements. No work is known to have been undertaken in relation to this issue but should be considered by the Commission's Working Group on intercalibration.

5.5 Development of more functionally orientated systems for assessing ecological quality

5.5.1 Background

The Commission's Scientific Committee on Toxicity, Ecotoxicity and the Environment (CSTEE) gave its opinion on the draft Directive in 1998. It recognised that defining ecological quality, for communities and ecosystems, is not currently possible from scientific first principles. This means the approach had to be pragmatic and be based fundamentally on the judgements of scientists concerning the levels of quality from "good" to "poor". Thus the Committee indicated that a long term goal should be to develop more functionally orientated systems for assessing ecological quality. This would require the definition of the functional characteristics of the different surface water ecosystems (rivers, lakes, transitional waters, coastal waters) which are more relevant for the evaluation of ecosystem quality in a sustainable sense, and the definition of cause-effect relationships between functional changes and both chemical and hydromorphological changes.

There is little operational experience in Europe of the use of the functional approach in assessing the ecological quality of surface waters. However, the use of functional indicators of ecological quality rather than the classical structural indicators that focus on community structure is a subject of considerable debate in the development of common biological assessment systems. Whilst there is potential for the development of more functionally orientated systems it is important to recognise that it is sensitive species and overall biological diversity that requires protection. Structural indicators can be regarded as a direct measure of these, whilst functional indicators (such as energy and nutrient flows) give insights into the nature of any problems and thus could be considered as second-tier tools concerned with the restoration of ecological quality.

The potential for the development of more functionally orientated systems for assessing ecological quality should thus be explored further although a cautious approach should be adopted. As an intermediary stage, the inclusion of semi-functional measures of ecological quality (whereby functional metrics are included based on structural information such as the presence of different feeding types) in the assessment of ecological quality should first be investigated further and their applicability to a range of water body types tested.

There are some semi-functional measures of ecological quality that are based on structural data that may be of value, such as those that classify taxa on the basis of trophic group, mode of life or reproductive strategy. For coastal waters the Infaunal Trophic Index can be categorised as a "semi-functional" index since it assesses the relative abundance of macrobenthos within four feeding strategies. It has been applied successfully to data sets in the UK.

It should be recognised that the introduction of functional measures will pose additional cost implications to existing methods of ecological assessment as the use of functional indicators in isolation may give misleading answers as to the health of the community. The cost-effective integration of functional methods of assessment into existing assessment programmes should be given further consideration.

5.5.2 River functioning

Studies are needed that focus on the interactions between rivers and riparian areas along geographical gradients (i.e. in different European regions) and management strategies. Riparian areas could be a good predictor of ecosystem function as well as river morphology (reflected in flooding frequency) could be a good predictor of ecosystem function in the riparian zone.

5.5.3 Lake functioning

Despite reduced phosphorus loading to many lakes, phosphorus concentrations will still be relatively high, especially in densely populated and intensively cultivated areas. Simultaneously, there is a risk that the nutrient loading from non-point sources will increase due to continuing intensification of farming practices, implying that nutrients will still be of prime importance for lake water quality.

To obtain satisfactory lake water quality it may therefore be necessary to introduce additional measures if the nutrient concentration of lakes is to be reduced. This is important particularly in the nutrient regime where both the clear-water and turbid state is possible. Thus further research is thus required into:

- Lake restoration and methods improving lake water quality.

- Improving knowledge about the transient phase after external loading is reduced, including impact and mechanisms of internal loading and biological resilience.

Furthermore, it has become clear that the biological structure is an important factor to consider when trying to establish clear-water conditions, particularly at the future nutrient level of many European lakes. It has also become evident that changes in biological structure have a considerable impact on the retention of both nitrogen and phosphorus, and this may have important implications not only for the lake itself, but also for downstream aquatic ecosystems. Thus research is also required into:

- Alternative stable states and factors determining the shift between the clear-water and the turbid state.

- Biological structure and interactions, including the regulating impact of submerged macrophytes on ecosystem quality.

- The importance of fish in structuring the ecosystem and its function and in particular the impact from young-of the-year fish in structuring the zooplankton community.

Relatively large and deep lakes usually attract the highest attention and concern with respect to lake water quality. However, small and shallow lakes are much more common and these ecosystems constitute important habitats for many plants and animals. However, generally the knowledge of these ecosystems is less comprehensive. Thus there is a need for increased research into relatively small and shallow lakes such as:

- The coupling between littoral and pelagic processes.

- The importance of benthic-pelagic coupling for the overall food chain interactions and nutrient dynamics.

Finally, freshwater lakes have traditionally been the object of attention. However, in many coastal areas of Europe brackish lakes constitute a significant part of wetland ecosystems and may be even more important as a habitat and foraging area for many birds. At present the knowledge of these systems is, however, lacking, but they seem to respond differently to changes in nutrient loading than freshwater systems. Research is thus needed into the structure and biological interactions of brackish lakes.

5.5.4 Other longer term research needs

Other fundamental longer term research identified in a study for the Commission (Clarke *et al*. 1999) included:

- Studies of the interactions between rivers and riparian areas.

- Investigation of the regulation of biomass and production of primary producers, and decomposition rates of organic matter.

- Investigation and quantification of relationships between:

  Catchment, physical status and biology in rivers.

  Bankside woodland, rivers and biology, between the hydrological regime and vital functions.

  Flows and morphological structure; flows, sedimentary dynamics and fine particle transport/deposition; flow and biological organisation.

5.6 Monitoring and assessment of groundwater status

In many European countries national groundwater monitoring networks are less well developed than surface water, particularly river, networks. This often reflects differences in national needs and priorities in terms, for example, of the primary source of drinking water. Thus in Austria where 53% of total freshwater abstraction comes from groundwater, there is a well-developed and established groundwater monitoring network (EEA 1999). In contrast in England and Wales there have only been recent plans to implement a national groundwater monitoring network, though monitoring of the major aquifers at a regional level has been undertaken for many years.

A survey undertaken by the European Topic Centre on Inland Waters indicated that the monitoring of groundwater quality has been undertaken in most European countries since the 1970's and 1980s (Koreimann *et al*. 1996). Most quality networks have the objectives of general surveillance and of detecting trends in contaminants. The density of sampling sites varies a great deal from 0.003 to 0.57 sites/km^2. The

number of measured determinands also varies from country-to-country from 15 to 106, with sampling frequencies varying from 0.5 to 12 times per year.

Thus it is probable that most if not all EU Member States will have to undertake a fundamental review of their groundwater quality and quantity networks to assess whether or not they meet the requirements of the Directive. Many networks will have to be subsequently developed and extended.

The achievement of good groundwater chemical status requires that the concentrations of pollutants in groundwater would not cause a failure of environmental objectives in associated surface water bodies nor any significant damage to terrestrial ecosystems which depend directly on the groundwater body. There is also an equivalent criterion that relates good quantitative groundwater status to the level of groundwater. There is thus a fundamental need to understand and quantify the interrelationships between groundwater bodies and surface ecosystems. There appears to be a lack of this fundamental information in many Member States.

