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# TWINBAS

## Twinning European and third countries rivers basins for development of integrated water resources management methods

An EC FP6 research project
co-funded within the topic *'Twinning European/third countries river basins*' under the *'Global change and ecosystems'* sub-priority

# Work Package 9

# Preliminary River Basin Management Plans (D9.2)

**April 2007**

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# 1. Introduction

The WFD provides a starting point for river basin planning. Its overall objective is consistent water management across Europe in order to reduce pollution, to prevent deterioration and improve the condition of aquatic ecosystems including wetlands, to promote the sustainable use of water, and to help reduce the effects of floods and droughts. The river basin planning process also provides an opportunity to address other challenges such as climate change, sustainable development, and other water-based activities in a more strategic and integrated manner. It provides a mechanism for coordination and integration between water plans and policies, for coordination and integration of water plans and policies with other relevant plans and strategies, and for enabling other public bodies and stakeholders who have an interest to influence the river basin management plans (RBMPs) and, hence, influence the approach to water management in the river basin (Defra, 2006).

The WFD basic management unit for river basin management is the river basin district. A river basin district may be a catchment or a group of catchments, and for international rivers, such as the Okavango basin in Southern Africa, the river basin district will transcend national boundaries. The RBMP developed for each river basin district will form the basis if achievement of water quality protection and improvement, and will include a programme of measures (see associated WP9 action efficiency report, 2007). However, although the primary aims of the WFD are environmental, RBMPs should also take economic and social needs into account, in line with the principles for sustainable development. To enable this, the involvement of all basin stakeholders is a key requirement of the river basin management planning process.

The timetable for RBMPs in the WFD is given in Appendix 1, which also indicates the principal related Articles of the WFD (Defra, 2002; FWR, 2004). The planning process is cyclical and the WFD requires periodic updates to RBMPs and associated programmes of measures every six years. The planning process comprises nine identifiable components (FWR, 2004), which align with the indicated TWINBAS Work Packages:

- ***Assessment of the current status of river basin districts***: their characteristics, the impact of human activity and an economic analysis of water use (WP1, WP4, WP5, WP7, WP8).

- ***Setting environmental objectives for identified water bodies in the river basin districts***: including the establishment of reference standards and the classification of water bodies (WP6).

- ***Establishment of monitoring programmes for each water body***: to meet surveillance, operational and investigative needs (WP2, WP4, WP7).

- ***Gap analysis***: determining for each water body any discrepancy between its existing status and that required under the WFD (WP6, WP9).

- ***Setting up programmes of measures***: the means by which the water bodies' good status will be preserved or restored as appropriate (WP9).

- ***Development of RBMPs***: pulling together of all the elements considered to date, firstly in draft form for public consultation and, secondly, in final form for Government approval (WP9).

- ***Public information and consultation***: the process by which stakeholders are informed of progress with the WFD implementation and consulted on the draft RBMPs (WP3).

- ***Implementation of the programme of measures***: the period over which the measures in the plan are implemented (post-TWINBAS).

- ***Evaluation of effectiveness of the RBMP and the programme of measures***: the core of a 6-yearly cycle of plan updates with the new plan being in plan once the previous plan period is ended (post-TWINBAS).

A summary of the issues to be covered in a RBMP is provided in Appendix 2. The first RBMPs, which must be established by the end of 2009 indicating the quantity and quality objectives to be achieved by 2015, are a transition between the initial analysis and implementation of the WFD (FWR, 2004). Their cyclical updating enables changes to the pressures on a water body, both natural and anthropogenic, to be recognised, and new measures developed to overcome them. Furthermore, refinements to the monitoring programme, and the availability of further data, will enable fine tuning to existing measures and give early warning of new problems so tat appropriate action can be taken. The evaluation process also gives the opportunity to review existing water body classifications, and derogations obtained during the preceding planning period, and the general effectiveness of the programme of measures in the achievement of good status in designated water bodies (FWR, 2004).

The WFD and RBMPs are an example of an approach to building a more flexible framework for managing water resources, known as adaptive management. The Collaborative Adaptive Management Network[1] (2007) defines adaptive management as "*a systematic management paradigm that assumes natural resource management policies and actions are not static, but are adjusted based on the combination of new scientific and socio-economic information in order to improve management by learning from the ecosystems being affected. A collaborative adaptive management approach incorporates and links knowledge and credible science with the experience and values of stakeholders and managers for more effective management decision-making". "Given the inherent ecological and social uncertainty in complex resource management decision-making, adaptive management recognises that it is not possible, a priori, to identify the best management alternative. Therefore, an experimental approach is warranted, and learning about the system becomes a deliberate goal similar to traditional ecological, economic, or social goals. Modelling, experimental design, monitoring, and the identification of key decision points are integral parts of adaptive management*." For more information, and examples of natural resources being managed in this way, see Boesch et al. (2006), Stankey et al. (2005) and Moberg and Galaz (2005).

After this introduction, Sections 2-6 report on the progress of the river basin planning process in each of the five TWINBAS river basins, including any existing management plans in the basin, and the contribution of TWINBAS towards the WFD RBMP process. Rather than integrating the approaches from each basin in separate topic chapters, this layout was chosen because the methodology in each river basin, and the progress made, are different. Because the TWINBAS RBMP contributions do not encompass all aspects or problems of water use in the case studies, due to budgetary limits, they are intended as examples, to be used by local or national planning authorities in their further work to produce authorised RBMPs. The contributions to the river basin planning process in each basin are a culmination of activities previous TWINBAS work packages (Figure 1.1), and build upon the programmes of measures presented in the associated action efficiency research report (WP9, 2007). Section 7 presents some concluding remarks and recommendations for each basin.

[1] http://www.adaptivemanagement.net

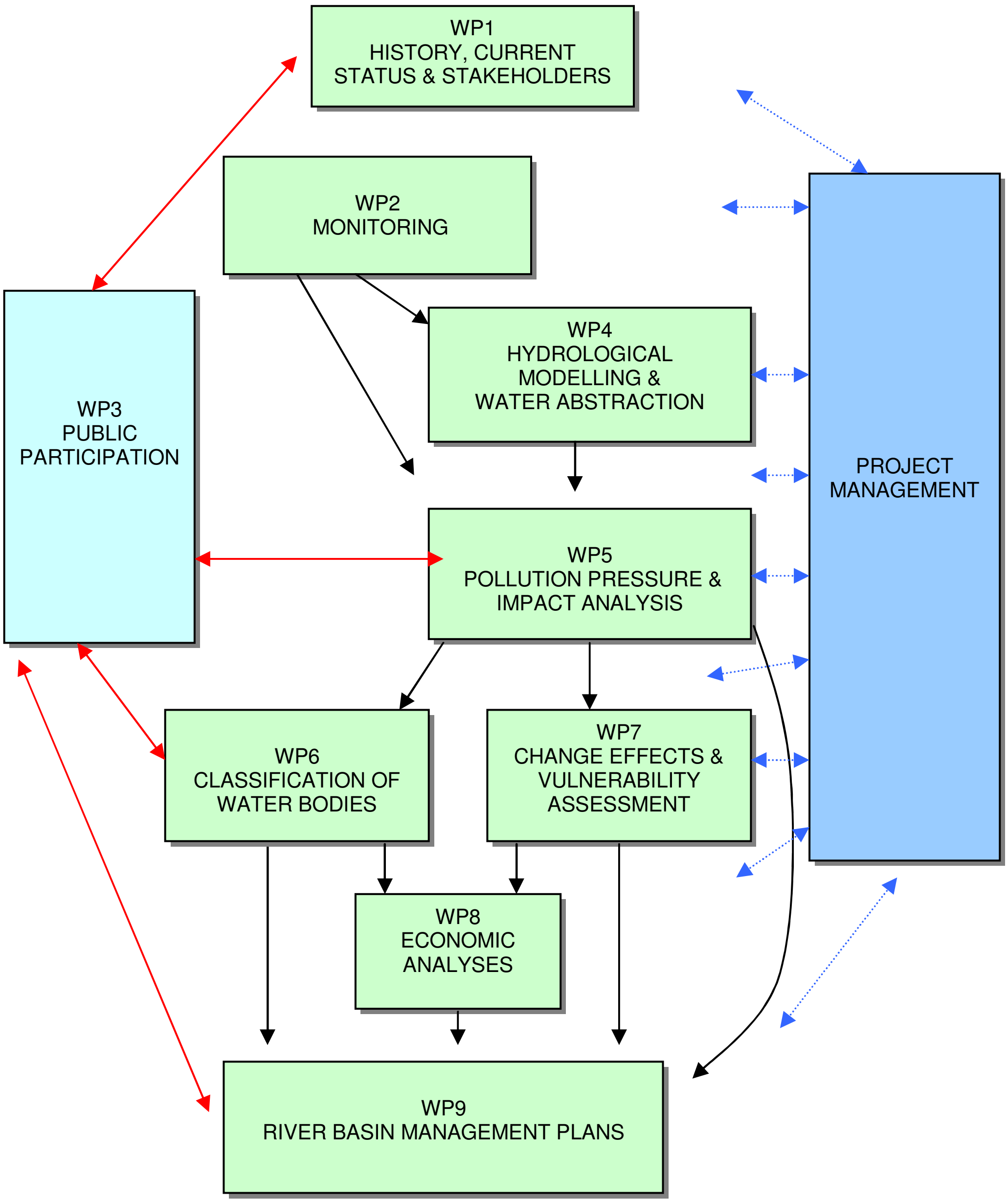


**Figure 1.1** Links between TWINBAS Work Packages

# 2. Biobío

## 2.1 Issues in the Biobío River Basin

The Biobío River Basin is Chile's third largest river basin and it occupies 3% of the country's continental territory. The basin has a high value in terms of biodiversity, characterised by a considerable number of endemic species. At the same time, the basin represents, at the national level, an important economic development centre. The most dynamic productive sectors are linked to the forestry, agriculture and industry (represented predominantly by the metallurgic, chemical, petroleum refining, textile industrial, pulp and paper mills industries, amongst others), and hydropower (constituting the principal source of electricity at the national level).

The annual average water flow of the Biobío river in the headwaters is 30 $m^3s^{-1}$. After running its 380 km course, the river reaches the Gulf of Arauco (an very important zone for the fishing industry at national level), near the city of Concepción. The annual average water flow at the river's mouth typically varies between 300 and 900 $m^3s^{-1}$, but can reach 8,000 $m^3s^{-1}$ after heavy rainfall and, it is estimated, reach 17,000 $m^3s^{-1}$, at least once every hundred years.

The two different hydrological regimes that can be distinguished in the Biobío River Basin are, thus, as follows:

- ***Pluvio-Nival***: This regime is characteristics of tributaries and streams located in the Andes Mountains, but also of reaches of the Biobío and Laja rivers in the Central Valley, due to the great influence of snowmelt produced in the upper part of the basin. Average monthly water flows are notably greater during the rainy and melting periods.

- ***Pluvial***: This regime is typical for the rivers that run through the Central Valley and the Coastal Mountain Range,and also for rivers that are limited to the western (lower) part of the Andes Mountains and Andean foothills, which exhibit a pluvial rather than a pluvio-nival behavior, due to the importance of orographic precipitation in this area. Maximum average monthly water flows are produced during the months of June and July.

The main pollution pressure impacts in the Biobío River Basin are associated with forest industries, particularly pulp and paper mills. This economic sector (second in terms of national exports) exhorts pressures on the water bodies of the Biobío basin which have impacts on water quality, as well as on quantity in the form of abstractions. The results from pollution modelling (WP5, 2007) show increases of pollutant concentrations, especially in reaches near to effluent discharge points. This report focuses on point pollution pressure into the Biobío basin.

## 2.2 Existing management plans

The organisation of Chilean water institutions has, to date, not facilitated an integrated management of water, soil, vegetation and environment. Since the 1990s, the authorities and academic sector (e.g. DGA, EULA, CONAMA, CONAF, and others) in the Biobío river basin, have worked at different levels and with different degrees of success towards integrated water resource management, the main work in this area lead by DGA with support from a French consulting firm. However, management of water resources in the Biobío basin is based mainly on the quantity of the resource available, and does not necessarily also consider the quality of the resource.

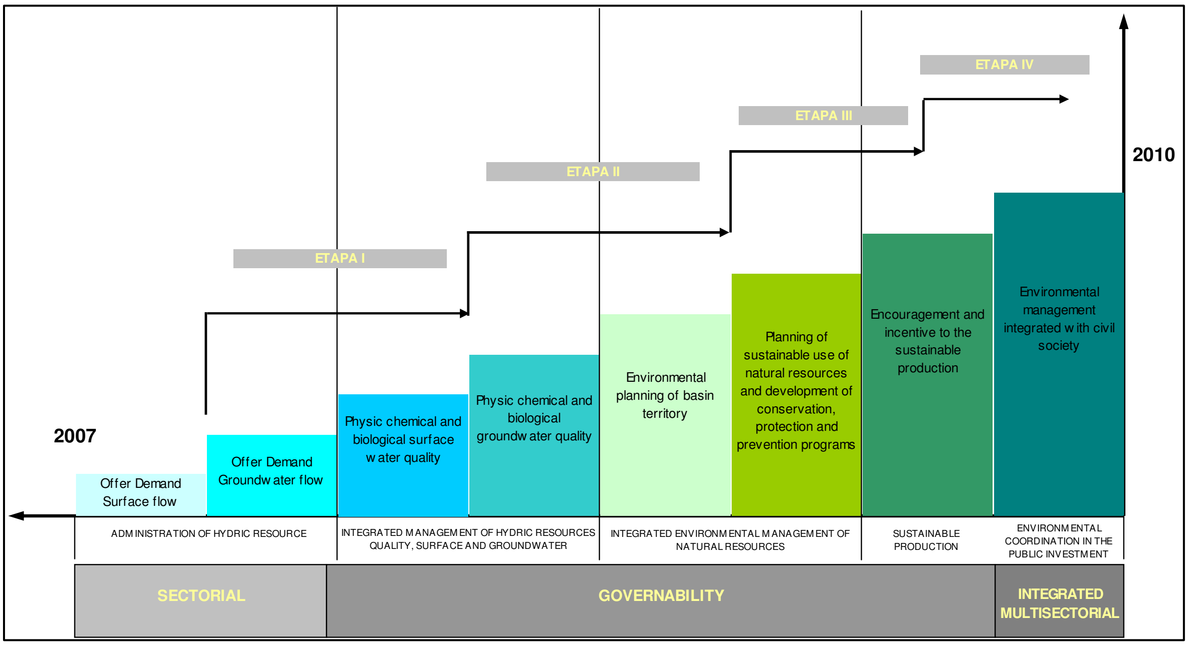


**Figure 2.1** Steps in the implementation of the National Strategy for Integrated Management of River Basins

Currently, the Government of Chile is working on the development of the National Strategy for Integrated Management of River Basins, which is one of the pillars of the Environmental Policy of the present Government. Influenced by the increasing awareness of the importance of an integrated approach to basin-wide problems at professional and directive levels, and not least by the TWINBAS project, this strategy was first presented to the electors in the middle of the last presidential campaign, and is now a priority in the presidential programme. The implementation process for the National Strategy is shown in Figure 2.1.

## 2.3 Contribution to the river basin management planning process

As has been discussed throughout this Section, the main contributions to RBMP development derived from the TWINBAS project have been in the form of inputs to several technical, social and economic agreements for the establishment of water quality standards for multiple reaches and multiple parameters. It is anticipated that this will lead to a series of projects aimed at further study of these standards, acceptance of them by all stakeholders, and actions to fulfil them, and at establishment of a baseline for better management of the water resources of the Biobío River Basin.

Some of the areas where there were less advances include establishment of biological water quality standards. The proposal of CONAMA and other organisations, among them EULA, to set biological quality standards for protection of ecosystems in the water bodies of the river basin, was only partially was accepted by the stakeholders from the industrial sector. This was eventually translated into an agreement in which biological parameters would be used only as indicators, in parallel with the official regulating parameters.

