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Hydroecology Integration for modern regulation



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Our work includes tackling flooding and pollution incidents, reducing industry's impacts on the environment, cleaning up rivers, coastal waters and contaminated land, and improving wildlife habitats.

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Foreword

Housing growth, climate change and increased demand for water are just some of the major challenges we are faced with in how we manage our water resources. In meeting these challenges we must ensure that the natural environment, which we all value, is protected and enhanced. There has never been more pressure on one of our most precious natural resources and we need to balance society's water needs with those of the environment. Hydroecology has a vital role to play in making sure that we achieve this balance in a sustainable way.

Whether you consider rivers, lakes, wetlands, estuaries or coastal waters, every aquatic system provides a different set of challenges in determining environmental priorities against the needs of water users. In fulfilling our current and future duties, we must use the most appropriate techniques and ensure that we apply them in a consistent manner. The need to deliver environmental improvements coupled with the pressures surrounding water demand and the implications of climate change mean that the need for the application of sound hydroecological science has never been greater.

This strategy sets out our aims and proposes the future priorities for hydroecology within water management for the next 5 years. The scope of the document extends far wider than just simply flagging the science needs at the heart of hydroecological assessments. It recognises that to deliver significant progress we need to move forward in other areas, such as the provision of supporting guidance, making sure that staff have appropriate skills, and improving links with external research organisations, the Conservation Agencies and other stakeholders. A yearly review will ensure that the document remains current while ensuring actions are progressed.

The production of this strategy highlights the significant commitment within Water Resources to improve the incorporation of ecological considerations within sustainable water resource management. I hope that this document will provide a platform from which we can engage others to ensure real progress is achieved.



Aileen Kirmond - Head of Water Resources Regulation

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Summary

The Environment Agency is the statutory body with a duty for strategic water resource management in England and Wales. It is our role to protect the long-term future of the water environment while encouraging sustainable development.

To fulfil its duty, the Agency must balance considerations of the water resource needs of society and the environment, both now and in the future. To achieve this balance we must make sure that ecological factors are taken into account. In particular, hydroecological information is essential in predicting and identifying ecological impact and monitoring changes resulting from mitigation.

While pressures on water resources continue to increase, balancing the needs of society and the environment often emphasises the inherent tension that exists in water management. Our challenge is to make sure that hydroecology is an integral part of sustainable water resource management.

This document aims to present a clear way forward for hydroecology and a strategic direction to its development and application. In the strategy we intend to:

- ensure that gaps within hydroecological tools and techniques are identified and prioritised;
- enable the dissemination of information and best practice on key hydroecological issues;
- establish a clear picture of current and future ecological monitoring needs in order to ensure consistency and allow efficiencies to be made;
- ensure close working between Agency staff involved in all aspects of hydroecology;
- enable effective communication between the Agency and external stakeholders;
- develop a strategic approach to the development of hydroecological science;
- ensure that hydroecological technical expertise is maintained in the Agency through appropriate training and development;
- ensure that policy revision and development takes into account new challenges such as climate change.

Significant progress has been made recently in a number of these areas. It is intended that this document will provide a strategic way forward and by ensuring that priorities for future work are clearly set out help us to avoid a fragmented approach. The strategy forms the basis of delivery over the next 5 years (2004 to 2009). The actions will be reviewed annually, so that progress is monitored and to allow for any revised or additional actions.

Water regulation and the environment

In order to fulfil its duty to secure the proper use of water resources throughout England and Wales, both now and in the future, the Environment Agency (the Agency) must balance the water resource needs of society and the environment.

To achieve this balance we must make sure that all ecological factors are taken into account.

The main focus of this 'Hydroecology Strategy' is the management of our water resources. However, the remit of hydroecology is not limited to water resources, and hydroecological information is also vital to the management of flood risk, water quality, land-use planning and development. The implementation of this strategy will ensure that we meet our obligations set out in statute and policy, through identifying and addressing improvements that need to be made. The strategy will also highlight future work on which the Agency should focus.

During the development of this strategy, both internal and external perspectives on the role of hydroecology within water management were sought. This document considers these views and discusses them, while taking into account the Agency's business needs.

The Agency's role

The Agency is the statutory body with a duty for strategic water resource management in England and Wales. It is our role to protect the long-term future of the water environment while encouraging sustainable development.

One of the main mechanisms that the Agency uses to manage water resources is the abstraction licensing system. This was originally introduced by the Water Resources Act 1963 and subsequently amended by various legislation that was consolidated by the Water Resources Act 1991.

In November 2000 the government published a draft Water Bill that outlined refinements and additions to existing legislation. The Bill received royal assent and became the Water Act 2003. This Act will strengthen the Agency's role and powers in respect of water resources management.

In its regulatory role, the Agency has additional duties under the Environment Act 1995 to contribute to sustainable development and to promote the conservation and enhancement of the natural environment. There is also a requirement for the Agency to take into account costs and benefits in the exercise of its functions, and to have regard to economic and social well-being.

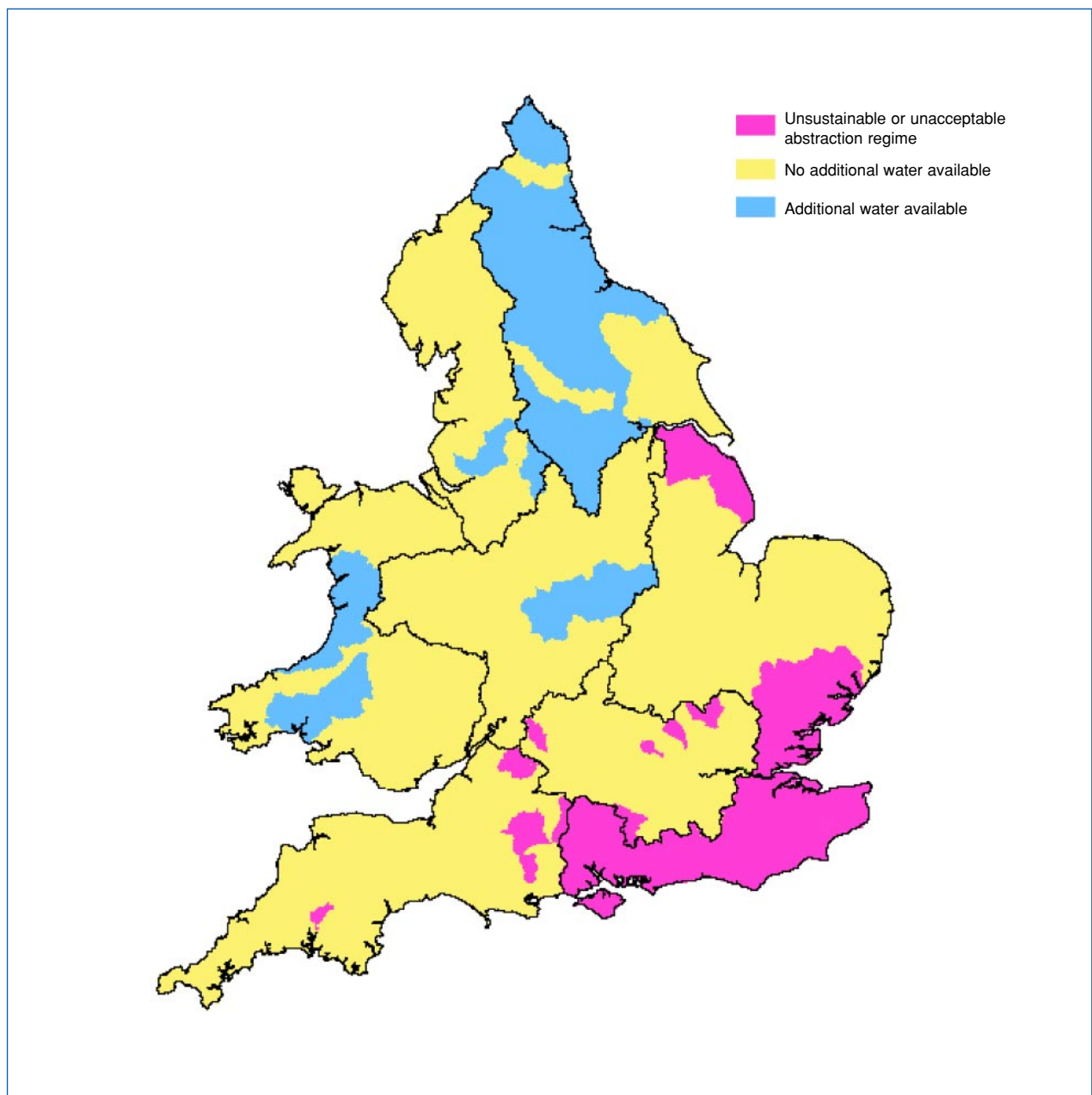
In achieving sustainable development in water resources the Agency must consider all water users, the environment and the representations made by the conservation agencies and others. Effective communication between the Agency and the conservation agencies on our overlapping duties is therefore fundamental. The Agency works closely with English Nature (EN) and the Countryside Council for Wales (CCW) to ensure the effective implementation of schemes or proposed works that may affect the features of designated sites.