Article 4 requires Member States to "implement the measures necessary to reverse any significant and sustained upward trend in the concentration of any pollutant resulting from the impact of human activity in order to progressively reduce pollution of groundwater". This objective was the subject of much detailed political and technical discussions during the final negotiations and drafting of the Directive. As a result there was no agreed methodology for detecting trends in the adopted Directive, nor on the starting point and end point for trend reversal and on the measures required to achieve such reversal. These aspects will be the subject of a groundwater Daughter Directive drawn up under Article 17. There is also a Commission Working Group working on guidance on tools for the assessment and classification of groundwater.

6. IDENTIFICATION OF GAPS BY ENVIRONMENT AGENCY STAFF

6.1 Brief overview of Agency Water Framework Directive R&D workshop

The purpose of the workshop was to continue the process of identifying what the Agency will need to do in order to enable effective implementation of the Water Framework Directive in a timely manner. Primarily the workshop aimed to identify a programme of, cross-functional, inter-related projects which will be necessary to provide the necessary tools and information for implementation according to the implementation timetable and for more effective implementation in the short, medium and long-term. This was intended to help the Agency align its R&D programme and ensure effective collaboration with other organisations across the EU. Staff from the Agency, SEPA, SNIFFER and NIEHS with a range of expertise and backgrounds were invited to ensure that discussions were focused towards achieving the aims of the workshop.

6.2 Overview of the workshop findings

Table 6.1 summarises the R&D gaps identified by workshop delegates. The priority status of identified gaps have been assigned a low, medium and high priority rating. Examples of past or current projects which will help fill the gaps are presented in the table and discussed further in Section 7 of the report. Appendix 2 gives a fuller record of the workshop.

The highest priority R&D gaps identified during the workshop were:

- Need for one or more virtual or real pilot study(s) aimed at identifying the needs of RBMP's.
- Better assessment of pollutant sources and in particular quantifying diffuse pollution.

Medium priority gaps identified were:

- Estimation and identification of significant water abstraction as a pressure on surface waters under Article 5.
- Land use in the recharge catchment or catchments.
- Classification of the ecological status for each body of surface water.
- Relating physicochemical elements (e.g. nutrients) to Ecological Quality (EQ).
- Relating hydromorphological elements to EQ.
- Interrelationship between groundwater and surface water.

All high priority areas identified during the workshop have R&D projects planned or currently underway which should help fill the identified gap. Areas that were identified as a low or medium R&D priority during the workshop that are not addressed by a current or future R&D project are:

- Identification of Pressures – land use in the recharge catchment.
- Assessment of impacts on groundwater.
- Monitoring – classification of groundwater quantitative status.
- Monitoring – classification of groundwater chemical status.
- Monitoring – interrelationship between groundwater and surface water.

The extent to which current or planned R&D will meet the requirements of the areas identified in Table 6.1 are discussed in section 7 of the report. A summary description of the gaps identified during the workshop is provided below.

Table 6.1: Summary of the WFD, the R & D required to meet the requirements of the WFD, in terms of priority, deadline, timescale and any current R & D projects

Article	Activity	Priority	Deadline	Timescale	Relevant Completed or Current R&D Projects
3	**Co-ordination of administrative arrangements with river basin districts**				
	Appropriate administrative arrangements	X			NERC (3.1); SE (3.2); EA (3.4); FEI (3.5)
4	**Environmental objectives**				
	Measures to reverse significant upward trends of pollutants	L			EA (4.1); DG XI (4.2)
	Designation of artificial and heavily modified water bodies	L	2004	2 years	FP5 (4.3)
	Environmental objectives	X			FEI (4.4-4.6); FREC (4.7-4.10 & 4.13); FF&G (4.11); Helsinki Uni (4.12); LIFE (4.14); EA 4.15 & 4.16)
5	**Characteristics of the river basin district**				
	Surface water				
	• Analysis of characteristics	X	2009	2 – 5 years	EU (5.1); FP5 (5.30-5.33), FP5 8.28), FEI (4.4 – 4.11)
	• typology of water bodies	H	2004	2 years	DG XI (5.2); EU (5.1); EA (5.5 & 5.8); FP5 (5.6)
	• identification and establishment of type-specific reference conditions	H	2004	2 – 5 years	DG XI (5.7); DG/NIVA/SEPA (5.9)
	• Integrated catchment management	X			EA (5.15, 5.18, 5.19 & 8.8); FP5 (5.28 & 5.29)
	Identification of pressures				
	• estimation and identification of significant point and diffuse source pollution	H			SE (5.3), WRc (5.12); EA (5.17 & 5.25) DG XI (4.3, EA components), FP5 (5.28 & 8.27)
	• estimation and identification of significant water abstraction	M	2004	2 years	DG XI (4.3, SNIFFER components)
	• estimation and identification of the impact of significant water flow regulation	L	2004	2 years	DG XI (4.3, SNIFFER components), FP5 (5.30 – 5.32)
	• identification of significant morphological alterations to water bodies	L	2004	2 years	DG XI (4.3, EA components)
	• estimation and identification of other significant anthropogenic impacts	X	2004	2 years	EA (5.10, 5.11, 5.14 & 5.16); FEI (5.26)
	• estimation of land use patterns	L			EA (5.26)
	Assessment of impact				
	• assessment of the likelihood that surface waters bodies will fail to meet EQOs	L			SE (5.2)
	Catchment case studies	H	2004	1 year	SE (3.3); EA (3.4), FP5 (8.30)

Article	Activity	Priority	Deadline	Timescale	Relevant Completed or Current R&D
	Groundwater				
	Analysis of characteristics	L	2004	5 years	EA (5.13), FP5 (5.20), NERC 5.21, 5.22 & 5.23), FP5 (5.27 &5.29)
	Identification of pressures				
	• points used for the abstraction of water intended for human consumption	X	2004	2 years	
	• the annual average rates of abstraction from such points,	X			
	• the chemical composition of water abstracted from the groundwater body,	X			
	• points into which water is directly discharged,	X			
	• the rates of discharge at such points,	X			
	• the chemical composition of discharges to the groundwater body	X			
	• land use in the recharge catchment or catchments	M	2004	1 – 2 years	FP5 (5.33)
	Assessment of impact • assessment of likelihood of failing EQS's	X			
	Catchment case studies	H			SE (3.3); EA (3.5)
	Economic analysis of water use	L			EA (9.1), Lille (9.2), Helsinki Uni (9.3), EA (4.14 & 4.16)
8	**Monitoring of surface water status, groundwater status and protected areas**		2006	1 year	
	Monitoring the ecological status for each body of surface water	X	2006	1 – 2 years	
	(Review of existing national and international methods)	H			
	(Sampling strategy e.g. frequencies, where and when)	M			
	• classification of the ecological status for each body of surface water,	M			EA (8.1, 8.3, 8.4, 8.6, 8.11, 8.15, 8.16, 8.18, 8.21 & 8.22) FET (8.14)
	• relating physicochemical elements (e.g. nutrients) to EQ	M	2009	5 – 10 years	EA (8.17, 8.23 & 8.25); FP5 (8.19), EA (8.24)
	• relating hydromorphological elements to EQ	M	2009	5 – 10 years	EA(8.5 & 8.17)
	• statistical aspects of classification	X			