Furthermore, clear agreements have not been obtained in respect of future administrative organisation for the management of the river basin, or in the degree of stakeholder participation in any organisations. Of particular concern in this context, is the lack of any modifications to the existing Water Code (Código de Aguas), especially related to the allocation of water rights in the river basin and mechanisms of expiry of such rights. This water rights “time bomb” has the potential to significantly reduce river flows in the basin in future years.

Overall, the TWINBAS project has demonstrated both a need and a willingness to work cooperatively, but gradually, towards solutions for urban sustainability. The protection of ecosystem status is being supported through innovation in point pollution discharges control, and in urban planning and design, in both local and national partnership projects.

# 3. Norrström

## 3.1 Issues in the Norrström River Basin

The Norrström River Basin covers an area of 22,600 km$^2$, representing some 5% of the area of Sweden. The basin includes two of country's largest lakes: Mälaren, which has an area of 1000 km$^2$, and Hjälmaren, which covers approximately 500 km$^2$. The number of people living in the area is approximately 1.2 million. In the Norrström basin, forests and mires dominate the landscape and cover about 70% of the surface area. The basin is commonly divided into 12 tributaries, all with outlets in Lake Mälaren. Administratively, the Norrström basin belongs to 31 municipalities, and is part of six different counties. The surface water in the Norrström basin is divided into 356 rivers at a total length of 2900 km. In addition to this, there are 790 lakes of a total area of 2780 km$^2$ (Figure 3.1).

Lake Mälaren provides drinking water to 1.5 million people and is also the recipient of the wastewater from the surrounding cities and industries. Lake Mälaren is both an important transport route for oil and chemical products and an appreciated recreational resource. Both the lake itself and its tributaries have been stepwise dammed since 1943. For instance, 24 hydropower stations are situated in Svartån, Arbogaån, Kolbäcksån and Hedströmmen, and many more dams and ponds control water flow in the Norrström basin.

***Pollution pressure impact***

The major problem in the Norrström basin is nutrient transport, which causes eutrophication both in smaller rivers and lakes as well as in Lake Mälaren and in the Baltic Sea. Since parts of the basin have a long tradition of mining, problems concerning heavy metal pollution also occur. The contamination from mining activities is usually caused by leakage of dissolved metals to the surface and groundwater, and also through dust and water erosion (Andersson, 2005). The substance of ore residues varies but usually contains high levels of arsenic, lead, copper or zinc.

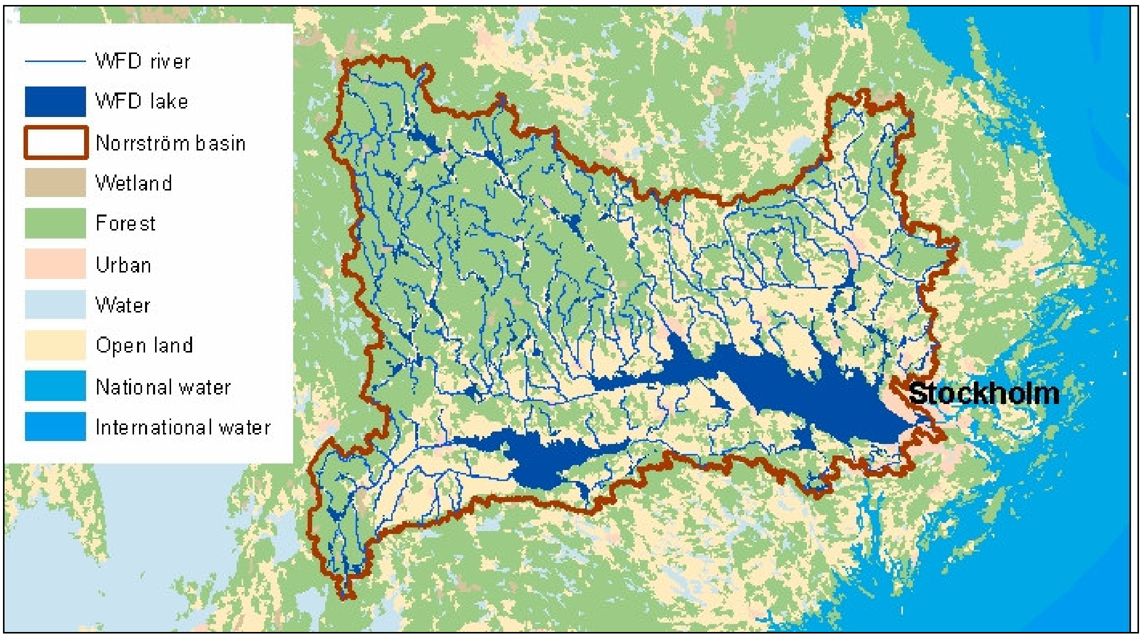


**Figure 3.1** Rivers and lakes in the Norrström River Basin according to WFD definitions

The major point sources in the Norrström basin include mining sites, domestic wastewater treatment plants and industries (Figure 3.2). There are also small point sources such as rural households, fish farms and pleasure boats that are of importance for nitrogen and phosphorus (Ekstrand et al., 2003). Since eutrophication is the main problem within the Norrström basin, the focus within the TWINBAS project has been on the collection and analysis of point source emission data for nitrogen and phosphorus. However, emission data concerning copper, cadmium, zinc and mercury have also been collected.

The monitoring of Lake Mälaren started in the mid 1960s. During the late 1960s and early 1970s, there were large improvements in chemical composition and biological status. The main reason was the introduction of chemical precipitation in municipal sewage treatment plants, causing a reduction of 60% of total phosphorus input in the lake. This caused a decrease in the phosphorus concentration in the water, as well as in the phytoplankton biomass.

After the introduction of chemical precipitation and the subsequent significant lowering of phosphorus amounts, the situation concerning phosphorus has been rather stable, with variations between years following variations in water flow. For nitrogen, the situation is somewhat different. In most watercourses, the amount of nitrogen increased during the first years of monitoring (i.e. during the late 1960s). The reasons for this were probably that more households became connected to the municipal sewage treatment plants, and that atmospheric deposition increased. A major change occurred, however, at the outlet of Lake Mälaren when the amount of nitrogen was decreased by about 20% around 1989. The reason was probably that the sewage treatment plant in Bromma started to discharge the water into the Baltic Sea instead of to Lake Mälaren at this time (Wallin, 2000).

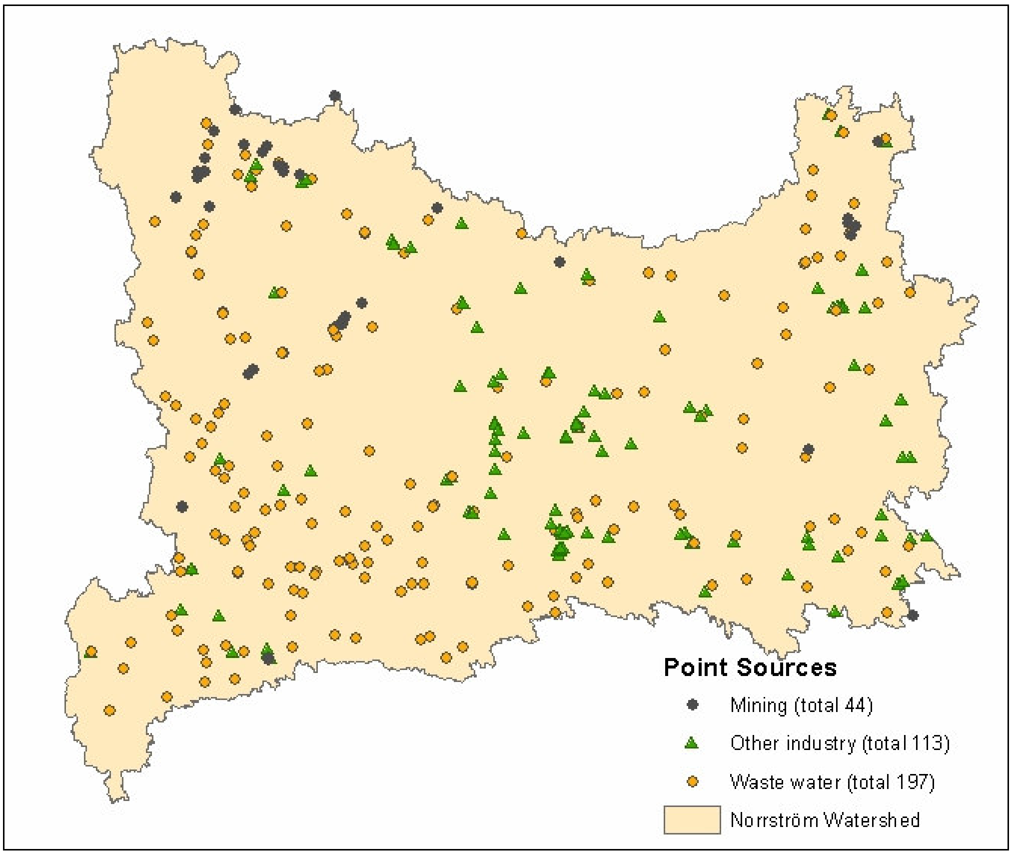


**Figure 3.2** Major point sources in the Norrström River Basin

The Norrström River Basin is one of the most studied areas in Sweden, very much because of its location in a densely populated area with its outlet to the Baltic Sea in Stockholm. Monitoring is rather extensive in the basin, and Lake Mälaren and its tributaries are generally very well investigated. However, within TWINBAS, three areas were identified early on where existing information was insufficient and complementary monitoring was needed:

- Nutrient losses from agricultural land in the immediate surroundings of Lake Mälaren
- Losses of heavy metals from agricultural land
- WFD priority substances / persistent organic compounds

During the project, the focus has been on nutrients and, in response to these monitoring needs, three small streams in agricultural land near Lake Mälaren were selected for measurements of nutrient losses from agricultural land. ,Two other agricultural areas were selected to also include analysis of metals.

***Ecological status***

Within the TWINBAS project, an ecological status classification for the Norrström River Basin was a scheduled activity, but the District Water Authority (DWA) requested that this task should not be carried out because they were due to produce a classification during 2006, and an alternative classification could result in confusion and misunderstandings. Therefore, an ecological status classification for the Norrström basin, or for any of the tributaries within the basin, was not produced.

***Identification of pilot area***

Hydrological modeling, as well as modelling of nitrogen and phosphorus, has been conducted in five of the 12 tributaries to Lake Mälaren. Models have been set up for another two tributaries, but due to difficulties related to water regulation and lack of flow data these rivers could not be modelled within TWINBAS. An area near Lake Mälaren, which is not part of any of the 12 main tributaries, but drained by small streams and ditches, is comparatively large at 4515 $km^2$, is dominated by agriculture and is, therefore, an important contributor to the eutrophication of the lake. This area is currently modelled in another river twinning project, TWINLATIN[2].

For further analysis, including public participation and detailed modelling based on locally collected data, a pilot area was selected. The selected area corresponds to the tributaries river Sagån and river Svartån and is situated in the northern part of the Norrström basin (Figure 3.3). It was selected because the area is representative of the basin in terms of land use and pollution problems, and because there are sufficient monitoring data available for the area. The stakeholders relevant to the pilot area were engaged in the stakeholder involvement process at an early stage. One of the main stakeholders from the start has been the City Council of Västerås City, by far the largest municipality with responsibilities for Sagån-Svartån. Västerås city has been deeply engaged in the TWINBAS stakeholder involvement process, trying to contribute to a long-term relationship between the city stakeholders, including different city agencies and the city-owned company providing sanitation, drinking water and energy on one hand, and the farmer community on the other. These are the two main stakeholder groups relevant to efforts towards reducing Sagåns-Svartån's contribution to the eutrophication of Lake Mälaren. Västerås City manifested its engagement by funding a parallel project to improve the details in the water quality status modelling and action cost-efficiency for Svartån-Sagån, and at a later stage to intensify the communication with the farmers.

[2] www.twinlatin.org

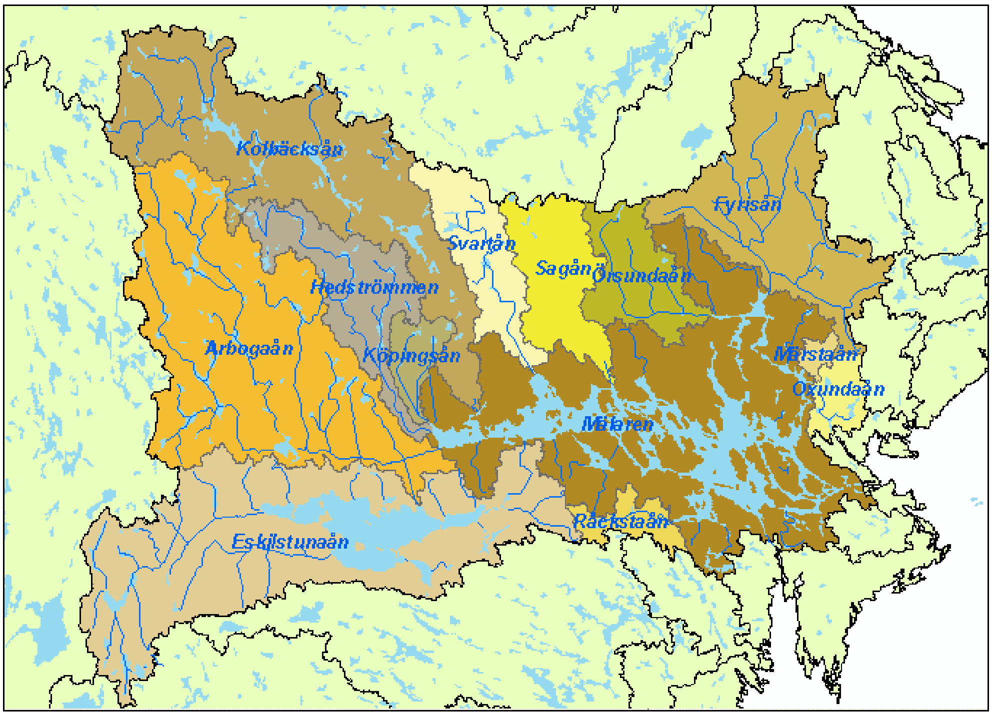


**Figure 3.3** Norrström River Basin with tributaries

Within the pilot area, an area of a size that would allow interviews with the majority of the farmers was identified for collection of local detail information. The Lillå stream, a tributary to the Sagån, with a catchment size of approximately 200 km$^2$, and dominated by arable land, was selected. Twenty of the farmers in this area, representing some 70% of the total number of farmers, were visited and interviewed.

The information gathered during the interviews was used as input data to modelling activities. The detailed input data provided by individual farmers visibly improved the modelling results, with better accuracy for phosphorus, and to a lesser extent also for nitrogen, when compared to measured data. The estimated level of leaching was also significantly reduced, by as much as 30% for phosphorus, demonstrating the advantage of using detailed farm input data in the modelling. With the detailed input data, the basis for analysing the effect of relevant measures was also significantly better.

***Water consumption***

The Norrström basin belongs to the North Baltic Water District which has the highest gross regional product of all the districts. It has also the largest number of households and the highest income per household. The industries using the most water are pulp mills, chemical manufactories, steel/metal industries and electricity/heat suppliers, which account for almost 85% of the national water outtake. In the North Baltic Water District, these industries contribute 5% of the gross regional product. The largest share of expenses for environmental protection is paid by the heat supplying companies. Households, as in other water districts, pay the largest share if environmental taxes, in the North Baltic Water District, covering about 50% of the environmental tax bill.

The largest water outtake is by the municipalities' water treatment plants, for water mostly used for domestic supply. The municipal water treatment plants account for the largest pollution discharges, and also the largest releases of cleaned water. Of the water intensive industries, the pulp mills have the largest pollution discharges.

The municipalities within the pilot area are Sala, Norberg and Västerås. These municipalities belong to the county of Västmanland. Table 3.1 shows water use in the three municipalities. The data applies only to users who are connected to the municipal water system. As shown, households are the dominant users of water supplied by the municipality. In general, however, the industrial sector is the biggest water user of surface and groundwater combined, the latter often withdrawn directly from the source aquifer.