Case Study 1. Strategic water resources situation across England and Wales

Water is a scarce resource across much of England and Wales, as shown in the map (Figure 1). Some of the existing licences are already causing environmental damage or would do so if fully utilised. The Agency has estimated that some 700 Ml/d (megalitres per day) of licensed abstractions may need to be recovered to ensure environmental protection. The recovery of this water is being progressed through the Agency's Restoring Sustainable Abstraction (RSA) Programme.

It is important for us to gain a greater understanding of the value of water to the natural environment not only to aid our own decision-making but also to justify the decisions we make to our stakeholders.

Figure 1 | Current indicative availability: summer surface water
Source: Environment Agency (2001a).



Defining hydroecology

In this strategy the scope of hydroecology is defined as:
Ensuring relevant ecological considerations are integral to water resource evaluation and management decisions across the range of temporal and spatial scales.

Hydroecological considerations need to be incorporated across a range of operating levels, from Head Office policy development to area operations. The fundamental understanding of complex hydroecological relationships that is gained through Science projects must be transferable into tools and techniques for use in practical applications. Staff need to develop an understanding of hydroecology to enable them to communicate effectively with Agency colleagues and external stakeholders.

At present, hydroecological factors are assessed, monitored and managed by the Agency through technical expertise and the application of a limited number of tools. Our challenge now is to build on this to make sure that hydroecology is an integral component of sustainable water resource management.

The Water Resources Improvements Team is responsible for developing and co-ordinating an effective approach to hydroecology. The team needs to work closely with other Water Resources and Environment Protection functions including Ecology, Conservation, Fisheries, and Monitoring and Assessment Process, to deal with the cross-cutting nature of the discipline.

Strategy objectives – Why is a strategy needed?

At present, the Agency is unable to fully meet all of its policy requirements across all water-related Agency functions, despite the integral role of hydroecology. This is mainly because hydrological assessments are not sufficiently consistent or robust.

Future business demands, especially those imposed by the requirements of the EU Water Framework Directive, are likely to make these issues more pronounced. In order to resolve this situation this strategy aims to:

- present a clear account of the Agency's stance on hydroecology for internal and external interested parties;
- provide a strategic direction to the development and application of hydroecology in order to ensure early identification and resolution of issues.

The strategy will clarify the role that hydroecology has to play within key work areas such as the Habitats Directive Review of Consents, Catchment Abstraction Management Strategies and implementation of Biodiversity Action Plans. It will also identify current and future challenges in terms of ecological monitoring, integrated working, science, staff skills and development, and climate change. The actions required will ensure that:

- the profile of hydroecology as a cross-cutting discipline within the Agency is raised;
- effective communication is established across the hydroecological remit within the Agency;
- working practices within the Water Resources, Ecology and Conservation, Fisheries, Flood Defence and related Environment Protection functions are improved in order to ensure consistency in decision-making at Head Office, Regional and Area levels;
- effective external working relationships are developed with conservation agencies, research organisations and academia, so that shortfalls within science are rectified;

- progress is made towards the integration of related water policies, therefore engaging water quality, resources and flood management concerns.

The strategy will also ensure the continued progression of several actions defined within the Agency's Water Resource Strategy 2001 (Environment Agency, 2001a). These actions are Defining environmental need (A22) and Relating water use to environment (A23).

Underpinning principles

Meeting the Agency's Vision

The Vision (Environment Agency, 2001b) establishes the Agency's long-term objectives to improve the environment. One of the main aims is to achieve the integrated and sustainable management of inland and coastal waters and the protection and enhancement of wildlife. This strategy draws on the change management programmes set out in the Vision, in particular Modernising Regulation and Challenging Efficiency.

Key themes within the change management programmes of importance to this strategy state that:

- regulation is to become increasingly effective and make greater use of supporting technology;
- development of skills and capabilities is fundamental;
- policies will be based on sound science, best practice and evidence;
- where there is uncertainty, we accept the need for precautionary, risk-based approaches;
- there is a need for the refinement of the management and implementation of R&D and Agency Science.

Sustainable development

The national plan for water resource management is defined in the Agency's Water Resource Strategy 2001 (Environment Agency, 2001a). This outlines the principles of managing the various demands upon water, and highlights that ecological considerations are of equal importance to other aspects.

The aim is to ensure abstraction of water that is environmentally and economically sustainable, providing the right amount of water for people, agriculture, commerce and industry, and an improved water-related environment.

This statement draws from the government's definition of sustainable development as first set out within its 1999 Strategy (DETR, 1999) and is reiterated within the government's 2002 water policy

document Directing the Flow (Defra, 2002). To meet the challenge of sustainable development the Agency must be able to evaluate environmental sustainability in a robust and sound manner.

Sound science

A key theme within the government's definition of sustainable development (DETR, 1999; Defra, 2002) and the Agency's Vision is the application of scientific knowledge. Decision-making and policy statements should be based on sound science; this means using the best available evidence-based information. The use of sound science within the discipline of hydroecology is critical. This is because of hydroecology's technical, often complex, cross-cutting nature, and the potential implications of hydroecological assessments.

The precautionary principle

Even with the application of the best available information, there will always be a level of uncertainty about outcomes. The precautionary principle states that, where there is uncertainty regarding the consequences of actions, decisions should be cautious and clarification should be sought on the source of the uncertainty. Risks and uncertainty need to be reflected in any assessment, but the need for caution is particularly relevant to hydroecology because of the significant degree of uncertainty often involved in hydroecological assessments.

Adopting a risk-based approach

The adoption of a risk-based approach is central to the Modernising Regulation change management programme of the Agency's Vision (Environment Agency, 2001b). In its drive to become an effective organisation that gains the most from existing resources it is essential that the Agency adopts tools and techniques that are risk based.

Case study 2: The London Plan

London provides a leading example of the challenges of delivering society's water needs and protecting the environment in a modern city. The city is experiencing huge population growth that is placing even more pressure on the already resource-stressed region. London's population has been steadily growing since 1989, and is projected to reach 8.1 million by 2016, about 700,000 more than at present (GLA, 2002).

The population growth and change in demographics will mean that London's housing capacity will also need to increase considerably. The Mayor's London Plan has indicated that 460,000 additional houses will need to be built to accommodate this expansion. It is clear that this growth will have significant implications for the water environment, in terms of both demand and waterside development.

Water resources pressure

The ability to accommodate this large predicted increase in households by 2016 relies on the sustainable management of water and supply. There are major economic and political factors to consider and the Agency, in taking a balanced view of the needs of environment and society, will play an invaluable role advising government and developers alike.

London already has a water supply–demand deficit of approximately 180 MI/d. Most of London's water supply comes from outside the city, from the River Thames, the River Lee and the associated pumped-storage reservoirs. Supplies are ultimately limited by seasonal rainfall and available reservoir and groundwater storage, and the amount that can be abstracted is limited to protect river ecosystems, maintain minimum river flows and meet water quality criteria.