Article	Activity	Priority	Deadline	Timescale	Relevant Completed or Current R&D
	Monitoring and classification of chemical status of surface waters	L	2006	2 - 5 years	EA (8.2, 8.9, 8.10 & 8.12)
	• derivation of EQSs	L	2006	2 years	EA (8.7)
	• statistical aspects of classification	X			
	Integrated catchment management	X			
	Monitoring and classification of groundwater quantitative status	L	2006	1 – 2 years	
	Monitoring and classification of groundwater chemical status	L	2006	1 – 2 years	
	Interrelationship between groundwater and surface water	H	2006	10 – 15 years	
	Trends in groundwater pollutants	X			
9	**Economic Analysis**	M	2004	1 – 2 years	
	Water pricing policies – incentives	X			EA (9.1); Lille (9.2); Helsinki Uni (9.3)
	Polluter pays principle	X			
10	**Combined approach for point and diffuse sources**				
	BAT	X			
	Best environmental practices	X			
	Emission limits	X			
	EQSs	X			
11	**Programmes of measures**				
	Efficient and sustainable water use	X			
	Reduction of level of treatment for production of drinking water	X			
	Authorisations for abstractions, impoundments and discharges	X			
	Groundwater recharge	X			
	Elimination of pollution by priority list substances	X			
	Cease or phase out emissions from priority hazardous substances	X			
	Reduce impact of accidental pollution – early warning systems	X			
	Supplementary measures	X			
13	**River Basin Management Plan**				
	GIS mapping	L	2009	1 – 2 years	
14	**Public information and consultation**	L	2008	2 – 5 years	

Article	Activity	Priority	Deadline	Timescale	Relevant Completed or Current R&D
15(1)	**Reporting:**				
	• River Basin Management Plans and all subsequent updates to the Commission	X			
15(2)	Summary reports	X			
	• the analyses required under Article 5 (Characteristics of river basin); and the	X			
15(3)	Interim reports	X			
	• progress with the implementation of measures	X			
16	**Strategies against pollution of water**				
	Priority list of substances (revised)	X			
	Risk assessment of chemical substances	X			
	Controls for progressive reduction of priority substances	X			
	Controls for cessation or phasing out of priory hazardous substances	X			
	Identification (by Commission) of appropriate cost-effective and proportionate level and	X			
	Proposals for EQS for priority substances in water, sediment and biota	X			
	Proposals for strategies against pollution e.g. accidental spills	X			
17	**Strategies to prevent and control pollution of groundwater**				

Note: L = low priority, M = medium priority, H = high priority, X = not identified as an R&D need by the workshop

Numbers in brackets are 'reference numbers' taken from Table 3.1.

NOTE: FEI = Finnish Environmental Institute; FREC = Finnish Regional Centre; FF&G = Finnish Fish and Game.

6.3 General Issues

General issues that were identified during the workshop were:

- Lack of clarity in definitions.
- Lack of guidance from DETR (now DEFRA) to date e.g. definition of groundwater bodies. It is recognised that the DEFRA (with the Agency and other bodies) are currently working on transposition issues and will produce guidance in time).
- It was felt that the Agency should take its own initiative in areas where the DETR (DEFRA) is not currently working.
- The question was therefore raised of whether there is a need for legal R&D including a glossary of terms used. If terms are not currently used should R&D define these terms?

The issues listed above in themselves do not represent R&D gaps. However these general issues will need to be considered during the development and implementation of projects aimed at addressing the gaps identified during the workshop and listed above.

6.3.1 River basin management planning

Gaps that have been identified in relation to river basin management planning were:

- Need for a case study approach to identify and solve problems associated with river basin management plans including:

  Need to extend programme to cover all main water types.

  Need to account for differences in pressures.

  Need to account for differences in natural conditions (e.g. geology).

  Tools and approaches to characterisation.

  Assessment of risk of failing objectives.

  Determination of monitoring and assessment requirements.

  Issues associated with classification and reporting.

This project was considered a high priority and it was felt should be undertaken within 1 year by the Agency. The need for a pilot study approach was also identified in an earlier seminar on integrated appraisal for water quality management. The value of this staged pilot study(s) approach to implementation is that it is more easily managed and will help identify and target specific R&D needs in the future. One of the aims of this project should therefore be to identify tools and resources that are needed to implement not only RBMP's but also the WFD generally.

6.3.2 Gaps in current monitoring and assessment systems

Gaps that have been identified in the current monitoring and assessment were:

- Need for a review of national and international tools and techniques (high priority, < 1 year).
- Need to establish reference conditions and levels (high priority, 2 to 5 years).
- Need for tools to assess changes chemical, physico-chemical and hydromorphological status in relation to biology (medium priority, long term 5 to 10 years).

It was identified that this gap would be best met by the Agency collaborating with, SNIFFER and other European agencies and organisations. Research and development that is needed to fill the gaps for the monitoring and assessment of biological quality elements are summarised in Table 6.2.

Table 6.2: Research and development that is needed to fill the gaps for the monitoring and assessment of biological quality elements.

	Aquatic flora (1)		Phytoplankton (2)		Benthic invertebrates (1)		Fish (3)	
	Directive	Gap	Directive	Gap	Directive	Gap	Directive	Gap
Rivers	Yes[m&p]	Small	Yes	Large	Yes	Small	Yes	Medium
Lakes	Yes[m&p]	Small	Yes	Large	Yes	Medium	Yes	Large
Transitional waters	Yes[a&s]	Large	Yes	Medium	Yes	Large	Yes (1)	Large
Coastal waters	Yes[a&s]	Large	Yes	Medium	Yes	Large	No	No

Notes: 1 = composition and abundance; 2 = composition, abundance and biomass; 3 = composition, abundance and age structure; Yes = required by the Directive; No = not required by the Directive; Gap = relative size of gap between current assessment systems and Directive requirements. m = macrophytes; p= phytobenthos; a = angiosperms; s = macroalgae.

Table 6.2 indicates that the largest gaps in biological monitoring tools exist for transitional and coastal waters and this is where R&D will need to be focused. The aim of this R&D should be to ensure that the types of tools that are currently available for use in rivers (e.g. RIVPACS) and to a lesser extent lakes are made available for use in transitional and coastal waters.

6.3.3 Gaps in the current monitoring strategy (surveillance, operational and investigative)

Gaps that were identified in the current monitoring strategy were:

- Need to define the basic monitoring strategy e.g. where, when, how much and how often in relation to water body types. Consideration needs to be given to the minimum frequencies and the 'desired' level of confidence and precision (medium priority, 1 to 2 years, dependent upon amount of data now available).

- Development of analytical methodologies for some/all priority substances in fresh and marine waters, in sediment and biota (high priority, 5 years for standard method).

An inventory of existing monitoring activities will need to be undertaken at the beginning of a programme aimed at defining the monitoring strategy. Current monitoring activities will then need to be assessed against the Directive in order to identify what changes are needed to meet the requirements. Developing standard analytical methods for priority substances is a significant task and is likely to require considerable expenditure. Because the development of standard methods is important to all Member States this gap is likely to be best addressed by collaborative research. The Joint Research Centre at ISPRA is working on this issue under the auspices of the Commissions Expert Advisory Forum on hazardous substances.

6.3.4 Groundwater

The gaps identified in the current groundwater monitoring programme were:

- Need for fundamental research on groundwater and surface water interactions. There is a need for long term monitoring data to develop and validate appropriate models (high priority, 10 to 15 years).