**Table 3.1** Water use 1000 $m^3$ (1995)

| Region | Norberg | % | Sala | % | Västerås | % |
|---|---|---|---|---|---|---|
| Households | 436 | 38 | 1457 | 53 | 9310 | 41 |
| Industries | 310 | 27 | 78 | 3 | 4742 | 21 |
| Agriculture | 21 | 2 | 442 | 16 | 792 | 4 |
| Other | 367 | 32 | 783 | 28 | 7611 | 34 |
| Total | 1134 | | 2760 | | 22455 | |

Agriculture is intense in the pilot area and, in the county of Västmanland, agricultural productivity has increased in average by more than 40% during the period 1998-2003 (Statistics Sweden, 2005).

The proportion of the population engaged in agriculture, hunting and fishery is estimated to around 5% for Sala, and around 1% each for Norberg and Västerås. The total agricultural land for the municipalities is 28,067, 1,669 and 30,249 ha, respectively.

***Change effects and vulnerability assessment***

Vulnerability assessment was carried out in the pilot area and possible developments of the region over the next 50 and 100 years were identified. The scenarios include changes expected from the climate as well as changes expected from increasing social and economic development.

The scenarios used were built with consideration of the IPCC's future greenhouse gas emission scenarios and climate science, and of local and regional climate change issues from SMHI's (Swedish Meteorological and Hydrological Institute) Rossby Centre. The following scenarios were modelled:

- In a "Provincial Enterprise" (A2) scenario, Europe is heterogeneous. Increasingly, the organisation of society is dictated by short-term consumerist values. More policy decisions are taken at a national and sub national level.

- In a "Local Sustainability" (B2) scenario, Europe is more committed to solving environmental problems by applying solutions that are attuned to local needs and circumstances. Thus, the dominant value system is more communitarian and ecocentric in nature, with greater commitment to longer term, strategic planning.

The results from modelling nutrient leakage according to the scenarios showed that the leakage of both nitrogen and phosphorus decreases in the future. The decrease is most obvious for the agricultural sector and refers to a combination of changed climate and changes in land cover and agricultural land use. Due to the changed climate, the model predicts an increase in agricultural biomass growth, and also an increase in nitrogen and phosphorus uptake.

The results correspond with the idea that a warmer climate will give a higher biomass growth for the Norrström basin, thereby leading to a higher nutrient uptake. There is, of course, the concern that the fertiliser load should be increased to match the higher yield, but even if technological improvements in fertiliser application cannot match the increase in growth and the loads need to be higher, the results are still interesting since they show a decrease of leakage due to climate change.

## 3.2 Existing management plans

The counties in and around the Norrström basin have been cooperating on water conservation issues for more than 30 years. The need for cooperation was identified early on as the use of Mälaren and Hjälmaren as recipients for sewage water, for drinking water, for shipping, for fishing and for recreation stressed the need for knowledge concerning pressure and status. Needs for measures concerning point sources from cities and industry were also defined at an early stage. Both the municipalities and the County Boards are organised into Lake Associations. For some of the tributaries, there are also River Associations consisting of stakeholders along the watercourse. An important task for these associations is monitoring, and the water quality situation and trends are briefly analysed and presented in short annual reports. Management plans have not been developed for any of the tributaries or the lakes.

In 2004, Sweden was divided into five water districts and one of the County Boards in each district then functioned as the water authority for that district. On behalf of the Swedish Government, the County Boards are responsible for specification of the national goals concerning the quality of the environment. The goals that specifically concern water are healthy lakes and watercourses, no overfeeding, only natural acidification and non-toxic environment.

In Sweden, there are both national and regional goals related to water and eutrophication. According to the Swedish EPA, the national goals are:

- No later than 2009, an abatement programme relative to the WFD should be available. The WFD advocates the integration of its requirements, which relate to improving water quality, into other EU and domestic policies within the European Member States.
- Until the year 2010, the provision of nitrogen to lakes, watercourses and coast relative to human activities should be reduced continuously from the 1995 level.
- Until the year 2010, the provision of phosphorus to lakes, watercourses and the coast relative to human activities should be reduced continuously from the 1995 level.
- Until the year 2010, emissions of ammoniac should be reduced by at least 15%.
- No later than 2010, all emissions of nitrous oxides to the air should be reduced by 148,000 tonnes.

The regional goals concerning the Norrström River Basin are:

- In 2010, the provision of nitrogen and phosphorus to lakes and watercourses will be reduced by 10% relative to the 1995 levels (Mälarens vattenvårdsförbund, 2004).

## 3.3 Contribution to the river basin management planning process

The most important water quality problem in the Norrström River Basin is by far the eutrophication of Lake Mälaren, to which all the tributaries in the basin transport nutrients, and TWINBAS has focused on this issue. The pollution sources are agriculture, point sources and rural households. The contribution of point sources and rural households is fairly easily quantified and, therefore, the development tasks within the TWINBAS project have concentrated on improving the dynamic modelling of nutrient leaching from agriculture. Application of the developed modelling technique has been carried out for five of the twelve main tributaries of Lake Mälaren. Analysis of action cost-effectiveness for agricultural management practice actions was, for budget reasons, limited to the Lillån sub-basin of the Sagån tributary, but can be generalised to large parts of the Norrström basin. Analysis of action cost-efficiency addressing point sources and households were carried out for, and are valid for, the entire basin, and for Sweden as a whole.

***Priority action list***

Table 3.2 presents the measures and results for the modelling in the Lillån sub-basin. Wetlands are ranked as the most cost-effective measure, followed by riparian buffer zones, catch crops, no Autumn preparation and energy crops (Salix). Modelling of reduction of fertiliser application did not show any effect. It should be noted that the ranking does not take into account administrative costs and subsidies. The results in Table 3.2 are representative not only for the Lillån sub-basin, but for the whole region of the Norrström basin where soil conditions and agriculture have the same characteristics as the Lillå area (Sagån, Svartån, Örsundaån, Hedströmmen and Köpingsån, lower parts of Kolbäcksån, and areas adjacent to Lake Mälaren).

**Table 3.2** Measures and cost-efficiency results for the measures modelled in the Lillå report (for details, please refer to the Norrström section of WP9 (2007) report on action efficiency research)

| Measure | Euro per ha per year | Effectiveness Kg N/ha or kg P/ha | Euro per kg reduced N | Euro per kg reduced P | Rank | Admin. costs & subsidies |
|---|---|---|---|---|---|---|
| Wetlands | 500 | 256-277 kg N<br>29-32 kg P | 1.85 | 15-17 | 1 | 0.5-1(P) |
| Riparian buffer zones | 42-63 | 1.7 kg N (40 %)<br>0,5 kg P (73 %) | 25-37 | 84-126 | 2 | 110 (P) |
| Catch crops | 38 | 0.9 kg N / ha<br>0 kg P / ha | 42 | | 3 | 6.3 (N) |
| No Autumn preparation | | 0.8 kg N<br>0.01 kg P | 50 | 400 | 4 | 8.4 (N) |
| Energy crops - Salix | 333 | 3.4 kg N per ha<br>0.61 kg P per ha | 97 | 528 | 5 | 100 (P) |
| Reduction of use of fertilisers | | No change in short term | | | | |

The actions recommended in this list have been presented to the DWA and the County Boards. These stakeholders have stated that the results are valuable and will be used in the process of identifying a programme of measures for the water district, due in 2008 according to the WFD.

An actor that will undoubtedly play a major role in the practical implementation of actions in Sagån-Svartån, most likely also with a financial responsibility, is Västerås City, who are integrating the TWINBAS results into its planning process, and are planning to fund a follow-up project in which technical solutions and costs will be analysed in detail for wetland installations and agricultural management practice measures, in collaboration with the farmers in the area.

When such a detailed inventory of technical solutions (concerning wetlands), costs and locations is in place, farmers and other stakeholders will be able to form their own opinion about these proposed measures. Their general attitude towards these actions is, however, currently positive, and detailed data provided by them have been used in the modelling as well as in the selection of measures.

It is clear, though, that the governmental (EU) funding currently available for environmental measures in the agricultural sector (e.g. for wetlands, buffer zones, pasture) does not fully cover costs and, therefore, needs to be strengthened, as well as widened to include the management practice measures that are currently not supported, but are clearly cost-effective in this region. The farmers are currently under considerable economic stress and many of them will not survive forced measure implementation if it is not fully financed, as they state that they will not be able to bear any further cost on a voluntarily basis.

# 4. Nura

## 4.1 Issues in the Nura River Basin

The 939 km Nura river, its terminal Korgaldzhino wetlands and Lake Tengiz are located in North Central Kazakhstan and drains an area of some 3147 $km^2$. As discussed in WP7 (2007) and WP8 (2007), the institutional structure for sustainable water resource planning in Kazakhstan is lacking and, although there is clear awareness of the need for change within the water resource sector, institutional inertia and vested interests limit the potential for implementing a sustainable river basin management plan. The first step in the development bnd implementation of a sustainable river basin water resource management plan has to be institutional and legal reform in this sector. JacobsGibb (2004) propose a strategy for developing a water resource management plan for the Nura Ishim Bain. Unfortunately, the overall proposed strategy lacks any consideration for maintaining the integrity of the terminal Korgaldzhino wetlands and Lake Tengiz, both of which are recognised as internationally important wetlands under the Ramsar Convention. They have however, proposed a rational way forward to implementing a water resource management plan, an approach that has been further developed in the TWINBAS project.

## 4.2 Existing management plans

At the present time, the Nura River Basin does not have an accepted sustainable water resource management plan or an institutional structure that would be capable of implementing and monitoring a sustainable water resource management it if one were to be developed along the lines of the one outlined by JacobsGibb (2004).

## 4.3 Contribution to the river basin management planning process

The TWINBAS project has made an unprecedented contribution to the planning of water resources in the Nura River Basin. The project has brought together the stakeholders who now have a much clearer awareness and understanding of each others conflicting interests in the water resources of the Nura basin, but there is a lot still to do before a rational plan for sustainable water management will be operating in the basin. All stakeholders appreciate the implications of further abstraction of water for the sustainability of the terminal Korgaldzhino wetlands, and acknowledge the need for sustainable development and management of the water resources of the basin, but as yet the true needs of the wetlands still needs to be recognised in water resource planning and management practices.

TWINBAS has highlighted the changes needed in the legal and institutional framework if the nation's new National Water Code is to be implemented to give the River Basin Authorities (RBOs) the powers and responsibilities to enable them to develop, implement and monitor sustainable river basin management plans. Other major issues that that need to be addressed before the RBOs can become a reality and ensure sustainable water resource development include:

- Provision of an adequate funding mechanism that will allow RBOs to operate independently
- Adoption of a strategy for development of a sustainable water resource management plan
- Provision of adequate staffing and training for the RBOs

- Implementation of a performance monitoring system
- Collection of sufficient hydrological and abstraction /discharge data

Other areas where the TWINBAS project in the Nura River Basin has made a valuable contribution are discussed below.

***Water quality***

Classification of the basin's river network (WP6, 2007) has enabled the river reaches that are most at risk failing to achieve good water quality status to be identified. The main risk is posed by the huge quantities of mercury that were dumped in the river below the town of Temirtau. Previous work had identified the physical distribution of mercury in the river, and this study established the level of risk that the mercury poses to the people that live in the river catchment. As fish is the main source of mercury intake in humans, a study of the mercury concentration in fish in different reaches of the river was conducted. The results showed that mercury levels in all fish were elevated, but in the terminal wetlands concentrations were no higher than were normally encountered. The mercury levels in the fish in the most contaminated parts of the river were, nevertheless, extremely high, and a significant proportion of fish had mercury levels that exceeded normally acceptable levels. However, it was not as high as might be expected given the high levels of mercury in the sediment which seem to be closely associated with the power station fly-ash that that has been dumped in the river.

Studies of the level of mercury in the population that are most at risk from mercury poisoning showed that, although their levels of mercury were elevated, only a small percentage of the population have mercury levels in their bodies that slightly exceed the EU and USEPA safety guidelines. The mercury clean-up plans proposed under an EU INCO-COPERNICUS project that the Government is implementing should reduce the level of risk further. However, it is recommended that the fish in the Nura river between Samarkand Reservoir and Intumak Reservoir should be considered not fit for human consumption as the people with the highest mercury levels generally ate fish taken from this part of the river.

***Monitoring***

The hydrological and meteorological data are the basis for water resource management. Unfortunately, such a monitoring system is completely lacking in the terminal Korgaldzhino wetlands, which are one of Kazakhstan's main national parks. To ensure their sustainability for future generations, and to develop a rational water resource management plan, good hydrological data are needed. TWINBAS has demonstrated the long-term devastating effect that additional water abstraction will have on the wetlands but adequate hydrological data to assess cyclical changes in the wetlands are lacking. Therefore, it is essential that an effective hydrological and meteorological network is installed, operated and maintained to provide all year round reliable hydrological data. It is recommended that the state Kazgidromet service needs to reinstall two discharge gauging stations, at Almas on the Nura river and at Aktubek on the Kulanutpes river. In addition, the short-term gauging posts that were level surveyed throughout the wetlands during the project, need converting into permanent reference levels.

***Water management in the Tengiz-Korgaldzhino lake system***

A Memorandum has been prepared for the Government relating to the hydrological measures that need to be addressed to ensure the sustainability of the ecosystems of Tengiz-Korgaldzhino lake system.

Two embankments have been constructed at the lower end of the Korgaldzhino wetlands where they decant into Lake Tengiz. These were built to overcome the drying of the wetlands in the 1960s when excessive amounts of water were abstracted from the Nura river. Water is still abstracted, and there are plans to abstract more. If these wetlands are too be preserved at the expense of the saline Lake Tengiz, it is essential that these embankments are maintained. Inspection shows them to be in poor condition and liable to failure. The project recommends that the embankments be engineered to modern standards and that adequate well-engineered spillways be installed. Sluice gates would also be desirable to allow normal discharge to be regulated.

# 5. Okavango

## 5.1 Issues in the Okavango River Basin

The Okavango Delta is situated at the northern most edge of the Kalahari sandveld in north-western Botswana, below the Caprivi Strip in Namibia. It is the largest designated inland wetland in the world and is fed by the water of the Okavango river with between 5-16 thousand million cubic metres of water per annum from the river's headwaters in Angola. The Ramsar site covers a total of 55,599 km$^2$, and the Okavango Delta (the wetland area) covers some 13,000 km$^2$ within this (Figure 5.1). The Ramsar site occupies more than half of the Ngamiland District, one out of ten districts of Botswana. Very few people live in the delta itself, though most of the population otherwise depending on the wetland live within the Ramsar site area.

The Ramsar site is a vast, very gently undulating plain. The only topographic feature which stands out is the slightly elevated Ghanzi ridge,which contains the Tsodilo Hills, in the extreme west of the area. The soils of the delta itself reflect the organic and sandy sediment load for the Okavango (Thomas & Shaw, 1991; SMEC, 1987; Tawana Land Board, 2006). Around the delta, the dry land soils are mostly Kalahari sands. There is no agricultural potential in the Ramsar site (Tawana Land Board, 2006).