Climate change is also likely to have serious implications for London. The massive increase in households will focus concerns, particularly on the existing impacts of climate change such as water supply, flooding and rising groundwater.

There is a need for better housing design and planning, to limit the pressure created on the water environment. Sustainable design and construction, including measures to promote water conservation and enhance biodiversity, should be incorporated into new development plans.

The role of hydroecology

While we recognise that the London Plan makes provisions for water supply, biodiversity and climate change, it is essential that the Agency is in a good position to assess, and where appropriate influence, plans for new developments. In carrying out its statutory duties the Agency needs to ensure that hydroecological considerations are integral to its ways of working so that it is able to influence effectively on all levels, from large-scale plans to individual planning applications.

Hydroecological thresholds must be one component in the assessment of the sustainability of increasing abstractions. The Agency must have the information available and skills in place to be able to show where proposals are not sustainable.

The scale of the London Plan shows the importance of being able to carry out robust and sound hydroecological assessment. If this is achieved, the Agency will be better placed to more accurately determine the sustainability of large development proposals.

The role of hydroecology within key Agency drivers

The requirement for environmental improvements, coupled with the uncertainty surrounding water demand and the implications of climate change, ensures that hydroecology has a much broader role to play than ever before.

In particular, hydroecological information is essential to predict and identify ecological impact and to monitor changes resulting from mitigation. There is a need for increased understanding of hydroecological interactions and application of best practice approaches at the individual site level.

Restoring Sustainable Abstraction Programme

The Restoring Sustainable Abstraction (RSA) Programme is the Agency's vehicle for addressing issues associated with water company and non-water company abstractions thought to be adversely affecting the environment. The programme acts as an "umbrella" for different initiatives including the Habitats Directive Review of Consents, the Countryside and Rights of Way Act 2000 and Biodiversity Action Plans. It provides a means of identifying sites and prioritising investigations and action on all abstractions that are known or suspected of causing environmental damage. Hydroecology has a significant role to play within the RSA Programme, not only in defining the current ecological status of a site but also in modelling and predicting what improvements may be possible and evaluating whether environmental improvements have been achieved through post-scheme appraisal.

Habitats Directive

The EU Habitats Directive has been implemented in England and Wales by the Conservation (Natural Habitats, &c.) Regulations 1994. The Directive's purpose is to safeguard the most valuable nature conservation sites and threatened species in the

European Union. These European sites form a network known as Natura 2000.

The Agency is a 'competent authority' under the Directive. It has a legal duty to ensure that no Agency authorised activity or permission results, directly or indirectly, in an adverse effect on the integrity of a Natura 2000 site, unless there are reasons of overriding public interest.

Meeting the challenges of the Habitats Directive has been a huge and continuing undertaking for the Agency. To help with the review of abstraction licences, effort has been targeted at providing generic guidance on the water resource requirements of designated species and habitats (Environment Agency, 2003), resolving fundamental gaps in understanding site types and refining existing tools. Even with supporting guidance, and using the best available information, decisions will have to be made using a risk-based approach and professional expertise.

Countryside and Rights of Way Act 2000

The Countryside and Rights of Way Act 2000 (CROW Act 2000) introduced a number of amendments to the Wildlife and Countryside Act 1981. The Agency, together with other public bodies, must "take reasonable steps, consistent with the proper exercise of their functions, to further the conservation and enhancement of SSSIs". The Agency must also consult with English Nature and/or the Countryside Council for Wales over any proposed works or authorisations that may damage a SSSI.

In addition, the Agency has an important contribution to make in achieving the government's Public Service Agreement (PSA) target to bring 95% of all SSSIs (by area) in England into 'favourable' or 'unfavourable recovering' condition by 2010.

Biodiversity Action Plans

The Agency has lead responsibility for 39 species and five habitats of wetland character under the UK Biodiversity Action Plan (UKBAP). The UKBAP identifies the need to take opportunities for enhancing wetland habitats. In its lead role, the Agency needs to explore with others how such opportunities can be supported. Management of water resources plays an important part in maintaining or enhancing biodiversity, and hydroecological assessment is fundamental to this.

In setting conditions on abstraction licences, the Agency considers the needs of wildlife and, where there is doubt, makes decisions based on the precautionary principle. The Agency is committed to enhancing biodiversity, and in all our work we need to consider opportunities to contribute to the success of the UKBAP.

Catchment Abstraction Management Strategies

Catchment Abstraction Management Strategies (CAMS) are the Agency's mechanism for managing the abstraction licensing of catchments nationally. CAMS are the Agency's first attempt to fully and consistently integrate ecological considerations within water resource regulation across England and Wales in order to ensure that sustainable development is at the forefront of the process.

CAMS have been a very successful initiative for incorporating ecological considerations within the development of catchment licensing strategies. Resource and Assessment Management (RAM) has established a methodology for catchment hydroecological assessment. There are still gaps within the methodology, including gaps in estuarine and wetland assessments and in ecologically relevant groundwater assessments.

A key lesson from RAM is that the hydroecological situation does not always appear to reflect the water resource situation. We need to understand why this is, and to develop our techniques and overall approach accordingly.

Abstraction licensing

The main legislation covering the abstraction of water is defined within the Water Resources Act (WRA) 1991. The Agency needs to be well placed to evaluate the possible environmental impacts of existing or proposed abstraction licences. The WRA includes a specific requirement to ensure that the water requirements of fisheries are not compromised (Section 21), but there is also a more general need to have due regard to other environmental factors. Effective ecological input is essential to ensure that the appropriate determination is reached.

Drought management

Ecological information has an important role to play in the appraisal of applications for drought orders and permits. Orders and permits provide a mechanism for managing water resources during times of additional water stress and require a balanced appraisal of the needs of supply, environment and other interests. The detection of environmental deterioration associated with short-term licence variations against the background effects of a severe drought remains extremely difficult. The 1995/6 drought showed us that we need to develop more effective monitoring approaches capable of achieving this.

Hydroecological information has an integral role in the assessment and reporting of "natural" droughts. We need to ensure that we are making the best use of existing data to aid drought reporting and that nationally this is applied consistently to cover the wide range of possible drought situations.

The Water Framework Directive

The Water Framework Directive (WFD) has been developed with the aim of creating a holistic approach to water management, and updating existing water legislation through the introduction of a statutory system of analysis and planning based upon river basin districts.

In essence, it will establish a framework for the protection of all waters (including inland surface waters, transitional waters, coastal waters and groundwater) which:

- prevents further deterioration of, and protects and enhances the status of water resources;
- promotes sustainable water use based on long-term protection of water resources;

- protects and improves the aquatic environment through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of priority hazardous substances;
- ensures the progressive reduction of pollution of groundwater and prevents its further pollution;
- contributes to mitigating the effects of floods and droughts.

The Directive therefore requires a change from the currently separate management of water quality and quantity to a new integrated approach based on ecological targets. The Agency will need to identify ecological indicators sensitive to a variety of physical or chemical disturbances in order to meet the requirements of the Directive to develop procedures for classifying surface waters according to their ecological status. Therefore, an understanding of ecological community response to hydrological, morphological, chemical and physico-chemical perturbations and also an understanding of the impacts of ecological systems (such as wetlands) on hydrology and water quality are required in order to deliver cost-effective solutions for assessing the ecological status of surface waters.

Flood risk management

Floodplains have a natural function in the provision of both storage and movement of water at times of high flow. In recent decades, drainage of floodplains has resulted in the large-scale loss of habitats and much of their associated wildlife. Sympathetic flood management practices can have significant ecological benefits while continuing to provide effective flood defence for urban areas.

The Agency's Flood Risk Management and Wetlands policy will help us to identify situations where aquatic habitats can be created, conserved or enhanced in relation to flood management schemes. Catchment Flood Management Plans (CFMPs) will be used to assess different options for flood risk management, and identifying environmental impact and enhancement opportunities is integral to this.