- Proactive technical participation of the groundwater daughter directive (high priority, within 2 years).

- Inventories of point and diffuse sources, assessment of other impacts (e.g. abstractions, impoundments, diversions, and obstructions to continuity) and the need for criteria for the assessment of 'likelihood of failure to meet the environmental objectives established for a body of water'.

During the workshop it was identified that work that is underway in the United States that will help address the need for appropriate models. It was also felt that a current suggested proposal on groundwater quality standards would also go some way to addressing the need for proactive technical participation on the Groundwater Directive. Developing an inventory of point and diffuse pollution sources to groundwater, establishing an inventory of impacts and developing assessment criteria were identified as lesser priorities and could be addressed through a combination of 'in-house' and external R&D.

6.3.5 Integrated catchment management

The gaps identified in relation to achieving integrated catchment management were:

- Assessment of the likelihood of failing environmental objectives.

- Need for predictive and diagnostic tools including diffuse pollution models.

- Need for a better understanding of processes in catchments e.g. groundwater contribution to river flow.

- Need to gather existing tools and resources together into a catchment management 'toolbox'.

Integrated catchment management is at the heart of the WFD and therefore there is a high priority for tools and resources for achieving integrated management. A pilot catchment study approach maybe the most sensible way of pulling together existing tools and identifying if new tools need to be developed to achieve integrated management. Work has begun on developing diffuse pollution models in the US and Europe. An assessment of the suitability of these models for assisting in the implementation of the WFD in the UK should be undertaken as a priority in order to assess whether there is a need to develop diffuse pollution models for the UK.

6.3.6 RBMP and stakeholder involvement

The gaps and issues identified in relation to ensuring and managing stakeholder involvement in the River Basin Management Planning process were:

- Need for a mechanism or understanding of how to involve all those involved in RBMP's e.g. public consultations.
- Consideration of where catchment boundaries are placed and how these will impact stakeholders.
- Need to outline the decision making process.
- Consideration of transboundary issues and different economic situations.
- Need to find examples of best practice internationally.
- The need for national approaches for some aspects e.g. use of expert judgement and how would it be perceived ?

The need for one or more pilot catchment study(s) has already been identified as a high priority. Consideration should be given to developing a study or possibly a group of complimentary and co-ordinated studies to address the points listed above. A pilot RBMP study is currently underway in Scotland and should be useful in this regard.

6.3.7 Achievement of less stringent environmental objectives

The gaps and issues identified in relation to the achievement of less stringent environmental objectives and their economic implications were:

- Need for research and development effort with DETR & MAFF (now DEFRA).
- It was thought that initiatives on heavily modified water bodies (HMWB) would meet the needs of this part of the WFD.

The DETR (DEFRA) has already undertaken some work to assess the potential costs of implementing the WFD. The findings of the current SNIFFER and Agency HMWB projects will inform the development of the Agency's approach to designating HMWB. The Agency project on Integrated Appraisal for River Basin Management Plans will also help inform the development of the Agency's approach to economic appraisal and consultation processes for

implementing the WFD. Derogation's have not been investigated to date and can therefore be considered a gap in the current understanding. Consideration will need to be given to undertaking a study, perhaps with the DETR (DEFRA) which addresses the issue of derogations.

6.3.8 Reference conditions

The need for the development of UK and European typology was identified at the workshop. It was thought that the best approach for defining reference conditions in the UK is by using expert judgement and models which account for identified catchment pressures. Defining reference conditions and assigning typologies is an important early step in the WFD implementation process and can be considered a significant gap.

6.3.9 Assessment and presentation of ecological quality

The gaps and issues identified in relation to assessing and presenting ecological quality were:

- Need to establish guidance on how various tools should be combined so that a 'matrix approach' can be used.
- Need to establish what the relationship is between quality measurements made using different quality elements and tools.

These two gaps are interrelated and together represent a significant gap. Guidance about how various tools should be combined so that a 'matrix approach' can be used is probably the more straightforward of the two needs identified in this area and could be achieved within 1 year. Establishing the relationship between quality measurements made using different quality elements and tools is likely to require more work time.

6.3.10 Impact of natural variation on environmental objectives

The gap that was identified in relation to the impact of natural variation on environmental objectives was in relation to determining what is natural, the impact of extreme events, the impact of climate change and recovery periods.

This gap is a composite of a number of gaps and issues that were raised during the workshop. It covers climate change, hydrology, long term records and ecological disturbance and recovery and would therefore need a multidisciplinary. This gap is seen as a lesser priority that can be addressed over a longer timeframe of perhaps 5-10 years.

7. WFD R&D STRATEGY

7.1 Introduction

The Agency now has to prioritise what R&D is required to fill the identified gaps taking into consideration how big (and hence costly) the gap is in terms of the current scientific knowledge base, operational practice and scale (local, regional or national) of the gap. Also the timescale required for the research should be considered as well as the date by which an operational tool is required to fulfil deadlines imposed by the Directive.

In addition, consideration will have to given as to whether or not to collaborate with other organisations within the UK and/or other countries. There are obvious benefits in collaborative research in that there is an opportunity to learn from common experience, problems and best practise. This could be a cost-effective approach and lead to a common approach across Europe. Having a common approach and understanding across Europe will be of benefit on both the political and operational levels. For example, this would facilitate the establishment of equivalent quality targets for improvements and hence to the attainment of a 'level playing field' in terms of the measures required and hence costs. There are also disadvantages of international collaboration, for example, timescales of projects may not meet the Agency's needs, the research may not be focused to the situation in England and Wales in terms of ecology, hydromorphology and administration. Also there might only be limited control as to the direction of the research resulting in the outcome being too 'academic' and not practical enough to be operational.

Figure 7.1 illustrates the timetable for the implementation of some of the key articles of the Directive. This illustrates that some R&D initiatives should start as soon as possible. In addition, although other R&D will take a longer time period to complete, action should be started soon if Directive deadlines are to be met.

7.2 High priorities

There are some administrative aspects associated with the establishment of River Basin Districts for Article 3 that require immediate attention. Current research was thought to meet the gaps here though participants at the workshop highlighted the need for guidance from the DETR (DEFRA) on definitions that would influence the process of establishing RBMDs.

A very strong recommendation arising from the Agency workshop was the need to undertake pilot implementation of the Directive in real or 'virtual' river basins. This would enable the Directive's requirements to be tested and further highlight gaps and difficulties in current procedures and tools. The Scottish Executive has already instigated such research and there is a proposal within the EC's Common Strategy to also use pilot catchments. It is strongly recommended that pilot studies are undertaken and that the Agency participates in appropriate 'European' pilot basin studies as and when they arise.

Many of the high priorities arise from Article 5 where River Basin Districts have to be characterised. This includes the typifying of water bodies including the identification of heavily modified water bodies. The Agency has existing tools that could be used for this such

as the RIVPACS model which could be used as a starting point to identify types of river. The next step on from this is to identify type-specific reference conditions. This is a key point in the process as reference conditions act as the anchor point for the subsequent ecological quality classification. In addition if a common level of high and good ecological status is to be established across Europe, it is essential that the Agency fully participates in relevant EU wide research. The Agency is already involved with European projects to define the typology and reference conditions for coastal and transitional water (TrACTAC) and one defining reference conditions in inland surface waters (REFCOND).