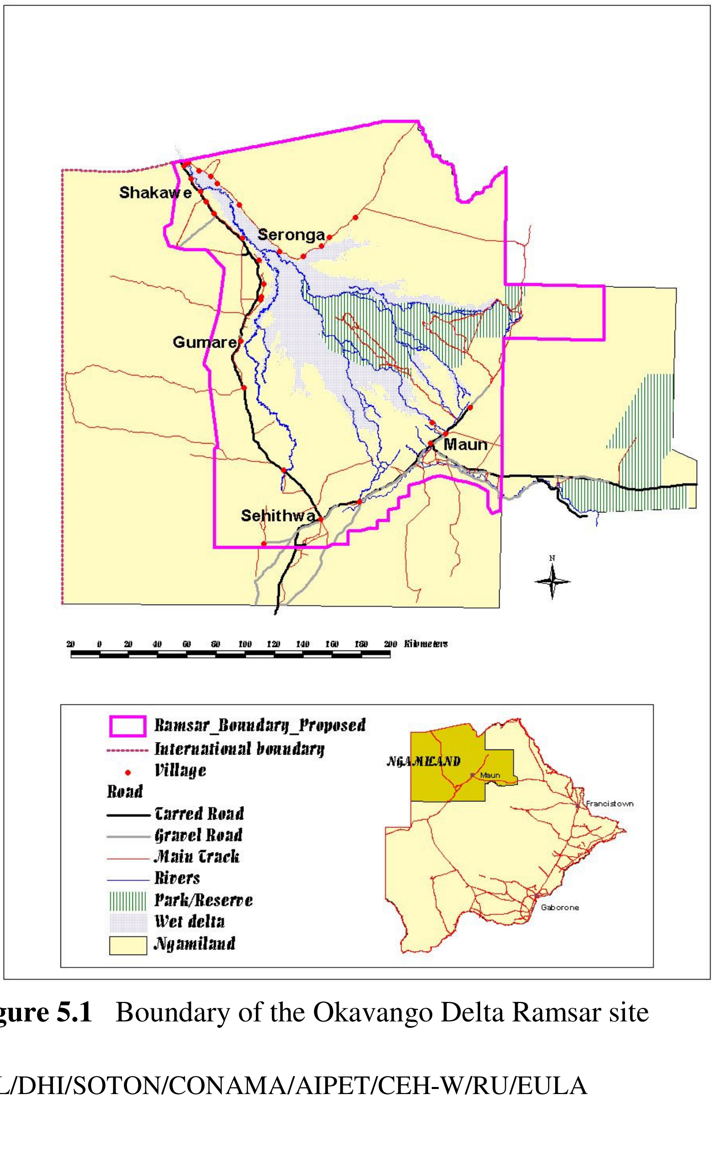


**Figure 5.1** Boundary of the Okavango Delta Ramsar site

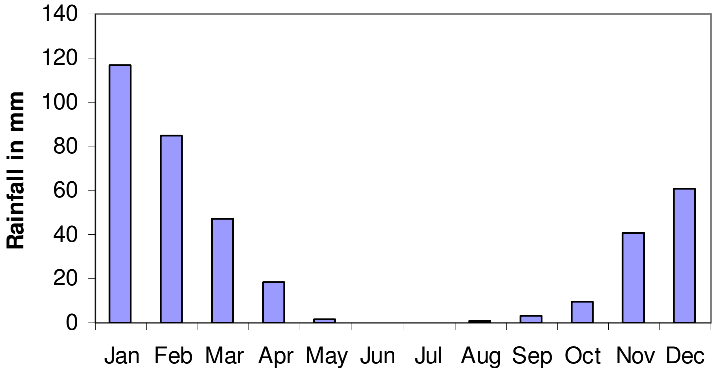


**Figure 5.2** Mean monthly rainfall in Maun for the period 1990 to 2004

The Okavango Delta is located in a semi-arid region of north-western Botswana with hot, wet Summers and cold, dry Winters. Because of its location, evaporation is about 2100 mm per annum, and amounts to far more than the average rainfall of 300–500 mm per annum, which occurs mainly from November to March. Most of the water flowing into the delta is thus lost to evaporation or evapotranspiration, with a very small proportion moving into groundwater aquifers (Jacobsen et al., 2005).

The pattern of flooding is roughly inverse to the pattern of rainfall. Rain falls in the upper catchment areas in Angola, some 600 km away, during Summer, and reaches the top of the panhandle in about April. The panhandle covers the 100 km stretch of the Okavango river from where it first enters Botswana to where it fans out into the delta proper. In an average year, some 9.4 $km^3$ of water reaches the delta, though this fluctuates widely from year to year, depending on rainfall in the Angola (Mendelsohn & el Obeid, 2004). The floodwater encounters tremendous resistance as it enters the papyrus swamps of the panhandle and then fans out into the distributaries and floodplains of the delta. There are three primary distribution channels (Thaoge, Jao-Boro and Maunachira-Khwai) and numerous smaller channels and floodplain areas. The delta is drained by the seasonal Thamalakane River which flows in a south-westerly direction through the town of Maun, and occasionally flows as far as Lake Ngami and into the Boteti river. However, only a small portion (on average 3%) of the inflow leaves the delta (Jacobsen et al., 2005). The waters, thus, take several months to reach the distal portions of the delta, finally reaching Maun only in the late dry season between August and October (Mendelsohn & el Obeid, 2004). As the floodwater arrives, the delta expands from about 5000 $km^2$ to between 6000 and 12000 $km^2$ in extent, depending on the size of the flood. Very little contribution is made by local rainfall, but in extremely high rainfall years (>800 mm per annum) rain-induced floods can occur (Wolski et al., 2005).

Table 5.1 shows the distribution of land categories in the Ramsar site, used in the hydrological modelling and in estimation of indirect use values. The delta consists of three major ecotypes: permanent swamp (channels and lagoons), seasonally inundated areas, and drier, higher land masses (Tawana Land Board, 2006). The latter are savannah habitats commonly known as the “sandveld tongues”, and are found in the southern and eastern delta. In addition, Chief’s Island is a large arid island in the middle of the delta. These islands are focal areas for tourism because of their wildlife, scenery and accessibility.

**Table 5.1** Size of the Ramsar site by different land categories (from Jacobson et al., 2005)

| | Land category | Area ($km^2$) |
|---|---|---|
| 5 | Water panhandle | 1,446 |
| 4 | Normally flooded area | 2,152 |
| 3 | Seasonally flooded | 2,328 |
| 2 | Occasionally flooded | 3,534 |
| 1 | Rarely flooded | 19,322 |
| | **Total delta** | **28,782** |

Within the Ramsar site, fish and wildlife are concentrated in the Okavango Delta. The Okavango Delta is a low nutrient/productivity system, with small local patches of higher production, and with a good diversity of macro and micro invertebrates, but no strong evidence of endemism i.e. species unique to the delta area (Scudder et al., 1993). The largest wildlife populations are found in Moremi Game Reserve. Lechwe are abundant totalling about 50–60,000 individuals. Some 20–30,000 elephants spend the dry season in the delta, their numbers having increased rapidly in recent years. In addition, the delta supports about 5000 tsessebe, 30-40,000 buffalo, 5–7000 giraffe, 20,000 impala, many sitatunga, small numbers of reedbuck, several hundred waterbuck and thousands of hippopotami. All large mammals except elephants are restricted in distribution by the veterinary fences which keeps them enclosed in the delta. Certain species such as lechwe, sitatunga, waterbuck, hippo and crocodile are largely confined to the permanently wet areas of the delta. Elephants are water-dependent but range widely throughout the area, resulting in human-elephant conflicts. In addition, over 500 species of birds have been recorded in the delta (Mendelsohn & el Obeid, 2004), including rare and endangered species such as Wattled Cranes and Pels' Fishing Owl. The densities of birds are relatively low, however, reflecting the low nutrient status and productivity in this ecosystem.

In terms of scenery and vegetation, the Okavango Delta comprises a mosaic of permanent waters, seasonally flooded open grasslands, woodlands and palm-fringed islands with forests. Lush forests line the river banks in the upper reaches, and the mid to lower reaches of the panhandle are dominated by papyrus *Cyperus papyrus* and *Phragmites* reeds. Below the panhandle, the perennial swamps are dominated by Papyrus and the *Phoenix* palm. The distribution of palms, which are slower to respond to change than papyrus, reflects the greater extent of the delta in the past e.g. along the Thaoge River. By the time the waters fan out into the main delta, they are depleted of much of their nutrient and sediment content, and the aquatic system is largely oligotrophic. Islands within the delta area contain dry land areas that are a combination of grasslands, forests, woodland and palms, as well as riparian trees. The delta is surrounded by mopane woodlands to the north east, dominated by the mopane *Colophospermun mopane*, and acacia woodlands to the south-west, which are characterised by *Acacia erioloba* and *Acacia tortilis* (Mendelsohn & el Obeid, 2004).

In recent years, increasing concerns have been expressed about possible local and external threats to the ecological functioning of the Okavango Delta. Locally, the growing population depends heavily on the natural resource base but meeting their needs for socio-economic development will increase their pressure on the ecosystem. Externally, proposed development projects in the Upper Okavango river basin in Angola and Namibia could also have adverse impacts on the Okavango Delta ecosystem. In addition, the possible implications of climate change for the Okavango Delta are poorly understood at present.

### *Population and settlement*

There are no up-to-date population figures specific to the upper basin in Angola, though the 1970 census has a figure of 300,000. The current population of Angola is estimated to be around 15 million, with an official growth rate of about 3% per year. 55% of the population lives in Luanda and other urban centres as a result of the Civil War in which many people migrated from the rural areas to the coastal cities. However, since the cessation of hostilities, some people are returning to the rural areas, which are estimated to have a population growth rate of the order of 1% per year (Huongo, 2007). There are also some proposals for Namibia to abstract water from the Okavango for domestic supply.

In Botswana, land is under three types of tenure, with Tribal Land making up 71%, State Land covering 23% and Freehold Land making up 6% of all land in the country. Within the Okavango Delta Ramsar Site, all but 4.6% of land is under Tribal Land tenure, the remainder being State Land; there is no Freehold Land in this area. Tribal Land is held in trust for communities by the Land Boards which are responsible for land administration. Usage rights are granted to Botswanan citizens either communally or to individuals, usually for residential purposes, ploughing or boreholes. These rights are typically passed on through generations. In addition, citizens and non-citizens can acquire 50-year leases for commercial and industrial developments; land cannot be sold, but the improvements or developments can.

The population of the Ramsar site is concentrated around the edge of the delta and along the main roads; there are a few small settlements within the delta. Most settlements are concentrated around the Panhandle, though half of the population is located in Maun. Of the approximately 67 settlements in the Ramsar Site, 54 have populations of less than 1000, and 11 of 1000–5000. There has also been a proliferation of ungazetted settlements (Tawana Land Board, 2006). Most people living in the area are rural and poor, and most households have a diversified production system aimed at reducing risks in an unstable environment. The importance of different activities varies between households and communities, and between seasons and years, in response to variations in rainfall, flooding, access to resources, labour and capital and other factors (Scudder et al., 1993). The main activities are dry land and flood recession agriculture, livestock, wage labour, a range of commercial activities, fishing, gathering and hunting (Scudder et al., 1993). Cattle keeping may not benefit more than 20% of the population (Campbell, 1976), but is preferred by most households who value cattle not only in terms of production but also for other reasons, including a means of saving and investment (Scudder et al., 1993). The tourism industry is the major employer of labour, with men being employed as polers, drivers, guides, camp builders and security guards, and women employed as maids, receptionists and in catering, cleaning and laundry (Tawana Land Board, 2006). Some villages (e.g. Ditshipi, Daonara, Seronga) have become centres for mekoro-based tourism.

### *Socio-economic activities*

In the upper basin in Angola, farming is carried out at subsistence level, with typical crops being sorghum and millet. There is some small-scale clearance of forested areas and some traditional slash and burn cultivation. With large-scale irrigation schemes, agricultural production could be increased, and commercial crops like maize and citrus fruit grown. The potential area that could be irrigated in the basin is estimated at 72,000 ha. There is also potential for commercial forestry which would be managed in a sustainable manner with replanting schemes, rather than converting the land to cultivation (Huongo, 2007). Upstream irrigation in Angola and Namibia could have a significant impact on the delta, reducing the area that remains flooded throughout the year by 40% in dry years and causing a risk of ecosystem deterioration. Angola and Namibia are participating in an assessment of the irrigation potential of the Okavango basin with support from SADC and ADB.

In the Okavango Delta, activities contributing directly to the economy include non-consumptive tourism, hunting tourism, household livestock production, household crop production, and household harvesting and processing of natural resource products. The economic values are overwhelmingly dominated by those generated by tourism, which takes place in the central zone, and which contributes 401M Pula annually to the GNP. 80% of the tourism value is from non-consumptive activities, and 90% is attributable to the wetland within the Delta. Agricultural pursuits take place mainly in the northern, western and southern zones, and contribute 42M Pula annually to the GNP. 90% of this is from livestock, and only 3% of it is derived from the wetland itself. Household harvesting and processing of natural resources also takes place in the north, west and south, and contributes 29M Pula annually to GNP, 53% of which is derived from the wetland.

The delta and the surrounding land contribute to the livelihoods of the people living there through profits (both cash and in-kind) from agricultural and natural resource use (99M Pula), through wages and salaries in the tourism sector (102M Pula), and from rentals and royalties in the tourism sector (25M Pula). The wetland contributes less than 3% of profits, but nearly all the wages and royalty benefits. Of the direct contribution made to the national GNP by the delta (472M Pula per annum) 31% accrues to low income elements of society. In the total (both direct and indirect) contribution made to the national GNP by the delta, this figure is lower, being some 18%.

***Upper basin development***

The other issue identified as a threat to inflows to the delta is potential upstream hydropower development. Immediate hydropower planning in Angola aims at meeting the immediate needs of the settlements along the river with several mini-hydro run-of-river schemes which will have no significant impact on the pattern of water, though in the longer term, larger dams may be constructed. Therefore, with environmentally sensitive operation, the potential dams in Angola with a combined storage approximately equal to the annual delta inflow, should not have a major impact on the waters of the delta. There is no net water consumption, and little water is stored in dry years, with correspondingly small releases in the dry period. The Ministry of Water and Energy is responsible for hydropower development, and their focus is on the Cuanza and Cunene rivers, rather than the Okavango (Huongo, 2007). Investigations of the feasibility of generating electricity through the construction of a small dam at Popa Falls in Namibia have also been carried out, but such a scheme does not appear to be regarded as feasible.

***Research***

In the past, many studies were carried out on social, economic, ecological and management topics related to the Okavango Delta. These studies have extended the collective understanding of the structure, functioning, and composition of the ecosystem components in the Okavango Delta, and broadened the knowledge of the ways in which local communities rely on the system for their livelihoods.

However, the understanding of the different ways in which the Okavango Delta system responds to changes in the external driving forces (principally related to climatic and hydrological features) and patterns of natural resource exploitation (driven mainly by ecological and social processes) remains incomplete. This is due to the fact that earlier studies followed individual research agendas, rather than forming part of a comprehensive and carefully co-ordinated research programme (Scanagri et.al., 2006).

Effective implementation of the Okavango Delta Management Plan (ODMP) requires information from two interdependent kinds of research. Experience elsewhere has shown that neither of these types of research are very useful when considered alone, and the correct management decisions need to be based on the deeper understanding provided by basic research. The two types of research are:

- Basic research in many different fields, as the basis for understanding the full range of physical, chemical, ecological, socio-economic and political factors that influence the interactions within and between society and ecosystem components
- Directed, management-orientated research that addresses focused "cause and effect" questions, that are essential for effective implementation of the ODMP

The hydrological model developed for the Okavango Delta (based on the MIKE SHE modelling framework) provides an efficient management tool for answering cause-and effect questions about the interactions between the hydrological, ecological and socio-economic functioning. This model needs to be finalised and adopted for routine management. In addition, the hydrological model will have very important implications for In stream Flow Requirement (IFR) studies at key points in the Okavango Delta, providing essential information for ecologists (Scanagri et.al., 2006).

## 5.2 Existing management plans

### 5.2.1 Angolan Water Sector Development Strategy

The challenge for sustained economic growth and poverty alleviation to meet the objectives of the EUWI and the MDGs in Southern Africa is closely associated with sustainable use of natural resources and better management of the environment. Water resource management is recognised as critical to development in the Upper Okavango, but the value of the data on which decisions are based is less well appreciated, with a decline in data collection and management in recent years. Consequences include a lack of real-time data for monitoring the progress of droughts and floods, and insufficient long-term data for the design of water-related schemes and for the integrated management of large multinational Okavango basin.

A more coherent approach to data collection and institutional reform are needed to acknowledge the importance of hydrometry and data management within, and by, the national hydrological and meteorological agencies in Angola and improve the current limited ability to collect the data needed for water resources management. The need for re-establishment of an adequate hydrometric network in the Upper Okavango, funded by the Angolan government and/or international donors, has been highlighted by the TWINBAS project.