Current and future challenges

Hydroecological monitoring – the utilisation of best practice

Current assessment tools

Hydroecological tools needed to define the ecological sensitivity and status of an aquatic system can be placed within three broad categories. The tools need to:

- define flow or water level regimes to ensure maintenance of ecological integrity;
- define what ecological damage is and where it is occurring;
- predict where and why ecological integrity is likely to be compromised.

A number of individual tools have been developed to meet specific needs on various scales. Some of them are discussed in detail below. Many of these tools have been developed without fully integrating ecology and hydrology/hydrogeology. In general, the wider consideration of impacts from water quality and quantity interactions has also been overlooked.

The PHABSIM methodology is perhaps the best known approach to quantifying flow–habitat relationships for particular organisms at the local site level. It is, however, only applicable on a site by site basis and focuses on target species (which may not be the most sensitive). Because of the high costs involved it is only justifiable under complex/high profile situations and for applications with significant environmental implications. It also requires extensive ecological understanding of the requirements of the particular organism involved, which has limited its application. It is currently the most widely used tool for defining flow level requirements at the site level.

On a catchment scale Resource and Assessment Management (RAM) provides a consistent approach for water resource assessment. It has the benefit of integrating the use of a number of ecological indicators, and it is easily understandable and can generally be applied using existing data. However, as stated earlier, there are a number of significant drawbacks to the method, particularly its restricted use on flowing habitats. In terms of meeting the three main tool requirements described above, RAM does determine river flow objectives, but without full ecological justification. It also provides an indication of where ecological damage is occurring and where

integrity is likely to be compromised (e.g. under fully licensed conditions).

The Lotic Invertebrate Flow Evaluation (LIFE) methodology (Extence et al., 1999) is a macro-invertebrate biotic index that was developed to compare the ecological sensitivity of a community to low flow velocity and the changing flow character of the reach. It is a component of the RAM assessment, but can also be used as a stand-alone tool to assess the flow sensitivity at a local reach level. The Agency is looking at the wider applicability of the use of LIFE (both to a number of river types and within impact assessment).

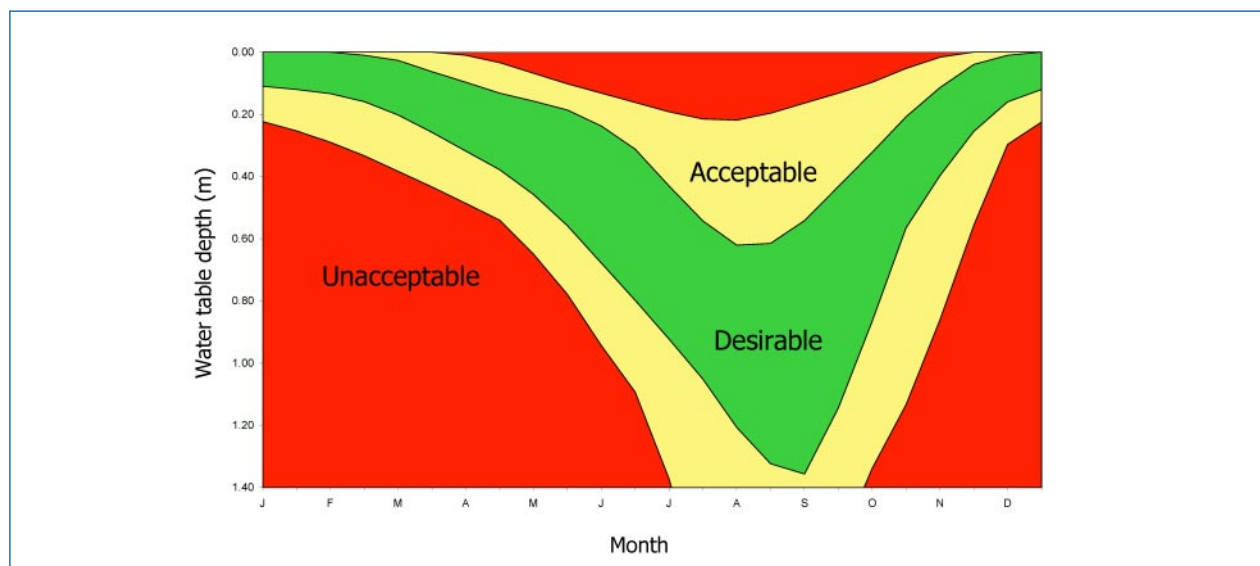
Recent progress has been made in furthering the understanding of wetland processes and how abstraction can impact on wetland sites. The Wetland Framework Project (Wheeler & Shaw, 2001) has developed a system in which wetlands are classified by their water supply mechanisms. This project, initially developed within the Anglian Region, has been extended to cover the rest of England and Wales.

Determining the water level requirements of wetland sites is difficult. Wetlands are often mosaics of habitats with subtle differences between the water requirements, influenced by geology and location among other factors. Guidelines for lowland wetland plant communities have been produced for some wetland habitat types (Entec, 2003), and these give “ideal” water levels throughout the year (see Figure 2). The definition of damage to wetland sites is also complex. A greater understanding of the water supply and the ecological requirements at a site helps prediction of impacts on wetland sites. It is possible to model the water levels in the aquifer although, at present, there is no straightforward way of modelling groundwater and surface water interactions at a site.

Addressing the needs

In the past, the development of assessment tools focused on delivery for a single driver or to address a single issue. We need to ensure that the Agency has a suite of complementary tools to allow balanced assessments of hydroecological considerations on both temporal and spatial scales. Good progress has been made in developing tools for the areas identified as being of immediate priority; however, several areas remain where significant development work is required. There is also a need for further

Figure 2 | Water table threshold requirements defined for MG13 grassland on the Ouse Washes, Cambridgeshire (Entec, 2003).



consideration of how various other types of ecological information (e.g. low flow and naturalisation prediction, groundwater–surface water interaction and hydraulic models) can be assessed alongside existing hydrological/hydrogeological techniques.

information on key hydroecological issues. This need is especially evident with Habitats Directive studies, but all work areas require the dissemination of information to help provide consistent application of methodologies. This will enable staff to tap into local area or Head Office based expertise, making the best use of staff with high technical understanding of hydroecological issues.

Action 1: Review existing tools and techniques, identify current approaches to linking ecological and hydrological/hydrogeological assessments and flag gaps within current assessment needs.

Action 2: Ensure that gaps in tools and techniques are prioritised against regulatory and business needs. Where appropriate, ensure that local-scale projects are integrated nationally to optimise the targeting of Science resources.

Action 3: Ensure that technical review of the performance of RAM is carried out for the forthcoming RAM revision. This will need to focus on the performance of the macro-invertebrate and macrophyte components and understanding the situations where ecology and hydrological components conflict.

Action 4: Improve provision of best practice information, especially on complex issues such as the assessment of compensation flows and drought impacts. Increase the availability of this information to Areas through use of Easinet, discussion groups and monthly updates etc.

Action 5: Establish a network of hydroecological specialists, detailing areas of specialisation and types of project work undertaken. Improve communication of best practice between staff undertaking assessment work.

Information provision

Even where we have the appropriate tools in place, we need to ensure that operational staff are aware of how best these can be applied. There is an immediate need to be more proactive in the dissemination of

Delivery of ecological monitoring

Within Ecological Appraisal teams a significant amount of staff time is allocated to meeting water resources requirements. The majority of work is currently targeted to delivery of CAMS and Habitats Directive. Many Areas also appear to be undertaking monitoring to support RSA, drought work and abstraction licensing.

However, a complete, clear picture of monitoring work that is being carried out and how it is resourced is not available. A full review of water resource related ecological monitoring is therefore required. This will ensure that efficiencies can be made where appropriate. It will ensure that all Areas are aware of the priorities for Water Resources ecological monitoring so that resources are targeted in an effective manner. It will also give us the opportunity to evaluate how current guidance is viewed and where improvements need to be made.