Article 5 also requires the estimation and identification of significant point and diffuse source pollution. The Agency currently does not have the tools or models to do the latter. It is recommended that R&D is initiated in the quantification of diffuse pollution as an immediate action.

The estimation of pressures on water bodies leads to an assessment of the impact of the pressures on water body status and the likelihood that they will fail to meet the environmental quality objectives set for the bodies under Article 4. Information arising from this assessment is then used to optimise the design of monitoring programmes and the programmes of measures. Again it is important that the Agency has appropriate procedures or modelling tools to undertake this assessment. These will have to take into account the statistical aspects of the classifications of ecological, chemical and quantitative status, and what is an acceptable level of confidence before deciding that a water body might fail its objectives.

Annex V of the Directive requires that surveillance monitoring includes parameters indicative of all biological quality elements for the different water body types. Sections 4 and 5 have indicated that there are gaps in the current biological quality assessment tools used by the European Countries and the Agency, particularly in transitional and coastal waters. Existing tools should also be re-examined to assess if they meet the requirements of the Directive. A case in point is RIVPACS where the 'good' quality sites used for comparison should be re-examined to determine whether they meet the definition of high ecological status. If not ways of improving the reference database should be pursued. There are a number of research programmes recently completed or underway for the Agency and at a European level in this area. For example, PLANTPACS has been completed for the Agency, and AQEM & STAR under the EC 5th Framework programme are underway.

A view expressed at the Agency workshop was that the starting point for developing new assessment tools for the Agency should be a thorough review of the tools currently used and being developed in the UK and across Europe. It is recommended that this initial R&D is undertaken straight away. Also the Agency should keep abreast of all European projects in this area, particular those arising from the 5th Framework programme. The Commission is also proposing a working group in this area under its Common Strategy and the Agency should actively participate in its work.

There are also gaps in the requirements to monitor the associated hydromorphological and physico-chemical quality elements in all water types and these should also be included in the above review and R&D.

R&D that should also start immediately is the development of suitable chemical analytical methods for the measurement of Priority Substances. The proposed list has yet to come into force but once it has EQSs will be established against which chemical status will be judged.

Existing methods may not be adequate, for example, in terms of limits of detection to quantify all of these substances. The development of suitable standard methods may take up to 5 years.

A major gap identified at both the European and UK level is the lack of basic information and knowledge of the interrelationship between groundwater and surface water. This lack of knowledge may prejudice the successful implementation of the Directive with regards to groundwater. In particular the characterisation of groundwater should be completed by end of 2004. The required research programme is however estimated to be of 10 to 15 years duration.

7.3 Medium priorities

The Directive also requires the estimation and identification of other pressures (apart from diffuse and point sources) such as significant water abstractions and land use in catchments. This is considered to be a medium priority as current procedures might be able to do this. The Directive also requires the collection of land use information in the recharge catchment of groundwater bodies. This cannot be undertaken until there is clarification (from DETR now DEFRA) as to the UK definition of a groundwater body.

The classification of the ecological status for each body of surface water is also a key issue and is intimately associated with the intercalibration exercise between Member States. This is aimed at achieving a common classification of at least high, good and moderate ecological quality. It is recommended that the Agency fully participate in joint studies with appropriate European countries and organisations in this aspect. The Agency has already undertaken an initial study with the French Agences de l'Eau on comparing respective river invertebrate assessment systems.

Annex V of the Directives quotes frequencies for the monitoring of surface waters for the biological, physicochemical and hydromorphological quality elements. A strong view at the workshop was that these were likely to be completely inadequate in terms of obtaining a quantitative assessment of ecological status. Thus research should be undertaken on what the optimum sampling strategies would be for the different water body types such as defining how, what and when should be sampled and at a frequency that gives acceptable levels of precision and confidence. It was felt that this was best undertaken when there were adequate data to work with, and the task should thus be given a medium priority.

There is also a need for research that will enable the physicochemical elements (e.g. nutrients) and hydromorphological elements (e.g. habitat structure) to be related the biological quality elements. A scoping project has already begun dealing with nutrients and biological quality. It is presumed that the outcome of the study will be extended to the other physicochemical elements required by the Directive, similar research will also be required relating hydromorphology to biological quality. The R&D is considered to be of medium priority as some research is already underway.

The development of guidance on economic analysis of water use is the subject for one of the Working Groups under the Commission's Common Strategy. France who has already held an international workshop on these issues in September 2000 will lead the group. The Agency more recently (November 2000) held a seminar on integrated appraisal for water quality management and also started a project on further work for economic appraisals. As there are

current research initiatives in this area it is considered that these aspects are of medium priority. It is, however, recommended that the Agency remains actively involved in the EC working group.

7.4 Lower priorities

There are a number of R&D requirements which though important are considered as being of lower priority than other needs. For some of these requirements work is already underway within the UK and/or Europe. An example is procedures for the designation of artificial and heavily modified water bodies (HMWB), and for the assessment of significant upward trends of pollutants in groundwater. The UK and Germany are leading an EU initiative on HMWB. In addition, Austria is leading on the assessment of groundwater trends.

The specific measures required to reverse significant upward trends of pollutants in groundwater are to be proposed by the Commission by end of 2002, and will have to be adopted by the Council and European Parliament as part of a 'daughter' directive. Though it will be important to have cost effective and practicable measures, it is thought research in this area is of a lower priority until the Commission starts to develop its specific proposals. At that stage it is recommended that then Agency remains involved in the technical discussions and developments.

Also the development of procedures for the identification of some of the pressures in the river basin district are also considered to be of lower priority than for those pressures already described, for example, for significant morphological alterations and for the impact of significant water flow regulation.

A gap has also been identified in how the Agency could monitor and classify groundwater quantitative and chemical status. This is considered a relatively low priority as work is already underway to develop a representative groundwater monitoring network for England and Wales. There are also gaps in the monitoring and classification of chemical status of surface waters and again this is considered of relatively low priority.

The Agency will have to produce River Basin Management Plans for each River Basin District, the first set being due by end of 2009. A significant aspect of the plans will be the use of maps to present information. The use of appropriate GIS (i.e. compatible with GISCO) is encouraged by the Commission, and would be of great value to the Agency not only as a mapping tool but also as an assessment tool (e.g. production of land cover information for sub-catchments). It was felt at the workshop that perhaps the current GIS tools and maps currently used by the Agency need to be assessed and if necessary refined into a harmonised system and tool.

A strong component of the Directive is the provision of public information and consultation by those responsible for the RBMP and the subsequent planned measures for improvement. This was an area where workshop delegates thought the Agency needed to strengthen and improve its procedures. It was however considered being of a relatively low priority for R&D.

7.5 More fundamental, longer-term research needs

There is also the need for more fundamental research associated with the understanding of some of the concepts of the Directive. This would include assessing and quantifying ecological quality. Much of this fundamental research is likely to be undertaken within academia, perhaps with funding from research programmes such as the Commission's 5th Framework Programme or NERC thematic programmes. It would be expected that the results from this research would not be available within the short term. Any tools or methodologies arising from the research would also have to be applicable in an operational sense if they were to be of any practical use to the regulatory agencies of Europe.