The Water Sector Development Strategy prepared by the National Directorate of Water in Angola is based on the concept of integrated water resource management. It incorporates elements such as meeting basic needs for water, achieving food security, working with neighboring countries to achieve equitable access to shared water resources, preparing for and managing droughts and floods, using appropriate technologies, applying economic valuation to water, decentralising decision-making in the sector, involving users, and reforming institutions.

Under the water sector reform proposals, hydrological information gathering is to be improved by the formation of a Water Resources Institute, with financing being provided by a National Fund, which is provided for in the Water Law. For the management of water resources, a National Water Council is to be formed which will be an umbrella body for a decentralised structure of Catchments Councils which some regulatory functions and responsibilities (Huongo, 2007).

### 5.2.2 Okavango Delta Management Plan

As a response to these perceived pressures outlined in Section 5.1, the Government of Botswana developed the draft National Wetlands Policy and Strategy in 2001. The provisions of this policy, together with the specific obligations of the Ramsar Convention, require the Botswana Government to develop an integrated management plan for the Okavango Delta. Several other international treaties, regional protocols and national policies, statutes and plans provide additional emphasis on the need for such a management plan.

The existing diverse and complex nature of the Okavango Delta in terms of its natural resources, its wide range of users and uses, its multiple managers (both in and outside government and including communities), and an array of national laws, policies and guidelines, as well as regional and international conventions, agreements and protocols, are all factors that dictate the need and determine the context for an integrated management planning process for the delta.

The ODMP planning process started in 2003 and borrowed from the Ramsar Planning Guidelines and the Ecosystem Approach to wetlands management. The ODMP is anchored on

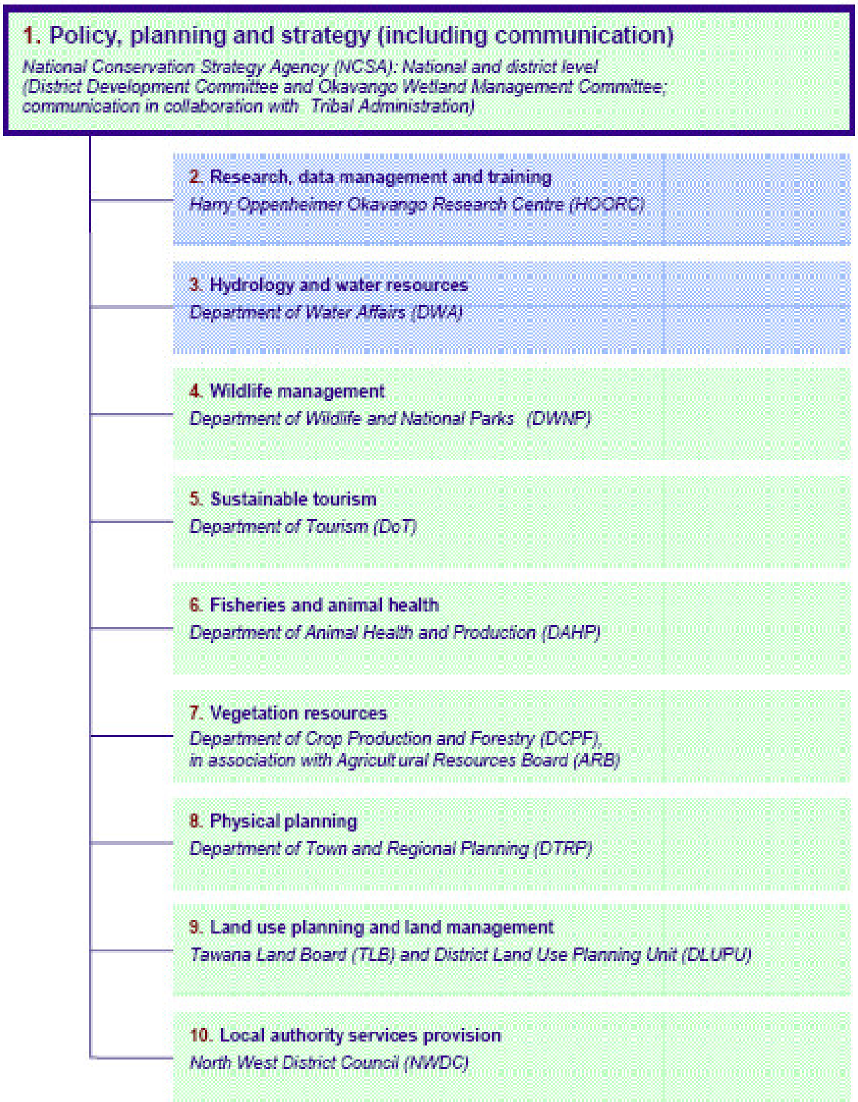


**Figure 5.3** Components of the Okavango Delta Management Plan

the main principle of strengthening ownership through accountability and the active participation of all stakeholders, both during the development and the implementation of the plan. The ownership of the ODMP process is premised on participatory mechanisms, association with international stakeholders, building partnerships at all levels.

The preparation of the ODMP has been organised in 10 components with the various relevant ministries responsible for implementation (Figure 5.3). The TWINBAS project has primarily contributed to two components, providing information and support for monitoring under the Research and Data Management component, and developing the main features of the Hydrology and Water Resources Component in close cooperation with Department of Water Affairs (DWA), as the implementing agency.

In order to address the risks, threats and expected impacts to the Okavango Delta ecosystem an ecosystem approach was used to categorise the management interventions into three thematic areas or subsystems of the ecosystem. This enables an integrated resource management planning approach by the various resource users and managers in implementing management interventions. The three subsystems are: institutional, physical and socio-economic (Table 5.2). The institutional subsystem entails the management infrastructure and associated tools; the physical includes the biotic and abiotic components of the ecosystem; and the socio-economic comprises different uses that man makes of the components of the physical subsystem, often referred to as the ecosystem products and services.

The strategic objectives were subjected to a strength, weakness, opportunities and threats (SWOT) analysis to determine operational objectives which are specific, measurable, achievable, realistic and timebound (SMART). These were in turn translated into action plans.

**Table 5.2** Thematic areas of the Okavango Delta Management Plan

| Overall Goal of the Okavango Delta Management Plan: to integrate resource management for the Okavango Delta that will ensure its long-term conservation and that will provide benefits for the present and future well being of the people, through sustainable use of its natural resources" | | |
|---|---|---|
| **Thematic Areas** | **Strategic Goals** | **Strategic Objectives** |
| Institutional | To establish viable management infrastructure and tools to sustainably manage the delta resources at local, district, national and international (River Basin) levels. | To establish viable management institutions for sustanaible management of the Okavango Delta ecosystem |
| | | To improve the regulatory framework for sustanaible management of the Okavango Delta ecosystem. |
| | | To raise public awareness, enhance knowledge and create a platform for information exchange and learning about the Okavango Delta ecosystem. |
| Physical | To ensure that the Okavango Delta (and its associated dry lands) continues to deliver present-day ecosystem services and products for the benefit of all organisms dependant on it. | To maintain and conserve the biotic and abiotic status of the Okavango Delta as well as their interaction |
| | | To maintain and restore the Okavango Delta wetland habitats and ecosystem |
| Socio-Economic | To sustainably use the delta resources for improvement of livelihoods of all stakeholders that are directly and indirectly dependent on the ecosystem products and services of the Okavango Delta (and associated dry lands) in an equitable way | To sustainably use the Okavango Delta wetland resources for the long term benefit of stakeholders dependant on it |
| | | To improve livelihoods of the Delta stakeholders through improved socio-economic opportunities |

*Monitoring and Evaluation Plan*

The implementation of the ODMP started in 2007. A Monitoring and Evaluation Plan (M&E) has been developed to track the implementation of the ODMP. The monitoring will be carried out at two levels: the first monitors implementation of outputs, and the second monitors changes at operational objective level. Within the context of the Government planning structure, the M&E equates to a performance measurement tool, as usually accompanies strategic plans.

In the Okavango Delta Ramsar site, the term "water management" covers a far wider array of issues than merely dealing with water abstraction from the system and ensuring that water supplies can meet the needs of people. Indeed, the fundamental role of water in all physical, chemical, ecological and social processes makes water management a central issue to the management of every issue in the entire Okavango Delta. Typical water management questions that need to be answered by the organisation responsible for managing the Okavango Delta Ramsar site include:

1. How can the water needs for upper and lower catchment users be balanced, while at the same time securing the ecological integrity of the Okavango Delta?

2. What are the potential impacts of proposed water development schemes in the upper catchment on the ecological and socio-economic functioning of the Delta?

3. What are the potential impacts of climate change on the ecological and socio-economic functioning of the Delta?

4. How can people's conditions and activities in the Delta and the ecosystem sustainability be balanced?

5. What are the implications of possible future flooding patterns for the positioning of communities and their agricultural activities?

6. What are the hydrological processes that determine or control the functioning and the biodiversity of the Delta ecosystems?

7. What are the impacts of vegetation and wildlife on water flow and water quality?

8. What are the impacts of the socio-economic system on water flow and water quality e.g. land use and water management strategies?

9. What are the impacts of changes in flooding behaviour on the socio-economic system e.g. settlements, water supply and sanitation, land-use, livelihoods, and tourism?

10. What are the impacts of changes in flooding behaviour on the functional biodiversity of the ecosystem and species habitats?

The hydrological model developed under ODMP and based on the MIKE SHE model provides an integrated and physically-based distributed description of all important surface and subsurface processes occurring in the Okavango Delta (DHI, 2005). The model represents the state of the art in integrated and distributed hydrological models and offers a robust modelling framework for quantitative descriptions and predictions of the Okavango Delta hydrology (Scanagri, 2006). Furthermore, the model offers user-friendly input-output facilities that facilitate using the model for management purposes and for presenting results to professionals, managers and stakeholders.

However, information on water quantity as well as water quality is needed for effective management of water resources. The model development carried out under the present stage of the development phase of ODMP only allows for predictions of water quantity and sediment transport, and a water quality module should be included as well.

The model is essential not only to water management for human purposes, but also for the the wildlife and vegetation that depend on water in the Okavango Delta. Based on the existing availability of input information, the current version of the model has a spatial discretisation of 1 $km^2$. This is suitable for overall water management, but not for management of wildlife and vegetation, which needs information at a much smaller scale. Future development of the model also needs to bear this in mind so that it can use data and information at a finer scale and provide this type of information for selected areas of the Okavango Delta where monitoring of vegetation and wildlife is essential.

***Management Plan Implementation Strategy***

The implementation of the ODMP is being coordinated by the Department of Environmental Affairs (DEA) through an integrated approach in order to optimise the use and management of resources. The ODMP recognises the current sectoral mandates and, while it seeks to maintain them, it accords prominence to the seemingly subdued elements of integration which are fundamental to the overall objective of the ODMP.

The implementation will further be strengthened by the presence of DEA in Maun to service the Ngamiland District in terms of its mandate, including the coordination of the implementation of the ODMP. With respect to the sectoral responsibilities outlined in the action plans, the current institutional arrangements still hold. The ODMP makes an attempt to recognise the institutional inadequacies which may hinder implementation and appropriate objectives are formulated to address these. It is proposed that implementation of the ODMP be guided by the Okavango Wetland Management Committee (OWMC) which is a district multi-sectoral structure set up during the development of plan. The establishment of the OWMC is provided for in the Draft National Wetlands Policy of 2001. This committee, like any other committee in the district, should be answerable to the District Development Committee.

In Angola, poor institutional arrangements continue to retard the advancement of sustainable water resource development and management (Huongo, 2007). The challenge in the upper basin is to foster effective coordination and collaboration among and between the diverse groups of stakeholders involved in the management of the basin at various levels. A critical activity to be enforced under the ODMP is, therefore, to engage the relevant authorities in Angola and Namibia in the basin-wide planning process under the OKACOM and within the Okavango Basin-wide forum.

## 5.3 Contribution to the river basin management planning process

TWINBAS has contributed substantially to providing the scientific and managerial foundation to reach the strategic objectives of the ODMP. The Integrated Hydrologic Model (IHM; DHI, 2006) has been developed and implemented in a Hydrological Modelling Unit within the DWA in their headquarters in Gaborone. Staff at the unit have been trained to be able to maintain the model and use it during the further implementation of the ODMP. Copies of the model have also been set-up at the DWA Office in Maun for their use in collaboration with the local ODMP Secretariat in Maun.

The IHM has been run to simulate present development conditions in the delta, and development conditions considered to constitute the major risks and pressures in a range of water resources development scenarios in the delta and the basin upstream, namely surface and groundwater abstractions from the delta, upstream water resources developments in the form of dams and irrigation schemes in Angola and Namibia, and regional climate change. These scenarios represent possible conditions in the basin, notionally in the year 2025, and are compared against the present conditions which serve as a baseline (DHI, 2005).

***Hydrologic inputs***

While the existing conditions and the scenario conditions may represent static development states in the basin, the basin is hydrologically dynamic, with variations in the rainfall and other climatic parameters, surface inflows and outflows, and storage changes both seasonally within one year, and over several annual cycles. In order to analyse the impact of the scenarios, representative hydrological input data have to be selected. The long term inflow in terms of volume per annum from 1933 to date is shown in Figure 5.4 for both Mukwe in Namibia and Mohembo in Botswana.

The period from 1992 to 1997 represents the sequence of the five lowest inflow years and is, therefore, chosen to provide the input data to analyse the impacts under critical conditions, for both the existing state and possible future states with water resources developments. The subsequent 5-year period, from 1997 to 2002, represents relatively normal hydrologic conditions in the delta, and has been used to assess how the delta may recover after a sequence of dry years. A high inflow period will also be selected e.g. 1987 to 1992, to assess the impacts under high inflow conditions.

***Water resource development scenarios***

The flooded area of the Okavango Delta is the parameter most sensitive to water resource developments, revealing individual rainstorms and delays in the timing of the upstream flood wave. It is possible to express the distribution and impacts on the flooded area using 1 $km^2$ grid-based maps (Figure 5.5), animated sequences showing the dynamic spatial variation, time series showing the variation in each of five zones within the delta, and summary tables, as preferred by stakeholders. Impacts on the flooded area from the scenarios investigated can be briefly summarised as:

- Present surface and groundwater abstractions from the delta are minimally significant, amounting to 0.25% of the inflow. The upper envelope of flooding in the normal years i.e. the area that may be flooded, is decreased by 68 $km^2$, or 0.5%.

- The potential dams in Angola with a combined storage approximately equal to the annual delta inflow have little impact. There is no nett water consumption, and little water is stored in dry years, with correspondingly small releases in the dry period.

- Upstream irrigation in Namibia and especially in Angola has a significant impact. The lower envelope of flooding i.e. the area that is permanently flooded, is reduced by 38%.

- Projected climate change has the most severe impact, reducing both inflows from upstream and rainfall over the delta, and increasing temperature and the rate of evapotranspiration. The lower envelope of flooding is reduced by around 55% in both dry and normal years (Figure 5.6).