Action 6: Review the status of Area ecologists contributions to the delivery of CAMS.

Action 7: Review the extent to which ecologists nationally are consulted on abstraction licence applications, review current service levels and update guidance.

Action 8: Review the current national level of drought monitoring in place and define national needs.

Action 9: Increase the awareness of the RSA Programme, especially within Area Ecological Appraisal, Fisheries and Biodiversity teams, through internal promotion and updating of guidance to account for ecological elements.

Action 10: Update guidance on determining environmental monitoring requirements in the assessment of drought periods, including the distinction of impacts and unacceptable environmental damage.

from CAMS there has been no national, consistent drive for better integration. This need for integration is not limited to Water Resources and Ecology and Conservation staff but also extends to staff involved in Water Quality and Flood Defence.

Integration problems are further exacerbated by the fact that throughout the Agency there is still a lack of staff with skills that span the two core disciplines. The need for training and development to address this is discussed further in a later section.

Action 11: Undertake work within the Ecological Monitoring Review to find out the level of communication/integration that is established within each Area.

Action 12: Highlight the need for hydroecological technical experts within cross-cutting national technical teams.

Action 13: Identify ways of improving working links between staff on all levels. Provide a strategic and integrated direction, ensuring efficiencies and early identification of issues.

Action 14: Consider opportunities to contribute to the success of the UK Biodiversity Action Plan, especially through programmes such as RSA.

Action 15: Ensure that ecological concerns regarding flow and level management are accounted for within CFMPs and Flood Risk Management proposals.

Action 16: Ensure that hydroecological factors continue to be accounted for within the various aspects of WFD development work.

Working together

Internal relationships

The Agency's Water Resources Improvements Team acts as the co-ordinator for hydroecological issues. However, to be effective in this role we need to ensure that links are established and maintained between a number of technical and policy orientated teams throughout the Water Management and Environment Protection Directorates.

Throughout the Agency, from Head Office to Area levels, CAMS has improved the level of integration of ecologists and hydrologists. However, the two disciplines are highly distinct and there is a commonly held view that ecologists and hydrologists do not speak the same language. It is vital that we gain an understanding of each other's viewpoints and priorities, and where this has happened working relationships are highly effective. However, apart

External relationships

Academic links

In order to develop an effective approach to defining Science project needs and priorities, strong links to academia are essential. However, there are barriers to achieving this because:

studies carried out within the Agency, research organisations and academia are often fragmented and have not taken a strategic view;

scientific research and effort in hydroecology has been underfunded and often done on an ad hoc basis;

researchers have expressed concern regarding the proliferation of research and methods within the

Agency that are not subject to external review, while Agency staff are trying to establish the best possible approach within a limited space of time and the applied nature of the research;

successful academic institutions are often less attracted by Agency type projects because of the limited scope for peer-reviewed papers.

Despite these problems, a number of integrated Science projects have been carried out. As with all Science projects, the challenge is turning research into tools for day to day use across a variety of scenarios. Therefore the scope and remit of the project needs to be carefully considered.

It has been suggested that one way of closer working is through Agency staff undertaking more applied research that would develop links with academics and improve communication in key areas. Academics also need a better understanding of what Agency staff do on the ground, the challenges that they face and time-scales for delivery. An increased understanding of each other's stances can only help clarify priorities and overlapping interests. Improved links between the various interested parties would undoubtedly bring benefits for all. The Agency would be able to exert more influence upon academic research and, despite the limited opportunity for peer-reviewed papers, many academics accept that involvement with and contribution to the Agency's work is the main route for seeing research widely applied and providing the greatest benefit to the environment.

Action 17: Engage academics and policy-makers on key hydroecological issues through establishment of a hydroecology action group. Increase academics' understanding of the Agency's working constraints and make the best use of academic support for hydroecological research.

Links with the conservation agencies

In order to achieve the sustainable management of water resources, the Agency is committed to working with others who are involved in water management and use. Close liaison with the conservation agencies (English Nature and the Countryside Council for Wales) is essential in the development of technical approaches, monitoring and policies. This liaison has proved valuable during the Habitats Directive Review of Consents process and has resulted in the formation of the Water Resources Habitats Directive Technical Advisory Group (TAG) and the Asset Management Plan (AMP4) Liaison Group.

The TAG has brought together key personnel from the three organisations to provide guidance on technical issues. The forum has also enabled open discussion of procedural and policy issues and a greater understanding of each other's perspectives, which in turn has reduced the risk of direct conflict and "sticking points" in the process.

The opportunity to discuss wider issues in a regular forum with a structure drawing on existing groups should be examined. The remit of such a group should enable discussion over both technical and policy issues.

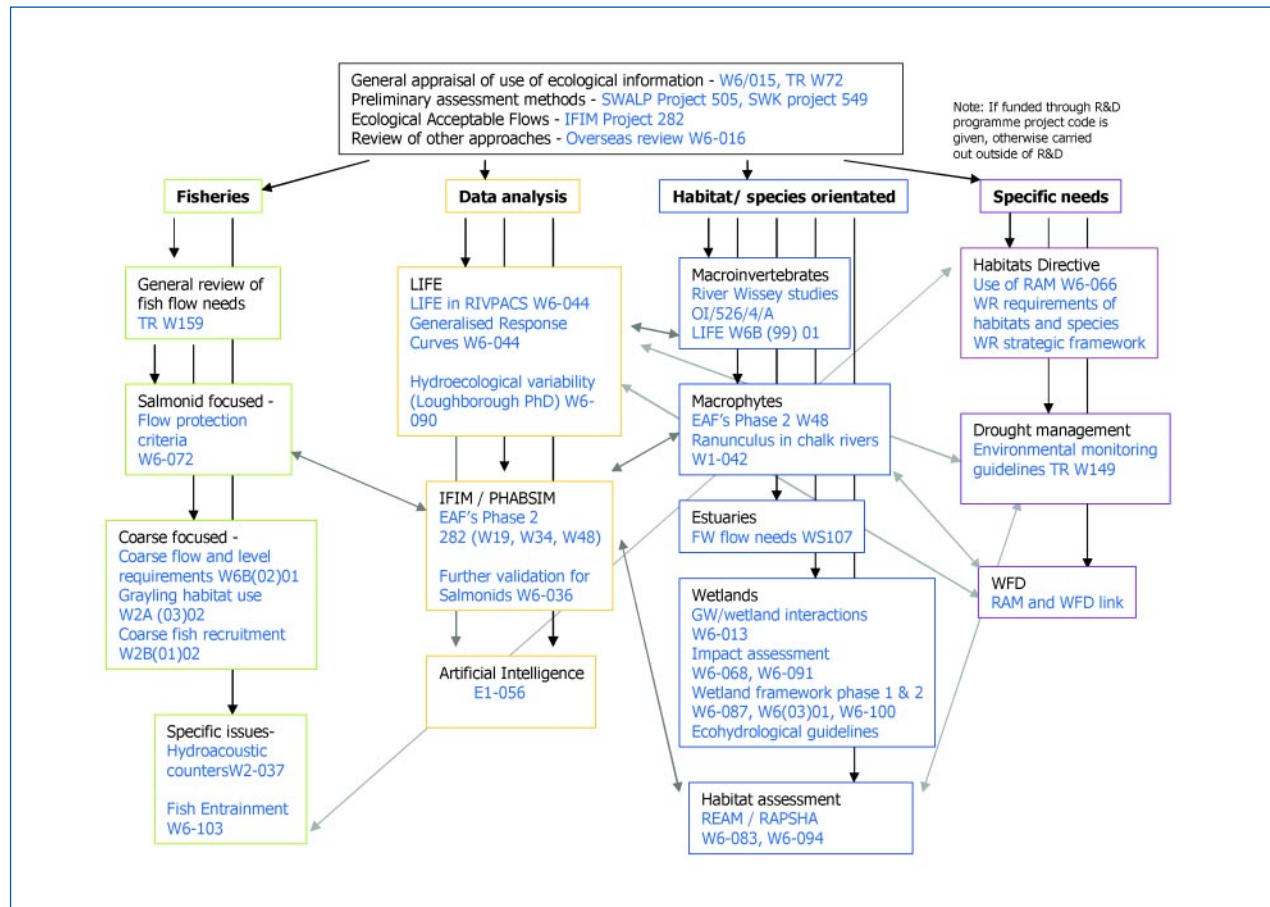
Action 18: Ensure that links developed through the Water Resources Habitats Directive TAG and the AMP4 Liaison Group are extended to cover the full range of interlinking issues, providing an open forum for discussion.