For example, the systems described in the Directive for the monitoring and classification of ecological status are largely based on the structural attributes of biological communities. The use of functional indicators of ecological quality rather than the classical structural indicators is a subject of considerable debate in the development of common biological assessment systems. It was, however, recommended by the CSTEE that the potential for the development of more functionally orientated systems for assessing ecological quality should be explored further. As an intermediary stage, the inclusion of semi-functional measures of ecological quality (whereby functional metrics are included based on structural information such as the presence of different feeding types) in the assessment of ecological quality should first be investigated further and their applicability to a range of water body types tested. Thus indices have been derived by combining several different measures of aquatic communities into a single value or "index". These measures or "metrics" can have both structural (e.g. diversity) and functional (e.g. mechanisms of feeding) components.

However, the introduction of functional measures will take many years of development work and would pose additional cost implications to existing methods of ecological assessment as the use of functional indicators in isolation may give misleading answers as to the health of the community.

There are also associated needs to better understand the basic ecological processes within aquatic ecosystems and their associated catchments. These would include:

- Evaluation and comparison of ecological quality measured by different elements;
- Studies of the interactions between rivers and riparian areas;
- Relationships between bankside woodland, rivers and biology;
- Flows and morphological structure;
- Flows, sedimentary dynamics and fine particle transport/deposition; flow and biological organisation.

A better understanding and quantification of the interrelationships and interactions between surface and groundwater processes would also fall into this category of research need.

7.6 Role of the European Environment Agency

The European Environment Agency (EEA) and its Topic Centre of Inland Waters provided technical assistance to the DG Environment desk officers during the technical developments and negotiations of some of the Technical Annexes of the Water Framework Directive. A joint workshop was convened between the Commissions WFD national expert group and the EEA's EIONET group in September 2000. The purpose was to discuss how the EEA's EUROWATERNET process and network could assist the Commission and Member States in reporting on certain aspects of the Directive.

The EEA's new Topic Centre on Water (ETC-Water) will be taking forward the recommendations arising from the workshop over the coming years. Thus the ETC-Water will participate in the WFD Strategic Co-ordination Group and working groups as appropriate, and provide technical support to DG Environment and countries via the Article 21 Committee on consistent definitions of ecological and hydro-morphological status of waters, monitoring techniques and analytical tools for assessing and reporting information. Support will also be given to DG Environment and the steering group on the common implementation project on transitional waters and coastal waters reference conditions (TrACTAC) if this project is funded.

Figure 7.1 Timetable for the implementation of the Water Framework Directive (entry into force in 22 December 2000)

Art.		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15		20
3	Co-ordination of administrative arrangements with river basin districts			◆														
8	Establishment of ecological quality reference sites for intercalibration network			◆														
4	Environmental Objectives																	
	Designation of artificial and heavily modified water bodies				◆													
	Assessment of environmental and socio-economic needs – cost benefit analysis				◆													
5	Analysis of characteristics of River Basin District				◆													
	Typology and reference conditions				◆													
	Interactions between groundwater and surface water				◆													
	Review of the environmental impact of human activity				◆													
	Economic analysis of water use				◆													
	Review and update													◆				
8	Monitoring programmes designed and made operational						◆											
	Classification of ecological, chemical and quantitative status						◆											
	Identification of trends in groundwater pollutants					◆												
14	Draft RBMPs published and made available for the public								◆						◆			
11	Programmes of measures established									◆								
13	Publish RBMPs									◆						◆		
15(1)	RBMP to Commission									◆						◆		
15(2)	Submission of summary reports of the analysis required under Art 5 and the monitoring programmes				◆													
15(3)	Interim report describing progress in implementation												◆					
16	Strategies against pollution of water																	
	Priority list of substances (revised)				◆													
	Controls for progressive reduction of priority substances															◆		
	Controls for cessation or phasing out of priority hazardous substances																	◆
	Proposals for EQS for priority substances in water, sediment and biota			◆														
17	Strategies to prevent and control pollution of groundwater – proposal for measures		◆															
18(1)	Commission report: including review of status of surface water and groundwater with EEA												◆					
18(3)	Commission report on progress on implementation						◆		◆									
18(4)	Commission report based on MSs interim reports															◆		

8. REFERENCES

C P Mainstone and J C Ellis (1998). Comparability of ecological quality assessments in the UK and France in relation to the reporting of ecological quality under the proposed EU Water Framework Directive. WRc Report No. CO 4621.

C. Koreimann, J. Grath, G. Winkler, W. Nagy and W. R. Vogel (1996) Groundwater monitoring in Europe. ETC/IW Report 14.

European Environment Agency (1999). Groundwater quality and quantity in Europe. Environmental assessment report, No. 3, EEA, Copenhagen.

European Environment Agency (2001). A European inventory of emissions to water: proposed operational methodology. EEA Copenhagen, in preparation.

S Clarke, S Nixon and A Steiner, T Moth Iversen, J Bøgestrand, J Leonard, S Stroffek, Y Souchon, and D Levet (1999). Technical specifications for classification and presentation of ecological status of surface waters. WRc report CO 4658/1 to the European Commission.

S C Nixon, A Gendebien, D M Forrow and L Laffon (2001) Comparative analysis of river quality classification schemes in Europe. EEA, Copenhagen, in press.

T Moth Iversen, Jens Bøgestrand, S Clarke, S Nixon, A Steiner, J Leonard, S Stroffek, Y Souchon, and D Levet (1999). Technical specifications for monitoring of ecological status of surface waters. National Environmental Research Institute (Denmark) report to the European Commission.

V De Paepe (2000). Nutrient emissions to inland waters: Comparability of assessments undertaken within a number of EU Member States. Report produced for Ecole Nationale du Génie de l'Eau et de l'Environnement de Strasbourg, and the European Topic Centre on Inland Waters.

APPENDIX 1 – LIST OF CONTACTS MADE

Organisation	Primary Contact
Agency's R&D Programmes, current and planned	Kim Thomas
Agency's outputs database	Denise Bennet, WRc
List of FP5 projects the Agency is supporting	Kim Thomas
List of planned projects	Alison Bramwell
SNIFFER ongoing and planned programme	Martin Marsden
DETR	Steven Reeves
NERC	Dr Liz Fellman
Commission – DGXI Ad-hoc funding	Alison Bramwell
Commission – DGXII FP5	Steve Nixon, WRc
EEA – past and planned projects	Steve Nixon, WRc
Other European National R&D Programmes that contributed (via ETC/IW).	NFP Austria NFP Finland NFP France NFP Greece NFP Ireland NFP UK

APPENDIX 2 - WORKSHOP

Purpose of Workshop

The purpose of the workshop held at Chepstow on 15-16th January 2001 was to continue the process of identifying what the Agency will need to do in order to enable effective implementation of the Water Framework Directive in a timely manner. Primarily the workshop aimed to identify a programme of, cross-functional, inter-related projects which will be necessary to provide the necessary tools and information for implementation according to the implementation timetable and for more effective implementation in the short, medium and long-term. This was intended to help the Agency align its R&D programme and ensure effective collaboration with other organisations across the EU. It is expected that identifying a WFD R&D strategy for the Agency will be an ongoing process requiring cross-functional interaction between many of the Agency's technical/business groups. The specific objectives for the workshop were:

- Present the requirements of the Water Framework Directive and provide an indication of what these mean for the Agency.
- Review current approaches and the extent to which we can already meet the requirements.
- Identify 'gaps' where current knowledge is insufficient to meet requirements.
- Where possible, identify the type and nature of research needed to meet these gaps.
- Prioritise the research needs.