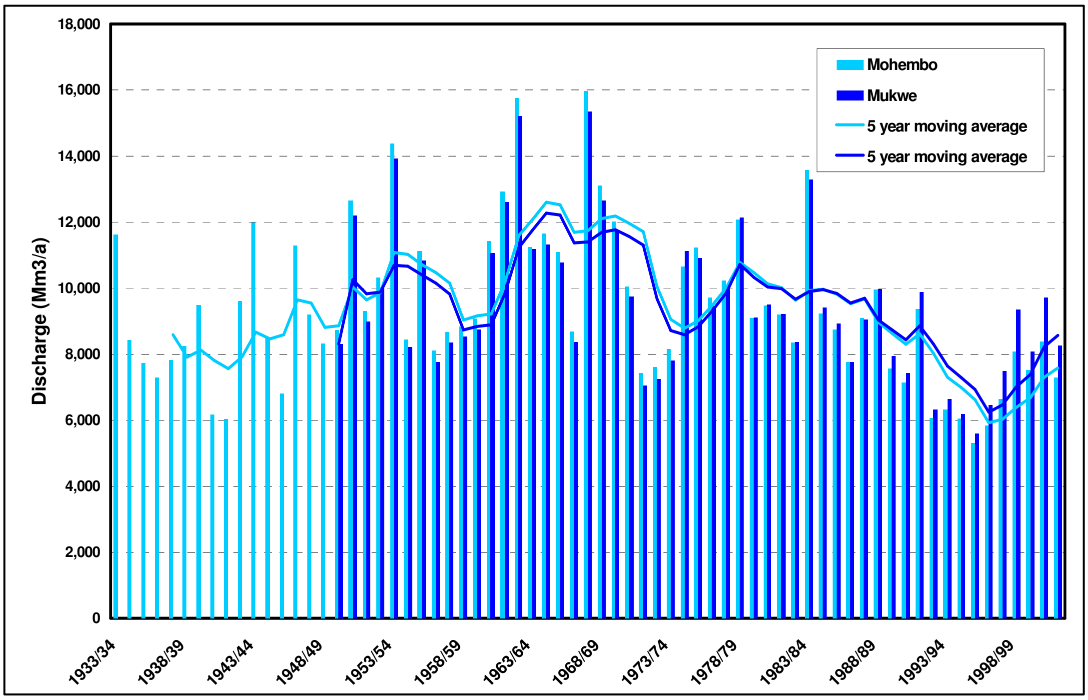


**Figure 5.4** Long-term inflows to Okavango Delta

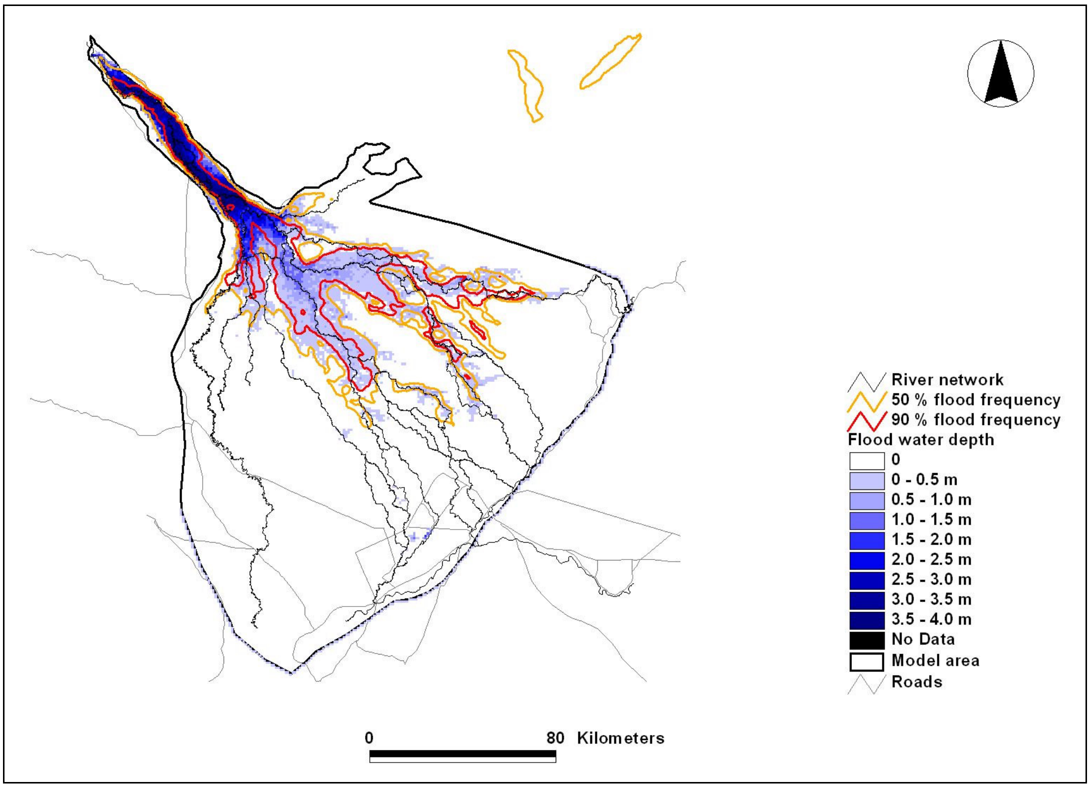


**Figure 5.5** Calibration against maximum flood extent (May 2001)

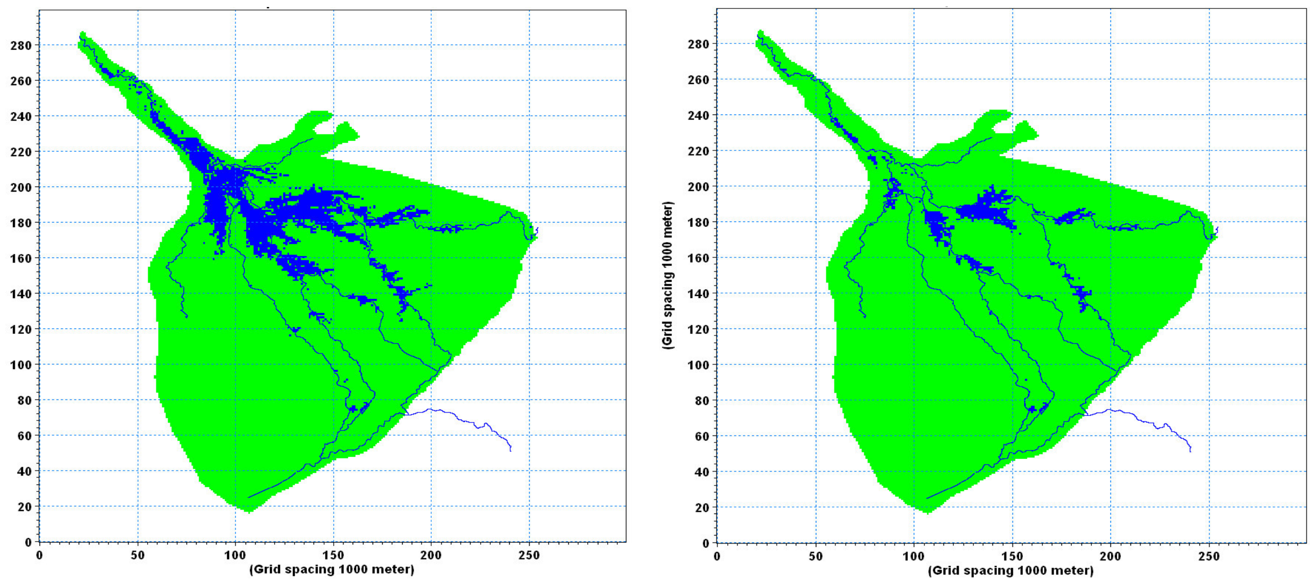


**Figure 5.6** Lower envelope of flood extent for baseline (left, 2770 km2) and climate change scenario (right, 900 km2) for the 1992-1997 dry period

***Priorities for protection***

The fundamental objective for protection of the Okavango Delta is the preservation of the unique biodiversity. In hydrologic terms, this biodiversity is primarily dependent on the inflows from the basin upstream, and the delta climate. Efforts, therefore, need to be directed to limit the artificial reduction and change in the pattern of the inflow, and to the extent possible climate change.

While water shortages are a constraint to the human and economic development of Botswana, and the delta represents the major of only two perennial surface water sources, Botswana has been wisely restrained in exploiting the water resources of the delta. This needs to continue, setting an example to the upstream riparian users, and winning the support of the international environmental community.

***Opportunities and constraints***

For the integrated analysis of the various sectoral issues, the results of the IHM showing the areas, depth and timing of the surface and subsurface waters can be overlaid with the other distributed information in the Okavango Delta Information System set up at Harry Oppenheimer Okavango Research Centre. The issues and concerns of the Ecology and Socio-Economic ODMP components in relation to Hydrology are summarised as follows:

***Ecology***

- **Sustainable Wildlife Management** is concerned about the spatial and temporal distribution of water in conjunction with settlements, wildlife and vegetation to help deal with the conflict between humans and wildlife.
- **Vegetation Resources Management** is concerned about the water distribution to predict the soil moisture for the species and distribution of the vegetation utilised by wildlife. High prolonged floods may limit biodiversity owing to water logging. Model results may also be used to assess the spread of alien, invasive species, to study bush encroachment as the delta

shrinks, and to study the distribution and spreading of fires. Scenarios on blocking and clearing channels can be used in an environmental impact assessment of the proposed deployment of weed clearing machinery.

- **Fisheries** are concerned about the flow patterns and flood extents in studying fish dynamics. Fish inhabit shallow and deep water: floodplains are breeding grounds for fish, and as the water recedes they move back into deeper water. The scenarios on blocking and clearing channels can also be useful. Fisheries would also like to see water quality included in the IHM.

***Socio-Economic***

- **Physical Planning** is preparing a development plan for Shakawe in the panhandle, and is concerned about the area liable to flooding. Shakawe has an area of 58.6 ha, well below the minimum 1 $km^2$ resolution of the IHM. Therefore, at this stage of development, the model can only provide an indication of the water levels and flood extent in the vicinity of Shakawe and other settlements in the delta.
- **Sustainable Land Management** is preparing a land use plan for the delta, and is concerned about the availability of surface and subsurface waters. Satellite observations are only available from 1984, and there may be limitations with respect to the IHM results with regard to delineating flood extents for low probability events (e.g. 50 and 100 year return periods). Baseline and scenario flood frequencies (from 15-year run periods) will be compared. In terms of groundwater, the IHM can give a general indication of the depth below the delta, but for detailed studies, finer grid groundwater models of local areas are required, together with detailed borehole information.
- **Tourism** is concerned about the density and distribution of lodges in the delta. The flow patterns for the baseline and scenarios, overlaid with the location of the lodges, will assist in determining the carrying capacity, particularly with respect to pollution from sewage and waste from lodges. However, neither surface nor groundwater quality is planned to be incorporated in the IHM at present, though the technology is available.

# 6. Thames

## 6.1 Issues in the Thames River Basin

The Thames River basin covers an area of 13,000 km$^2$, representing some 4% of the area of the United Kingdom (Figure 6.1). However, it houses a population of over 12 million people (one fifth of the UK's population), and generates more than a quarter of the Gross National Product (GNP). Land use in the basin ranges from predominantly rural, agricultural land in the west, to heavily urbanised in the east. There are 5330 km of main river and 896 km$^2$ of floodplain in the basin, which is rich in rivers, canals, lakes and flooded gravel pits, many of which are home to a range of wildlife. The Thames basin receives an average of 690 mm rainfall per year, compared with a national average of 897 mm, making it one of the driest parts of the UK. The demand on land and water for homes, offices and other developments creates intense pressure on the natural environment and stress on the basin's water resources and waste disposal capacity. During Summer months when there is already no surface water surplus for approximately 80% of the basin. For groundwater sources, approximately 50% of the basin has no surplus. With the increases in water demand associated with the forecast growth in both basin population and number of households, and the predicted impacts of climate change, effective and sustainable management of the basin's water resources is becoming increasingly important (Defra, 2005a).

Environmental management responsibilities in the Thames basin are split between several organisations which all have a slightly different environmental focus. The principal one is the Environment Agency, who works with the Department for Environment, Food and Rural Affairs (Defra), the Government body responsible for implementing the WFD in the UK. The Environment Agency also works in partnership with a wide range of other organisations and stakeholders towards the common goal of sustainable development. Stakeholders with an interest in, or who are affected by water, include regulators, public authorities, government agencies, professional bodies, local organisations and members of the public.

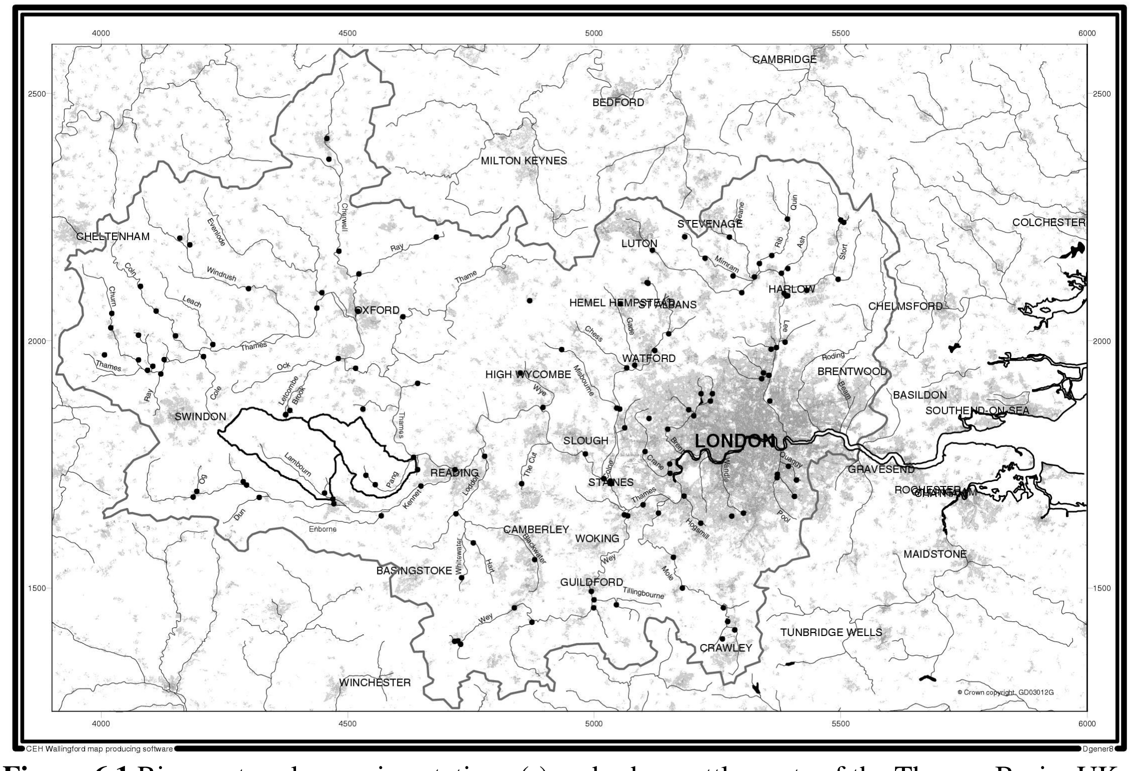


**Figure 6.1** River network, gauging stations (•) and urban settlements of the Thames Basin, UK

The Environment Agency advocates a "toolkit" approach to stakeholder participation, with a range of methods available to be used as appropriate for the degree of concern in different locations and the breadth of key issues (Environment Agency, 2005b; WP3, 2007). Through this, the Environment Agency plans to ensure that all its diverse stakeholders are able to contribute effectively by helping them understand river systems and how these systems affect their interests, as well as being clear about how and when decisions are made and where their input informs the decision-making process. By bringing all stakeholders together, they can understand how their often conflicting demands can often not always be fully met given natural water availability and, thereby, provide a structured framework for negotiated compromise settlements. Through extensive consultation, stakeholders are fully involved in all stages of the river basin management planning process (Environment Agency, 2005a). A focal point of the Environment Agency's approach is their comprehensive website[3] which contains much useful information about key issues in the Thames basin and implementation of the WFD, as well as details of all open consultations.

## 6.2 Existing management plans

River basin management has been practised in the Thames basin since the formation in 1974 of the former Water Authorities with responsibility for water supply, land drainage and flood prevention, and effluent disposal and pollution prevention. The 1989 Water Act split the suppliers of water and the policers of water from each other, with the formation of the privatised water companies (water utilities) and the National River Authority. In the Thames basin, water supply and sewaerage are provided by Thames Water. The conduct of the water companies is overseen by a regulatory body called Ofwat. The National River Authority extended its remit to cover the whole environment, rather than just rivers and, with the addition of the drinking water and air pollution inspectorates, became the Environment Agency in 1995.