The Agency's Science programme

Figure 3 summarises Agency commissioned hydrological science since 1990. As can be seen, significant progress has been made to fill gaps in fundamental understanding as well as to provide tools and techniques through applied research. However, the system of prioritising and funding in Science often draws out lead-in/negotiating times, resulting in reduced completion times. This is a particular problem for research topics whose conclusions can be extremely complex and of strategic importance.

There are still areas where gaps in our fundamental understanding are yet to be filled, and some of these are presented, along with broad priorities, in the Appendix. A strategic approach to the future prioritisation of Science is vital. We need to highlight where fundamental science is lacking, how far applied research has taken us and ultimately what tools and techniques are needed both in terms of current requirements and future challenges. This three-tier approach will allow prioritisation and a strategic view of hydroecological research to be established. This cannot be carried out in isolation; the Agency needs to link with the key players for this to be a success. Initial thoughts on Science priorities have been gathered during strategy consultation and these are presented in the Appendix.

Figure 3 Agency Science hydroecology project linkages.



Action 19: Develop a strategic approach to prioritisation of hydroecological science, building on a risk-based (three-tier) approach and priorities put forward.

Action 20: Establish mechanisms for developing long-term (5–10 years) Science plans (i.e. timing, priorities etc).

common issues. A basic understanding of the other's discipline is essential to this. It is proposed that the most effective way to achieve this is through integrated one-day workshops that would focus on a variety of issues and case studies.

It would also be beneficial for the Agency to be more proactive in promoting hydroecology in university post-graduate courses. There are already a number of water management/environmental science degrees and masters available, but the Agency could promote more specialist MSc courses spanning the disciplines of ecology and hydrology.

Staff skills and development

Training needs

There is no dedicated forum for bringing ecologists and water resources staff together to improve understanding and communication. Both the Water Resources Process and Ecology Policy and Process teams are assessing their staff training needs and have expressed an interest in developing hydroecological components within their training plans.

Staff comments indicate the value of getting ecologists and hydrologists together and communicating on

Loss of expertise

As technical hydroecological expertise is limited within the organisation, the Agency must be proactive in retaining specialist staff to ensure that expertise is not lost from the organisation. Such expertise is particularly important for managing issues on complex sites, such as winterbournes, or for interpreting information that is infrequently dealt with, such as drought data.

Team leaders should be aware of the value of hydroecological competence within staff, and this should be reflected in development plans and objectives. Job shadowing and job swaps should be encouraged where possible to improve understanding of other's roles.

Action 21: Within Water Resources and Ecology teams progress the development of a hydroecology training course/annual seminar, highlighting needs and coverage.

Action 22: Encourage the inclusion of hydroecological aspects within development plans of both ecologists and hydrologists, and encourage staff to take the opportunity of job swaps and shadowing to gain an improved understanding of each other's roles and day to day technical challenges.

Action 23: Link to Environmental Policy Team and their development of a strategy for climate change.

Action 24: Ensure that policy formulation and revision takes full account of climate change implications where possible.

Action 25: Where appropriate, have regard to climate change scenarios in hydroecology science projects.

Future uncertainty – the challenge of climate change

Achieving a balance between the needs of society and those of the environment is central to water resource management. However, if climate change predictions are correct and the amount of resource is reduced at key periods how do we ensure that both the environment and society "share the pain"? Until we have addressed such basic issues, we cannot really adopt a long-term adaptation strategy to climate change.

A central question to be addressed is how the reduction in water levels/flow/alteration to flow regimes can be accommodated before there is "significant" environmental impact, and what are the thresholds at which change becomes significant?

Drought and flood evaluation deals with short-term extremes, yet climate change assessment requires an understanding of longer-term implications and more subtle alterations. Extending from this we need to establish the social and economic consequences of climate change predictions and examine whether the current legislative framework enables the Agency to regulate abstraction within these limits.

Actions and the way forward

Overview

Within this strategy we have set out the role that hydroecology currently plays in water resource management and where the limitations to the full integration of hydroecology lie. We also designed the strategy to highlight the work that needs to be done to make sure that we meet its aims.

All the actions have been collated into Table 1. It sets out what is required for the actions to be delivered, how actions link, who will need to be involved and when actions will happen. Resources have been allocated within the Water Resource Improvements Team Business Plan for 2004/5 to ensure that outcomes are delivered.

Through this strategy and the actions identified within it we have planned a clear way forward for the Agency's stance on hydroecology. We intend this document to provide strategic guidance to ensure its full application within Agency business for several years to come. Effective communication will be an important element in the delivery of this strategy, as will working closely with other teams to gain their ongoing input and commitment.

The future of the strategy

The actions from this document are summarised in Table 1, which also contains details on delivery and future development of this strategy. The strategy is the considered view of what needs to be delivered over the next 5 years. The actions will be reviewed annually to monitor progress and to allow for any revised or additional actions.

Table 1 | Actions list

Action	Number	Links to other actions	How will it be delivered?	Who else will be involved/kept informed	What will it contribute to	Time-scale of delivery
Review existing tools and techniques, identify current approaches to linking ecological and hydrological/hydrogeological assessments, and flag gaps within current assessment needs.	1	2, 3	Improvements Team to lead review of ecological monitoring. Link to development of the Hydrology Strategy.	Hydrology Hydrogeology Ecology Technical Fisheries Technical Science	Improve internal working relationships Sound science	June to August 2004
Ensure that gaps in tools and techniques are prioritised against regulatory and business needs. Where appropriate, ensure that local-scale projects are integrated nationally to optimise the targeting of Science resources.	2	1, 3	Improvements Team to lead.	As above, plus Area Ecological Appraisal Regulation	Risk-based approach Sound science Improve internal working relationships	June 2004 onwards
Ensure that technical review of the performance of RAM is carried out for the forthcoming RAM revision. This will need to focus on the performance of the macro-invertebrate and macrophyte components and understanding the situations where ecology and hydrological components conflict.	3	1, 2	Improvements Team to contribute to RAM Version 4 project to be led by Water Resources Regulation.	Water Resources Regulation	Sound science	December 2004 onwards
Improve provision of best practice information, especially on complex issues such as the assessment of compensation flows and drought impacts. Increase the availability to Areas through use of the Easinet, discussion groups and monthly updates etc.	4	5	Improvements Team to lead. Link with Fisheries Technical Team grey literature project.	Hydrology Hydrogeology Ecology Fisheries Science	Risk-based Sound science Improve internal working relationships	May 2004 onwards
Establish a network of hydroecological specialists, detailing areas of specialisation and types of project work undertaken. Improve communication of best practice between staff undertaking assessment work.	5	4, 12	Improvements Team to collate initial information. List to be placed on Hydroecology Easinet pages.	Water Resources, Ecology, Fisheries Policy & Process and Technical teams Area Hydrologists and Ecological Appraisal	Raise profile Improve communication Improve internal working relationships	May to August 2004 (requiring regular updates)