Workshop Format

The workshop was held over 2 days (15-16th January 2001) at Chepstow in Wales. The workshop began with a series of introductory background presentations, which identified the following:

- Purpose of the workshop.
- General requirements of the Directive.
- Agency preparation for implementation.
- Significant WFD activity.
- Major R&D initiatives in UK agencies and elsewhere.

A series of structured discussion sessions was held over Day 2 with two groups rotating between three sessions to identify and review current approaches and identify and prioritise R&D needs in the following broad areas within the Directive:

- Article 3 & 5 – Identification and Characterisation of River Basins.
- Article 4 – Environmental Objectives.

- Article 8 – Monitoring.

Summary of Workshop Discussions

The discussions were structured around the following nine questions:

- What does the Directive say ?
- What is needed to meet the requirements ?
- What do we have to meet these requirements ?
- How far will this take us towards meeting these requirements ?
- Do we know what is needed to meet the gap ?
- What is needed to fill the gap ?
- Who should fill this need ?
- How big a task is this ?
- If we only had a limited time what would we do ?

This section summarises the discussions held by each group.

Article 3 & 5 – Identification and Characterisation of River Basins

In general both discussion groups agreed that Article 3 – Identification of River Basins was an administrative issue and did not require any R&D. The following points summarise the issues raised during the discussions:

- The process of identifying RBD's is currently underway at the DETR with significant input from the Agency and the first consultation documents are expected soon.
- Important that lessons from other countries such as Australia where RBD's have been set up are learnt.
- Technical problems will arise as a result of tidal flow in coastal areas and also definition of ground water boundaries.
- The importance of understanding who the stakeholders are and how the placement of boundaries will impact them was identified as a possible R&D need.
- The question of what element of the river network will be included in the Directive was considered a fundamental question requiring clarification. There is a digitised river network which can provide a baseline but this is known to be incomplete.

- There is a working assumption that System B will be used to define typology in the UK due to its flexibility. This will be included in the DETR consultation so the Agency needs to develop a firm view.

- The Directive requires divisions into physical and ecological types (typologies). On this basis RIVPACS, which is widely assumed to meet the Directive need would need further development for each typology.

- GIS is required for analysis and reporting but the river network is not yet complete and there is almost nothing for estuaries and coastal waters. All Agency databases need integrating into GIS. There was concern that the Agency were playing catch up with technology and should be being more innovative/imaginative with GIS developments. GIS was not seen as a software issue but one of collating the information and ensuring expertise is available. The system should be set up nationally at Twerton but must be available throughout the regions. The commitment to populate is a key issue. We should be able to tap into ongoing initiatives so probably no R&D requirements.

- R&D is needed to link currently measured physical and ecological elements to understand how they interrelate in terms of reference conditions. The work should include developing an understanding of river ecosystem function.

- Is there a need to collect data for all elements considered under the Directive or can the Agency focus on 'indicator species' or those elements. Is there a danger in applying this approach ?. Estuaries and coastal waters are a particular problem as we have less information available on them.

- Much attention has been paid to point sources and we tend to assume all the rest is diffuse but this is actually not a good enough assessment – we need to understand more.

- There was a view that intermittent pressures are not well understood and there is a need to look at potential hazards using a risk based approach.

- Concerns were expressed over the method of funding and prioritising R&D and hence its ability to meet the long-terms objectives which are always very expensive. There were doubts raised over a suggested approach of using WFD R&D to meet the short-term needs and other R&D budgets to meet the longer term requirements.

- The Agency must first work on making the existing tools fit the job then in the longer term work on understanding the systems more fully to get a better understanding and better predictive tools. R&D requirements exist in both short and the long-term.

- Quantifying pressures associated with water abstraction and the linkage to ecology is the problem with a requirement for diagnostic tools to assess the significance of pressures. R&D is going on but lots more work is needed and may require additional funding.

- View that the likelihood of failing objectives will initially be based on current knowledge but it is doubtful that existing tools will meet the requirements for estuaries and coastal waters.

- We currently we have no definition for what a groundwater is. If ground waters are defined as minor aquifers then work will be required on how minor aquifers work.

- R&D into integrated modelling is ongoing and will take some 10 years in development – no new R&D requirements.

- There is probably less than 10% of the river network that is at risk of causing a problem under the WFD and there is therefore a need for some analysis of how big a problem it really is. Priority should be given to some pilot attempts at implementing the Directive to 'calm' nerves.

Article 4 – Environmental Objectives

- A coherent programme of work is being developed for standing waters at the moment though it is not certain how suitable these are to the requirements of the WFD. There are very few tools and techniques developed for transitional and coastal waters. It was thought that the Dutch / Norwegians may have a classification system for coastal waters.

- The time required for the UK to develop its own system for transitional and coastal waters was estimated to be 5-6 years. Any system may be prohibitively expensive to apply.

- It was identified that there is a need to carry out a review of the tools and techniques for each water body type. This could be supplemented with some work that will identify the costs of applying these tools and techniques.

- Reference conditions can be determined using a network of sites, historical information or modelling. It was identified that there is a need to look at what is the best method for use in the UK and also for better co-ordination of the various European R&D projects on reference conditions.

- No specific proposals for priority / hazardous substances were identified although it was identified that there will be a need to carry out work if European EQSs are not tight enough.

- Questions were raised over the comparability of reference conditions between Member States that have used different methods to setting and whether intercalibration is a one-off for the life of the Directive or whether it will be carried out at the beginning of each cycle.

- Assessing ecological potential was identified as a big area of R&D need.

- R&D is needed to set reference conditions and groundwater standards for chemical status of groundwaters. It was identified that there is a need to co-ordinate this work with those working on standards for the Landfill Directive. Concerns were raised about the direction of the Austrian project that is looking at "upward trend".

- It was believed that the Agency is better placed to deliver quantitative aspects of groundwater although a lack of monitoring data for small non-public water supply aquifers was identified as a problem.

- The Agency is currently scoping ground-surface water interactions with the findings of this study due to be delivered in Spring 2001.

Article 8 – Monitoring

- It was generally agreed that the priority is to perform some semi-real WFD implementation trials studies in river basins to assess operational capabilities, assess the suitability of available tools and guidance and identify gaps and R&D needs. It was thought that this would help identify the short as well as long term solutions.

- It was believed that more work is required to develop institutional relationships for RBD planning and management as well as on economics and options/ appraisal (some work is going on at EU and Agency/DETR level e.g. development of appraisal systems for RBDM).

- More work is required on getting appropriate stakeholder involvement and developing efficient processes for this to occur.

- It was believed more work is required on international standardisation of approaches/tools.

- Understanding how systems work (fluxes, loads, groundwater-surface water interactions) and integrating this understanding into catchment models and management tools was identified as an R&D need.

- Data transfer between different tools and institutions (e.g. area to region to Twerton to DETR and ETC/IW to Commission etc) was identified as an R&D need.