Table 6.1 lists current water management plans lead by the Environment Agency (EA) and others. There has been a significant improvement in river water quality in the UK, particularly over the last decade since the formation of the Environment Agency. However, water quality objectives set throughout this period tended to be use-based and were not statutory and, furthermore, economic and social aspects were not a part of the river basin management process. The new disciplines and approaches imposed by the WFD will improve the river basin management processes already carried out by the Environment Agency (FWR, 2004).

In the Thames River Basin, the active involvement of stakeholders in WFD implementation began with a public consultation process that preceded the incorporation of the WFD into law. Respondents to this process, and other notable stakeholders, were invited to join a national Stakeholder Group to act as a sounding board on implementation issues. In 2006, the Environment Agency started a three-stage stakeholder consultation[4] about the river basin planning process, which will create a wider awareness of the challenges facing the water environment and the ways in which they can be tackled. The ***Working Together*** consultation will be followed by the ***Significant Water Management Issues*** consultation and completed by the ***Draft River Basin Management Plan*** consultation, with the aim of producing a first RBMP for the Thames basin in 2009. Other relevant documents are the ***Framework for River Basin Planning*** (Environment Agency, 2005a) and ***River Basin Planning Guidance*** (Defra, 2006).

[3] www.environment-agency.gov/uk/regions/thames
[4] Consultation open at http://wfdconsultation.environment-agency.gov.uk/site/questions.asp?CID=20

**Table 6.1** Existing water management plans in the Thames River Basin (from Defra, 2002)

| Type of plan | Main bodies involved | Purpose |
|---|---|---|
| Local Environment Agency Plan (LEAP) | EA & others | Consultation on environmental improvement for local area |
| Catchment Abstraction Management Strategy (CAMS) | EA, water companies, other abstractors | Sustainable use of water resources within a catchment area |
| Water resource management plan | Water companies, EA, water regulator (Ofwat) | To ensure that water companies can meet long-term water resource needs |
| Shoreline management plan | Defra, Maritime Local Authorities, EA | Strategic planning for coastal defence |
| Drought plan | EA, water companies | Maintaining public water supplies & protecting the environment during severe droughts |
| Water Resources Strategy | EA & others | Framework for planning & managing water resources until 2025 |
| Integrated Coastal Zone Management Plan (ICZM) | Local Authorities, EA & others | Balancing flood defence needs with other coastal activities |
| Estuary Management Plan (a type of CZMP) | English Nature, EA & others | To link management of estuaries for conservation with other needs/uses |
| Water Level Management Plan | EA, English Nature, Internal Drainage Boards | Balancing/integrating the water level requirements for particular inland areas |
| Catchment Flood Management Plan | EA lead | To develop a holistic approach to flood management |
| Habitats Directive – Management Schemes for European Marine Sites | English Nature, EA & others | Management of marine Habitats Directive sites |
| Coastal Habitats Management Plan (CHaMP) | EA, English Nature, Defra & others | Balancing coastal defence needs and conservation objectives at Habitats Directive sites |
| Biodiversity Action Plan/ Local Agenda 21 Plan | Many bodies | Improving biodiversity through implementation of Rio Convention etc |

The three priority basin-wide issues identified in the Thames basin in the associated action efficiency report (WP9, 2007) concerned the future water resource supply, particularly during drought events, flood risk and water quality (Environment Agency, 2001). The remainder of this Section considers examples of some of the existing management plans in the Thames basin relevant to these issues.

***Water resource supply***

Proposed actions and impacts from the Environment Agency's 5-year plan (2006) to address the issue of water resource supply now and in the future require the Environment Agency to continue to work closely with the public to use water more efficiently, and with water companies to meet the water demand needs of both people and the environment, control leakage and develop new resources as necessary.

***Catchment Abstraction Management Strategies*** (CAMS) are 6-year plans for the management of water resources at a local level (Environment Agency, 2002). They inform the public on water resource and licensing practices, provide a consistent approach to local water resource management, help balance the needs of water users and the environment, and involve the public in managing the water resources in their area. In the Thames River Basin, twelve CAMS (out of 14) are already completed or are currently being developed and/or in consultation phases. During the 6-year period between CAMS reviews (coincidentally the same as that for revision of RBMPs under the WFD), new abstraction licences may be issued and changes to existing licences may be made which, in some catchments, could result in a change in water resource availability.

The 2005-2006 drought in south-east England was a timely reminder that water resources in the Thames basin are already under stress, with little surplus in the basin to cover extreme events. In April 2007, following a consultation period, the Environment Agency published its ***Drought Plan for Thames Region*** (DP; Environment Agency, 2007a). The regional DP provides a structured and flexible framework to deal with droughts of different types and severities, and sets out a system of monitoring and reporting to identify and track the onset and progress of droughts. The DP outlines the Thames region's drought management structure, the drought monitoring that will be undertaken by the regional drought team, the drought management actions that the regional drought team may need to take and the triggers for these actions, how the regional drought team are involved with drought permit and drought order applications, the Thames region's drought communication actions, and how the Thames region will report on drought. Within the Thames region, there are separate drought plans for the south-east, north-east and west areas, setting out local management actions. Water companies, the largest abstractors of water in the Thames basin, must also develop ***Drought Management Plans*** addressing what measures the water company might need to take to restrain the demand for water within its area, what measures the water company might need to take to obtain extra water from other sources, and how the water company will monitor the effects of drought and of the measures undertaken under the drought plan (Thames Water, 2006a).

Thames Water is the principal provider of water services in the Thames River Basin. To meet the demand forecast for 2020, Thames Water predicts that it will need to develop new resources, as well as tackling leakage and encouraging customers to use water more efficiently. The London area and the Swindon-Oxford area are at particular risk of "running out" of water, with an extra 280 ML per day and extra 60 ML per day, respectively, needed in 2030 (Thames Water, 2006). Possible solutions under consideration include metering properties on change of occupancy, enhanced water efficiency (old and new technology), water saving from new build designs, leakage reduction (proactive, seeking out leaks, rather then reactive), groundwater development, aquifer recharge, and a dual function reservoir (water supply and environmental flow support). In the London area, additional proposals include desalination in the Thames estuary and indirect use of treated wastewater.

In the Swindon-Oxford area, additional proposals include a new reservoir to the south-west of Abingdon, south of Oxford (Figure 6.1). To date, two stakeholder consultations on the proposed ***Upper Thames Major Resource Development*** (UTMRD; Thames Water, 2006b) have taken place. Stage I (which finished in November 2006) set out how much water Thames Water predicts it needs for the future, what options it has looked at to meet this need, and the possible location of a reservoir. Stage II (which finished in March 2007) considered the conservation, landscape, impact of construction and after-use of its proposed reservoir site. The Environment

Agency, as the major stakeholder, has responded robustly in line with its role to review the need for new resources, to ensure that Thames Water has considered all the appropriate options including demand management, leakage reduction and better use of resources, and to evaluate the possible options and consider the environmental impacts and social costs and benefits.

***Flood risk***

Proposed actions and impacts from the Environment Agency's 5-year plan (2006) to address the issue of flood risk now and in the future require the Environment Agency to work closely with planners and developers to ensure that inappropriate development in the floodplain stops, and that it can be used as a storage area for flood waters as is its natural purpose. New planning policy guidance (CLG, 2006) is intended to control floodplain development. The Environment Agency must also continue to improve its own systems for flood warning, and to maintain existing flood defences and build new ones as necessary.

In January 2007, the Environment Agency opened a 3-month consultation on the ***Thames Region Catchment Flood Management Plan*** (CFMP; Environment Agency, 2007b). The CFMP provides an overview for managing the long-term flood risk in the Thames basin over the next 50-100 years, and will be used to identify and agree policies for sustainable flood risk management when working with other organisations and decision-makers.

The CFMP has four main messages which form the basis of the approach to managing flood risk in a sustainable way and for the whole of the basin, namely that: flood defences cannot be built to protect everything and future management will focus increasingly on the consequences rather than the likelihood of flooding; climate change will be a major cause of increased flood risk in the future; the floodplain is the most important asset in managing flood risk; and development and urban regeneration provide a valuable opportunity to manage flood risk. The CFMP identifies six different types of floodplain in the Thames basin: undeveloped natural floodplain, developed floodplain with no built flood defences, developed floodplain with built flood defences, developed floodplain with typically concrete river channels, major urban expansion in or close to floodplains, and narrow floodplains and mixed land use. Each of these floodplain types have different characteristics that require different measures for managing the flood risk, presented in strategic action plans.

The city of Oxford, on the Thames in the upper part of the basin (Figure 6.1), falls into the "developed floodplain with no built flood defences" category. The Environment Agency began a detailed study into the causes of, and potential solutions to, flooding in Oxford after floods in December 2000 affected around 160 properties. Further floods in January 2003 affected some 250 properties. In total, 2500 properties throughout the Oxford floodplain have been identified as at risk of flooding. In June 2005, following an investigation of the causes of flooding and recommendations for possible solutions, the Environment Agency opened a consultation on the ***Oxford Flood Risk Management Study*** (OFRMS; Environment Agency, 2005c). Preliminary testing ensured that short-listed solutions offered the potential to be cost-effective, technically achievable, and not damaging to the environment, and work well either as stand-alone schemes, in conjunction with each other, or in combination with additional complementary measures. The OFRMS outlines the short-listed options now undergoing intense scrutiny, feasibility testing and impact assessment, scheduled to be completed in 2009. Assuming Government funding for the preferred scheme is forthcoming, and allowing time for a public enquiry and any necessary planning approvals, the scheme to protect Oxford from flooding could be completed in 2015.

***Water quality***

Proposed actions and impacts from the Environment Agency's 5-year plan (2006) to address the issue of water resource supply now and in the future are in two main areas: waste water treatment and agriculture. The actions require the Environment Agency to work closely with water companies, developers and farmers to reduce point and diffuse pollution problems from urban and rural runoff and waste water throughout the basin.

A good example of management plans to improve water quality and quantity is provided by the recent chalk catchment studies in the Pang, Lambourn and Kennet tributaries of the Thames (Douglas, 2006; NERC, 2006; Environment Agency, 2004). In these catchments, groundwater is an important source of water, and Winter rainfall is important to top up aquifers and maintain low flows in streams in Summer. However, in recent years, several streams have dried up in Summer, and fish and plants have been adversely affected. In 1995, much of the Kennet was designated as an SSSI, but environmental pressures have caused a serious decline in recent years and reduced its ability to support its accustomed range and abundance of wildlife, including some rare and vulnerable species. It is believed that changes in land use and agricultural practices have altered the patterns of movement of sediments and chemicals.

The ***Kennet Chalkstream Restoration Project*** started in 2004 to restore the clarity of the river and to enhance its value to wildlife and as a recreational fishery (Environment Agency, 2007c). In addition, the project will take account of current legitimate uses of the river, its tributaries and the Kennet and Avon canal, and the project team includes a range of stakeholders from the EA and appropriate external bodies. The project is about achieving real improvements and is designed to embrace and enhance current actions as well as to develop new ideas, and is based on ten work areas designed to respond to the main pressures on the river: land use, habitat restoration, canal/river interface, canal management, alien species, CAMS, effluent discharges, built development, structures and river management.

The land use work area involves support and develop programmes to tackle the issue of diffuse pollution of silt and nutrients from land use and agriculture. A Diffuse Pollution Officer has been appointed to work on the Kennet, Pang and Lambourn Valleys Countryside Project, managed by the Farming and Wildlife Advisory Group. The officer will deliver on-farm advice to farmers and landowners and help them apply for agri-environment schemes with the aim to reduce the impact of nutrients and sediments to all three rivers. The canal/river interface work area aims to resolve issues over water resources and silt resulting from the complex interaction between the Kennet river and the Kennet and Avon canal. The Environment Agency have begun to identify ways of reducing the impact that the canal has on the river, concentrating on the area where the river and canal first meet, with the aim of identifying the sources of problems, and identifying and cost engineering and canal/river management options. The Environment Agency has established a wide range of automatic water quality monitoring sites at strategic sites on the Kennet, measuring a range of parameters including turbidity (water clarity), chlorophyll, temperature and dissolved oxygen, to monitor the current condition of the river and provide information that may influence the work programmes, but also to monitor the effectiveness of these two current actions.

## 6.3 Contribution to the river basin management planning process

Given the advanced state of river basin management and the abundance of management plans in the Thames River Basin, and the wholehearted implementation of the WFD by the Environment Agency, a relatively small STREP project like TWINBAS has had little influence on progress towards RBMPs for the Thames basin. However, as basin stakeholders, individuals at CEH-W, and CEH-W as an organisation, have many opportunities to comment on and contribute to the numerous consultation exercises conducted by the Environment Agency.

Instead, the Thames has very much contributed to TWINBAS by demonstrating good practice in order to encourage improved management approaches. The other partners can evaluate how the UK methodologies for implementation of the WFD need to be adapted to their particular basin and circumstances. The pioneering work on water body classification in the Biobío and Nura basins, both based on the approach taken in the Thames basin, are excellent examples of this kind of transfer of knowledge.

# 7. Summary and recommendations

The WFD aims to establish a holistic approach to managing the water environment, based on river basins, and integrating water quantity with quality considerations, the latter based on an ecological classification system. River basin management plans (RBMPs), which set out specific objectives and the measures to achieve them, are the key planning documents to achieve this aim. The stages in the implementation of the WFD and the development of RBMPs can be summarised in five steps (FWR, 2004): identifying the water bodies that comprise the river basin district and the pressures upon them, establishing the environmental objectives that signify good status for each water body, setting-up a monitoring programme to measure water body status, establishing and implementing a RBMP and a programme of measures to achieve and maintain good status, and finally, reviewing and updating the RBMP and the programme of measures to take into account any change of circumstances. The first RBMPs, which must be established by the end of 2009 indicating the quantity and quality objectives to be achieved by 2015, are the first cycle of the river basin planning process. Their periodic updating, every six years, is a refining process based on improved data and understanding, and allowing for changes of circumstances in the river basins (FWR, 2004).

Adaptive management such as this is regarded as especially appropriate for situations where significant risk may be present, such as the risk of basin water bodies not achieving good status due to anthropological and other pressures, but requires the collection and analysis of extensive amounts of data and information, which may be difficult in countries where institutions are weak and resources are limited, making this type of approach particularly challenging in developing countries (Boesch et al., 2006). Hence, the efforts made in the TWINBAS project by the very different basins in Chile, Kazakhstan and Southern Africa, are the more highly commendable. The progress described in this report and the outcomes summarised below serve to demonstrate that the WFD does provide an approach for integrated water resource management that can be adapted and implemented in very different circumstances.

***Biobío***

The organisation of Chilean water institutions has, to date, not facilitated an integrated management of water, soil, vegetation and environment, and management of water resources has been based mainly on the quantity of the resource available, and not also on the quality of the resource. The main contributions to RBMP development derived from the TWINBAS project in the Biobío River Basin have been in the form of inputs to agreements for the establishment of water quality standards, though biological standards are less advanced than others in this respect.

Other issues of concern relate to the future institutional and administrative arrangements for the management of the river basin, and the degree of stakeholder involvement in this process. The e existing Water Code (Código de Aguas) requires urgent revision regarding the allocation of water rights and the expiry of such rights, as this problem has the potential to significantly and negatively impact on river flows in the basin in future years.

Many lessons can be learned from the TWINBAS project, not least that it is not sufficient to continue to fund institutions motivated by purely academic and commercial objectives who may develop territorial, political or geopolitical ambitions, and may not endorse adapted instruments from the governmental political level. Instead, both local and national partnership projects, fully involving all basin stakeholders, are necessary to achieve sustainable development and management of the river basin, supported by a high-level political impetus. The National Strategy for Integrated Management of River Basins is a major first step in this direction.

***Norrström***

Up to the formation of the DWA, the management of the Norrström River Basin was fragmented. Six County Boards were responsible for different parts of the basins, and the municipalities had the major practical responsibility for measures and water quality. The Swedish EPA defined environmental goals and classification systems for water quality parameters, including nutrients, on a national level, but a lack of monitoring data and funds for measures at regional and local levels (e.g. County Board and municipality level), in many cases prevented measures that would result in acceptable or good water standards. The exception to this was the domestic treatment plants, the majority of which were upgraded to an advanced level during the 1980s, although nitrogen treatment is sometimes still insufficient.