Action	Number	Links to other actions	How will it be delivered?	Who else will be involved/kept informed	What will it contribute to	Time-scale of delivery
Review the status of Area ecologists contribution to the delivery of CAMS.	6	7, 8, 11, 13	Delivered through Ecological Monitoring Review to be led by Improvements Team.	Environmental Monitoring & Assessment Process Ecology, Fisheries Policy & Process Area Ecological Appraisal	Clear stance Improve internal working relationships	April to September 2004
Review the extent to which ecologists nationally are consulted on abstraction licence applications, review current service levels and update guidance.	7	6, 8	Delivered through Ecological Monitoring Review to be led by Improvements Team.	Environmental Monitoring & Assessment Process Ecology, Fisheries Policy & Process Area Ecological Appraisal	Clear stance Improve internal working relationships	April 2004 onwards
Review the current national level of drought monitoring in place and define national needs.	8	6, 7, 10	As above and input to Drought Procedures Review being led by Water Resources Strategic Planning.	As above, plus Water Resources Strategic Planning	Clear stance Improve internal working relationships Sound science	April 2004 onwards
Increase the awareness of the RSA Programme, especially within Area Ecological Appraisal, Fisheries and Biodiversity teams, through internal promotion and updating of guidance to account for ecological elements.	9	14	Link to RSA Project within wider Improvements Team.	Wider Improvements Team Ecology, Fisheries and Conservation Policy & Process Environmental Monitoring & Assessment Process	Clear stance Raise profile Improve internal working relationships Sound science	April 2004 onwards
Update guidance on determining environmental monitoring requirements in the assessment of drought periods, including the distinction of impacts and unacceptable environmental damage.	10	8	Input to Drought Procedures Review being led by Water Resources Strategic Planning. Improvements Team to manage ecological drought monitoring elements.	Water Resources Strategic Planning	Clear stance Raise profile Improve internal working relationships Sound science	May 2004 onwards
Undertake work within the Ecological Monitoring Review to find out the level of communication/integration that is established within each Area	11	6	Improvements Team to deliver through Ecological Monitoring Review.	Ecology and Fisheries Policy & Process Environmental Monitoring & Assessment Process	Improve communication Improve internal working relationships	April to September 2004

Action	Number	Links to other actions	How will it be delivered?	Who else will be involved/kept informed	What will it contribute to	Time-scale of delivery
Highlight the need for hydroecological technical experts within cross-cutting national technical teams.	12	5	Support case being put forward in-part through Ecology Policy & Process Review of Biology.	Ecology Policy & Process	Raise profile Clear stance	Ongoing
Identify ways of improving working links between staff on all levels. Provide a strategic and integrated direction, ensuring efficiencies and early identification of issues.	13	6	Ideas obtained through Ecological Monitoring Review. Consider need for one-day hydroecological workshops.Link to development of Hydrology Strategy. Consider regular	liaisons with key teams. Ecology and Fisheries Policy & Process Water Resources Policy, Process & Technical teams Area Ecology, Biodiversity and Fisheries teams	Improve communication Clear stance Raise profile Improve internal working relationships	May 2004 onwards
Consider opportunities to contribute to the success of the UK Biodiversity Action Plan, especially through programmes such as the RSA.	14	9	Link to RSA Refocus Project within wider Improvements Team.	Wider Improvements Team Ecology, Fisheries and Conservation Policy & Process	Strategic direction Clear stance Integration of policies	May 2004 onwards
Ensure that ecological concerns regarding flow and level management are accounted for within CFMPs and Flood Risk Management proposals.		15	Improvements Team to liaise with Flood Defence.	Flood Defence Conservation Policy & Process	Clear stance Strategic direction Integration of policies	September 2004 onwards
Ensure that hydroecological considerations continue to be accounted for within the various aspects of WFD development work.	16		Involvement within relevant WFD project groups and ongoing liaison within wider Improvements Team.	EMCAR Project Rivers Task team sub-groups River Basin Characterisation Project	Sound science Integration of policies	Ongoing
Engage academics and policy-makers on key hydroecological issues through a hydroecology action group. Increase academics' understanding of the Agency's working constraints and make the best use of academic support for hydroecological research.	17	19, 20, 25	Improvements Team to consider establishment of hydroecology action group.	Agency national teams Academia Centre for Ecology & Hydrology	Clear stance Raise profile Effective external relationships	June 2004 onwards

Action	Number	Links to other actions	How will it be delivered?	Who else will be involved/kept informed	What will it contribute to	Time-scale of delivery
Ensure that links developed through the Water Resources Habitats Directive TAG and the AMP4 Liaison Group are extended to cover the full range of interlinking issues, providing an open forum for discussion.	18		Improvements Team to consider appropriate forum for discussion for key areas with conservation agencies.	Conservation agencies Conservation Policy & Process	Effective external relationships Integration of policies Clear stance	July 2004 onwards
Develop a strategic approach to prioritisation of hydroecological science, building on a risk-based (three-tier) approach and priorities put forward.	19	17, 20, 25	Improvements Team to build on Appendix I with key contacts.	Science Water Resources Ecology, Conservation & Fisheries Technical teams Area Technical Specialists Academia Centre for Ecology & Hydrology	Sound science	July 2004 onwards
Establish mechanisms for developing long-term (5–10 years) Science plans (i.e. timing, priorities etc.).	20	17, 19	Improvements Team to liaise with Science.	Science Water Resources Ecology, Conservation & Fisheries Technical teams Area Technical Specialists Academia Centre for Ecology & Hydrology	Sound science	June 2004
Within Water Resources and Ecology teams progress the development of a hydroecology training course/annual seminar.	21	22	Improvements Team to liaise with Water Resources Process and Ecology Policy & Process.	Ecology Policy & Process Water Resources Process	Effective external relationships Improve communication	September 2004 onwards
Encourage the inclusion of hydroecological aspects within development plans of both ecologists and hydrologists, and encourage staff to take the opportunity of job swaps and shadowing to gain an improved understanding of each other's roles and day to day technical challenges.	22	21	Improvements Team to liaise with Water Resources Process and Ecology Policy & Process.	Ecology Policy & Process Water Resources Process	Effective external relationships Improve communication	September 2004 onwards

Action	Number	Links to other actions	How will it be delivered?	Who else will be involved/kept informed	What will it contribute to	Time-scale of delivery
Link to the Environmental Policy Team and their development of a strategy for climate change.	23	24	Improvements Team to liaise with Environmental Policy Team.	Environmental Policy Team	Integration of policies	Ongoing
Ensure that policy formulation and revision takes full account of climate change implications where possible.	24	23	Improvements Team to liaise with Environmental Policy Team.	Environmental Policy Team	Sound science Improve internal working relationships Integration of policies	When required
Where appropriate, have regard to climate change scenarios in hydroecology science projects.	25	17, 19	Improvements Team to liaise with Environmental Policy Team.	Environmental Policy Team	Sound science Integration of policies	When required

References

Defra (2002). *Directing the Flow: Priorities for Future Water Policy*. Department for Environment, Food and Rural Affairs, London.

DETR (1999). *A Better Quality of Life: A Strategy for Sustainable Development for the United Kingdom*. Department of the Environment, Transport and the Regions, London.

Entec (2003). *Ecohydrological Guidelines for Lowland Wetland Plant Communities*. Draft report to Anglian Region, Environment Agency.

Environment Agency (2001a). *Water Resources for the Future: A Strategy for England and Wales*. Environment Agency, Bristol.

Environment Agency (2001b). *Our Vision: Making it Happen*. Environment Agency, Bristol.

Environment Agency (2003). *Water Resources and Conservation: A Framework for the Assessment of the Hydrological Requirements of Habitats and Species*. Environment Agency, Bristol.

Extence, C.A., Balbi, D.M. & Chadd, R.P. (1999). River flow indexing using British benthic macro-invertebrates: a framework for setting hydroecological objectives. *Regulated Rivers: Research & Management*, 15, 543–574.

GLA (2002). *The Draft London Plan*. Greater London Authority.

Wheeler, B.D. & Shaw, S.C. (2001). *A Wetland Framework for Impact Assessment at Statutory Sites in Eastern England*. R&D Notes W6-068/TR1 and W6-068/TR2. Environment Agency, Bristol.

Appendix:

Ideas bank and Science priorities

Table 2 | Ideas Bank.