- Need to consider the difference between historically pristine conditions separately from those current sites that are not anthropogenically impacted. Also the difference between those sites that are at risk and/or sensitive (i.e. likelihood of effects in particular locations) from those that are not.

- It was stated that there was a need to identify and develop quality elements which are most sensitive to particular pressures using indicators which are sensitive to intermittent pressures (e.g. land-use change).

- Tools and frameworks to diagnose cause-effect and information to better understand how changes to pressures (including land use) affect aquatic ecology were identified as a R&D need.

- There is a need for long-term research programmes and long-term datasets to study groundwater-surface water interactions. This is in both quantitative and qualitative terms. This would include fundamental research of surface-groundwater interactions, development of long-term datasets and subsequent development of predictive models. Work could be done at EU level and should look at the work being done in the US. This work may take 5-15 years.

- There is a need to develop risk assessment tools to identify pressures and "at risk areas" to better target monitoring programmes. Need to make use of monitoring being performed for other directives (e.g. Landfill Directive).

- The R&D needs for groundwater status may depend on transposition (e.g. only consider major aquifers).

- The development of a groundwater level monitoring network is an area for long-term research. There is an operational need to develop good monitoring networks for the major aquifers. Historically these have been designed to assess the local impact of pumping rather than the status of whole groundwaters. Design of networks may require R&D. Level monitoring will not be a big problem in major aquifers. There may be a need to develop 3D monitoring. Monitoring networks for minor aquifers are even less developed. There may be a requirement to design monitoring networks for minor aquifers particularly those that are layered.

- It was identified that there are larger deficiencies in groundwater monitoring networks for groundwaters in Scotland and Northern Ireland. However it was considered that this could be progressed through operational initiatives rather than R&D. Of particular interest/ concern would be how the rate and direction of movement of groundwaters would be recorded particularly across national boundaries.

- There was an R&D requirement to develop methodologies for measuring groundwater recharge.

- It was seen to be important to try and influence any EU activity on the development of chemical quality standards for groundwaters (a daughter directive is planned) to ensure we have standards appropriate to the UK (The NCGWCL have submitted an R&D proposal to develop GW standards).

- As with groundwater quantity R&D may be required to develop appropriate groundwater quality monitoring networks.

- A EU ad-hoc project is looking at what constitutes an 'upward trend in groundwater quality' and how to monitor it. It was considered appropriate that the Agency remains involved to influence this project.

- We need to review the surface water biological monitoring techniques we already have to assess how appropriate they are in relation to the needs of the Directive, suggest how they need to be modified and identify appropriate ways of doing this (incl. R&D). For instance RIVPACS does not consider physical modification and is not reference based with regards to a typology.

- Other needs that were identified were the need for phytoplankton monitoring tools and predictive reference based tools for coastal/estuarine waters (e.g. coastal RIVPACs).

- It was questioned as to what the most appropriate endpoints are for assessing fish communities. Growth and physiology were suggested as more appropriate than abundance/presence/absence. It was thought that an ‘indicator species’ approach may be useful.

- There is a need to understand how particular pressures affect the biological elements in order to know to what degree we need to manage those pressures to bring about biological improvement. It was thought that there is a need to develop biological methodologies for indicators of particular pressures.

- A suite of diagnostic tools (incl. biological and chemical) is also needed to tease out cause-effect relationships. Guidance is required on the most efficient and effective ways of using these tools.

- There is a need to decide what the type specific reference conditions for physicochemical parameters are i.e. what are background levels and also to describe the relationship between physicochemical conditions (particularly chemical species) and biological status.

- There is a need to understand the relationship between hydromorphology and biology and the significance of changes in hydomorphology to biology (e.g. what hydrodynamic parameters are important in defining the biology ?). Coastal/transitional were identified as a priority.

- Catchment based modelling is required for hazardous chemicals with the need to incorporate risk assessment models for specific pollutants.

- It was identified that there was a need to develop tools for monitoring risk of failure to achieve RQO's.

Workshop attendance

The workshop was attended by Environment Agency staff from all functions and also by staff from the Scottish Environmental Protection Agency (SEPA), Scottish & Northern Ireland Forum for Environmental Research (SNIFFER) & the Northern Ireland Environment & Heritage Service (NIEHS). The contractors for this project (WRc) also attended to participate in the running of the workshop. The attendees are identified in the table below.

NAME	ORGANISATION	FUNCTION	WORK AREA
Isobel Austin	Environment Agency	WFD Project	WFD Technical/Policy co-ordination
Rebecca Badger	SNIFFER		WFD R&D Manager/ stakeholder involvement/ social
Peter Bird	Environment Agency	EMA	EC & International commitments
Mervyn Bramley	Environment Agency	FD	Flood defence
Bill Brierly	Environment Agency	R&D	Water Resources R&D
Mike Child	Consultant to Agency FD		Flood defence
Victoria Crone	NIEHS		Freshwater ecology

Rachael Dils	Environment Agency	NCEHS	Nutrients
Alastair Ferguson	Environment Agency	EMA	Environmental Monitoring
Jonathon Fisher	Environment Agency	NCRAOA	Environmental economics/appraisal
Rachael Fleming	Environment Agency	R&D	R&D Planning
Steve Fletcher	Environment Agency	NCGWCL	Groundwater quantity
Dave Forrow	Environment Agency	WFD Project R&D Manager	WFD R&D co-ordination
Dave Foster	Environment Agency	WFD Project Manager	WFD Policy
Dave Griffiths	Environment Agency	WQ	Diffuse Pollution Sources
Martin Griffiths	Environment Agency	WQ	Water Quality
Barrie Harbott	Environment Agency	Regional/area WQ	Water Quality
Bob Harris	Environment Agency	NCGWCL	Groundwater quality
Jo Kennedy	Environment Agency	WQ	Chemicals R&D
Aileen Kirmond	Environment Agency	WR	Water Resources
Paul Logan	Environment Agency	Conservation & Ecology	Ecology
Tony Marsland	Environment Agency	NCGWCL	Groundwater quality
Angus McRobert	NIEHS		Marine ecology
Richard Montgomerie	WRc	Contractor	Ecology
Marc Naura	Environment Agency	Ecology and Conservation	RHS/ hydromorphology
Steve Nixon	WRc- ETC-W	Contractor	Ecology
Geoff Philips	Environment Agency	NCRAOA	Ecology/ nutrients
Peter Pollard	SEPA		Freshwater ecology
Helen Richardson	Environment Agency	WQ	Diffuse pollution R&D co-ordination
Kevin Thomas	Environment Agency (Wales)	WQ	Water quality
Ron Thomas	Environment Agency	NCEDS	Databases/GIS
Tessa Wardley	Secondee Consultant to Environment Agency		Water Quality
Cindy Warwick	Environment Agency	WR	Water resources
Jim Wharfe	Environment Agency	NCEHS	Hazardous substances
Richard Wightman	Environment Agency	Fisheries	Fisheries
Robert Willows	Environment Agency	NCRAOA	Marine Ecology
Aram Wood	Environment Agency	WFD Project	WFD implementation planning/ WQ
Craig Woolhouse	Environment Agency	Regional/area FD/WR	River Basin management planning
Claire Vincent	NIEHS		Marine ecology