Theoretically, this situation was improved by the formation of the DWA (as one of five Swedish districts) which has authority over a somewhat larger area than the Norrström basin itself. In practice, however, little improvement has and will be achieved. A lack of funds reserved for the water authorities by the Government has caused serious delays in the WFD tasks to be carried out by the authorities. In particular, the acute deficiency of resources has resulted in a continued lack of monitoring data and high-quality modelling data. The programmes of measures soon to be formulated will most likely be based on a relatively weak information base, with large gaps in the information relating to pollution pressure and source apportionment, and maybe even more importantly, gaps in information regarding ecological status, the cornerstone of the WFD, as well as in knowledge on cost-effectiveness of the proposed measures.

Furthermore, the DWA has indicated that it may leave the responsibility to identify and fund measures to reduce nutrient leaching from agriculture to the Swedish Board of Agriculture, who is currently responsible for support to the agricultural sector, including support for environmental measures. Consequently, the present fragmentation of responsibility would prevail, and support to measures reducing the largest part of the nutrient pollution would still be based on the very general countrywide support provided through the EU Common Agriculture Policy, instead of addressing the actual needs, problems and ecological status in each water body and river basin. By these circumstances, the fundamental idea of the WFD would be disregarded.

An additional problem is that, with the level of autonomy that the Swedish municipalities have, any directive given by the DWAs addressing pollution for which municipalities are responsible, could be disregarded if the municipalities do not have the financial means to implement the relevant measures. The legal means for the DWA to enforce municipality actions are weak. In fact, since the municipalities, including powerful actors like Stockholm, Gothenburg and Malmö, were denied representation on the Boards of the DWAs, they are not participating in the current WFD process, and may be reluctant to carry out measures given by the DWAs.

From the research perspective, taking an objective view on water management, there is an evident need for an independent review of whether Sweden's and the other Member States' practical implementation of the WFD actually follows the intentions of the WFD and enables qualitatively adequate analyses of pollution pressure, ecological status assessment and development of well-funded programmes of measures. The approaches developed in TWINBAS, REFCOND and other WFD-related EU projects provide usable methods in many areas but, in practice, there is an impending risk that the level of ambition in the implementation of the WFD will not reach an acceptable level. Thus, programmes of measures may for many river basins be sub-optimal and inadequate.

***Nura***

There is a low level of sustainable water resource management and planning in Kazakhstan. The key issues that need to be addressed if the water resources of the Nura River Basin are to be sustainably managed are:

- Development and implementation of a legal and institutional framework to give River Basin Authorities (RBOs) the powers and responsibilities to develop, implement and monitor water basin management plans
- Provision of an adequate funding mechanism that will allow RBOs to operate independently
- Provision of adequate staffing and training for the RBOs
- Adoption of a strategy for development of a sustainable water resource management plan
- Implementation of a performance monitoring system

In terms of monitoring the sustainability of the Kurgaldzhino wetlands, permanent, well-maintained gauging stations are needed on the Nura river at Almas and the Kulanuptes river at Aktubek, where they enter the wetlands, and permanent level gauges need to be installed and monitored monthly throughout the wetlands. These will provide the data against which the effectiveness of water management can be assessed.

***Okavango***

The Okavango Delta cannot be considered in isolation as many of the pressures on it are likely to come from developments in the upper basin in Angola, where there is a lack of firm data and information. The permanent Okavango River Basin Water Commission (OKACOM) was established in September 1994 to reach a shared vision among the three riparian nations for the basin, and to consult on the development of water resources. TWINBAS has highlighted the need for an integrated approach to water planning and management: emphasis must be on international cooperation in the management of the whole basin, from the upper basin in Angola to the terminal delta in Botswana. The OKACOM rotating secretariat is first being established in Maun, Botswana. International assistance is being provided by USAID and SIDA, focussing initially on data collection in the basin. DWA and ODMP should be closely involved with these activities, to ensure that the hardware and software systems are compatible across the basin, though no difficulties are anticipated in this respect.

Taking a pragmatic view, given that Botswana derives significant economic benefit from the delta, and there is worldwide environmental (and economic) benefit from preserving the biodiversity, it may be that through negotiations Botswana together with the international community compensate the upstream riparian countries for limiting their exploitation of the water resources of the basin. However, it is essential that Botswana is able to substantiate its arguments for sustaining the inflows to the delta with hard facts, rather than indications based on limited and uncertain data and information. Without facts, assertions of shrinkage of the delta can be challenged as unsubstantiated. First and foremost, the improved hydrologic monitoring of the delta is essential, for climatic, surface and groundwater, and for sediment transport and water quality. As access is constantly a problem, the systematic collection and processing of remotely-sensed satellite information has to be initiated and continually advanced with the rapidly developing technology. These data can feed into a continuously developing IHM which includes all required functionality except water quality. Further improvements of the model to make it more rigorous, and the results fully acceptable at negotiations, depend on improved data. There may also be scope for Botswana to receive assistance with its delta monitoring programme, though efforts are presently concentrated in Angola, where the need is greatest. Indeed, water resource planning for the upstream basin is an important issue. Two projects have completed valuable work on this: the USAID-funded Sharing Water and the EU-funded WERRD (Andersson et al., 2006; Hughes et al., 2006; Wilk et al., 2006), and TWINBAS has built on and continued their efforts (Folwell & Farquharson, 2006). However, this work must now be continued on a long-term basis in the OKACOM secretariat. The upper basin models and IHM of the delta should be transferred to the secretariat, and compatibility with the basin planning model assured.

The main threats to the biodiversity and unique ecological function of the Okavango Delta relating to hydrology as addressed under the TWINBAS project are water resource developments in the basin upstream, water resources developments within the delta, and potential climate change over the basin. Civil strife in the basin upstream in Angola, which has spilled over to Namibia, has prevented upstream water resources developments for the past 30 years. With peace settling on the region, Angola and Namibia are likely to develop the water resources for water supply, irrigation and hydropower. While water resources are plentiful throughout Angola, perennial surface sources in Namibia and Botswana are very limited. Other than the Okavango river, Namibia has the remote Cunene river in the north-west, access to the Kuando-Zambezi river in the far north-east, and the Orange river in the south (though technically this belongs entirely to South Africa). The sole alternative source of perennial surface water in Botswana is a 40 km front on the Chobe river bordering Namibia in the north-east. OKACOM will play a vital role in negotiating the exploitation of the water resources of the basin, to satisfy the demands of, and with the agreement of ,all riparian stakeholders. Proposed measures include:

- ***Water supply*** - With refugees returning to the upstream basin in Angola, the demand for water supply for domestic, livestock and industry will increase. Namibia has investigated the feasibility of water supply from the Okavango river to Grootfontein and further to Windhoek. While the quantity is not large, and the impact on the delta barely significant, this interbasin transfer may be questioned in principle, as opening doors to further exploitation of the basin's water resources, the accumulated effect of which could be significant. Botswana abstracts surface and groundwater from the delta for local domestic and livestock water supply. This amounts to around 0.25% of the average inflow, and is barely significant. While detailed water supply is being examined by other ODMP components, neither projected increases in population nor in per capita demand are expected to have a significant impact on the hydrology of the delta. The feasibility of abstraction further afield, to the Orapa diamond mines and villages along the route, was studied but abandoned as a result of national and international environmental pressure. It seems very unlikely that any such proposal for similar abstractions will be considered again in Botswana, and international environmental pressure may similarly constrain major exploitation of the water resources in the upstream basin.

- ***Irrigation*** - While the potential for irrigation development in the basin is limited, the damand for and consumption of abstracted water is greatest outside the rainfall period. The impact on the dry season flows into the delta could be significant. No plans have been formally presented by the upstream riparians, but from studies of what areas could be irrigated and assumed cropping patterns, dry winter inflows to the delta could be reduced by 50%, with a correspondingly significant impact on the area of the delta which will remain flooded through the dry period.

- ***Hydropower*** - Plans existed in the early 1970s for the development of dams for hydropower in the upstream Okavango River Basin in Angola. While Angola has significant potential hydropower development on other river basins, including the adjacent Zambezi and Cunene, and electric power is easily transported, there may still be pressure for hydropower development on the upstream tributaries of the Okavango river. To date, three basin-wide projects have carried out tentative water resource planning studies on the basin, assuming some or all of the planned dams are constructed and also assuming their operating rules (Sharing Water, WERRD and TWINBAS), and the results of the planning studies have been applied to the IHM. As hydropower does not directly consume water (through there is only a small increase in the evaporation from the surface of the reservoirs), and according to the applied operating rules there is limited storage in dry years, the impact on the flooded area of the delta is not significant. Nonetheless, there is a change in the flow pattern with lower peak flows and higher dry period flows, and the amount of sediment conveyed into the delta maybe reduced. Feasibility studies for a small hydropower plant at Popa Falls on the Okavango river in Namibia 30 km upstream of the border with Botswana are currently suspended. The falls have a drop of around 4m, and upstream storage will be limited, with presumably a marginal impact on the flows downstream. However, this dam would also trap sediment, which may have an impact on the morphological processes in the panhandle and the delta downstream.

- ***Channel interventions*** - The hydrology and vegetation of the delta are dynamic, with shifting seasonal and longer term patterns of sedimentation and vegetation growth, leading to the realignment of river channels and larger scale flow patterns. In the past, people have attempted to influence these processes, to restore access to villages, fisheries and other natural resources of the delta, and to maintain the flow of water to fisheries, wildlife areas and tourist lodges. This has entailed cutting new and clearing blocked channels through the dense swamp vegetation. So far this has been carried out by manual labour, and is time consuming and expensive in human resources and, as a result, the cutting and clearing has been carried out on a relatively small scale. It has also proved largely ineffective, as the vegetation soon reasserts itself on the waterscape. Plans have been mooted to acquire mechanical means to clear channels through the delta. It seems unlikely that this could be economic or effective, and is unlikely to be implemented.

- ***Climate change*** - Climate change will have the potentially greatest impacts on the basin and the delta, but these impact are the most difficult to quantify. There are numerous climate models, each with different estimates of the impact of emissions on the long-term climate, though there is general consensus that rainfall will decrease and temperature increase in the longer term. In a preliminary analysis, the HadCM3 model scenario was applied to analyse the impact on the hydrology of the basin and delta. This scenario was chosen as it gives a good representation of historical climate patterns, and its predictions of changed climate are average among climate models. The projected impact on the delta is a 60% reduction in area of the delta which remains flooded through the dry period, and a 40% reduction in the maximum area flooded. There would also be significantly reduced water in the soil moisture and in the deeper groundwater. However, there is scope to improve the estimates of impacts through improved climate change scenarios using regional models.

***Thames***

The Thames River Basin already faces some of the biggest environmental issues in the UK, such as water resource supply, flood risk and water quality, compounded by the effects of climate change and unprecedented levels of growth over the next ten years. The Environment Agency aims for effective and sustainable management of the region's water resources (both quantity and quality), flood defences, waste management, and its major construction and development projects (Environment Agency, 2006).

Progress towards implementation of all aspects of the WFD by the Environment Agency is very advanced. The water body classification and risk assessment will allow the Environment Agency and other stakeholders in the Thames basin to take a more holistic and integrated approach to water management and the improvement of aquatic environments. The proportion of water bodies identified as being “at risk” may increase in the future as further risk assessment work (including data from targeted monitoring) improves confidence in the risk to those waters.

Results of a cost effectiveness analysis, including environmental costs and benefits, and assessment of disproportionate costs, to be carried out as components of an ongoing collaborative research programme into integrating economics into river basin planning, will provide inputs to decision-making and public participation processes in the development of programmes of measures for water bodies at risk of not achieving good status in the Thames basin, and RBMPs.

The periodic reassessment carried out by the Environment Agency in preparation of its 5-year Plan will inform the WFD river basin planning process in the Thames basin. Through a comprehensive toolkit for public participation, all stakeholders within the Thames basin have opportunities to comment on and contribute to the numerous consultation exercises on all aspects of river basin management conducted by the Environment Agency. The latest series of consultations will create a wider awareness of the challenges facing the water environment and the ways in which they can be tackled, and will culminate in the production of a first RBMP for the Thames basin in 2009.

The advanced state of river basin management and the abundance of management plans in the Thames basin, has enabled it to demonstrate and contribute examples of good practice to the other TWINBAS basins in order to encourage improved management approaches.

However, at the same time, these numerous plans may present some challenges in implementing the WFD in the Thames basin itself. In the basin, rivers and estuaries are already divided into stretches to help target the management of point source discharges of pollution, and the Catchment Abstraction Management Strategy (CAMS) and Catchment Flood Management Plan frameworks already use water resource management units (Environment Agency, 2005a). The relationships between these detailed local and catchment scale sectoral plans and the river basin district scale plans at the WFD level remain to be completely demarcated: such local and catchment scale planning can make significant contributions to river basin planning in providing data, identifying issues affecting particular catchments, and agreeing measures to be taken at catchment level. Engagement with existing stakeholder networks and forums will also be important at both the catchment and local levels.

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# Appendix 1 WFD timetable for River Basin Management Plans

| Date | Activity | Article |
|---|---|---|
| Dec 2000 | • WFD enters into force | 22 |
| Dec 2003 | • Requirements transposed into national law<br>• River basin districts and competent authorities identified | 3,24 |
| Dec 2004 | • Complete analysis of river basin characteristics including review of pressures & human impacts on water body status<br>• Identify artificial and heavily modified water bodies<br>• Complete economic analysis of water use<br>• Establish register of protected areas & identify water bodies used for the abstraction of drinking water | 5,6,7 |
| Dec 2005 | • Identify significant upward trends in water pollution & criteria for establishing the starting point of trend reversal | 17 |
| Dec 2006 | • Establish environmental monitoring programmes<br>• Publish work programmes for producing the first RBMP for consultation<br>• Establish environmental quality standards for substances included on first priority list & controls on principal sources | 8,14,16 |
| Dec 2007 | • Publish interim overview of significant water management issues for consultation | 14 |
| Dec 2008 | • Publish draft RBMPs for consultation | 14 |
| Dec 2009 | • Designate heavily modified water bodies<br>• Set environmental objectives<br>• Finalise programme of measures to meet objectives<br>• Finalise and publish first RBMPs | 11,13 |
| Dec 2010 | • Ensure “true-cost” water pricing policies are in place | 9 |
| Dec 2012 | • Ensure that programme of measures is operational<br>• Publish timetable and work programmes for second RBMP for consultation<br>• Report interim progress in implementing measures | 11,15 |
| Dec 2013 | • Review first RBMPs and publish interim overview of issues for the second RBMP for consultation | |
| Dec 2015 | • Achieve environmental objectives specified in first RBMP<br>• Finalise and publish second RBMP with revised programme of measures (to be achieved in 2021) | 4,13,14,15 |

(source: Defra, 2002; FWR, 2004)

# Appendix 2 Summary of the issues to be covered in River Basin Management Plans

- General description of the characteristics of the river basin district, including a map showing the location and boundaries of the surface and groundwater bodies, and a further map showing the types of surface water bodies within the basin.

- Summary of the significant pressures and impacts of anthropogenic activity on the status of surface and groundwaters including point source pollution, diffuse pollution and related land sue, the quantitative status of water bodies including abstractions, and an analysis of other impacts of human activity on water body status.

- Map showing any protected areas.

- Map of the monitoring network.

- Map showing the status of all water bodies and protected areas.

- List of the environmental objectives set for all water bodies, including those where the use has been made of derogations.

- Summary of the economic analysis of water use.

- Summary of the programme(s) of measures.

- Register of any more detailed programmes and management plans and a summary of their contents.

- Summary of the public information and the consultation measures taken, their results and the changes to the plan as a consequence.

- List of competent authorities.

- Contact points and procedures of obtaining background documentation and information, including actual monitoring data.

(source: FWR, 2004; based on EC CIS Guidance Document 1, 2003)