The table collates ideas put forward from a variety of sources during initial consultation (autumn 2003).

Proposed type	Comments
General	
To reconcile broad-scale approaches (e.g. CAMS) with more detailed process-based approaches, allowing a transition between screening and other WFD-type activities and more detailed local assessments/investigations.	Need to therefore make sure that we have a suite of complementary tools whose use is applicable across the ranges of scale. This has already been highlighted within abstraction licensing as a priority.
Habitats Directive – need to ensure that the processes of dealing with new permissions fully benefit from the advances in our understanding of ecological impacts of abstraction.	Guidance and best practice will continue to be updated in accordance with increased understanding.
Need improved storage and integration of national data-sets to permit wide-scale analyses.	Current progress is being made to ensure that ecological data and analyses are incorporated into B4W (BIOSIS), but there is a need to look at accessibility to the whole suite of hydroecological data types.
Fundamental understanding	
Need to understand how flow regulation and altering the flow regime impacts on the ecology, rather than focusing just on low flows.	Underpins all hydroecological projects – need to ensure that where fundamental understanding is lacking the project starts from basics and builds up.
Need to determine the importance of spatial and temporal variability.	As above. Links to fundamental understanding of hydrology and ecology.
Gaining an understanding of the four main types of flow (population, critical, stress and habitat flows) and their effects on the ecology of the watercourse.	This is being addressed for fish via the coarse fish & flows project; however, need to expand to other key groups where appropriate.
Freshwater flow needs to estuaries.	Literature review currently ongoing, but following project needs to be defined once completed.
The relationship of hydrology to siltation and resuspension and how this can have ecological implications.	Has been the focus of a WFD project, need to ensure this is built upon. Within the Agency stronger links need to be established between hydroecology and hydromorphology.
Need to understand the importance of substrate in determining hydrological microhabitat.	Links to above point.
Need to understand hydrological longitudinal and lateral connectivity and continuity and how this affects biology and is best managed to ensure migration/nutrient supply etc. in systems.	With respect to fish this is currently being addressed within coarse fish & flows project.

Fundamental understanding (cont.)

Need to understand the impact of abstraction pressures on lakes.	Currently being addressed via suite of WFD projects. However, ongoing research will be required.
How far can we push a system? (e.g. resilience/resistance critical low or high flows).	This is critical to defining ecological damage, with particular reference to the appraisal of licences/drought order permits. Currently being progressed within coarse fish & flows project. Will need to be a major component of next stage of LIFE method development.
What is needed to ensure recovery? Need for mosaic of habitat types (e.g. for macrophytes and individual life stages of fish).	As above.
Links between surface and groundwater ecological functioning.	Progress made within context of wetlands; however, this is a priority that needs wider progression.
Linkages between atmospheric and aquatic ecosystems (e.g. utilising Agency long-term flow series, ecological data and non-Agency atmospheric data).	Appraisal of wider system functioning has so far received little attention; this is a long-term Science priority.
Linkages between riparian and in-stream functioning.	As above.
Nutrient dynamics within floodplains and their ecological impacts constitute a major gap in knowledge at present.	Project currently being undertaken by CEH Wallingford.

Applied research

Improve knowledge about impacts of flow regulation, and look at best practice to see how it can be managed in the most environmentally beneficial way (e.g. better assessment of compensation flows).	Flow regulation including compensation flows and impacts from hydrological structures need appraisal.
Low flows, siltation and defining appropriate management regimes.	The progression of fundamental research is a priority, this will need to be wider than Water Resources (e.g. includes agriculture and land management practices).
Drought orders/permits – appraisal and taking account of environmental implications.	Planned for progression in 2004/5.
Need to develop tools which do not preclude linkages with other pressures, as suggested by the WFD. To separate impacts due to hydrology from those due to river engineering and water quality.	This is a high priority within the range of WFD projects currently being progressed. Communication across the relevant groups is essential to ensuring integrated tools. CAMS/RAM will undoubtedly benefit from the development of tools with WFD.
Disassociating the effect of our interventions (i.e. licensing changes) with those of climate change or other “natural” events.	As above.
Need to better understand the hydrology of wetlands and how this affects chemistry and biology.	As above.

Tool development/technical guidance

To improve reference condition-based tools such as RIVPACS so that hydrological impacts to biota are fully considered.	Current RIVPACS project will ensure expected LIFE score is fully integrated. However, there are other issues that will need to be resolved (e.g. abundance data, and applicability of reference sites within data-set).
Further development of RIVPACS in line with water resources needs, (e.g. species abundance prediction, improved precision of expected LIFE score, inclusion of headwater sites vulnerable to stress linked to groundwater abstraction etc.).	As above.
Wet woodland, wet heath guidelines for Habitats Directive.	2004 Science proposal.
Further refinement/extension of the generalised response curve work currently being undertaken by CEH Wallingford.	Current project due to complete by June 2004. Results of this will define next stage of project.
Improved validation/development of the tools we are already using within RAM.	RAM version 4 to be progressed from December 2004. Appraisal of current RAM tools will be required for this. LEAFPACS is being developed through WFD, and links have been established to ensure RAM will benefit from this. Coarse fish & flows project is focusing on delivering a range of tools including developing fisheries assessment within RAM.
Accurate quantification of ecological stress due to low flows for the WFD rather than reliance on arbitrary hydrological rules.	Until we progress fundamental understanding, best expert opinion will continue to be applied. Appraisal of the ecological flows generated through RAM will allow refinement of current understanding to aid WFD.
Need to develop better diagnostic tools for measuring biological response to specific stresses (e.g. can we differentiate effects of reduced flows from those of increased nutrients?).	Links to above points made on integrated assessments.
Need to develop hydromorphological pressure-sensitive classification tools.	Currently progressed via WFD projects.
Mapping RAM river flow objectives to ecological status under the WFD.	The use of RAM within WFD is already well progressed. Further Characterisation will allow this fully. 2004 Science proposal.

Economics

Economic values of ecology.	Link to Economics to ensure progression. Some progress has been made via WFD project.
Economic level of leakage to include the environmental costs of providing the extra water to replace that which has been allowed to leak away.	Link to Economics to ensure progression.

Table 3 | Science Priorities.

The table is defined using broad habitat types, and currently excludes the full range of additional habitats designated under the Habitats Directive, most notably saline-influenced habitats (other than estuaries). It also excludes temporary habitats such as winterbournes.

Habitats/species	Drivers				
	WFD	RSA Programme (incl. Habitats Directive)	CAMS/RAM	Abstraction licensing	Drought
Rivers/streams					
Salmonid and coarse fish	Red	Green	Purple	Purple	Green
Plants	Red	Green	Dark Blue	Purple	Green
Macro-invertebrates	Red	Green	Dark Blue	Purple	Green
Estuaries					
Salmonid and coarse fish	Red	Green	Red	Light Blue	Green
Plants	Red	Green	Red	Light Blue	Green
Macro-invertebrates	Red	Green	Red	Light Blue	Green
Lakes/ponds					
Coarse fish	Red	Green	Red	Light Blue	Green
Plants	Red	Green	Red	Light Blue	Green
Macro-invertebrates	Red	Green	Red	Light Blue	Green
Ditches/dykes/drains					
Coarse fish	Red	Green	Red	Light Blue	Green
Plants	Red	Green	Red	Light Blue	Green
Macro-invertebrates	Red	Green	Red	Light Blue	Green
Floodplain and other groundwater-fed habitats					
Plants	Red	Yellow	Yellow	Yellow	Yellow
Birds	Red	Yellow	Yellow	Yellow	Yellow
Invertebrates	Red	Yellow	Yellow	Yellow	Yellow

Key:			
Consistent methods exist, will need regular revision	Dark Blue	Best practice guidance/local expertise currently used	Green
Methods require further development – high priority	Purple	No consistent method exists, research ongoing – medium priority	Yellow
Methods require further development – medium priority	Light Blue	Currently under development – high priority	Red

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